On Channel Repeater Implementation for HD Radio™ Coverage Improvement

October 2009

Featuring GatesAir's

Rich Redmond
Chief Product Officer

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On Channel Repeater Implementation for HD Radio™ Coverage Improvement

Richard Redmond, Director Strategic Marketing

Presentation Outline

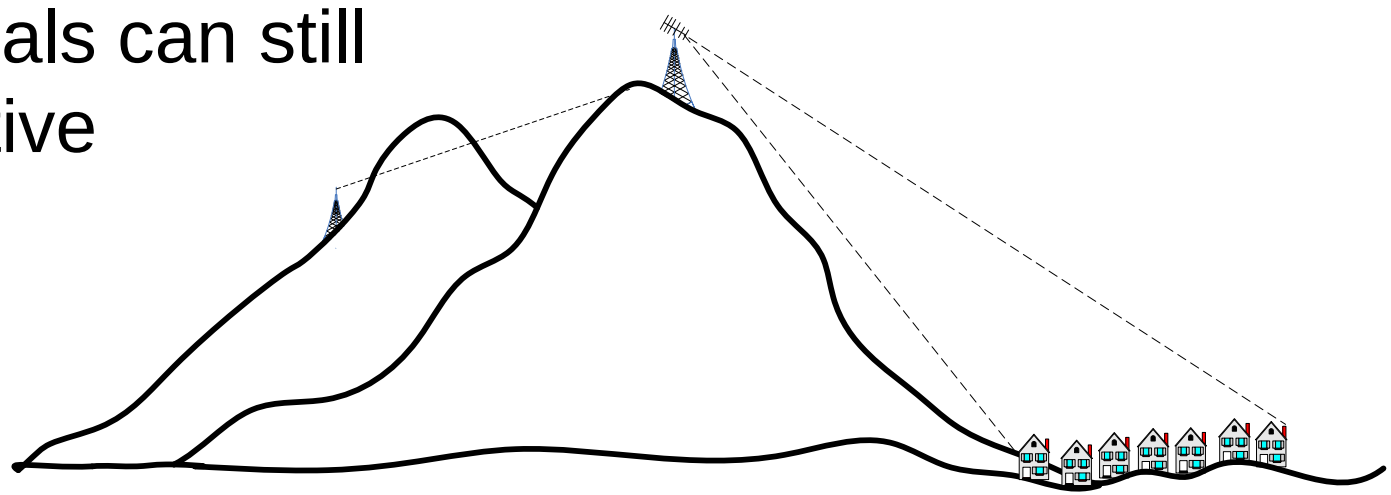
- Current HD Radio Coverage
- FM Boosters – yesterday and today
- Digital Gap Fillers
- Filtering requirements
- Echo Cancelation
- Implementation options

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.

