MP System Hardware Guide

Check BIOPAC.COM > Support > Manuals for updates

The MP Hardware Guide describes how to connect and set up various signal conditioning and amplifier modules for use with an MP150, MP100 or MP36R System, and details applications and uses for the MP System.

✓ All specifications are subject to change without notice.

BIOPAC Systems, Inc.
42 Aero Camino, Goleta, CA 93117
Tel (805) 685-0066 | Fax (805) 685-0067
www.biopac.com

Chapter 1 MP Systems

The MP System is a computer-based data acquisition system that performs many of the same functions as a chart recorder or other data viewing device, but is superior to such devices in that it transcends the physical limits commonly encountered (such as paper width or speed). The MP data acquisition unit (MP150 or MP100) is the heart of the MP System. The MP unit takes incoming signals and converts them into digital signals that can be processed with the computer.

MP Systems can be used for a wide array of applications, including:

Cardiovascular Hemodynamics	Evoked Response	MRI
ECG: Cardiology	Exercise Physiology	Plethysmography
EDA: Electrodermal Aactivity	Impedance Cardiography	Psychophysiology
EEG: Electroencephalogram	Interfacing with Existing Equipment	Pulmonary Function
EMG: Electromyogram	*In vitro* Pharmacology	Remote Monitoring
EOG / Eye Movement	Laser Doppler	Sleep Studies

Data collection generally involves taking incoming signals (usually analog) and sending them to the computer, where they are (a) displayed on the screen and (b) stored in the computer's memory (or on the hard disk). These signals can then be stored for future examination, much as a word processor stores a document or a statistics saves a data file. Graphical and numerical representations of the data can also be produced for use with other programs.

- ❖ Application Notes are provided at www.biopac.com under Support; see page 22.
- ❖ ***Quick Start*** Templates are provided in the Samples folder to simplify setup; see page 23.

The MP System can be used on a PC with Windows® or a Macintosh®. The software has the same "look and feel" on both Windows and Mac® computer operating systems. MP Systems and accessories are CE marked and adhere to IEC60601-1 standards where applicable.

MP150 STARTER SYSTEM

The MP150 high-speed data acquisition system utilizes the very latest in Ethernet technology. The MP150 is compliant with any Ethernet (UDP) ready PC running Windows or Macintosh. This next generation product takes full advantage of cutting edge technology. Access multiple MP150 devices located on a local area network and record data to any computer connected to the same LAN. Record multiple channels with variable sample rates to maximize storage efficiency. Record at speeds up to 400 kHz (aggregate).

<u>MP150 System includes:</u>

Data acquisition unit: MP150A-CE

Universal interface module: UIM100C

Acq*Knowledge*® software CD

Software Guide (PDF)

Ethernet Connection

Windows Ethernet Card ETHCARD1 (DFE-530TX+)
or ETHCARD2 (PCMCIA adapter)
and Crossover Cable: CBLETH2

Mac Ethernet Switch ETHSWITCH1
and Patch Cable CBLETH1

Transformer: AC150A

*MP150 Specifications are on page 9.

Recommended MP150 configuration

Windows: For the best possible performance, connect the MP System directly to the ETHCARD1 or ETHCARD2 network interface card, via the CBLETH2 Ethernet crossover cable supplied with the system. This allows users to continue using an existing Ethernet card for accessing the internet and local area network while using the MP System.

Mac: Connect the MP System to the ETHSW1 using the CBLETH1 Ethernet cable. If a computer has no Ethernet port, users need to install an industry standard PCI Ethernet card (Intel, 3COM, etc.).

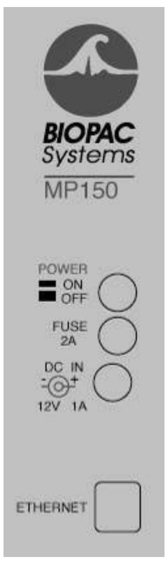
If a computer does not require simultaneous connection to the network, standard crossover Ethernet cable can be used to connect the MP System to a computer.

MP150 Symbology

Front panel — **See "Light Status" section for functionality details.**

POWER	**Green light**	Indicates MP150 Power status.
ACTIVITY	**Amber light**	Indicates data traffic to or from MP150— *similar to Hard Disk activity light on any personal computer.*
BUSY	**Green light**	Indicates MP150 data acquisition.

Back panel



Power

ON Push in to power up the MP150

OFF Pop out to cut the flow of power to the MP150

IMPORTANT! The MP150 does not have a "Hardware Reset" switch like a personal computer does. To reset the MP150 for any reason, turn the MP150 off, wait a few seconds, and then turn it back on.

Fuse 2A 2 Amp fast-blow fuse holder; the maximum capacity of the fuse is 2 Amps.

- To remove the fuse, use a screwdriver to remove the fuse cover, which is located below the word **Fuse**.

DC Input Use the **DC Input** to connect a battery, AC/DC converter or other power supply to the MP150.

- The MP150 requires 12 VDC @ 1 Amp (minimum), 2 Amp (nominal)
- The receptacle can accept a "+" (positive) input in the center of the connector and a "–" (negative) input on the connector housing.

Ethernet The MP150 connects to the computer via the Ethernet port, located just to the right of the word **Ethernet**.

- Uses a standard RJ-Ethernet connector (10 base T).

Side panel

Module connections The two connector inputs are designed to connect directly to the UIM100C.

- **Analog signals** are transmitted through the 37-pin connector (upper right side)
- **Digital signals** are transmitted through the 25-pin connector (lower-right side)

Bottom

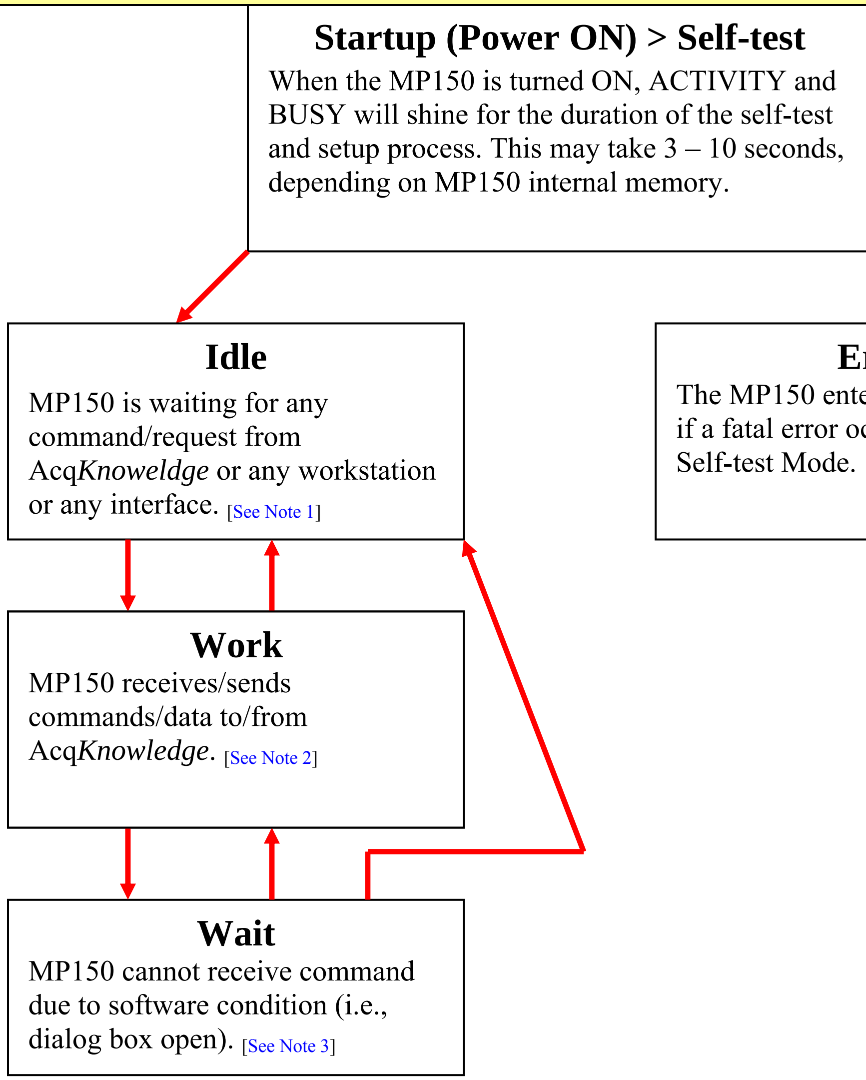
Firmware Rollback Switch

IMPORTANT! This is NOT A RESET SWITCH
The Firmware Rollback Switch is located on the bottom of the MP150 unit and is recessed to prevent accidental activation—it is NOT A RESET for the MP150 unit.

Warning! Activation of the Firmware Rollback Switch will cause the MP150 unit to operate under the previous version of firmware loaded into the unit. Refer to **Appendix F** of the **Acq*Knowledge* Software Guide** for procedural details.

ACTIVITY BUSY	MODE	DESCRIPTION
A Bright **B Bright**	Self-Test Work Error	ACTIVITY and BUSY be bright for the duration of the self-test and setup process. This may take 3 – 10 seconds, depending on MP150 internal memory. During data acquisition, ACTIVITY reflects command/data traffic (for acquisition speeds of 1000 Hz or more, ACTIVITY will be permanently bright or blink at a high frequency) and BUSY will be bright. It is normal for both lights to be on—this does not indicate a problem unless an Error Message is generated on the computer screen. ERROR: In rare cases, a serious problem may prevent a self-test and the lights may be erratic: both on, both off, or any other static combination.
A Bright **B Blink**	Error	The MP150 enters the Error Mode if a fatal error occurs during the Self-test Mode. In the Error Mode, ACTIVITY is bright and BUSY is blinking at a frequency of 5 Hz.
A Blink **B Bright**	Error	If the self-test fails or setup fails, the Error mode is initiated and ACTIVITY will blink at about 5 Hz rate and BUSY will remain bright.
A Blink **B off**	Idle-1 Idle-2	ACTIVITY blinks twice with approximately 1.5-2 second interval and BUSY is OFF. Double blink means: - MP150 may be disconnected from LAN or, - MP150 is connected to LAN but did not receive IP address from network's DHCP server and default 169.254.xxx.xxx address is self-assigned to MP150. This is the standard state for MP150 connected to NIC through crossover network cable. It means the MP150 is in working condition and ready for acquisition. Acq*Knowledge* may communicate with the MP150 through a serial cable or through a network by using 169.254.xxx.xxx address and/or crossover cable. ACTIVITY blinks once with approximately 1.5-2 second interval and BUSY is OFF. Single blink means: - MP150 is connected to LAN and received IP address from network's DHCP server. It means the MP150 is in working condition and ready for acquisition.
A off **B off**	Self-Test Wait Error	ACTIVITY and BUSY will go dark for less than 1 second at the end of the self-test before proceeding to the Idle mode. Under some conditions, such as when a dialog box is open, Acq*Knowledge* cannot send commands to the MP150. When command flow from the workstation stops, the MP150 acts as if there is an open dialog and enters the Wait Mode to wait for a command from the workstation it is "locked" to—commands from any other work station will be ignored. When it receives a command, the MP150 return to the Work mode. After five minutes with no command communication, the MP150 will revert to the Idle mode. ERROR: In rare cases, a serious problem may prevent a self-test and the lights may be erratic: both on, both off, or a static combination.

MP150 STATUS LIGHT PATHS

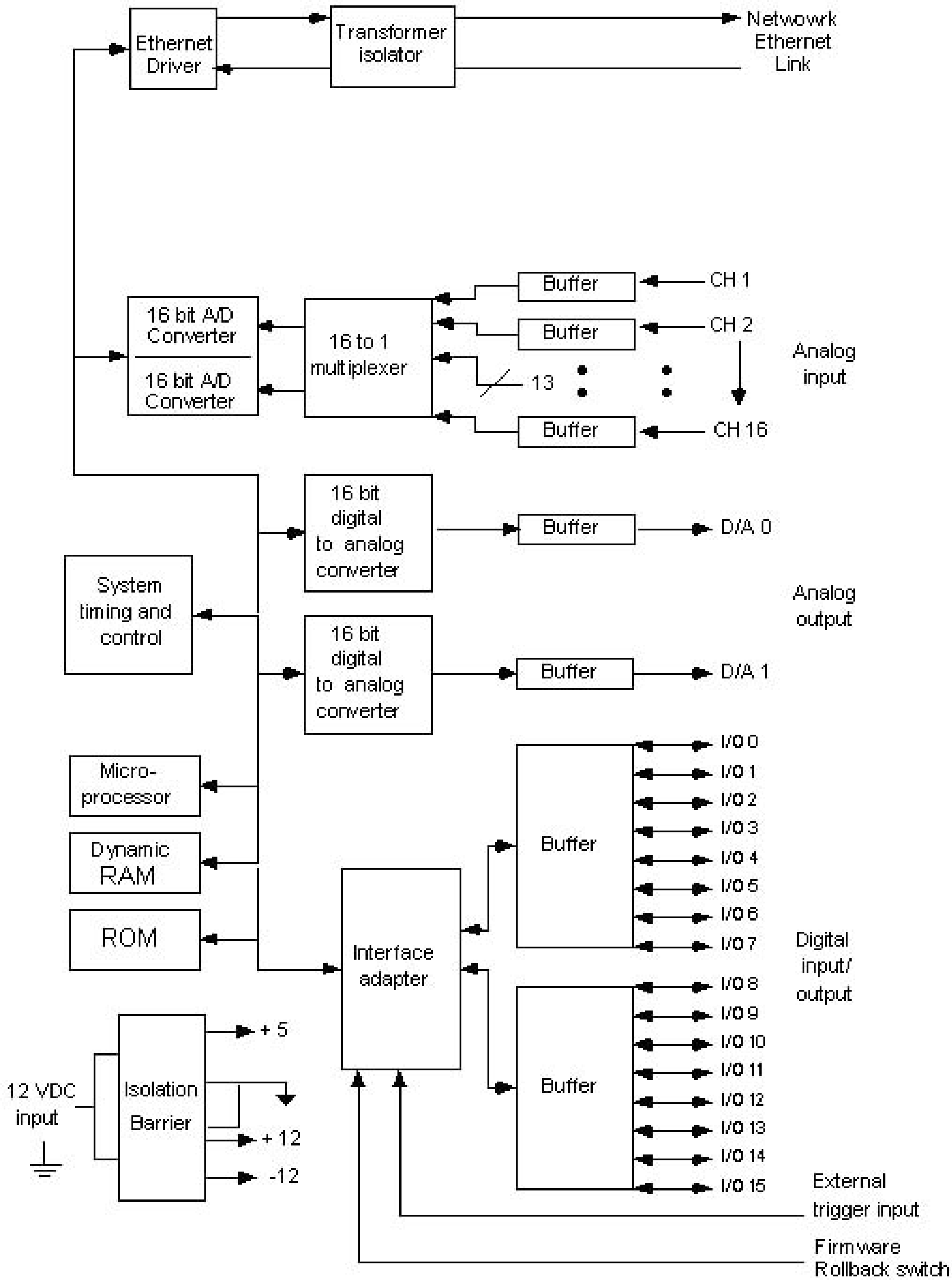


NOTES

1. **IDLE**—Both light patterns are normal and indicate that the MP150 is waiting for a command—neither indicates a problem with the MP150. The MP150 can switch between Idle-1 and Idle-2. Idle-1 or Idle-2 pattern indicates which IP address the MP150 is using:
   - Idle-1: self-assigned address in 169.254.xxx.xxx network
   - Idle-2: address from DHCP server).
2. **WORK** — When the MP150 receives any command from any workstation, it locks on to that workstation and communicates with it exclusively. The MP150 "remembers" the active workstation and will ignore commands from any other workstation. The MP150 usually remains in the Working Mode until the Acq*Knowledge* software program is closed.
3. **WAIT** — Under some conditions, such as when a dialog box is open, Acq*Knowledge* cannot send commands to the MP150. When command flow from the workstation stops, the MP150 acts as if there is an open dialog and enters the Wait Mode to wait for a command from the workstation it is "locked" to—commands from any other work station will be ignored. When it receives a command, the MP150 enters the Work mode; if the MP150 does not receive a command within five minutes, it reverts to Idle.

MP150A-CE Data Acquisition Unit Block Diagram

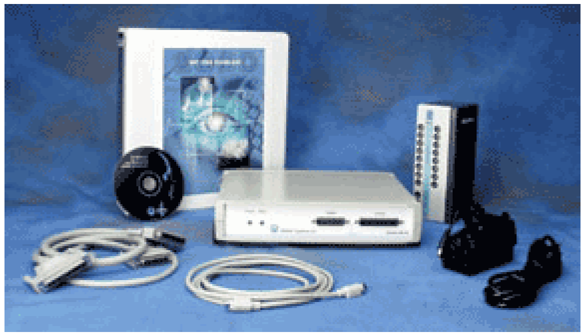
The MP150 has an internal microprocessor to control the data acquisition and communication with the computer. There are 16 analog input channels, two analog output channels, 16 digital channels that can be used for either input or output, and an external trigger input. The digital lines can be programmed as either inputs or outputs and function in 8 channel blocks. Block 1 (I/O lines 0 through 7) can be programmed as either all inputs or all outputs, independently of block 2 (I/O lines 8 through 15).



MP150A-CE block diagram

*MP150 Specifications are on page 9.

MP100 STARTER SYSTEM



*MP100 Specifications are on page 9.

The MP100 system offers USB-ready data acquisition and analysis. Record multiple channels with differing sample rates. Record at speeds up to 70 kHz or 16 kHz (aggregate to disk)

<u>MP100 System includes</u>*:*

Data acquisition unit: MP100A-CE	Transformer: AC100A
Universal interface module: UIM100C	Cables: CBLSERA cable, CBLS100 cable set
USB adapter: USB1W (PC) *or* USB1M (Macintosh)	Acq*Knowledge*® software CD

*Recommended MP100 configuration***:**

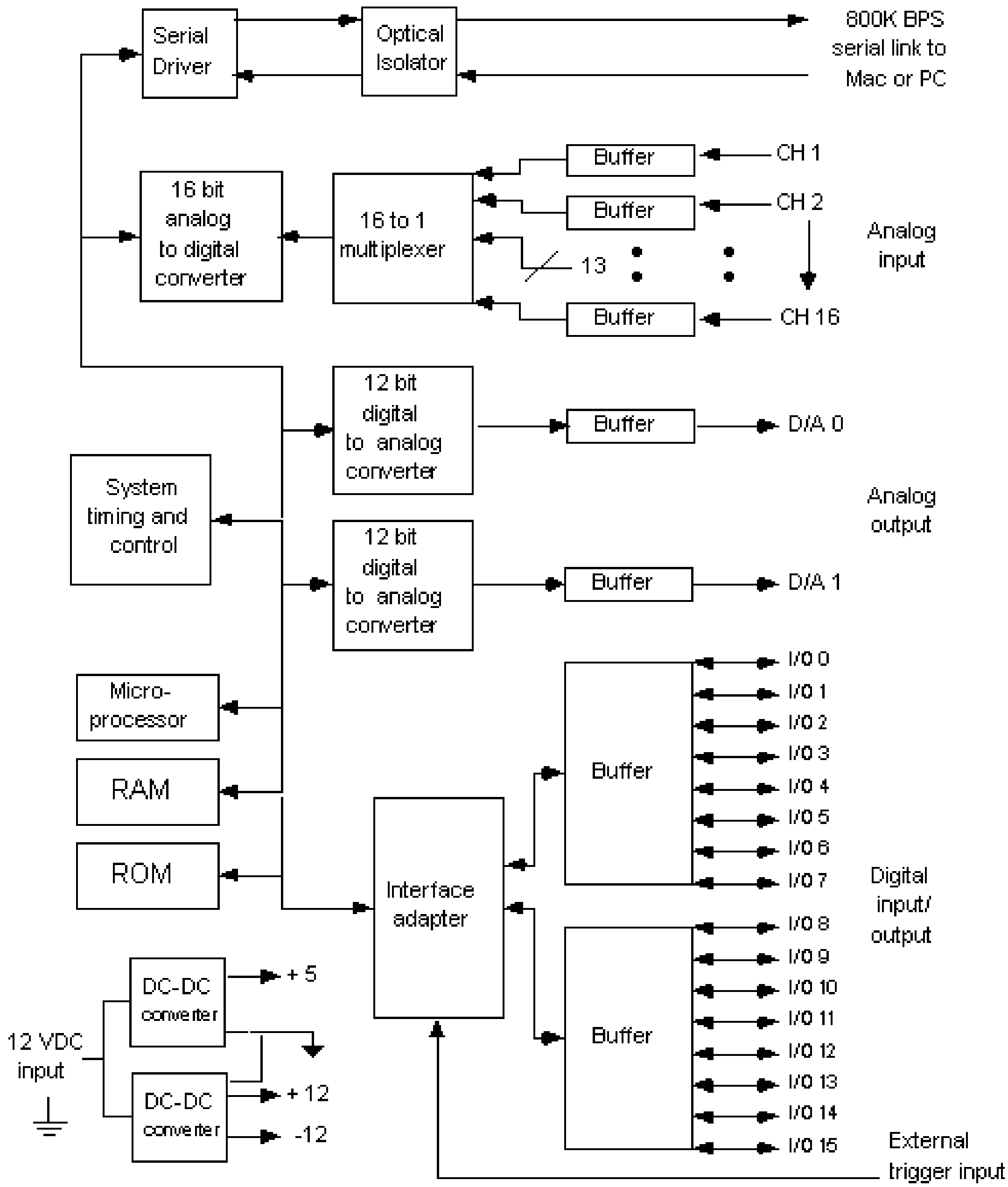
For the best possible performance, connect the MP System to the computer's USB port, with no other USB traffic intensive devices (e.g. scanners, hard drives, cameras) running simultaneously. If a computer has no USB port, users need to install an industry standard PCI USB card.

MP100 Symbology

Front panel		
POWER	Power status	**On** if MP100 is turned ON. **Off** if MP10 is turned OFF.
BUSY	MP100 acquisition status	**On** during acquisition or during the first 1-5 seconds after the MP100 is powered ON.
CABLE INPUTS	25-pin cable connection	Digital signals
	37-pin cable connection	Analog signals
Back panel		
Power switch	**On** powers up the MP100 **Off** cuts the flow of power to the MP100	
Fuse holder	Next to the power switch is a 2 Amp fast-blow fuse holder. To remove the fuse, use a screwdriver to remove the fuse cover, which is located below the word **Fuse**. The maximum capacity of the fuse is 2 Amps.	
DC Input	The **DC Input,** located between the fuse holder and the serial cable, is where a battery, AC/DC converter or other power supply connects to the MP100. The power supply requirements for the MP100 are 12 VDC @ 1 Amp, The receptacle is configured to accept a "+" (positive) input in the center of the connector and a "–" (negative) input on the connector housing.	
Serial port	The MP100 connects to the computer via a serial port, located just below the word **Serial**. Uses a standard MINI DIN 8 connector. Should only be used to connect the MP100 to a PC or Macintosh.	

MP100A-CE Data Acquisition Unit Block Diagram

The MP100 has an internal microprocessor to control the data acquisition and communication with the computer. There are 16 analog input channels, two analog output channels, 16 digital channels that can be used for either input or output, and an external trigger input. The digital lines can be programmed as either inputs or outputs and function in 8 channel blocks. Block 1 (I/O lines 0 through 7) can be programmed as either all inputs or all outputs, independently of block 2 (I/O lines 8 through 15).



MP100 block diagram

*MP100 Specifications follow.

MP System Specifications — for MP150 and MP100

MP150 and MP100 Data Acquisition Unit Specifications:

Application Programming Interfaces options:

- Hardware Interface BHAPI
- Software Interface ACKAPI

Analog Inputs		
Number of Channels:	16	
Absolute Maximum Input:	±15 V	
Operational Input Voltage:	±10 V	
A/D Resolution:	16 Bits	
Accuracy (% of FSR):	±0.003	
Input impedance:	1.0 MΩ	
Analog Outputs		
Number of Channels:	2	
Max output with acquisition:	MP150: 2 channels, MP100: 1 channel	
Output Voltage Range:	±10 V	
D/A Resolution:	MP150: 16 bits, MP100: 12 Bits	
Accuracy (% of FSR):	MP150: ±0.003, MP100: ±0.02	
Output Drive Current:	±5 mA (max)	
Output Impedance:	100 Ω	
Digital I/O		
Number of Channels:	16	
Voltage Levels:	TTL, CMOS	
Output Drive Current:	±20 mA (max)	
External Trigger Input:	TTL, CMOS compatible - see External Trigger Inputs, page 18	
Time Base		
Min Sample Rate:	2 samples/hour	
Trigger Options:	Internal, External or Signal Level	
Power		
Amplifier Module Isolation:	Provided by the MP unit	
CE Marking:	EC Low Voltage and EMC Directives	
Leakage current:	<8 µA (Normal), <400 µA (Single Fault)	
Fuse:	2 A (fast blow)	
Device specific specs	***MP150***	***MP100***
Max Sample Rate		
MP Internal Memory:	200 K samples/sec (400K aggregate)	70 K samples/sec (70 K aggregate)
PC Memory/Disk:	200 K samples/sec (400K aggregate)	11 K samples/sec (16K aggregate)
Internal Buffer:	6 M samples	16 K samples
Waveform Output Buffer:	500 K samples	4 K samples
Serial Interface Type/Rate:	Ethernet: UDP (10M bits/sec)	Serial: RS422 (800 Kbits/sec)
Transmission Type:	Ethernet	USB only (Windows via USB1W or Mac via USB1M)
Maximum cable length:	100 meters (Ethernet cable)	7 meters (USB + SERIAL cable)
Power Requirements:	12VDC @ 2 amp (uses AC150A)	12 VDC @ 1amp (uses AC100A)
Dimensions:	10cm x 11cm x 19cm	7cm x 29cm x 25cm
Weight:	1.0 kg	1.8 kg
OS Compatibility		
Ethernet Interface		
Windows	Windows XP, Vista, 7	Not supported
Mac	OS X	Not supported
USB Interface		
Windows	Not supported	Windows XP, Vista, 7
Mac	Not supported	OS X

Isolation

Designed to satisfy the following Medical Safety Test Standards affiliated with IEC6061-1:

- Creepage and Air Clearance
- Dielectric Strength
- Patient Leakage Current

Contact BIOPAC for additional details.

Signal conditioning module compatibility

BioNomadix	EGG100C	LDF100C	RSP100C
$CO_2$100C	EMG100C	MCE100C	SKT100C
DA100C	EOG100C	NICO100C	STP100C
EBI100C	ERS100C	$O_2$100C	STM100C
ECG100C	GSR100C	OXY100C/E	TEL100C
EEG100C	HLT100C	PPG100C	

Cleaning procedures

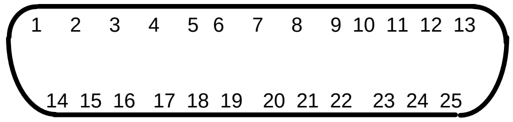
Be sure to unplug the power supply from the MP150/100 before cleaning. To clean the MP150/100, use a damp, soft cloth. Abrasive cleaners are not recommended as they might damage the housing. Do not immerse the MP150/100 or any of its components, as this can damage the system. Let the unit air-dry until it is safe to reconnect the power supply.

AC150/100A Power Supplies

The 12-volt in-line switching transformer connects the MP unit to the AC mains wall outlet. One transformer is included with each MP System; replacements can be ordered separately. These transformers are specified to satisfy IEC60601-1 requirements and will accommodate 120-240 VAC (50/60 Hz) mains input.

MP SYSTEM PIN-OUTS — FOR MP150 AND MP100

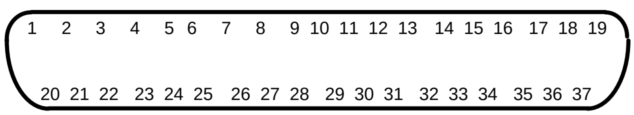
Digital DSUB 25 (male) Pin-outs



DIGITAL

Pin	Description	Pin	Description
1	I/O 0	**14**	I/O 4
2	I/O 1	**15**	I/O 5
3	I/O 2	**16**	I/O 6
4	I/O 3	**17**	I/O 7
5	GND D	**18**	GND A
6	GND D	**19**	Out 1
7	EXT T	**20**	Out 0
8	+5 VD	**21**	GND A
9	+5 VD	**22**	I/O 12
10	I/O 8	**23**	I/O 13
11	I/O 9	**24**	I/O 14
12	I/O 10	**25**	I/O 15
13	I/O 11		

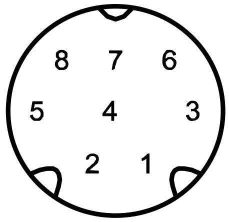
Analog DSUB 37 (male) Pin-outs



ANALOG

Pin	Description	Pin	Description
1	GND A	**20**	CH 1
2	GND A	**21**	CH 2
3	GND A	**22**	CH 3
4	GND A	**23**	CH 4
5	GND A	**24**	CH 5
6	GND A	**25**	CH 6
7	GND A	**26**	CH 7
8	GND A	**27**	CH 8
9	+12 V	**28**	+12 V
10	GND A	**29**	- 12 V
11	-12 V	**30**	CH 9
12	GND A	**31**	CH 10
13	GND A	**32**	CH 11
14	GND A	**33**	CH 12
15	GND A	**34**	CH 13
16	GND A	**35**	CH 14
17	GND A	**36**	CH 15
18	GND A	**37**	CH 16
19	GND A		

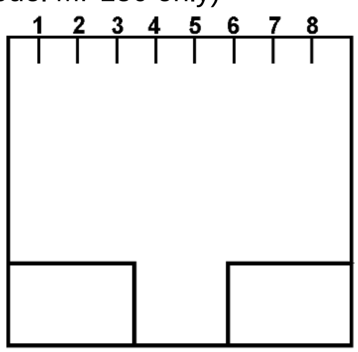
Serial MINI DIN 8 (female) Pin-outs—MP100 Only



SERIAL

Pin	Description
1	No Connection
2	Clock (MP Output)
3	Rx+ (MP Input)
4	GND computer
5	Tx+ (MP Output)
6	Rx- (MP Input)
7	No Connection
8	Tx- (MP Output)

Ethernet connector Pin-outs (for model MP150 only)



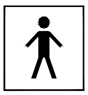
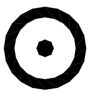
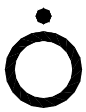
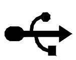
Front View

Pin	Description
1	TXD+
2	TXD-
3	RXD+
4	No Connection
5	No Connection
6	RXD-
7	No Connection
8	No Connection

MP36R STARTER SYSTEM

The MP36R data acquisition unit has an internal microprocessor to control data acquisition and communication with the computer. The MP36R unit takes incoming signals and converts them into digital signals that can be processed with the computer. There are four analog input channels, one of which can be used as a trigger input. To record signals, connect the MP36R unit to the computer and connect electrodes, transducers, and I/O devices to the MP36R unit.

MP36R SYMBOLOGY

Symbol	Description	Explanation
	**Type BF Equipment**	Classification
	**Attention**	Consult accompanying documents
	**On** (partial)	Turns MP36/35 on assuming AC300A power adapter is powered by the mains
	**Off** (partial)	Turns MP36/35 off if but AC300A power adapter remains powered by the mains
	Direct current	Direct current output
	**USB**	USB port

COMPLIANCE

SAFETY

The MP36R satisfies the Medical Safety Test Standards affiliated with IEC60601-1 and is designated as Class I Type BF medical equipment

EMC

The MP36R satisfies the Medical Electromagnetic Compatibility (EMC) Test Standards affiliated with IEC60601-1-2.

TYPES OF INPUT DEVICES

There are three types of devices that connect to the MP36R: electrodes, transducers, and I/O devices.

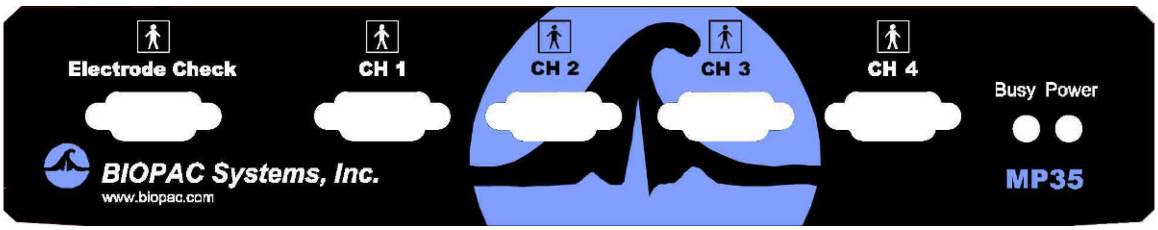
- Electrodes are relatively simple instruments that attach to the surface of the skin and pick up electrical signals in the body.
- Transducers, on the other hand, convert a physical signal into a proportional electrical signal.
- Input/Output devices (I/O for short) are specialized devices like pushbutton switches and headphones.

SIMPLE SENSOR CONNECTORS

Regardless of the type of device connected, every sensor or I/O device connects to the MP36R using a “Simple Sensor” connector. Simple Sensor connectors are designed to plugs only one way into the MP36R—it’s not possible to plug items in upside down or into the wrong socket.

- Electrodes, transducers, and the pushbutton switch all connect to the channel input ports on the front panel of the MP36R.
- Headphones and the stimulator connect to the “Analog out” port on the back panel of the MP36R.
- Digital devices connect to the “I/O Port” on the back panel.
- Trigger devices connect to the “Trigger” port on the back panel.

MP36R FRONT PANEL



The front panel of the MP36R has an electrode check port, four analog input ports, and two status indicators.

Electrode Check

- The Electrode Check port is a diagnostic tool used with Acq*Knowledge* 4.1 software to determine if the electrodes are properly attached to the subject.

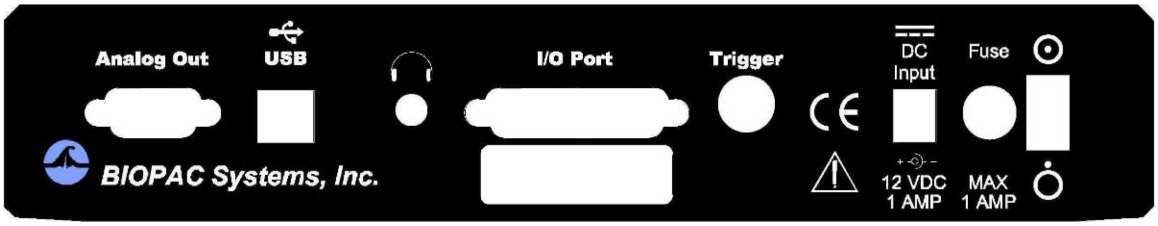
Input ports: CH 1, CH 2, CH 3, and CH 4

- The four 9-pin female analog input ports on the MP36R acquisition unit are referred to as Channels.

Status indicators

- **Busy**—indicator is activated when the MP36R is acquiring data and also during the first few seconds after the MP3X is powered on to indicate that a self-test is in progress. (When the MP3X passes the power-on test, the Busy light will turn off.)
- **Power**—status indicator is illuminated when the MP36R is turned on.

MP36R BACK PANEL



The back panel of the MP36R has an analog output port, a USB port, an I/O Port, a Trigger Port, a DC input, a fuse holder, and a power switch, and the unit's serial number.

Analog Out port – Low Voltage Stimulator

There is one 9-pin male "D" analog output port on the back of the MP36R that allows signals to be amplified and sent out to devices such as headphones. On the MP36, Analog Out is built-in low voltage stimulator.

USB connection

The MP36R connects to the computer via a USB Port, located just below the word USB.

- Uses a standard USB connector.
- Should only be used to connect the MP36R to a PC or Macintosh.

Headphone Output

- Accepts a standard (1/4" or 6.3mm) stereo headphone jack.

I/O Port

- Accepts a DB 25 Female connector.
- Input/Output port used to connect digital devices to the MP36R.

Trigger Input

- Accepts a male BNC connector.
- Input port used to send trigger signals from another device to the MP36R.
- See External Trigger Inputs, page 18

DC Input

Use the DC Input to connect a battery, AC/DC converter or other power supply to the MP36R.

- The power supply requirements for the MP36R are 12 VDC @ 1 Amp. Only use the AC300A power adapter with the MP36R. The AC300A is a 12 VDC @ 1.25 Amp power supply adapter that can connect to any mains rated as 100-250 VAC @ 50/60Hz, 40VA.
- The receptacle is configured to accept a "+" (positive) input in the center of the connector and a "-" (negative) input on the connector housing.

Fuse holder

The fuse holder contains a fast-blow fuse that helps protect the MP3X from shorts on its power, analog, and digital I/O lines. The MP36R uses a 1.0 amp fast-blow fuse.

- To remove the fuse, use a screwdriver to remove the fuse cover located below the word Fuse.

Power switch

ON position — powers up the MP Unit OFF position — cuts the flow of power

MP36R Specifications

ELECTRODE CHECK Resistance Range	0-1 MΩ (Vin+ and Vin- to GND)
ANALOG INPUTS	4 isolated channels (front panel CH 1–CH 4)
SAMPLE RATE Max	4 CH @ 100K s/second
Min	1 sample/second
Trigger Input	Analog CH1-CH4 or Digital D1-D8
Threshold	Adjustable threshold level with Positive or Negative Trigger
A/D resolution	24-bit (before digital filtering)
Signal to noise ratio	> 89 dB (nominal) Tested at lowest Gain at 1,000 s/s with grounded front end
Voltage resolution	Gain dependent: 2.38 microvolts /bit (Gain 5) to 0.024 nanovolts /bit (Gain 50,000)
Storage Buffer	512 K
Input voltage range	Gain dependent: 400 microvolts to 4.0 Volts p-p
Input protection	± 1 mA/V current limited
Maximum Input Voltage	4 V p-p (between Vin+ and Vin-)
Differential Input Impedance	2 MΩ (between Vin+ and Vin-)
Filters	3 two-pole IIR digital filters per channel (automatic or user adjustable)
Common Mode Input	(between Vin+/Vin- and GND)
Impedance DC	11 MΩ
AC (50/60 Hz)	1,000 MΩ
CMRR	110 dB minimum at 50/60 Hz
Gain ranges	5 – 50,000 (automatic preset or user adjustable)
Baseline adjustment	*Gain* (automatic or user adjustable) 5, 10, 20, 50: ±100 mV 100, 200, 500: ±10 mV 1,000 to 50,000: ±4 mV
Electrode offset potential tolerance	*Gain* 5, 10, 20, 50: ±2 V 100, 200, 500: ±200 mV 1,000 to 50,000: ±80 mV
ANALOG OUTPUT	
Number of channels	1
D/A resolution	16 bits
Accuracy	±0.01% of FSR
Headphones	
Output impedance	50 Ω
Output voltage	-10 V to +10 V
Output drive current	
SERIAL INTERFACE	USB, Type 2.0 high speed
HEADPHONE	Drives 16-32 Ω standard stereo headphones
I/O PORT	8 TTL compatible inputs and 8 TTL compatible outputs
TRIGGER	TTL compatible input and synchronization port – see External Trigger Inputs, page 18
DC INPUT	Power input; requires 12 VDC @ 1 Amp. Use the AC300A 12 VDC @ 1.25 Amp power supply adapter to connect to any mains rated as 100-250 VAC @ 50/60Hz, 40VA.
FUSE	1.0 amp fast-blow fuse
Dimensions & Weight	7 cm x 29 cm x 25 cm 1.4 Kg

Mains Power Disconnection

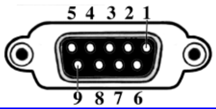
To completely disconnect the MP36R unit and the AC300A power adapter from all poles of the supply mains, extract the power cord plug from the mains outlet.

Please note that the power switch on the back of the MP36R unit turns power ON and OFF to the MP36R unit only.

Extract the plug by grasping the plastic shell of the plug and pull firmly away from the mains outlet in a direction perpendicular to the face of the mains outlet. Take care not to touch the metal blades associated with the plug. This procedure will fully power down (de-energize) the MP36R unit and AC300A power adapter.

MP36R UNIT PIN-OUTS

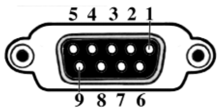
Electrode Check



9-PIN FEMALE DSUB

2 Vin+	Electrode connection
3 GND	
4 Vin-	Electrode connection

CH Input

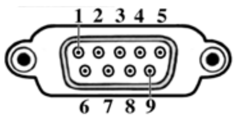


9 PIN FEMALE DSUB

(1 of 4)

1 Shield drive	6 +5 V (100 mA max aggregate)
2 Vin+	7 ID resistor lead 1; I^{2}C SCL
3 GND	8 ID resistor lead 2; I^{2}C SDA
4 Vin –	9 –5 V (100 mA max aggregate)
5 Shield drive	

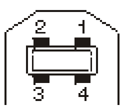
Analog Output



9 PIN MALE DSUB

1 Buffered analog or pulse output A.C. coupled (1,000 uF) Analog range: +/- 2.048 V Pulse range: 0 to 2.048 V	4 +5 V (100mA max.)
	5 Buffered pulse output Z out = 1 kΩ Range: 0 to 5 V
2 Low voltage stimulator Buffered, D.C. coupled Z out = 50 Ω Range: -10 V to +10 V	6 +12 V (100 mA max)
	7 I^{2}C SCL – Do not connect
	8 I^{2}C SDA
	9 Monitor – Do not connect
3 GND	

Connector

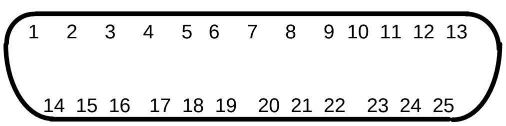


USB

1 +5	5 n/a
2 -Data	6 n/a
3 Data +	7 n/a
4 GND	8 n/a

I/O Port

DSUB 25 (male)



† Digital Input are 0-5 V with 100 K ohm pullups to 5 V on board

1	Digital Output 1 0-5 V 8 ma	15	Digital Output 6
2	Digital Output 2 0-5 V 8 ma	16	Digital Output 7
3	Digital Output 3 0-5 V 8 ma	17	Digital Output 8
4	Digital Output 4 0-5 V 8 ma	18	Analog Input, Right 1 VRMS, centered at 0 V
5	GND Unisolated		
6	GND Unisolated	19	Analog Input, Left 1 VRMS, centered at 0 V
7	RS-232-RX		
8	+5 V Unisolated/fused	20	RS-232-TX 0-5 V
9	I^{2}C-SDA 3.3. V	21	I^{2}C-SCL 3.3 V
10	Digital Input 1† 0-5 V	22	Digital Input 5
11	Digital Input 2† 0-5 V	23	Digital Input 6
12	Digital Input 3† 0-5 V	24	Digital Input 7
13	Digital Input 4† 0-5 V	25	Digital Input 8
14	Digital Output 5		

MP36R CLEANING PROCEDURES

Before cleaning, be sure to unplug the power supply from the MP36R. To clean the MP36R, use a damp, soft cloth. Abrasive cleaners are not recommended as they might damage the housing. Do not immerse the MP36R or any of its components in water (or any other fluid) or expose to extreme temperatures as this can damage the unit.

Cleaning & Disinfecting BIOPAC Components

The following disinfectants are recommended for LIQUID "COLD" sterilization of BIOPAC transducers:

- **Cidex® OPA** Disinfectant Solution, Johnson & Johnson
- **Perform®** Powder Disinfectant Concentrate, Schülke & Mayr
- **Terralin®**, Liquid Disinfectant Concentrate, Schülke & Mayr

> Always follow the manufacturer's directions.

AFT25 Facemask

- See detailed guide shipped with the product; also available at www.biopac.com.

EL250 Series Electrodes

- Store electrodes in clean, dry area.
- After use, clean electrode with cold to tepid water
- DO NOT use hot water.
- Cotton swabs are suggested.
- Let the electrode dry completely before storing it.
- DO NOT allow the electrodes to come in contact with each other during storage.
- Electrodes may form a brown coating if they have not been used regularly. To remove the coating, gently polish the surface of the electrode element with non-metallic material or wipe it with mild ammonium hydroxide. Rinse with water and store the electrode in a clean, dry container.

GASSYS2

- See page 296 or detailed guide shipped with the product; also available at www.biopac.com.

LDF100C

- See page 204.

Probes

- Immersion temperature probes can be cleaned using standard liquid disinfectant methods, with direct immersion for the recommended period.
- Non-immersion probes can be wiped down with liquid disinfectant or alcohol.

RX137 Series Airflow Heads

- Thorough cleaning retains precise measurements. Disinfecting is only useful on a previously cleaned apparatus. Using a gas for disinfecting does not provide cleaning. An appropriate disinfectant solution can clean and disinfect simultaneously.
  1. Immerse the apparatus in the liquid. It can be completely immersed since the electrical part is waterproof; a 30- to 60-minute bath is usually sufficient to detach or dissolve the dirt.
  2. Rinse under a strong tap.
  3. Rinse with distilled or demineralized water.
  4. Use air or another compressed gas to dry the apparatus. Blow through the screen and in each pressure tube; a pressure of 5 to 6 bars is acceptable.
  5. Finish drying with atmospheric air or with a warm blow dryer (hair dryer).
- WARNING!

Do not use organic solvents	Dilute the disinfectant (as for hand washing)
Do not heat the apparatus above 50ºC	Never touch the screen with a tool

- Examples of liquids that may be used: Cidex, Glutaral, Glutaraldéhyde
- Example of gas that may be used: Ethylene oxide

TSD130 Series Goniomoters & Torsiometers

- Important: Disconnect sensors from instrumentation before cleaning or disinfecting.
- Cleaning: Wipe the sensors with a damp cloth, or a cloth moistened with soapy water. Do not use solvents, strong alkaline or acidic materials to clean the sensors.
- Disinfection: Wipe the sensors with a cloth moistened with disinfectant.

TSD140 Probes

- See page 204.

External Trigger Inputs—MP150/100/36R

MP system external trigger inputs are TTL compatible—this means that one needs to send the external trigger input 0 volts for a TTL low and 5 volts for a TTL high.

The external trigger inputs are equipped with internal pull-up resistors—this means that they automatically sit at TTL high, if left unattached.

- This is a common and helpful implementation, because all one requires to implement an external trigger is to pull the external trigger input low.
- This implementation is typically performed with an external switch placed between the external trigger input and ground.
    - When the switch is closed the external trigger input is pulled to TTL low.
    - When the switch is opened the external trigger input is pulled back (by the internal pull-up resistor) to TTL high.

To sync several MP systems together, so that one external trigger can start all the MP systems simultaneously:

1. Connect all the MP systems grounds together.
2. Connect all the MP systems external trigger inputs together.
3. Place a switch between any MP system external trigger input and ground.

When the switch is pressed, all the MP systems that are connected together will be triggered simultaneously.

MP System Applications

Features

With proper hardware selection and setup, the MP System with Acq*Knowledge* software can be used for a wide array of application features. See the Acq*Knowledge* Software Guide or BIOPAC.COM for descriptions of the following features. For additional support, or for help with an unlisted application, please contact the BIOPAC Technical Support Division — an Applications Specialist will be glad to help.

Active Electrodes
Allergies
Amplitude Histogram
Anaerobic Threshold
Animal studies
Auditory Evoked Response (AER)
Automate Acquisition Protocols
Automated Data Analysis
Automatic Data Reduction
Autonomic Nervous System Studies
Biomechanics Measurements
Blood Flow / Blood Pressure /Blood Volume
Body Composition Analysis
Breath-By-Breath Respiratory Gas Analysis
Cardiac Output
Cardiology Research
Cell Transport
Cerebral Blood Flow
Chaos Plots
Common Interface Connections
Connect to MP Systems
Control Pumps and Valves
Cross- and Auto-correlation
Current Clamping
Defibrillation & Electrocautery
Dividing EEG into Specific Epochs
ECG Analysis
ECG Recordings, 12-Lead
ECG Recordings, 6-Lead
EEG Spectral Analysis
Einthoven's Triangle
EMG and Force
EMG Power Spectrum Analysis
End-tidal CO2
Episode Counting
Ergonomics Evaluation
Event-related Potentials
Evoked Response
Exercise Physiology
External equipment, controlling
Extra-cellular Spike Recording
Facial EMG
FFT & Histograms
FFT for Frequency Analysis
Field Potential Measurements
Fine Wire EMG
Forced Expiratory Flow & Volume
Gait Analysis
Gastric Myoelectric Activity
Gastric Slow Wave Propagation
Gastrointestinal Motility Analysis
Hardware Flexibility
Heart Rate Variability
Heart Sounds
Histogram Analysis
Imaging Equipment, Interfacing
Indirect Blood Pressure Recordings
Integrated (RMS) EMG
Interface with Existing Equipment
Interface with Third-party transducer
Invasive Electrode Measurements
Ion-selective Micro-electrode Interfacing
Iontophoresis
Irritants & Inflammation
Isolated Inputs & Outputs
Isolated Lung Studies
Isometric Contraction
Isotonic Contraction
Jewett Sequence
Langendorff Heart Preparations
Laser Doppler Flowmetry
Left Cardiac Work
Long-term Monitoring
Lung Volume Measurement
LVP
Median & Mean Frequency Analysis
Micro-electrode signal amplification
Migrating Myoelectric Complex
Motor Unit Action Potential
Movement Analysis
MRI Applications
Multi-Channel Sleep Recording
Nerve Conduction Studies
Neurology Research
Noninvasive Cardiac Output
Noninvasive Electrode Measurements
Nystagmus Investigation
Oculomotor Research
Off-line ECG Averaging
On-line Analysis
On-line ECG Analysis
Orthostatic Testing
Peripheral Blood Flow
Peristaltic (Slow Wave) Propagation
Planted Tissue
Pressure Volume Loops
Psychophysiology
Pulsatile Tissue Studies
Pulse Rate Measurement
Pulse Transit Time
Range of Motion
Real-time EEG Filtering
Real-time EEG Filtering
Recurrent Patterns
Regional Blood Flow
Relative BP Measurement
Remote Monitoring
Respiration Monitoring

Respiratory Exchange Ratio
Rheumatology
Saccadic Eye Movements
Sexual Arousal Studies
Signal Averaging
Simultaneous Monitoring
Single Channel Analysis
Single-fiber EMG
Software-controlled Stimulator
Somatosensory Evoked Response
Spectral Analysis
Spike Counting
SpO2 Analysis
Stand Alone Amplifiers
Standard Operating Procedures
Startle Eye Blink Tests
Startle Response
Stimulator, software-controlled
Systemic Vascular Resistance
Template Analysis
Tissue Bath Monitoring
Tissue Conductance Measurement
Tissue Magnitude & Phase Modeling
Tissue Resistance & Reactance
Ussing Chamber Measurements
Ventricular Late Potentials
Vestibular Function
Video Capture, Synchronous
Visual Attention
Visual Evoked Response
VO2 Consumption
Volume/Flow Loop Relationships
Working Heart Preparations

Application Notes

BIOPAC has prepared a wide variety of application notes as a useful source of information concerning certain operations and procedures. The notes are static pages that provide detailed technical information about either a product or application. A partial list of Application Notes follows.

View or print application notes directly from the "Support" section of the BIOPAC web site www.biopac.com.

Recording Hardware

- **004 - MP150 Firmware Compatibility**
- **218 - Hardware API**
- **223 - Physiological Measurement in MRI Systems**
- **230 - Connections for Physiological Signals in an MRI**
- **234 - Virtual Reality / Immersive Environment**
- **235 - Zygomaticus Measures with Pressure Pad vs. EMG in MRI or fMRI**
- **239 - Send to AcqKnowledge from Vizard via parallel port**
- **240 - Measurement Computing card setup**
- **241 - Recording EMG data in an fMRI**
- **242 - Recording ECG Data in an fMRI**
- **243 - Gated Analysis for Data Recorded in an MRI**

Amplifiers

- **102 - Biopotential Amplifier Testing With CBLCAL**
- **103 - Remote Monitoring System - TEL100**
- **109 - 3-, 6-, and 12-Lead ECG**
- **110 - Amplifier Baseline Offset Adjustment**
- **126 - Wireless Remote Monitoring - TEL100C-RF**
- **136 - Battery Pack Instructions - BAT100**
- **149 - O2100C Module Setup for the MP System**
- **151 - CO2100C Module Setup for the MP System**
- **154 - High Level Transducer Connections - HLT100C**
- **160 - Gas Analysis Module Response Time**
- **162 - Stimulation Features of MP150/100 Systems**
- **170 - Laser Doppler Flow Module - LDF100C**
- **175 - Stimulus Isolator Guidelines - STMISOC**
- **184 - Interfacing Millar Mikro-Tip Catheters with MP150/100**
- **185 - iMac and G3 Compatibility Issues**
- **187 - Electrodermal Response Guidelines - GSR100C**
- **190 - Micro-Electrode Amplifier Guidelines - MCE100C**
- **195 - MP System Data Sampling Reference**
- **196 - Cardiac Output Measurement - EBI100C**
- **206 - Continuous 12-Lead ECG**
- **207, 208, 209 - UDP Install**
- **215 - Noninvasive Cardiac Ouput - NICO100C and LEAD130**
- **224 - Noninvasive Blood Pressure NIBP100A Calibration**
- **231 - Noninvasive Blood Pressure NIBP100B-R Calibration**

Transducers

- **101 - Transducer Calibration and Signal Re-Scaling**
- **114/b - Pneumotach Transducer - TSD107A /TSD107B***
- **127 - Precision Force Transducers**
- **130 - Noninvasive Blood Pressure Measurement - TSD120**
- **132 - Variable Force Transducer- TSD105A**
- **135 - Pneumotach Transducer - TSD117**
- **140 - Goniometers: Angular Measurements - TSD130 series**
- **141 - Tri-axial Accelerometer Calib - TSD109 series/SS26/27**
- **144 - Hand Dynamometer Calibration - TSD121C**
- **145 - Respiratory Effort Transducer - TSD101B**
- **153 - Physiological Sounds Microphone - TSD108**
- **159 - Hand Switch and Foot Switch - TSD116 Series**
- **186 - Variable Assessment Transducer - TSD115**

Software

- **105 - Auditory Brainstem Response (ABR) Testing**
- **105b - ABR Testing for Jewett Sequence**
- **108 - Data Reduction of Large Files**
- **111 - Nerve Conduction Velocity**
- **113 - Troubleshooting AcqKnowledge for Windows**
- **115 - Hemodynamic Measurements**
- **117 - Pulse Transit Time and Velocity Calculation**
- **118 - EMG Frequency Signal Analysis**
- **120 - X/Y Loop Area Analysis**
- **121 - Waveform Data Reduction**
- **122 - Power Spectrum Analysis**
- **129 - Heart Rate Variability**
- **131 - Averaging Mode in the MP System**
- **148 - Automated ECG Analysis**
- **150 - O2100C Module for Oxygen Consumption**
- **152 - CO2100C Module for End-Tidal CO2**
- **155 - AcqKnowledge File Formats for Mac OS**
- **156 - AcqKnowledge File Formats for Windows OS**
- **158 - Analyzing Inspired & Expired Lung Volume**
- **161 - Automated Tissue Bath Analysis**
- **168 - Analyzing Intraventricular Pressure Wave Data (LVP Analysis)**
- **169 - Speech Motor Control**
- **177 - ECG Analysis Using the Offline Averaging Mode**
- **182 - Analysis of Blood Flow Data**
- **183 - VO2 and RER Measurement**
- **191 - Digital I/O Channels**
- **198 - Prepulse Inhibition of Startle**
- **199 - Impedance Cardiography and Pre-ejection Period**
- **200 - Creating Arbitrary Waveforms for Stimulators**
- **201 - SuperLab with AcqKnowledge**
- **211 - EEG Analysis with AcqKnowledge**
- **214 - EMG Startle Scoring for Prepulse Inhibition**
- **216 - Electrodermal Activity (GSR) Scoring Methods**
- **221 - Simplified VO2 Measurement (without CO2 Values)**
- **222 - Pseudorandom Stimuli after Stim Presentation**
- **226 - BIOPAC Software on Mac-Intel Core Duo Cmpt.**
- **232 - EMG: Normalize to Max Voluntary Contraction**
- **233 - Heart Rate Variability - Preparing Data**
- **238 - Controlling the SDS100 Scent Delivery System**

Acq*Knowledge* QUICK STARTS

"Quick Start" template files were installed to the Sample folder of the BIOPAC Program folder. Use a Quick Start template to establish the hardware and software settings required for a particular application or as a good starting point for customized applications.

Q##	**Application(s)**	**Feature**
1	EEG	Real-time EEG Filtering
	Sleep Studies	Real-time EEG Filtering
2	EEG	Evoked Responses
3	EEG	Event-related Potentials
	Evoked Response	Event-related Potentials
4	Evoked Response	Nerve Conduction Studies
5	Evoked Response	Auditory Evoked response & Jewett Sequence
6	Evoked Response	Visual Evoked Response
7	Evoked Response	Somatosensory Evoked Response
9	Evoked Response	Extra-cellular Spike Recording
10	Pyschophysiology	Autonmic Nervous System Studies
12	Pyschophysiology	Sexual Arousal Studies
13	EBI	Cardiac Output
	Cardiovasc. Hemodynamics	Noninvasive Cardiac Output Measurement
	Exercise Physiology	Noninvasive Cardiac Output
15	EOG	Nystagmus Investigation
16	EOG	Saccadic Eye Movements
17	Plethsymography	Indirect Blood Pressure Recordings
19	Sleep Studies	Multiple-channel Sleep Recording
20	Sleep Studies	Cardiovasc. Hemodynamics
	ECG	*On-line ECG Analysis*
	ECG Analysis	On-line ECG Analysis
21	Sleep Studies	SpO_2 Analysis
22	ECG	Einthoven's Triangle & 6-lead ECG
23	ECG	12-lead ECG Recordings
24	ECG	Heart Sounds
25	Cardiovasc. Hemodynamics	On-line Analysis
26	Cardiovasc. Hemodynamics	Blood Pressure
27	Cardiovasc. Hemodynamics	Blood Flow
28	Cardiovasc. Hemodynamics	LVP
31	NIBP	Pyschophysiology
32	*In vitro* Pharmacology	Tissue Bath Monitoring
33	*In vitro* Pharmacology	Pulsatile Tissue Studies
34	*In vitro* Pharmacology	Langendorff & Working Heart Preparations
35	*In vitro* Pharmacology	Pulmonary Function
	Isolated Lung Studies	Animal Studies
38	Pulmonary Function	Lung Volume Measurement
39	Exercise Physiology	Respiratory Exchange Ratio
40	EMG	Integrated (RMS) EMG
41	EMG	EMG and Force
42	Biomechanics	Gait Analysis
43	Remote Monitoring	Biomechanics Measurements
44	Biomechanics	Range of Motion

Chapter 2 Interface Modules

HLT100C UIM100C

When connecting the analog output sourcing from external devices to the MP100 or MP150, channel contention must be considered. To connect external device outputs to the MP100 or MP150:

- **Non-human subjects or only collecting data from external devices**—If the MP System is only collecting signals from non-human subjects (via MP system amplifier modules) or if the MP System is only collecting data from external devices:
    - Connect external device output signal to an unused **UIM100C** input channel (1-16)
- **Human subjects**—If the MP System is collecting signals from human subjects (via MP system amplifier modules), it's important to isolate the external device output signal from the MP System input.
    - Connect external device output signal to an unused **HLT100C** input channel (1-16) via **INISO**.

Channel contention issues

1. If an analog channel is used on the UIM100C or HLT100C, make certain that two external devices do not use the same analog channel.
2. If amplifier modules are connected to the MP System then those amplifier modules must be set to a channel which is not used by external devices plugged into the UIM100C or HLT100C.

For example:

Two external device outputs are connected to the MP150 system.Device one is a Noninvasive Blood Pressure (NIBP) monitor and device two is an Electronic Scale. In addition, an ECG100C module is attached to the MP150 System and is being used to measure the electrocardiogram. All devices are connected to a human subject.

In this case, to fully isolate the human subject:

- Both the NIBP monitor and the Electronic scale outputs should be connected to the MP150 inputs via the HLT100C, using one INISO for each input channel.
- The ECG100C should be snapped directly to the MP150 System and connected directly to the subject with the appropriate leads and electrodes.
- Assuming the NIBP is connected via INISO to HLT100C channel 1 and the Electronic Scale is connected via INISO to HLT100C channel 2, then the ECG100C amplifier must be set to a channel between 3-16.
    - The ECG100C can't use Channels 1 and 2 because both of these channels are being used by other devices.

If additional instruction or a special cable is required to connect the MP System to the device, please contact a BIOPAC Systems, Inc. applications engineer at support@biopac.com.

UIM100C UNIVERSAL INTERFACE MODULE

The UIM100C Universal Interface Module is the interface between the MP150/100 and external devices. Typically, the UIM100C is used to input pre-amplified signals (usually greater than +/– 0.1 volt peak-peak) and/or digital signals to the MP150/100 acquisition unit. Other signals (e.g., those from electrodes or transducers) connect to various signal-conditioning modules.

The Universal Interface Module (UIM100C) is designed to serve as a general-purpose interface to most types of laboratory equipment. The UIM100C consists of sixteen 3.5 mm mini-phone jack connectors for analog inputs, two 3.5 mm mini-phone jack connectors for analog outputs, and screw terminals for the 16 digital lines, external trigger, and supply voltages.

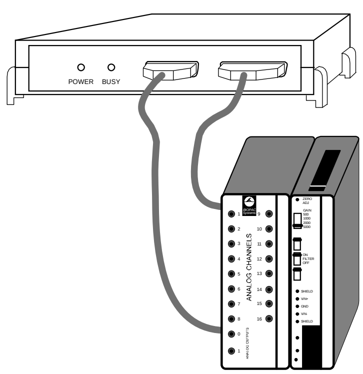
The UIM100C is typically used alone to connect polygraph and chart recorder analog outputs to the MP System. BIOPAC Systems, Inc. offers a series of cables that permit the UIM100C to connect directly to a number of standard analog signal connectors. Most chart recorders or polygraphs have analog signal outputs, which can be connected directly to the UIM100C.

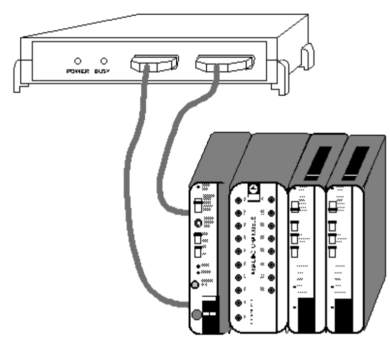
The UIM100C allows access to 16 analog inputs and 2 analog outputs on one side, and 16 digital input/output lines, an external trigger, and supply voltages on the other side. The UIM100C is designed to be compatible with a variety of different input devices, including the BIOPAC series of signal conditioning amplifiers (such as the ECG100C).

Connecting the UIM100C to the MP System

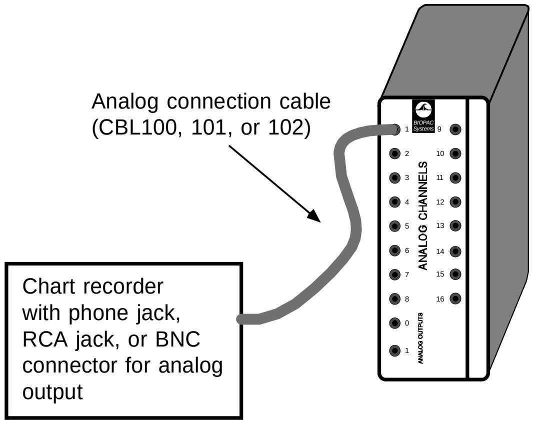
- MP150: Snap the UIM100C onto the right side of the MP150.
- MP100: Connect the UIM100C to the MP100 acquisition unit via two included 0.6-meter cables:
    - o 37-pin connector for analog signals
    - o 25-pin connector for digital signals

When using the Universal Interface Module (UIM100C) with other 100-Series modules, the UIM100C is usually the first module cascaded in the chain. If using the STM100C, OXY100C or HLT100C, the module must be plugged in on the **left** of the UIM100C. Up to seventeen modules (including the UIM100C) can be snapped together, as illustrated in the following diagrams:



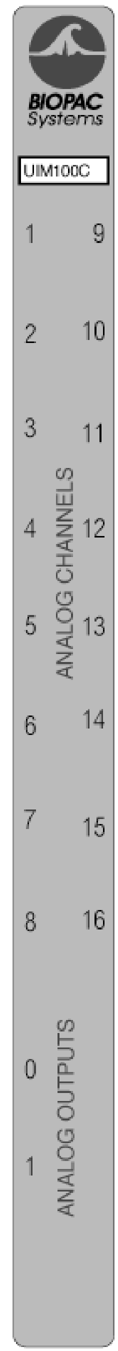


MP100 to UIM100C and amplifier moduleSTM10right 0C and UIM100C and amplifier modules



Typical UIM100C to polygraph interface

When using the UIM100C, be careful not to short the "analog output" terminals together, and not to short across any of the connectors on the "Digital" (back) side of the module.



IMPORTANT USAGE NOTE

Mains powered external laboratory equipment should be connected to an MP System through signal isolators when the system also connects to electrodes attached to humans.

To couple external equipment to an MP System, use:

- For **analog** signals — **INISO** or **OUTISO** isolator (with **HLT100C**)
- For **digital** signals — **STP100C** (with **UIM100C**)

Contact BIOPAC for details.

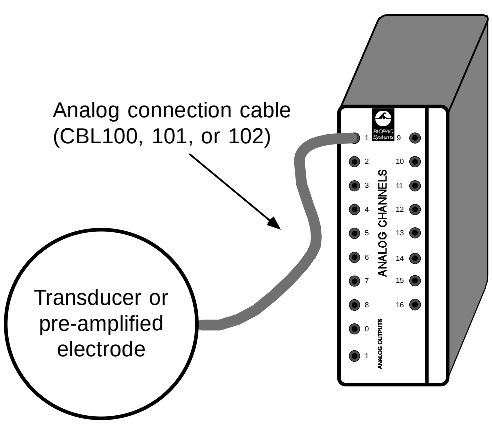
Analog connections

- See setup notes on page 24 for external devices and channel contention issues.

As noted, the UIM100C requires cables equipped with standard 3.5mm mini-phone plugs to connect to analog signal sources. This type of connector is commonly available with many different mating ends. BIOPAC Systems, Inc. carries several different types, including BNC and phone plugs. Since the MP150/100 analog inputs are single-ended, the tip of the mini-phone plug is the input and the base (shield) of the mini-phone plug is the ground (or common).

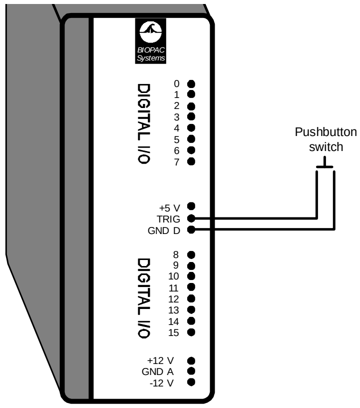
NOTE: Make sure the cable that is routed into the UIM100C is a <u>**mono**</u> 3.5 mm phone plug.

To connect to existing equipment (such as polygraphs or chart recorders), run a cable from the analog output terminal of the external device to the UIM100C. Since there are so many different devices that can connect to the MP150/100 it's impossible to cover them all.

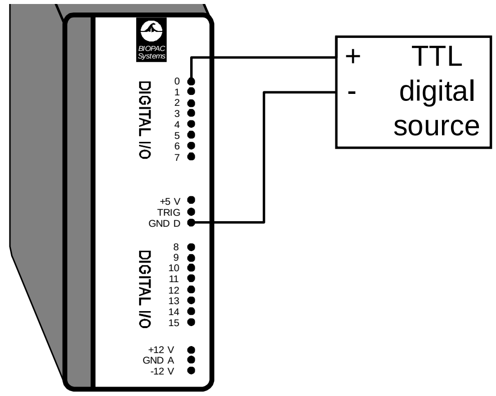


UIM100C connected to external analog signal source

Digital connections



Trigger connected to UIM100C



MP unit to digital source connection

A digital signal has only two voltage levels: 0 Volts = binary 0 and +5 volts = binary 1.

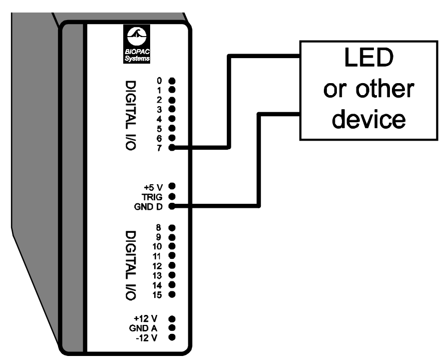
A **positive edge** is a 0 to 1 transition and a **negative edge** is a 1 to 0 transition.

The MP150/100 digital I/O lines have internal pull-up resistors so that unconnected inputs read "1." This means that external passive switches can be used to introduce digital (ON/OFF) data into the UIM100C by connecting the switch terminal between the digital I/O (0-15) and Ground (GND). In this configuration, the input will be read as "0.0" when the switch is closed and as "+5 V" when the switch is open.

The 16 digital input/output lines on the UIM100C have screw terminals that can accept pin plugs or bare wires, as shown above. Be careful not to short the +5, +12 V and –12 V terminals together or to the GND A or GND D output terminal, or the MP150/100 may become damaged.

The 16 digital lines are divided into two blocks, I/O 0 through 7 and I/O 8 through 15. Each block can be programmed as either inputs or outputs. Do not connect a digital input source to a block that is programmed as an output.

Output devices (such as leads or an LED) can be connected to the digital side of the UIM100C. Outputs can be connected so that they are "ON" either when a signal output from the UIM100C reads 0 Volts or when a +5 V signal is being output.



- When connecting to an LED, be sure to use a current-limiting resistor (typically 330Ω) in series with the LED.

To connect an LED so that it defaults to "OFF" (i.e., the digital I/O reads 0), attach one lead of the output device to the GND D terminal on the UIM100C and connect the other lead to one of the digital I/O lines (I/O 7, for example). When configured this way, the device will be "OFF" when I/O 7 reads 0, and "ON" when I/O 7 reads a digital "1" (+5 Volts).

Alternatively, connect one of the device leads to the +5V terminal on the UIM100C and leave the other lead connected to the digital line (e.g., I/O 7). With this setup, the device will be "ON" when the I/O line (in this case digital I/O 7) reads 0, and "OFF" when the I/O reads a digital "1" (+5 Volts).

UIM100C Specifications

Analog I/O:	16 channels (front panel) – 3.5 mm phone jacks
D/A Outputs:	2 channels (front panel) – 3.5 mm phone jacks
Digital I/O:	16 channels (back panel) – screw terminals
External Trigger:	1 channel (back panel) – screw terminal
Isolated Power:	±12 V, +5 V @ 100 ma (back panel) – screw terminals
Weight: 520	g
Dimensions:	7 cm (wide) x 11 cm (deep) x 19 cm (high)

BIONOMADIX SERIES

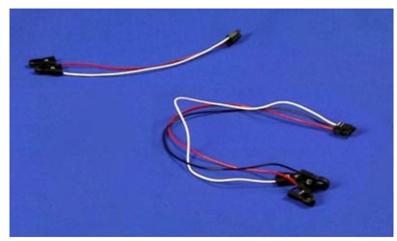
The BioNomadix system is a wireless, multi-channel physiological recording platform. Its untethered design allows for nearly unlimited freedom of movement and unsurpassed comfort, enabling subjects to easily relax into their protocol. There are twelve different BioNomadix modules sets, each consisting of a matched transmitter and receiver specifically optimized for desired physiological signals. Multiple BioNomadix module sets (typically eight maximum) can be used to create a customized BioNomadix system.

Each BioNomadix module set is capable of recording of two independent channels, with the exception of the Accelerometer module, which records three channels.

BioNomadix Transmitter and Receiver Sets

BN-ACCL3	BioNomadix Accelerometer	BN-EOG2	BioNomadix 2-Channel EOG
BN-ECG2	BioNomadix 2-Channel ECG	BN-GYRO	BioNomadix Gyro -75 or -300
BN-EEG2	BioNomadix 2-Channel EEG	BN-NICO	BioNomadix Cardiac Output
BN-EGG2	BioNomadix 2-Channel EGG	BN-RSP2	BioNomadix 2-Channel Respiration
BN-EMG2	BioNomadix 2-Channel EMG	BN-RSPEC	BioNomadix RSP & ECG
BN-PPGED	BioNomadix PPG and EDA	BN-SKT2	BioNomadix 2-Channel Skin Temp

BioNomadix Electrode Lead Sets



BN-EL15-LEAD2	Electrode Lead 2 x 15cm to BioNomadix
BN-EL15-LEAD3	Electrode Lead 3 x 15cm to BioNomadix
BN-EL30-LEAD2	Electrode Lead 2 x 30cm to BioNomadix
BN-EL30-LEAD3	Electrode Lead 3 x 30cm to BioNomadix
BN-EL45-LEAD2	Electrode Lead 2 x 45cm to BioNomadix
BN-EL45-LEAD3	Electrode Lead 3 x 45cm to BioNomadix
BN-EL50-LEAD4	Electrode Lead 4 x 50cm to BioNomadix BN-NICO
BN-EDA-LEAD2	EDA Electrode Lead to BioNomadix BN-PPGED

BioNomadix Transducers

BN-PULSE-XDCR	Pulse Transducer for BioNomadix BN-PPGED
BN-RESP-XDCR	Respiration Transducer for BioNomadix BN-RSP2 or BN-RSPEC
BN-TEMP-A-XDCR	Skin Temp Skin Transducer for BioNomadix BN-SKT2
BN-TEMP-B-XDCR	Fast-Response Temp Transducer for BioNomadix BN-SKT2

BioNomadix Accessories

Shirts

BN-SHIRT-XS	BioNomadix Shirt - XS
BN-SHIRT-S	BioNomadix Shirt - Small
BN-SHIRT-M	BioNomadix Shirt - Medium
BN-SHIRT-L	BioNomadix Shirt - Large
BN-SHIRT-XL	BioNomadix Shirt - XL

Straps

RXSTRAPBN-20	BioNomadix Strap 20 cm x 25.4 mm
RXSTRAPBN-33	BioNomadix Strap 33 cm x 25.4 mm
RXSTRAPBN-76	BioNomadix Strap 76 cm x 25.4 mm
RXSTRAPBN-137	BioNomadix Strap 137 cm x 25.4 mm

Charger

BN-BAT-CHRG BioNomadix Battery Charger – *full charge lasts approx. 72 hours, Transmitter batteries will last 500 charge/discharge cycles—or approximately 35,000 hours!*

Setup Overview

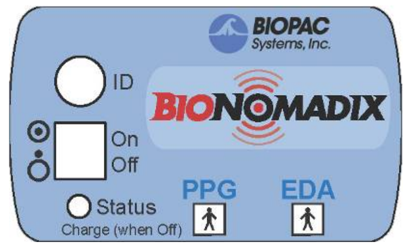
1. Setup the BioNomadix transmitter with subject
2. Setup the BioNomadix receiver
3. Setup the software

Hardware Setup

Transmitter and Receiver units are shipped as a matched pair and must always be used as a pair (see serial number and ID sync options). Up to 16 channels per BioNomadix system can be monitored simultaneously, returning data quality equal to standard BIOPAC MP modules. Normal operating range between transmitter and receiver is 10 meters line of sight in standard laboratory environments.

BioNomadix Transmitter

Setup



1. Connect the electrode lead set or transducer to the BioNomadix Transmitter module inputs. Squeeze lock connector and push until it clicks into place. CH A and CH B require an appropriate lead set or transducer based on signal type.
2. Attach electrodes and electrode leads or transducer to the Subject Position
3. Secure the Transmitter module on Subject, (i.e. with a strap, or inside a BioNomandix shirt pocket).
    - For optimum results, the BioNomadix Custom Sport Shirt is recommended. This specially-designed shirt is made of a lightweight material with numerous “pockets” for housing multiple transmitters. The BioNomadix shirt incoporates zippered openings for positioning electrode leads properly.
4. Set the power switch on the BioNomadix Transmitter to ON. The Status light will flash sequences based upon connectivity and battery lif
5. Double blinks occurring every two seconds indicate successful pairing and normal operation between transmitter and receiver.

Controls

ID: Press to illuminate Status light of matching Receiver unit.

On/Off: Power switch for the transmitter. The transmitter power must be turned OFF for charging.

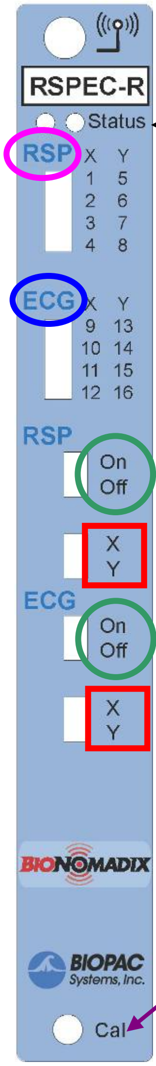
Status: Solid amber when battery power is low. Approximately one hour of operation remains after light turns amber, full-charge with BN-BAT-CGR battery charger typically requires one hour.

Channels: Connect the electrode leads to the matched BioNomadix Transmitter module inputs. (Squeeze lock connector and push until it clicks into place).

BioNomadix Receiver

BEFORE BEGINNING:

- Decide whether one or both available channels will be used. (If using only one channel, set “**A**” to ON and “**B**” to OFF)
- Decide which channel bank will be used and select “**X**” or “**Y**”.
- Set channel slider to correct position.
- Attach Receiver unit to the right side of the MP150 unit, or the left side of the IPS100C. The Status light will turn green when communicating with transmitter. As with standard BIOPAC hardware, additional modules can be attached to the receiver.
- Set desired channel options on the Receiver module.



The **RSPEC** Receiver unit is depicted, but controls operate similarly for all units.

 Wireless antenna input

Receiver LED: Steady green when paired with transmitter. Blinks amber once per second when communication is interrupted.

Input Signals: A = ⬬ B = ⬬

"A" Assigns the input signals for channels 1-8.

"B" Assigns the input signals for channels 9-16.

On/Off ●

Enables or disables module channels: **"A"** channels 1-8 **"B"** channels 9-16

X/Y channel banks ■

Selects between "X" channel bank or "Y" channel bank

"A" **X** bank is 1-4, **Y** bank is 5-8

"B" **X** bank is 9-12, **Y** bank 13-16.

NOTE: "A" or "B" banks that are turned off will free up those associated Analog channels for use by other signal types.

Cal: Recessed Calibration button. **NOTE**: Calibration is not required, most users can use factory presets. Calibration is an advanced procedure, see page 40.

Transmitter Battery Life

Transmitter battery life is described below as a change of color in the sequence of LED flashes.

LED Color Pattern				**Charge %**
green	green	green	green	75% - 100%
yellow	green	green	green	50% - 75%
yellow	yellow	green	green	25% - 50%
yellow	yellow	yellow	green	5% - 25%
yellow	yellow	yellow	yellow	< 5%

Software Setup

Recording data with Acq*Knowledge* software

After completing setup, click Start in the Acq*Knowledge* software to begin recording data.

If the paired signal is interrupted due to electrical interference or a subject wandering out of range, the most recently-acquired data point will be retained, with normal acquisition continuing once communication is reestablished. See *BioNomadix Operational Range and Characteristics* on page 35.

Full BioNomadix Module Specs

Table 1: BioNomadix Dual Biopotential Pairs – See Table 2 for Transducer or Combo, and Table 3 for Accelerometer and Gyro

BioNomadix Pair	**BN-ECG2**	**BN-EEG2**	**BN-EGG2**	**BN-EMG2**	**BN-EOG2**
Signal type:	Dual Channel ECG	Dual Channel EEG	Dual Channel EGG	Dual Channel EMG	Dual Channel EOG
Bandlimits ***Max*****:** ***Factory preset*****:** **Filter options:** **Alternative signal:**	0.05 Hz to 150 Hz 1 Hz to 35 Hz 0.05 or 1 Hz HP, 35 or 150 Hz LP Heart Rate Mode	0.1 Hz to 100 Hz 0.5 Hz to 35 Hz 0.1 or 0.5 Hz HP, 35 or 100 Hz LP Delta, Theta, Alpha, Beta	0.005 Hz to 1.0 Hz 0.005 Hz to 1.0 Hz 0.005 Hz HP, 1 Hz LP	5 Hz to 500 Hz 10 Hz to 500 Hz 5 or 10 Hz HP, 250 or 500 Hz LP Envelope Detection Mode	0.005 Hz to 100 Hz 0.005 Hz to 35 Hz 0.005 or 1 Hz HP, 35 or 100 Hz LP Derivative Mode
Notch filter:	50/60 Hz user-controlled switch; typically not required—factory preset OFF. *See Appendix for more hardware-specific output options.*				
Noise Voltage (shorted inputs)**:**	0.9 µV rms (bandwidth of 0.05 Hz to 150 Hz)	0.2 µV rms (bandwidth of 0.10 Hz to 100 Hz)	0.5 µV rms (bandwidth of 0.005 Hz to 1 Hz)	1.5 µV rms (bandwidth of 1.0 Hz to 500 Hz)	0.9 µV rms (bandwidth of 0.005 Hz to 100 Hz)
Input Voltage Range:	up to 10 mV P-P	up to 2 mV P-P	up to 10 mV P-P	up to 10 mV P-P	up to 10 mV P-P
Output Voltage Range:	±10 V (receiver output)				
CMRR	110 dB typical at 50/60Hz; 90dB minimum for ECG, EEG, EMG, and EOG, 100 db minimum for EGG				
CMII	1000 mΩ (50/60 Hz)				
Transmitter type & rate	Type: Ultra-low power, 2.4 GHz bi-directional digital RF transmitter Rate: 2,000 Hz (between transmitter and receiver)				
Operational Range:	10 meters (line-of-sight) typical, in standard laboratory setups. See *BioNomadix Operational Range and Characteristics* on page 35.				
Fixed Gain:	2,000	10,000	2,000	2,000	2,000
Transmitter Battery: **Charger:**	BioNomadix transmitters use an L-ion battery: full charge takes approx. 1 hour to provide maximum operating time A battery charger is included with each module pair. See BN-CHARGER for charge time and recharge cycle details.				
Operating Time:	72-90 hours				
Receiver Power:	Use with an MP Research System or with isolated power supply IPS100C for 3rd-party data acquisition system.				
Included strap:	137 cm - BN-STRAP137	76 cm - BN-STRAP76	137 cm - BN-STRAP137	33 cm - BN-STRAP33	76 cm – BN-STRAP76
Size & Weight:	Transmitter (approx.): 6 cm x 4 cm x 2 cm; 54 grams; Receiver (approx).: 4 cm x 11 cm x 19 cm; 380 grams				
Input:	See BioNomadix electrode lead cable options (BN-ELxx-LEADx). Each biopotential transmitter requires at least one GND. To eliminate redundant biopotential GND, use a 3-lead electrode lead cable for one input (CH A or B) and a 2-lead electrode lead cable for the other input (CH A or B) on each BioNomadix transmitter.				

Table 2: BioNomadix Dual Transducer & Combo Pairs – See Table 1 for Biopotentials, and Table 3 for Accelerometer and Gyro

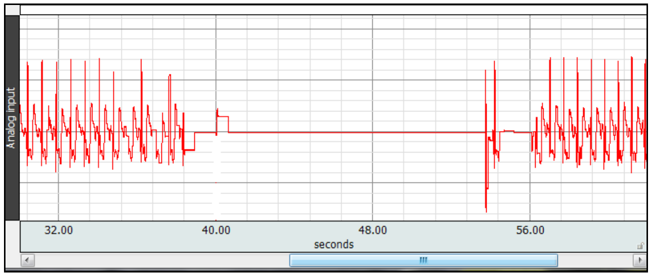
BioNomadix	**BN-SKT2**	**BN-RSP2**	**BN-RSPEC**	**BN-PPGED**	**BN-NICO**
Signal type:	Dual Channel SKT *temp*	Dual Channel RSP *resp*	RSP plus ECG	PPG plus EDA	Z and dZ/dt
Bandlimits*Max*: ***Factory preset*:** ***Filter Options:***	DC to 10 Hz DC to 1 Hz DC, 0.5 Hz HP, 1 or 10 Hz LP	DC to 10 Hz DC to 1 Hz DC, 0.5 Hz HP, 1 or 10 Hz LP	Respiration (CH A): *see BN-RSP2 spec* ECG (CH B) : *see BN-ECG2 spec*	Both: DC to 10 Hz: PPG: 0.5 Hz to 3 Hz EDA: DC to 3 Hz Both: DC, 0.5 Hz HP, 3 or 10 Hz LP EDA: 1 Hz LP	DC to 10 Hz DC to 10 Hz DC, 1, 3, 5, 10 Hz LP
Notch filter:	50/60 Hz user-controlled switch; typically not required—factory preset OFF. *See Appendix for additional hardware-specific output options.*				n/a
Noise (resolution):	0.01 °C (rms)	FSR/4096; (4.88 mV)	*see BN-RSP2 and BN-ECG2 specs*	PPG: FSR/4096; (4.88 mV) EDA: 0.012 µS (min step)	Z: nominally ~0.05 Ω (rms) at 10 Hz BW dZ/dt: ~0.01 Ω/sec (rms) at 10 Hz BW
Signal range:	13 to 51 °C	± 10 V (at output)	*see BN-RSP2 and BN-ECG2 specs*	PPG: ±10 V (at output) EDA: 0 to 50 µS; *excitation*: 0.5 V constant V	Z: 5 to 100 Ω (mag) dZ/dt: ±10 Ω/sec
Output Voltage range:	± 10 V (receiver output)				
Transmitter type & rate:	Type: Ultra-low power, 2.4 GHz bi-directional digital RF transmitter Rate: 2,000 Hz (between transmitter and receiver)				
Operational range:	10 meters (line-of-sight) typical in standard laboratory setups. See *Operational Range and Characteristics* on page 35.				
Transmitter Battery: **Charger:**	BioNomadix transmitters use an L-ion battery: full charge takes approx. 1 hour to provide maximum operating time A battery charger is included with each module pair. See BN-CHARGER for charge time and recharge cycle details.				
Operating time:	72-90 hours			24 hours	24 hours
Receiver Power:	Use with an MP Research System or with isolated power supply IPS100C for 3rd-party data acquisition system.				
Included strap:	137 cm - BN-STRAP137	137 cm - BN-STRAP137	137 cm - BN-STRAP137	33 cm - BN-STRAP33	137 cm - BN-STRAP137
Size & Weight:	Transmitter (approx.): 6 cm x 4 cm x 2 cm; 54 grams; Receiver (approx).: 4 cm x 11 cm x 19 cm; 380 grams				
Input:	BN-TEMP-A/B-XDCR	BN-RESP-XDCR	CH A: BN-RESP-XDCR CH B: BN-ELxx-LEAD3	CH A: BN-PULSE-XDCR CH B: BN-EDA-LEAD2	2 x BN-EL50-LEAD4 (or 2 x BN-ELxx-LEAD2)

Table 3: BioNomadix Accelerometer & Gyro – See Table 1 for Biopotentials and Tabe 2 for Transducer or Combo

BioNomadix	**BN-ACCL3**	**BN-GYRO-75**	**BN-GYRO-300**
Signal type:	G (X, Y, Z)	Angular Rate (degrees/sec)	
Bandlimits ***Max*:** ***Factory preset*:** ***Filter Options:*** **Alternative signal:**	±2, ±4, ±8 or ±16 G ± 16 G at 400 Hz LP DC to 3.13 Hz LP up to 400 Hz LP (in power of 2 steps) Tap Event Mark Mode (*replaces* G)	DC to 75 Hz DC to 10 Hz DC, 10 Hz or 75 Hz LP	
Noise (resolution):	X: 5 mg rms, Y: 6 mg rms, Z: 9 mg (rms) (±2 G scale at 400 Hz LP)	0.14 degrees/sec (rms) (DC - 10 Hz)	0.55 degrees/sec (rms) (DC - 10 Hz)
Signal range:	*Selectable:* ±2, ±4, ±8 or ±16 G	±75 deg/sec	±300 deg/sec
Output Voltage range:	±10 V (receiver output)		
Transmitter type & rate	Type: Ultra-low power, 2.4 GHz bi-directional digital RF transmitter Rate: 2,000 Hz (between transmitter and receiver)		
Operational range:	10 meters (line-of-sight) typical in standard laboratory setups. See *Operational Range and Characteristics* on page 35.		
Transmitter Battery: **Charger:**	BioNomadix transmitters use an L-ion battery: full charge takes approx. 1 hour to provide maximum operating time. A battery charger is included with each module pair. See BN-CHARGER for charge time and recharge cycle details.		
Operating time:	72-90 hours		12 hours
Receiver Power:	Use with an MP Research System or with isolated power supply IPS100C for 3rd-party data acquisition system.		
Included strap:	33 cm - BN-STRAP33		
Size & Weight:	Transmitter (approx.): 6 cm x 4 cm x 2 cm; 54 grams; Receiver (approx.): 4 cm x 11 cm x 19 cm; 380 grams		
Input:	Attach BioNomadix transmitter to subject – no additional hardware input required; sensor is internal to transmitter.		

BioNomadix Operational Range and Characteristics

10 meters line-of-sight, typical, in standard laboratory environments. Operational range can be more or less depending on factors such as presence of electromagnetic interference, multipath, or RF signal blocking. In the event of a communications failure, BioNomadix modules will attempt to re-establish communication over a one second period and during this time, the data will be kept at the last successfully transmitted value. After 0.5 second of communication failure, the BioNomadix transmitter will return the data to a “0” value and will continue to attempt to re-establish communication with the paired receiver.



ECG signal temporarily interrupted by subject wandering out of range

The BioNomadix transmitter is purposely kept at very low power so as not to disrupt the sensitive biophysical parameter measured and to enhance battery life. If the BioNomadix pair is used outside the laboratory (used without the benefit of multipath) and if the Transmitter is line-of-sight blocked from the Receiver, then communication dropouts are increasingly possible. A functional solution is to keep the Transmitter and Receiver in constant line-of-site view.

BioNomadix Electrode Leads

All BioNomadix electrode leads use lightweight, insulated tinsel wire 1.25 mm OD with female mini-pinch clips and squeeze lock connectors

2-Lead BioNomadix Electrodes Leads

Lead wires:	2 (red and white)
Electrode clips:	2
Length:	BN-EL15-LEAD2: 15 cm, BN-EL30-LEAD2; 30 cm, BN-EL45-LEAD2; 45 cm
Interface:	Secondary channel lead for the following BioNomadix Transmitters: BN-ECG2, BN-EEG2, BN-EGG2, BN-EMG2, BN-EOG2, (*first channel lead* should be a BN-ELxx-LEAD3 three lead set to establish ground). *Do not use for EDA or NICO!*

To eliminate redundant ground leads for biopotentials, use 3-lead for primary input and 2-lead for secondary input for each BioNomadix unit.

3-Lead BioNomadix Electrodes Leads

Lead wires:	2 (red, white and black)
Electrode clips:	2
Length:	BN-EL15-LEAD3; 15 cm, BN-EL30-LEAD3; 30 cm, BN-EL45-LEAD3; 45 cm
Interface:	Primary and secondary channel lead for the following BioNomadix Transmitters: BN-ECG2, BN-EEG2, BN-EGG2, BN-EMG2, BN-EOG2. *Do not use for EDA or NICO!*

4-Lead BioNomadix Electrode Leads

Leads:	4 (red x 2 and white x 2)
Electrode clips:	4
Length:	BN-EL50-LEAD4; 50 cm
Interface:	designed for BN-NICO: CH A or CH B (can be used with other BioNomadix biopotential transmitters)

EDA BioNomadix Electrode Leads

Leads:	2 (red and black)
Electrode clips:	2
Length:	BN-EDA-LEAD2; 30 cm
Interface:	Only use in CH B EDA on wireless BioNomadix Transmitter BN-PPGED

BioNomadix Transducers

Pulse BioNomadix Transducer	**BN-PULSE-XDCR**
Emitter/Detector Wavelength:	860 nm ± 60 nm
Optical LP Filter Cutoff:	800 nm
	The operational range of the emitter and detector falls within the wavelength range of 800 nm to 920 nm. The filter is placed over the receiver; the filter of 800 nm is an optical lowpass, so wavelengths longer than 800 nm will pass thru.
Nominal Output:	20 mV (peak-peak)
Power:	10 mA drive current
Sterilizable:	Yes (contact BIOPAC for details)
Dimensions (L x W x H):	16 mm x 17 mm x 8 mm
Transducer Weight:	4.5 grams Cable: 45 cm
Interface:	only use in CH A PPG on the BioNomadix BN-PPGED

Respiration BioNomadix Transducer BN-RESP-XDCR

Response:	True DC
Circumference Range:	15 cm x 150 cm (increase with a longer strap)
Dimensions:	66 mm (long) x 40 mm (wide) x 15mm (thick)
Weight:	18 grams
Sterilizable:	YES: use standard gas sterilization techniques [i.e., Ethylene Oxide (EtO)]
Variable Resistance Output:	5 - 125 KOhm
Cable:	30 cm
Interface:	BN-RSP2 CH A RSP or CHB RSP, or BN-RSPEC CHA RSP

Skin Temp BioNomadix Transducers

	BN-TEMP-A-XDCR	**BN-PULSE-XDCR**
Response time:	1.1 sec (attached to skin)	0.6 sec (in air)
Size:	9.8mm x 3.3mm	1.7 mm x 5 mm
Nominal Resistance:	2252 ohms at 25°C (when used with BN-SKT2)	
Maximum operating temperature:	60°C	
Accuracy and Interchangeability:	0.2°C	
Compatibility:	YSI series 400 temperature probes	
Sterilizable:	YES (contact BIOPAC for details)	
Cable:	30 cm	
Interface:	only use CH A SKT or CH B SKT BioNomadix BN-SKT2	

BioNomadix Accessories

BioNomadix Shirt

Attachment Features:	*22 pockets*: 2 neck front, 2 neck back, 4 chest center, 4 back center, 2 hip front, 2 hip back, 3 left arm, 3 right arm *4 zippers*: right front from arm to hip, left back from shoulder to hip, right and left under arm from neck front to neck back *4 strap bands*: 4 rows of strap bands (2 loops front, 2 loops back) for RSP transducer strap
Materials:	Black 6 oz. eyelet mesh 88% Polyester / 12 % Spandex; metal zippers
Sizes:	BN-SHIRT-XS extra small BN-SHIRT-L large BN-SHIRT-S small BN-SHIRT-XL extra large
BN-SHIRT-	M medium
Care instructions:	Machine Wash, Warm / Line Dry

BioNomadix Strap

Dimensions:	Length 20 cm, 33 cm, 76, cm, 137 cm (all widths 2.5 cm)
Material:	stretch Velcro® - hook/loop type
Use with:	BioNomadix Transmitters
Length:	RXSTRAP-BN-20; 20 cm RX-STRAP-BN-33; 33 cm RXSTRAP-BN-76; 76 cm RXSTRAP-BN-137; 137 cm

BioNomadix Battery Charger: BN-BAT-CHRG

To charge, the BioNomadix Transmitter must be in the OFF position and have no electrode leads or transducers attached.

Connector:	DC polarized squeeze-clip plug to mate with all BioNomadix Transmitters
Number of cells:	1 L-ion
Charger current	1000 mA (660 mA for IB-16800
Current tolerance:	+10%
Voltage limit:	Preset
Voltage limit tolerance:	+0.2%
Operating temperature:	0˚C to 40˚C
Input voltage:	90 VAC to 240 VAC
Frequency	50 Hz to 60 Hz
Wall plug:	ships with US blades; adapters available for Euro, China or Australia
Output cable length:	1.7 meter (~6 feet)
Connector	DC polarized squeeze-clip plug to mate with all BioNomadix Transmitters
Weight:	142 grams (5 oz.)
Dimensions:	75 mm x 51 mm x 40 mm
Lithium Ion Chemistry	
Ter mination algoritm:	CCCV
Termination indicated	Current falls to limit value/5
Top-off charge:	1 hour or current falls to limit value/10
Restart threshold:	7/8 of termination voltage or every 2 hours
Mantainence charge:	N/A
Charge voltage limit:	Preset to 4.20V (one L-ion cell)
Override timer:	None

FCC Notice

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Industry Canada Information

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter (IC: 9901A-BNXR1) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

WLAN antenna, maximum gain 1.5 dBi, 50 ohm

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio (IC: 9901A-BNXR1) de modèle s'il fait partie du matériel de catégorieI) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

réseau local sans fil antenne, le gain max 1.5 dBi, 50 ohm

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Isolated Power Supply

To use BioNomadix with the Isolated Power Supply (IPS100C), use CBL102S cable to connect the IPS100C to the Receiver output channel. This is accessible via the front panel of the IPS100C.

Signal Validation

Bionamadix units are factory calibrated, but if user-calibration is desired for measurement verification, the following steps may be used. Please see the appropriate section for Bionomadix calibration guidelines.

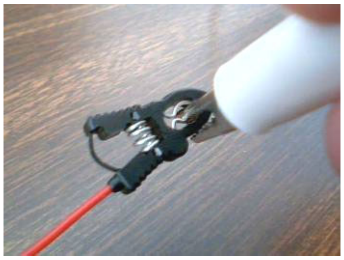
- BN-ACCL
- BN-ECG, BN-EEG, BN-EGG, BN-EMG, BN-EOG
- BN-EDA
- BN-GYRO
- BN-NICO
- BN-SKT
- BN-PPG and BN-RSP

BN-ACCL Accelerometer Calibration

Orient Transmitter unit in the X, Y, and Z directions with respect to Earth's gravity. This action will introduce 1G in positive axis direction and -1G in the negative axis direction. The accelerometer Transmitter/Receiver set has user-selectable ranges: ±2, ±4, ±8 or ±16 G. The maximum value of each range selection provides a +10 V output and the minimum value of each range selection provides a -10 V output. When using the ±2 G range, a + 1 G input will provide a +5 V output and a -1 G input will provide a -5 V output.

BN-ECG, BN-EEG, BN-EGG, BN-EMG, BN-EOG Biopotential Calibration

Three alligator clips will be required to calibrate a Biopotential Transmitter/Receiver set.



1) Attach alligator clip to LEAD side of electrode pinch clip (see figure on right).

2) Connect black and white pinch clips together (this combination is attached to signal generator ground).

3) Connect red pinch clip to signal generator output for the Transmitter/Receiver set.

   - ECG, EGG, EMG, EOG

     The signal generator should be set to 1 mV peak to peak sine wave in the appropriate signal frequency range for the Transmitter/Receiver set. The total gain of the Transmitter/Receiver set is 2,000. The measured output voltage from the Receiver should be 1 mV p-p * 2000 or 2 V p-p. The maximum input signal is 10 mV p-p.

