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TRANSMISSION TALK TUESDAY

Episode #83

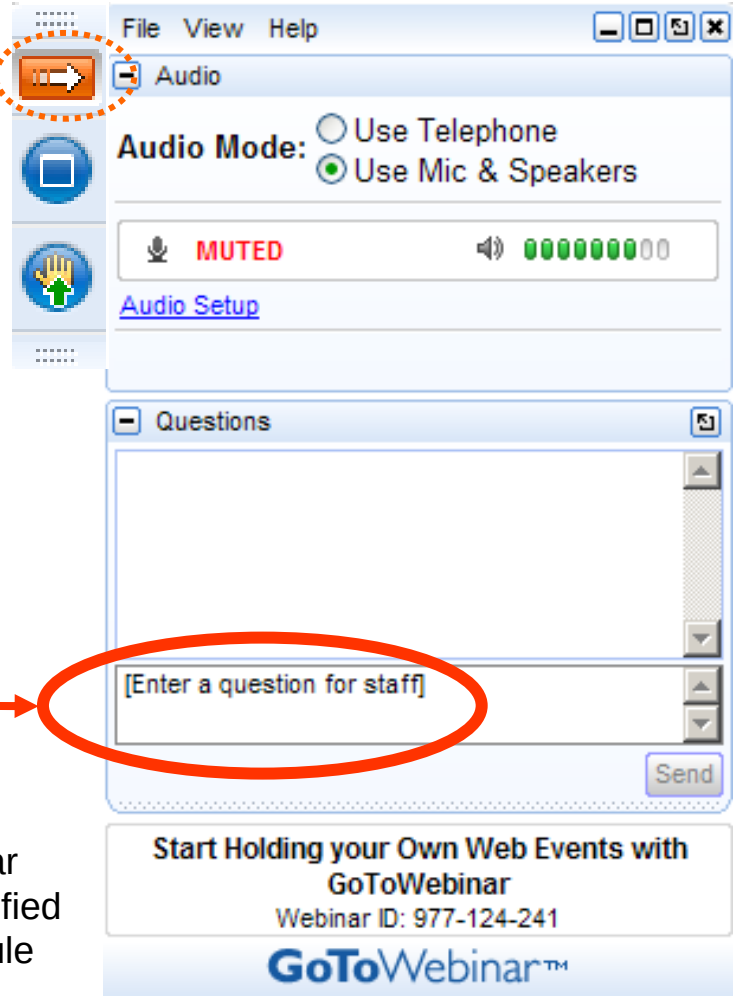
HD Radio from the Ground Up

nautel
AM/FM Radio Transmitters

Your questions please?

(if you don't see the control panel, click on the orange arrow icon to expand it)

Please enter your questions in the text box of the webinar control panel (remember to press send)



Remember: The completion of a Nautel webinar qualifies for ½ SBE re-certification credit, identified under Category I of the Re-certification Schedule for SBE Certifications.

Online Information

Webinars
https://www.nautel.com/resources/webinars/

Nautel Waves Newsletter
https://www.nautel.com/newsletters/

YouTube
http://www.youtube.com/user/NautelLtd

Online Info, such as the Broadcasters' Desktop Resource
https://www.thebdr.net/

TRANSMISSION TALK TUESDAY

Introduction

FM

- Combining techniques
  - Pros and cons of each
  - Optimizing systems

AM

- MA1 vs MA3
  - What's required for best performance

The "myths"

  - What they're based on
  - How to prevent them

- Future talk
  - How can broadcasting benefit?