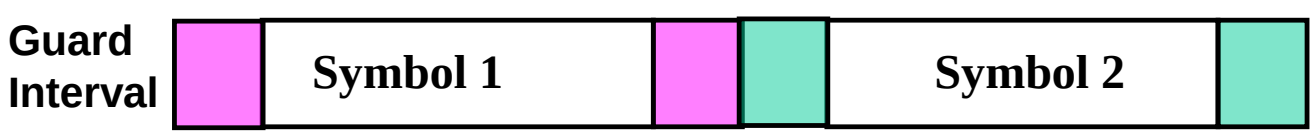
Analog FM Boosters

- 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

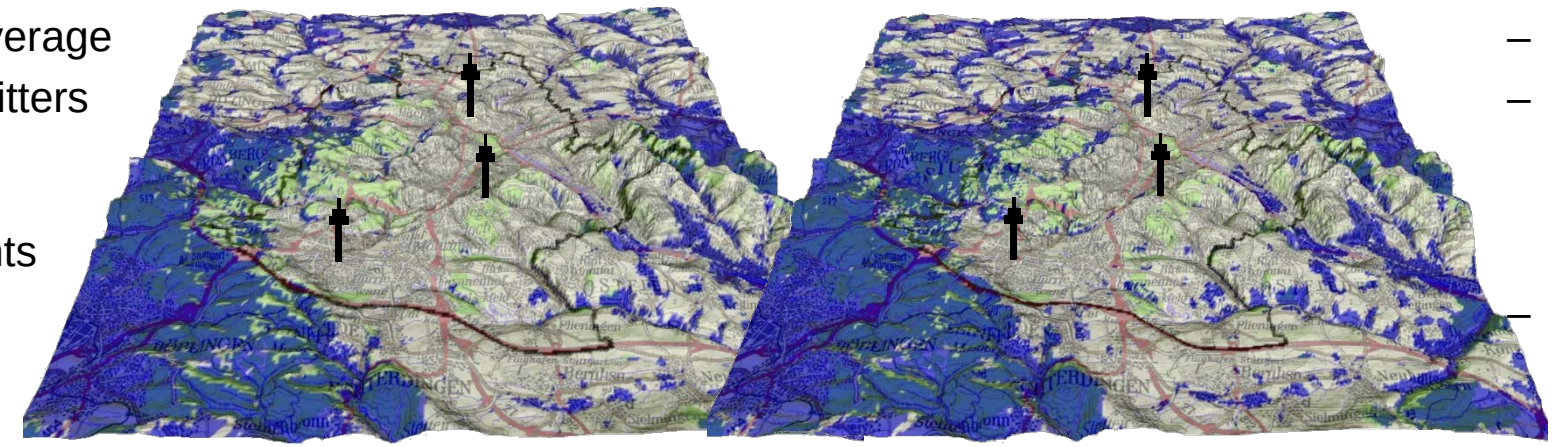
- Digital system provide the promise of “interference free” reception
- Multi-carrier COFDM digital modulation
  - Constructive reception of multiple signals by providing the frequency diversity required to overcome channel fading
  - Guard time intervals in the coding of the data modulation provide 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