   - EEG

     The signal generator should be set to 1 mV peak to peak in the appropriate signal frequency range for the Transmitter/Receiver set. The total gain of the Transmitter/Receiver set is 10,000. The measured output voltage from the Receiver should be 1 mV p-p * 10,000 or 10 V p-p. The maximum input signal is 2 mV p-p.

BN-EDA Electrodermal Calibration

Transmitter/Receiver set can be calibrated by applying a known resistance (conductance) to the EDA electrode pinch connectors via alligator clips. Suggested values of conductance would be 0 µSiemens (infinite ohms – no connection) and 10 µSiemens (100K ohms). The EDA Transmitter/Receiver set outputs +10 V for a 50 µS measured conductance. The EDA Transmitter/Receiver set will output approximately +2 V for a 10 µS measured conductance.

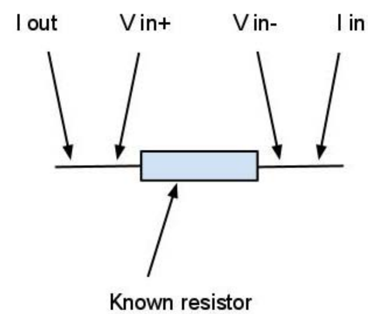
BN-GYRO Gyroscope Calibration

Transmitter unit can be rotated a specific number of degrees per second, using a motor/turntable assembly which is capable of free turning through 360 degrees (i.e. an office chair). Integration of the angular rate output (degrees/sec) can be performed, using Acq*Knowledge*, to verify the proper calibration. The GYRO Transmitter/Receiver set is provided in a ±75 or ±300 degree/second total range. The maximum value in each range will provide a +10 V output and the minimum value in each range will provide a -10 V output.

BN-NICO Calibration

Mapping for Z: 0.8 V to 10 ohms 9 V to 100 ohms

The calibration values for Z are approximate. For a more exact calibration for Z, introduce a 10 ohm resistor between the paired leads (Iout, Vin+) and (Vin-, Iin) to simulate a 10 ohm impedance magnitude. Use a 100 ohm resistor to simulate a 100 ohm impedance magnitude. See figure at right for details:



For the most accurate calibrations, use known impedances (resistances) that bracket the expected high and low values being recorded. For conventional noninvasive cardiac output measurements, optimal low impedance is 15 ohms and optimal high impedance is 40 ohms.

Mapping for dZ/dt: 0 V to 0 ohms/sec 10 V to 10 ohms/sec

The calibration values for dZ/dt can be accomplished by introducing a known and varying resistance that can be precisely set to a specific rate of change. For calibration related to cardiac output measurements, a varying resistance of ±1 ohms/seconds to ±5 ohms/second is ideal. A photonically-isolated voltage controlled resistance can be used for this calibration. A cadmium sulfide cell in parallel with a resistance of 25 ohms can be employed in conjunction with a signal generator driven LED to provide a varying light intensity to modulate the resistance of the cadmium sulfide cell.

BN-PPG and BN-RSP Pulse and Respiration Calibration

User-calibration not recommended, as the measurements performed are essentially dimensionless. However, it's possible to calibrate the PPG Transmitter/Receiver set by introducing a variable gray-scale density pattern to the PPG probe in a dark environment. The RSP Transmitter/Receiver set can be calibrated by applying differing amounts of force to the RSP transducer/belt combination to stretch the belt over different distances.

BN-SKT Skin Temperature Calibration

Insert probe into temperature well set to the appropriate temperature. As an alternative, replace the thermistor with known temperature(s) that reflects the specific temperature(s) simulated. The temperature probe specifications are equivalent to YSI@ 400 series probes. The temperature range for the SKT Transmitter/Receiver set is 13 to 51 degrees C. Using the specified temperature probe: 13 degrees provides a -10 V output and 51 degrees provides a +10 V output.

HLT100C High Level Transducer Interface Module

The HLT100C module is used to interface all high level output transducers to the MP System. The HLT100C module provides 16 input and 2 output channels. The HLT100C is similar in function to the UIM100C Universal Interface Module, but it also provides power to the transducer when making a connection.

High level output transducers and adapters connect to the HLT100C via standard 6 pin RJ11 type connectors. Transducers and adapters that presently require the HLT100C module are:

TSD109	C/F: Tri-axial Accelerometers
TSD111A	Heel/Toe Strike Transducer
TSD115	Variable Assessment Transducer
TSD116	A/B/C: Switches and Markers
TSD150	A/B: Active Electrodes
INISO	Input Signal Isolator
OUTISO	Output Signal Isolator
DTU100	Digital Trigger Unit (MRI Synchronization)
NIBP-MRI	Noninvasive Blood Pressure for MR

Alternatively, the HLT100C module can be used to connect mains powered external equipment to the MP System when the system also connects to electrodes attached to humans.

IMPORTANT USAGE NOTE

To provide the maximum in subject safety and isolation, use electrically isolated signal adapters to connect mains powered external equipment (i.e., chart recorders, oscilloscopes, etc.) to the MP System. Use the INISO adapter to connect to MP analog system inputs and the OUTISO adapter to connect to analog system outputs.

Hardware Setup

- See setup notes on page 24 for external devices and channel contention issues.

Connect the Digital and Analog cables from the MP150 directly to the HLT100C, then connect the UIM100C to the HLT100C. The HLT100C module must be connected on the left side of the UIM100C module. This allows the use of other amplifier modules with the UIM100C while the HLT100C is connected.

High level output transducers (e.g., TSD109 Tri-Axial Accelerometer) or active electrodes (e.g., TSD150A Active Electrode) connect via the 16 analog RJ11 jacks on the front of the HLT100C. Up to 16 analog channels can be used at the same time, as long as there are no other analog channels in use by the UIM100C module or by other BIOPAC modules.

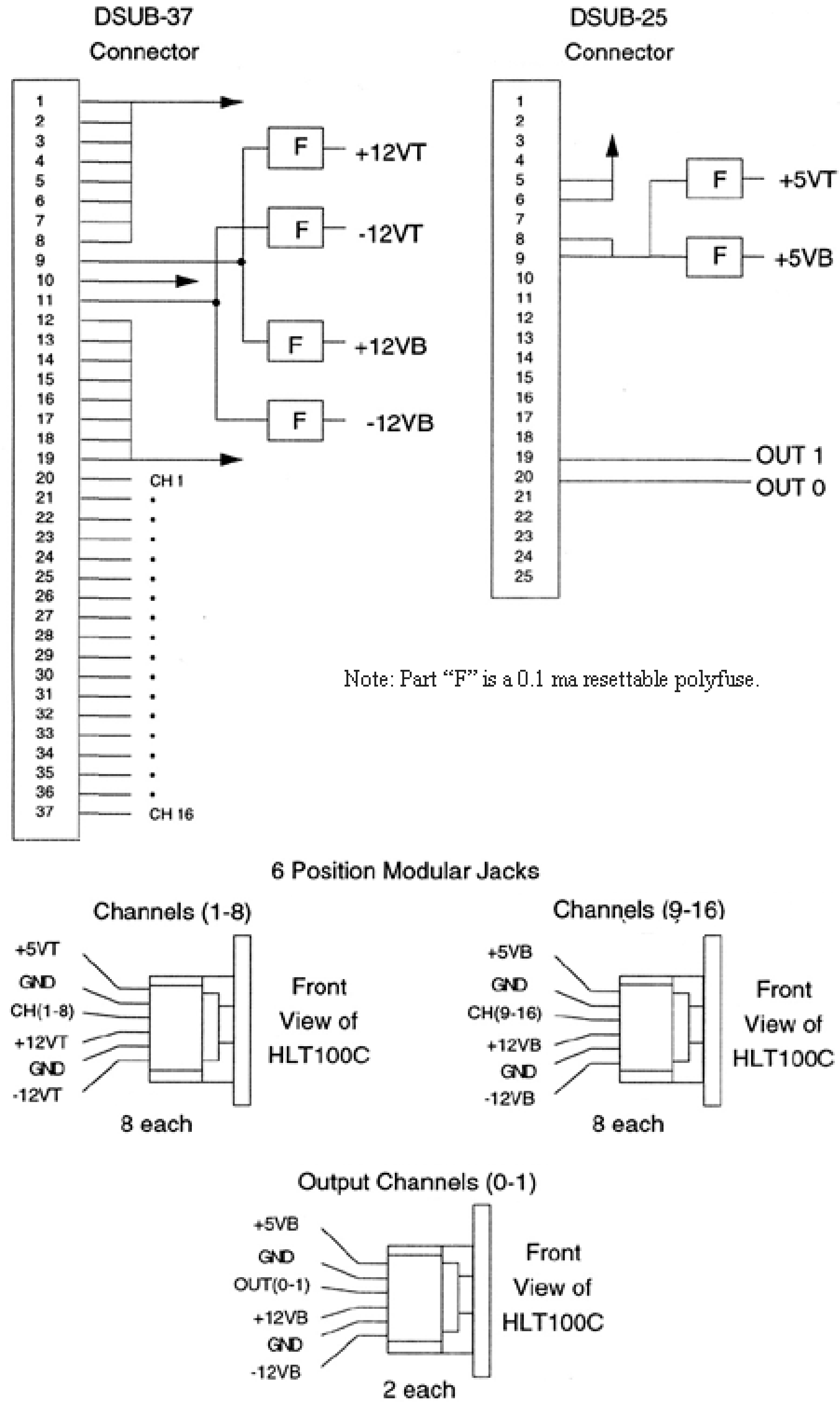
NOTE: If active electrodes are used, it may be necessary to attach a single ground lead to the UIM100C via the GND A terminal on the back of the module.

IMPORTANT!

If contention exists, the channel data will be corrupted. For example, if four channels [Ch.1-4] were in use by the UIM100C, then only 12 channels [Ch. 5-16] could be used by the HLT100C.

HLT100C Specifications

Transducer Inputs:	16 channels (front panel) – RJ11 jacks
System D/A Outputs:	2 channels (front panel) – RJ11 jacks
Isolated Power Access:	±12 V, +5 V @ 100 ma (via all RJ11 jacks)
Weight:	540 grams
Dimensions:	7 cm (wide) x 11 cm (deep) x 19 cm (high)
Pin-outs:	



SIGNAL ISOLATORS

INISO and OUTISO shown with HLT100C

These analog signal isolators are used to connect mains powered external laboratory equipment to the MP System when it also connects to electrodes attached to humans. Each signal isolator comes with an RJ11 cable for connection to the HLT100C module.

- ❖ For digital (TTL compatible) isolation to the MP digital I/O ports, use the STP100C optical interface (see page 253).
- ❖ If the MP System does not electrically connect to human subjects, signal connections to external equipment can be made through the UIM100C module and the respective analog or digital connection cable.

INISO Input Signal Isolated Adapter

Use the INISO to connect external equipment outputs to MP analog input channels. The INISO plugs directly into any of the 16 input channels on the HLT100C module and incorporates a 3.5mm phone jack for signal input connections. Select the appropriate analog connection cable to connect to the external equipment's output.

- See setup notes on page 24 for external devices and channel contention issues.

OUTISO Output Signal Isolated Adapter

Use the OUTISO to connect MP analog signal outputs (amplifier and D/A) to external equipment inputs. The OUTISO plugs directly into any of the 16 signal output channels, plus the two D/A outputs, on the HLT100C module and incorporates a 3.5 mm phone jack for signal output connections. The OUTISO is very useful when the biopotential amplifier output signal requires routing to external equipment while being sampled by the MP System. Select the appropriate analog connection cable to connect to the external equipment's input.

INISO and OUTISO Specifications

Isolator Type:	Analog	Isolation Voltage:	1500 VDC
Bandwidth:	DC to 50 kHz	Isolation Capacitance:	30 pF
Input/Output Range:	±10 V	Connector:	3.5 mm mono phone jack
Input Resistance:	200K Ω	Weight:	50 g
Output Resistance:	120 Ω	Dimensions:	2.6 cm (high) x 2.6 cm (wide) x 7.6 cm (long)
Output Current:	±5 mA		
Offset Voltage:	±20 mV (nominal)	Included Cable:	2.1 m (straight through, M/M, 6 pin, RJ11)
Temperature Drift:	200 µV/°C (nominal)		
Noise:	2.5 mV (rms)	Interface:	HLT100C—see page 42

TSD109 Series Tri-Axial Accelerometers

The Tri-Axial Accelerometers are high level output transducers with an amplifier built into the transducer, so no additional amplification is required. They connect directly to the **HLT100C** High Level Transducer module to provide three outputs, which measure acceleration in the X, Y, and Z direction simultaneously.

- The **TSD109C** (5g) is well suited for measuring slow movements
- The **TSD109F** (50G) is made to measure quick movements.

With the proper equipment and proper scaling parameters listed below, precise acceleration measurements can be obtained.

Equipment

MP Starter System

HLT100C High Level Transducer Module

TSD109C Tri-Axial Accelerometer- Output +/- 5G (400 mV/G)

TSD109F Tri-Axial Accelerometer- Output +/- 50G (40 mV/G)

Hardware Setup

Connect the HLT100C to the UIM100C Universal Interface Module. The TSD109 has 3 output connectors, 1 each for the X, Y, and Z axes. Each output connector must be connected to the appropriate HLT100C input channel. For example the X-axis to channel 1, the Y-axis to channel 2, and the Z-axis to channel 3.

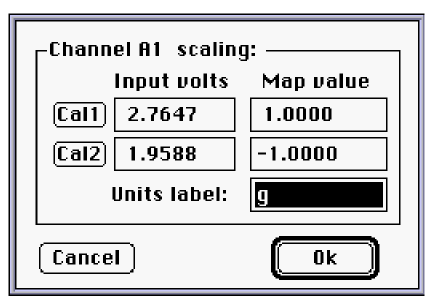
IMPORTANT

Make sure that the chosen channel is **not** already assigned to any other BIOPAC module; up to 5 Accelerometers can be used with a single MP System. **If contention exists, the channel data will be corrupted.**

- o See setup notes on page 24 for external devices and channel contention issues.

TSD109 Calibration

Software Setup



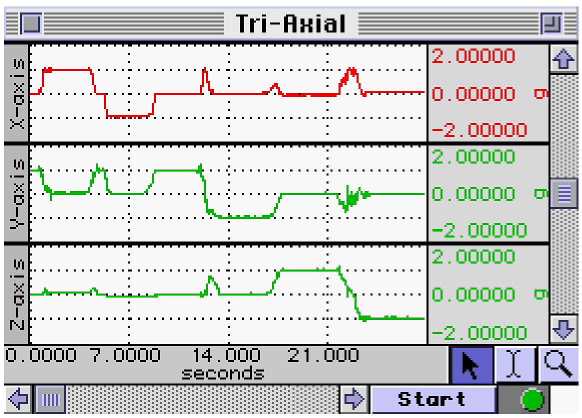
1. Select **Setup Channels** under the MP menu and enable 3 analog channels, one for each axis. 2. Select **Scaling** (MPWSW) to generate the Scaling dialog.
3. In the **Map value** column, enter the scaling factors required, **1** and -**1**.
4. Enter "**g**" for the **Units label,** as shown.
5. Take the TSD109 and rest it in the upright position on the tabletop.
6. Calibrate the device by rotating it through 180 degrees and taking a calibration reading at each point.

To calibrate the Y-axis, set the transducer face up on a flat surface (such as a table) and click CAL1. Rotate the transducer 180 degrees, so that it is upside down, and click the CAL2 button. This procedure must be followed for each axis. A label on the front of the transducer displays the X and Y axes. The Z-axis rotates from the end with the label and the end with the cable.

Testing Calibration

1. Start acquisition (for the test procedure, a sample rate of 50 samples per second should be used)
2. Rotate the TSD109 180° through each axis while continuing to acquire data.
3. Set the vertical scale to 1 and the midpoint to 0 for all channels.
4. Repeat the calibration procedure (by rotating the transducer 180°) through each axis.
5. Visually confirm the correct calibration.

This screenshot shows a TSD109 being rotated through each axis. Channel 1 (X-axis) shows the signal moving from 1g to -1g as the transducer is rotated. Likewise, Channel 2 (Y-axis) shows the same phenomenon as previously described. Finally, Channel 3 (Z-axis) has also been tested and the calibration confirmed.



TSD109 Series Specifications

Channels:	3 – (X, Y, Z axis)
Range (Output)	
TSD109C:	±5G (400 mV/G)
TSD109F:	±50G (40 mV/G)
Noise	
TSD109C:	325 µG/√Hz rms
TSD109F:	2.5 mG/√Hz rms
Bandwidth:	DC – 500 Hz (-3dB)
Nonlinearity:	0.2% of Full Scale
Transverse Axis Sensitivity:	±2%
Alignment Error:	±1°
Package:	Compliant silicone housing
Power:	+5V @ 9mA (via HLT100C)
Sterilizable:	Yes (contact BIOPAC for details)
Cable Length:	3 meters
Weight: 17	grams
Dimensions:	33mm long, 28mm wide (at base), 19mm high
Interface: HLT100C—see	page 42
TEL100C Compatibility:	SS26 (5G) and SS27 (50G)—see page 270

TSD110 Pressure Pad/Respiration Transducer

TSD110-MRI Pressure Pad/Respiration Transducer

The multipurpose TSD110 pressure Pad/Respiration (pneumogram) transducer can be used to:

- Noninvasively measure respiration—from a small mouse to a human.
- Measure small pressing forces (like pinching fingers together) for Parkinson's evaluations.
- Measure human smiling (with the sensor on the cheekbone).
- Measure pulse when placed close to the heart.
- Measure spacing and pressure between teeth coming together.

The TSD110 consists of a TSD160B differential pressure transducer, RX110 pressure pad, and tubing. Use TAPE1 or other single-sided adhesive to affix to the subject. The TSD110-MRI includes two (2) AFT30-XL. To control for ambient pressure changes that may occur between the MRI Control Room and the MRI Chamber Room (such as if the control room door is opened), run the second AFT30-XL from the TSD160A through the wave guide into the MRI chamber room. The AFT30-XL tubing will add lesss than 50 msec to the sensing of the waveform peak.

	TSD110	TSD110-MRI
Tubing Length:	1.6 m	11 m
Interface:	DA100C	MECMRI-DA to DA100C

Sensor type:	Self-inflating pressure pad	Sensor Tubing Length:	1 m
Sensor Pad Diameter:	20 mm	Sensor Tubing ID:	1.6 mm
Sensor Pad Thickness:	3.18 mm	Tubing Termination:	Luer male
Sensor Tubing Diameter:	2.2 mm		

RX110 Pressure Pad

The RX110 pressure pad can be used many times, but may eventually need to be replaced because it is a sensitive sensor and may become damaged with rough use.

TSD111A Heel/Toe Strike Transducer

Each TSD111A heel/toe strike transducer incorporates two force sensitive resistor (FSR) sensors designed for attachment to the sole of a shoe. Typically, one FSR is placed (taped) under the heel and the other is placed under the toe. The FSRs indicate the precise moment of pressure placed on the heel and toe as the subject walks. The heel/toe strike data is encoded onto a single analog channel; the heel strike results in a [-1V] signal and the toe strike results in a [+1V] signal. If heel and toe strike timing is required for both feet, two TSD111A transducers are required. The TSD111A comes equipped with a 7.6-meter cable and is designed for direct connection to the HLT100C module.

> ***Note***
>
> Heel/Toe Strike Transducers without the "A" suffix in the part number (TSD111, SS28) do not have a replaceable sensor. Check the part number or check the cable for a removable sensor connector before ordering this replacement.

TSD111A Specifications

Nominal Output Range:	-1 to +1 V
Nominal Contact Force:	200g to indicate heel/toe strike
Attachment:	tape (use TAPE1, TAPE2, or vinyl, electrical or duct tape)
FSR Active Area:	12.7 mm (dia)
FSR Dimensions:	18.3 mm (dia) x 0.36 mm (thick) and 30 cm pigtail lead
Cable Length:	7.6 m
Interface: HLT100C—see	page 42
TEL100C compatibility:	SS28A—see page 270

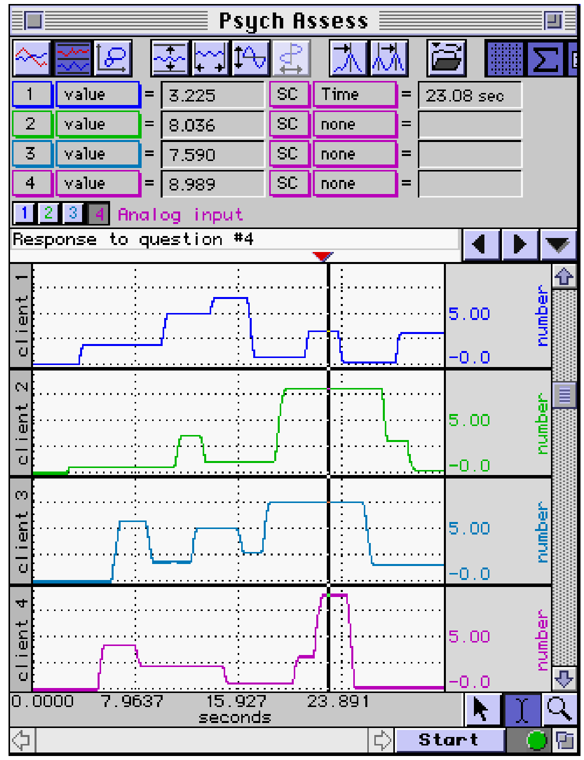
RX111 Heel/Toe Strike Sensor

Replacement strike sensor for Heel/Toe Strike transducers:

- TSD111A (research systems)

- SS28A (telemetry systems)

TSD115 Variable Assessment Transducer
TSD115-MRI Variable Assessment Transducer for MRI

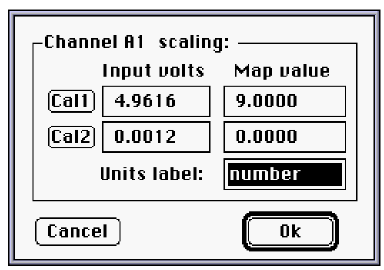


The TSD115 incorporates a slide control with graduated scale that allows the user to gauge their subjective response to a variety of different stimuli. Multiple TSD115 transducers can be used simultaneously allowing several people to answer the same question or otherwise respond to stimuli. The transducer is lightweight and fits easily into the subject's hand or lap. The TSD115 comes equipped with a 7.6-meter cable and is designed for direct connection to the HLT100C module.

This graph shows a measurement that identifies the responses (on a scale from 0 to 9) of the four clients to a particular question. In this case, at 23.08 seconds into the recording, the responses to question four were:

Client 1: 3.225	Client 3: 7.590
Client 2: 8.036	Client 4: 8.989

TSD115 Calibration

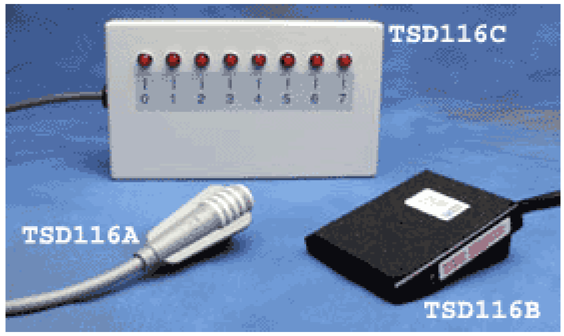


1. Generate the **Scaling** dialog for the first selected channel.
2. Slide the horizontal indicator all the way to the right side of the TSD115. (This reports the highest output for the TSD115, a value close to +5.0 volts.)
3. Click on the **Cal1** button to assign this value to "9." (This directs the system to collect the exact value output by the TSD115 when it's set to any specific indicator position.)
4. Slide the horizontal indicator all the way to the left on the TSD115. (This reports the lowest output for the TSD115, a value close to 0.0 volts.)
5. Click on the **Cal2** button to assign this value to "0."
6. Select the next channel and repeat this procedure for the remaining channels.

TSD115 Specifications

	TSD115	TSD115-MRI
Cable Length:	7.6 m	8 m
Interface:	HLT100C—see page 42	MECMRI-HLT to HLT100C
Scale Output Range:	0-5 V DC	
Scale Resolution:	Infinitely adjustable	
Slide Control Length:	10 cm	
Dimensions:	4 cm (high) x 11 cm (deep) x 19 cm (wide)	
Weight:	230 g	
See also:	Application Note #AH186 – Psychological Assessment (TSD115)	

TSD116 Series Switches and Markers



The TSD116 series is used for externally triggering data acquisition, remote event marking, or psychophysiological response tests. The switches connect to the UIM100C digital I/O ports and can be monitored as input channels. The TSD116 series incorporate momentary ON operation (switch is ON only when pressed).

TSD116A — single channel hand switch

TSD116B — single channel foot switch

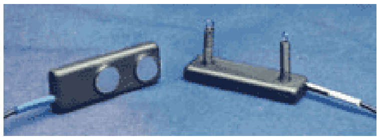
TSD116C — compact 8-channel digital marker

The TSD116C allows the user to independently mark events, or provide responses, on up to eight channels simultaneously. Because digital channels can be interleaved with analog channels, when using Acq*Knowledge*, it's easy to assign separate digital channels as event markers for individual analog input channels.

TSD116 Series Specifications

Switch Type:	Pushbutton: (ON) – OFF
Dimensions	
TSD116A:	19mm (dia) x 63mm (long)
TSD116B:	69mm (wide) x 90mm (long) x 26mm (high)
TSD116C:	19cm (wide) x 11cm (deep) x 4cm (high)
Cable Length	
TSD116A:	1.8 meters
TSD116B:	1.8 meters
TSD116C:	3 meters
Connector Type:	
TSD116A:	2mm pin plugs
TSD116B:	2mm pin plugs
TSD116C:	Stripped and tinned wires
Interface: UIM100C	
TEL100C Compatibility:	SS10 Hand switch—see page 270

TSD150 Series Active Electrode



TSD150A — 35 mm spacing **TSD150B** — 20 mm spacing

TSD150 Active Electrodes are available in three configurations; the difference is the spacing between the stainless steel pads of the surface electrode. The surface electrode pads of the TSD150A and TSD150B have a diameter of 11.4 mm.

Note: **GROUND MUST BE USED —** Unlike most active electrodes, TSD150 series active electrodes have only two stainless steel disks attached to an electrode case. The third disk, commonly centered between the two, is not necessary. In place of this third disk, a separate ground electrode is used. The LEAD110A is typically used as the ground electrode, and is inserted into the GND A terminal at the rear of the UIM100C. If one or more active electrodes are used on a single subject, only one Ground lead (LEAD110A) is required to act as Ground reference for all the active electrodes.

TSD150A/B Active Electrodes –35 mm, 20 mm

TSD150A and TSD150B may be used as a surface electrode or as a fine wire electrode. Conversion of the surface to fine wire electrode is easily accomplished by replacing the stainless steel pads with screw-springs that connect to the internal amplifier.

Conversion from Surface Electrode to Fine Wire Electrode System

To convert the active electrode from a surface electrode to a fine wire electrode system, the stainless steel pads of the surface electrode must be unscrewed from the active electrode case. To accomplish this task:

1) Grasp the stainless steel pads and rotate them counterclockwise until they are disconnected from the case.
2) Screw the screw-spring combinations (fine wire electrode attachment) into the holes left by the removal of the stainless steel pads.
3) Attach the active electrode case (using tape or an elastic strap) to the limb of the subject, near the insertion site of the fine wire electrodes.
4) Gently bend the springs and place one fine wire electrode in the gap formed by bending the spring. Allow the spring to return to its upright position.
5) Repeat this procedure for the other fine wire electrode.

Note: If the wire-spring contact does not provide a good EMG signal, it may be necessary to rub the fine wire electrode with an emery cloth to remove the insulation prior to placing the wire in the spring.

To convert the system back to a surface electrode system, simply unscrew the screw-spring combinations, place them in a secure place and re-screw the stainless steel electrode pads into the electrode case.

Operation

1) Attach the active electrode to the subject, with pads to the skin surface; use surgical tape (TAPE1) or an elastic strap. The active electrode requires good skin surface contact, so to obtain the best readings; select an area where skin surface is free of hair and/or lesions and abrade the skin slightly with the ELPAD.
2) Plug the active electrode into the desired channel (1-16) of the HLT100C module.

   IMPORTANT! Make sure that the chosen channel is **not** already assigned to any other BIOPAC module; up to 16 active electrodes can be used with a single MP System. **If contention exists, the channel data will be corrupted.**
3) After inserting the active electrode into the HLT100C module and attaching the active electrode to the subject, a Ground electrode will still need to be attached to the subject if no other ground is provided via another biopotential amplifer. The Ground electrode will act as reference for 1 to 16 active electrodes. The LEAD110A, 3-meter, unshielded electrode lead is recommended for this purpose. The LEAD110A will connect directly to any standard snap surface electrode (like the EL503). The surface electrode can be placed at any point on the subject, and performance is optimal when the electrode makes good contact with the skin surface.
4) The free end of the LEAD110A is inserted directly to the GND A terminal on the back of the UIM100C. To insert the LEAD110A into the GND A terminal, use a small screwdriver to back out the terminal locking screw, insert the LEAD110A 2 mm pin plug into the terminal opening and then tighten down the locking screw.
5) At this point, the active electrode is ready for data collection. Set up the active electrode **Scaling** in Acq*Knowledge*, by setting the MAP values to a factor of the default value divided by 330. See the Acq*Knowledge* Software Guide for more information on channel scaling. The recommended sampling rate for the MP System is 2000 Hz on each active electrode channel.

TSD150A/B Calibration

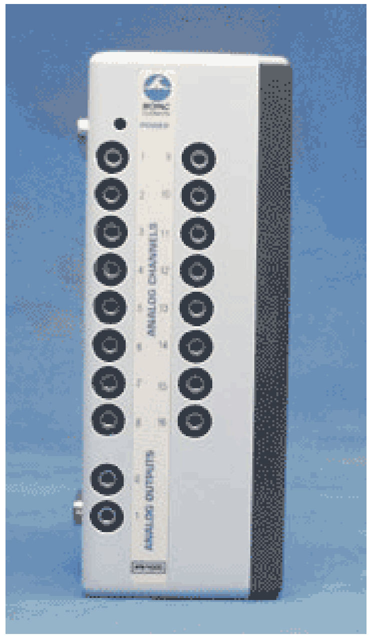
The TSD150 series does not require calibration.

TSD150A/B Active Electrode Specifications

Recommended Sample Rate:	*Best*: 2000 Hz, *Minimum*: 1000 Hz
Gain: 330	(nominal)
Input Impedance:	100 MΩ
CMRR:	95 dB (Nominal)
3 dB Bandwidth:	12Hz – 500 Hz
Noise Voltage:	2 µv rms (bandwidth of 12-500 Hz)
Cable:	3 meters, lightweight, shielded
Electrode Spacing	
TSD150A:	Wide — 35 mm
TSD150B:	Narrow — 20 mm
Stainless steel disk diameter:	11.4 mm
Fine Wire Attachment:	Screw springs
Ground Lead:	Requires LEAD110A for proper operation (one per subject)
Dimensions:	17.4mm wide x 51 mm long x 6.4 mm thick
Weight: 9.5	grams
Interface: HLT100C—see	page 42

See also: LEAD110A
TAPE1 / TAPE2

IPS100C ISOLATED POWER SUPPLY MODULE



The IPS100C is used to operate 100-series amplifier modules **independent** of an MP data acquisition unit. The IPS100C module couples the 100-series amplifier outputs directly to any **other** data acquisition system, oscilloscope or chart recorder. Amplifier modules snap onto the side of the IPS100C to receive the necessary isolated power and to direct the modules' output to the front panel of the IPS100C. The IPS100C allows users to operate up to 16 amplifiers on a stand-alone basis. The analog channel outputs are provided via 3.5mm phone jacks on the front panel. The IPS100C is generally used with animal or tissue preparations. When collecting data from electrodes attached to humans, use the HLT100C module with INISO and OUTISO adapters to couple signals to external equipment.

Includes In-line Transformer (AC100A) and USA or EURO power cord.

IMPORTANT USAGE NOTE

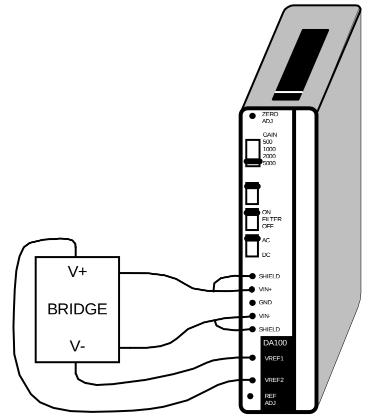
Do not use the IPS100C with an MP based system. For a fully isolated recording system using the IPS100C, couple signal inputs and outputs through the HLT100C module and INISO and OUTISO adapters, respectively. Contact BIOPAC for details.

IPS100C Specifications

Amplifier Output Access:	16 channels (front panel) – 3.5mm phone jacks
Isolated Power Access:	±12V, +5V @ 100 ma (back panel) – screw terminals
Weight: 610	grams
Dimensions:	7cm (wide) x 11cm (deep) x 19cm (high)
Power Source:	12VDC @ 1 amp (uses AC100A transformer)

Chapter 3 General Purpose Transducer Amplifier Module

DA100C – DIFFERENTIAL AMPLIFIER MODULE



The differential amplifier module (DA100C) is a general purpose, single channel, differential amplifier. The DA100C is designed for use in the following measurement applications:

Blood pressure (hemodynamics)	Physiological sounds
Displacement (linear or angular)	Temperature
Muscle strain or force (pharmacology)	Humidity

The DA100C has one differential input linear amplifier with adjustable offset and gain. The DA100C is used to amplify low-level signals from a variety of sources. The DA100C has built-in excitation capability, so it can work directly with many different types of transducers, such as:

Pressure transducers	Piezo sensors
Strain gauges	Wheatstone bridges
Accelerometers Photocells	
Microphones Therm	istors
Electrogoniometers	

Compatible BIOPAC Transducers are:

TRANSDUCER	TYPE	TRANSDUCER	TYPE
TSD104A	Precision Pressure	TSD121C	Hand Dynamometer
TSD105A	Variable Range Force	TSD125 Series	Fixed Range Force
TSD107B	High Flow Pneumotach	TSD127	Low Flow Pneumotach
TSD108	Physiological Microphone	TSD130 Series	Goniometers & Torsiometers
TSD117	Medium Flow Pneumotach	TSD137 Series	Very Low Flow Pneumotach
TSD120	Noninvasive BP cuff	TSD160 Series	Differential Pressure

If the input signal is applied differentially between the VIN+ and VIN- inputs, the Input Signal Range can be centered on any voltage from -10 V to +10 V with respect to GND. If the signal is applied to a single input (with the other input grounded), then that signal can range over the selected Input Signal (pk- pk) with respect to GND.

The DA100C can be used to directly connect existing transducers. The DA100C can be outfitted with connector assemblies for easy interfacing to a variety of "off the shelf" pressure transducers, force gauges, and strain gauges.

These transducer connector interfaces (TCIs) have pin plugs on one side and the transducer mating connector on the other. The following TCIs are available. Or the TCI Kit can be used to make a custom adapter.

TCI100 Grass/Astromed transducers – 6 pin
TCI101 Beckman transducers – 5 pin
TCI102 World Precision Instrument transducers – 8 pin
TCI103 Lafayette Instrument transducers – 9 pin
TCI104 Honeywell transducers – 6 pin
TCI105 Modular phone jack connector – 4 pin
TCI106 Beckman transducers – 12 pin
TCI107 Nihon Koden transducers – 5 pin
TCI108 Narco transducers – 7 pin
TCI109 Fukuda transducers – 8 pin
TCI110 Gould transducers – 12 pin
TCI111 Liquid metal transducers – two 2mm sockets
TCI112 Hokanson transducers – 4 pin
TCI113 Hugo Sachs/Harvard Apparatus — 6 pin
TCI114 "SS" Series Transducers

Important Notes when using TCI114

- Set REF ADJ pot. On the DA100C: VREF1 to +5V, VREF2 to –5V
- The following SS Series Transducers require multiple channel inputs and therefore require a corresponding number of TCI114 with a DA100C each:
  - SS20L and SS21L Twin-axis Goniometers (2 channels)
  - SS26L and SS27L Tri-Axial Accelerometers (3 channels)
  - SS31L Noninvasive Cardiac Output Sensor (2 channels)
- The TCI114 interface is designed for SS Series Transducers only
  - SS1L, SS1LA, SS2L, or SS29L Electrode Leads and Adapters – not recommended: signal may be obtained but quality may be impaired.
  - SS53L, SS54L, and SS55L Digital Switches – not supported: digital interface required; use TSD116 Series Switches & Markers.
  - SS58L Low-Voltage Stimulator – not supported.
  - OUT1 Headphones – not supported.

TCI115 Interface XLR Microphone

The TCI115 will operate with a balanced (differential output) or unbalanced (single-ended output) XLR microphone. Interface all standard XLR microphones to the BIOPAC DA100C for use with a Research System. Accommodates a six meter XLR microphone cable. Input signal level maximum is 400 mv (p-p).

Microphones must be dynamic or have battery-powered condenser (the MP system does not provide 48 V phantom powering).

TCIPPG1 Geer to PPG100C only — 7 pin

Voltage References

The DA100C has two adjustable voltage sources (VREF1 and VREF2) for activating passive sensors like pressure transducers, strain gauges, thermistors and photocells. The references can be set anywhere from -5.0 to +5.0 V. GND is at 0 V. VREF1 and VREF2 track each other with opposite polarity, thus a maximum differential of 10 V is obtainable for driving external transducers. For example, if VREF1 is set to +1.0 V (with respect to GND), then VREF2 will automatically be set to –1.0 V.

The references can be adjusted using the **REF ADJ** potentiometer near the bottom of the module. The voltage references can handle up to 20 mA sourcing or sinking to each other or GND. Pay close attention to the sensor drive requirements so as to minimize overall current consumption.

Frequency Response Characteristics

Use the **10 Hz LP** lowpass filter for connecting the DA100C to most pressure, force, and strain transducers (i.e., TSD104A, TSD105A, TSD120, TSD121C, TSD125 Series, and TSD130 Series).

Use the **300 Hz LP** lowpass filter for connecting the DA100C to devices with higher frequency output signals (i.e., TSD107B, TSD108, TSD117).

Use the **5,000 Hz LP** lowpass filter for connecting the DA100C to devices with the highest frequency signals, such as microphones and clamp signals (patch, voltage or current).

See the sample frequency response plots beginning on page 287: 10 Hz LP, 300 Hz LP, 5000 Hz LP

DA100C Calibration

A. Reference calibration
B. Amplifier gain calibration
C. Transducer calibration if applying physical variable
D. Transducer calibration if not applying physical variable

A. Reference Calibration

The **REFCAL** (see page 57) is used to check the reference voltage of the **DA100C**. The ref voltage is used to provide excitation to passive transducers.

B. Amplifier Gain Calibration

Use the CBLCAL/C.

C. Transducer Calibration if applying physical variable

1. Plug transducer it into the DA100C.
2. Set the gain switch on the DA100C to the desired level.
3. Apply the physical variable to the transducer on the low end of the expected range.
4. Press on Cal 1 in the scaling window in Acq*Knowledge*.
5. Apply the physical variable to the transducer on the high end of the expected range.
6. Press on Cal 2 in the scaling window in Acq*Knowledge*.
7. Review the Input Voltage differential (provided in the scaling window as a consequence of pressing CAL1 and CAL2) and adjust if necessary.
   - ❖ If the Input Voltage differential signal is less than +/- 50 mV it may be appropriate to increase the gain setting on the DA100C.
   - ❖ If either Input Voltage differential signal is higher than 9.9V or less than –9.9V, then reduce the gain setting on the DA100C.

If the Gain switch setting on the DA100C is adjusted, steps 3-7 will need to be repeated.

The **physical variable** for calibration varies based on the transducer type. See the appropriate transducer specification for details:

TRANSDUCER	TYPE	TRANSDUCER	TYPE
TSD104A	Precision Pressure	**TSD121C**	Hand Dynamometer
TSD105A	Variable Range Force	**TSD125 Series**	Fixed Range Force
TSD107B	High Flow Pneumotach	**TSD127**	Low Flow Pneumotach
TSD108	Physiological Microphone	**TSD130 Series**	Goniometers & Torsiometers
TSD117	Medium Flow Pneumotach	**TSD137 Series**	Very Low Flow Pneumotach
TSD120	Noninvasive BP cuff	**TSD160 Series**	Differential Pressure

D. Transducer Calibration if not applying physical variable

Use this procedure to calibrate the transducer if the required physical variable changes can't easily be generated.

1. Calculate the de-normalized voltage calibration factor, V_Y.
   a) Note the factory calibration constant "K" (generally listed as "Output" in the transducer specifications), expressed in the form of voltage/physical variable per volt excitation ((V/P)/V),
   b) Multiply K ((V/P)/V) by the reference voltage (RV) of the DA100C (2 V factory preset).
   c) Multiply the result [K((V/P)/V)* RV] = V_Y by the Gain switch setting value on the DA100C.
2. Plug the transducer into the DA100C.
3. Place the transducer in the ambient or zero state.
4. Press CAL1 …this will generate a value Vzero in the Input Voltage box
5. Enter the ambient or zero physical value in the Cal 1 Map/Scale window
6. Enter CAL2 Input Voltage as $V_{zero} + V_Y$
7. Enter the ambient + delta physical value in the Cal 2 Map/Scale window

DA100C Specifications

Gain:	50, 200, 1000, 5000
Output Range:	±10 V (analog)
Frequency Response	Maximum bandwidth (DC-5,000 Hz)
Low Pass Filter:	10 Hz, 300 Hz, 5000 Hz
High Pass Filter:	DC, 0.05 Hz
Input Voltage (max):	±200 mV (protected)
Noise Voltage:	0.11µV rms – (0.05-10 Hz)
Temperature Drift:	0.3µV/°C
Z (Differential input):	2MΩ
CMRR:	90 dB min
CMIV—referenced to	
Amplifier ground:	±10 V
Mains ground:	±1500 VDC
Voltage Reference:	-10 to +10 V infinitely adjustable @ 20ma (max) (preset to 2 volts excitation)
Signal Source:	Variety of transducers
Input Voltage Range	Gain Vin (mV)
50	±200
200	±50
1000	±10
5000	±2
Weight: 350	grams
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)

REFCAL Reference Calibrator for the DA100C

The **REFCAL** is used to check the reference voltage of the **DA100C**. It connects to the DA100C and displays the reference voltage as an analog input signal. This makes it very easy to adjust the reference voltage of the DA100C to suit the transducer.

The REFCAL connects the VREF1 and VREF2 voltage reference outputs directly to the DA100C inputs via a precision attenuator of value (1/50). When using the REFCAL to set the DA100C references, the DA100C should be set to DC with a gain of 50.

The voltage output on the selected channel of the DA100C will be the voltage difference between VREF1 and VRREF2:

$$V_{OUT} = V_{REF1} - V_{REF2}$$

CBLCAL Calibration Cable for the DA100C

Use the CBLCAL to verify the signal calibration of the DA100C. This cable (1.8m) connects between the DA100C input and the UIM100C D/A output 0 or 1. To verify the DA100C's frequency response and gain settings, create a stimulus signal with Acq*Knowledge* and monitor the DA100C's output. The CBLCAL incorporates a precision 1/1000 signal attenuator.

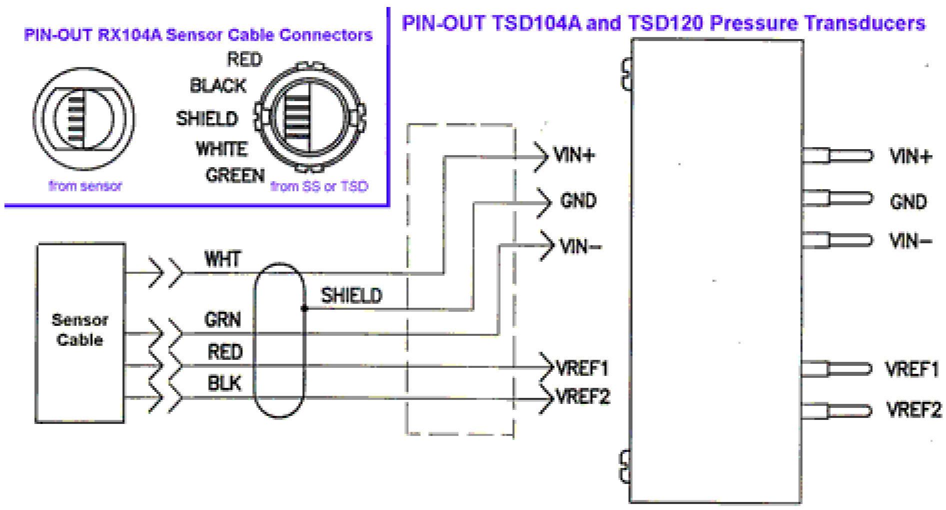
See also: Application Note #AH102 — Biopotential Amplifier Testing using CBLCAL

TSD104A BLOOD PRESSURE TRANSDUCER

RX104A Replacement Element

The TSD104A is used to measure direct arterial or venous blood pressure in animals for research or teaching. It is designed to interface with the DA100C via a 3-meter cable (supplied). The RX104A is a replacement element for the TSD104A blood pressure transducer; it does not include the TCI connector and cable.

TSD104A Specifications

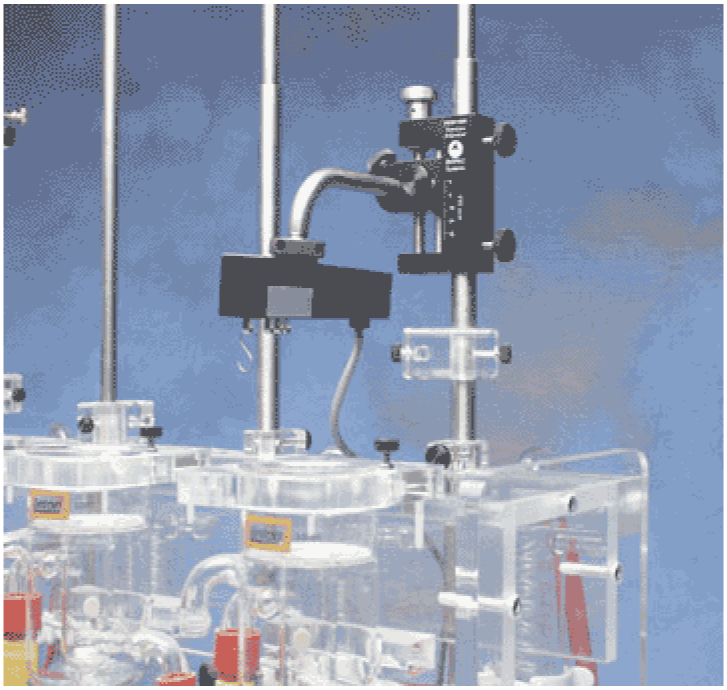


Operational pressure:	-50 mmHg to +300 mmHg
Overpressure:	-400 mmHg to +4,000 mmHg
Dynamic Response:	100 Hz
Unbalance: 50	mmHg max
Connection Ports:	male Luer and female Luer (sensors shipped prior to summer 2010 were male Luer on both sides)
Eight-hour Drift:	1mmHg after 5 minute warm-up
Isolation:	$\leq$ 5 µA leakage at 120 VAC/60 Hz
Defibrillation:	Withstands 5 discharges of 400 joules in 5 minutes across a load
Operating temperature:	+15° C to +40° C
Storage Temperature:	-30° C to +60° C
Temperature Coefficient:	± 0.4 mmHg / deg C
Combined effects of sensitivity, linearity, and hysteresis:	1 mmHg (nominal)
Output: 5	µV/mmHg (normalized to 1V excitation)
Weight: 11.5	grams
Transducer Dimensions:	67mm long x 25mm wide
Cable length:	3 meters
Interface: DA100C	

TSD104A Calibration

See DA100C Calibration options on page 55.

TSD105A ADJUSTABLE FORCE TRANSDUCER



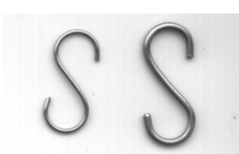
TSD105A shown with HDW100A

Force transducers are devices capable of transforming a force into a proportional electrical signal. The TSD105A force transducer element is a cantilever beam load cell incorporating a thin-film strain gauge. Because the strain elements have been photolithographically etched directly on the strain beam, these transducers are rugged while maintaining low non-linearity and hysteresis. Drift with time and temperature is also minimized, because the strain elements track extremely well, due to the deposition method and the elements' close physical proximity. The TSD105A also incorporates impact and drop shock protection to insure against rough laboratory handling.

Forces are transmitted back to the beam via a lever arm to insure accurate force measurements. Changing the attachment point changes the full scale range of the force transducer from 50g to 1000g. The beam and lever arm are mounted in a sealed aluminum enclosure that includes a 3/8" diameter mounting rod for holding the transducer in a large variety of orientations. The TSD105A comes equipped with a 2-meter cable and plugs directly into the DA100C amplifier.

The TSD105A mounting rod can be screwed into the transducer body in three different locations, two on the top and one on the end surfaces of the transducer. The mounting rod can be placed in any angle relative to the transducer orientation. The TSD105A can be used in any axis and can be easily mounted in any standard measurement fixture, including pharmacological setups, muscle tissue baths and organ chambers.

The TSD105A has 5 different attachment points that determine the effective range of the force transducer. These ranges are 50g, 100g, 200g, 500g and 1,000g. The point closest to the end is the 50g attachment point, while the point closest to the middle is the 1,000g attachment point.



Two hooks are provided with the TSD105A. One with a .051" diameter wire and the other with a .032" diameter wire. The larger hook is intended for the 500g and 1000g ranges and the smaller hook is to be used for the 50g, 100g and 200g ranges.

TSD105A Calibration

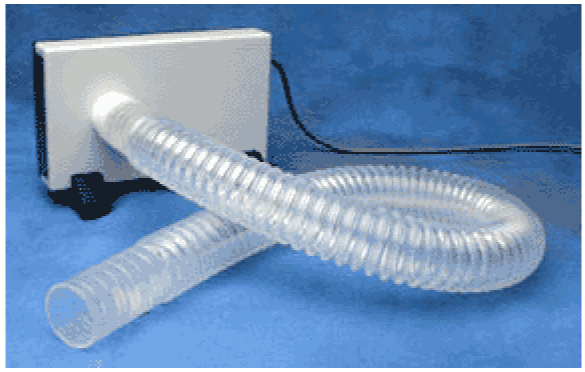
The TSD105A is easily calibrated using weights of known mass. Ideally, calibration should be performed with weights that encompass the range of the forces expected during measurement and should cover at least 20% of the full scale range of the transducer. When calibrating for maximum range on the force transducer, use weights that correspond to 10% and 90% of the full scale range for best overall performance.

See DA100C Calibration options on page 55.

TSD105A Specifications

Rated Output:	1mV/V (normalized to 1V excitation)
Ranges:	50, 100, 200, 500, 1000 grams
Noise (rms):	(Range/50)mg @ 10 volts excitation, 1Hz bandwidth
Nonlinearity: <±	0.025% FSR
Hysteresis: <±0.05%	FSR
Nonrepeatability: <±0.05%	FSR
30 minute creep:	<±0.05% FSR
Temperature Range:	-10°C to 70°C
Thermal Zero Shift:	<±0.03% FSR/°C
Thermal Range Shift:	<0.03% Reading/°C
Maximum Excitation:	10 VDC
Mounting Rod:	9.5mm (dia) – variable orientation
Weight:	300g (with mounting rod)
Length:	19mm (wide), 25mm (thick), 190mm (long)
Cable Length:	3 meters
Interface: DA100C—see	page 53

TSD107B HIGH-FLOW PNEUMOTACH TRANSDUCER



The TSD107B is a highly linear, wide range, airflow transducer. Using the TSD107B and a DA100C amplifier with the MP System, a variety of tests relating to airflow and lung volume can be performed. With the equipment listed below and the proper software parameters, precise lung volume measurements can be obtained.

Equipment

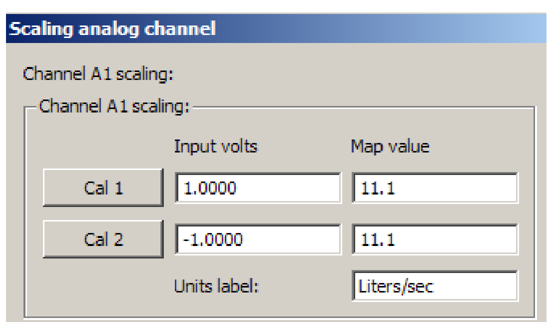
- MP System for data acquisition
- DA100C general purpose amplifier
- TSD107B pneumotach transducer

Hardware Setup

1. Select DA100C module for Channel 1.
2. Set Gain at 1000.
3. Set the high frequency response to 10 Hz (300 Hz in some cases).
4. Set the low frequency response to DC.
5. Set VREF1 to +1.0 Volts (default) with a Volt/ohm meter or with BIOPAC REFCAL (VREF2 will track VREF1 with opposite polarity).
6. Plug the TCI connector into DA100C.
7. Insert the airflow tube between the bacterial filter and the airflow transducer.
8. Place the mouthpiece on the free end of the bacterial filter.

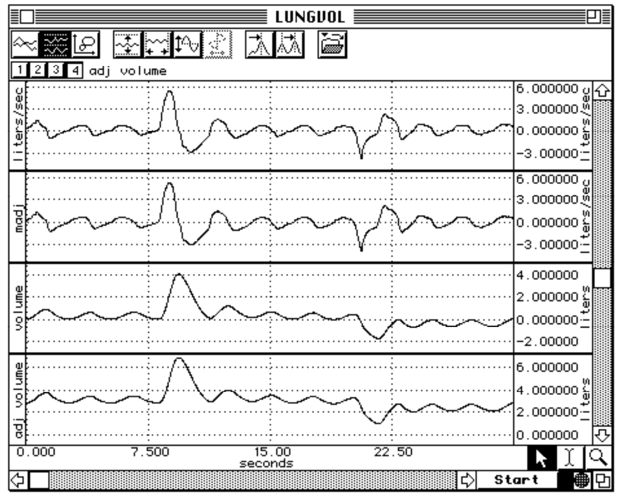
Software Setup

1. Under **Setup Channels** select channel 1 and click on the scaling button.
2. Complete the scaling dialog box as shown here:



3. Under **Setup Acquisition** set
   a) Storage: Disk
   b) Sample rate: 50 samples per second
   c) Acquisition length: 30 seconds.

Recording Procedure



1. Start breathing normally through the mouthpiece.
2. After several normal breaths, inspire as deeply as possible (just once) and then return to normal breathing for several seconds
3. Expire as completely as possible.
4. Return to normal breathing for the remainder of the recording.

The recorded wave should look something like the top wave in the following graph. Normal Tidal Volume can vary quite a bit, even over a 30-second period. Note that in Wave 4 – adj volume, the starting tidal volume is almost a liter, then, as the test progresses, the tidal volume drops to about 0.5 liters. This level of variation is somewhat expected, since respiratory effort has a strong voluntary component.

*Analysis — Acq*Knowledge

1. Duplicate the recorded data.
2. Subtract the mean value of the entire record from the duplicated data to create the Mean Adjusted Flow (madj). This procedure will simply remove any DC bias from the airflow signal.
3. Duplicate madj.
4. Integrate the duplicated madj channel. This process results in the third wave, which is the volume (in liters), which correlates to the airflow.
5. To correct for the proper residual volume in the lungs (estimated at about 1 liter), add a constant to the third wave to create a new adjusted volume (adj volume). The minimum point on this curve should be the estimated residual lung volume (1 liter).

TSD107B Calibration

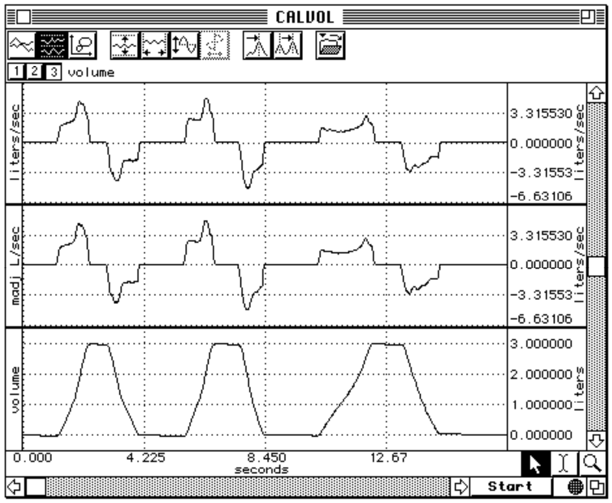
The TSD107B is factory calibrated to nominally satisfy the scaling factor:

1 mVolt output = 11.1 liters/sec flow rate

When connected to the DA100C with Gain =1,000, the calibration factor is:

1 Volt = 11.1 liters/sec

This graph illustrates how a calibration check is performed.



1. Insert a three-liter calibration syringe into the free end of the airflow tube.
2. Push three liters of air through the airflow transducer, first one direction, then the other.
3. Subtract the mean value of the first wave from the second wave, to correct for DC bias.
4. Integrate the second wave; the result will be placed in the third channel (volume).

As air is forced back and forth through the transducer, the expected volume would be from 0 to 3 liters. As air goes one way the volume climbs to 3 liters, and as that same air is then pulled the other direction through the transducer, the volume signal should head back to 0. As shown in the sample graph, the volume measurement is independent of the rate of flow, as would be expected for a linear airflow measurement transducer.

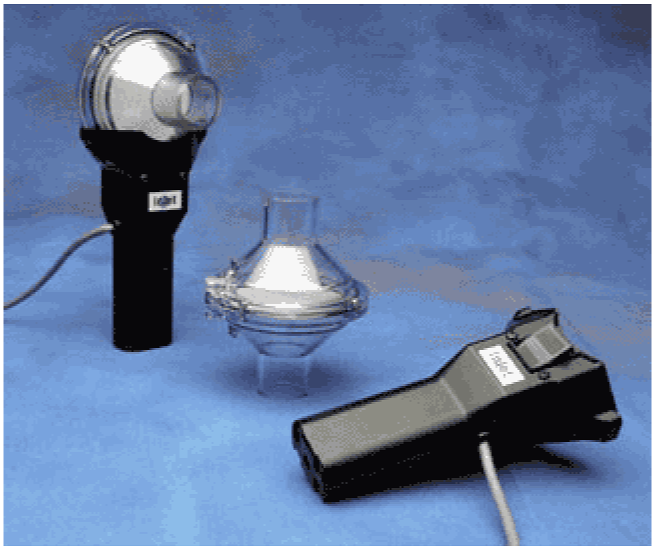
See DA100C Calibration options on page 55.

TSD107B Specifications

Pneumotach type:	Hans Rudolf® #4813 with integral differential pressure transducer
Voltage excitation:	+/- 5 volts (10 volts pk-pk) maximum
Nominal Output:	45 µV/[liters/sec] (normalized to 1V excitation)
Calibration factor:	90 micro-volts/(liters/second) – normalized to 2 VDC excitation
Calibrated flow range:	±800 Liters/min
Dead space volume:	87.8 ml
Back pressure:	2.8 cm H_2O/400 liters/min
Flow bore (Ports):	35mm OD
Weight: 690	grams
Dimensions:	4cm (deep) x 11cm (high) x 19cm (wide)
Cable: 3	meters
Interface: DA100C—see	page 53

TSD117 Medium-flow Pneumotach Transducer

TSD117-MRI Medium-flow Pneumotach Transducer for MRI



The TSD117 can be used to measure respiratory flow over a wide range of subjects and conditions. The TSD117 includes an optically clear detachable flow head (RX117) for easy cleaning and inspection. As the detachable flow head is snapped into the TSD117 handle, the flow head plugs directly into an integral, precision low-differential pressure transducer. Accordingly, the TSD117 will output an electrical signal proportional to respiratory flow. The TSD117 plugs directly into the DA100C amplifier module. The RX117 detachable flow head can be cold sterilized, autoclaved (220° F max), or placed in a dishwasher.

- For airflow and lung volume measurements, use the TSD117 with the AFT2 mouthpiece and the AFT1 bacterial filter.
- For measurements of expired gases, use the TSD117 with the AFT22 non-rebreathing T valve with AFT10 facemask and the AFT15A or AFT15B mixing chambers.

All connections can be performed with AFT12 (22mm ID) tubing and AFT11 series couplers (page 168).

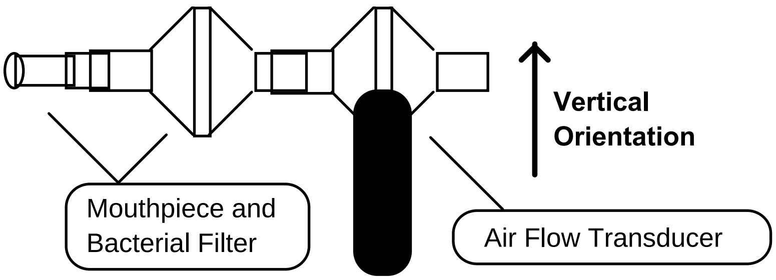
Please note the following:

a) The bacterial filter and mouthpiece are disposable and are "one per person" items. Please use a new disposable filter and mouthpiece each time a different person is to be breathing through the airflow transducer.

b) For more effective calibration, use a bacterial filter between the calibration syringe and the airflow transducer.

c) Either the bacterial filter and mouthpiece are inserted into the airflow transducer or the calibration syringe (with attached filter) is inserted into the airflow transducer.

Normal measurement connections:



For the most accurate lung volume recording, be sure to use a noseclip to prevent airflow through the nose. Also, be sure not to remove the airflow transducer assembly from the mouth during the recording. All air leaving or entering the lungs must pass through the airflow transducer during the lung volume measurement.

Use the following measurement procedure for determining lung volume:

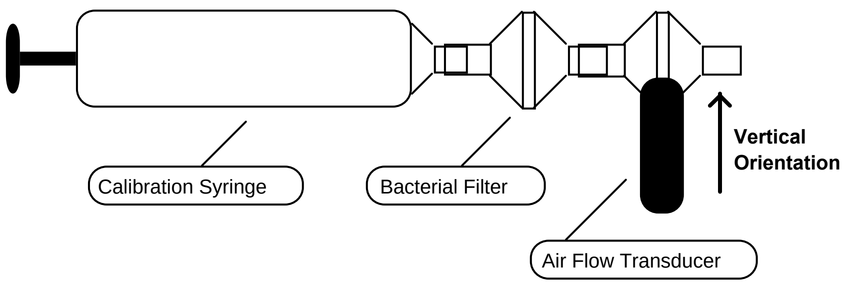
1. Breathe normally for 3 cycles (start on inspire)
2. Inspire as deeply as possible
3. Return to normal breathing for 3 cycles
4. Expire as deeply as possible
5. Return to normal breathing (end on expire)

Data Processing

When integrating the collected data to determine lung volume, it's important to integrate from the starting point of the first inspire, to the end point of the last expire. Before integration, the mean of the selected (airflow) data must be determined and then subtracted from the record. This process insures that the integral will have the same starting and ending point.

TSD117 Calibration

Calibration connections:



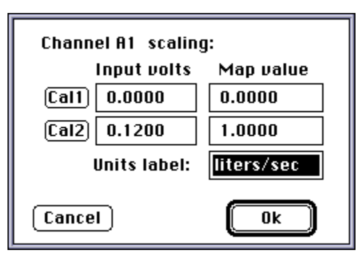
After the calibration process, please remove the calibration syringe and attach a new bacterial filter and mouthpiece to the airflow transducer.

It's very important that each individual use his/her own mouthpiece and bacterial filter.

Place the narrow end of the bacterial filter and mouthpiece assembly into either side of the airflow transducer. Airflow data can now be recorded. For best results, hold the airflow transducer vertically.

Calibration Procedure Options

The TSD117 can be roughly calibrated without using the calibration syringe. Using the TSD117's nominal output of 60µV per liter/sec (normalized to 1 volt excitation), the following calibration factors can be entered in the Acq*Knowledge* Scaling window.



Scaling Factors for Rough Calibration of the TSD117

The following equation illustrates why 0.12 volts maps to 1.00 liter/sec :

$$\text{Calibration Constant} \bullet \text{Amp Gain} \bullet \text{Amp Excitation} = \text{Scale Factor}$$

thus

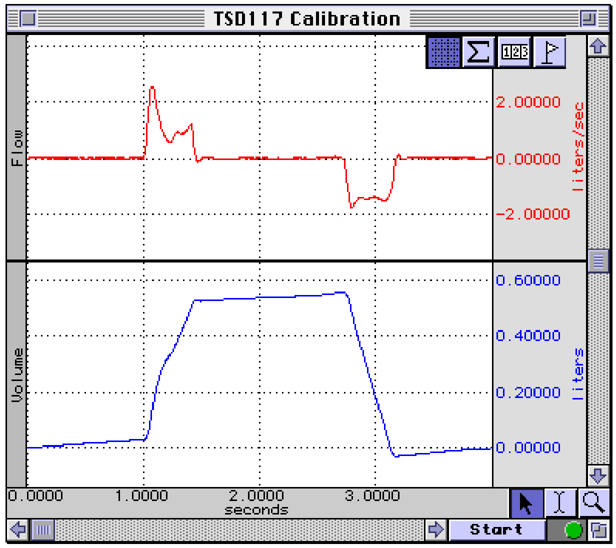
$$60\ \mu\text{V/[liter/sec]} \bullet 1000 \bullet 2\ \text{Volts} = 0.12\ \text{V / [liter/sec]}$$

Data can now be collected directly. Prior to analyzing the data, remember that there will always be some offset recorded in the case of zero flow. It's possible to largely trim this offset out, using the ZERO potentiometer on the DA100 amplifier, but some residual will always remain.

To remove residual offset after the flow data has been collected, select a portion of the baseline (zero flow reading) and calculate the mean value using the popup measurements. Subtract this mean value from the raw data to obtain a mean corrected flow signal.

Now, the integral of the mean can be calculated as shown in this graph →

In this case, a 600ml-calibration syringe was used to check the rough calibration of the TSD117 airflow transducer. The rough calibration indicates a syringe volume of about 550ml, so this method may only be expected to be accurate within ±10% of the real reading.



Flow Measurement and Volume Calculation

<u>To achieve a more exact calibration</u>, start with the above scaling factors and then boost or drop them slightly as indicated by the rough calibration. In this case, if the map value correlating to 0.12 volts were boosted about 10% to 1.10 (from 1.0 liters/sec), the resulting calibration would be fairly accurate.

Also see DA100C Calibration options on page 55.

TSD117 Technical Specifications

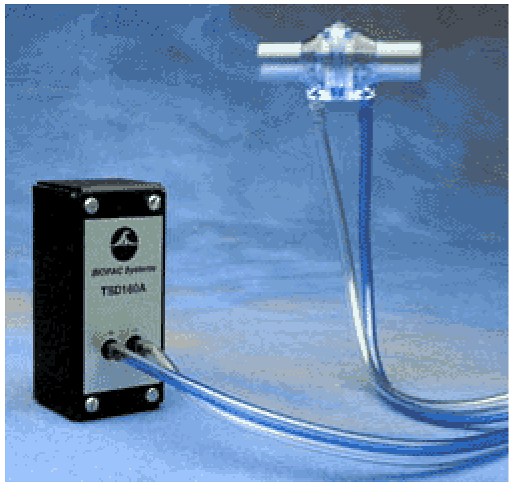
	TSD117	TSD117-MRI
Interface: DA100C—see	page 53	MECMRI-DA to DA100C
Flow Rate:	±300 Liters/min (±5 Liters/sec)	
Nominal Output:	60 µV/[liters/sec] (normalized to 1 V excitation)	
Dead space:	93 ml	
1/4” 25 TPI mounting nut:	standard camera mount	
Flow Bore (Ports):	22 mm (ID), 29 mm (OD)	
Flow Head Dimensions:	82.5 mm (dia) x 101.5 mm (long)	
Flow Head Weight:	80 g	
Flow Head Construction:	Clear Polycarbonate	
Handle Dimensions:	127 mm (long) x 23 mm (thick) x 35 mm (wide)	
Handle Weight:	85 g	
Handle Construction:	Black ABS	
Cable Length:	3 m, shielded	
TEL100C Compatibility:	SS11A—see page 270	

RX117 REPLACEMENT AIRFLOW HEAD

The RX117 is a sterilizable airflow head for the TSD117 pneumotach transducer. The material used in the flow head is polycarbonate and the screen is Stainless Steel. To reduce the cost of disposable items, use the RX117 with the AFT8 sterilizable mouthpiece. (22mm ID/30mm OD). Multiple RX117 heads help eliminate equipment downtime during cleaning procedures.

Recommended sterilization: cold sterilization (i.e., Cidex®) or autoclave. If autoclaved, RX117 Airflow Heads should be cleaned at the lowest autoclave temperature setting. The life cycle will be about 10-20 cycles, depending upon temperature used.

TSD127 Pneumotach Airflow Transducer (Low Flow)



The TSD127 can perform a variety of pulmonary measurements relating to airflow, lung volume and expired gas analysis. The TSD127 is intended for animal use and consists of a low flow, pneumotach airflow head (RX127) coupled to a precision, highly sensitive, differential pressure transducer (TSD160A). The TSD127 will connect directly to a breathing circuit or plethysmogram chamber. The detachable flow head (RX127) makes cleaning and sterilization easy.

- For airflow and lung volume measurements, connect a short airflow cannula to the TSD127.
- For measurements of expired gases, use the TSD127 with the AFT22 non-rebreathing valve.

All connections can be performed with AFT11 series couplers (page 168).

TSD127 Calibration

Follow the procedure for TSD117 (see page 65) but move the calibration syringe plunger at a reduced velocity due to the higher sensitivity to flow of the TSD127.

Also see DA100C Calibration options on page 55.

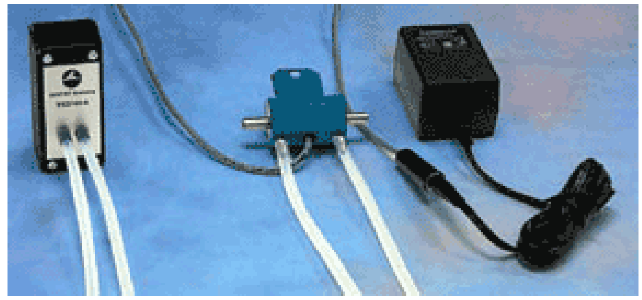
TSD127 Specifications

Range:	± 90 Liters/min (±1.5 Liters/sec)
Nominal Output:	500 µV/[liters/sec] (normalized to 1V excitation)
Dead Space:	11cc
Weight:	11 grams – airflow head
Dimensions:	5.7cm (long) – airflow head
Ports:	15mm OD / 11mm ID
Tubing Length:	1.8 meters (to DA100C)
Interface: DA100C	

RX127 Replacement Airflow Head

The RX127 is a low airflow head for the TSD127 pneumotach transducer. Multiple RX127 heads help eliminate equipment downtime during cleaning procedures. (11mm ID/15mm OD)

TSD137 SERIES PNEUMOTACH AIRFLOW TRANSDUCERS (VERY LOW FLOW)



The TSD137 series pneumotachs can be used to perform a variety of small animal pulmonary measurements relating to airflow, lung volume and expired gas analysis. The TSD137 series consists of a low flow, pneumotach airflow head (RX137A through RX137E) coupled to a precision, highly sensitive, differential pressure transducer (TSD160A, page 89). The TSD137 series pneumotachs will connect directly to a breathing circuit or plethysmogram chamber. For airflow and lung volume measurements, connect a short airflow cannula to the TSD137 series flow head. All of the TSD137 series pneumotachs are equipped with an internal heating element that can be optionally attached to the AC137A 6 volt power supply (see page 273).

TSD137 Calibration

Connect tubing and a flow restrictor between the calibration syringe and the TSD137 transducer, then follow the procedure for TSD117 (see page 65) but move the calibration syringe plunger at a reduced velocity due to the very high sensitivity to flow of the TSD137 series. Each of the TSD137 series is factory calibrated to a known flow level, as indicated on the transducer.

Also see DA100C Calibration options on page 55.

TSD137 Series Specifications

Unit	Range (ml/sec)	Dead Space (cc)	Nominal Output (µV/[ml/sec])	Flow Ports (OD/mm)	Animal	
					Approx. Size	Approx. Wt.
TSD137A	±12	0.1	25.7	7	Small Mouse	30 g
TSD137B	±20	0.8	15.4	7	Mouse	50 g
TSD137C	±60	0.9	5.78	7	Rat/Guinea Pig	350 g
TSD137D	±150	2.0	2.10	10	Cat/Rabbit	750 g
TSD137E	±350	4.0	0.924	11	Small Dog	5.5 kg
Nominal Output:	Normalized to 1 V excitation					
Tubing length:	1.8 m (to TSD160A)					
Interface:	DA100C					

RX137 Series Replacement Airflow Heads

For TSD137 Series Pneumotachs

The RX137 series are low airflow heads for the TSD137 series pneumotach transducers. The RX137 heads can be mixed and matched with any of the TSD137 series pneumotachs. Switching one head for another when using a single TSD137 pneumotach can accommodate a wide range in flows. RX137 heads connect to the TSD160A differential pressure transducer via standard 3mm or 4mm ID tubing. Multiple RX137 heads help eliminate equipment downtime during cleaning procedures.

RX137 Series Specifications

Head	**Range**	**Dead Space**	**Length**	**Flow Ports**		**Weight**
(m	l/sec)	(cc)	(mm)	**ID** (mm)	**OD** (gram	s)
RX137A ±	12	0.1	75	1.35	7	100
RX137B ±	20	0.8	75	6.00	7	90
RX137C ±	60	0.9	75	6.00	7	90
RX137D ±	150	2.0	75	9.00	10	100
RX137E ±	350	4.0	60	10.00	11	60

TSD237 Series Pneumotach Airflow Transducers

These flow transducers are designed for humans (TSD237H) and animals ranging in size from mice to medium-sized dogs (TSD237B, D, and F). They include a detachable flow head (RX237B through H) and a differential pressure transducer (TSD160A, page 89).

Applications:

TSD237B with RX237B – 17 ml/sec	Mouse/Rat
TSD237D with RX237D – 167 ml/sec	Cat/Rabbit
TSD237F with RX237F – 1.67 L/sec	Medium Dog
TSD237H with RX237H – 16.7 L/sec	Human

- Lightweight and robust
- Linear and direction sensitive
- Twin, non kink silicone tubing
- Economical, sensitive and robust
- Easily cleaned, disinfected or sterilized

For TSD237/RX237 cleaning instructions, see the **Cleaning Guidelines**

Note: One of the problems historically encountered with pneumotachographs is condensation from expired air. This can be prevented by fitting a non-return valve and measuring only inspiration or alternatively by heating the flowhead, but viscosity errors may arise (from which in the first few breaths especially) preheat the inspired air most uncomfortably. In this range of flow heads, ***the problem is approached from a fresh angle.*** By mounting fine stainless steel gauze in plastic rings, thermal inertia is greatly reduced. The gauze therefore rapidly equilibrates in temperature with passing air and condensation is minimal.

RX237 Series Replacement Airflow Heads

For TSD237 Series Pneumotachs

Detachable flow heads in the TSD237 Series are machined from acetal to give good stability with low weight and have found application in pediatrics and in the respiration measurement of animals such as dogs, cats, rats and mice.

TSD/RX237 Series Specifications

BIOPAC Part #		**Flowhead Type**	**Dead Space (ml)**	**Linear Range L/min**	**Approx. Flow for 10mm WG**	**Tube (OD mm)**	**Length (mm)**	**Weight (gm)**
Transducer	Flowhead							
TSD237B	RX237B	F1L	0.6	± 1	1.2 L/min	5	40	14
TSD237D	RX237D	F10L	2	± 10	12 L/min	8	54	22
TSD237F	RX237F	F100L	9	± 100	90 L/min	16	54	38
TSD237H	RX237H	F1000L	320	± 1000	550 L/min	29.5	198	230

TSD108 Physiological Sounds transducer

The TSD108 connects to the DA100C General Purpose Transducer Amplifier. The TSD108 can be used with the TSD120 Noninvasive Blood Pressure Cuff or as a stand-alone device. If used with the TSD120, Korotkoff sounds can be recorded for easy determination of systolic and diastolic blood pressure (see page for 71 details). When used on its own, it can record a variety of acoustical signals, including heart sounds and sounds associated with ribbing or grinding (e.g., Bruxism. The acoustical transducer) element is a Piezo-electric ceramic disk that is bonded to the interior of a circular metallic housing.

Grounding Note When using this transducer with the EBI100C module, do not connect the GROUND pin of the TSD108 to the DA100C module. Doing so will cause inaccurate impedance measures, because the TSD108 contact surface is tied to the isolated ground. An alternative is to insulate the TSD108 from the skin surface by using a latex balloon or some other non-conductive barrier. If the latter procedure is followed, the GROUND pin may be attached to the DA100 module.

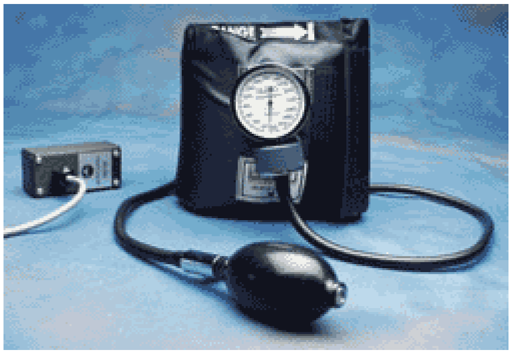
TSD108 Calibration

The TSD108 does not require calibration.

TSD108 Specifications

Frequency Response:	35 Hz to 3500 Hz
Housing: Stainless	Steel
Sterilizable:	Yes (contact BIOPAC for details)
Noise:	5µV rms – (500 Hz - 3500 Hz)
Output:	2V (p-p) maximum
Weight: 9	g
Dimensions:	29 mm diameter, 6 mm thick
Cable Length:	3 m
Interface: DA100C	
TEL100C Compatibility:	SS17—see page 270

TSD120 Blood Pressure Cuff



TSD120

RX120A and RX120F cuff options

Blood Pressure Measurement

The most common form of indirect blood pressure measurement employs a pressure cuff, pump and pressure transducer. This complete assembly is commonly referred to as a *sphygmomanometer*.

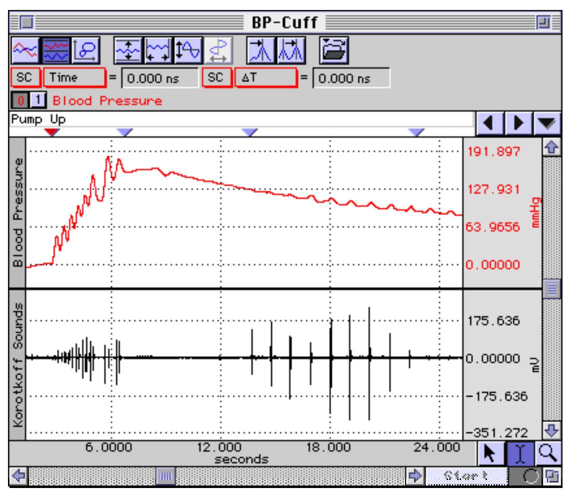
Typically, the cuff is wrapped around the upper arm and is inflated to a pressure exceeding that of the brachial artery. This amount of pressure collapses the artery and stops the flow of blood to the arm. The pressure of the cuff is slowly reduced as the pressure transducer monitors the pressure in the cuff. As the pressure drops, it will eventually match the systolic (peak) arterial pressure. At this point, the blood is able to “squirt” through the brachial artery. This squirting results in turbulence that creates the Korotkoff sounds. The Korotkoff sounds are detected using a **TSD108** physiological sounds transducer (see page 70). The cuff pressure continues to drop, and the pressure eventually matches the diastolic pressure of the artery. At that point, the Korotkoff sounds stop completely, because the blood is now flowing unrestricted through the artery.

The following graph illustrates a typical recording using the TSD120 and TSD108.

The TSD120 pressure signal was recorded via a DA100C amplifier set to DC, 10 Hz LP and a gain of 200.

The TSD108 Korotkoff signal was recorded by a DA100C amplifier set to .05 Hz HP, 300 Hz LP and a gain of 50 to 200.

The signal for the TSD108 was further conditioned by the Acq*Knowledge* software.



Cuff Blood Pressure Versus Korotkoff Sounds

In a calculation channel, the TSD108 signal is bandpass filtered from 50 to 200 Hz. Accordingly, the sampling rate for the entire recording needs to be about 600 Hz, assuming the TSD108 transducer is used.

As the cuff is wrapped around the upper arm of the subject, be sure to place the TSD108 transducer **underneath** the blood pressure cuff, **directly over the brachial artery**. TSD108 placement is very important to get the best possible recordings of Korotkoff sounds. Finish wrapping the cuff around the upper arm and secure it with the Velcro® seal. Now, start inflating the cuff with the pump bulb.

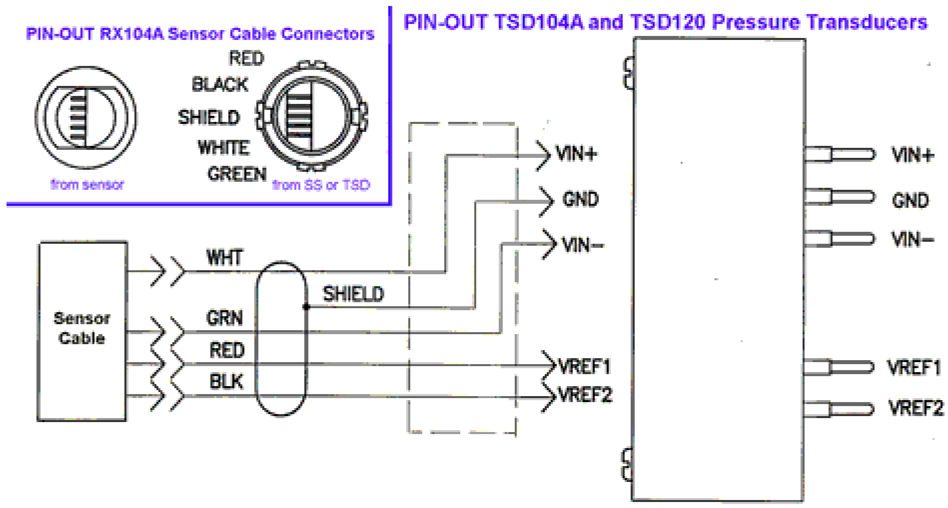
The pressure trace shows the hand pump driving the cuff pressure up to about 150 mmHg. Then the cuff pressure is slowly released by adjusting the pump bulb deflation orifice. Notice that the Korotkoff sounds begin appearing when the cuff pressure drops to about 125 mmHg (bottom trace). As the pressure continues to drop, the Korotkoff sounds eventually disappear, at about 85 mmHg. The **systolic pressure** would be identified at 125 mmHg and the **diastolic pressure** would be 85 mmHg.

TSD120 Calibration

The TSD120's built-in pressure transducer will require an initial calibration prior to use. To calibrate the transducer, wrap the cuff into a roll and begin to inflate the cuff slowly with the pump bulb. The pressure change will be noticeable on the mechanical indicator. Set the cuff pressure to one lower pressure (typically 20 mmHg) and then one higher pressure (typically 100 mmHg). In this manner the pressure transducer can be calibrated using the standard procedure in the SCALING dialog (in Acq*Knowledge*). To use the cuff at a future date, simply save the calibration settings in a stored file.

Also see DA100C Calibration options on page 55.

TSD120 Blood Pressure Cuff Specifications



Pressure range:	20 mmHg to 300 mmHg
Manometer accuracy:	±3 mmHg
Output:	5 µV/mmHg (normalized to 1V excitation)
Cuff circumference range:	25.4 cm to 40.6 cm (as shipped with RX120 d; cuff is switchable)
Cuff Dimensions:	14.5cm (wide) x 54cm (long)
Weight: 350	grams
Cable Length:	3 meters, shielded
Interface: DA100C	

RX120 SERIES Blood Pressure Cuffs for the TSD120

The RX120 series are optional blood pressure cuffs, of varying sizes, which can be quickly and easily swapped in and out of the TSD120 noninvasive blood pressure cuff transducer. Use a single TSD120 and substitute one cuff for another to accommodate a wide range in limb circumferences.

RX120 Specifications

Cuff	**Circumference Range** (cm)	**Width** (cm)	**Length** (cm)
RX120A 9.5-13	.5	5.2	18.5
RX120B 13.0-1	9.0	7.5	26.1
RX120C 18.4-2	6.7	10.5	34.2
RX120 d	25.4-40.6	14.5	54.0
RX120E 34.3-5	0.8	17.6	63.3
RX120F 40.6-6	6.0	21.0	82.5

TSD121C Hand Dynamometer

The multi-purpose hand dynamometer adds a new dimension to force measurements. This fully isometric transducer can be used in the traditional hand grip strength fashion, pulled apart by both hands (the Dynagrips option), or mounted against a wall and pulled. The hand dynamometer can be used in isolation, or combined with EMG recordings for in-depth studies of muscular activity. The isometric design improves experiment repeatability and accuracy. The hand dynamometer is designed to interface with the DA100C General Purpose Transducer Amplifier, and the TEL100C remote monitoring module. The hand dynamometer transducer is the same for each system, but they each use a different connector and a different part number. The equipment section provides a list of the appropriate part numbers and interfaces.

TSD121C Calibration

With the proper equipment and correct scaling techniques described below, precise force measurements can be obtained.

Equipment

TSD121C Hand Dynamometer

MP System and DA100C General Purpose Transduce Amplifier

SS25 Simple Sensor Hand Dynamometer

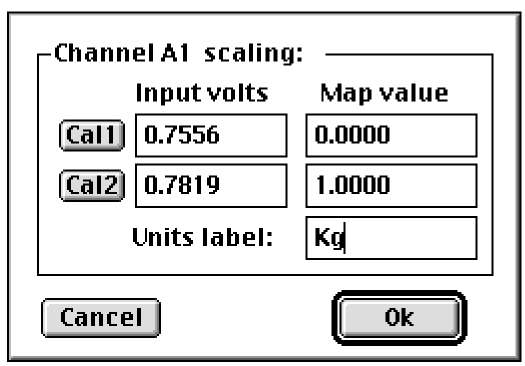
MP System and TEL100C Remote Monitoring Module Set

Hardware Setup

Connect the TSD121C to the DA100C, or the SS25 to the TEL100C. When using this type of transducer, proper hand placement is at the uppermost portion of the foam grip, directly below the dynagrip connections.

Software Setup

1. Select **Setup Channels** under the MP menu and enable one analog channel; make sure to correlate this with the Analog Output Channel selected on the DA100C module.
2. Select **Scaling**. A dialog similar to the one shown here will be generated.
3. In the **Map value** column, enter the scaling factors of 0 and 1, respectively. These represent 0 and 1 kilograms.



4. Enter "Kg" for the **Units label,** as shown.
5. Take the TSD121C and rest it on the table.
6. Click on the **Cal 1** button with the mouse to get a calibration reading.

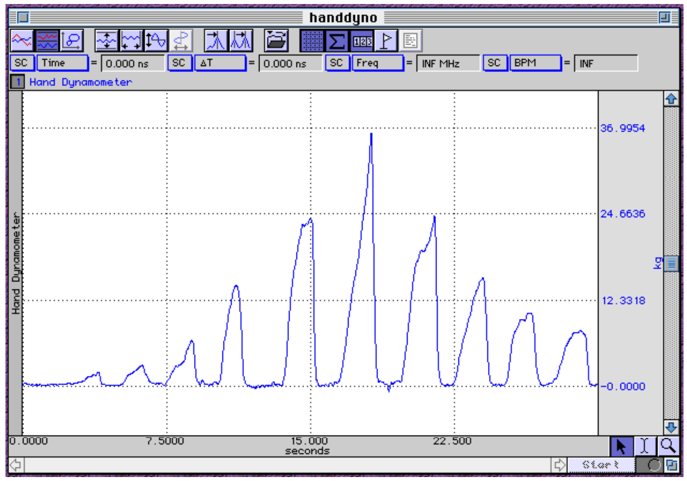
To obtain a value for the **Cal 2** box, add 13.15µV per volt of excitation (V_{ex}) to the value from the Cal 1 box. Currently, the DA100C is factory set to 2 V (±1 V) of excitation. If the amplifier has been set to another level of excitation, use the following equation wherein V = volts of excitation per 1 kg and G = gain setting on the DA100C or TEL100C module:

$$(13.15\mu V * G * V_{ex}) + Cal\ 1 = Cal\ 2$$

Testing Calibration

To see if the calibration is correct for the MP System:

1. Start acquiring data.
2. Place the hand dynamometer on a flat surface.
3. Place a known weight on the uppermost portion of the grip.
4. Check the data — the weight should be reflected accurately in the data acquired.

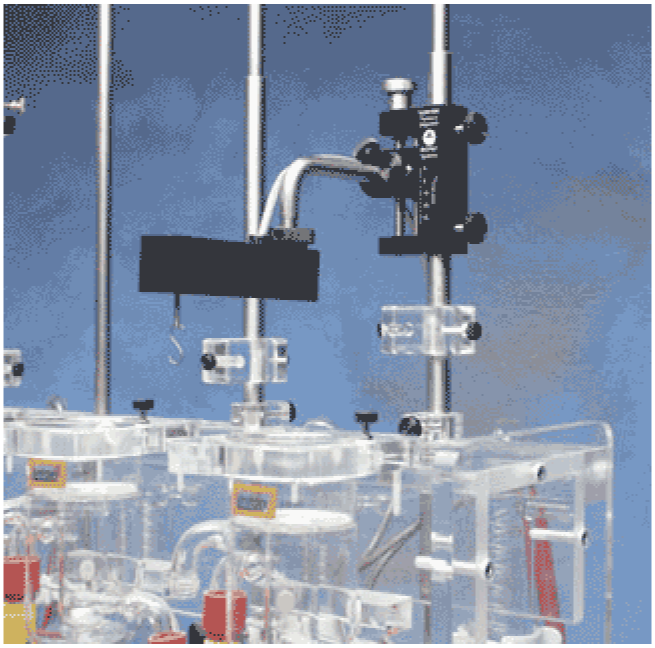


Sample Data

Also see DA100C Calibration options on page 55.

TSD121C Specifications

Isometric Range:	0-100 Kg
Nominal Output:	13.2 µV/kg (normalized to 1V excitation)
Weight: 315	g
Dimensions:	185 mm (long) x 42 mm (wide) x 30 mm (thick)
Cable Length:	3 m
Interface: DA100C—see	page 53
TEL100C compatibility:	SS25—see page 270



TSD125 shown with HDW100A

Force transducers are devices capable of transforming a force into a proportional electrical signal. The TSD125 series force transducer elements are cantilever beam load cells incorporating thin-film strain gauges. Because the strain elements have been photolithographically etched directly on the strain beam, these transducers are rugged while maintaining low non-linearity and hysteresis. Drift with time and temperature is also minimized, because the strain elements track extremely well, due to the deposition method and the elements close physical proximity. Forces are transmitted back to the beam via a self-centering pull-pin to insure accurate force measurements. The cantilever beam is mounted in a sealed aluminum enclosure that includes a 3/8" diameter mounting rod for holding the transducer in a large variety of orientations.

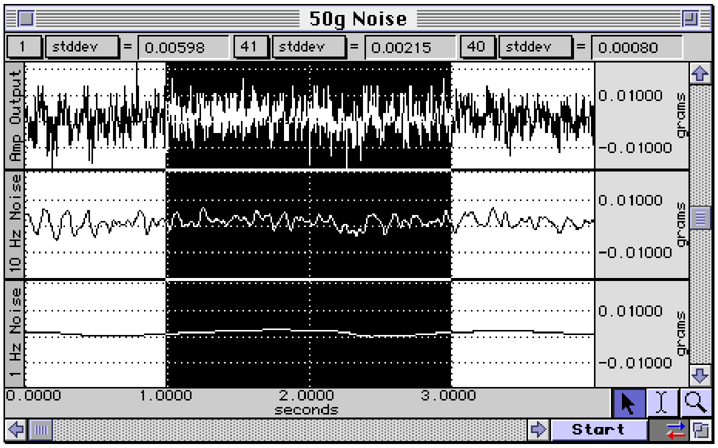
TSD125 Series Calibration

The following graphs illustrate actual data taken with the TSD125C (50 gram force transducer) and TSD125F (500 gram force transducer). The force transducers were connected directly to a DA100C amplifier with the excitation set to ±5 Volts. The DA100C gain was set to 1,000. The RMS noise output was determined by calculating the standard deviation of the amplified and calibrated signal over a period of time.

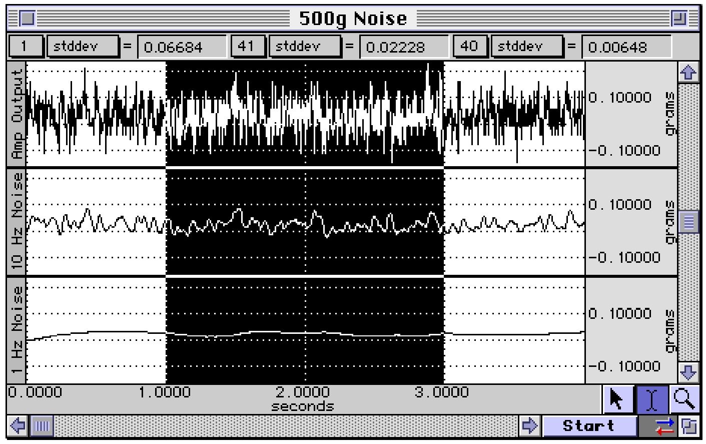
The RMS noise of each force transducer was determined in three different settings.

1) Channel 1 RMS Noise at DA100C output
2) Channel 41 RMS Noise after 10 Hz Low Pass IIR real time filtering
3) Channel 40 RMS Noise after 1Hz Low Pass IIR real time filtering

RMS noise performance of TSD125F for different bandwidths



RMS noise performance of TSD125C for different bandwidths



See DA100C Calibration options on page 55.

TSD125 series Specifications

Device	Full Scale Range (FSR)	RMS Noise [10 volts Excitation] 10 Hz	1 Hz
TSD125B:	20 gram	1.0 mg RMS	.04 mg RMS
TSD125C:	50 gram	2.5 mg RMS	1 mg RMS
TSD125D:	100 gram	5 mg RMS	2 mg RMS
TSD125E:	200 gram	10 mg RMS	4 mg RMS
TSD125F:	500 gram	25 mg RMS	10 mg RMS

Nonlinearity:	<± 0.025% FSR
Hysteresis:	<±0.05% FSR
Nonrepeatability:	<±0.05% FSR
30-Minute Creep:	<±0.05% FSR
Temperature Range:	-10°C to 70°C
Thermal Zero Shift:	<±0.03% FSR/°C
Thermal Range Shift:	<0.03% Reading/°C
Maximum Excitation:	10 VDC
Full Scale Output:	1mV/V (normalized to 1V excitation)
Weight:	250 grams
Dimensions:	100mm (long) x 19mm (wide) x 25mm (high)
Mounting Rod:	9.5mm (dia) – variable orientation
Cable Length:	3 meters
Interface:	DA100C—see page 53

HDW100A Force Transducer Tension Adjuster

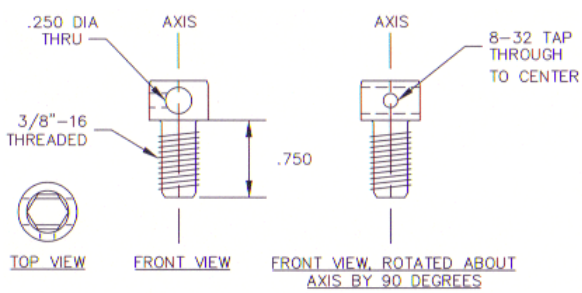
HDW100A and TSD125

The HDW100A tension adjuster operates with the TSD105A and TSD125 series force transducers. The rugged design and stability of the mounting allow for fine position control. The position adjuster is located on the top for easy access and smooth operation. Vertical scales are provided for both metric and standard units. The HDW100A slides directly onto vertical rod laboratory stands and force transducers are clamped into the unit horizontally.

HDW100A Specifications

Travel Range:	25mm
Resolution:	0.0025mm per degree rotation
Stand Clamp:	13.25mm ID
Transducer Clamp	11mm ID
Weight: 140	grams
Dimensions:	93mm (high) x 19mm (thick) x 74mm (deep)

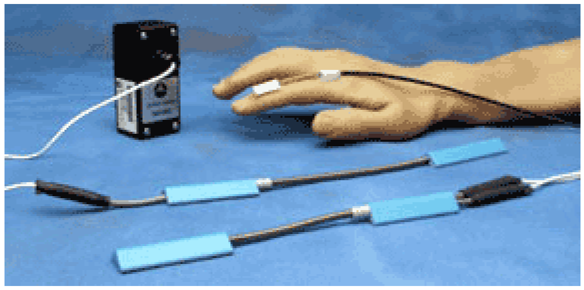
HDW200 Adapter for 3rd-party Tension Adjusters



This adapter allows 3rd-party tension adjusters to interface with BIOPAC Force Transducers.

- Fits any tension adjuster with an arm diameter of 6.35 mm (1/4") or less, such as “riser” style tension adjusters from Lafayette and Wards.

TSD 130 Series Goniometers & Torsiometers

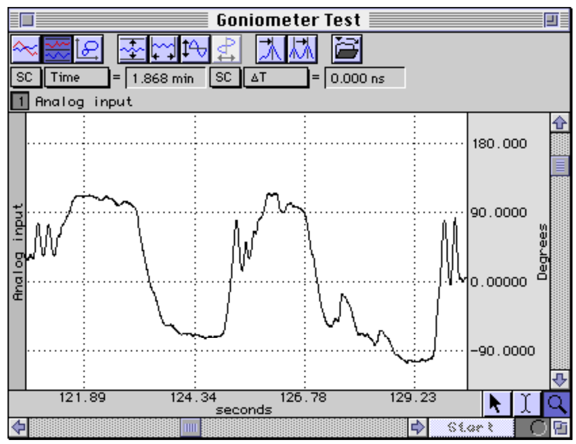


The TSD130 Series are designed for the measurement of limb angular movement. Goniometers transform angular position into a proportional electrical signal. The TSD130 series goniometers incorporate gauge elements that measure bending strain along or around a particular axis.

