PILOT radio test bed

NAVIGATING BROADCASTING'S FUTURE

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PILOT radio test bed

NAVIGATING BROADCASTING'S FUTURE

- Built for NAB by Cavell, Mertz and Associates (CMA) in 2014
  - Principally for **co- and adjacent-channel** testing
  - Dan Ryson and Mike Rhodes, project engineers
  - 3 AM and 3 FM transmitters
  - Originally located in Manassas, VA at CMA offices
  - Moved to NAB's 1M Street SE HQ in 2021

CAVELL, MERTZ & ASSOCIATES, INC.

- Why build a radio test bed?
  - Support innovations in broadcast technology, rules and regulations
  - Supplement field tests (coverage) with lab tests (interference)
  - Contribute technical information to FCC in rulemakings, etc.
  - Make available for hire

2

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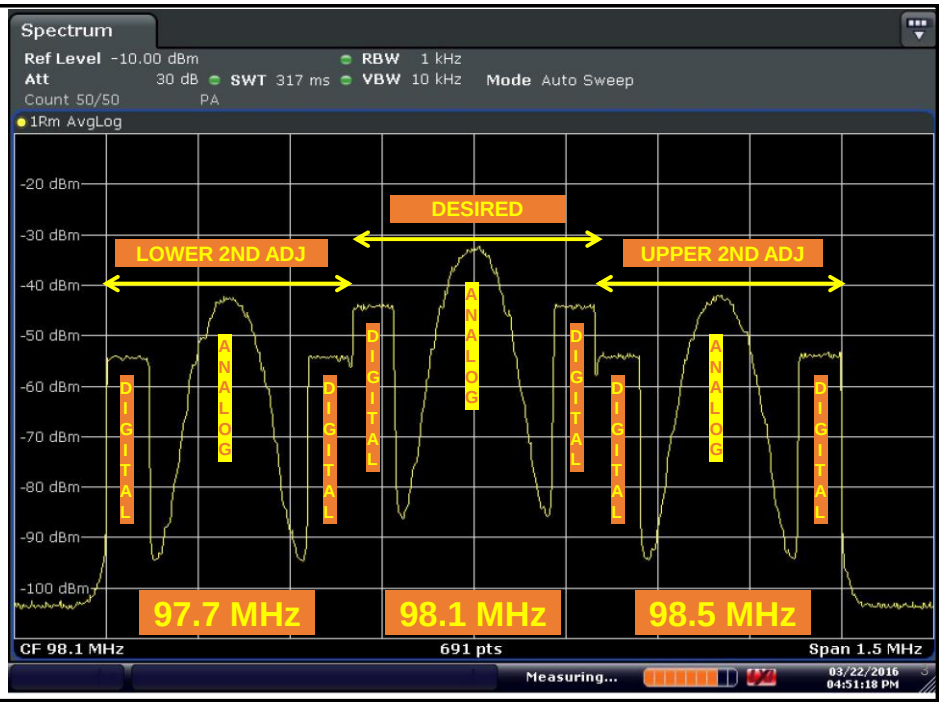
Adjacent-channel testing example showing three FM-band HD Radio signals



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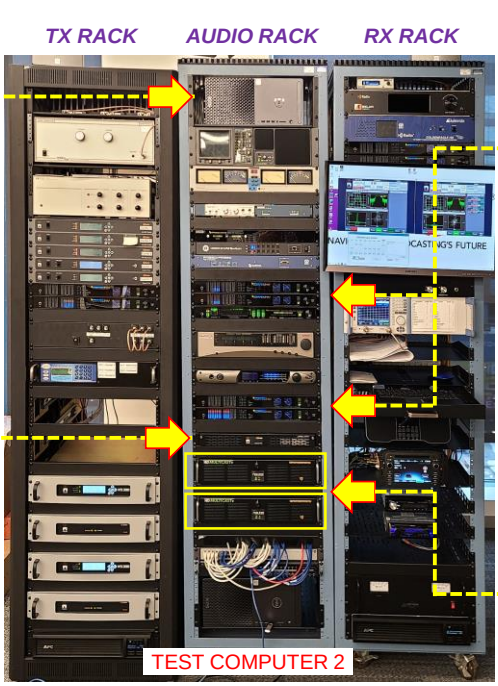
PILOT radio test bed (2021)



(RED INDICATES NEW EQUIPMENT IN 2021 UPGRADE)

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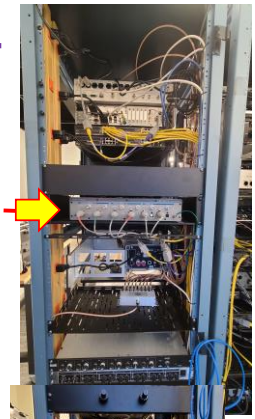
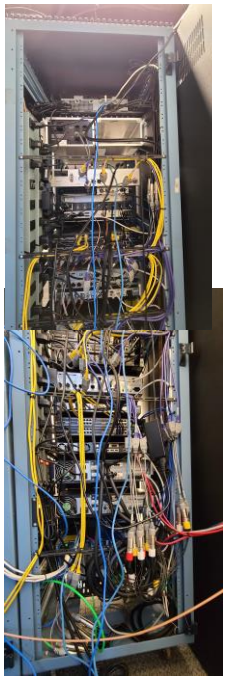
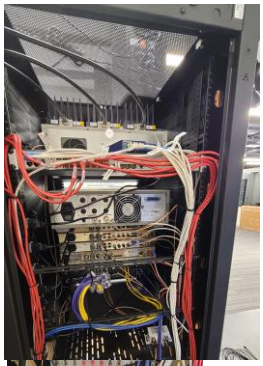
PILOT radio test bed (2022)

AUDIO PRECISION TEST SET







PILOT NAVIGATING BROADCASTING'S FUTURE

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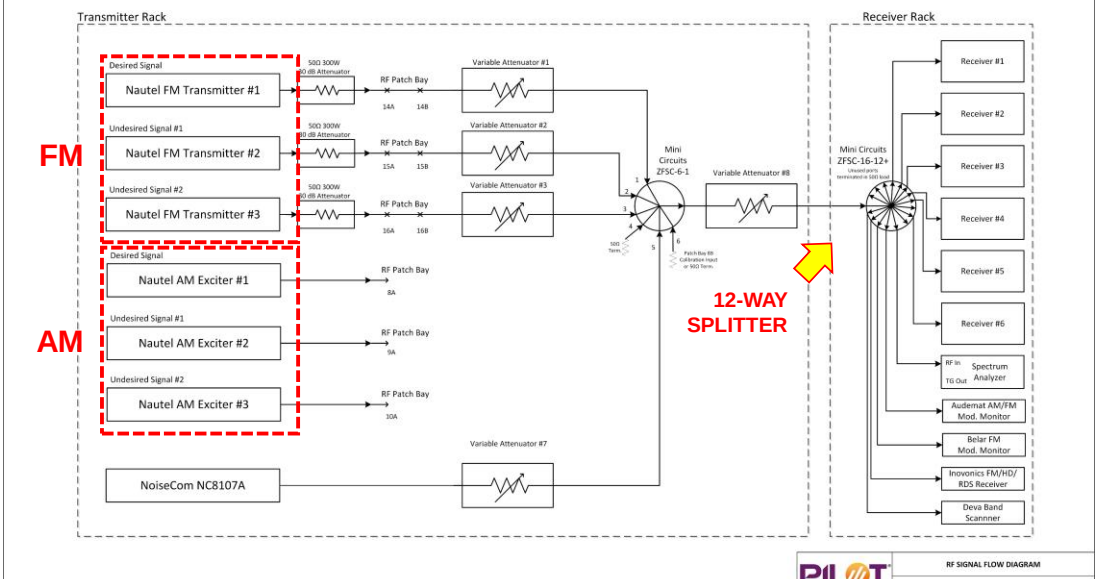
RF BLOCK DIAGRAM



