HD Receiver Display with Album Art

All Digital AM in the Real World

DRM

HD Radio®
Digital AM & FM

Agenda

- Why All Digital AM?
- All Digital AM on WWFD
- Future vision from Xperi
- Future vision from DRM
- What about the antenna?
- Attributes of the ideal AM transmitter for all digital
- Your questions

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Senior Broadcast Engineer
WTOP/WFED

Mike Raide
Senior Manager
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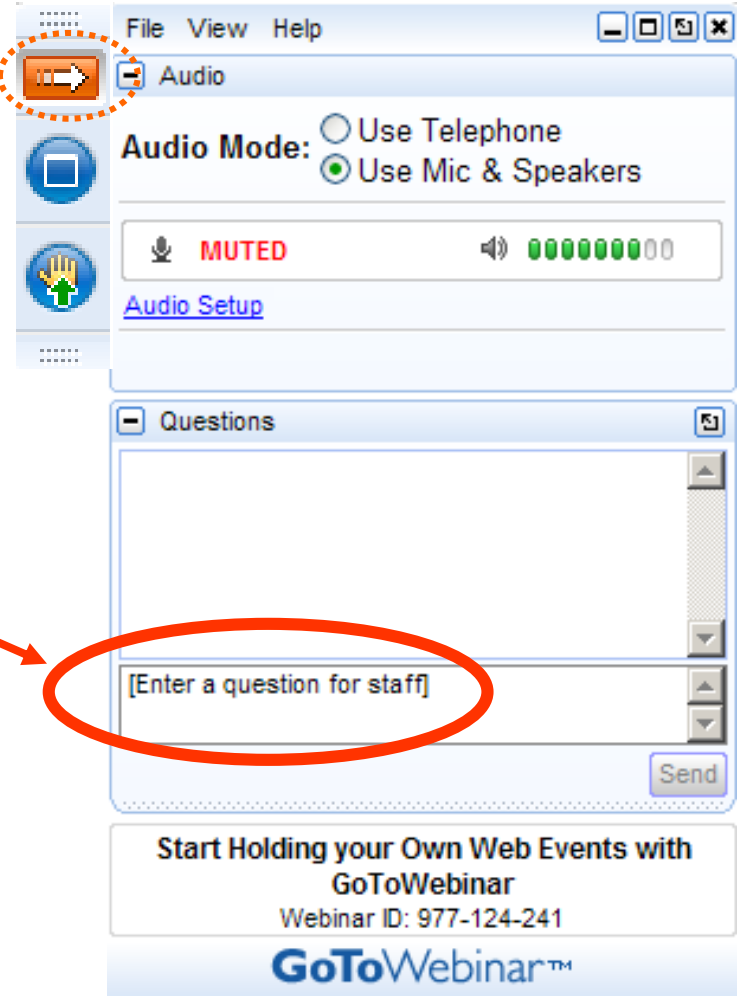
Project Engineer
Kintronic Labs

Philipp Schmid
Research Engineer
Nautel

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)



SBE.

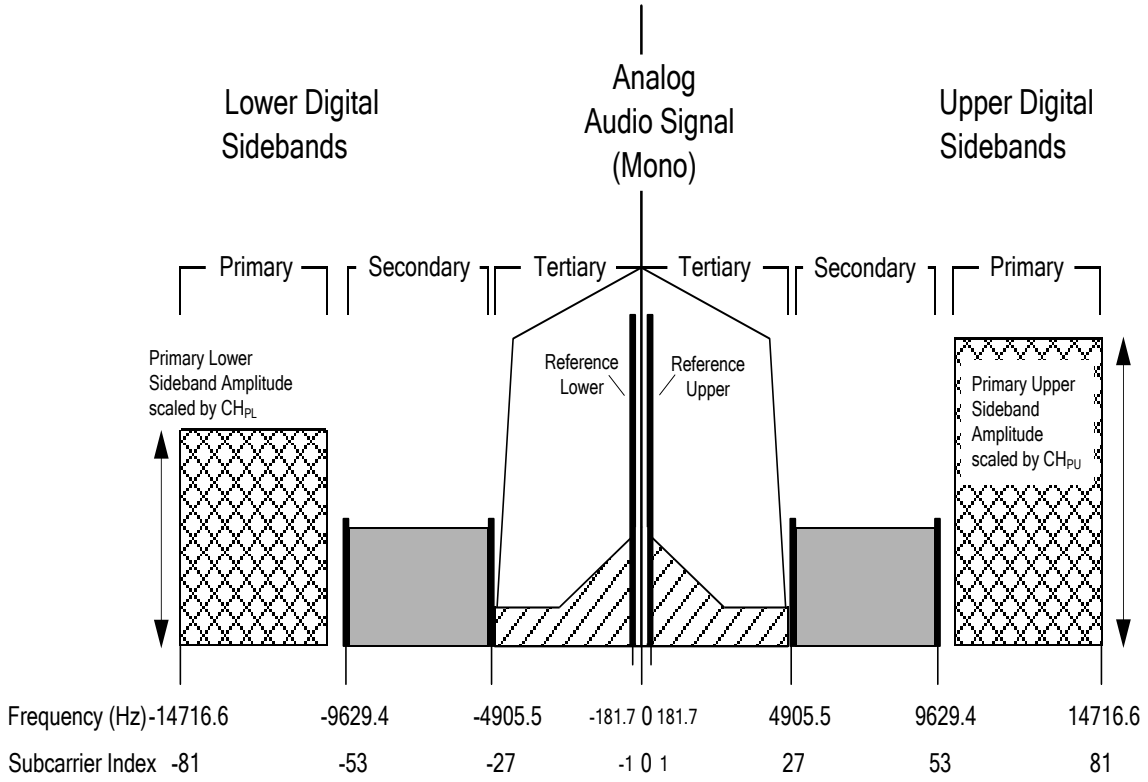
Remember: The completion of a Nautel webinar qualifies for ½ SBE re-certification credit, identified under Category I of the Re-certification Schedule for SBE Certifications.

All Digital-AM: A Cooperative Effort

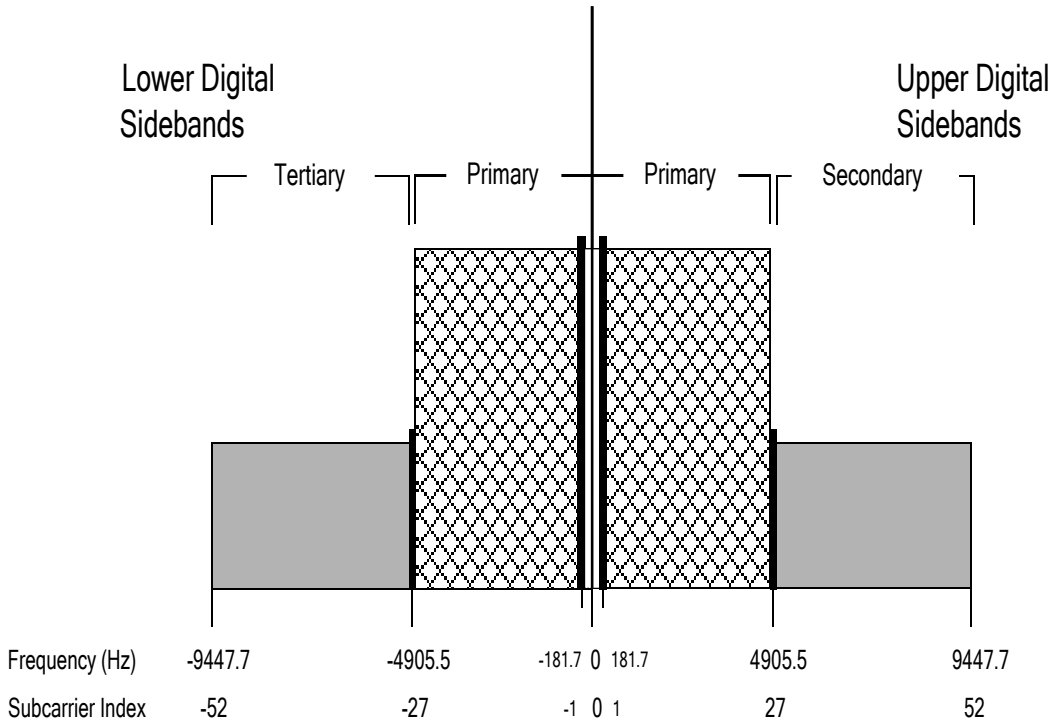
WWFD 820 kHz, Frederick MD
4.3 kW Daytime, 0.43 kW DA Nighttime

All-Digital AM Broadcasting: What and Why

- MA1 Waveform



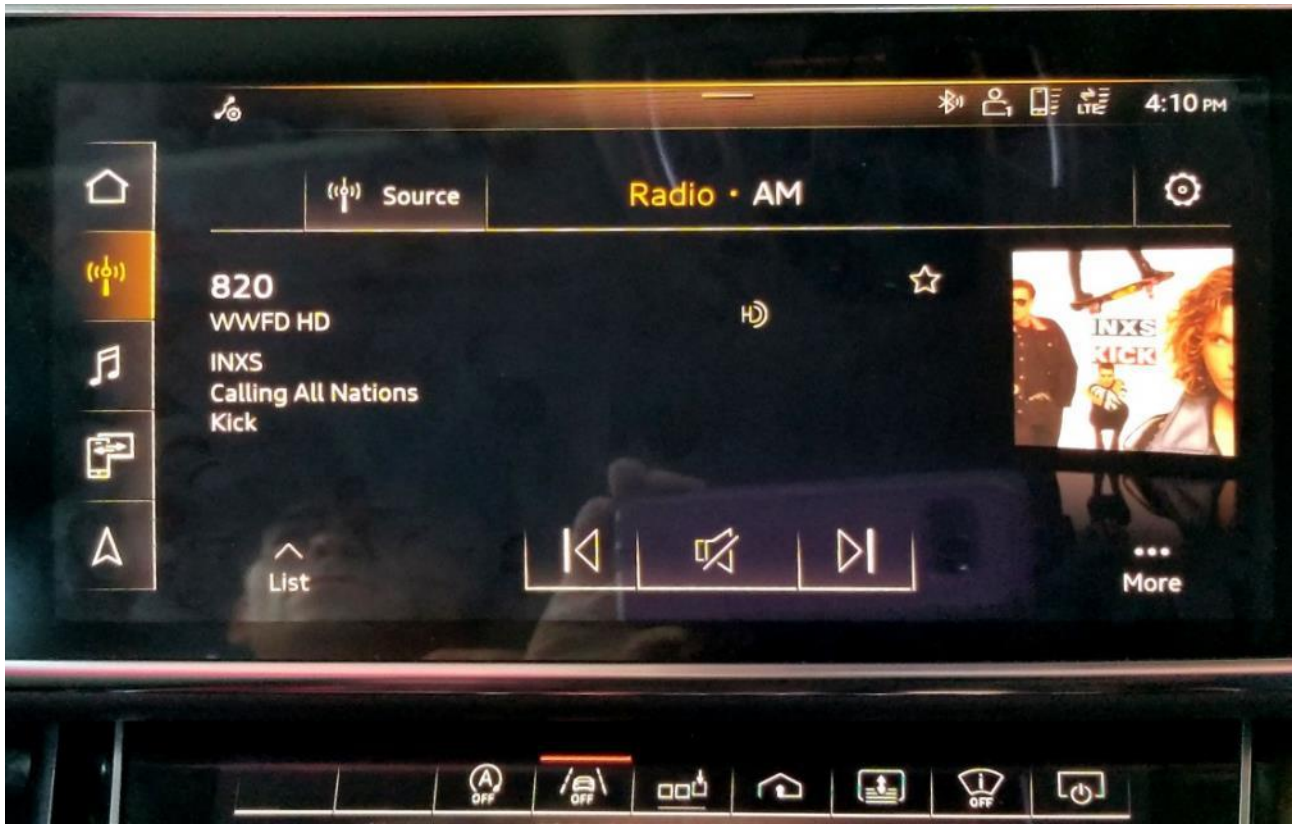
- MA3 Waveform



nautel 50 YEARS 1969–2019

making digital broadcasting work

All-Digital AM Broadcasting: What and Why



WWFD, in MA3 HD, as observed in a pre-production Audi A8. Aural and visual parity with other services is possible for AM broadcasters in the MA3 mode.

