Application of Modulation Dependent Carrier Level ("MDCL") Control Technologies to Amplitude Modulation Transmission Systems

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Featuring GatesAir's

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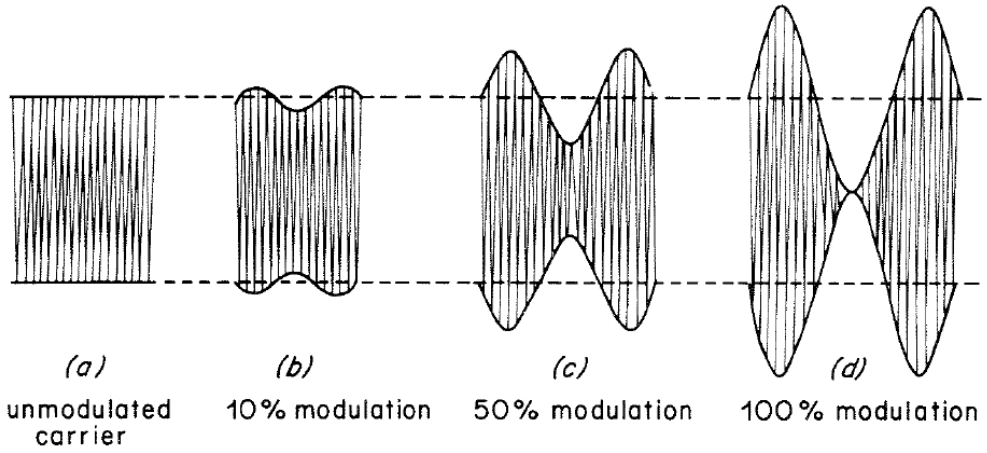
Application of Modulation Dependent Carrier Level (“MDCL”) Control Technologies to Amplitude Modulation Transmission Systems

What is MDCL?

- MDCL is synonymous with **Dynamic Carrier Control**, or DCC and includes the techniques:
  - Adaptive Carrier Control (ACC)
  - Amplitude Modulation Companding (AMC),
  - Dynamic Amplitude Modulation (DAM)

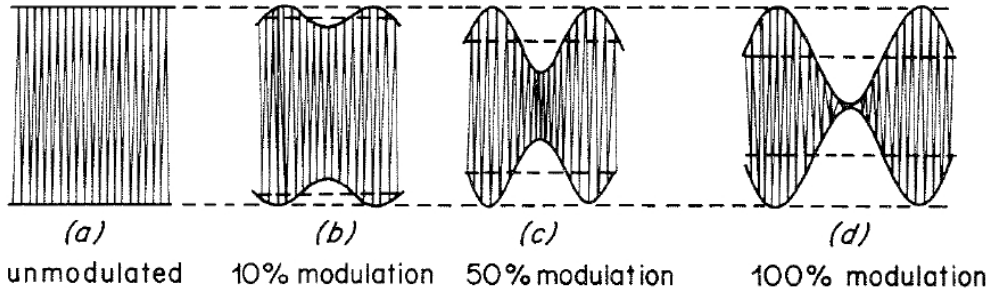
Since the early 1990's, GatesAir has offered two schemes, ACC+ and, AMC+

How Does MDCL Save Energy?



If a transmitter is modulated 100% then the carrier is fully utilized

If the audio input is reduced and modulation is only 50%, then carrier power is wasted



