Advanced Digital Radio: HD Radio, DRM, DAB & CDR

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Featuring GatesAir’s Tim Anderson
Radio Product & Business Development Manager
Advanced Digital Radio:
HD Radio, DRM, DAB & CDR

Tim Anderson
Terrestrial Digital Radio Modulations

- All use OFDM modulation
- Differences in spectrum use and data capacity
- For optimized coverage Single Frequency Network (SFN) in DAB+, DRM+ and HD Radio possible
- DAB+ effective solution for large number of programs, Network operators and centralized distribution where Band III is available.
- DRM & HD Radio (IBOC) effective solution for smaller, independent operators with fewer programs where Band II frequencies are available
# Comparison FM, HD Radio™, China Digital, DRM+ and DAB+

<table>
<thead>
<tr>
<th>Parameter</th>
<th>FM</th>
<th>HD Radio</th>
<th>China Digital</th>
<th>DRM+</th>
<th>DAB+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>87.5 MHz - 108 MHz</td>
<td>55kHz - 1705kHz</td>
<td>87.5 MHz - 108 MHz</td>
<td>47 MHz - 68 MHz</td>
<td>174 MHz - 240 MHz</td>
</tr>
<tr>
<td></td>
<td>Band II</td>
<td>87.5 MHz - 108 MHz</td>
<td>Band II</td>
<td>87.5 MHz - 108 MHz</td>
<td>Band III</td>
</tr>
<tr>
<td>Programs / Channel</td>
<td>1</td>
<td>1 to 4 (max)</td>
<td>1 to 4 (or More)</td>
<td>1 to 4 (max)</td>
<td>Typically 9 to 24 (64 max )</td>
</tr>
<tr>
<td>Data / Channel</td>
<td>RDS 1,2 kB/s</td>
<td>Flexible Program</td>
<td>Flexible Program</td>
<td>Flexible Program</td>
<td>Flexible Program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Associated and Non</td>
<td>Associated and Non</td>
<td>Associated and Non</td>
<td>Associated and Non</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Program</td>
<td>Program</td>
<td>Program</td>
<td>Program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Associated Data</td>
<td>Associated Data</td>
<td>Associated Data</td>
<td>Associated Data</td>
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<tr>
<td></td>
<td></td>
<td>rates</td>
<td>rates</td>
<td>rates</td>
<td>rates</td>
</tr>
<tr>
<td>Analog Simulcast</td>
<td>N/A</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes*</td>
<td>No</td>
</tr>
<tr>
<td>Channel</td>
<td>200 kHz</td>
<td>400kHz</td>
<td>400kHz</td>
<td>96 kHz</td>
<td>1.5 MHz</td>
</tr>
<tr>
<td>BW Capacity</td>
<td>N/A</td>
<td>96/124 kB/s</td>
<td>96 kB/s-1.5 MB/s</td>
<td>96 kB/s</td>
<td>1.5 Mbits/s</td>
</tr>
<tr>
<td>Modulation</td>
<td>Single Carrier FM</td>
<td>Multi-carrier (up to 524) OFDM, 4 QAM</td>
<td>Multi-carrier (up to 524) OFDM, 4 QAM</td>
<td>Multi carrier (106) OFDM, 4 or 16 QAM</td>
<td>Multi Carrier (1536) OFDM, type DQPSK</td>
</tr>
<tr>
<td></td>
<td>-100 kHz</td>
<td>-200 kHz</td>
<td>-200 kHz</td>
<td>-48 kHz</td>
<td>-768 kHz</td>
</tr>
<tr>
<td></td>
<td>+100 kHz</td>
<td>+200 kHz</td>
<td>+200 kHz</td>
<td>+48 kHz</td>
<td>+768 kHz</td>
</tr>
</tbody>
</table>
Digital Radio Standards IBOC & DAB+

AM

<table>
<thead>
<tr>
<th>LW</th>
<th>MW</th>
<th>SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRM30 – Worldwide use</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FM

<table>
<thead>
<tr>
<th>B1</th>
<th>B2</th>
<th>B3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRM+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CDR

100 kHZ  1 MHz  10 MHz Frequency  100 MHz
Cost efficiency of FM vs. IBOC and DAB+