WWFD-AM, Frederick MD

- 4,300 watts daytime, non-directional
- 460 watts nighttime, directional (DA)
- Tower #1 (left) is DA reference
- Tower #2 (right) is day antenna
- Series-fed towers

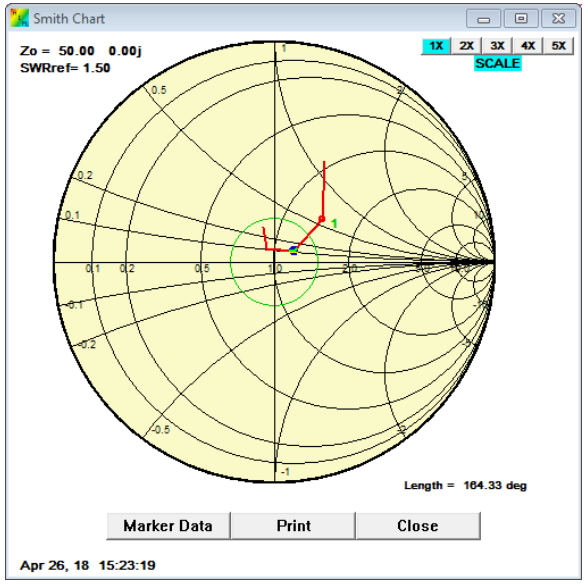
Facility was proposed to operate in the all-digital HD AM Mode (MA3) at the Consumer Electronics Show (CES), January 2017

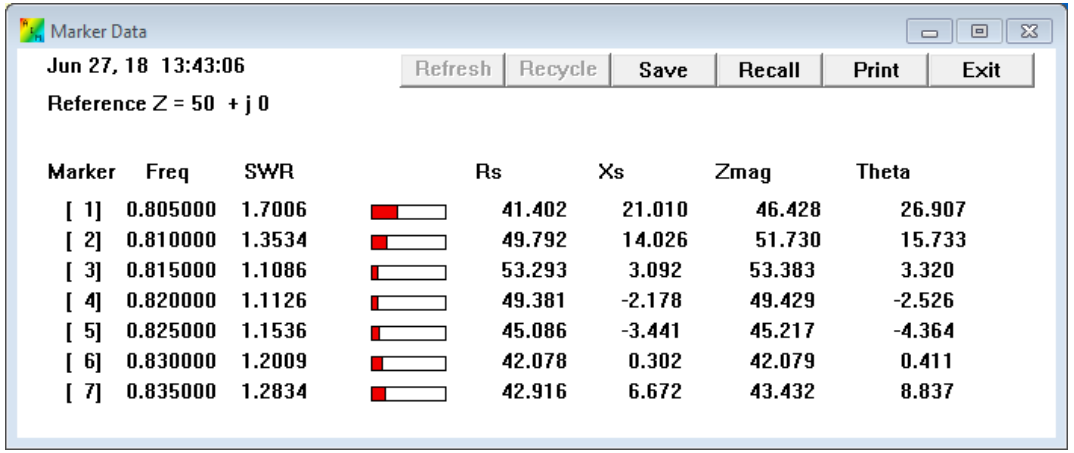
Facility Conversion: Overview

- Evaluation and modification of antenna system, if necessary
- Transmitter installation and setup
- Experimental Authority for all-digital operation
- Sign-on and testing

Antenna System Modifications – Approaching the New Model

- Antenna system documented and modeled by Kintronic Labs
- Modifications to permit digital operation are suggested, then implemented, by Hubbard and Xperi engineers
- Antenna system is brought back into adjustment per the station license





Marker	Freq	SWR	Rs	Xs	Zmag	Theta
[1]	0.805000	1.7006	41.402	21.010	46.428	26.907
[2]	0.810000	1.3534	49.792	14.026	51.730	15.733
[3]	0.815000	1.1086	53.293	3.092	53.383	3.320
[4]	0.820000	1.1126	49.381	-2.178	49.429	-2.526
[5]	0.825000	1.1536	45.086	-3.441	45.217	-4.364
[6]	0.830000	1.2009	42.078	0.302	42.079	0.411
[7]	0.835000	1.2834	42.916	6.672	43.432	8.837

WWFD-AM Transmitter Configuration

Nautel Multicast+ Importer

Nautel AM IBOC Exciter

Magnitude thru H-Pad

Phase

BE AM-6A

Nautel Exporter Plus

Program Audio

CSRDS Datacasting Software

BE ASi-10

Magnitude

Phase

Gates Five

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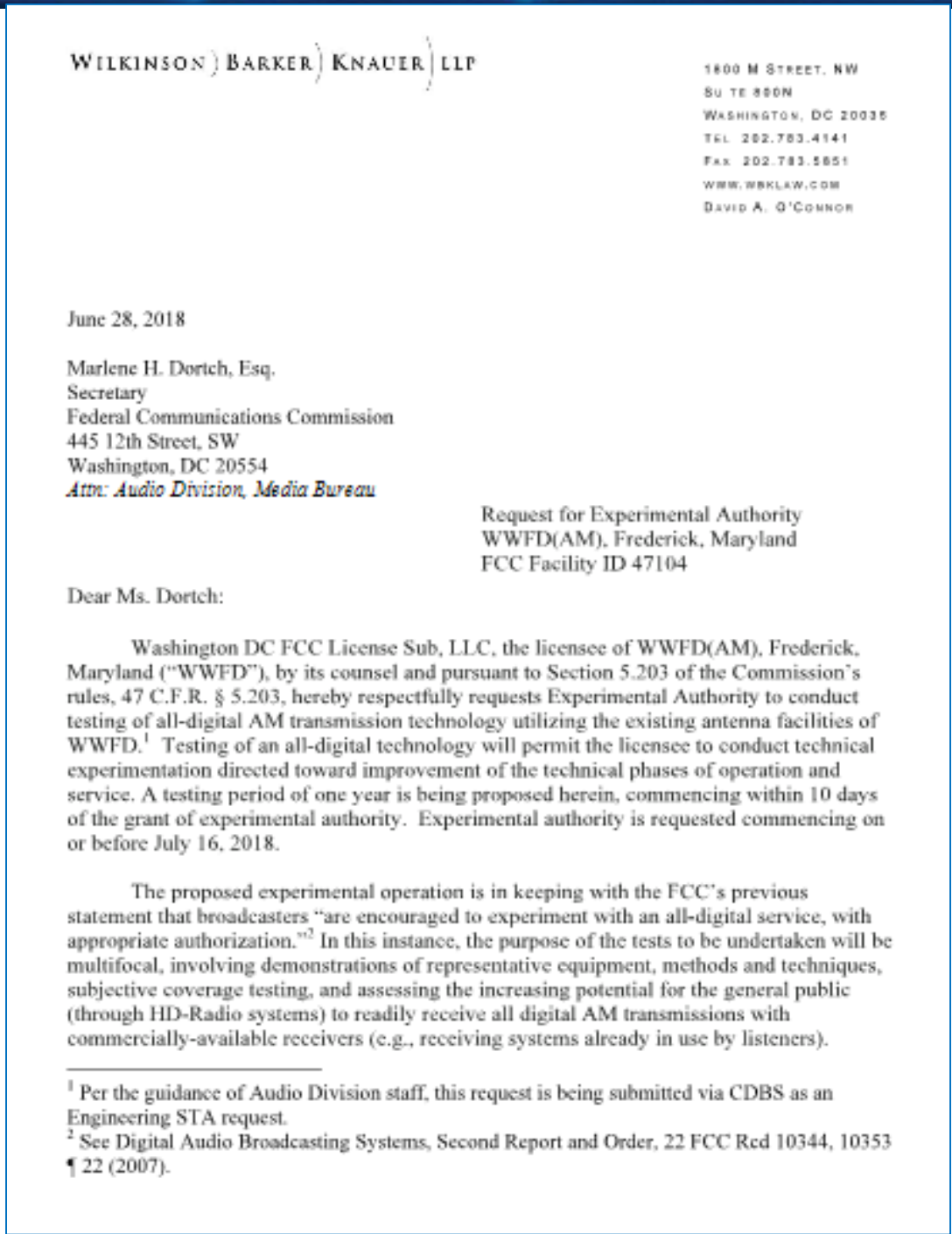
making digital broadcasting work

The FCC granted a one-year Experimental Authorization for WWFD to transmit in the all-digital MA3 mode beginning July 16, 2018



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DAVID A. O'CONNOR

June 28, 2018

Marlene H. Dortch, Esq.
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554
Attn: Audio Division, Media Bureau

Request for Experimental Authority
WWFD(AM), Frederick, Maryland
FCC Facility ID 47104

Dear Ms. Dortch:

Washington DC FCC License Sub, LLC, the licensee of WWFD(AM), Frederick, Maryland ("WWFD"), by its counsel and pursuant to Section 5.203 of the Commission's rules, 47 C.F.R. § 5.203, hereby respectfully requests Experimental Authority to conduct testing of all-digital AM transmission technology utilizing the existing antenna facilities of WWFD.[1] Testing of an all-digital technology will permit the licensee to conduct technical experimentation directed toward improvement of the technical phases of operation and service. A testing period of one year is being proposed herein, commencing within 10 days of the grant of experimental authority. Experimental authority is requested commencing on or before July 16, 2018.

The proposed experimental operation is in keeping with the FCC's previous statement that broadcasters "are encouraged to experiment with an all-digital service, with appropriate authorization."[2] In this instance, the purpose of the tests to be undertaken will be multifocal, involving demonstrations of representative equipment, methods and techniques, subjective coverage testing, and assessing the increasing potential for the general public (through HD-Radio systems) to readily receive all digital AM transmissions with commercially-available receivers (e.g., receiving systems already in use by listeners).

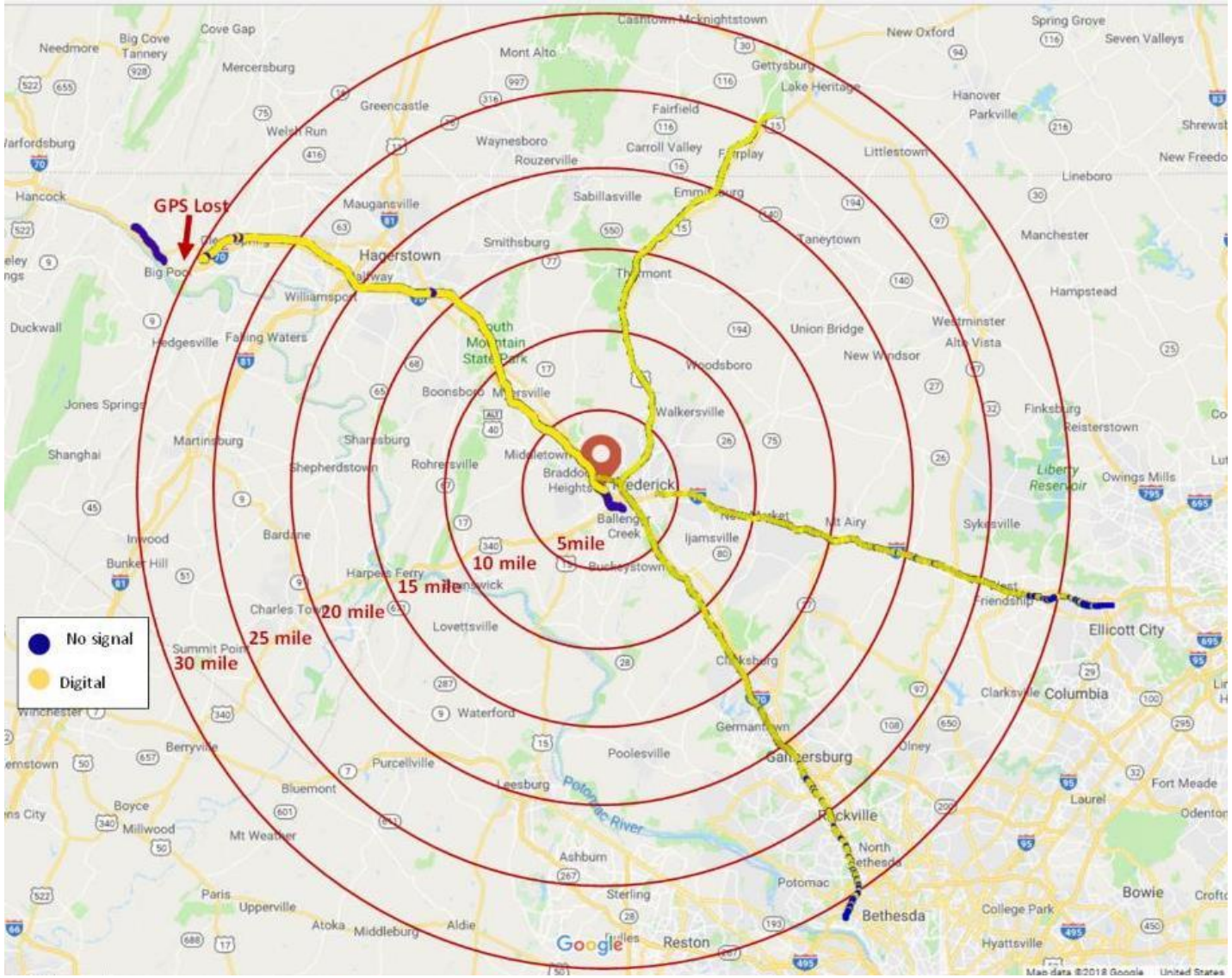
[1] Per the guidance of Audio Division staff, this request is being submitted via CDBS as an Engineering STA request.
[2] See Digital Audio Broadcasting Systems, Second Report and Order, 22 FCC Rcd 10344, 10353 ¶ 22 (2007).

MA3 Transmission Commencement

- July 16, 2018: WWFD turns on its digital transmitter
- Verify base currents, directional parameters and monitor points
- Begin drive testing

MA3 Drive Testing

- Under ideal circumstances, MA3 core mode can be decoded down to the 0.1 mV contour in the daytime
- Reception reports at or near the 0.1 mV contour include Harrisburg, PA and Cambridge, MD
- Nighttime reception seems to be possible beyond the Nighttime Interference Free (NIF) contour, where C/No exceeds 20 dB



Outstanding Issues & Future Work

- MA3 secondary carriers do not have enough C/No to lock at the receiver
  - Enhanced audio and data services such as Artist Experience are affected
  - Cause is under investigation
- Documentation of effects of noise vs. signal robustness and useful coverage
  - Power line interference
  - Electrical storms
  - Indoor noise environments

Transition to all-digital radio

- FM translators may factor into AM all-digital transition strategy
  - Over half of AM stations now have FM translators
  - Can serve listeners on both analog and digital radios
  - Coverage areas will be different

- WWFD (820 kHz, Frederick, MD) is pioneering this strategy
  - AM signal now all-digital (under experimental authority)
  - FM translator signal is still receivable on analog radios

All Digital potential

- Stereo audio, free from fading and noise
- Program Service Data
- Data services on par with FM services
- Emergency Alerts

Demonstrate to various Automotive OEM's AM band relevance

Innovation is still happening on AM

Broadcasters still investing in AM

All Digital potential

- Over 55.0 million HD Radio-equipped cars on the road in North America
  + Over 3.8 million consumer HD Radio home and portable receivers
  = Over 58.8 million HD Radio receivers in U.S., Canada & Mexico
  100 % of all AM equipped HD Radio's available are MA3 capable!