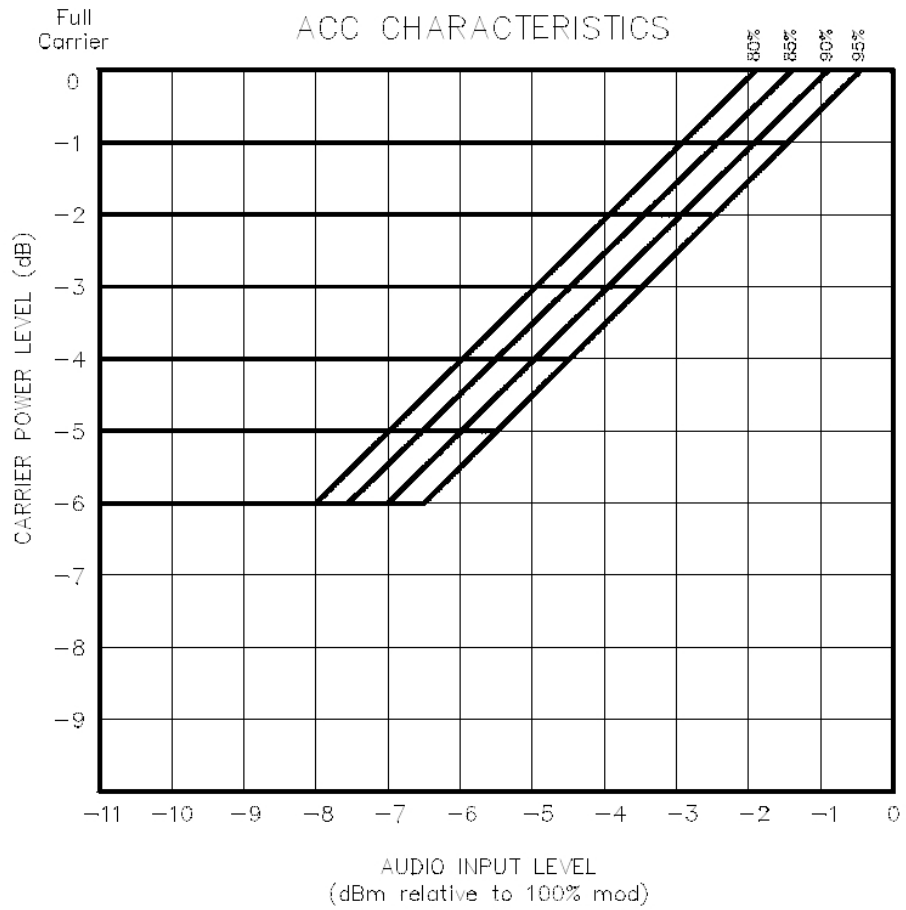
- ACC lowers the carrier power with a DECREASE in audio input
- AMC lowers the carrier power with an INCREASE in audio input

AMC vs. ACC

- **ACC+** and **AMC+** both reduce AM carrier power as a function of modulation level, resulting in significant energy savings.
- **ACC**+ reduces the carrier level during segments when audio modulation levels are low.
- **AMC**+ reduces the carrier level during segments when modulation levels are high.

- Determining which algorithm will work best will be dependent on the format of the station (i.e., talk vs. music), the audio processing and personal preference.

Adaptive Carrier Control (ACC)



