All Digital AM in the Real World
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
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 Recertification 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

- Analog Audio Signal (Mono)

- Lower Digital Sidebands
  - Primary
  - Secondary
  - Tertiary

- Upper Digital Sidebands
  - Primary
  - Secondary
  - Tertiary

- Frequency (Hz)
  - 14716.6
  - 9629.4
  - -27
  - -181.7
  - 27
  - 53

- Subcarrier Index
  - -81
  - -53
  - -27
  - -181.7
  - 27
  - 53

• MA3 Waveform

- Lower Digital Sidebands
  - Primary
  - Secondary
  - Tertiary

- Upper Digital Sidebands
  - Primary
  - Secondary
  - Tertiary

- Frequency (Hz)
  - 9447.7
  - 4905.5
  - -27
  - -181.7
  - 27
  - 52

- Subcarrier Index
  - -52
  - -27
  - -181.7
  - 27
  - 52
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
WWFD-AM Transmitter Configuration

Nautel Multicast+ Importer

Nautel Exporter Plus

Program Audio

CSRDS Datacasting Software

Nautel AM IBOC Exciter

Magnitude thru H-Pad

Phase

BE ASi-10

Magnitude

Phase

BE AM-6A

Gates Five
The FCC granted a one-year Experimental Authorization for WWFD to transmit in the all-digital MA3 mode beginning July 16, 2018.
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 Digital Radio standard – One single standard: Same key features throughout

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

30 MHz
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

**AM analogue MW:** 142 kW, 1 service

**DRM on MW:** 50 kW, 1–3 services (plus multimedia)

- **AM Coverage:**
  - 100 kW MW transmitter
  - 600 km
  - 100 kW ERP @ 72% efficiency → 142 kW power consumption

- **DRM Coverage:**
  - 100 kW MW transmitter
  - 600 km
  - 40 kW ERP @ 80% efficiency → 50 kW 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"

<table>
<thead>
<tr>
<th>MW – 35 transmitters</th>
<th>SW – 4 transmitters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 kW - 2</td>
<td>500 kW - 1</td>
</tr>
<tr>
<td>300 kW - 6</td>
<td>250 kW - 1</td>
</tr>
<tr>
<td>200 kW - 10</td>
<td>100 kW - 2</td>
</tr>
<tr>
<td>100 kW - 11</td>
<td></td>
</tr>
<tr>
<td>20 kW – 6</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Frequency</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnitude</td>
<td>Carrier</td>
<td>Matched</td>
</tr>
<tr>
<td></td>
<td>± 10 KHz</td>
<td>VSWR &lt; 1.2:1</td>
</tr>
<tr>
<td></td>
<td>± 15 KHz</td>
<td>VSWR &lt; 1.4:1</td>
</tr>
<tr>
<td>Symmetry</td>
<td>± 5 KHz</td>
<td>VSWR of Side Band Normalized to Complex Conjugate &lt; 1.035:1</td>
</tr>
<tr>
<td>Rotation</td>
<td>± 15 KHz</td>
<td>Cusp Oriented Such That Transmitter Final Stage Sees it Open to the Left</td>
</tr>
</tbody>
</table>

- 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
2. Remove Any Unused Equipment That Is Bonded To The Tower.
TOP LOADING
### RHOMBIC SKIRT

#### Series Fed 70° Tower

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

#### Rhombic (Diamond) Skirt

<table>
<thead>
<tr>
<th>KHz</th>
<th>Normalized VSWR</th>
<th>Impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>980</td>
<td>1.360</td>
<td>49.8-97.7i</td>
</tr>
<tr>
<td>985</td>
<td>1.257</td>
<td>50.0-93.7i</td>
</tr>
<tr>
<td>990</td>
<td>1.163</td>
<td>50.2-89.8i</td>
</tr>
<tr>
<td>995</td>
<td>1.078</td>
<td>50.5-86.0i</td>
</tr>
<tr>
<td>1000</td>
<td>1.000</td>
<td>50.7-82.2i</td>
</tr>
<tr>
<td>1005</td>
<td>1.076</td>
<td>51.0-78.5i</td>
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<tr>
<td>1010</td>
<td>1.154</td>
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</tr>
<tr>
<td>1015</td>
<td>1.238</td>
<td>51.5-71.3i</td>
</tr>
<tr>
<td>1020</td>
<td>1.327</td>
<td>51.8-67.7i</td>
</tr>
</tbody>
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FOLDED UNIPOLE
TIPS FOR IMPROVEMENT

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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:

“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

<table>
<thead>
<tr>
<th>Signal</th>
<th>Carrier</th>
<th>RMS</th>
<th>Peak (clipped)</th>
<th>Averaging meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog AM</td>
<td>50 kW</td>
<td>52.5 kW</td>
<td>253 kW</td>
<td>50 kW</td>
</tr>
<tr>
<td>MA1 + AM</td>
<td>50 kW</td>
<td>55.5 kW</td>
<td>288+ kW</td>
<td>51 kW</td>
</tr>
<tr>
<td>MA3</td>
<td>19.1 kW</td>
<td>50 kW</td>
<td>288+ kW</td>
<td>40.3 kW</td>
</tr>
</tbody>
</table>
NX Transmitter Measurement tools
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
Questions?

Click on to open/close webinar panel

Enter questions here …then press Send
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