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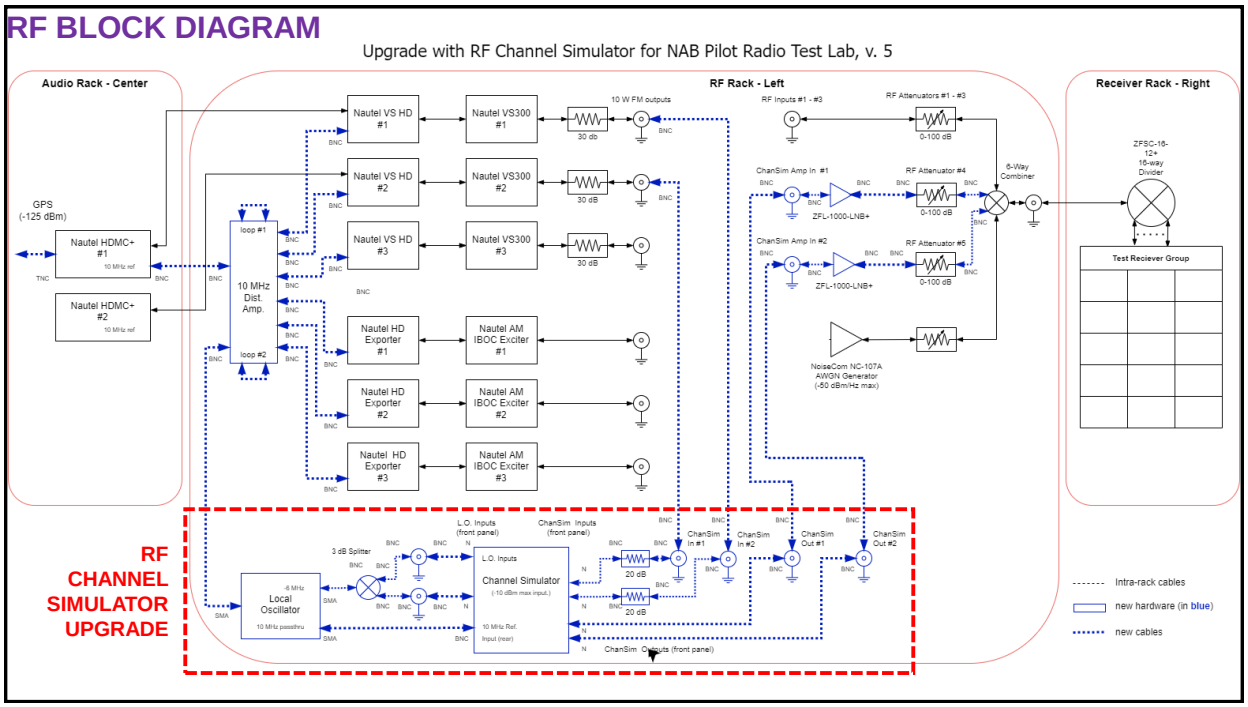
RF BLOCK DIAGRAM



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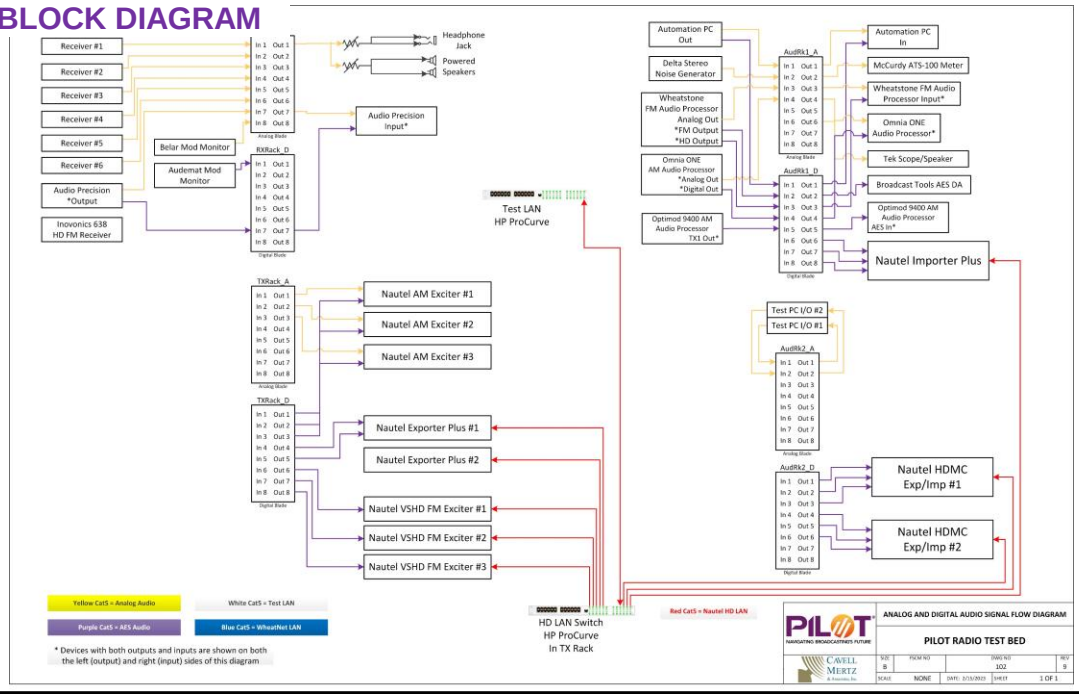
AUDIO BLOCK DIAGRAM