The goniometers are unobtrusive and lightweight, and can be attached to the body surface using double-sided surgical tape (and can be further secured with single sided tape). The goniometers have a telescopic endblock that compensates for changes in distance between the two mounting points as the limb moves. The gauge mechanism allows for accurate measurement of polycentric joints. All sensors connect directly to the MP150/100 unit as part of an MP System. Activity data can be displayed and recorded, leaving the subject to move freely in the normal environment.

The bending strain is proportional to the sum total angular shift along the axis. Because the bending force is extremely small, the output signal is uniquely a proportional function of the angular shift.

In the example at right, the TSD130A was connected directly to a DA100C amplifier, the DA100C gain was set to 1,000, and Acq*Knowledge* was used to calibrate the signal to provide angular measurements from approximately +90° to -90°.



Twin axis goniometers	Dual output devices that can measure angular rotation about two orthogonal planes simultaneously. Goniometers provide outputs to simultaneously measure around two orthogonally rotational axes (e.g. wrist flexion/extension and radial/ulnar deviations).
	TSD130A — use on the wrist or ankle.
	TSD130B — use on the elbow, knee or shoulder.
Torsiometers	Measure angular twisting (as on the torso, spine or neck) as opposed to bending. Torsiometers measure rotation about a single axis (e.g. forearm pronation/supination).
	TSD130C — use on the neck.
	TSD130D — use along the torso or spine.
Single-axis goniometer	Measures the angle in one plane only; designed to measure finger joint movement.
	TSD130E — use on the fingers, thumb or toes.

ATTACHMENT TO THE SUBJECT

Various combinations of display and recording instrumentation have been carefully developed fulfilling the requirements of specific research applications. Due to the wide range of applications, one method of attachment cannot be recommended. Experience has proven that standard medical adhesive tape is an excellent adhesion method in the majority of cases. Single-sided and double-sided medical tape (such as BIOPAC TAPE1 or TAPE2) should be used for the best results.

1) Attach pieces of double-sided tape to the underside of the goniometer endblocks.

2) Stick the tape to the subject and allow for the telescoping of the goniometer. The goniometer should be fully extended when the joint is fully flexed.
3) Press the two endblocks firmly onto the subject and ensure that the goniometer is lying over the top of the joint. When the joint is extended, the goniometer may present an “oxbow.”
4) For additional security, pass a single wrap of single-sided medical tape around each endblock.
5) Secure the cable and connector leaving the goniometer with tape to ensure that they do not pull and detach the goniometer.

For accurate results from long recordings

Employ double-sided adhesive between the endblocks and skin, and place single-sided adhesive tape over the top of the endblocks. **No tape should come into contact with the spring**. The connection lead should also be taped down near the goniometer.

For applications where quick or rapid movements are involved

Fit a “sock” bandage over the whole sensor and interconnect lead. This does not apply to goniometer TSD130E, which has a different working mechanism.

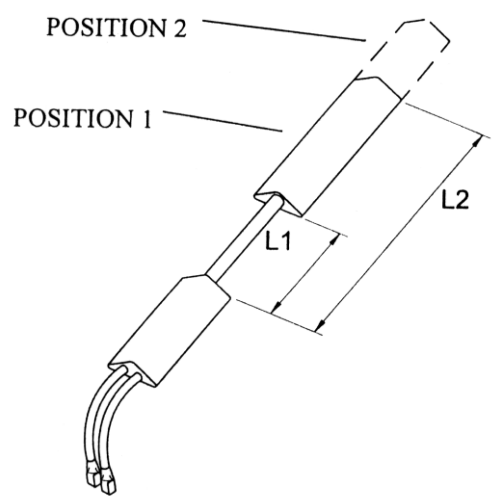
When the goniometer is mounted across the joint, the center of rotation of the sensor measuring element may not coincide with the center of rotation of the joint (for example, when measuring flexion /extension of the wrist). As the joint moves through a determined angle, the relative linear distance between the two mounting positions will change.

To compensate for this, all sensors are fitted with a telescopic endblock that permits changes in linear displacement between the two endblocks along axis ZZ without the measuring element becoming over-stretched or buckled.

In the free or unstretched position, the distance between the two endblocks is L1.

If a light force is applied, pushing the endblocks away from each other, this length will increase to a maximum of L2.

When the light force is removed, the distance between the two endblocks will automatically return to L1.

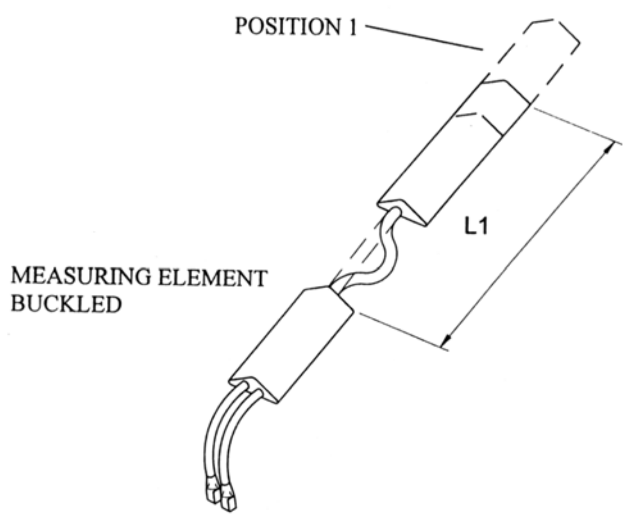


This creates several advantages: accuracy is improved; sensors can be worn comfortably and undetected under normal clothing; the tendency for the position of the sensors to move relative to the underlying skeletal structure is reduced.

If a light force is now applied, pushing the two endblocks linearly towards each other, the only way the distance L1 can decrease in length is if the measuring element buckles.

Buckling is detrimental to the accuracy of the TSD130A, TSD130B, TSD130C and TSD130D sensors, so attachment instructions are provided (on page 86) for the most commonly measured joints, to ensure that it does not occur in practice.

There is no universal rule governing which size of sensor is most suitable for a particular joint; this depends on the size of the subject.



In general, the sensor must be capable of reaching across the joint so that the two endblocks can be mounted where the least movement occurs between the skin and the underlying skeletal structure. In certain circumstances, more than one size of sensor will be appropriate.

WARNINGS

1. Take care to handle the goniometer and torsiometer sensors as instructed. Mishandling may result in inaccurate data, reduced equipment life, or even failure.
2. Observe the minimum bend radius value for each goniometer and torsiometer at all times, particularly when attaching and removing the sensors from the subject. Failure to do this will result in reduced equipment life or failure.
3. Never remove the goniometer from the subject by pulling on the measurement element and/or protective spring. Remove the endblocks individually and carefully, making sure not to exceed the minimum permissible bend radius, particularly where the measuring element enters the endblocks.
4. Take care when mounting goniometers to ensure that the measurement element always forms a "simple" bend shape. Accuracy will be reduced if an "oxbow" shape occurs in the element.
5. Do not bend the finger goniometer more than ±20° in the Y-Y Plane or reduced equipment life and/or failure may result.
6. Do not exceed rotations of ± 90° about ZZ. Exceeding the torsiometer range may result in a reduction of the life of the unit or failure.
7. Disconnect the transducers from the MP150/100 before cleaning or disinfecting goniometers and torsiometers.

MAINTENANCE & SERVICE

No periodic maintenance is required to ensure the correct functioning of the sensors.

The sensors contain no user serviceable components.

If the sensor fails, it should be returned to BIOPAC Systems, Inc.

Please request a Return Merchandise Authorization (RMA) number before returning the sensor and include a description of what has been observed and what instrumentation was in use at the time of sensor failure in the return package.

TSD130 Series Calibration

Each goniometer requires a DA100C amplifier per rotational axis. Accordingly, the twin axis goniometers will need two DA100C amplifiers to measure both rotational axes simultaneously. The recommended DA100C excitation voltage is ±5 VDC.

When using all goniometers and torsiometers**, the minimum value of bend radius must be observed at all times**, particularly when attaching and removing the sensors from the subject. Failure to do this will result in reduced unit life or failure.

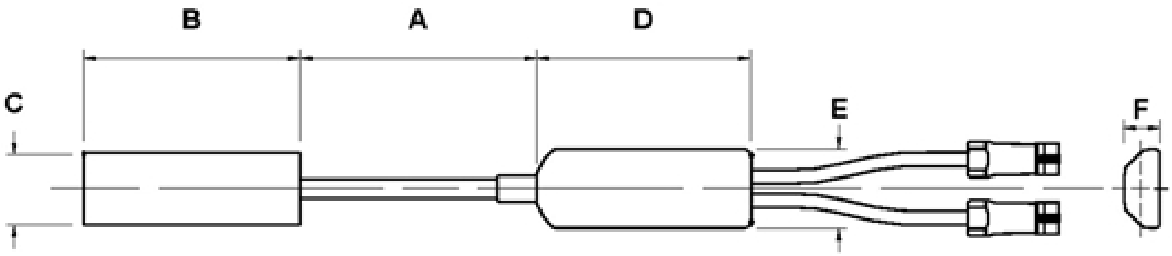
The sensors have been designed to be as light as possible and the operating force to be a minimum. This permits free movement of the joint without influence by the sensors. The sensors measure the angle subtended between the endblocks. Use the software calibration features (Under **Setup Channels**) to calibrate any of the BIOPAC series goniometers.

See DA100C Calibration options on page 55.

TSD130 Specifications

Transducer	TSD130A	TSD130B	TSD130C	TSD130D	TSD130E
Type:	Twin-Axis Goniometer		Torsiometer	Single-axis Torsiometer	Finger goniometer
Nominal Output:	5 µV/ degree (normalized to 1 V excitation)				
Temperature Zero Drift:	0.15 degrees angle / °C				
Cable Length (Detachable):	6 meters	6 meters	3 meters	6 meters	6 meters
Interface:	DA100C - see page 53				

TEL100C Compatibility: SS20 thru SS24—see page 270



Part #	MP150 or MP100 / Telemetry TEL100C / MP36/36R/35/30/45	TSD130A / SS20 / SS20L	TSD130B / SS21 / SS21L	TSD130C / SS22 / SS22L	TSD130D / SS23 / SS23L	TSD130E / SS24L / SS24L
Number of Channels		2	2	1	1	1
Measuring Range		±150°	±150°	±150°	±150°	±150°
Dimensions mm						
A. Maximum		110	150	110	170	35
A. Minimum		70	50	70	115	30
B.		60	120	60	70	18
C.		18	18	18	18	8
D		54	54	54	54	15
E		20	20	20	20	8
F.		9	9	9	9	5
Bend radius (mm) - minimum:		18	18	18	18	3
Weight (g)		23	27	22	23	8
Crosstalk[1]		≤ ±5%	≤ ±5%	N/A	N/A	N/A

Endblock height:	cable end 9.4 mm, distal end 8.2 mm
Transducer type	strain gauge
Life[2]	600,000 cycles minimum
Accuracy	±2° measured over 90° from neutral position
Repeatability	better than ±1°
Analog resolution **(typical):**	**0.05 degrees rms (5 V excitation, bandwidth DC-50 Hz)**
Operating temperature range:	+ 0°C to +40°C
Storage temperature range:	-20°C to +50°C
Operating humidity range:	30% to 75%
Storage humidity range:	30% to 75%
Atmospheric pressure range:	operation: 700hPa to 1060hPa
	storage: 500hPa to 1060hPa

[1] Specification of crosstalk for all Biometrics twin axis SG series goniometers is measured over ± 60°. i.e. if a joint is moved through 60° from the neutral position in one plane without movement in the orthogonal plane, then the sensor output in the orthogonal plane may change by a maximum ±3°.

[2] Life test results have been collected by cycling the sensors through movements that would happen during everyday use. For example, placing a sensor on an adult elbow and moving from the neutral position to maximum flexion and back to the neutral position, the unit will function for a minimum of 600,000 cycles.

Additional Specs – Goniometers/Torsiometers

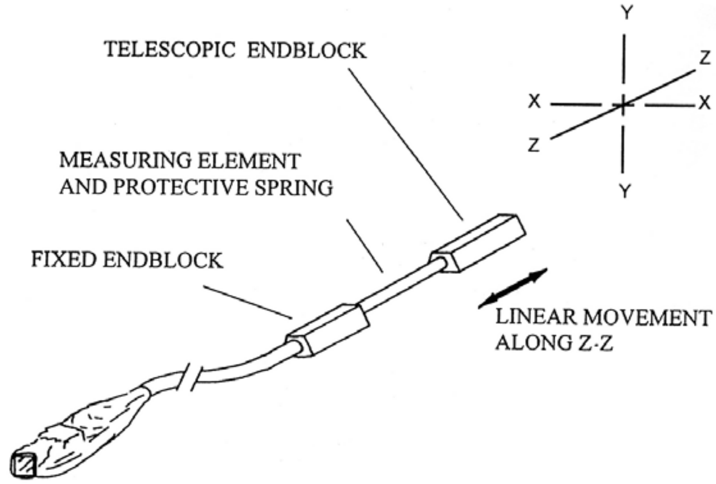
OVERVIEW OF THE BIOPAC GONIOMETER SERIES

As with all measuring equipment, to correctly interpret the data, understanding the working principles (i.e., what the sensor measures) before use is helpful. BIOPAC Systems, Inc. manufactures three types of sensors:

1. The TSD130E single axis finger goniometer permits the measurement of angles in one plane.

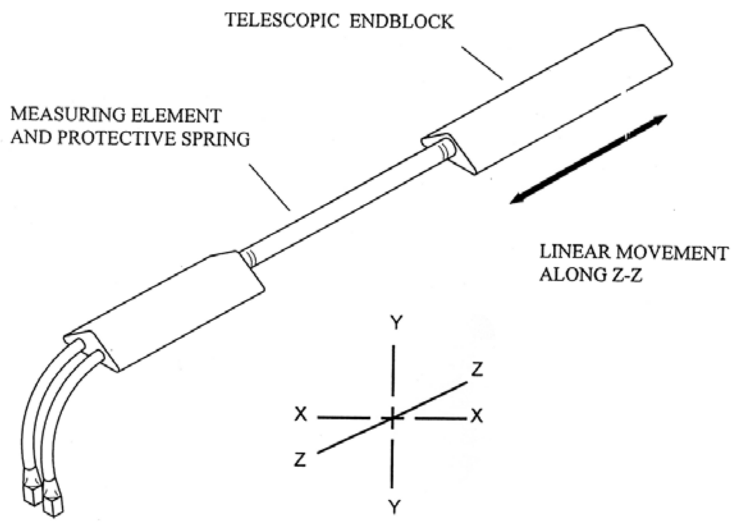
   Angles are measured when rotating one endblock relative to the other about axis X-X.

   The goniometer is not designed to measure rotations about Y-Y. Any attempt to bend the unit in this way more than ± 20 from the neutral position will result in a reduction of the life of the unit or failure.



The goniometer does not measure rotations about axis Z-Z, though this movement is permitted without reduced life or damage occurring. This goniometer is designed primarily for the measurement of finger and toe flexion/extension.

2. The TSD130A and TSD130B twin axis goniometers permit the simultaneous measurement of angles in two planes, e.g. wrist flexion / extension and radial / ulnar deviation. Rotation of one endblock relative to the other about axis X-X is measured using the gray plug. Similarly, rotation of one endblock relative to the other about axis Y-Y is measured using the blue marked plug.



Assuming the goniometer is mounted correctly (as outlined here), the outputs of the two channels are independent of linear displacements along axis Z-Z.

It should be noted that rotation of one endblock relative to the other around axis Z-Z cannot be measured.

All TSD130A and TSD130B series goniometers function in the same way, and differ only in size.

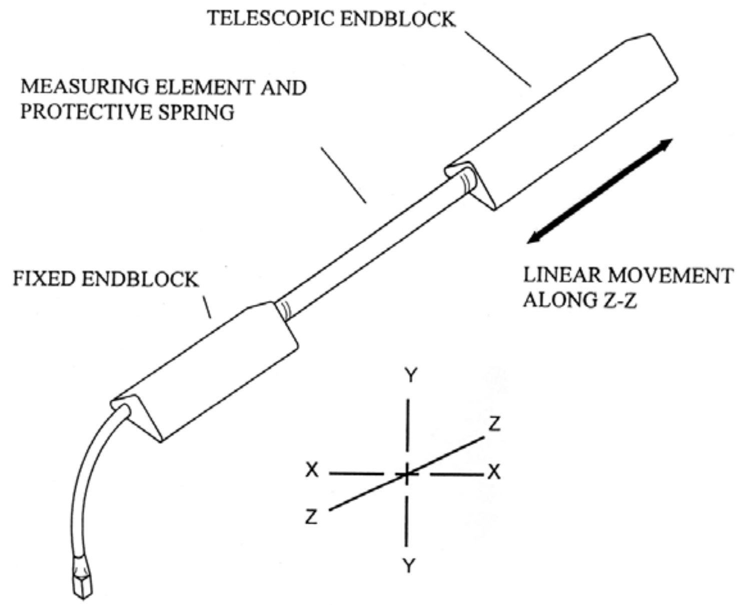
3.

The TSD130C and TSD130D single axis torsiometers permit the measurement of rotation in one plane, e.g. forearm pronation/supination.

Axial rotation of one endblock relative to the other along axis Z-Z is measured from the gray plug.

If the torsiometer is bent in planes X-X or Y-Y, the output remains constant.

All torsiometers function in the same way, and difference only in size.

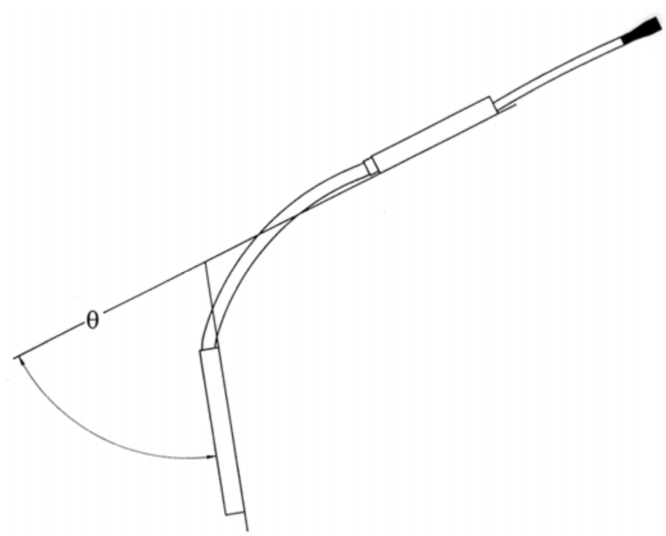


WARNING!

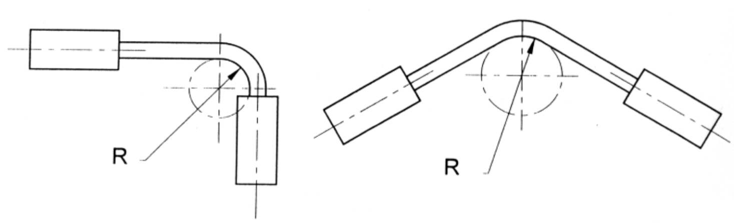
Torsiometers measure rotations about ZZ in the range ± 90°. Exceeding the range may result in a reduction of the life of the unit or failure.

The working mechanism is the same for all three types of sensors. There is a composite wire between the two endblocks that has a series of strain inside the protective spring gauges mounted around the circumference. As the angle between the two ends changes, the change in strain along the length of the wire is measured and this is equated to an angle. The design is such that only angular displacements are measured.

If the two ends move linearly relative to each other, within the limits of telescopic endblock, without changing the relative angles between them, then the outputs remain constant.

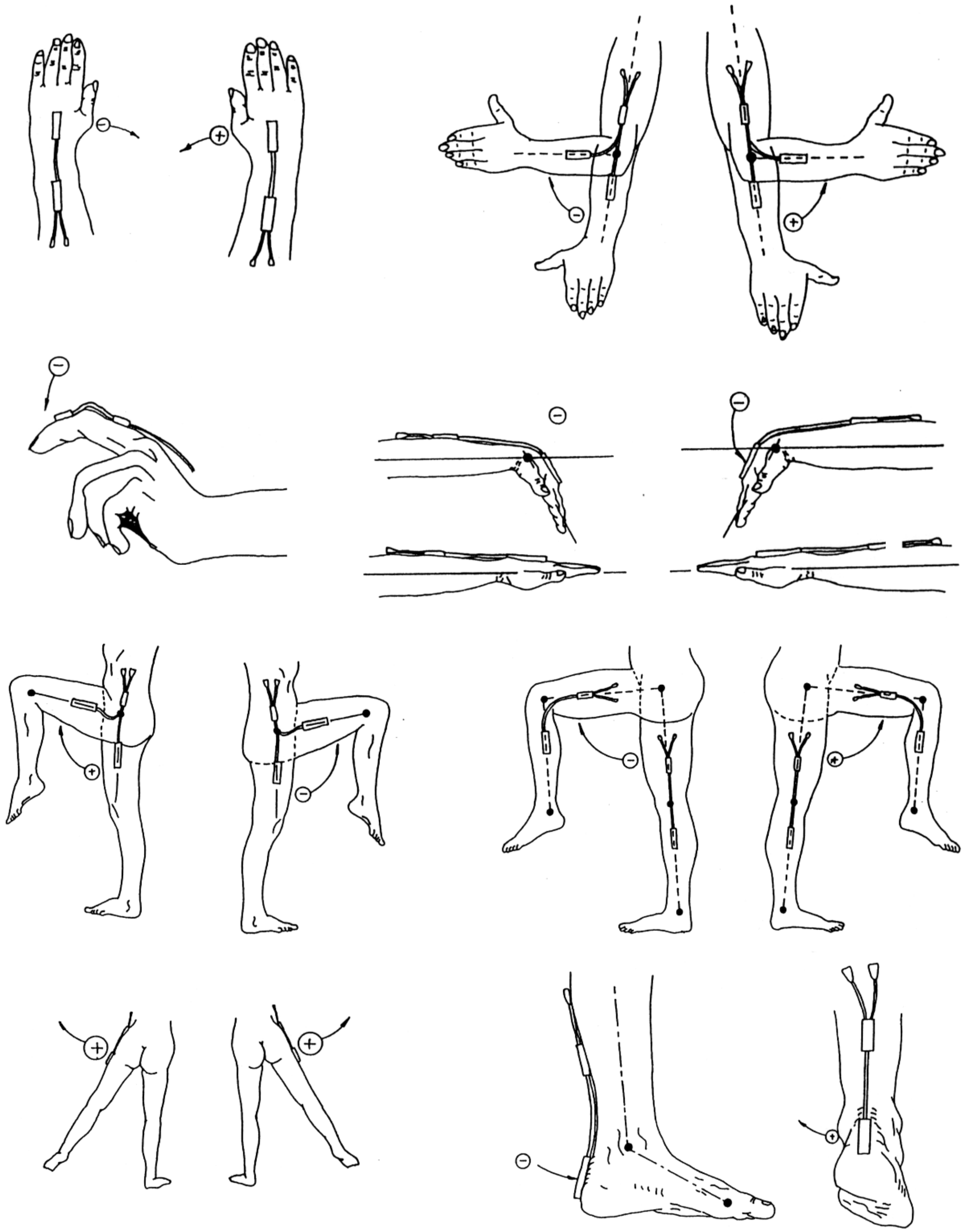


The amount of strain induced in the gauges is inversely proportional to the bend radius that the beam is bent around. If the stated minimum permissible bend radius is exceeded then unit life will be reduced or, in severe cases, failure may result.



SIGN CONVENTIONS

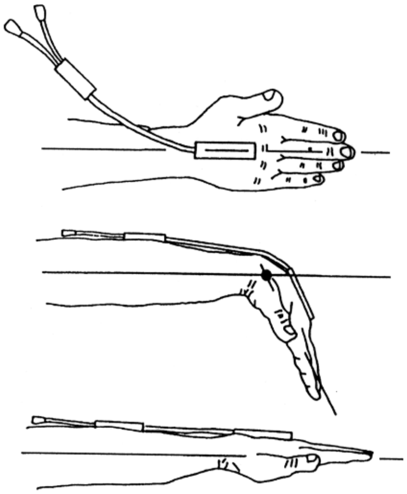
The sign convention for certain joints will differ, depending which side of the body the sensor is attached to. The following figures show sign conventions for the most common joints.



THE WRIST – **TSD130A** Goniometer

Attach the telescopic endblock to the back of the hand, with the center axis of the hand and endblock coincident (top of figure — viewed in the frontal plane).

While fully flexing the wrist (middle and bottom of figure), extend the goniometer to Position 2 (as shown on page 79) and attach the fixed endblock to the forearm so that when viewed from the dorsal plane, the axes of the forearm and endblock are coincident. The wrist may now be flexed or extended, abducted or adducted, with the goniometer freely sliding between Positions 1 and 2. Measurement of flexion/extension is obtained from the gray plug, and abduction/adduction is obtained from the blue plug.

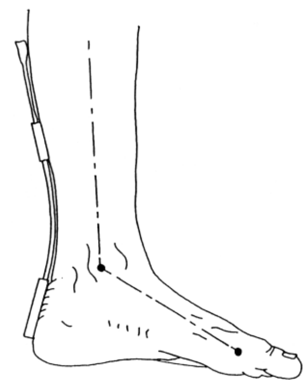


THE ARTICULAR COMPLEX OF THE FOOT – TSD130A Goniometer

Attach the telescopic endblock to the back of the heel.

Extend the ankle to the maximum extension anticipated during measurement, and attach the fixed endblock to the posterior of the leg, with the goniometer in Position 1 (maximum length, as shown on page 79) so that the axes of the leg endblock are coincident.

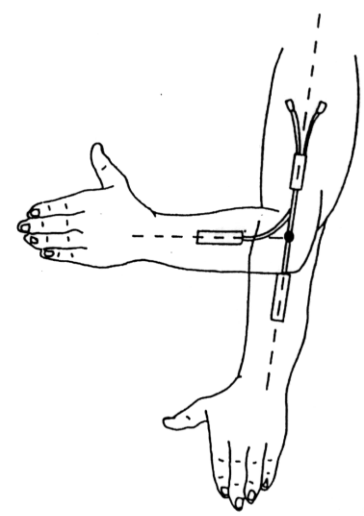
Flexion/extension of the ankle may now be monitored using the gray plug and pronation/supination using the blue marked plug.



THE ELBOW – TSD130B Goniometer

Attach the telescopic endblock to the forearm with the center axis of the endblock coincident with the center axis of the forearm. With the elbow fully extended, move the goniometer to Position 2 (maximum length, as shown on page 79) and attach the fixed endblocks to the upper arm, with the center of the endblock and the center axis of the upper arm coincident.

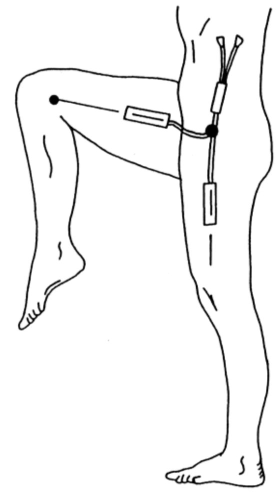
Now the elbow may be fully extended with the telescopic endblock freely sliding between Positions 1 and 2. Measurement of flexion/extension is obtained from the blue marked plug, and the gray plug is redundant. Note that the telescopic endblock is mounted on the half of the forearm nearest to the elbow joint. Movements of pronation and supination may be made and will affect the measurement of flexion/extension by a small amount.



THE HIP – TSD130B Goniometer

Attach the fixed endblock to the side of the trunk in the pelvic region. With the limb in the position of reference, extend the goniometer to Position 2 (maximum length, as shown on page 79) and attach the telescopic endblock to the thigh, so that axes of the thigh and endblock coincide (when viewed in the sagittal plane, as shown).

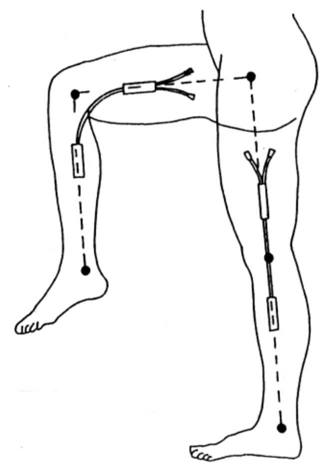
The thigh may now be flexed or extended, abducted or adducted, with the goniometer sliding freely between Positions 1 and 2. Measurements of flexion/extension are obtained from the blue marked, and abduction/adduction from the gray plug.



THE KNEE – TSD130B Goniometer

Mount the telescopic endblock laterally on the leg so the axes of the leg and endblock coincide, when viewed in the sagittal plane. With the leg fully extended in the position of reference, extend the goniometer to Position 2 (maximum length, as shown on page 79) and attach the fixed endblock to the thigh so the axes of the thigh and endblock coincide.

The knee may now be flexed or extended with the goniometer freely sliding between Positions 1 and 2. Measurements of flexion/extension may be monitored using the blue marked plug and varus/valgus may be monitored using the gray plug.



FOREARM PRONATION /SUPINATION –
TSD130C or **TSD130D** Torsiometer

Attach the two endblocks of the torsiometer to the forearm, with the slider mechanism approximately midway between the two extremes.

Measurements of pronation/supination may now be made from the gray plug. Movements of wrist flexion/extension or radial/ulnar deviation will not affect the output.

FINGERS AND TOES – TSD130E Goniometer

The TSD130E goniometer is a single axis goniometer intended for use on fingers and toes. Angles are measured by rotating one endblock relative to the other about axis X-X (as shown on page 79).

The goniometer is not designed to measure rotations about Y-Y. **Any attempt to bend the unit in this way more than +/-20° from the neutral position will result in reduced unit life or failure**. The goniometer does not measure rotations about the axis Z-Z.

The unit is designed to fit over the joint to be measured and has extremely high flexibility to ensure the instrument does not interfere with normal joint movement. One endblock is attached either side of the joint.

Unlike the TSD130A and TSD130B series and "Z" series sensors, an "oxbow" shape is permitted in the measuring element. This is not detrimental to the results and does not reduce life of sensor. Care should be taken, however, **that the minimum bend radius is not exceeded**.

The TSD160 series differential pressure transducers are designed for low range pressure monitoring. The transducers plug directly into the DA100C general-purpose differential amplifier. The differential pressure ports are located on the front of the transducers and are easily connected to breathing circuits, pneumotachs or plethysmograph boxes. These transducers are very useful for interfacing a variety of small animal pneumotachs or plethysmographs to the MP System. The transducers are extremely sensitive and come in three ranges to suit a number of different applications. RX137 heads connect to the TSD160A differential pressure transducer via standard 3mm or 4mm ID tubing.

TSD160 Series Specifications

Part	TSD160A	TSD160B	TSD160C	TSD160 d	TSD160E	TSD160F
Operational Pressure:	±2.5 cm H_2O	±12.5 cm H_2O	±25 cm H_2O	±75 cm H_2O	±350 cm H_2O	±1,000 cm H_2O
Overpressure (max):	±250 cm H_2O	±380 cm H_2O	±380 cm H_2O	±700 cm H_2O	±700 cm H_2O	±4,200 cm H_2O
Voltage Output (normalized to 1 volt excitation):	327.5 µV/cm H_2O	131 µV/cm H_2O	65.5 µV/cm H_2O	21.9 µV/cm H_2O	14.22 µV/cm H_2O	7.11 µV/cm H_2O

Warm-up Drift: ±50µV
Stability: ±100µV
Operating Temperature: 0°C to +50°C (compensated)
Storage Temperature: -40°C to +125°C
Combined Linearity and Hysteresis Error: ±0.05%
Dynamic Response: 100 Hz
Connection Ports: Accepts 3 mm to 4.5 mm ID tubing
Dimensions: 8.3 cm (high) x 3.8 cm (wide) x 3.2 cm (deep)
Weight: 76 g
Interface: DA100C

TSD160 Series Calibration

See DA100C Calibration options on page 55.

TSD250 VIBROMYOGRAPHY TRANSDUCER

The TSD250 is a sensitive microelectromechanical (MEMS) accelerometer for use with BIOPAC Vibromyography Systems that use advanced signal analysis algorithms to monitor muscle vibration.

Accelerometers are placed over the muscle belly and held in place using a strap (included) and record the small vibrations that occur when the muscle is activated. The technique allows researchers to study muscle performance and strength balance.

VMG provides extremely reproducible results. The single sensor solution and the lack of skin preparation improve the reliability and reproducibility of muscle effort recordings between muscles and across subjects. One major benefit of being able to compare readings between muscles and between subjects is the ability to perform muscle balance assessments.

Benefits

- Ability to perform muscle balance assessments
- Improved reproducibility between muscles and individuals
- Convenient setup
- Reduced setup time
- Improved subject comfort
- No electrodes
- No skin preparation

The VMG transducer (with Sonostics BPS-II sensor) integrates a low noise accelerometer with low and high pass filtering and pre-amplification. The transducer operates in differential mode in order to achieve superior noise reduction, delivering two channels of vibration data along a three meter cable to a converter unit which both converts the signal to single-ended mode and adapts the VMG signal appropriately for use with the BIOPAC research platforms.

VMG functionality is available through an optional license available with Acq*Knowledge* 4.1.1 or above. The VMG license must be authorized to access VMG functionality. To add a VMG license to an existing MP System, please contact BIOPAC. The VMG license:

- adds “Vibromyography” Calculation channel Preset with required scaling and calibration
- adds “Vibromyography Filter” option under the Analysis menu
- includes Quick*Start* Q45 Vibromyography (.gtl format)

Specifications

Sensor Operational Frequency Range: 20-360 Hz

Input range: ±2 Volts

Sensitivity: 30 V/g (MP150), 0.6 V/g (MP36R)

Noise Floor: 8 mV rms (MP150), 0.8 mV rms (MP36R)

Temperature range: -55C to +125C

Maximum Shock: 2000 g

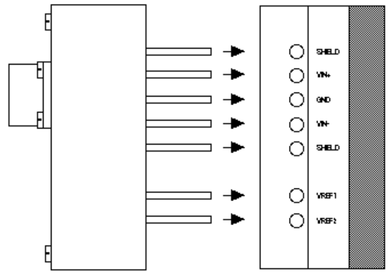
Voltage output: ±10 V (MP150), ±0.2 V (MP36R)

Type: Sonostics VMG BPS-II

Cable

Length: 3 meters

Termination: RJ-25 connector (MP150), 9-pin connector (MP36R)



TCI interface options ***TCI to DA100C Connection***

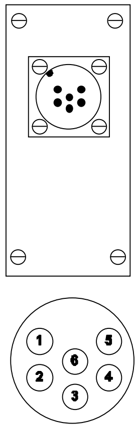
The transducer connector interfaces (TCIs) adapt a variety of transducer types to the DA100C module. The front of the TCI contains the appropriate connector while the rear has seven 2 mm pin jacks which plug directly into the DA100C.Probes and transducers normally used with Grass, Beckman, World Precision Instruments and Lafayette Instrument’s equipment can be used directly with the DA100C when used with the appropriate transducer connector interface.

The TCIs match the DA100C to the transducer brands listed below. If no existing connector matches the required equipment, BIOPAC will build a special TCI for users, or users can use the TCIKIT to build their own. Please call or write BIOPAC with specific needs.

TCI100	Grass/Astromed transducers – 6 pin
TCI101	Beckman transducers – 5 pin
TCI102	World Precision Instrument transducers – 8 pin
TCI103	Lafayette Instrument transducers – 9 pin
TCI104	Honeywell transducers – 6 pin
TCI105	Modular phone jack connector – 4 pin *(also used to interface NIBP100A and NIBP100D)*
TCI106	Beckman transducers – 12 pin
TCI107	Nihon Koden transducers – 5 pin
TCI108	Narco transducers – 7 pin
TCI109	Fukuda transducers – 8 pin
TCI110	Gould transducers – 12 pin: Discontinued → use Fogg Cable and an available BIOPAC TCI
TCI111	Liquid metal transducers – 2mm sockets (two)
TCI112	Hokanson transducers – 4 pin
TCI113	Hugo-Sachs/Harvard Apparatus – 6 pin
TCI114	BIOPAC SS Series Transducers – 9 pin
TCI115	Interface XLR Microphone
TCIPPG1	PPG100C amplifier to Geer Photo-electric (IR) plethysmogram transducer – 7 pin

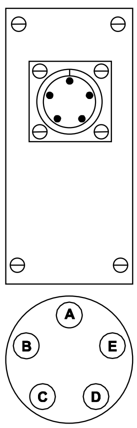
TCIKIT/C	Build a customized adapter to the DA100C — see page 97

TCI100 Grass transducer interface



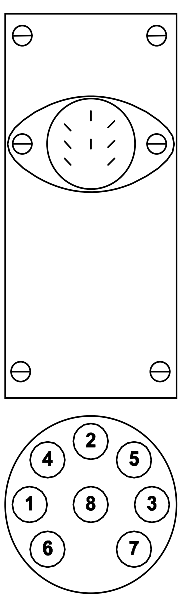
Pin	Signal
1	VREF2 (Set to -1V)
2 VIN-	
3 VIN+	
4	VREF1 (Set to +1V)
6 GND	
Connector ITT	Cannon WK-F-32S
Typical VREF	±1V

TCI101 Beckman transducer interface



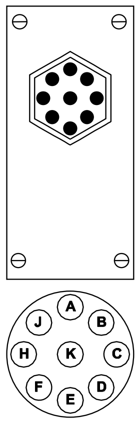
Pin	Signal
A VIN-	
B VIN+	
C	VREF1 (Set to +1V)
D	VREF2 (Set to -1V)
E GND	
Connector ITT	Cannon CA-3102-E-14S-5S
Typical VREF	±1V

TCI102 WPI transducer interface



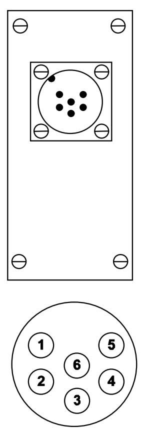
Pin	Signal
1	VREF1 (Set to +5V)
2 VIN+	
3 VIN-	
4	VREF2 (Set to -5V)
Connector	CUI Stack SDS-80J
Typical VREF	±5V

TCI103 Lafayette transducer interface



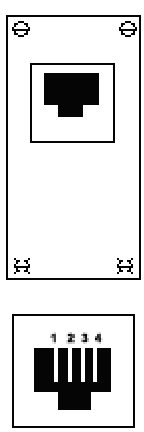
Pin	Signal
C	VREF2 (Set to -5 V)
E GROU	ND
H VIN+	
K	VREF1 (Set to +5 V)
Connector Am	phenol 12F-013
Typical VREF	± 5V

TCI104 Honeywell transducer interface



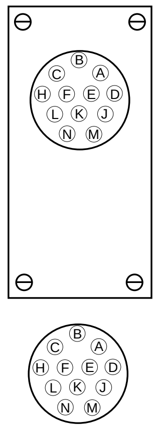
Pin	Signal
1	VREF2 (Set to -1 V)
2 VIN-	
3 VIN+	
4	VREF1 (Set to +1 V)
5 GND	
Connector ITT	Cannon WK-F-32S
Typical VREF	±1V

TCI105 Phone plug (RJ-11) transducer interface



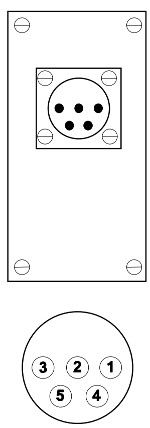
Pin	Signal
1	VREF1 (Set to +3 V)
2 VIN	+
3 VIN	–
4	VREF2 (Set to -3 V)
Connector RJ-11	Phone plug
Typical VREF	±2 V DC

TCI106 Beckman (12-pin) transducer interface



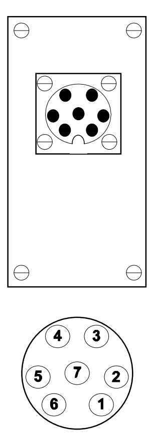
Pin	Signal
A VIN	+
B VIN	–
C	VREF2 (-1 V)
D	VREF1 (+1 V)
E Ground	
Connector Am	phenol 165-12
Typical VREF	±1 V

TCI107 Nihon Kohden transducer interface



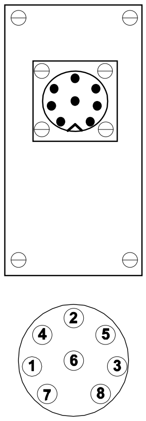
Pin	Signal
2 VIN+	
3	VREF1 (+1 V)
4	VREF2 (-1 V)
5 VIN	–
Connector JAE	SRC-02A13-5S
Typical VREF	±1 V

TCI108 Narco (7-pin) transducer interface



Pin	Signal
1 VIN+	
2 VIN	–
4 GND	
5	(connect 1,600-ohm resistor between pins 5 and 7)
6	VREF1 (+1 V)
7	VREF2 (-1 V)
Connector Am	phenol 703-91T-3478-009
Typical VREF	±1 V

TCI109 Fukuda transducer interface

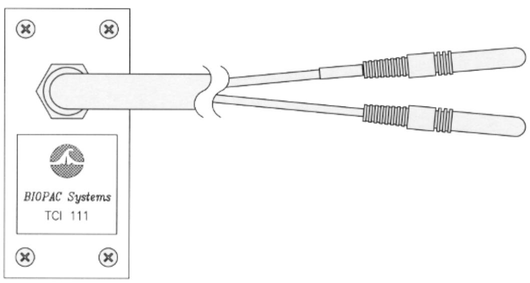


Pin	Signal
1 VIN+	
3 VIN-	
6 VREF2	(-1V)
7 VREF1	(+1V)
Connector Hirsh	mann MAS 8100
Typical VREF	±1 V

TCI110 Gould transducer interface

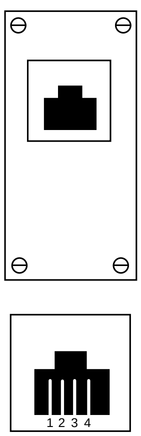
Discontinued – [see options online]

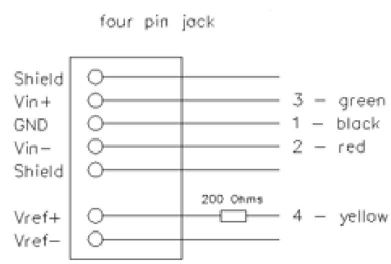
TCI111 Liquid metal transducer interface



Connector:	Signal
A (top)	XDCR
B (bottom)	XDCR
Connector Type:	2 mm socket (accepts 2mm pin XDCRs)

TCI112 Hokanson transducer interface

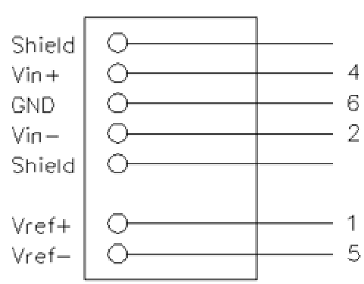


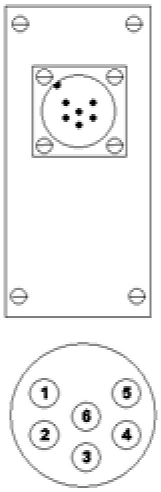


Pin	Signal
1 Iex	+
2 VIN	+
3 VIN	−
4 Iex	−
Connector RJ-11	Phone plug
Typical Iex:	5 mA

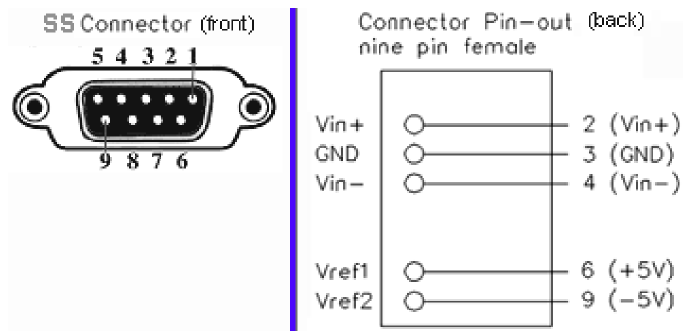
TCI113 Hugo Sachs/Harvard Apparatus Interface

Six-pin female:

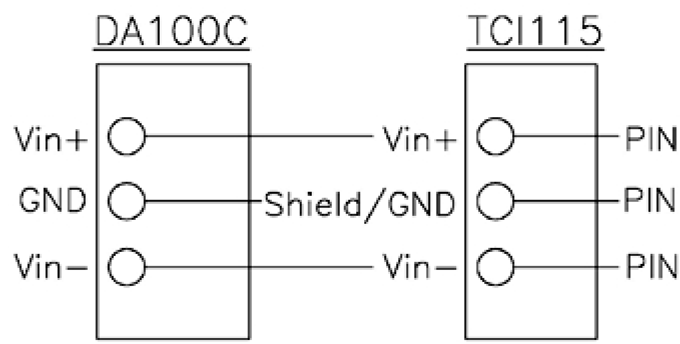




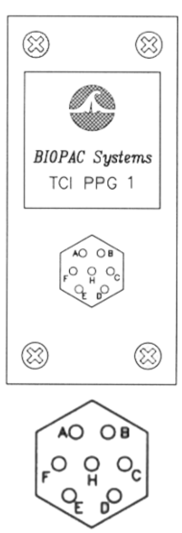
TCI114 BIOPAC SS Series Interface



TCI115 Inteface XLR Microphone

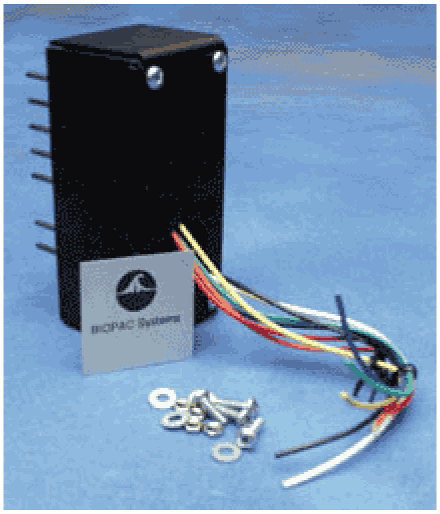


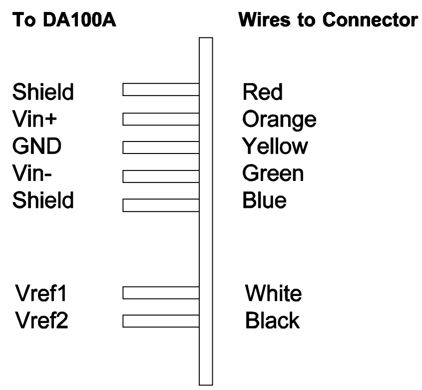
TCIPPG1 PPG—Geer transducer interface



Pin	**Signal**
A not	used
B not	used
C not	used
D Ground	
E VIN	+
F +5	Vex
G not	used
Connector Am	phenol 7-pin

TCIKIT AND TCIKITC CUSTOM INTERFACE KITS





Build custom transducer connector interfaces for DA100C amplifier modules.

- **TCIKIT** do-it-theself kit includes housing, PC board with 7 attached PIN plugs (2 mm) and instructions. The kit comes partially assembled. Mount a connector to the housing and solder wires to the pins.
- **TCIKITC** is used to connect non-BIOPAC electrodes and transducers directly to BIOPAC biopotential or transducer amplifer modules.

The TCI case has two connector holes on the front, 0.44” and 0.75” in diameter. These sizes should accommodate most connectors. The aluminum label is intended to cover up the unused hole. Color-coded wires have been soldered to each of the seven DA100C input pins. They are connected as shown above.

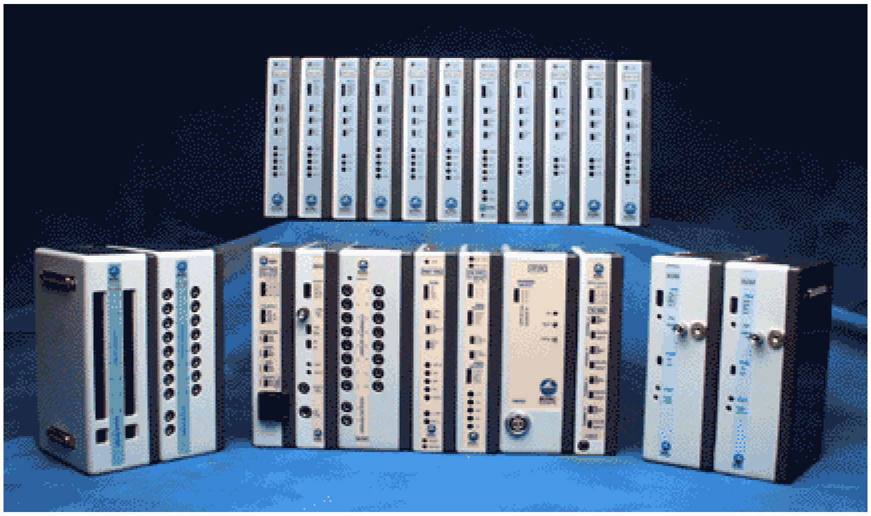
Adapting the TCI

The following instructions are for adapting the TCI for any particular connection. A “Bulkhead Mount” connector is the best type of connector to use.

1. Remove four screws from back of TCI so that the TCI PC board and case are separate.
2. Remove four connector-mounting screws from TCI case and set aside.
3. Check to see that the connector fits the TCI case. If not, the smaller (0.44”) hole can be enlarged using a hole enlarging drill bit.
4. Clip off unused wires from the TCI PC board. Be very careful not to clip the ones that will be used.
5. Note that most connectors must be mounted from the outside of the case. This means that the wires should first be routed through the appropriate hole, then soldered to the connector.
6. Solder the appropriate wires to the connector.

   CAUTION! When soldering wires or components on the TCI PC board, be very careful not to desolder the pre-aligned pin plugs—albeit might not be possible to get them straight if they are inadvertently desoldered.
7. Bolt the connector to the case using the supplied 4-40 screws and nuts.
8. Bolt the TCI PC board to the TCI case.
9. Cover unused hole with supplied label.

Chapter 4 Biopotential / Transducer Modules



100C series modules

The 100C series biopotential/transducer amplifier modules are single channel, differential input, linear amplifiers with adjustable offset and gain. These modules are used to amplify smaller voltage signals coming from raw electrodes and transducers (typically less than ±0.01 volt). In addition to amplifying signals, most of the 100C series modules include selectable signal conditioning ability so that data may be filtered or transformed as it is being collected.

- **Biopotential modules**: ECG100C, EEG100C, EGG100C, EMG100C, EOG100C, ERS100C (specifications start on page 98)
- **MRI Smart modules**—advanced signal processing circuitry removes spurious MRI artifact from the source physiological data: ECG100C-MRI; EDA100C-MRI; EEG100C-MRI; EMG100C-MRI; PPG100C-MRI.
- **Transducer modules**: GSR100C; PPG100C; RSP100C; SKT100C (specifications start on page 117)

Modules can be cascaded by snapping the modules together. Up to sixteen 100C series modules can be connected to the MP System at any one time.

IMPORTANT

When cascading modules, it is important to remember that **no two amplifiers may be set to the same channel**. If two connected amplifier modules are left on the same channel, then contention will result and both amplifier outputs will give erroneous readings.

Amplifier offset Set by the zero adjust control trim potentiometer near the top of the module. The offset control can be used to adjust the zero point or "baseline" of a signal.

Gain Switch The four-position slide Gain switch controls sensitivity. Lower gain settings will amplify the signal to a lesser extent than higher gain settings. If the signal plotted on the screen appears to be very small for a given channel, increase the Gain for that particular channel. Conversely, if the signal seems to be "cropped" at +10 Volts or –10 Volts, decrease the Gain.

Connections Transducers and electrodes connect to the amplifiers using Touchproof connectors.

Electrodes The biopotential amplifier modules use a three-electrode arrangement (VIN+, GND, VIN–). Although certain applications may require different arrangements of electrodes and/or transducers, some generalizations about electrode and transducer connections can be made. Electrodes measure the electrical activity at the surface of the skin, and since electricity flows from – to +, measuring the flow of a signal requires that there be (at least) one "-" electrode and (at least) one "+" electrode. An additional electrode, a "ground" (or earth) electrode is used to control for the general level of electrical activity in the body.

Leads Typically, electrode leads are used to connect individual electrodes to the *xxx*100C amplifier. Most electrode leads are shielded, which means they introduce less noise than an unshielded lead. A shielded electrode lead has an extra jack on one end that plugs into the SHIELD input on the amplifier modules. A standard electrode lead configuration consists of two LEAD110S electrode leads (one connected to the VIN + input and one to the VIN – input on the amplifier) and a single LEAD110 (connected to the GND input on a biopotential amplifier).

Transducers Transducers, on the other hand, are not designed to measure electrical activity directly and usually involve simpler connections. The transducers discussed in this manual translate physical changes (in temperature, for instance) into electrical signals. Connections for individual transducers are discussed in each section.

Channel The active channel is selected using the channel select switch on the top of the module. The channel select switch can direct the amplifier output to one of sixteen possible MP System input channels. *Remember to make sure that each amplifier module is set to a unique channel.*

Zero Adjust On input signals, a limited range in baseline level (DC offset) can be "zeroed out" using the zero adjust potentiometer. Typically, the zero adjust will not have to be used (as it is preset at the factory). However, some of the 100C series modules can measure DC signals and, in certain circumstances, signal "zeroing" may be required.

Setup All 100C Series biopotential or transducer amplifiers incorporate specific gain, coupling and filtering options that are appropriate for the biopotential type or transducer signal that requires measurement. Generally, when an electrode or transducer is inserted into the corresponding 100C series module, the amplifier will immediately produce a useful output, with no user adjustments necessary.

Certain functionality is added to each module to optimize its performance with its intended signal measurement. For example, all 100C series biopotential amplifiers incorporate a selectable interference filter. When the interference filter is on, 50/60 Hz interfering signals are suppressed.

Filters All 100C series amplifiers are constructed with filters that have a high degree of phase linearity. This means the 100C series modules will filter signals with as little distortion as possible. These modules also incorporate protection circuitry to limit input current in the event of input signal overload. Notch and bandstop filters have the potential to cause distortion, especially in the form of "ringing" in the data stream; biopotential hardware notch filters are implemented in conjunction with LP or HP functions to minimize distortion.

Line Freq Line Frequency is set using the recessed switch boxes on the back of the amplifier module (50 Hz = all switches down). All MP biopotential amplifier modules which contain a 50/60 Hz notch filter only engage the filter when the pass filter is also ON:

- ECG100C, EEG100C, EOG100C amplifiers: the 50/60 Hz notch is only engaged when the 35 Hz LPN low pass notch filter switch is set to ON.
- EMG100C, ERS100C amplifiers: the 50/60 HZ notch is only engaged when the 100 Hz HPN high pass notch filter switch is set to ON.

See individual module sections for details.

Biopotential Modules

Biopotential amplifier modules: ECG; EEG; EGG, EMG; EOG; ERS.

Amplifier Filtering

All MP System biopotential amplifier modules which contain a 50/60 Hz notch filter only engage the filter when the pass filter is also ON:

- ECG100C, EEG100C, EOG100C amplifiers: the 50/60 Hz notch is only engaged when the 35 Hz LPN low pass notch filter switch is set to ON.
- EMG100C and ERS100C (plus MCE100C) amplifiers: the 50/60 HZ notch is only engaged when the 100 Hz HPN high pass notch filter switch is set to ON.

When a biopotential amplifier is used in conjunction with an MP150 or MP100 System, users can set the Notch filter switch to OFF (creates a "full-band" filter for EEG, ECG, etc.) and then perform a bandstop or comb bandstop filter in Acq*Knowledge*. Comb bandstop is the preferred method for removing power line interference, because the power line always includes harmonics. For 60 Hz power, harmonics are at 60, 120, 180, 240, 300, etc Hz. A comb bandstop removes all of these interferences.

Notch and bandstop filters have the potential to cause distortion, especially in the form of "ringing" in the data stream; biopotential hardware notch filters are implemented in conjunction with LP or HP functions to minimize distortion.

For example:

- If an ECG100C amplifier is set to full band and then a notch filter is used in AcqKnowledge, the ECG waveform will be distorted by the appearance of ringing on the falling edge of the R-wave.
- If an EEG100C amplifier is set to full band
  - for a non-transient biopotential recording (such as long-term EEG), the notch filter will remove the interfering frequencies but also remove EEG data in that region.
  - for transient recordings (such as P300), the notch filter will cause a distortion in the resulting data.

If the BIOPAC biopotential amplifier will be used without an MP system, contact BIOPAC to discuss potential harmonic interference problems and solutions.

ECG100C – ELECTROCARDIOGRAM AMPLIFIER MODULE

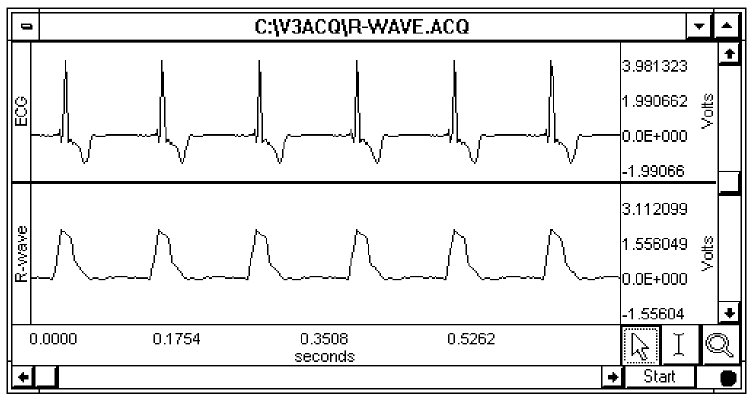
The electrocardiogram amplifier module (ECG100C) is a single channel, high gain, differential input, biopotential amplifier designed specifically for monitoring the heart's electrical activity, and for use in the following applications:

- Conventional electrocardiogram (12-lead ECG)
- Einthoven's triangle potential measurement (3-lead ECG)
- Transverse-plane ECG measurement (V1 through V6)
- Vectorcardiogram measurement
- Chaos investigations (heart rate variability)
- Heart arrhythmia analysis
- Exercise physiology studies

The ECG100C will connect directly to any of BIOPAC Systems, Inc.'s series of Ag-AgCl lead electrodes. The best choice for electrodes depends on the application, but typically the EL500 series (i.e., EL501, EL502, EL503) of adhesive/disposable snap electrodes are used in conjunction with the LEAD110/LEAD110S pinch lead. If reusable electrodes are required, the EL258 is typically used; when using EL258 electrodes, adhesive disks (ADD208) and electrode gel (GEL100) are also needed. Use two shielded electrodes (EL208S) for the signal inputs and one unshielded electrode (EL258S) for the ground.

The ECG100C has built in drive capability for use with shielded electrode leads. If high bandwidth (resolution) ECG measurements are required, then shielded electrode leads are recommended. When the interference filter is switched on, shielded leads are typically not necessary. The ECG100C is designed to pass the ECG signal (P, Q, R, S, T waves) with minimal distortion.

R-wave detector function



The ECG100C has an additional R-wave detector function. When enabled, the output signal will produce a smoothed positive peak every time the R-wave is detected.

This graph illustrates ECG data recorded with the ECG100C. The top waveform is a raw ECG wave, and the bottom waveform is the same signal processed using the R-wave detector in the ECG100C module.

This function is extremely useful for rate calculations when a well-defined peak is desired. Enabling the R-wave detector is useful for calculating BPM and IBI, as it tends to remove any components of the waveform that might be mistaken for peaks.

The R-wave detector circuitry consists of:

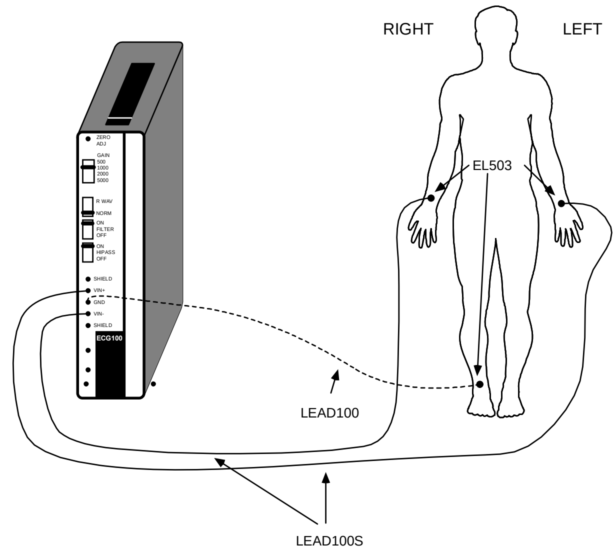
- 17Hz band pass filter with Q = 5
- Full wave rectifier
- 10.0 Hz, three pole, low pass filter with Q = 0.707

These settings are optimized for ECG data sampled at 250 Hz or faster. For data sampled at less than 250 Hz, the low pass filter might be set to 5 Hz.

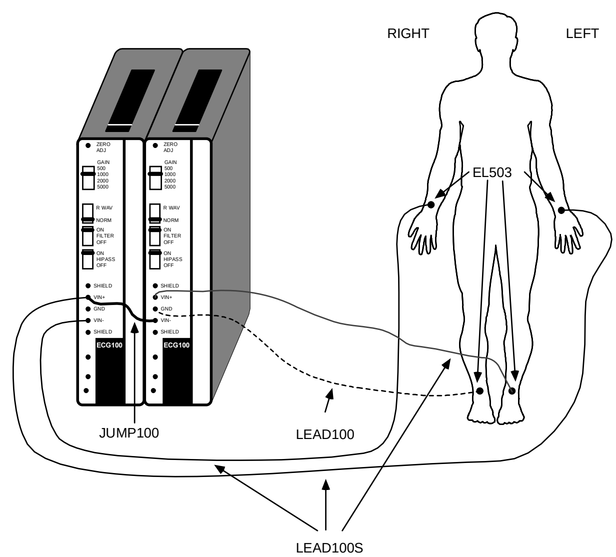
Recording a 12-lead ECG

- For full, simultaneous, 12-lead ECG recording, eight ECG100C amplifiers are required, along with a WT100C Wilson Terminal (see page 103). Two of the ECG100C are used to simultaneous record Leads I, II, III, aVR, aVL and aVF, while the remaining six ECG100C are used to generate the six precordial leads.
- To perform a standard 12-lead ECG recording using only three ECG100C amplifiers, use the TSD155C (page 103). The TSD155C multi-lead ECG cable is 3 meters long and incorporates a built-in Wilson Terminal for simultaneous recording of Leads I, II, III, aVR, aVL, aVF and one (movable) precordial lead [V1, V2, V3, V4, V5 or V6].

This figure shows the electrode connections to the ECG100C for the measurement of **Lead I**. Signals from this electrode montage can be used to calculate BPM (or IBI) and general-purpose ECG applications.



This figure shows the electrode connections to two ECG100C modules for recording a standard **two lead ECG** (Lead I and Lead III). Although only two channels are directly acquired, Lead II can be computed (either on-line or after the fact) by summing Lead I and Lead III. For this setup, the GND input on Lead I is internally connected to the GND input on Lead III, and the VIN+ on Lead I is connected to the VIN- on Lead III via a JUMP100C jumper lead.



Frequency Response Characteristics

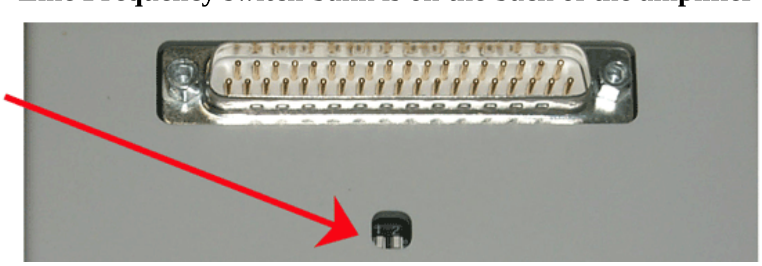
The ECG100C includes a high pass filter that is used to stabilize the ECG baseline. When the **HP** switch is set to 0.5 Hz, P and T wave amplitudes will be reduced somewhat, but the QRS wave will be virtually unchanged. The HP switch is usually ON when using the ECG100C for rate measurements only or when monitoring the ECG of an active subject.

The 0.05 Hz and 0.5 Hz lower frequency response high pass filter settings are single pole roll-off filters.

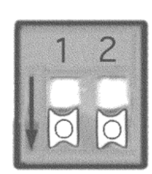
Modules can be set for 50 Hz or 60 Hz notch options to match the wall-power line frequency of the destination country. The proper setting reduces noise from interfering signals when the notch filter is engaged. Generally, wall-power line frequency is 60 Hz in the United States and 50 Hz in most of Europe; if necessary, contact BIOPAC to determine the correct line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

The 50/60 Hz notch is only engaged when the 35 Hz LPN filter switch on the ECG100C amplifer is set to ON.

Line Frequency switch bank is on the back of the amplifier

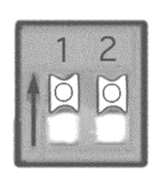


50 Hz



Both switches DOWN

60 Hz



Both switches UP

See the sample frequency response plots beginning on page 287: 35 Hz LPN option (with 50 Hz notch enabled), 150 Hz LP option, and 35 Hz LPN option (with 60 Hz notch enabled)

ECG100C Calibration

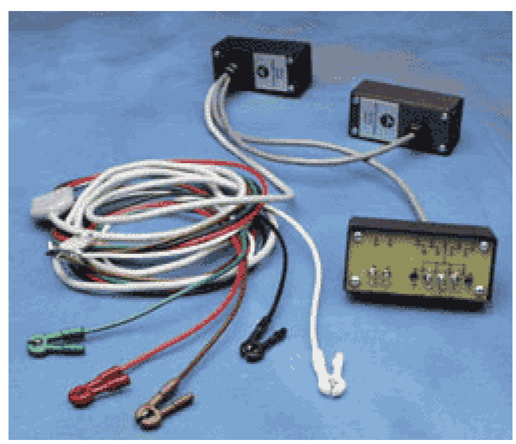
The ECG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

ECG100C Specifications

Gain:	500, 1000, 2000, 5000	
Output Selection:	Normal, R-wave indicator	
Output Range:	±10 V (analog)	
Frequency Response	Maximum bandwidth (.05 Hz – 150 Hz)	
	Low Pass Filter:	35 Hz, 150 Hz
	High Pass Filter:	0.05 Hz, 1.0 Hz
Notch Filter:	50 dB rejection @ 50 Hz or 60 Hz	
Noise Voltage:	0.1 µV rms – (0.05-35 Hz)	
Signal Source:	Electrodes (three electrode leads required)	
Z (input)	Differential:	2MΩ
	Common mode:	1000MΩ
CMRR:	110 dB min (50/60 Hz); see Shield Drive Operation on page 287	
CMIV–referenced to	Amplifier ground:	±10 V
	Mains ground:	±1500 VDC
Input Voltage Range:	Gain Vin (mV)	
500	±20	
1000	±10	
2000	±5	
5000	±2	
Weight: 350	grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

See also: JUMP100C and MEC series

TSD155C Multi-lead ECG Cable



To record 12-lead ECG with a movable chest lead, use the TSD155C The TSD155C multi-lead ECG cable is 3 meters long and incorporates a built-in Wilson Terminal for simultaneous recording of Leads I, II, III, aVR, aVL, aVF and one (movable) precordial lead [V1, V2, V3, V4, V5 or V6].

The TSD155C is used for performing a standard 12-lead ECG recording using only 3 ECG100C amplifiers.

TEL100 Compatibility: SS29, page 270

WT100C Wilson Terminal for the ECG100C

The WT100C is used to create a virtual reference electrode when measuring the transverse plane (i.e., precordial) ECG components [V1, V2, V3, V4, V5, and V6]. The virtual reference is created by the summation of the Right Arm (RA), Left Arm (LA) and Left Leg (LL) electrode leads. To measure all six transverse plane components, six ECG100C amplifiers are required. Use five of the JUMP100C jumper connectors to tie together the reference (Vin-) inputs of these amplifiers. This common reference connects to the virtual reference created by the WT100C.

EEG100C – ELECTROENCEPHALOGRAM AMPLIFIER MODULE

The electroencephalogram amplifier module (EEG100C) is a single-channel, high-gain, differential input, biopotential amplifier designed specifically for monitoring the neuronal activity of the brain. The EEG100C is designed for use in the following applications:

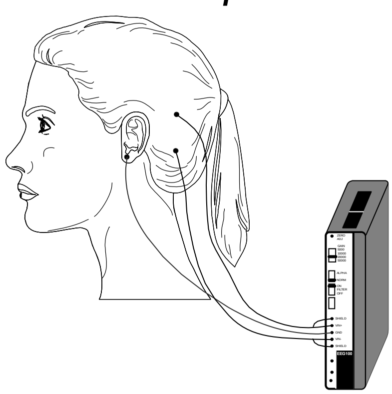
Conventional EEG (16 channel, unipolar or bipolar)	Sleep studies
Epilepsy investigations	Evoked responses
Tumor pathology studies	Cognition studies

The EEG100C will connect directly to any of BIOPAC Systems, Inc.'s series of Ag-AgCl lead electrodes. Typically, EL503 electrodes are recommended for evoked response measurements. Use two shielded electrodes (LEAD110S) for the signal inputs and one unshielded electrode (LEAD110) for ground. If hair is present, disposable electrodes don't work very well for scalp attachment—add electrode gel (GEL100) and tape the electrode lightly in place or use a conductive adhesive paste (like Ten20® or Collodion HV®).

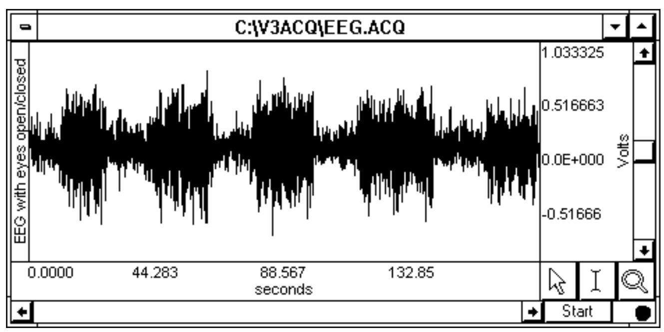
The EEG100C has built-in drive capability for use with shielded electrode leads. If high bandwidth (resolution) EEG measurements are required, then shielded electrode leads are recommended. When the interference filter is switched on, shielded leads are typically not necessary.

This module is designed to pass the EEG signal ranges (Delta, Theta, Alpha, Beta, and Gamma) with minimal distortion. In addition, the EEG100C has a built-in Alpha wave detector. When enabled, the output signal will produce a smoothed wave with peaks that indicate points of maximum Alpha activity. The Alpha wave detector consists of a highly selective, six pole, 8-13Hz bandpass filter, followed by a full wave rectifier, followed by a 6Hz, three pole, low pass filter.

Bipolar EEG electrode placement



Bipolar connection to the occipital lobe



EEG waveform with eyes closed then opened

The illustration above shows a bipolar connection to the occipital lobe; to make a unipolar connection, relocate the VIN- electrode to the earlobe (where GND is attached). The graph indicates the change in the occipital EEG when eyes are closed and opened. The data is shown compressed, but can easily be expanded to show waveform differences in greater detail.

Frequency Response Characteristics

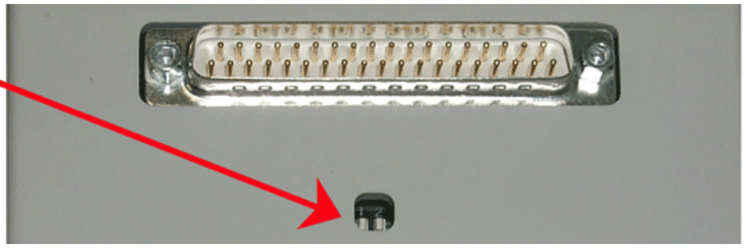
The 0.1Hz high pass and 1Hz high pass lower frequency response settings are single pole, roll-off filters.

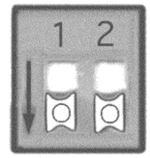
Modules can be set for 50 Hz or 60 Hz notch options to match the wall-power line frequency of the destination country. The proper setting reduces noise from interfering signals when the notch filter is engaged. Generally, wall-power line frequency is 60 Hz in the United States and 50 Hz in most of Europe; if necessary, contact BIOPAC to determine the appropriate line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module (as shown on the next page).

The 50/60 Hz notch is only engaged when the 35 Hz LPN filter switch on the EEG100C amplifer is set to ON.

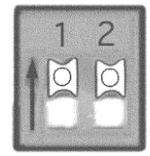
See the Frequency response Plots beginning on page 287: 35 Hz LPN (with 50 Hz notch enabled)
35 Hz LPN (with 60 Hz notch)
100 Hz LP option

Line Frequency switch bank is on the back of the amplifier **50 Hz** **60 Hz**





Both switches DOWN



Both switches UP

EEG100C Calibration

The EEG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

Hardware settings are based on line frequency, which varies by country. To confirm that line frequency is set correctly for the country, check the switches on the back panel of the amplifier.

EEG100C Specifications

Gain:	5000, 10000, 20000, 50000
Output Selection:	Normal, Alpha Wave indicator
Output Range:	±10 V (analog)
Frequency Response	Maximum bandwidth (0.1 Hz – 100 Hz)
Low Pass Filter:	35 Hz, 100 Hz
High Pass Filter:	0.1Hz, 1.0 Hz
Notch Filter:	50 dB rejection @ 50 Hz or 60 Hz
Noise Voltage:	0.1µV rms – (0.1–35 Hz)
Signal Source:	Electrodes (three electrode leads required)
Z (input)	Differential: 2MΩ Co mmon mode: 1000MΩ
CMRR:	110 dB min (50/60 Hz); see Shield Drive Operation on page 287
CMIV—referenced to	Amplifier ground: ±10 V Mains ground: ±1500 VDC

Input Voltage Range:

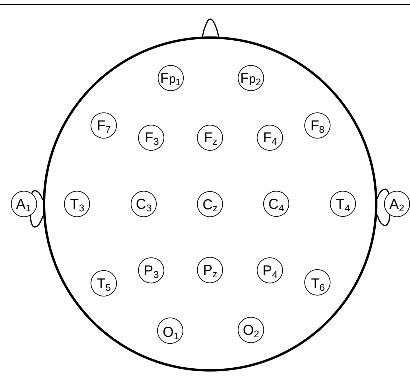
Gain	Vin (mV)	Gain	Vin (mV)
5000	±2	20000	±0.5
1000 0	±1	50000	±0.2

Weight: 350	grams
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)

See also: JUMP100C and MEC series

CAP100C Electrode Cap

Electrode cap (CAP100C)

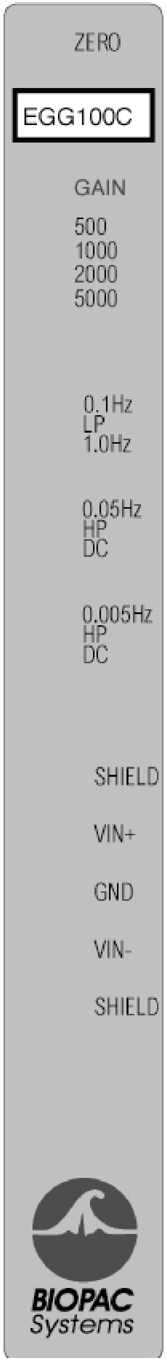


International 10-20 electrode montag

The CAP100C is a fabric cap with recessed tin electrodes attached to the Lycra-type fabric. The electrodes are pre-positioned in the International 10-20 montage (shown above). The standard (medium) electrode cap fits most subjects over age five; infant, small, and large caps are also available.

Leads from the electrode cap terminate in 2-mm pin plugs, which are typically connected to inputs on the **EEG100C**.

Since leads are available for all electrodes, unipolar or bipolar montage recordings can be obtained. The electrode cap comes with two ground electrodes, and can also be used for evoked potential investigations (such as ABR).



The EGG100C amplifies the electrical signal resulting from stomach and intestinal smooth muscle activity. The amplifier monitors the DC potential on the skin surrounding, or surface of, the intestine and stomach, which is indicative of the degree of slow wave contraction. The amplifier permits DC coupling to electrodes for signal amplification and presentation without discernible decay. The EGG100C also has built-in drive capability for use with shielded electrode leads.

The gastric slow wave (ECA) originates in the proximal stomach and propagates distally towards the pylorus. For recording, place multiple surface electrodes on the abdomen along the gastric axis and connect them to respective EGG100C amplifiers that have a common reference electrode placed near the xiphoid process. For consistent electrode-to-electrode spacing, use the EL500 dual electrodes with LEAD110 leads. For extremely tight electrode-to-electrode spacing, use the EL254 or EL258 reusable Ag-AgCl lead electrodes. The signals amplified at each electrode will be displayed on consecutive channels in Acq*Knowledge*.

Frequency Response Characteristics

Modules can be set for 50 or 60 Hz notch options, depending on the destination country.

The 0.005 Hz high pass lower frequency response setting is a single pole, roll-off filter.

See the Frequency Response Plots beginning on page 287: .05 Hz HP, 0.1 Hz LP, 1 Hz LP.

EGG100C Calibration

The EGG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

EGG100C Specifications

Gain & Input Voltage:	Gain Vin	(mV)
500		±20
1000		±10
2000		±5
	5000	±2
Output Range:	±10 V (analog)	
Frequency Response	Maximum bandwidth (DC – 1 Hz)	
Low Pass Filter:	0.1Hz, 1Hz	
High Pass Filter:	DC, 0.005 Hz, 0.05 Hz	
Notch Filter:	50 dB rejection @ 50 Hz or 60 Hz	
Noise Voltage:	0.1µV rms – (0.005-1.0 Hz)	
Signal Source:	Electrodes (three electrode leads required)	
Z (input)		
Differential:	2MΩ	
Co mmon mode:	1000MΩ	
CMRR:	110 dB min (50/60 Hz); see Shield Drive Operation on page 287	
CMIV—referenced to		
Amplifier ground:	±10 V	
Mains ground:	±1500 VDC	
Weight: 350	grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

EMG100C – ELECTROMYOGRAM AMPLIFIER MODULE

The electromyogram amplifier module (EMG100C) is a single-channel, high-gain, differential input, biopotential amplifier designed specificallyfor monitoring muscle and nerve response activity.

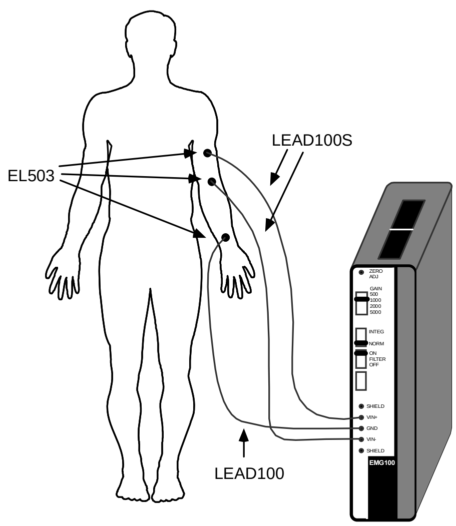
The EMG100C is designed for use in the following applications:

- Conventional bipolar EMG measurement
- Biomechanics
- Nerve conduction measurement
- Muscular reflex studies
- Motor unit potential measurement

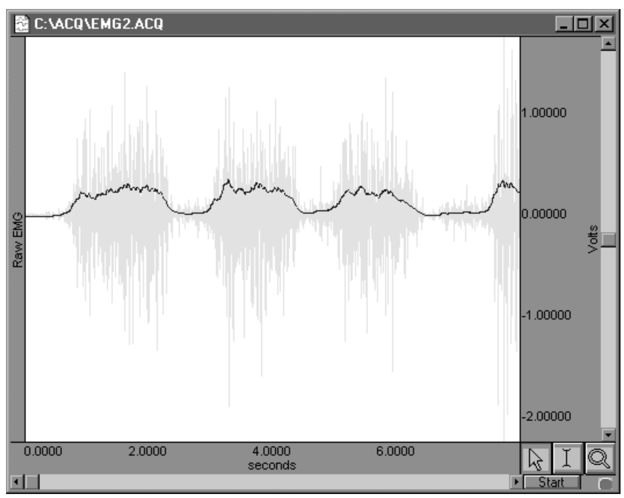
The EMG100C will connect directly to any of BIOPAC Systems, Inc.'s series of Ag-AgCl lead electrodes. The best choice for electrodes depends on the application, but typically, the EL503 adhesive/disposable snap electrodes are used in conjunction with the LEAD110S pinch lead. If reusable electrodes are required, the EL508S is typically used; when using EL508S electrodes, adhesive disks (ADD208) and electrode gel (GEL100) are also required. Use two shielded electrodes (LEAD110S/EL503 or EL508S) for the signal inputs and one unshielded electrode (LEAD110/EL503 or EL508) for ground.

The EMG100C has built-in drive capability for use with shielded electrode leads. Shielded leads are typically required, as the EMG100C has a frequency response that extends through the 50/60 Hz interference bands. The EMG100C is designed to pass EMG signals and signals associated with nerve responses.

The EMG100C incorporates a variety of filtering options to optimize the amplifier performance when recording from either surface or needle electrodes, and when recording from either muscle or nerves. For instance, when recording EMG (muscle) from surface electrodes, the 10 Hz to 500 Hz bandwidth setting could be used, but when recording nerve propagation times, the 100 Hz to 5,000 Hz bandwidth setting could be used.



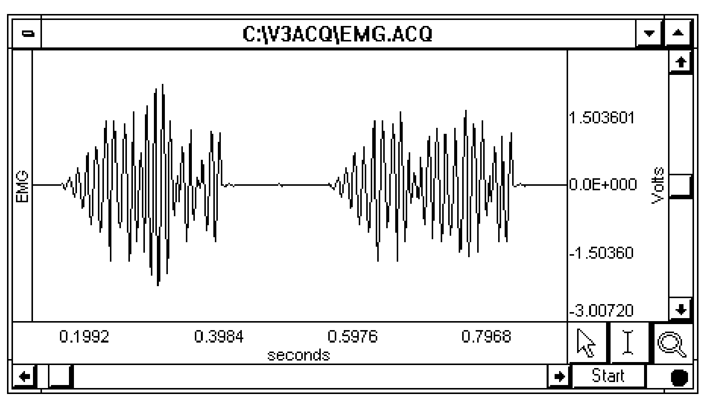
Electrode connections to the EMG1EMG100C to measure EMG activity from the arm biceps



This graph shows a typical raw EMG recording. Waveform peaks indicate points of peak muscle activity.

This graph shows raw EMG and integrated EMG.

To integrate EMG in real-time, set up a calculation channel in AcqKnowledge using the Integrate function with Rectify checked ON. In this case, this waveform would be augmented by a smoothed curve following the positive envelope of the EMG signal.



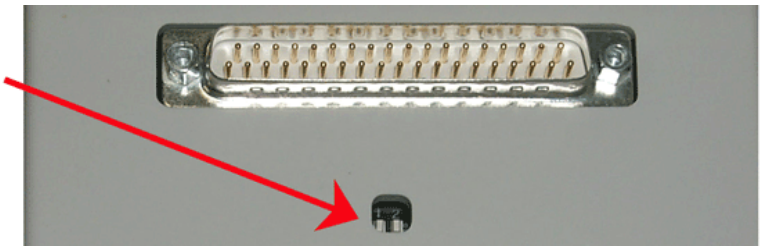
Frequency Response Characteristics

The 1 Hz high pass and 10 Hz high pass lower frequency response settings are single pole roll-off filters.

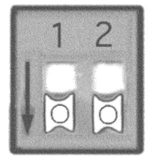
Modules can be set for 50 Hz or 60 Hz notch options to match the wall-power line frequency of the destination country. The proper setting reduces noise from interfering signals when the notch filter is engaged. Generally, wall-power line frequency is 60 Hz in the United States and 50 Hz in most of Europe; if necessary, contact BIOPAC to determine the appropriate line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

The 50/60 Hz notch is only engaged when the 100 Hz HPN filter switch on the EMG100C amplifer is set to ON.

Line Frequency switch bank is on the back of the amplifier

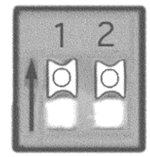


50 Hz



Both switches DOWN

60 Hz



Both switches UP

See the sample frequency response plots beginning on page 287:

- 100 Hz HPN option (with 50 Hz notch enabled)
- 100 Hz HPN option (with 60 Hz notch enabled)
- 500 Hz LP option
- 5000 Hz LP

EMG100C Calibration

The EMG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCAL.

EMG100C Specifications

Gain:	500, 1000, 2000, 5000
Output Range:	±10 V (analog)
Frequency Response	Maximum bandwidth (1.0 Hz – 5,000 Hz)
Low Pass Filter:	500 Hz, 5000 Hz
High Pass Filter:	1.0 Hz, 10 Hz, 100 Hz
Notch Filter:	50 dB rejection @ 50 Hz or 60 Hz
Noise Voltage:	0.2µV rms – (10-500 Hz)
Signal Source:	Electrodes (three electrode leads required)
Z (input)	
Differential:	2MΩ
Co mmon mode:	1000MΩ
CMRR:	110 dB min (50/60 Hz); see Shield Drive Operation on page 287
CMIV–referenced to	
Amplifier ground:	±10 V
Mains ground:	± 1500 VDC
Input Voltage Range	Gain Vin (mV)
500	±20
1000	±10
2000	±5
5000	±2
Weight: 350	grams
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)

See also: JUMP100C

MEC series

EOG100C – ELECTROOCULOGRAM AMPLIFIER MODULE

The electrooculogram amplifier module (EOG100C) is a single-channel, high-gain, differential input, biopotential amplifier designed for tracking eye movement. The EOG100C is designed for use in the following applications:

Sleep studies   Nystagmus testing Vertigo   investigations

Eye motion and tracking   REM activity analysis   Vestibular function studies

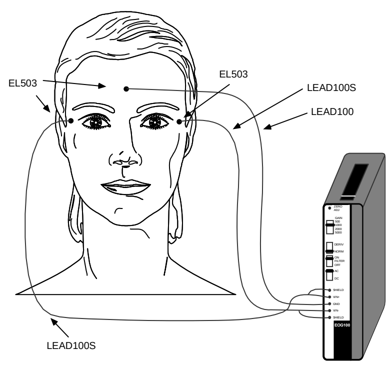
The EOG100C senses the corneal-retinal potential inherent in the eyeball. As the eyes move in the horizontal and vertical planes, these potentials are superimposed to generate a DC voltage variation in the region immediately surrounding the eye sockets.

The EOG100C will connect directly to any of BIOPAC's Ag-AgCl series lead electrodes. For most EOG applications, EL503 electrodes are used. Use two shielded electrode leads (LEAD110S) for the signal inputs and one unshielded electrode lead (LEAD110) for ground.

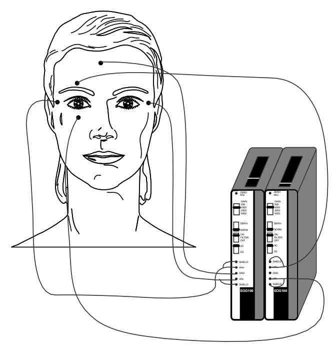
The EOG100C has built-in drive capability for use with shielded electrode leads. If high bandwidth (resolution) EOG measurements are required, then shielded electrode leads are recommended. When the interference filter is switched on, shielded leads are typically not necessary. The EOG100C is designed to pass the EOG signal to accommodate a large velocity range with minimal distortion.

This module includes an HP selection switch, which permits either absolute (DC) or relative (AC: 0.05 Hz HP) eye motion measurements. When performing absolute eye motion measurement, the eye position signal will still decay, but the time constant will be significantly longer than when performing relative eye motion measurement.

The EOG100C also has an EOG derivative function. When enabled, the output signal will produce a wave that will be directly proportional to the velocity of eye movement. Eye velocity measurement is useful for performing Nystagmus testing. The derivative function is obtained through the use of a specially designed bandpass filter (center frequency of 30 Hz, Q=0.8).



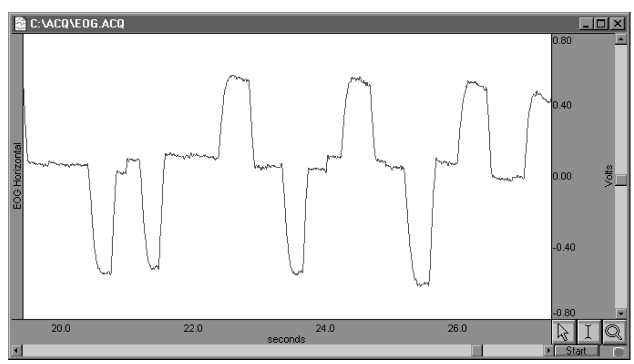
Setup to record horizontal eye movement



Setup for two EOG100C modules to record vertical and horizontal eye movement

To increase accuracy, use electrodes above and below each eye and parallel them with JUMP100C Jumper leads when connecting to the vertical track EOG100C module.

This graph shows a horizontal eye movement recording. The positive peaks indicate eyes looking left. The negative peaks indicate eyes looking right. The derivative of this waveform would indicate the speed of eye motion during this time.



Typical EOG signal

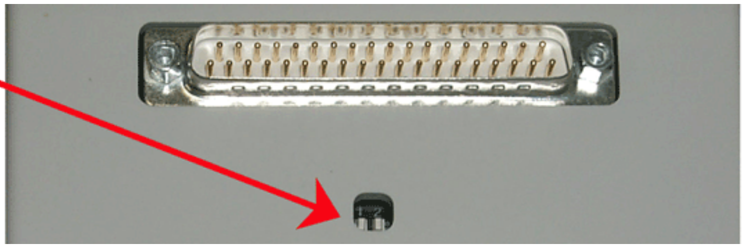
Frequency Response Characteristics

The 0.05 Hz high pass lower frequency response setting is a single pole roll-off filter.

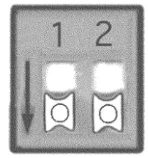
Modules can be set for 50 Hz or 60 Hz notch options to match the wall-power line frequency of the destination country. The proper setting reduces noise from interfering signals when the notch filter is engaged. Generally, wall-power line frequency is 60 Hz in the United States and 50 Hz in most of Europe; if necessary, contact BIOPAC to determine the appropriate line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

The 50/60 Hz notch is only engaged when the 35 Hz LPN filter switch on the EOG100C amplifer is set to ON.

Line Frequency switch bank is on the back of the amplifier

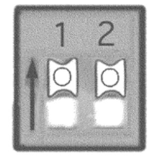


50 Hz



Both switches
DOWN

60 Hz



Both switches
UP

See the sample frequency response plots beginning on page 287:

35 Hz LPN (with 50 Hz notch) 100 Hz LP

35 Hz LPN (with 60 Hz notch)

EOG100C Calibration

The EOG100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

EOG100C Specifications

Gain:	500, 1000, 2000, 5000	
Output Selection:	Normal, Derivative output	
Output Range:	±10 V (analog)	
Frequency Response	Maximum bandwidth (DC – 100 Hz)	
Low Pass Filter:	35 Hz, 100 Hz	
High Pass Filter:	DC, 0.05 Hz	
Notch Filter:	50 dB rejection @ 50/60 Hz	
Noise Voltage:	0.1µV rms – (0.05-35 Hz)	
Signal Source:	Electrodes (three electrode leads required)	
Z (input)		
Differential:	2MΩ	
Co mmon mode:	1000MΩ	
CMRR:	110 dB min (50/60 Hz); see Shield Drive Operation on page 287	
CMIV–referenced to		
Amplifier ground:	±10 V	
Mains ground:	±1500 VDC	
Input Voltage Range	Gain Vin	(mV)
500		±20
1000		±10
2000		±5
	5000	±2
Weight: 350	grams	
Dimensions (WxDxH):	4 cm x 11 cm x 19 cm	

See also: JUMP100C and MEC series

ERS100C – Evoked Response Amplifier Module

The evoked response amplifier module (ERS100C) is a single channel, high gain, extremely low noise, differential input, biopotential amplifier designed to accurately amplify the very small potentials (< 200 nV) associated with evoked response measurement. The ERS100C is designed for use in the following applications:

Auditory brainstem response (ABR) testing	Visual evoked response testing
Nerve conduction velocity and latency recording	Somatosensory response testing

The ERS100C will connect directly to any of BIOPAC Systems, Inc.'s Ag-AgCl series of lead electrodes. Typically, the EL503 electrodes are recommended for evoked response measurements. Use two shielded electrodes (LEAD110S) for the signal inputs and one unshielded electrode (LEAD110) for the ground. If hair is present, disposable electrodes don't work very well for scalp attachment—use electrode gel (GEL100) and tape the electrode lightly in place or use a conductive adhesive paste (like Ten20® or Collodion HV®).

The ERS100C has built-in drive capability for use with shielded electrode leads. Shielded leads are typically required, as the ERS100C has a frequency response that extends through the 50/60 Hz interference bands. Furthermore, the ERS100C is used to amplify extremely low level signals that can be easily corrupted by interfering signals.

The ERS100C incorporates selectable gain and bandwidth options to perform a variety of evoked response testing. The ERS100C is typically used with two shielded electrodes for signal input and one unshielded electrode for ground. In nearly all cases of stimulus response testing, the ERS100C will be used in conjunction with the STM100C and the MP System.

- The STM100C is a general-purpose stimulator that can be used to present auditory, visual or mechanical stimulus signals.

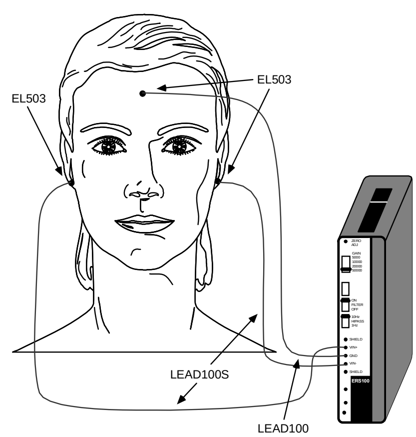
For most types of evoked response testing, the MP System will be operating in averaging mode. Typically, the stimulus output (usually a pulse) will be output through one of the analog channels (Out 0 or Out 1) or I/0 15 just prior to the data collection pass. Stimuli output on analog channels typically consists of pulses or tones, and stimulus output waveforms can easily be created and modified using the stimulator setup window, described in the Acq*Knowledge* Software Guide.

Auditory evoked potentials

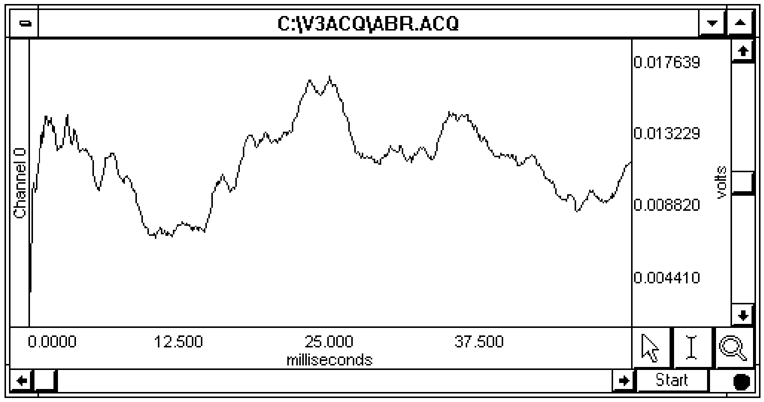
The ERS100C can record auditory evoked potentials, like the ABR. Use the STM100C to present an auditory pulse or "click" to the auditory stimulator, such as the ER-3A Tubephone. Present the acoustical signal to the active ear using a calibrated auditory earphone like the OUT101 Tubephone.

To record the ABR:

1) Place the active (VIN+) electrode at the earlobe or mastoid.
2) Place the reference (VIN-) electrode at the vertex.
3) Place the ground electrode at the forehead.



The MP System collected the data in the "Averaging" mode.



2000 trial ABR test performed using the ERS100C with the STM100C and OUT101 (Tubephone)

Somatosensory response
Somatosensory tests are used to characterize the perception of touch. Active electrodes are usually placed on an earlobe, and passive electrodes are placed on the contralateral earlobe. The ground electrode is placed on the forehead. In somatosensory response tests, the stimulation source is usually an electrical pulse or mechanical impulse applied at some point along the leg or arm.

General nerve conduction velocity
The ERS100C can also be used for general nerve conduction velocity tests, and will perform exceptionally well since the ultra low noise characteristics of the ERS100C are not required to obtain the best results and these tests don't require the extensive averaging required for auditory or visual evoked response measurements.

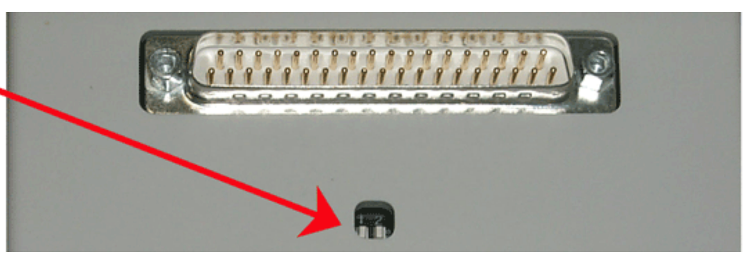
Frequency Response Characteristics

The 1 Hz high pass or 20 Hz high pass lower frequency response settings are single pole roll-off filters.

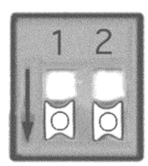
Modules can be set for 50 Hz or 60 Hz notch options to match the wall-power line frequency of the destination country. The proper setting reduces noise from interfering signals when the notch filter is engaged. Generally, wall-power line frequency is 60 Hz in the United States and 50 Hz in most of Europe; if necessary, contact BIOPAC to determine the appropriate line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

The 50/60 Hz notch is only engaged when the 100 Hz HPN filter switch on the ERS100C amplifer is set to ON.

Line Frequency switch bank is on the back of the amplifier

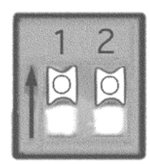


50 Hz



Both switches DOWN

60 Hz



Both switches UP

See the sample frequency response plots beginning on page 287: 100 Hz HPN (with 50 Hz notch)
100 Hz HPN (with 60 Hz notch)
3,000 Hz LP
10 kHz LP

ERS100C Calibration

The ERS100C is factory set and does not require calibration. To confirm the accuracy of the device, use the CBLCALC.