Time Line

- 1992 – First HD Radio transmission (WILL,Champagne, IL)
- 2000 – USADR and Lucent Digital Radio merge
- 2002 – FCC authorizes use of IBOC
- 2009 – FCC authorizes increased HD injection levels
- 2017 – 2441 stations licensed to broadcast HD signals
    - 2103 (20%) of FM stations licensed for HD
- 2018 – 50% of new cars included HD radios

Pieces

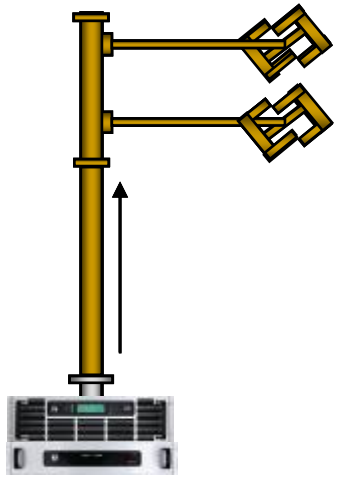
- Exporter – generates HD1 and multiplexes all HD data signals into one stream feeding Exgine in exciter.
- Importer – generates HD2/3/4, adds PAD and feeds this signal to the Exporter
- Exgine – usually found in Exciter now (or in Exporter in earlier systems), takes the HD data and creates an I/Q signal to drive exciter.

Transmitters: High level injection

- Less transmitter cost than hybrid
- No additional antenna required
- Higher HD injection level may reduce the analog TPO capability
- Much higher cost of operation, due to losses in injector
- Much bigger footprint
- Overall project cost could exceed other options significantly
- Requires a reject load

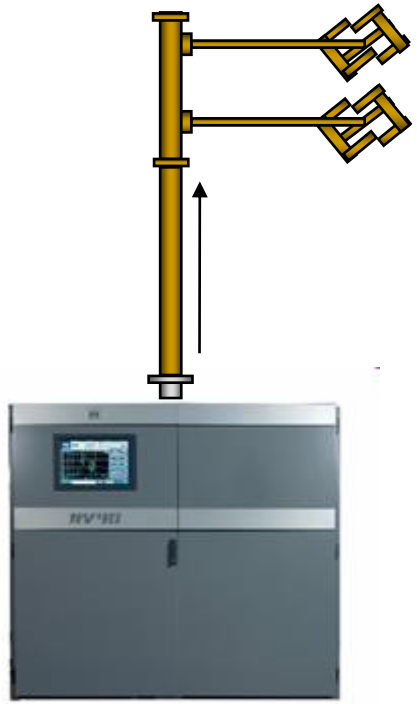
Transmitters: Space Combined

- More efficient
- Digital transmitter/antenna can be used as backup
- Takes up more space
  - In site
  - On tower
- Pattern replication issues



Transmitters: Hybrid (low level) Combined

- Simple architecture
- Single box installation
- Higher HD injection level may reduce the analog TPO capability
- May need to replace your transmitter or combine another for higher total power
- Higher injection levels reduce efficiency*



* HD PowerBoost increases digital injection and efficiency of an existing transmitter.

Transmitters: Backfed Combiner

- Sometimes effective in channel combiner applications, with multiple stations on site.
- Can be significantly restricted by combiner capabilities
- Cost of operation breaks even with hybrid at higher injection levels.

WETA-FM

History

- 1962 – FCC limited stations to 50kW or less
  - Wording was “commercial stations”

- 1970 (April) – WETA-FM signed on at 50kW
- 1970 – WETA applied for (and granted) license for 75kW
  - WETA is a Superpower!

- 1999 – USA Digital Radio installed test rig for HD
  - ERP: 75kW @ -20dB = 750W ERP
  - TPO: 32kW @ -20dB = 320W *going to antenna*

WETA-FM: 1999

- Analog - Nautel Q40 (two Q20s plus switchless combiner)
- Digital - Harris Z10 (heavily modified, by hand)
- Passive Power Products IBOC Combiner / Injector
- Bird Oil Filled Reject Load (10kW)

WETA-FM: 1999

Passive Power Products Combiner / Injector

- 90% efficient Analog; 9% efficient Digital
- Analog: 32kW @ Antenna; needs 35.5kW TPO
- Digital: 320W @ Antenna; need 3.5kW TPO
- Excess power is heat: 35.5-32+3.5-0.320 = 6.68kW
- 6.68kW = 22,792 BTU = 1.9 tons of heat