Example: 18 Radio Programs same coverage

**FM**
- Tx 1, 2, 3
- .......
- 16, 17, 18
- 18x FM Transmitter
- 18x Frequencies
- 18x Frequency License fee
- 18x Studio-Transmitter Link (STL)
- 18x RDS encoder/Data
- 18x High-Power antenna

**IBOC**
- 20 Programs possible - 2 program channels left over
- 5x FM Transmitter
- 5x Frequencies
- 5x Frequency License fee
- 4x Studio-Transmitter Link (STL)
- 4x RDS encoder/Data
- 4x DAB+ Play-out/Multiplexer
- 5x Medium power Antenna

**DAB+**
- Tx 1 carries 18 programs
- 1x DAB+ Transmitter
- 1x Frequency
- 1x Frequency License fee
- 1x Studio-Transmitter Link (STL)
- 1x DAB+ Play-out/Multiplexer
- 1x Medium power antenna
### Cost efficiency of FM vs. IBOC and DAB+

**Example: 18 Radio Programs same coverage**

<table>
<thead>
<tr>
<th>Transmitter</th>
<th>FM</th>
<th>IBOC - HDR/DRM/CDR</th>
<th>DAB+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>10 kW</td>
<td>2.5 kW</td>
<td>2.5 kW</td>
</tr>
<tr>
<td>Efficiency</td>
<td>72%</td>
<td>50%</td>
<td>40%</td>
</tr>
<tr>
<td>Energy consumption Per TX</td>
<td>13.9 kW</td>
<td>5 kW</td>
<td>6.25 kW</td>
</tr>
<tr>
<td>Transmitters</td>
<td>18</td>
<td>4.5</td>
<td>1</td>
</tr>
<tr>
<td>Energy all Transmitters</td>
<td>250 kW</td>
<td>22.5 kW</td>
<td>6,25 kW</td>
</tr>
<tr>
<td>Annual cost of energy</td>
<td>$328,500</td>
<td>$29,565</td>
<td>8,000 USD</td>
</tr>
</tbody>
</table>

Assumes 0.15 USD per kWh
DAB family of standards - no difference for the transmitter

- Net data rate of 1.152MBit/s for commonly used rate ½ FEC coding
  - Flexibility for data rate / transmission power trade off from 576kbps to 1.728Mbps
- Each DAB transmitter can operate DAB, DAB+, DMB without changes
- There is no difference in Hardware or Software for the transmitter!

- The differences are managed by the Play-Out equipment
  - audio encoding
  - video encoding (DMB)
  - data server
  - error protection

up to 10 Radio/Data
up to 24 Radio/Data
up to 7 Video/Radio/Data
Use cases for IBOC - HD Radio, DRM and China Digital

DRM30 MW complementary to DAB+ or separate usage possible for:

- coverage of large territories and international coverage
  - Digital Medium Wave (DRM30 and HD Radio)
  - Digital Short Wave and Long wave (DRM30)

- FM Band II HDR, DRM+ or CDR complementary if frequencies available for simulcast of analog + digital
  - Up to 4 programs plus data services per frequency. More programs but with individual coverage
  - Local programs
  - In case broadcasters want to stay in control of Tx equipment and
  - Want to keep using parts of existing FM infrastructure (antennas, exciters)

- DRM+ standardized also in Band I and Band III
HD RADIO SYSTEM FEATURES

• Broadcasting in AM and FM bands
• Migration from and co-existence with analogue broadcasting: Complies with existing spectrum masks and analogue frequency grids.
• Up to four services per frequency, each of which can be any mixture of audio and data.
• Single-frequency and multi-frequency networks, plus associated signaling and automated receiver tuning.
• HDC Audio Coding supporting bit-rates from 32kB/s to 124kb
• Data Services, Album Art,, traffic services and news headlines and a wide range of similar value added services.
DRM SYSTEM FEATURES

• Broadcasting in all the AM and FM bands extending from 150kHz through to VHF Band III.
• Migration from and co-existence with analogue broadcasting: Complies with existing spectrum masks and analogue frequency grids.
• Up to four services per frequency, each of which can be any mixture of audio and data.
• Single-frequency and multi-frequency networks, plus associated signaling and automated receiver tuning.
• A choice of three audio coders supporting bit-rates from 2kB/s upwards.
• Text-messaging, slide-shows, multi-media object transmission, traffic and news headlines and a wide range of similar value added services.
Global Situation for Digital Radio
Global DAB+ Coverage