- HD Radio U.S. auto penetration over 19% in the top 10 DMAs:
  - #1 - New York: **33.0%**
  - #2 - Los Angeles: **30.2%**
  - #3 - Chicago: **20.7%**
  - #4 - Philadelphia: **21.5%**
  - #5 - Dallas: **20.0%**
  - #6 - Washington, DC: **21.9%**
  - #7 - Houston: **21.1%**
  - #8 - San Francisco: **27.1%**
  - #9 - Atlanta: **19.1%**
  - #10 - Boston: **26.0%**

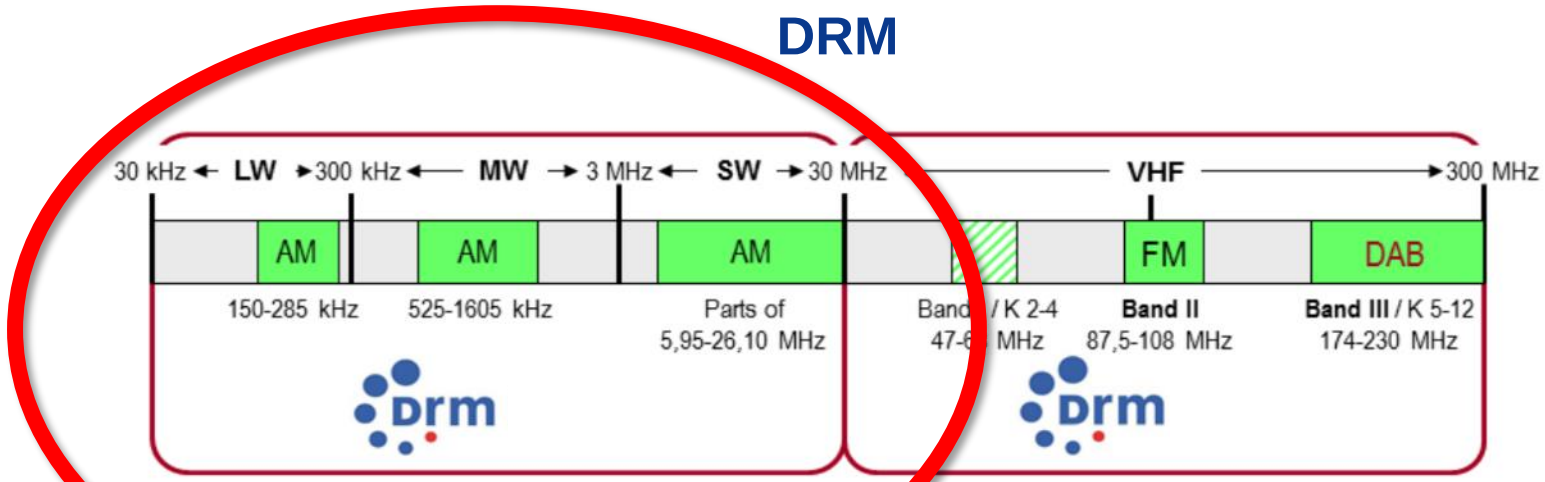
DRM in AM Bands

DRM for local / regional coverage (VHF bands)
(Band I, II – FM band, III)

30 MHz

DRM for medium/large area coverage (AM bands)
(or LW, MW, SW) – the AM bands

DRM



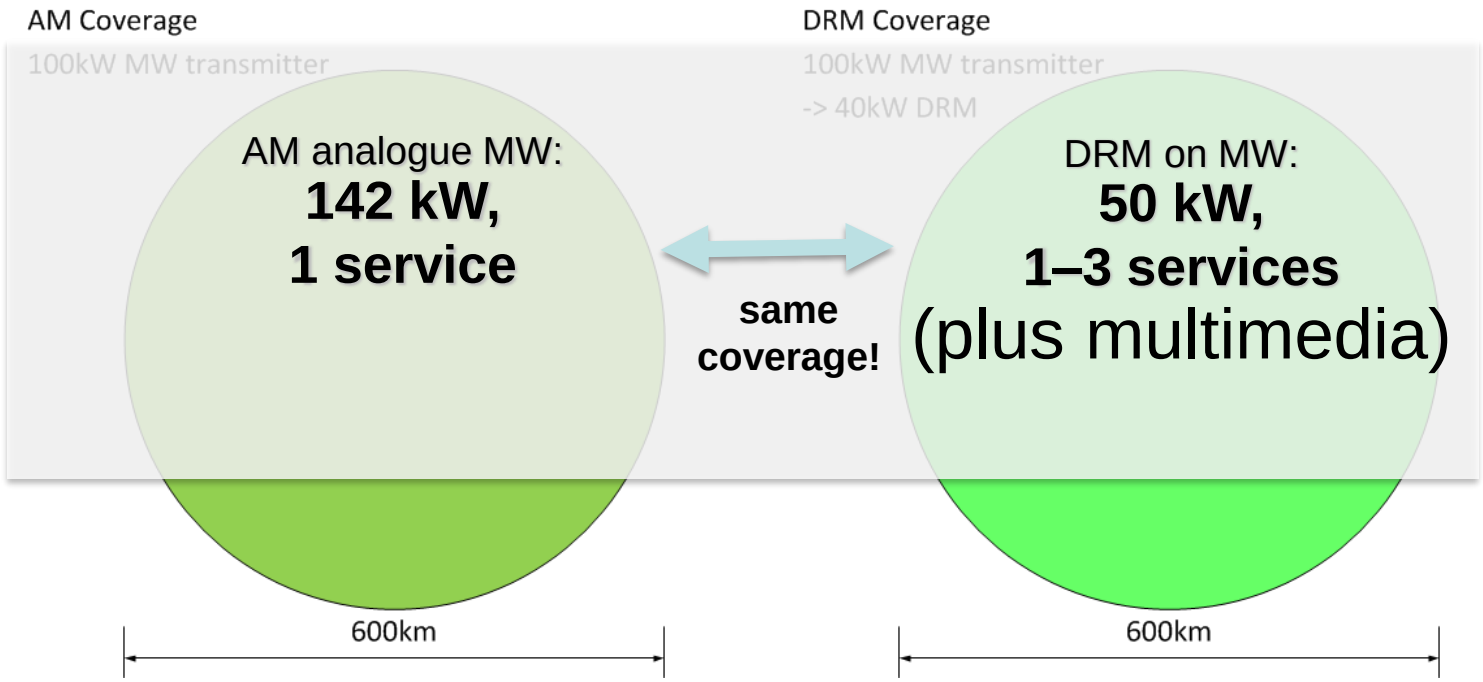
DRM Digital Radio standard – One single standard:
Same key features throughout

DRM Features – Analogue + or Different?

- **More choice** for listeners
  - Up to 3 programmes + multimedia on 1 frequency
  - Simulcast analogue / digital
- **Excellent audio** quality
  - No distortion
  - Stereo and 5.1 surround sound
- **Multimedia Applications**
  - Great listener benefits
  - Extra revenue opportunities for broadcasters
- **Good coverage** area and robust signal
  - Supporting SFN (Single Frequency Networks)
  - Green and energy efficient
- **Automatic tuning**
  - by station name, no longer by frequency
  - re-tunes when leaving coverage area
- **Emergency warning & alert**
  - All stations switch, present audio and text information

Coverage Matters! – AM analogue vs. DRM

AM analogue vs. DRM – Same coverage, 1 single tx



100 kW ERP @ 72% efficiency
→ 142 kW power consumption

40 kW ERP @ 80% efficiency
→ 50kW power consumption

DRM for Large Area Coverage (AM Bands)

- DRM standard applied in the AM bands: optimised system for **wide area coverage**
- Simple AM to DRM upgrade path
  → **no need for complete new infrastructure**
  → **secures long-term invest and existing transmitter networks**
- Transmission **energy saving** (MW and SW example) more than **60%** compared to analog AM coverage (enabling **1–3 programmes** and **extra benefits**)
- **Lower cost** for maintenance and spare inventory

→ All new AM transmitters today are **analogue & DRM broadcast ready**

DRM in the World - Some Key Countries

- India
- Indonesia
- Bangladesh
- Pakistan
- Russia
- Southern Africa
- Brazil

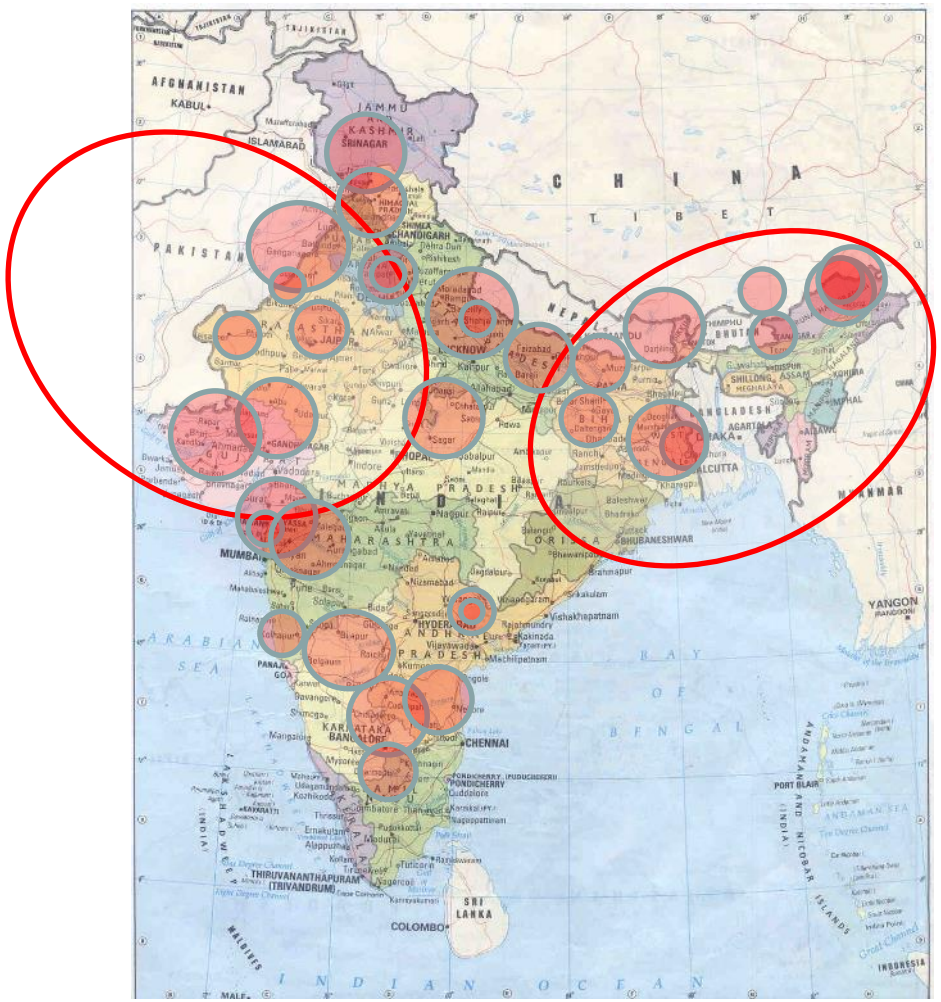
AIR – DRM Implementation

"One of the world's largest digital radio deployments"