Q40

- 68% efficient; 16.7kW heat = 57,000 BTU = 4.7 tons

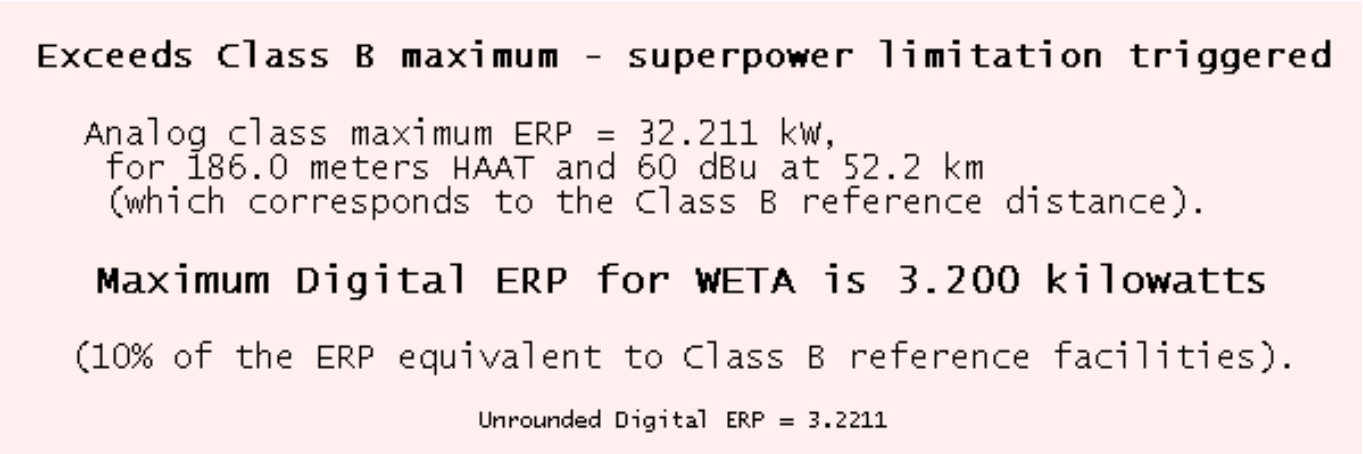
Z10

- 26% efficient; 13.5kW heat = 46,000 BTU = 3.8 tons

TOTAL HEAT = 10.4 TONS

WETA-FM

- 2010 – FCC allows increase to -14dB – not for Superpower
- https://www.fcc.gov/media/radio/digital-radio-superpowered-fm-stations
- "…digital ERP is limited to 10% of the ERP which, for the station's antenna height, would produce a 60 dBu (1 mV/m) contour distance equivalent to the reference facilities for the station's class…"



13.7dB

WETA-FM: 2013

- Analog - Nautel Q40 (two Q20s plus switchless combiner)
- Digital – Nautel NV15
- ERI 788A IBOC Combiner
- Air Cooled Reject Load (5kW)

WETA-FM: 2013

ERI 788A Combiner

- 92% efficient Analog; 73% efficient Digital
- Analog: 32kW @ Antenna; needs 34.8kW TPO
- Digital: 3.2kW @ Antenna; need 4.38kW TPO
- Excess power is heat: 34.8-32+4.38-3.2 = 3.98kW
- 3.98kW = 13,579 BTU = 1.1 tons of heat

Q40

- 68% efficient; 16.7kW heat = 57,000 BTU = 4.7 tons

NV15

- 32% efficient; 13.7kW heat = 46,744 BTU = 3.9 tons

TOTAL HEAT = 9.7 TONS

WETA-FM: 2013 – Hybrid (Theoretical)

Nautel NV40 Hybrid Transmitter

- Analog: 32kW TPO
- Digital: 3.2kW TPO
- 47% efficient (approx) 40% @ -10dB; 55% @ -20dB
- 36kW heat = 122,832 BTU = 10.26 tons

TOTAL HEAT = 10.26 TONS

WETA-FM: 2023 – Hybrid (Theorectical)

Nautel GV40 Hybrid Transmitter

- Analog: 32kW TPO
- Digital: 3.2kW TPO
- 60% efficient
- 21.3kW heat = 72,788 BTU = 6.07 tons

