



Adding HD Radio™ to Existing FM Combining Systems

CCBE Conference

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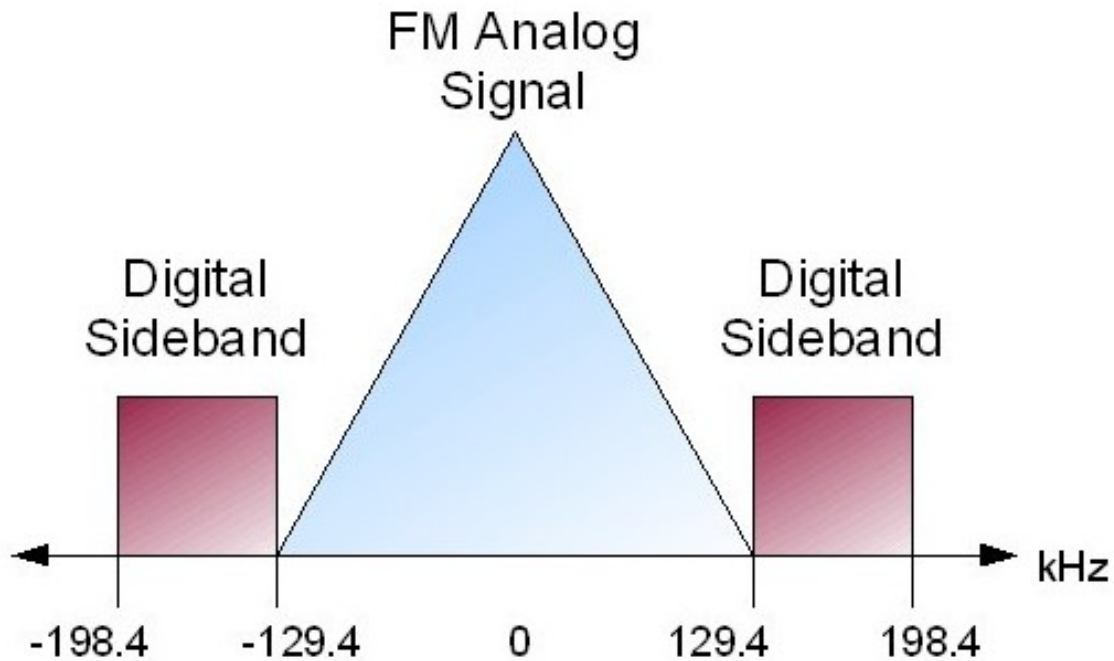


Overview

- HD Radio signal (IBOC)
- Options to implement HD Radio
- FM combiner types
- Options that can be used with existing combiners
- What are the concerns? solutions?



HD Radio Signal (IBOC)





HD Radio Implementation Options

- Low Level Combined (common amplification)
- High Level Combined (10dB Hybrid)
- Split Level Combined
- Separate Antennas (space combined)

