FUTURE ELECTRONICS

INTEGRATING NXP PROCESSORS AND TRI-RADIO TECHNOLOGY: A CASE STUDY WITH THE FUTURE ELECTRONICS GOLDILOCKS PLATFORM

Bruce Muff
RSM, Future Connectivity Solutions

Chris Molina
RSM, Future Intelligent Solutions

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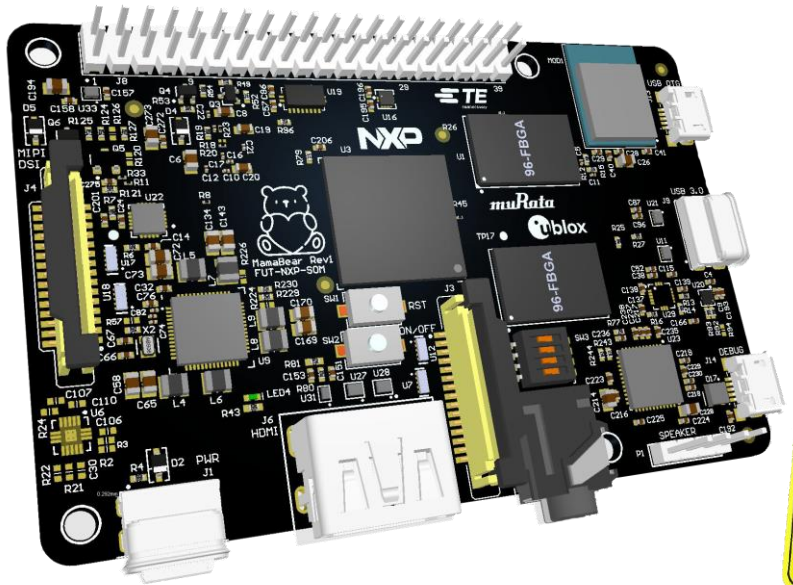
Boston, Massachusetts

INTRODUCING GOLDILOCKS

Hub and Wearable Monitor Reference Design Platform

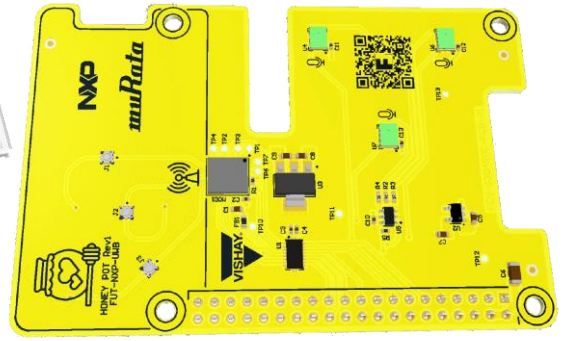
Mama Bear



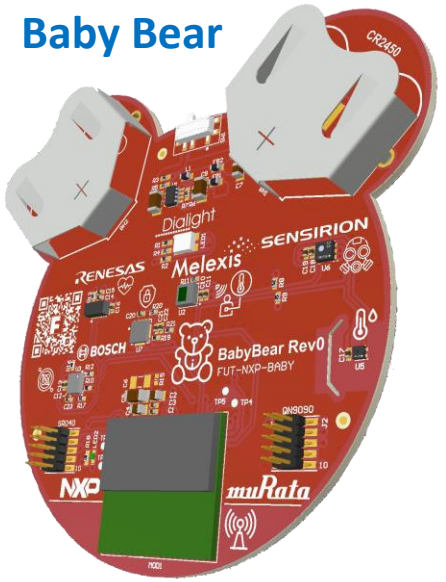
UWB Link (Position)

BLE Link (Sensors)

Honey Pot



Baby Bear



HUB

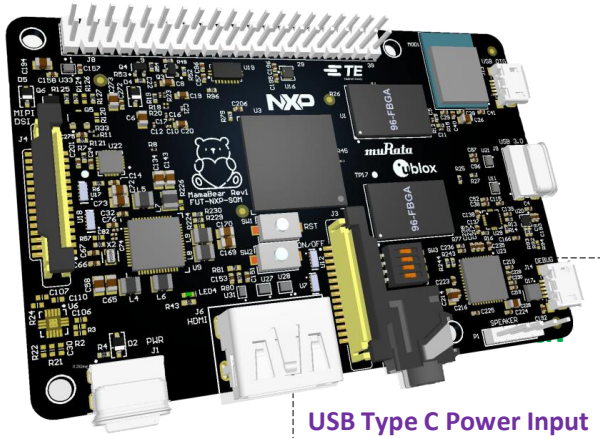
- RaspPi form factor
- Standalone system
  - Camera Input, Display & Audio
- MPU running Linux
- Hub concentrator (UWB/BLE/WiFi/Matter)

UWB/MIC HAT

- Includes
  - Type 2BD UWB module
  - MEMS microphone
- Connects to Mama Bear board through 40-pin connector

WEARABLE MONITOR

- Low power (battery)
- Small (wearable)
- Sensors monitoring (BLE)
- Localization (UWB)



GOLDILOCKS – MAMA BEAR

PMIC
PCA9450CHN

Power Switch
NX20P5090UKAZ

Interface CC USB-C
PTN5110DHQ

USB to UART
FT231XS-R

Interface CC USB-C
PTN5110NHQZ

Controlled Load Switch
AP22653QW6-7

LDO Regulator +2.5V
NCP115AMX250TCG

LDO Regulator +3.3V
NCP115AMX330TCG

WiFi + Bluetooth + 802.15.4 Three Radio
MAYA-W276
iW612

DDR4 2x1GB
DDR4
D5116AN9CXGXNI-U

QSPI Flash (32MB)
MX25U25645GZ4I00

i.MX8M Plus
MIMX8ML8CVNKZAB

eMMC 64GB
EMMC64G-TY29

Secure IC
SE051W2

Interface Audio Codec
TSCS42xx

USB Type C Power Input
1-2305018-2

5V@ max 3A

USB_CC

Debug Interface
2013499-1

USB1 OTG (USB2.0)
2013499-1

USB2 OTG (USB3.0)
1-2305018-2

Rev 1

+2.5V

+3.3V

SDIO/SPI/ UART/GPIO

DDR4

QSPI

I2C/GPIO

I2C

UART

USB OTG

USB HOST

I2C

MMC

I2C

I2S

I2C/GPIO/SPI/PDM/UART

SDHC

MIPI DSI

HDMI

MIPI CSI

Interface Connector
7-146256-0

Micro-SD Card
DM3CS-SF

Display MIPI Interface
1-1734248-5

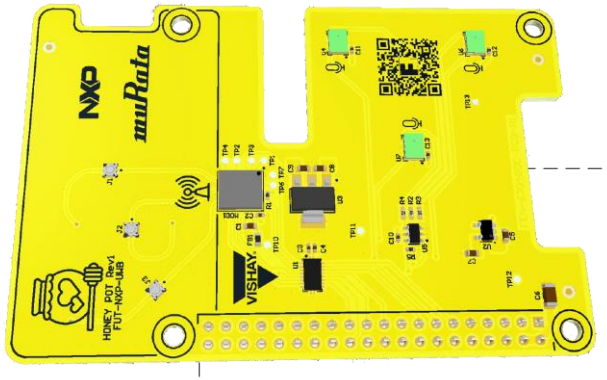
Display HDMI Interface
1747981-1

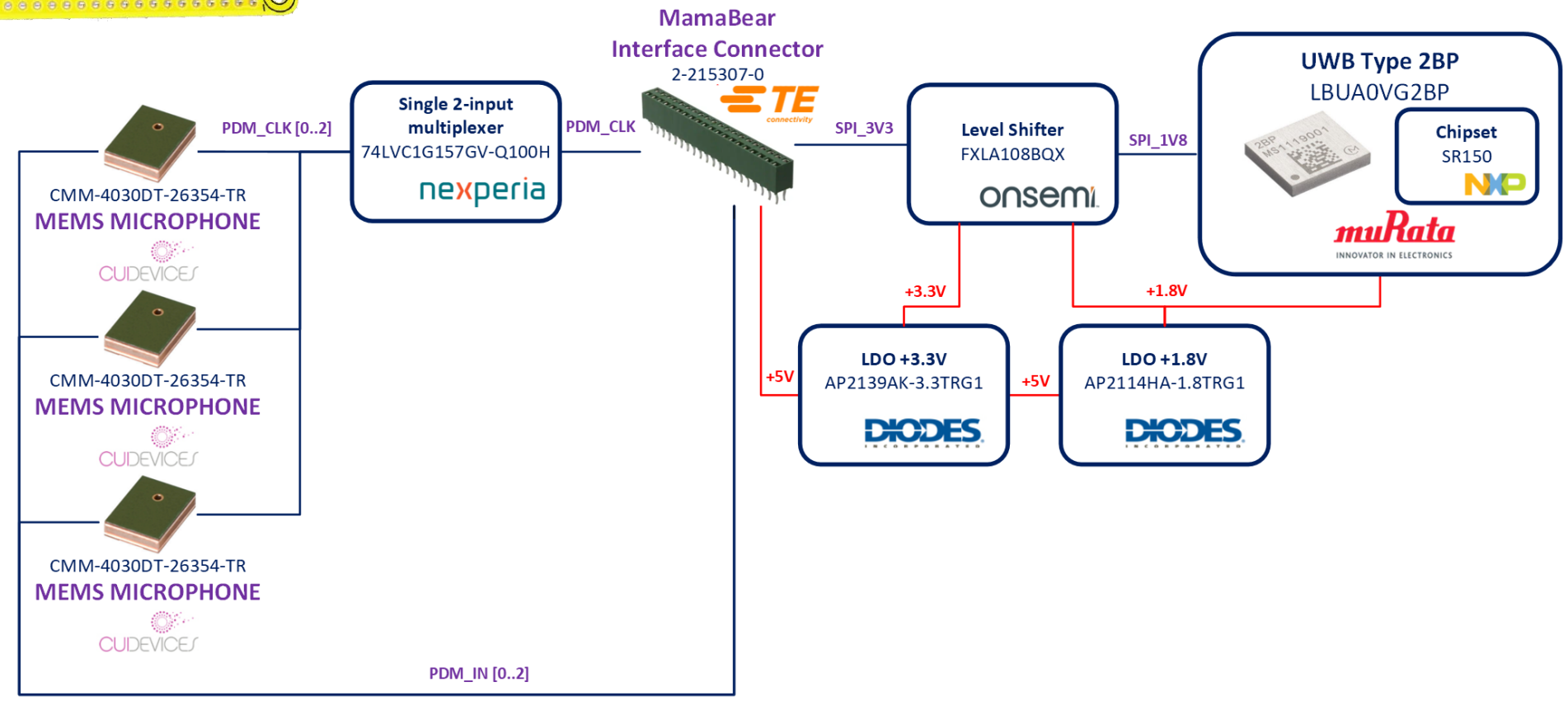
Camera Interface
1-1734248-5

5-146277-4
External Speaker Connector

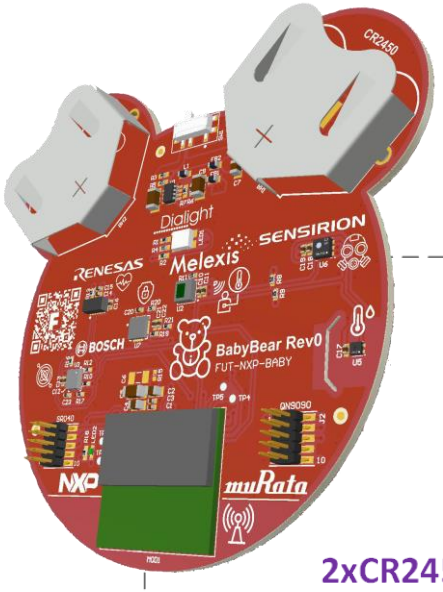
SJ-43515TS
3.5mm TRRS HP Jack

GOLDILOCKS – HONEY POT





GOLDILOCKS – BABY BEAR



2xCR2450 Batteries

Switch

+6V

Power +3.3V
MP2159

+3.3V

FIR Temperature Sensor
MLX90632
Melexis

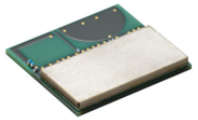
Accelerometer Gyroscope
BMI323
BOSCH

VOC
SGP40
SENSIRION

Humidity and Temperature Sensor
SHT40
SENSIRION

I2C

UWB/BLE
LBUA2ZZ2DK



muRata
INNOVATOR IN ELECTRONICS

MCU + BLE
QN9090
NXP

UWB Chipset
SR040
NXP

I2C

GPIO

LED Indicator
598-8A80-102F
Dialight

RGB LED
5988610307F
Dialight

Secure IC
SE050
NXP

Rev 1

GOLDILOCKS TARGET APPLICATIONS /USE CASES

- Smart Home, Building, and Agriculture Applications
- Remote Monitoring / Access Control
- Wireless IoT
- Interior Localization (Ultrawideband)
- Matter introductory platform
- AI/ML platfrom for Sensor Applications and Machine Vision
- Home Patient and Elderly Monitor