TOTAL HEAT = 6.07 TONS

Opinions on High Level Combining

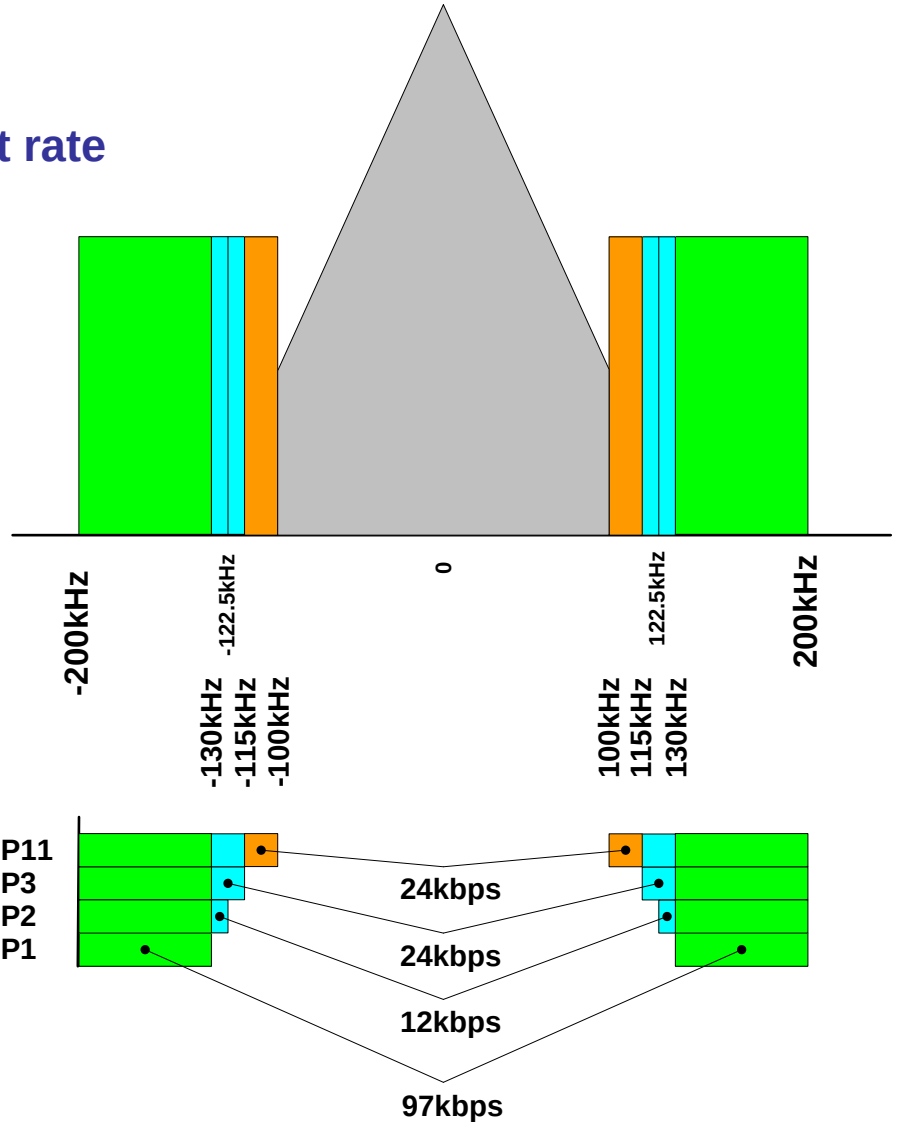
- Doesn’t make sense for stations under 20kW (2013)