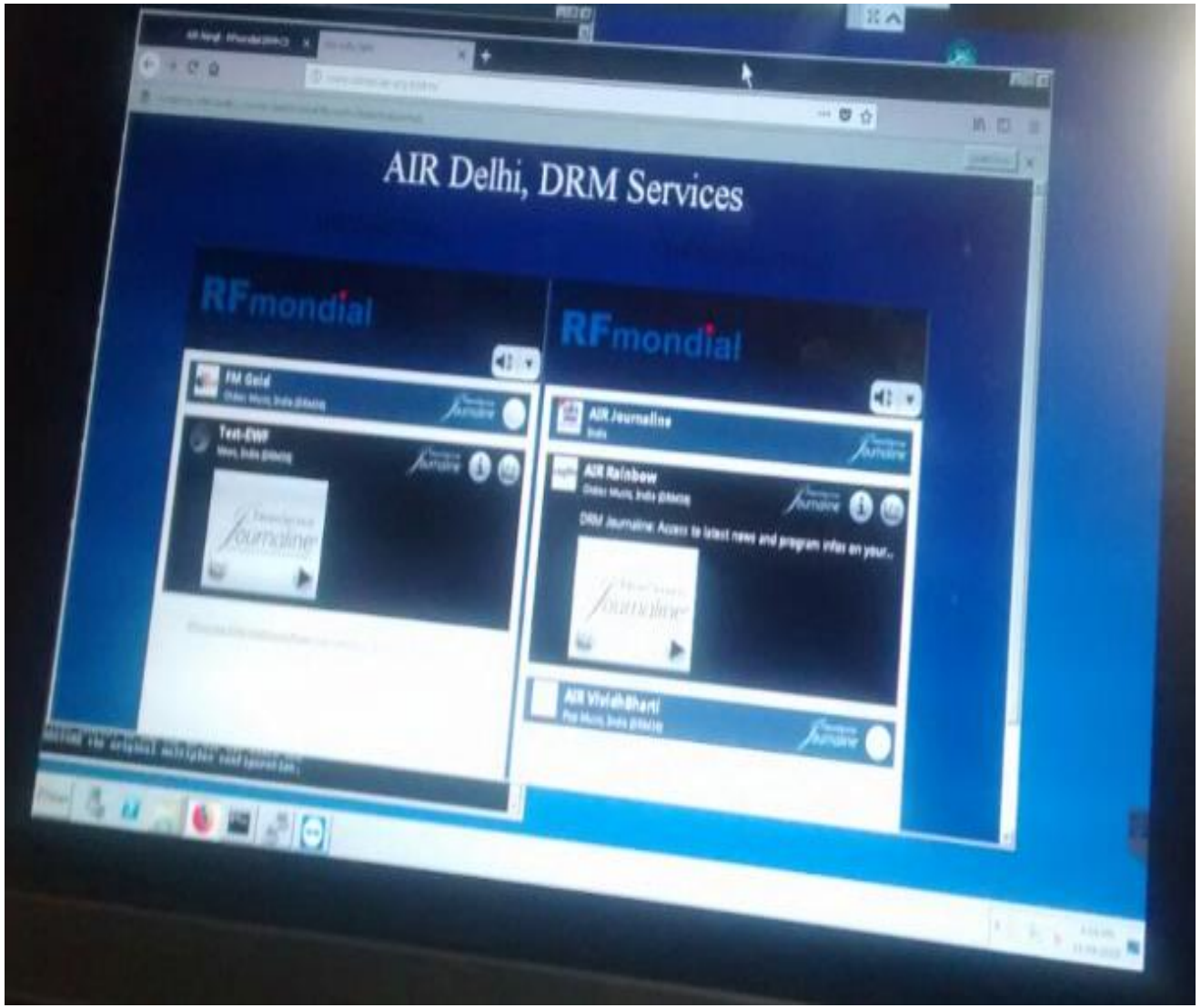
MW – 35 transmitters
1000 kW - 2
300 kW - 6
200 kW - 10
100 kW - 11
20 kW – 6

SW – 4 transmitters
500 kW - 1
250 kW - 1
100 kW - 2

Transmitters **39**
Investment **Over Rs 300 crore**
Power **8,000 kW**
Coverage **0.6 Billion people**



Emergency Warning Functionality
Trials carried out in association with NDMA



DRM in Cars

> 1 million cars with DRM receivers on the road in India
– by end of 2018

ALL Digital AM (MW and SW) is the Future not the Past !

- **Audience:** more choice (up to **3 programmes** on 1 frequency, **better audio** quality, **text and information services** in several languages. **Emergency warning** in case of disaster, **socio-economic benefits**
- **Government/Regulator**: More services, **full country coverage, additional revenue** from spectrum licensing authorities, ads
- **Broadcasters**: More and **improved services to the audience** – **FM quality with AM coverage**, additional audiences, new revenue opportunities, lower operating (**energy**) costs
- **Transmitter/Receiver Industry:** a whole **new industry digital eco-system** with potential for job creation

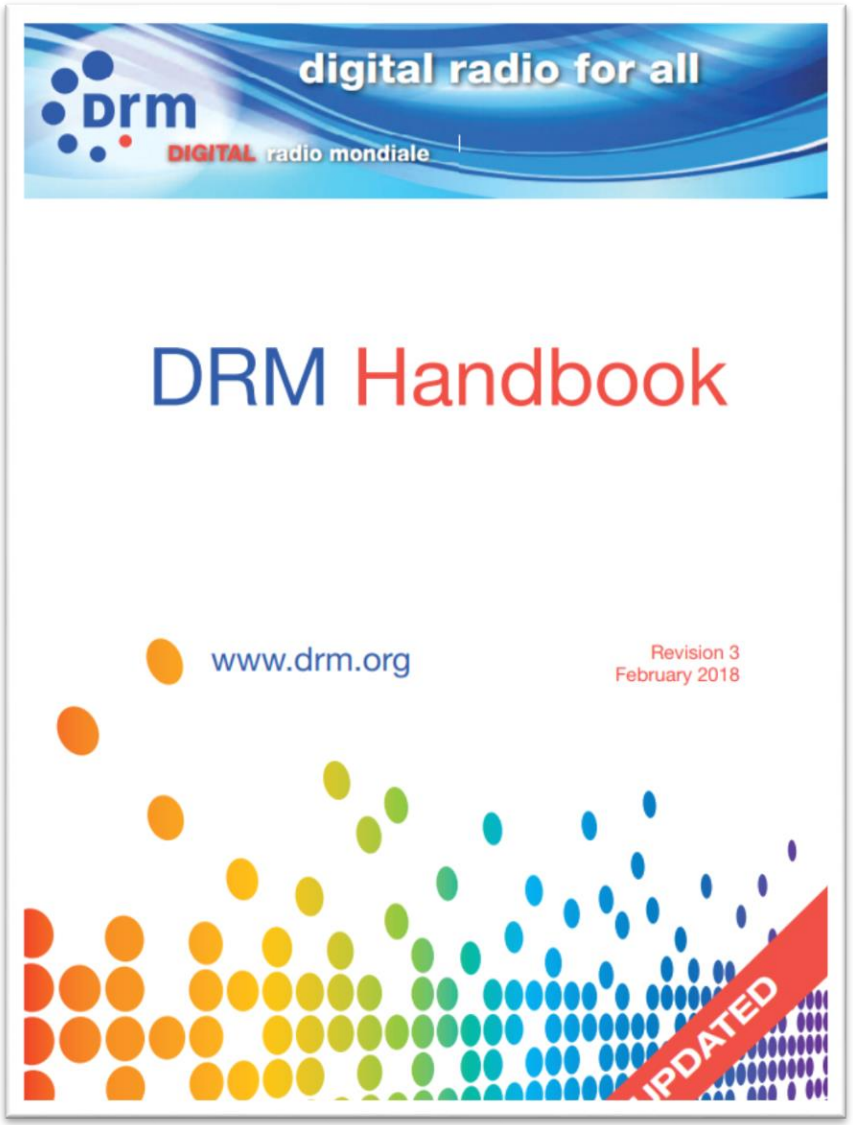
➢ **Digital AM links to the internet without the data plans, is a new digital platform, offers data and file carriage and futureproofs radio**

All you need to know about DRM Digital Radio

DRM Handbook

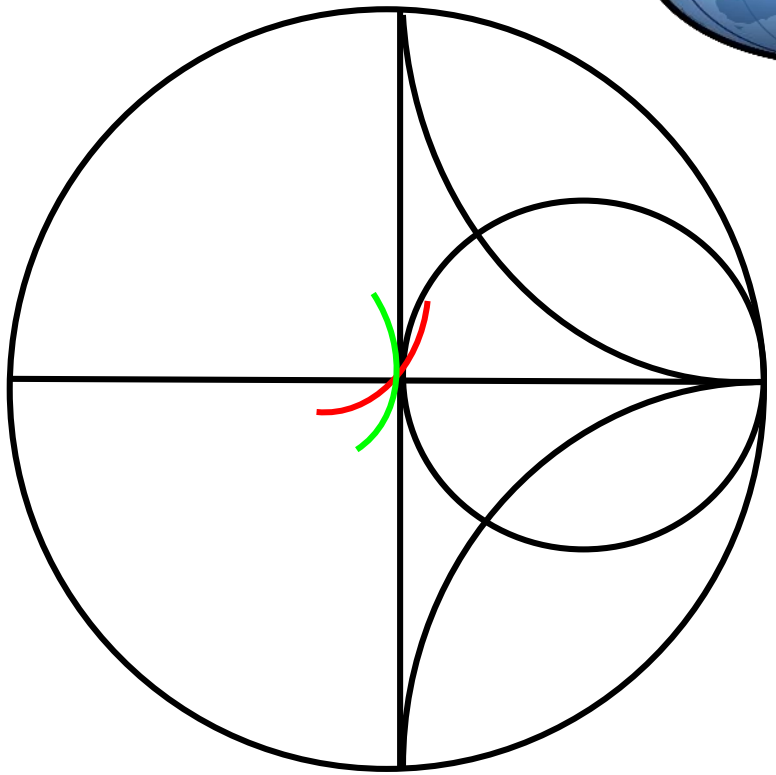
New Version 3!