- Provide ready to go embedded design for new applications
- Train engineers on Matter, AI/ML, and embedded Linux
- Offer Raspberry Pi customers an option for their designs in same form factor

DEMO SLIDE 1

BT Speaker

UWB Console

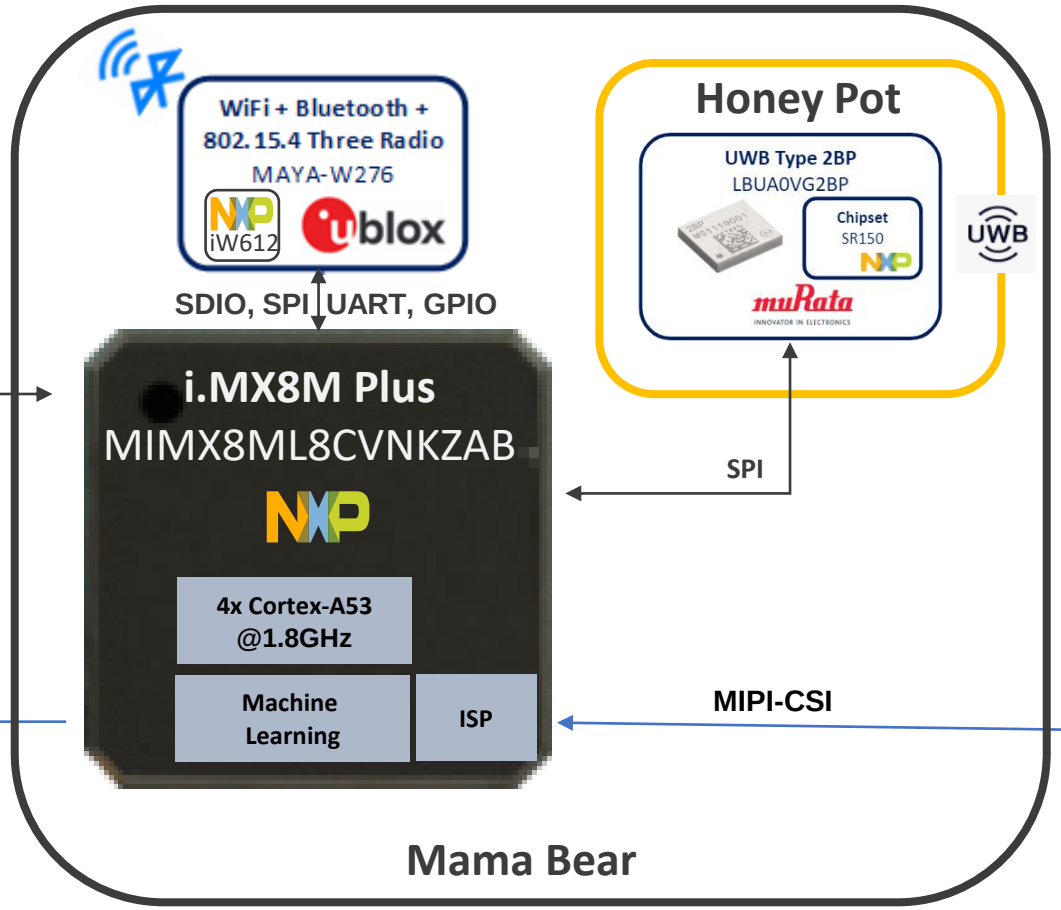
HDMI

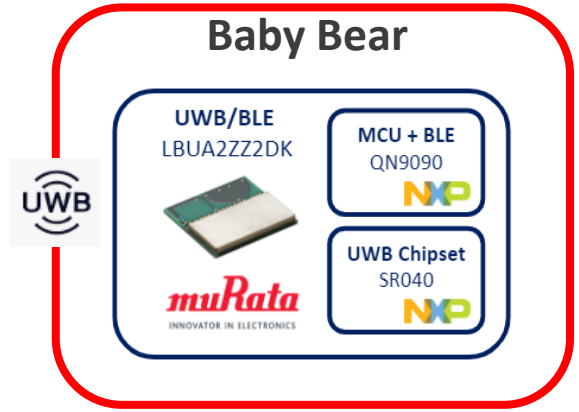
Object Detection Display

MIPI DSI

Camera

MIPI-CSI





DEMO SLIDE 2

BT or wired Speaker

SDIO, SPI UART, GPIO

SJ-43515TS CUDEVICES
3.5mm TRRS HP Jack

5-146277-4 TE connectivity
External Speaker Connector

Console

Dashboard

HDMI

MIPI DSI

Mama Bear Hub

WiFi + Bluetooth + 802.15.4 Three Radio
MAYA-W276
u-blox

Interface Audio Codec
TSCS42xx
TSI

I2S

SDIO
SPI
UART
GPIO

Honey Pot

UWB Type 2BP
LBUA0VG2BP
Chipset SR150 NXP
UWB
muRata

SPI

PDM [0..2]

i.MX8M Plus
MIMX8ML8CVNKZAB
NXP

MIPI-CSI

Camera

Baby Bear

UWB/BLE
LBUA2ZZ2DK
muRata

MCU + BLE
QN9090
NXP

UWB Chipset
SR040
NXP

FIR Temperature Sensor
MLX90632
Melexis

Accelerometer Gyroscope
BMI323

I2C

Humidity and Temperature Sensor
SHT40
SENSIRION

VOC
SGP40
SENSIRION

I.MX 8M FAMILY OF APPLICATIONS PROCESSORS

FUTURE ELECTRONICS

Software Compatible

Pin-to-pin Compatible

i.MX 6 QuadPlus
i.MX 6 Quad
i.MX 6 DualPlus
i.MX 6 Dual
i.MX 6 DualLite
i.MX 6 Solo
i.MX 6 SoloX
i.MX 6 SoloLite
i.MX 6SLL
i.MX 6 UltraLite
i.MX 6ULL
i.MX 6ULZ

Arm® v7-A

A9
A9
M4
A7

i.MX 8 family — A72, A53, M4
Advanced Graphics, Vision & Performance

i.MX 8M family — A53, M4/M7, NPU
Advanced Computing, Audio/Video & Voice

i.MX 8ULP family — A35, M33
Ultra Low Power with Graphics

i.MX 8X family — A35, M4
Safety Certifiable & Efficient Performance

Arm® v8-A (32-bit/ 64-bit)

i.MX 7 family — A7, M4
Flexible Efficient Connectivity

i.MX 7ULP family — A7, M4
Ultra Low Power with Graphics

Arm® v7-A (32-bit)

i.MX 8M Plus — Production
- 8M Plus Quad/QuadLite
- 8M Plus Dual

i.MX 8M — Production
- 8M Quad/QuadLite
- 8M Dual

i.MX 8M Mini — Production
- 8M Mini Quad/QuadLite
- 8M Mini Dual/DualLite
- 8M Mini Solo/SoloLite

i.MX 8M Nano — Production
- 8M Nano Quad/QuadLite
- 8M Nano Dual/DualLite
- 8M Nano Solo/SoloLite
- 8M Nano Quad UltraLite*
- 8M Nano Dual UltraLite*
- 8M Nano Solo UltraLite*

*11x11 package not pin-compatible with 14x14 package i.MX 8M Mini or Nano

Pin-to-pin Compatible

Software Compatible

I.MX8M PLUS

Security

- Arm® TrustZone®
- DRM Ciphers
- Secure Clock
- eFuse Key Storage
- Random Number
- 32 KB Secure RAM

System Control

- Smart DMA x3
- XTAL
- PLLs
- Watchdog x 3
- PWM x 4
- Timer x 6
- Secure JTAG
- Temperature Sensor

Main CPU Platform

- 4 x Arm Cortex®-A53
  - 32 KB I-cache
  - 32 KB D-cache
  - Arm NEON™
  - FPU
- 512 KB L2 Cache (ECC)

Secondary Cores

- HiFi4 DSP
- Cortex-M7
- 768 KB On-chip RAM (ECC)

Machine Learning

- Machine Learning Accelerator: 2.3 TOPS

Graphics

- 3D Graphics: GC7000UL
- 2D Graphics: GC520L

Video

- 1080p60 H.265, H.264, VP9, VP8 decoder
- 1080p60 H.265, H.264 encoder

Vision

- Dual Camera ISP (2x HD/1x 12MP) HDR, dewarp
- 2 x MIPI-CSI (4-lane) with PHY

Display

- HDMI 2.0a Tx (eARC) with PHY
- MIPI-DSI (4-lane) with PHY
- 1 x LVDS Tx (4 or 8-lane) with PHY

Audio

- 18 x I²S TDM 32 bit at 768 kHz
- SP/DIF Tx and Rx
- eARC (HDMI)
- ASRC
- 8-ch. PDM Microphone Input

Connectivity and I/O

- 2 x USB 3.0/2.0 OTG with PHY
- 2 x Gbit Ethernet with IEEE® 1588, AVB (One also supports TSN)
- 2 x CAN FD
- 1 x PCIe® Gen 3 – 1-lane L1 Substates
- 4 x UART 5 Mbit/s 5 x I²C, 3 x SPI

External Memory

- x16/x32 LPDDR4/DDR4/DDR3L (Inline ECC)
- 3 x SDIO3.0/MMC5.1
- Dual-ch. QuadSPI (XIP) or 1 x OctalSPI (XIP)
- NAND Controller (BCH62)

i.MX 8M PLUS KEY FEATURES

High-Performance Power-Efficient

High-Performance

- Dual/Quad-core Cortex-A53 cores up to 1.8 GHz;
- Cortex-M7 up to 800MHz (task offload, power optimizations)
- 3D GPU and VPU enables efficient video and display
- LPDDR4/DDR4 (Inline ECC)