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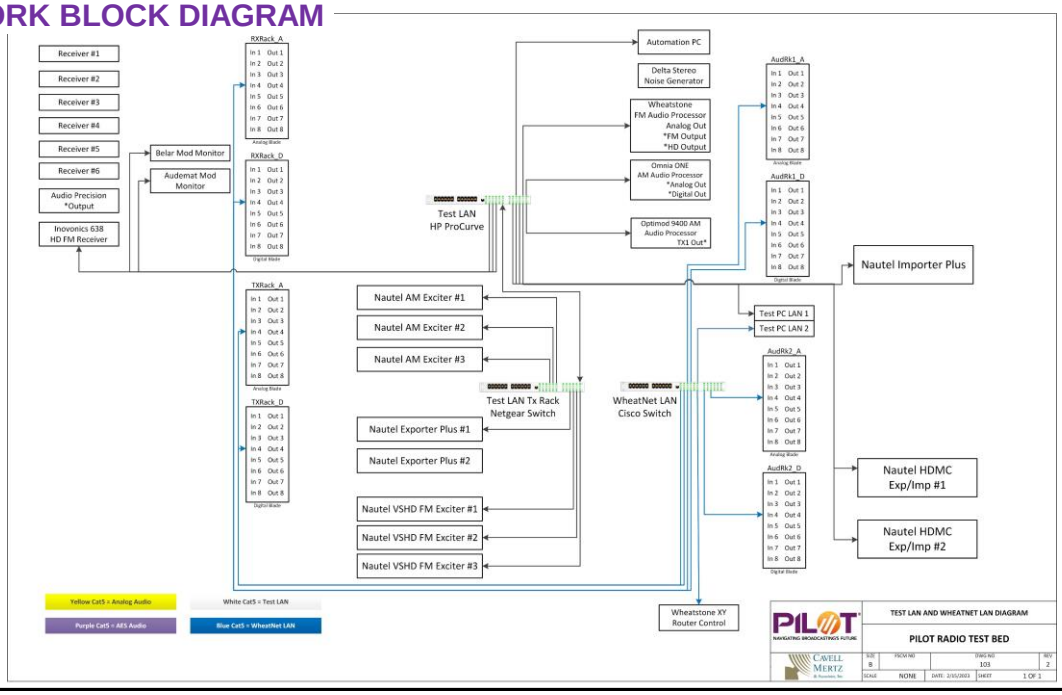
NETWORK BLOCK DIAGRAM



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PILOT radio test bed – evolution

- **2014:** Built at CMA, 2 racks, AM only
- **2017:** 3 racks, AM and FM
- **2021:** Moved to NAB HQ, modernized audio distribution, updated exciters
- **2022:** Metadata integration, RF channel simulator integration

2014

2017

2021

10

10

PILOT radio test bed - 2014

- Original test bed:
  - Built and operated at CMA facility in Manassas, VA
  - Two racks
  - AM-only
- Includes donated equipment from Xperi
  - Including equip. from ATTC
  - Racks, analog audio distribution equipment

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PILOT radio test bed – audio router

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PILOT radio test bed - 2017

- After first upgrade:
  - Same room at CMA facility in Manassas (tight fit!)
  - Three racks
  - AM and FM

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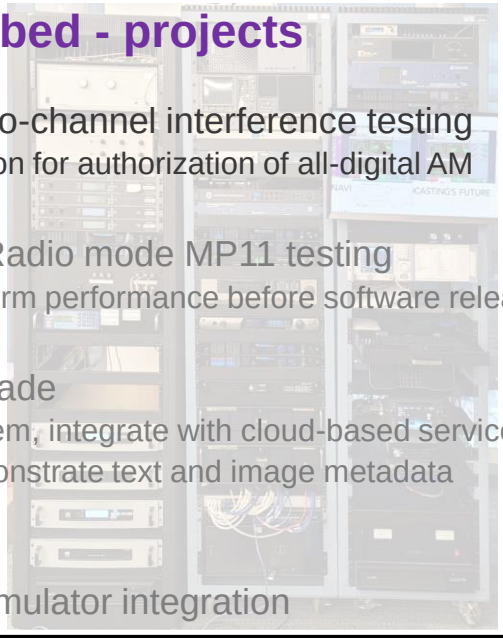
PILOT radio test bed - projects



- **2016** - All-digital AM co-channel interference testing
  - Used to support petition for authorization of all-digital AM
- **2019** - FM-band HD Radio mode MP11 testing
  - Used by Xperi to confirm performance before software release
- **2022** - Metadata upgrade
  - Upgrade playout system, integrate with cloud-based service provider
  - Used to test and demonstrate text and image metadata
  - Still underway
- **2023** – RF channel simulator integration

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All-digital AM co-channel interference testing

- Four co-channel combinations:

DESIRED	UNDESIRED	
ALL-DIGITAL	ANALOG	
	ALL-DIGITAL	
ANALOG	ANALOG	← *BASELINE*
	ALL-DIGITAL	← *FOCUS*

- Focus is on impact of undesired all-digital into desired analog
  - Measure audio signal-to-noise ratio (SNR) of analog desired
  - Compare impact of all-digital interferer to analog interferer
  - Also made audio recordings for future subjective evaluation

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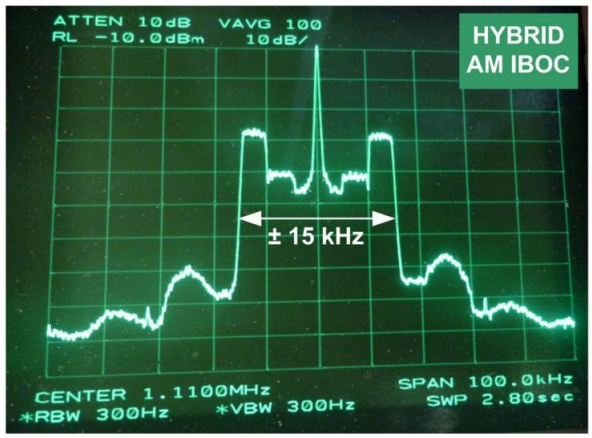
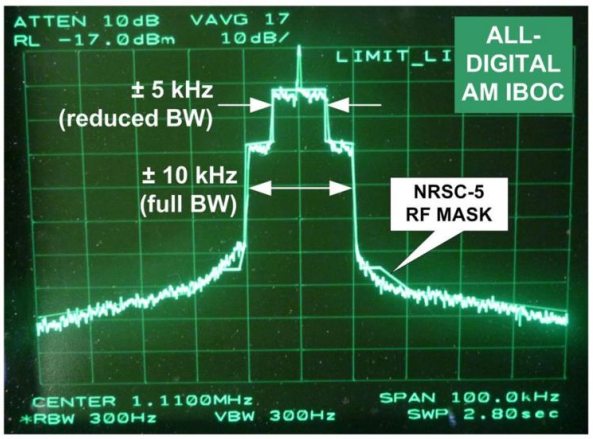
All-digital and hybrid AM spectra





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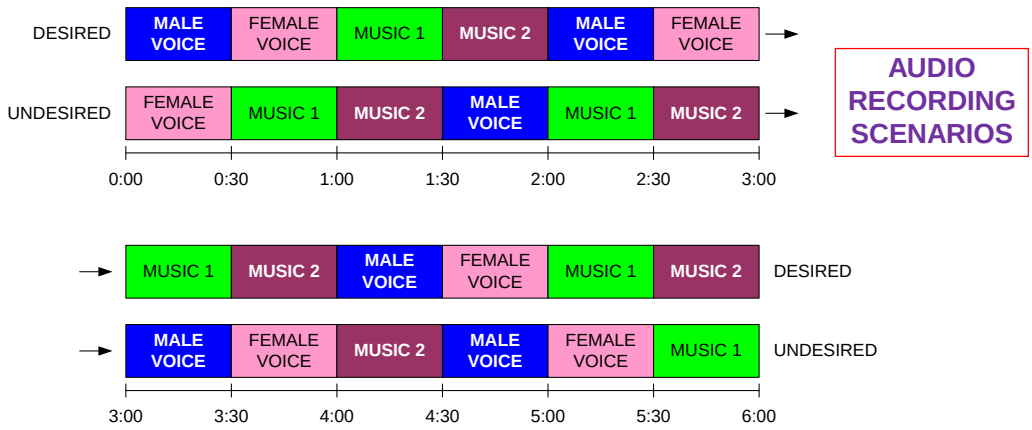
All-digital AM co-channel interference testing