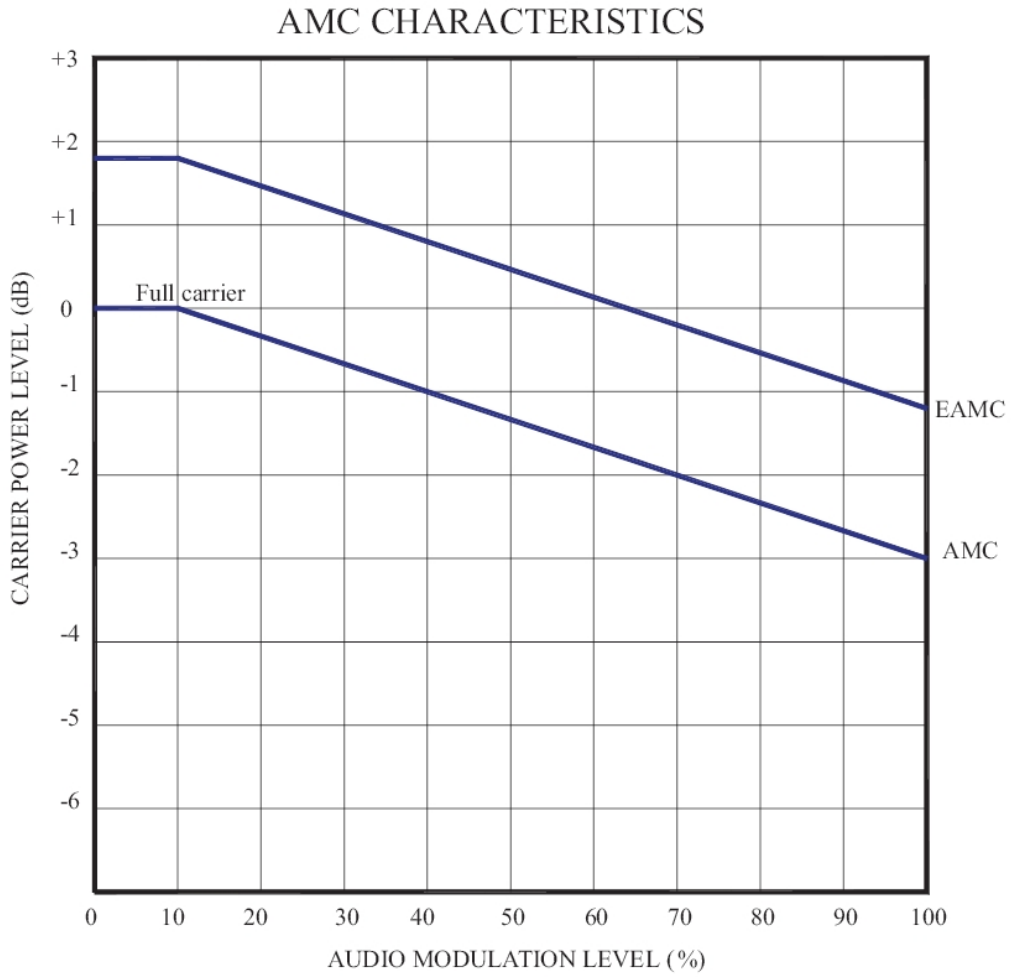
ACC tracks the overall audio input amplitude and reduces the carrier power until 95% modulation (for example) is attained. If the audio input is increased, ACC increases the carrier power high enough to prevent negative clipping, and still attain 95% modulation.

•The amount of carrier reduction is controllable from -1 to -6 dB, in 1 dB steps. (Horizontal Lines)

•The modulation range at which ACC varies the carrier is selectable from 47.5-95%, 45-90%, 42.5-85%, and 40-80% modulation. (Sloping Lines)

•ACC has 24 different user selectable combinations

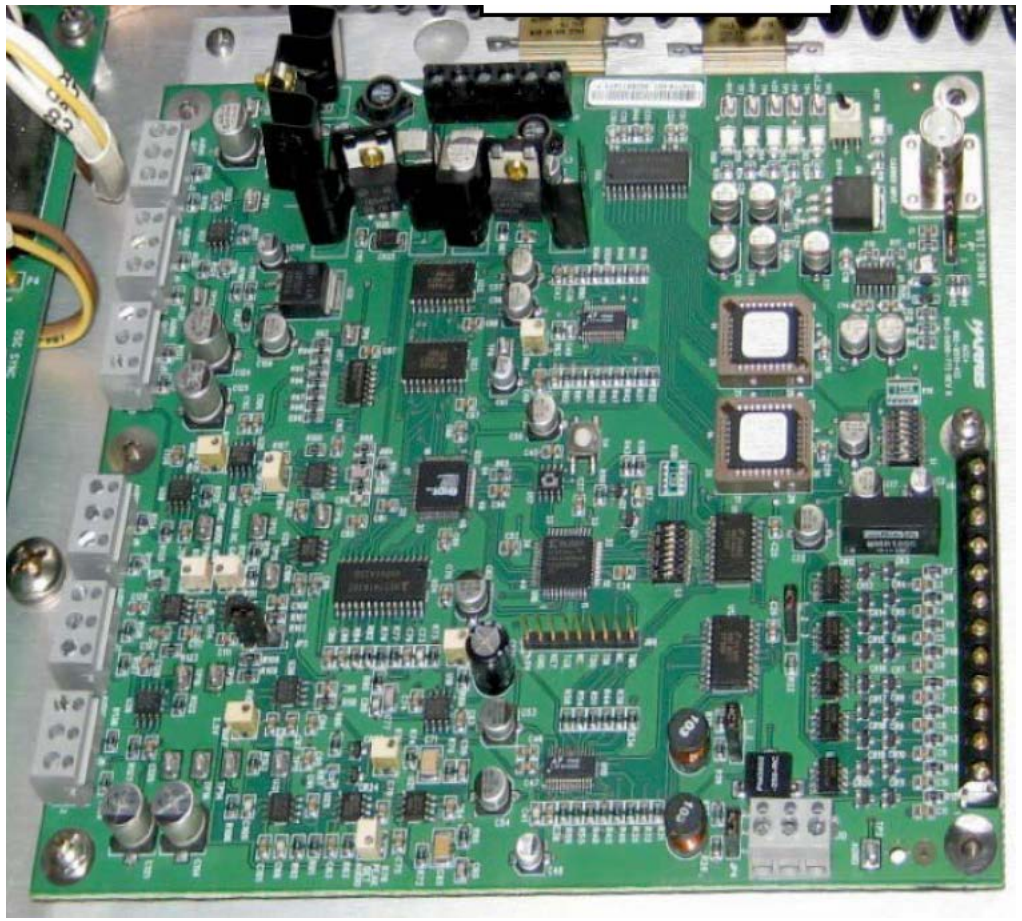
Amplitude Modulation Companding (AMC)