Power-Efficiency

- Dynamic Voltage Frequency Scaling (DVFS), power gating, clock gating.
- Built in 14nm FinFET LPC technology for low-power & high-performance

Machine Learning, Vision & Voice

Machine Learning

- Neural Network Accelerator up to 2.3TOPS

Vision System

- Camera (up to 2 cameras):
- 2x MIPI-CSI (4 lanes each, 1080p)
- Camera ISP: 2x187MPix or 1x375MPix scale, de-warp

Low-Power Voice

- Low Power Voice Accelerator

Advanced Multimedia

Video:

- 1080p60 video decoding (H.265, H.264, VP9, VP8)
- 1080p60 video encoding (H.265, H.264)
- 2D and 3D GPU

Audio:

- 18x I2S TDM (32-bit @ 768KHz),
- DSD512,
- SP/DIF Tx + Rx
- 8-ch PDM Mic input
- HDMI 2.0b Tx + eARC
- ASRC
- 8ch PDM DMIC input for voice capture

Connectivity & Interfaces

Display Interfaces

- 1x MIPI-DSI
- 1x HDMI 2.0b Tx (+eARC)
- LVDS (4/8-lane) Tx
- Up to 3 display simultaneously

High Speed Interfaces

- 3x SDIO 3.0 for boot / storage / Wi-Fi (max flexibility)
- 1x PCIe 3.0 to connect to high-performing Wi-Fi solutions and other systems
- 2x Gigabit Ethernet with IEEE 1588, AVB (one with TSN, one with IEEE)
- 2x USB 3.0/2.0 OTG with PHY
- 2x CAN-FD

matter

NXP'S LEADERSHIP IN MATTER

Total Smart Home Solution

Complete fit for purpose product offering

Covering connectivity, security, and processing

Hostless and hosted architecture options

Trusted Development Partner

Silicon, software, tools and services

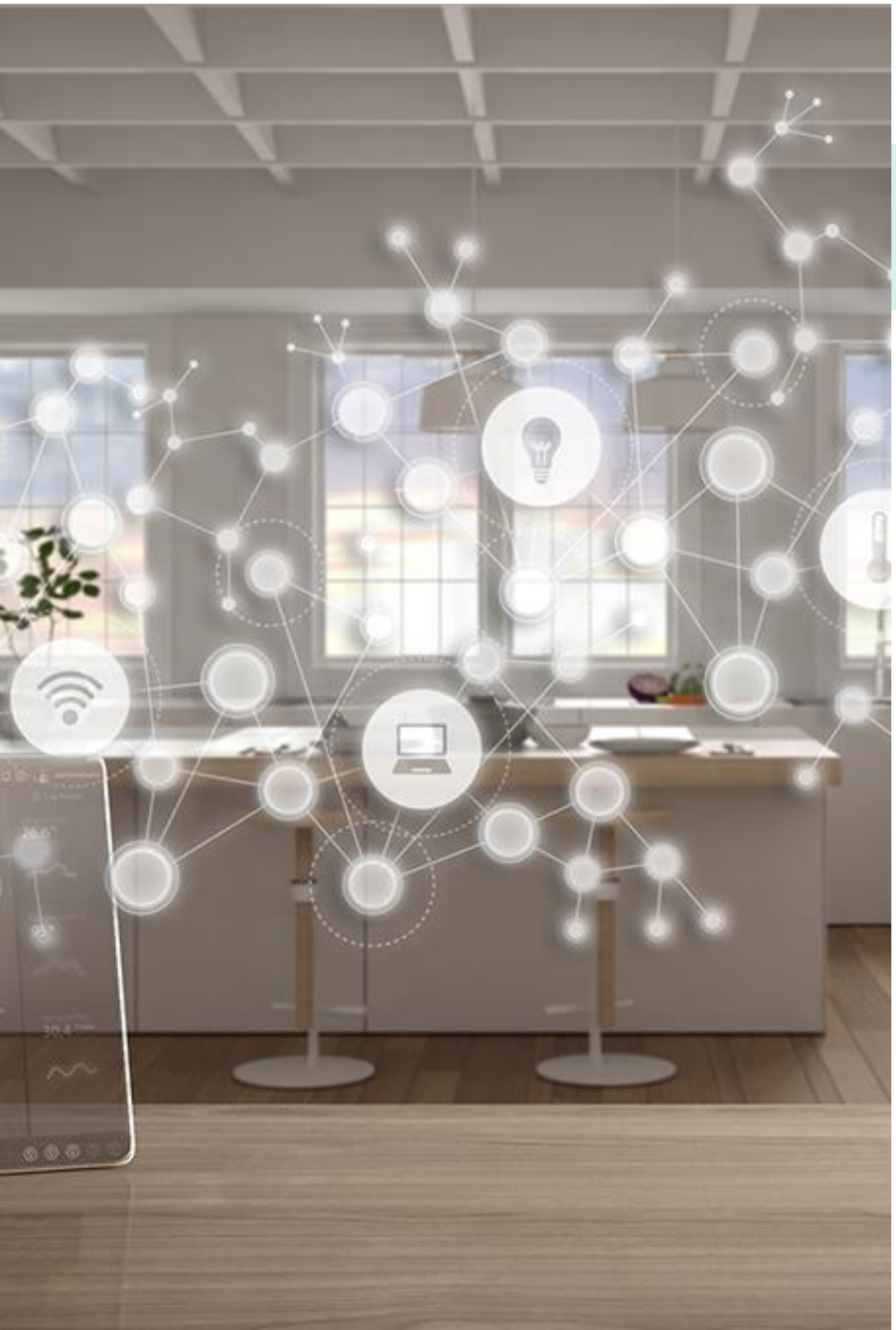
Leadership in IoT standards

Innovation Enabler

Developers time to focus on user experience innovation

IoT technology solutions

Partnered with ecosystem platform providers



MATTER

A unified IP-based protocol to securely and robustly connect smart devices with each other, regardless of brand, and across smart home ecosystems

- Bring interoperability in Smart Home Ecosystem
- Increase reliability for consumers
- Ensure security and privacy
- Simplify development for “things”

Links:

Matter

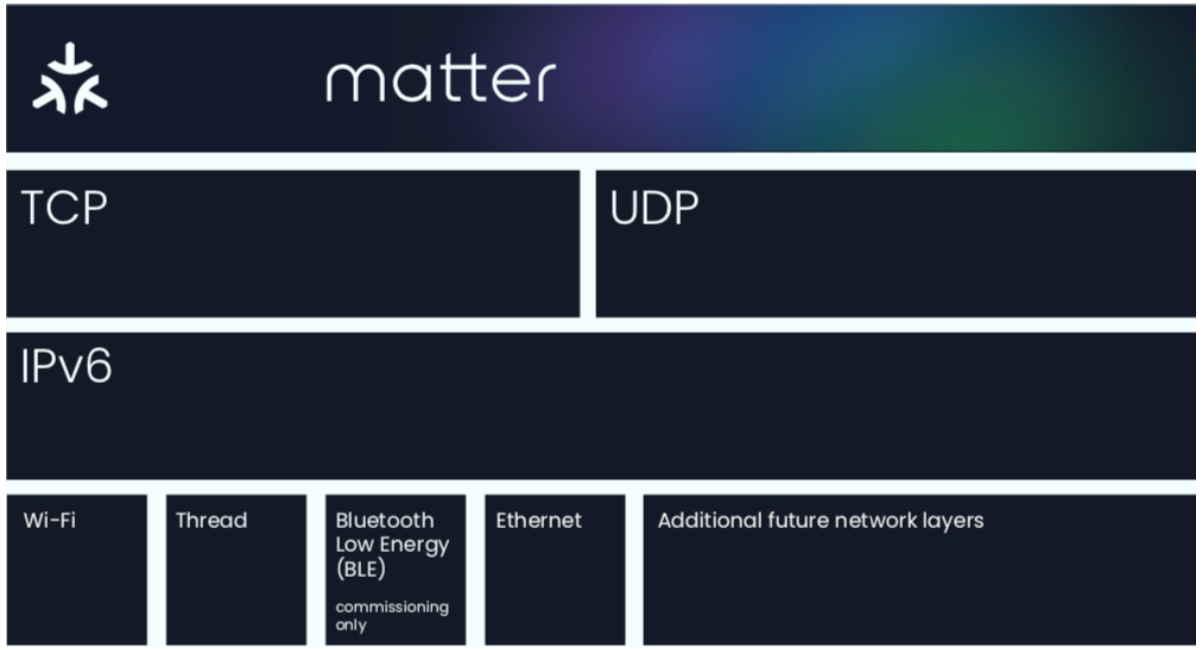
NXP for Matter

Led by global brands

And > 250 other companies!

csa connectivity standards alliance

MATTER FOR IOT DEVICES



Local network to connect smart devices to each other across ecosystems

- Reliable network, doesn't depend on the cloud

IP-based connectivity specification

- Eliminates need for dedicated hubs, gateways and translators

Open, royalty-free standard, Open-Source software

Security & privacy as design tenets

Interoperability through certification

MATTER NETWORK TOPOLOGY OVERVIEW

Sleepy Edge Nodes
Typically battery powered devices that connect to Thread edge nodes or Border Routers.

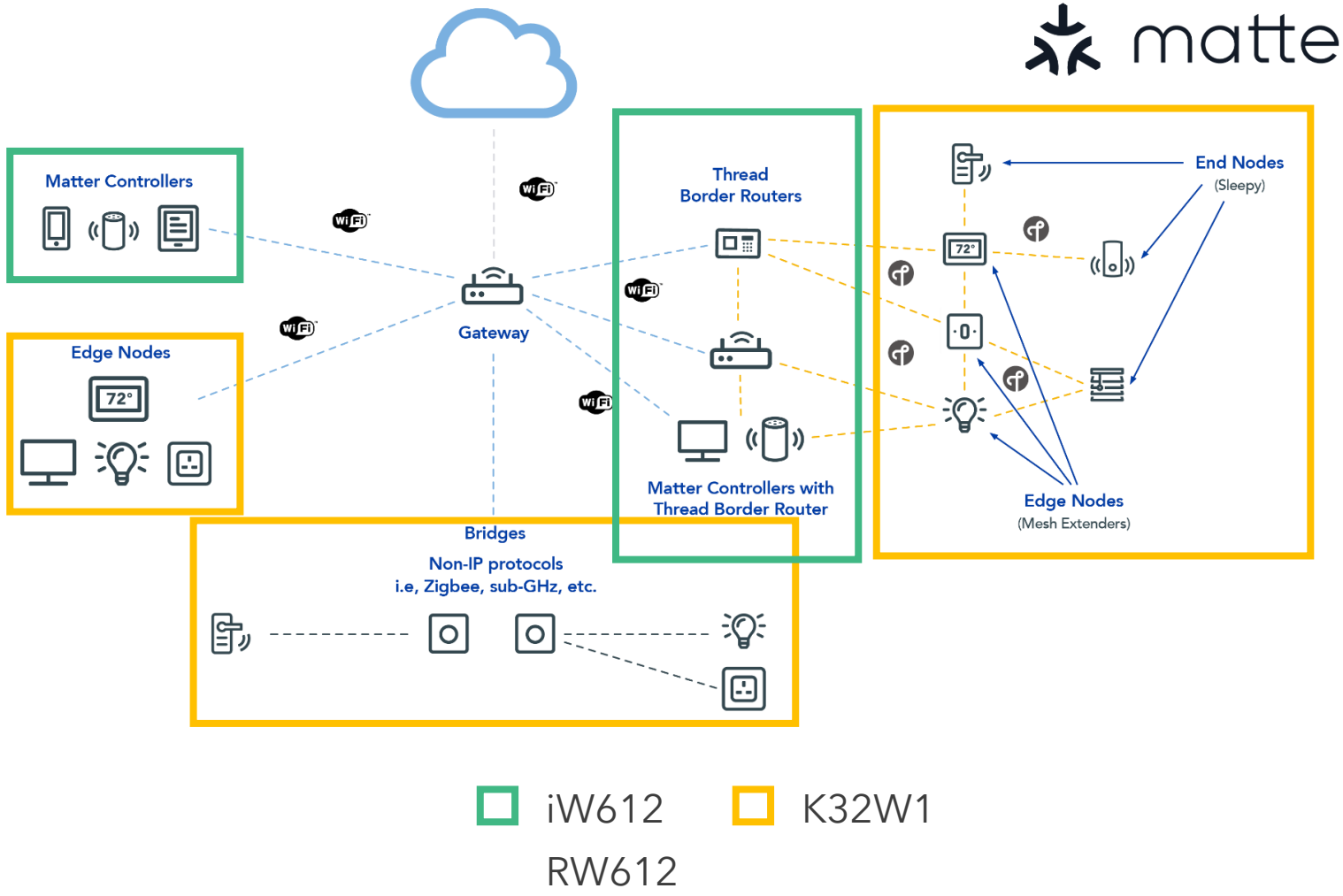
Edge Nodes
Typically wall powered devices connected to Wi-Fi or Thread Mesh Extender devices.