ERS100C Specifications

Gain:	5000, 10000, 20000, 50000	
Output Range:	±10 V (analog)	
Frequencty Response	Maximum bandwidth (1.0 Hz – 10 kHz)	
Low Pass Filter:	3 kHz, 10 kHz	
High Pass Filter:	1.0 Hz, 20 Hz, 100 Hz	
Notch Filter:	50 dB rejection @ 50 Hz or 60 Hz	
Noise Voltage:	0.5µV rms – (100-3000 Hz)	
Signal Source:	Electrodes (three electrode leads required)	
Z (input)		
Differential:	2MΩ	
Co mmon mode:	1000MΩ	
CMRR:	110 dB min (50/60 Hz); see Shield Drive Operation on page 287	
CMIV–referenced to		
Amplifier ground:	±10 V	
Mains ground	±1500 VDC	
Input Voltage Range	Gain Vin	(mV)
5000		±2
1000	0	±1
2000	0	±0.5
5000	0	±0.2
Weight: 350	grams	
Dimensions:	4 cm (wide) x 11 cm (deep) x 19 cm (high)	

CBLCALC Calibration Cable for 100C-series Biopotential Amplifiers

CBLCAL Calibration Cable 100-B series Biopotential Amplifiers

Use CBLCAL/C to verify the calibration of the any of the Biopotential amplifiers. The cable (1.8m) connects between the amplifier input and the UIM100C D/A output 0 or 1. To verify the amplifier's frequency response and gain settings, create a stimulus signal using Acq*Knowledge* and monitor the output of the amplifier connected to the Calibration Cable. The Calibration Cable incorporates a precision 1/1000 signal attenuator.

Amplifier specification tests are performed at the factory before shipping, but a Calibration Cable can ensure users peace of mind by permitting precise frequency response and gain calibrations for exact measurements.

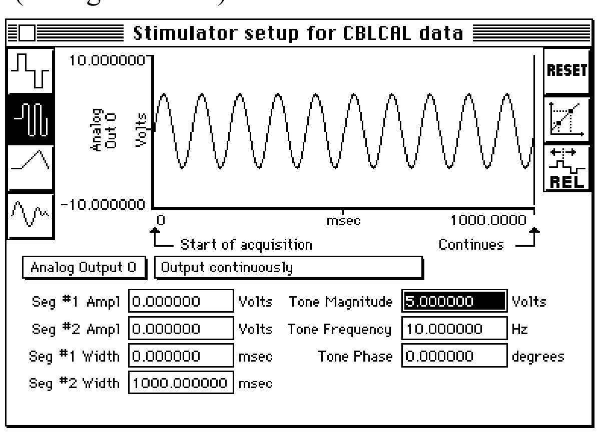
CBLCAL/C Calibration

Hardware Setup

1. Connect the MP150/100, UIM100C and biopotential amplifiers as normal.
2. Connect the CBLCAL/C between the selected amplifier and the UIM100C, inserting the single 3.5mm plug into the Analog Output "0" port on the UIM100C.
3. Connect the end containing several 2mm pins into the corresponding holes on the face of the biopotential amplifier.
4. Select a Gain setting of 1,000 for DA, ECG, EGG, EMG, and EOG, or 5,000 for EEG and ERS.
5. Turn all filters to the desired position.
6. Select an appropriate channel on the top of the amplifier being tested (usually channel one, as this is the default setup in the software).

Software Setup

1. Under **Channel Setup**, insure that the default is set to analog channel one (A1).
2. Under **Acquisition Setup**
   a) Choose a sampling rate of 2000 Hz (or higher).
   b) Choose an acquisition period of at least 5 seconds.
   c) Choose Record Last mode.
3. Under **Stimulator Setup** (see figure below)



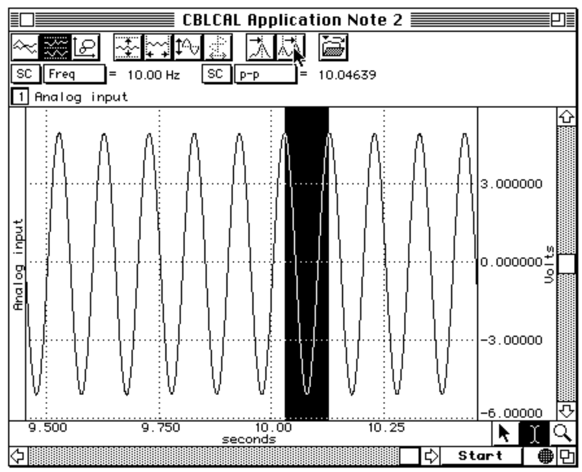
   a) Select the sine wave for the shape of the output signal.

b) Set the "Seg. #1 Width' to zero. This means that the signal will be transmitted continuously starting at time-point zero.
c) Set "Seg. #2 Width" to 1,000 msec (one second). This is the length of the output signal.
d) Select "Analog Output: 0."
e) Select "Output continuously."
f) The most important settings are the signal magnitude and frequency. Set the magnitude to 5 Volts (i.e., 10 V p-p) if the module gain setting is 1,000. If the lowest module gain setting available is 5,000, choose 1 Volt.
g) Set the frequency to 10 Hz to check the gain calibration (on a sinusoidal signal, this setting is appropriate for all biopotential amplifiers).

Calibration Procedure

Acq*Knowledge* is now set-up to check for the proper calibration of biopotential amplifiers.

1. Start the acquisition. Theoretically, since **record last** mode is enabled signal output is continuous, Acq*Knowledge* could acquire data forever.
2. Stop the acquisition when the waveform has stabilized.

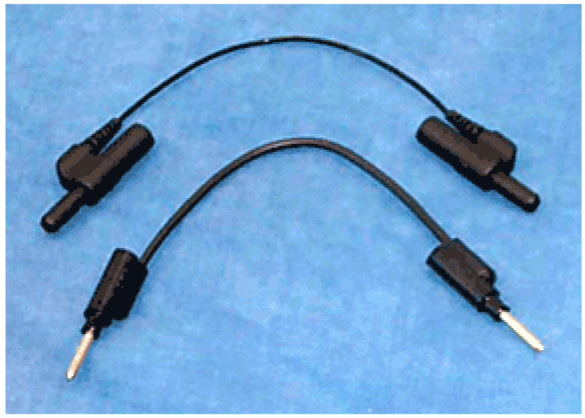


3. Use the "I-beam" cursor to select the latter part of the record.
4. Perform all the calibration measurements on the latter part of the collected record.
   a) Scale the waveform into some semblance of the one in the following figure.
   b) Select the Pk-Pk (peak to peak) measurement to determine amplitude. The measured voltage depends on the voltage input and the gain setting on the amplifier. Use the following formula to determine this number.

   Measured Voltage =
   (Stimulator Input Voltage) * (1/1,000) * (Biopotential Amplifier Gain Setting)

   If the amplifier gain setting is 1,000, it will cancel the CBLCAL/C attenuation (1/1,000). Therefore, the measured voltage will equal the stimulator input voltage. In this example, assuming a gain setting of 1,000 and a stimulator input of 10 V (pk-pk), the expected signal will be very close to 10 V (p-p).
   c) It is important to measure the amplitude of the acquired waveform correctly. Highlight several peaks with the "I-beam" cursor.
   d) Click the "peak detection" icon at the top of the graph window twice. This will precisely highlight one of the many peak-to-peak amplitudes.
   e) Open one of the pop-up measurement, windows and select "p-p" to measure the amplitude of the waveform. This result indicates the vertical distance of the waveform between the two selected peaks (see figure above).
   f) To verify the consistency of the difference in peak-to peak values, click the "peak detection" icon again. This will move the cursor to the next available peak below.
   g) Repeat this several times to verify the subsequent peak heights. If the measured peak-to-peak height is 10.04 Volts, the acquired signal can be ascertained as ±5.02 Volts. If the stimulator outputs a 5 Volt magnitude signal, then measuring 5.02 Volts (0-pk) is considered accurate for any biopotential amplifier (the analog output stimulator is accurate to within ± .5%). To best determine the accuracy of the amplifier, consider an average of measurements.

JUMP100/C Jumper Connectors for Biopotential Amplifiers



JUMP100 — for all connections between all 100B-series Biopotential amplifiers

JUMP100C — for all connections between all 100C-series Biopotential amplifiers

These jumper connectors (10 cm long) are used to create a common reference between Biopotential amplifier modules. Link one reference electrode to multiple amplifier inputs using one jumper connector per amplifier. Jumper connectors are required when connecting the same reference electrode lead to two or more amplifiers, as in multi-lead ECG or unipolar EEG measurements.

Transducer Modules

Transducer modules include: GSR; PPG; RSP; SKT.

GSR100C – Electrodermal Activity Amplifier Module

The GSR100C electrodermal activity amplifier module is a single-channel, high-gain, differential amplifier designed to measure skin conductance via the constant voltage technique. The GSR100C is designed for use in the following applications:

General eccrine activity measurement	Vestibular function analysis
Vertigo and motion sickness studies	Psychophysiological investigations

The GSR100C includes a selection switch for lower frequency response.

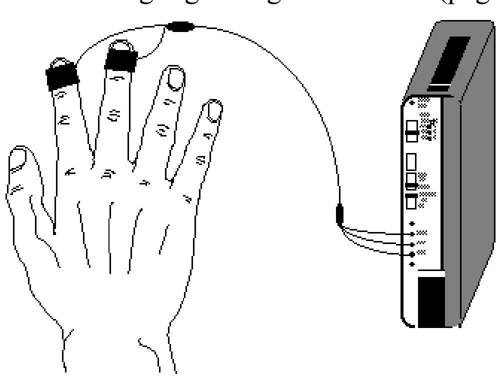
- DC—For **absolute** measures (e.g. skin conductance level)
- 0.05 Hz—For **relative** measures (e.g. skin conductance response)

---**IMPORTANT**---

GROUNDING When using the GSR100C amplifier with other biopotential amplifiers attached to the same subject, it's not necessary to attach the ground lead from the biopotential amplifier(s) to the subject. The subject is already appropriately referenced (grounded) to the system via the attachment to the GSR100C. If a biopotential ground is attached to the subject, then currents sourced from the GSR100C will be split to the biopotential amplifier ground lead, potentially resulting in measurement errors.

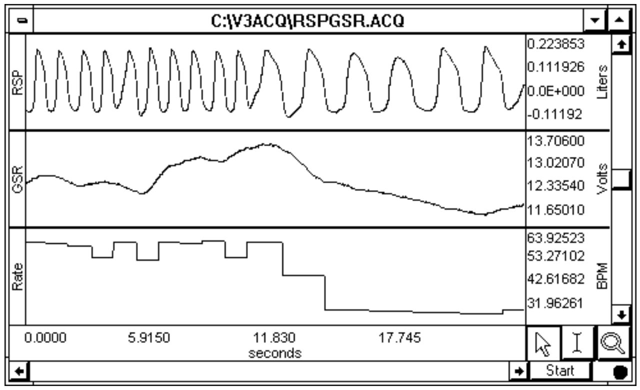
---**IMPORTANT**---

The GSR100C is typically used with TSD203 Ag-AgCl finger electrodes (page 119).



Skin conductance measurement using GSR100C and TSD203

The following graph shows the relationship between respiration rate and the electrodermal activity response (galvanic skin response). The left half of the graph marks the onset and completion of fast breathing (panting), and the subject begins to breathe normally at the time index corresponding to 12 seconds.



Electrodermal activity response, respiration and respiration rate waveforms

Frequency Response Characteristics

The 0.05 Hz high pass lower frequency response setting is a single pole roll-off filter.

Modules can be set for 50 or 60 Hz notch options, depending on the destination country.

See the sample frequency response plots beginning on page 287: 1Hz LP
10 Hz LP

GSR100C Calibration

Note that the GSR100C has scale setting in units of "µmho per volt." This is identical to the respective scale setting of µS or microsiemens per volt. Namely, 1 µmho = 1 µS.

To set up Acq*Knowledge* to record skin conductance directly, perform the following:

Lower frequency response at DC:

In the scaling window, set the input voltages so they map to the DC conductance ranges indicated by the sensitivity setting. For example, if the GSR100C is set to a Gain of 5 µmho/V, then 0 V will map to 0 µmhos or infinite resistance, and 1 V will map to 5 µmho or 200 kohm.

Lower frequency response at 0.05 Hz:

In the scaling window, set the input voltages so they map to the "0.05 Hz" conductance ranges indicated by the sensitivity setting. For example if the GSR100C is set to a Gain of 5 µmho/V, then 0 V will map to X µmhos and 1V will map to (X+5) µmhos. Where "X" is the mean conductance being recorded.

To verify the Gain setting of the GSR100C:

1. Calibrate Acq*Knowledge* as detailed above for lower frequency response at DC.
2. Place the lower frequency response to DC.
3. Set the Gain switch on the GSR100C to 5µmho/V.
4. Perform measurement with electrodes disconnected.
    - Acq*Knowledge* should produce a reading of 0 µmho.
5. Insulate a 100kohm resistor and place it from electrode pad to electrode pad (resistor must be insulated from fingers).
6. Perform measurement with electrode-resistor setup.
    - Acq*Knowledge* should produce a reading of 10 µmho.

GSR100C Specifications

Unit Note—BIOPAC software calculates SCL/SCR in mho, the traditional unit of conductance. Micromho (µmho) is interchangeable with the alternative microsiemen (µS). To use Ohm, the traditional measure of resistance, convert as 1 µmhos equals 1,000,000 ohms.

Gain: 20, 10, 5, 2 micro-mhos/volt (i.e., micro-siemens/volt)

Input conductance range			
DC	0.05 Hz	*Minimum Resistance*	*Sensitivity*
0 to 200 µmho	±200 µmho	5,000 Ω	20 µmho/V
0 to 100 µmho	±100 µmho	10,000 Ω	10 µmho/V
0 to 50 µmho	±50 µmho	20,000 Ω	5 µmho/V
0 to 20 µmho	±20 µmho	50,000 Ω	2 µmho/V

Note: Normal human range is 1-50 µmho

Output Range: 0-10 V nominal, ±10 V full (analog)

Frequency Response

- Low Pass Filter: 1Hz, 10 Hz
- High Pass Filter: DC, 0.05 Hz, 0.5 Hz

Sensitivity: 0.7 nano-mhos – with MP System

Excitation: Vex = 0.5 VDC (Constant Voltage)

Signal Source: TSD203

Weight: 350 grams

Dimensions: 4cm (wide) x 11cm (deep) x 19cm (high)

TSD203 – ELECTRODERMAL RESPONSE TRANSDUCER

The TSD203 is a set of two Ag-AgCl electrodes, which incorporate molded housings designed for finger attachment. The TSD203 is used when measuring the electrodermal response. Each transducer includes a stretchable Velcro® strap for easy attachment.

When the TSD203 is used to measure electrodermal response, the choice of electrolyte is extremely important. A higher impedance electrolyte using hyposaturated electrolyte concentrations of Cl- (on the order of physiological levels) is necessary for effective monitoring of local eccrine activity.

Use GEL101 (page 138) as an isotonic, hyposaturated, conductant with the TSD203 EDR transducer.

Storing and Cleaning

1. Store the transducer in a clean, dry area.
2. After use, clean the transducer with cold to tepid water.
   a) DO NOT use hot water.
   b) Cotton swabs are suggested.
   c) Let the transducer dry completely before storing it.
3. DO NOT allow transducers to come in contact with each other during storage (adverse reaction could occur).
4. Transducers may form a brown coating if they have not been used regularly. To remove the coating, gently polish the surface of the transducer element with non-metallic material or wipe it with mild ammonium hydroxide. Rinse with water and store the transducer in a clean, dry container.

TSD203 Specifications

Electrode Type: Ag-AgCl (unpolarizable)

Contact area: 6 mm (dia)

Cable length: 3 m

Dimensions (LxWxH each): 16 mm x 17 mm x 8 mm

Attachment: integral Velcro strap

Sterilizable: Yes, contact BIOPAC

Interface: GSR100C

TEL100C compatibility: SS3A

TSD203 Calibration

See the GSR100C transducer module.

PPG100C – PHOTOPLETHYSMOGRAM AMPLIFIER MODULE

The photoplethysmogram amplifier module (PPG100C) is a single channel amplifier designed for indirect measurement of blood pressure or density. The PPG100C is designed for use in the following applications:

- General pulse rate determination
- Blood pressure analysis
- Exercise physiology studies
- Psychophysiological investigations

The PPG100C works with the TSD200 photoplethysmogram transducer (page 122). The peak measurement recorded by the PPG100C indicates the point of maximal blood density in the respective location. Indications of blood pressure can be inferred by comparing the point of R-wave onset in the ECG to the point of maximum blood density recorded by the PPG100C.

The PPG100C includes lower frequency response selection switches, which permits either absolute (DC) or relative (via 0.05 or 0.5 Hz highpass filters) blood density measurements.

Frequency Response Characteristics

The 0.05 Hz high pass and 0.5 Hz high pass lower frequency response settings are single pole roll-off filters.

Modules can be set for 50 Hz or 60 Hz notch options, depending on the destination country.

See the sample frequency response plots beginning on page 287: 10 Hz LP

PPG100C Calibration

None required.

PPG100C Specifications

Gain:	10, 20, 50, 100
Output Range:	±10 V (analog)
Low Pass Filter:	3 Hz, 10 Hz
High Pass Filter:	DC, 0.05 Hz, 0.5 Hz
Noise Voltage:	0.5 µV rms – amplifier contribution
Excitation: 6	V
Signal Source:	TSD200 Pulse Transducer
Weight: 350	grams
Dimensions:	4 cm (wide) x 11 cm (deep) x 19 cm (high)

Excitation Voltage	6.0 V
Upper Frequency Response	10 Hz
Lower Frequency Response	DC or 0.05 Hz or 0.5 Hz
Noise Voltage	0.5 µV (rms) – amplifier contribution

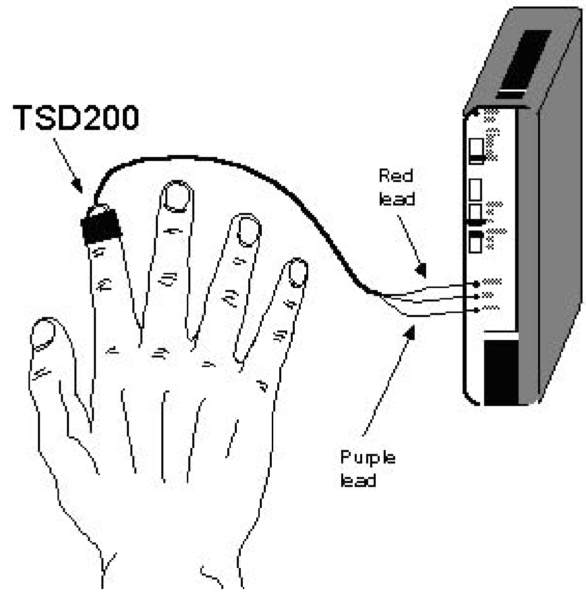
Gain Settings

Input Signal Range (pk-pk)	*Gain*
2000 mV	x 10
1000 mV	x 20
400 mV	x 50
200 mV	x 100

This illustration shows the proper connections to use the TSD200 with the PPG100C. The TSD200 can be placed on other body locations by employing ADD208 adhesive disks to hold the TSD200 in place.

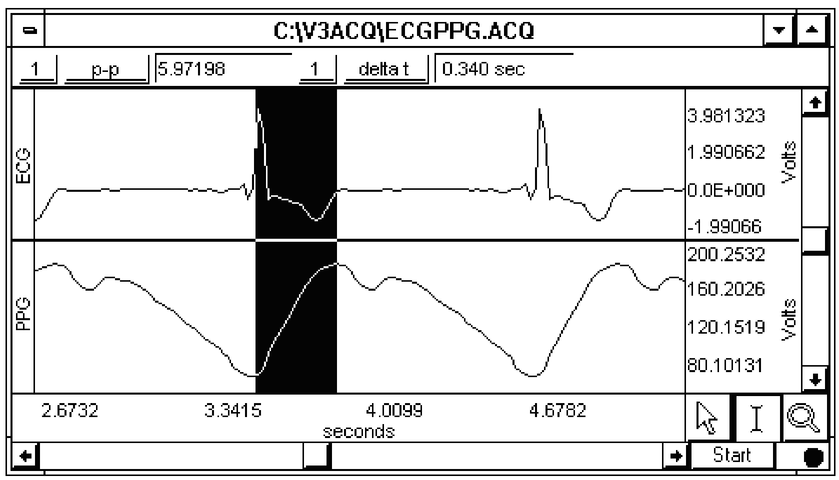
The TSD200 connects to the PPG100C as follows:

TSD200 Lead	PPG100C
Red lead	*+VSUP*
Black lead	GND
Purple or Blue lead	INPUT



Finger pulse measurement using the PPG100C and TSD200

This graph illustrates pulse plethysmogram data indicating blood density with respect to the acquired ECG. The distance between peaks on the two channels can provide indications of blood pressure, vascular resistance and compliance.



Pulse plethysmograph and ECG waveforms

TSD200 PHOTOPLETHYSMOGRAM TRANSDUCER

The TSD200 consists of a matched infrared emitter and photo diode, which transmits changes in blood density (caused by varying blood pressure) in specific body locations. When the TSD200 is attached to the skin, the infrared light is modulated by blood pulsing through the tissue below. The modulated, reflected light results in small changes in the resistance of the photo resistor, which yields a proportional change in voltage output.

The TSD200 includes a shielded 2-meter cable and a stretchable Velcro® strap for easy attachment to the fingers, or it can be taped to other body parts. The TSD200 can also be placed on other body locations by employing ADD208 adhesive disks to hold the TSD200 in place. Use the TSD200C ear clip transducer for easy attachment to the ear.

Place the transducer around the finger and adjust the Velcro® closure to provide only slight tension. Blood density readings can vary considerably depending on transducer location and tension changes.

The TSD200 connects to the PPG100C as follows (see page 121—PPG100C for a diagram):

TSD200 Lead	PPG100C
Red lead	*+VSUP*
Black lead	GND
Purple or Blue lead	INPUT

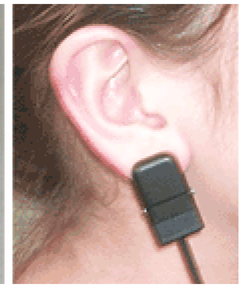
TSD200 Calibration

The TSD200 does not require calibration.

TSD200 Specifications

Emitter/Detector Wavelength:	860 nm ± 60 nm
Optical Low Pass Filter Cutoff Wavelength:	800 nm
Note	The operational range of the emitter and detector fall within the wavelength range of 800 nm to 920 nm. The filter is placed over the receiver, the filter of 800 nm is an optical lowpass, so wavelengths longer than 800 nm will pass thru.
Nominal Output:	20 mV (peak-peak)
Power:	6 VDC Excitation @ 5 mA
Sterilizable:	Yes (Contact BIOPAC for details)
Weight: 4.5	g
Dimensions (L x W x H):	16 mm x 17 mm x 8 mm
Attachment: Velcro	strap
Cable:	3 m, shielded
Interface: PPG100C	
TEL100C Compatibility:	SS4A

TSD200C PHOTOELECTRIC PULSE PLETHYSMOGRAPH WITH EARCLIP



The photodetector operates via incident photons, from an IR transmitter, impacting an IR detector. The incident photons result in a proportional passage of electrons in the detector. The IR detector operates like a photon-controlled current source. The transducer incorporates an appropriate clipping range, with linearity insured for arbitrarily low levels of reflected light. For the expected magnitude of incident infrared light, the photodetector operates in a linear fashion. Situations have not been encountered where the detector is operating non-linearly (near saturation).

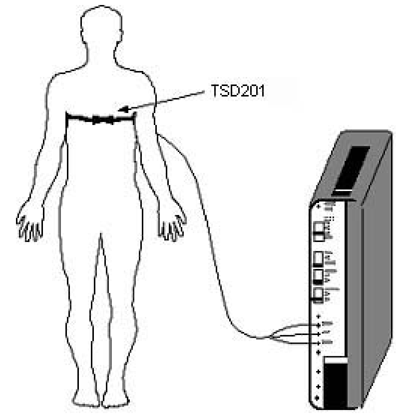
The TSD200C transducer operates with the PPG100C amplifier to record the pulse pressure waveform. The TSD200C consists of a matched infrared emitter and photo diode, which transmits changes in infrared reflectance resulting from varying blood flow. The ergonomic housing design improves contact with the subject and helps reduce motion artifact. The TSD200C is primarily designed for ear attachment and comes with a shielded 3-meter cable and ear clip.

TSD200C Specifications

Emitter/Detector Wavelength:	860 nm ± 60 nm
Optical Low Pass Filter Cutoff Wavelength:	800 nm
Note	The operational range of the emitter and detector fall within the wavelength range of 800 nm to 920 nm. The filter is placed over the receiver, the filter of 800 nm is an optical lowpass, so wavelengths longer than 800 nm will pass thru.
Nominal Output:	20 mV (peak-peak)
Power:	6 VDC Excitation @ 5 mA
Sterilizable:	Yes (Contact BIOPAC for details)
Weight: 4.5	g
Dimensions (L x W x H):	16 mm x 17 mm x 8 mm (clip gap)
Attachment: earclip	
Cable:	3 m, shielded
Interface: PPG100C	
TEL100C Compatibility:	SS4A (finger style)

Note The TSD200A ear clip transducer was discontinued in August 2008.

RSP100C – RESPIRATION PNEUMOGRAM AMPLIFIER MODULE



The RSP100C respiration pneumogram amplifier module is a single channel, differential amplifier designed specifically for recording respiration effort. The RSP100C is designed for use in the following applications:

Allergic responses analysis

Exercise physiology studies

Psy chophysiological investigations

Respiration rate determination

Sleep studies

The RSP100C works with the TSD201 respiration transducer (page 126) to measure abdominal or thoracic expansion and contraction.

The RSP100C includes a lower frequency response selection switch that permits either absolute (DC) or relative (via a 0.05 highpass filter) respiratory effort measurements.

The following illustration shows the placement and connections for recording thoracic respiration effort using the RSP100C and the TSD201 respiration transducer.

RSP100C Amplifier Module Settings

The RSP100C has three built-in filters and a number of different gain settings for the different uses of the transducer.

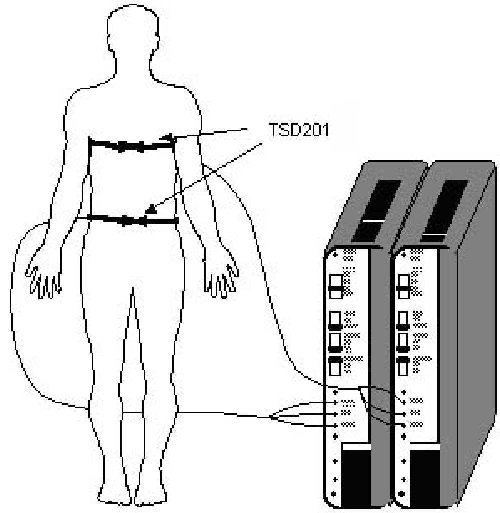
Type of Use	Gain Setting	Low Pass Filter	.5 Hz Filter	.05 Hz Filter
General	10	10 Hz	DC	DC
Exercise Physiology	10	1 Hz	.5 Hz	.05 Hz
Small Animal	20+	10 Hz	.5 Hz	.05 Hz

General For most measurements with little or no subject movement. The most common setting is with all three filters at their bottom settings (10 Hz, DC, and DC) and the gain set at 10. This allows any signals slower than 10 Hz (cyclic rate) to pass, and is usually good for most measurements with little or no subject movement.

Exercise physiology The transducer produces the best signal at the lowest gain and with all three filter settings at their top position (1Hz, .5 Hz, and .05 Hz). This setting will allow only a signal between .5 Hz and 1Hz to be transmitted, filtering out most of the signal interference due to extraneous chest and abdominal movement resulting from limb motion.

Smaller animals For measurements with very small changes in thoracic circumference, increase the gain to magnify the signal. Increase the gain until a clear signal is obtained, but not so much that the signal is clipped.

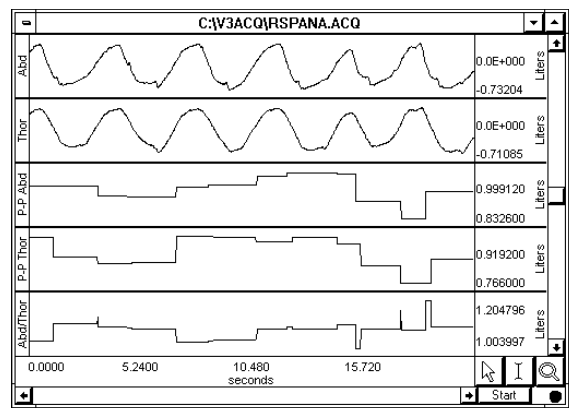
This illustration shows the placement and connections to record thoracic and abdominal respiration effort using two RSP100C amplifier modules and two TSD201 respiration transducers.



Connections for Thoracic and Abdominal Respiratory Effort Measurement

This graph shows the relationship between abdominal and thoracic expansion and contraction.

Calculate the peak-to-peak values for both abdominal and thoracic respiration effort were calculated with Acq*Knowledge*, and then the two peak-to-peak values were compared in the lowest channel. When abdominal breathing effort changes with respect to thoracic breathing effort, the lowest channel will quantify the extent of the change.



Thoracic vs. Abdominal respiration effort data

Frequency Response Characteristics

The 0.05 Hz high pass lower frequency response setting is a single pole roll-off filter. The 0.5 Hz high pass lower frequency response setting is a two pole roll-off filter.

Modules can be set for 50 or 60 Hz notch options, depending on the destination country.

See the sample frequency response plots beginning on page 287: 1 Hz LP
10 Hz LP

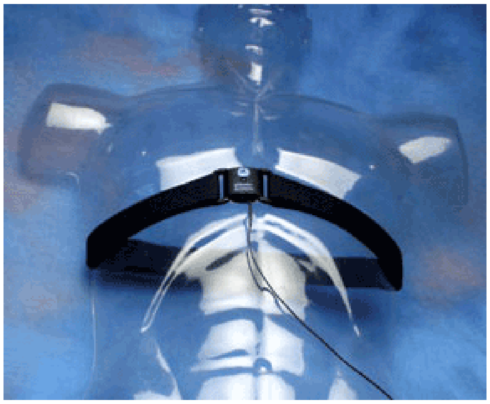
RSP100C Calibration

None required.

RSP100C Specifications

Gain:	10, 20, 50, 100
Output Range:	±10 V (analog)
Frequency Response	
Low Pass Filter:	1Hz, 10 Hz
High Pass Filter:	DC, 0.05 Hz, 0.5 Hz
Excitation Voltage	±0.5 V
Noise Voltage:	0.2µV rms – amplifier contribution
Signal Source:	TSD201
Weight: 350	g
Dimensions:	4 cm (wide) x 11 cm (deep) x 19 cm (high)

TSD201 – Respiration transducer



Sample Data for Subject at Rest

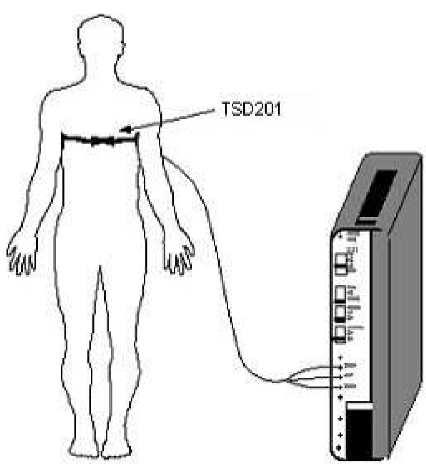
The TSD201 is a strain gauge transducer designed to measure respiratory-induced changes in thoracic or abdominal circumference, and can therefore be used to record respiratory effort. The TSD201 is essentially a resistive transducer and responds in a linear fashion to changes in elongation through its length, with resistance increasing as length increases.

The transducer is ideal for a variety of applications because it presents minimal resistance to movement and is extremely unobtrusive. Due to its unique construction, the TSD201 can measure extremely slow respiration patterns with no loss in signal amplitude while maintaining excellent linearity and minimal hysteresis.

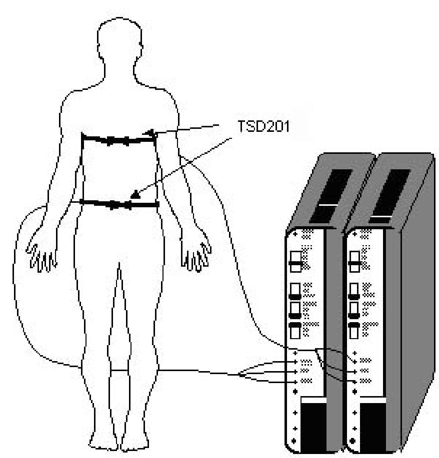
The TSD201 plugs directly into the RSP100C amplifier module (page 124). It includes a fully adjustable nylon strap to accommodate a large range of circumferences (9 cm to 130 cm). To attach the nylon belt to the respiration transducer, thread the nylon strap through the corresponding slots so the strap clamps into place when tightened. Place the transducer around the body at the level of maximum respiratory expansion. This location will vary from the erect to supine positions (generally about 5 cm below the armpits).

Correct tension adjustment of the respiration transducer is important. For best sensitivity, the transducer must be just slightly tight at the point of minimum circumference (maximum expiration). To obtain proper tension, stretch the belt around the body and have the subject exhale. At maximum expiration, adjust the nylon strap so there is slight tension to hold the strap around the chest.

The transducer has three 2 mm pin plugs to connect to the amplifier. Insert the two blue lead transducer pin plugs into the two RSP100C inputs labeled XDCR. Either blue lead can be connected to either XDCR input. Insert the single black transducer lead into the GND input of the RSP100C. The respiration transducer is ready for measurement.



using one TSD201 respiration transducer



using two TSD201 respiration transducers

Placement and Connections for Thoracic and Abdominal Respiratory Effort Measurement

TSD201 Calibration

The TSD201 does not require calibration.

TSD201 Specifications

True DC Response:	Yes
Variable Resistance Output:	5-125 KΩ (increases as length increases)
Circumference Range:	15 cm x 150 cm (can be increased with a longer strap)
Attachment:	Velcro® strap (adjustable length)
Sterilizable:	Yes (contact BIOPAC for details)
Sensor Weight:	18 gs
Sensor Dimensions:	66 mm (long), 40 mm (wide), 15 mm (thick)
Cable Length:	3 m
Interface:	RSP100C—see page 124
TEL100C compatibility:	SS5B
Frequency Response:	DC – 500 Hz
Operating Humidity Range:	0-95% non-condensing
Operating Temperature Range:	-20 deg C to +80 deg C

Sensitivity: Monotonic analog output. Sufficiently sensitive to detect heart motion in thoracic cavity, in addition to thoracic/abdominal expansion and contraction.

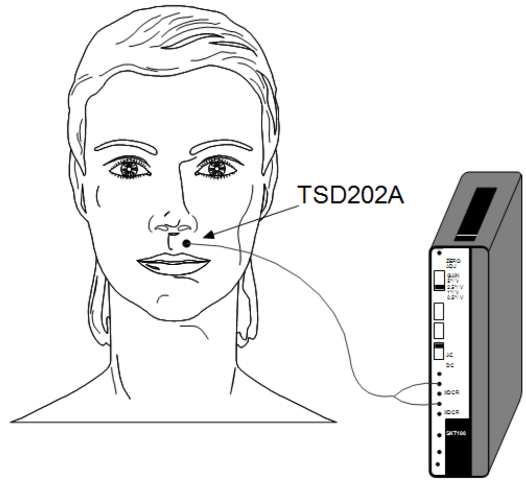
SKT100C – SKIN TEMPERATURE AMPLIFIER MODULE

The SKT100C skin temperature amplifier module is a single channel, differential amplifier designed especially for skin and core temperature and respiration flow (rate) monitoring. The SKT100C is designed for use in the following applications:

General temperature measurement	Respiration rate determination
Psychophysiological investigations	Sleep studies

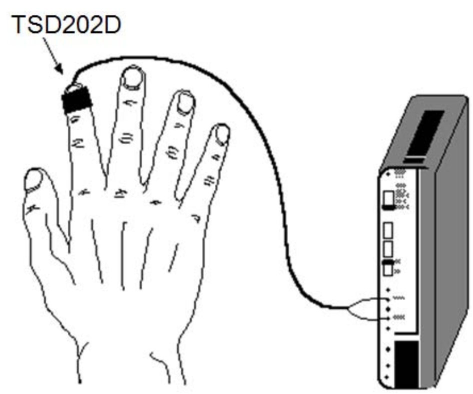
The SKT100C employs any of the BIOPAC TSD202 series thermistor transducers (page 130) to measure temperature. The SKT100C includes a lower frequency response selection switch that permits either absolute (DC) or relative (via a 0.05 Hz or 0.5 Hz high pass filter) temperature measurements.

Cnnections and placement for **measuring respiration flow** using the SKT100C and the TSD202A fast-response surface temperature thermistor.



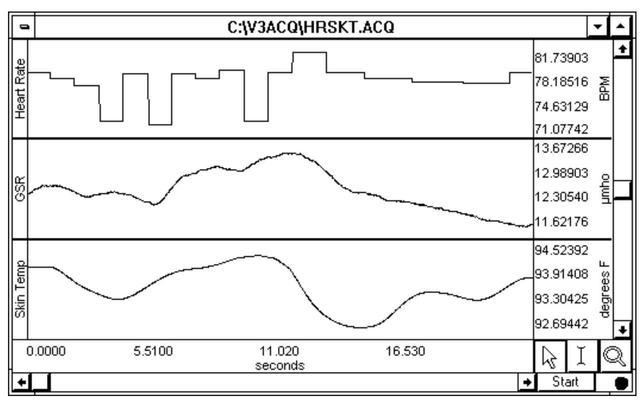
Respiration flow measurement using SKT100C and TSD202B

Connections and placement for **measuring index fingertip temperature** using the SKT100C and the TSD202D digit surface temperature probe. The probe is secured to the finger using the Velcro® strap on the transducer.



Index finger temperature measurement with TSD202D

This graph shows the relationship between fingertip skin temperature, skin conductance and heart rate. This configuration of physiological measurements can be useful for psychological testing and evaluation.



SKT versus GSR versus Heart Rate Waveforms

Frequency Response Characteristics

The 0.05 Hz high pass lower frequency response setting is a single pole roll-off filter.

Modules can be set for 50 Hz or 60 Hz notch options, depending on the destination country.

See the sample frequency response plots beginning on page 287: 1 Hz LP and 10 Hz LP

SKT100C Calibration

Temperature Measurements

To measure **absolute** temperature, set the lower frequency response to DC.

To measure **relative** temperature changes, set the lower frequency response to 0.05 Hz or 0.5 Hz.

To set up Acq*Knowledge* to record temperature directly, perform the following:

A. Lower frequency response at **DC**:
   In the scaling window, set the input voltages so they map to the respective temperature ranges indicated by the sensitivity setting. In this case, 0 V will always map to 90° F.

B. Lower frequency response at **0.05 Hz** or **0.5 Hz**:
   In the scaling window, set the input voltages so they map to the respective temperature ranges indicated by the sensitivity setting. In this case, 0 V will map to the mean (average) temperature during the recording. Use this setting when temperature delta measurement is important, as when monitoring airflow (respiration rate).

Skin Temperature Measurements

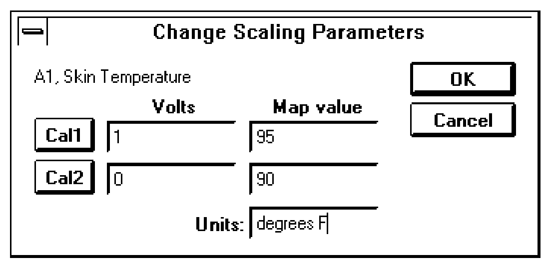
To measure **absolute** skin temperature, place the lower frequency response to DC.

To measure **relative** skin temperature changes or **respiration** rate (**airflow**), place the lower frequency response to 0.05 Hz or 0.5 Hz.

To set up Acq*Knowledge* to record temperature directly, perform the following:

A. Lower frequency response to **DC**:
   In the scaling window, set the input voltages so they map to the "DC on" temperature ranges indicated by the sensitivity setting. In this case, 0 V will always map to 90° F.

B. Lower frequency response to **0.05 Hz** or **0.5 Hz.**:
   In the scaling window, set the input voltages so they map to the respective temperature ranges indicated by the sensitivity setting. In this case, 0 V will map to the mean (average) temperature measured during the recording and 1 V will map to one-half the "delta range" values, which corresponds to the chosen Gain setting.



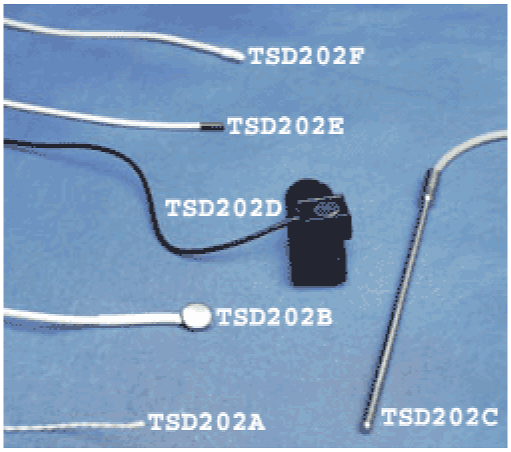
Scaling setup window set to correspond to 5°/V setting on SKT100C

SKT100C Specifications

Gain:	5, 2, 1, 0.5 °F/V— can also calibrate in °C (see Input Signal Range below)
Output Range:	±10 V (analog)
Low Pass Filter:	1 Hz, 10 Hz
High Pass Filter:	DC, 0.05 Hz, 0.5 Hz
Sensitivity:	180 micro °F (100 micro °C)— with MP System
Signal Source:	TSD202 Series Temperature Probe
Weight: 350	g
Dimensions:	4 cm (wide) x 11 cm (deep) x 19 cm (high)

Input Signal Range: Gain	Range (°F)	Range (°C)	Delta Range (°F)	Delta Range (°C)
5	40-140	4.44-60	100	55.56
2	70-110	21.11-43.33	50	27.78
1	80-100	26.67-37.78	20	11.11
0.5	85-95	29.44-35	10	5.56

TSD202 Series Temperature Transducers



TSD202 SERIES

TSD202A The TSD202A employs a fast response thermistorand is appropriate for use in locations where temperature changes rapidly, as with the temperature changes of inspired/expired breath. The TSD202A is useful for measuring skin temperature (in small areas) or airflow rate resulting from respiration, and is not designed for liquid immersion. For measuring skin (surface) temperature, simply tape the TSD202A to the location of interest. For measuring respiration rates, by monitoring airflow, place the TSD202A next to the mouth or nose so that inspired or exhaled air will intercept the tip of the TSD202A transducer.

RX202A Replacement Fast-response Temperature Sensor

TSD202B The TSD202B is a “Banjo” style surface probe useful for measuring surface temperature. The “Banjo” design allows efficient skin temperature measurements on a variety of body locations. The TSD202B is not designed for liquid immersion. For measuring skin (surface) temperature, simply tape the TSD202B to the location of interest.

TSD202C The TSD202C encases the internal thermistor in a stainless steel, waterproof housing, and is designed for liquid immersion and other temperature measurement applications where ruggedness is required and fast response is not critical.

TSD202D The TSD202D is a modified TSD202B, with a housing that conforms to curved skin surfaces and includes a stretchy Velcro® strap for easy attachment to the fingers or toes. The “Banjo” design allows efficient skin temperature measurements. The TSD202D is not designed for liquid immersion. For measuring skin (surface) temperature, simply tape the TSD202D to the location of interest. Insert the two blue lead transducer pin plugs into the two SKT100C inputs labeled XDCR. Either blue lead can be connected to either XDCR input.

TSD202E The TSD202E is a general-purpose waterproof thermistor.

TSD202F The TSD202F is a small, flexible waterproof thermistor.

TSD202 SERIES Specifications

Response Time	
TSD202A:	0.6 sec
TSD202B:	1.1 sec
TSD202C:	3.6 sec
TSD202D:	1.1 sec
TSD202E:	0.9 sec
TSD202F:	1.1 sec
Size with housing	
TSD202A:	1.7 mm (diameter) *x* 5 mm (long)
TSD202B:	9.8 mm (diameter) *x* 3.3 mm (high)
TSD202C:	4 mm (diameter) *x* 115 mm (long)
TSD202D:	16 mm (long) *x* 17 mm (wide) *x* 8 mm (high)
(TSD202D – sensor only:	10 mm sensing diameter, 1.4 mm sensor thickness)
TSD202E:	9.8 mm (long) x 3.3 mm (diameter)
TSD202F:	9.8 mm (long) x 3.3 mm (diameter)
Sensor only:	10 mm sensing diameter, 1.4 mm sensor thickness
Interface: SKT100C—see	page 128
Nominal Resistance:	2252 Ω at 25° C
Maximum operating temperature:	60° C (when used with SKT100C)
Accuracy and Interchangability	0.2° C
Cable length:	3 meters
Compatibility: YSI	® series 400 temperature probes
Sterilizable:	Yes (contact BIOPAC for details)
TEL100 Compatibility:	SS6—see page 270

Electrodes: Reusable and Disposable

Application Instructions for all electrodes:

In selecting the application site, care should be taken that:

a) Electrode site is dry and free of excessive hair.

b) Electrode is not placed over scar tissue or on an area of established erythema or lesion.

Skin is properly prepared. (Prepare the skin at the electrode site. Use the ELPAD to lightly abrade the skin surface. Use a brisk dry rub to prepare the application site. Avoid excessive abrasion of the skin surface.)

EL120 Contact Posts

The EL120 electrode has contact posts designed to improve contact through fur or hair. The 12 posts create a 10 mm contact area. The posts are 2mm deep to push through the fur/hair to provide good contact with the skin surface. Silver-silver chloride (Ag-AgCl) electrodes provide accurate and clear transmission of surface biopotentials and are useful for recording all surface biopotentials on animals and human EEG. Shipped in packs of 10. Requires one LEAD120 per electrode (see page 135).

EL160 Gold Cup

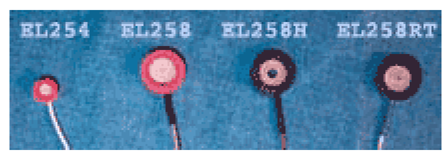
Reusable gold cup electrode with 10 mm cup diameter and 1.2 m cable.

One electrode per package.

- EL160 with black cable
- EL160-R with red cable
- EL160-W with white cable

The leadwire terminates in a standard Touchproof connector. Use with MEC Series Module Extension Cables for MP Research Systems or SS1LA Touchproof Electrode Lead Adapter for BSL Systems.

EL250 Series — Reusable Ag-AgCl electrodes



Small Reusable

EL254 unshielded

EL254S shielded

EL254RT unshielded

General-purpose

EL258 unshielded

EL258S shielded

EL258RT unshielded

EL258H unshielded, low-profile, 2mm hole

Silver-silver chloride (Ag-AgCl) electrodes provide accurate and clear transmission of surface biopotentials. Reusable electrodes are permanently connected to robust and pliable lead wires (1mm OD). The lead wires terminate in standard Touchproof connectors for interfacing to 100C-series Biopotential modules or MEC Series modular extension cables. Unshielded electrodes terminate in a single Touchproof connector. Shielded electrodes terminate in two Touchproof connectors; one connects to the Ag-AgCl disk and the other connects to the lead wire shield.

The EL258 series is suitable for most applications (i.e., ECG, EEG, EGG, EMG, EOG and ERS recordings). Use EL254 series lead electrodes when closely spaced biopotentials are required. Generally, for each Biopotential amplifier module, two EL254S or EL258S and one EL254 or EL258 are required.

For best signal performance use shielded electrodes (EL254S or EL258S) as recording electrodes and unshielded electrodes (EL254 or EL258) as ground or reference electrodes.

H: Gel Hole For ease of setup, use the EL258H for both recording and reference electrodes (useful for EEG monitoring). Inject gel in the center hole after an EL258H electrode is attached.

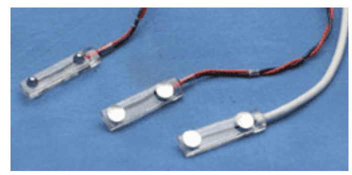
RT: Radiotrans. These electrodes employ carbon fiber lead wire for superior radiotranslucent performance, as defined on page 140. For radiotranslucent requirements, use three of the EL254RT or EL258RT with each Biopotential module.

Applying EL250 Series Electrodes:

1. Remove an appropriate size adhesive collar (ADD204 or ADD208, page 138) from its waxed paper strip and carefully apply the washer to the electrode so the center hole of the washer is directly over the electrode cavity. Use ADD204 adhesive collars with the EL254 series and use ADD208 adhesive collars with the EL258 series.
2. Fill the cavity with electrode gel (GEL100). No air bubbles should be present in the cavity.
3. Remove the white backing from the washer to expose the second adhesive side.
4. Place electrode on prepared skin area and smooth the washer into place.
5. Apply a few drops of electrode gel to fingertip and rub the exposed side of the adhesive collar (around the electrode) to rid its surface of adhesive quality.

EL250 Specifications

Part	**EL254**	**EL254RT**	**EL254S**	**EL258**	**EL258H**	**EL258RT**	**EL258S**
Outer diameter	7.2 mm	7.2 mm	7.2 mm	12.5 mm	12.5 mm	12.5 mm	12.5 mm
Recording dia.	4 mm	4 mm	4 mm	8 mm	8 mm	8 mm	8 mm
Height	6 mm	6 mm	6 mm	6 mm	4 mm	6 mm	6 mm
Lead length	1 m	1.5 m	1 m	1 m	1 m	1.5 m	1 m

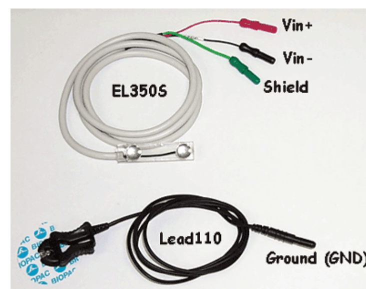


EL350 Series — Bar lead electrodes

EL350 Concave bar lead electrode, use for stimulating or recording.

EL350S Concave bar lead electrode, shielded, use for recording

EL351 Convex bar lead electrode, use for stimulating

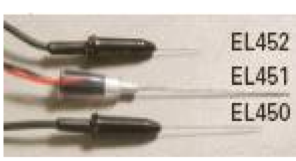


All bar electrodes consist of two tin electrodes placed 30 mm apart in a watertight acrylic bar. This configuration permits easy electrode placement without disturbing electrode-to-electrode spacing. Bar electrodes are recommended when applying a stimulus or recording a signal, or during nerve conduction, somatosensory or muscle twitch recordings. When using bar electrodes for signal recording, a single ground lead (LEAD110 with EL503) is required. When using the EL350S the "Shield" line should be placed into one of the two shield connectors on any biopotential amplifier; a ground lead is still required when using the EL350S.

EL350 Series Specifications

Electrode Spacing:	30 mm
Lead length:	61 cm
Interface:	Leads terminate in standard Touchproof connectors, which connect to any 100C-series Biopotential amplifier or stimulus isolation adapter (STMISOC/D/E). CBL201 required for connection to 100A/100B-series amplifiers.
Contact Area:	EL350/EL350S—9.5 mm base; 0.6 mm depth (circular concave area)
	EL351—6.3 mm base; 4.3 mm height (circular convex)

EL450 Series — Needle electrodes



These needle electrodes are fully insulated, with a clear Teflon® overcoat, except for the conductive needle tip. EL450 and EL452 are unipolar and the EL451 is a concentric bipolar electrode. Needle electrodes are equipped with a flexible lead terminating in standard Touchproof connectors. Use needle electrodes for stimulation or recording in animal subjects and tissue preparations. Needle electrodes are shipped non-sterile, so pre-sterilization is required.

- ❖ For general-purpose recording (e.g. ECG), use a pair of EL450 or EL452 electrodes and one EL452 uncoated ground electrode.
- ❖ When recording from a single site (e.g. studies of individual muscle fibers), use one EL451 and one EL452 uncoated ground electrode.
- ❖ For stimulation, use a pair of EL450 or EL452 electrodes.

- To record a biopotential signal (such as ECG), abrade the Teflon® off the needle to maximize the contact area.

EL450 Specifications

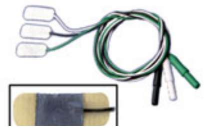
Type:	28-gauge stainless steel, needle electrodes		
Dimensions Needle	______ Dia	___meter Cable	_____
EL450:	2.5 cm	300 µm 61	cm
EL451:	3.7 cm	460 µm 61	cm
EL452:	1.5cm	300µm	61cm

EL500 Series — Disposable electrodes


EL504


EL508


EL509


EL510

The EL500 Series snap electrodes, designed for one use only, provide the same signal transmission as BIOPAC's reusable electrodes, with added convenience and hygiene. Each peel-and-stick disposable electrode is pre-gelled and requires no additional electrode gel or adhesive.

Remove an electrode from the waxed paper strip and position it in the desired location, then snap on LEAD110 or LEAD110S leads (see page 183).

EL500 Specifications

Type: Disposable Ag-AgCl
Fastener: Snap fastener for attachment to LEAD110 or LEAD110S unless otherwise noted
Gel: Hypoallergenic gel
Contact area: 1 cm diameter (circular)

EL500 Paired (Dual) Electrodes; foam; 41 mm x 82 mm x 1.5 mm

EL501 Small Stress Test Electrodes; foam; 38 mm diameter

EL502 Long-term Recording Electrodes; tape; 41 mm diameter

EL503 General-Purpose Electrodes, vinyl tape; 35 mm diameter

EL504 Cloth Electrodes—Facial EMG; cloth; 2.5 cm sq

EL506 Strip Electrode—Bioimpedance; cloth; 25 cm (can be cut)

EL507 EDA/GSR Snap Electrodes; foam; 2.5 cm x 4.5 cm
Wet Gel: 0.5% Chloride Salt.

EL508 MRI-Compatible, Radiotranslucent Vinyl Tape Electrode; 38 mm diameter backing; requires LEAD108, see page 146

EL509 MRI-Compatible, Radiotranslucent, Disposable dry electrode, 1 cm diameter circular contact area. Backing: 25 mm x 44 mm; No shelf-life limitation. Use with LEAD108 and electrode gel—GEL101 recommended for EDA/GSR

EL510 MRI compatible, Radioluscent RT electrode set of three electrodes with hydrogel centers and hydrocolloid ends that terminate in Touchproof leads. 25 mm x 10 mm with a 10 mm x 10 mm gelled contact area, and the micro-lead cables are 58 cm.

ELSTM2 Animal Stim. Needle Electrode

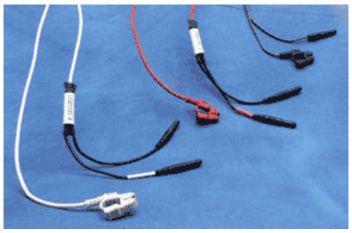
Recommended for use when applying a stimulus to animal subjects and tissue preparations. The dual stainless steel needles are Teflon coated.

Connector: BNC
Length: Leadwire 2.5 m; Needle 2.5 cm
Diameter: Leadwire 2.4 mm (2 x 1.2 mm); Needle 0.3 mm

NOTE Needle electrodes are shipped non-sterile; pre-sterilization is required.

ELECTRODE LEADS

LEAD110 Series — Electrode leads



The LEAD110 Series, for use with disposable and other snap connector electrodes, are pinch leads for easy connection between the EL500-series snap electrodes and any BIOPAC biopotential amplifier or the GND terminal on the back of the UIM100C. Leads terminate in standard 2 mm pin plug and connect to BIOPAC modules or to a Modular Extension Cable (MEC series).

LEAD	TYPE	LENGTH	USAGE NOTE
LEAD110	Unshielded	1 m	Works best as a ground electrode
LEAD110A	Unshielded	3 m	Works best with ground or reference electrodes
LEAD110S-R	Shielded; red	1 m	Use with recording electrodes for minimal noise interference. White lead plug is for electrode contact; black lead pin plug is for lead shield.
LEAD110S-W	Shielded; white	1 m	Use with recording electrodes for minimal noise interference. White lead plug is for electrode contact; black lead pin plug is for lead shield.

See also: TSD155C Multi-lead ECG Cable, page 103
WT100C Wilson Terminal (virtual reference), page 103

LEAD120 Lead for EL120

This 1-meter lead with Touchproof connector works exclusively with the reusable EL120 electrode (page 132). Snap the electrode into place and then plug the lead in with the Touchproof connector. White—LEAD120-W Red—LEAD120-R

LEAD130 Shielded Lead Assembly

LEAD130 Shielded Lead Assembly is for use with the EBI100C Electrical Bioimpedance Module or the NICO100C Noninvasive Cardiac Output Module. The shielded lead assembly terminates with an adapter that plugs into the front of the amplifier module and includes four leads:

White = I+ **Red** = Vin+ **Green** = Vin- **Black** = I- (GND)

Important Usage Notes:

- If using multiple biopotential modules, do not connect the ground (GND) for the other modules — establish one ground per subject.
- If using a GSR100C Electrodermal Response Amplifier with the EBI100C or the NICO100C, please note that the black I- (GND) connection will shunt current from the GSR100C excitation source. Accordingly, GSR100C measurement values will be shifted somewhat higher in absolute conductance, and should be used for relative measures only.

See also: EBI100C Electrical Bioimpedance Module, page 183.
NICO100C Noninvasive Cardiac Output Module, page 187.
EL506 Bioimpedance Strip Electrode and EL500 Series Disposable Electrodes, page 134.
Application Note 215 - Noninvasive Cardiac Ouput - NICO100C and LEAD130.

LEAD140 Series Clip Leads

LEAD140 Series clip leads have a 1 m black cable and a Touchproof connector, and require the SS1LA interface.

LEAD140 Alligator clip with teeth, 40 mm: Use this fully-insulated, unshielded lead to connect fine wire electrodes, including irregular surfaces. There is ferrous metal in the clip.

LEAD141 Alligator clip with smooth (flat) clamp, 40 mm: Use this fully-insulated, unshielded lead to connect to fine wire electrodes without damage, including arbitrarily small electrode wires. There is ferrous metal in the clip.

LEAD142 Retractable clip lead with copper extension contacts, 3.5 mm: Use this unshielded lead to connect to fine wire electrodes up to 1mm diameter. There is non-ferrous copper alloy in the clip.

MICROMANIPULATOR

This manual micromanipulator is a reliable, durable, and economical solution for high-precision experiments.

- Vernier scales allow readings to 0.1 mm
- X-axis fine control allows readings to 10 µm
- Includes tilting base
- Includes standard 12 mm clamp
- Includes 14 cm electrode holder
- All control knobs project to the rear, so units can be tightly grouped.

Travel	Range	Resolution
X-axis fine	10 mm	0.01 mm
X-axis	35 mm	0.1 mm
Y-axis	25 mm	0.1 mm
Z-axis	25 mm	0.1 mm

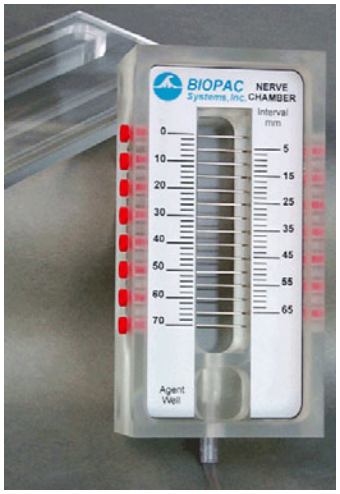
Weight: 1.4 kg (3 lbs.)

Specify left- or right-handed unit when ordering.

MANIPULATOR-R Right-handed

MANIPULATOR-L Left-handed

NERVE CHAMBERS



NERVE1 Specifications	
Pins:	15, stainless steel
Spacing:	5mm
Sockets:	accept 2mm pin plugs
Reservoir:	holds 35mL (or use drain/valve)
Agent well:	1.4cm x 2cm x 2cm (h x w x l)
Dimensions:	4.5cm x 7cm x 14cm (h x w l)
Lid:	50mm thick

This acrylic, desktop Nerve Chamber has 15 stainless steel pins for recording and stimulating a variety of different nerve preparations. Each stainless steel pin is spaced 5mm apart to provide a variety of recording and stimulating configurations. The sockets accept 2 mm pin plugs.

NERVE1 The **unique design** of the NERVE1 chamber includes:

- **Deep Reservoir** (35 mL) for containing Ringers or other solutions
- **Drain (with valve & hose)** to facilitate extended viability of the preparation
- **Agent Well** for adding compounds (such as ether or dry ice)
- **Lid** to enclose the preparation when the protocol requires it.

NERVE2 This basic nerve chamber option does not include agent well, drain, or lid.

Related components:

- STM100C Stimulator Module
- STMISO Series Stimulator Modules
- MCE100C Micro-electrode Amplifier
- ERS100C Evoked Response Amplifier
- EMG100C Electromyogram Amplifier

To connect the Nerve Chamber to MP-series Biopotential amplifiers (MCE100C, ERS100C, or EMG100C), use three JUMP100 connectors and three CBL200 adapter cables. Optionally, for additional lead length, use one MEC110C extension cable.

1. Plug the three JUMP100s into the desired points of the Nerve Chamber.
2. Connect the free ends of the JUMP100s to the mating ends of the CBL200s.
3. Then connect the free ends of the CBL200s to the Biopotential amplifier inputs. For additional lead length, plug the MEC110C into the Biopotential amplifier and plug the free ends of the CBL200s into the free end of the MEC110C.

To connect the Nerve Chamber to the STM100C Stimulator, use one CBL106 and one CBL102.

1. Plug the red and black leads (2mm pins) of the CBL106 into the desired points of the Nerve Chamber.
2. Connect the free end (Female BNC) of the CBL106 to the mating end (Male BNC) of the CBL102.
3. Then insert the free end of the CBL102 (3.5mm phone plug) into the 50 Ohm output of the STM100C.

Note: If the STM100C Stimulator is used with a Biopotential amplifier on the same nerve—which is nearly always the case—make sure that the black lead of the CBL106 (stimulation negative) is connected to the same pin as the ground lead going to the Biopotential amplifier. This is easy to do because the design of the JUMP100 allows stacking connections.

Electrode Accessories

Abrasive Pads

Before applying electrodes, abrade the skin lightly with an ELPAD to remove non-conductive skin cells and sensitize skin for optimal adhesion.

Adhesive

Use adhesive tape for attaching Active Electrodes and other devices. Use the preferred tape or BIOPAC's adhesive tape: **TAPE1** single-sided; **TAPE2** double-sided.

Adhesive Disks

Two-sided adhesive collars hold reusable electrodes in place. **ADD204** 19 mm outside diameter, use with EL254 and EL254S; **ADD208** 22 mm outside diameter, use with EL258 and EL258S.

Electrode Gels

GEL1 & GEL100 Non-irritating, hypo-allergenic gel used as a conductant with the EL250 series reusable electrodes. GEL1 = 50 g; GEL100 = 250 g

GEL101 Non-irritating, isotonic gel is primarily used as a conductant for the TSD203 electrodermal response electrodes. Each tube contains 114 g (~4 ounces).

GEL101 is 0.5% Saline in a neutral base and is the appropriate GEL to use for GSR, EDA, EDR, SCR, and SCL. This electrode paste has an approximate molarity of 0.05M NaCl and is 0.5% Saline; the Saline concentration is adjusted to obtain a final paste molarity of 0.05M NaCl. This particular molarity is in line with the recommendation made by Fowles (1981). Psychophysiology, 18, 232-239

GEL102 Ten20 Conductive Gel 114 g(~4 ounces). This gel is abrasive and should be used with care not to overabrade the skin. It is not recommended for use with current inducing electrodes, such as defibrillator or neuro-stimulating equipment. Not to be used on patients with a history of skin allergies to cosmetics and lotions. Topical use only.

- ECG:Apply gel to entire electrode site with gauze pad. Rub into skin lightly. Rub off excess with clean gauze pad. Apply proper electrode gel and electrode.
- EEG:Apply gel to electrode site on scalp with cotton swab. Rub lightly. Apply electrode paste and electrode over the gel. Wash skin promptly after use.

GEL103 Tensive Adhesive Gel, 33 ml. Conductive adhesive gel. This safe, non-flammable, odorless gel is recommended for TENS, EMG, EEG, and similar protocols.

- Eliminates tape and tape irritation
- Conductive immediately, no need to wait
- Non-flammable, no solvent odor
- Best adhesive gel available
- Hypoallergenic, bacteriostatic, non-irritating
- Water soluble, easily removed with water

GEL104 Electrode Gel - salt free - 250 g (8.5 oz). **SPECTRA 360®** electrode gel.The only salt-free and chloride-free electrically conductive gel, recommended for all electromedical procedures. Salt-free characteristics make it particularly suitable for long-term applications. Spectra 360 differs significantly from all other electrically conductive media...it works by wetting the skin, thereby reducing skin resistance.

- Salt-free, no sodium ion transfer
- Non-irritating, hypoallergenic, bacteriostatic
- Product of choice for conductive rubber/carbon electrodes
- Product of choice for ECG and TENS
- Non-gritty STAY-WET® formula allows for prolonged use without re-application

Coban Wrap

Self-adhesive Coban™ wrap can be used to hold electrodes, VMG transducers and *f*NIR sensors on a subject.

- 4 inch x 5 yard (fully stretched) (100 mm x 4.5 m)
- Latex free self-adherent wrap
- Nonsterile
- Tan

Chapter 5 MRI & MP System Components

Magnetic Resonance Imaging and MP System Components

MRI-compatibility Statement

“Radiotranslucent” and “MRI-compatible” products are ones which are brought into the MRI Chamber room. All other BIOPAC products can be brought into the MRI control room, as this room is not subject to the high field gradients in the MRI.

BIOPAC defines “Radiotranslucent” products as products that have no thermally or electrically conductive metal and no robustly magnetically susceptable materials (i.e. significantly Ferromagnetic or Ferrimagnetic materials) in the applied part. These products may include electrically conductive materials (i.e. carbon fiber, electrode gel), but due to relatively low instrinic electrical conductance, self-heating effects due to eddy currents are typically minimal. These products are best suited for MRI and fMRI applications.

BIOPAC defines “MRI-compatible” products as products that have some thermally and electrically conductive metals, but no robustly magnetically susceptable materials (i.e. Ferromagnetic, Ferrimagnetic) in the applied part. These may be suitable for some MRI and fMRI applications. Because these products include some relatively high thermal and electrically conductive components, self-heating effects due to eddy currents can become problematic. In cases where this problem manifests, some consideration to thermal insulation from the thermally and electrically conductive applied part to the subject is relevant.

BIOPAC defines “Radio-opaque” products as products whose applied part is easily visible in an x-ray machine viewer so it can be better manipulated. Radiotranslucent in this context implies that the applied part is only partially or not visible in the x-ray viewer. Radio-opaque products are not necessarily suitable for use in MRI or fMRI applications.

Setup Guidelines

See **App Note AH-223** Physiological Measurements using BIOPAC in MRI Systems

App Note AH-230 Connections for Physiological Signals in an MRI

➧ **Contact BIOPAC with any questions regarding set up and grounding to maintain subject safety in accordance with IEC 60601-1.**

Safety Issues

Caution is required when employing electrode leads and electrodes in an MRI environment. Under certain conditions, single fault and otherwise, low impedance conduction through the subject represents a potential hazard due to currents that may be induced in loops placed in the time-varying MRI field gradients and RF fields, and due to body movement in the static MRI field. Low impedance conduction can result in significant heating at the electrode/skin junction, because this point is often the part of the signal path with the highest impedance. Sufficient heating at the electrode/skin junction could result in burns.

Important Note

BIOPAC Systems, Inc. products (including instruments, components, accessories, electrodes and electrode leads) are designed for educational and research applications. BIOPAC does not condone the use of its products for clinical medical applications. Products provided by BIOPAC are not intended for the diagnosis, mitigation, treatment, cure or prevention of disease.

General recommendations for use:

Try to use pressure-based measurements in the MRI whenever possible, given the option. These measurements are very safe and they are instrinsically radio translucent and they do not couple EMI...plus they are always less expensive to implement. Pressure based measurements can record many physiological variables (finger tapping pressure, blood pressure, pulse, hand grip strength, variable assessment, heartsounds, body movements, smiling/frowning)

Where possible, couple all electrical signals via MECMRI cables.

Recommendations for specific applications:

- Airflow
    - higher airflow: use AFT21 or AFT22 or AFT25 with lots of AFT7 or AFT12 tubing to TSD117 (in Control room)
    - low airflow use TSD127 with dual AFT30 tubing to TSD160A (in Control room)
- Biopotential recording: use LEAD108A and EL508.
- Blood pressure, use RX-120 series, with dual AFT30 Tubing and TSD104A (in Control Room)
- Blood Volume Pulse and O2SAT: use TSD123A or TSD123B, with MECMRI-OXY to OXY100C.
- Finger twitch, use SS61L (w/long cable) to MRIRFIF to custom cable to DA100C.
- For GSR measurements, use LEAD108A to record via:
    - EL509 (dry electrode and add gel).
    - *or* transducer: TSD203 with GEL101
- Hand strength (dynamometry), use SS25LA (w/long cable) to MRIRFIF to custom cable to DA100C
- Laser Doppler Flow measurements have the problem of proximity of LDF unit to magnet (only 2 meters), so these are best used when short distances can be tolerated from MRI to LDF unit. This would be the case with smaller bore magnets, which are used for animal work. The best choices here are the disposable probes because they will provide extra length, with disposable fiber + driver. If the LDF100C is to be used with humans for MRI or fMRI, contact BIOPAC to discuss custom LDF probe options for longer lengths.
- Pressure-based signals: route via waveguide using AFT30 series tubing
- Pulse measurements, use TSD110 with AFT30 tubing and TSD160A (secure with TAPE1)
- Respiration rate use TSD201or TSD202A (via thermistor over nose) with MECMRI-TRANS to appropriate amp.
- Skin temperature, use TSD202A with TAPE1, with MECMRI-TRANS to SKT100C
- Stimulation, use LEAD108 (shorter carbon leads) and EL508 or EL509
- Trigger – see **DTU100** Digital Trigger and **DTU200/300** Gating, starting on page 104
- Variable assessment, use TSD115A to MRIRFIF to custom cable to DA100C
- Variable assessment/hand strength: use pump bulb and AFT30 tubing to TSD160 series or TSD104A.

MRI Smart Modules

- ECG Electrocardiogram MRI-Compatible Amplifier - ECG100C-MRI
- EDA Electrodermal Activity MRI-Compatible Amplifier - EDA100C-MRI
- Electroencephalogram MRI-Compatible Amplifier - EEG100C-MRI
- EMG Electromyogram MRI-Compatible Amplifier - EMG100C-MRI
- Pulse Plethysmogram MRI-Compatible Amplifier - PPG100C-MRI

The MRI smart amplifiers incorporate advanced signal processing circuitry which removes spurious MRI artifact from the source physiological data. Signal processors are able to distinguish between physiological signal and MRI artifact as manifested by gradient switching during MRI sequences, such as Shim or EPI.

Because MRI-related transient artifact is removed at the source, the MRI version amplifier can be sampled at the same rate as during normal (non-MRI) physiological recording. There is no longer any requirement to over-sample the amplifier output to capture every nuance of MRI artifact to train secondary computer-based processing steps to remove such artifact.

In every aspect, data recording is easier and the final results are cleaner when using the MRI version amplifiers to record physiological data in the fMRI or MRI.

Features:

- Less sensitivity to electrode and transducer lead placement
- Improved gain selectability
- No missing spectra in physiological signal frequency band
- No requirement for acquisition oversampling
- No need for computer-based real-time or post-processing signal processing
- Clean data available as real-time analog output

Safety Guideines for Recording Biopotential Measurements in the MRI Environment

1. Place electrodes on the subject according to these guidelines:

A) Prepare the subject's skin surface with ELPAD to create low contact source impedance at the electrode attachment site. Be careful to wipe away any excess electrode gel form the surface of the subject's skin.

B) Attach the EL508 or EL509 electrodes as close to each other as possible, on the subject's skin, for the measurement.

C) Place electrodes in as straight of a line as possible which is perpendicular to the magnet's axis.

D) Place electrodes between 3-5 cm apart, if possible; the larger the area between the electrodes, the stronger the MRI gradient artifact.

2. Connect the electrode lead set to the electrodes according to these guidelines:

A) Make sure that the electrode leads do not loop in a "circle", "S" or "U" shape. Also, do not twist or braid the electrode leads.

Looped, braided or twisted leads pick up RF energy, resulting in current induction and increased localized heating.

B) Run the leads out of the chamber bore in the simplest (straightest) manner possible.

C) Do not allow the electrode leads to touch the subject's bare skin. Electrode leads may heat up in the MRI.
- Use a thermal insulator (such as a blanket or towel) between the electrode lead and the subject's skin.
- It's also possible to use thermally-insulating foam jacket, similar to those used for insulating copper tubing, for placing the electrode leads to keep them away from the subject's skin.

See also: Safety Awareness Notes for Cables and Electrodes During MRI

ECG100C-MRI

Gain:	500, 1000, 2000, 5000
Output selection:	Normal, R wave indicator
Frequency Response	Maximum Bandwidth (.05 Hz - 150 Hz), can be customized at BIOPAC
Low Pass Filter:	35 Hz, 150 Hz
High Pass Filter:	0.05 Hz, 1.0 Hz
Notch Interference Filter:	50 dB rejection @ 50 or 60 Hz
Noise Voltage (0.05-35 Hz):	0.1 µV (rms)
Zin:	2M ohm (Differential), 1000M ohm (Common mode)
CMRR:	110 dB min (50/60 Hz)
Common Mode Input Voltage Range:	±10 V (referenced to amplifier ground) ±1500 VDC (referenced to mains ground)
Output Range:	±10 V (analog)
Input Voltage Range	Gain / Vin (mV)
	500 / ±20
	1000 / ±10
	2000 / ±5
	5000 / ±2

EDA100C-MRI

Gain:	20, 10, 5, 2 µsiemens/volt (i.e. µmhos/volt)
Low Pass Filter:	1 Hz, 10 Hz
High Pass Filter:	DC, 0.05 Hz, 0.5 Hz
Sensitivity:	0.7 nano-siemens (with MP System)
Constant Voltage Excitation:	Vex = 0.5 VDC
Output Range:	±10 V full range (analog); 0-10 V nominal range
INPUT SIGNAL RANGE	Gain / Range (µmho)
	20 / 0-200
	10 / 0-100
	5 / 0-50
	2 / 0-20

Note: Normal human range is 1-50 µmho.

Unit Note—BIOPAC software calculates SCL/SCR in µmho, the traditional unit of conductance. Micromho (µmho) is interchangeable with the alternative microsiemen (µS). To use Ohm, the traditional measure of *resistance*, convert as 1 µmho equals 1,000,000 ohm.

EEG100C-MRI

Gain:	5000, 10000, 20000, 50000	
Output selection:	Normal, Alpha wave indicator	
Low Pass Filter:	35 Hz, 100 Hz	
High Pass Filter:	0.1 Hz, 1.0 Hz	
Notch Interference Filter:	50 dB rejection @ 50/60 Hz	
Noise Voltage (0.1-35 Hz):	0.1 µV (rms)	
Zin:	2 Mohm (Differential)	
	1000 Mohm (Common mode)	
CMRR:	110 dB min (50/60 Hz)	
Common Mode Input Voltage Range:	±10 V (referenced to amplifier ground)	
	±1500 VDC (referenced to mains ground)	
Output Range:	±10 V (analog)	
Input Voltage Range:	Gain	Vin
	5000	±2 mV
	10000	±1 mV
	20000	±0.5 mV
5000	0	±0.2 mV

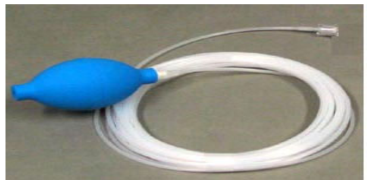
EMG100C-MRI

Gain:	500, 1000, 2000, 5000	
Low Pass Filter:	500 Hz, 5000 Hz	
High Pass Filter:	1.0 Hz, 10 Hz, 100 Hz	
Notch Interference Filter:	50 dB rejection	
	@ 50/60 Hz	
Noise Voltage (10-500 Hz):	0.2 µV (rms)	
Zin:	2M ohm (Differential),	
	1000M ohm (Common mode)	
CMRR:	110 dB min (50/60 Hz)	
Common Mode Input Voltage Range:	±10 V (referenced to amplifier ground)	
	±1500 VDC (referenced to mains ground)	
Output Range	±10 V (analog)	
Input Voltage Range		
	Gain	Vin (mV)
	500	±20
	1000	±10
	2000	±5
	5000	±2

PPG100C-MRI

Gain:	10, 20, 50, 100
Low Pass Filter:	3 Hz, 10Hz
High Pass Filter:	DC, 0.05 Hz, 0.5 Hz
Noise Voltage:	0.5 µV (RMS); amplifier contribution
Output Range:	±10 V (analog)
Input Signal Source:	TSD200
Excitation:	6 V

TSD114-MRI Response/Hand Force Transducer for MRI




The TSD114-MRI consists of a pump bulb (RXPUMPBULB), pressure transducer (TSD104A equivalent, terminated in DSUB9), and tubing (AFT30-XL). Subjects can squeeze the bulb by hand or apply pressure via foot, thigh, etc. to indicate a response while in the MRI.

- Requires MECMRI-DA for proper operation.

The output of the TSD114-MRI device is ultimately voltage. The device provides a output voltage which moves in a variably linear fashion with respect to applied pressure in the squeeze bulb. To obtain usable voltage output, the device requires amplification via BIOPAC's DA100C.

The device has high accuracy for pressure measurements, on the order of ±1%. It's based on pneumatic principles of operation. It comes equipped with a 10 meter polyethylene tube; additional polyethylene tube extensions are available from BIOPAC.

To use the TSD114-MRI with a third-party A/D converter, use DA100C and IPS100C.

DA100C amplifies and conditions the mV level signal coming from TSD114-MRI

IPS100C will supply isolated power to DA100C

High level output voltage (anywhere in the range of ±10 V, such as 0-5 V) can be obtained via the front panel of IPS100C, via 3.5 mm phono plug. This signal can be directed straight to the third-party A/D converter.

TSD114-MRI Specifications

Pump Bulb: Rubber bulb with endcap for connection to the pressure transducer
Transducer: Equivalent to TSD104A
Sensitivity: 5 µV per mmHg (for 1V excitation)

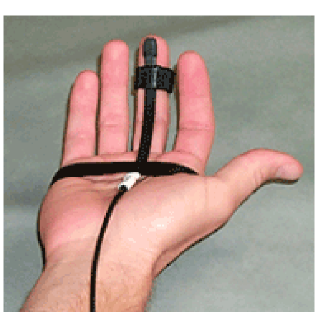
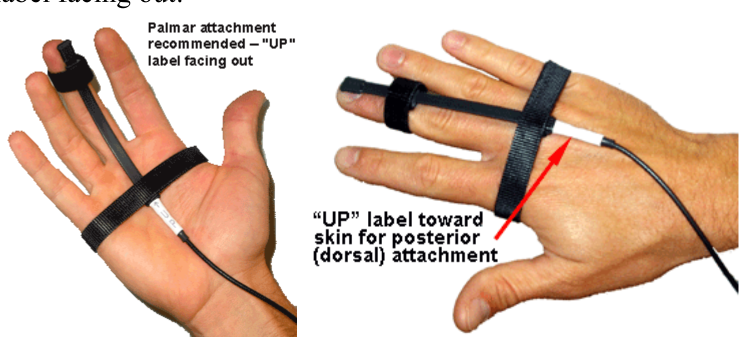
- Used with the DA100C with factory CAL 2 V excitation, sensitivity is 10 µV per mmHg
- Set for DA100C at Av =1000, sensitivity at MP150 is 10 mV per mmHg
- The MP150 can resolve to 300 µV, so the system can resolve (.3 mV)/(10 mV/mmHg) or 0.03 mmHg
- To increase sensitivity, increase the excitation voltage up to 10 V (contact BIOPAC)

Tubing: See AFT30-XL

TSD131-MRI Finger Twitch Transducer for MRI

The TSD131-MRI transducers record finger twitch responses from human subjects in the MRI. The transducer conforms to the shape of the finger and attaches via Velcro straps.

Palmar attachment recommended, with "UP" label facing out:

If a protocol requires posterior (dorsal) attachment, "UP" label must be placed toward skin for optimum response:

TSD131-MRI Specifications

Weight: 7 g
Dimensions (l x w): 14.6 cm x 0.50 cm
Cable Length: 8 m

Interface: MECMRI-HLT to HLT100C

TSD121B-MRI HAND DYNAMOMETER FOR MRI

- Terminates in DSUB9 and **requires MECMRI-DA** for proper operation.

The hand dynamometer measures clench force in the MRI. The lightweight, ergonomically designed transducer provides direct readings in kilograms or pounds. Use in isolation or combine with EMG recordings for in-depth studies of muscular activity. The isometric design improves experiment repeatability and accuracy. The isometric design improves experiment repeatability and accuracy. The TSD121B-MRI has an 8 meter cable terminated for connection to the MECMRI-DA. Simple calibration procedure makes this device very easy to use.

TSD121B-MRI Specifications

Isometric Range: 0-90 kg
Nominal Output*: 782 µV/kg
Weight: 323 g
Dimensions: 17.78 cm x 5.59 cm x 2.54 cm
Cable Length: 8 m
Interface: MECMRI-DA to DA100C in control room

* Nominal Output 782 uV/kg assumes that DA100C VREF1 is set to +1 volt, the factory default.

TSD121B-MRI Calibration

Sample calibration *Sample values shown are for Gain 200 (per switch on the DA100C) and Range 20 kg*

1. Multiply Gain by Nominal Output: 200 * 782 µV/kg = 0.1564 V/kg.
2. Multiply the result by the Range: 0.1564 V * 20 kg = 3.128 V per 20 kg range.
3. Plug the TSD121B-MRI into the cabling system/amplifier.
4. For **CAL1**: remove all weight from the TSD121B-MRI, press CAL1 to get the Input Value, and then enter 0 for Map (Scale) Value.
5. For **CAL2**: add 3.128 V (the result from step 2) to the CAL1 Input Value and enter it in the CAL2 Input Value, and then enter 20 kg for the Map (Scale) Value.
6. Click **OK**.

LEAD108 Series — MRI-compatible/Radiotranslucent Leads for EL508/EL509

Use the LEAD108 series with EL508 MRI-compatible, radiotranslucent electrodes and EL509 disposable radiotranslucent dry electrodes (see page 140 for definitions and details of MRI terms).

Construction: Carbon fiber leadwire and electrode snap
Leadwire Diameter: 1.5 mm
Leadwire Resistance: 156 Ohms/meter
Leadwire Length: **LEAD108** 1.8 m, **LEAD108A** 3.6 m, **LEAD108B** 15 cm, **LEAD108C** 30cm

MRI Components

MRI Cable/Filter Sets The table below illustrates the components of each cable/filter set. See below for full descriptions of each included cable and filter.

Cable/Filter Sets	MRIRFIF	MRIRFIF-2	MECMRI-1	MECMRI-2	MECMRI-3	MECMRI-4	MECMRI-5	MECMRI-6
MECMRI-DA — For recordings with a transducer in the MRI chamber room and the DA100C in the MRI control room. Use to connect directly to the following transducers: Medium Flow Pneumotach (TSD117-MRI) or Hand clench dynamometer (TSD121B-MRI).	X						X	
MECMRI-HLT — For recordings in the MRI with the HLT100C. Use to connect directly to the following transducers: TSD115-MRI or TSD131-MRI.	X							X
MECMRI-OXY — Use to connect to the OXY100C Pulse Oximeter and TSD123A/B Oximetry transducers for MRI applications.		X						
MECMRI-STMISO — Use to connect directly to the following stim isolation adapters: STMISOC, STMISOD, or STMISOE.	X		X			X		
MECMRI-TRANS —For **Transducer** recordings in the MRI. Use to connect directly to the following transducer amplifiers: GSR100C, PPG100C, RSP100C, or SKT100C. Connection Sequence: Subject to transducer to MECMRI-1 to MRIRFIF to MECMRI-3 to transducer module.	X		X		X			
MECMRI-BIOP — Component set for **Biopotential** recordings in the MRI. Use to connect directly to any of the following biopotential amplifiers: ECG100C, EEG100C, EGG100C, EMG100C, EOG100C, ERS100C. Connection Sequence: Subject to electrodes to leads to MECMRI-1 to MRIRFIF to MECMRI-2 to Biopotential Module	X		X	X				

MRIRFIF(Combination Filter)

MRIRFIF is a five-line Pi filter set, designed for interfacing between the MECMRI-1 chamber room cable and any of the MRI control room cables (MECMRI2-MECMRI6).

See also: App Note 223 Physiological Measurements in Magnetic Resonance Imaging Systems Using BIOPAC Equipment.

1. **MRIRFIF**: -3 dB point = 100 kHz
2. **MRIRFIF-2**: -3 dB point = 1 MHz
3. **MRIRFIF + MRIRFIF-2** = 3 dB point = 70 kHz

- attenuation is -60 db from 7 MHz to 1,000 MHz
- attenuation slope from 70 kHz to 7 Mhz is 30 dB per decade

This Pi filter set has a dielectric withstand voltage of 1,500 VDC and is thus compatible with IEC 60601-1 requirements. The Pi filter set is designed to shunt RF energy from the MRI or control room chambers to EARTH GROUND without sacrificing CMRR performance for the recording of small valued biopotential or transducer signals.

The MRIRFIF's symmetrical construction, with dual 9-pin female connectors, results in a pin swap for pins 1, 2, 3, 4, 5, regarding signal flow as illustrated here:

MRIRFIF	DSUB 9 female				
Control Room side	1	2	3	4	5
Chamber Room side	5	4	3	2	1

Accordingly, if the MRIRFIF and associated cable assemblies (such as MECMRI-#) are used with any existing patch panel connectors, the existing connector must be a male/female 9-pin straight-through DSUB patch or filter connector. The male side of the existing connector must be on the Control room side to successfully connect the MRIRFIF to this connector.

Best performance is obtained by robustly attaching the GROUND of the MRIRFIF (metal enclosure) to EARTH GROUND at the junction panel. Mounting the MRIRFIF to the junction panel via the included L-bracket establishes an excellent ground to the panel. EARTH GROUND must be robust and held to the same potential as MAINS GROUND.

Leakage Currents

1. **MRIRFIF:** The IEC 60601-1 standard specifies a leakage current of 5 ma assuming double fault conditions. 265 VAC at 60 Hz will source 5ma into a reactance of 53 K. This reactance is equivalent to an effective subject capacitance to equipment ground of 0.05uF. The BIOPAC MP unit establishes a subject to ground capacitance of 0.005 uF. The Pi filter (MRIRFIF) incorporates a 0.002uF subject capacitance to ground (2 of 0.001 uF caps). Accordingly, even with 16 MECMRI cables—with 16 MRIRFIFs—this results in a capacitance of .037 uF, which is 74% of the IEC 60601-1 limit, assuming mains is 265 VAC at 60 Hz.
2. **MRIRFIF-2:** This filter has a dielectric withstand voltage of 1,500 VDC and is compatible with IEC60601-1 requirements. The filter is designed

to shunt RF energy from the MRI or control room chambers to EARTH GROUND without sacrificing CMRR performance for the recording of small valued signals.

- MRIRFIF-2: -3 dB point = 1 MHz

  This nine-line Pi filter is designed for interfacing between the MRI chamber room cable (MECMRI-OXY) and the MRI control room cable (OXY-MRI). If the MECMRI-OXY set is used with an existing patch panel connector, the MRIRFIF-2 should be plugged into the Control Room side of the patch panel connector, which must be a male/female 9-pin straight-through DSUB patch or filter connector. The male side of the existing connector must be on the Control room side to successfully connect to the MRIRFIF-2 and OXY cables.

  Best performance is obtained by robustly attaching the GROUND of the MRIRFIF-2 (metal enclosure) to EARTH GROUND at the junction panel. Mounting the MRIRFIF-2 to the junction panel establishes an excellent ground to the panel. EARTH GROUND must be robust and held to the same potential as MAINS GROUND.

  The IEC 60601-1 standard specifies a leakage current of 5 ma assuming double fault conditions. 265 VAC at 60 Hz will source 5 ma into a reactance of 53 K. This reactance is equivalent to an effective subject capacitance to equipment ground of 0.05 uF. The BIOPAC MP unit establishes a subject to ground capacitance of 0.005 uF, and the Pi filter (MRIRFIF-2) incorporates a 0.0018 uF subject capacitance to ground. Accordingly, even with 16 MECMRI cables with 16 MRIRFIFs, this results in a capacitance of .0338 uF, which is 68% of the IEC 60601-1 limit, assuming mains is 265 VAC at 60 Hz.

3. **MRIRFIF + MRIRFIF-2:** The IEC 60601-1 standard specifies a leakage current of 5 ma assuming double fault conditions. 265 VAC at 60 Hz will source 5 ma into a reactance of 53 K. This reactance is equivalent to an effective subject capacitance to equipment ground of 0.05 uF. The BIOPAC MP unit establishes a subject to ground capacitance of 0.005 uF. The Pi filter set (MRIRFIF + MRIRFIF-2) incorporates a 0.003 uF subject capacitance to ground. Accordingly, even with 15 MECMRI cables—with 15 MRIRFIFs—this results in a capacitance of .05 uF, which is 100% of the IEC 60601-1 limit, assuming mains is 265 VAC at 60 Hz

MECMRI-1

This is a Biopotential or Transducer cable for use inside the MRI chamber room. It supports one to five subject or transducer electrical connections and is 8 meters long. The cable incorporates a plastic housed DSUB9 Male connector to panel mount with the chamber room exposed DSUB9 female connector of the MRIRFIF.

MECMRI-2

This is a Biopotential cable for use inside the MRI control room. It supports one to five subject electrical connections and is 2 meters long. The cable incorporates a plastic housed DSUB9 Male connector to panel mount with the control room exposed DSUB9 female connector of the MRIRFIF. This cable connects directly to any of the following biopotential amplifiers: ECG100C, EEG100C, EGG100C, EMG100C, EOG100C, ERS100C.

MECMRI-3

This is a Transducer cable for use inside the MRI control room. It supports one- to three-subject transducer connections and is 2 meters long. The cable incorporates a plastic housed DSUB9 Male connector to panel mount with the control room exposed DSUB9 female connector of the MRIRFIF.

- This cable connects directly to any of the following transducer amplifiers: GSR100C, PPG100C, RSP100C, SKT100C.

MECMRI-4

This cable is used inside the MRI control room. It supports one channel of subject stimulator connection and is 2 meters long. The cable incorporates a plastic housed DSUB9 Male connector to panel mount with the control room exposed DSUB9 female connector of the MRIRFIF interference filter. This cable connects directly to any of the following stim isolatation adapters: STMISOC, STMISOD, or STMISOE.

Note One MECMRI-4 comes with the MECMRI-STIMISO setup kit.

MECMRI-5

This 2-meter cable is used inside the MRI control room. It supports one channel of general-purpose transducer output and connects directly to the DA100C high-level transducer module and the MRIRFIF interference filter. Cable incorporates a plastic housed DSUB9 male connector to panel mount with the control room exposed DSUB9 female connector of the MRIRFIF interference filter.

Note One MECMRI-5 is included with the MECMRI-DA setup kit.

MECMRI-6

This cable is used inside the MRI control room. It supports one channel of high-level transducer output and is 2 meters long. The cable incorporates a plastic housed DSUB9 Male connector to panel mount with the control room exposed DSUB9 female connector of the MRIRFIF interference filter. This cable connects directly to the HLT100C high level transducer module.

Note One MECMRI-6 is included with the MECMRI-HLT setup kit.

OXYMRI

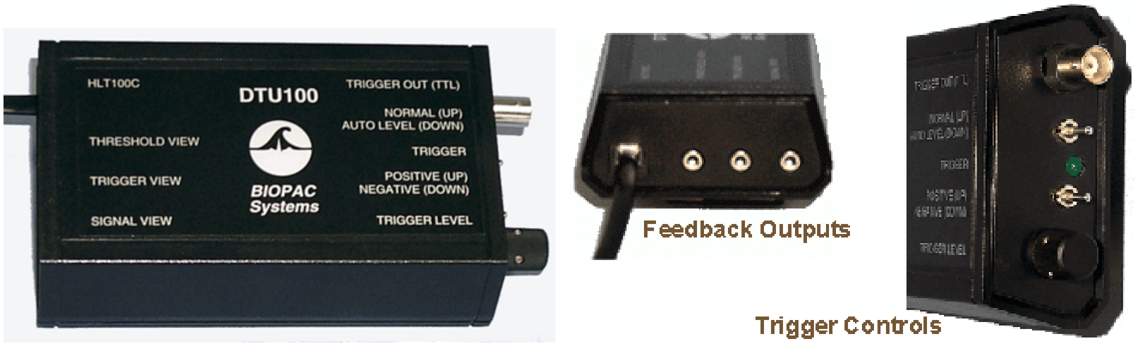
Use this 8-meter MRI chamber room cable for one channel of pulse oximeter connection via TSD123A or TSD123B. One end terminates in a connector that accepts the TSD123A or the TSD123B; the other end terminates in a plastic-housed DSUB9 male connector to panel mount with the chamber room exposed DSUB9 female connector of the MRIRFIF-2 interference filter.

MECMRI-OXY

This 2-meter MRI control room cable provides one channel of connection to the OXY100C. One end terminates for connection to the OXY100C; the other end terminates in a plastic-housed DSUB9 male connector to panel mount with the control room exposed DSUB9 female connector of the MRIRFIF-2 filter.

DTU100 Digital Trigger Unit

Digital Trigger (MRI Trigger)



Use the DTU100 Digital Trigger Unit to trigger an MRI System with the occurrence of the R-wave present in animal (high frequency) ECG data. The DTU100 provides high-level (3000 v) isolation between the MP System and external equipment; the DTU100 is always used with the HLT100C module. This isolation is very important to maintain both subject safety and high quality signal recording. This external hardware module can accept data from any analog output associated with an MP System and convert that analog signal into a TTL compatible trigger suitable for synchronizing with external devices.

For the DTU100, "Analog output" means:

1) Analog output associated with any MP module (DA100C, ECG100C, etc) that is sending data to an MP System on Analog Input channels 1–16.
2) Analog output coming from the MP system via one of its D/A converters on Analog Output channel 0–1.

DTU100 CONTROLS

HLT100C The DTU100 is always used with the HLT100C module. Use the RJ-11 straight through cable provided by BIOPAC to plug the DTU100 into the HLT100C.

Feedback Views The DTU100 incorporates three feedback outputs that can be monitored on the MP System to properly set the threshold (trigger) level and required Trigger Out polarity for any type of analog input. Use a 3.5 mm mono phono cable (CBL100) to connect the respective line to an unused MP system input channel.

Threshold View Shows the Threshold (Trigger) Level

Trigger View Shows the Trigger Output as sent to the external equipment.

Signal View Shows the analog input signal as sent to the DTU100.

Trigger Out Connect a TTL line with BNC female connector between the DTU100 and the trigger device.

Normal/Auto Level The DTU100 incorporates an optional Automatic Level control circuit. The Automatic Level control circuit will expand or compress the analog input signal to fit inside of a ±5v range.

- Normal — use if the analog input signal is clearly defined.
- Auto Level — use if the analog input signal has a widely varying baseline or significant change in amplitude from one desired trigger point to the next; or to try to improve signal definition.

Trigger The Trigger LED (green) lights up whenever the Trigger Out signal goes high.

Positive/Negative If analog data is above the threshold setting the DTU100 output can be set to either high (+5v) or low (0.0 V). When analog data drops below the threshold value the output will be the opposite level.

Trigger Level Select a trigger level (or threshold) that will fire when analog data reaches that threshold.

SYNCHRONIZATION

To synchronize an MRI System with the occurrence of the R-wave, record animal (high frequency) ECG data on an ECG100C amplifier and direct the output to an analog input channel on the MP100/150 Unit.

a) Connect the DTU100 RJ11 cable to the HLT100C channel that is sourcing the ECG analog signal. For example, if acquiring ECG waveform on Channel 2, connect DTU100 RJ11 to channel 2 on the HLT100C.

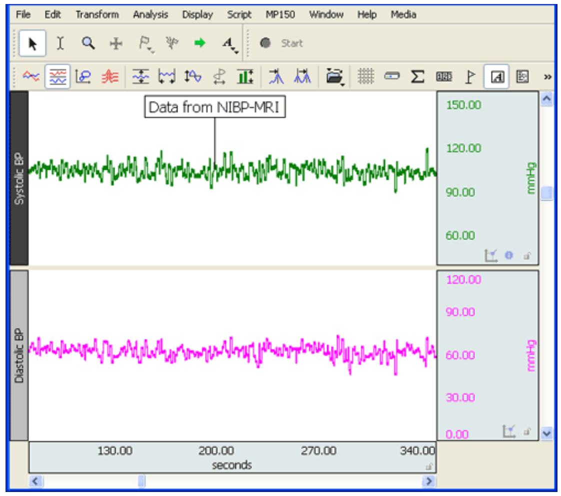
b) Use CBL100 cables to connect the Threshold, Trigger and/or Signal View to unused analog channel inputs on the UIM100C to monitor signals in Acq*Knowledge*.

c) Connect the Trigger Out (TTL) line to the MRI system requiring synchronization to the R-wave of the ECG.

d) If the R-Wave is a clearly defined peak, run the DTU100 in Normal mode. If the R-wave is not always predominant, consider operating the DTU100 in Auto Level mode, or change the location of ECG leads on the subject to obtain a better-defined R-wave peak.

e) Adjust the Trigger Level potentiometer to obtain a Trigger Signal. Change the Trigger Out polarity to Positive or Negative as required for the MRI equipment. Verify proper operation by noting the periodic lighting of the green Trigger LED. This LED should light briefly whenever the R-wave is detected.

NIBP-MRI Noninvasive Blood Pressure for MRI



The NIBP-MRI is a wireless and noninvasive physiological monitoring system that tracks blood pressure, using Pulse-Decomposition Analysis (PDA) technology, as well as heart rate.

NIBP-MRI operates passively at a low constant coupling pressure of 40 mmHg. After being provided a calibrated blood pressure reading, the device tracks blood pressure by analyzing the timing and amplitudes of the primary left ventricular ejection pulse as well as the arterial pulse reflections, at the middle phalange of the middle finger, at the wrist or upper arm.