ANALOG UNDESIRED



AUDIO RECORDING SCENARIOS

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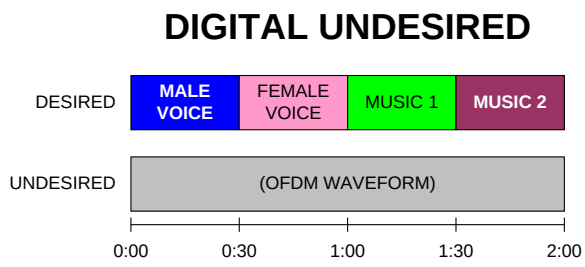
All-digital AM co-channel interference testing

PILOT
NAVIGATING BROADCASTING'S FUTURE



AUDIO RECORDING SCENARIOS

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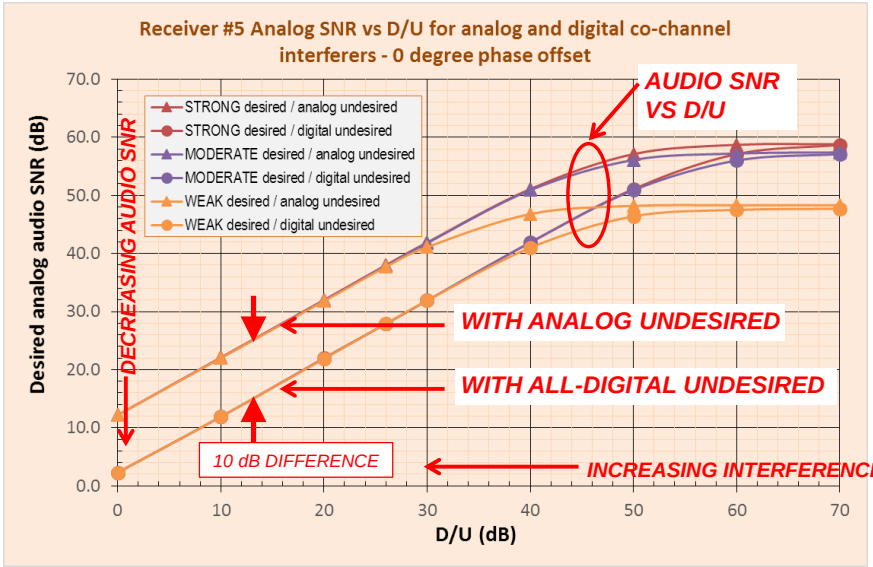
PHASE 1 TEST RESULTS

All-digital AM lab testing

NO RF NOISE



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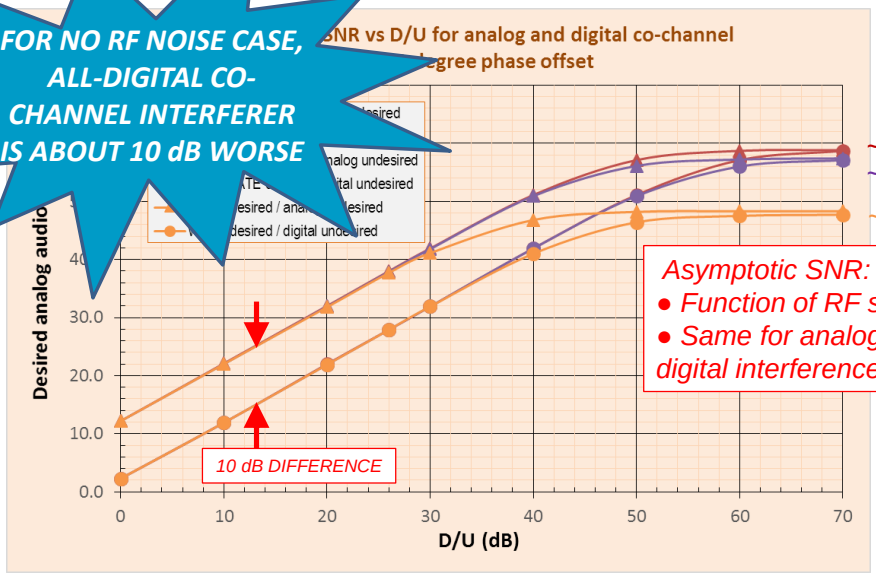
PHASE 1 TEST RESULTS

All-digital AM lab testing

NO RF NOISE

FOR NO RF NOISE CASE, ALL-DIGITAL CO-CHANNEL INTERFERER IS ABOUT 10 dB WORSE



Asymptotic SNR:
- *Function of RF signal level*
- *Same for analog and all-digital interference cases*

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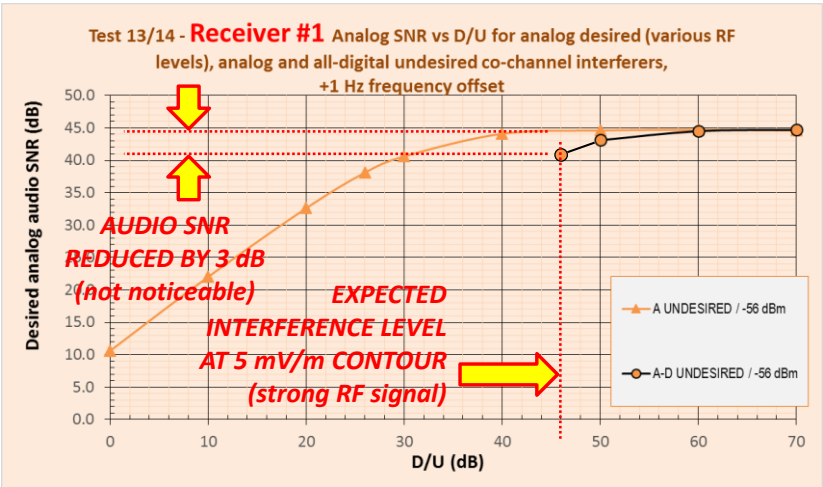
PHASE 2 TEST RESULTS

All-digital AM lab testing

WITH RF NOISE



- Interference from ***all-digital AM*** shown here (strong RF signal)
- Curve stops at point of maximum expected interference
- Audio SNR reduced 3 dB, not noticeable