Free download from: www.drm.org

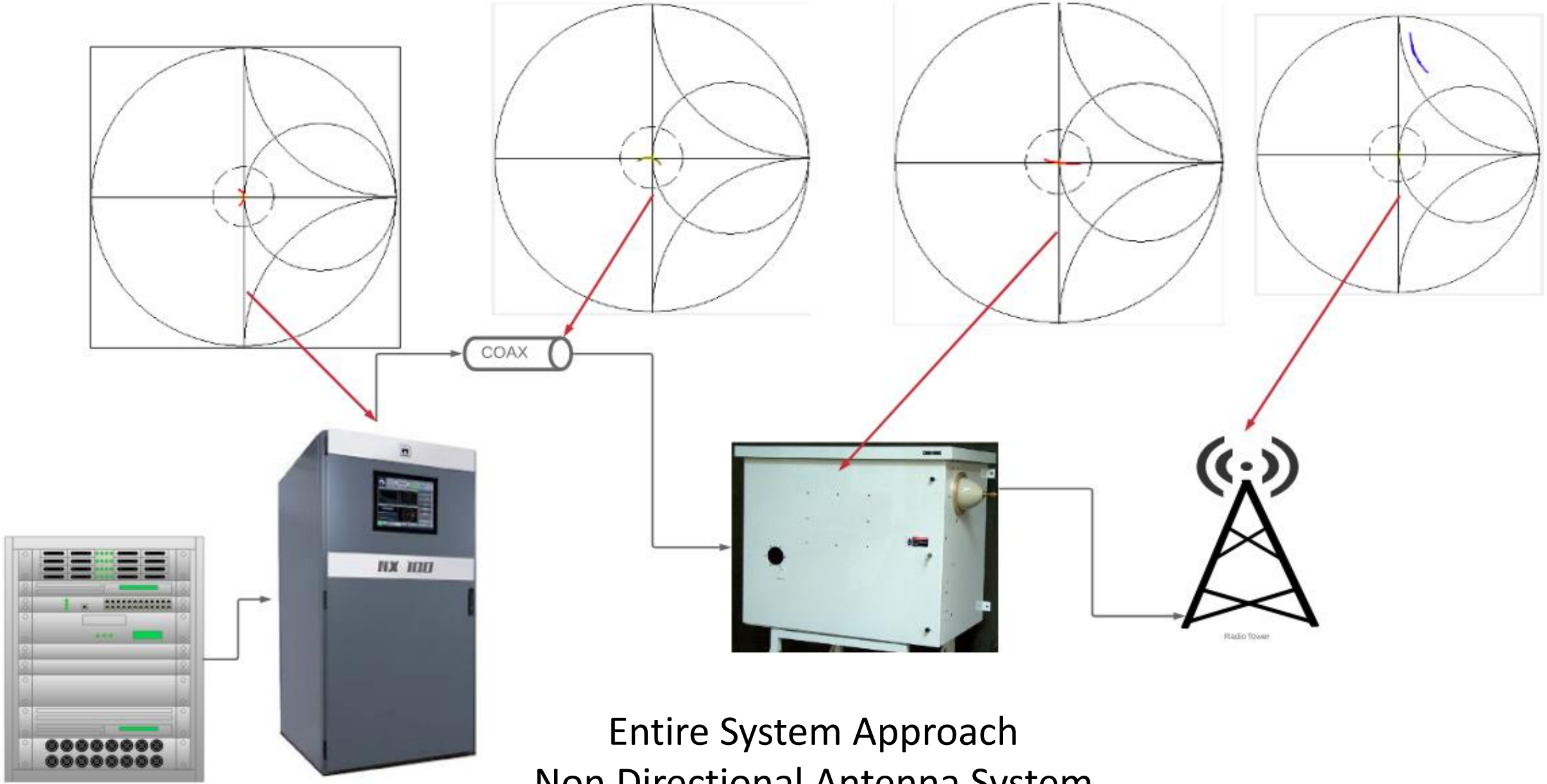


ANTENNA SYSTEM GOALS

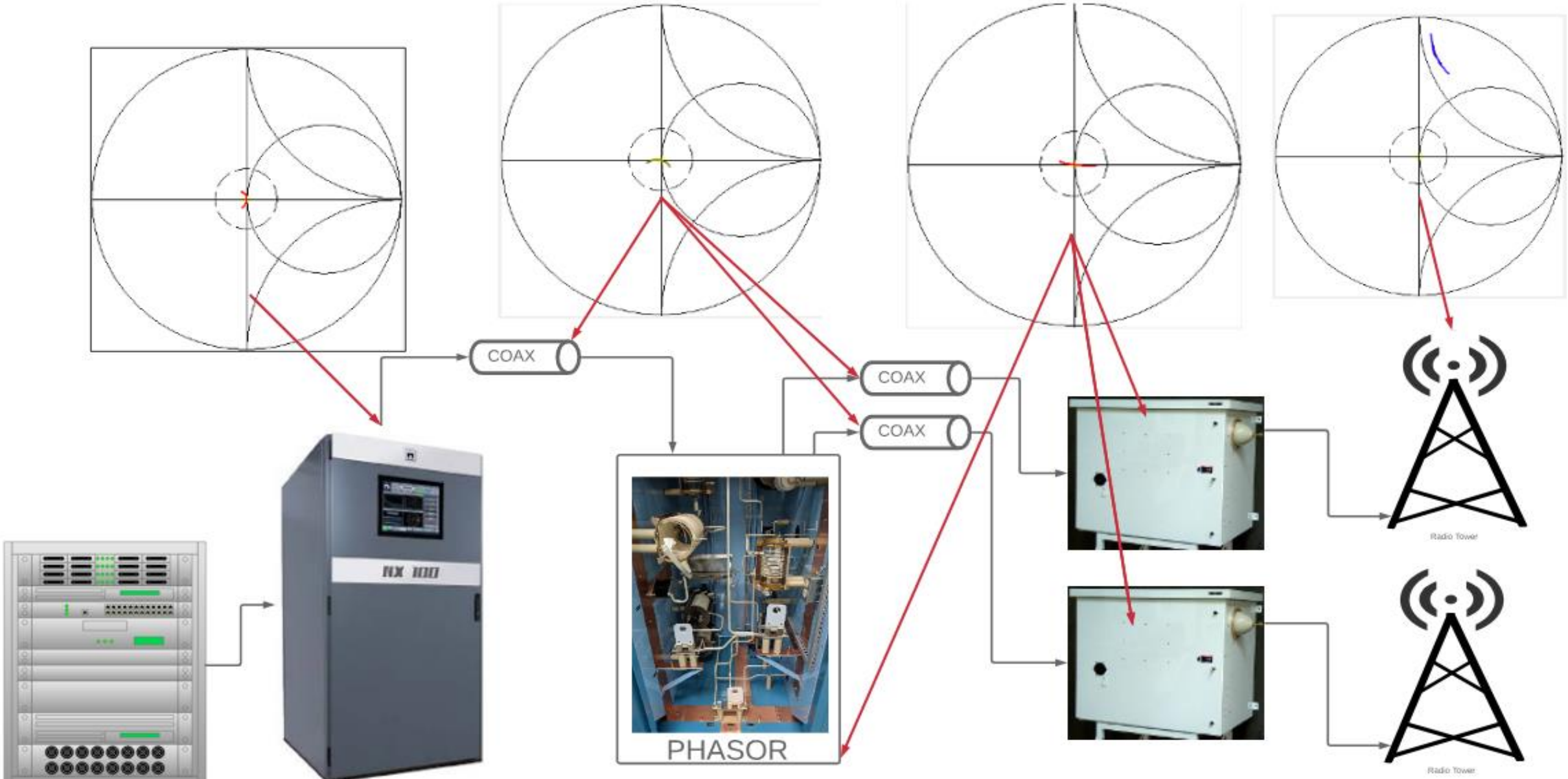
Quantity	Frequency	Requirement
Magnitude	Carrier	Matched
	∓ 10 KHz	VSWR < 1.2:1
	∓ 15 KHz	VSWR < 1.4:1
Symmetry	∓ 5 KHz	VSWR of Side Band Normalized to Complex Conjugate < 1.035:1
Rotation	∓ 15 KHz	Cusp Oriented Such That Transmitter Final Stage Sees it Open to the Left



- THESE IMPEDANCE CHARACTERISTICS SHOULD BE PRESENTED TO THE FINAL RF AMPLIFIER WITHIN THE TRANSMITTER.
- DESIGN GOAL CURRENTLY USED: ∓ 5KHZ VSWR < 1.05:1



Entire System Approach
Non Directional Antenna System



Entire System Approach
Directional Antenna System

TIPS FOR IMPROVEMENT

TOWER MODIFICATIONS

1. Guy Wire Top Loading
2. Rhombic Skirt Feed On A Guyed Tower
3. If Unipole Already Exists, Consider A Broadband Folded Unipole Design

PHASE ROTATION METHODS

1. Add A Phase Rotation Network (This Can Be A T-network Or An L-network)
2. Adding A Shunted Capacitor Or Inductor Can Add Limited Phase Shift

SIDEBAND IMPEDANCE IMPROVEMENT METHODS FOR NEW SYSTEM DESIGNS

1. Broadbanding Methods Such As Slope Correction, Pre-matching, And Cascading Networks
2. Good Matches To The Transmission Lines Are Very Important.

SIDEBAND IMPEDANCE IMPROVEMENT METHODS FOR EXISTING SYSTEMS

1. Check Design Of Existing Filters
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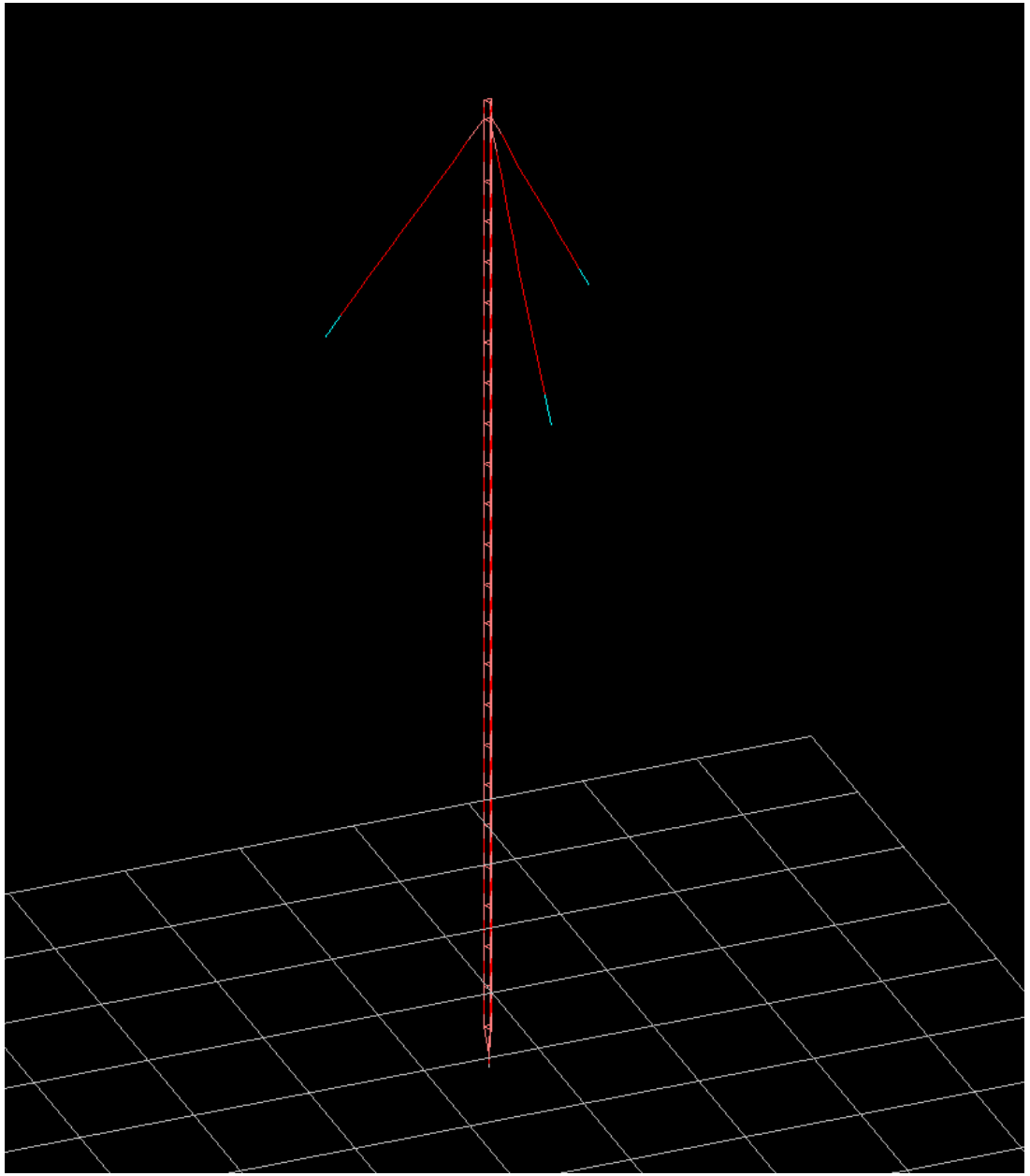
TOP LOADING



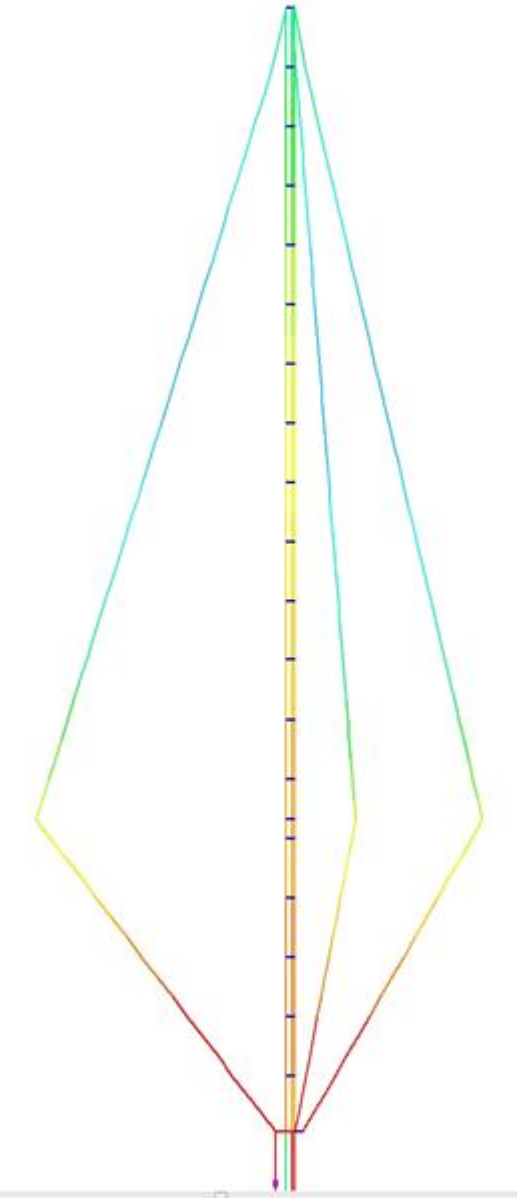
RHOMBIC SKIRT

Series Fed 70° Tower

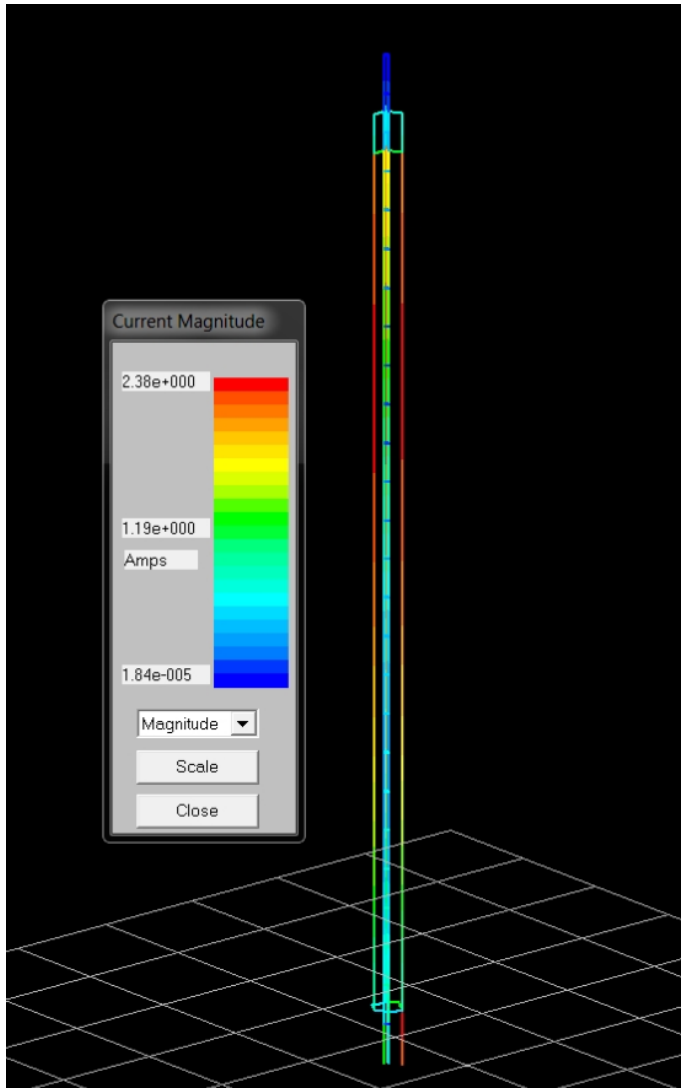
KHz	Normalized VSWR	Impedance
980	1.559	17.3-82.1i
985	1.390	17.6-80.1i
990	1.243	17.8-78.1i
995	1.117	18.1-76.2i
1000	1.000	18.3-74.2i
1005	1.116	18.6-72.2i
1010	1.236	18.8-70.3i
1015	1.373	19.1-68.3i
1020	1.515	19.3-66.4i