- Advantage – Redundancy
- Advantage – Reduced Capital Expenditure

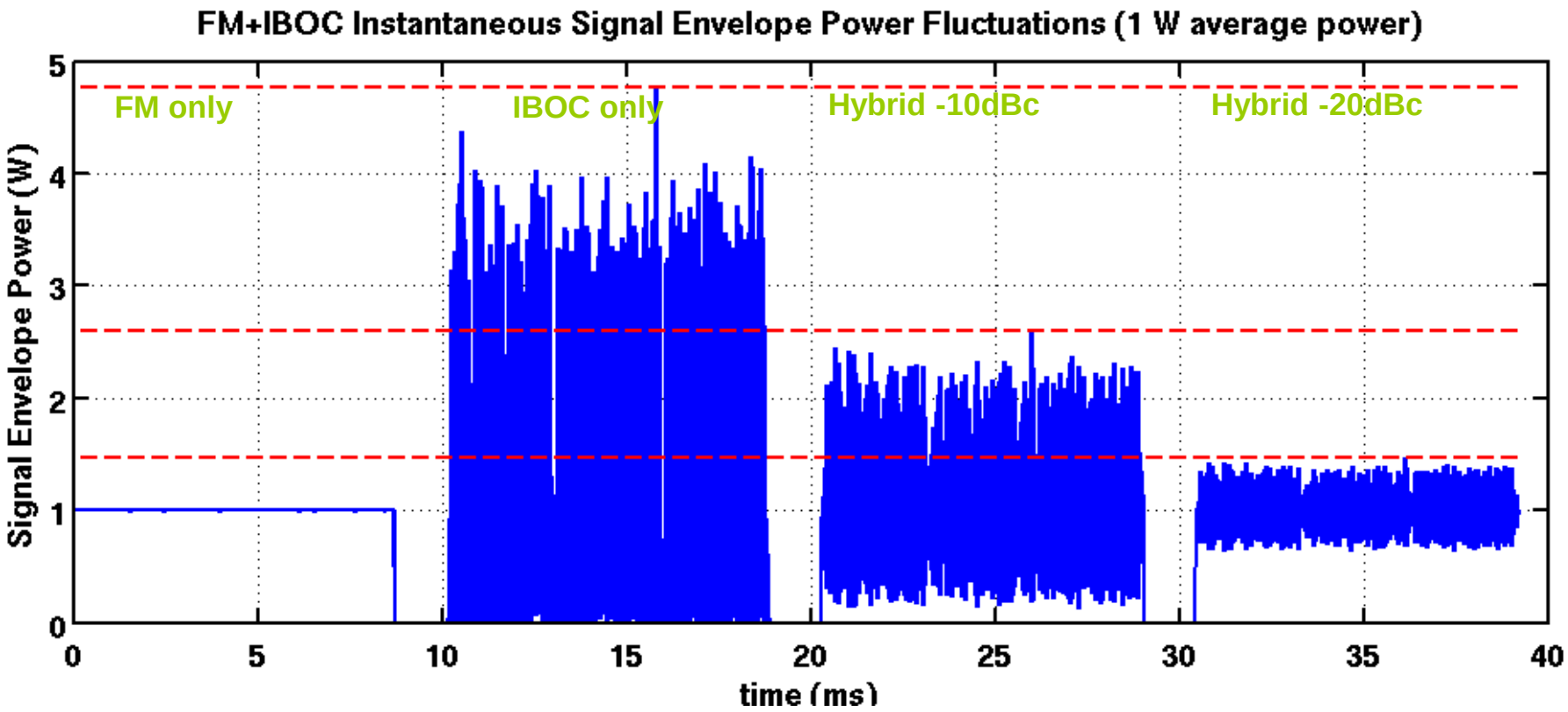
- Drawback – Space
- Drawback – Complexity