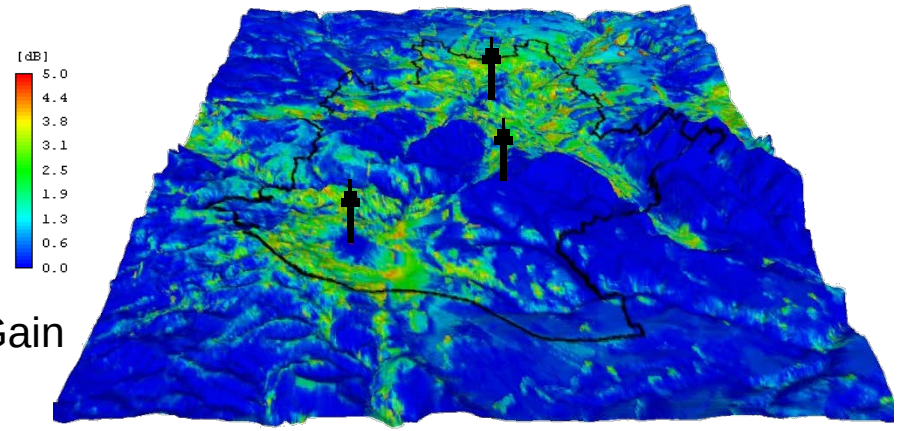
Impact of constructive interference

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

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



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



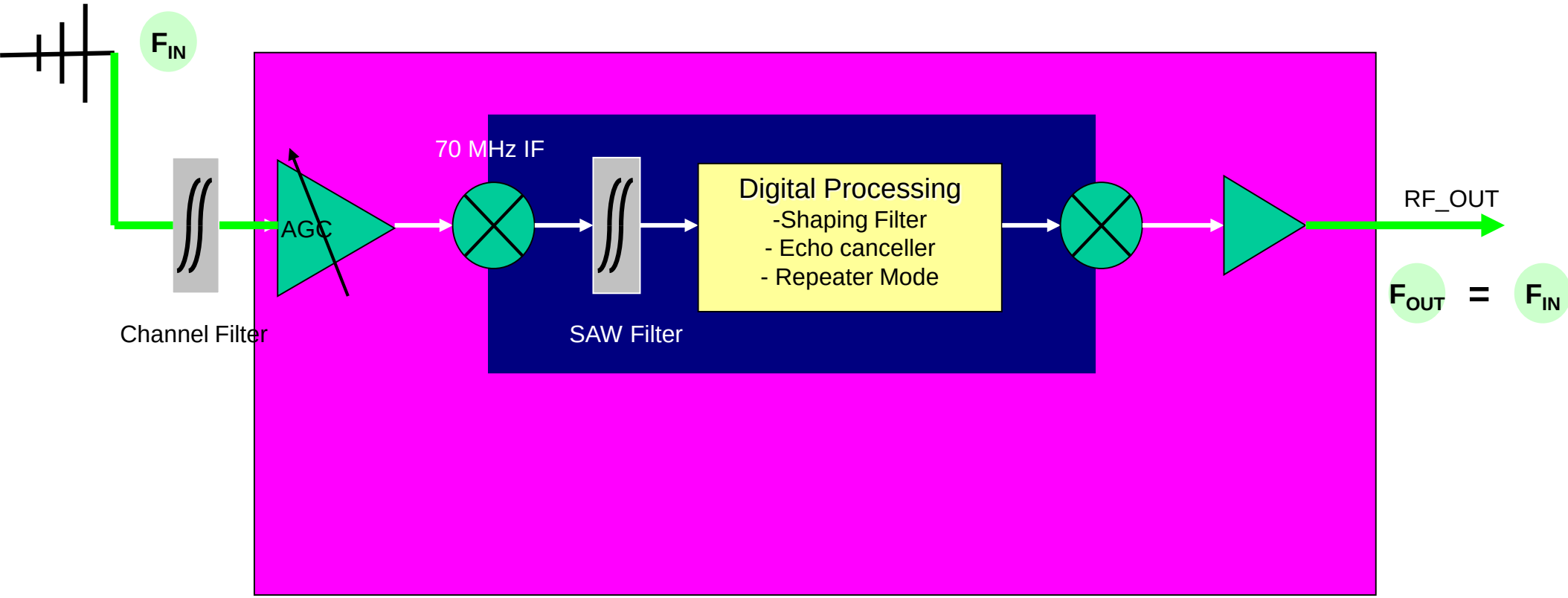
- SFN Level Gain

Study complements of LS Telecom

Digital Gap Filler

- 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.

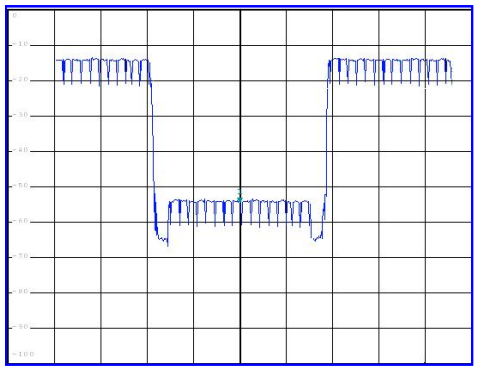
GAP Filler Engine



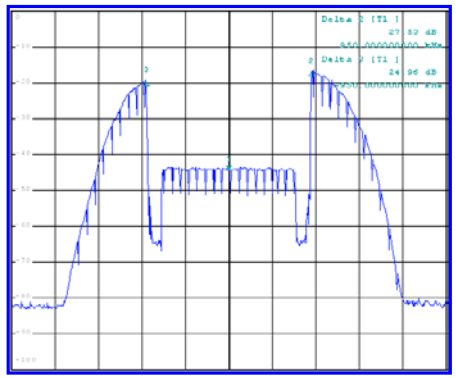
- Time through system must be short – can't consume the guard interval
- More digital processing = more delay