- **AMC** provides full carrier power during periods of less than 10% or no audio, and provides a maximum of 3 dB reduction to the transmitter's carrier power, with increases in audio input and modulation. There are no user selectable curve reduction adjustments.

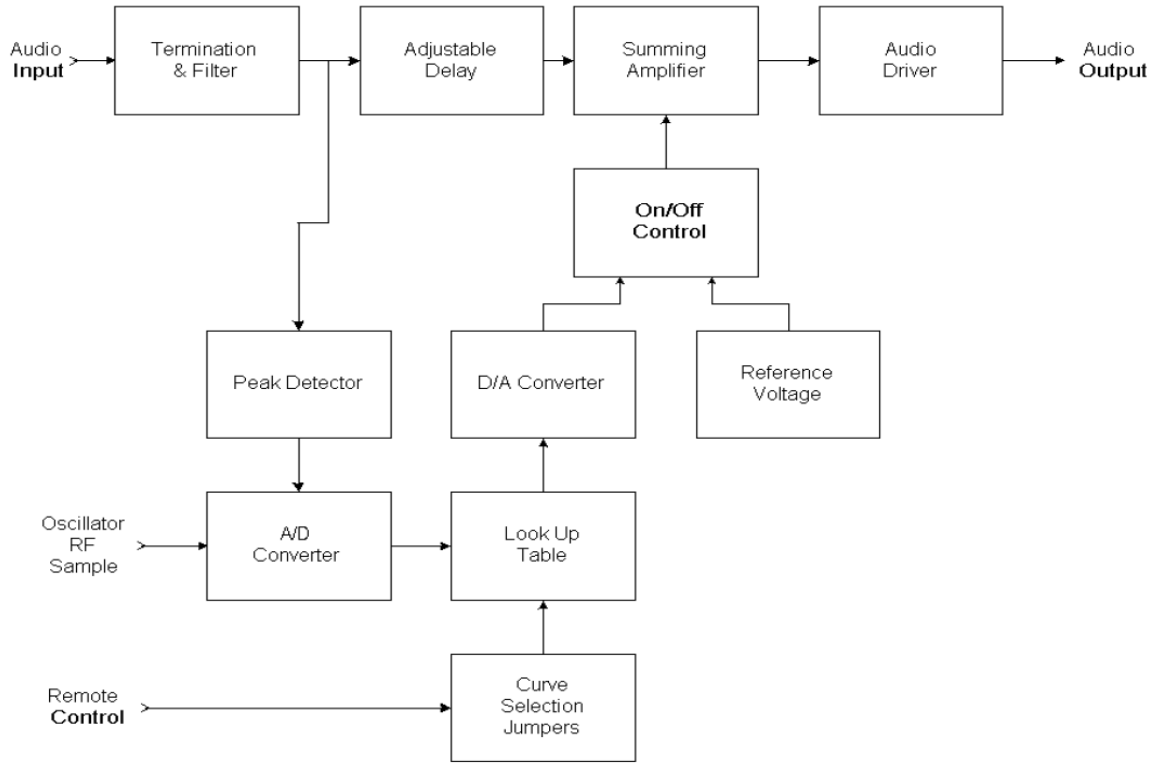
- Enhanced Amplitude Modulation Companding, or EAMC, increases the carrier power by 1.76 dB, then follows the same carrier reduction curve as AMC