The system provides relative, real-time, beat-to-beat pressure measurement values during magnetic resonance imaging. The system includes NIBP-MRI Amplifier and Transducer, Bluetooth Dongle, USB D/A Converter and Cables, INISO Optically Isolated Input Adapter, Automatic Blood Pressure Calibration Unit, and runs on a computer using Windows XP or Vista and sends analog signals back to a BIOPAC MP Device or third-party A/D convertors; add an HLT100C to interface the INISO Optically Isolated Input Adapter to the MP150—this combination provides optimal isolation for improved subject safety.

The NIBP-MRI device is controlled from and streams data to the software running on a PC computer. Communication is wireless using the Bluetooth transmission protocol. The device weighs ~114 grams and runs for about 12-hours on a single battery charge. Since the device tracks pulse reflections that stem from the central arteries, it appears to be capable of tracking central blood pressure. Recent experiments furthermore suggest that the technology is particularly suitable as a hemorrhage detector. This is due to the fact that PDA is particularly adept at tracking pulse pressure, which is a sensitive and specific marker for central hypovolemia.

The digital sensor features a miniaturized design based on a piezo-electric sensor and proprietary pulsation-exteriorization as well as electronic filtering and amplification techniques. The device communicates wirelessly with PC-based computers using the Bluetooth protocol.

The device's signal quality is sufficiently high as to allow detailed contour analysis of the radial or digital pulse shape, which is influenced by factors such as systolic and diastolic blood pressure, arterial distensibility and the pressure impedance effects of artery/arteriole interfaces. Specifically, it makes the resolution of the component pulse structure of the radial/digital pulse envelope possible.

NOTE: NIBP-MRI is NOT FDA approved for clinical use.

NIBP-MRI specifications on following page:

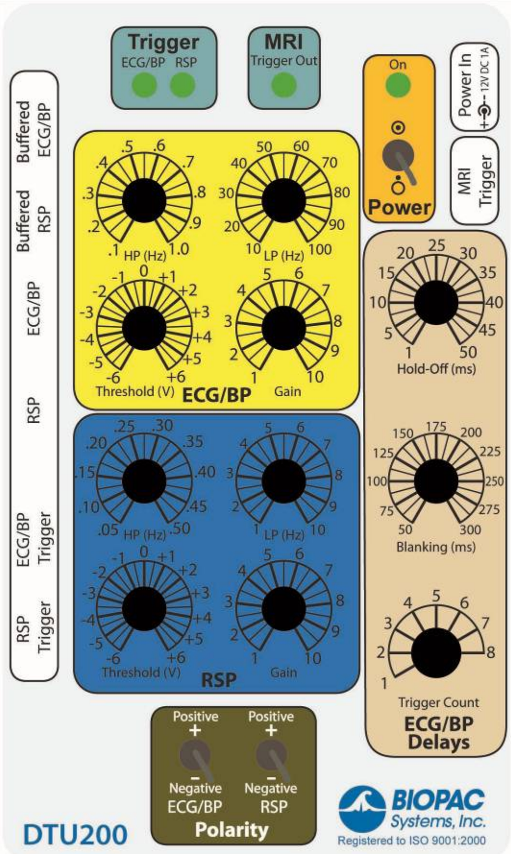
NIBP-MPI Specs:

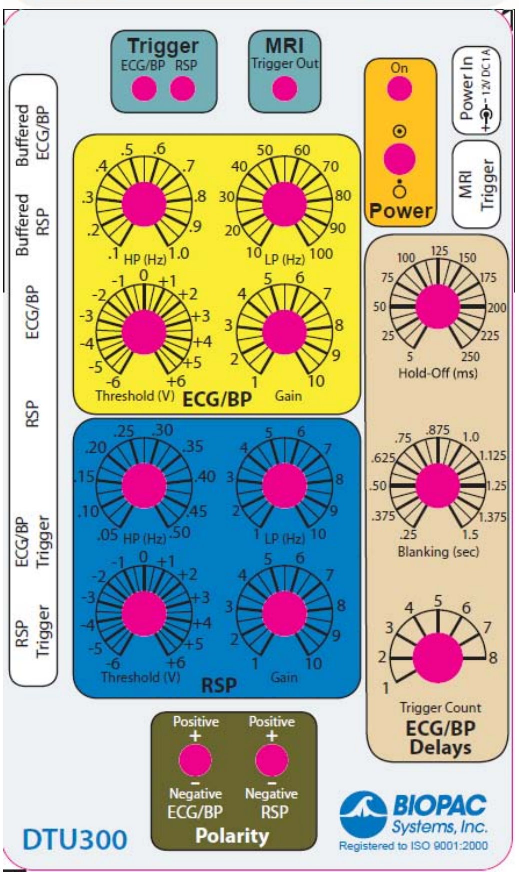
Includes:	NIBP-MRI Amplifier and Transducer with 8 m tubing, Bluetooth Dongle, USB D/A Converter and Cables, INISO Optically Isolated Input Adapter, Automatic Blood Pressure Calibration Unit
Device Dimensions:	78 x 55 x 27 mm
Weight:	114 Grams
Operating Temp:	0 to 40 °C
Operating Humidity:	0 to 95% non-condensing
Latency:	Two seconds for beat-by-beat blood pressure and other analysis; real time for pulse signal
Charge Time:	Two hours; works on charger whether charged or not
Charger Operating Voltages:	Input: 100-240 VAC, 50-60 Hz, 0.6A Output: 5 V, 3.2 A (switch mode power supply)
Charge Life:	Operates 12 hours after full charge
Tubing Length:	8 Meters
Measurement Technique:	Pulse-Decomposition Analysis
Software Compatibility:	Windows 7
MRI Compatible:	YES

NOTE: The HLT100C high-level transducer module is required to interface the INISO Optically Isolated Input Adapter to the MP150 data acquisition unit. This combination provides optimal isolation for improved subject safety.

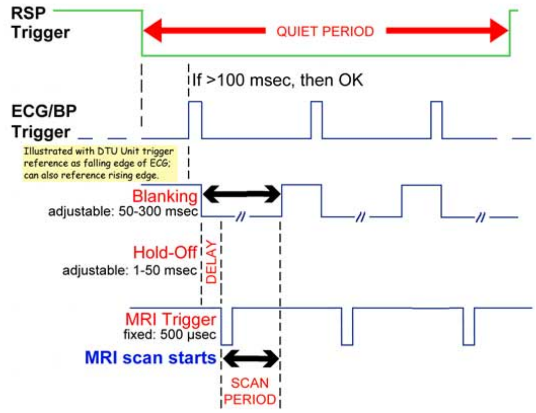
DTU200/300 Dual Channel Gating Systems

- DTU200 dual channel gating system for small animal
- DTU300 dual channel gating system for human/large animal





DTU200 and DTU300 dual channel gating systems for MRI applications send cardiac trigger pulses to the MRI when a respiration signal is in the quiet phase. Pre-processing filters and gain controls further refine the quality of the signal and ensure reliable triggering.



The system requires two analog input signals:

1. Cardiac signal (ECG or BP) from either an ECG100C Electrocardiogram Amplifier or an MPMS100A Micro Pressure Measurement System.
2. Respiration signal from a TSD110-MRI small animal respiration pad with a DA100C General Purpose Transducer Amplifier.

Cardiac phase

- **Threshold**: The ECG or Blood pressure signal passes through a user selectable threshold that creates a square wave (0-5 volt) cardiac trigger signal.
  - **The R-wave or BP signal crosses the threshold in both directions to initiate the MRI trigger signal pulse**.
- **Hold-Off**: A delay control allows precise timing of the trigger signal pulse relative to the rising or falling edge of the ECG R-wave (DTU200: 1-50 msec; DTU300 5-250 msec).
- **Blanking**: A blanking control, initiated on the falling edge of the first accepted ECG in the quiet period, provides a time discriminator (DTU200: 50-300 msec; DTU300: 250-1,500 msec) that prevents the DTU system from falsely triggering on an MRI-corrupted ECG signal.
- **Monitoring**: The cardiac trigger channel is available for monitoring purposes using a BNC to 3.5mm cable (CBL102, included). BIOPAC recommends monitoring this signal with the MP150 data acquisition and analysis system.

Respiration

- **Threshold**: The respiratory system also passes through a similar threshold to create a square wave when the signal crosses the threshold in both directions. The quiet period is user-selectable to be the interval between rising and falling edges or falling and rising edges of the RSP signal.
- **Monitoring**: This signal is available for monitoring purposes using a BNC to 3.5 mm cable (included) CBL102. BIOPAC recommends monitoring this signal with the MP150 data acquisition and analysis system.

Signal Conditioning

- **Cardiac** Gain: 1-10 Low Pass Filter: 10-100 Hz High Pass Filter: 0.1-1 Hz
- **Respiration** Gain: 1-10 Low Pass Filter: 1-10 Hz High Pass Filter: 0.05-0.5 Hz

Output controls

The MRI trigger channel only outputs a cardiac trigger when the respiration trigger channel goes into the quiet period, which occurs when the animal is between breaths and still. The system will output a precise number of cardiac triggers between each respiratory period by adjusting the trigger count control (1-8). Cardiac cycles are only considered if they occur >100 msec after the respiration trigger goes into the quiet period. If there isn't enough time to complete the required number of triggers, the unit will stop and wait for the next quiet period before starting a new count. For example, if the counter is set to output 5 triggers, but there is only enough time to send 4, the unit will ignore the fifth trigger and wait for the next quiet period before starting the count again.

Signal Monitoring

There are outputs for the cardiac and respiration conditioned signals (available at BNC ports: Buffered ECG/BP and Buffered RSP) and the respective triggers. The conditioned signals are in the ±10 volt level range and trigger outputs are 0-5 volts. Seven BNC to 3.5 mm monitoring cables (CBL102) are included.

Compatibility

The unit will interface with either a BIOPAC MP100 or MP150 system. It will also work with third-party amplifiers and data acquisition systems that operate in the ±10 volt range.

DTU200/300 Specifications

Inputs	**ECG/BP**	ECG /BP Trigger	Buffered ECG/BP
RSP		RSP Trigger	Buffered RSP
MRI	**Trigger**	Pulse width 500 µsec, active low	
Signal Controls	**ECG/BP**	HP high-pass filter	LP low-pass filter
	Threshold	.10 - 1.0 Hz	-6 - +6 V (infinitely variable)
	Gain Range	10 - 100 Hz	1 - 10 (infinitely variable)
RSP		HP high-pass filter	LP low-pass filter
	Threshold	05 - 0.5 Hz	1 - 10 Hz
	Gain Range	-6 - +6 V (infinitely variable)	1 - 10 V (infinitely variable)
Polarity	**ECG/BP**	+ (pos, up) or - (neg, down)	
RSP		+ (pos, up) or - (neg, down)	
ECG/BP Delays	**Hold-Off**	DTU200: 1 - 50 ms, DTU300: 5-250 ms (infinitely variable)	
	Blanking	DTU200: 50 -300 ms, DTU300: 250-1,500 ms (infinitely variable)	
Trigge	**r Count**	1 – 8	
Status LED	**Trigger**	ECG/BP red	RSP red
	MRI Trigger Out	green	
Po	**wer**	yellow	
Power	**Switch**	ON (up), OFF (down)	
Supply		12 V DC 1 A	

ECG Gating—Complete Systems provide the cardiac trigger via an electrocardiogram amplifier

- **GATE-CARDRESP-E Gating System for small animal ECG (DTU200)**
- **GATE-CARDRSP-EL Gating System for human/lg anim ECG (DTU300)**

  - DTU200 or DTU300 Dual Channel Cardiac Respiratory Gating System
  - MP150 Data Acquisition & Analysis System with Acq*Knowledge* software (for Windows or Mac)
  - ECG100C Electrocardiogram Amplifier Module
  - MECMRI-BIOP MRI Cable/Filter Set to Biopotential Amplifiers
  - LEAD108 (x 3) Radiotranslucent Clip Lead—unshielded, 1.8 m
  - EL508 (100/pk) Disposable Radiotranslucent Electrodes
  - TSD110-MRI Respiration Transducer
  - DA100C General-purpose Transducer Amplifier

Blood Pressure Gating—Complete Systems provide the cardiac trigger via a Micro Pressure Measurement System

- **GATE-CARDRESP-B Gating System for small animal BP (DTU200)**
- **GATE-CARDRSP-BL Gating System for large animal BP (DTU300)**

  - DTU200 or DTU300 Dual Channel Cardiac Respiratory Gating System
  - MP150 Data Acquisition & Analysis System with Acq*Knowledge* software (for Windows or Mac)
  - MPMS100A-1 Micro Pressure Measurement System
  - TSD173A or TSD173B MRI-compatible Samba Preclin Micro Pressure Transducer
  - TSD110-MRI Respiration Transducer (transducer, sensor, and tubing)
  - DA100C General-purpose transducer amplifier

Chapter 6 Gas Concentration Measurement Modules

O2100C and CO2100C

BIOPAC offers two fast-response analyzers for gas analysis. Each module measures partial pressure (of O_2 or CO_2, respectively) and thus module output is proportional to the pressure in the sample cell. Gas sampled must be free of liquids or any condensable vapors and should be filtered to 5 microns or better.

O2100C Records quickly varying oxygen concentration levels. ***See setup on page 162***

Ideal for monitoring time-averaged O_2 levels using mixing chambers or real-time O_2 levels for breath-by-breath measurements.

Employs an analysis technique based on the parametric oxygen measurement principle.

CO2100C Records quickly varying carbon dioxide concentration levels. ***See setup on page 164***

Ideal for monitoring time-averaged CO_2 levels using mixing chambers or real-time CO_2 levels for breath-by-breath measurements.

Employs a single beam infrared, single wavelength, measurement technique.

Both modules are equipped with a variable speed pump to adjust the flow over a wide range of sampling conditions. Sampling line connections for input and output flow are readily accessible on the front panel of either module.

Each module can interface with the AFT15A and AFT15B mixing chambers (via the AFT20 gas sampling interface kit), the AFT21 and AFT22 non-rebreathing T valves or the AFT25 mask with integral non-rebreathing T valve.

Technical Use Notes

1. Snap the module together with the UIM100C (or other BIOPAC modules).
2. Select an unused channel on the channel selector switch on top of the module.
   - If two or more BIOPAC modules are set to the same channel, the outputs will conflict, resulting in erroneous readings.
3. Turn the MP150/MP100 unit on and start the Acq*Knowledge* software.
   - Please consult the "Acq*Knowledge* Software Guide" for information about Acq*Knowledge*.
4. Plug the adapter into the main power and insert the adapter plug into the back of the module.
   - The module is supplied with a 12 vdc @ 1 amp wall adapter**—do not use other wall adapters with a gas analysis module.**
   - The green POWER LED should light up. If it doesn't, check the adapter main power and the connection to the O2100C module and then, if necessary, check the FUSE on the back of the O2100C module. [The FUSE ratings are: Instrumentation Type, Fast Blow @ 2 amps.]
   - The O2100C module has a warm-up time of approximately 5 minutes. Output readings during this warm-up period will be very erratic.
5. Check for pump operation by turning the PUMP switch ON (after the green POWER LED comes on).
   - The box should emit a hum, indicating that the pump is working. Generally, the PUMP SPEED control will never have to be adjusted.
   - The PUMP will start fast, then slow down and stabilize on a speed after a few seconds. This is a perfectly normal process, designed to overcome the pump's initial mechanical hysteresis.
   - If the pump does not come on or comes on for a brief period and then shuts off, the PUMP SPEED control is set to a very low value (i.e., zero speed). To change the pump speed, keep the PUMP switch in the ON position and use a small straight blade screwdriver to turn the recessed potentiometer in the PUMP SPEED control. Turn trim POT clockwise to increase PUMP speed or Counter-clockwise to decrease PUMP speed
6. Adjust the GAIN switch on the front of the module after proper startup.

Module	**Gain**	**1V output = % gas concentration**	**Voltage output range**
O_2	**100% / V**	10 0% **O_2**	0 to 1 volt
O_2	**50% / V**	50 % **O_2**	0 to 2 volts
O_2	**20% / V**	20 % **O_2**	0 to 5 volts
O_2	**10% / V**	10 % **O_2**	0 to 10 volts
CO_2	**10% / V**	10 % **CO_2**	0 to 1 volt
CO_2	**5% / V**	5% **CO_2**	0 to 2 volts
CO_2	**2% / V**	2% **CO_2**	0 to 5 volts
CO_2	**1% / V**	1% **CO_2**	0 to 10 volts

O_2 example: If the **100% / V** setting is used, then 20.93% oxygen (atmospheric level) will be output as 0.2093 volts or 209.3 mV. Generally, GAIN can be left at the setting of 100% oxygen per volt (top position).

CO_2 example: If the **10% / V** setting is used, then 4% carbon dioxide (approximate concentration in expired breath) will be output as 0.40 V or 400 mV. Generally, GAIN can be left at the setting of 10% carbon dioxide per volt (top position).

Gas Sampling Setup

1. Stabilize the measurement setup prior to sampling any gases.
   Pump speed, filters and sampling lines all affect the oxygen measurement of the module. Everything should be stable prior to attempting module calibration.
2. Attach a 5 micron filter (or better) on the sample input port prior to sampling any gases.
   The sample input port is a male Luer fitting on the front of the module. The module incorporates an internal particulate filter, however the addition of this external filter will extend the life of the internal filter and otherwise improve the long-term performance of the module. Always use a 5 micron hydrophobic sampling filter (or better) at the sampling input of the module. One is included with each module and each Gas Sampling Interface Kit (AFT20). The 5-micron hydrophobic filter will help to protect the module from airborne particulate matter and other contaminants.
3. Screw a 10/32 Luer adapter into the bulkhead fitting and attach the venting line to the Luer adapter to vent undesirable gases away from the site of the module.
   The sample output port is adjacent to the sample input port (on the right, facing the front panel of the module) and is a bulkhead fitting with a 10/32 internal thread.

Important

Sample dry gases only. All water vapor needs to be removed from the sampling stream prior to being monitored by the module. To dry the sampling stream, use water vapor permeable tubing (i.e., NAFION®). The AFT20 Gas Sampling Interface Kit includes all the items necessary (including NAFION® tubing) to efficiently connect the module to the sampling chamber.

Calibration

Each gas concentration module comes factory-calibrated to ± 1% concentration accuracy. At increased flow rates, the calibration may veer further from ±1% accuracy. Generally, **a gas calibration should be performed prior to all exacting measurements**. This may also be required when running at increased pump speeds and thus increased flow rate. Initial (Factory) oxygen accuracy calibration is usually inadequate for varying setup protocols. Proper calibration of the module should be performed after the specific measurement setup is in place.

Choose the calibration gases to bracket the expected measurements. For example

- When performing End Tidal O_2 measurements, normal air can be used as the first calibration gas because the oxygen concentration is known as 20.93%. For the second gas, it might be best to use a calibration gas of 16% oxygen and 84% nitrogen. In this case, the measurements will be most accurate for the range of 16.00% to 20.93% oxygen.
- When performing End Tidal CO_2 measurements, normal air can be used as the first calibration gas because the carbon dioxide concentration is known as 0.04%. For the second gas, it might be best to use a calibration gas of 4% carbon dioxide and 96% nitrogen. In this case, the measurements will be most accurate for the range of 0.04% to 4% carbon dioxide.

Exact calibration is typically performed in Acq*Knowledge*, using the **Scaling** function under **Setup Channels**, once the measurement setup is in place.

1. Set up the measurement so that all gas sampling lines are in place between the module and the sampling chamber.
2. Adjust the PUMP SPEED control (if required) on the module.
3. Run the module and click on the CAL1 button when the first calibration gas is introduced into the sampling chamber.
4. Introduce a second calibration gas into the chamber and click on CAL2 when the second calibration gas is introduced into the sampling chamber.

Note: Do not change the pump speed, the sampling filter or the sampling line length/configuration during or after a calibration. Changing any of these elements may reduce the accuracy of the calibration.

Pump Speed Control

The pump speed is factory preset to result in a sampling flow rate of approximately 100 ml/min, when used with the AFT20 Gas Sampling Interface Kit. The time delay between change of oxygen concentration at the sampling end of the Gas Sampling Interface Kit (AFT20) to measurement at the module is approximately 2.4 seconds. This is because the pump will move 100 ml/min and the internal volume of the Gas Sampling Interface Kit is about 4.0 ml.

$$\text{Volume in ml} = (\pi) \bullet (\text{radius in cm})^2 \bullet (\text{length in cm})$$

The Gas Sampling Interface Kit volume is calculated using:

PVC Sample Line:	72" long at 0.060" D	Volume = 3.336 ml
NAFION® Dryer:	12" long at 0.050" D	Volume = 0.386 ml
Misc. Tubing/Junctions:	6" long at 0.060" D	Volume = 0.278 ml

If the sample rate is 100 ml/min, then the pump will pull 4 ml in 2.4 seconds:

$$(60 \text{ sec/min}) \bullet (4 \text{ ml}) / (100 \text{ ml/min}) = 2.4 \text{ sec}$$

To check the flow rate, breathe into the free end of the sampling line and simultaneously mark the recording (using the marker function in Acq*Knowledge*). The oxygen concentration level should not show a change until after 2.4 seconds. Please note that the pump speed can be changed to a relatively fast level. It's quite possible to exceed the maximum acceptable flow rate to the module, depending on the sampling line type and conditions. A fast flow rate setting won't harm the module, but erroneous readings may occur.

To achieve the best results:

O2100C: Run the pump speed so the flow rate to the module does not exceed 150 ml/min.

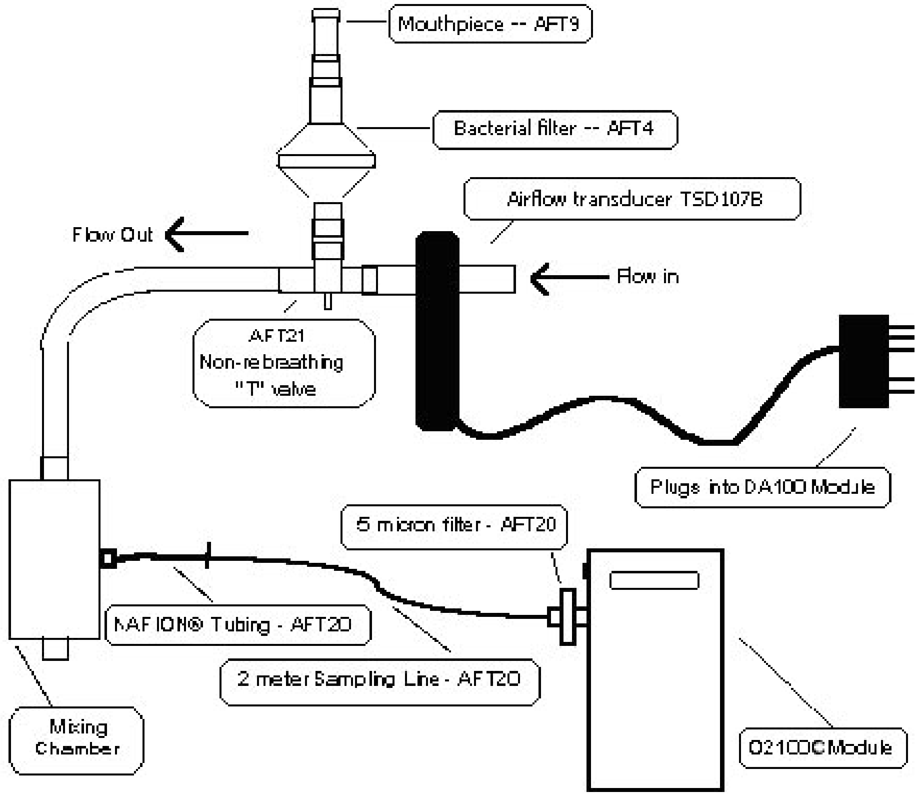
- Between 50 and 100 ml/min, the O2100C module output will be relatively insensitive to flow changes.
- Above 100 ml/min, module output will become increasingly sensitive to flow rate.
- Up to 150 ml/min, the output signal will increase; past 150 ml/min, the signal may oscillate, decrease, or become erratic.
- Response times can often be boosted 50% over the nominal response times of 500ms at 100 ml/min. This particular increase is not exactly specified, as it is somewhat module dependent.
- Run at flow rates between 100 ml/min and 150 ml/min to improve the response time of the O2100C module.

CO2100C: Run the pump speed so the flow rate to the module does not exceed 200 ml/min.

- Between 50 and 200 ml/min, the CO2100C module output will be relatively insensitive to flow changes.
- Above 100 ml/min, module output will become increasingly sensitive to flow rate.
- Above 200 ml/min, the CO2100C module output may become erratic.
- Response times can often be boosted 10% over the nominal response times of 100ms at 100 ml/min. This particular increase is not exactly specified, as it is somewhat module dependent.

O2100C Oxygen Measurement Module

Typical connection for the O2100Cmodule to a mixing chamber, AFT21 and TSD107B:

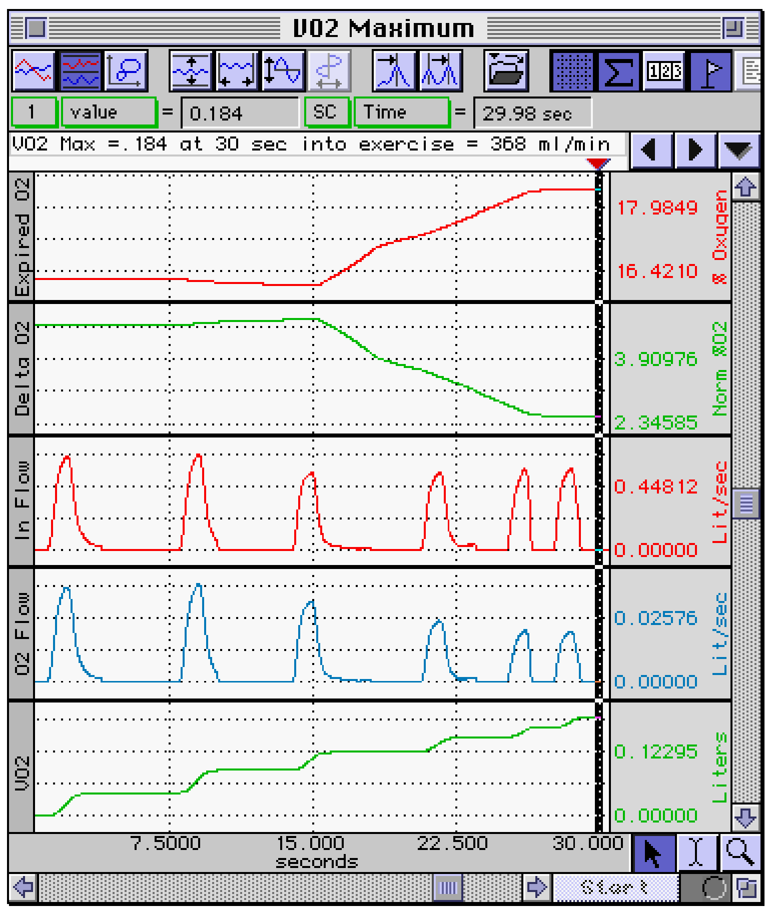


The subject breathes through the mouthpiece (AFT9) that attaches to the non-rebreathing “T” valve (AFT21) via a bacteria filter (AFT4). When the subject inspires, air is drawn into the AFT21, through the TSD107B, as shown by the “Flow In” arrow. When the subject expires, air is forced out through the mixing chamber, as shown by the “Flow Out” arrow.

Assuming the O2100C module is connected to the sampling port of the mixing chamber (via the AFT20 Gas Sampling Interface Kit), the O2100C module will sense the changes in oxygen concentration that occur as the subject breathes.

If the TSD107B is placed in the “Flow In” line, the total volume of expired air can be calculated on a breath-by-breath basis. Because both the oxygen concentration and total volume of expired air are known, it is possible to determine the precise amount of oxygen consumed by the subject during the course of breathing.

The following graph illustrates data collected using this procedure.



Acq*Knowledge* calculated and derived the waveforms in real-time.

Waveform descriptions (as referenced from the top down):

Waveform 1: Expired O_2

This waveform is the O2100C module output. The O2100Cmodule samples the O_2 concentration directly from the mixing chamber.

Waveform 2: Delta O_2

This waveform is the O_2 concentration in the mixing chamber subtracted from the O_2 concentration in the ambient environment (O_2 = 20.93%). This waveform is the O_2 concentration consumed.

Waveform 3: Inspired Flow

This waveform is the total inspired O_2 flow.

Waveform 4: O_2 Flow

This waveform is the mathematical result of multiplying the expired airflow signal measured by the TSD107B by the consumed oxygen concentration (waveform 2). Accordingly, this waveform is the oxygen flow consumed by the subject. Note how the flow signal drops as the normalized oxygen concentration level drops.

Waveform 5: VO_2

This waveform is the integral of the oxygen flow consumed by the subject. The integral of the oxygen flow is the amount of oxygen consumed up to a particular point in time. In this case, V O_2 equaled 184 ml after 30 seconds of exercise, which extends to an estimate of 368 ml/min oxygen consumption.

O2100CSpecifications

Range:	0-100% O_2
Gain:	10, 20, 50, 100 (%O_2/Volt)
Output Range:	0-10 V
Repeatability:	±0.1% O_2
Resolution:	0.1% O_2
Linearity:	±0.2% O_2
Zero Stability:	±0.01% O_2/hr
Response Time	
@50 ml/min:	1000 msec (T10-T90)
@ 100 ml/min:	500 msec (T10-T90) — factory preset
@ 200 ml/min:	160 msec (T10-T90)
Flow Range:	50-200 ml/min (50-150 ml/min recommended)

> ***Note:***
> The module measures the partial pressure of O_2 so the module output is proportional to the pressure in the sample cell. Gas sampled must be free of any liquid or condensable vapors. Gas should be filtered to 5 microns or better. The module utilizes Servomex, Inc. technology for O_2 concentration signal processing.

Delay: *With Delay in Sec and Flow in ml/min:*

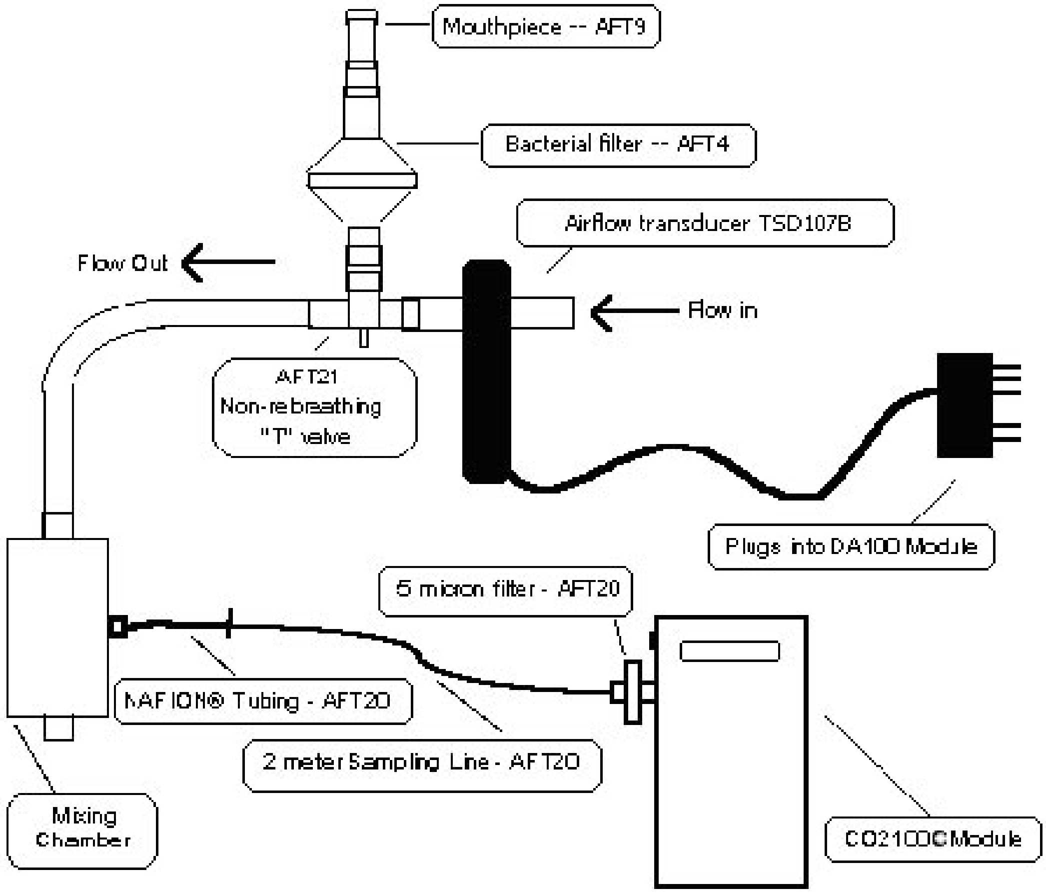
Delay/4.6 = 1/flow
Delay = 240/flow
Flow (ml/min) = 240/Delay (sec)
Example: Delay = 2 sec
Flow = 120 ml/min

Temp Range:	5-50°C
Zero Drift:	±0.05% O_2/°C
Span Drift	±0.25% O_2/°C
Sampling Port:	Male Luer
Weight:	990 g
Dimensions:	7 cm (wide) x 11 cm (deep) x 19 cm (high)
Power Source:	12VDC @ 1 amp (uses AC100A transformer)

See also: AFT Series Airflow & Gas Analysis Accessories, page 167.
Application Note # AH149 — O2100C Module
Application Note # # AH150 — O2100C Module: Sample application

CO2100C Carbon Dioxide Measurement Module

Typical connection for the CO2100C module to a mixing chamber, AFT21 and TSD107B:

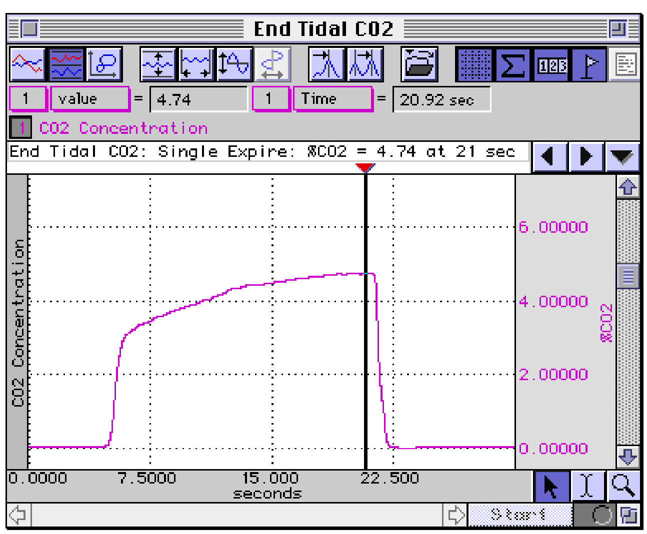


The subject breathes through the mouthpiece (AFT9), which attaches to the non-rebreathing "T" valve (AFT21) via a bacteria filter (AFT4).

When the subject inspires, air is drawn into the AFT21 through the TSD107B (see "**Flow In**" arrow).

When the subject expires, air is forced out through the mixing chamber (see "**Flow Out**" arrow).

This waveform above shows the output of the CO2100C module recorded during a subject's single expiration. Note that the CO_2 concentration peaks out just prior to the Subject's inspiration



It would be possible to monitor the total flow (via the TSD107B) and then multiply the flow by the concentration change. The result would be the precise amount of carbon dioxide expired by the subject.

CO2100C Specifications

CO_2 Range: 0-10% CO_2
Gain 1, 2, 5, 10 (%CO_2/Volt)
Output Range: 0-10 V
Repeatability: 0.03% CO_2
Resolution: 0.1% CO_2
Linearity: 0.1% CO_2
Zero Stability: 0.1% CO_2/24 hours
Response Time:
@ 50 ml/min 130 msec (T10-T90)
@ 100 ml/min 100 msec (T10-T90) — factory preset
@ 200 ml/min 90 msec (T10-T90)
Flow Range: 50-200 ml/min
Delay: *With Delay in Sec and Flow in ml/min:*
Delay/4.6 = 1/flow
Delay = 240/flow
Flow (ml/min) = 240/Delay (sec)
Example: Delay = 2 sec
Flow = 120 ml/min
Temp Range: 10-45°C
Zero Drift: 0.01% CO_2/°C
Span Drift: 0.02% CO_2/°C
Warm Up Time: 5 minutes @ 25°C
Sampling Port: Male Luer
Weight: 740 g
Dimensions: 7cm (wide) x 11cm (deep) x 19cm (high)
Power Source: 12VDC @ 1 amp (uses AC100A transformer)

Note: The module measures the partial pressure of CO_2 so the module output is a function of the pressure in the sample cell. Gas sampled must be free of any liquid or condensable vapors. Gas should be filtered to 5 microns or better. The module utilizes Servomex, Inc. technology for CO_2 concentration signal processing.

See also: AFT Series Airflow & Gas Analysis Accessories, page 167.
Application Note # AH151 — CO2100C Module
Application Note # AH152 — CO2100C Module: Sample Application

GASSYS2-RA/B CO2 & O2 Gas Analysis System

See the **AFT series** of accessories for airflow and gas analysis (page 144).

Modular assembly makes complete cleaning easy!
See page 256 for cleaning details

GASSYS2 modules measure expired O_2 and CO_2 concentrations. When the subject inspires, air is drawn into the GASSYS2 through the TSD107B airflow transducer. The TSD107B is placed on the inspiration side to eliminate any effects associated with expired air humidity. When the subject expires, air is directed to the GASSYS2 module. The GASSYS2 is designed to work with saturated expired air.

Obtain real-time Oxygen Consumption (VO_2) and Respiratory Exchange Ratio (RER) measurements using the MP System with a GASSYS2 module and some airflow accessories. The GASSYS2 connects directly to the MP System via the UIM100C and requires two channels.

The non-rebreathing T-valve directs only expired air to the GASSYS2. Because only expired air is directed to the module, the system acts to average respiratory outflows. This averaging effect causes the CO_2 and O_2 concentrations to vary in accordance to the mean values resident in a few expired breaths.

Two chamber sizes are available for the GASSYS2. Each chamber assembly includes the chamber casing and rod. The chambers work exactly the same way and are interchangeable on the module base. Use the smaller chamber size for small children/medium sized animals.

5-liter chamber — included in the **GASSYS2-RA**; order chamber only as **RX-GASA**

1-liter chamber — included in the **GASSYS2-RB**; order chamber only as **RX-GASB**

The GASSYS2 also includes **AFT7** tubing, **AFT11E** Coupler, **AFT22** Non-rebreathing T-Valve, and a power supply.

GASSYS2 Specs

O_2 sensor: Warm-up: 10 minutes. Response time 10-90%: 30 sec. Accuracy: ±1% FSR*.
Zirconia solid electrolyte with a 0.1-25% sensing range. It runs hot, which helps burn off humidity.

Expected O2 sensor lifespan (in years): [5,256/(number of hours used per year)]*5

- If used for 10 hours per week or 520 total hours in a year, then O2 sensor lifespan would be [5,256/520]* 5 = 50.5 years

CO_2 sensor: Warm-up: 2 minutes. Response time 10-90%: 45 sec. Accuracy: ±3% FSR*.
Uses a humidity-repellant (hydrophobic) membrane and has a sensing range of 0-5%. It uses non-dispersive infrared diffusion with single-beam IR and a self-calibrating algorithm. It also runs hot, which burns off humidity.

Calibration: GASSYS2 sensors are factory calibrated prior to shipping.

Power Supply: 12 V DC @ 1 amp (AC100A) wall adapter for serial numbers ending 200 or greater

*FSR = Full Scale Reading

GASCAL Calibration Gas

GASREG REGULATOR

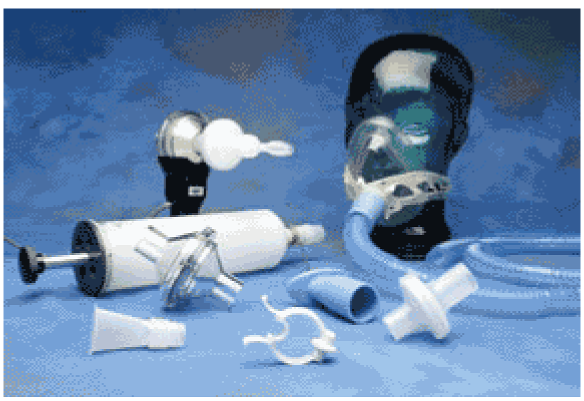
Calibration Gas Specs	
Composition:	4% Carbon Dioxide, 16% Oxygen, balance Nitrogen
Cylinder Type:	ED
Valve Connection:	CGA-973
Accuracy:	+/-0.03% absolute
Stability Guarantee:	3 years
Cylinder Pressure:	2200 psig
Gas Volume:	560 liters

Use the single stage, non-corrosive, general-purpose GASREG regulator with the GASCAL Calibration Gas Cylinder. Single-stage pressure regulators reduce the cylinder pressure to the delivery or outlet pressure in one step, and are generally good for short duration applications.

GASCAL Cylinder Recycling Program available.

- Call 1-800-457-0809 to receive instructions for returning a cylinder; delivery paid by sender and recycling covered by manufacturer.

AFT Series Airflow & Gas Analysis Accessories



AFT1 Disposable Bacterial Filter
Designed to remove airborne bacteria. Pore Size: Virus Filtration Efficiency (VFE): 3.1 micron; Bacterial Filtration Efficiency (BFE): 2.8 micron. Use between the TSD117 and the AFT2. 22 mm ID/OD.

AFT2 Disposable Mouthpiece
22 mm OD; connects to the TSD117 via the AFT1.

AFT3 Disposable Noseclip
Gently squeezes the nostrils shut.

AFT4 Disposable Bacterial Filter
Designed to remove airborne bacteria; for use with the TSD107B, connects between the AFT7 and the AFT9. (35 mm ID/35 mm OD)

AFT6A Calibration Syringe
0.6 liter calibration syringe. *See also*: AFT26 2.0 liter Calibration Syringe

AFT7 Smooth Bore Tubing
1 m length, 35 mm ID; connects to the TSD107B.

***** See the AFT part guide on page 172 for additional applications. *****

AFT8 Autoclavable Mouthpiece

30 mm ID; interfaces with the TSD117 and reduces the cost of disposable parts.

RX117 Replacement Sterilizable Airflow Head

22 mm ID/30 mm OD; autoclavable transducer head for the TSD117; can be used with the AFT8 to reduce the cost of disposable items.

AFT 9 Reusable Mouthpiece

35 mm ID; designed to connect to the TSD107B with the AFT7 via the AFT4. (Also connects to the AFT21 Non-rebreathing T Valve.)

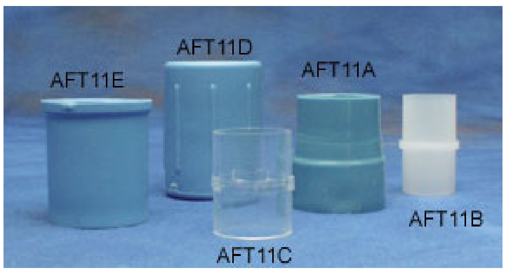
AFT10 Disposable Adult Facemask

These mouthpieces connect to 22 mm breathing circuits. Connects directly to the AFT1, AFT22 non-rebreathing T valve or TSD117 airflow transducer (via AFT11B coupler). Includes hook-ring to secure AFT10S adjustable head strap. (22 mm ID/25 mm OD)

AFT10S Adjustable Head Strap

This fully adjustable latex head strap holds the AFT10 disposable facemask securely to the subject's head. Use one or more straps to securely fasten the mask.

AFT11 Couplers



AFT11A Flexible
AFT11B Rigid
AFT11C Rigid
AFT11D Flexible
AFT11E Flexible
AFT11F Rigid
AFT11H Flexible
AFT11I Flexible (for AFT26)

These couplers are very useful for connecting up a variety of airflow port IDs and ODs to transducers, tubing and calibration syringes. Pick an AFT11 Series coupler that matches the port sizes to be interfaced.

AFT11 Series Coupler Guide

Item 1	Item 2	Coupler
15 mm OD	22 mm ID	AFT11B
20 mm OD	22 mm ID	AFT11B
22 mm ID	15 mm OD	AFT11B
	20 mm OD	AFT11B
	22 mm ID	AFT11B
	22 mm OD	AFT11I
22 mm OD	22 mm ID	AFT11C
	22 mm OD	AFT11C
	25 mm ID	AFT11C
22-25 mm OD	22 mm OD	AFT11E
	25 mm ID	AFT11E

Item 1	Item 2	Coupler
25 mm ID	25 mm ID	AFT11C
25-30 mmOD	25-30 mm OD	AFT11A
	28-35 mm ID	AFT11A
28-35 mm ID	25-30 mm OD	AFT11A
	35 mm ID	AFT11A
34-37 mm ID	41-47 mm ID	AFT11F
35 mm ID	28-35 mm ID	AFT11A
	38 mm ID	AFT11E
35-38 mm ID	22-25 mm OD	AFT11E
35-38 mm OD	35-38 mm OD	AFT11D
35 mm OD	28.6 mm OD	AFT11H

***** See the AFT part guides on on page 172 for common applications. *****

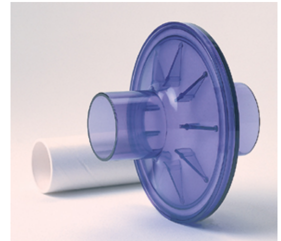
AFT12 Tubing (22mm)

Smooth bore tubing for use in 22mm breathing circuits. (1.8 meter length, 22mm ID)

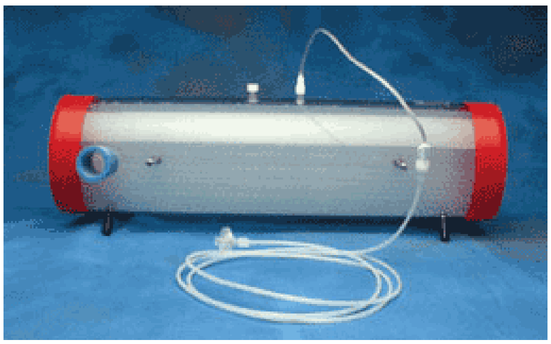
AFT13 Disposable Pulmonary Function Filter and Mouthpiece

Available in packs of 10 or 250

Eliminate cross-contamination concerns with this bacteriological filter with disposable plastic-coated paper mouthpiece to protect subjects and equipment. These exceed all recommended performance standards with 99.9% bacterial filtration efficiency and 99.9% viral filtration efficiency. They feature low resistance and minimal dead space (45 ml when measured without tube fittings). These surpass published ATS recommendations for flow resistance in pulmonary function instrumentation, which suggest resistance should be below 1.5 cm H2O/L/sec at flow rates less than 12 L/sec1. Port: 30 mm OD.



AFT15 Mixing Chambers



AFT15A/B mixing chambers incorporate dual baffles and flexible connection ports capable of interfacing with 35mm or 22mm breathing circuits.

Two female Luer connection ports are provided between the baffles for the simultaneous monitoring of O_2 and CO_2 concentrations.

AFT15A shown with AFT20 (not included)

Use for demanding expired gas analysis measurements (e.g. VO_2 or RER measurements).

Dimensions: 13 cm (dia) x 47 cm (long)   Coupling Ports: 35 mm OD, 25 mm ID

AFT15B — 8 Liter

Use for very high volume and rate expired gas analysis measurements (e.g. VO_2 or RER measurements).

Dimensions: 13 cm (dia) x 73 cm (long)   Coupling Ports: 35 mm OD, 25 mm ID

AFT20 Gas sampling Interface kit

Use to interface the CO2100Cand the O2100C modules with the TSD107B or TSD117 Airflow Transducer breathing circuits.

Includes: 1.8 meters of 1.5mm diameter polyethylene tubing with M/F Luer connector; 30cm Nafion® water vapor permeable tubing with M/F Luer connector; 5 micron filter with M/F Luer connector; M/F Luer to female Luer "Y" connector.

The AFT20 connects the CO2100C or O2100C directly to the sampling port of a mixing chamber. The AFT20 also permits sampling connections to the Non-rebreathing "T" Valves (AFT21 or AFT22).

AFT21 Non-Rebreathing "T" Valve: Female, 35 mm

High performance, very low dead space, low airflow resistance valve, suitable for high airflow applications (e.g. exercise physiology). The non-rebreathing "T" valve incorporates a Female Luer connector gas sampling port for interfacing with the AFT20. All ports are 35 mmOD, 30 mm ID.

Includes: 35 mm OD coupler

Requires: AFT4, AFT7, and AFT9 for proper operation.

AFT22 (top left), **AFT21** (top right) and **AFT21** (bottom)

***** See the AFT part guide on on page 172 for common applications. *****

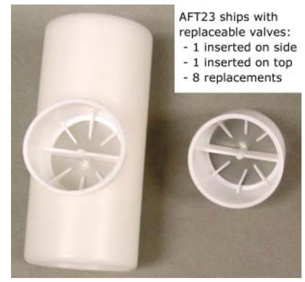
AFT22 Non-Rebreathing "T" Valve: Male, 22 mm

Very low dead space valve, suitable for low to medium airflow applications. The non-rebreathing "T" valve incorporates a Male Luer connector gas sampling port for interfacing with the AFT20. Coupler ports are 22 mm OD fittings. Common port incorporates a 15 mm ID connection. Dead space 20 cc. Resistance: 0.29 cmH2O at 5 liter per minute flow, 0.65 cmH2O at 10 liter per minute. Single subject disposable item **– do not autoclave**. Includes: 22 mm OD coupler

Requires: AFT1 and AFT2 for proper operation.

Includes: 22 mm OD coupler *Requires*: AFT1 and AFT2 for proper operation.

AFT23 Non-Rebreathing T-Valve, 35 mm



The AFT23 is a disposable paper mouthpiece featuring a one-way valve for pulmonary function measurements (expiratory only). It provides low air resistance, adds cross-contamination protection, and is strong and durable. It ships with eight extra valves. Mouthpiece OD: 35 mm. Fits AFT13 pulmonary function filter & mouthpiece set. Used in Curriculum > L18 Metabolic Rate.

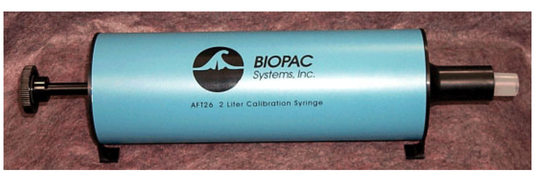
AFT24 Head Support

The AFT24 head support is used when breathing directly into the AFT21 non-rebreathing T valve for exercise physiology measurements. The AFT21 is secured directly in front of the subject and minimizes the strain associated with the weight of valves and tubing.

AFT25 Facemask with Valve

This adult facemask with integral non-rebreathing T valve is a high performance, very low dead space, low airflow resistance mask and valve; suitable for high airflow applications (e.g. exercise physiology). The AFT25 incorporates two gas sampling ports (female Luer) for interfacing with the AFT20 Gas Sampling Kit. All ports are 35 mm OD, 28 mm ID.

AFT26 Calibration Syringe (2.0 liter)



The AFT26 Calibration Syringe is certified to have a 2-liter volume that meets or exceeds an accuracy ± 1% of the total displacement volume. The increased size and accuracy of this 2.0 liter calibration syringe provide a wider calibration range than the AFT6A for advanced studies. A coupler is included and can be reordered as AFT11I if it is inadvertantly discarded when an airflow accessory is removed.

AFT30 Tubing and M/F Luer Locks

Use this 1.5 mm tubing with male and female Luer locks to interface with the RX110 self-inflating pressure pad, TSD114 response/hand force pump bulb, or gas sampling ports on AFT15 mixing chambers, CO2100C module, or O2100C module. *See AFT31-MRI for gas sampling in the MRI.*

AFT30: 1.8 m **AFT30-L**: 4 m **AFT30-XL**: 10 m

The length of tubing will add a delay of less than 50 msec to the sensing of the waveform peak.

AFT31-MRI Gas Sampling Interface for MRI

Use this 3.175 mm tubing with Luer locks to interface with gas sampling ports on the CO2100C or O2100C module, or AFT15 mixing chambers for MRI studies.

ID/OD: 3.175 mm (1/8") / 6.35 mm (1/4")

Maximum Pressure: 358 psi @ 70º F

Operating Temperature Range: -100° to +175° F

“Y” connector: 1 x male to 2 x female

Length: 10 m

Type: Crack-Resistant Polyethylene Tubing

Material: Linear LowDensity Polyethylene

Wall Thickness: 1.588 (1/16")

Bend Radius: 2"

Durometer: 95A (Firm)

***** See the AFT part guide on on page 172 for common applications. *****

Part Summary for Typical Airflow / Gas Analysis Applications

Pulmonary Function

Part #	**High Flow** *Exercising human*	**Med. Flow** *Resting human*	**Low Flow** *Child, Pig, Dog*	**Very Low Flow** *Small Animals*
AFT2 Mouthpiece		X		
AFT3 Noseclip	X	X		
AFT6A Calibration Syringe	X	X	X	
AFT7 Tubing	X (2)			
AFT9 Mouthpiece	X			
AFT21 T Valve	X			
AFT24 Head Support	X (optional)			
AC137 In-line Transformer				
DA100C Amplifier	X (2)	X	X	X
TSD107B Pneumotach (High)	X (2)			X
TSD117 Pneumotach (Med.)		X		
TSD127 Pneumotach (Low)			X	
TSD137 A-E Pneumotachs (Very Low)				X (by size)

Part Options: AFT25 = AFT21 + AFT9 + AFT3 + optional AFT24
AFT2 + AFT3 = AFT0 + AFT11B

Exercise Physiology

Part #	**Mixed Expiratory Gases**		**Breath-by-Breath**		
	High Flow *Exercising human*	Med. Flow *Resting human*	High Flow *Exercising human*	Med. Flow *Resting human*	Low Flow *Dog*
AFT6A Calibration Syringe	X	X	X	X	X
AFT7 Tubing	X (2)		X		
AFT10 Facemask		X		X	
AFT10S Head Strap		X		X	
AFT11 Series Couplers		X (3)*		X	X (2)**
AFT12 Tubing		X (2)		X	
AFT15A Mixing Chamber	X	X			
AFT20 Interface Kit	X (2)	X (2)	X (2)	X	X (2)
AFT22 T Valve		X		X	X
AFT25 Facemask w/Valve	X		X		
DA100C Amplifier	X	X	X	X	X
CO2100C CO2 Module	X	X	X	X	X
O2100C O2 Module	X	X	X	X	X
TSD107B Pneumotach (High)	X		X		
TSD117 Pneumotach (Med.)		X		X	
TSD127 Pneumotach (Low)					X

Part Options: AFT25 = AFT21 + AFT9 + AFT3 + optional AFT24 * use 2 AFT11B and 1 AFT11C
AFT10 + AFT10S = AFT2 + AFT3 + AFT11C ** use 1 AFT11B and 1 AFT11C

***** See the AFT coupler guide on page 168 for additional applications. *****

Chapter 7 Specialty Modules

OXY100E **NIBP100D** **MPMS100A-1/MPMS100A-2**

OXY100E Pulse Oximeter Module

The OXY100E measures beat-by-beat, blood oxygen saturation (SpO_2) level in a noninvasive fashion. The OXY100E outputs four signals simultaneously:

A: SpO_2 value (Ch 1, 2, 3, or 4)

B: Pulse Plethysmogram (Ch 5, 6, 7, or 8)

C: Heart pulse rate (Ch 9, 10, 11, or 12)

D: Module Status (Ch 13, 14, 15, or 16)

These signals are directed to switchable blocks of different MP input channels. Up to four OXY100E modules can be used with a single MP System. The OXY100E has built-in calibration for a simplified setup procedure. Each OXY100E module requires one of the TSD124 series SpO_2 transducers.

The OXY100E operates in accordance to the principles outlined by the Lambert-Beer law; this is an empirical relationship that relates the absorption of light to the properties of the material through which the light is traveling.

The OXY100E is a noninvasive instrument which measures blood-oxygen percentage levels. The OXY100E probe incorporates light-emitting diodes (LEDs) which face photodiodes through a translucent part of the subject's body, usually a fingertip or an earlobe. One LED is red, with wavelength of 660 nm, and the other is infrared (approximately 910 nm). Light absorption at these wavelengths is different between oxyhemoglobin and its deoxygenated form. The oxyhemoglobin/deoxyhemoglobin ratio can be calculated via the ratio of the absorption of the red and infrared light. In particular, the OXY100E outputs (as a proportional voltage) the percentage of arterial hemoglobin in the oxyhemoglobin state.

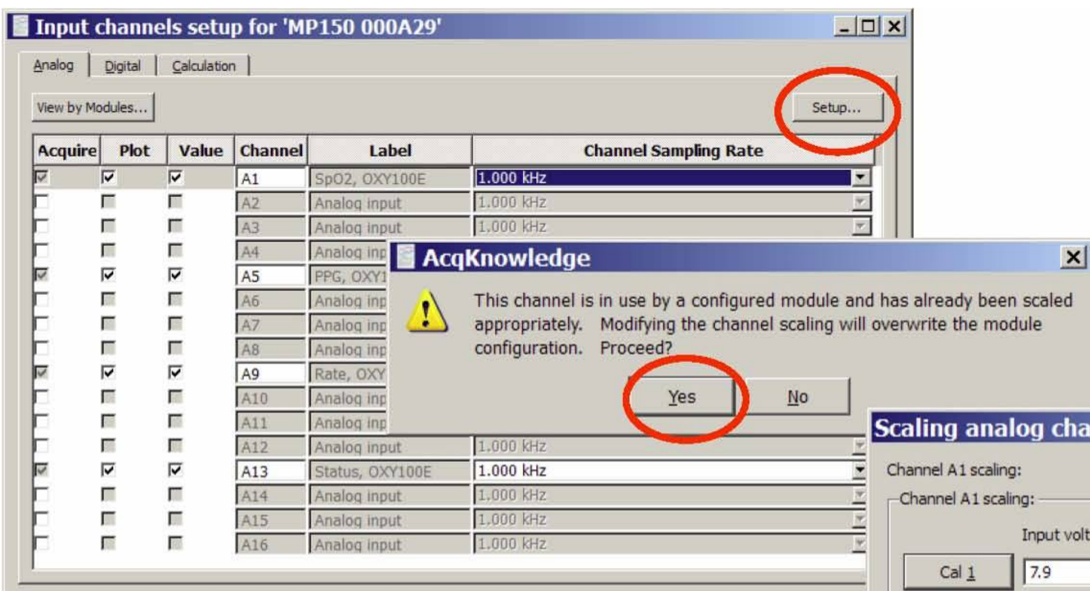
OXY100E Series Specifications

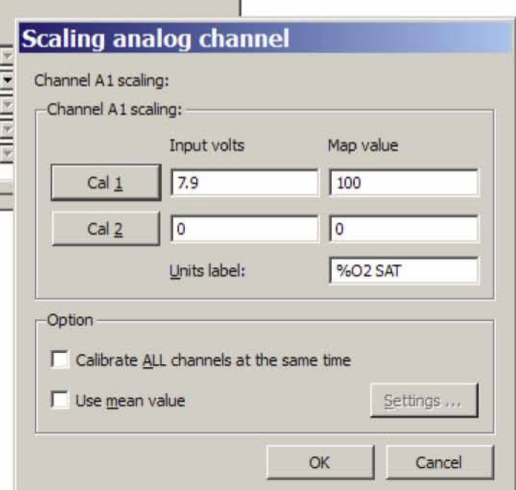
Outputs: SpO$_2$, Pulse Rate, Pulse Waveform & Module Status
Pulse Rate Range: 18-321 BPM
SpO_2 Range: 0-100%
SpO_2 Accuracy: 70-100% ±2%
Measurement Wavelengths and Output Power: Red: 660 nanometers @ 0.8 mW maximum average
Infared: 910 nanometers @ 12 mW maximum average
Operating Temperature Range: 0-50 degrees C
Operating Humidity Range: 10-90% (non-condensing)
Beat to Beat (un-averaged, non-slew limited, beat-to-beat value)
Fast (non-slew limited, 4 beat average)
Standard (4 beat average, slew limited)
Extended (8 beat average, slew limited)
Pulse Rate Output Options*: Standard (4 beat average, slew limited)
Extended (8 beat average, slew limited)
*for un-averaged, Beat-to-Beat Pulse Rate: use AcqKnowledge Rate detector on Pulse Waveform Output.
Compatible Sensors: BIOPAC TSD124 series
Principle of Operation: Lambert-Beer law employing dual wavelengths

Pulse Oximeter Calibration OXY100E/OXY200

Modules will operate with default values unless an exact calibration is performed using the recessed "Cal" button on the OXY100E module and Acq*Knowledge* scaling.

To access the "Scaling analog channel" dialog, click MP menu > Set Up Channels and then click "View by Channels," click "Setup…" and click "Yes" when prompted.





Approximate output (defaults) for "Low' and 'High' calibration modes:

	LOW	HIGH
SpO_2:	0% SpO_2 (~ 0V)	100% SpO_2 (~ 7.9V)
Pleth:	~0 V	~9.0 V
HR:	0 bpm (~ 0V)	321 bpm (human) (~ 6.27V)
Status:	'Out of track' (~0V)	'Yellow propulsion' (~8.8V)

On the OXY100E module, use a paperclip or pen tip to press and hold the recessed "Cal" button. "Press and hold" the "Cal" button for ~1.5 seconds to switch between modes, as indicated by the Status LED states.

"Normal" Status LEDS = GREEN OFF and YELLOW OFF (YELLOW may occasionally flicker due to background processing)

"Calibration Low" Status LEDs = CONSTANT GREEN ON and YELLOW OFF

“Calibration High” Status LEDs = GREEN OFF and CONSTANT YELLOW ON

Release the “Cal” button as soon as the mode switches—continuously holding the button in the depressed state will *not* lead to another mode change. Modes cycle from normal to low, then to high, then back to normal.

- “Press and hold” the “Cal” button for ~1.5 seconds to switch to “Calibration Low” mode and then click the “Cal2” button in the software for any of the OXY100E analog channels that are enabled.
- “Press and hold” the “Cal” button again for ~1.5 seconds to switch to “Calibration High” mode and then click the “Cal1” button in the software for any of the OXY100E analog channels that are enabled.
- “Press and hold” the “Cal” button again for ~1.5 seconds to return to “Normal” mode.

It’s best to calibrate the OXY100E once, then **Save As > Graph Template** to save the respective scale values.

OXY100E AND OXY200 SWITCHES

The switch bank on the back panel can be used to control output for the SpO_2 and HR channels.
Use ‘Calibration’ for exact output levels. Output is ~10 V if the sensor is ‘out of track.’

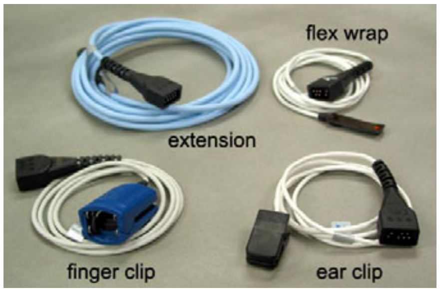
Switch			Channel	Output details
1	**2**	**3**	**SpO_2**	Range is 0 V (0%) to ~7.9 V (100%)
OFF	OFF	OFF	0-127 BPM	4-beat average values in standard[1] mode *Factory setting*
OFF	ON	ON	0-127 BPM	4-beat average values in standard[1] mode
ON	ON	ON	0-127 BPM	4-beat average values in standard[1] mode
ON	OFF	OFF	0-127 BPM	4-beat average displayed values in display[2] mode
OFF	OFF	ON	0-127 BPM	8-beat average values in standard[1] mode
ON	OFF	ON	0-127 BPM	8-beat average displayed values in display[2] mode
OFF	ON	OFF	0-127 BPM	Non-slew limited saturation with 4-beat averaging in standard[1] mode
ON	ON	OFF	0-127 BPM	Non-slew limited, not averaged, beat to beat value in standard[1] mode
4	**5**		**HR**	Range is 0 V (0 BPM) to ~6.27 V (321 BPM) for human OXY100E 0 V (0 BPM) to ~8.86V (450 BPM) for veterinary OXY200
OFF	OFF		0-max[3] BPM	4-beat average values in standard[1] mode *Factory setting*
ON	OFF		0-max BPM	4- beat average displayed values in display[2] mode
OFF	ON		0-max BPM	8-beat average values in standard[1] mode
ON	ON		0-max BPM	8-beat average displayed values in display[2] mode

[1] **Standard** SpO_2 and Pulse rate updated on every pulse beat.
SpO_2 and Heart Rate values are set to missing data values and out of track indicated.

[2] **Display** SpO_2 and Pulse rate updated every 1.5 seconds.
Last in track values transmitted for ten seconds and out of track indicated; after ten seconds, values are set to missing data values.

[3] **511 BPM** Output of 511 BPM (+10 V) indicates that sensor is not connected or signal is bad (out of track or sensor is not secured on the finger).
The module never outputs BPM between range max (321 or 450) and 511.

TSD 124 SERIES SpO_2 TRANSDUCERS FOR OXY100E




TSD124 Series ***TSD124A Finger*** ***TSD124C Flex Wrap***

The TSD124 series human oximetry transducers are reliable and simple to use on a wide range of subjects for both short-term and continuous noninvasive monitoring. The transducers incorporate Nonin's PureLight® sensors and are backed by a six-month warranty. Use with the OXY100E oximetry amplifier.

Available types:

TSD124A Finger Clip Transducer

Subject Range: > 30 kg (66 lbs)

Preferred application: Index, middle or ring fingers

TSD124B Ear Clip SpO_2 Transducer

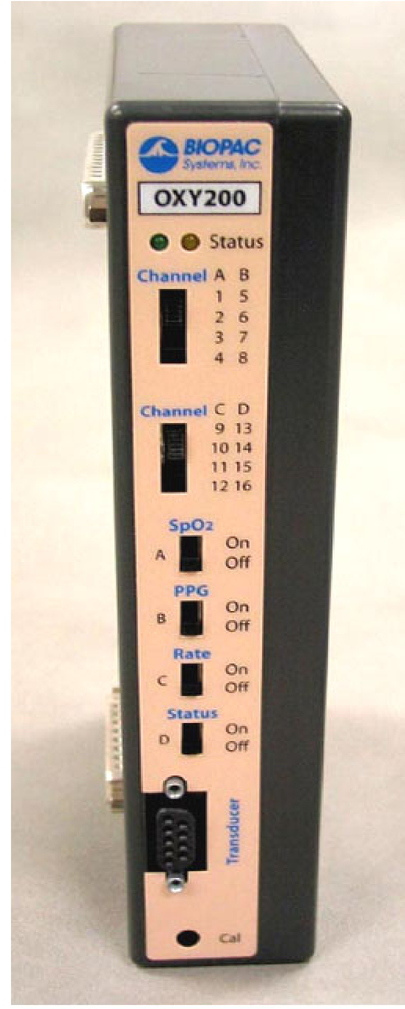
Subject Range: > 40 kg (88 lbs)

Length: 1 m

TSD124C Flex Wrap SpO_2 Transducer (Ships with 25 adhesive wrap guides)

Also available: OXY100E-200 EXT Pulse Oximeter extension cable – 3m

OXY200 Pulse Oximeter Module (for veterinary use only)



Veterinary pulse oximeter - 18 to 450 bpm

The OXY200 provides four outputs:

A: SpO_2 value (Ch 1, 2, 3, or 4)

B: Pulse Plethysmogram (Ch 5, 6, 7, or 8)

C: Heart pulse rate (Ch 9, 10, 11, or 12)

D: Status (Ch 13, 14, 15, or 16)

Channels can be individually enabled or disabled--monitor or record only the channels that suit the protocol. Switches on the side allow for output to be routed to MP System Analog inputs.

For OXY200 switch settings see table on page 175.

For OXY200 calibration, see page 174.

TSD 270 Series SpO_2 Transducers for OXY200

The TSD270 series veterinary oximetry transducers are reliable and simple to use on a wide range of animals for both short-term and continuous noninvasive monitoring. The transducers incorporate Nonin's PureLight® sensors and are backed by a six-month warranty. Use with the OXY200 Veterinary oximetry amplifier.

TSD270A Transflectance Transducer

The Transflectance Sensor, the smallest probe, is ideally suited for continuous monitoring from the paw, tail, or other vascularized part of the animal. It can be conveniently placed on the underside, base of the tail or other well-perfused surfaces. It is an excellent option during dental procedures.

TSD270A

TSD270B Small Animal Wrap Transducer

The flexible wrap sensor can be placed on a small, well-perfused appendage. This sensor is easily secured making it ideal for continuous monitoring during long surgical or other procedures. It is most often used on rodents or other very small animals.

TSD270B

Also available: OXY100 – 200 EXT Pulse Oximeter extension cable – 3m

OXY100C Pulse Oximeter Module

Note: Effective August 2010, the OXY100E replaced the OXY100C

The OXY100C Pulse Oximeter Module is primarily used to measure beat-by-beat blood oxygen saturation (SpO2) in a noninvasive fashion. The OXY100C probe incorporates light-emitting diodes (LEDs) which face photodiodes through a translucent part of the patient's body, usually a fingertip or an earlobe. One LED is red, with wavelength of 660 nm, and the other is infrared (approximately 910 nm). Light absorption at these wavelengths is different between oxyhemoglobin and its deoxygenated form. The oxyhemoglobin/deoxyhemoglobin ratio can be calculated via the ratio of the absorption of the red and infrared light. In particular, the OXY100C outputs (as a proportional voltage) the percentage of arterial hemoglobin in the oxyhemoglobin state.This ratio is expressed as the O2 Saturation Level and will vary between 0% and 100%.

The OXY100C operates in accordance to the principles outlined by the Lambert-Beer law. This is an empirical relationship that relates the absorption of light to the properties of the material through which the light is traveling.

The Pulse Oximeter Module connects directly to the MP150 via the UIM100C. Up to four OXY100C modules can be used with a single MP System. The Pulse Oximeter Transducer (TSD123) connects to the OXY100C via a 3-meter extension cable (included with the OXY100C).

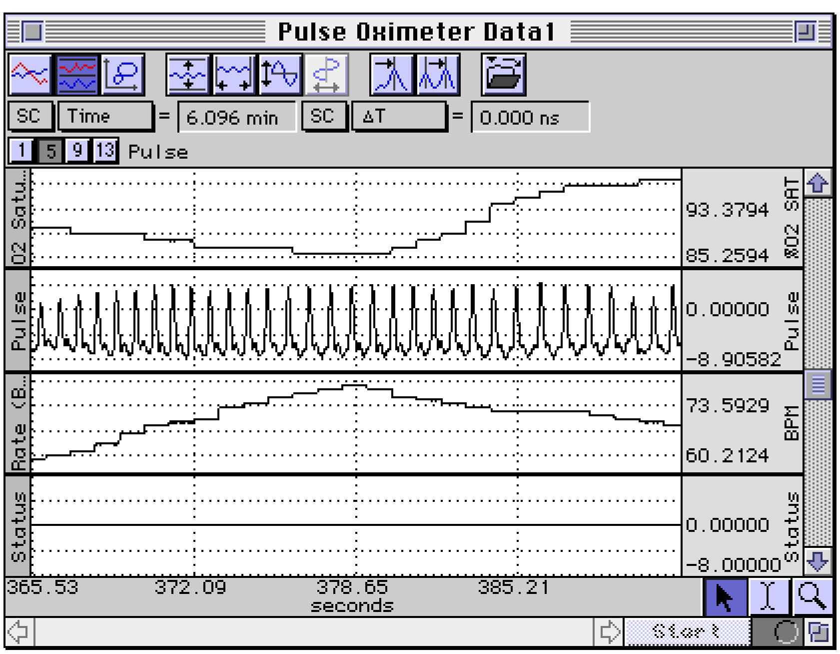
The OXY100C outputs four signals simultaneously. Output signals can be optionally directed to a number of different MP System input channels as determined with the **BANK SELECT**:

CH	SIGNAL	Bank 1	Bank 2	Bank 3	Bank 4
A	O_2 Saturation	Channel 1	Channel 2	Channel 3	Channel 4
B	Pulse Waveform	Channel 5	Channel 6	Channel 7	Channel 8
C	Pulse Rate	Channel 9	Channel 10	Channel 11	Channel 12
D	Module Status	Channel 13	Channel 14	Channel 15	Channel 16

There is an **ON/OFF** switch for each signal output channel on the OXY100C. Set the switch for each signal output channel to sample all, some or none of the signals. When any Signal Channel Enable switch is OFF (bottom position), the corresponding MP150 channel can be used by another input device.

The OXY100C includes Calibration features that permit easy scaling of all these signals when using the OXY100C with the MP System.

The graph on the following page shows sample output.



O_2 Saturation
(beat-by-beat, CH 1)

Pulse Waveform
(beat-by-beat, CH 5)

Pulse Rate
(continuous, CH 9)

Module Status
(dynamic, CH13)

OXY100C Calibration

Initial setup— OXY100C with an MP System:

1. Snap the OXY100C into the side of the UIM100C.
2. Connect the Analog cables directly from the MP150 to the OXY100C Analog mating connectors.
3. Connect the Digital cables directly from the MP150 to the OXY100C Digital mating connectors.
4. When the cable connections are secure, power up the MP150.
5. On the OXY100C module, place the four-position **Bank Select** switch to the first bank (top position). In this position, the OXY100C output signals will be directed as follows:

O_2 Saturation	Channel 1	Pulse Rate	Channel 9
Pulse Waveform	Channel 5	Module Status	Channel 13

   If using multiple OXY100C modules with a single MP System, be sure to place additional OXY100C modules on unique banks. Furthermore, please check that any OXY100C output does not reside on the same channel used by any other amplifier module.
6. On the OXY100C module, slide the four-position **Calibration** switch to the **OFF** position (bottom).
7. On the OXY100C module, set all the **Signal Channel Enables** to **ON** (top position).
8. Using the **Input Channels Setup** in Acq*Knowledge*, label the OXY100C signal outputs as follows:

Channel	Label
A5	Pulse
A9	Rate (BPM)
A13	Status (status reports a voltage, after calibration the stat

9. It's best to calibrate the OXY100C once, then **Save As > Graph Template** to save the respective scale values.

Scale Setting

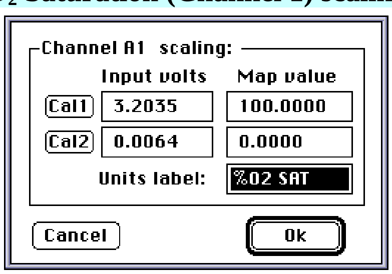
1. **Determine the highest frequency component** of all the waveforms sampled. To properly sample the signals from the OXY100C, the sample rate of the MP150 (set from Acq*Knowledge*) will need to be double the rate of the highest frequency component resident in the input data.

   If just the OXY100C is being used, the maximum sampling rate will normally be 50 Hz or less.

   If the Pulse Waveform signal is not being sampled, the maximum sampling rate drops to double what the expected pulse rate maximum would be.

   The fastest pulse rate detectable by the OXY100C is 250 BPM, so the safe sampling rate minimum would be: 2 x [250 BPM]/[60 sec/min] or 8.33Hz
2. **Establish the Calibration Scaling for each channel**

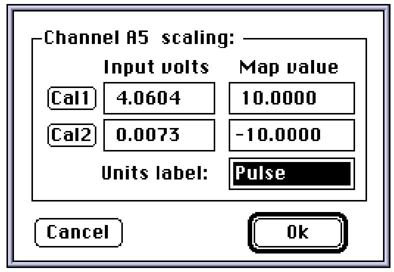
O_2 Saturation (Channel 1) scaling



a) Slide the OXY100C Calibration switch on the OXY100C module to the CAL LO position.
b) Click on the Cal2 button in the Channel A1 scaling dialog box.
c) Slide the OXY100C Calibration switch to the CAL HI position.
d) Click on the Cal1 button in the Channel A1 scaling dialog box.
e) Enter the Map values: Cal1 = 100.00, Cal2 = 0.00
f) Enter the Units label: %O2 SAT

Ideally, the nominal Cal1/Input volts value should be exactly 3.200. The nominal Cal2/Input volts value should be exactly 0.00. In practice, there will be very slight deviations from these expected values. The minimum O_2 Saturation level detectable by the OXY100C is 0.00%. The maximum O_2 Saturation level detectable is 100%. In the range from 80% to 100% the O_2 Saturation level is ±2% accurate. From 0% to 79%, the O_2 Saturation level is unspecified.

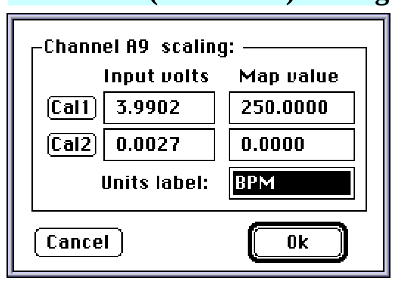
Pulse Waveform (Channel 5) scaling



a) Slide the OXY100C Calibration switch on the OXY100C module to the CAL LO position.
b) Click on the Cal2 button in the Channel A5 scaling dialog box.
c) Slide the OXY100C Calibration switch to the CAL HI position.
d) Click on the Cal1 button in the Channel A5 scaling dialog box.
e) Enter the Map values: Cal1 = 10.00, Cal2 = -10.00.
f) Enter the Units label: Pulse

Ideally, the nominal **Cal1/Input** volts value should be exactly 4.064. The nominal **Cal2/Input volts** value should be exactly 0.00. In practice, there will be very slight deviations from these expected values. The Pulse Waveform output from the OXY100C is functionally equivalent to a standard plethysmographic waveform, such as obtained with the PPG100C and TSD200.

Pulse Rate (Channel 9) scaling

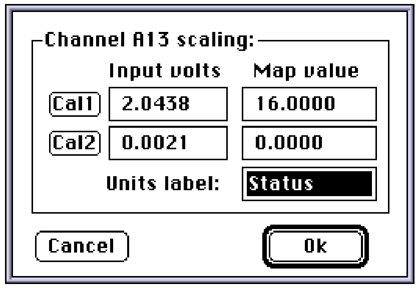


a) Slide the OXY100C Calibration switch on the OXY100C module to the CAL LO position.
b) Click on the Cal2 button in the Channel A9 scaling dialog box.
c) Slide the OXY100C Calibration switch to the CAL HI position.
d) Click on the Cal1 button in the Channel A9 scaling dialog box.
e) Enter the Map values: Cal1 = 250.00, Cal2 = 0.00.
f) Enter the Units label: BPM.

Ideally, the nominal **Cal1/Input volts** value should be exactly 4.00. The nominal **Cal2/Input volts** value should be exactly 0.00. In practice, there will be very slight deviations from these expected values.

The minimum BPM detectable by the OXY100C is 30. The maximum BPM detectable is 250. The BPM accuracy in the range of 30-250 BPM is ±1%. The BPM settles to ±1% of the final reading less than 15 seconds after the sensor is properly applied.

Module Status (Channel 13) scaling



1. Slide the OXY100C Calibration switch on the OXY100C module to the CAL LO position.
2. Click on the Cal2 button in the Channel A13 scaling dialog box.
3. Slide the OXY100C Calibration switch to the CAL HI position.
4. Click on the Cal1 button in the Channel A13 scaling dialog box.
5. Enter the Map values: Cal1 = 16.00, Cal2 = 0.00.
6. Enter the Units label: Status.

Ideally, the nominal **Cal1/Input volts** value should be exactly 2.048. The nominal **Cal2/Input volts** value should be exactly 0.00. In practice, there will be very slight deviations from these expected values.

The Module Status levels are:

0 – no status errors, all is well

1 – probe fell off subject, outputs at full scale

2 – unused

3 – insufficient light, mean path is to low for valid readings

4 – light interference, ambient noise detected on front end

5 – pulse out of range, pulse rate exceeds 250 BPM

6 – low signal strength, AC signal too low

7 – monitor error 1, front end fatal error

8 – probe error 1, sensor's red led has failed

9 – probe error 2, sensor's IR led has failed

10 – connect probe, probe not connected to OXY100C

11 – incorrect probe, incompatible probe connected

12 – front end initializing

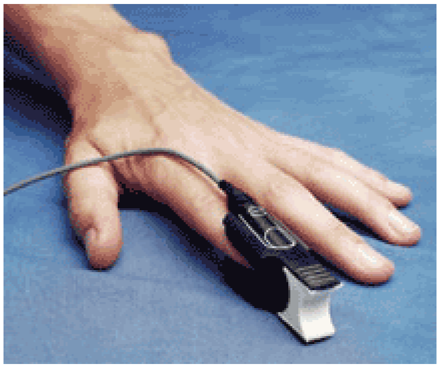
13 – unused

14 – unused

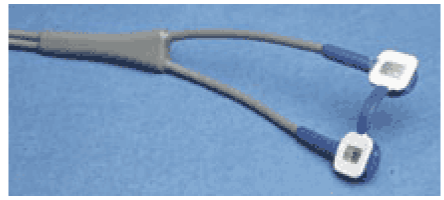
15 – unidentified probe, can't determine if probe is correct

16 – probe failure, general probe malfunction

TSD 123 Series SpO_2 Transducers for OXY100C



TSD123A



TSD123B

Note: TSD123 series is for existing OXY100C users only! New users should see SpO2 Pulse Oximeter Amplifier - OXY100E and TSD124 series transducers on page 176.

TSD123A SpO_2 Finger Transducer

The TSD123A Blood Oxygen Saturation Finger transducer connects to the OXY100C Pulse Oximeter module and is ideal for short term SpO_2 monitoring.

The transducer, with the OXY100C, provides continuous readings for SpO_2, pulse rate, Pulse Waveform, and Module Status. The transducer comes with a 1-meter cable, which plugs into the (3m) extension cable included with the OXY100C.

TSD 123B Universal Adhesive SpO_2 Transducer

The Universal Adhesive TSD123B Blood Oxygen Saturation Transducer connects to the OXY100C Pulse Oximeter module, and comes with a 1-meter cable, which plugs into the (3m) extension cable included with the OXY100C. Adhesive patches can be used to connect to the TSD123B to fingers, ears, and toes. The transducer fits into a special window cut into the adhesive patch, which allows the transducer to be located on almost any part of the body and is ideal for long-term monitoring.

The TSD123B, with the OXY100C, provides continuous readings for SpO_2, Pulse rate, Pulse Waveform, and Module Status.

TSD123A/B Calibration

See the OXY100 transducer.

TSD123 Series Specifications

Optical Transmission:	Red (660nm) and IR (940nm)
Weight:	TSD123A: 23 grams, TSD123B: 6 grams
Dimensions:	TSD123A: 62mm (long) x 23mm (wide) x 26mm (high)
	TSD123B: 12mm (long) x 12mm (wide) x 12mm (high)
Sterilizable:	Yes (contact BIOPAC for details)
Cable Length:	1 meter
Interface: OXY100C—see	page 178

EBI100C Electrical Bio-Impedance Amplifier

> ***See also***
> **Application Note #AH-196**
> Cardiac Output Measurement
> **www.biopac.com**
> and
> **Applications** (Appendix) in the "Acq*Knowledge* Software Guide"

The EBI100C records the parameters associated with cardiac output measurements, thoracic impedance changes as a function of respiration or any kind of biological impedance monitoring.

The EBI100C incorporates a precision high frequency current source, which injects a very small (400µA) current through the measurement tissue volume defined by the placement of a set of current source electrodes. A separate set of monitoring electrodes then measures the voltage developed across the tissue volume. Because the current is constant, the voltage measured is proportional to the characteristics of the biological impedance of the tissue volume.

The EBI100C simultaneously measures impedance **magnitude** and **phase**. Impedance can be recorded at four different measurement frequencies, from 12.5 kHz to 100 kHz; cardiac output measurements are usually performed at a measurement frequency of 50 kHz.

For operation, the EBI100C connects to four unshielded electrode leads terminating in Touchproof sockets. The EBI100C is typically used with EL500 paired disposable electrodes, but can function with spot or ring electrodes, reusable electrodes, or needle electrodes.

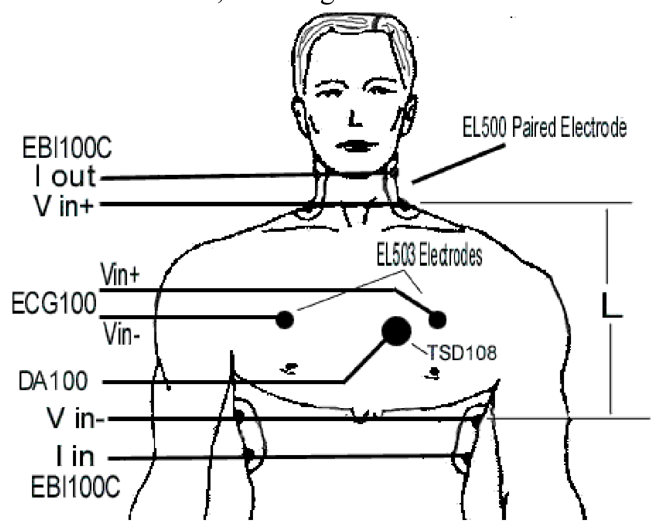
The **CH SELECT** switch has four bank settings, which assign EBI100C output (i.e., Magnitude or Phase) channels as follows:

Bank	Magnitude (MAG)	Phase (PHS)
1	Channel 1	Channel 9
2	Channel 2	Channel 10
3	Channel 3	Channel 11
4	Channel 4	Channel 12

If the particular EBI100C output is not used, the respective assigned channel cannot be used for another module's output; users should simply not record on the unwanted, but assigned channel.

Typical Configuration for Cardiac Output Measurements

For injecting current and averaging voltage at four paired-electrode sites (required for **cardiac output measurements**), use four CBL204 Touchproof "Y" electrode lead adapters (see page 278) and eight LEAD110 electrode leads with each EBI100C.



Grounding

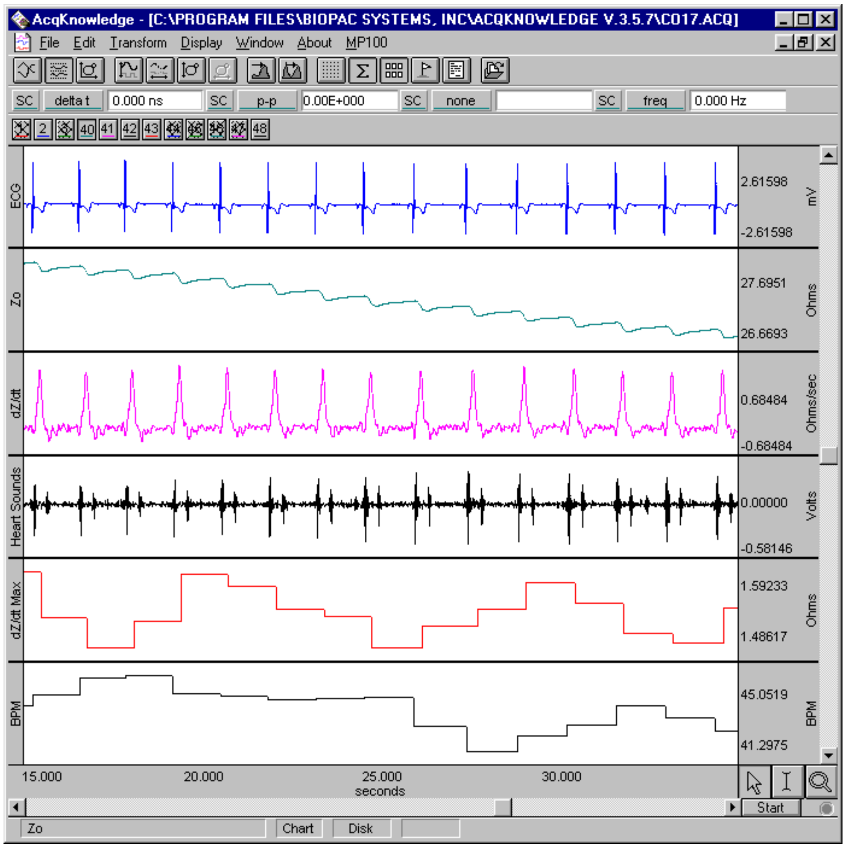
When using the EBI100C amplifier with other biopotential amplifiers attached to the same subject, it's not necessary to attach the ground lead from the biopotential amplifier(s) to the subject. The subject is already appropriately referenced to the subject via the attachment to the EBI100C. If a biopotential ground is attached to the subject, then currents sourced from the EBI100C will be split to the biopotential amplifier ground lead, potentially resulting in measurement errors.

Derivative Polarity – EBI100C vs. NICO100C

EBI100C calculates derivative in the software and the software result is negative.

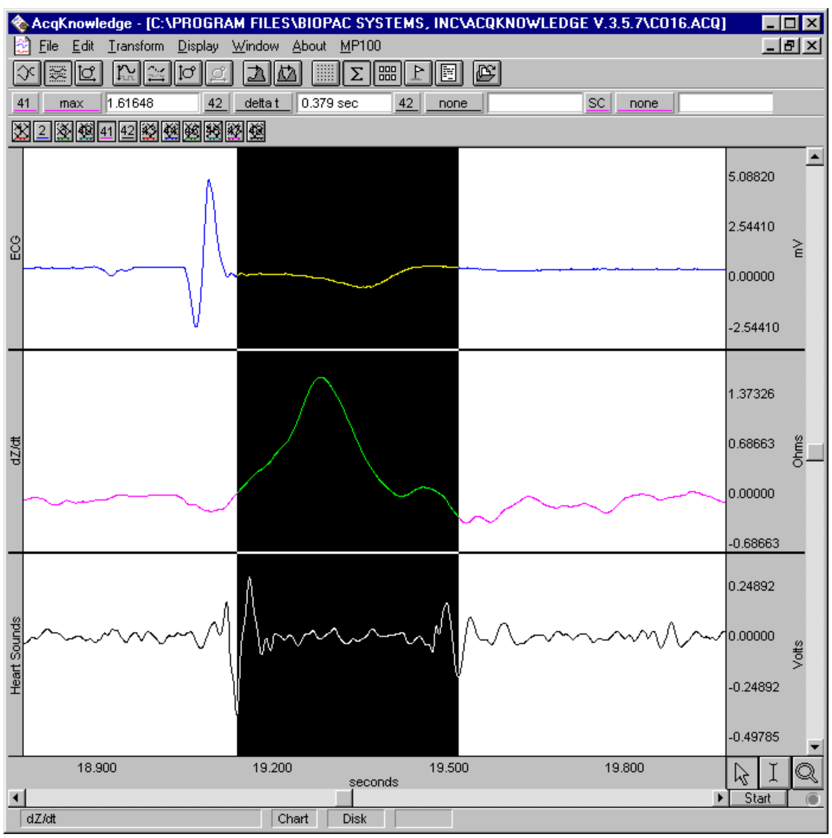
NICO100C calculates derivative in the hardware device and the result is inverted to create positive peaks.

Sample Data



Note that dZ/dt maximum is determined on a cycle-by-cycle basis from the raw dZ/dt waveform.

Similarly, the heart rate in BPM is derived from the raw ECG waveform in Channel 1.



This graph illustrates the procedure for measuring Left Ventricular Ejection Time (T).

The Acq*Knowledge* cursor was swept to bridge from peak to peak in the filtered (40-60 Hz) Heart Sounds channel.

The delta t (0.379 seconds) indicates the time from aortic valve opening to closing.

Applications

Cardiac Output

Cardiac Output can be determined, noninvasively, by employing electrical bioimpedance measurement techniques. Electrical bioimpedance is simply the characteristic impedance of a volume of tissue and fluid. In the case of Cardiac Output measures, the relevant tissue includes the heart and the immediate surrounding volume of the thorax, and the relevant fluid is blood. The electrical impedance of the thorax can be thought of as composed of two impedance types:

1. **Zo** (the base impedance) corresponds to non-time varying tissues, such as muscle, bone and fat.
2. **dZ/dt** is the magnitude of the largest impedance change during systole (Ω /sec).

BIOPAC Application Note #AH-196 Cardiac Output Measurements, implements the following equation, but other equations/modifications can be incorporated:

$$SV = r \cdot (L^2/Zo^2) \cdot T \cdot dZ/dt$$

Where: SV = Stroke volume (ml)
r = Resistivity of blood (Ω · cm)
L = Length between inner band electrodes (cm)

Water Content Measurement and Adiposity

Please see the NIH reference site for a discussion of **BIA Technology in the Estimation of Total Body Water, Fat-Free Mass, and Adiposity**: http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=hstat4.section.26000

This is an area of active research and so specific methods of performing total body water (TBW) measurements using BIA may change. The following formula is sometimes used:

$$TBW = A * (H**2/R) + C$$

Where: A = a proportionality constant specific for a given subject population
H = subject's height
R = resistance obtained by single-frequency BIA (usually 50 kHz)
C = a constant.

It may also be possible to obtain additional specificity in TBW measurements by performing BIA at multiple frequencies.

Frequency Response Plots

The 0.05 Hz lower frequency response setting is a single pole roll-off filter.

See the sample frequency response plots beginning on page 287: 10 Hz LP, 100 Hz LP

EBI100C Calibration

The EBI100C can be calibrated using external loads.BIOPAC factory calibration is performed with 20, 200 and 900 Ohm loads.

The EBI100C can measure from zero phase to 90 degree phase at the limits. Measurements of zero phase (using resistors) may not mean the output voltage of the phase signal is exactly zero. The user will need to scale the output voltage to 0 degrees phase when calibrating. Typically, a couple of tenths of volts are possible to obtain (at zero phase), depending on frequency of excitation.

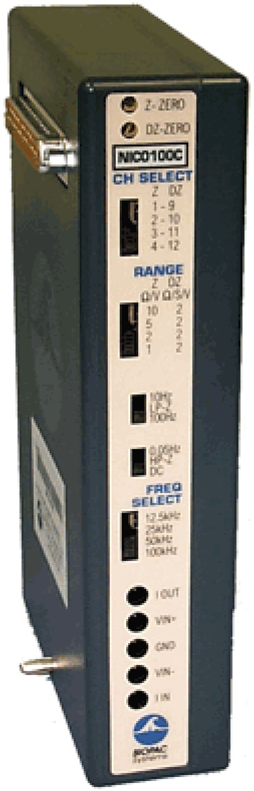
For Cardiac Output Measurements

1. Set the EBI100C to a Frequency of 50 kHz and a Magnitude Gain range of 5 ohms/volt.
2. Introduce a 20 ohm resistor between the I Out / Vin+ combination terminal to the I In / Vin- combination terminal.
3. Press the Cal1 button…
4. Introduce a 40 ohm resistor between the I Out / Vin+ combination terminal to the I In / Vin- combination terminal.
5. Press the Cal2 button…

EBI100C Specifications

Number of Channels:	2 – Magnitude (MAG) and Phase (PHS)
Operational Frequencies:	12.5, 25, 50, 100 kHz
Current Output:	400µA (rms)—constant sinusoidal current
Outputs:	MAG of Impedance (0-1000Ω) PHS of Impedance (0-90°)
Output Range:	±10 V (analog)
Operational Resistance:	The resistance range is 10 Ohms to 1,000 ohms; the minimum operational resistance is around 10 Ohms. A delta of 0.1 ohms is quite simple to measure with the correct EBI100C settings (assuming the data acquisition system used provides sufficient resolution.)
MAG Gain Range:	100, 20, 5, 1 Ω/volt
MAG LP Filter:	10 Hz, 100 Hz
MAG HP Filter:	DC, 0.05 Hz
MAG Sensitivity:	0.0015 Ω rms @ 10 Hz bandwidth
PHS Gain:	90°/10 volts
PHS LP Filter:	100 Hz
PHS HP Filter:	DC coupled
PHS Sensitivity:	0.0025 degrees @ 10 Hz bandwidth
CMIV – referenced to	
Amplifier ground:	±10 V
Mains ground:	±1500 VDC
Signal Source:	Electrodes (four electrode leads required)
Weight: 370	grams
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)

NICO100C



The NICO100C noninvasive cardiac output amplifier records the parameters associated with cardiac output measurements. It incorporates a precision high frequency current source, which injects a very small (400µA) measurement current through the thoracic volume defined by the placement of a set of current source electrodes. A separate set of monitoring electrodes then measures the voltage developed across the thorax volume. Because the current is constant, the voltage measured is proportional to the impedance characteristics of the thorax.

The NICO100C simultaneously measures impedance magnitude (Zo; labeled "Z" on the module) and derivative (dZ/dt; labeled "DZ" on the module). Zo and dZ/dt can be recorded at four different measurement frequencies, from 12.5kHz to 100 kHz; cardiac output measurements are usually performed at a measurement frequency of 50 kHz.

For operation, the NICO100C connects to four unshielded electrode leads terminating in Touchproof sockets.

The NICO100C is typically used with EL500 paired disposable electrodes, but can function with spot or ring (tape) electrodes, reusable electrodes, or needle electrodes.

For injecting current and averaging voltage at four paired-electrode sites (often required for cardiac output measurements), use four CBL204 Touchproof "Y" electrode lead adapters and eight LEAD110 electrode leads with each NICO100C. In this situation, due to the anatomical shape of the thorax, the best placement for all eight electrodes is along the frontal plane (wider dimension). When directed through the thorax, the measurement current seeks the shortest and most conducting pathway. Consequently, the measurement current flows through the thoracic aorta and vena cava superior and inferior.

Use the CH SELECT switch bank to assign NICO100C output (Zo and dZ/dt) channels as follows:

Bank	Magnitude (Zo)	Derivative (dZ/dt)
1	Channel 1	Channel 9
2	Channel 2	Channel 10
3	Channel 3	Channel 11
4	Channel 4	Channel 12

If the particular NICO100C output is not used, the respective assigned channel cannot be used for another module's output; users should simply not record on the unwanted, but assigned channel.

GROUNDING

When using the NICO100C amplifier with other biopotential amplifiers attached to the same subject, it's not necessary to attach the ground lead from the biopotential amplifier(s) to the subject. The subject is already appropriately referenced to the subject via the attachment to the NICO100C. If a biopotential ground is attached to the subject, then currents sourced from the NICO100C will be split to the biopotential amplifier ground lead, potentially resulting in measurement errors.

Derivative Polarity – NICO100C vs. EBI100C

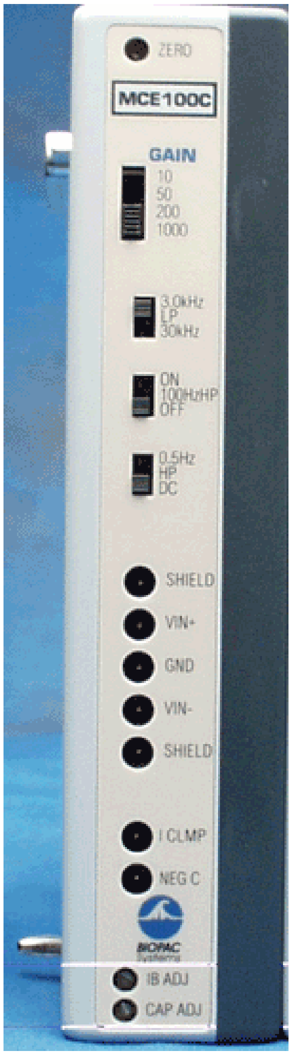
NICO100C calculates derivative in the hardware device and the result is inverted to create positive peaks.

