AM Radio

Still Sexy after 100+ years!

Jeff Welton, Regional Sales Manager, Central U.S.

Agenda

- A bit about the technology
- What cool things can we do now?
  - efficiency
  - MDCL
  - MA3
- Where is it going?

Relative Efficiency of Amplifier Classes

Amplifier Class	Anode Efficiency (%)
A	30
A–B	60
B	67
C	84
C–D	90
D	95

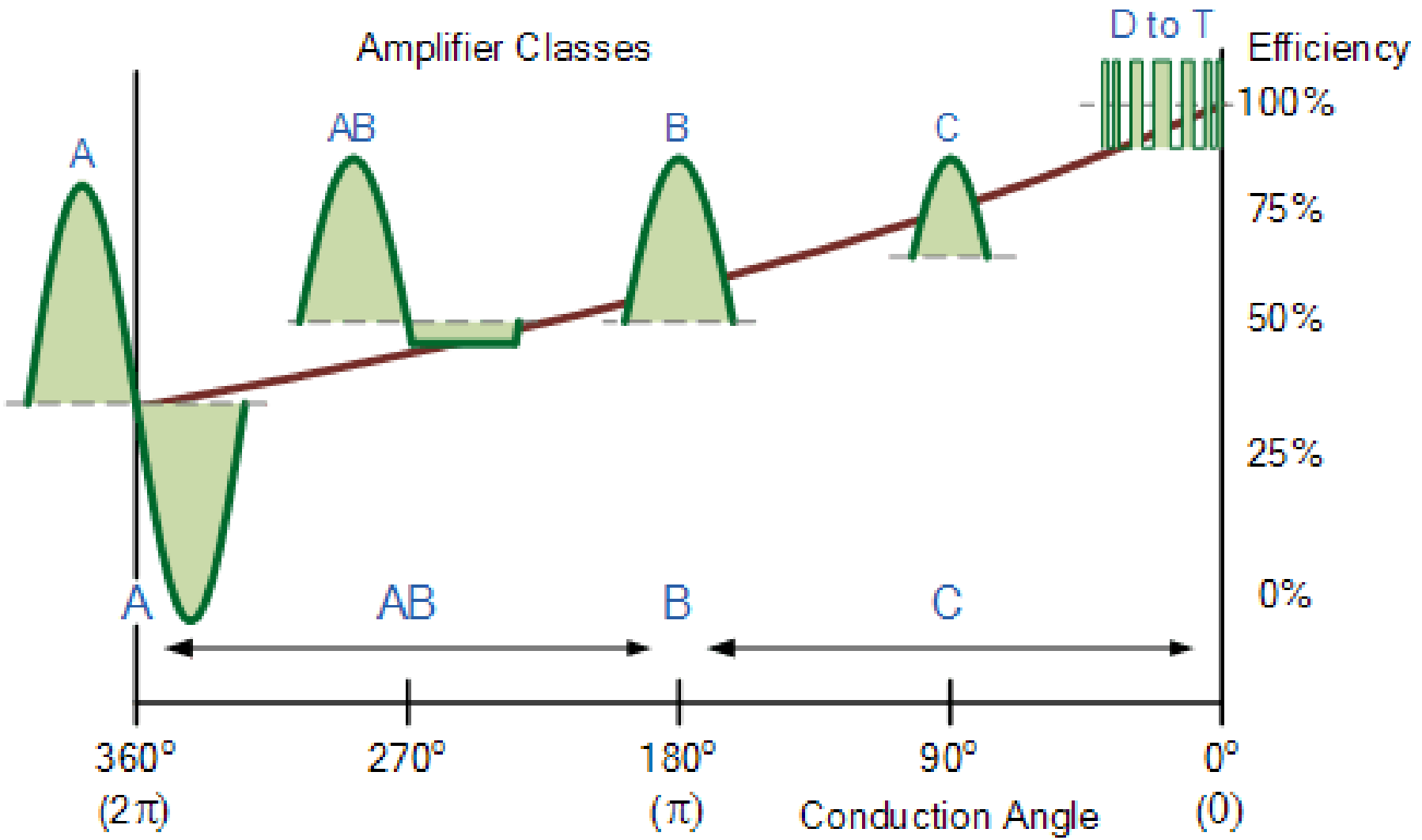
Class A
- very linear
- always on
- most inefficient

Class B
- only conducts for half a cycle
- more efficient than class A
- crossover distortion

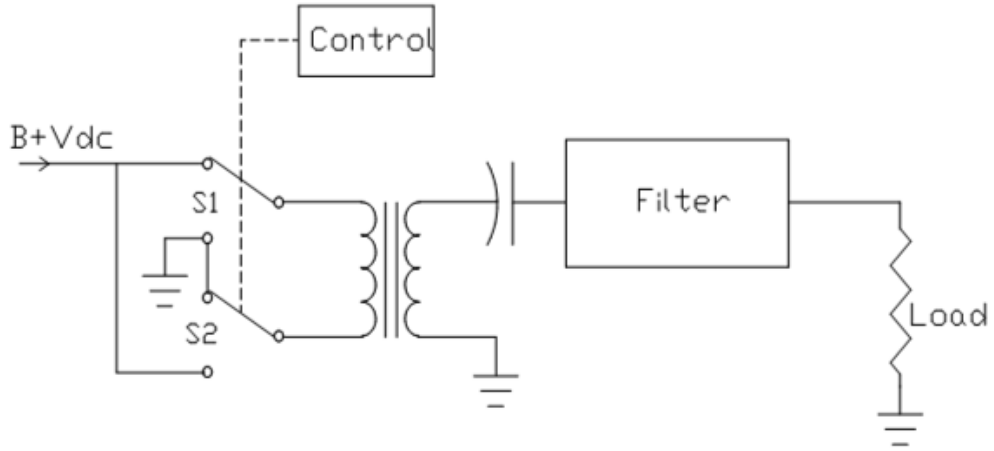
Class AB
- biased to conduct through zero crossing
- resolves crossover distortion

Class C
- better efficiency
- less linearity
- not great for audio, but good for analog RF

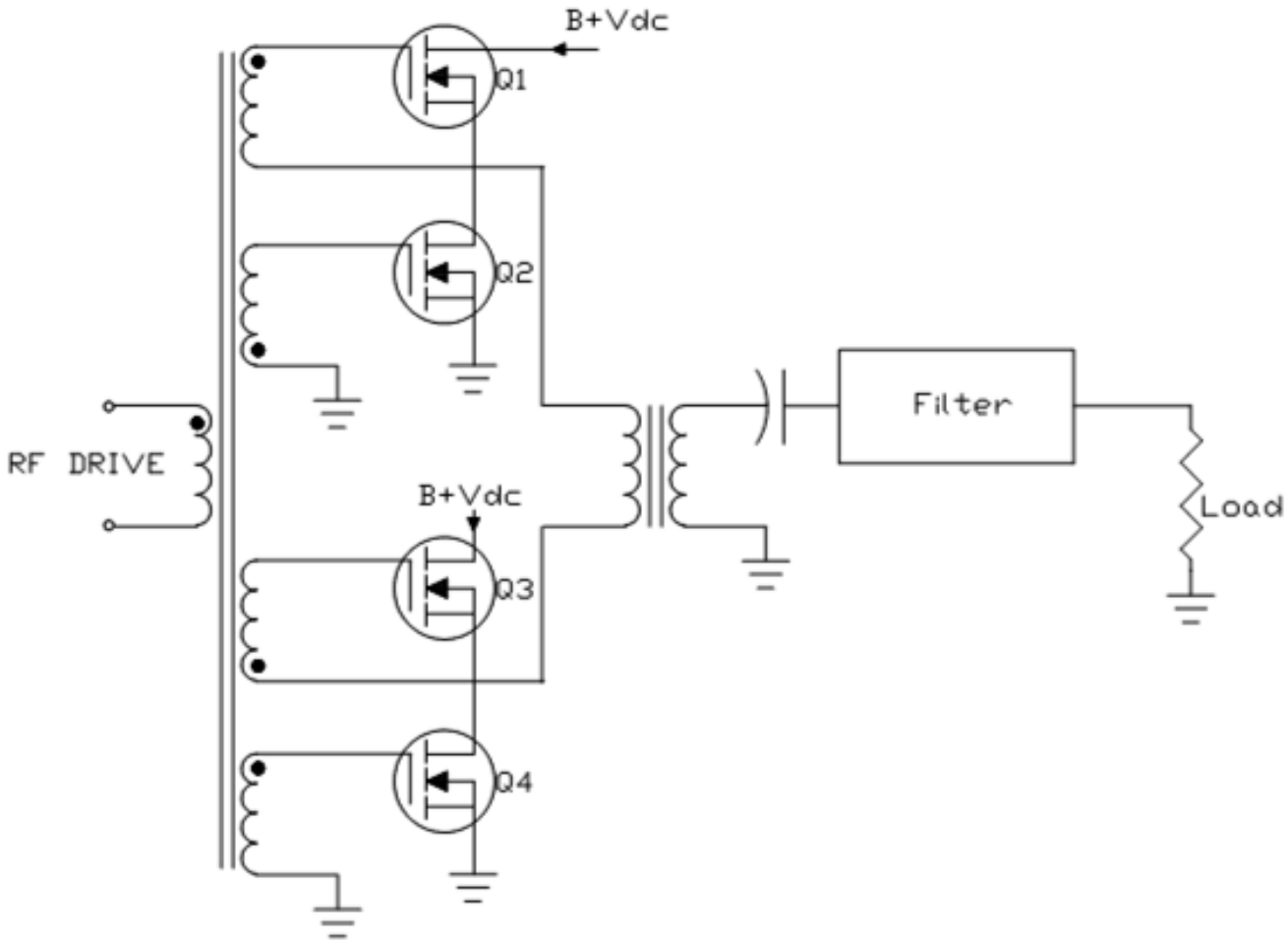
Class D
- best efficiency
- is a switch, full saturation or cutoff, no linear portion



https://www.electronics-tutorials.ws/amplifier/amplifier-classes.html



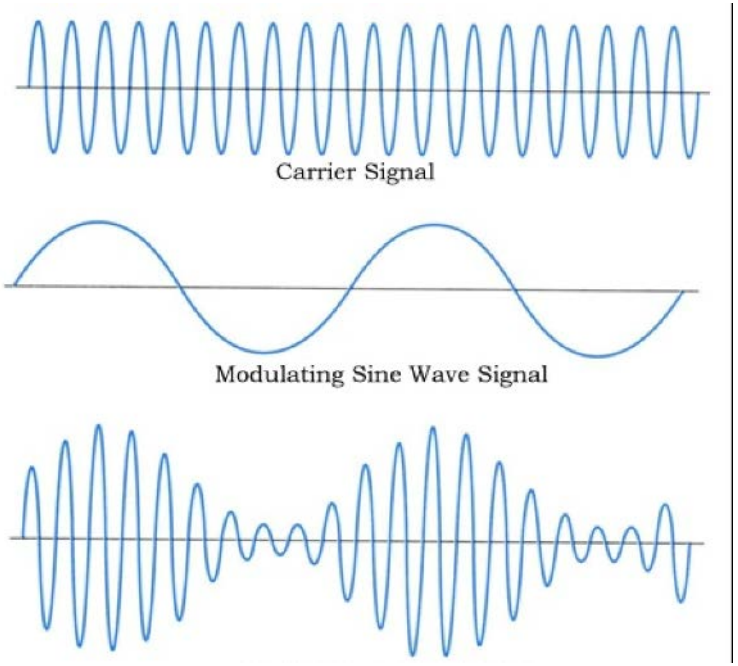
Simplified Class D Amplifier (push-pull configuration)