- Over 500 million people worldwide are within range of a DAB/DAB+ signal
- Over 1,000 services on air
- Several thousand receiver models available for home & car.
- Successes: Australia, Belgium, Germany, Hong Kong, Netherlands, Norway*, South Korea, Switzerland
- Failures: Canada, United Kingdom
Global HD Radio Coverage

- Adopted as THE Digital Radio Standard in the US
  - 90% of the US population can receive an HD Radio signal
- Mexico and Brazil have adopted and actively broadcasting
- Argentina, China and others are actively testing
- Canada has renewed interest and is actively pursuing

1. Adoption and Nationwide Operation
2. Adoption and Regional Operation
3. Limited Operation
4. Testing/Advanced Interest
5. Active Interest
Key DRM Global Markets

- India
- Russia
- Brazil
- Africa
China Digital Coverage

- The Chinese government’s Academy of Broadcast Science (ABS) has developed their own FM digital radio standard called China Digital Radio (CDR).
- GatesAir has agreed to assist the State Administration of Radio, Film and Television (SARFT) with the development of actual hardware platforms for signal generation (CDR Exciters) and RF transmission systems.
- The CDR Channel Coding Modulator uses the G4 Exgine option card developed for HD Radio in the Flexiva FAX transmitters/exciter.
- CDR has similarities with HD Radio, in that it is a hybrid analog/digital, in-band-on-channel (IBOC) system using upper and lower OFDM subcarriers.
- It also closely resembles CMMB “lite” using Low Density Parity Check (LDPC) error correction with the DRA (Chinese) audio codec. So, this is technology with which we have substantial experience.
- The first two GatesAir FAX10kW CDR transmitters are being shipped to Guangdong Province now and expected to be on-air in April.
- 300 Cities expected to be deployed over next 5 years

We believe that export of CDR to Africa is in their plans much as CMMB.
<table>
<thead>
<tr>
<th>Competition</th>
<th>DTV</th>
<th>AM</th>
<th>FM</th>
<th>BM</th>
<th>CDR</th>
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<tbody>
<tr>
<td>AMPEGON</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>AM</td>
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<tr>
<td>BBEF, Beijing</td>
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<td>BE</td>
<td>NO</td>
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<td>YES</td>
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<td>EBONICA</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>AM/FM</td>
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<td>CTE</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
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<td>électrosys</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
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<td>GATESAIR</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>AM/FM</td>
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<td>Katieng, Beijing</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
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<td>YES</td>
<td>YES</td>
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<td>NO</td>
<td>YES</td>
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<td>NO</td>
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<td>ROHDE &amp; SCHWARZ</td>
<td>YES</td>
<td>NO</td>
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<td>NO</td>
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<td>B.V.B</td>
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<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>FM???</td>
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<td>THOMSON</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>AM</td>
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<tr>
<td>TRANSRADIO</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>AM</td>
</tr>
</tbody>
</table>

Many significant competitors across the radio space.

GatesAir is the only supplier of ALL digital radio and TV modulations.
GatesAir Digital Radio Solutions
Connecting What's Next

IBOC & DAB+ Transmission System

- DRM Content Server
- DRM Signaling
- Administration
- Multimedia data or other non Program Associated Data.
- Flexiva FAX DRM+ Transmitter:
  - FAX 1K DRM – 500 Watts
  - FAX 2K DRM – 1000 Watts
  - FAX 3.5K DRM – 1750 Watts
  - FAX 5K DRM – 2500 Watts
  - FAX 10K DRM – 4000 Watts

Up to 4 programs possible depending on bandwidth and error correction desired. Remaining bandwidth can be used for data. The audio coding is done in usually in the studios.
FM HD Radio Installation

- KAJM and KNRL dual-redundant FAX20 HD Radio transmitters
- Four 20kW transmitters and equipment racks in six racks
- Sierra H Broadcasting - 8,000 feet in central Arizona's Sonoran desert
AM HD Radio Installation

- WOR AM
- Rutherford, NJ
- Dual 3DX50 50kW AM HD Radio Transmitters
DAB+ Radio Installation