Digital Filtering

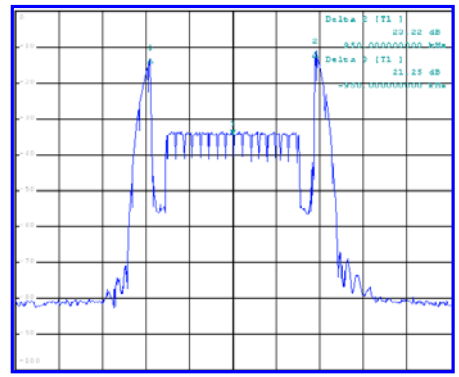
- Gap fillers implement multiple filtering stages:
  - RF Channel input filter
  - IF SAW filter
  - Digital Shaping Filter
- Digital Shaping Filter drastically increases adjacent channels rejection (4 x modes)
- Increases usability – trade off with delay through system



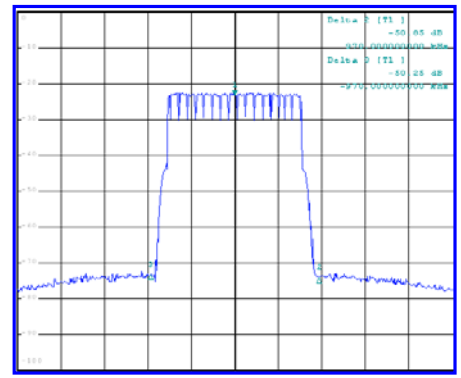
Input with 2 Adjacent channels



Analog Filter SF off



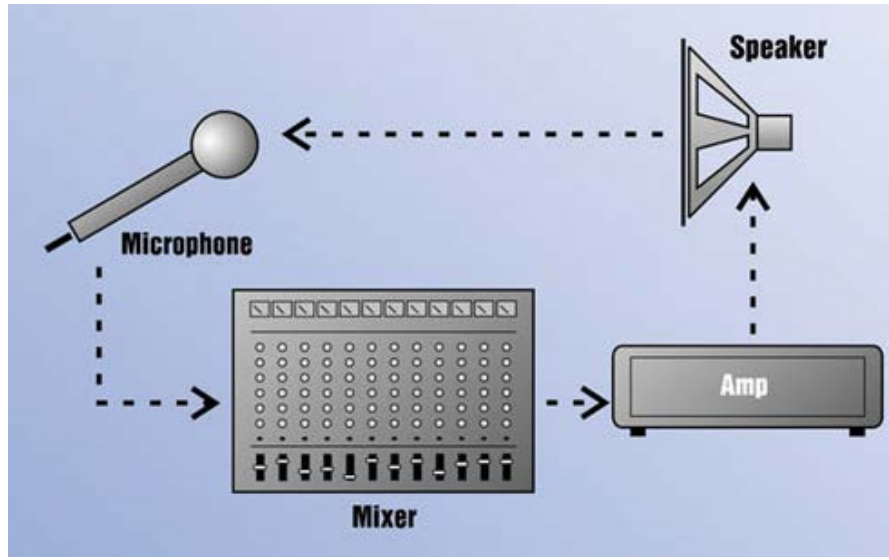
SF mode medium



SF mode aggressive

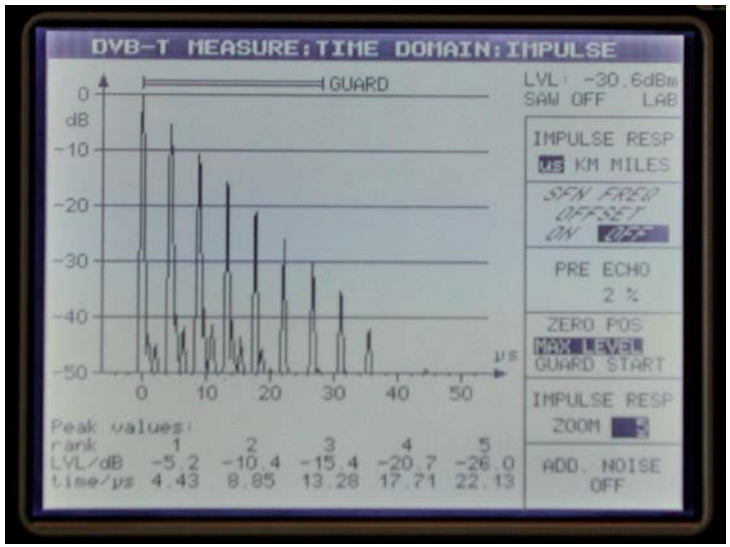
Echo Cancelation

- 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