Thread Border Router
Connects Wi-Fi and Thread networks. Multiple Border Routers possible to improve reliability.

Gateway/Hub
Connects Matter network to the cloud.

Bridge
Connects Matter network to legacy Smart Home system.

Controller
Provisions Matter devices to the network.



INTRODUCING INDUSTRY'S FIRST TRI-RADIO SOC – IW612

FUTURE ELECTRONICS

NXP GOLD PARTNER

u-blox

- **Industry's first Secure Tri-Radio monolithic solution**
  - Latest Wi-Fi 6, BT/Bluetooth LE 5.2 and 802.15.4 standards
  - Designed for Smart Home: Border routers (gateways)/bridges/hubs
  - Ideal for Matter standardizing control and enablement across ecosystems
- **Advanced Coexistence**
  - Flexible internal coexistence for multi-radio operation designed specifically to be market leading across a broad range of key target applications
  - Additional support for external radios (UWB, 802.15.4, LTE, etc.)
- **NXP EdgeLock™ Security**
  - Leverage NXP security IP and industry leadership
  - Eases customers concerns devices will be compromised once deployed
- **NXP Microprocessor and Microcontroller IP and Broad Market Portfolio**
  - Eliminates need for customers to develop and integrate complex host operating systems and drivers
  - Single source for major components in design
- **System Cost Savings**
  - Reduced bill-of-materials and footprint – Integrated radios, LNA, high-power PAs
  - Simplifies complex RF design
  - Fewer components to procure

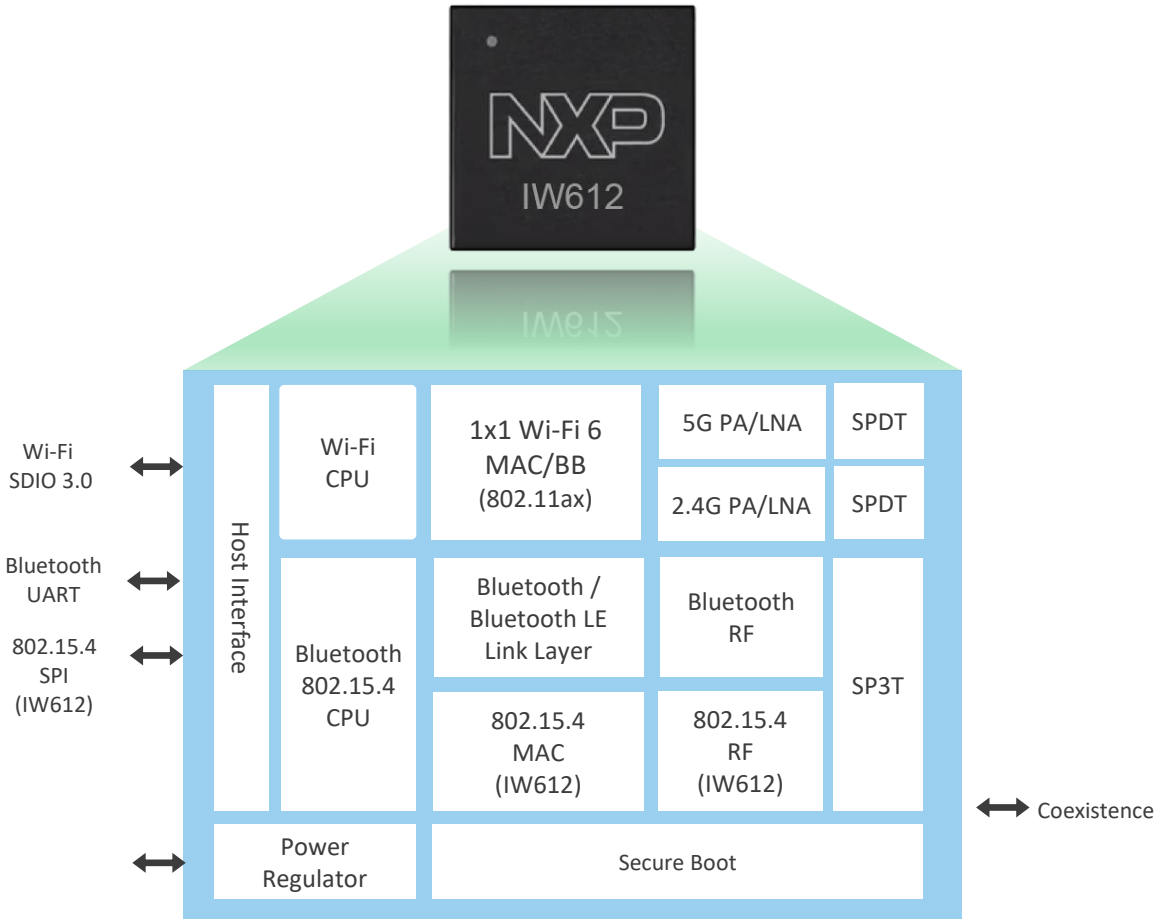
MAYA-W2

Most compact and cost-effective,
Wi-Fi 6 dual-band / Bluetooth 5.2 / IEEE 802.15.4

- Very small footprint
- Wi-Fi 6 dual-band
- Dual mode Bluetooth 5.2 (Classic/ Bluetooth LE)
- 802.15.4 radio for Thread / Matter or Zigbee applications
- WPA3 security
- Variants with PCB-antenna, U.FL connectors, and antenna pins

IW611/612 PRODUCT OVERVIEW

1x1 Dual-Band Wi-Fi 6 + Bluetooth 5.2 + 802.15.4 optimized for IoT and Industrial Applications



Key Radio Features

- **Wi-Fi 6**
  - 1x1 SISO 2.4 GHz / 5 GHz 802.11 a/b/g/n/ax
  - UL/DL OFDMA, STA UL MU-MIMO Tx and DL MU-MIMO Rx
  - 1024 QAM, 20/40/80 MHz channels, Peak Data Rate: 480 Mbps
  - 2.4 GHz Tx @ 21 dBm; 5 GHz Tx @ 20 dBm
  - 802.11ax extended range (ER), dual carrier modulation (DCM), target wait time (TWT)
  - WPA3 security with hardware encryption engines
  - Integrated PA, LNA and T/R switches
- **Bluetooth & Bluetooth Low Energy 5.2 with up to +20 dBm output power**
  - Class 1 and Class 2
  - High speed, long range, advertising extensions
  - Isochronous channels supporting LE Audio
  - Support for 2 wideband speech (WBS) links
- **802.15.4 supporting Thread with up to +20 dBm output power**
- **Support for Matter over Wi-Fi and Matter over Thread**
- **Advanced internal and external coexistence design for multi-radio operation**
- **Single or dual antenna configurations**
- **Lowest RBOM cost with integrated PAs, LNAs, switches and power mgmt.**
- **EdgeLock Security**
  - Secure boot, debug and firmware update, secure key generation and management, HW crypto, TRNG, PUF, OTP and lifecycle management
- **Android, Linux and FreeRTOS**

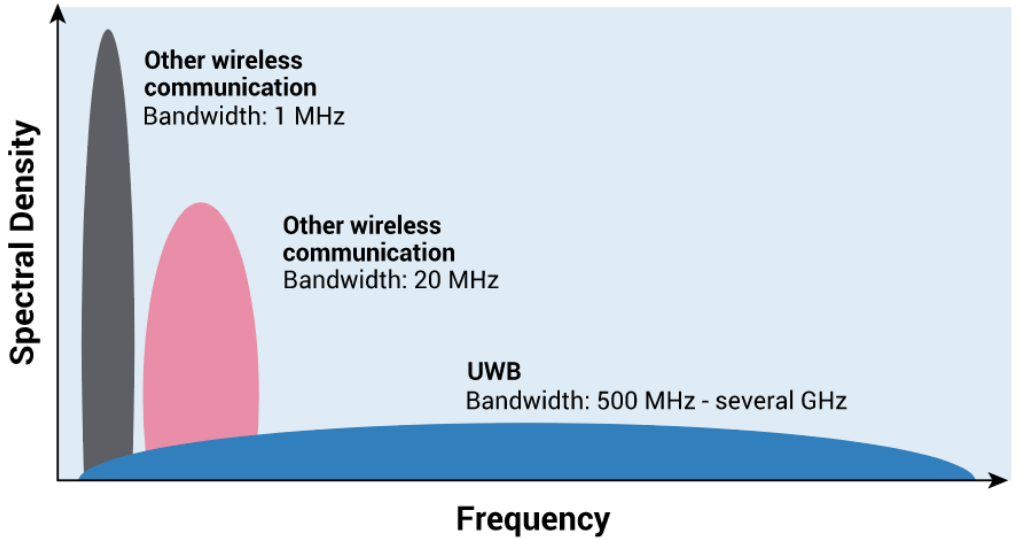
General Features

- **9 mm x 9 mm, 0.5p 116-pin HVQFN**
- **4.96 mm x 4.385 mm, 0.3p 140-pin WLCSP**
- **Supply voltages: 3.3V & 1.8V**
- **Operating temperatures**
  - Commercial: 0 to +70°C
  - Industrial: -40 to +85°C

WHAT IS UWB

Ultra wideband technology

- Radio technology based on the IEEE 802.15.4a and 802.15.4z standards
- Operates at very high frequency 3.5GHz to 10 GHz
- Enable very accurate measurement of the Time of Flight of the radio signal
- Centimeter accuracy distance/location measurement.
- Indoor GPS- fast way to track humans, pets and objects
- Secure communication- no interference even in congested multi-path environments



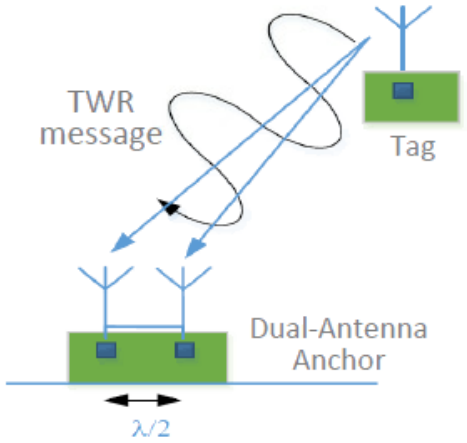
Spectral density for UWB and narrowband

HOW DOES UWB WORK?