EBI100C calculates derivative in the software and the software result is negative.

NICO100C Specifications

Number of Channels:	2 – Magnitude (Zo) and dZ/dt	
Operational Frequencies:	12.5, 25, 50, 100 kHz	
Current Output:	400µA (rms)—constant sinusoidal current	
Outputs:	MAG of Impedance: 0-100 Ω	dZ/dt of Impedance: 2 (Ω/sec)/v
Output Range:	±10 V (analog)	
CMIV, referenced to…	Amplifier ground: ±10 V	Mains ground: ±1500 VDC
Signal Source:	Electrodes (requires 4 electrode leads)	
Gain Range:	MAG: 10, 5, 2, 1 Ω/V d	Z/dt: 2 (Ω/sec)/v constant (independent of MAG Gain)
LP Filter:	MAG: 10 Hz, 100 Hz	dZ/dt: 100 Hz
HP Filter:	MAG: DC, 0.05 Hz	dZ/dt: DC coupled
Sensitivity: MAG:	0.0015 Ω rms @ 10 Hz bandwidth	dZ/dt: 0.002 (Ω/s)/V rms @ 10 Hz bandwidth
Weight: 37	0 g	
Dimensions:	4 cm (wide) x 11 cm (deep) x 19 cm (high)	

MCE100C Micro-electrode Amplifier



> ***See also***
> **Application Note #AH-190**
> Using the MCE100C
> Micro-electrode Amplifier
> **www.biopac.com**
> and
> **Applications** (Appendix)
> in the "Acq*Knowledge*
> Software Guide"

The MCE100C is an extremely high input impedance, low-noise differential amplifier that accurately amplifies signals derived from micro-electrodes. A number of selectable options make the module useful for general-purpose recording of cortical, muscle and nerve action/resting potentials or cellular recordings with the optional use of input capacity compensation and a current clamp.

Cable shield drives for input signals can be configured for voltage following (for reduced input capacitance) or simply grounded (for low feedback noise).

The MCE100C includes manual controls for input capacity compensation (±100pF) and clamp current zeroing (I bias). It also incorporates an external voltage control to vary the clamp current proportionally to the control voltage (100 mV/nA).

When performing voltage measurements using Ion Selective Microelectrodes, the adjacent shield output, associated with either the Vin+ or Vin- input, is the buffered output of the input signal (1x gain) at the Vin+ or Vin- port. These shield outputs can be used to measure reference electrode voltages (against a remote non-polarizable Ag/AgCl -indifferent-electrode) and the output of the MCE100C can be used to measure the differential voltages between a pair of ISM electrodes, one of them being the reference.

For very accurate (less than ±10 mV error) reference or differential voltage measurements, it's important to first calibrate out amplifier offset voltages by shorting the various inputs together to obtain a true 0 volt input for each measurement type.

An MP150A D/A output channel can drive this external voltage control to change clamp currents automatically during recording. The MCE100C also includes a clamp current monitor output so the clamp current can easily be recorded by another MP150 input channel.

For general-purpose recording, without input capacity compensation or a current clamp, use standard shielded or unshielded electrode leads terminating in Touchproof sockets.

Add simple input capacity compensation and current clamp control by connecting the respective signal ports to the [Vin+] input of the MCE100C using the JUMP100C jumper connectors.

For the best performance and shielding, use the MCEKITC (page 190) to interface a micro-electrode lead cable to the MCE100C.

Current Clamping can be enabled/disabled, by connecting/disconnecting the "I CLMP" port to either differential input of the MCE100C. Negative Capacity Compensation can be enabled/disabled, by connecting/disconnecting the "NEG C" port to either differential input of the MCE100C.

- See Application Note 190 - Micro-Electrode Amplifier Guidelines - MCE100C for details.

IMPORTANT USAGE NOTE

Although the MCE100C will function with an MP100 System, an MP150 system is recommended due to the module's wide operational bandwidth. Contact BIOPAC for details.

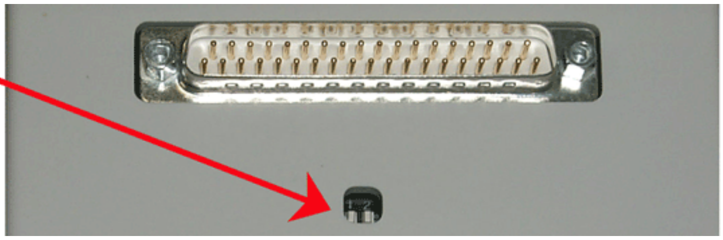
Frequency Response Plots

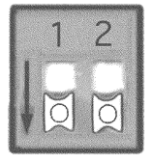
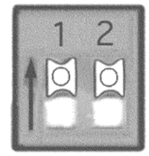
The 0.5 Hz high pass lower frequency response setting is a single pole roll-off filter.

Modules can be set for 50 Hz or 60 Hz notch options to match the wall-power line frequency of the destination country. The proper setting reduces noise from interfering signals when the notch filter is engaged. Generally, wall-power line frequency is 60 Hz in the United States and 50 Hz in most of Europe; if necessary, contact BIOPAC to determine the correct line frequency, adjust the bank of switches on the back of the amplifier module.

- The 50/60 Hz notch on the MCE100C is only engaged when the 100 Hz HPN high pass notch filter switch is set to ON—see *Amplifer Filtering* on page 100 for details.

Line Frequency switch bank is on the back of the amplifier



50 Hz	60 Hz
	
Both switches DOWN	Both switches UP

See the sample frequency response plots beginning on page 287: 100 Hz HPN (with 50 Hz notch)
100 Hz HPN (with 60 Hz notch)
3 kHz LP
30 kHz LP

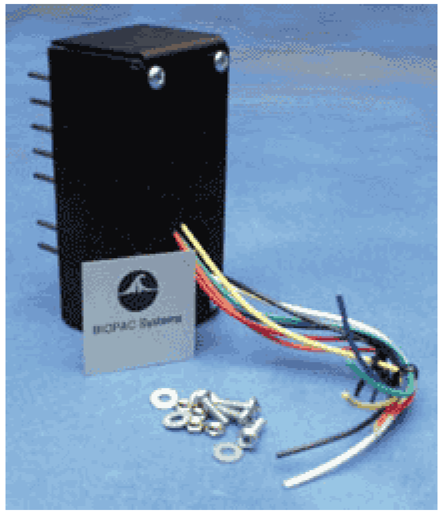
MCE100C Calibration

No calibration required. Use the CBLCALC to verify accuracy.

MCE100C Specifications

Gain & Input Voltage:	Gain Vin	(mV)
10		±1000
50		±200
200		±50
1000		±10
Output Range:	±10 V (analog)	
Offset Voltage (DI):	Differential Input:	±5 mV maximum (Vin+ to Vin-)
Offset Voltage (SE):	Driven Shield to Input:	±15 mV typical (Vin+ or Vin- to Adjacent Shield)
Low Pass Filter:	3 kHz, 30 kHz	
High Pass Filter:	DC, 0.5 Hz, 100 Hz	
CMRR:	92 dB typical; see Shield Drive Operation on page 287	
CMIV – referenced to:	Isolated ground:	±10 V
	Mains ground:	±1500 VDC
Notch Filter:	50 dB rejection (50/60 Hz)	
Noise Voltage:	2.1 µV rms – (DC-3000 Hz)	
Noise Current:	0.1 fA/√Hz	
Input Bias Current:	±3 fA (typical), ±100 fA (maximum)	
	Note: Current Clamping and Negative Capacity Compensation Disabled	
Z (input)		
Differential:	10 E15 Ω	
Co mmon mode:	10 E15 Ω	
Capacit. Comp (Neg):	Input capacitance compensation (0-100 pF) – manual control	
	I Clamp (I CLMP port):	Adjustable (±100 nA) - voltage control
I Clamp Control:	Input 3.5mm phone jack (100 mV/nA)	
I Clamp Monitor:	Output 3.5mm phone jack (100 mV/nA)	
Signal Source:	Micro-electrodes	
Weight: 350	grams	
Dimensions:	4 cm (wide) x 11 cm (deep) x 19 cm (high)	

MCEKITC Connector Kit for MCE100C Micro-electrode Amplifier



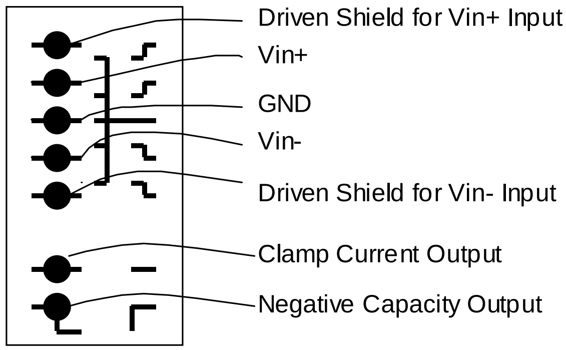
Build a customized adapter to a micro-electrode shielded cable. Cable shields can be tied to voltage follower drive or simply grounded. Input capacity compensation and clamp current options can be independently added to or removed from a cable configuration. The MCEKITC comes with seven attached Touchproof sockets (1.5 mm) and instructions.

The MCEKITC is a junction box assembly that plugs directly into the front panel of the MCE100C amplifier. The MCEKITC comes equipped with an assortment of wire and coaxial cable to customize the MCE100C for a variety of micro-electrode lead connectors. The MCEKITC construction allows the appropriate interface connector to be mounted to the housing and the respective socket pin wires to be soldered.

The MCEKITC is required when either of the last two MCE100C operational modes (5, 6) are used with micro-electrodes. The following table illustrates the configuration desired. The amplifier configuration is determined via the MCEKITC. The MCEKITC connects to the MCE100C and modifies the MCE100C appropriately. See the respective figure to determine the correct MCEKITC configuration for the application.

INPUT TYPE	SHIELD	CURRENT CLAMP	NEGATIVE CAPACITY	MCEKITC FIGURE
Differential	Grounded	No	No	A
Differential	Driven	No	No	B
Single-ended	Grounded	No	No	C
Single-ended	Grounded	No	Yes	D
Single-ended	Grounded	Yes	Yes	E
Single-ended	Driven	Yes	Yes	F

MCEKITC LEGEND



MCEKITC CONFIGURATIONS

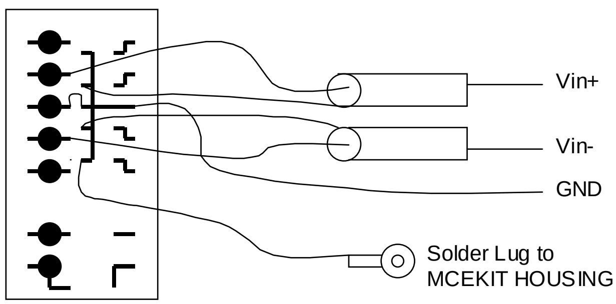


FIGURE A

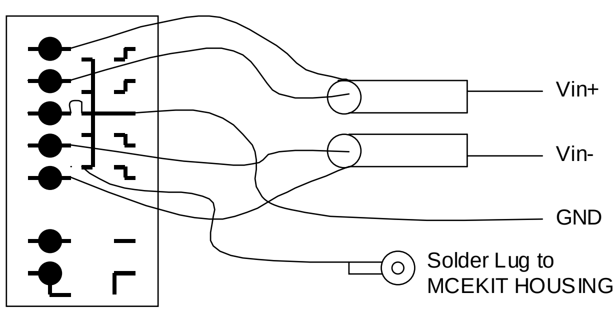


FIGURE B

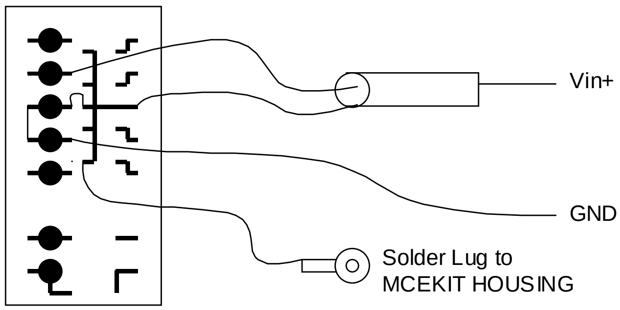


FIGURE C

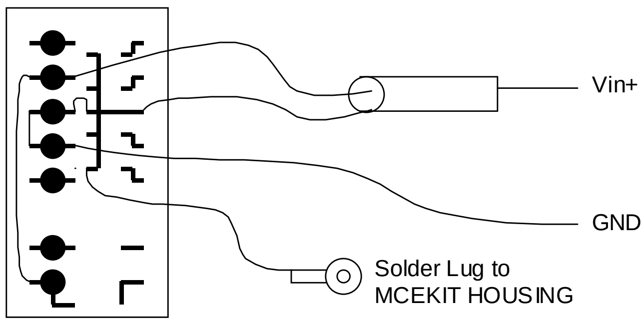


FIGURE D

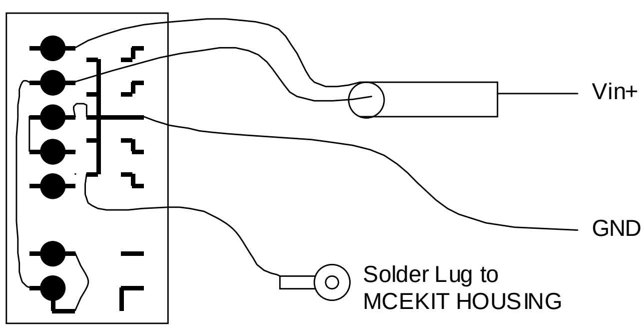


FIGURE E

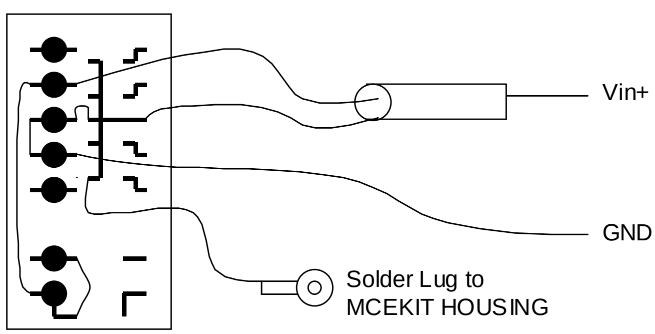
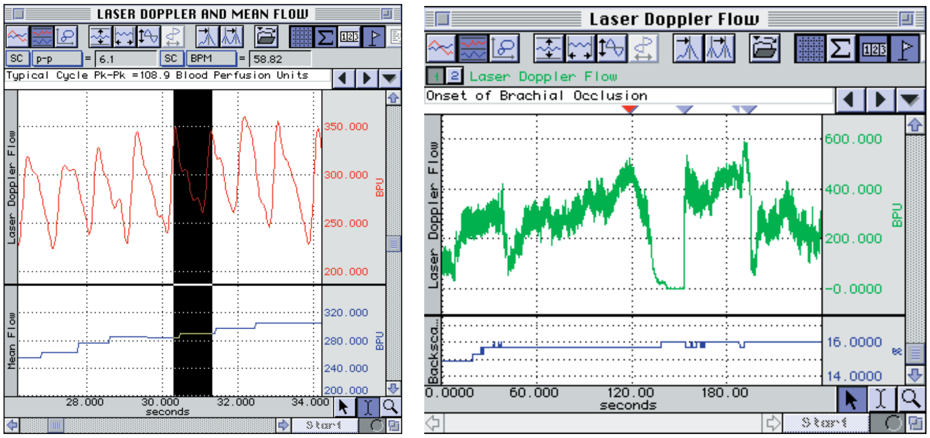


FIGURE F

Laser Doppler Flowmetry



Sample blood perfusion data acquired with the LDF100C

Laser Doppler Flowmetry (or simply "LDF") is an established and reliable method for the measurement of blood perfusion in microvascular research. Most LDF applications are concerned with monitoring the competence of regional (microvascular) blood supply following trauma, degenerative and pathological disease, surgical intervention and drug therapy.

LDF measurements are performed with the Laser Doppler Flowmetry module (LDF100C) and a wide range of fiber-optic based probes (TSD140 series) in order to access the tissue. Probes include small and lightweight probes for (non-invasive) skin and tissue surface measurements and needle type probes for direct (invasive) measurements within tissue, such as muscle and organ. Double-sided adhesive rings (ADD200 series) can be used to attach surface type probes to tissue; one size of ring fits both standard and miniature surface probes

LDF Calibration requires a calibration kit (LDFCAL), which includes a motility standard and positioning device to hold a probe in the solution during calibration. The motility standard comprises a carefully controlled solution of microspheres undergoing Brownian motion, which provides a standard calibration value of 1000 BPU ±5% at 21°C.

The Laser Doppler Flowmetry section covers

- LDF100C laser Doppler flowmetry module & specifications
- TSD140 series laser Doppler probes & specifications
- LDFCAL Calibration Kit
- LDF Setup (module & probes)
- LDF Calibration Procedure
- LDF Troubleshooting
- Storage & Maintenance
- LDF — Basic Principles

Unpacking LDF Components

1. Inspect the packaging for damage before unpacking the component(s).
   - If the outer packaging or carton is wet or damaged in any way, immediately notify the shipping agent and file a claim. It is the receiver's duty to notify the specific carrier's local office. In the event of any damage, please save the shipping carton as evidence.
2. Unpack the component(s) and check the part(s) against the enclosed packing slip.
3. Remove the packaging and check for signs of obvious damage or defect either to the main body of the LDF100C module or the TSD140 series laser Doppler probes.
   - Contact BIOPAC Systems, Inc. for replacement of any damaged component.

IMPORTANT

It is essential that the **Warnings** and **Cautions** are fully understood before the LDF100C is used.

LDF100C Laser Doppler Flowmetry Module

> **IMPORTANT**
> It is essential that the **Warnings** and **Cautions** are fully understand before the LDF100C is used.

The LDF100C is a laser Doppler microvascular perfusion module that is capable of monitoring red blood cell (erythrocyte) perfusion in the microcirculation of a tissue. This module uses a Laser Doppler Flowmetry technique.

- Microvascular blood perfusion is indicated on the Acq*Knowledge* software display in relative units called Blood Perfusion Units (BPU).
- In common with all LDF devices, quantitative measurements of tissue blood perfusion in absolute units (e.g. ml/min/g of tissue) are not possible with the LDF100C.

The LDF100C laser Doppler microvascular perfusion module works by illuminating tissue with low power laser light using a probe (TSD140 series) containing optical fiber light guides. Laser light from one fiber is scattered within the tissue and some is scattered back to the probe. Another optical fiber collects the backscattered light from the tissue and returns it to the module. Most of the light is scattered by tissue that is not moving but a small percentage of the returned light is scattered by moving red blood cells. The light returned to the module undergoes signal processing to extract the signal related to the moving red blood cells.

The LDF100C is not a medical device. It is not designed for the diagnosis, mitigation or treatment of disease in humans.

Flow/flux/perfusion are the SAME—this manual and the module use the term "flow."

Controls, Indicators and Symbols

Interface: Connect the LDF100 directly to the UIM100C as part of an MP system for data acquisition.

Channel Select Switch: Choose a channel setting that will not conflict with other modules to display Flow and Backscatter as follows:

Flow	Backscatter
CH 1	CH 5
CH 2	CH 6
CH 3	CH 7
CH 4	CH 8

If the particular output (i.e., Flow or Backscatter) is not used, the respective assigned channel cannot be used for another module's output. Do not record on the unwanted, but assigned channel.

Cal Button: For calibrating new or existing probes (intentionally recessed).

Status LED:

Red	laser is powered; i.e., probe is connected
Green	software is running correctly and no probe or defective probe is connected; or calibration status
Amber	software is running correctly and a recognized or unrecognized probe is connected

Analog Indicators:

Warning	Backscatter (BS)	Perfusion (LDF)
Calibrate probe	0 V	0 V
No probe	0 V	0 V
BS low	0 V	0 V
LDF over range	Data	5 V

Probe Connector: Combined fiber optic and electrical connector. Use only TSD140 series probes.

Power plug: Mini-Din socket on the back panel; use to connect the AC101 DC power adapter that is included with each LDF100C module.

See also: **TSD140** series probes, page 196 — LDF Warnings & Cautions, page 202
LDFCAL calibration standard, page 200 — LDF Troubleshooting, 205
LDF Calibration, page 200-200 — Principles of Laser Doppler Flow, page 209

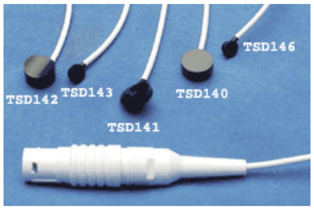
LDF100C Specifications

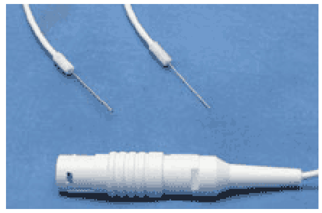
PERFORMANCE	
Measurements	Primary Measure: Microvascular blood flow (Relative RBC flow Units: 0 – 5,000 BPU (blood perfusion units); 0 – 100% BS (backscatter)
Range (linearity)	Up to 0.35% moving scatterers by volume
Stability of reading	5%
Probe identification	TSD140 Series Laser Doppler Probes use Smart Probe Technology. Calibration coefficients are automatically selected for previously calibrated probes
Probe calibration	Flow: User set via LDFCAL motility standard of 1000 BPU ±5% @ 21°C Factory set using a motility standard (i.e., known concentration solution of latex spheres undergoing Brownian motion) Factory or user calibration using LDF CAL calibration solution.
Zeroing	Automatic, controlled (unplug probe to check the zero level of the backscatter output)
LASER	
Type	Temperature stabilized semi-conductor laser diode
Mode of operation	Continuous
Wavelength	830±10 nm
Class	Class 1 (EN 60825-1 and 21 CFR 1040.10)
Power at probe	< 0.5 mW from the probe
ENVIRONMENTAL	
Operating temp	10°C – 35°C
Storage temp	5°C – 50°C
Operating humidity	0 – 70% (non-condensing)
ELECTRICAL	
Power supply unit (PSU)	Ships with ±12, +5 VDC @ 2 amp (AC101A DC power adapter) PSU spec affects warm-up time and operating range. The LDF100C heats and cools the laser. At 3 A at +5 V, the laser is at the correct temperature after about 30 seconds.
DATA OUTPUTS	
Analog	2 analog outputs
Signals	

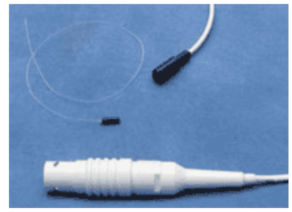
Type	Units	Range	Resolution	Time Constant (filtering)	Output voltage
Blood perfusion (BPU) *LDF*	0 – 5000 BPU	0 – 5 V	< 2.5 BPU	200 ms	0 to +5 V Scaling: 1 BPU corresponds to 1 mV
Backscatter (BS) *tissue remittance*	0 – 100%	0 – 5 V	≤ 0.05%	200 ms	0 to +5 V Scaling: 1% corresponds to 50 mV

General	Technology: Oxford Optronix, Ltd. technology for LDF signal processing Weight: 790 g Dimensions: 19 cm x 7 cm x 11 cm (H × W × D)

TSD140 Series Probes







The TSD140 series offers a wide range of laser Doppler probes that interface with the LDF100C module. Probes are designed to allow the local monitoring of blood perfusion from almost any tissue type. All probes contain optical fibers, which are used to direct low power laser light to and from the tissue. Three types of probes (surface, needle, and disposable) and a driver are stocked for the LDF100C; other probes styles are available. Standard cable length for all probes is 3 m. Single fiber probes have an overall length of 30-100 cm and require the use of TSD148; they can be cut to any length with a sharp scalpel.

Probe cable lengths between 1 m and 8 m and needle and needle probes with shaft lengths of between 10 mm to 70 mm may be custom ordered. Contact *BIOPAC* Systems, Inc. for more information.

PROBE OPTIONS

SURFACE Designed for skin and exposed tissue blood flow monitoring. Ideal for noninvasive measurements from skin or organ surfaces. The signal delivery fiber intersects the probe body at a right angle, making the probes easy to secure to the skin or tissue surface. Made from Tempalux.

TSD140 Cutaneous blood flow anywhere on the skin surface.

TSD142 Micro-vascular skin blood flow in the digits.

TSD143 Small animal work, including post-operative monitoring, i.e., reconstructive surgery (suturable).

TSD146 Small animal work and general tissue surface monitoring (this is a non-suturable version of the TSD143).

NEEDLE Designed for invasive and endoscopic blood flow monitoring of tissue. Needle probes can be used both for noninvasive monitoring from the surface of tissues (by positioning the tip in contact/close proximity to the tissue) or for invasive placement and monitoring from regions within tissues. The signal delivery fiber terminates flush with the top of the needle, making the probes easy to insert into tissue. Made from medical grade stainless steel.

TSD144 Microvascular blood flow measurements. Typically positioned using a micromanipulator clamp over soft tissues such as brain and muscle.

TSD145 Micro-vessel or micro-vascular blood flow within skin, muscle, tumor and organ tissues. Fine probe diameters facilitate blood flow measurements from only a small number of capillaries.

DISPOSABLE Designed for safe, continuous, invasive microvascular blood flow monitoring. Composed of a polymethyl methacrylate core and a tough fluorinated polymer cladding. Incorporate a coupling bead to interface with the TSD148 single fiber driver for connection to the LDF100C module.

TSD147A Blood flow measurements under the skin (use a standard 22G ID cannula to insert directly into tissue).

DRIVER

TSD148 This is a precision-machined coupling system for interfacing the TSD147 series single fiber probes to the LDF100C. The TSD148 consists of a compact laser driver housed in a non-metallic Tempalux housing, terminated with a 2-meter cable for connection to the LDF100C module.

HANDLING TSD140 SERIES PROBES

⚠ TSD140 series probes must be handled with care. Failure to do this may result in breakage of the internal optical fibers, scratching the polished probe ends or separation of the cable from the probe ends or connectors.

⚠ Do not use a worn or damaged probe.

The optical fibers used in the TSD140 series probes are glass and have a diameter of 125 µm. The fibers are flexible and can be bent; however, it is recommended that they are not subjected to bends with a radius less than 30 mm.

The connectors on TSD140 series probes must be kept clean and free from dust. Connectors should be inspected before each use. Dust can be removed from the connectors using a good quality 'air-duster.'

Check the integrity of TSD140 series probes by holding the probe end to a source of bright diffuse light (e.g. a lamp) and inspecting the connector end. Two bright spots of light of equal intensity should be visible from the pins within the connector.

APPLYING PROBES TO TISSUE

Surface Surface probes may be attached to tissue using double-sided adhesive rings (such as ADD204 or ADD208). Alternatively, the miniature suturable probe can be sutured directly into position.

Needle Needle probes can be secured in a micromanipulator assembly or stand and placed above the tissue. Depending on the tissue, fine needle probes may be introduced directly into tissue after first ensuring an appropriate superficial incision has been made. Alternatively, a suitable introducer or catheter should be used. All needle style probes can optionally be secured in a micromanipulator assembly or stand.

- Bear in mind that all needle probes have a blunt end and may cause some degree of tissue trauma when inserted directly into tissue without using a suitable introducer.

Single fiber The insertable probe can be inserted into tissue using a standard 2G ID cannula. These probes can be cut to the desired length with a sharp scalpel. The single fiber probes require the TSD148 driver.

It is important to control the relative movements of the tissue (induced by breathing, etc.) with respect to the probe to reduce artifact in the perfusion signal. Allowing the supported probe to lightly come into contact with the surface of the tissue can reduce these artifacts. Under some conditions it may be best to hold the probe in position by hand.

It is essential to ensure that the pressure on the tissue is minimal, otherwise local occlusion of the microvasculature may result.

Avoid direct illumination of the measurement site from external lighting sources and direct sunlight. Excessive ambient lighting at the probe site can disturb the blood perfusion reading. If erroneous readings due to excessive ambient lighting levels are suspected, cover the attached probe and measurement area with a light piece of opaque material.

- Place the LDF100C module on a flat surface close to the point of measurement; note that the standard probe cable length is 3 m.
- The probe can be placed in or on tissue at any stage, either prior to or following connection to the LDF100C. Allow the module to warm up with a probe attached before taking any measurements.
- The probe can be exchanged for another at any stage without the need to first switch off the LDF100C.
- The probe does not need to be disconnected from the LDF100C prior to turning off the LDF100C.

SOFTWARE SCALING

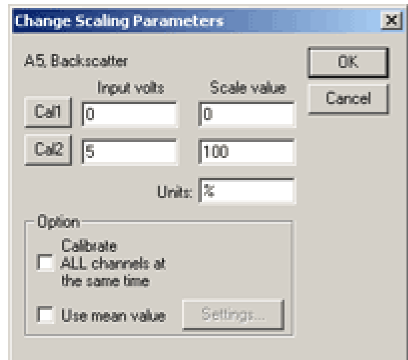
Acq*Knowledge* must be set o scale the input values to the correct units for LDF measurements. Access the Change Scaling Parameters dialog under MP menu>Setup Channels>Scaling, and then set the parameters for BPU (Channel A1) and Backscatter (Channel A5) as follows:

BPU (A1)

	Input	Scale	Units
Cal1	0	0	BPU
Cal2	5	5000	

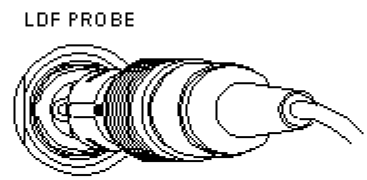
Backscatter (A5)

	Input	Scale	Units
Cal1	0	0	%
Cal2	5	100	



CONNECTING PROBES TO THE LDF100C

Very carefully remove the probe from its protective case and check that the Probe Connector is clean and free from dust. The TSD140 series probes plug into the front of the LDF100C module, which contains the laser source, sensitive photo-detection and signal processing circuitry. All probes are standardized using a reference motility standard (LDFCAL) consisting of latex microspheres undergoing Brownian motion.



1. Connect the LDF100C module to a power source and then switch ON.
   - The LED status indicator will be illuminated in Amber. (When the probe is not inserted, the indicator will illuminate Green only.)
   - The start-up beeps are the same whether a probe is connected or not and whether a probe is calibrated.
   - Analog indicators
     - no probe: BS = 0 V, LDF = 0 V
     - uncalibrated probe: BS = 0 V, LDF = 0 V (see page 200 for probe calibration)
2. Select a TSD140 series probe.
3. Plug the TSD140 probe into the “PROBE” connector located on the front panel of the LDF100C, taking care to orient the connector plug with respect to the socket. Align the probe and push the connector firmly home into the socket until a click is heard.
4. After a short delay, the module will enter Trend Mode, and the Acq*Knowledge* software display should show blood perfusion values as **XXXX BPU** (where XXXX is a number in the range 0-5000 units) and backscatter as **%** (a percentage).

   ⚠ Since the LDF100C is a light-based measurement system, random values may appear on the software display while probes are not attached to tissue. When the probe is in the air, the module will set the analog outputs to BS = 0 V, LDF = 0 V instead of outputting random values.

No warm up period is required after connecting a probe if the module was already ON. If the module was not ON, allow 30 seconds minimum for warm up.

<u>Disconnect</u>

To disconnect the probe plug from the front panel socket, gently pull the connector by the ribbed part of the connector.

⚠ Attempting to remove the connector by any other part of the probe (for example, by pulling the cable sleeving) will cause irreparable damage to the probe.

PROBE IDENTIFICATION

The LDF100C system incorporates proprietary Smart Sensor technology that enables the module to recognize a previously calibrated probe and to automatically apply the necessary probe calibration coefficients. This alleviates the need to re-calibrate a probe every time a different probe is plugged in to the module. The module 'recognizes' a specific probe every time the probe is plugged in.

New Probe

If a new (previously uncalibrated) probe is connected to the LDF100C module, then the module's Flow and Backscatter outputs will be at 0 V. To take measurements, the probe must be calibrated (see following section on calibrating probes) or removed and replaced by a recognized probe. The status LED will be amber when a probe, recognized or unrecognized, is connected to the LDF100C.

Temperature out of range (Single beep every 16 seconds

This warning will sound) if the laser temperature is below the minimum or above the maximum for stable operation. It may occur during the warm-up period if the ambient temperature is low—this is normal and not a cause for concern. If this occurs during operation, the instrument should be moved to a cooler or warmer environment depending on the ambient temperature. With the temperature out of range, output signals will continue to be generated but may no longer be within the calibrated tolerance of the system and should be interpreted with caution. If the environmental temperature is below 25°C and this message occurs repeatedly soon after power-on, then a fault may have occurred; please contact BIOPAC Systems, Inc. for further advice.

TSD140 Series Probe Specifications

Part #	Style	Suturable	Body Dimensions	Angle of Laser Delivery & Collection	Skin & Tissue Monitoring
TSD140	Standard surface. Reusable, may be autoclaved.	no	8mm (high) x 17mm (dia)	Right angle to probe body	yes
TSD142	Digit surface. Reusable, may be autoclaved.	no	10mm (high) x 17mm (dia)	Right angle to probe body	yes
TSD143	Suturable Miniature surface. Reusable, may be autoclaved.	yes	5mm (high) x 12mm (dia)	Right angle to probe body	yes
TSD144	Needle. Reusable, may be autoclaved.	no	25mm (long) x 1mm (dia)	Straight	Invasive and endoscopic
TSD145	Fine needle. Reusable, may be autoclaved.	no	25mm (long) x 0.5mm (dia)	Straight	Invasive and endoscopic
TSD146	Miniature surface. Reusable, may be autoclaved.	no	5mm (high) x 12mm (dia)	Right angle to probe body	yes
TSD147A*	Disposable, insertable single fiber. Single-use recommended.	no	30cm (long) x 0.5mm (dia)	Straight	Insert via 22G ID cannula
TSD147AL*	Disposable, insertable single fiber. Single-use recommended.	no	100cm (long) x 0.5mm (dia)	Straight	Insert via 22G ID cannula
Part #	**Style**	**Used with**	**Body Dimensions**	**Connection Type**	**Cable Length**
TSD148	Single fiber Driver	TSD147A TSD147AL	28mm (long) x 8mm (dia)	In-line single fiber connector	3 meters

***Requires the TSD148 Single Fiber Driver for operation with the LDF100C.**

QUICK SET UP AND USE GUIDE

1. Place the LDF100C module on a flat surface close to the point of measurement.
2. Connect the AC100A to the LDF100C and plug the AC101 into a properly grounded AC Mains socket.
   - When the module is powered (immediately after the double beep) the analog outputs both go to 0 V (half scale) for 3 sec and then to 0 V for a further 3 sec before outputting data.
3. Allow the instrument to warm up for 5 minutes before making any measurements.
4. Select a probe to make measurements with and connect it respecting the correct orientation. If no probe is connected to the LDF100C module, the Flow analog output will be held at 0 V and the Backscatter output at 0 volts. The status LED will be green when no probe is connected.

INTRODUCTION TO PROBE CALIBRATION

The LDF100C system incorporates proprietary Smart Sensor technology that enables the module to recognize a previously calibrated probe and to automatically apply the necessary probe calibration coefficients. This alleviates the need to re-calibrate a probe every time a different probe is plugged in to the module. The module ‘recognizes’ a specific probe every time the probe is plugged in.

When probes are ordered at the same time as the LDF100C, BIOPAC will calibrate the LDF100C to the ordered probes with a “motility standard” before shipping the items. If a probe has previously been calibrated then there is generally no need to re-calibrate that probe. However, when probes are purchased separately they will require calibrating before use using an LAF CAL calibration kit. When the calibration procedure ends, the calibration data is automatically stored in the module. The calibration data is automatically retrieved every time that particular probe is connected to the module.

LDFCAL CALIBRATION KIT

Contents: Motility standard and positioning device

- The motility standard is a colloidal solution of suspended latex spheres. The size and concentration of spheres are carefully controlled so that calibration values are always reproducible.
- The size and relative density of the latex spheres is such that the artifact due to settling and aggregation is negligible during the calibration process.

Intended use: Use the calibration standard with the LDF100C blood flow monitor and probes when required. Probes require calibration if they are purchased separately from a monitor and for routine calibration purposes.

IMPORTANT! Please read the information contained in this section before using the calibration standard. Pay particular attention to the warnings and cautions ⚠

Read the entire LDF100C section (page 193-211) for further details.

Manufacturer: Oxford Optronix Ltd.

PROBE CALIBRATION PROCEDURE—TSD140-TSD47

- To calibrate the single fiber driver adapter (TSD148), refer to the next section.

To perform a new probe calibration, a Calibration Kit (LDFCAL) is required, which contains a motility standard and a positioning device. The parameters are automatically stored and recalled when that particular probe is subsequently connected.

⚠ Every probe is supplied with a probe identification number (Probe ID) on the probe box label. The number is between 5 and 36 and must be unique for the probes used; using two probes with the same ID will result in invalid calibration data being used.

Calibration errors may occur if probes with the same probe identification number are used. Contact BIOPAC for advice if multiple probes have the same ID number.

⚠ The motility standard has a limited life. The expiration date is indicated on the label. The solution must not be used beyond this date, as it will produce misleading values due to the aggregation of the latex spheres.

⚠ Do not use the motility standard in ambient temperatures below 15°C or above 25°C.

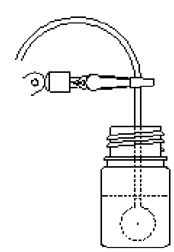
⚠ Store the motility standard within the temperature range 3 – 25°C. Do not freeze the solution.

⚠ Never attempt to re-fill the bottle with spilt solution. Errors may arise as a result of contamination.

⚠ Do not dilute the motility standard.

⚠ It is essential that the calibration procedure be performed on a stable and vibration-free surface. This is very important, any movement or vibration during the calibration procedure, however slight, is likely to result in erroneous calibration data.

1. Connect the probe to the front panel of the blood flow monitor.
2. Gently swirl the bottle to disperse the contents.
3. Open the bottle and allow the contents to settle for one minute before proceeding.
4. Carefully position the probe in the solution. This is best achieved by holding the probe cable within the jaws of the clamp and carefully lowering the active area of the probe into the center of the solution.



IMPORTANT! Keep the active surface of the probe as far as possible from the edge of the bottle. The probe should be supported in such a way that it does not swing or move while it is in the solution.

Read through all the instructions first before proceeding.

5. Press the CAL button on the front panel of the LDF100C once and then press the CAL button again within 10 seconds to confirm calibration. To end calibration at this point, wait 10 seconds and the calibration process will time out and stop. If proceeding, there will be one long beep.

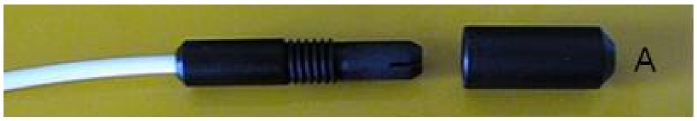
IMPORTANT! Any vibration or movement during this period will invalidate the calibration procedure.

6. An audible double beep indicates a successful calibration.
   - A series of audible beeps (long beep followed by a pause and then a number of rapid beeps) indicates a failed calibration. The number of rapid beeps equates to the error code—refer to Troubleshooting for more information on the error codes.

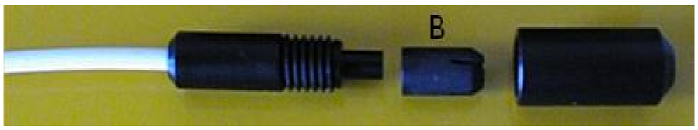
Driver Calibration Procedure— TSD 148

- To calibrate a probe (TSD140-TSD147), refer to the preceding section.

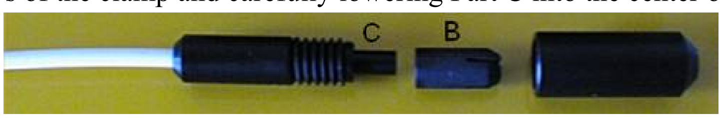
1. **IMPORTANT!** Read the following information before attempting to calibrate the single fiber probe connecting adapter. Refer to calibration standard instructions for precautions to be taken.
2. Unscrew Part A.



3. Pull off Part B. (Note: This is a tight fit and may need to be twisted while it is pulled.)



4. Connect the single fiber adapter into the front panel of the blood flow monitor.
5. Gently swirl the bottle to disperse the contents before use. Open the bottle and allow the contents to settle for one minute before proceeding.
6. Carefully position Part C of the adapter in the solution. This is best achieved by holding the adapter cable within the jaws of the clamp and carefully lowering Part C into the center of the solution.



IMPORTANT! Keep the active surface of the probe as far as possible from the edge of the bottle. The adapter cable should be supported in such a way that it does not swing or move while in the solution. Follow the calibration procedure detailed in the preceding section.

7. Clean Part C to remove residual calibration solution by washing and wiping using water or 70% IMS or IPA. Allow Part C to dry before reassembling the adapter by pushing Part B onto Part C and then attaching Part A.

LDF SAFETY

This section contains important safety information related to the general use of the LDF100C laser Doppler perfusion module. Important safety information also appears throughout the LDF100C and TSD140 series sections as Warnings and Cautions.

! Warning A warning indicates the possibility of injury to the operator.

⚠ A caution indicates a condition that may lead to equipment damage and/or malfunction.

LDF100C incorporates semiconductor laser diode devices operating in continuous mode and emitting invisible laser radiation at a nominal operating wavelength of 830 nm. The maximum output power at the probe tip is less than 0.5 mW. Laser light emitted from the optical fiber is highly divergent. Although the characteristics of the laser radiation place the LDF100C device within the "Class 1" classification users should avoid directing the laser radiation onto the eye. Applying the probe to any tissue **OTHER THAN THE EYE** is harmless, even over prolonged time periods.

Warnings

! Warning **Never** apply an LDF100C probe directly to the eye. The laser beam may cause permanent damage to the retina.

! Warning **Do not** attempt to use the LDF100C if it is damaged or does not operate as described in this manual. There is a risk of electrical shock or other injury. The module must be returned to BIOPAC for repair.

Cautions for the Module

⚠ **Do not** attempt to operate the LDF100C in the vicinity of imaging or therapeutic equipment that emits ionizing radiation or produces a strong magnetic field as the performance of the module may be affected. Extra long probes are available that allow the LDF100C module to be operated at a safe distance from such equipment.

⚠ **Do not** attempt to autoclave, pressure sterilize, or expose to radiation, any part of the module.

⚠ **Do not** attempt repairs to the LDF100C module or TSD140 series probes. Only BIOPAC trained personnel should undertake repairs.

⚠ **Do not** use the LDF100C in the presence of strong or changing ambient lighting levels as this may result in erroneous measurements and artifacts.

⚠ **Do not** use probes, cables and other accessories unless supplied by BIOPAC, otherwise serious damage may result.

⚠ **Do not** mishandle the module; use extreme care at all times.

⚠ **Do not** use the module in the presence of flammable anesthetics, which represent an explosive hazard.

Cautions for the Probes

⚠ **Do not** drop, pull, stretch or apply mechanical shock to a TSD140 series probe. Permanent damage to the probe may result.

⚠ **Do not** apply tension to the probe cable. Permanent damage to the probe may result.

⚠ **Do not** soak or immerse the probe in any corrosive liquid solution. Permanent damage to the probe may result.

⚠ **Do not** mishandle. Handle the probes with great care to avoid breaking the optical fibers, scratching the polished ends or separating the probe ends or connectors from the fibers.

MAINTENANCE

User Responsibility Never use a defective product. Replace parts that are missing, broken, worn or damaged in any way immediately. This product (or its components) should be repaired only by BIOPAC Systems, Inc. trained engineers. Any exceptions to this recommendation must be made using written instructions supplied by BIOPAC Systems, Inc. If service is not provided by BIOPAC Systems, Inc. (or its appointed agents) then the user of this product will have the sole responsibility for any losses incurred as a result of unauthorized maintenance, improper repair, alterations or damage.

LDF100C

! Warning Only BIOPAC technical staff should remove the cover of the LDF100C module. There are no user-serviceable parts inside.

Inspect the module regularly for signs of wear and tear.

TSD140 Series Probes

Inspect TSD140 series probes regularly to check the integrity of the internal optical fibers.

- A simple check is to hold the probe end to a source of bright diffuse light (e.g. a lamp) while visually inspecting the connector end. Two bright spots of light of equal intensity should be visible from the two large pins within the connector.

STORAGE & CLEANING

LDF100C Storage & Cleaning

When not in use, the LDF100C module should ideally be stored at room temperature, although it may be stored between 5°C to 50°C. When returning from extremes of temperature, it is important to allow the module to stabilize at room temperature before use.

To clean the surface of the module: wipe lightly with a dry, lint-free cloth. Or wipe lightly with a soft cloth dampened with a commercial, nonabrasive cleaner, or use a low-pressure air line to blow dust free, or carefully clean with a suitable vacuum cleaner.

To disinfect the module, wipe the surface with a soft cloth dampened with a solution of 70% alcohol in water.

! Warning Do not spray, pour or spill any liquid on the LDF100C module, its accessories, connectors, switches or openings.

TSD140 Series Probes Storage & Cleaning

When not in use, TSD140 series probes for the LDF100C should be stored in the probe box with the optical fiber coiled neatly. Following sterilization, probes should be stored unopened in the packaging in which they were sterilized.

Cleaning

Probes are cleaned prior to packing and shipment. It is recommended that the probe end on all new probes be wiped with a soft cloth, preferably one that does not shed fibers, dampened with a solution of 70% alcohol in water.

Probes should be cleaned immediately after use as it is easier to remove soiling and particulate matter before it dries onto surfaces.

Visually inspect the probe end, cable and connector.

- If there is no visible soiling, wipe the probe end and cable with a soft cloth dampened with a solution of 70% alcohol in water. Allow the alcohol to dry completely before using the probe.
- If there is visible soiling, clean the probe with warm water containing a mild detergent. To ensure that all soiling and particulate matter is removed, keep the probe beneath the surface of the cleaning solution and rub it carefully with a soft cloth or brush. Avoid immersing the probe connector in the cleaning solution. Rinse the probe end and cable in clean water. Wipe the probe end and cable with an absorbent cloth and leave the probe to dry completely.

Disinfection

To disinfect TSD140 series probes, immerse the probe end and cable (for the disinfectant manufacturer's recommended immersion times) in:

- 2% glutaraldehyde (Cidex)
- 70% alcohol in water

Sterilization

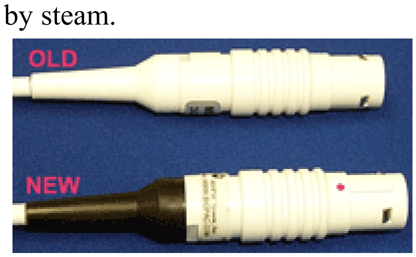
Some of the TSD140 series dedicated perfusion probes may be sterilized by moist heat (steam). They are capable of withstanding an autoclave cycle of 134°C for 3 minutes. With care a TSD140 series probe can be expected to survive between 10 – 20 sterilization cycles.

⚠ TSD140 series probes must be cleaned prior to sterilization.

⚠ It is the responsibility of the user to validate the sterility of TSD140 series probes after sterilization.

The TSD140 series probe should be packaged to maintain sterility after processing. The packaging material used should be appropriate for sterilization by steam, e.g. a tray within a pouch. The dimensions of the base of the tray should not be smaller than 15cm x10cm for a standard length probe.

1. Place the probe in the tray in a neat coil.
   - Starting at the connector end, tape the connector to the base of the tray using autoclave tape. Coil the probe onto the tray and lay the probe end in the center of the coil. Autoclave tape may be used to secure the cable to the tray. Do not use tape on the probe end. Do not rest the connector on the cable as it is heavy and may distort the cable.
2. Seal the tray into a pouch designed to withstand sterilization by steam.
3. Use only a validated autoclave to sterilize the TSD140 series probes.
   - Probes can be immersed in a non-corrosive sterilizing solution, such as 2% Glutaraldehyde (Cidex) or in a low-temperature, ethylene-oxide gas sterilization chamber. The maximum temperature to which **older** style probes can be exposed is 60 °C.



TROUBLESHOOTING

! Warning Only BIOPAC technical staff should remove the cover of the LDF100C module. There are no user-serviceable parts inside.

⚠ Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Contact support@biopac.com for problems using the LDF100C.

BEEP & LED GUIDE

Beep	LED	Indication
Two beeps	Off	Initializing with no probe.
Two beeps	Red	Initializing with a probe connected.
—	Green	Instrument ready for use; no probe connected.
—	Amber	Instrument operating correctly with probe connected.
Single beep every 16 seconds	Amber or green	Laser temperature out of range (too hot or too cold).
Double beeps	Alternating amber/red, synchronized with beeps	Calibration button was pressed, awaiting confirmation. *Note* If the calibration button was pressed in error, wait 10 seconds for normal operation to resume. To confirm calibration, press the calibration button again during that 10-second period.
Long beep	Alternating amber/red	Calibration in progress.
Double beep	Amber	Calibration successful.
Long beep followed by a number of short beeps indicating the error.	Alternating red/amber, synchronized with error code beeps	Calibration failed. **Error: 1, 2, 3, 4, 7** *Incorrect probe position or malfunctioning probe.* Reposition probe in motility standard and repeat calibration procedure. **Error: 5, 6** *Vibration or movement of probe or cable.* Ensure LDFCAL motility standard is on a vibration-free surface and eliminate probe and cable movement; repeat calibration procedure.
Single beep	Amber	Calibration aborted (probe removed or calibration button pressed).

REDUCING SIGNAL ARTIFACT

⚠ Certain environmental conditions and probe application and positioning errors can affect laser Doppler blood perfusion readings.

Irrespective of the probe used, it is important to reduce the possibility of signal artifact, noise and signal dropout in the blood perfusion reading. The presence of motion artifact noise in the blood perfusion signal is often due to relative movements of the tissue (e.g. induced by breathing) with respect to the probe and/or probe cable movements. To minimize artifact, allow the probe to come into contact with the tissue such that the probe and tissue 'move together' and ensure that the cables do not move. It may be helpful to secure the probe cable to the table with adhesive tape at intervals.

It is also essential to ensure that undue probe pressure is not applied to the tissue, otherwise local occlusion of the microvasculature may result in a corresponding reduced blood perfusion reading.

Excessive ambient lighting at the probe measurement site can also disturb the blood perfusion reading. Avoid direct illumination of the measurement site from external lighting sources and direct sunlight. If erroneous readings due to excessive ambient lighting levels are suspected, cover the attached probe and measurement area with a light piece of opaque material.

In summary, avoid the following situations:

- Probe movement relative to the tissue.
- Movement of the probe cables.
- Strong ambient lighting sources such as surgical lights, fluorescent lights and direct sunlight.
- Changing ambient lighting.

Loss of signal due to excessive tissue occlusion could occur for the following reasons:

- Excessive probe pressure on the tissue.
- The formation of a hematoma (blood clot) within the tissue.

ELECTRO-MAGNETIC INTERFERENCE

⚠ With the proliferation of radio-frequency transmitting equipment and other sources of electrical noise in research environments (e.g. mobile phones, electrical appliances), high levels of such interference due to close proximity or strength of a source may result in disruption of performance of this device.

Erratic readings, cessation of operation or other incorrect functioning may indicate electro-magnetic interference to the module. If this occurs, survey the location of use to determine the source of the disruption and take actions to eliminate it:

- Turn equipment off in the vicinity of the module to isolate the equipment generating the electromagnetic interference.
- Relocate the other device(s).
- Increase the separation between the interfering equipment and the LDF100C module.

For further information and assistance contact BIOPAC.

POSSIBLE ERRORS & SUGGESTIONS

A. There is no response to the Power On button and the Power On LED indicator fails to light green.

The power adapter may not be properly connected to the LDF100C or to the Mains outlet, or it may not be functioning. Check all connections. If possible, try another adapter with the *same specification*; the adapter must have the same specification to maintain electrical safety.

B. There is no double beep upon power on and/or the initial beep does not occur.

If the power on indicator is not lit, the power supply may not be working. Notify institution service personnel to check and if necessary, replace with the same type and rating of adapter. If the power on indicator is lit, the module has failed the power on self-test. Do not use the module. Contact BIOPAC.

C. There is a continuous sound upon power on.

The module has failed the power-on self-test. Do not use the module. Contact BIOPAC.

D. The `Temp. Out of Range` beep sequence is emitted (an audible beep every 16 seconds).

This is normal during the warm-up period and not indicative of a fault.

Warning sounds if the laser temperature is above or below the range for stable operation. If this occurs, the instrument should be moved to warmer or cooler environment for proper operation. Output signals (analog voltage outputs and serial data) will be generated but should be interpreted with caution.

If the environmental ambient temperature is below 25°C and this error occurs repeatedly soon after power-on, then a fault may have occurred—contact BIOPAC for further advice.

E. The status LED remains green even though there is a probe connected.

This is likely a problem with the probe. If a spare probe is available, replace the probe connected to the module with the spare probe. It may be possible to determine which probe is faulty.

If the problem can't be resolved, contact BIOPAC.

F. The `analog outputs are both 0 V`.

This might occur a) when the probe is connected to the LDF100C; b) due to a low backscatter signal; and c) because probe calibration is required. Follow the instructions for probe calibration given in section 4.12.

G. Pressing the CAL button for probe calibration does not emit a double beep to indicate a probe calibration is under way.

The calibration process has failed to start. Try pressing the CAL button again. If there is still no response, contact BIOPAC.

H. The `Error` beep sequence (varying number of beeps) is emitted.

Probe calibration has failed. There are 7 series of error beeps used to indicate the reason for calibration failure. Beep sequences are explained below:

Error: 1, 2, 3, 4, 7	*Incorrect probe position or malfunctioning probe.* Reposition probe in motility standard and repeat calibration procedure.
Error: 5, 6	*Vibration or movement of probe or cable.* Ensure LDFCAL motility standard is on a vibration-free surface and eliminate probe and cable movement; repeat calibration procedure.

I. The BPU values are erratic.

The probe may have become detached, check and replace if required. Tissue movement may be excessive. The probe cable may be moving; re-route the cable and/or secure that cable at intervals using adhesive tape. There may be local electro-magnetic interference —see page 207.

J. The analog output signal is zero.

There may be a cable problem. Check that the cable attached to the analog output connector(s) is correctly configured. Notify institution service personnel and request that they check that i) the cable is correct and ii) the output signal(s) are available on the pins of the connector(s).

If the problem cannot be resolved, contact BIOPAC.

Obtaining Technical Assistance

For technical information and assistance or to order additional probes and accessories, please contact BIOPAC. When calling BIOPAC for technical support, it is helpful to have the serial number of the LDF100C module and/or TSD140 series probes and the version of Acq*Knowledge* software.

- The serial number of the LDF100C module can be found on the back panel.
- Probe serial numbers can be found on the cable label and Probe ID numbers are on the probe box.
- The Acq*Knowledge* software version appears under the **About** menu in the software.

Returning LDF Components

Contact BIOPAC for shipping instructions including a Returned Materials Authorization (RMA) number and a RMA Declaration (including decontamination of equipment) form.

Pack the module in its original shipping carton. If the original carton is not available, wrap the module securely using bubble wrap and pack it in a strong box surrounded by polystyrene chips and/or suitable foam inserts.

A probe should be returned in the probe storage box. If returning a probe on its own, wrap the probe storage box in bubble wrap and pack it in a strong box.

Use a recognized courier company for the return of the module and probes.

Warranty

BIOPAC warrants that this device is free from defects in both materials and workmanship.

THE ABOVE WARRANTIES ARE IN LIEU OF ALL WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The user shall determine suitability for use of this device for any procedure. BIOPAC shall not be liable for incidental or consequential loss or damages of any kind.

Principles of Laser Doppler Flowmetry

What does the LDF100C measure?

The LDF100C is a laser Doppler blood flow (perfusion) module whose primary purpose is to measure real-time microvascular red blood cell (or erythrocyte) flow (perfusion) in tissue. Perfusion is sometimes also referred to as red blood cell flux. Laser Doppler signals from the tissue are recorded in BPU (Blood Perfusion Units) which is a relative units scale defined using a carefully controlled motility standard comprising a suspension of latex spheres undergoing Brownian motion.

The LDF100C laser Doppler flow module employs a technique called laser Doppler Flowmetry (LDF) and works by illuminating the tissue under observation with low power laser light from a probe containing optical fiber light guides. Laser light from one fiber is scattered within the tissue and some is scattered back to the probe. Another optical fiber collects the backscattered light from the tissue and returns it to the monitor. Most of the light is scattered by tissue that is not moving but a small percentage of the returned light is scattered by moving red blood cells. The light returned to the monitor undergoes signal processing to extract the signal related to the moving red blood cells. Microvascular blood flow (perfusion) is indicated in the Acq*Knowledge* software display in relative units called Blood Perfusion Units (BPU).

The LDF technique offers substantial advantages over other methods in the measurement of microvascular blood perfusion.

- Studies have shown that it is both highly sensitive and responsive to local blood perfusion and is also versatile and easy to use for continuous monitoring.
- The LDF100C is potentially noninvasive (since the TSD140 series probe is not actually required to touch the surface of the tissue) and in no way harms or disturbs the normal physiological state of the microcirculation.
- The small probe dimensions enable it to be employed in experimental environments not readily accessible using other techniques.

Measurements obtained by LDF are intrinsically of a relative nature. Although such measurements are proportional to flow, the factor of proportionality will be different for different tissues.

Blood Perfusion Signal and the BPU.

The primary function of the LDF100C is to produce a blood perfusion output signal that is proportional to the red blood cell flow (perfusion). This represents the transport of blood cells through microvasculature and is defined as:

Microvascular Flow (Red Blood Cell Flux)	=	Number of blood cells moving in the tissue sampling volume	x	Mean velocity of these cells

Microvascular blood perfusion therefore, is the product of mean blood cell velocity and mean blood cell number concentration present in the small measuring volume of tissue under illumination from the probe. For the LDF100C, microvascular blood perfusion is indicated in the Acq*Knowledge* software display in relative units called Blood Perfusion Units (BPU). All LDF100C devices have been calibrated with a constant, known motility standard so that, for a given perfusion situation, all LDF100C probes will read the same value of blood perfusion expressed in blood perfusion units (BPU).

The standard Blood Perfusion output on the LDF100C has been optimally filtered with a time constant of 200 ms to give a clean and smooth looking signal while being able to respond to dynamic changes and pulsatile blood flow. This output is available as a continuous analog voltage for recording purposes via the MP system.

Backscatter Signal (BS)

The LDF100C also produces a signal, which is proportional to the total light remitted or backscattered from the tissue. This is called the Backscatter Signal (BS) and is available as an analog voltage output for recording purposes via the MP system. The backscatter is expressed as a percentage fraction of the laser light remitted from the tissue from the percentage of the maximum analog output possible for the backscatter signal. For example, in highly perfused tissues, the BS will be low due to increased photon absorption. Situations where the BS signal is close to zero may indicate that the probe has come into contact with whole blood. This could cause the BPU reading to saturate since the system is no longer monitoring microvascular perfusion.

What is the Meaning of Zero and Negative BPU?

The zero (0.00 V) reading of the LDF100C has been obtained by calibrating the system against a special static scattering material where no movements occur. In such cases the back-scattered light processed by the LDF100C contains no Doppler shifted frequency components and a true zero is obtained. In a true physical sense, 'noise' around zero can be both positive and negative, thus it is possible that a small negative reading (of up to –10 BPU) can be observed in conditions of zero perfusion.

A zero reading indicates zero motion both in the measuring volume under examination and artifactual motion arising from relative movements between the probe and the measuring volume. During *in vivo* measurements, rarely is an absolute zero obtained. Even during total occlusion of tissue blood perfusion, there is often some small, residual motion of blood cells trapped in the vessels, as well as some small muscle and tissue movement in the measuring volume. Even after surgical removal of tissue, localized cell movement and Brownian motion may still occur in the severed blood vessels.

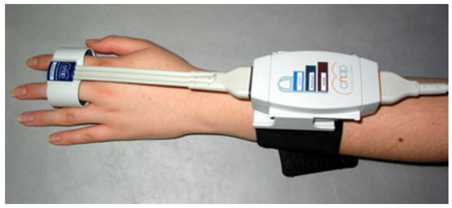
What volume of tissue does the LDF100C measure?

LDF defines a flow (perfusion) parameter from information contained in the optical spectrum of light remitted from the tissue. The actual measurement sampling volume or depth can only be determined by identifying precisely which blood vessels and erythrocytes have interacted with the remitted light, which in turn, is principally dependant on two parameters; namely the optical scattering and optical absorption coefficients of the tissue under observation. Since both of these coefficients are entirely dependent on the site of observation and perfusion of the microvasculature at the time of measurement, it is impossible to determine the actual sampling volume/depth at any tissue site. Generally speaking, for well-perfused tissue such as muscle, the mean sampling depth has been estimated to be in the region 0.5-1.0 mm with a concomitant sampling volume in the region 0.3-0.5 mm^3. For cutaneous measurements, the sampling depth is likely to be in the range 1.0 – 1.5 mm. These estimates have been obtained heuristically through many years of experience and are based on both *in vitro* observations and mathematical modeling of photon diffusion through "imaginary tissues" using Monte-Carlo techniques.

RXNIBPA

The sensor in the older module NIBP100A requires replacement every six (6) months. The sensor has an internal processor that monitors the age of the sensor. The sensor starts counting after the first few uses and then automatically stops on the 6-month anniversary. The sensor also has a 24-month shelf life and should be used within that time frame.

NIBP100D Noninvasive Blood Pressure Monitoring System



The NIBP100D Noninvasive Blood Pressure Monitoring System is suitable for small children (~4-5 years) to large adults

- **Accurate noninvasive blood pressure values**
- **Comfortable for subjects to wear**
- **Real-time, continuous, noninvasive blood pressure**
- **Easy to use**

The NIBP100D noninvasive blood pressure system provides a continuous, beat-to-beat, blood pressure signal recorded from the fingers of a subject. The system outputs a continuous blood pressure waveform that is similar to a direct arterial pressure waveform. The monitor displays values for systolic, diastolic, mean blood pressure, and heart rate.

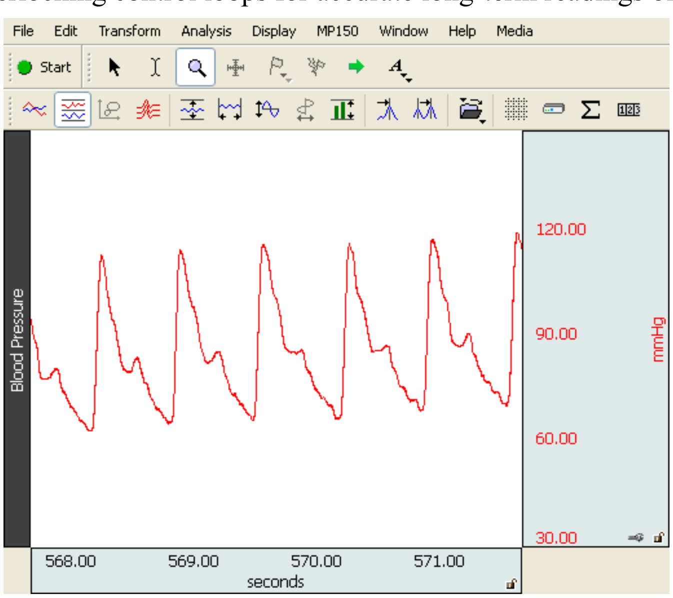
The noninvasive blood pressure (NIBP) monitoring system uses a double finger cuff that is comfortable for the subject to wear and easy to place on the hand. The cuffs (included with system) come in three sizes to accommodate children through large adults.

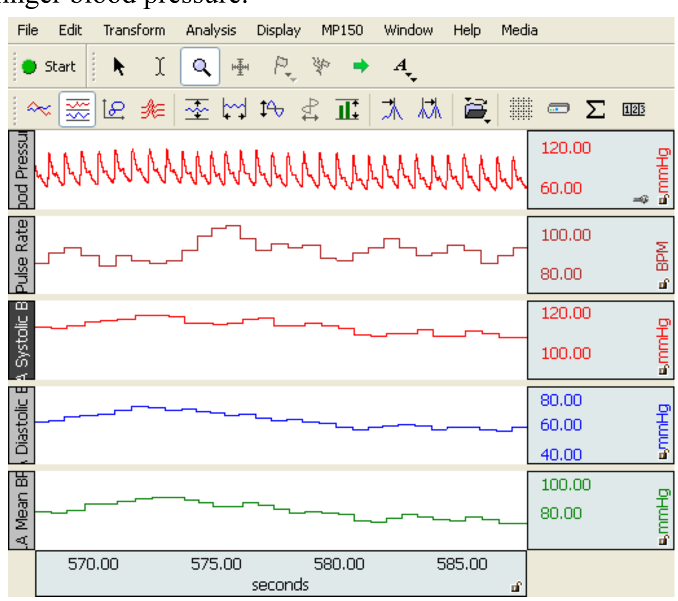
The NIBP100D interfaces with an MP150 data acquisition system (or third-party data acquisition system), via a DA100C and TCI105 Interface Connector. The Acq*Knowledge* software displays the blood pressure signal, plus systolic, diastolic, mean blood pressure and heart rate. It will also provide a detailed beat-to-beat analysis of the blood pressure signal.

The NIBP100D is calibrated using a standard blood pressure cuff that is placed around the subject's upper arm. The unit automatically takes a blood pressure measurement from the subject and uses the value for calibration purposes. During the calibration process the system locates the pulse at the finger and performs a partial occlusion. It will switch from one finger to the next during the course of the recording to relieve the pressure from the occluded finger. The interval between finger rotations is user-selectable and can be as long as 60 minutes. During the rotation, the system takes another calibration reading to ensure that values are accurate.

The system is very user friendly and the initial setup and calibration period takes less than three minutes—that time includes placing the cuff around the upper arm and the sensor on the fingers. Placing the finger sensor is as simple as sliding the subject's fingers through the two cuffs.

The system employs a vascular unloading technique to measure blood pressure at the fingers. A refined version of the Penáz' principle is used to deliver a continuous noninvasive blood pressure signal. The method is based on concentrically interlocking control loops for accurate long-term readings of finger blood pressure.





Specifications

*For complete specifications, see the **NIBP100D User Manual** online under the product page "Resource" tab.*

Components

- **Double-Cuff Finger Sensors** – one each size
  - o **L** 24 - 28 mm dark red, **M** 18 - 24 mm Dark blue, **S** 10 - 18 mm Light blue
- **Blood Pressure Cuffs** — one each size, latex-free
  - o **Child** (12 – 19 cm), **Small Adult** (17 – 25 cm), **Adult** (23 – 33 cm), **Large Adult** (31 – 40 cm)
- **NIBP100D Monito**r
  - o Dimensions 280 x 270 x 250 mm (11 x 10.6 x 9.8 in.)
  - o Weight 7.5 Kg (16.6 lbs) including components and accessories necessary for operability of device
  - o Battery Sealed lead gel, operating time = 2h (fully charged battery, normal conditions)

Electrical properties

- Nominal voltage: 18 VDC ±10%
- Nominal current: 3A
- Operability: No time-limit if powered by external mains adapter, at least 2h if on battery-operation (fully charged battery)

NIBP100D continuous noninvasive arterial pressure

- Parameter classification
  - o Sys, Dia, Mean [mmHg]
  - o Pulse [bpm]
- Measuring range
  - o Sys: 40 - 250 mmHg (5.3 – 33.3 kPa)
  - o Dia: 30 - 210 mmHg (4 - 28 kPa)
  - o Mean: 35 - 230 mmHg (4 – 30.6 kPa)
  - o Heart rate indication range 20-200 bpm
  - o Accuracy ±5 mmHg (0,6 kPa)
- Display resolution 1 mmHg (0.1 kPa)
- Inflation pressure
  - o Typ.: 120 mmHg (16 kPa)
  - o Min.: 30 mmHg (4 kPa)
  - o Max.: 300 ±10 mmHg (41.3 kPa ±1.3 kPa)
- Excess pressure limit
  - o 300 ±10 mmHg (40 kPa ±1.3 kPa)
  - o Response time: < 3 sec.
  - o Deflation time: < 15 sec
  - o Protection against electric shock: Type BF

Output

- Sensor bridge voltage: 2 – 10 V (external monitor)
- Sensitivity: 5 µV/V/mmHg
- BP Wave Out: CNAP™ transducer cable 0.3 m; connector RJ11 6P4C (e.g. Abbott IBP catheter)
- Max delay of analog out signal: 80 msec (means the BP waveform may be delayed with respect to other waveforms acquired by the MP150 unit, such as ECG, by max 80 msec)

Interface

- To DA100C via TCI105 (sold separately)

External mains adapter

- Nominal voltage: 100 – 240 VAC
- Power frequency: ~50/60 Hz
- Power output: 18 V, 3.3 A
- Safety class: Class II with functional earth
- Earth leakage current: < 500 µA

Standards

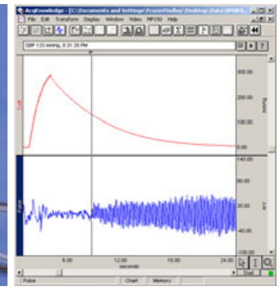
- EN 60601-1+A1+A2+A12+A13: 1996
- EN 60601-1-2: 2003
- EN 60601-1-4:1996 +A1: 1999
- EN 60601-1-6: 2004
- EN 60601-1-8:2004+A1: 2006
- EN 60601-2-30: 2000
- EN 1060-1: 1995
- EN 1060-3:1997+A1: 2005
- ANSI/AAMI SP10: 2002

CE

Note Electric and magnetic fields may interfere with the functional reliability of the device, so avoid using the NIBP100D CNAP™ Monitor 500 close to devices emitting powerful electromagnetic fields, e.g. x-ray equipment, diathermy applications or magnetic resonance tomographs.

NIBP200A Small Animal Tail Blood Pressure System

- NIBP200A1 = 110 V /60 Hz
- NIBP200A2 = 220 V /50 Hz



NIBP200A System includes:

- NIBP200A control unit
- One tail cuff sensor
  - RXTCUFSENSOR9.5 = 9.5 mm, 100-220 g
  - RXTCUFSENSOR11 = 11 mm, 200-280 g
  - RXTCUFSENSOR13 =13 mm, 250-350 g
- One small animal restrainer
  - RXRESTRAINER-MICE, 10 g-25 g (mice)
  - RXRESTRAINER-S, 70g-150g (small rat)
  - RXRESTRAINER-M, 150g-250g (medium rat)
  - RXRESTRAINER-L, 250g-350g (large rat)

Optional MRI-compatible sensors available — add to an existing NIBVP200A system

- RXCUF9.5-MRI = 9.5 mm, 100-220 g
- RXCUFF-11-MRI = 11 mm, 200-280 g
- RXCUF-13-MRI =13 mm, 250-350 g

NIBP200A SYSTEM CONNECTIONS


NIBP200A Front Panel


NIBP200A Rear Panel

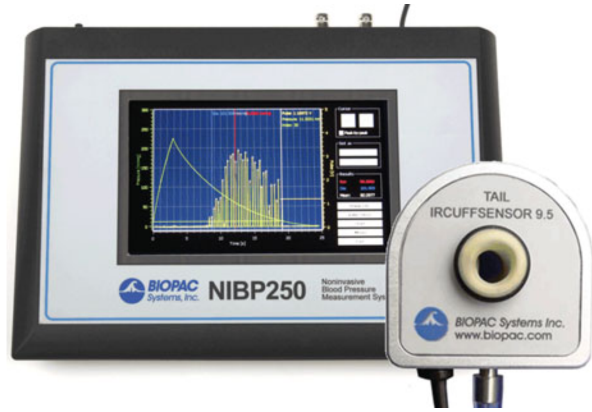
1. Connect the CBL150-Pre cable
   a. BNC to the PRESSURE output on the back panel of the NIBP200A.
   b. other end to A1 on the front of the UIM100C unit
2. Connect the CBL150-Pls cable
   a. BNC to the PULSE output on the back panel of the NIBP200A.
   b. other end to A2 on the front of the UIM100C unit.
3. Connect the IRSENSOR
   a. Black cord to the sensor input on the front panel of the NIBP200A.
   b. tubing in the cuff on the front panel of the NIBP200A.
4. Connect the power
   a. AC100 adapter to the 12V DC input on the back panel of the NIBP200A.
   b. AC100 to Mains power.
5. Switch the POWER on.

Specifications

Cut-off Pressure Range:	0-100 mmHg, 0-150 mmHg, 0-200 mmHg, 0-250 mmHg, 0-300 mmHg
Pressure Accuracy	300 mmHg Full Scale 1%
Pressure Sensitivity	0.1 mmHg
Pressure signal output:	300 mmHg/3 Volt DC
Pulse Gain:	5% to 100% (adjustable)
Pulse signal Output:	0- 4 Volt DC

A2 Pulse Display:	Pulse intensity is displayed on A2, derived from plethysmographic measures. The tail sensor detects blood flow and pulse intensity is increased or decreased, depending on the flow ratio.
Analog output:	BNC connectors
Power Supply:	12 Volt 1 Amp – External

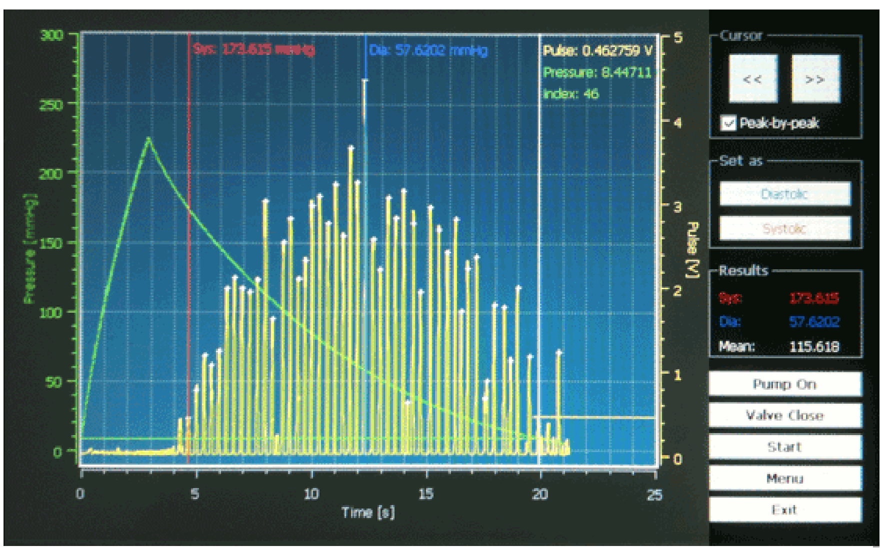
NIBP250 Small Animal Noninvasive Blood Pressure Amplifier



The NIBP250 small animal tail noninvasive blood pressure equipment is a stand-alone device to measure the blood pressure of small animals and has a touch screen LCD user interface easing the use of the equipment. The NIBP250 incorporates a built-in pump that automatically inflates the blood pressure cuff to occlude the vessel in the tail of a rat or similar small animal. Once the pump reaches the inflation point it slowly deflates the cuff, providing a linear drop in pressure.

A touch screen LCD monitors the pressure and pulse signals and by using the simple touch screen interface, the points where systolic and diastolic blood pressure appear are easily marked by user inspection. The NIBP250 gives the marked values for the systolic and the diastolic blood pressures and the calculated values for the mean blood pressure and the heart rate.The maximum inflation point can be adjusted in the properties window. The NIBP250 also includes pressure calibration and validation tools to be able to refresh and check the factory calibration. The cuff assembly attaches to the equipment via a Luer lock connector and the pulse sensor attaches via a BNC connector. The equipment also has a gain adjustment control to amplify or attenuate the pulse signal. NIBP250 provides two analog outputs for uncalibrated pressure and pulse waveforms.

NIBP250 equipment has a USB 1.1 compatible flash memory port and SD card slot for moving your data to your computer for further analysis and publishing. It reports the raw and analyzed data files in ascii format which can easily be imported into your favorite application (e.g. AcqKnowledge, Excel, SPSS, MATLAB, etc.).



Each NIBP250 system includes:

- 1 - amplifier unit (switching power supply works for 110 V or 220 V)
- 1 - cuff/sensor (size 11 mm is included, but can be specified as 9.5 mm or 13 mm when ordering)
- 1 - restrainer (size medium is included, but can be specified as small or large when ordering)
- 1 - Pulse cable to MP System or third-party A/D hardware
- 1 - Pressure cable to MP System or third-party A/D hardware

Optional accessories

- Tail Heating Unit TAILHEATING-A (110 V 60 Hz) or TAILHEATING-B (220 V 50 Hz)

Specifications

Cut-off Pressure Range:	100 – 300 mmHg (adjustable by 1mmHg steps)
Pressure Accuracy:	300 mmHg Full Scale 1%
Pressure Sensitivity:	0.1 mmHg
Pressure Signal output:	300 mmHg/3 Volt DC
Pulse Gain Levels:	x1, x2, x4, x5, x8, x16, x32 (adjustable)
Pulse Signal Output:	0- 4 Volt DC
Pulse Display:	Pulse intensity is displayed on A2, derived from plethysmographic measures. The tail sensor detects blood flow and pulse intensity is increased or decreased, depending on the flow ratio.
LCD Display:	7" 800x480 TFT
User Interface:	Resistive Touch Panel
Analog outputs:	Two BNC connectors for uncalibrated pressure and pulse signals
Triggers:	Two BNC connectors for TTL Compatible trigger in and out signals
Power Supply:	12 Volt 2 Amp – External

NIBP250 Quick Guide

Prepare
- While the unit is turned OFF, attach the sensor and cuff connectors.
- Turn the unit ON and wait for the unit to start and show the main acquisition screen.
- Prepare the animal and attach the sensor-cuff to its tail.

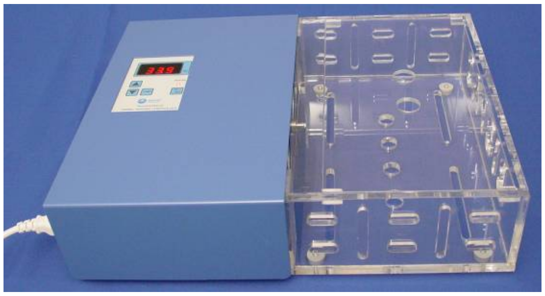
Acquire
- When the animal is prepped, press the Start button on the main screen to start the acquisition of the cuff pressure and the blood pulsations. The button label changes to Stop and you can stop the acquisition in any emergency situation.
- When the acquisition starts, the unit automatically closes the leakage valve and starts the pump for inflating the cuff.
- After the pressure reaches the maximum level it stops the pump and opens the leakage valve to make the pressure decrease slowly. The acquisition stops when the pressure reduced to the certain level.

Analyze
- After the acquisition stops, the unit automatically finds the peaks of pulsations using the pre-configured parameters, and a marker guide will appear on the screen.
- The marker can be moved along the time axis by your finger or by the cursor buttons on the top-right. You can change the movement mode by checking the peak-by-peak option under the buttons.
- After moving the marker to the systolic or the diastolic peaks, press the Sys or Dia buttons to calculate the corresponding pressure values. After marking the diastolic peak, the unit will automatically calculate the heart rate and and show it in the results section.
- Peak positions can be changed any time during analyzing step.
- Press the Save button under the results--this will automatically generate a result code that will be displayed on the top of the results section.

Save Results
- The previously saved results can be listed by pressing the Load button in the results section. Then a list will appear showing the analyzed results and the date of saving for each measurement with the result code.
- By marking the desired measurement and pressing OK button you can load the recorded pressure and pulse curves and the previously calculated results.
- After loading finishes you can easily evaluate the results and re-analyze your measurement.

Turn Off
- Before turning off the unit, be sure that the last measurement was saved.
- Power off the unit by switching the power button on the back.

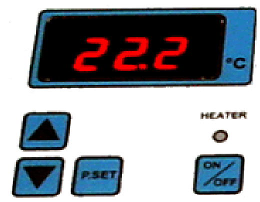
ANIMAL PREPARATION



Optional Heating Chamber

Restrainer Animal Holders

Tail Cuff/Sensor

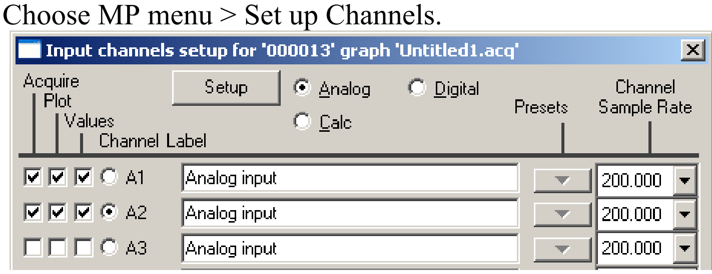


1. Turn the Animal Heating Chamber on.
2. Set the temperature value (press and hold P.Set and then press the up or down arrow to reach the desired value).
   - For accurate noninvasive blood pressure measurement, the animal or its tail should be warmed to 32°C.
3. Press the Heater button to start heating to the selected temperature value.
4. Place the animal inside the RESTRAINER "Animal Holder" (select the suitable size for the animal volume).
   - Leave the tail outside.
   - Adjust the length to obtain a position where the animal has limited movement.
5. Place the RESTRAINER (with the animal) in the heating section of the Animal Heating Chamber.
6. Wait approximately 30 minutes for the animal to reach the selected temperature.
7. Remove the RESTRAINER from the Animal Heating Chamber.
8. Connect the IRSENSOR to the tail of the animal inside the RESTRAINER.
9. Check if the sensor just fits to the tail. The sensor should be between the mid point of tail and tail end (spinal column). To achieve this, a suitable sensor should be selected.
10. Wait for the animal to relax and become inactive before starting measurements.

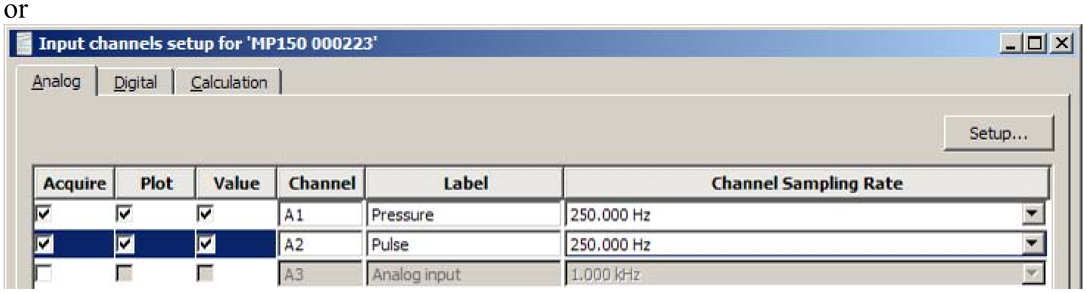
TIP Before starting the experiment, to condition the animal, put the animal inside the holder several times a day and repeat the heating each time.

SOFTWARE SETUP

1. Launch the BIOPAC software.
2. Choose MP menu > Set up Channels.



or

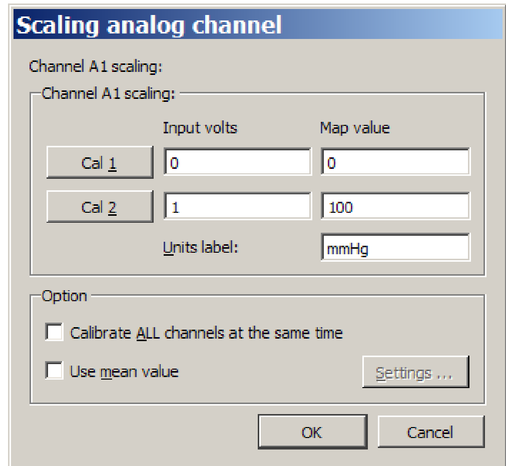


3. Enable analog inputs A1 and A2 to Acquire Data, Plot on Screen and Enable Value Display.

- If desired, enter channel Labels: A1 Pressure and A2 Pulse

4. Calibrate for the pressure measurement of IRSENSOR.
   a. Select A1 (Pressure) and click Setup and establish these settings:

	Input volts	Scale (Map) value
Cal 1	0	0
Cal 2	1	100
	Units Label:	mmHg



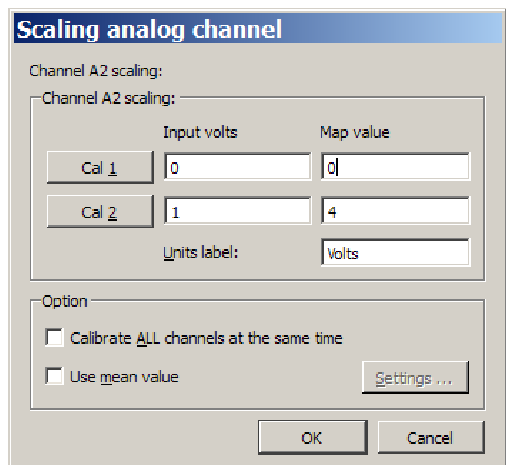
The scaling must be adjusted as the cut-off pressure switch settings are changed. If the pressure switch is set to 300 mmHg, then the settings should be:

	Input volts	Scale (Map) value
Cal 1	0	0
Cal 2	3	300
	Units Label:	mmHg

   b. Click OK as needed to close out of A1 setup.

5. Calibrate for the pulse measurement of IRSENSOR.
   a. Ensure that the tail is not inside the IRSENSOR and it is empty, and the sensor resides freely.
   b. Select A2 (Pulse) and click Setup and establish these settings:

	Input volts	Scale (Map) value
Cal 1	0	0
Cal 2	1	4
	Units Label:	Volts



   c. Click OK as needed to close out of A2 setup and the Setup Channels dialog.

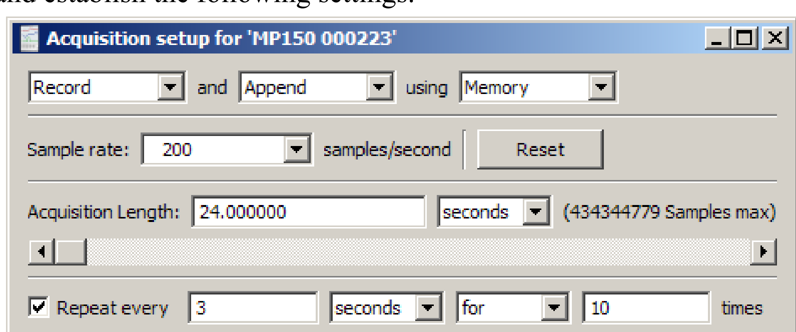
6. Choose MP menu > Set up Acquisition and establish the following settings.

   Mode = Record and Append to Memory

   Sample Rate = 200 samples/second

   Total Length = 24 seconds

   Repeat = every 3 seconds for 10 times



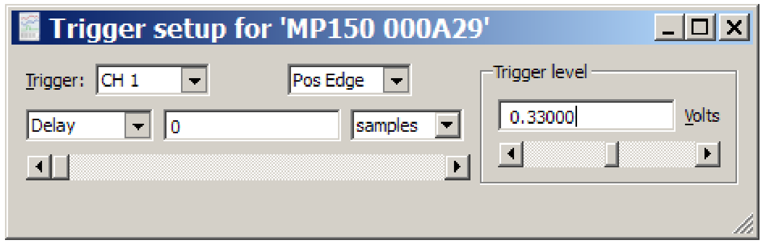
7. Close out of Set up Acquisition.
8. Choose MP menu > Setup Trigger and establish the following settings.

Source = CH 1

Pos Edge

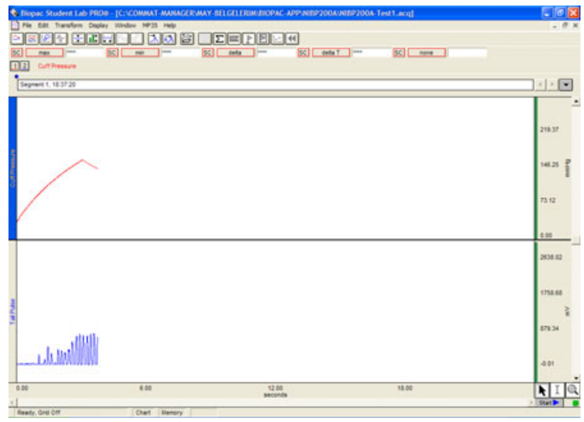
Trigger Level = 0.33
(based on 1 V ≈ 100 mmHg)

Delay = 0



9. Close out of Set up Triggering.

RECORDING

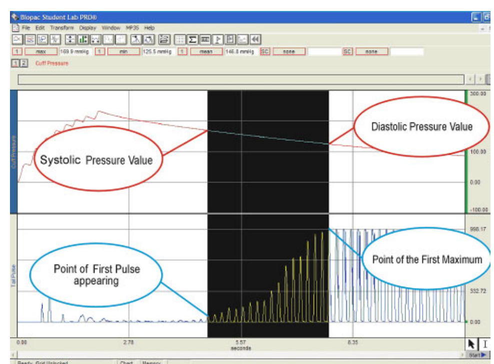


1. Confirm that the animal is ready and that the IRSENSOR is attached to the tail.
2. Click “Start” in the BIOPAC software window.
3. Press START button on the front panel of NIBP200A.
   - IRSENSOR will pump up the Cuff automatically.
   - When the Cuff Pressure on A1 reaches 30 mmHg, the cuff pressure and tail pulse signals will be generated.
   - The recording will stop automatically after 24 seconds.
4. Press START to continue with the next measurement and repeat as necessary.
5. Choose File > Save or Save as when done.

TIP A generally accepted application is that for each animal, 10 measurements are recorded and mean values are calculated. In the append mode, 10 consecutive measurements can be made in the same file.

ANALYSIS

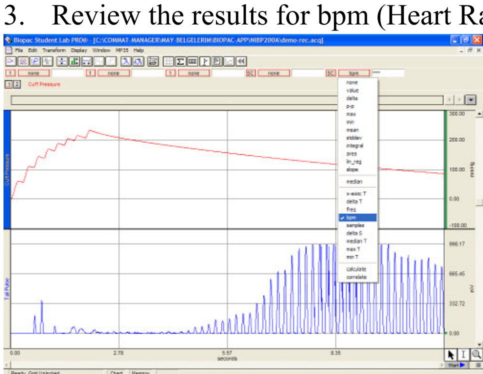
Calculation of Systolic, Diastolic and Mean

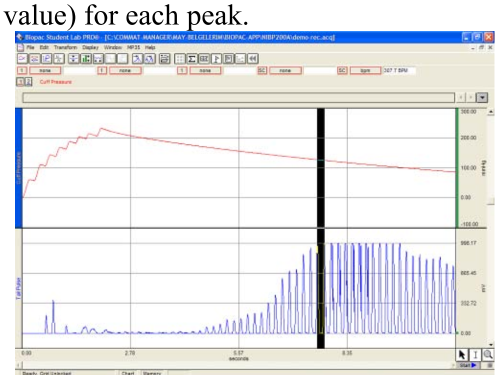


1. Click the Calculation Label.
2. Select from the list Max, Min, Mean for three different Labels.
3. Select A1 as channel option.
4. Select cursor ‘I’ from the cursor option on the bottom right of the screen.
5. On the graphical display, starting from the point of first pulse, select an area to the maximum.
6. Review the results for max (Systolic), min (Diastolic), and mean measurements.

Calculation of BPM Heart

1. Set a measurement for **bpm**.
2. Use the I-beam cursor to select the maximum points of the peaks of the A2 pulse waveform.
3. Review the results for bpm (Heart Rate value) for each peak.





TROUBLESHOOTING

Tail Pulse signals are not regular.

- The animal may be under stress, restless and moves the tail steadily. Take the animal out of the holder and let it rest, and continue with the experiment.
- The tail may not be warmed enough or cooled down. Put the animal again in the Heater Chamber and heat it up again.
- Sensor dimensions may not be suitable for the tail. Select a suitable sensor.
- Position of the Sensor on the tail may not be well-matched. Take the Sensor out, put it again by trying different positions.

Compressor is working uninterruptedly.

- Close the NIBP200A system immediately.
- Take the Tubing out from the Cuff connector on the front panel of NIBP200A.
- Turn the system on again.
- Close the air outlet by pressing the finger on the Cuff output and press the Start button. The compressor will work for a few seconds and stop (please inform BIOPAC if the Compressor does not stop). The pressure chart should be viewable on the screen.
- If the Compressor stops automatically, it means that the system is working normally.

There is a leakage with the tubing connections and Cuff of the IRSENSOR.

- Check and remove the leakage.

TAILHEAT Heater for Small Animal Tail BP

- TAILHEATA Tail heating unit, 110 V / 60 Hz
- TAILHEATB Tail heating unit, 220 V / 50 Hz

See NIBP200A for setup and usage guidelines.

fNIR100 Functional Near Infrared Brain Imaging System

The *f*NIR100 is a stand-alone functional brain imaging system that includes a control unit and sensor for continuous *f*NIR spectroscopy (NIRS). The device provides 16 channels of information through 4 sources and 10 detectors. The *f*NIR100 System includes software to view the data in real time and save it for post acquisition analysis.

*f*NIR is an optical imaging technology that measures neural activity and hemodynamic response in the prefrontal cortex. The subject wears a sensor on the forehead that includes four IR light sources and ten detectors that are mounted in a flexible band. The *f*NIR sensor detects the oxygen levels in the prefrontal cortex and provides values for oxy-hemoglobin and deoxygenated hemoglobin in real-time. It provides a continuous and real-time display of the oxygen changes as the subject performs different tasks.

The *f*NIR100 provides users with an in-lab assessment of cognitive function. It eliminates a great many of the drawbacks of a functional MRI. The subject can sit in front of a computer and take a test or perform mobile tasks. It integrates with stimulus presentation systems and BIOPAC's virtual reality products.

The *f*NIR data combines with other physiological variables such as ECG, respiration, cardiac output, blood pressure, electrodermal activity and stimulus response markers. Acq*Knowledge* software provides automated analysis tools for event related potentials and ensemble averaging. Combining the *f*NIR data with the other physiological signals provides researchers with a detailed subject assessment.

*f*NIR100 is suitable for a wide range of applications.

- Human Performance Assessment
- Depth of Anesthesia Monitoring
- Pain Assessment
- Brain Computer Interface
- Virtual Reality
- Neurorehabilitation
- Autism
- Credibility Assessment (lie detection)

Specifications

Continuous wave NIR spectroscopy (NIRS) control box

- 40 pin connector (20 channels)
- 2 x 14-pin connectors (8 channels each)
- USB Cable
- Switching medical grade power supply (+12, +5, -5)
- foldable front legs

16 Channel sensor

- 4 sources
- 10 detectors
- 2 wavelengths
- 2 x 6" cables with 14-pin connectors

COBI Studio data collection software suite

- Configurable number of channels
- Built-in artifact removal
- Requires 1 GB free disk space to run efficiently under Windows (COBI Studio software does not use all the disk space specified)

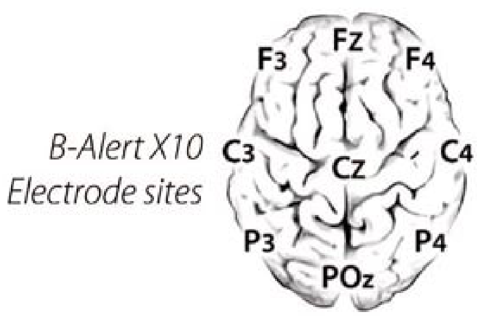
Headband

- screen the ambient light and keep the sensor in place

B-Alert X10 Wireless EEG Headset System

This complete system includes the B-Alert X10 for **wireless** acquisition of 9 channels of high fidelity EEG plus ECG, head movement & position, Acq*Knowledge* software with powerful analysis tools, including automated scoring and reporting options, and B-Alert Cognitive State software.

- Set up in less than 5 minutes
- Comfortable and nonintrusive—low profile fits comfortably under headgear
- Data quality monitoring and feedback simplifies acquisition for non-technical personnel
- Cognitive state classification for engagement, confusion/distraction, drowsiness, workload and stress
- Patented real-time artifact decontamination



Standard Signals

9 mono-polar EEG with impedance
2-lead ECG
Heart rate
Head movement
PSD by channel

Optional signals

Differential signals for B-Alert and workload

B-Alert X10 Wireless System

The B-Alert X10 mobile-wireless EEG system delivers real-time measurements for a variety of research and engineering applications, including closed-loop performance monitoring and simulation training; HCI design assessment; situational awareness and team dynamics monitoring; tools for productivity and training enhancement; and fatigue management.

B-Alert X10 Setup Overview

- For step-by-step direction, request **B-Alert X10 User Training Videos** from support@biopac.com.

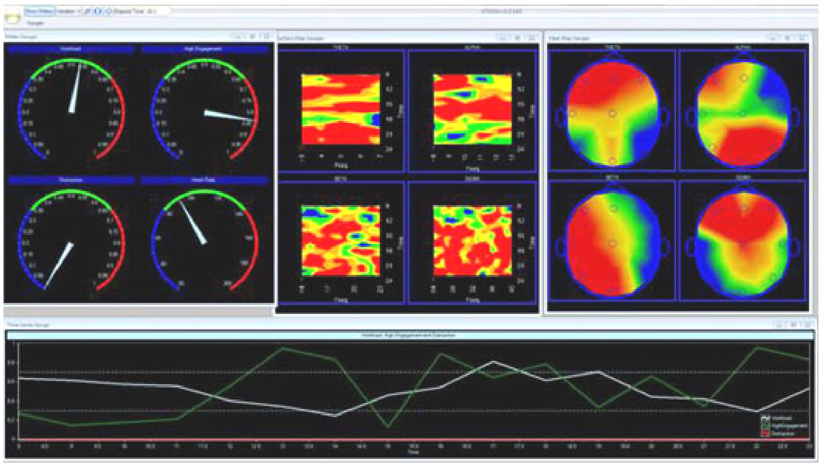
Overview

1. Prepare the B-Alert System.
2. Fill the foam sensors.
3. Apply X10 System to Participant.
4. Applying Mastoid and ECG Sensors.
5. Start Data Collection.
6. Remove X10 from Participant.
7. Clean X10 System.