Hybrid FM modes

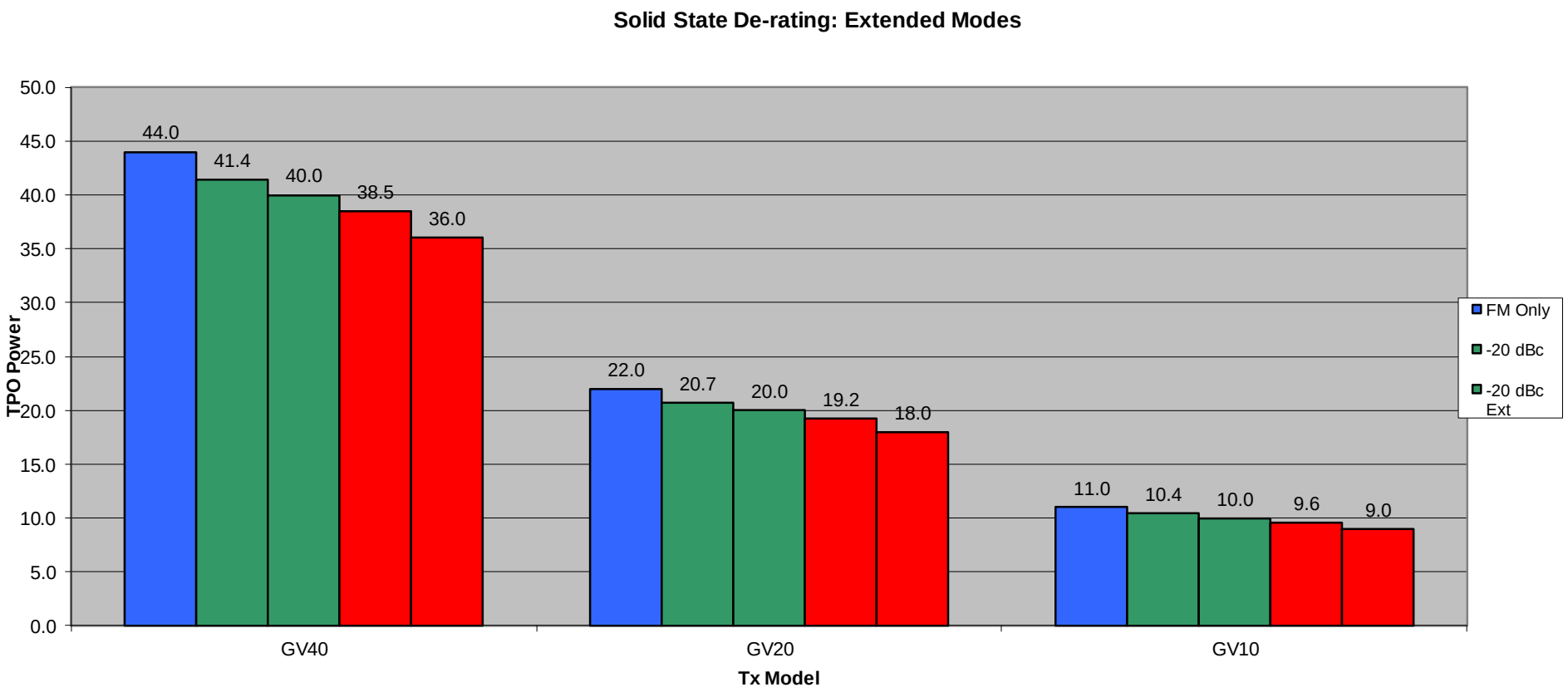
Frequency allocation vs. bit rate



Relative Power Requirements



Extended Mode Derating (MP1 vs MP3)



Power considerations

- MP Mode: MP1 MP3
- Injection level
- PowerBoost vs no PowerBoost, or Gen 3 vs. Gen 4 (or Gen 5)
- VSWR
- Headroom
- Work with your representative

Program Associated Data (PAD)

- PAD typically requires additional equipment/software. Arctic Palm CSRDS (more later), or Enco PADapult, for example.

- Ports for PAD are manufacturer specific.

- Requires JMSAC to be implemented on Importer (included with HDMC+)
  - http://www3.nautel.com/pub/Importer/JMSAC/windows/2.0.5/

- Album art can be used (requires license and may need 3rd party SW), or station logo/art – specs for config can be found in: http://www3.nautel.com/pub/Importer/JMSAC/windows/2.0.5/Artist%20Experience_JMSAC.pdf

Other considerations

- Infrastructure (getting either analog plus HD data or three analog channels from studio to site, as well as any RDS/PAD).