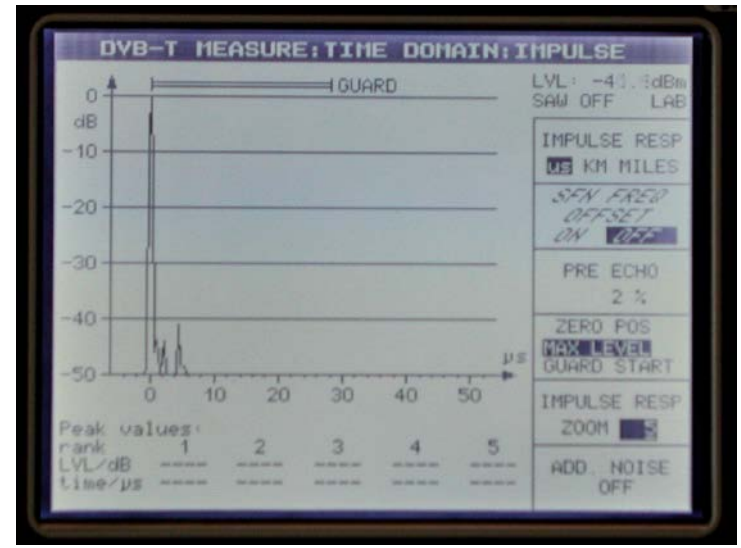


Adaptive Echo Cancelation

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



Echo canceller OFF

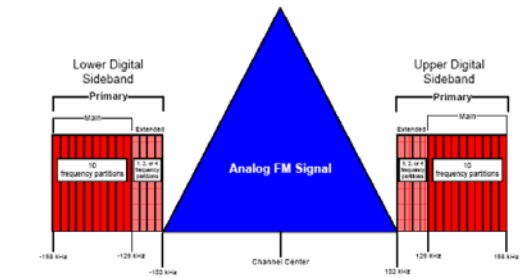


Echo canceller ON

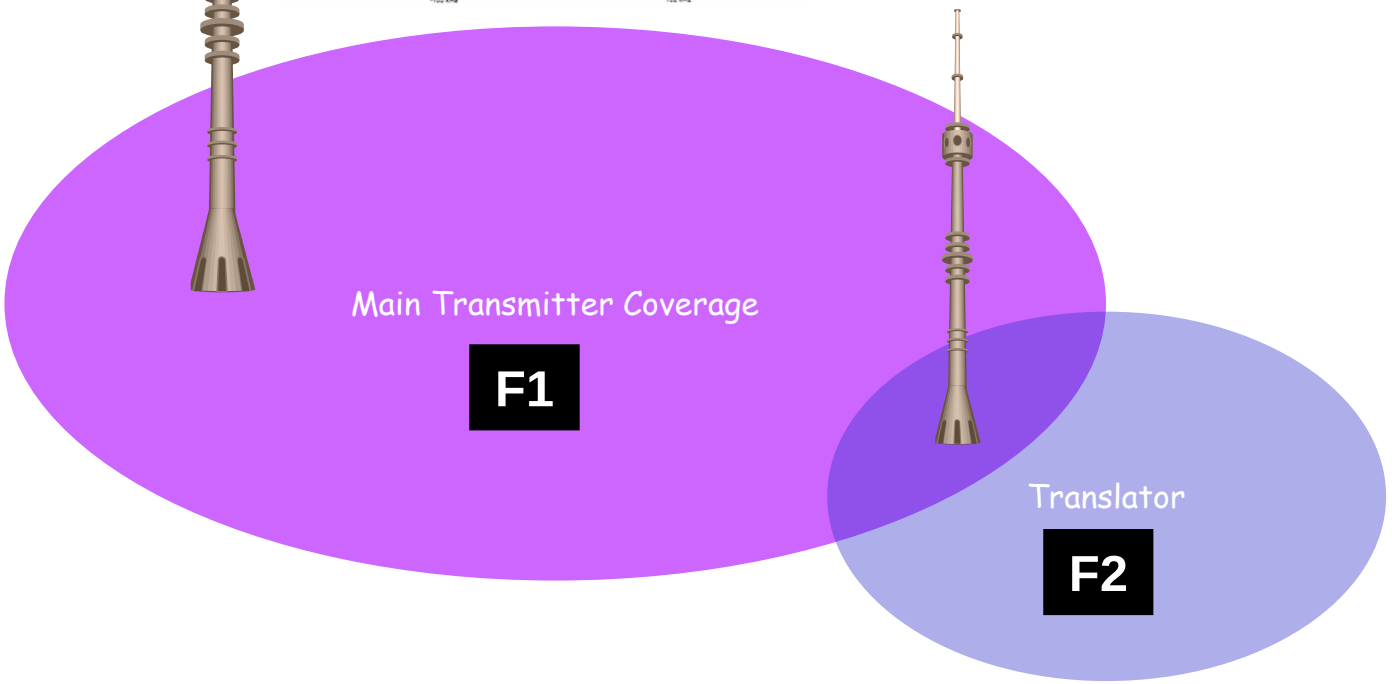
HD Radio Applications

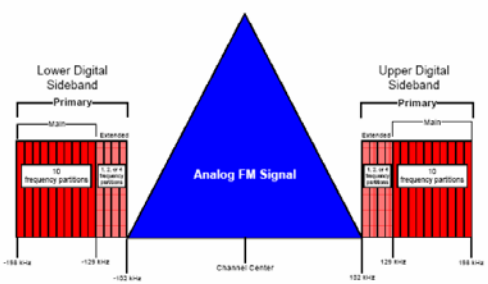
- Repeat the analog host and the digital sidebands on a different frequency
- Repeat both the analog host, and the digital sidebands on the same channel
- Repeat only the digital sidebands from the primary station

Application #1



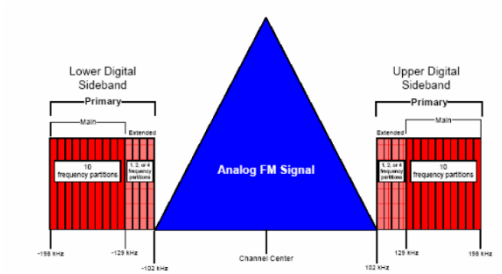