MDCL OPTION BOARD



- GatesAir offers MDCL as an internal board kit or as a 1RU rack mount chassis, which can be implemented in virtually any transmitter.
- When implementing in DX or other legacy transmitters, two minor modifications are required.
- Audio input capacitors must be shorted to allow DC coupling in order to control the carrier power.
- Internal DC carrier control from the transmitter must be defeated

AMC / ACC SYSTEM BLOCK DIAGRAM



- Programming of the lookup table for U9 and U10 determines operation in the ACC or AMC
- All digital circuits are operating synchronously; clocked to the transmitter's carrier frequency for best performance and minimized inter-modulation products.

- MDCL circuitry is inserted in series with the audio path of the transmitter. The processor converts the analog audio to digital.
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- Using a lookup table consisting of two EEPROMs (U9 and U10) to create the digital representation of the dynamic carrier control is created which is then , converted back to an analog DC control voltage.
- The delayed audio and DC voltage for carrier control are then summed, gain controlled, and converted to a balanced input. A trim is also provided to match MDCL on and off modulation and carrier power parameters.

UPDATE - MDCL FOR AM TRANSMITTERS

- Used outside US for over 20 years on high power xmtrs
- Successfully tested by Alaska Public Radio earlier this year
- Energy saving technology – now permitted in US (waiver)
- MDCL provides significant reduction in power consumption without impacting audio quality, signal coverage, HD Radio operation, or Arbitron audience rating data
- Compatibility tests of (4) different MDCL algorithms
  - ACC (-2,-3,-4dB @ 0%) and AMC (-3dB @ 100%)
  - AM IBOC, HD Radio
  - Arbitron Portable People Meter (PPM) data encoding/decoding

FCC NOTICE ALLOWING MDCL TEST

- FCC Issued Public Notice DA-11-1535 on September 13, 2011
- AM licensees who wish to implement MDCL technology shall file with the Audio Division a letter requesting waiver of Section 73.1560(a) of the Rules
- MDCL Waivers:

  Federal Communications Commission

  Audio Division, Media Bureau

  445 12th Street SW, Room 2-B450

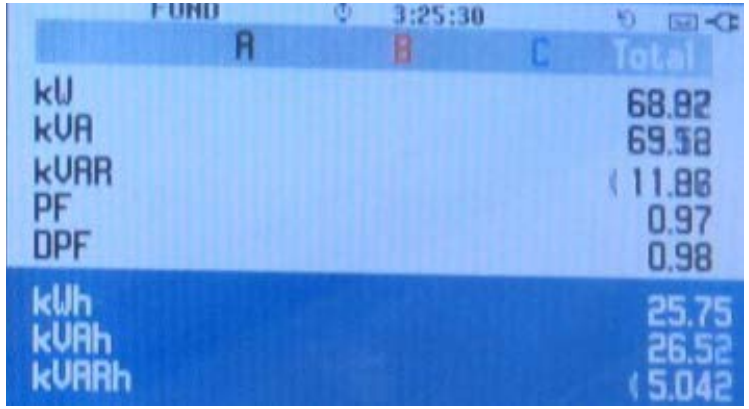
  Washington, DC 20554
- A copy of the request, in PDF format, sent by e-mail to Ann.Gallagher@fcc.gov
- Letter shall specify the technology the licensee plans to use and discuss its implementation at the licensee's station
- Upon favorable consideration of the letter request, the Audio Division will issue a modified station license indicating that a waiver has been granted to permit use of a specific MDCL technology, resulting in the variation of transmitter power to levels below 90 percent of the station's nominal licensed power
- Transmitter shall achieve full licensed power at some audio input level, or when the MDCL is temporarily disabled