Class D Amplifier (push-pull configuration) using MOSFETs

AM Radio

- Outside of Spark-Gap and CW it's the oldest form of modulation
- Take a carrier and modulate it with audio!
- Simple and easy to implement and it's been on the air for 100 years



nautel orban

AM Power Saving

AM Efficiency

- The downside to AM
  - Very inefficient to transmit
  - The AM carrier uses 66% of the transmitter power
    - Yet delivers no information!
    - Even with modern PWM AM transmitters the power consumption for a 50 kW AM station is substantial
  - So how do we make AM more efficient?
  - We modify transmitted waveform to reduce power without reducing received quality in receivers - MDCL

AM Efficiency

Forms of MDCL (also known as DCC – Dynamic Carrier Control) have been used for decades in ham radio.

DCC or variations have been used in European AM broadcast since the 1980s and have been available for Nautel transmitters since 1995.

At NAB2009, Nautel presented a white paper on MDCL.

In late 2010, Alaska Public Radio was granted experimental authorization to begin testing MDCL on several of its stations.

In September 2011, the FCC issued a Public Notice (DA 11-1535) approving the use of MDCL and leaving the specific algorithm up to the individual broadcasters.

Since then, several US broadcasters have implemented MDCL and have reported power savings of 20-40%

The Ingredients: Achieving exceptional power savings

NX Series AM Transmitters

Only NX Series transmitters have advanced digital modulation that permits high signal density, exceptional power savings, noise floor and loudness improvements.

-6 dB MDCL

Nautel has worked with broadcasters to develop Modulation Dependent Carrier Level (MDCL) parameters that result in significantly higher power savings.

Orban XPN-AM

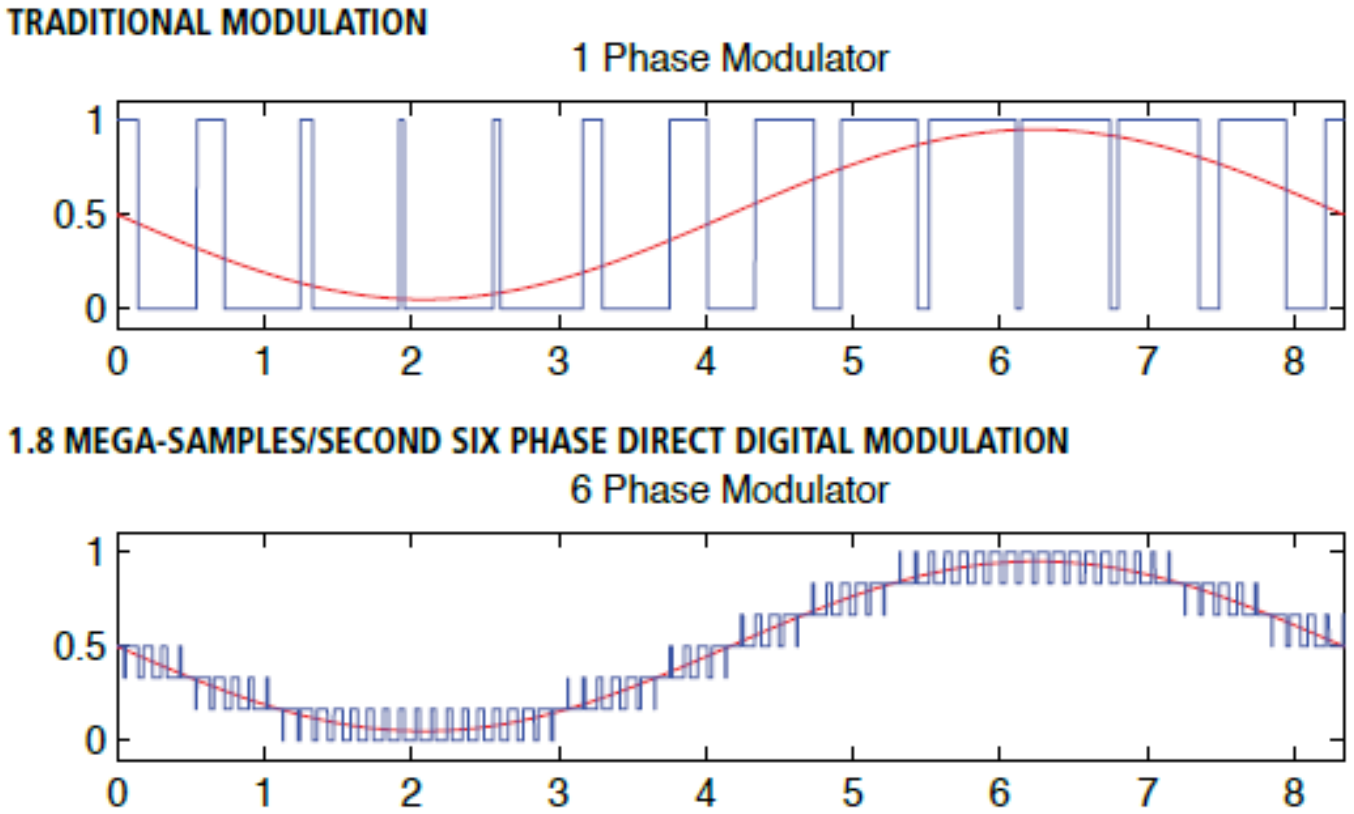
The XPN's revolutionary limiter offers unprecedented loudness, cleanliness, crispness, speech intelligibility, and coverage. Greater density with lower distortion can significantly reduce power consumption.

NX Series: Digital modulation allows high density

Why this matters?

- Higher sample rates
- Can crank up the density without creating as many audible artifacts.

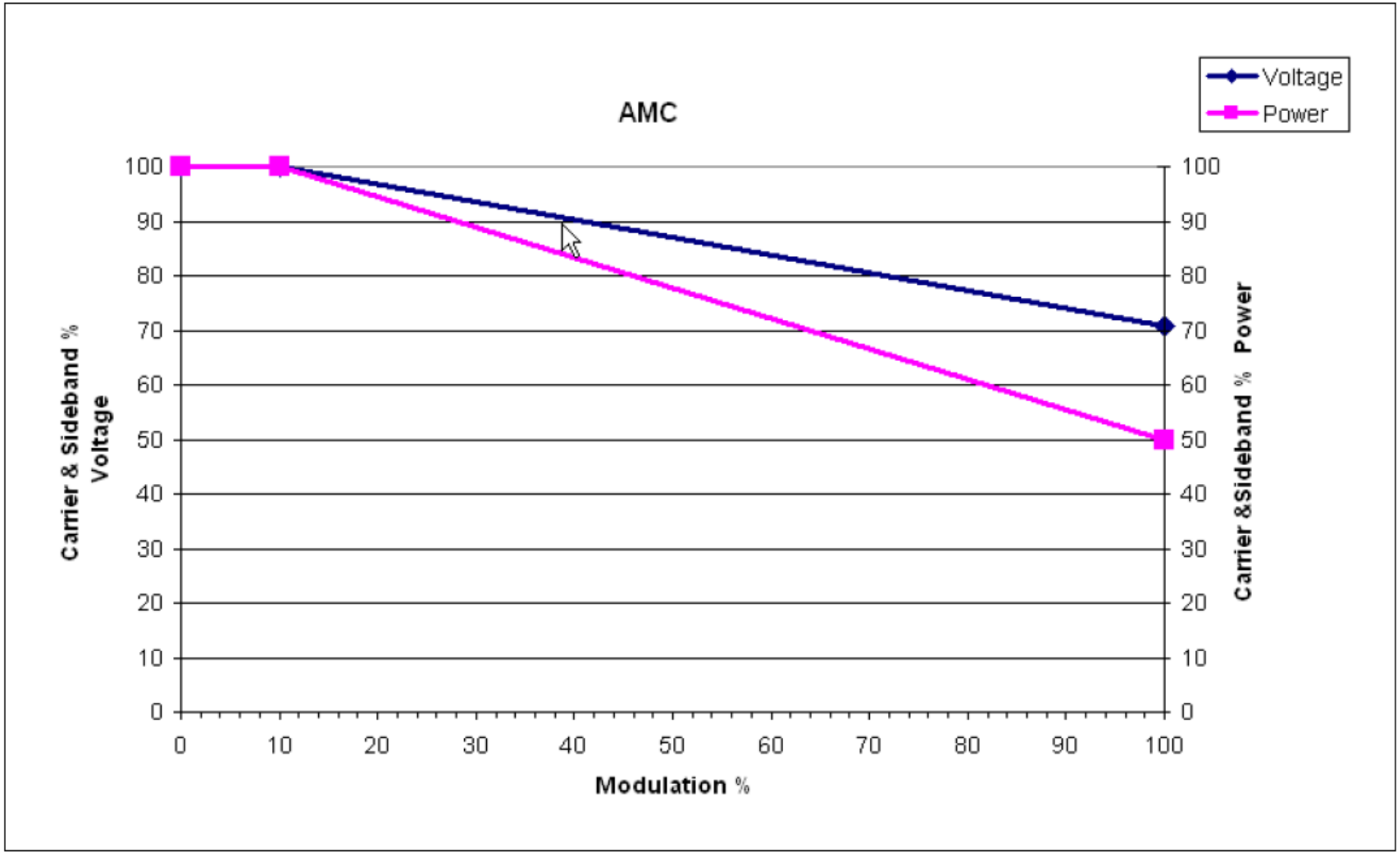
1.8 MHz Direct Digital Modulation



AM MDCL AMC

- Carrier and modulation together are decreased with increasing audio modulation
- The carrier is increased to full power during quiet periods when noise is most easily perceived
- As modulation density has substantially increased with modern audio processing AMC can generate greater efficiency
- Significant power savings

AM MDCL AMC Gain Function



Field Testing

AM 100% Symmetrical Field Strength uV/m	dBm	AC Power kW	MDCL AMC 125%	Field Strength uV/m	dBm	Delta dBm	AC Power kW	Delta AC kW	Reduction in power consumption
610	-51.28	5.26	3 dB	436	-54.20	-2.92	2.74	-2.52	-47.83%
			4 dB	386	-55.28	-4.00	2.21	-3.05	-57.98%
			5 dB	349	-56.13	-4.85	1.96	-3.30	-62.74%
			6 dB	325	-56.75	-5.47	1.18	-4.08	-77.51%

Field Test Results

- Greater carrier suppression
  - Higher modulation density gives the MDCL system the ability to suppress the carrier to a much greater extent for longer periods of time
- 77% power reduction
  - At 6dB of AMC, 77% reduction in transmitter power consumption
- Slight degradation in fringe coverage at AMC levels > than 3 dB
- Zero listener complaints
  - Townsquare & Bonneville stations running 6 dB AMC on NX transmitters have significant power savings and zero listener complaints since 2020
  - **WEPN 1050 KHz, WINS 1010 KHz,WNYM 970 KHz,WCBS 880 KHz,WABC 770 KHz,WFAN 660 KHz all in New York City**

What next?