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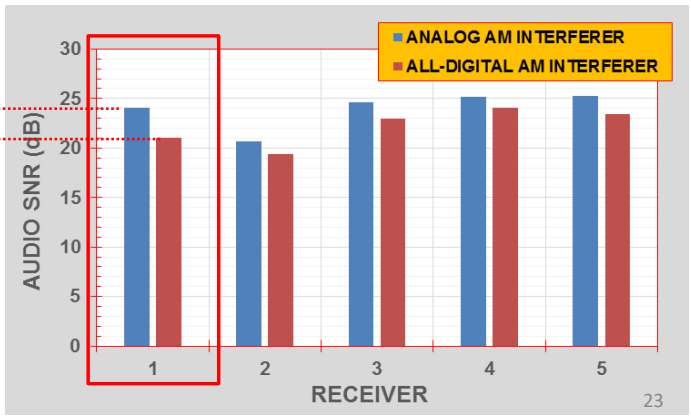
PHASE 2 TEST RESULTS

All-digital AM lab testing

WITH RF NOISE

- Results for all receivers (weak signal level) at 26 dB D/U:

AUDIO SNR REDUCED BY 3 dB (not noticeable)



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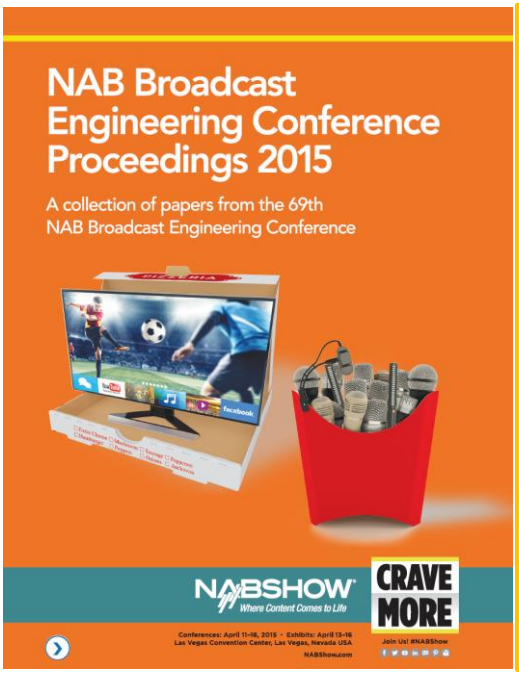

NAB Labs All-digital AM Test Project

David H. Layer
National Association of Broadcasters
Washington, DC

Abstract – *Since 2012, NAB Labs has been conducting a number of field tests (and more recently, laboratory testing) of the HD Radio all-digital AM signal.*[2] *The purpose of this test project has been to characterize the digital coverage performance and interference behavior of the all-digital AM signal under a variety of conditions, with the goals of better understanding the capabilities and limitations of this signal and to develop a technical record in examining the feasibility of possible FCC authorization of an all-digital AM service. This paper provides a brief description of the all-digital AM signal, then offers a summary of some of the field test results on nine stations obtained by NAB Labs to-date, as well as a discussion of the lab tests being conducted, and discusses possible future test activities.*

Introduction

AM and FM band digital radio broadcasting in the United States was authorized by the FCC in 2002, using the hybrid mode of the HD Radio™ in-band/on-channel (IBOC) system developed by iBiquity Digital Corporation. [1] This digital radio technology, standardized by the National Radio Systems Committee (NRSC) in 2005 as NRSC-5,[2] supports not only the hybrid mode of operation currently authorized for use (which includes both legacy analog and digital signal components) but also an "all-digital" mode (not currently authorized) that eliminates the analog portion of the signal and provides a number of benefits including improved robustness, a reduction in adjacent-channel interference, and a greater coverage area than the hybrid version of the system. [2]

At the end of 2014, nearly 25 million HD Radio receivers were in the marketplace and nearly 2000 radio stations were broadcasting an HD Radio signal. [3] As marketplace acceptance of this technology continues to increase, at some point broadcasters may consider introduction of the all-digital mode of operation. It has been generally accepted that an all-digital mode would not be introduced until market penetration of receivers was sufficiently high, since once broadcasters switch to all-digital operation, analog radio receivers (those not equipped to receiver the HD Radio signal) will go silent. Note that the vast majority of HD Radio receivers being sold are capable of receiving both hybrid and all-digital signals, with the only exceptions being a few low-power portable models (that are also FM-only).

Further, within the broadcasting industry there has been more interest in the all-digital version of the AM system than the all-digital version of the FM system because, for a variety of reasons, the hybrid AM system has not been widely deployed by broadcasters and has not received the same level of market acceptance as has the hybrid FM system. As a result, some AM broadcasters have been looking beyond hybrid to the all-digital AM system as a possible digital radio solution for the AM band.

Other than the technical information on the design of the all-digital AM system included in NRSC-5, there is little information in the public record on the performance and capabilities of this system.[3] The purpose of the test project reported on herein has been to add to this record by characterizing the digital coverage performance and interference behavior of the system under a variety of conditions, with the goals of better understanding the capabilities and limitations of this signal and to develop a technical record examining the feasibility of possible FCC authorization of an all-digital AM service.

The HD Radio All-digital AM Signal

The all-digital AM signal consists of an unmodulated carrier which is surrounded by groups of orthogonal frequency division multiplexed (OFDM) digital subcarriers as shown in Figure 1. Some of the parameters of this signal are given in Table 1. This signal is referred to as the "MA3" service mode, and is presently designed to support a single audio channel (called the "main program service" or MPS) as well as supplementary data information (specifically, "program service data" or PSD and "station information service" or SIS).[4]

Part of the MA3 mode system specification includes an RF mask which constrains the spectral emissions.[5] This mask was designed based on a theoretical analysis of the MA3 mode of operation so as to minimize the impact of out-of-band (*i.e.*, beyond the ±10 kHz full bandwidth spectrum of the signal) emissions on adjacent-channel signals while

[1] Created in 2012, NAB Labs is an initiative of the National Association of Broadcasters (NAB), providing a platform for innovation, a venue for forging partnerships and testing new technology, and educational events to create awareness about over-the-air radio and television technology initiatives.

[2] Since its original adoption, the NRSC-5 Standard has been updated by the NRSC three times, most recently in 2011 (NRSC-5-C).

[3] Limited field tests were conducted by iBiquity in 2002 at stations WTOP-AM in Washington, DC and WDZX-AM in Cincinnati, OH and reported on in [4]. The next engineering report on this system was not published until 2013, as part of the project being discussed in this paper. [5]

[4] Note that the hybrid AM signal is referred to as the "MA1" service mode.

[5] See [7], Section 4.5.4.