- Peak voltages – remember to allow 6dB margin for the digital power
  - E.g.- a 10kW analog TPO, at -10dBc injection, requires components capable of 14kW…

    10kW + (1kW * 4)

- Processing required for HD signals. Needs to be optimized for low bitrate audio – streaming processor vs. FM processor.

Other considerations

- STL… must handle bitrates. Must be stable with respect to dither.

- IP conflicts – use QoS routing when possible. Note IP addresses and port assignments.

- Sample rate conversions… down is okay, up is bad. Avoid as much as possible.

Other considerations

- Audio levels can be set in board, processor, some STLs, Exporter and Exciter. Especially when using AES/EBU, keep the reference level the same throughout the chain – it helps to make troubleshooting easier.

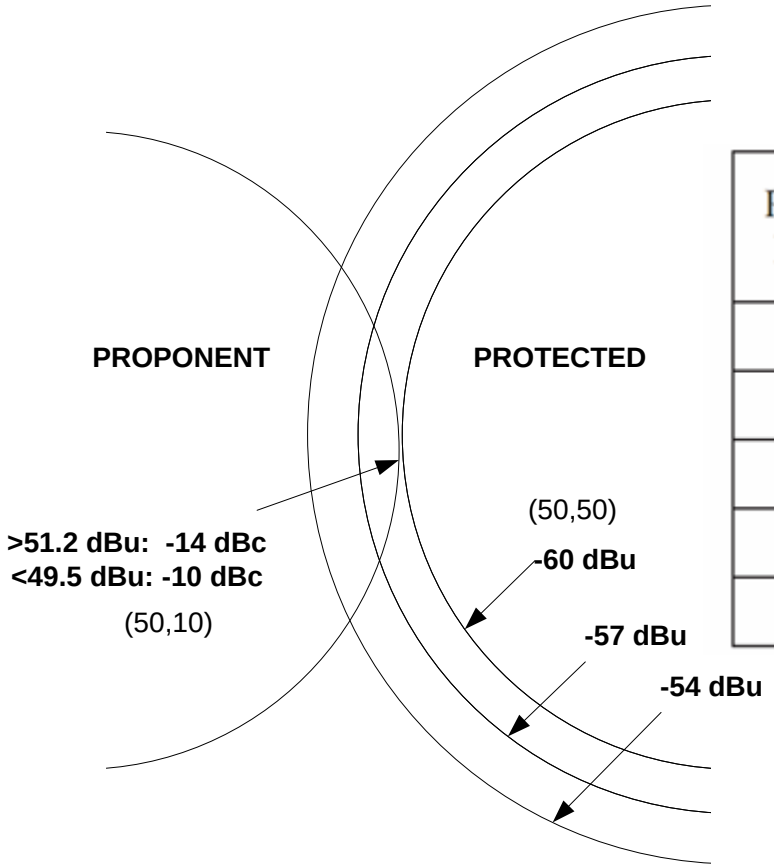
- Audio delay can be set in the Processor, Exporter or some Exciters… determine if you want your analog running through the Exporter.

- Time alignment is critical.
  - Common location can rely on audio synch/GPS
  - Paths with latency or dither may require correction (e.g.- Inovonics JUSTIN 808)

Why **Asymmetrical?**

- Manage coverage vs interference
- 4,000 stations can benefit
- Both AM/FM can benefit
- Here, we're just discussing FM

Adjacent Channel **Protection**



Proponent Analog F(50,10) Field Strength at Protected Analog 60 dBu F(50,50) Contour	Maximum Permissible FM Digital ERP
51.2 dBµ and above	-14 dBc
50.7 dBµ - 51.1 dBµ	-13 dBc
50.3 dBµ - 50.6 dBµ	-12 dBc
49.6 dBµ - 50.2 dBµ	-11 dBc
49.5 dBµ or less	-10 dBc

Coverage Reduction by increased MER

Data Carrier MER	Reduction in Service Contour
18 dB	.22 dB
17 dB	.25 dB
16 dB	.31 dB
15 dB	.37 dB
14 dB	.48 dB
13 dB	.59 dB
12 dB	.74 dB
11 dB	.91 dB
10 dB	1.13 dB
9 dB	1.38 dB
8 dB	1.73 dB

iBiquity system typically is 17.5 dB

Nautel's most aggressive PAPR is 16.5, well exceeding the spec of 14

Means a 20 kW transmitter can produce 15 kW of analog + HD (at -10 dBc) compared with ~11 kW without Nautel PAPR.