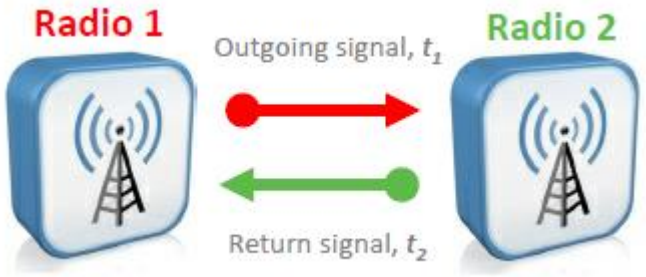
UWB leverages Time of Flight (ToF), a method for measuring the distance between two radio transceivers by multiplying the Time of Flight of the signal by the speed of light.

There are several ways UWB technology can determine location using Time-of-Flight measurements, based on target application:

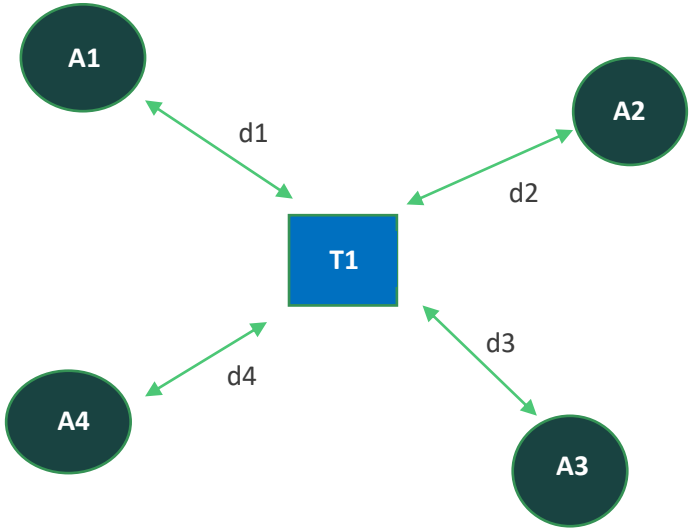
Phase Difference of Arrival (PDoA)



Two Way Ranging

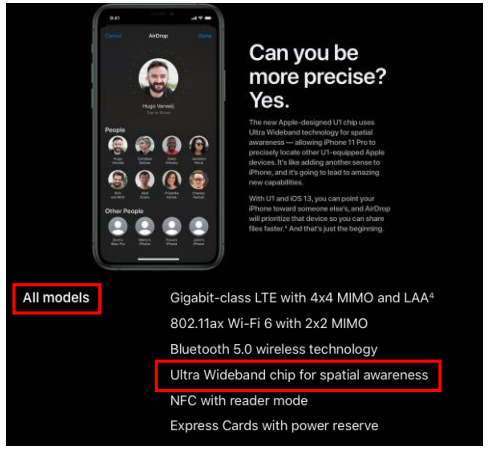


Time Difference of Arrival (TDoA)



UWB – INTEROPERABILITY

Technology is vetted by Apple



Industry Alliance for Interoperability between IiOT - Consumer - Mobile

fira

OUR VISION IS TO PROVIDE SEAMLESS USER EXPERIENCES USING THE SECURED FINE RANGING AND POSITIONING CAPABILITIES OF INTEROPERABLE UWB TECHNOLOGIES.

ASSA ABLOY · BOSCH Invented for life · HID · qorvo · NXP · SAMSUNG

Industry Alliance to lobby UWB regulations

UWB ALLIANCE · omlox · HYUNDAI · KIA · iRobot · ZEBRA · Ubisense · qorvo

Industry Alliance for Interoperability between Automotive - Mobile

CARCONNECTIVITY consortium® · qorvo · SAMSUNG · HUAWEI · Google · NXP · FCA FIAT CHRYSLER AUTOMOBILES · TOYOTA · LAND ROVER · JAGUAR · PSA GROUPE · Mercedes-Benz · BOSCH

MURATA UWB MODULES

UWB Modules

NEW Trimension SR150

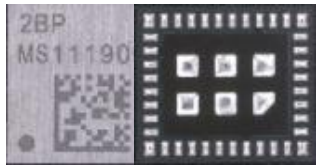
- Full PHY+MAC solution for smart home, infrastructure,…
- Connected to EdgeLock SE for Secure Ranging Use Cases
- Support for AoA
- RTOS and Linux SW Solution for IoT integration
- In accordance with FiRa

Type 2BP

PN: LBUA0VG2BP-SMP

NXP SR150T

6.6 x 5.8 x 1.2 mm



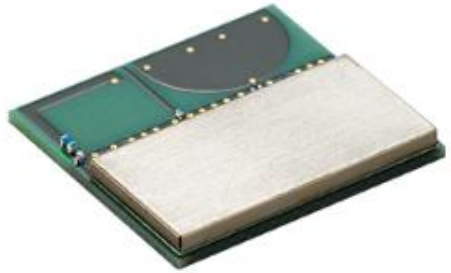
FCC/IC/CE* /Japan Certified (plan)

Type 2DK

PN: LBUA2ZZ2DK-SMP

NXP SR040 + NXP QN9090 (for Tag)

19.6 x 18.2 x 2.3 mm



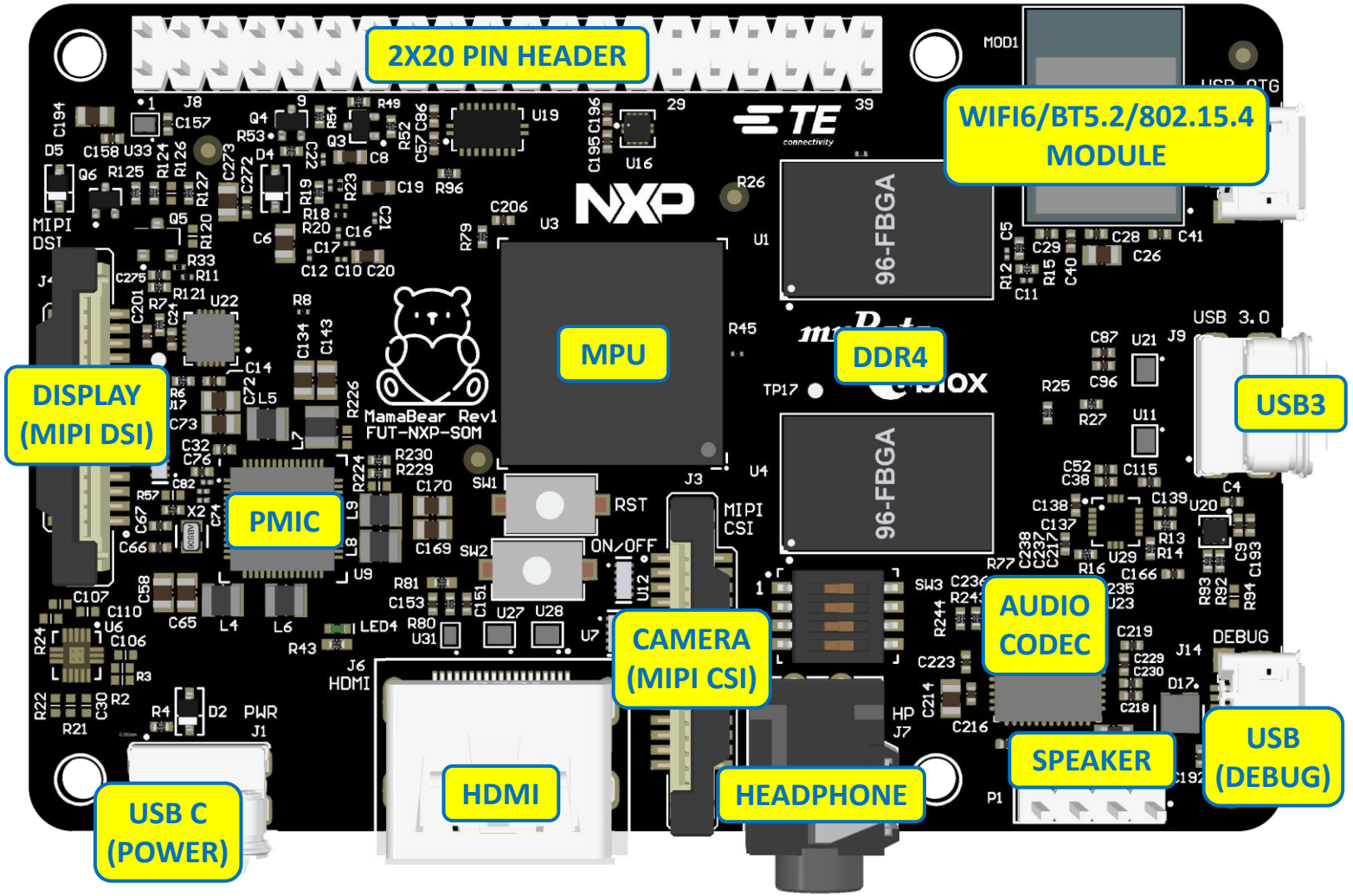
FCC/IC/CE* /Japan Certified (plan)

NEW Trimension SR040

- Full PHY+MAC solution for tags
- Optimized for coin-cell operated applications
- Optimized low-power modes
- In accordance with FiRa
- Arm® Cortex®-based