WOR 710 AM – COMPATIBILITY TESTS

- GatesAir first to test on 50KW US AM station @ WOR 710 NYC in October 2011
- WOR received a FCC waiver to their license permitting “on air” tests of this energy saving technology
- The tests were conducted on a 50,000 Watt, GatesAir 3DX-50 transmitter feeding a three tower directional antenna array
- WOR’s programming format is news talk radio with heavily processed audio
- Listening tests at weak signal areas on several different types of receivers with digital, analog, and synchronous AM detectors showed no noticeable loss of audio quality
- iBiquity doing follow-up tests on HD Radio compatibility

WOR MDCL TESTS ON GatesAir 3DX50

POWER CONSUMPTION MEASURMENT



WOR - MDCL TEST SETUP

WOR Modulation Dependent Carrier Level Tests	
Date:	10/26/2011
Station:	WOR AM
Frequency:	710 kHz
Power:	50KW
Antenna:	3 tower DA-1
Transmitter:	Harris 3DX50 S/N PRD99655440001 10/08/04
Power Analyzer:	Fluke Model 434 power quality analyzer in power and energy averaging mode
Receivers:	Day Sequerra M2
	Kenwood KD-545U Auto radio
	Sony ICF-SW7600G Portable radio with both envelope and synchronous AM detectors

3DX-50 BASE POWER CONSUMPTION - WOR

Efficiency and Power Consumption with HD Radio IBOC = ON	
with normal analog modulation without MDCL (Test Run #1)	
3DX50 Front Panel Power Reading:	53KW
50 Ohm RF Load RF Amperes:	30.5A
Power Factor (1 second):	0.95
Average KW (1 second):	63 to 70KW
Average KW Hours(7.5 minutes):	8.34KWH
Average KW Hours (15.0 minutes):	16.68KWH
Average KW Hours (60.0 minutes):	66.72KWH
Average AC to RF Efficiency:	87.00%

ACC -3dB POWER CONSUMPTION

- 50KW EQUIVALENT COVERAGE ON GatesAir 3DX-50 TRANSMITTER

Efficiency and Power Consumption with HD Radio IBOC = ON	
with normal analog modulation and ACC+ (-3dB @ 0%)	
Slope=95% to 47.5% MDCL (Test Run #5)	
Normal HD Radio decoding and no PPM data errors "on air"	
3DX50 Front Panel Power Reading:	29 to 43KW
Antenna Common Point RF Amperes:	19.5 to 28.8A
Power Factor (1 second):	0.94
Average KW (1 second):	38 to 62KW
Average KW Hours (7.5 minutes):	6.46KW
Average KW Hours (15.0 minutes):	13.14KW
Average KWH Hours (60.0 minutes):	52.56KW
Average Percent Reduction in AC Power Consumption:	19.40%
(Compared to base line test run #2)	

ACC -6dB POWER CONSUMPTION

- 50KW EQUIVALENT COVERAGE ON GatesAir 3DX-50 TRANSMITTER

Efficiency and Power Consumption with HD Radio IBOC = ON		
and normal analog modulation with ACC+ (-6dB @ 0%)		
Slope=95% to 47.5% MDCL (Test Run #6)		
Normal HD Radio decoding and no PPM data errors "on air"		
3DX50 Front Panel Power Reading:	15 to 44KW	
Antenna Common Point RF Amperes:	12.5 to 28.8A	
Power Factor (1 second):	0.9	
Average KW (1 second):	17 to 65KW	
Average KW Hours (7.5 minutes):	6.32KW	
Average KW Hours (15.0 minutes):	12.95KW	
Average KWH Hours (60.0 minutes):	51.80KW	
Average Percent Reduction in AC Power Consumption:	22.30%	
(Compared to base line test run #2)		