- Calculator
- Leasing options
- Contact

AM Power Savings

Replacing legacy technology with a Nautel NX Series MW transmitter running MDCL could yield energy savings of up to $100,000 USD per year based on real world examples.

Calculate your energy savings with Nautel's MDCL technology

Enter values into the green cells to estimate your savings.

	Select Modulation Density		Mild		
	Current	NX Power 50	DCC MDCL	AMC 3dB MDCL	AMC 6dB MDCL
Cost per kW/h (US cents)	15	15	15	15	15
Power of Transmitter in kW	50	50	50	50	50
Rated Efficiency	73%	88%	88%	88%	88%
Modulation Factor	1.1	1.1	1.1	1.1	1.1
Consumption in kW/H	75.30	62.50	34.40	50.00	43.80
Hours of Operation / Day	24	24	24	24	24
Days of Operation / Year	365	365	365	365	365
Total Yearly					

www.nautel.com/am-mdcl-savings/

- All-digital AM may be a long-term solution for AM radio
  - Significantly more immune to noise and interference than either analog or hybrid digital AM
  - Improved audio quality (as good or better than analog FM)
  - Potential to support data services and multicasting
  - **Receivable on EXISTING HD Radio receivers**
- All-digital AM is significantly better than hybrid digital AM
  - *Hybrid digital AM is currently-authorized HD Radio signal*
- NAB Labs test project to fully characterize all-digital AM is well underway

All-digital AM

- There are a lot of AM broadcasters in the U.S.
- As of December 31, 2020:

AM STATIONS	4551	
FM COMMERCIAL	6699	
FM EDUCATIONAL	4195	
TOTAL		**15,445**
UHF COMMERCIAL TV	994	
VHF COMMERCIAL TV	377	
UHF EDUCATIONAL TV	267	
VHF EDUCATIONAL TV	120	
TOTAL		**1,758**
CLASS A UHF STATIONS	357	
CLASS A VHF STATIONS	31	
TOTAL		**388**
FM TRANSLATORS & BOOSTERS	8420	
UHF TRANSLATORS	2572	
VHF TRANSLATORS	834	
TOTAL		**11,826**
UHF LOW POWER TV	1517	
VHF LOW POWER TV	494	
TOTAL		**2,011**
LOW POWER FM	2136	**2,136**
TOTAL BROADCAST STATIONS		**33,564**

All-digital AM

- Principal drawback: all-digital signal not receivable on analog-only radios
  - Introduction of all-digital service requires significant penetration of HD Radio receivers in marketplace
- Another issue: all-digital is not authorized by the FCC
  - Prior to NAB Labs effort, very little testing on all-digital AM
  - First step towards getting FCC authorization is to develop a technical record of all-digital system performance

All-digital AM – test project partners

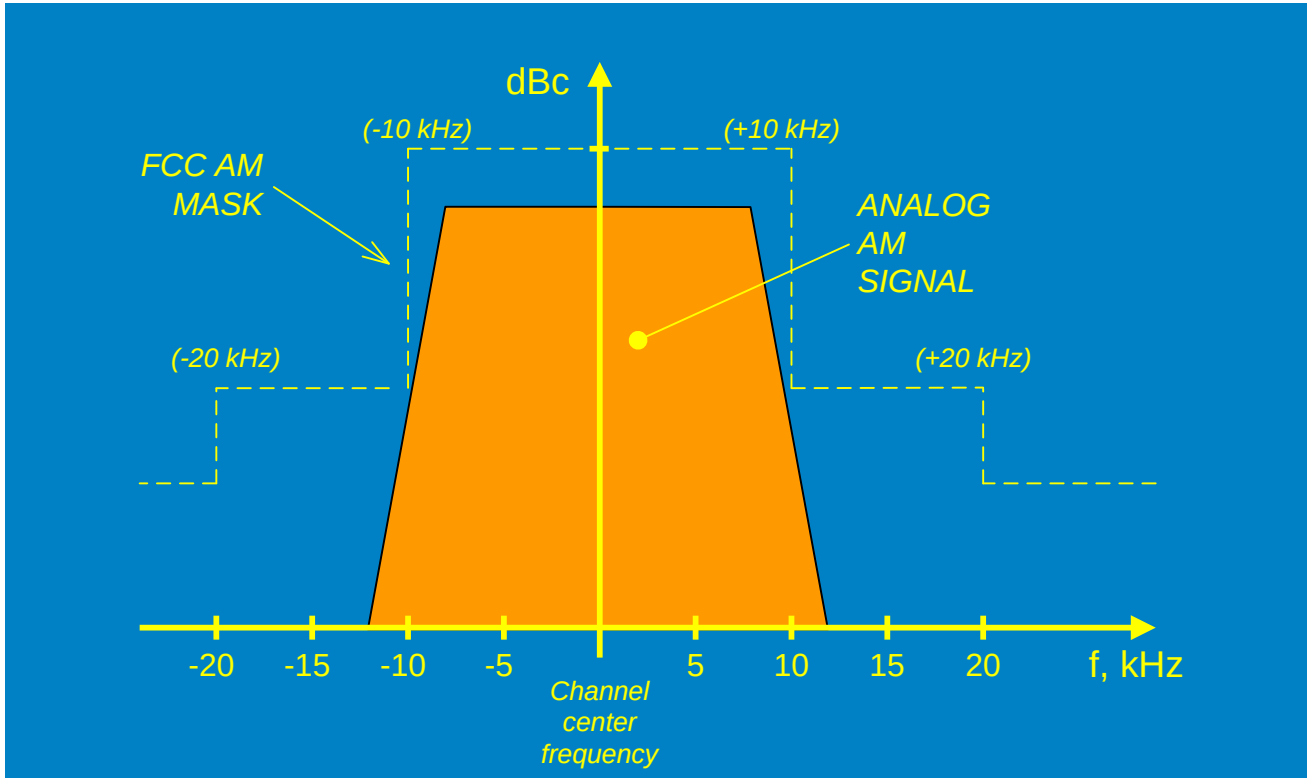
- Broadcasters:

- Equipment manufacturers:

- Others:

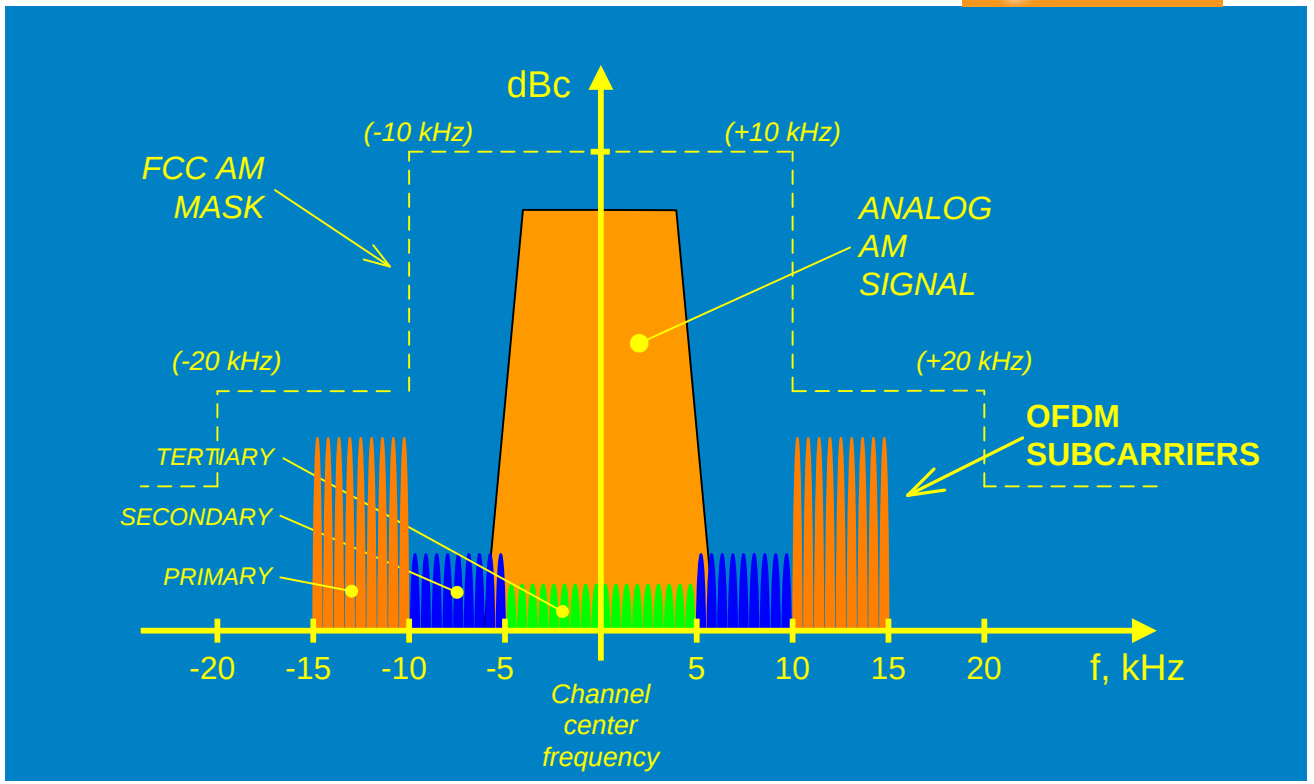
All-digital AM IBOC

- Analog AM signal
  - Plagued by high levels of noise and interference
  - No data capability, not even song title and artist