DESIGN CONSIDERATIONS: MAMA BEAR

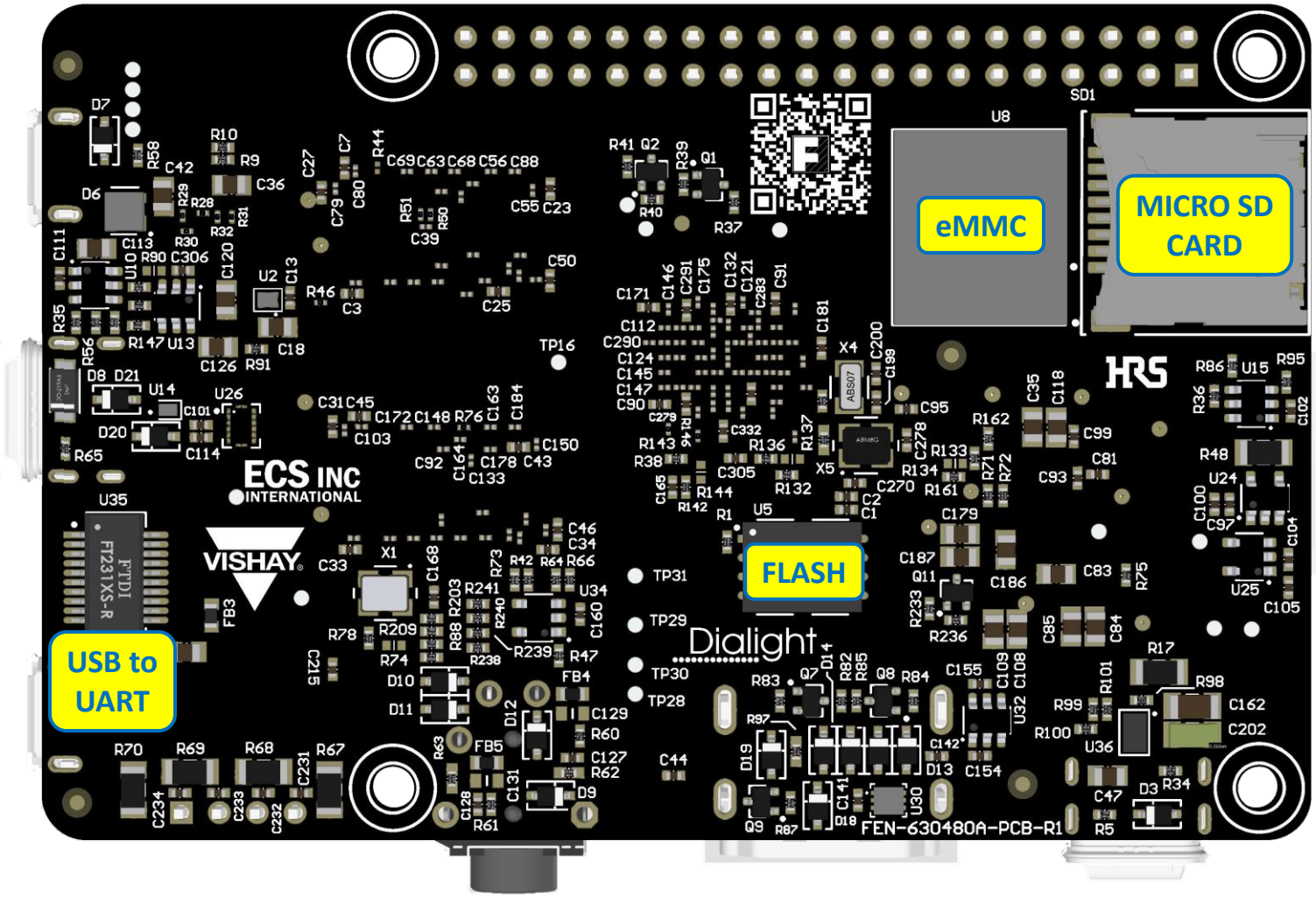
Overall Placement – Top Layer



- Small RaspPi form factor = placement challenge
  - 85.6 mm × 56.5 mm (3.37 in × 2.22 in) with connector / mounting hole constraints
- Densely populated with
  - i.MX 8M Plus MPU
  - PCA9450 PMIC
  - WiFi/BT/802.15.4
  - DDR4
  - Audio CODEC
  - MIPI Camera and Display interfaces

DESIGN CONSIDERATIONS: MAMA BEAR

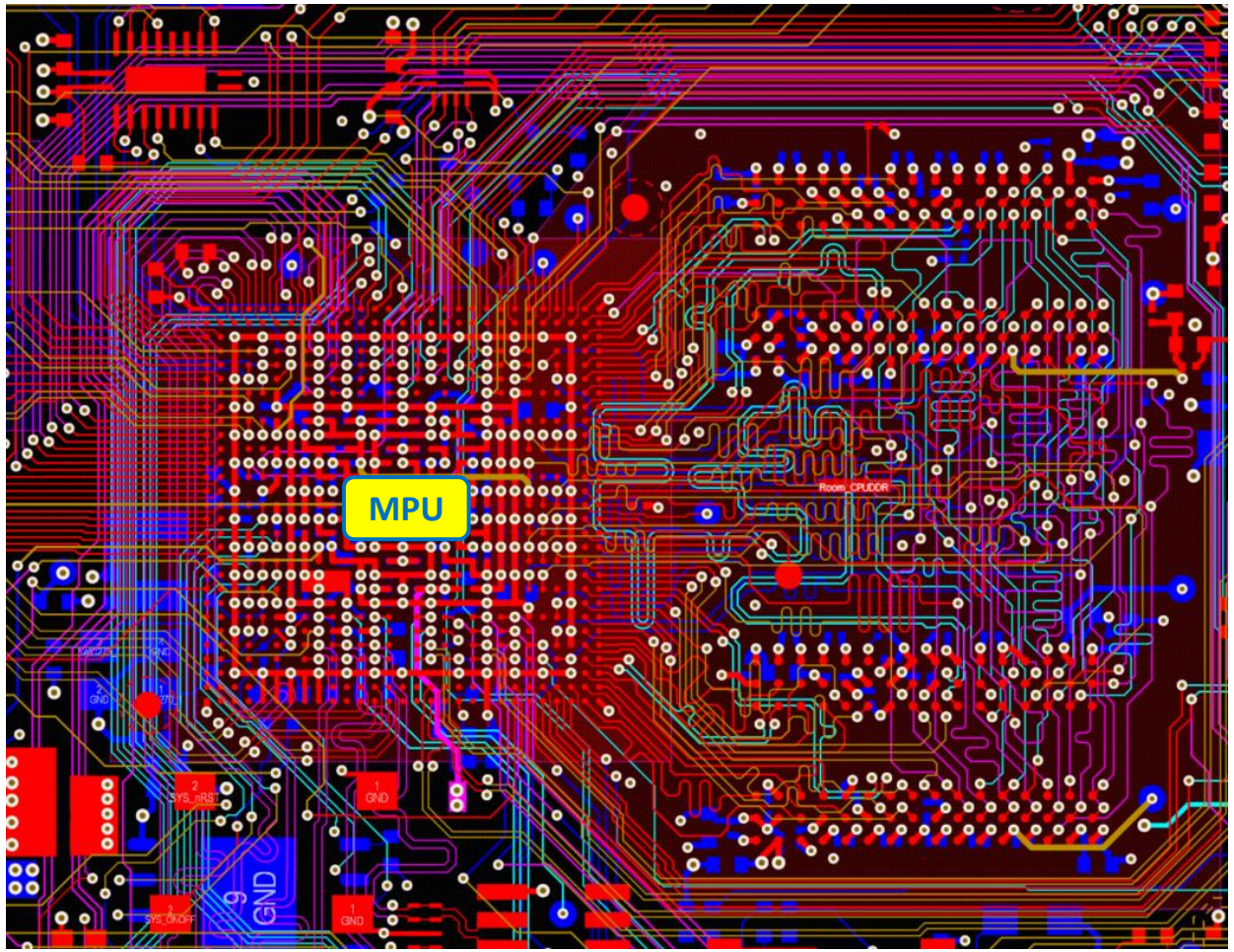
Overall Placement – Bottom Layer



- Bottom layer includes
  - eMMC
  - MicroSD card connector
  - Flash memory
  - USB to UART (for debug)

DESIGN CONSIDERATIONS: MAMA BEAR

Complex Trace Routing from i.MX 8M Plus Processor



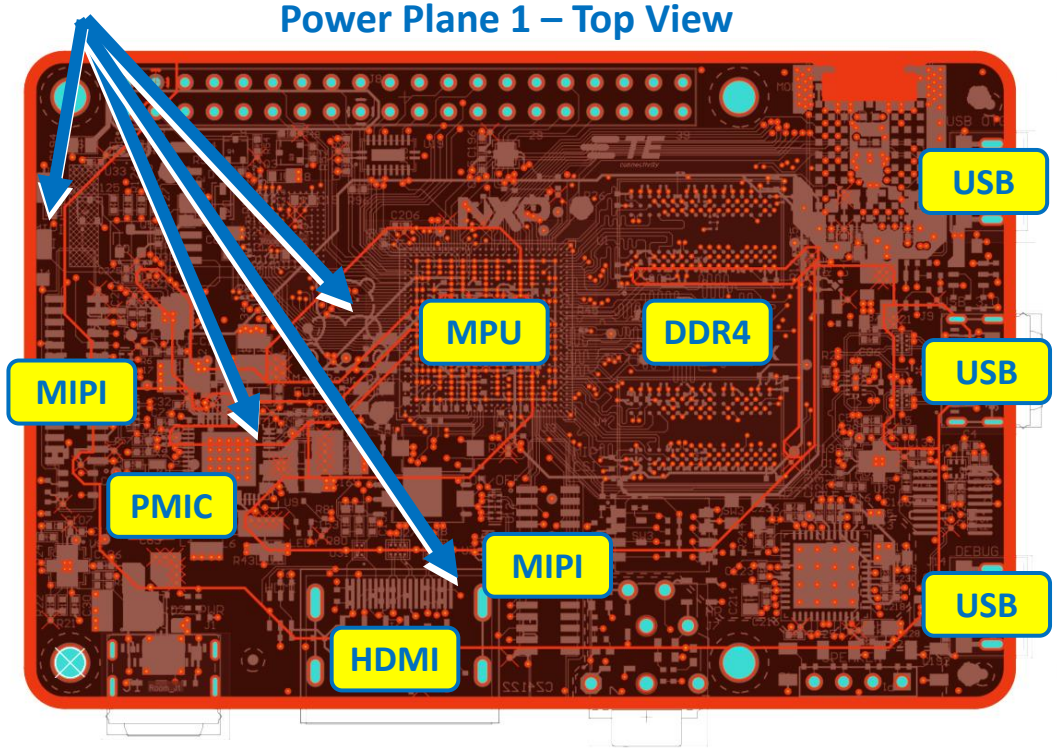
- Most MPU pins used in this design
  - Config Tools for i.MX (CONFIG-TOOLS-IMX) used to confirm as many pin assignments as possible
- Fanout from the MPU (0.5mm pitch BGA) requires thin traces and small clearance between trace and vias
  - Determine layer stack-up and PCB rules early in the design stage - places limitation on fab houses / CMs used
- Important to use NXP's Hardware Developer's Guide (HDG) as checklist
  - PDF, Rev 0, 3/16/21 (IMX8MPHDG)

DESIGN CONSIDERATIONS: MAMA BEAR

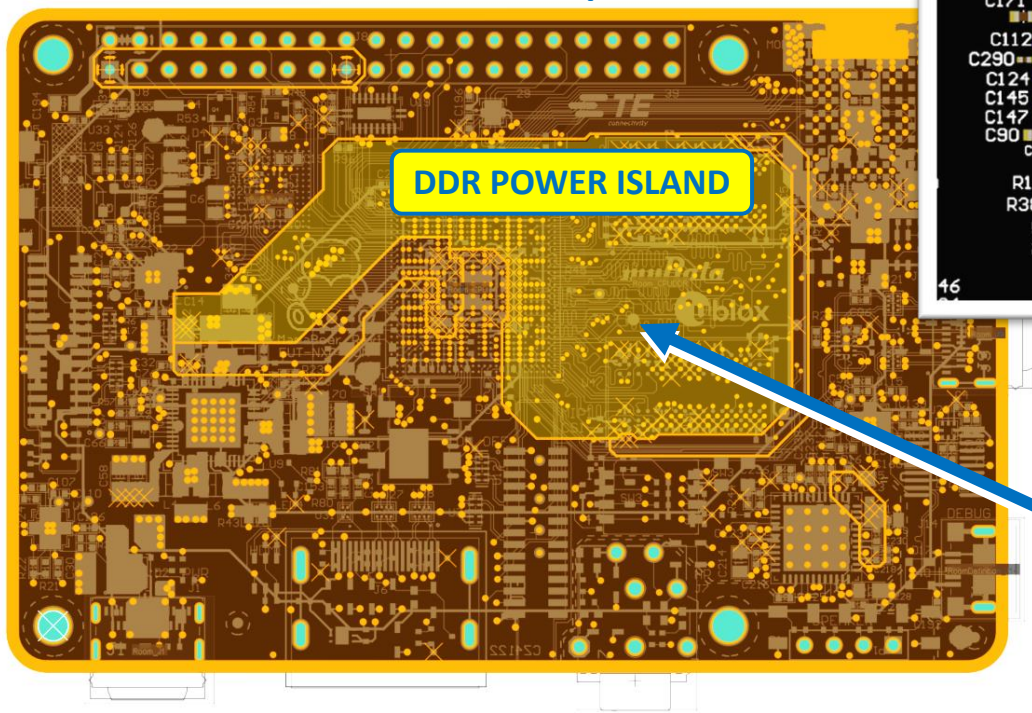
Power (PMIC, MPU, DDR)