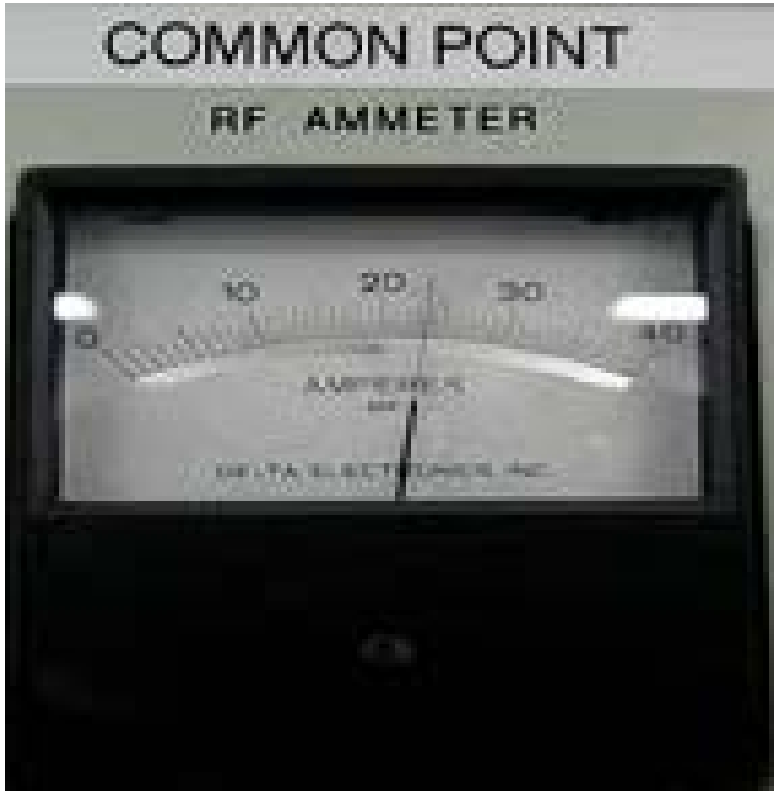
AMC -3dB POWER CONSUMPTION

- 50KW EQUIVALENT COVERAGE ON GatesAir 3DX-50 TRANSMITTER

Efficiency and Power Consumption with HD Radio IBOC = ON	
with normal analog modulation and AMC (-3dB @ 100%) MDCL (Test Run #1)	
Normal HD Radio decoding and no PPM data errors "on air"	
3DX50 Front Panel Power Reading:	29.5 to 39.0KW
Antenna Common Point RF Amperes:	22.5 to 29.0A
Power Factor (1 second):	0.92
Average KW Hours (1 second):	35 to 43KW
Average KW Hours (7.5 minutes):	5.21KWH
Average KW Hours (15.0 minutes):	10.43KWH
Average KW Hours (60.0 minutes):	41.72KWH
Average Percent Reduction in AC Power Consumption:	37.50%
(Compared to base line test run #1)	