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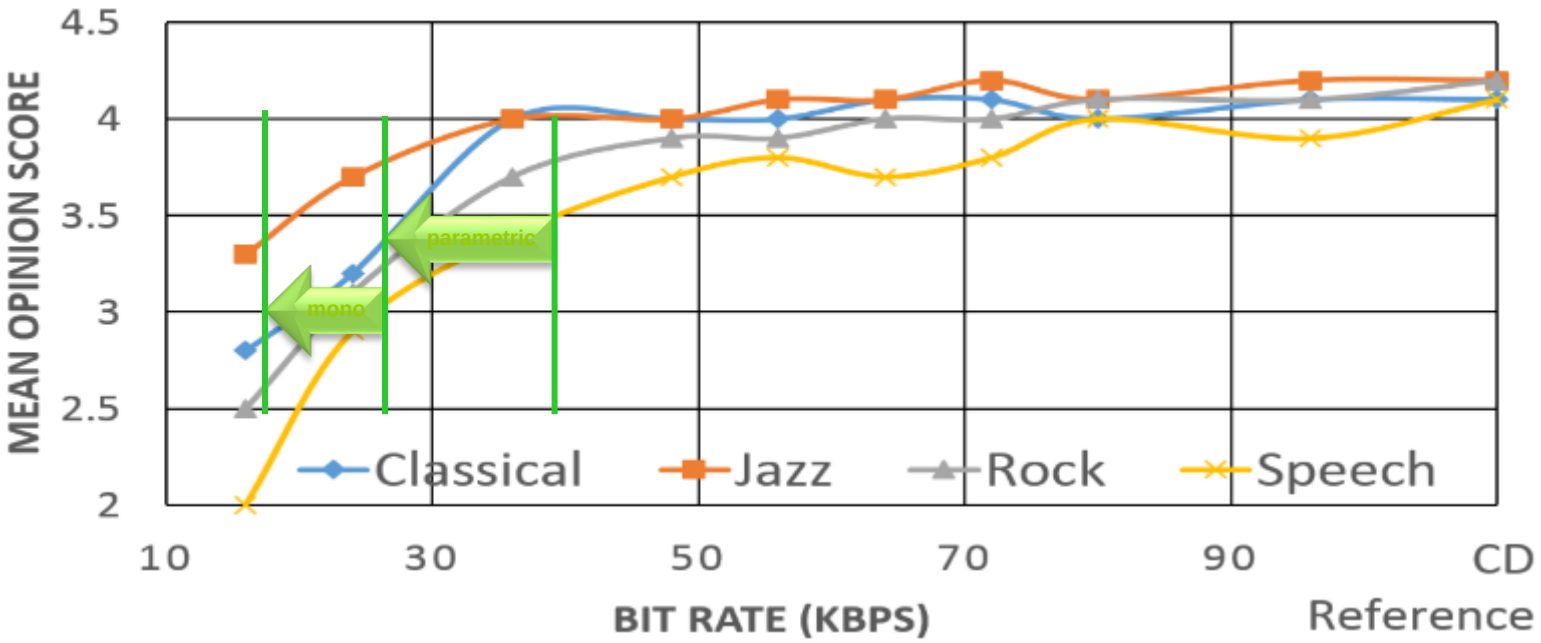
HD Radio: Perceptual Codec Performance



Consumer listening tests

- Most cannot tell quality improvement above 48 kBps
- Stereo mode good performance until 36 kBps
- Parametric stereo good performance until 24 kBps
- Mono mode good performance until 16 kBps
- HD audio processing and pre-conditioning is key

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54 years of NAUTEL 1969 2023

THANK YOU!

nautel
AM/FM Radio Transmitters