Norkring – Oslo Norway

2 x 5kW VAX3D DAB+ Transmitters
Maxiva™ VAX Compact:
DAB Transmitter
Low Power VHF Band III TV/DAB Transmitter/
Transposer/Gap Filler

- Broadband frequency; agile design 168 MHz to 242 MHz
- 10W to 150W DAB/DAB+/DMB
- Automatic digital pre-correction (non-linear and linear) using GatesAir’s RTACTM technology for outstanding performance
- Compact, space-saving 2RU design
**Maxiva™ VAX 3D: DAB Transmitter**

Medium & High Power, Air-Cooled with PowerSmart®3D

- High-efficiency design
- Broadband operation 170MHz to 240MHz, no tuning or power amplifier modification
- 1.25kW to 10kW DAB/DAB+/DMB
- High active and passive redundancy
- Automatic digital pre-correction (non-linear and linear) using GatesAir’s RTAC™ technology for outstanding performance
- Hot-swappable low-weight power amplifier and power supplies
- Rugged design for operation in critical environments
Maxiva™ for DAB+

Maxiva™ VLX: DAB Transmitter
High Power, Liquid-Cooled with PowerSmart® 3D

- Broadband operation 170MHz to 240MHz; no tuning or power amplifier modification
- Hot-swappable power amplifier
- 1,1kW to 9,6kW DAB/DAB+/DMB
- Automatic digital pre-correction (non-linear and linear) using GatesAir’s RTAC™ technology for outstanding performance
- Pump system rack integrated or external

www.gatesair.com
The next generation DAB+ Exciter will be the XTM Universal Exciter Platform in development now.

Will be integrated into VAX3D

- More processor power
- Improved pre-correction
- Improved Crest Factor Reduction
- Improved performance
- Lower production cost than UEP
Flexiva™ FAX Compact: HD Radio, DRM+ and China Digital Radio Transmitters
Low Power VHF Band II Analog FM or Digital Radio options for HDR/DRM+/CDR

- Broadband frequency agile design. 88 to 108MHz
- 10 Watts to 1500W HDR/DRM+/CDR
- Automatic digital linear and non-linear pre-correction using GatesAir’s RTAC™ technology
- Compact, space-saving design – 2, 3 & 4RU
- Easy conversion from analog to digital with G4 Engine
**Flexiva™ for HD Radio, DRM+ and China Digital Radio**

**Flexiva™ FAX High-Power:**
HD Radio, DRM+ and China Digital Radio Transmitters

High-Power Power VHF Band II Analog FM or Digital Radio options for HDR/DRM+/CDR

- Broadband frequency agile design. 88 to 108MHz
- 2.5kW to 40kW HDR/DRM+/CDR
- Automatic digital linear and non-linear pre-correction using GatesAir’s RTAC™ technology
- Compact, space-saving design
- Highest Efficiency, highest power density
- Uses FAX Compact exciter for easy conversion from analog to digital with G4 Exgine
Flexiva G4 Exgine Digital Radio Modulator

- Provides easy upgrade from analog to digital for all Flexiva FM transmitters
- Hybrid Crest Factor Reduction reduce the high peak-to-average power ratio (PAPR) improving RF power amplifier utilization
- Real-Time Adaptive Correction (RTAC™) for digital pre-correction of non-linear distortions providing continuously superior RF mask performance
- High quality Spectrum Analyzer for verifying FCC, NRSC & ITU spectral mask compliance
- Modulation Error Ratio (MER) measures the digital signal-to-noise ratio for data-bearing and reference carriers within the OFDM sidebands giving diagnostic signal-to-noise reference
- Graphical User Interface GUI) provides full control of all of the digital radio generation processes integrated with the Flexiva GUI

Flexiva™ FAX G4 Modulator for HD Radio, DRM+ and China Digital Radio Transmitters
HD Radio Control & Analysis from FAX GUI
HD Radio Control & Analysis from FAX GUI

[Image of a computer interface showing HD Radio control and analysis features, including options for Hybrid Crest Factor Reduction (HCFR & MER), PAPR/MER, MER, and various controls for exciters, drive chains, power amps, power supplies, outputs, systems, and mute.]
HD Radio Control & Analysis from FAX GUI
Thank You!