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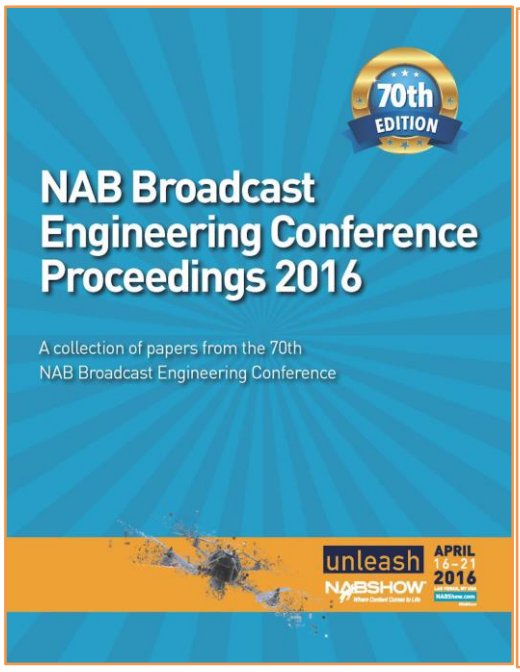

NAB Labs All-digital AM Test Project - Part II, Co-channel Laboratory Test Results

David H. Layer, National Association of Broadcasters, Washington, DC
Michael D. Rhodes, Cavell, Mertz & Associates, Manassas, VA
Daniel G. Ryson, Cavell, Mertz & Associates, Manassas, VA

Abstract – *Since 2012, NAB Labs has been conducting field and laboratory tests of the HD Radio all-digital AM system. The purpose of this test project has been to characterize the digital coverage performance and interference behavior of the all-digital AM signal under a variety of conditions, with the goals of better understanding the capabilities and limitations of this signal and to develop a technical record of this as-yet unauthorized service. This paper, the second in a series, focuses on the laboratory interference testing portion of the project including a summary of the co-channel laboratory test results obtained by NAB Labs.*

Introduction

The National Association of Broadcasters, through its NAB Labs initiative,[1] performed a series of laboratory tests on all-digital AM signals using the HD Radio digital radio system. The purpose of these tests was to characterize the co-channel interference behavior of the HD Radio all-digital AM system.[2]

The laboratory test plan for these tests is based in part upon the National Radio Systems Committee's (NRSC's) AM band IBOC laboratory test procedures, developed in 2002 as part of the laboratory test program conducted on the HD Radio hybrid AM system [2]. That test program and subsequent test results were thoroughly evaluated by the NRSC's Digital Audio Broadcasting (DAB) Subcommittee [3]. This NRSC evaluation was submitted to the FCC and was instrumental in the FCC's adoption of hybrid IBOC as the U.S. digital radio standard.

Laboratory testing is ideally suited for characterizing differences between various receivers and differences in modulation schemes. As detailed below, the laboratory environment permits measurements under consistent signal propagation conditions, a necessity for repeatable results. The tests detailed in this report are grouped into "Phase 1" and "Phase 2," where the Phase 1 tests are intended to simulate ideal (noise-free) conditions, and Phase 2 tests are intended to simulate "real world" (noisy) reception environments.

Test bed description

During these tests, the NAB Labs test bed was located in the Manassas, VA facilities of the broadcast engineering firm of Cavell, Mertz & Associates. It consists of two equipment racks (an RF equipment rack and an audio equipment rack) and some associated peripheral equipment. The RF equipment rack contains the RF equipment including exciters, exporters, combiner, splitter, attenuators, RF patch panel, RF noise generator, spectrum analyzer and the test receivers. The system's UPS and receiver 12V power supply are also mounted in this rack.

The audio equipment rack contains the audio router, audio test and measurement equipment, automation and control computer, audio processors, and audio noise generator. Both racks incorporate grounding bars with all equipment chassis directly connected to the ground bars and the ground bars are connected to the system common power supply ground. All power to the test bed is supplied through the UPS.

The diagrams and pictures below serve to further document and describe the test bed. Figure 1 shows the test bed RF signal flow, while Figure 2 illustrates the audio signal flow. Figure 3 and Figure 4 show the equipment rack layouts for the RF and audio portions of the system, respectively.

Preliminary testing was conducted using a carrier frequency of 1000 kHz, in the middle of the AM broadcast band. However, a low level spurious emission from the exciters was discovered within 80 kHz of the 1000 kHz carrier frequency. Changing the carrier frequency caused the spur to change frequency non-linearly with respect to the carrier. In a desire to avoid this spur when testing adjacent channels, it was determined that the nearest carrier frequency on which this spur would not be a factor was 890 kHz. Therefore all testing herein was performed at a carrier frequency of 890 kHz.

This spur was discussed with the exciter manufacturer engineers and it was determined that the spur is only on the RF monitor output of the exciter that is being used for these tests. The spur would not be present on the magnitude/phase outputs that would typically be connected to a transmitter. It was further verified with the manufacturer that the RF monitor output is otherwise acceptable for performing the interference tests described in this paper.

[1] NAB Labs is now part of NAB's PILOT initiative.

[2] See [1] for information on the field test portion of this NAB Labs all-digital AM project, as well as for additional background information on the all-digital AM system.

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PILOT
NAVIGATING BROADCASTING'S FUTURE

PILOT radio test bed - projects

- **2016** - All-digital AM co-channel interference testing
  - Used to support petition for authorization of all-digital AM
- **2019** - FM-band HD Radio mode MP11 testing
  - Used by Xperi to confirm performance before software release
- **2022** - Metadata upgrade
  - Upgrade playout system, integrate with cloud-based service provider
  - Used to test and demonstrate text and image metadata
  - Still underway
- **2023** – RF channel simulator integration

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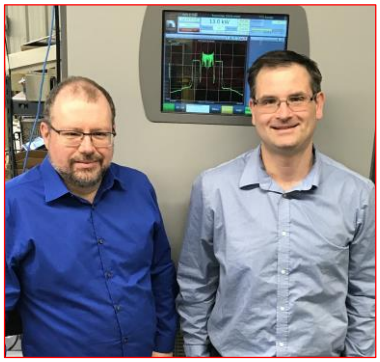
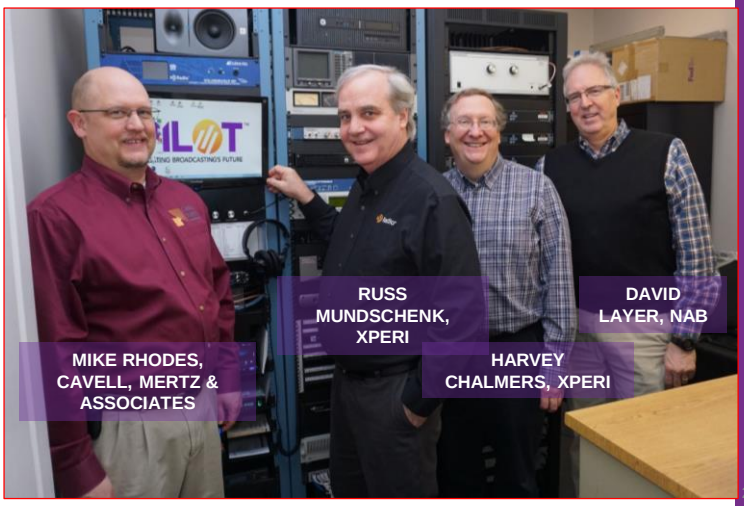
MP11 testing – test team



SCOTT MELVIN, NAUTEL

PHILIPP SCHMID, NAUTEL



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MP11 testing - background

- Hybrid FM HD Radio system supports various modes of operation
  - MP11 mode has highest bit rate (**148 kbps**), but not currently supported
- Modes defined in NRSC-5-D IBOC standard:

					Bit rates (kbps)			
No.	Mode	Hybrid	All-digital	Supported	Total	Core	Non-core	RF bandwidth (kHz)
1	MP1	✓		Y	98	48	50	138.1
2	MP6	✓	✓	Y	99		51	193.3
3	MP2	✓		Y	110		62	151.9
4	MP3	✓		Y	123		75	165.7
5	MP5	✓	✓	Y	124	24	100	193.3
6	MP11	✓		N	148	48	100	193.3

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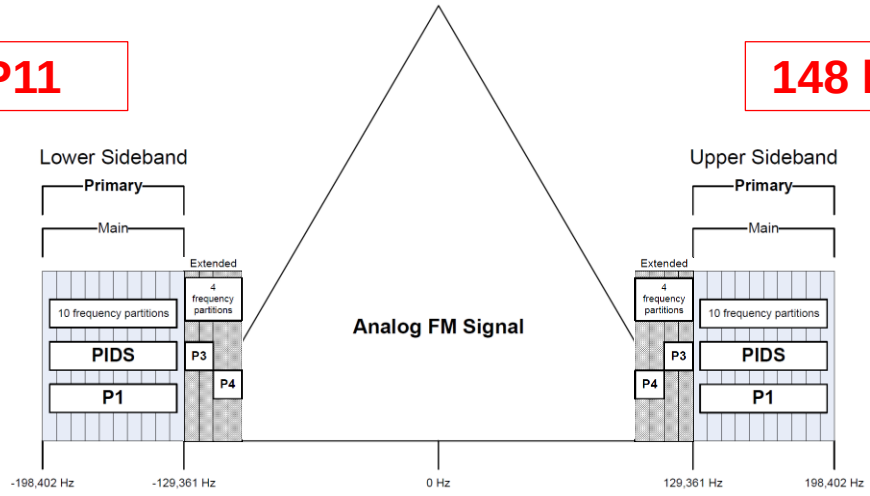
Hybrid FM HD Radio signal – MP11

MP11

148 kbps



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MP11 testing - Nautel STE

- This test project required special test equipment (STE) provided by Nautel
- Software implementation of Exporter and Exciter
  - Existing equipment has insufficient computing power for MP11 and PAR-2
- Precursor to cloud-based (virtual) HD Radio equipment
  - Currently being pursued by NABRTC HD Radio next-gen architecture sub-group

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MP11 testing - digital into analog tests

- Measure audio signal-to-noise ratio in host analog signal, for 6 different receivers, for 3 different modes
  - Use Audio Precision test set
  - Use 7-tone and 25-tone test signals

- Test three modes: (at -10 and -14 dBc)

MODE	BIT RATE (kbps)	# OF EXTENDED PARTITIONS
MP1	98	0
MP3	123	2
MP11	148	4

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MP11 testing - digital into analog tests

- Expect audio SNR to decrease as number of extended partitions increases

- RDS error rate measured using DEVA Band Scanner 2 – no errors

MODE	BIT RATE (kbps)	# OF EXTENDED PARTITIONS
MP1	98	0
MP3	123	2
MP11	148	4

32

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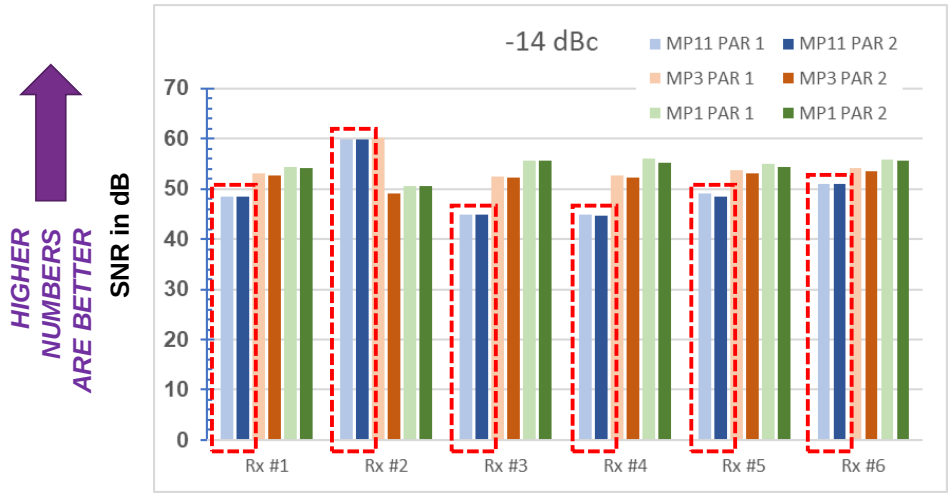
MP11 testing - test results – D►A



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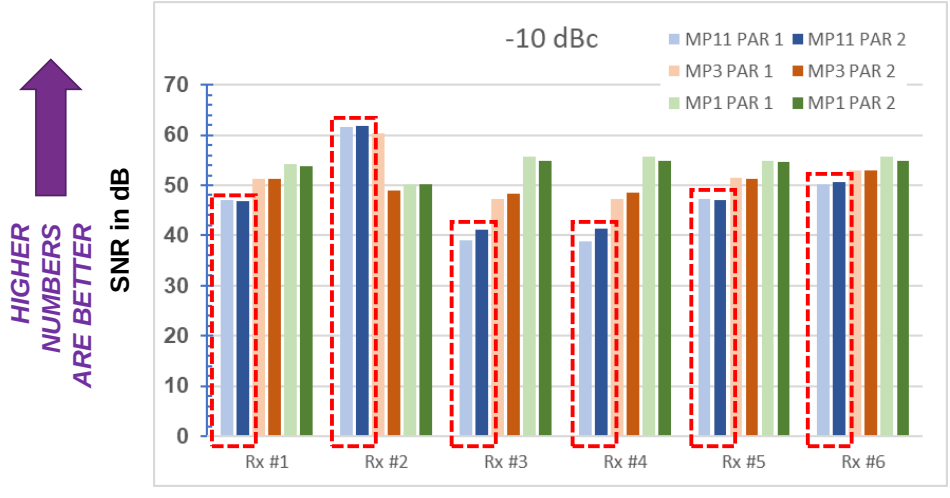
MP11 testing - test results – D►A



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MP11 testing - analog into digital tests

- Concentrated on MP11 (not MP3, MP1)
- Significant variables are:
  - Peak-to-average power ratio (PAR) reduction method
  - Analog modulation type
- Two PAR methods evaluated – PAR1 and PAR2
  - *Not PowerBoost*
- Five analog mods: CHR, Urban, Country, Classical, no mod