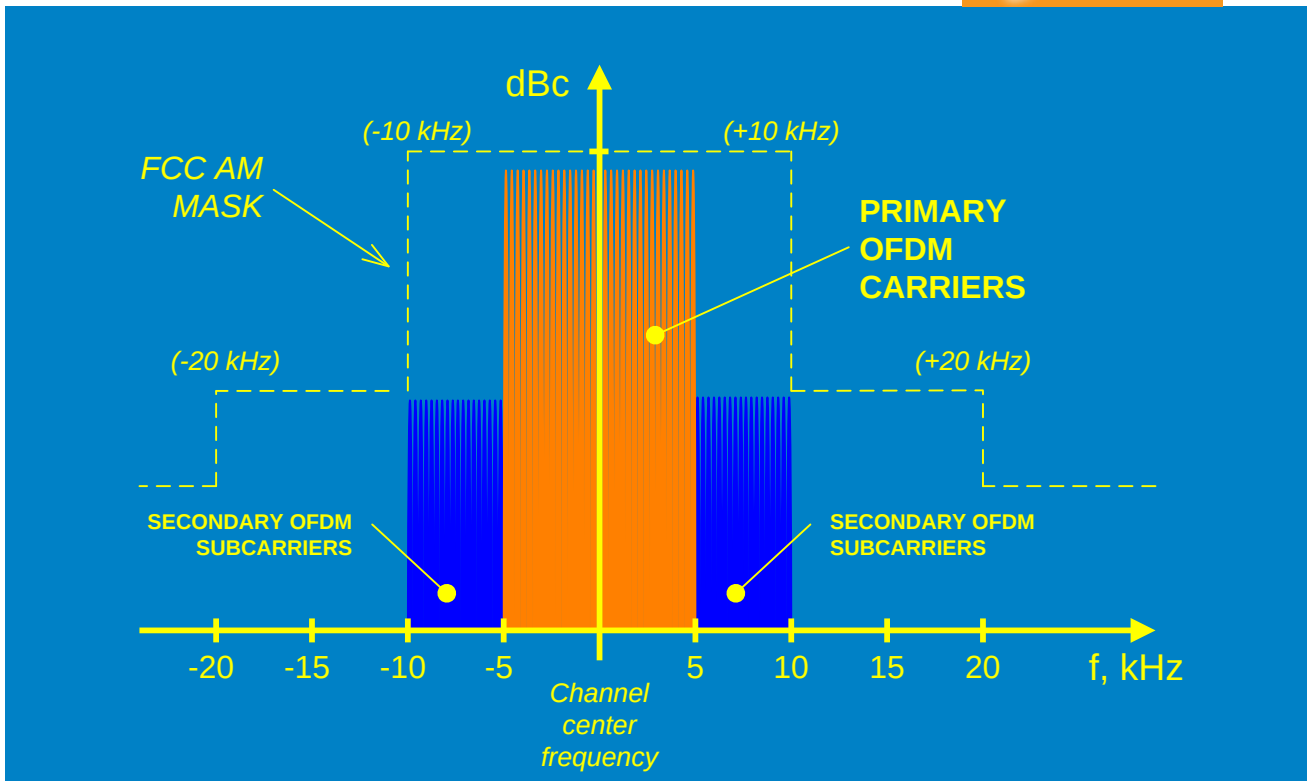
All-digital AM IBOC

- Hybrid AM IBOC signal
  - Authorized by FCC in 2002
  - “HD Radio” is the trademark of iBiquity Digital Corp.
  - Approximately 300 stations licensed for hybrid AM



All-digital IBOC

- All-digital AM IBOC signal
  - Currently requires experimental authority from FCC
  - Not receivable on analog AM radios
  - IS receivable on existing HD Radio receivers



All-digital AM field testing

- Original 2014/2015 test sites:

	WBCN	WNCT	WBT	WD2XXM	KTUC	WDGY	KKXA	KRKO
Location	Charlotte, NC	Greenville, NC	Charlotte, NC	Frederick, MD	Tucson, AZ	Hudson, WI	Snohomish, WA	Everett, WA
Freq (kHz)	1660	1070	1110	1670	1400	740	1520	1380
Class	B	B	A	*EXPERIMENTAL*	C	D	B	B
Day pwr (kW)	10.0	25.0	*(not tested)*	3.0	1.0	5.0	50.0	50.0
Night pwr (kW)	1.0	10.0	50.0	3.0	1.0	n/a	50.0	50.0
# of towers	1	5	3	1	1	3	4	4
Antenna	ND1	DA2	DAN	ND1	ND1	DAD	DAN	DAN
Date(s) tested	12/12	7/13	8/13, 3/14	10/13, 12/13	2/14	6/14	10/14	10/14

All-digital AM

- Why so many tests?
  - 4,551 AM radio stations as of December 31, 2020 - down 174 since 2014
  - Tremendous variety of AM stations – classes, frequencies, implementations, locales
  - All of these variables have an impact on performance
  - NAB Radio Technology Committee has developed a “test matrix” establishing a minimum set of recommended tests
  - Unusual or not-well-understood results lead to re-tests
    - Class A station WBT was re-tested in March
    - WD2XXM testing was follow-up to earlier tests as well

Data collection

- NAB Labs is using consumer receivers for characterizing all-digital signal coverage
  - Primarily OEM receivers in Ford vehicles, available at rental car facilities
  - Limited testing of BMW, Volvo, Mercedes
- Data collection based upon reception of digital audio
  - Connect data collection system to car door speaker wires
  - Software developed by iBiquity

Ford SYNC OEM receiver

Data collection

- Using antenna optimized by automaker for particular vehicle
- Avoids issues with custom data collection system:
  - Sub-optimal antenna
  - Unrealistic antenna
  - RF signal distribution
- Makes troubleshooting more difficult
- Very reflective of actual consumer experience

All-digital AM – overall status

- NAB Labs test project consisted of three components:
  - Field testing – demonstrates “real-world” coverage, helps to troubleshoot system and educate broadcasters
  - Lab testing – establishes interference behavior between stations
  - Allocation studies – needed to understand impact on FCC rules

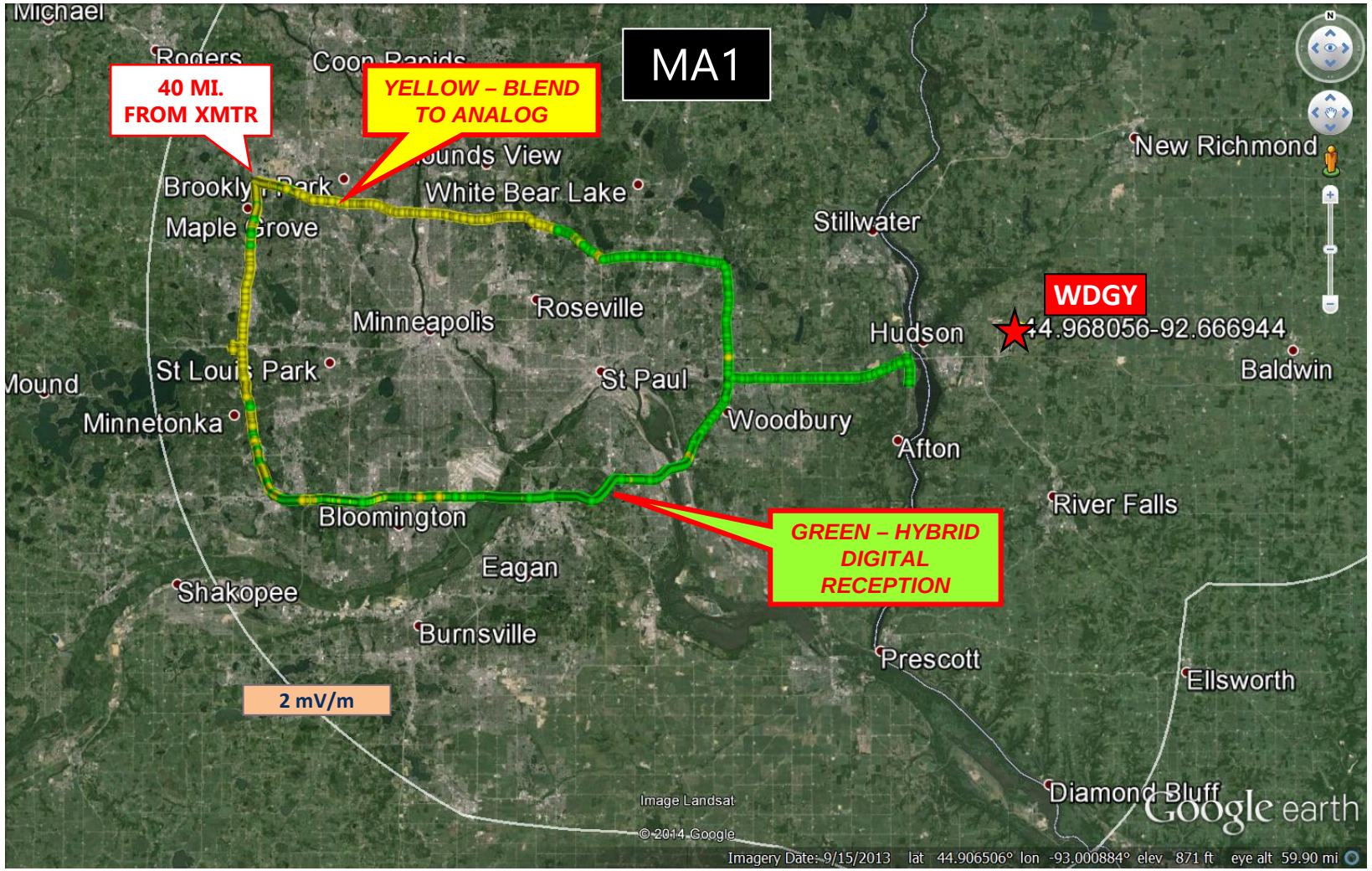
NAB Labs *initiated* and is *performed* the industry evaluation of all-digital AM radio

WDGY – 740 kHz, Hudson, MI

- Class D, 5 kW, owned by WRPX, Inc.
- Thanks to Greg Borgen

DAN RYSON, Cavell, Mertz & Associates	***RUSS MUNDSCHENK, iBiquity***	***DAVID LAYER, NAB***	***GREG BORGEN, WDGY***	***JIM DUBOIS, MINN. ASSOC. OF B'CASTERS***