F1-F2 Translator





Timing not critical - The translator mode shifts the signal to a new frequency.

Application #2



F1-F1 Analog and digital

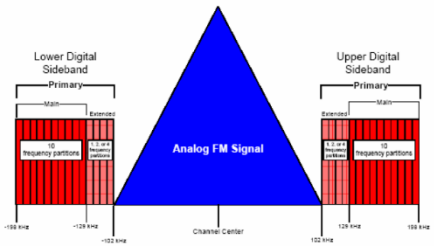
Main Transmitter Coverage

F1

SFN Gap Filler

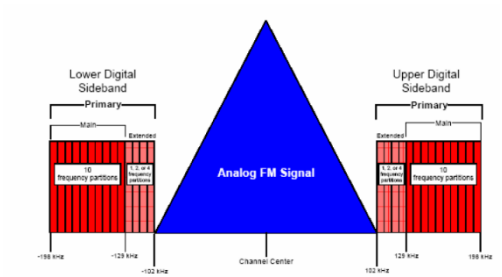
F1

Analog Interference unless some terrain shielding

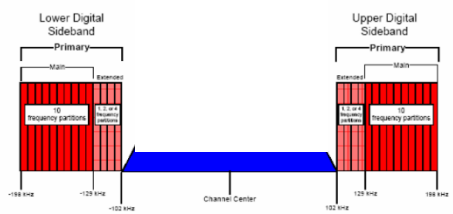


Gap Filler transit delay low – Signal replicated – Echo Canceller ON

Application #3



F1-F1
Digital only



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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