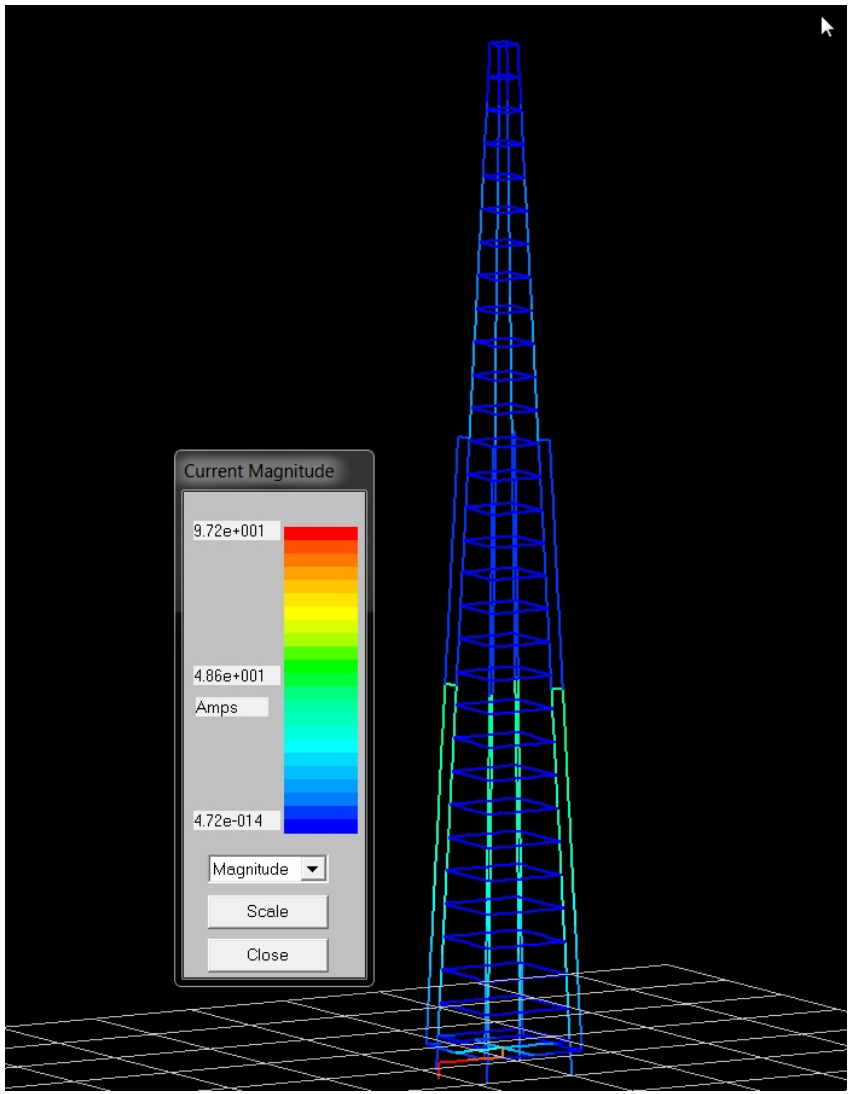
Rhombic (Diamond) Skirt

KHz	Normalized VSWR	Impedance
980	1.360	49.8-97.7i
985	1.257	50.0-93.7i
990	1.163	50.2-89.8i
995	1.078	50.5-86.0i
1000	1.000	50.7-82.2i
1005	1.076	51.0-78.5i
1010	1.154	51.2-74.9i
1015	1.238	51.5-71.3i
1020	1.327	51.8-67.7i



FOLDED UNIPOLE





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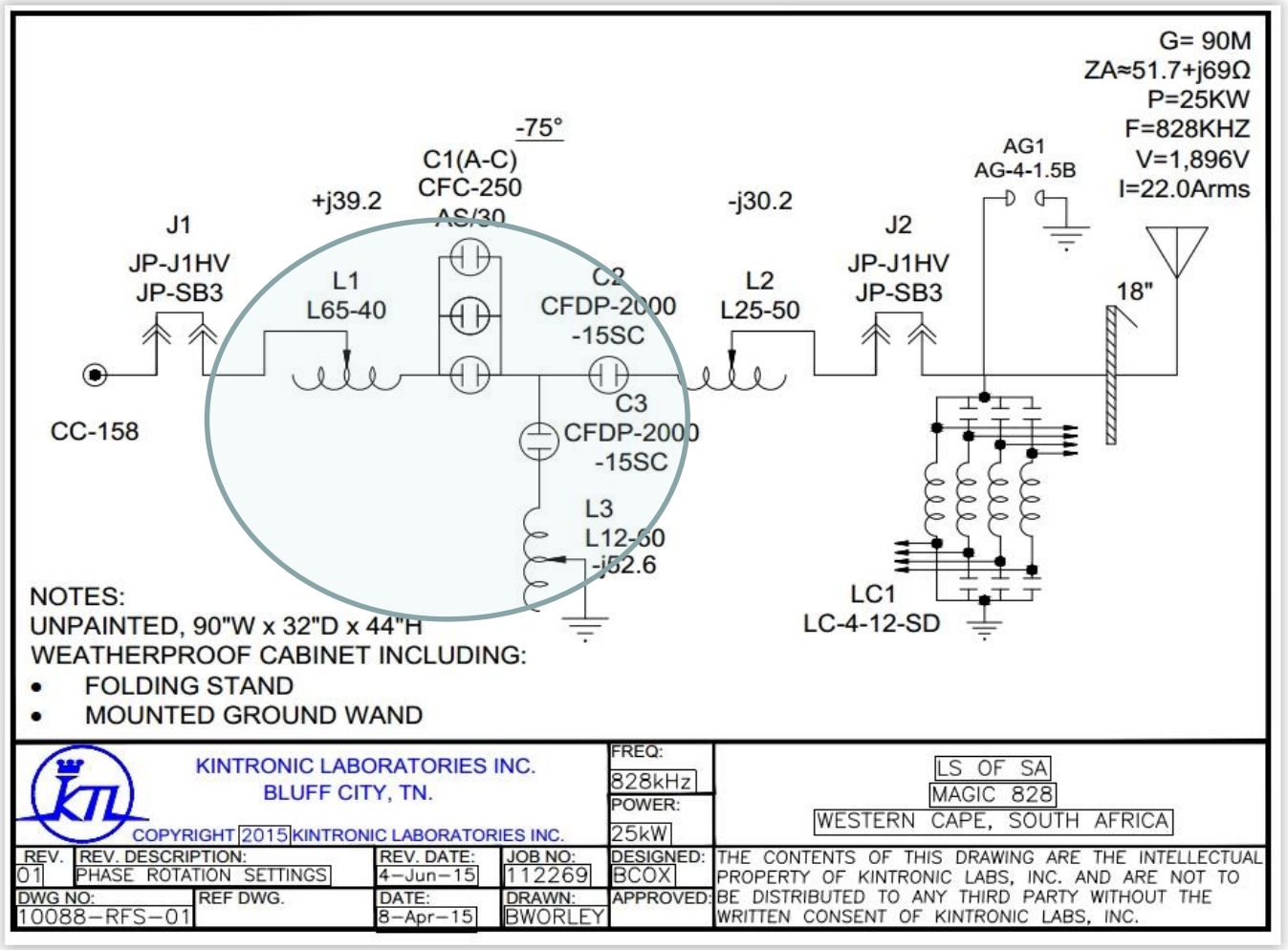
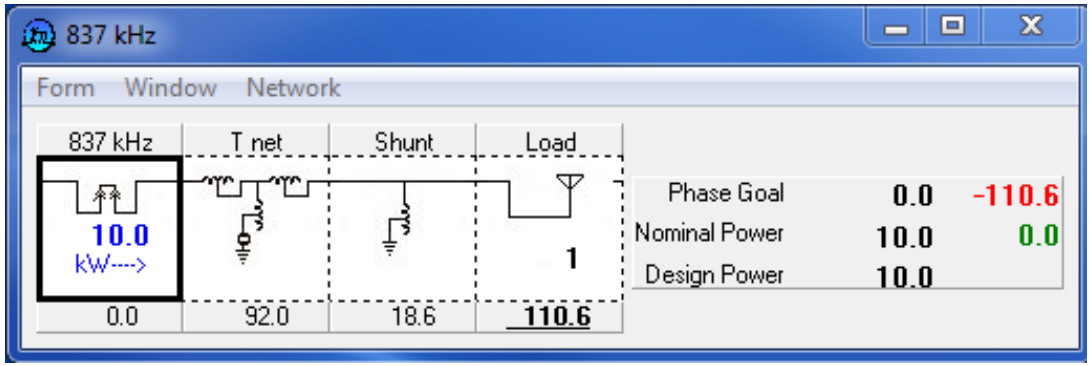
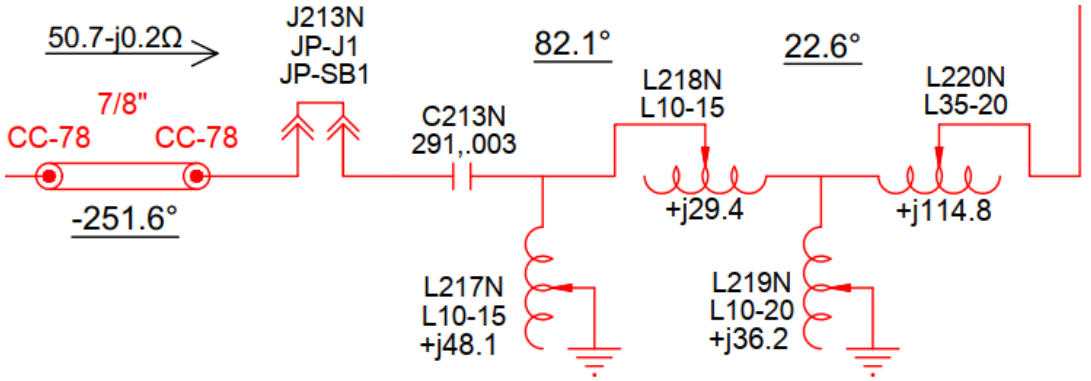
SLOPE CORRECTION, PRE-MATCHING, CASCADED NETWORKS







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THE RIGHT TOOL

Field Engineer Ready, Easy to Use, Cost Effective, and Light Weight

1. AIM-4300-DX - Antenna Analyzer, 5 kHz to 300 MHz.
2. RigExpert AA-230 ZOOM (100kHz to 230MHz)

Precision Tuning Capability, Great for Noisy Environments, but Expensive

1. Network Analyzer with Tunwall Set and Power Amplifier

FINAL WORD

WE ARE HERE TO SUPPORT ALL EFFORTS TO TRANSITION YOUR NEW OR EXISTING BROADCAST STATION TO ALL DIGITAL OPERATION.

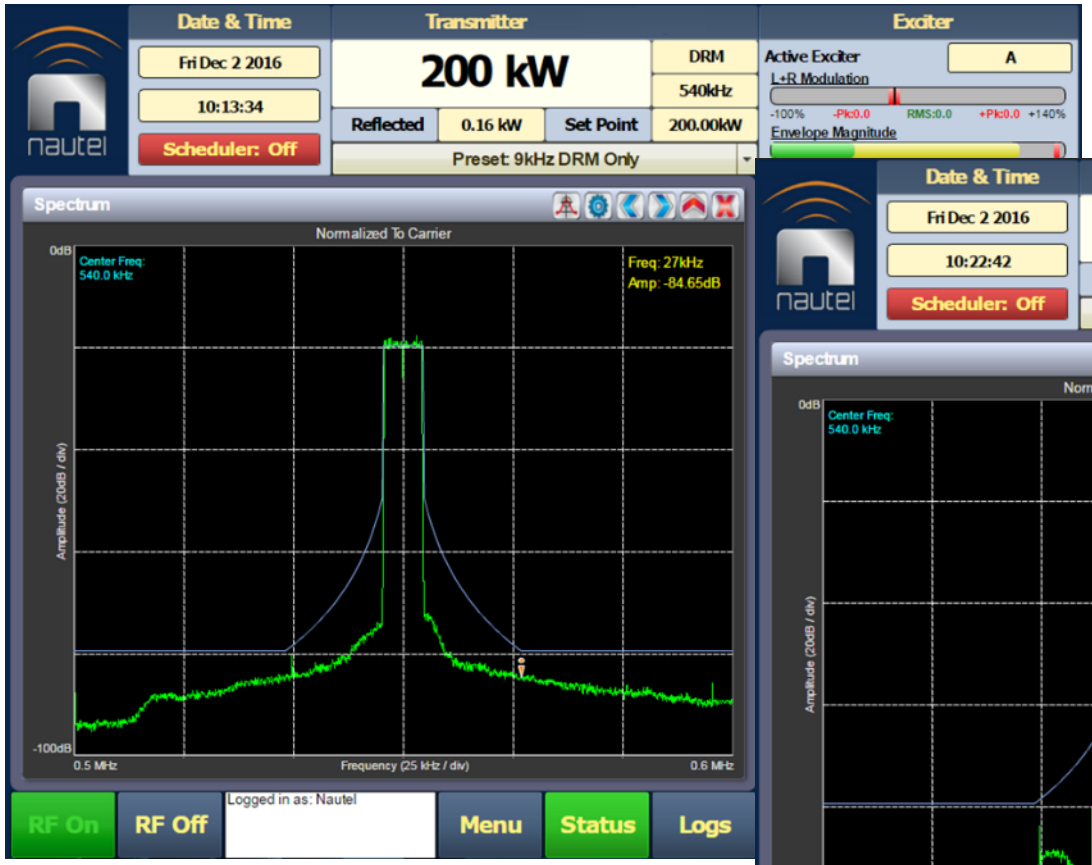
REFERENCES:

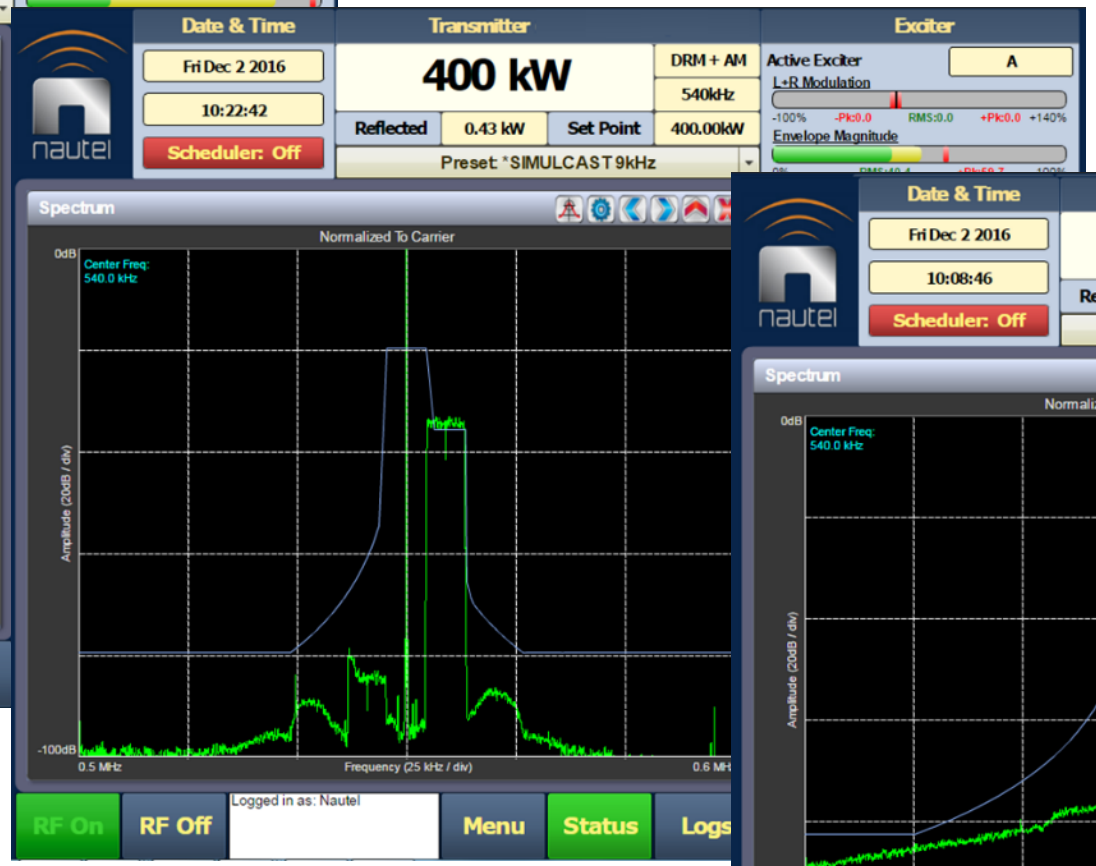
“Evaluations and Improvement of AM Antenna Characteristics For Optimal Digital Performance”, Ron Rackley, 2004 NAB Engineering Conference Proceedings

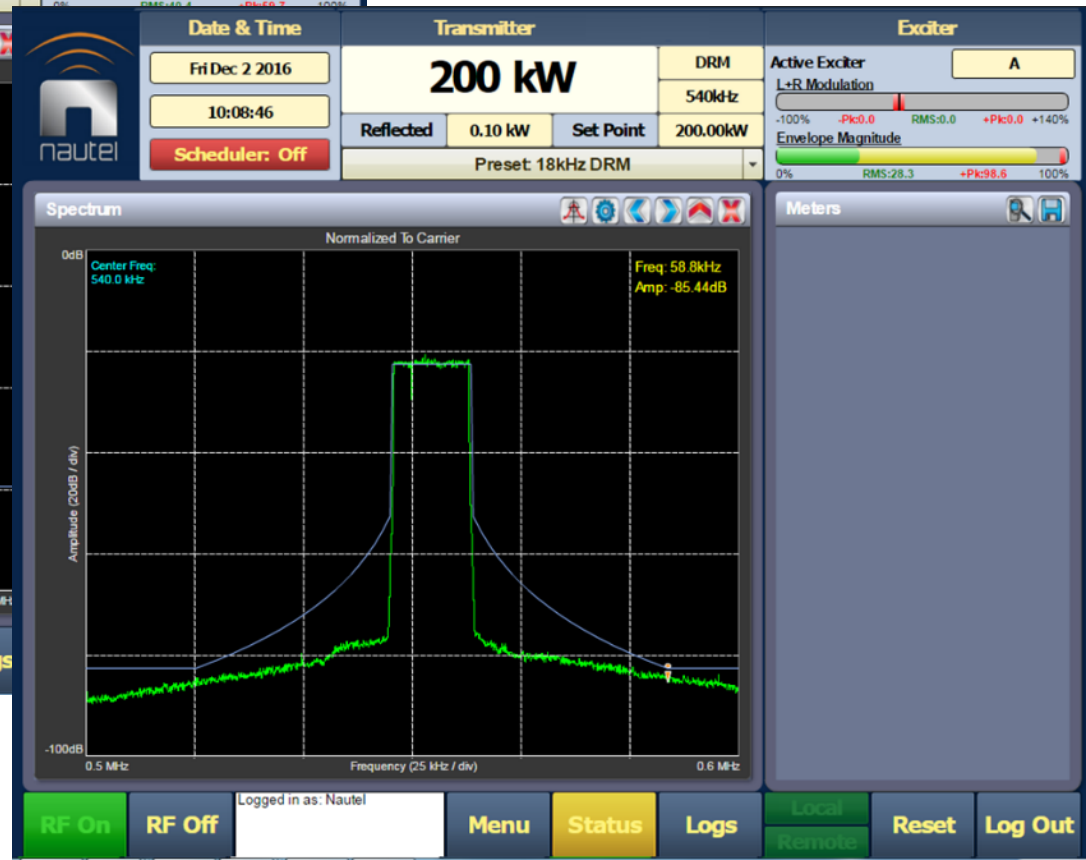
“Medium Wave Feeder Design For Digital Broadcast”, Jim Moser, Jacob Depriest, 2005 NAB Engineering Conference Proceedings

NX Transmitter All Digital Signals: DRM

- All DRM modes are supported (Modes A,B,C,D)