Multiple power islands

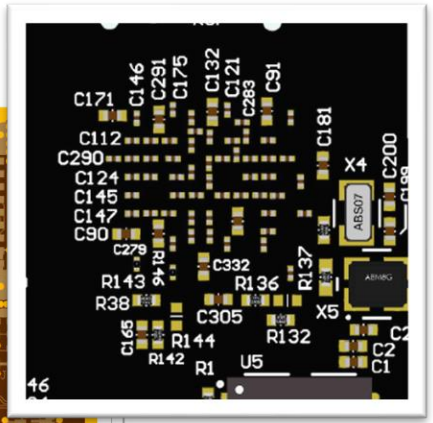
Power Plane 1 – Top View



Power Plane 2 – Top View



Decoupling Under MPU



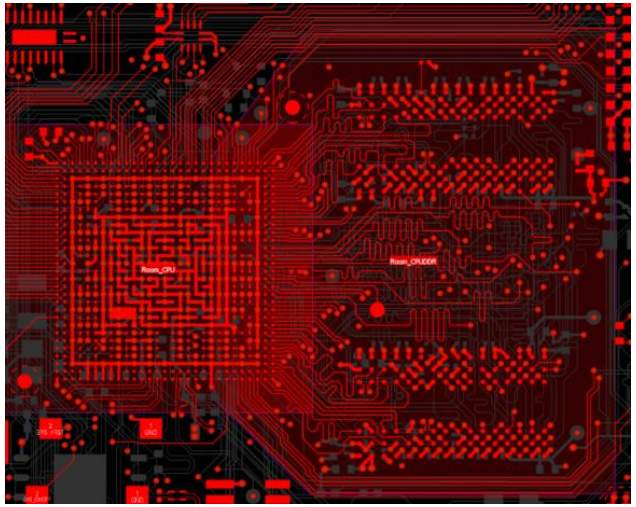
High speed signals coupled to power plane to minimize layers; should not cross plane boundary

- Multiple power rails with sequencing (PMIC)
  - PMIC placed away from MPU / DDR4 region
- Power planes / decoupling 1st, then signal routing
  - Signals coupled to power islands should not cross boundary
  - After routing, check islands to ensure area supports current
- DDR4 placed close to MPU over power islands
  - Constrained by space needed for signal routing / length matching
- Decoupling caps placed close to MPU pins to block AC noise
- TVS diodes and Common-mode EMI filters with ESD protection used at USB / HDMI / MIPI ports

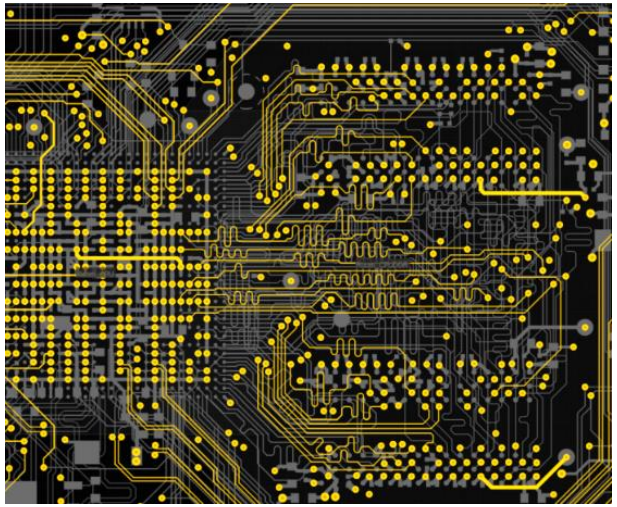
DESIGN CONSIDERATIONS: MAMA BEAR

i.MX and DDR4 Routing

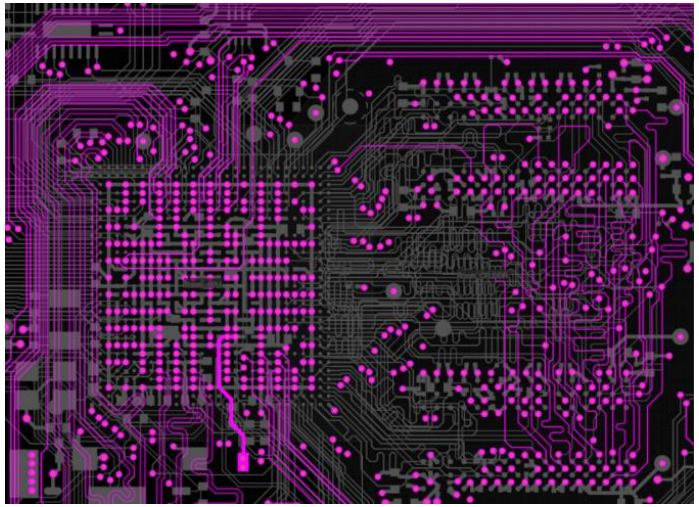
TOP



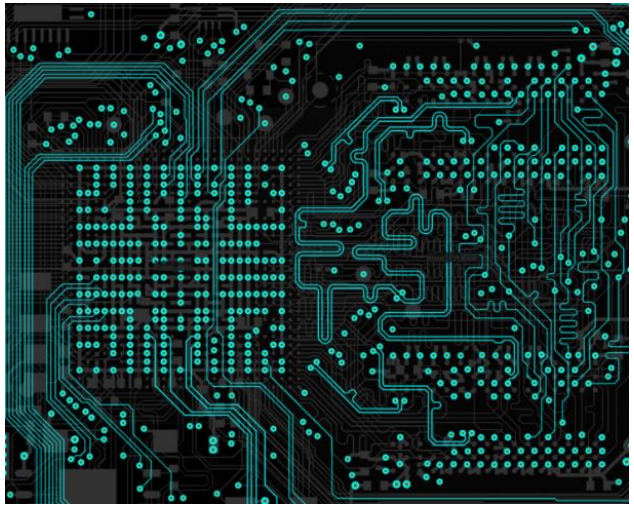
MID_SIG2



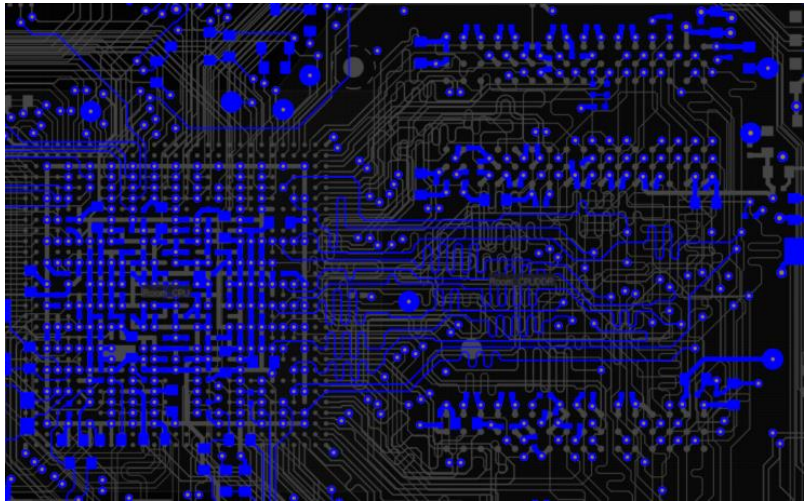
MID_SIG3



MID_SIG4



BOTTOM

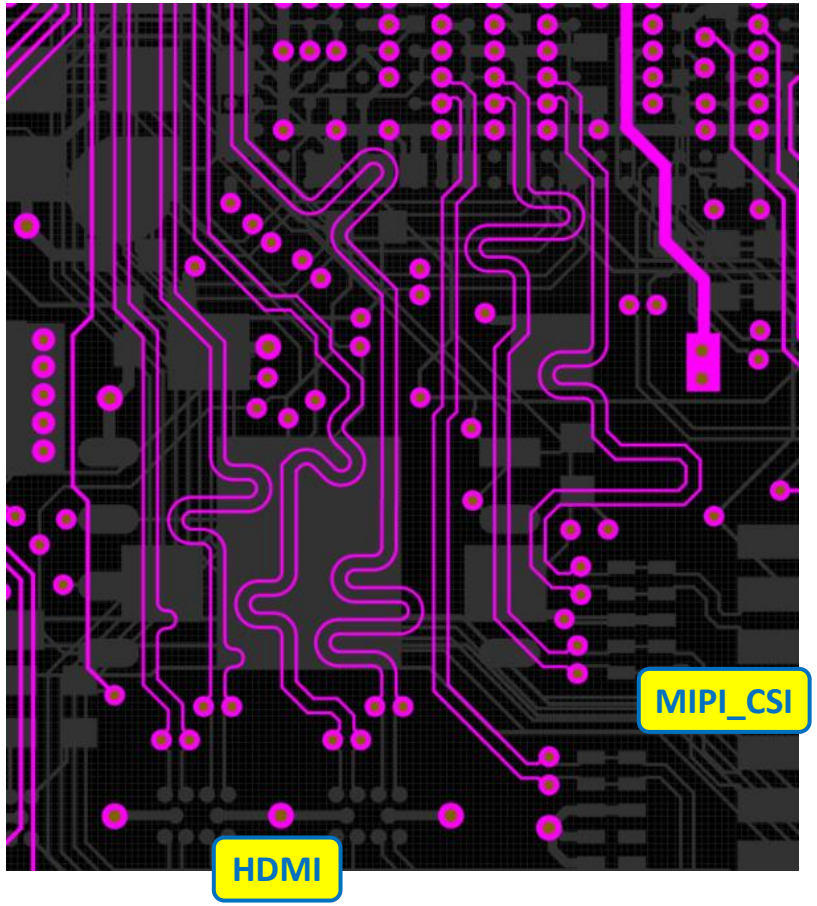


- Route DDR4, then match delay
  - Package pins and vias should be included in matching
  - Adhere as closely as possible to trace clearance guidance in HDG given space constraints
  - Add GND vias nearby when changing signal layers