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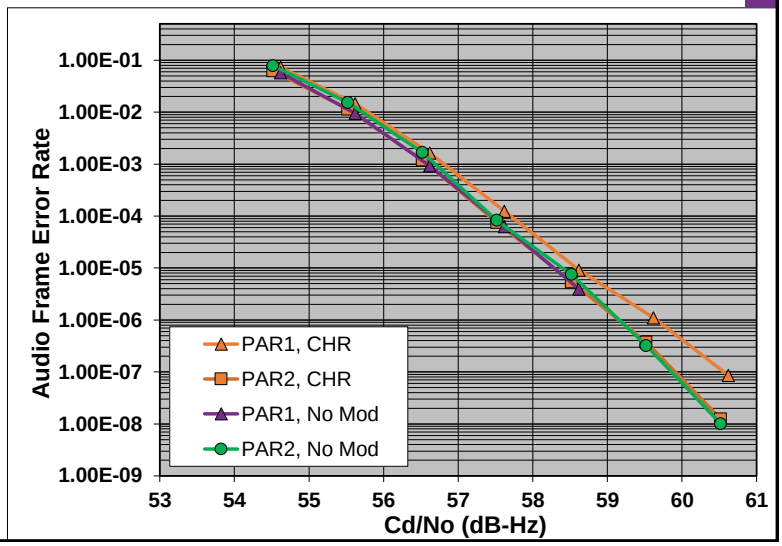
Test results – A►D – PAR1 vs. PAR2

- MP11 P4
  Bit Error Rate (BER)
  - CHR audio (most interference) and no mod
  - At -14 dBc
  - Demonstrates value of PAR2



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MP11 testing - summary

- MP11 now being supported by Xperi
  - In all software, as manufacturers update their platforms
- Receiver manufacturers are required to support in new implementations and software updates
  - All recent IC software supports MP11
  - Toyota is supporting MP11 in some receivers NOW
- MP11 required to support HD-5 multicast channels

HOME › TECH AND GEAR › DIGITAL RADIO

Hubbard Turns on an HD5 Audio Channel

Demand for leased capacity is met by an implementation of MP11

BY PAUL MCLANE -
PUBLISHED: JANUARY 25, 2023 · UPDATED: FEBRUARY 2, 2023

An FM station in northern Virginia is broadcasting what is believed to be the first HD5 audio subchannel in regular service. It's a development that could have implications for FM HD Radio stations that wish to lease more capacity on their signals.

The station is WWWT(FM), one of three Washington-area FM frequencies that carry the simulcast of WTOP, Hubbard Radio's big news station.

The signal is at 107.7 MHz in Manassas, Va. An HD5 subchannel using the MP11 transmission mode was flipped on by engineer Dave Kolesar of Hubbard Radio in November, assisted by Mike Raide of Xperi. The new subchannel is being leased by Metro Radio to feed an FM translator on 106.3 MHz.

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  - Used to test and demonstrate text and image metadata
  - Still underway
- **2023** – RF channel simulator integration

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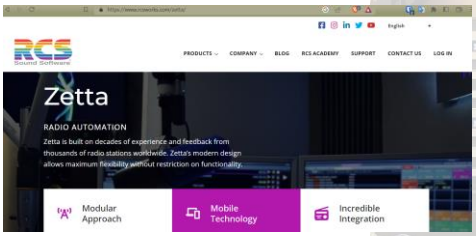
Metadata project

- Goal: add metadata capabilities to PILOT radio test bed
- Installed Zetta and RAPID to support rich metadata:
  - **Zetta** - create three automated audio programs (Hot AC, Country, Classical) which include songs and metadata, spots, and news and weather segments at the top of the hour
  - **Rapid** – Xperi-owned cloud service to provide formatted text-based and image metadata for all three audio programs



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Metadata project

- Supports:
  - Broadcast RDS metadata (FM signals)
  - Broadcast HD Radio metadata (AM and FM signals)
  - Broadcast metadata on main and multicast channels (HD Radio)

- Added additional HD Radio receivers to radio test bed with flat-panel touch screen displays, capable of displaying Artist Experience and logo images

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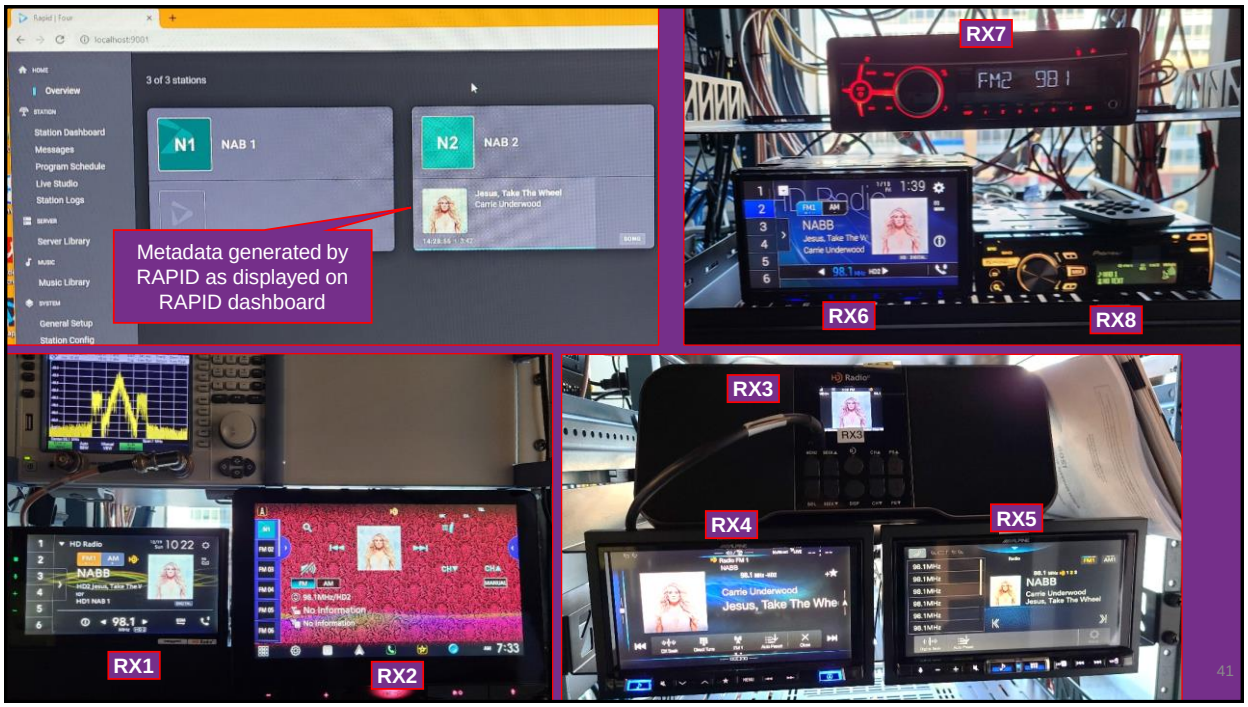

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PILOT
NAVIGATING BROADCASTING'S FUTURE

PILOT radio test bed

- Summary:
  - NAB has developed a valuable resource for the radio broadcasting industry
  - Locating the test bed in the NAB Technology lab has been beneficial
  - Look forward to leveraging this resource for the benefit of NAB members
- Special thanks to Gary Cavell and co. for their support

CAVELL, MERTZ & ASSOCIATES, INC.

- Let's go see it!

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