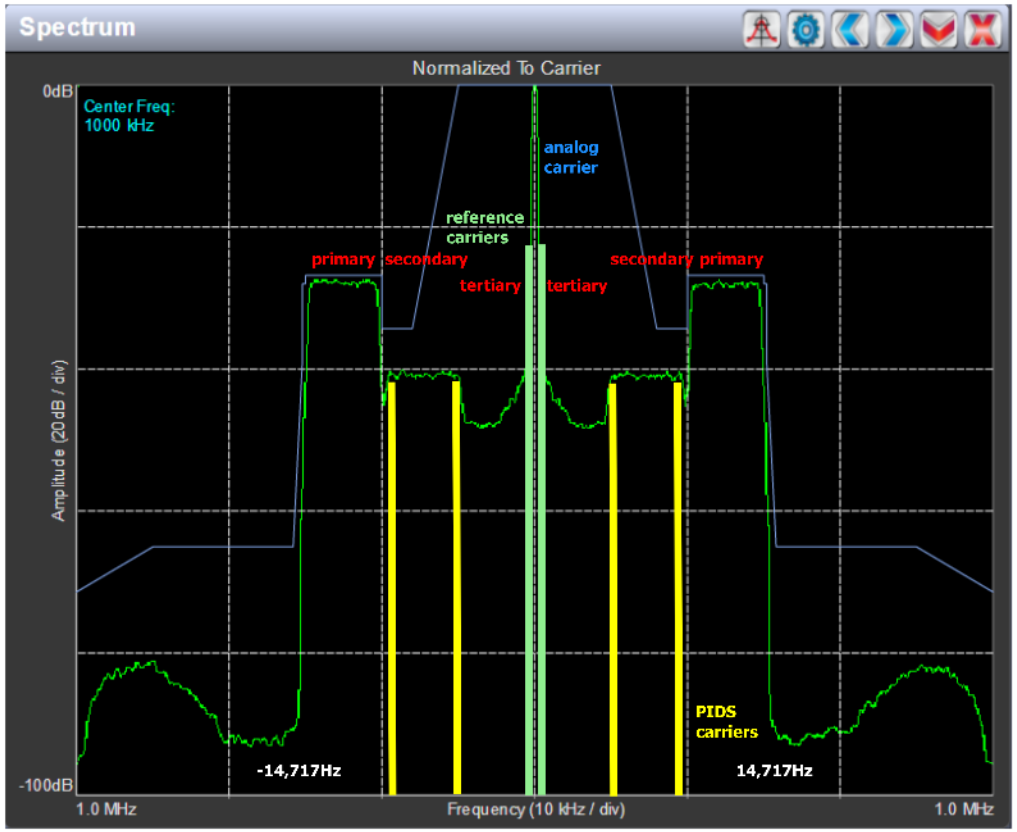




NX Transmitter All Digital Signals: IBOC

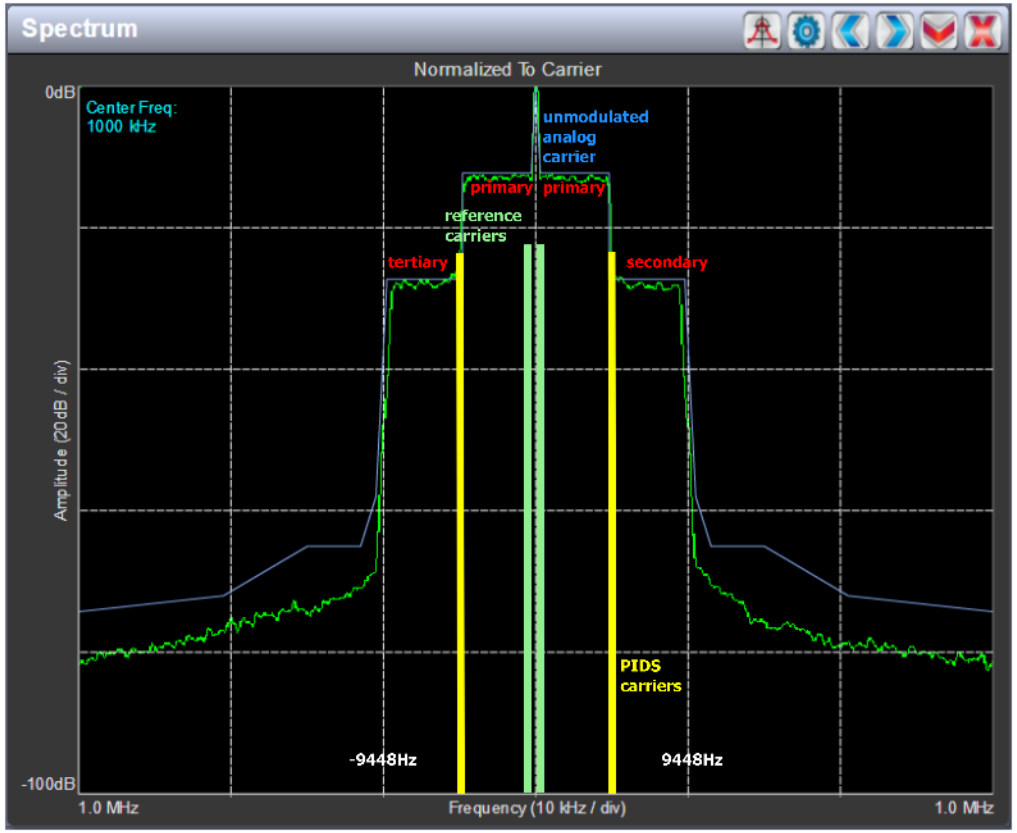
Hybrid MA1 without AM Modulation

30 kHz BW: 20 kbps core / 16 kbps enhanced



All Digital MA3

20 kHz BW: 20 kbps core / 20 kbps enhanced

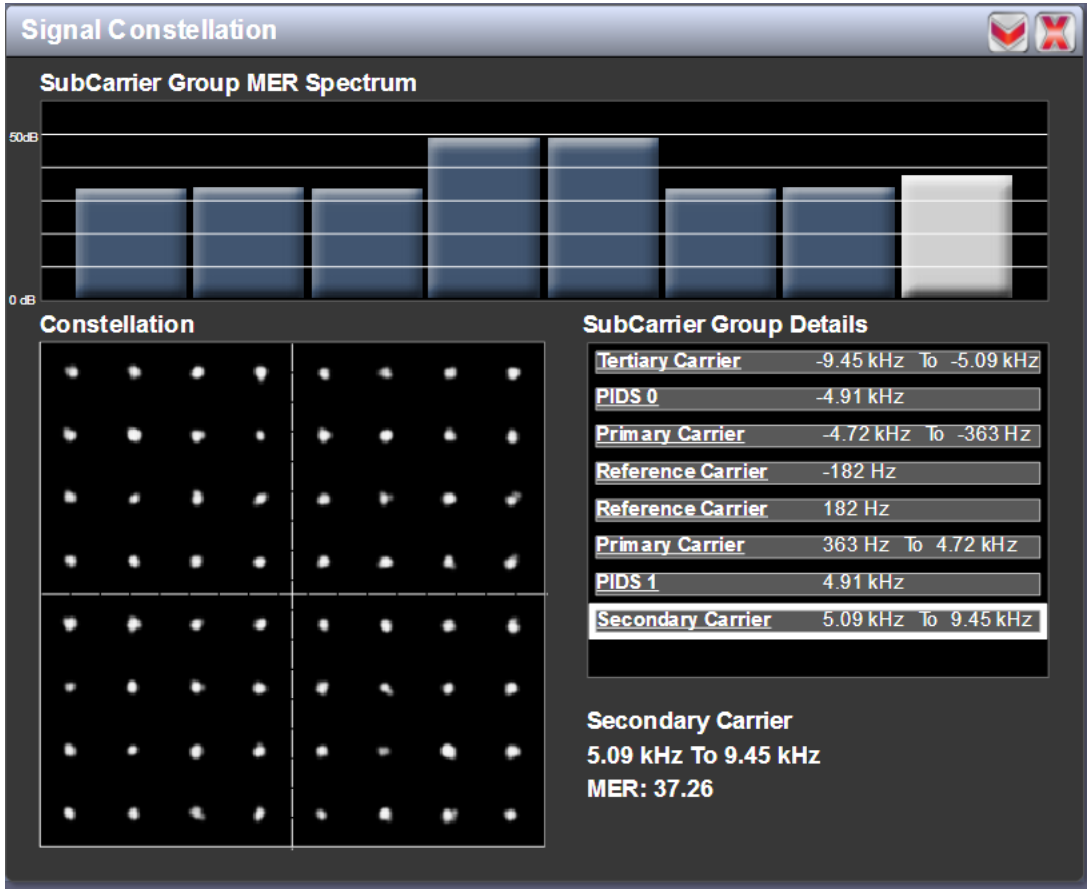


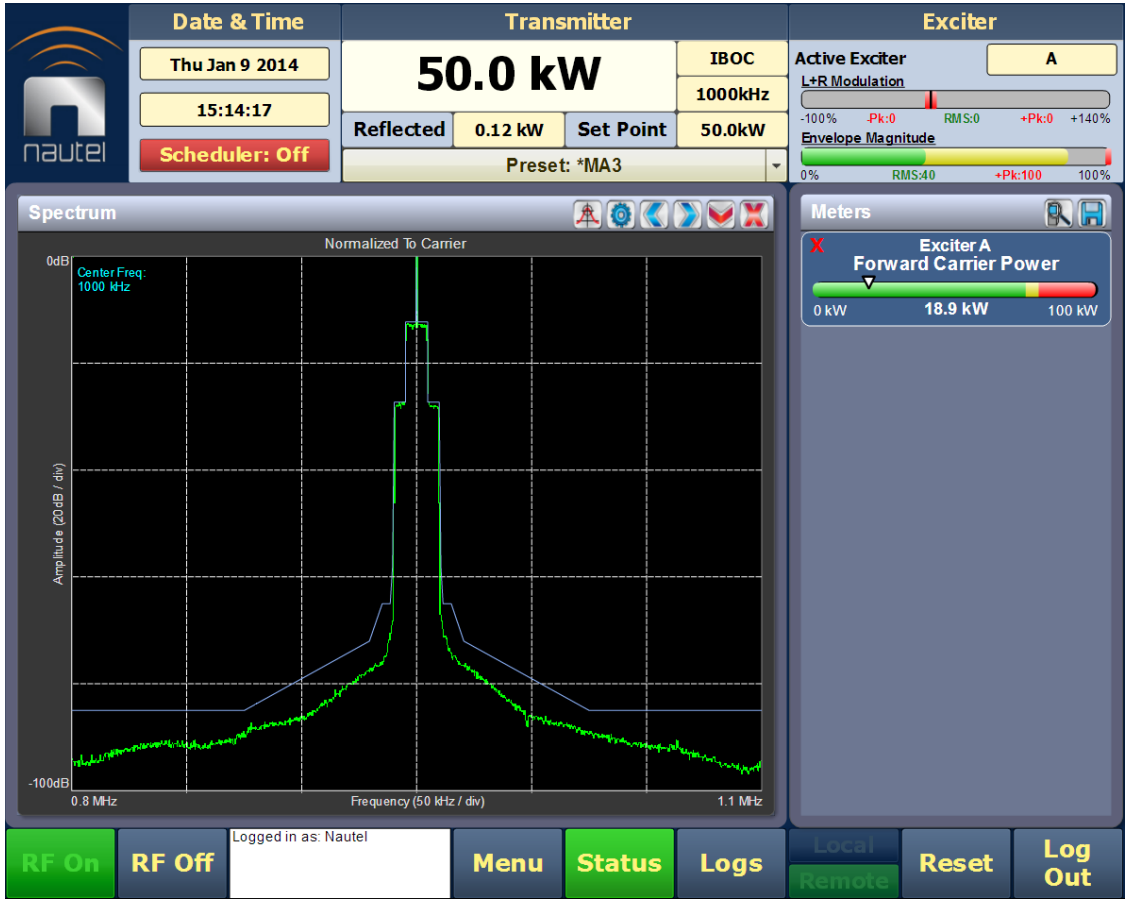
Measuring Power in MA3

- To properly measure power in this mode, an RMS power meter is required that can handle the peak to average ratio (8-11 dB).
- Nautel NX transmitters **display RMS power** not carrier power in MA3

Signal	Carrier	RMS	Peak (clipped)	Averaging meter
Analog AM	50 kW	52.5 kW	253 kW	50 kW
MA1 + AM	50 kW	55.5 kW	288+ kW	51 kW
MA3	19.1 kW	50 kW	288+ kW	40.3 kW

NX Transmitter Measurement tools





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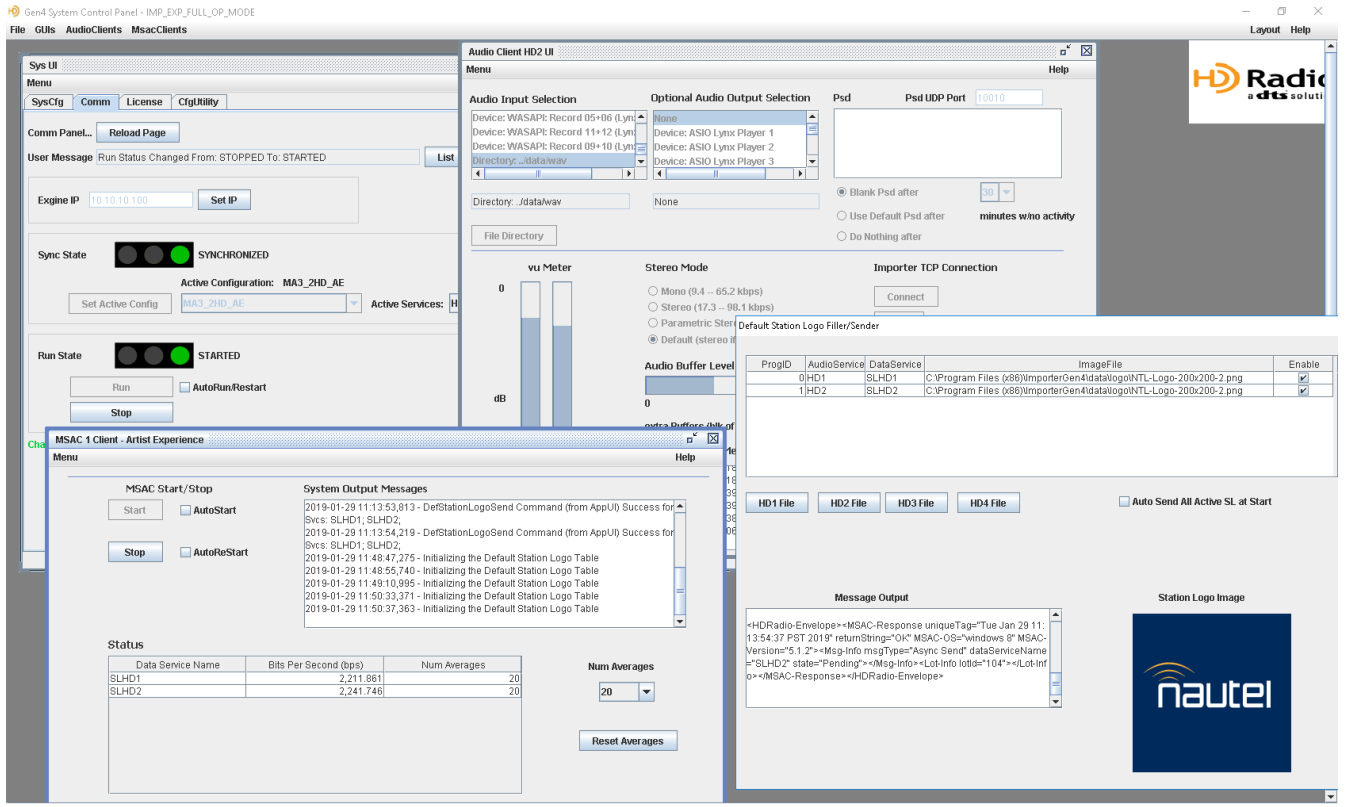
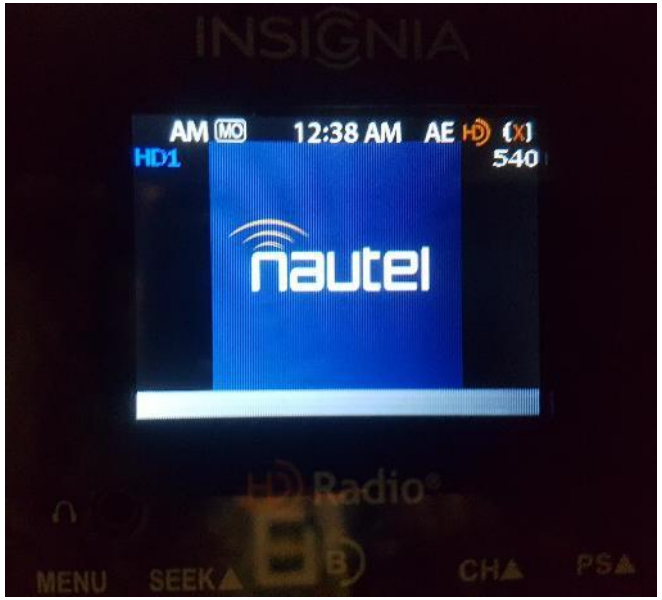
NX Transmitter Features for All Digital AM

- Mag/Phase Delay
- AM-AM
- AM-PM
- Magnitude Path Equalization
- B+ Compensation

HD Multicast+ for AM Data and Audio Services





Nautel HD Multicast+
Gen4 combined Importer/Exporter can now be used for AM and FM

- station logo
- artist experience
- HD2

nautel 50 YEARS 1969-2019

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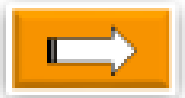
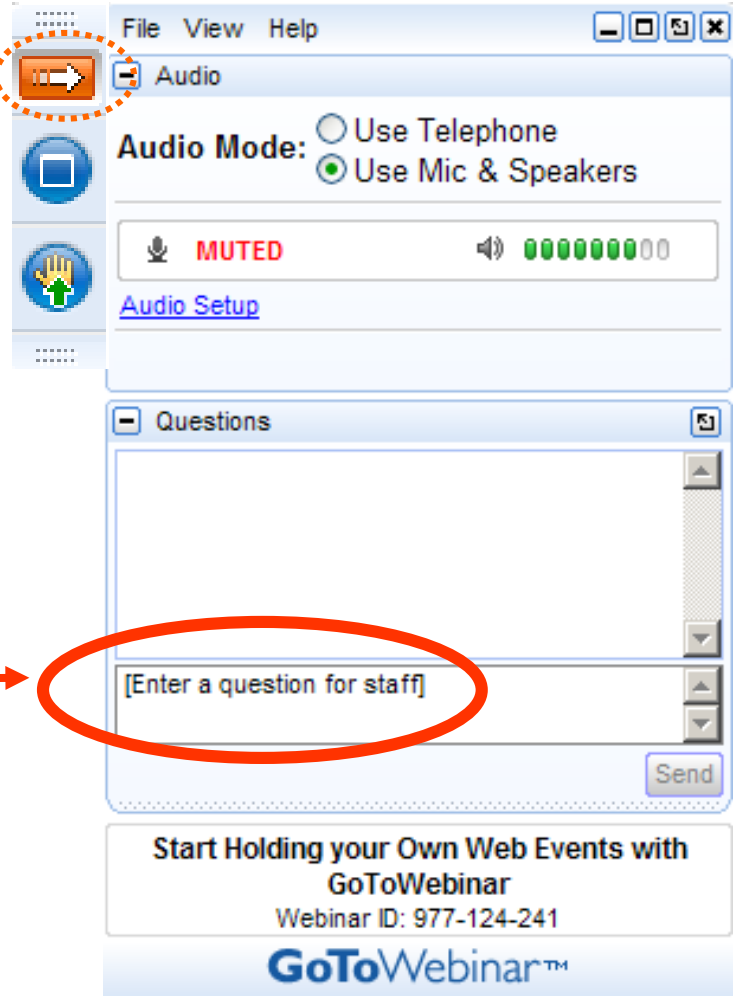
Questions?

Click on  *to open/close webinar panel*



Enter questions here
…then press **Send**

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Thank you!

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