WDGY – MA1 vs. MA3



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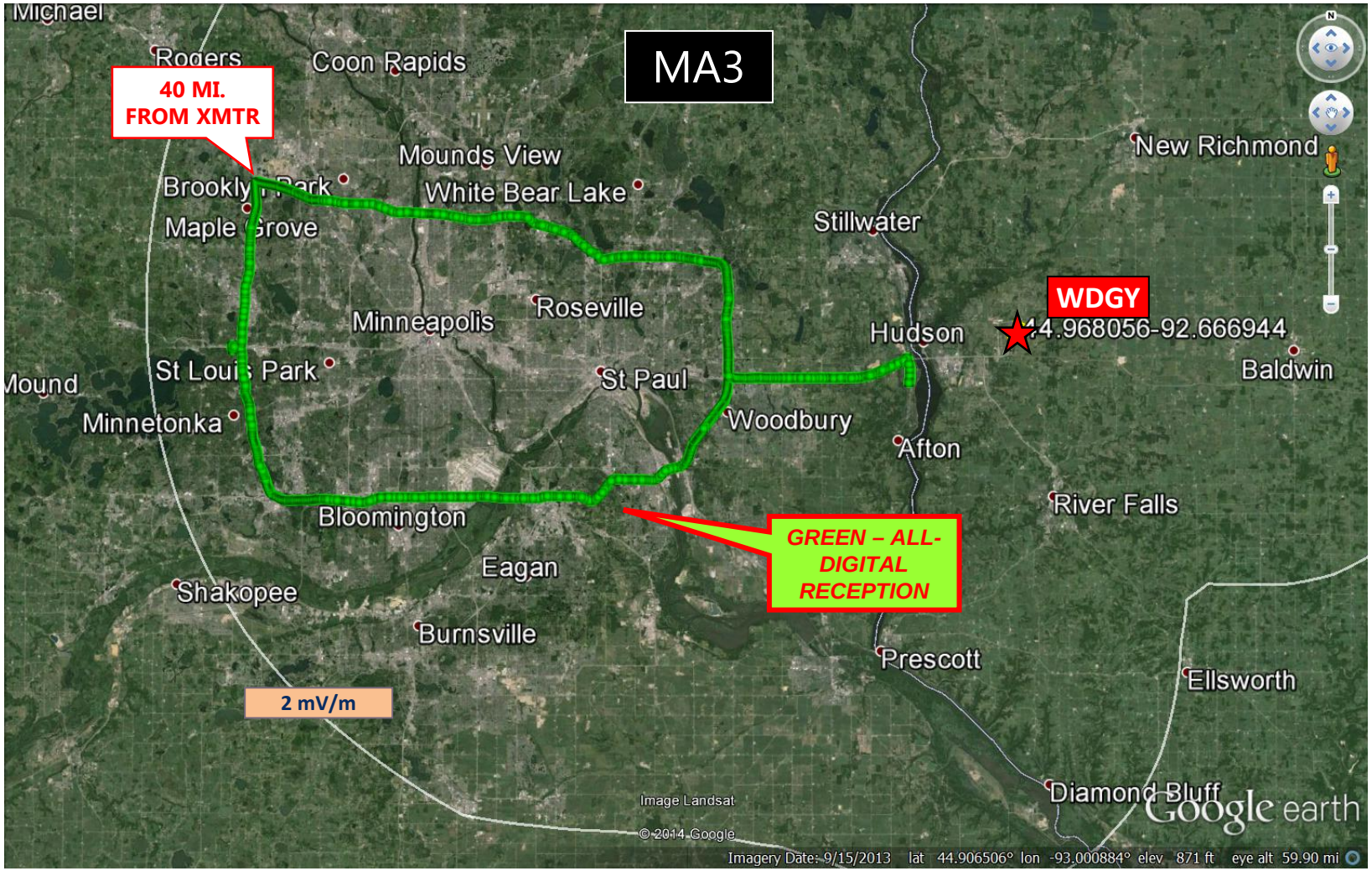
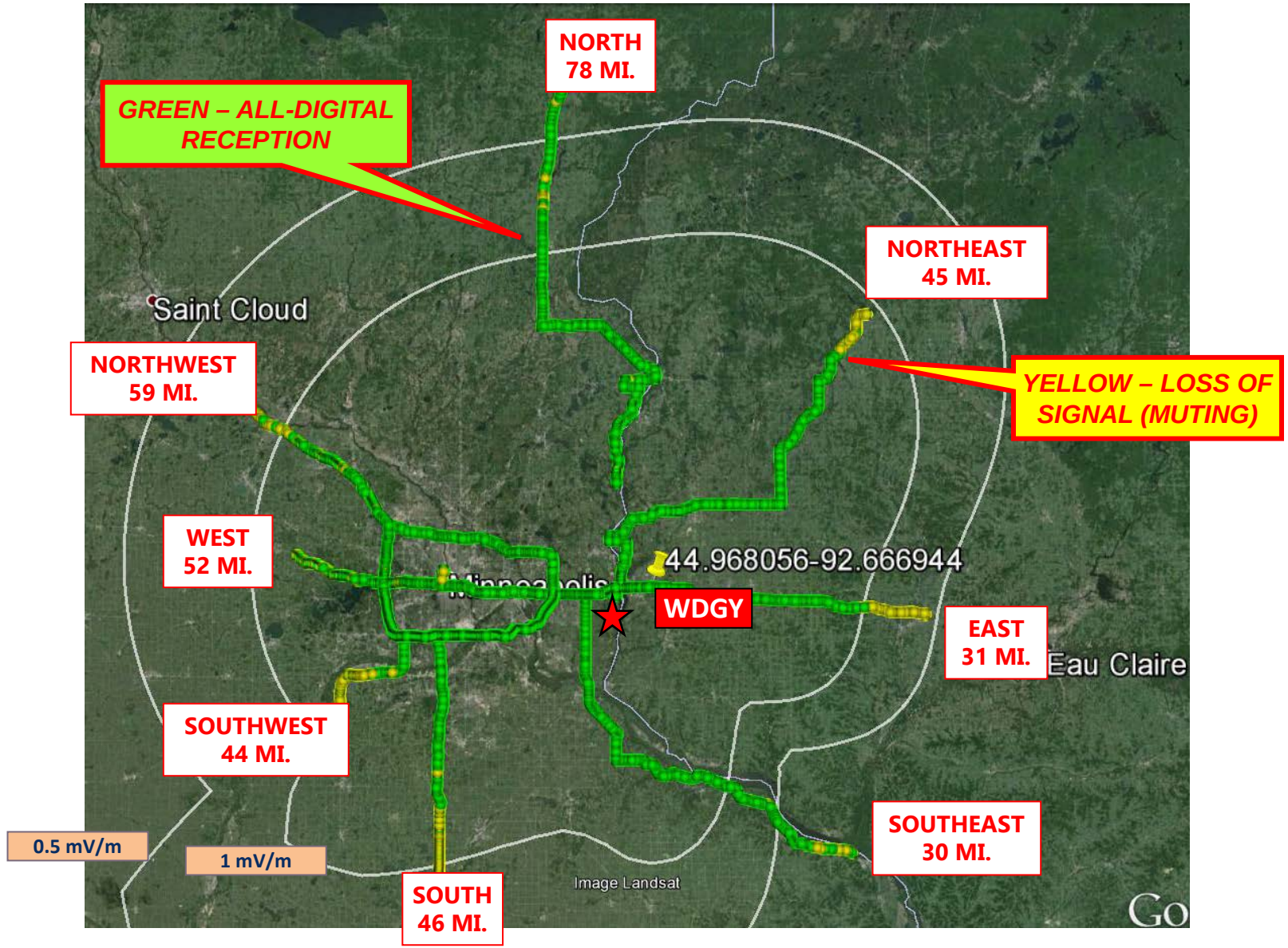
making digital broadcasting work

WDGY – MA1 vs. MA3



WDGY – 5 kW MA3 mode – daytime coverage

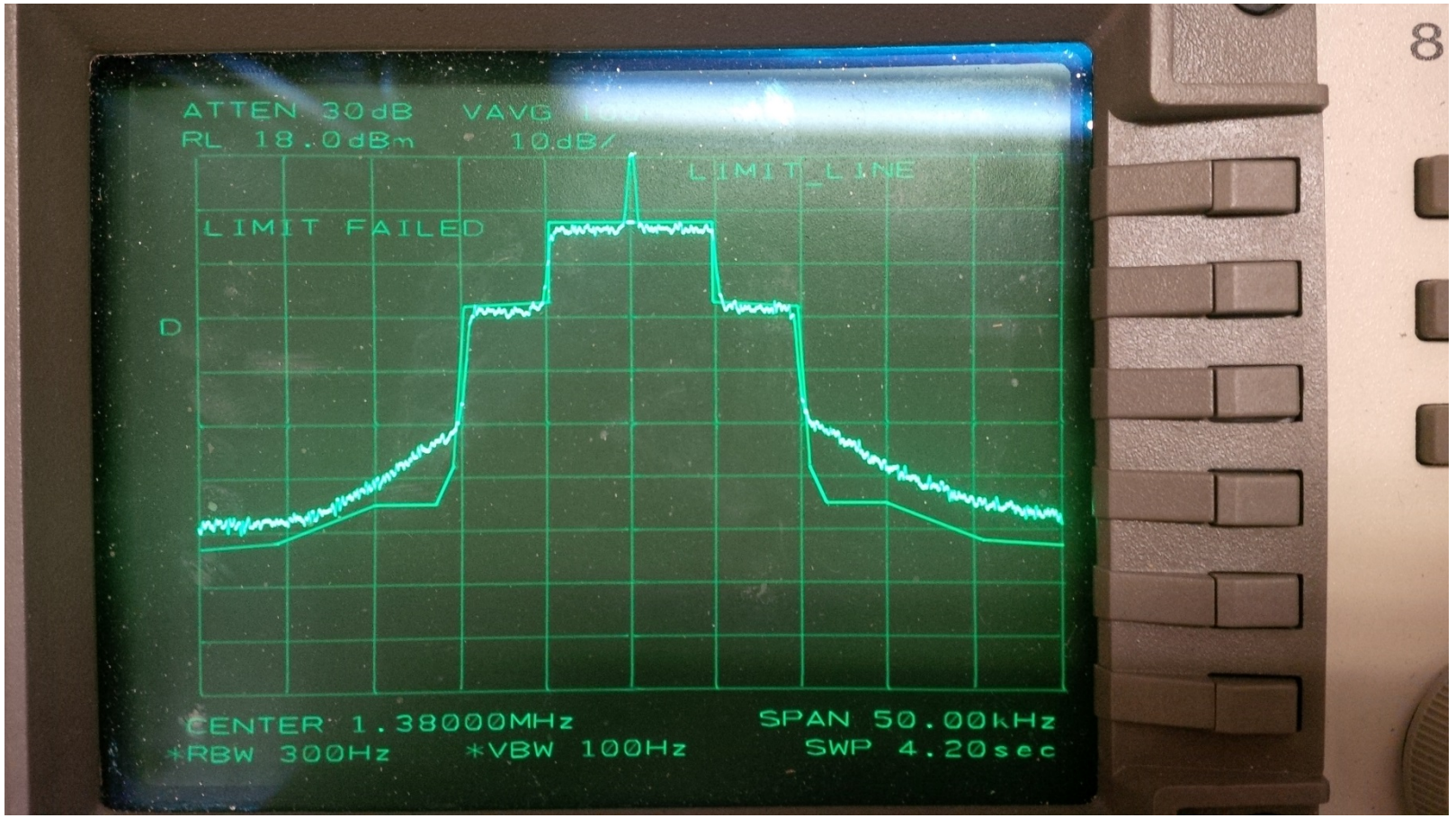


Challenges

At the default signal level, MA3 output power (RMS) is about 80% of MA1 power.