Plus—Classify Cognitive States

This system includes the B-Alert Cognitive State software with proprietary metrics for real-time monitoring of subject fatigue, stress, confusion, engagement and workload (classify data from B-Alert Wireless EEG systems). The GUI intuitively represents both the raw and processed data for easy understanding by even the untrained user and up to six systems can run simultaneously on a single PC—*Windows 7/XP OS only*.

To facilitate both real-time and offline analysis, the B-Alert Athena gauges are fully customizable to fit the requirements of the user. In the standard format (shown below), the easy-to-read dashboard gauges (*Top Left*) and time series (*Bottom*) windows present B-Alert's highly validated second by second metrics: Engagement, Workload and Drowsiness (along with Heart Rate). Heat maps (*Top Right*) display EEG power spectral densities (PSD) in both spatial and temporal maps for the traditional Hz bands (Beta, Alpha, Theta, Sigma).



B-Alert Wireless EEG bio-metrics are normalized to an individual subject using 5-minutes of baseline data from three distinct tasks with the sleep onset class predicted from the baseline PSD values. A probability-of-fit is then generated for each of the four classes for each epoch with the sum of the probabilities across the four classes equaling 1.0 (e.g., 0.45 high engagement, 0.30 low engagement, 0.20 distraction and 0.05 sleep onset). Cognitive State for a given second represents the class with the greatest probability. B-Alert cognitive state metrics are derived for each one-second epoch using 1 Hz power spectra densities (PSD) bins from differential sites FzPO and CzPO in a four-class quadratic discriminant function analysis (DFA) that is fitted to the individual's unique EEG patterns. The table briefly describes each baseline task and the B-Alert classification.

Baseline task	Action	B-Alert Class probabilities
3-choice vigilance task (~7-min; optional 20-min)	Choose between primary vs. secondary or tertiary task every 1.5 to 3-seconds	High Engagement
Eyes open (5-min)	Respond to visual probe every 2-seconds	Low Engagement
Eyes closed (5-min)	Respond to audio tone every 2-seconds	Distraction if episodic Drowsy if sequential
None	Derived by regression from other three tasks	Sleep Onset

Hardware Specifications:

Channels: 9 EEG with fixed gain referenced to linked mastoids; 1 auxiliary differential channel with programmable gain
Sampling rate: 256 samples/second
Dynamic range: Fixed gain ± 1,000 µV
Resolution: 16 bit, CMRR 105 dB
Bandpass characteristics: 0.1 Hz and 65Hz (at 3dB attenuation)
Noise: ~ +1.5 µV @ 10 Hz and 50 kO impedance
Head movement/position: Angles obtained with 3D 12-bit accelerometer
Battery charging: Internally charged with custom cable and USB wall charger
On-line impedance monitoring: Initiated by host computer using bi-directional link
Head unit dimensions: Size 13 cm (L) x 6 cm (W) x 2.5 cm (H); Weight 110 g with standard battery
User control: On/Off
Indicator LEDs: Green - wireless synced, Red – on but not synced
Software
Compatibility: Windows 7 and XP, PC with 2.0 GHz or higher processor 1 GB of RAM

RF Band: 2.4 to 2.48 GHz (ISM band)
Transmission mode: Bi-Directional with B-Alert BT – USB dongle
Data transmission range: ~ 10 meters, line of sight with onboard antenna
Transmission power: ~ 1 mW
System power consumption: ~ 40 mA @ 3.7 V
Battery capacity: Standard 2 x Li-ION batteries - 500 mAH, 12-hours of continuous use
Optional 4 x Li-ION batteries: 1000 mAH, 24-hours of continuous use
Sensor Headset & Accessories

Sensor sites Fz, F3, F4, Cz, C3, C4, POz, P3, P4
Sensor strips Streamline – medium; Standard – small, medium and large
Medium = Nasium to Inion ~36 cm
Electrode cream" Highly conductive, electrolytes and preservatives in non-ionic, hypoallergenic base, buffered to skin pH
Windows 7 or XP OS only.

B-Alert Accessories

X10 Sensor Strips

Sensors are sized for placement between Nasium and Inion. Sensor strips are typically good for 40 recordings, depending on care during use and cleaning. Worn out strips should be replaced to ensure good data quality. Strip warranty is 180 days.

Strip 9 Sensor & replacement Neoprene

X10-SENSOR-S	small	32.0-34.5 cm	(approx. 12.6- 13.6")
X10 SENSOR-M	medium	> 34.5 cm	

Note: Small and Medium sensors should cover 99% of subjects, but a large is available by request in the very rare cases it is needed.

FOTS100 Fiber Optic Temperature System

This is a stand alone system, but it can also be interfaced to MP150 or MP100 Systems via CBL101. Use with high-accuracy, MRI-compatible fiber optic temperature probes TSD180 or TSD181.

FOTS100 includes control unit with RS-232 port, ± 5 V analog output, and rubber boot; power via 9 V battery or wall power.

The analog output parameters comprise the scale factor and the offset. The scale factor corresponds to the physical unit per Volt (unit/V) outputted by the system, while the offset corresponds to the physical value at which the user wants the analog output to be at zero volt.

For example, with a scale factor set to 10 °C / V and the offset set to 5 °C, the temperature as a function of the analog output voltage is given by:

Temperature = [Voltage output] x 10 °C / V + 5 °C.

The default value of the scale factor is 50 °C / V (or its equivalent in °F) and the default value of the offset is 0 °C (or its equivalent in °F). During a No Signal condition, the analog output and the serial ports output constant values as follow:

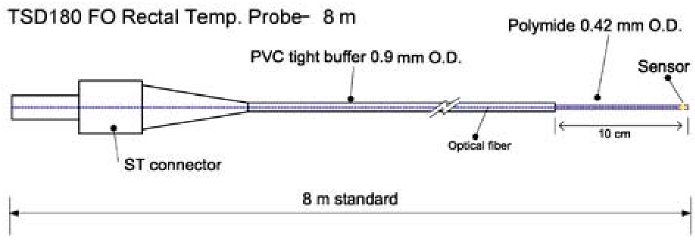
Output	No Signal condition output value
Analog	0 Volt
RS-232	65 536.0

For more details, please see the complete FOTS100 User Manual, available online.

FOTS100 Specifications

Output interface: Display, ±5 Volts Analog output, and RS-232 standard
BIOPAC interface for MP1X0: add CBL101 (RCA to 3.5 mm cable)
Channels: One
Compatibility: TSD180 and TSD181 high accuracy fiber-optic temperature sensors
Accuracy: ±0.3 °C (Total accuracy - includes both signal conditioner and transducer errors)
Temperature range: 20 °C to 60 °C (higher range also available)
Resolution: 0.1 °C
Sampling rate: 50 Hz (20 ms)
Communication protocol: SCPI (default)
Input power: 9 to 24 VDC (AC/DC wall-transformer adapter included)
Consumption: 1.8 Watts typical
Battery: 9 V
Enclosure: Plastic casing with a removable rubber boot protection
Dimensions (without rubber boot protection): 45 mm (H) x 105 mm (W) x 165 mm (L)
Storage temperature: -40 °C to 65 °C
Operating temperature: 0 °C to 45 °C
Humidity: 95 % non condensing
Light source life span: > 150,000 hours (> 17 years) MTBF

TSD180 Rectal Temp Probe: 300 µm OD Polyimide tubing, 8 m



- The Polyimide round tubing protects the sensing element its flexibility and rigidity provide excellent pushability.

TSD180 Specifications

Temperature range: 0 °C to +85 °C (other ranges AUR)
Response Time: 250 ms and better
Temperature operating & calibrated range: 20°C to 45 °C (other ranges AUR)
Accuracy: ±0.2°C (Total accuracy over the calibrated range including both signal conditioner and sensor errors)
Resolution: 0.05 °C
Operating humidity range: 0-100 %
MRI/EMI/RFI susceptibility: Complete immunity
Calibration: NIST traceable
Optical connector: ST standard
Cable sheathing: 420 µm OD of Polyimide tubing; 900 µm OD tight buffer PVC
Cable length: 8 m
Signal conditioner compatibility: FOTS100 system
Interface: FOTS100 is a stand alone Fiber Optice Temperature System
Optional interface: MP150 or MP100 System via FOTS100 and CBL101

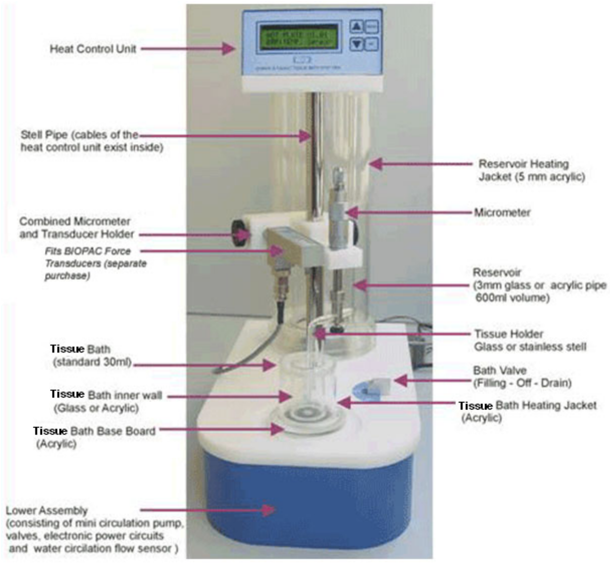
TSD181 Surface Temp Probe: sensor 1 mm OD, PFA tubing 0.9 mm OD, 8 m

- cable sheath rated up to 85 °C.

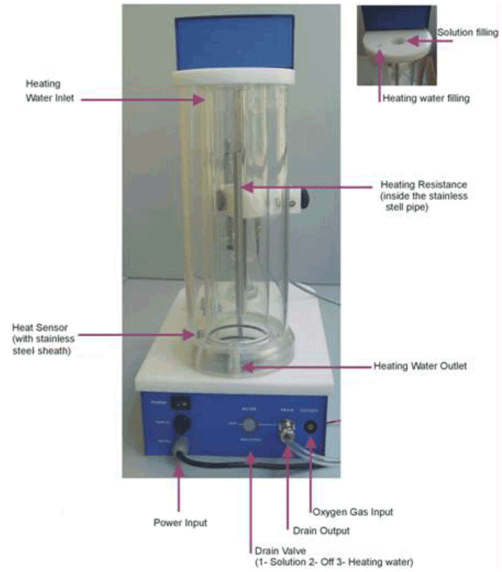
TSD181 Specifications

Temperature range: 0 °C to +85 °C (other ranges AUR)
Response Time: 1.5 sec. typical
Temperature operating & calibrated range: 20°C to 45 °C (other ranges AUR)
Accuracy: ±0.3°C (Total accuracy over the calibrated range including both signal conditioner and sensor errors)
Resolution: 0.05 °C
Operating humidity range: 0-100 %
MRI/EMI/RFI susceptibility: Complete immunity
Calibration: NIST traceable
Optical connector: ST standard
Cable sheathing: 3 mm OD Kevlar reinforced PVC cable
Cable length: 8 m
Signal conditioner compatibility: FOTS100 system
Interface: FOTS100 is a stand alone Fiber Optic Temperature System
Optional interface: MP150 or MP100 System via FOTS100 and CBL101

ITBS100 Integrated Tissue Bath



Front of the ITBS100



Back of the ITBS100

The Integrated Tissue Bath & Heater System is a modular, durable solution for the lab. Features include:

- Jacketed bath and reservoir in a range of volumes
- Integrated, programmable heating circulator
- 500 ml/min circulation flow
- Movable micrometer-transducer assembly
- User-friendly display and controls
- One-switch control of fill and drain cycle
- Microprocessor control
- Low-level alarm for water temperature
- Acrylic, robust bath
- Small dimensions, lightweight

BIOPAC Tissue Bath Systems utilize technology from ***COMMAT Ltd.*** *Pharmacology, Physiology and Biophysics Instrumentation (Turkey).*

ITBS100 Setup Instructions

1. Connect the hoses.
   a. Drain hose to the back panel DRAIN port and into a receptacle for the drained fluid (bucket, lab sink, etc.)—drain end should be lower than tissue bath station.
   b. Oxygen hose from the OXYGEN valve to an oxygen source.
2. Turn the back panel dial (WATER—OFF—SOLUTION) to OFF.

3. Fill the reservoirs.

   a. Use the funnel to fill the reservoir heating jacket—smaller holes on the top of the reservoir—with water.
      - Water level must be above the indicator post that hangs down from the top.
      - The unit won't start if water drops below the indicator. The system alarm will sound and the heater will shut off.
   b. Use the funnel to fill the reservoir—larger holes on the top of the reservoir—with Kreb's solution.
4. Toggle the POWER switch on the back panel to ON.
   - The power indicator light under the reservoir should flash **red**.
5. Set the heating temperature.

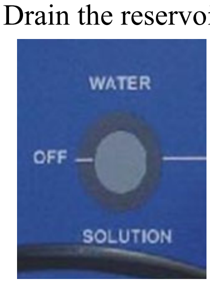
   a. Press MENU on the Heat Control Unit to display the heating temperature (the solution will be maintained at this temperature).
   b. Use the arrow keys to set to 37.5.
   c. Press OK.
6. Wait for the water to heat—display will change from HEATING to READY.
7. Check the water temp with a thermometer and, if necessary, set a temperature offset.
   a. Press MENU on the Heat Control Unit to display Set Offset.
   b. Use the up and down arrows to adjust the temperature (cold = +, hot = -).
   c. Press OK.
   d. Wait for the temperature to adjust to the desired heating temperature.
8. Fill the tissue bath.

   a. Turn the bath valve to FILL and watch the level rise—there is no auto OFF.
      - The reservoir will be depleted to fill the tissue bath.
      - The bath fills and drains from the bottom of the bath.
   b. When the desired level is reached, turn the bath valve to OFF.

After the experiment:

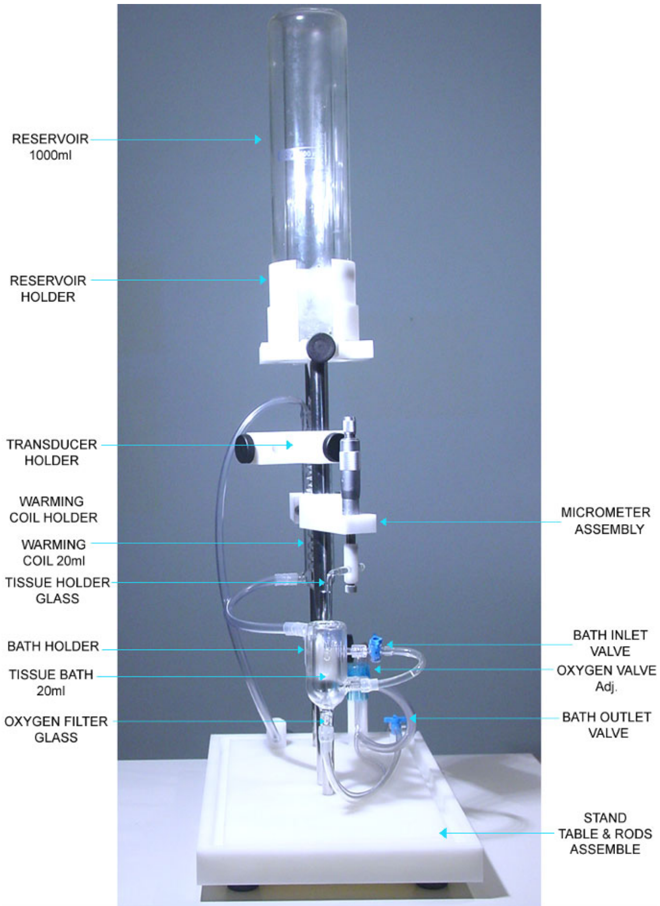
1. Toggle the POWER switch on the back panel to OFF.
2. Drain the tissue bath.

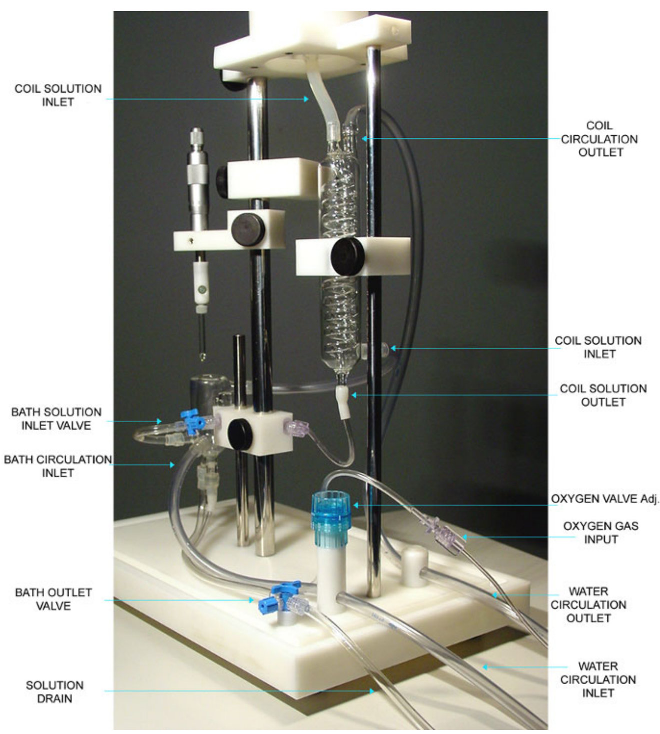
   a. Turn the bath valve to DRAIN.
3. Drain the reservoirs.



   a. Turn the back panel dial to WATER to drain the water.
   b. Turn the back panel dial to SOLUTION to drain the Kreb's.
   c. If necessary, tilt the station to completely drain it.

Tissue Bath 1, 2, 4, 8 Tissue Bath Stations





The Tissue Bath Station is completely modular, and can be purchased in multiples of one unit. The System includes all of the glassware, tubing, reservoir, tissue hooks and mounting accessories, force transducer and micrometer tension adjuster.

The ergonomic design of the station allows the tissue bath to be lowered away from the tissue holder so that mounting of the tissue preparation is very easy. The taps for filling and draining the bath are mounted on the tubing to avoid the risk of accidental bath breakage. The entire station is mounted on a convenient base stand, which creates a sturdy platform for the experiment. The unique design makes it easy to add or remove stations to provide the optimal solution for the requirements.

When a system is ordered, the size of the tissue bath and heating coil must be specified.

Each **Tissue Bath** station includes:

1 Reservoir
1 Reservoir Holder
1 Transducer Holder
1 Warming Coil Holder
1 Warming Coil (specify 5ml, 10ml, 20ml, or 30ml size)
1 Tissue Holder (glass; left)
1 Tissue Holder (stainless steel; right)
2 Triangle Tissue Holder (stainless steel)
2 Tissue Clip (stainless steel)
1 Bath Holder
1 Tissue Bath (specify 5ml, 10ml, 20ml, or 30ml size)
1 Oxygen Filter (glass)
1 Micro meter Assembly
1 Mount Accessories Kit
1 Base Station with Support Rods
1 TSD125 Force Transducer (specify TSD125 model C, D, E or F)

See also: BIOPAC Circulators, page 231, or use an existing system.

RX Tissue Bath Accessories / Reorder Parts

Tissue Holders

Tissue Clips

Warming Coil

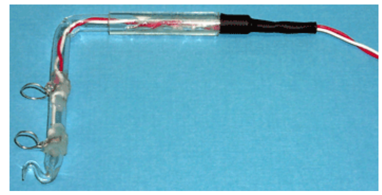
Oxygen Filter

Tissue Bath

Reservoir

Mount Accessories

Field Stimulation Electrode



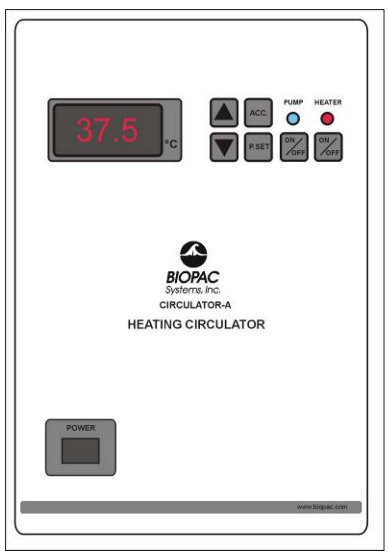
RXHOLDER-S	Tissue Holder (stainless steel)	**RXCOIL**	Warming Coil
RXHOLDER-G	Tissue Holder (glass)	**RXO2FILTER**	Oxygen Filter (glass)
RXHOLDER-T	Triangle Tissue Holder (stainless)	**RXBATH**	Tissue Bath
RXCLIP	Tissue Clip (stainless steel)	**RXRESERV**	Reservoir 1000ml
RXCLIP-TRI	Triangle Tissue Clip for Rings (stainless steel)	**RXMOUNT**	Mount Accessories Kit
		STIMHOLDER	Field Stimulation Electrode

Circulator A/B Heating Circulators

Heating circulators are used with Tissue Bath Stations and include a digital temperature display and the following controls:

- **Preset**
- **Temperature**
- **Power**
- **Heater**
- **Circulation**

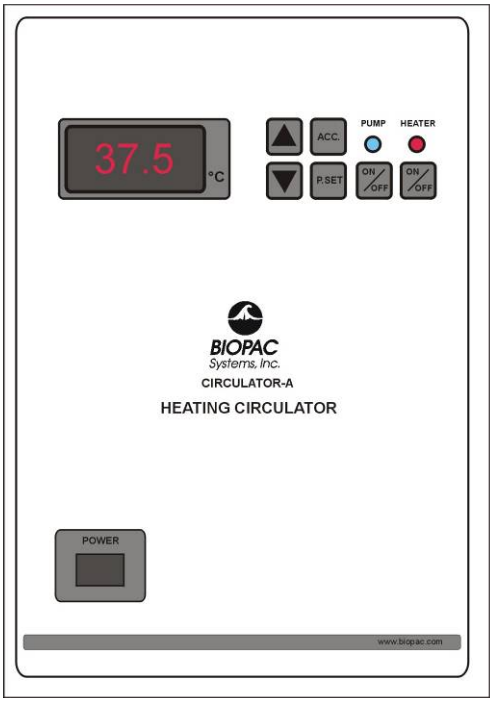
Inlet and **Outlet** ports are on the back, along with the power cord.

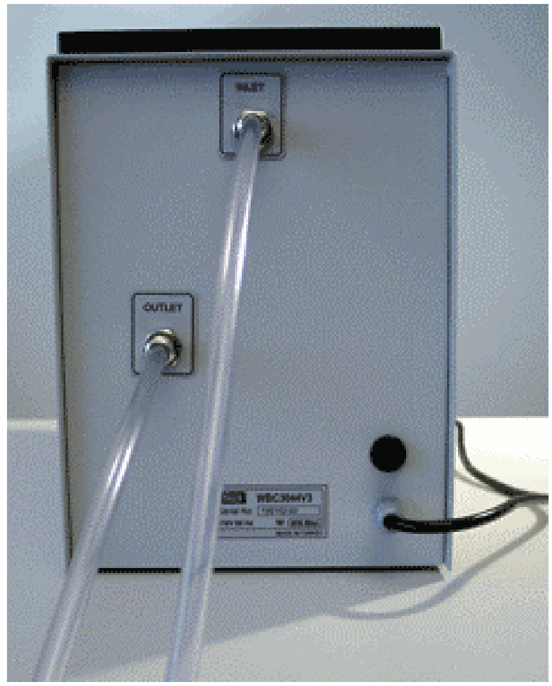


Circulator A:
110 V, 60 Hz

Circulator B:
220 V, 50 Hz

See the ***Setup and Usage Guide*** on page 231.





BIOPAC Heating Circulators will maintain water temperature at a preset value in the range 30^{0}C to 45^{0}C and circulate the water through tissue baths.

Heating circulators include a digital temperature display and the following controls:

Preset
Temperature
Power
Heater
Circulation

Inlet and **Outlet** ports are on the back, along with the power cord.

Circulator A:
110 V, 60 H

Circulator B:
220 V, 50 H

Calibration

Although the offset value for the temperature sensor is factory-calibrated, the user can calibrate the controller's internal temperature sensor. To calibrate the sensor:

1. Install a calibrated reference thermometer in the bath.
2. Adjust the offset value to zero.
3. Adjust the preset value to an appropriate temperature.
4. Once the bath reaches the preset value and stabilizes, calculate the offset value by noting the difference between the reference thermometer value and the preset value.
5. Enter this value as an offset.

Error Codes

Display

Lo	Water in the bath is not enough or the bath is empty.
Sen	Microprocessor cannot communicate with the temperature sensor.

CIRCULATOR SETUP & USAGE GUIDELINES

1. Connect a hose from the INLET on the back of the circulator to the tissue bath OUTPUT.
   - For more than one tissue bath, connect the tissue baths serially.
2. Connect a hose from the OUTLET on the back of the circulator to the tissue bath INPUT.
3. Fill the stainless steel water bath with 4.5 liters of water.
   - A buzzer sound warning will be emitted if there is not enough water in the bath when the Circulator is powered on. See *Error Codes* above.
4. Place the glass lid on the bath to close.
5. Plug the power cord from the back of the Circulator to a power source.
6. Press the **POWER** key to turn on the circulator.
7. To see the preset temperature value, press the **P.SET** key.
   - To change the preset temperature value, hold down the P.SET key and, at the same time, repeatedly press the UP or DOWN arrow keys to increase or decrease the preset value.
8. To see the acceleration value of the Circulator, press the **ACC** key.
   - To change the preset acceleration value, hold down the ACC key and, at the same time, repeatedly press the UP or DOWN arrow keys to increase or decrease the preset value. The higher values for acceleration indicate more rapid heating.
9. To see the offset temperature value, press the ACC and P.SET keys at the same time.
   - This is a factory-calibrated value. To calibrate the temperature sensor, see *Calibration* above.
   - All preset values are written to non-volatile memory.
10. Press the **PUMP ON/OFF** key to start the circulation pump.
    - Check that the **blue** Pump Status LED is ON. The pump should begin circulating water.
11. Check that the water goes out of the circulator and flows through the waterway of the tissue bath(s).
    - With initial setup, some air may remain in the circulator pump. See *Troubleshooting* below.
12. Press the **P.SET** button and confirm the set value of the desired temperature.
13. Press the **HEATER ON/OFF** key to turn on the heater.
    - Check that the **red** Heater Status LED is ON.
    - Check that the Heater Display LED is on to confirm that the heater inside the bath is working.
    - Circulator will maintain the preset temperature of water in the bath; variations of +/-0.2^{0}C are acceptable.
14. Check the water level periodically and add water to the bath if the level drops below 4 liters.
    - **Caution**: Over time, the water level inside the bath may decrease. Do not operate the circulator with less than 4 liters of water in the bath.
15. To turn the PUMP and HEATER on and off individually, press their respective ON/OFF keys.
16. To stop operation, press ON/OFF keys.
    - Power down equipment in the following order: PUMP, HEATER, POWER.

TROUBLESHOOTING

- **There is no water circulation or very little.**
  1. Check the hose connections and be sure they are connected to the correct positions.
  2. Check that the hoses are not bent or twisted (which might impede the flow of water).
  3. Confirm that there is at least 4 liters of water in the bath.
- **There is some air in the waterway.**

  To remove the air:
  1. Press the PUMP ON/OFF key to **OFF** stop the circulator pump.
  2. Disconnect the hose from the INPUT of tissue bath. (Leave other end connected to the Circulator OUTLET.)
  3. Put the end of the hose in a bucket to catch the water flow.
  4. Press the PUMP ON/OFF to **ON** to start the circulator pump.
  5. Operate the circulator pump for a few 1-2 second cycles.
  6. Press the PUMP ON/OFF key to **OFF** stop the circulator pump.
  7. Reconnect the hose to the INPUT of the tissue bath.
  8. Press the PUMP ON/OFF to **ON** to start the circulator pump and continue with normal operation.

Technical Specifications

Temperature Range:	30^0C to 44^0C
Reading Sensitivity:	0.1^0C
Display:	3 digit (LED Display)
Water Bath Volume:	4.5 liters (Stainless Steel)
Circulation Flow:	2 liter/min.
Heater Resistance:	1000 Watt
Circulation Pump:	110 V 100W Plastic Head
Supply Voltage:	
CIRCULATA:	110 Volt 60 Hz (1000 Watt)
CIRCULATB:	220 V 50 Hz (1100 Watt)
Inlet/Outlet	OD 8.5mm, ID 6.3mm Tubing
Temperature Offset Range:	0^0C to 1.2^0C
Acceleration Levels:	0 to 5

TISSUE BATH ACCESSORIES Specifications

1 x Tissue Holder—stainless steel; 15 mm high x 9 mm wide; reorder as RXHOLDER-TR

1 x Tissue Holder—glass; reorder as RXHOLDER-G

1 x Tissue Holder —stainless steel; reorder as RXHOLDER-S

2 x Tissue Clip—stainless steel; 15 mm high x 5 mm wide: reorder as RXCLIP

2 x Triangle Tissue Clip—stainless steel; 15 mm high x 12 mm wide; reorder as RXCLIP-TRI

1 x Integrated heater—1,600 ml volume, programmable temp. 20° - 44° C

1 x Circulator pump—15 W; 500 ml/min

1 x Warming Coil; reorder as RXCOIL

1 x Oxygen Filter; reorder as RX02FILTER

1 x Bath —reorder as RXBATH

1 x Reservoir—1000 ml; reorder as RXRESERV

Mount Accessories Kit; reorder as RXMOUNT

Field Stimulation Electrode; reorder as STIMHOLDER

1 x Micrometer-transducer assembly

1 x 3 way Rotary Valve

1 x Power Supply – 110V/60 Hz or 220V/50 Hz

MPMS100A-1/MPMS100A-2 Micro Pressure Measurement System

MPMS100A Control Unit

- The **MPMS100A-1** features one fiber-optic port.
- The **MPMS100A-2** features two ports, which allow for extended operations.

BIOPAC's NEW **Micro Pressure Measurement System** from samba sensors is the complete solution for demanding pressure measurements using advanced optoelectronic technology—and is the premier choice for a variety of pressure measurements where accurate data, high speed, and small size are key features.

- Click to review Micro Pressure Measurement Technology (PDF) or download a MPMS100A System product summary (PDF).
- TSD170 series Samba Preclin sensors are very small and well suited for application areas such as: cardiovascular blood pressure, LVP from within the heart of a small animal. Click here to request a video of this procedure on a mouse, Institute for Experimental Medical Research), intracranial pressure, intervertebral disc pressure, pediatric intensive care respiratory monitoring, muscle pressure, and pressure in the bladder or in the urinary tract.

Intelligent electronics in conjunction with fiber optics produce accurate data at high speed, making instantaneous pressure change analysis possible.

The electromagnetic immunity inherent in the SAMBA technology makes pressure measurement trouble-free, even in environments with high electromagnetic field strength, such as in MRI applications.

- The system consists of a **control unit** and a **micro pressure transducer** (see TSD170 series; separate purchase).

The compact, portable, battery-operated control unit is based on advanced optoelectronic technology from Samba Sensors. All settings can be made on the front panel. Analog output and serial RS232 make connection with a BIOPAC MP unit easy. Measurement data can be monitored in real time and stored for further data analysis.

- The **MPMS100A-1** features one fiber-optic port.
- The **MPMS100A-2** features two ports, which allow for extended operations.

The individual calibration data stored on the EPROM of each connected Samba transducer is automatically read by the control units to ensure exact measurements.

MPMS100A Control Unit

The compact, portable, battery-operated control unit is based on advanced optoelectronic technology from Samba Sensors. All settings can be made on the front panel. Analog output and serial RS232 make connection with a BIOPAC MP unit easy. Measurement data can be monitored in real time and stored for further data analysis.

The individual calibration data stored on the EPROM of each connected Samba transducer is automatically read by the control units to ensure exact measurements. The USB 2.0 data interface simplifies data transmission to the computer and the 3.2-inch display performs sharp figures.

Control Unit Specifications

Fiber optic ports: 1 (MPMS100A-1), or 2 (MPMS100A-2)
Resolution: 0.018 mbar (0.18 mmH2O; TSD170 series transducer)
Numerical resolution: 15 bit
Measurement Modes: Absolute/Relative (plus /Diff. for MPMS100A-2)
Measurement Frequency (update rate):
  Analog Output 40-40,000 Hz
  Digital (USB) 1-625 Hz
Pressure Measurement Bandwith: DC (Measurement Freq)*0.44 Hz g
  Example: At an analog output update rate of 5000 Hz, the pressure measurement bandwidth is (5000)*(0.44) = 2.2 kHz
Outputs: USB 2.0, Analog out
Analog output: 0–5 V
Battery operation: up to ~5 hours (2 channels at 40 kHz)
Operating temperature 15–35ºC (59–95ºF)
Display: 8.1 cm (3.2 inch), monochrome
Dimensions: 210 x 110 x 45 mm (8.3 x 4.3 x 1.8 inch)
Weight: 850 g (1.9 lbs)

Note *The BIOPAC MPMS100A Micro Pressure Measurement System utilizes technology from Samba Sensors (Gothenburg, Sweden).*

TSD170 Series Micro Pressure Transducers

TSD170 Series Micro Pressure Transducer

TSD173 MRI-compatible and radiotranslucent (see page 140 for definitions and details).

- **TSD173A** -50 to 350 mbar, 10 m/5 cm
- **TSD173B** -50 to 350 mbar, 10 m/15 cm

TSD174 Radio-opaque, designed for use in x-ray machines (see page 140 for definitions and details).

- **TSD174A** -50 to 350 mbar, 4 m/5 cm
- **TSD174B** -50 to 350 mbar, 4 m/15 cm

TSD175 MRI-compatible and radiotranslucent (see page 140 for definitions and details); cables are shorter and may not suit every application.

- **TSD175A** -50 to 350 mbar, 4 m/5 cm
- **TSD175B** -50 to 350 mbar, 4 m/15 cm

The Micro Pressure Transducers fit the MPMS100A-1/MPMS100A-2 Micro Pressure Measurement System. Each optical transducer is very stable, has a low temperature coefficient, and is easy to use. These transduces are biocompatible, have intrinsic electrical isolation, and can be made radio opaque. The micro dimensions of the transducer tip ensure a well-defined measurement location and minimal influence on the measurement environment.

Each transducer consists of a silicon sensor element, 0.42 mm in diameter, bonded to an optical fiber 0.25 mm to 0.40 mm diameter. Each transducer is delivered calibrated to minimize the need for customer calibration. This simplifies the use of the system and reduces the risk of human errors.

The sensors can withstand truly excessive over-pressure. The R&D department hasn't been able to design a study where over-pressure (gas/fluid) would break the sensor. When reaching these extreme high pressure levels it becomes difficult to setup and handle; for example, the highest measurable upper limit is 17 bar which equals 17,000 cm water (=558 feet of water).

Control Unit with TSD170 series transducer

- The system consists of a **Control Unit** (see MPMS100A-1/MPMS100A-2; separate purchase) and a **Micro Pressure Transducer**.

Transducer Specifications

Other pressure ranges available upon request.

Sensor ø: 0.42 mm
Fiber ø: 0.25 to 0.40 mm
Calibration: Factory calibrated
Measurement Media: Gases and fluids
Minimum Bend Radius: 10 mm
Long-term Stability: < 0.5% of range
Storage Temperature: -40 to + 80° C
Standard Length: 4 m (for MRI: 10 m)

Accuracy;
- -50 to 250 mbar: ±0.5 mbar plus ± 2% of reading
- 250 to 350 mbar: ± 4% of reading
- 5 bar: ± 10 mbar plus ± 2% of reading
- 10 bar: ± 15 mbar plus ± 2% of reading
- 17 bar: ± 20 mbar plus ± 2% of reading

Temperature Coefficient:
- -50 to 250 mbar: < 0.2 mbar/° C (20-45°C)
- 250 to 350 mbar: < 0.2 mbar/° C (20-45°C)
- 5 bar: < 3.5 mbar/° C (20-45°C)
- 10 bar: < 7 mbar/° C (20-45°C
- 17 bar: < 14 mbar/° C (20-45°C)

Chapter 8 Stimulation Options

STM100C Stimulator module

The STM100C is a single channel stimulation amplifier that was designed for use in the following applications:

Stimulus and Response Testing

Auditory brainstem response testing

Visual evoked response testing

Somatosensory response testing

Nerve conduction velocity and latency recording

Biofeedback Procedures

Auditory, visual or mechanical feedback from biophysical signals

The STM100C incorporates manual and automatic attenuation and polarity controls. Automatic attenuation can be effected in 1-dB steps over a 128-dB range. The STM100C has dual stimulus outputs. The **50 Ω Output** can be AC or DC coupled. The **Ext Stim** output is a very low-impedance, high-power, AC coupled output that can be used to drive headphones, speakers and other low impedance devices like lights and solenoids.

The STM100C can amplify and condition signals from four possible sources:

Analog (D/A) Output 0

Analog (D/A) Output 1

Pulse (Digital I/O 15)

Analog Input CH 16

IMPORTANT!

A) STM100C is placed on the **opposite side** of the UIM100C, compared to other 100C-series amplifier modules.

B) Check the "**Stim 100**" option in the Manual Control dialog box (accessed via the MP menu). See the Acq*Knowledge* Software Guide for Manual Control details

C) The STM100C always requires connection of both analog and digital cables to the MP150/100. The MP150 analog and digital cables first plug into the STM100C, then the UIM100C snaps onto the free side of the STM100C. Other amplifier modules, like the ERS100C, snap onto the UIM100C.

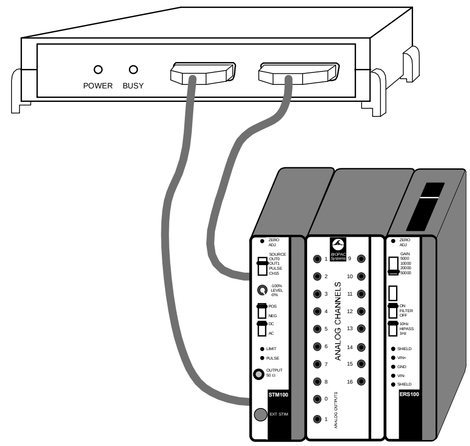
See also: Application Note AH162—Using the Stimulation Features of the MP System

The following diagram illustrates proper connection of the STM100C to the MP150/100 and other modules.

Stimulus response testing

In nearly all cases of stimulus response testing, the **STM100C** will be used in conjunction with the **ERS100C** and the **MP System**. The ERS100C is a very low noise biopotential amplifier, with sufficient bandwidth ranges to accommodate the variety of evoked potential testing.

For most types of evoked response testing, the MP150/100 will be operating in averaging mode. Typically, the stimulus output waveform is generated in the stimulator setup window and ported through either analog output 0 or analog output 1, and the output device (such as the OUT101 Tubephone) is connected to the external stimulus jack on the STM100C. This allows for complex pulses, tones, ramp waves and arbitrary shaped analog waveforms to be used as stimulus signals.



STM100C connection to MP device, UIM100C and ERS100C

See the Acq*Knowledge* Software Guide for details.

Alternatively, a single variable-length digital pulse can be output on I/O 15. The analog output options offer greater flexibility and are generally easier to use, but I/O 15 allows for greater resolution (1 µsec vs. 22 µsec for analog output options). In either case, the stimulus signal is output just prior to each data collection pass in the averaging sequence.

IMPORTANT!

Make sure that the settings on the STM100C match those in the stimulator setup windows (i.e., the output channel in the stimulator window matches the output channel selected on the STM100C).

Auditory evoked potentials

Auditory evoked potentials, like the **ABR** can be implemented using the STM100C. The STM100C is used to present the auditory pulse or "click" to an auditory stimulator, like the *Tubephone* (OUT101). The OUT101 or headphones (OUT100) plug directly into the EXT STIM jack on the STM100C. "Clicks" can be either rarefaction or condensation (positive or negative pulses). "Click" attenuation can be controlled manually or via the computer in 1-dB steps over a 128-dB range.

Somatosensory response tests

These tests are very similar to ABR and VEP tests, except the stimulation source is usually an electrical pulse or mechanical impulse applied at some point along the leg or arm. Somatosensory tests are used to characterize the perception of touch. By connecting a solenoid to the EXT STIM output of the STM100C, a mechanical pulse can be generated for peripheral nervous system stimulation.

General nerve conduction velocity tests

General nerve conduction velocity tests are evoked potential tests, but they generally do not require extensive signal averaging like the ABR or EP tests. The STM100C can perform this type of test, however the STM100C output is limited to a 20-Volt pk-pk signal. In the case of ***in vitro*** or ***in vivo*** experimentation, the 20-Volt range of the STM100C is typically adequate. For surface electrode stimulators, higher voltage is often required.

→ For higher voltage outputs, use the STMISOD or STMISOE (with the STM100C) to boost the voltage stimulus signal to 100 V or 200 V, respectively.

Biofeedback procedures

The STM100C can be used to condition and amplify the signals coming from any biopotential or transducer amplifier. The source amplifier must have its output switched to CH 16 (last channel), and the STM100C SOURCE switch needs to be placed on CH 16 as well. With the headphones or speaker plugged into the EXT STIM jack, biopotential signals like EMG can be heard directly. The EXT STIM output can also be used to drive visual indicators directly, so rhythmic or pulsatile signals (like ECG or respiration) can be easily observed. Mechanical actuators like relays and solenoids can be directly connected to the STM100C.

STM100C Calibration

None required.

STM100C Specifications

Stimulus Output Voltage:	20 Volts (p-p) maximum. Voltages of up to 200 V are possible by connecting STMISO Series to the **Ext Stim** output on the STM100C.	
Current Output Drives:		
50 Ω Output:	±200 mA (3.5 mm phone jack)	
Ext. Stim. Output:	±1.0 amp (6.35 mm [¼"] phono jack)	
Ext. Stim Z (out):	Less than 0.1 Ω	
Input Sources:	D/A0, D/A1, PULSE (DIG I/O 15), CH 16 (Analog)	
Polarity Control:	Manual or digital control (DIG I/O 7, H-POS, L-NEG)	
Attenuation Control:	Manual or digital control	
Attenuation Control Range:	128dB (Digital I/O 0-6, LSB-MSB)	
Attenuation Step Resolution:	1dB	
LED Indicators:	Pulse, Current Limit	
Uniphasic Pulse Width:	10µs (min) with 5µs resolution	
Biphasic Pulse Width:	MP150: 20µs (min)	MP100: 50µs (min)
Biphasic Pulse Resolution:	MP150: 10µs	MP100: 25µs
Arbitrary Wave Resolution:	MP150: 10µs	MP100: 25µs
Weight: 380	grams	
Dimensions:	4cm (wide) x 11cm (deep) x 19cm (high)	

TSD190 Series Haptic (Tactile) Stimulator

The TSD190 is a haptic (tactile) stimulator. The TSD190 is ergonomically designed to strap onto a variety of body locations and it incorporates an internal electromagnetically actuated plunger which can be used to mechanically stimulate a 1.5 mm diameter area of skin surface. Both plunger force and travel can be infinitely adjusted between zero and a specified maximum value. Applications include somatosensory and other types of tactile sensory tests. It's possible to employ the TSD190 in an averaging-type sensory nerve test to determine the speed of propagation and activation threshold of somatosensory nerves.

The TSD190 connects directly to the STM100C stimulation module. Plunger activation force, width of stimulus pulse, and pulse repetition rate are established via the Acq*Knowledge* Set up Stimulator window. To output a stimulus waveform which has a precisely controlled rate-of-change in both onset and offset, ramp up or down the applied stimulus voltage to the TSD190. The TSD190 will respond to any kind of applied waveform, such as square, triangle, sinusoidal or arbitrary.

Visual or audio cues can be replaced or augmented with haptic feedback. For one example, see *Kahol K., French, J., et al.* (2006). Evaluating the Role of Visio-Haptic Feedback in Multimodal Interfaces through EEG Analysis. Augmented Cognition: Past, Present and Future. D. Schmorrow, K. Stanney and L. Reeves. Arlington, VA, Strategic Analysis, Inc.: 289-296.

TSD190 Specifications

Stimulus Plunger Diameter: 1.5 mm
Stimulus Pulse Widths: 1 msec (min) to 100 msec (max)
Waveform Stimulus Types: Digital or Analog Drive
Stroke length: (0-3mm) - set screw adjustable
Force: (0-1.5 Newton) - adjustable via applied stimulus voltage (0-24 V)
Interface: Connects directly to STM100C Stimulator (External Stim Port)
Input Connector: 6.35 mm male phono plug
Cable length: 2 meters
Velcro Omni® Strap (included): 30 cm long x 25 mm wide
Weight: 39 grams
Length: 62 mm
Diameter: 22 mm

STM200 Stimulator

The STM200 can be used to stimulate any preparation or subject, including

- tissue baths (range 0-100 V at 0.1-200ms pulse width)
- nerve or muscle stimulation that requires higher energy than a STMISOC/D/E can deliver

Controls & Connections

Front Panel

Range Establishes the stimulus pulse output level range in Volts (0-10 Volts or 0-100 Volts).

- Turn right to select a range of 0-10 Volts.
- Turn left to select a range of 0-100 Volts.
- Remove the key for added safety and control.

If the Range is changed before recording begins, the scaling must also be changed (MP menu > Set Up Channels) to maintain direct Level recordings.

If the Range is changed during recording, the user should manually enter a software marker to note the change (F9 on Windows or Esc on Mac). The pulse Level could then be determined by (mentally) moving the decimal place to the right or left, depending on how the Range was changed.

Reference Refers to the pulse width of the signal on the Reference Output (on the back panel).

- Actual reflects the actual output width.
- Fixed (15 ms) establishes a pulse width of 15 ms, regardless of the actual pulse width.

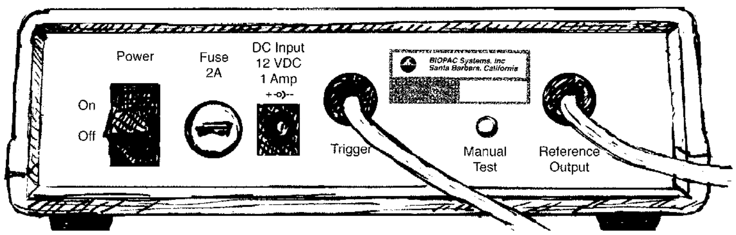
The Reference control only affects the pulse width; in either case, the pulse level reflects the actual output level.

Level Level is used in conjunction with Range to set the stimulus pulse output level. Turn the Level control (right to increase, left to decrease) to establish the desired Level, as indicated on the digital display.

Output Standard BNC connector to output the stimulus pulse to external electrodes or other devices.

LCD light The red LCD is activated when the DC adapter is plugged in and the power switch on the back panel is turned ON, and flashes when the stimulus pulse is active.

Back Panel



Power Rocker switch for turning the STM200 power ON and OFF.

Fuse If the fuse blows and must be replaced, use a screwdriver to open (counterclockwise) and close (clockwise) the fuse cap.

DC Input Socket for DC adapter (AC100A).

Trigger This cable terminates in a 3.5mm mono plug for connection to the UIM100C Analog Output 0 or the STM100C 50 ohm output.

Manual Test Used to diagnose problems with the STM200 stimulator unit. When the Trigger and Reference Output cables are disconnected, press the Manual Test button to initiate a stimulus with a fixed pulse width of 2.5 milliseconds.

Reference Out This output cable terminates in an RJ-11 plug for connection to the HLT100C. The cable reports the stimulator marker pulse to the MP System, via the channel it is connected to. A marker pulse will be generated each time the stimulator generates a pulse. The front panel Reference switch determines the marker amplitude:

- Actual varies between 0-1v and maps to 0-100 V or 0-10 V
- Fixed is 15ms

Stand-Alone Setup

To use the STM200 as a stand-alone stimulator from the MP System, the user must supply

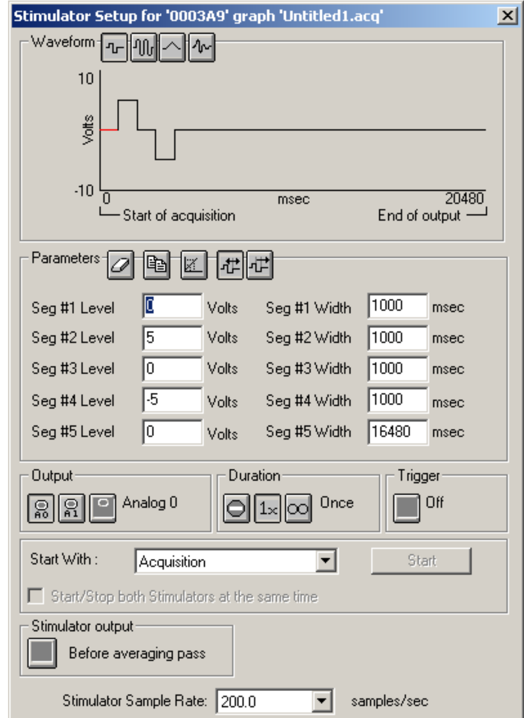
a) TTL high pulse to the tip of the mono phone plug connector, with respect to the plug shield.

b) power (+5v and GND)

c) signal conditioning to the output to observe results.

The report signal can be observed via the RJ-11 cable. The Reference Output cable does not need to be used for STM200 operation, because the front panel LCD panel indicator will show the pulse height output and the pulse width will simply be the pulse directed to the STM200.

Software Setup



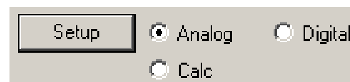
The stimulation waveform must be created using stimulator setup (MP menu > Setup Stimulator). The output waveform should be designed so that it has

- one or more pulses
- baseline of 0 V
- pulse amplitude of 5v.
- pulse length from 0.1ms to 200ms
- related pulse duty cycle should not normally exceed 10%; higher duty cycles are supportable in certain circumstances.

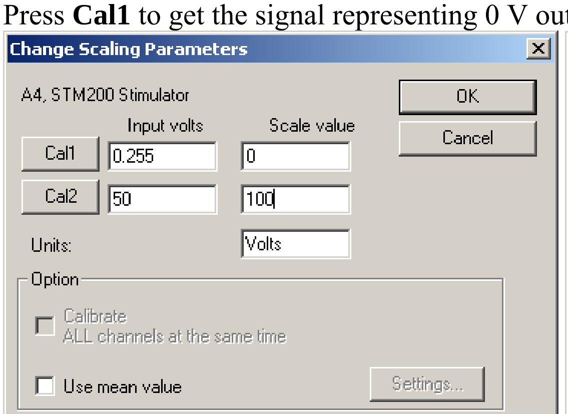
Calibration

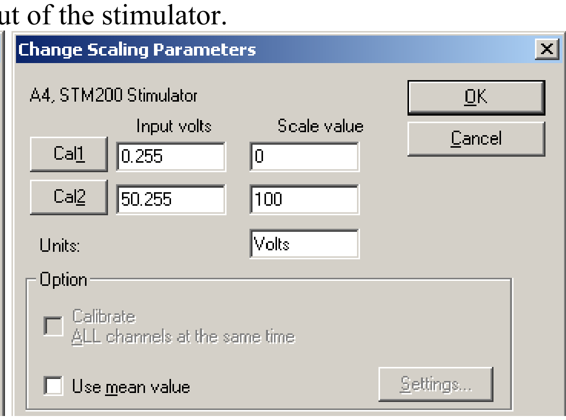
The "Reference Output" signal should be calibrated to optimize results.

1. With the STM200 connected and ON, turn the Level control counter-clockwise until the display reads 0 (or as close to 0 as possible).
2. MP menu > Set Up Channels >Setup button for the stimulator channel.



3. Press **Cal1** to get the signal representing 0 V out of the stimulator.





4. Add the Input value found with Cal1 to the Input Value displayed for **Cal2**.
   - For example, if "Cal1" is pressed and returns an Input Value of .255 mV, .255 mV should be added to the existing 50 mV and manually entered as the total value of 50.255 mV for Cal2 Input Value.

   Note Even if the Cal1 Input Value is negative, it must still be "added" to the number for Cal2 (which essentially subtracts it) to arrive at the proper value.

5. Click **OK** to close out of the Scaling window and then close out of the Setup Channel window.

Optional: The setup can be saved as a Graph Template to save these new scale settings. As long as neither the MP unit nor stimulator changes, the calibration should not need to be repeated.

STMISOL Linear Isolated Stimulator

The STMISOL Constant Current and Constant Voltage Stimulator will connect to any analog output signal drive (±10 V input) and has two functional modes:

- **Voltage and current stimulator (unipolar or bipolar)**—the STMISOL connects directly to the MP3x Analog Out or the UIM100C Analog Output (A0 or A1 port) associated with the MP1X0 system.
- **Linear stimulator**—the STMISOL can be used to generate stimulation signals that can have arbitrary waveshape. Typically, stimulators can only generate simple unipolar or bipolar pulses. The STMISOL, however, can output unipolar or bipolar **arbitrary** waves such as pulse (single or train), square, sine, triangle, exponentially decaying, modulated envelopes and fully user-specified signal types.

The STMISOL can output either voltage or current waveforms.

- **Voltage (V) mode**—the STMISOL multiplies the Control Input Voltage by a factor of 20, to present that amplified signal at the STMISOL output.
  - In the case of a maximum ±10 V input control signal, the STMISOL will output a ±200 V signal, with a current compliance of ±100 ma.
- **Current (I) mode**—the STMISOL will multiplies the control voltage by a factor of (10 ma/V) to present that associated output current at the STMISOL output.
  - In the case of a maximum ±10 V Control Input Voltage, the STMISOL will output a ±100 ma current signal, with a voltage compliance of ±200 V.

Isolation characteristics—The STMISOL isolates the Control Input Voltage from the stimulus output to 1500 VDC HiPot and approximately 90 pF of coupling capacitance.

This *very high degree of input/output isolation* helps ensure subject safety and helps to substantially reduce, or eliminate, stimulus artifact.

Stimulus artifact results when some percentage of electrical current from the stimulation site is directed to the recording site due to electrical leakage paths intrinsic to the stimulation/recording equipment. In the case of the STMISOL, the leakage conductances and capacitances that permit this artifact to occur are reduced to extremely small values.

OPERATING DETAILS

→ Review Important Notes and Safety Notes before operating the STMISOL

Important Notes

A) In Current (I) Mode stimulation, if the output has a load (typically high impedance) that induces railing for the specific output current, then the STMISOL will immediately go into "Protect" mode. In the case of an unloaded output, this state will happen as soon as the STMISOL is placed into Current (I) Mode stimulation. This happens because an "unloaded" STMISOL output simply means that an arbitrarily high resistance load is attached to the STMISOL. To correctly operate in Current (I) Mode stimulation, the proper load must be placed between stimulation electrodes and then "Reset" pushbutton must be pressed to 3 seconds to activate the unit.

B) In either stimulation mode (V or I), the output level (OL) will directly be a function of the applied Control Input Voltage (CIV). The conversion ratios are as follows:

Voltage (V) Mode: CIV (volts)*20 (volts/volts) = OL (volts)

Current (I) Mode: CIV (volts)*10 (ma/volts) = OL (ma)

C) In order to be sensitive to output waveform presence, the output waveform indicator—**red** LED just above BNC output connector —will glow very slightly. Waveform output indication can be observed as an increasing intensity of this red LED. This output waveform indicator is designed to provide a visual indication of output, even if the wave duration is extremely short, so it may be possible that this indicator shows a waveform output for some brief period of time after the output wave has already passed.

Safety Notes

1. Never place the stimulation electrodes so that it's possible for stimulation current to pass through the subject's heart. This can happen if electrodes are placed so that the leads "straddle" to the left and right sides of the subject's body. Place the stimulation electrodes close together on the SAME (left or right) side of the subject's body appendage. Only place stimulation electrodes so they are on the appendage of interest. For example, for left leg stimulation, only place stimulation electrodes on the left leg and on NO other location on the body.
2. Do not power ON or OFF the STMISOL unit while electrodes attached to the subject. Always be sure to place the STMISOL in VOLTAGE mode, with zero volts applied to input, before attaching/removing electrodes to/from the subject. Zero volts is automatically applied to the STMISOL input if the STMISOL input cable is unplugged from any signal source.
3. It is ideal to use the STM100C for stimulation control, because it permits manual control of the stimulation level. To use the STM100C:
   - Plug the Control Input Voltage line for the STMISOL into the 50 ohm output of the STM100C.
   - Before stimulation begins, turn the Output Level Control knob to 0%.
   - Initiate stimulation in the Acq*Knowledge* software (see Application Note AH162).
   - After stimulation is initiated, slowly turn the STM100C Output Level Control to the desired level.
   - When the stimulation session is ended, turn the STM100C Output Level Control back to 0%.
4. Do not remove electrodes while in current (I) mode; it's possible for subjects to receive a shock if they remove electrodes while the STMISOL is in current (I) mode because the STMISOL responds to the impedance increase and causes the current source to swing to a positive or negative rail.

Operating Procedure

→ Review Important Notes and Safety Notes before operating the STMISOL

1. Plug AC100A into back of STMISOL unit.
2. Connect Control Input (3.5 mm male phono plug) to output: UIM100C (Analog Out 0 or 1) or STM100C (50 ohms).
3. **Before powering ON the STMISOL** (turning from OFF to ON), make sure that stimulation electrodes are not attached to the subject.
4. Power ON STMISOL.
   - Note that "Protect" red LED on front panel is ON, when STMISOL is powered ON.
5. Set "Output Mode" switch to **V** for Voltage stimulation.
6. Press "Reset" pushbutton switch for 3 seconds to enable STMISOL.
7. Make sure that STMISOL input voltage is Zero volts.
8. Connect electrodes to subject and then to STMISOL output.
9. Place STMISOL in Current (I) mode, if desired.
   - Note that if output is unloaded and if STMISOL is in Current (I) Mode, then the "Protect" light will stay ON, thus activating shutdown protection (see Important Note A).
10. Send Control Voltage (STMISOL input) to affect desired wave output (see Acq*Knowledge* Software Guide or BIOPAC Application Notes AH162 and AS200).
11. When stimulation session is ended, place STMISOL in Voltage (V) Mode and make sure that STMISOL unit input control voltage is Zero volts.
12. **Before powering OFF the STMISOL** (turning from ON to OFF), remove stimulation leads and/or electrodes from subject.
    - Do not remove electrodes while in current (I) mode; it's possible for subjects to receive a shock if they remove electrodes while the STMISOL is in current (I) mode because the STMISOL responds to the impedance increase and causes the current source to swing to a positive or negative rail.
13. Power OFF STMISOL after making sure that stimulation electrodes are not attached to the subject.

STMISOL Specifications

Control Voltage:	±10 V maximum input	
Control Voltage Interface:	Male 3.5 mm mono phone plug	
Isolation:	Control Voltage GND to Isolated Output GND: 90 pF at 1500 VDC HiPot	
Output Stimulation:	Voltage (V) Mode:	±200 V with ±100 ma compliance; output impedance = 100 Ω
	Current (I) Mode:	±100 ma with ±200 V compliance; output impedance = 1 GΩ
Timing:	Voltage Rise time:	200 V in 12 µsec (T10-T90)
	Current Rise Time:	100 ma in 12 µsec (T10-T90)
	Max pulse width:	100 msec
	Max sine frequency:	30 kHz (-3 dB)
Input to Output Ratio:	Voltage (V) Mode:	±10 VDC input creates output of ±200 VDC (1:20 ratio - V/V)
	Current (I) Mode:	±10 VDC input creates output of ±100 mA (1:10 ratio - V/ma)
Input Control Voltage:	Physical Interface:	3.5mm male mono phone plug
	Compatibility:	UIM100C (Analog Output A1 or A0); STM100C (50 Ω), MP36 with OUT3 and BSLCBL6; MP35 with SS58L and BSLCBL6; any signal generator which outputs in ±10 V range
Noise:	Very low, about +/-0.02% of Full Scale Range (FSR)	
also "Standard Deviation"	- current output: accuracy to voltage input is within +/- 2%, FSR is +/-100mA\ - linearity is +/- 0.1%	
Protection:	Wave (Pulse) Duration: Output or current compliance voltage (Vout): Vout (magnitude) < 100 V -fully arbitrary, no limit to wave (pulse) duration Output or current compliance voltage (Vout): Vout (magnitude) > 100 V -100 msec typical (limiting to 20 ms at 100 ma current drive)	
	Current Limiting:	±350 ma — (short circuit)
	Voltage Limiting:	±210 V — nominal
	Reset Push Button:	Required with each power ON < in for 3 seconds to Reset
Manual Test:	Voltage Output Pulse:	100 V for 2 msec
	Current Output Pulse:	50 ma for 2 msec
Output Indicator:	ON for P-P amplitudes > 1% FSR	
Fuse:	2 amp fast blow	
Power Adapter	12 VDC at 1 amp (AC100A)	
Compatibility:	MP: UIM100C (Analog Out 0 or 1), STM100C (50 Ω) BSL: MP36 use BSLCBL6+OUT3; MP35 use BSLCBL6+SS58L 3rd-party: signal generator with ±10 V output range	

STMEPM Programmable Stimulator for E-Prime

The STMEPM Programmable Stimulation System for E-Prime allows a user to interface the STMISOL Stimulator with E-Prime to control the stimulus frequency and stimulus intensity for real-time stimulus delivery changes based on a subject's responses.

The system includes

- STMISOL Constant Current and Constant Voltage Linear Isolated Stimulator
- USB 4-ch D/A Unit
- Software Utility (STMISOL<--> E-Prime) with sample E-Prime experiment
- Interface cables

The sample E-Prime experiment provides the necessary interface commands to communicate with the D/A unit. The D/A unit provides the STMISOL with the appropriate voltage levels to stimulate a subject. The system supports up to four STMISOL (and includes one).

Specifications

STMISOL: see Constant Current and Constant Voltage Linear Isolated Stimulator specs

CBLEPM connection cable x 4: 3.5 mm to 2 x tinned wire (STMISOL to D/A card)

D/A Unit: High-speed multifunction module with eight 13-bit, 1 MS/s analog inputs and four 12-bit, 1 MS/s analog outputs

Four 12-bit, ±10 V analog outputs with 1 MS/s update rate
USB-bus powered (type: 2.0 high speed; compatibility: 1.1 or 2.0)
8 single-ended/4 differential analog inputs
13-bit resolution
1 MS/s sample rate
Single-ended ranges: ±10 V, ±5 V, ±2.5 V or 0 to10 V
Differential ranges: ±20 V, ±10 V, or ±5 V
16 digital I/O lines
Two 32-bit counters
One 32-bit PWM timer output

MRI Compatibility

STMEPM should not be used in an MRI and is not for use in stimulating subjects who are to be placed in an MRI. A largely equivalent replacement for MRI permits the same basic functionality as STMEPM, but is not subject to the same possible errant stimulation issues if a suitable patch panel filtering structure is not constructed. This substitute setup is restricted in terms of pulse width (2 ms max) and only voltage controlled voltage stimulation is possible. However, this substitute setup can generate stimulation of differing intensity under E-Prime control.

To use this TYPE of system for MRI applications, the following stimulation structure is recommended to be intrinisically safe, despite possible errors in user recording setup:

Replace the STMISOLand its power supply with

- Isolated Power Supply IPS100C
- Stimulator Module STM100C
- Stimulus Isolation Adapter STMISOC
- Connection cable CBL100

STMISO Stimulus isolation adapters

See also: *Stimulator Setup* notes in Acq*Knowledge* Software Guide

BIOPAC offers three stimulus isolation adapters:

STMISOC	constant current or constant voltage (5X / 10X) stimulation; see page 250.
STMISOD	multiplies STM100C voltage by 5; see page 251.
STMISOE	multiplies STM100C voltage by 10; see page 251.

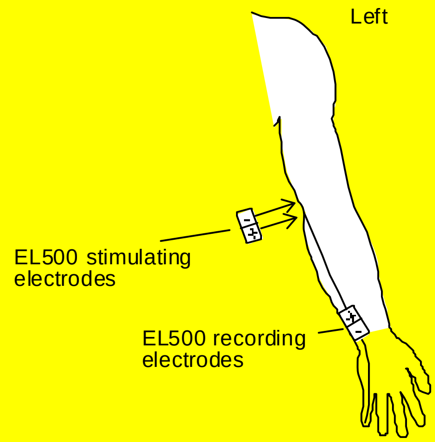
IMPORTANT SAFETY NOTES!

When using the STMISOC, STMISOD, or STMISOE, it is possible to generate voltages as high as 200 v p-p. These voltages are potentially dangerous, especially if the stimulator's high voltage outputs are connected across the subject's heart. Across the heart means that the heart is potentially in the electrical path from lead to lead. This situation occurs when the stimulation electrodes are placed on opposite sides of the subject's body.

NEVER PLACE STIMULATION ELECTRODES ON OPPPOSITE SIDES OF THE SUBJECT'S BODY!

Always use the stimulator with the leads placed in relatively close proximity to each other and relatively far from the heart, and with the leads placed only on the **SAME** side of the body. The figure to the right illustrates correct connection techniques when using the STMISOC/D/E.

Example of correct stimulation electrode placement:



STMISO SAFETY

The harmonized, international regulatory standard relating to the safety of nerve and muscle stimulators is **IEC 601-2-10**. Certain stimulation equipment is excluded from this standard, such as stimulators intended for cardiac defibrillation; however, for the purposes of defining relevant safety metrics for STMISOC, STMISOD, or STMISOE stimulation units, this standard is quite relevant.

STMISOC, STMISOD, and STMISOE stimulation units are designed in such a manner that the power available to stimulate the subject is limited. This limitation of power is achieved through the use of stimulus isolation transformers which have physical constraints (due to their size and construction) which absolutely —in accordance to known physical laws — constrain the maximum transferable power to be no more than a specific level.

Section **51.104** of the IEC 601-2-10 standard clearly specifies the **limitation of output power** for a variety of wave types.

* For stimulus pulse outputs, the maximum energy per pulse shall not exceed 300mJ, when applied to a load resistance of 500 ohms,
* For stimulus pulse outputs, the maximum output voltage shall not exceed a peak value of 500 V, when measured under open circuit conditions.

STMISOC, STMISOD, and STMISOE units employ stimulus isolation transformers that limit the output pulse width to 2ms maximum, under 500 ohm load conditions. In addition, the highest available output voltage is 200 V pk-pk (STMISOC or STMISOE) under open circuit conditions.

For the pulse energy calculation for STMISOC and STMISOE:

Joules = Watts x Seconds
Watts (instantaneous maximum) = (200 V x 200 V) / 500 ohms = 80
Joules = 80 W x 0.002 seconds = 0.16 Joules = 160mJ

Accordingly, the highest possible energy output using the STMISOC or STMISOE is **160mJ**.

The remaining stimulus isolation unit, STMISOD, has a maximum voltage output of 100 V. In this case, the maximum energy output is:

Watts (instantaneous maximum) = (100 V x 100 V) / 500 ohms = 20
Joules = 20 W x 0.002 seconds = 0.04 Joules = 40mJ

In all cases the maximum available energy, from the STMISO series stimulus isolation units, is limited to be considerably **less than the 300mJ maximum** as specified by IEC 601-2-10.

CAUTIONS FOR USE!

Even the safest stimulation units, if used incorrectly, can cause serious harm. The following points illustrate fundamental rules for using stimulus isolation units to stimulate subjects.

1) **NEVER APPLY THE STIMULUS SIGNAL IN SUCH A MANNER AS TO CAUSE CURRENT TO FLOW THROUGH THE HEART**.

   Primarily considered, this rule implies that stimulation leads should never be split apart so as to be able to touch opposing sides of the body surrounding the heart.

   For example: NEVER CONNECT THE STIMULUS ISOLATION UNIT SO THAT ONE LEAD TOUCHES THE LEFT ARM AND THE OTHER LEAD TOUCHES THE RIGHT ARM.

   Both stimulus leads [(+) and (-)], should be applied to the SAME side (left or right) of the subject's'body. Furthermore, always stimulate AWAY from the heart. Stimulation probes (such as BIOPAC's'EL350 or the EL351), which constrain the distance from the positive stimulation output to the negative stimulation output, should always be used for skin surface stimulation of nerve or muscle.

   The EL350 or the EL351 stimulation probes fix the distance between stimulation outputs to 35mm. It is not recommended that this distance be increased for skin surface stimulation of nerve or muscle. An increase in this distance simply allows stimulation currents to circulate over a larger area, which is usually not necessary for nerve or muscle stimulation scenarios.

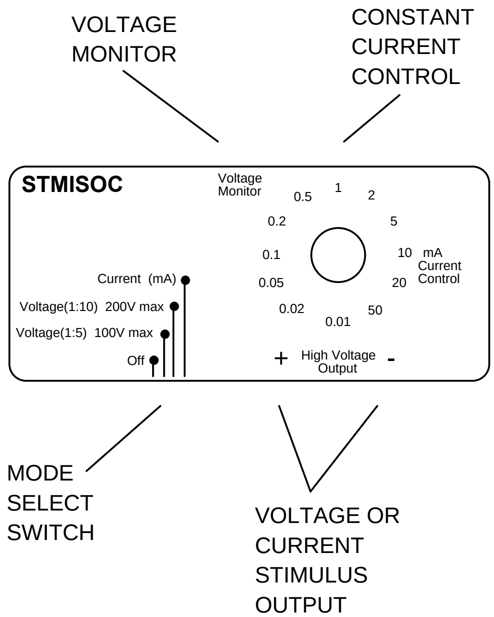
2) **Always start the stimulation process with the stimulator control set the LOWEST possible level**. The control for the STMISO series stimulus isolation units is located on the STM100C stimulation module. Set the control knob to the 0% level, prior to the onset of the stimulation protocol. During the protocol, increase the stimulus intensity by SLOWLY turning the control knob towards the 100% level. Stop increasing the intensity at the first sign of subject discomfort.

IMPORTANT NOTES!

A) It takes as little as **15 micro-amps** directed across the heart to instigate ventricular fibrillation. This situation can be readily achieved by using sub-surface stimulation needle electrodes that insert directly into the heart. It is considerably more difficult to achieve ventricular fibrillation on the same heart using surface electrodes, but it is possible to do so, evidenced by the performance of cardiac defibrillation units used in hospitals or by paramedics.

B) **Qualified experienced professionals** should supervise any protocols where electrical stimulation is applied to human subjects. Electrical stimulation protocols are not simple. Please contact BIOPAC Systems for any questions regarding the use of BIOPAC's stimulation units or accessories.

STMISOC Constant voltage or constant current stimulus isolation adapter



To use the STMISOC, an MP System with (minimally) one STM100C Stimulator module is required.

Plug the STMISOC directly into the EXT STIM jack on the STM100C module.

Use two LEAD110 electrode leads to connect the stimulus output to the subject. The LEAD110 electrode leads are required because they have the proper plug type for the new safety lead standard used on the STMISOC module. (1.6 mm pin connectors)

In the Voltage mode, the STMISOC can be used with bipolar stimulation and with different waveform types (square, sine, triangle).

See Safety Notes on pages 249-250.

STMISOC Mode	Signal output if LEVEL control is set to 100%
OFF	No signal will be output from the STMISOC.
Voltage (1:5) 100 V Max	Signal output will be 5x the values shown in the Stimulator Setup dialog (acts like a STMISOD).
Voltage (1:10) 200 V Max	Signal output will be 10x the values shown in the Stimulator Setup dialog (acts like a STMISOE).
Current	Signal output will be positive constant current output; set signal value with the Current Control rotary switch. It's important to output **positive pulses** only. Pulses should have a height of at least 10 V because pulse height output determines the voltage compliance of the current stimulation signal. The compliance of the current stimulation signal is determined by multiplying the pulse voltage amplitude by 10. For a 10 V pulse, the compliance would be 100 V. This means that the STMISOC can output a current of up to 100 V/R load. If R load = 5 k ohms, in this case the maximum output current would be 100 V/5k = 20ma. The maximum pulse height can be as much as 20 V, so it's possible to have a compliance as high as 200 V.

The **Voltage Monitor Output** provides a proportional output of the exact voltage used to stimulate the subject. Use a CBL100 to connect the Voltage Monitor Output to an unused channel on the UIM100C. If the Current mode is selected, the Voltage Monitor Output will be disabled. The Voltage Monitor output provides output as follows:

Voltage (1:5) 100 V Max setting: 1/10 proportional output

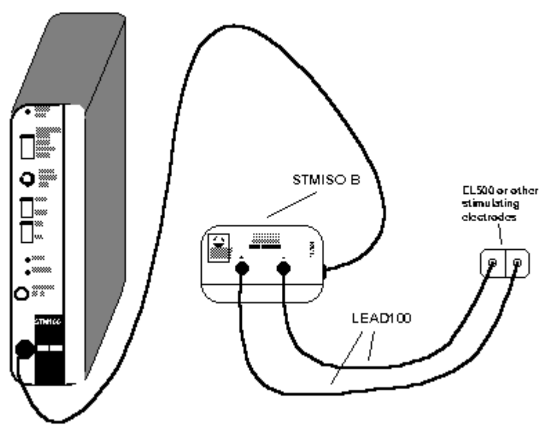
Voltage (1:10) 200 V Max setting: 1/20proportional output

For example, if the mode is set to Voltage (1:10) 200 V Max setting, then the Voltage Monitor Output will output a voltage that is 1/20 of the actual stimulation voltage.

STMISOC Specifications

Stimulus Pulse Width:	50µsec to 2msec (voltage and current)
Stimulus Sine Wave Range:	100 Hz to 5kHz (voltage only)
Step Up Voltage Ratio:	Selectable: (1:5) or (1:10)
Maximum Output Voltage:	(1:5) mode 100 V (p-p); (1:10) mode 200 V (p-p) into 5k ± load
Constant Current Range:	0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 50.0 ma (unipolar only)
Current Source Compliance:	200 V maximum
Current stimulation mode:	Positive current only
Isolation Capacitance:	150 pf
Isolation Voltage:	1500 VDC (from amplifier ground)
Cable Length:	1.8 meters
Weight: 190	grams
Dimensions:	10cm (wide) x 5cm (deep) x 4.5cm (high)
Interface: STM100C—see	page 211
Off mode	Turns off Voltage or Current stimulation to subject.
Voltage Monitor output	
Output via	3.5mm mono phono jack
(1:5) mode	1:10 of stimulation voltage
(1:10) mode	1:20 of stimulation voltage
Current mode	disabled
OFF	Reports a signal of approximately 50% of the voltage indicated in the stimulator setup window.

STMISOD/STMISOE



See Safety Notes on pages 249-250.

STMISOD/E setup for EL500 electrodes

The STMISOD/E plugs into the STM100C external stimulus output to provide an isolated voltage stimulus for response studies requiring a voltage stimulus (nerve conduction, somatosensory, etc.).

STMISOD adapter — boosts the voltage of the STM100C by a multiple of **5x** to provide a stimulus of up to ±50 V (or 100 V pk-pk).

STMISOE adapter — boosts the voltage of the STM100C by a multiple of **10x** to provide a stimulus of up to ±100 V (or 200 V pk-pk).

The front of the STMISOD/E has two 1.6mm pin plugs that accept any of BIOPAC's "safe lead" electrode leads, including bar electrodes, needle electrodes, and reusable electrodes.

The STMISOD/E has 1.6mm "safe lead" pin plug outputs to accept most needle or stimulating electrodes. For voltage stimulus applications, the EL500 bar electrode or the EL500 electrodes with two of the LEAD110 electrode leads are recommended.

The STMISOD/E comes with an attached 2-meter cable that has a 1/4" phone plug on the end that connects to the EXT STIM output on the STM100C.

STMISOD/E Calibration

See Safety Notes on pages 249-250.

To use the STMISOD/E, simply set up the stimulator in the software, and hook the STMISOD/E adapter as shown in the previous figure. Then, hook the stimulating electrodes of the choice to the two 1.6mm "safe lead" pin plugs.

The STMISOD/E provides an additional barrier of galvanic isolation between the MP150 and the stimulating electrodes. When using the STMISOD/E to create a pulsed voltage stimulus output, the pulse width must be between 50 µsec and 2 msec.

If the pulse is narrower than 10 µsec, the STMISOD/E will not reproduce the pulse well, due to rise-time constraints.

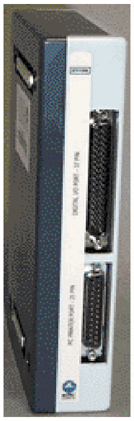
If the pulse is greater than 2 msec, the pulse output will sag due to lower frequency response limits. The pulse may sag before 2 msec, depending on load and drive levels.

When using the STMISOD/E for voltage stimulus applications, turn the level control to 0% on the STM100C, then, after stimulation has begun, turn the level control up slowly. This approach will help to determine the appropriate voltage level for stimulating the subject.

STMISOD/E Specifications

Stimulus Pulse Width:	50 µsec to 2 msec (voltage only)
Stimulus Sine Wave Range:	100 Hz to 5 kHz (voltage only)
Step Up Voltage Ratio:	STMISOD (1:5)
STMISOE	(1:10)
Maximum Output Voltage:	STMISOD 100 V (p-p) into 5 k ohm load
	STMISOE 200 V (p-p) into 5 k ohm load
Isolation Capacitance:	120 pf
Isolation Voltage:	1500 VDC (from amplifier ground)
Cable Length:	1.8 meters
Weight: 140	grams
Dimensions (WxDxH):	6.5 cm x 5 cm x 4.8 cm
Interface: STM100C—see	page 211

STP100C Isolated Digital Interface for the UIM100C



STP100C (center) connected to MP150 and UIM100C (not included)

The STP100C provides 8 lines for digital data inputs and 8 lines for digital data outputs. All inputs and outputs associated with the STP100C safely isolate connections to the MP System to 1500 VDC isolation.

- MP System Digital Input Lines: I/O 8-15
- MP System Digital Output Lines: I/O 1-7

The STP100C is used to safely isolate digital input and output lines to and from the MP System (MP100 and MP150).

The STP100C connects the MP System to computers running SuperLab, E-Prime, Inquisit, DirectRT, and other psychophysiological stimulation applications. The STP100C also includes output to drive solid state relay and incorporates a BNC accessible External Trigger input line. The STP100C module can also be used to connect digital signals (TTL compatible) from any mains powered external equipment to the MP System when the system also connects to electrodes attached to humans.

The STP100C module comes equipped with a 3-meter ribbon cable (37 pin F/F) for easy system interfacing.

- **STP100C** digital I/O card 37-pin connector pins (10-3) map to I/O15 - I/O8 on MP unit.
- **STP100** (older model) digital I/O card 37-pin connector pins (10-3) map to I/O8 - I/O15 on MP unit.

Superlab Interface (uses Digital I/O card with 37 pin DSUB connector)

The STP100C optical interface can be used to interface to the MP System when SuperLab™ and the Digital I/O card with the Support Pack are already available. The STP100C interface connects between the SuperLab™ Digital I/O card and the UIM100C module.

PORT A - Input to Superlab: (pins 37-30) connect to MP System Digital I/O lines 0-7
PORT B - Output from Superlab: (pins 3-10) connect to MP System Digital I/O lines 8-15

Parallel Port interface (uses standard PC printer port with DSUB 25 connector)

Output from E-Prime: (pins 2-9) connect to MP System Digital I/O lines 8-15

Input to E-Prime: (pins 13-10) connect to MP System Digital I/O lines 4-7

Output Drives (for relays)

The STP100C can drive up to four (4) solid state relays directly via MP System Digital I/O lines 0-3. MP System Digital I/O line 4 is used as an enable to activate these drive lines.

ON = low (0 V) signal on I/O line 4
OFF = high (5V) signal on I/O line 4

The output drives (for relays) have 0 to 5 V output voltages and are current limited with 200 ohm resistors. This means that for solid state relay drive requirements, output current will be limited to approximately 20 mA, assuming an optically isolated solid state relay input diode drop of 1.2 V. Nearly all solid state relays can operate with as little as 5 mA of current drive.
The STP100C is designed to work with digital inputs in the range of 0-3.3V (which is increasingly common with laptop I/O cards and printer ports) or 0-5.0 volts.

Isolated External Trigger Input

The optically isolated external trigger input is TTL compatible. This line is accessible via a BNC female connector (labeled TRIG on the front of the STP100C) and connects to the MP unit External Trigger input via optical isolation, compliant to 1500 VDC. The voltage range for this drive must be 0-5 V (TTL input levels).

When the STP100C trigger is unused, it is pulled to a high state (+5 V) via an internal 100 kΩ resistor. To properly drive this line, connect a standard TTL driver to this port. For non-TTL type drivers, the low voltage applied to a trigger must be between 0 and 0.5 V. The high voltage applied to the trigger must be between 2.5 and 5 V. The maximum recommended source impedance of the driver should not exceed 1 K Ω.

Additionally, to use the STP100C external trigger in a manual mode, the input can be pulled low with an external switch connected between the trigger input and ground.

To externally trigger MP Unit acquisition, send a TTL signal to the External Trigger of the STP100C (TRIG). This line connects to the MP Unit External Trigger via optical isolation.

To use an MP System line that is normally dedicated to an I/O input (lines 8-15) as an External Trigger drive, use a JUMP100 jumper wire to connect that line directly to External Trigger (EXT T) on the back of the UIM100C.

Note The older model STP100 tied the MP System External Trigger directly to MP System I/O 8.

STP100C Instructions:

1. Snap the STP100C module DSUB I/0 connectors on the left side of the UIM100C module.
2. Use the 3-meter ribbon cable to connect the STP100C module (computer I/O 37-pin connector) to the digital I/O card in the PC.
   - Connects Port A (inputs; pins 30-37) on the digital I/O card to digital I/O lines 0-7 on the MP unit.
   - Connects Port B (outputs; pins 3-10) on the digital I/O card to digital I/O lines 8-15 on the MP unit.
3. For debugging purposes, ground pins are:
   - 37-pin digital I/O cable (CBL110A): pins 19 and 21 are GND; pin 20 is +5 V
   - 25-pin printer port cable (CBL110C): pins 18 and 25 are GND

Application example — P300 visual evoked response test

To set up the STP100W with an MP System to perform a P300 visual evoked response test:

1. Connect two **SuperLab** outputs to the respective MP System digital inputs.
   - These **SuperLab** outputs are assigned to respective images that will be presented to the subject during the recording session. Typically, image presentation occurs within a statistical framework, i.e., *Image 1* is presented 20% of the time and *Image 2* is presented 80%. The **SuperLab** outputs will be tightly (1 ms) synchronized to the respective image presentation.
2. Set the MP System up to record EEG and the two **SuperLab** outputs, which should be directed to the MP System digital inputs.
3. After the recording session has been completed, use Acq*Knowledge* to perform specific averaging on the collected EEG data.
   a) Use the digital input corresponding to **SuperLab** output 1 as a “Control Channel” in the Find Peak Averaging Setup; all the responses resulting from *Image 1* presentation will be averaged together to create the composite response for *Image 1* presentation.
   b) Repeat the above procedure with the “Control Channel” assigned to **SuperLab** Output 2 to create the composite response for *Image 2* presentation.

For more information on setting up the **Find Peak (Peak Detector) Off-line Averaging** for this kind of measurement, see the Acq*Knowledge* Software Guide.pdf.

EPM100W/WP Stimulus Presentation Systems with E-Prime 2

These stimulus presentation packages includes E-Prime experiment generator and an isolated digital interface (STP100C) with parallel port cable (CBL100C).

E-Prime provides experiment generation and millisecond precision data collection through data handling and processing. E-Prime is a powerful suite of applications combining precise millisecond timing, a user-friendly environment, and the flexibility to create simple to complex experiments for both advanced and novice users.

- EPM100W include E-Prime 2.0
- EMP100WP includes E-Prime 2.0 Professional

Use the Acq*Knowledge* Digital inputs to stim events tool to automatically score and label digital event marks from the E-Prime presentation. The digital channels are interpreted as a binary number. Each stimulus event placed into the graph has the corresponding number included with its label. This allows further analysis to distinguish between different types of stimulus events for automated event related analysis.

Specifications

STP100C: See specs on page 273.

CBL110C: See product specs on page 276.

E-Prime: Requires Intel PCs with Windows® XP/Vista/7

Minimum	**Recommended**
- Pentium Processor 1 GHz	- Pentium Processor 2GHz or higher
- 512MB RAM	- 1024MB RAM or higher
- PCI DirectXTM video card with 32MB RAM	- 8X AGP Video or PCI Express DirectXTM video card with 128MB RAM or higher
- PCI DirectXTM sound card	- Sound Blaster AudigyTM sound card
- CD-ROM	- CD-ROM
- USB Port	- USB Port
- Serial Port*	- Serial Port*
	- Internet Connection

E-Prime Device Drivers are not supported for Windows® XP 64 and Windows® Vista 64 at this time. Windows® Vista requires installing the E-Prime Device Drivers separately.

STK100 StimTracker Univer Marker Interface

The new StimTracker interfaces with the existing SuperLab software to provide digital trigger marks. Requires a USB port and works with Windows and Mac. Includes two (2) photocells for precise event marking (one black and one white).

Deliver markers via USB from the stimulus presentation computer and deliver markers from voice key, audio channels/speakers (2), TTL input lines (6) or photocells (up to 4).

An STP100C with the parallel port cable option (CBL110C) should be used with this device; STP100C sold separately.

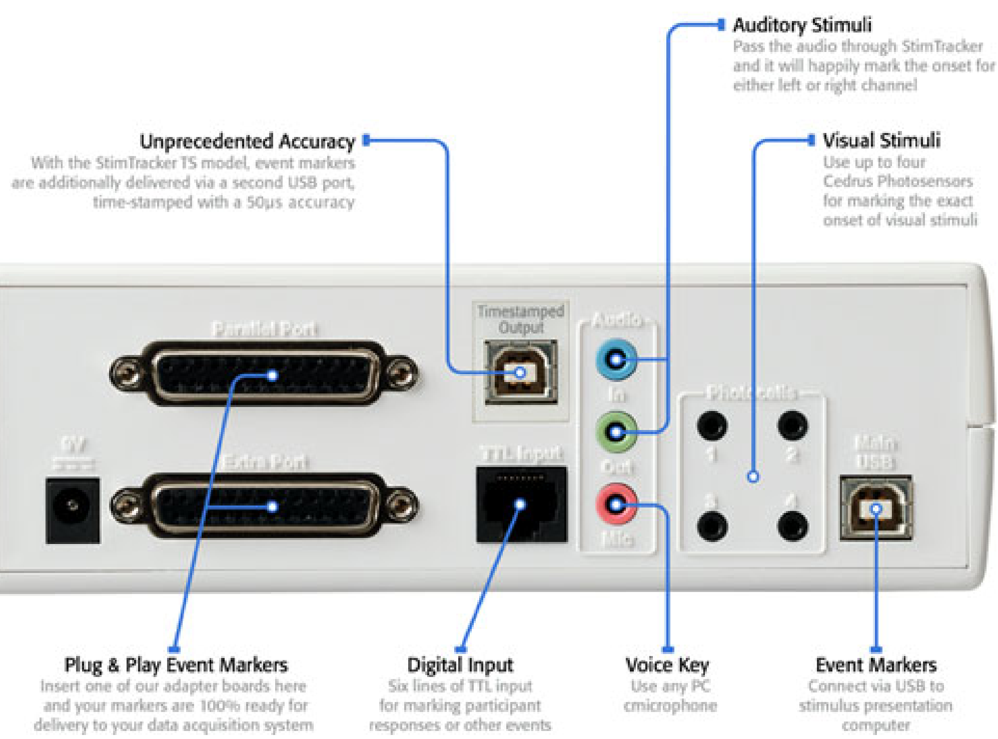
- For complete packages—StimTracker, SuperLab 4.0, and cables—see STK100W (Windows) and STK100M (Mac).

Specifications

- Universal marker Interface module

- Photocells x 2 (8 by 14 mm)

- USB



STK100M/W StimTracker Universal Marker Interface with SuperLab

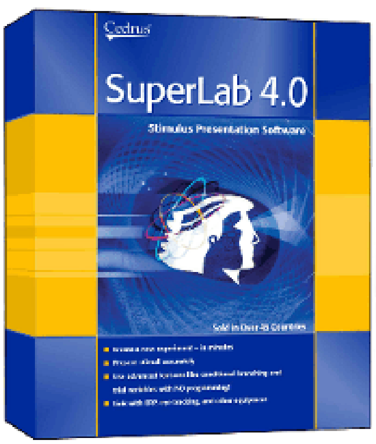
These stimulus presentation packages include SuperLab 4.0 and the new StimTracker universal marker interface to provide digital trigger information from SuperLab.

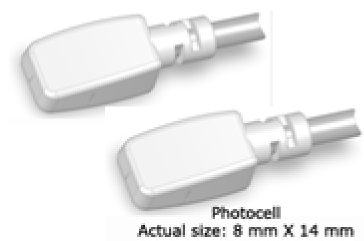
The package includes two (2) photocells for precise event marking and the STP100C Isolated Digital Interface with the parallel port cable option (CBL110C); if additional photocells are required, please contact BIOPAC.

STK100: See product description and specs on page 256.

STP100C: See product description and specs on page 273.

CBL110C: See product description and specs on page 276.





STP100W Stimulus Presentation System (SuperLab™)

The STP100W system includes:

SuperLab™ Pro Software (Windows)

STP100C Optical Interface (w/3-meter ribbon cable)

- ✓ Measures physiological responses to stimuli
- ✓ Permits up to eight synchronization signals (input or output) between the STP100W and the MP System

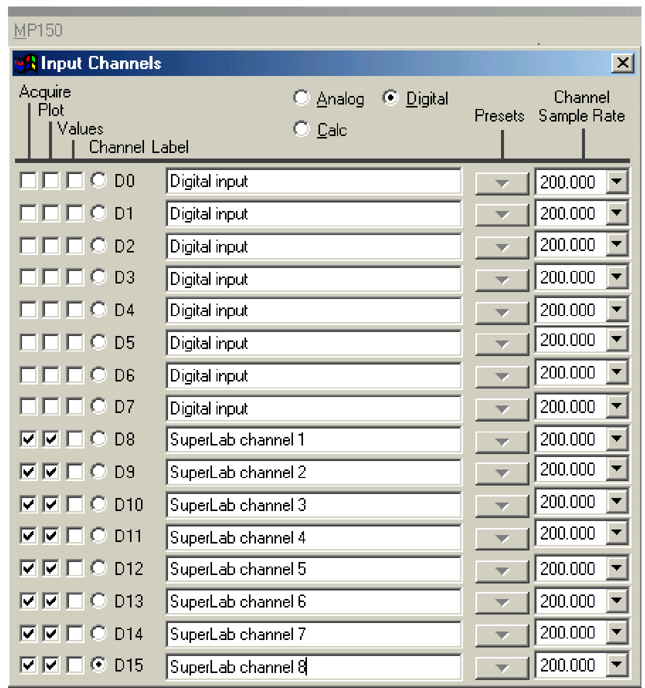
Digital I/O Card (PCI slot required)

Support Pack for Digital I/O Card (Windows)

Pushbutton Keycap Color Change Kit

Six Pushbutton Response Box

- ✓ Performs accurate (1 ms resolution) reaction time measurements



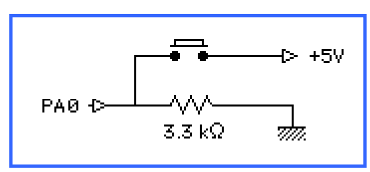
The STP100W is a stand-alone system that measures subject responses to visual or auditory stimuli. It can present visual stimuli on a computer screen, or auditory stimuli via headphones or speakers, and simultaneously (1ms resolution) send trigger signals to an MP System on a different computer for data synchronization and collection purposes.

The SuperLab™ Pro software can change the placement of visual stimuli on the screen or change the screen's background color. It offers a variety of input and timing options, and will provide feedback based on the subject's response or reaction time. Different trigger channels can be paired to different visual or auditory stimuli to perform sophisticated evoked response averaging tests (e.g. P300).

Second PC required— The synchronization signal(s) coming from the STP100W can be directed to an MP System running on a Mac or PC, but it's not possible to run the STP100W on the same computer as the MP System. The STP100W requires that the SuperLab™ software and a Digital I/O card be placed on a PC.

SuperLab Set up

1. Connect the **SuperLab** output card via the STP100C **(**page 253) to the UIM100C and the BIOPAC MP100 or MP150 System.



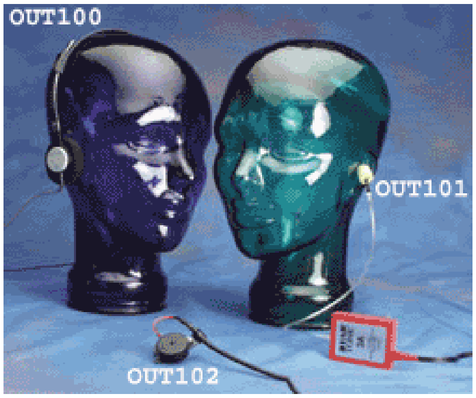
2. Create the presentation using the appropriate digital outputs from the **SuperLab** PC to the MP150.
   - See the **SuperLab Manual** for instructions on how to create the presentation.
3. Setup digital channels 8-15 (as used in the presentation) using the MP150>Setup Channels>Digital dialog.
   - The **SuperLab** stimulus output synchronization signals will be output on digital lines 8 through 15. In order to record the changes and use the stimulus for analysis purposes, the appropriate channels must have "Acquire" enabled.

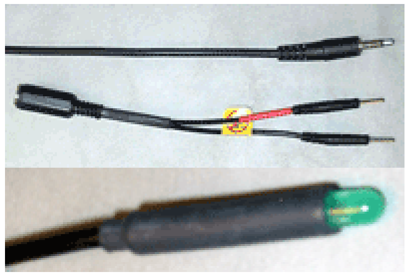
✓ **SuperLab** employs a digital I/O PCI card that uses Port A for input and Port B for output (Port C is unused). For input, lines must be "pulled low" (connected to ground by a resistor). The diagram illustrates how this is done for line A0 (pin 37). The same diagram applies for lines A1 to A7. The resistor's value may range from 2.2 kilo-ohm to 5 kilo-ohm.

Cedrus highly recommends that all lines on Port A are pulled low even if all 8 input lines will not be used. ***Better yet***: connect unused lines directly to ground.

To add other digital inputs and outputs to the system, simply remove the 2 mm pin plugs from the STP100C Interface Module. The 2 mm pins are screwed in and can be removed and added to mirror the particular application.

OUT Series for the STM100C





OUT100 Mono headphones

The OUT100 is a monaural, wide response, high efficiency headphone compatible with the STM100C. It's typically used with the STM100C in applications where audio feedback is required while monitoring a specific physiological signal; the most common application for the OUT100 is the audio monitoring of EMG as data is being recorded. The OUT100 weighs 3 ounces and includes a 1.8-meter cord.

OUT101 Tubephone

The OUT101 is a single channel tubephone compatible with the STM100C. It has a response that can be matched to audiometric headphones (TDH-39, TDH-49, and/or TDH-50). Because the OUT101 uses a flexible plastic tube to couple the sound energy to the eardrum, two advantages result when comparing to conventional audiometric headphones. First, significant ambient noise reduction is obtained, which is useful for testing performed outside of a standard audiometric test booth. Second, the tube itself creates a 1 ms delay in the auditory signal, so electrical artifact can be easily separated from true response in auditory evoked response applications.

The OUT101 is typically used with the STM100C in auditory evoked response applications like the ABR. It measures 3.8 cm x 5 cm x 1 cm, and has a clip attached to secure to fabric or fixtures. Each Tubephone set includes one plastic tubephone, 50 foam ear inserts, and a 2-meter cable.

MP150/100 System interface:

- STM100C: connects directly to stimulator model

MP36 and MP36R interface options:

- BSL System stimulator (model BSLSTM): use BSLCBL6 and Radio Shack P/N 274-047 ¼" to 1/8" phono adapter
- BSL MP36 data acquisition unit Analog Out port: use OUT3 plus BSLCBL6 and Radio Shack P/N 274-047 ¼" to 1/8" phono adapter
- MP36 headphone port: use Radio Shack P/N 274-047 ¼" to 1/8" phono adapter; note—volume may not reach the same levels as the Analog Out port

Calibration for Auditory Brainstem Response Studies

To calibrate the OUT101 Tubephone, use an Etymotic ER-7C Probe Microphone—this microphone provides a calibrated output voltage which is a function of applied Sound Pressure Level (SPL). The sensitivity is 50 mV/Pascal (-46 dB re: 1 V/uBar): 0 dB SPL = 0 dBuV.

Place the Probe Microphone insert tube in the auditory canal prior to the insertion of the OUT101 foam tip. The OUT101 Tubephone sound delivery tube and the Probe Microphone sound input tube will then be exposed to the same auditory chamber. Accordingly, the SPL is recorded, via the Probe Microphone, simultaneously with applied auditory stimulus from the OUT101 Tubephone.

OUT102 Piezo Audio Transducer

The OUT102 piezo transducer is typically connected directly to the STM100C stimulator module. When the stimulator module output rises above 1.5 volts, the piezo indicator will emit a constant audible signal (3.0 kHz @ 80 dB). Accordingly, the device is very useful for providing an audible stimulus, or alarm, when a physiological signal passes a certain threshold. As such, the OUT102 makes an excellent audible BPM indicator for ECG, blood pressure or respiration signals. The device can also be used to indicate when temperature or other slowly moving variable (e.g. electrodermal response) passes a certain threshold. The threshold for the OUT102 is determined by adjusting the amplitude control on the STM100C module. The specific Biopotential or Transducer amplifier signal monitored can be recorded while simultaneously directed through the STM100C module. The OUT102 also connects directly to the UIM100C digital I/O ports for operation with Control Channel outputs. The OUT102 measures 2.5cm (dia) x 1cm (high) and comes equipped with a 1.8m cable terminated in a 3.5mm phone plug. An adapter is included for connecting the OUT102 to the UIM100C digital I/O ports.

OUT103 LED Cable

Use this LED cable to synchronize a light flash. The 3 meter cable makes it easy to use the LED for a variety of protocols. Terminates for connection to Analog OUT 0/1 and includes adapter for connection to Digital I/O.
Media synchronization - Windows only - AcqKnowledge 4.1 and above

MP150/MP100 and UIM100C setup

a. Connect the OUT103 2 mm pin adapter to the 3.5 mm plug on the OUT103 cable.
b. Connect the red OUT103 2 mm pin to a Digital I/O channel on the rear of the UIM100C and the black pin to GND D on the rear of the UIM100C.
c. Use MP150 > Set Up Channels to acquire and plot the Digital I/O channel the OUT103 is connected to.
d. Set MP150 > Show Manual Control

- set for 'Output'
- enable the 'Set immediately' option
- click the Digital I/O channel the OUT103 was connected to to toggle between 0 to 1

If necessary, click the 'Set' button to update the manual control and output a digital pulse.