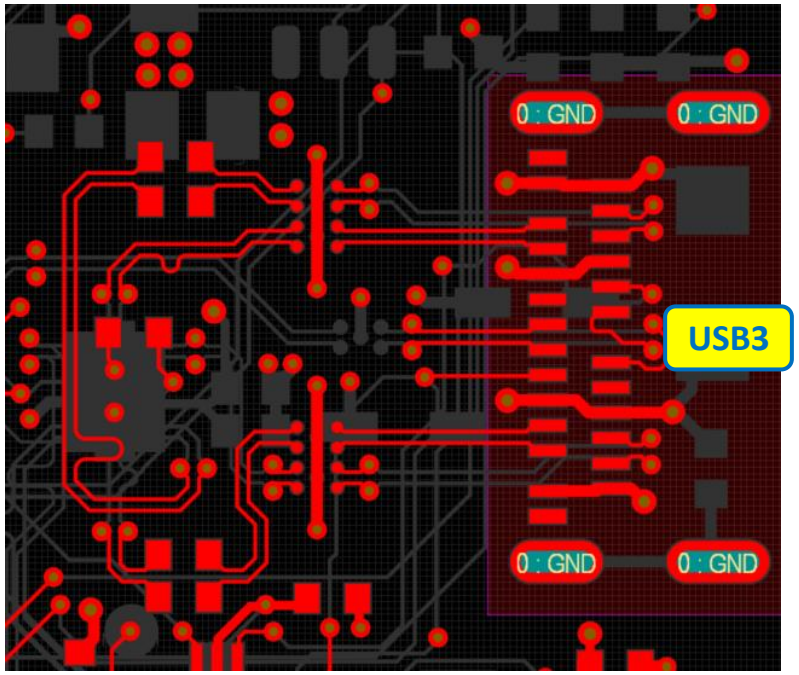
DESIGN CONSIDERATIONS: MAMA BEAR

Additional High Speed Signal Routing

HDMI and MIPI_CSI Delay Matching



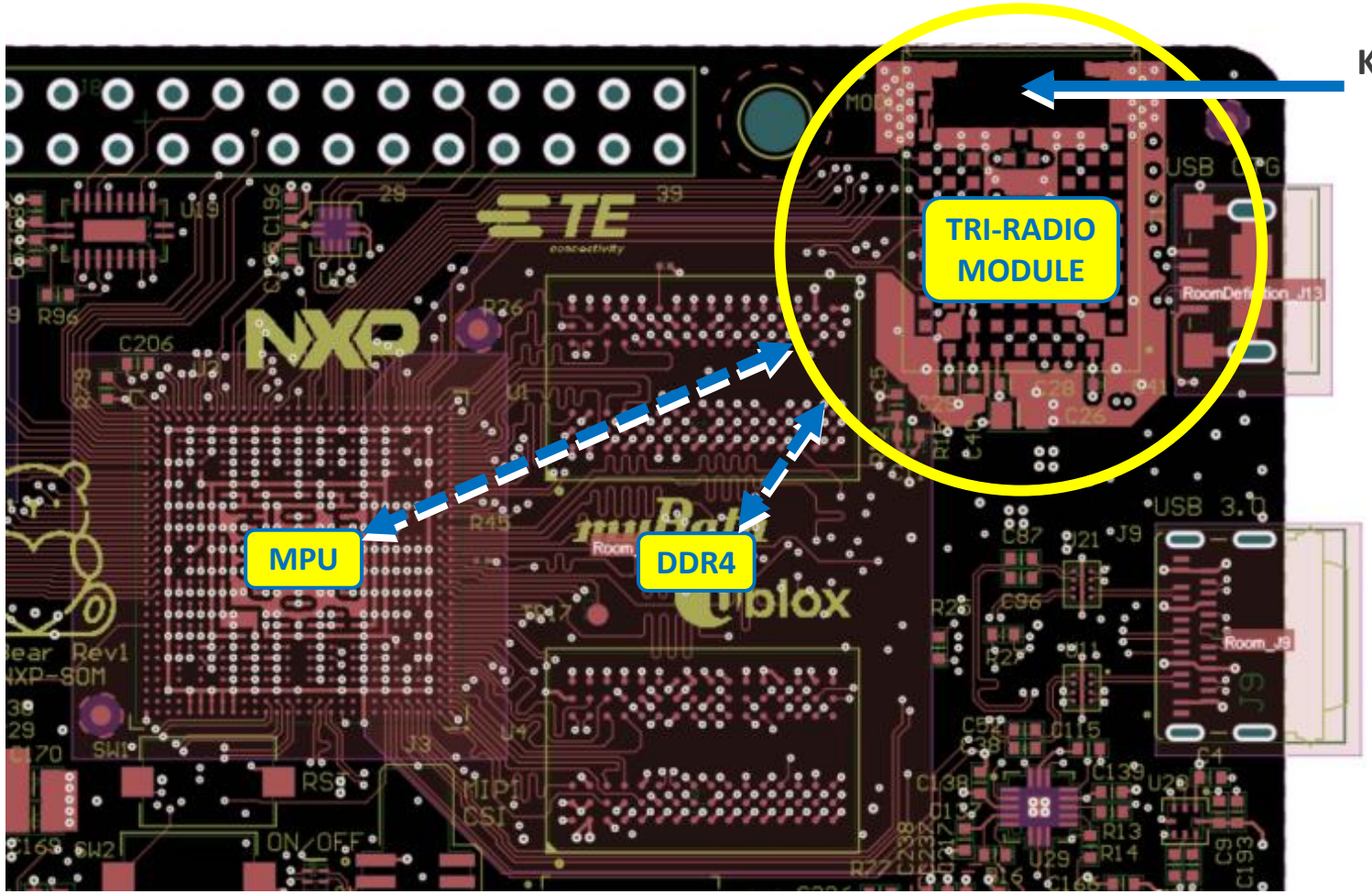
USB3 Delay Matching



- In addition to DDR, delay matching should be applied to other signals:
  - SDIO
  - HDMI
  - USB2/3
  - MIPI_CSI
  - MIPI_DSI
- Maintain clearance between high speed signals and other signals
- Routing over GND planes is preferred

DESIGN CONSIDERATIONS: MAMA BEAR

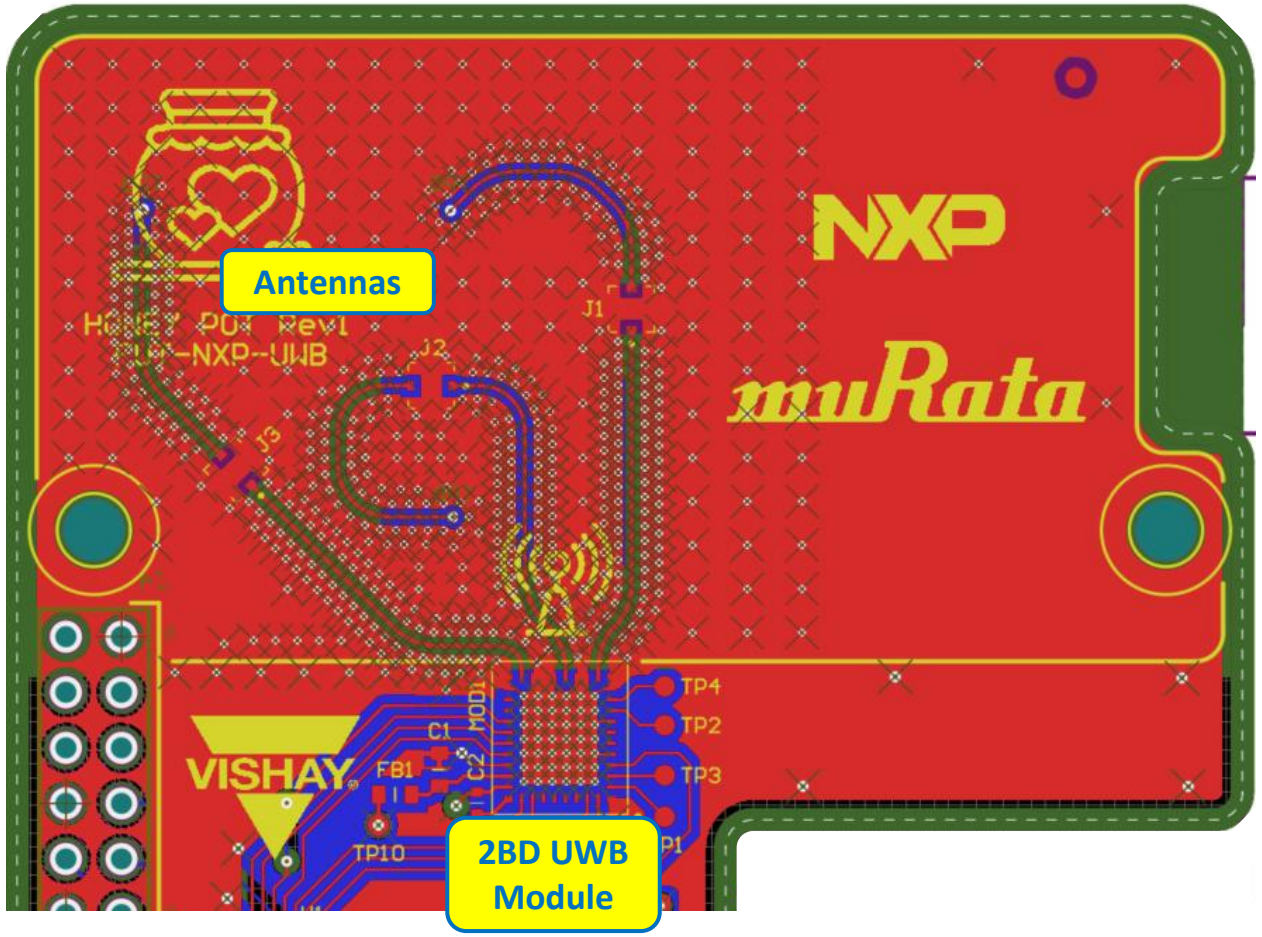
Tri-Radio Module



- Tri-radio module ideally placed far/isolated from DDR4 and other circuitry
  - Given the limited space in this board, the maximum possible distances were achieved
- Clearance should be maintained near antenna area
  - Keepout zone through all layers

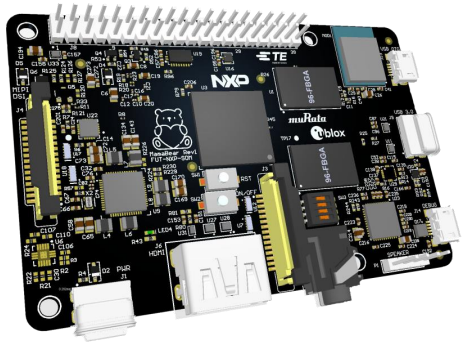
DESIGN CONSIDERATIONS: HONEY POT

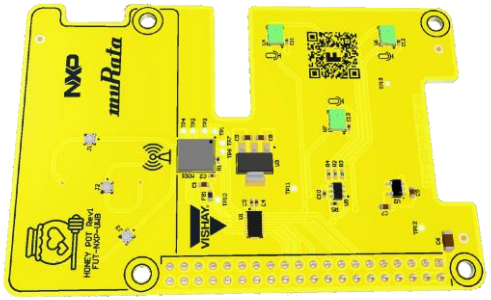
2BP Module and Three Antennas

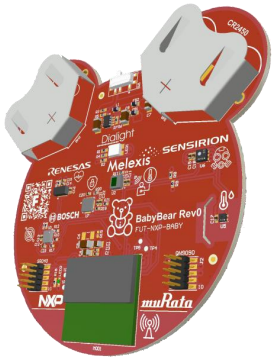


- Three antennas required for Type 2BD UWB module
  - Module based on NXP Trimension™ SR150 UWB solution
- Important to adhere to manufacturer PCB antenna patterns
  - Import manufacturer DXF vector file
  - Avoids RF tuning after PCB done

SUMMARY







- Compact platform for prototyping many different design concepts.
- Take advantage of Rpi ecosystem.
- Out of box demos to showcase multiple features.
- includes tri-band WiFi6 radio, UWB, quad core A53 processor w/ integrated AI accelerator, camera interface, multiple display interfaces, and a sensor HUB.
- Multiple design considerations addressed to help speed up product development and time to market.