When MA3 is corrected to equal the MA1 RMS power, using a thermocouple ammeter, there can be mask issues.

This will require further work in setting precorrection and predistortion curves.



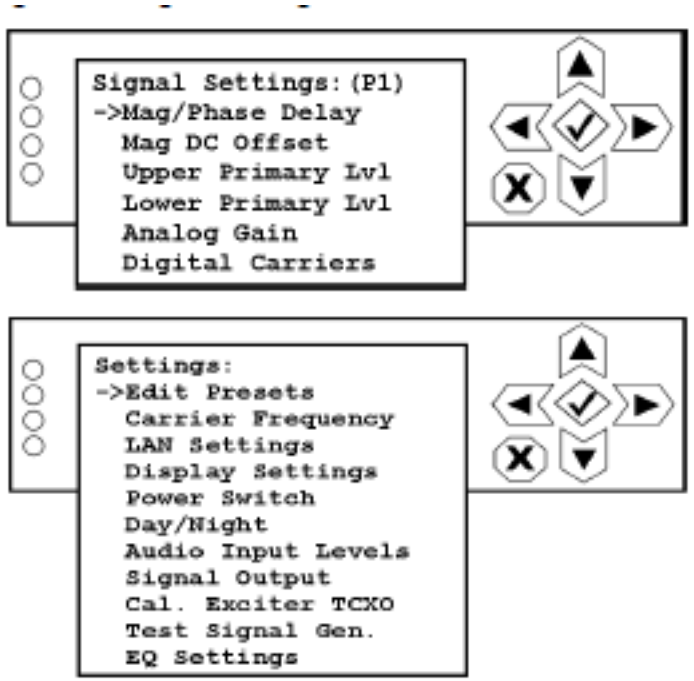
Challenges

Some correction of the mask can be done with the standard signal settings in the Exporter or Exgine units.

As the purpose of field tests was to provide head-to-head comparisons, this wasn't done, so as to preserve a level playing field.

Further improvements can be made by loading customer specific EQ Settings, to provide predistortion curves matched to optimize antenna systems.

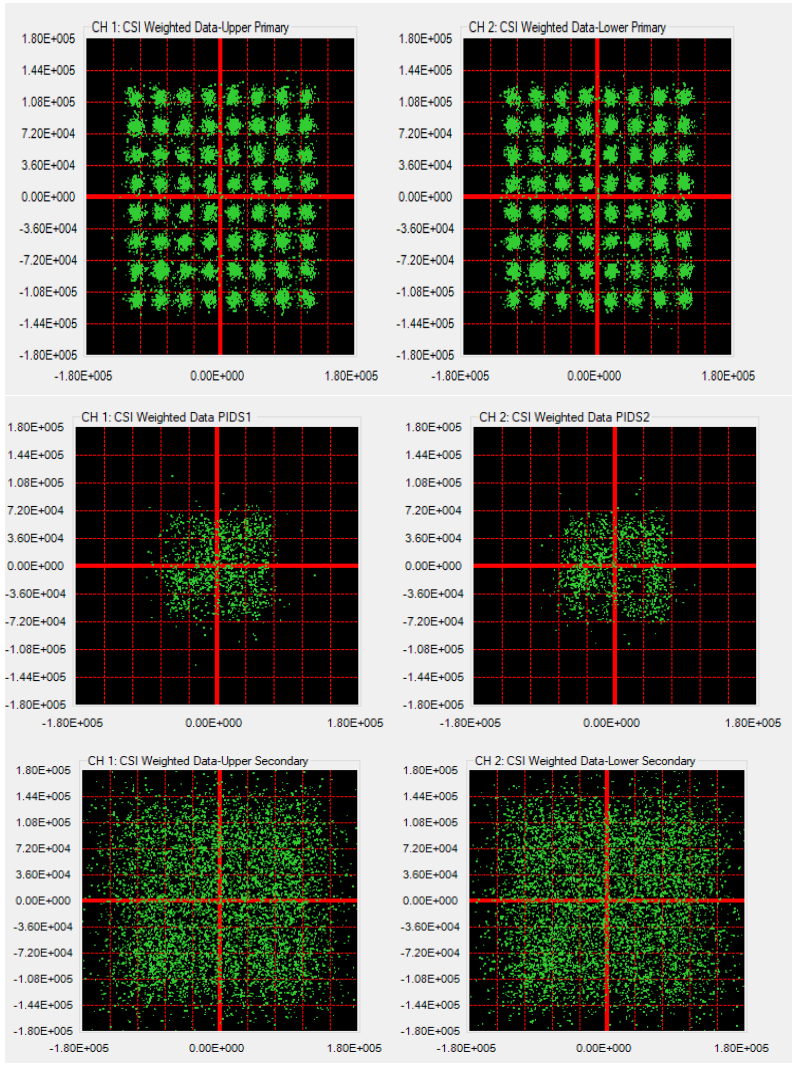
Similar to AM Stereo setup, there may be some compromise between day/night pattern optimization.

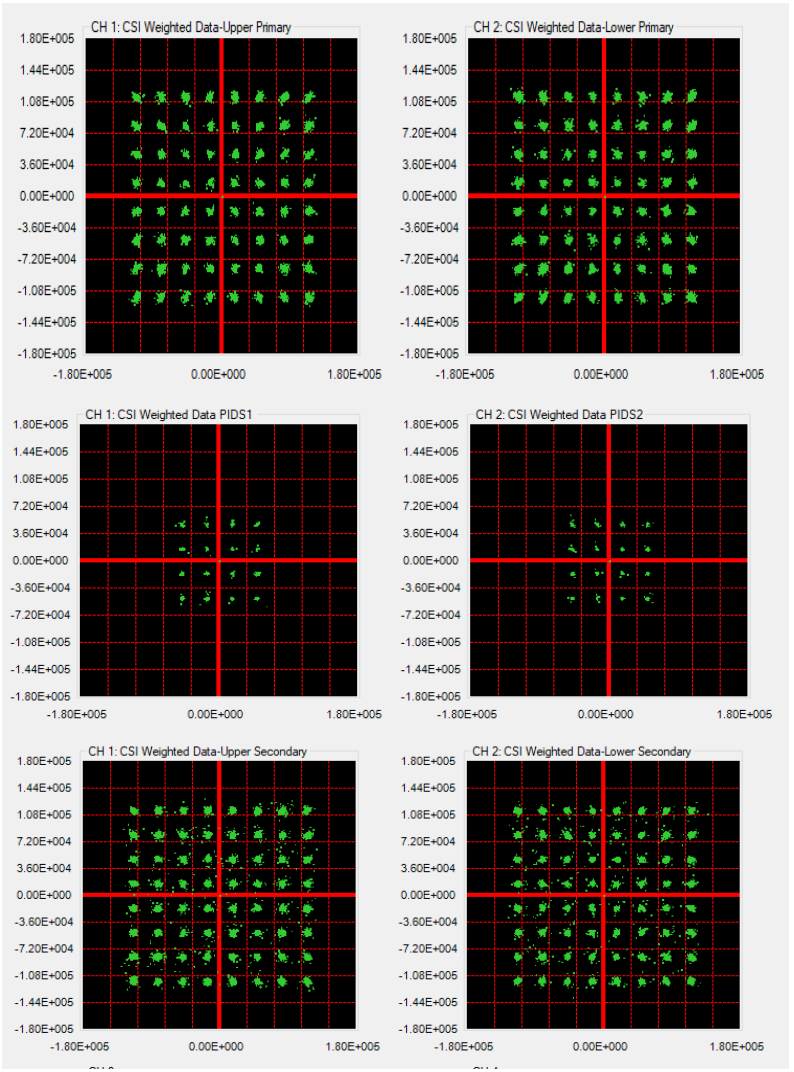


Power measurement changes

Photo courtesy of www.radiomuseum.org

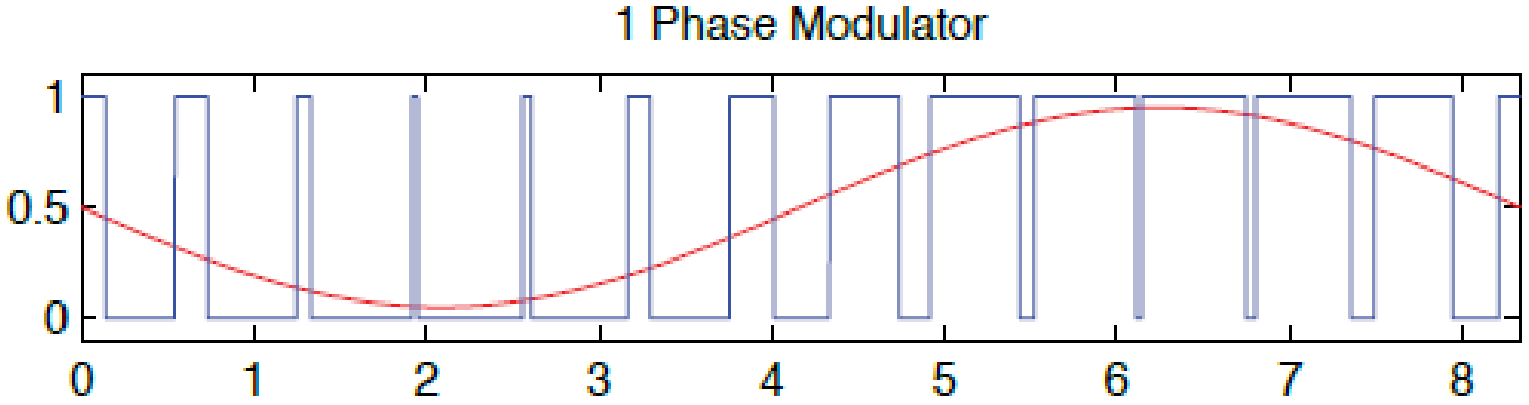
Transmitter with inadequate PDM switching frequency & no CFR vs. Transmitter with proper PDM switching frequency & CFR applied.



