On Channel Repeater Implementation for HD Radio™ Coverage Improvement

October 2009

Featuring GatesAir's Rich Redmond, Chief Product Officer
On Channel Repeater Implementation for HD Radio™ Coverage Improvement

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Presentation Outline

• Current HD Radio Coverage

• FM Boosters – yesterday and today

• Digital Gap Fillers

• Filtering requirements

• Echo Cancelation

• Implementation options
Current Situation

• Over 1800 US stations have adopted HD Radio
  – In excess of 1000 digital only multicast channels offered
• Initial approach of 1% digital power delivers less digital coverage than analog FM in some cases
• Elevated side band levels from -20 to -10 tested and proposed to increase coverage
  – Increased power at main transmitter
• Digital may open new opportunities to improve coverage
  – Distributed transmission – Single Frequency Network
  – Booster or Gap Filler approach provides targeted signal improvement.
Analog FM Boosters

- Authorized for some time – mixed results
  - 1 to n sites synchronized often mixed power levels
- Terrain shielding provides the best results
- GPS lock of transmitter frequency
- Alignment of timing – modulator – audio delay
  - Systems such as Harris Syncrocast - Flexstar
- Adjust delay of sites to control interference
- Reflective signals can still cause destructive interference
Digital Transmission

- Digital system provide the promise of “interference free” reception
- Multi-carrier COFDM digital modulation
  - Constructive reception of multiple signals by providing the frequency diversity required to overcome channel fading
  - Guard time intervals in the coding of the data modulation provide a degree of immunity to errors in the presence of echoes and reflections
- The guard interval is inserted prior to the beginning of each symbol transmitted
  - As long as the echo or multipath delayed data is received during the guard interval period, the data can be demodulated without interference.
  - Longer guard interval = more robust reception however at the cost of data payload
- Both points support SFN-Gap fillers for improved coverage
**Impact of constructive interference**

- **SFN and statistical Gain**
  - Positive effects due to constructive overy

- **SFN Coverage**
  - 3 transmitters covering 90% of inhabitants

- **MFN Coverage**
  - 3 transmitters covering only 80% of inhabitants
  - 4 additional transmitters are necessary for 90%

- **SFN Level Gain**

Study complements of LS Telecom
A gap filler is a system which retransmits the “off air” signal from another transmitter to supplement coverage in certain areas of weak or minimal coverage.

The gap filler receives the signal off the air it requires no STL, exciter or encoding equipment, thereby reducing the cost and complexity of the installation from an equipment perspective.

There are not any T1 or IP circuits used, the on-going operating expense is also reduced.
- Time through system must be short – can’t consume the guard interval
- More digital processing = more delay
**Digital Filtering**

- Gap fillers implement multiple filtering stages:
  - RF Channel input filter
  - IF SAW filter
  - Digital Shaping Filter
- Digital Shaping Filter drastically increases adjacent channels rejection (4 x modes)
- Increases usability - trade off with delay through system
Echo Cancelation

- Echo’s are signals that arrive at the receiver after the primary signal
  - Multipath
  - Output of a gap filler to input

- Main to Booster Isolation
  - Tunnels - Structures
  - Terrain obstruction
  - Antenna separation
    - Physical
    - Polarization

- RF Echo's ~ Audio feedback
  - Output to input isolation
  - Echo cancelation is like audio feedback reduction
Adaptive Echo Cancelation

- Identify primary signal to be repeated
- Reject time delayed “echos”
  - Simple - Main output feedback
  - Multiple - Reflections for nearby terrain or buildings
- Reject echo’s higher than main input - 12db
- Technology a must for useful coverage improvement
HD Radio Applications

• Repeat the analog host and the digital sidebands on a different frequency

• Repeat both the analog host, and the digital sidebands on the same channel

• Repeat only the digital sidebands from the primary station
Application #1

Timing not critical - The translator mode shifts the signal to a new frequency.
**Application #2**

**F1-F1 Analog and digital**

**Main Transmitter Coverage**

**SFN Gap Filler**

Analog Interference unless some terrain shielding

**Gap Filler transit delay low - Signal replicated - Echo Canceller ON**
Main Transmitter Coverage

SFN Gap Filler

Gap Filler transit delay low - Signal replicated - Echo Canceller ON
Conclusions

- Technology can be leveraged from other digital standards and applications
- Some signal shielding is still needed for effective operation
- Gap fillers offer low cost of operation
- Powerful digital filtering is a must
- Adaptive echo cancellation is needed to provide higher output power
- Careful implementation planning is required for solid results
- Special thanks to colleagues Geoffrey Mendenhall, Timothy Anderson
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