MP36R setup - *additional items required*

a. Connect an OUT3 (BNC adapter) to the 'Analog Out' port on the rear of the MP36R.

b. Connect a BSLCBL6 (interface cable: BNC to 3.5 mm) to the OUT3.

c. Connect the OUT103 3.5 mm plug to the BSLCBL6 3.5 mm socket.
d. Set MP36 > Output Control 'Low Voltage Stim' option

- set Pulse width to 100 msec
- set Pulse level to 5 Volts
- set Reference Channel to any digital channel
- click the 'ON' button to output a digital pulse

OUT Series Calibration

The OUT series does not require calibration.

TSD122 Stroboscope

The TSD122 Stroboscope connects directly to the UIM100C or STM100C for Visual Evoked Response applications. This battery-operated device will provide 360,000 flashes between charges. The unit will go from zero to a maximum of 12,000 flashes per minute. It has external TTL synchronization and Trigger facilities for interfacing with the MP System and other equipment.

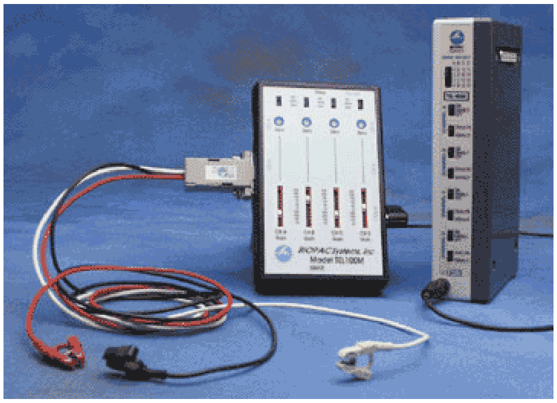
The TSD122 can also be used to trigger the MP System, via the External Trigger terminal block (on the back of the UIM100C).

TSD122 Specifications

Display: Digital	LCD
Battery: Built-in,	rechargeable
Battery Life:	60 hours at 100 strobes/sec (360,000 strobes between charges)
Flash duration:	30µsec
Flash energy:	180mJoule
External TTL:	Sync/Trigger
Weight: 1.1	kg
Body Dimensions:	9.3cm (wide) 9 cm (high) x 23cm (long)
Reflector Housing:	12.2cm (dia)
Handle: 10.8cm	(long)
I/O Ports:	TTL (Sync input and output)—3.5mm phone jacks
Cables: CBL102	and CBL106
Interface: UIM100C—see	page 25
	STM100C (triggered)—see page 211

Chapter 9 Remote Monitoring

TEL100C Remote Monitoring System



The TEL100C is a remote monitoring system designed for use with an existing MP System. In addition, the TEL100C System can be used with existing BIOPAC amplifiers (e.g., ECG100C, RSP100C) and/or other TEL100C Systems. Up to four TEL100C Systems can be connected to a single MP System, and a single TEL100C System can be used with as many as 15 existing amplifiers or direct analog inputs.

Each TEL100C System consists of four major components (as shown above):

- transmitter with 4 channel inputs (TEL100M-C)
- receiver (TEL100D-C)
- cable to connect transmitter to receiver (CBL117)
- up to four "Simple Sensor" electrode/transducer assemblies (which must be purchased separately).

The TEL100C is intended for biophysical ambulatory measurements (ECG, EMG, joint angle, acceleration, respiration, finger twitch, heel/toe strike, PPG, EDA/GSR, temperature, etc.). The system is not designed for high-accuracy, precision measurements (force, pressure, strain, etc.). Any slowly moving signal that must be measured to high accuracy and precision should be recorded with the respective amplifier module (typically DA100C or SKT100C).

TEL100D-C

The TEL100D-C is a four-channel receiver module that is compatible with all other MP150/100 modules. The TEL100D-C includes filtering and channel select controls.

- Select the **bank** (A, B, C and D) to assign channels to. Make sure no other 100C series amplifiers are assigned to those same channels.
- If certain channels in a particular bank are already being used (and can't be moved), then turn the telemetry channel off, via the "**Enable ON/OFF**" switch on the front panel of the TEL100D-C.

Up to four TEL100D-C units can be connected to a single MP150, allowing for up to 16 channels of transmitted data originating from up to four separate TEL100M-C units. For every TEL100M-C, a TEL100D-C must be available to receive its data signals.

TEL100M-C

Each TEL100M-C is a miniature four-channel remote amplifier/transmitter that connects directly to the TEL100D-C via a lightweight coaxial transmission cable. The TEL100M-C does the work of four 100C series amplifiers and includes filtering, offset and gain control for each of its four channels.

All BIOPAC SS series transducers and electrodes will function directly with the TEL100M-C. Excitation voltages are available on each channel input to provide power for "Simple Sensor" transducer assemblies (such as RSP, GSR, PPG and SKT).

The TEL100M-C requires one 9V alkaline battery for operation. A low battery indicator light will flash when the battery requires replacing. Expected battery life is approximately 12 hours of continuous operation.

The TEL100C module set is a modulation/demodulation system.

- The modulation process occurs in the TEL100M-C.
- The demodulation process occurs in the TEL100D-C.

The TEL100M-C amplifies and filters the four input channels. After amplification the channel signals are time division multiplexed (TDM) into a single transmission channel and are sent through the CBL117 (coaxial cable) to the TEL100D-C (see diagram on page 265). The TDM process intrinsically samples the four input channels at a rate of 2000 Hz / per channel. This sampling process occurs in the TEL100M-C module and is independent of the MP System.

Prior to the TDM process, the four input channels are low-pass filtered to 500 Hz. The TDM process always samples at 2000 Hz for each channel and each channel's maximum bandwidth is 500 Hz. Accordingly, the sampling process does not affect the user or the rate at which the MP150 samples data. The TEL100M-C transmits an analog signal.

The TEL100D-C demodulates the transmission from the TEL100M-C and incorporates user-selectable 35 Hz LPN or 500 Hz LP **filters** for removing noise and/or 50/60 Hz interference from any of the four input channels. Filters (35 Hz LPN or 500 Hz LP) can be independently assigned **on** or **off** for each channel.

  - Use of the 35 Hz LPN filter automatically engages the notch filter (50 Hz or 60 Hz).
  - Use of the 500 Hz LP filter disables the notch filter.

The TEL100D-C produces a ±10 volt range analog output for each channel, and then these analog outputs are sampled by the MP150.

- Analog outputs are also available via the front panel of the UIM100C to direct the outputs to an alternate recording system in conjunction with the MP System.

The TEL100C module set has an upper frequency limit of 500 Hz for each channel. The TEL100C is not recommended for physiological measurements requiring higher frequency measurements (e.g. certain evoked response applications). However, a wide range of physiological activity can be monitored with the TEL100C, including ECG, EOG, EEG, GSR, SKT, PPG, RSP and surface EMG.

- Specialized signal processing of physiologic variables (like RMS filtered EMG, or QRS detection) are performed on the computer via calculation channels.

Up to four TEL100C module sets can be connected to a single MP System, providing a maximum of 16 transmitted channels. The TEL100C module set behaves the same as four alternate 100 series modules.

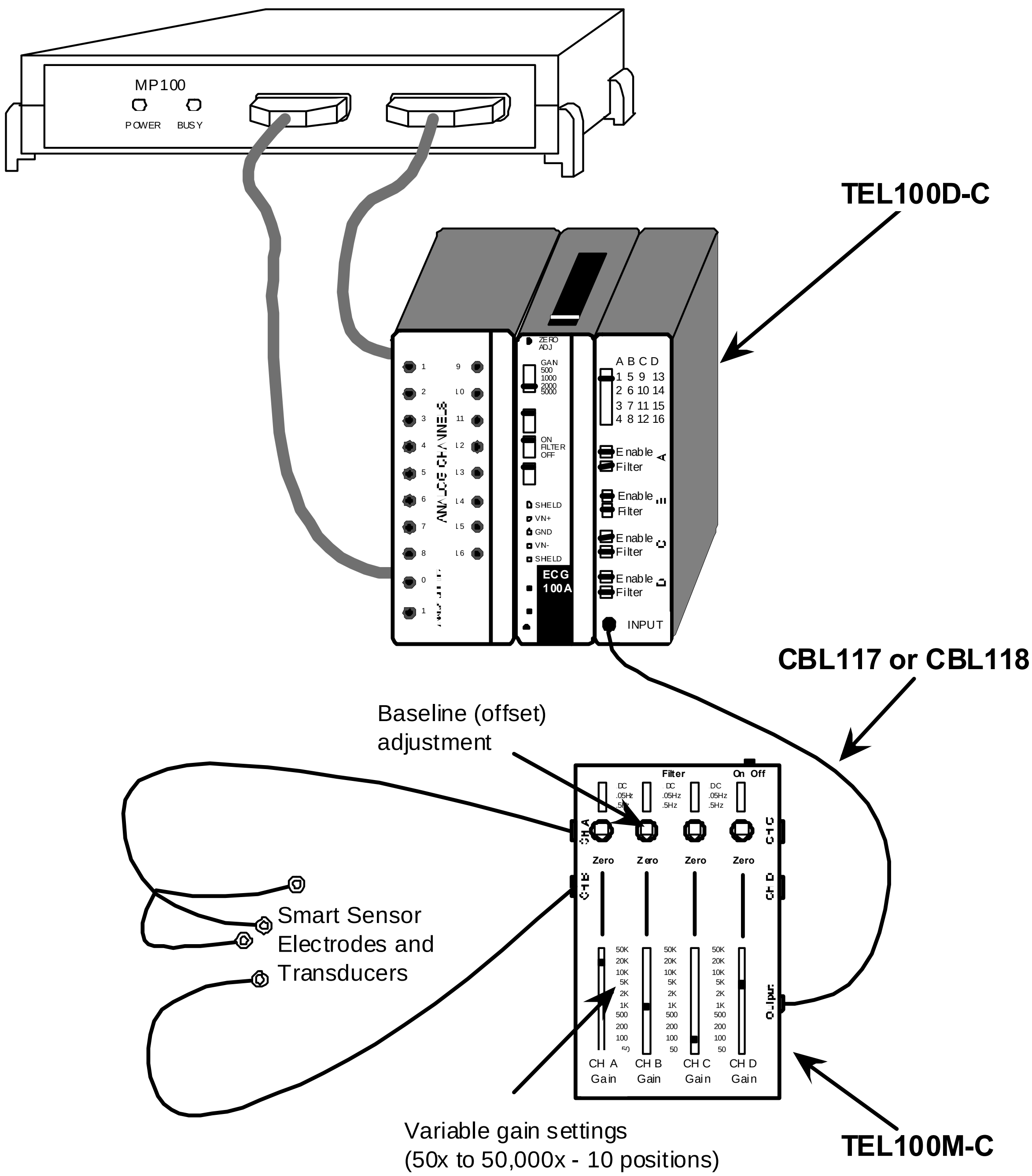
The 2000 Hz sampling rate of the TEL100C module set is independent of the MP System sampling rate.

- If a TEL100C channel is low-pass filtered at 35 Hz LPN, it would be appropriate for the MP System to sample that channel at 100 Hz or greater.

The TEL100C module set can be used independently from the MP System and, instead, with a different data acquisition system. The recommended configuration requires the IPS100C in addition to the TEL100C. Up to four TEL100C units can be used with a single IPS100C. The TEL100C channel outputs are then accessed via the front panel of the IPS100C using CBL102 3.5 mm phone plug to BNC male cables.

For studies that employ surface electrodes (e.g., ECG, EMG), gain settings from 500 to 5000 are typically appropriate. Similar settings are also appropriate for measurements with the RSP and PPG Simple Sensors. Moreover, non-electrode measurements (temperature, pulse, respiration and so forth) are typically performed with the **hipass** switch on the TEL100M-C set to DC (or 0.05 Hz to remove baseline drift), and the **filter** switch on the TEL100D-C in the ON position.

No special software is required to use the TEL100C module set. The TEL100C operates on the same Acq*Knowledge* software platform as the MP150. The TEL100C module set behaves equivalently to any four 100 series modules. All the surface electrode measurements (ECG, EEG, EMG and EOG) terminate in an SS2 Simple Sensor shielded electrode lead assembly. See the section on Simple Sensors (page 270) for information about the termination of other physiological variables.



TEL100C—MP System setup

CBL117 This 10-meter cable connects the TEL100D-C receiver to the TEL100M-C transmitter and is included in the TEL100C remote monitoring module set. The lightweight coaxial cable minimizes hindrance caused by multiple heavy cables. For increased operating distance, use CBL118.

CBL118 This 60-meter cable connects the TEL100D-C receiver to the TEL100M-C transmitter and is designed as an extension option for the TEL100C remote monitoring module set. The lightweight coaxial cable minimizes hindrance caused by multiple heavy cables.

TEL100C Calibration

To begin using the TEL100C system:

1. Plug the TEL100D-C into the side of the UIM100C
2. Select a bank to assign the channels to (A, B, C and D). Make sure no other 100C series amplifiers are assigned to those same channels. If certain channels in a particular bank are already being used (and can't be moved), then turn the telemetry channel off, via the "Enable" switch on the front panel of the TEL100D-C.
3. Plug the CBL117 into the TEL100M-C and the TEL100D-C.
4. When recording in Acq*Knowledge*, turn on the TEL100M-C, by flipping the power switch from right to left. The LED on the TEL100M-C should blink once then stay off. If the LED continues to blink, the 9V battery needs to be replaced (use 9 Volt alkaline batteries).
5. If bank 1 is selected on the TEL100D-C, then TEL100 Channels A, B, C and D will be assigned to MP150/100 channels 1, 5, 9 and 13 respectively. When using Acq*Knowledge*, select these channels when viewing data assigned to bank 1. The following documentation assumes that bank 1 is the selected bank.
6. To determine correct operation, rotate the zero balance for channel A on the TEL100M-C. Channel 1 in Acq*Knowledge* should indicate a moving baseline that changes as the zero is adjusted. Set the zero balance for channels A, B, C and D, so that the Acq*Knowledge* screen trace is centered. Plug the desired Simple Sensor into the TEL100M-C.

For EDA/GSR measurements, the following **Gain** settings correspond to μmhos per Volt. Similarly, for temperature measurements, the **Gain** settings listed correspond to ºF per Volt. Using the **scaling** or **rescaling** features in Acq*Knowledge*, these settings can be used to calibrate the signal.

The equipment calibrations for TEL100C and GSR are:

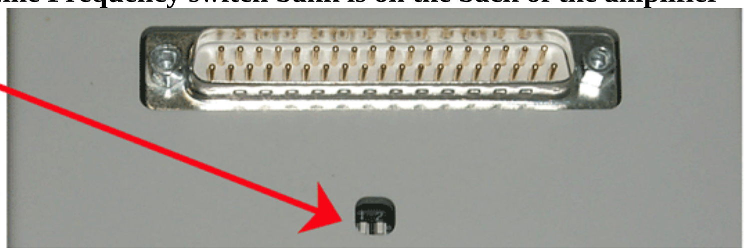
10 micro-mhos = 1mV, so for a gain of 1000, this translates to 10 micro-mhos per 1 volt.
A gain of 5000 on TEL100M would put the translation as 2 micro-mhos for 1 volt output.

Gain	EDA/GSR (SS3A) μmhos/V	SKT (SS6) ºF/V
50	200	100
100	100	50
200 50		25
500	20	10
1,000	10	5
2,000	5	2.5
5,000	2	1
10,000 1		0.5
20,000 .5		0.25
50,000 .2		0.1

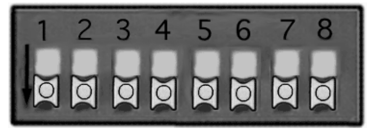
As with the SKT100C amplifier, temperature data collected with the TEL100C is centered around 90º F assuming the SKT100C is set to "DC." Supposing data was acquired using a gain setting of 500, a reading of 0 Volts would correspond to 90ºF, whereas a signal of +2 Volts (read on the MP150) would correlate to a temperature of 110ºF. These values could then be used to rescale the incoming signal from raw voltages to degrees Fahrenheit.

Modules can be set for 50 Hz or 60 Hz notch options to match the wall-power line frequency of the destination country. The proper setting reduces noise from interfering signals when the notch filter is engaged. Generally, wall-power line frequency is 60 Hz in the United States and 50 Hz in most of Europe; if necessary, contact BIOPAC to determine the correct line frequency. To reset the line frequency setting, adjust the bank of switches on the back of the amplifier module.

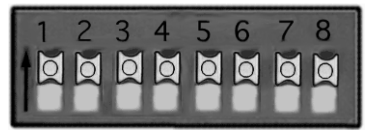
Line Frequency switch bank is on the back of the amplifier



(The TEL100 has an 8-switch bank vs. 2-switch bank shown)



50 Hz = All 8 switches DOWN



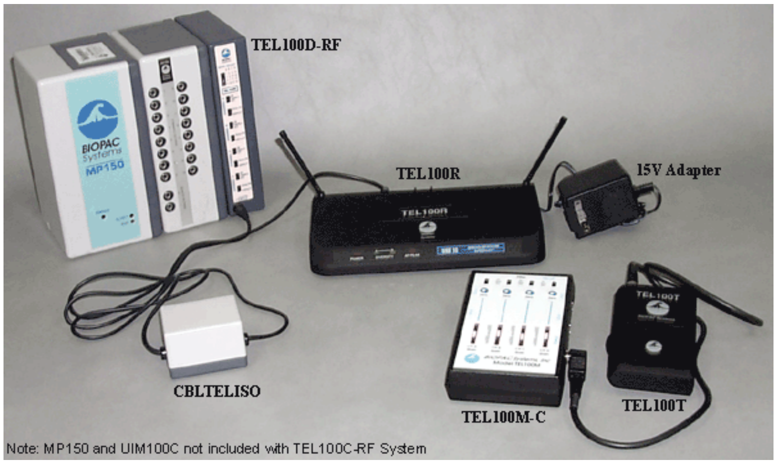
60 Hz = All 8 switches UP

TEL100C System Specifications

Number of Channels:	4
Sampling Rate:	2000 Hz (per channel) [Transparent to user]
Frequency response	(independent bandwidth settings per channel)
Low Pass Filters:	35 Hz LPN, 500 Hz LP
High Pass Filters:	DC, 0.05 Hz and 0.5 Hz
Channel Gain Control:	x50, x100, x200, x500, x1000, x2000, x5000, x10000, x20000, x50000
Output Range:	±9V (analog)
Offset Control:	Yes
Input Signal Level:	Max: ±50 mV
Input Impedance:	2 MΩ (differential)
CMRR (1 kΩ source imbalance):	110 dB min (50/60 Hz); see Shield Drive Operation on page 287
CMII: 11	MΩ (DC), >1000 MΩ (50/60 Hz)
CMIV:	±7V (referenced to amplifier ground) ±1500 VDC (referenced to mains ground)
Noise Voltage:	0.1µV rms (0.05-30 Hz)
Transducer Excitation:	±5V (10 V pk) @ 20ma (total max current from four channels)
Signal/Crosstalk Ratio:	(0.05-500 Hz) 65dB min
Signal/Noise Ratio:	(0.05-30 Hz) 75dB min, (0.05-500 Hz) 65dB min
Encoding: TDM-DSB/LC	
Signal transmission range:	≤ 60 meters via coaxial cable
TEL100M Power Source:	9V alkaline battery (24 hrs nominal)
Dimensions Size	Weight
TEL100D-C:	4 cm *x* 11 cm *x* 19 cm 400 g
TEL100M-C:	9 cm *x* 15 cm *x* 3.3 cm 308 g
Pin-outs TEL100M-C:	Female DSUB 9 connector pin 1: Shield Drive pin 2: Vin+ pin 3: Ground pin 4: Vin- pin 5: Shield Drive pin 6: Vref+ (+5 V excitation at 5 mA nominal) pin 7: no connection pin 8: no connection pin 9: Vref- (-5 V excitation at 5 mA nominal)

See also: SS Series Simple Sensor Transducers, page 270.

TEL100C-RF Wireless Remote Monitoring System – 110 V
TEL100C-RFA Wireless Remote Monitoring System – 220 V



See **Application Note #AH126** for setup and, operational guidelines, and a comparison to the TEL100C specs.

Each **TEL100C-RF system** includes:

TEL100D-C receiver	module
TEL100M-C portable	4-channel amplifier/transmitter (wireless set includes TEL100T transmitter and TEL100R receiver)
TEL100-RFL	radio frequency link
or	
TEL100-RFLA	radio freq link 220 V
CBL119	2-meter connection cable (RCA-M to 1/4-M mono)

The TEL100C-RF/RFA system offers a completely wireless transmission scheme to record data while subjects are mobile and/or physically distant (75-150 meters) from the recording system. The TEL100C-RF/RFA will work with the current MP System and any other standard 100-series amplifiers. Use with BIOPAC SS series Simple Sensor transducers and electrodes.

The TEL100C-RF/RFA system includes a portable amplifier/transmitter, which converts up to four channels of data into a modulated data stream. This data stream is transmitted to the receiver module, and then the receiver demodulates the data and sends it to the MP System for recording and analysis. Up to four TEL100C-RF/RFA module sets can be used with a single MP System, allowing up to 16 channels of transmitted data originating from up to four distinct locations. Each channel incorporates a switchable, non-distorting 50/60 Hz interference filter. Gain and bandwidth can be adjusted independently for each channel.

BIOPAC does not recommend converting the wireless TEL100C-RF to a tethered system; TEL100C-RF components are not optimized for tethered physiological recordings. For tethered remote monitoring, use the TEL100C System.

TEL100C-RF/RFA Specifications

NOTE -RFA uses 230 V adapter and Euro connectors

Number of Channels:	4
Channel Bandwidth:	500 Hz or 35 HzLPN (low pass filters)
Notch Filters:	50 or 60 Hz (user selectable on side panel); Independent bandwidth per channel
Sampling Rate:	2000 Hz (per channel)
Encoding: TDM-DSB/LC-FM	
Channel Gain Control:	10 levels: 50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, 50000
Input Signal Level:	Max: ±50 mV
Offset Control:	Yes
AC/DC Coupling:	DC, 0.05 Hz and 0.5 Hz
Transducer Excitation:	±5 V @ 20 ma (total max current from four channels)
Transmit Frequency Options:	Four channels (selected group ranging from 170 to 216 MHz)
Transmit Frequency Stability:	±0.005% (crystal controlled)
RF Power Out:	50 mW (max allowed by FCC)
Transmission Range:	75 meters (nominal), 150 meters (line-of-sight)
Signal/Crosstalk Ratio:	35 dB (nominal)
Signal/Noise Ratio:	0.05-35 Hz: 40 dB (nominal); 0.05-500 Hz: 35 dB (nominal)
Pk-Pk Noise:	Voltage (Shorted Inputs): 0.28 µV rms (0.1-10 Hz)

Biopotential Amplifiers (in TEL100M-C):

Input Impedance:	2 MΩ (differential)
CMRR (1 kΩ source imbalance):	110 dB min. (50/60 Hz); see Shield Drive Operation on page 287.
CMII: Co	mmon 11 MΩ (DC), >1000 MΩ (50/60 Hz)
CMIV:	±7 V (referenced to amplifier ground)

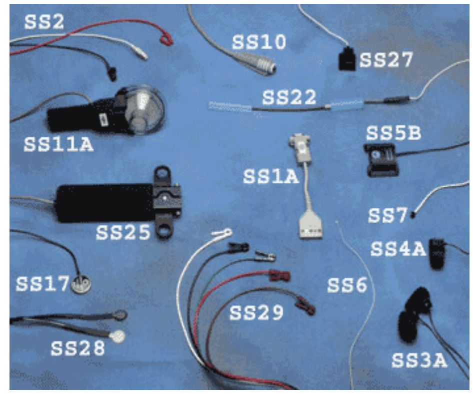
Component Dimensions and Weight:

TEL100D-C:	10.92cm x 19.05cm x 4.06cm (0.397 kg)
TEL100M-C:	8.89cm x 14.22cm x 3.05cm (0.312 kg w/ battery)
TEL100T:	6.38cm x 10.57cm x 2.41cm (0.120 kg w/ battery)
TEL100R:	12.98cm x 20.50cm x 4.09cm (0.450 kg)

Pin-outs TEL100M-C: Female DSUB 9 connector

pin 1: Shield Drive
pin 2: Vin+
pin 3: Ground
pin 4: Vin-
pin 5: Shield Drive
pin 6: Vref+ (+5 V excitation at 5 µA nominal)
pin 7: no connection
pin 8: no connection
pin 9: Vref- (-5 V excitation at 5 µA nominal)

Simple Sensor (SS) Electrodes and Transducers for the TEL100C



Simple Sensor (SS) electrodes and transducers are explicitly designed to connect to the **TEL100M-C** transmitter, and most come with a 1.2 meter cable. SS assemblies include specific circuitry to adapt various physiological variables to the TEL100M-C.

Any SS electrode or transducer can be plugged into any TEL100M-C input. The "smart" configuration of each electrode and transducer assembly communicates its specific signal type. Certain transducers (such as SS26 and SS27 Accelerometers) will reduce the overall recording life of the 9-Volt battery, but it is generally possible to record biopotentials and other signals for up to 12 hours.

Simple Sensors take the place of BIOPAC's traditional electrodes and transducers in that they are only compatible with the TEL100M-C amplifier. All the surface electrode measurements (ECG, EEG, EGG, EMG and EOG) terminate in an SS2 (Simple Sensor shielded electrode lead assembly).

The Simple Sensor connector varies from the transducer connector, but functionality is the same. The following physiological variables terminate as shown—see the corresponding transducer section for information about each Simple Sensor.

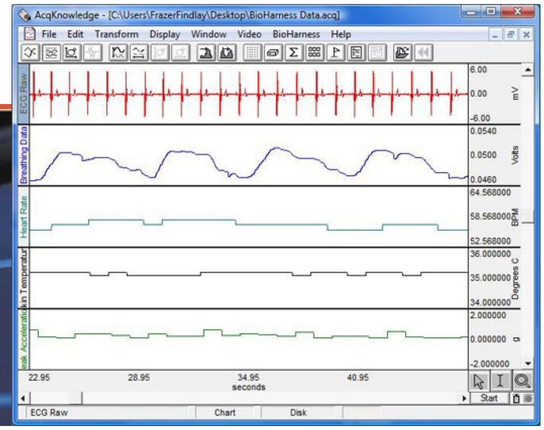
SS #	Description	Corresponding Transducer	
SS1A	Unshielded Touchproof Electrode Adapter (10 cm)		
SS2	Shielded Electrode Lead Assembly (1 meter)		
SS3A	Electrodermal Response Transducer	*see* TSD203	page 119
SS4A	Pulse Plethysmogram Transducer	*see* TSD200	page 122
SS5B	Respiratory Effort Transducer	*see* TSD201	page 126
SS6	Fast Response Temperature Probe	*see* TSD202A	page 130
SS7	Skin Surface Temperature Probe	*see* TSD202B	page 130
SS10	Hand Switch	*see* TSD116A	page 49
SS11A	Airflow Transducer (medium)	*see* TSD117	page 64
SS17	Physiological Sounds Microphone	*see* TSD108	page 70
SS18	Skin Surface Temperature Probe	see TSD202D	page 130
SS20	Twin-Axis Goniometer (110mm) — requires 2 channels	*see* TSD130A	page 78
SS21	Twin-Axis Goniometer (180mm) — requires 2 channels	*see* TSD130B	page 78
SS22	Single Axis Torsiometer (110mm)	*see* TSD130C	page 78
SS23	Single Axis Torsiometer (180mm)	*see* TSD130D	page 78
SS24	Finger Goniometer (35mm)	*see* TSD130E	page 78
SS25	Hand Dynamometer	*see* TSD121C	page 73
SS26	Tri-Axial Accelerometer (5G) — requires 3 channels	*see* TSD109C	page 45
SS27	Tri-Axial Accelerometer (50G) — requires 3 channels	*see* TSD109F	page 45
SS28A	Heel/Toe Strike Transducer	*see* TSD111A	page 47
SS29	Multi-lead ECG Cable — requires 3 channels	*see* TSD155C	page 103
SS28A	Heel/Toe Strike Transducer	*see* TSD111A	page 47
SS29	Multi-lead ECG Cable — requires 3 channels	*see* TSD155C	page 103

Simple Sensor Calibration

Refer to the corresponding transducer section.

BioHarness with Acq*Knowledge*

- **Go to www.biopac.com for a video of BioHarness in use** (.wmv)
- **Complete BioHarness Users Guide is online**



BioHarness™ with Acq*Knowledge*® software is a state-of-the-art lightweight portable biological data logger and telemetry system. It monitors, analyzes and records a variety of physiological parameters including ECG, respiration, temperature, posture, and acceleration. The BioHarness operates in RF (Radio Frequency) transmitting mode for live viewing of data or data logging mode. In the data logging mode, the BioHarness logs the data for later download to the Acq*Knowledge*™ software using the USB docking and charging cradle that comes with the system. BioHarness applications include physiology, psychology, psychophysiology, exercise physiology, ergonomics, human factors, and more.

BioHarness Data Channels

- ECG - Raw(RF only; not logged)
- Breathing
- RR Interval
- Heart Rate
- Respiration Rate
- Skin Temperature
- Posture
- Vector Magnitude
- Peak Acceleration
- Breathing Wave Amplitude
- X axis acceleration min
- X axis acceleration peak
- Y axis acceleration min
- Y axis acceleration peak
- Z axis acceleration peak
- Z axis acceleration min

Live data viewing features include a variety of selectable waveforms and trend data including

- ECG
- Heart Rate
- RR values
- Respiration
- Tri-axial accelermeter (X, Y & Z)
- Activity level
- Posture (attitude of device in degrees from vertical)

Specifications

Acceleration	Highpass 0; Low pass limited to 10.5 Hz, and sampled at 18 Hz. The maximum and minimum measured in each second are reported.
Temperature	Stabilizes to a new reading, following a step change, in 900 ms; the reporting rate is 1 Hz.
Posture	Highpass 0. Based on the accelerometer with a 6.5 Hz low pass filter to limit the noise resulting from movement and provide a stable reading.
Activity	Requires the magnitude of the AC components of each axis; uses a digital 0.1 Hz highpass filter and a 10.5 Hz lowpass hardware filter. Sampled at 18 Hz and accumulated for 1 second reporting.
Respiration	Detect breathing rates from 3 BPM to 70 BPM (0.05 Hz to 1.166 Hz)
ECG	In hardware, the signal is filtered with a highpass filter at 15 Hz and a low pass filter at 78 Hz. The low end filter cut-off enables heart rate measurement under vigorous activity (high resistance to motion artifact). The sample frequency is 250 Hz, which is also the reporting rate over RF (not reported in logged data).

Smart Fabric Strap

Chest Strap: Adjustable, Velcro® fastening

Material: Elasticized webbing incorporating Zephyr Smart Fabric sensors

Width: 50 mm

Weight: 50 grams

Size: BioHarness ships with a medium strap (no substitutions).
Additional straps are available for individual purchase or in 5 packs (one size) or 50 packs (mix sizes):

- Extra Small (custom)
- Small (26" to 32.5")
- Medium (32.5" to 39")
- Large (39" to 45.5")
- Extra Large (custom)

Optional shoulder straps available for a more secure fit of the chest strap for very active subjects or those who wear specialized outerwear which may make adjustment of chest strap position difficult. Shoulder straps attach at the front by plastic clips and pass through an elasticized loop at the back.

BioHarness Transmitter/Logger

Frequency: ISM radio band (868 - 929 MHz); Frequency is software configurable for country-specific bands

Sample Rate: 250 Hz Max.

Memory Capacity: ~480 hours

Transmit Range: Up to 100 m, environment and antenna dependent

Weight: 35 grams

Dimensions: 80 x 40 x 15 mm

Battery Life

~ 5 hours transmitting

~ 8 hours logging

Charging is intelligent - the device cannot be overcharged

- Quick Charge (90%): 1 hour from fully discharged
- Full charge (100%): 3 hours from fully discharged

Operating System

Windows® XP or Vista

Connectivity

USB

Compliance

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

TEAM System Antenna

Simultaneously monitor multiple people in real time, anywhere in a stadium, field or other wide-area setting. TEAM Systems support up to 64 participants. Antenna and case included with TEAMSystem-4 and TEAMSYstem-16.

BioHarness™ is a trademark of Zephyr Technology Limited.

Chapter 10 Power & Cables

IN-LINE POWER TRANSFORMERS

All AC series in-line power transformers are CE marked for the EC Low Voltage Directive and EMC Directive, and all have UL and TUV approval. The units have standard IEC power input plugs and operate over mains power ratings of 100-240 VAC, 50-60 Hz. Each includes a USA or EURO power cord.

AC100A	+12 volt, 1 amp	Connects the MP100 System, IPS100C, CO2100C or O2100C to the AC mains wall outlet. One transformer is included with each MP100 Starter System, IPS100C, CO2100C or O2100C module.
AC101A	±12 volt, +5 volt, 1 amp	Connects the LDF100C to the AC mains wall outlet. One transformer is included with each LDF100C module.
AC137A	+6 volt, 1.5 amp	Powers the heating element for any of the TSD137 series pneumotachs.
AC150A	+12 volt, 4.17 amp	Connects the MP System to the AC mains wall outlet. One transformer is included with each MP150 Starter system.

See also: IPS100C Isolated Power Supply, page 52

BAT100A Rechargeable Battery Pack

BAT100A with Recharger

The BAT100A is a high energy density and lightweight battery pack designed to operate MP150 or MP3X Systems. A universal input voltage 3 amp battery charger is also included. The battery pack is lightweight and comes with a supplied carrying case with integral shoulder strap. The carrying case holds battery pack, charger and all associated cords.

The BAT100A chemistry is Lithium Iron Phosphate (LiFePO4). A key advantage over other lithium-ion batteries is the superior thermal and chemical stability, which provides better safety characteristics than other lithium-ion batteries with different cathode materials. Due to the significantly stronger bonds between oxygen atoms in the phosphate, oxygen is not readily released, and as a result, lithium iron phosphate cells are virtually incombustible in the event of mishandling during charge or discharge, and can handle high temperatures without decomposing.

Ships as USA or EURO version based on delivery address.

BAT100A replaces BAT100 effective June 2011.

Operation

1. Only charge the BAT100A (12 v @ 15 AH LiFePO4) using the included charger.
2. Discontinue use of the BAT100A when the performance of the MP System begins to deteriorate.

Charging the Battery Pack

1. When the BAT100A is being charged, the charger will indicate a RED charging LED.
2. When the BAT100A is fully charged, the charger will indicate a GREEN charging LED.

Storage

1. Store the Battery Pack in a fully charged condition.
2. Store the Battery Pack in a cool place (normal room temperature or lower).

(See following page for BAT100A specifications)

BAT100A Battery Pack Specifications

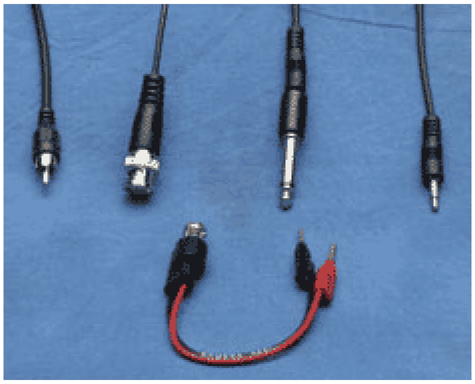
Battery

Chemistry:	$LiFePO_4$ (Lithium Iron Phosphate)
Output Capacity:	12V @ 15 amp-hours
Working Output Voltage Range:	13.2 V – 12 V
Output Connector:	DC Barrel Plug (5.5 mm OD, 2.1 mm ID – Center positive)
Operating Time:	MP3X with 4 sensors: 26 hours nominal MP150 with 4 modules: 16 hours nominal
Charge Time:	5 hours (nominal)
Recharge Cycles: (number of cycles to 80% of original capacity):	1500 (typical minimum)
Operating Temperature Range:	0° C to 45° C
Storage Temperature Range:	-20° C to 60° C
Weight:	2.45 kg
Dimensions: (includes carrying case)	14cm (high) x 19cm (wide) x 14cm (deep)

Battery Charger (For BAT100A only)

Maximum Nominal Charge Voltage:	14.4 V @ 3.0 amps (Charges at 3 amps to 14.4 V, then potentiostatic at 14.4 V until current is less than 0.5 amps)
Input:	120/240 VAC @ 50/60 Hz (USA or EURO power cord)
Output Connector:	DC Barrel Socket (5.5 mm OD, 2.1 mm ID – Center positive)
Operating Temperature Range:	0° C to 45° C
Storage Temperature Range:	-20° C to 60° C
Weight:	285 grams
Dimensions:	3.8cm (high) x 6.4cm (wide) x 15cm (long)

CBL100 Series Analog Connection Cables



CBL100 series

The CBL100 Series analog connection cables are used to connect the stand-alone equipment to the MP System. Analog outputs (from chart recorders, force plates, pre-amplifiers, oscilloscopes, etc.) can be connected to the UIM100C module or other MP System modules. Select the cable number with the plug corresponding to the output jack of the equipment. Use one cable per recording channel.

CBL100 2 meter; 3.5 mm mono phone plug to 3.5 mm mono phone plug

CBL101 2 meter; 3.5 mm mono phone plug to male RCA

CBL102 2 meter; 3.5 mm mono phone plug to male BNC

CBL105 2 meter; 3.5 mm mono phone plug to 6.35 mm (¼”) mono phone plug

CBL106 10 cm; 2 mm pin plugs to female BNC
The CBL106 is a multi-purpose adapter that can be used to:
Connect BNC terminated equipment to the DA100C
Connect a BNC cable to the digital I/O lines on the UIM100C
Connect the STM100C to nerve conduction chambers (via the CBL101)

CBL107 10 meter, 3.5 mm mono plug to 3.5 mm mono phone plug

CBL108 60 meter, 3.5 mm mono plug to 3.5 mm mono phone plug

CBL110A DB37 F/F Ribbon Cable. Use this 3-meter ribbon cable to interface a SuperLab presentation system with the STP100C Isolated Digital Interface for an MP150 or MP100 System. Pins 19 and 21 are GND; pin 20 is +5 V.

CBL110C DB25 M/F Ribbon Cable. Use this 3-meter ribbon cable to send digital I/O info to the STP100C Isolated Digital Interface to interface visual presentation systems that use a computer's parallel printer port (E-Prime, DirectRT, MediaLab, Inquisit, etc.) with an MP150 or MP100 System. Pins 18 and 25 are GND.

CBL117 10 meter RCA male plug to RCA male R/A plug for TEL100C

CBL118 60 meter RCA male plug to RCA male R/A plug for TEL100C

External Device Interfaces to an MP System using UIM100C

Custom cables are available from BIOPAC for connectors not listed.

Company	Device	Connector Type	BIOPAC cable
AMTI	MSA-6: Force Plate Amp (Use AMTI cable 5405C) MCA: Force Plate Amp (Use AMTI cable 5405C)	BNC female	CBL102
Axon	All Amplifiers	BNC female	CBL102
Buxco	MAX II	3.5 mm mini-phone jack	CBL100
Data Sciences International	Physio Tel Receiver with ART Analog Adapter	BNC female	CBL102
Gould	6600 Series	BNC female	CBL102
Grass	Model 7 (J6)	3.5 mm mini-phone jack	CBL100
	P55, P122, and P511 Series	BNC female	CBL102
Harvard	HSE PLUGSYS AH 69-0026 Dissolved Oxygen Meter	BNC female	CBL102
	AH 60-2994-2999 Research Grade Isometric Transducers AH 6-03000/3001 Research Grade Isotonic Transducers	4 mm double banana jack	CBL102 with CBL106
Kent	TRN(001-012) Amplifiers	BNC female	CBL102
Kissler	Force Plates	BNC female	CBL102
Millar	TCB600: Transducer Control Unit	¼" phone jack	CBL105
	TC-510 (Specify Grass Cable interface #850-3028)	6-pin	TCI100 (to DA100C)
Sonometrics	Sonomicrometer Systems with Optional Adapter	BNC female	CBL102
Transonic	T106, T206, T106U, T206U: Animal Research Flowmeters T110: Lab Tubing Flowmeter BLF21D/21: Laser Doppler Meters	BNC female	CBL102
Triton	CBI System System 6	¼" phone jack	CBL105
Tucker Davis	All Digital BioAmp Systems	BNC female	CBL102
WPI	705: Electro 705 Electrometer 721: Cyto 721 Electrometer 767: Intra 767 Electrometer 773: Duo 773 Electrometer DAM50: Bio-amplifier DBA Series Digital Biological Amps DVC-1000: Voltage Current Clamp EVC-4000-(1-4): Voltage Clamp FD223: Dual Electrometer ISO2: Dissolved Oxygen Meter & Electrode ISODAM: Low Noise Preamplifier ISO-DAM8A-(1-8): Bio-amplifier System NOMK2: ISO-NO Mark II Nitric Oxide Meter TRN001, TRN002, TRN011, TRN012: Isometric Transducers VF-4: 4-Channel Buffer Amplifier	BNC female	CBL102
	DAM60, DAM70, DAM80: Bio-amplifiers	3.5 mm mini-phone jack	CBL100

Interfaces are available for a variety of connectors. If a different interface is required, contact BIOPAC to discuss custom options. All brand or product names are the trademarks or registered trademarks of their respective holders.

CBL200 Series   Lead Connector Conversion Cables

See the guide to *External Device Interfaces* on page 277 for connections to common devices

CBL200	10 cm, 2 mm pin to 1.5 mm socket	Convertsa 2 mm pin electrode or transducer lead to a Touchproof socket (1.5 mm ID), for connection to any of the 100C-series Biopotential or Transducer amplifiers or STMISO series modules. One CBL200 is required for each Touchproof socket.
CBL201	10 cm, 1.5 mm socket to 2 mm pin	Converts a Touchproof (1.5 mm ID) socket electrode or transducer lead to an old-style 2mm pin, for connection to any of the 100B-series Biopotential or Transducer amplifier modules. Also used to connect a ground electrode lead (e.g. LEAD110A) to the UIM100C module (required when using the TSD150 active electrodes). One CBL201 is required for each Touchproof socket.
CBL202	2 mm Male pins to 6.3 mm (¼″) mono phone jack	Adapts transducers with a 6.3 mm (¼″) mono phone plug to the DA100C.
CBL203	1.5 mm Female to 6.3 mm (¼″) mono phone jack	Adapts temperature transducers with a 6.3 mm mono phone plug to the SKT100C.
CBL204	25 cm, Touchproof "Y" adapter	Connects multiple electrode sites to a single amplifier input or stimulator output. The CBL204 plugs into any 100C-series biopotential amplifier input or STMISO series output and provides two sockets to connect to electrode leads terminating in Touchproof sockets. Plug multiple CBL204s together to reference 3 or more electrode leads to the same input or output.

CBL205 1.5 mm AC-Coupled electrode lead adapter

USE CBL205 when more than one ground is required while recording electrodermal activity (e.g., galvanic skin response). One end of the adapter plugs into the ground on the amplifier and the other end accepts the electrode lead.

To record GSR with other biopotential signals (ECG, EEG, EOG, EGG, EMG, ERS), BIOPAC recommends using CBL205 connected to one ground on any of the biopotential amplifiers. The subject will be grounded through the Vin- of the GSR electrodes, but in some cases it is necessary to have more than one ground; in such cases, use CBL205 to prevent ground loops.

- For example, if—while recording a biopotential and GSR— the GSR electrode is removed during a stage of the experiment, to maintain a ground for the biopotential and avoid ground loops:
  1. Connect the Vin- lead of the GSR as ground.
  2. Connect an AC-coupled ground to the biopotential amplifier.

MEC Series Module Extension Cables

MEC100C and MEC110C

These module extension cables are used to increase the distance between subject and recording system, allowing increased subject movement and comfort. Each extension cable attaches to one amplifier; electrodes and transducers plug into the extension cable's molded plastic input plug. The 3-meter extension includes a clip for attaching to a subject's belt loop or clothing.

The MEC series extension cables contain no ferrous parts (less the removable clothing clip). The MEC100C is designed for Transducer amplifiers. The MEC110C and MEC111C are designed for Biopotential amplifiers. Use the MEC100C or MEC110C to increase the lead length to the amplifier.

The MEC111C is required for the protection of a system and Biopotential amplifiers when electrocautery or defibrillation equipment is used while recording data.

IMPORTANT SAFETY NOTES

1. MEC series cables are not to be used on humans when they are undergoing electrosurgery or defibrillation. In fact, no BIOPAC equipment should be connected to human subjects during the course of defibrillation or electrosurgery.
2. When MEC series cables are used, be careful to preserve the isolation of MP system during defibrillation. No external lab equipment should be connected directly to the UIM100C, IPS100C or any included amplifier module. To preserve MP system isolation, all connections of this type should be made using INISO or OUTISO with the HLT100C. To verify that the isolation of the recording system is intact, use a multimeter to measure resistance from subject ground (on biopotential amplifier) to mains ground; there should be no DC conductivity.
3. Do not connect the electrode leads attached to the MEC series cables directly to defibrillator paddles. When using MEC cables, electrode leads should be connected to the subject directly and not via the defibrillator paddles.

COMMON EXTENSIONS

MEC100C	100C-series Transducer amplifiers to Touchproof inputs
MEC110C	100C-series Biopotential amplifiers to Touchproof inputs
MEC111C	100C-series Biopotential amplifiers to Touchproof inputs—Protected

LESS COMMON EXTENSIONS

MEC100	DA100C or 100B-series Biopotential or Transducer amplifiers to 2mm socket inputs
MEC101	100B-Series Biopotential amplifiers to 2mm socket inputs – Protected
MEC110	100B-series Biopotential or Transducer amplifiers to Touchproof inputs
MEC111	100B-series Biopotential amplifiers to Touchproof inputs—Protected

Chapter 11 Virtual Reality

BIOPAC's VR/Immersive hardware is for use with Vizard VR Toolkit software.

Head Mounted Displays

HMD1 Head-Mounted Display

Two high-contrast microdisplays (SVGA 3D OLED) deliver fluid, full-motion video in more than 16.7 million colors. The highly responsive head-tracking system provides a full 360° angle of view. Specially developed optics deliver a bright, crisp image with a nearly 40° field of view.

HMD1 Specifications

Viewing Equivalent: 105" diagonal movie screen viewed at 12'
View Angle: ~ 40° diagonal FOV
Headtracking: 360° horizontal, > 60° vertical, 6° of freedom motion tracking – downloadable SDK available
Aspect Ratio: 4 x 3
Resolution SVGA: 800 x 600 triad pixels per display (1.44 megapixels)
Number of Colors: 24-bit color for more than 16.7 million
Brightness: > 50 cd/m2
Contrast Ratio: > 200:1
Stereovision: Automatic detect of frame-sequential stereovision data
Renders: 2D or 3D video
Controller Dimension (L x W x D): 6.1" x 3.45" x 1.15"
Weight (display set): < 8 oz (< 227 g)
Power Consumption: < 1.25 W typical
Power Supply: USB or 5 V DC regulated
Signal Input Mode: RGB Signal Input (PC D-Sub) 24 bit per pixel color
Audio Output: Attached stereo sound
Microphone System: Built-in noise-canceling microphone
Operating Environment Operating Temperature: 0° to 40°C
Storage Temperature: -10° to 50°C
Related Safety & Ergonomics: Adjustable interpupilary distance & tilt adjustment, automatic shutdown after two hours (turn off and on to reset)

HMD2 Head-Mounted Display—High Res

HMD2 is a state-of-the-art head-mounted display (HMD) for advanced virtual reality applications. It incorporates high-resolution color microdisplays with custom engineered optics to deliver unsurpassed visual acuity in a wide field-of-view format.

HDS100 Haptic Delivery System

The HDS100 haptic delivery system provides tactile feedback during virtual reality experiments. The system includes:

- audio amplifier that connects to a computer sound card
- interface cables (3): HDS100 to an existing sound card (3.5 mm stereo phone plug to dual RCA Y); HDS100 to actuators (18 gauge, 7.3 m); and signal to HDS100 *and* speakers (stereo splitter, 13.5 mm)
- actuators & isolators that vibrate based on the sound from the sound card

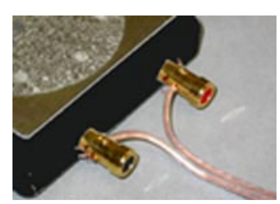
Actuators are placed under chair legs or on a platform and deliver vibrations based on the VR environment (e.g. movement of elevators).

The system is compatible with SuperLab, E-Prime, Vizard VR Toolkit, and other presentation systems that interface the computer's sound card.

HDS100 Specifications

Includes:

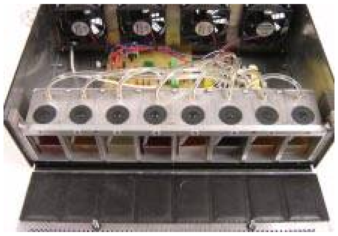
- 1 amplifier
  - Features remote control and and rear-mounted IR Input
  - Bass management, filter and gain control for limitless personalization
  - Drives up to four linear actuators with two channels 150 W each RMS (6 ohm)
  - Rack mountable with optional ears
  - Variable Low Pass Filter (20-600 Hz)
  - Three inputs (Left, Right, LFE)
  - Signal sense auto on/off
  - Ultraquiet variable speed fan
  - Size 2U (43 cm x 9 cm x 36 cm) or (48 cm x 9 cm x 36 cm with optional Rackmount Adapters)



- 2 linear actuators—These electromagnetic motors deliver low-frequency motion to a wide range of furnishings.
- 2 motion isolators—The motion isolators reduce the amount of tactile motion transmitted to the floor and surrounding environment, effectively isolating the tactile sensation to the couch or chair.
- Interface cables
  - HDS100 to an existing sound card: 3.5 mm stereo phone plug to dual RCA Y (CBL120)
  - HDS100 to actuators: 18 gauge, 7.3 m
  - signal to HDS100 *and* speakers: stereo splitter, 13.5 mm

Replacement actuators/isolators available as **RXHDS**.

SDS100 Scent Delivery System



SDS100 is a computer-controlled (USB), eight-cartridge scent machine that uses compressed air* to project different scents on cue for a predetermined time followed by a burst of unscented air to clear for the next scent. Scents are triggered from the virtual reality environment.

* Requires companion air compressor, such as SDSAIRA-1 (US) or SDSAIRB-1 (Euro).

SDS100 Specifications

Scent receptacles: 8

Scent cartridges: separate purchase; see SCENT

Scent dispersement*: 3 m - 6 m

Scent control: See App Note 238 - Software options for controlling the SDS100 Scent Delivery System

Operational input pressure range: 35-50 psi (35 psi - mild scent; 50 psi - strong scent)

Maximum input pressure: 100 psi

Output: 1/4" NPT male output

Power:
Description Wall Mount AC Adapter (2-prong flat blade)
Input 100-240 V, 0.7 amps, 47-63 Hz
Output 12 V, 2.1 amps

Compressor (such as SDSAIRA/B-1): needs to have maximum output pressure of 60 psi and > 0.2 CFM air flow at 30 psi

Shipping Weight: 5.44 kg (12 lbs.)

Product Dimensions (LxWxH): 41.9 cm x 25.4 cm x 14 cm (16-1/2" x 10" x 5-1/2")

SDSAIRA-1/B-1 Mini Air Compressor

SDSAIR is a 1/8 HP mini air compressor for use with the SDS100 Scent Delivery System.

- SDSAIRA-1 for 110 V/60 Hz.
- SDSAIRB-1 for 240 V/50

SDSAIRA/B Specifications

Compressor
- Input: 115 V, 1 A, 1 phase, 60 cycle
- Output: 1/8 hp, 0.25 cfm @ 30 psi
- 1/8" NPT male input
- includes connection hose to SDS100

Cord: grounded 3-wire cord, 1.83 m (6')

Pressure: Can deliver up to 40 lb pressure
Diaphragm: Uses oil-less diaphragm
Air-Bleed Valve (regulates pressure)
Weight: 5.44 kg (12 lbs)
Ratings: CSA approved and UL listed

Chapter 12 Eye Tracking

Eye Tracking System Specifications	
Real-time display	Gaze point history, gaze trace, fixation duration, pupil size and ROIs, can be graphically displayed over stimulus image. Visible to the user and / or the subject for fixed and HMD options. Real-time pen plots of X and Y position of gaze, velocity, ocular torsion, pupil width and pupil aspect ratio.
Allowable head movement	Fixed and HMD options: Small movements allowed. Subject's pupil and corneal reflection must remain within the camera image. Scene camera options: unlimited
Tracking Method	Infrared video. Monocular or binocular options. Pupil tracking—Fixed and HMD options = bright or dark pupil; scene camera options = dark pupil.
Visual range	Fixed options: *Horizontal* ±44° of visual arc, *Vertical*± 20° of visual arc HMD options: tracking will depend on the field of view of the HMD. Scene camera options, included with the system either: Color 70º horizontal field of view **or** B&W 60º horizontal field of view.
Measurement principle	The user can select between three methods: Pupil only, corneal reflection only, or both together (both provides greater tolerance to head movements for the fixed and HMD options).
Accuracy*	Approximately 0.25° - 1.0° visual arc
Spatial resolution*	Approximately 0.15° visual arc
Temporal resolution	between 60 Hz and 30 Hz, user-selectable
Blink suppression	Automatic blink detection and suppression
Pupil size resolution	Measures pupil height and width to better than 0.03 mm instantaneous (no averaging).
Auto threshold	The program scans over the video image for the pupil and / or for the corneal reflection. Little or no manual adjustment required. luminance threshold can be adjusted auto threshold feature provides good threshold levels automatically
Real-time communication	Same computer: Software Developers Kit (SDK) supplies everything required for seamless interface between ViewPoint and the program. This includes: DLL with shared memory, .h and .lib files plus sample source code written in C Language. Serial port: Sends eye data packets and asynchronous packets equivalent to information in ASCII data files at rates of up to 56K. Receive real time data from other programs and store it asynchronously into data files. AnalogOut option: Selectable unipolar or bipolar voltage ranges: +/- 10, 5, 2.5. Selectable data items: position of gaze (x,y), pupil (h,w), velocity (dx,dy), and raw pupil, glint or vector data. TTL capabilities. 2 or 4 channel options. TTL in/out option: Eight TTL input channels are interfaced to place marker codes into the *ViewPoint* data file. Eight TTL output channels that indicate when the position of gaze is inside *ViewPoint* region of interest areas ROI-0 to ROI-7. Ethernet: full real-time synchronization across machines via the Ethernet.
Stimulus Presentation	Pictures and movies can be displayed in full stimulus windows or in user specified ROIs. Auditory cues can be integrated. Gaze contingent stimulus presentation via state logic.
Data recorded	Data is stored in ASCII files.

	Eye data: X, Y position of gaze, pupil height and width, ocular torsion, delta time, total time, and regions of interest (ROI). Asynchronous records include: State transition markers, key presses, data from other programs.
Calibration	Fixed and HMD options: ViewPoint starts in a roughly calibrated state that is adequate for determining screen quadrants or other relative movement measurement such as objective preference-of-looking tasks. Scene camera options: Calibration is performed relative to the pixels of the CCD array, not the image content. This is analogous to calibrating relative to the CRT screen and not the image displayed on it. New subject setup time between 1-5 minutes. For accurate position of gaze, calibration is required only once per subject—settings can be stored and reused each time a subject returns. Easy Slip Correction feature and re-presentation of stray calibration points.
System requirements:	OS: Windows 7/Vista or XP Machine: Fixed and HMD options—Pentium compatible Scene camera options—2.8 GHz Pentium or higher, or Athlon XP 2800+ or higher

Fixed Head Systems

These eye tracking systems use **Arrington Research**® technology and include cables required to interface to a BIOPAC MP system—MP150 or MP100 data acquisition unit and Acq*Knowledge* software.

EYEFIXMONO *Monocular Fixed Head Eye Track System*

This turnkey monocular eye tracking system is for users who have their own means of stabilizing the head and mounting the camera.

- PCI capture card
- Close Focus Camera and illuminator system
- ViewPoint PC-60 software—record vertical position, horizontal position, pupil size, etc.
- Analog output (4 channels)—real-time analog voltage signals
    - 4-Channel 12-Bit Analog Output Board with 48-Bits of Digital I/O
    - AnalogOut software for use with ViewPoint PC-6
    - 0.61 meter 100 Pin High Density Connector to 2 50 Pin IDC
    - 50 Pin Universal Screw Terminal and screws
    - TTL capabilities
- Interface cables to MP System: CBL102 x 2 and CBL106 x 2
    - Use the full power of the MP Research System and Acq*Knowledge* software.
    - To record biopotential signals in the same record while maintaining subject isolation, add an HLT100C and one INISO for each eye track channel

Fee-based consulting for integration can be provided.

EYEFIXBINO Binocular Fixed Head Eye Track System

This turnkey eye tracking system is for users who have their own means of stabilizing the head and mounting the camera.

- Dual input PCI capture card
- Two Close Focus Cameras and illuminator systems
- ViewPoint PC-60 software with binocular option enabled—record vertical position, horizontal position, pupil size, etc.
- Analog output (4 channels)—real-time analog voltage signals
    - 4-Channel 12-Bit Analog Output Board with 48-Bits of Digital I/O
    - AnalogOut software for use with ViewPoint PC-6
    - 0.61 meter 100 Pin High Density Connector to 2 50 Pin IDC
    - 50 Pin Universal Screw Terminal and screws
    - TTL capabilities
- Interface cables to MP System: CBL102 x 4 and CBL106 x 4
    - Use the full power of the MP Research System and Acq*Knowledge* software.
    - To record biopotential signals in the same record while maintaining subject isolation, add an HLT100C and one INISO for each eye track channel

Fee-based consulting for integration can be provided.

EYEFIXMONOCLAMP Fixed Head+Clamp, Monocular Eye Tracking System

EYEFIXBINOCLAMP Fixed Head+Clamp, Binocular Eye Tracking System

Moveable Head Systems

EYETRAKHMD1MONO *Monocular HMD1 Eye Tracking System*

APPENDIX

Shield Drive Operation

ECG100C	EGG100C EOG100C MCE100C		*
EEG100C EMG100C		ERS100C	TEL100C

The shield drive for BIOPAC biopotential front-end differential amplifiers is developed as the arithmetic mean of the voltages sensed on the positive and negative differential inputs with respect to Ground. Given that interfering noise sources (usually 50 Hz / 60 Hz) nearly always appear as high level voltage signals of similar value on the positive and negative differential inputs, creating a shield drive for the positive and negative input leads will act to increase the amplifier's Common Mode Rejection Ratio (CMRR) via capacitance reduction of the differential input to its respective shield. Because the shield drive is introduced identically to the differential inputs, additive noise from the shield drive will have a tendency to cancel out due to the operation of the differential amplifier front end.

Generally, it's helpful to have an active shield drive for interfering noise reduction. However, in special cases, it may be worthwhile to ground the cable shields connecting to the amplifer's differential inputs or to dispense with shielding altogether. Any BIOPAC biopotential front-end differential amplifier can be user-adapted to satisfy these special cases; please contact BIOPAC Systems, Inc. for details.

* The MCE100C shield drive is independent for both ($Vin^{+)}$ and ($Vin^{-)}$ inputs.

Amplifier Frequency Response Characteristics

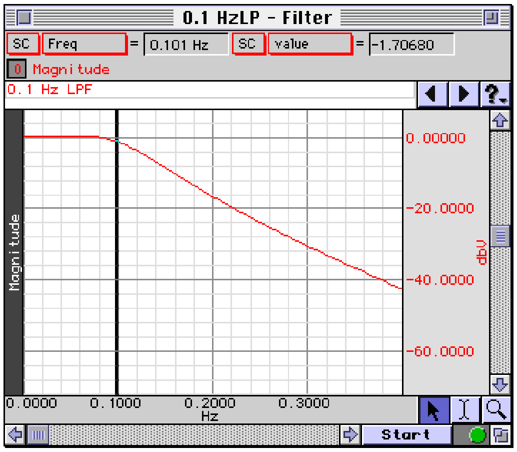
The following frequency response plots illustrate the frequency response selections available on the indicated amplifier modules. LP is low pass, HP is high pass, and the N suffix indicates the notch setting. Modules (except for the DA100C) can be set for 50 or 60 Hz notch options, depending on the destination country.

Setting	Modules
0.1Hz LP	EGG100C
1Hz LP	EGG100C, GSR100C, SKT100C
3Hz LP	PPG100C, RSP100C
10 Hz LP	DA100C, EBI100C, GSR100C, PPG100C, RSP100C, SKT100C
35 Hz LPN (with 50 Hz notch)	ECG100C, EEG100C, EOG100C, TEL100C
35 Hz LPN (with 60 Hz notch)	ECG100C, EEG100C, EOG100C, TEL100C
100 Hz LP	EBI100C, EEG100C, EOG100C
150 Hz LP	ECG100C
100 Hz HPN (with 50 Hz notch)	EMG100C, ERS100C, MCE100C
100 Hz HPN (with 60 Hz notch)	EMG100C, ERS100C, MCE100C
300 Hz LP	DA100C
500 Hz LP	EMG100C, TEL100C
3,000 Hz LP	ERS100C, MCE100C
5000 Hz LP	DA100C, EMG100C
10 kHz LP	ERS100C
30 kHz LP	MCE100C

Sample plots follow…

0.1Hz LP

EGG100C

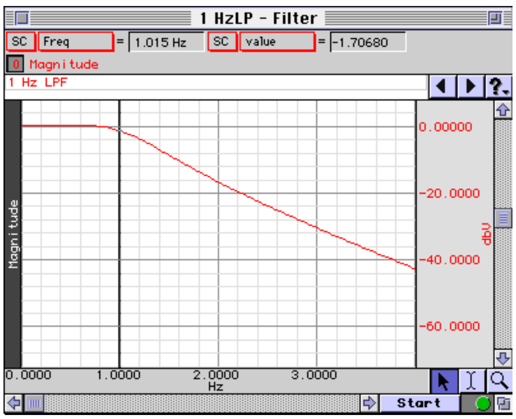


1Hz LP

EGG100C

GSR100C

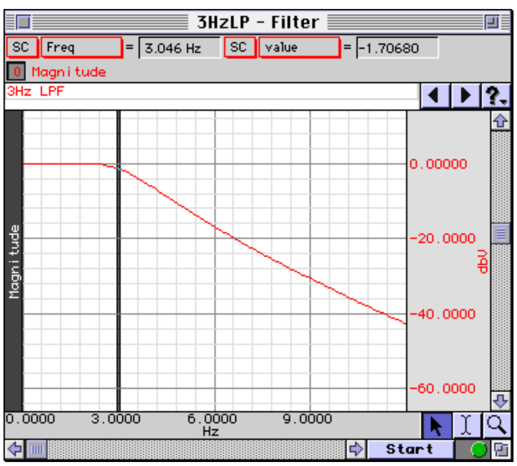
SKT100C



3Hz LP

PPG100C

RSP100C



10 Hz LP

DA 100C

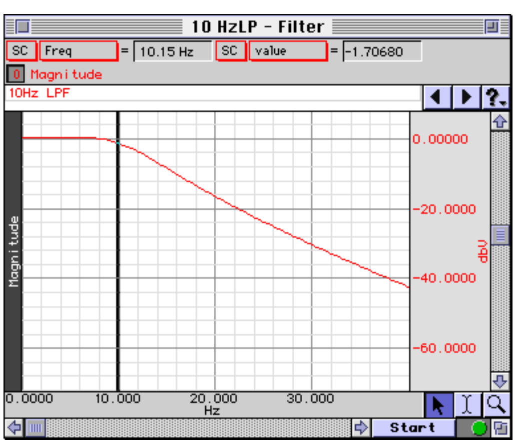
EBI 100C

GSR 100C

PPG 100C

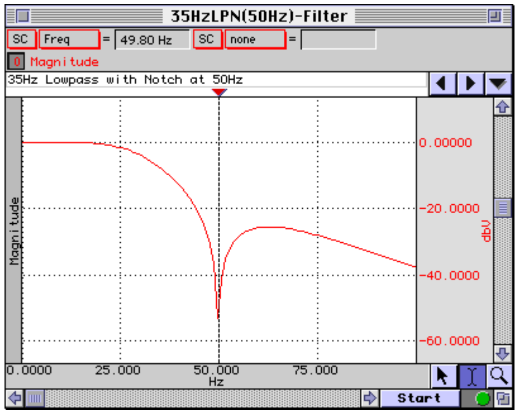
RSP100C

SKT100C



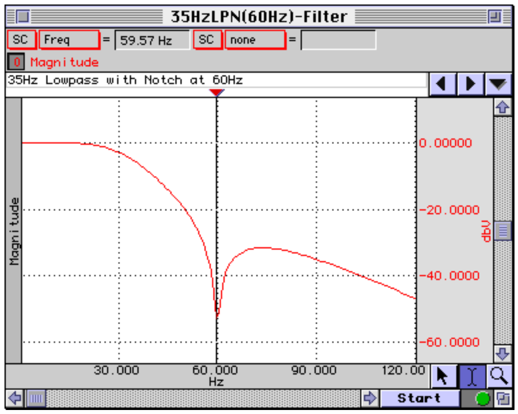
35 Hz LPN
(with 50 Hz notch enabled)

ECG100C
EEG100C
EOG100C
TEL100C



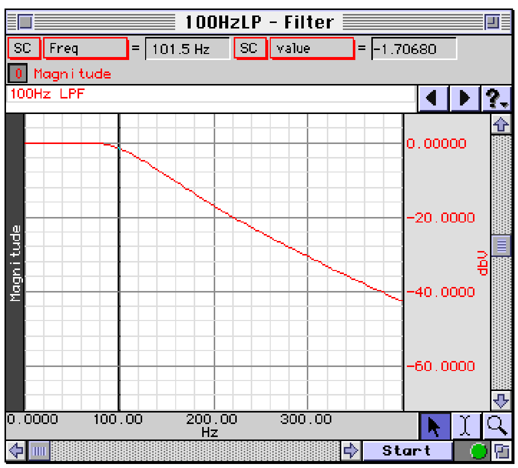
35 Hz LPN
(with 60 Hz notch enabled)

ECG1 00C
EEG100C
EOG100C
TEL100C



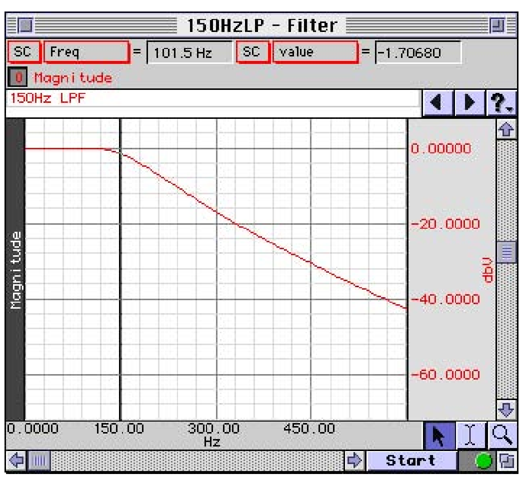
100 Hz LP

EBI100C
EEG1 00C
EOG100C
NICO100C



150 Hz LP

ECG100C



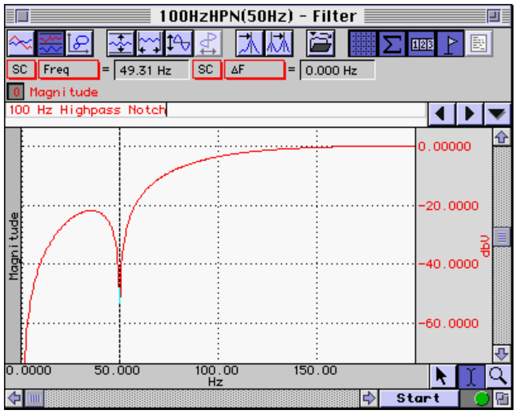
100C series Amplifers - Sample Frequency Response Plots

100 Hz HPN
(with 50 Hz notch enabled)

EMG100C

ERS100C

MCE100C

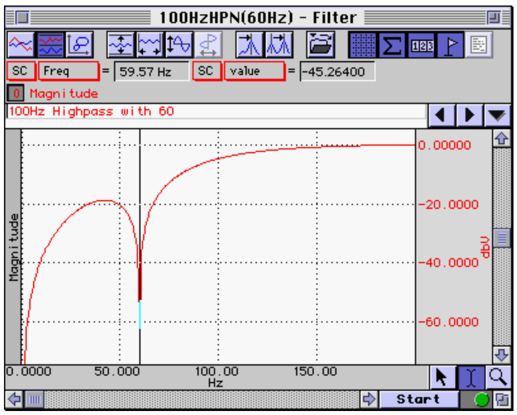


100 Hz HPN
(with 60 Hz notch enabled)
MCE100C

EMG100C

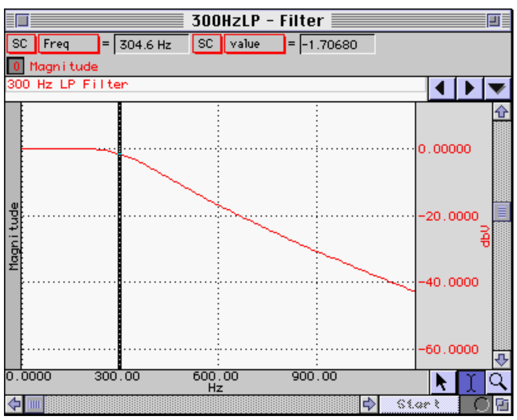
ERS100C

MCE100C



300 Hz LP

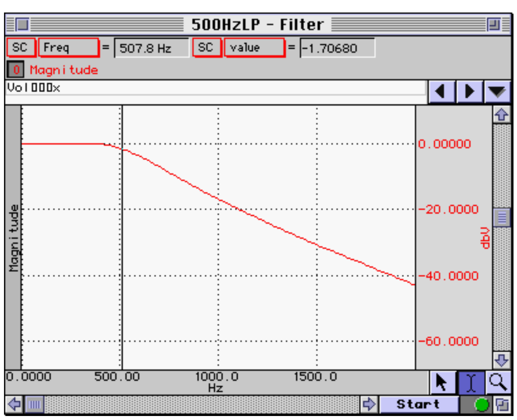
DA100C



500 Hz LP

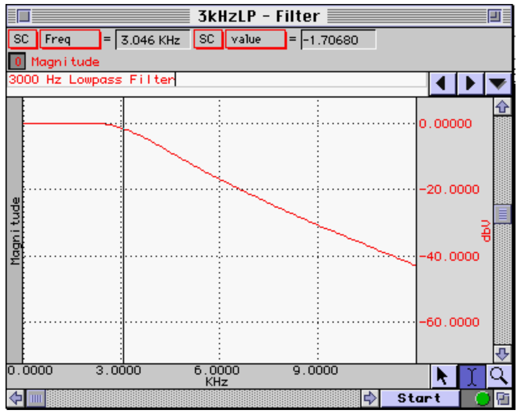
EMG100 C

TEL100

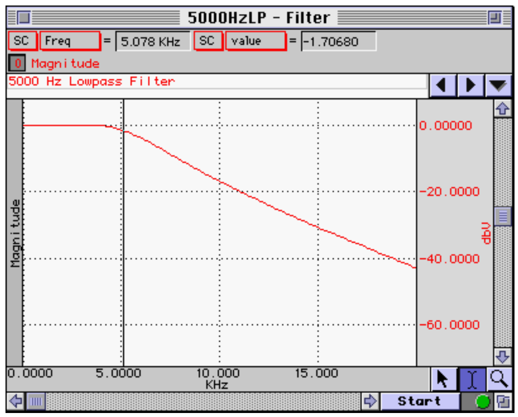


100C series Amplifers - Sample Frequency Response Plots

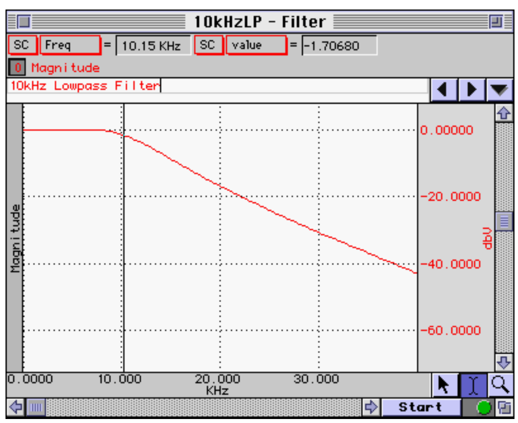
3,000 Hz LP
ERS100C
MCE100



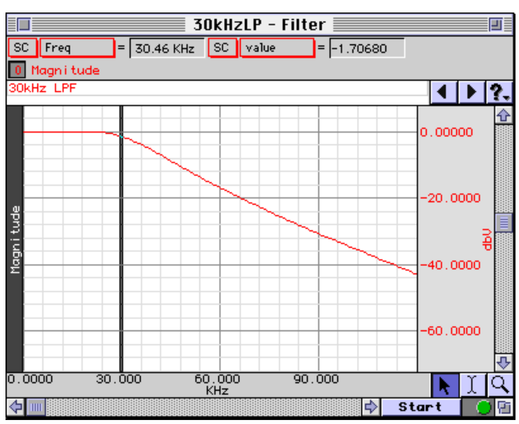
5000 Hz LP
DA100C
EMG100 C



10 kHz LP
ERS100C



30 kHz LP
MCE100C



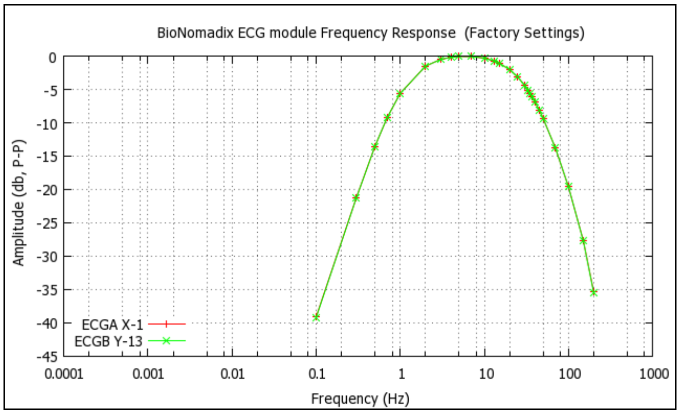
BioNomadix Transmitter-Receiver Modules - Sample Frequency Response Plots

Note BioNomadix frequency responses are identified via -3dB point, which is representative of 0.707 (70.7%) of the peak midband gain.

BN-ECG2

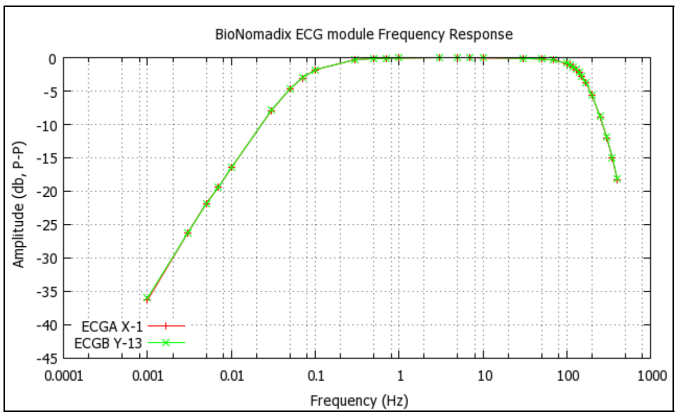
1 Hz HP

35 Hz LP



0.05 Hz HP

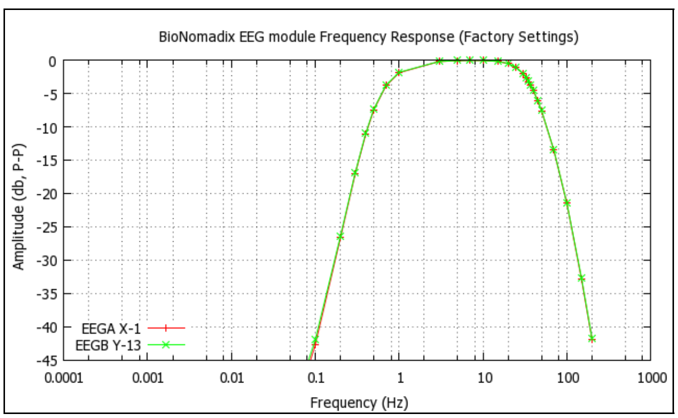
150 Hz LP



BN-EEG2

0.5 Hz HP

35 Hz LP

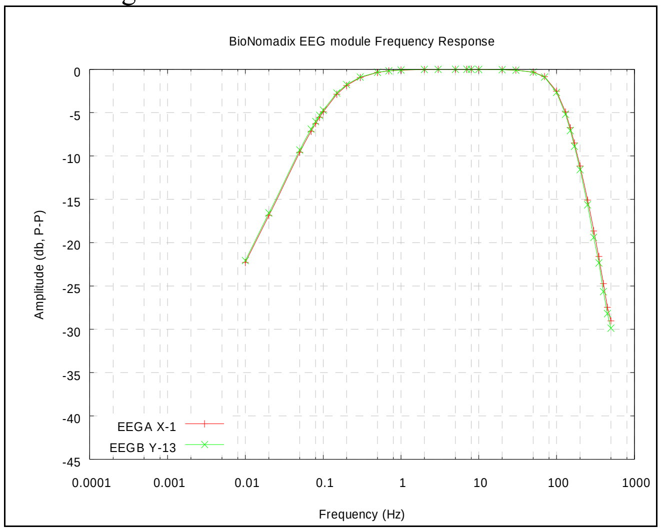


BioNomadix Transmitter-Receiver Modules - Sample Frequency Response Plots

Note BioNomadix frequency responses are identified via -3dB point, which is representative of 0.707 (70.7%) of the peak midband gain.

0.1 Hz HP

100 Hz LP

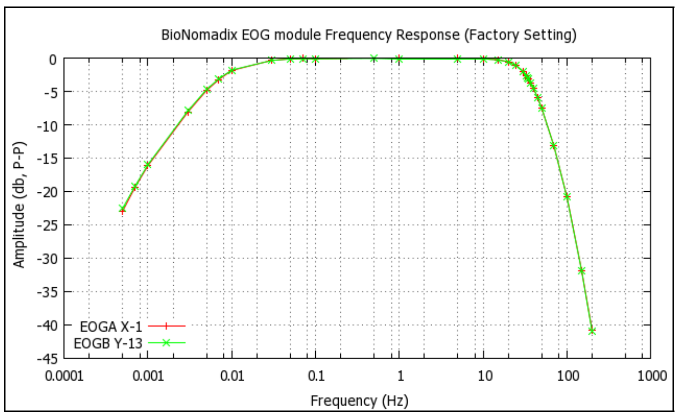


NOTE: All BioNomadix frequency responses are calculated from the 3dB level, which is approximately 50% of the peak frequency.

BN-EOG2

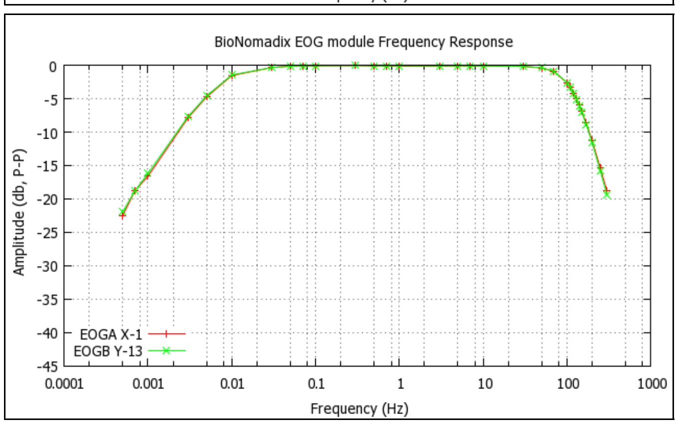
0.005 Hz HP

35 Hz LP



0.005 Hz HP

100 Hz LP



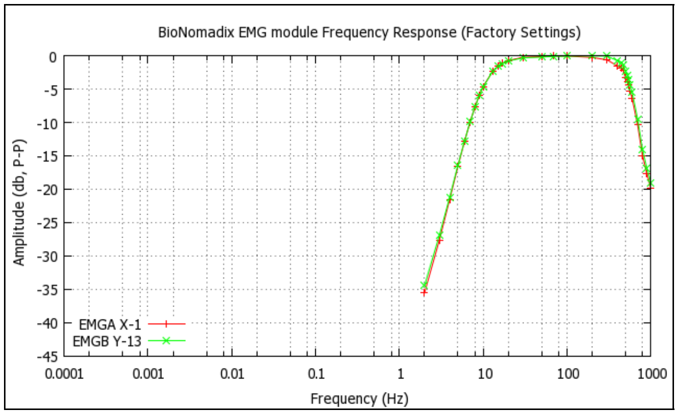
BioNomadix Transmitter-Receiver Modules - Sample Frequency Response Plots

Note BioNomadix frequency responses are identified via -3dB point, which is representative of 0.707 (70.7%) of the peak midband gain.

BN-EMG2

10 Hz HP

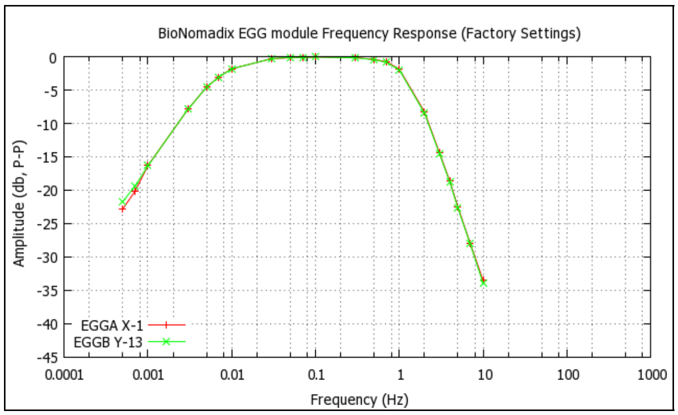
500 Hz LP



BN-EGG2

0.005 HP

1 Hz LP



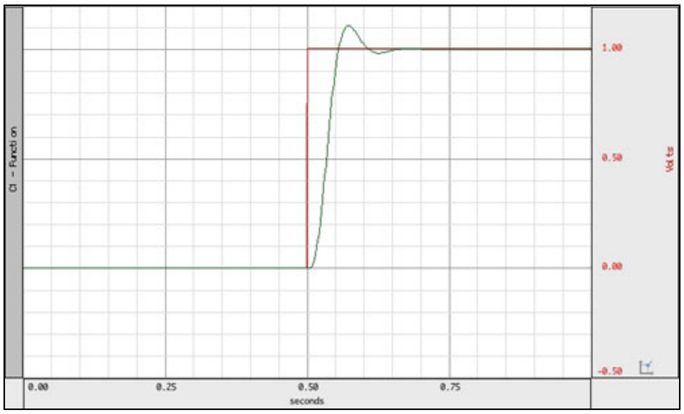
Amplifier Module Filter Response Times

The MP series amplifier modules incorporate a variety of filtering options. The low pass filtering options have an effect on the signal response time, which is sometimes referred to as signal delay.

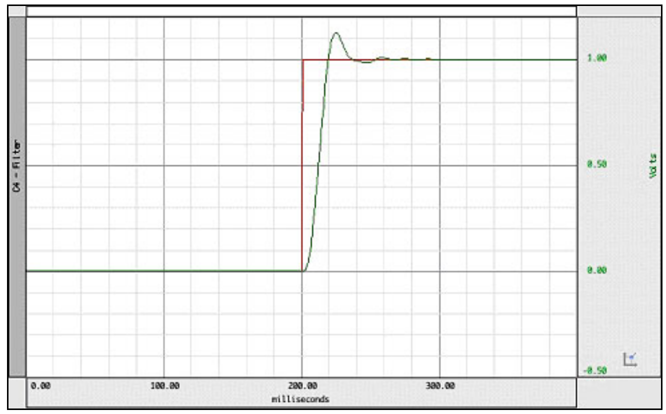
Signal delay is often plotted as the function "group delay" versus frequency. This type of plot shows the typical delay the filter will have for a wide range of frequencies. The group delay plot is the derivative of the filter phase plot with respect to frequency. If the filter is perfectly linear phase, the group delay plot will be a straight horizontal line, because the derivative of a constant (linear) slope is a constant.

In practice it's often difficult to utilize a group delay plot to get a quick and simple handle on essential filter signal delay, unless one is experienced in reading such plots. Instead, it's typically better to show the filter response to a well-understood input signal, such as a step function.

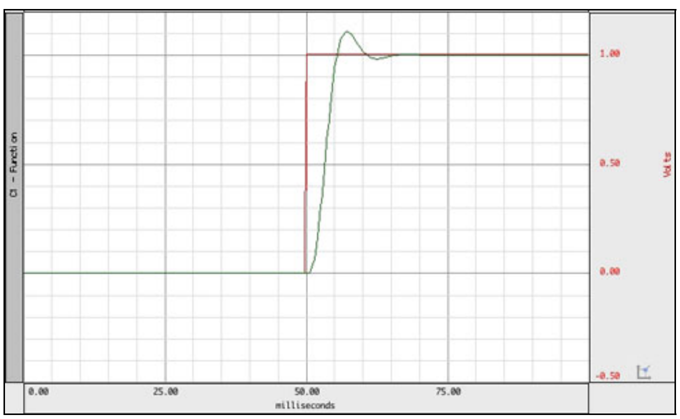
The following plots illustrate the delay times for a variety of low pass filter settings.



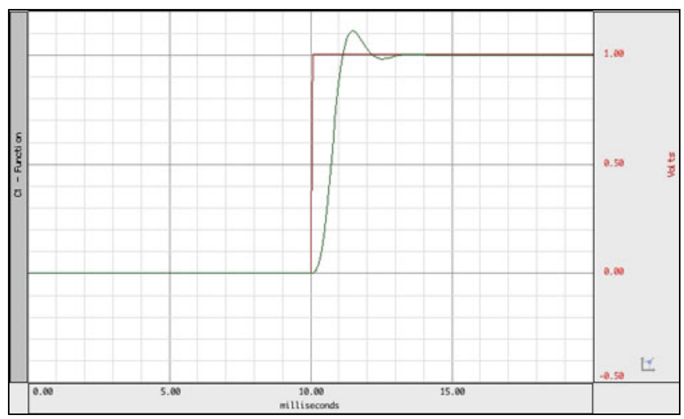
10 Hz Low Pass Filter – 4 pole Besselworth



35 Hz Low Pass Notch Filter – 4 pole Besselworth – Notch at 60 Hz



100 Hz Low Pass Filter – 4 pole Besselworth



500 Hz Low Pass Filter – 4 pole Besselworth

Note that signal delay is proportional to the cut-off frequency for any particular 4 pole low pass Besselworth filter. The one minor exception is the 35 Hz LPN filter, because it consists of a 4 pole Besselworth filter and a 60 Hz Notch (band reject) filter. This additional filter adds a small additional delay.

Step Response Signal Delay (approximate)

Filter Type:	**10 Hz LP**	**35 Hz LP**	**100 Hz LP**	**500 Hz LP**
Delay at 50% (approximate):	30 ms	11 ms	3 ms	0.6 ms

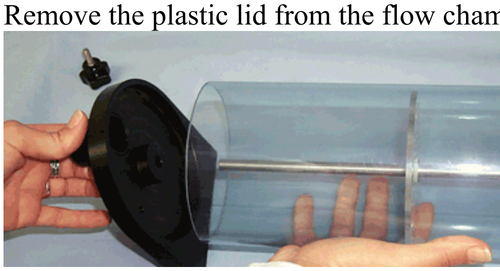
Cleaning the BIOPAC GASSYS2

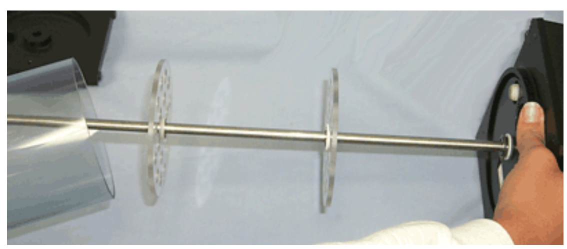
GASSYS2 - See page 166 for specs.

> ***Note***: Never clean the sensor base of the device. The two sensors, a screen and a copper-colored gas detector, are highly sensitive.

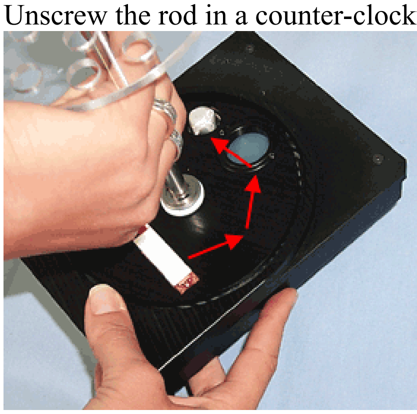
1) Unscrew the top knob attachment.

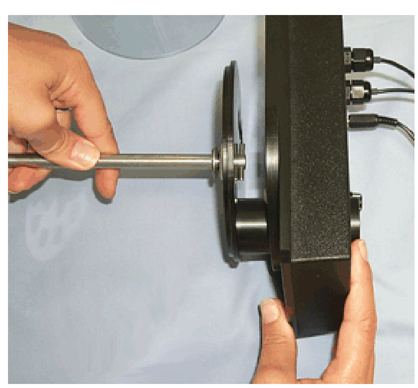
2) Remove the plastic lid from the flow chamber.





3) Gently pull the clear cylinder off the sensor base.
4) Detach the metal standing rod and its lower base attachment by holding the third of the standing rod nearest the base of the module and unscrewing the rod in a counter-clockwise motion.
    a. Depress the rod by applying pressure at the base – this unlocks the rod's position and allows movement.
    b. Unscrew the rod in a counter-clockwise motion.





5) Remove the chamber stand (gently pull back the chamber stand from the electronics base).

6) Clean the flow chamber with one of two methods:

   a. Use a soft cloth and Cidex Plus Sterilizing and Disinfecting Solution cleanser. Spray a light mist of Cidex cleanser on the parts of the device to be cleaned, and wipe the pieces with a dry rag. It is important never to get Cidex near the sensors of the device.

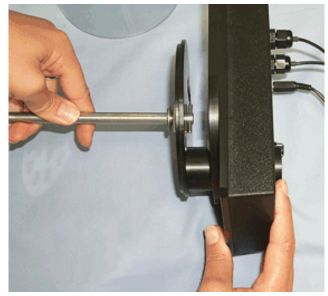
      - Other cleansers should not be substituted for Cidex – non-Cidex cleansers might damage or abrade the flow chamber pieces.

   b. Heating the components in an autoclave sterilizing oven.

7) After cleaning reattach the platformed-standing rod to the electronics base.

   a. Align the exhaust tube at the bottom of the rod stand with the exhaust port on the electronics base and insert securely.

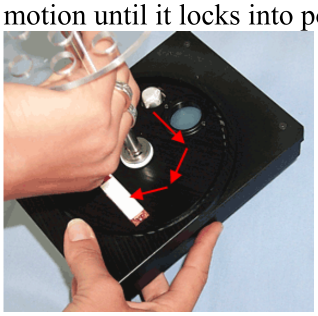
   b. Gently ease the rod stand back into its appropriate position on the electronics base. The sensors are very delicate—slowly lower the plastic base of the standing rod to the electronics base to make sure that the openings in the standing rod base correspond with the appropriate sensors.



8) Locate the latch opening for the security screw and align it with the screw, and then press the base of the standing rod to the sensor base.

   a. Revolve the rod until the lower screw drops into its opening. When the screw meets its opening, it should drop into the hole.

   b. Depress the rod by applying pressure on the lower third of the piece and rotate it in a clockwise motion until it locks into position.



9) Ease the clear cylinder back onto the device and lay its lower edge in the track on the electronics base.

10) Re-attach the plastic top to the clear cylinder.

11) Lock the plastic top into place by screwing in the security knob.

Return to… GASSYS2

Filter Option Switch Guide

Switches are on the back of the BioNomadix receiver. Adjust switch position with a small tipped screwdriver.

Switch positions: “UP” = ON, DOWN” = OFF

NOTE: If the switch settings are modified, preset MP150 module setup cannot be used and and channels must be configured manually.

Mains Notch Filter

- All modules except GYRO, ACCL3 and NICO

Notch Filter	**SW1**	**SW2**
60 Hz	UP	DOWN
50 Hz	UP	UP
OFF	DOWN*	DOWN or UP

*indicates Factory Preset

BioNomadix Receiver Switches

- SW3 is ignored if Alternative Signal is enabled (UP); see page 300.

ECG2-R BioNomadix Receiver	
Filter Option	Switch Number
High Pass	**SW3**
0.05 Hz HP	DOWN
1 Hz HP	UP*
Low Pass	**SW4**
35 Hz LP	UP*
150 Hz LP	DOWN

* indicates Factory Preset

EMG2-R BioNomadix Receiver	
Filter Option	Switch Number
High Pass	**SW3**
5 Hz HP	DOWN
10 Hz HP	UP*
Low Pass	**SW4**
250 Hz LP	UP
500 Hz LP	DOWN*

EEG2-R BioNomadix Receiver	
Filter Option	Switch Number
High Pass	**SW3**
0.1 Hz HP	DOWN
0.5 Hz HP	UP*
Low Pass	**SW4**
35 Hz LP	UP*
100 Hz LP	DOWN

EOG2-R BioNomadix Receiver	
Filter Option	Switch Number
High Pass	**SW3**
0.005 HP	DOWN*
1 Hz HP	UP
Low Pass	**SW4**
35 Hz LP	UP*
100 Hz LP	DOWN

EGG2-R BioNomadix Receiver	
Filter Option	Switch Number
Low Pass	**SW3**
1 Hz HP	UP*
Disabled	DOWN

SKT2-R BioNomadix Receiver		
Filter Option	CH A	CH B
Low Pass	**SW3**	**SW5**
10 Hz LP	DOWN	DOWN
1 Hz LP	UP**	UP*

RSP2-R BioNomadix Receiver			* indicates Factory Preset
Filter Option	CH A	CH B	
Low Pass	**SW3**	**SW5**	
10 Hz LP	DOWN	DOWN	
1 Hz LP	UP*	UP*	
High Pass	**SW4**	**SW6**	
0.5 Hz HP	UP	UP	
DC	DOWN*	DOWN*	

PPGED-R BioNomadix Receiver		
Filter Option	PPG CH A	EDA CH B
Low Pass	**SW3**	**SW5**
3 Hz LP	UP*	UP*
10 Hz LP	DOWN	DOWN
High Pass	**SW4**	**SW6**
0.5 Hz HP	UP*	UP
DC	DOWN	DOWN*

RSPEC-R BioNomadix Receiver				
Filter Option	RESP CH A		ECG CH B	
Low Pass	**SW6**		**SW4**	
	1 Hz LP	UP*	35 Hz LP	UP*
	10 Hz LP	DOWN	150 Hz LP	DOWN
High Pass	**SW7**		**SW3**	
	0.5 Hz HP	UP	1 Hz HP	UP*
	DC	DOWN*	0.05 Hz HP	DOWN

NICO-R BioNomadix Receiver		
Filter Option	Switch Number	
Low Pass	**SW1 (Z CH)**	**SW2 (dZ CH)**
5 Hz LP	UP	UP
Low Pass	**SW3 (Z CH)**	**SW4 (dZ CH)**
3 Hz LP	UP	UP
Low Pass	**SW5 (ZCH)**	**SW6 (dZ CH)**
1 Hz LP	UP	UP
DC to 10 Hz	DOWN for all switches*	

GYRO-R BioNomadix Receiver	
Filter Option	Switch Number
Low Pass	**SW1**
No LP filters	DOWN
10 Hz LP	UP*

	ACCL3-R BioNomadix Receiver			
G-Mode	Filter Option	Switch Number		
	Rate	**SW1**	**SW2**	**SW3**
	6.25 Hz	UP	UP	UP
	12.5 Hz	DOWN	UP	UP
	25 Hz	UP	DOWN	UP
	50 Hz	DOWN	DOWN	UP
	100 Hz	UP	UP	DOWN
	200 Hz	DOWN	UP	DOWN
	400 Hz	UP	DOWN	DOWN
	800 Hz	DOWN*	DOWN*	DOWN*
	Range	**SW4**	**SW5**	
	2 G	UP	UP	
	4 G	DOWN	UP	
	8 G	UP	DOWN	
	16 G	DOWN*	DOWN*	

Alternative Signal Switch Guide

Warning: Alternative signal *replaces* the raw signal. To display raw and processed signal alternative(s), use Acq*Knowledge* calculation channels.

ECG2-R and RSPEC-R BioNomadix Receivers	
Signal Output	**SW5**
ECG – Factory Preset	DOWN
Heart Rate – Alternative Signal	UP

EOG2-R BioNomadix Receiver	
Signal Output	**SW5**
EOG – Factory Preset	DOWN
Derivative – Alternative Signal	UP

EEG2-R BioNomadix Receiver				
Signal Output	**SW5**	**SW6**	**SW7**	**SW8**
EEG – Factory Preset	DOWN	DOWN	DOWN	DOWN
Delta – Alternative Signal	UP	DOWN	DOWN	DOWN
Theta – Alternative Signal	--	UP	DOWN	DOWN
Alpha – Alternative Signal	--	--	UP	DOWN
Beta – Alternative Signal	--	--	--	UP

EMG2-R BioNomadix Receiver	
Signal Output	**SW5**
EMG – Factory Preset	DOWN
Integrated RMS Alternative Signal (Envelope Detection Mode)	UP

ACCL3-R BioNomadix Receiver	
G – Factory Preset	DOWN
Tap (Event Mark) – Alternative Signal	UP
Signal Output	**SW6**
G-Mode	DOWN
Tap Mode	UP

ACCL3-R switch settings for Alternative Signal TAP				
	Filter Option	Switch Number		
Tap-Mode	**Rate (G-Mode) or Duration (Tap Mode)**	**SW1**	**SW2**	**SW3**
	5000 µS	UP	UP	UP
	4375 µS	DOWN	UP	UP
	3750 µS	UP	DOWN	UP
	3125 µS	DOWN	DOWN	UP
	2500 µS	UP	UP	DOWN
	1875 µS	DOWN	UP	DOWN
	1875 µS	UP	DOWN	DOWN
	625 µS	DOWN	DOWN	DOWN
	Range (G-Mode) or Threshold (Tap Mode)	**SW4**	**SW5**	
	2 G	UP	UP	
	4 G	DOWN	UP	
	6 G	UP	DOWN	
	8 G	DOWN	DOWN	

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