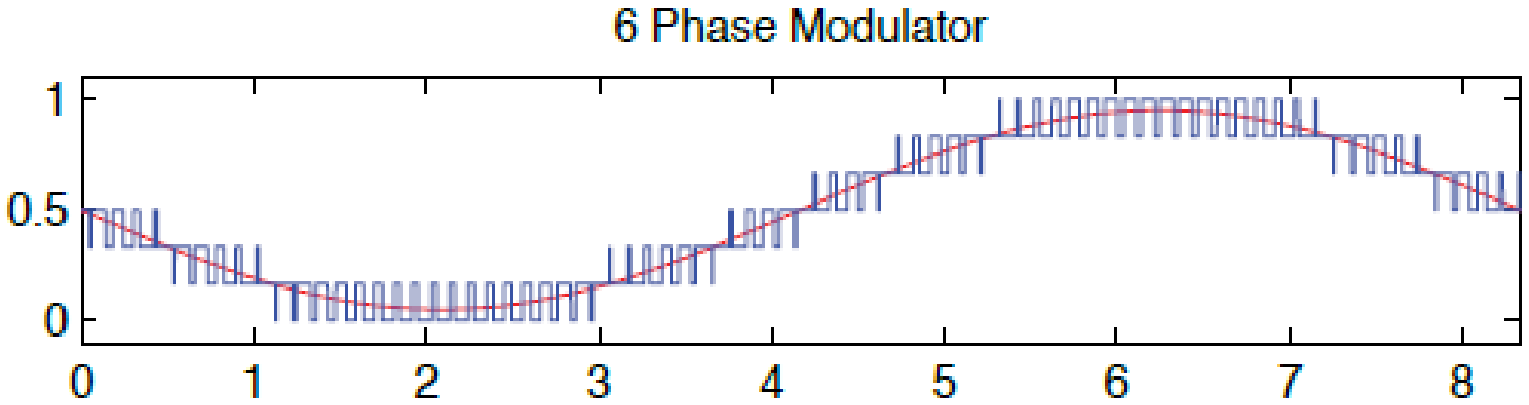


1.8 MHz Direct Digital Modulation

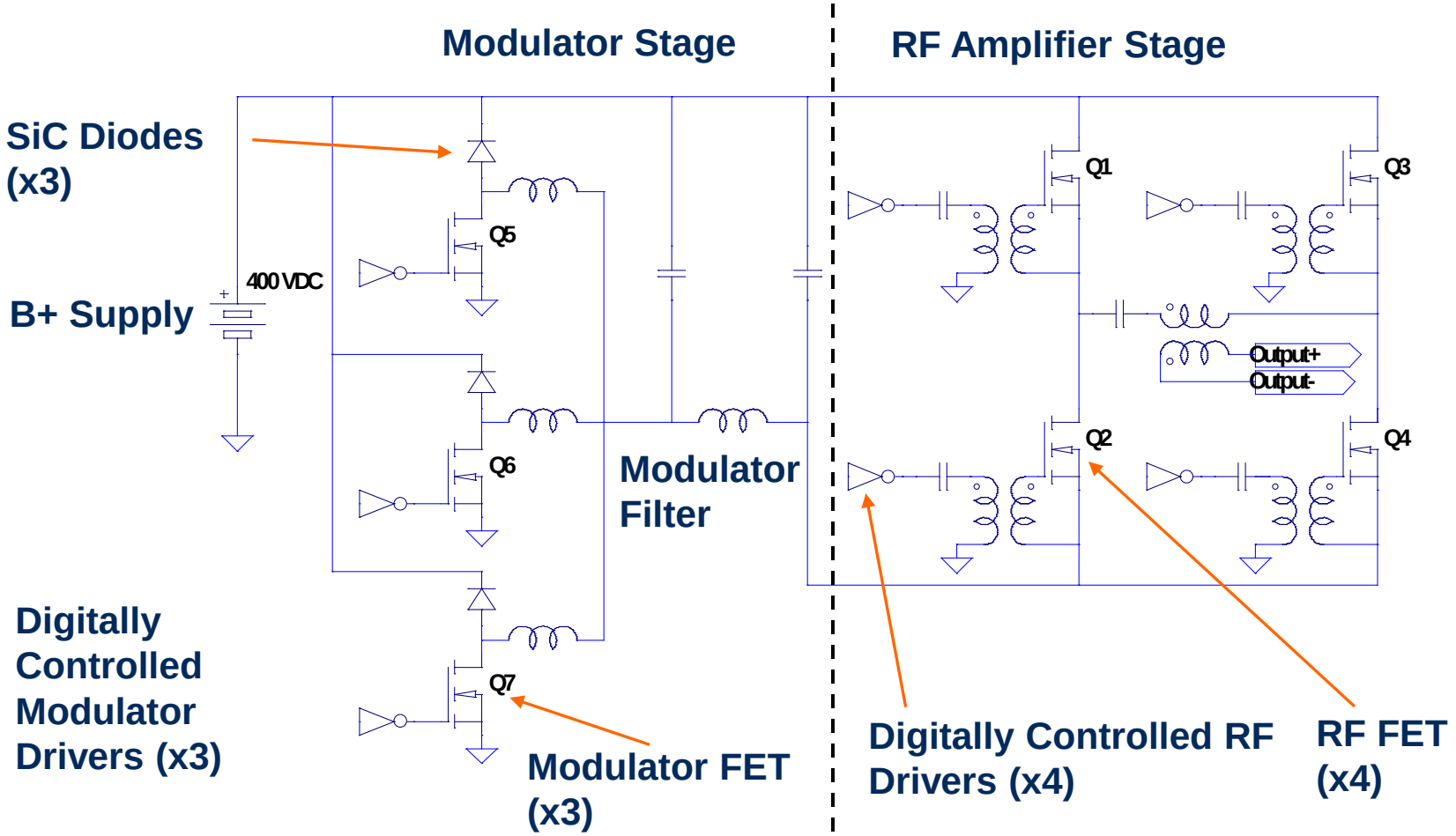
TRADITIONAL MODULATION



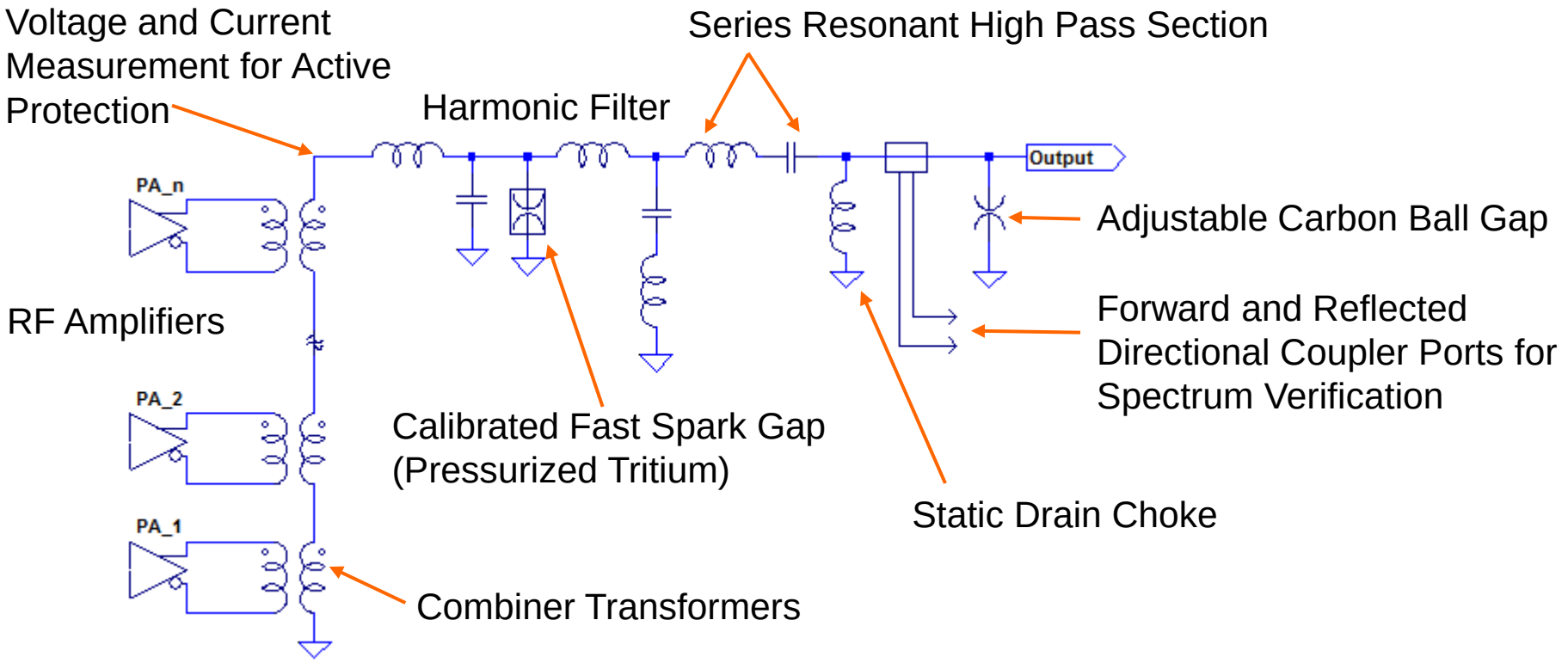
1.8 MEGA-SAMPLES/SECOND SIX PHASE DIRECT DIGITAL MODULATION