WOR RF AMMETER

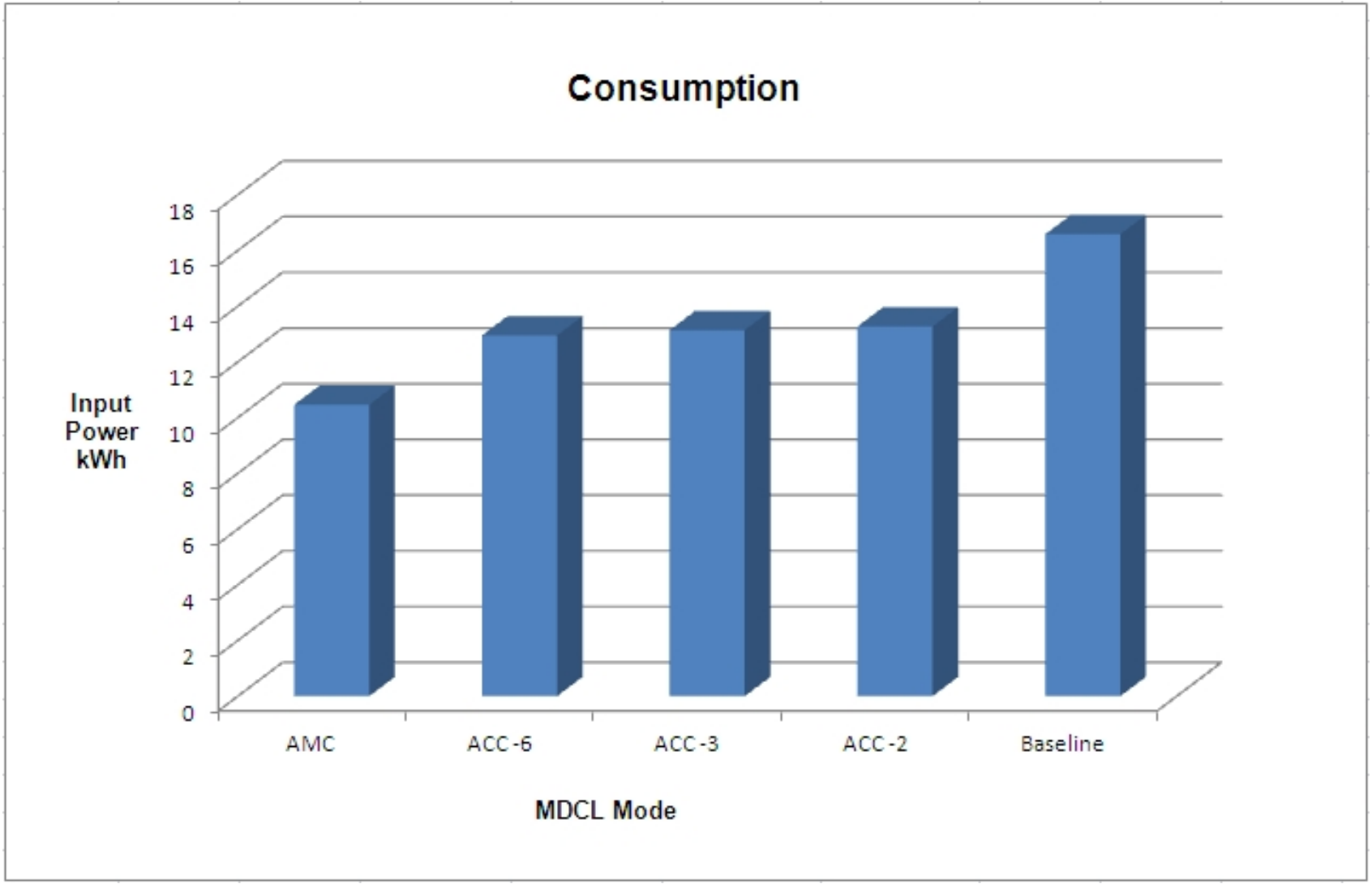
•Normal



•AMC @ -3dB

AVERAGE POWER OUTPUT – AMC -3dB

Power Consumption Summary



IBOC Considerations

- AMC is most compatible with IBOC
  - At low modulation depths the envelope is not reduced so the background noise from the IBOC is not increased
  - At higher modulation with the carriers reduced, the increased background noise is masked by the audio.
- Works best with enhanced carriers disabled
- Reducing the carrier has the same effect on spectral re-growth as raising the IBOC carriers

MDCL FOR AM - SUMMARY

- The algorithms tested were: Amplitude Modulation Companding (AMC) with a carrier reduction level of 3dB at peak modulation and Adaptive Carrier Control (ACC) at carrier reductions of 2dB, 3dB, and 6dB at minimum modulation
- The initial tests found that AMC was the most compatible with simultaneous HD Radio operation, causing no noticeable change in HD Radio coverage
- AMC also provided the largest reduction in transmitter power consumption, by saving 37% in average AC power input to the transmitter
- All of the AMC and ACC modes tested were fully compatible with Arbitron PPM data collection
- Measurements made by Arbitron in NYC showed no PPM data errors during the “on air” tests of any MDCL operating mode

Questions ?

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