RF Amplifier / Modulator Module

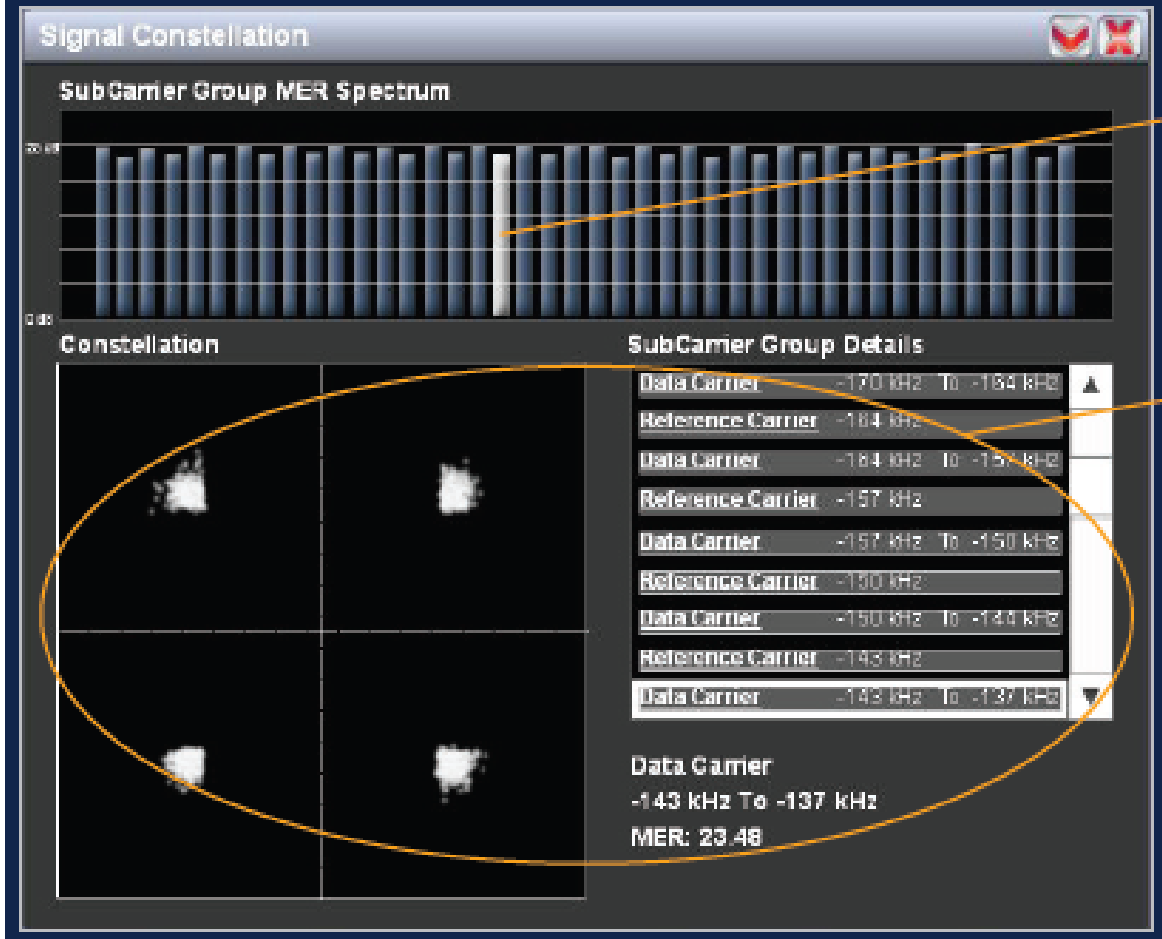


Combiner/Filter & Transient Protection



Frequency Agile: Harmonic Filter Re-Tune in a Few Hours

MER metering



Signal Constellation View

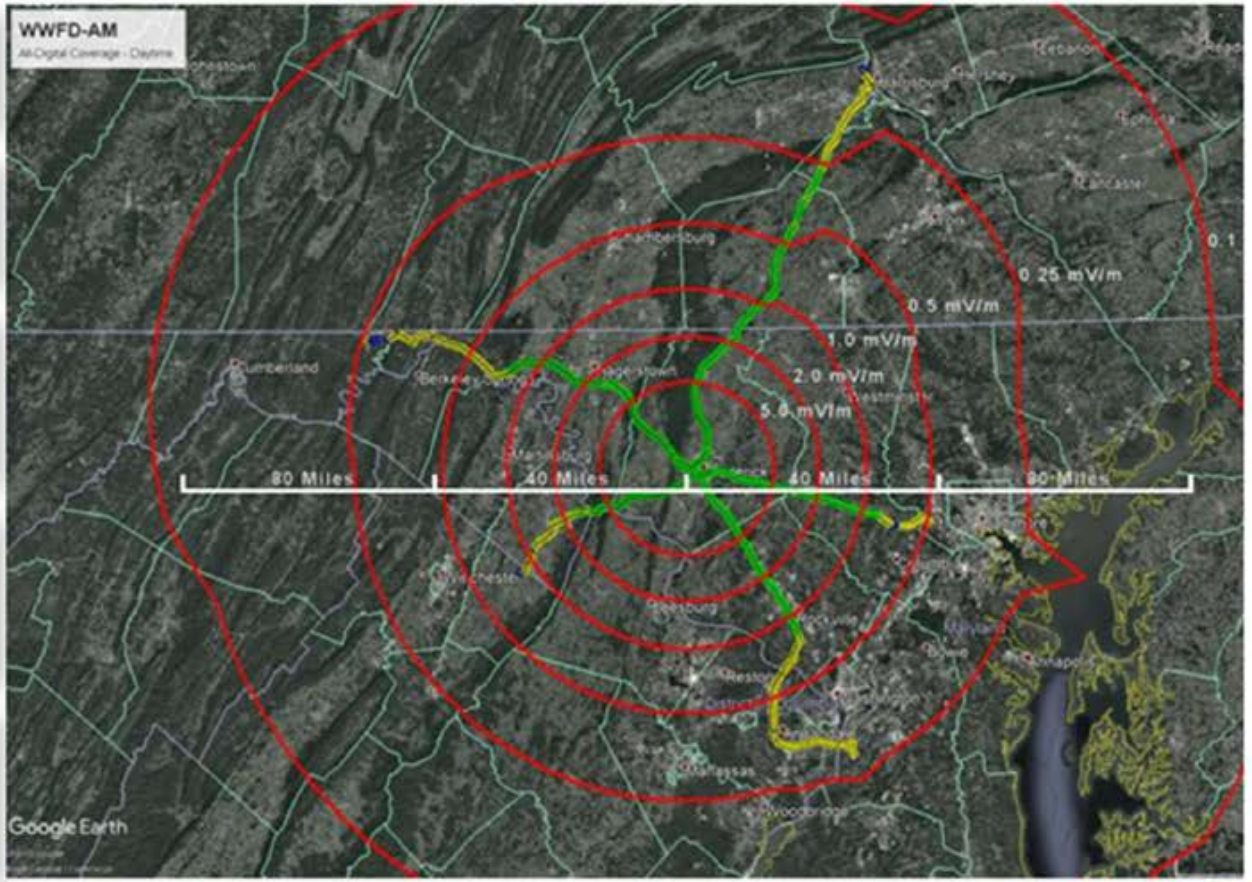
Select a subcarrier using the mouse or AUI touchscreen

Full MER analysis shown for the subcarrier

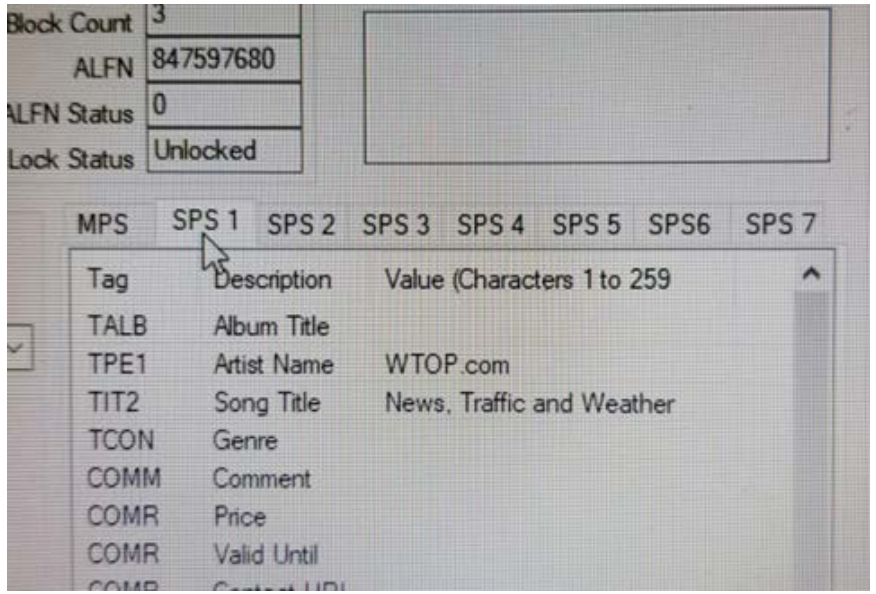
HD RADIO TECHNOLOGY

WWFD-AM DAYTIME PATTERN – ALL DIGITAL

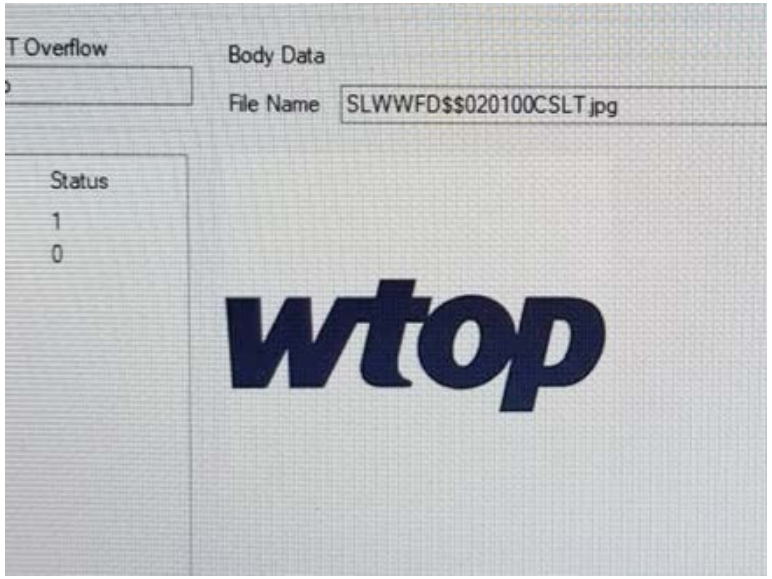
- 5.0 / 2.0 / 1.0 / 0.5 / 0.25 mV/m contours shown
- All-digital signal fills in 0.5 mV/m protected daytime contour
- Class: B – 820 kHz
  Daytime Power: 4.3 kW
  Day – Non-Directional
- Enhanced Mode = Green
  Core Only Mode = Yellow
  Mute Mode = Blue
- 5.0 mV/m population = 215,124
  2.0 mV/m population = 456,791
  0.5 mV/m population = 2,777,722



MA3 Improvements: HD2 Testing



- The first AM HD2 was tested on WWFD in December 2019
- Program Service Data (PSD) and a Station Logo was transmitted as well



- Signal was received on an Xperi test receiver
- Proof-of-concept demonstrates flexibility of MA3 system
- Possible FM translator implications for AM stations

Considerations:

- Core vs Enhanced mode
- Bandwidth
- PDM frequency
- Interference

- What's the goal?

Other Questions?

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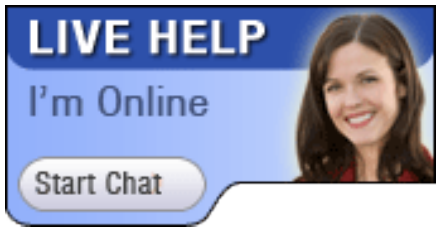

Thank You