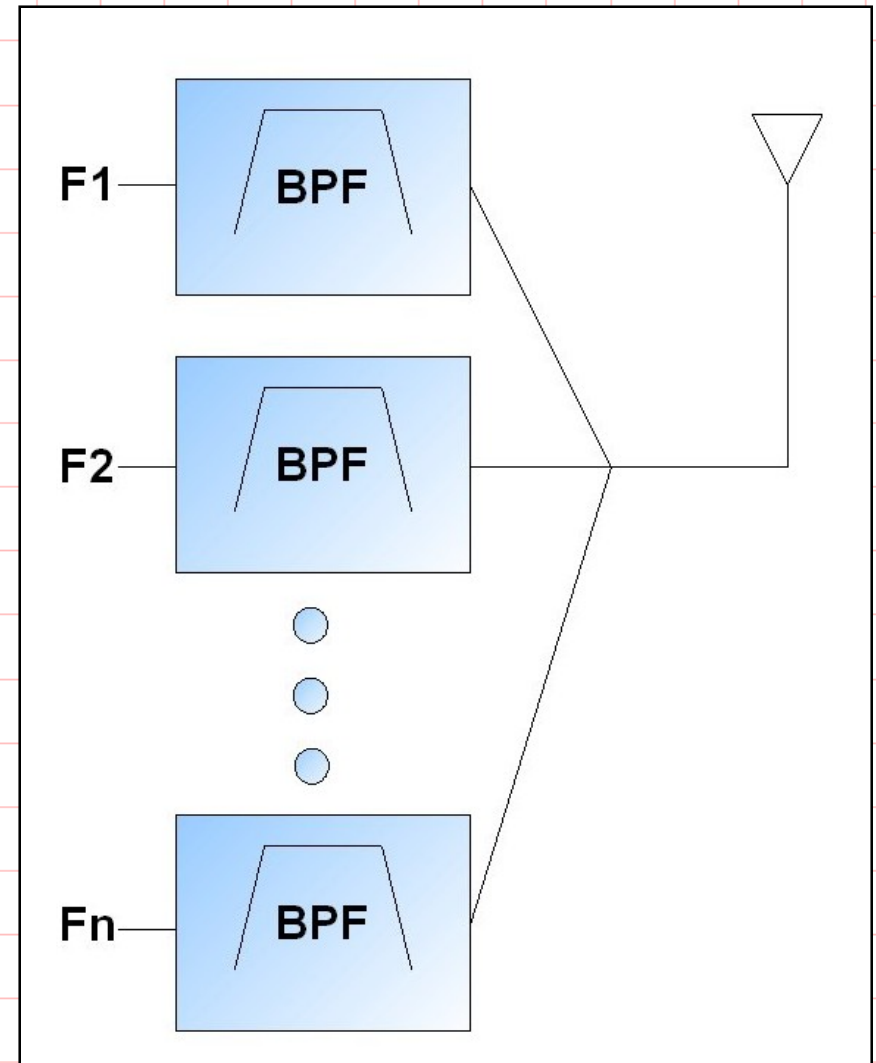


FM Multi-Channel Combiners

- Starpoint (Branched)
- Constant Impedance

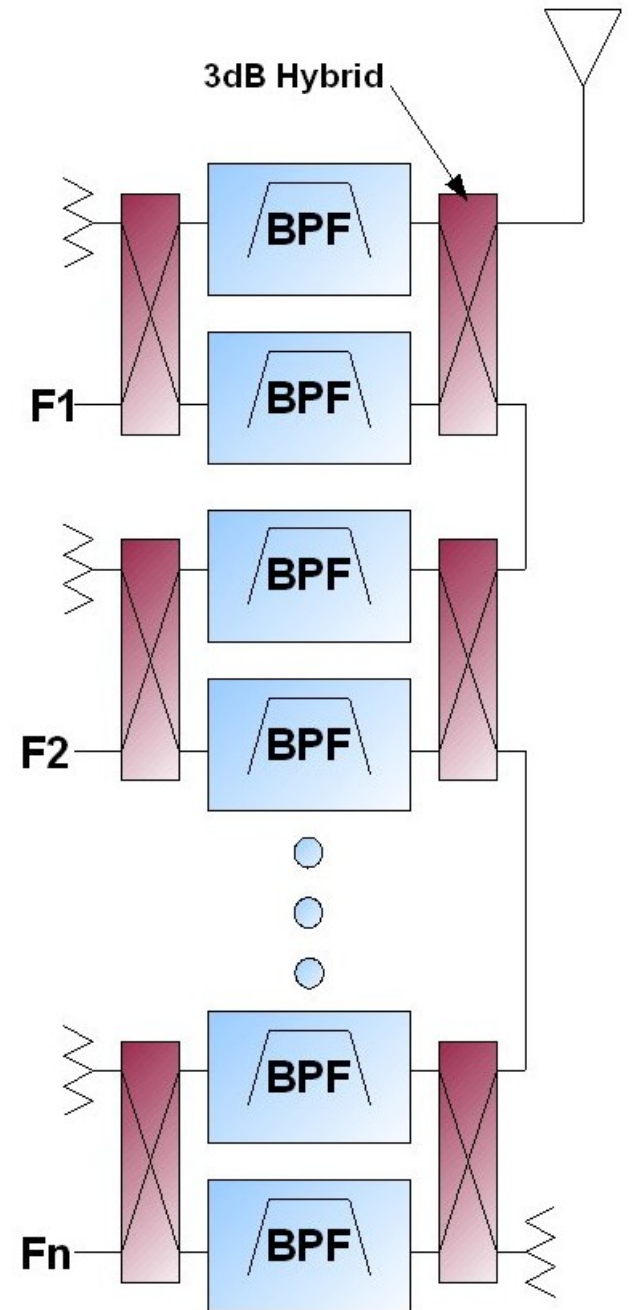
FM Multi-Channel Combiners

- Starpoint



FM Multi-Channel Combiners

- Constant Impedance





Multi-Channel FM Combiner HD Radio Options

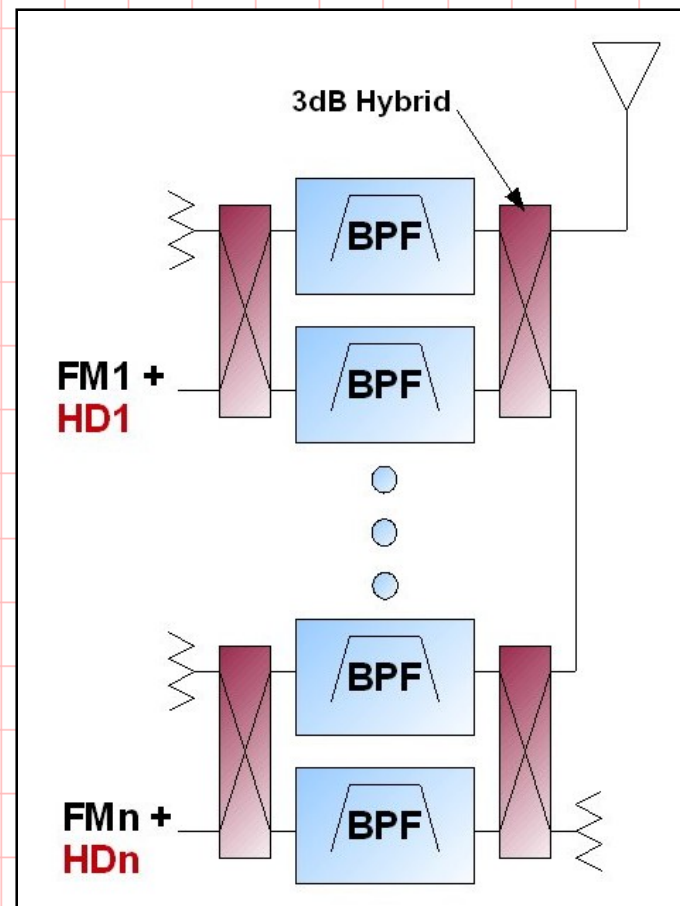
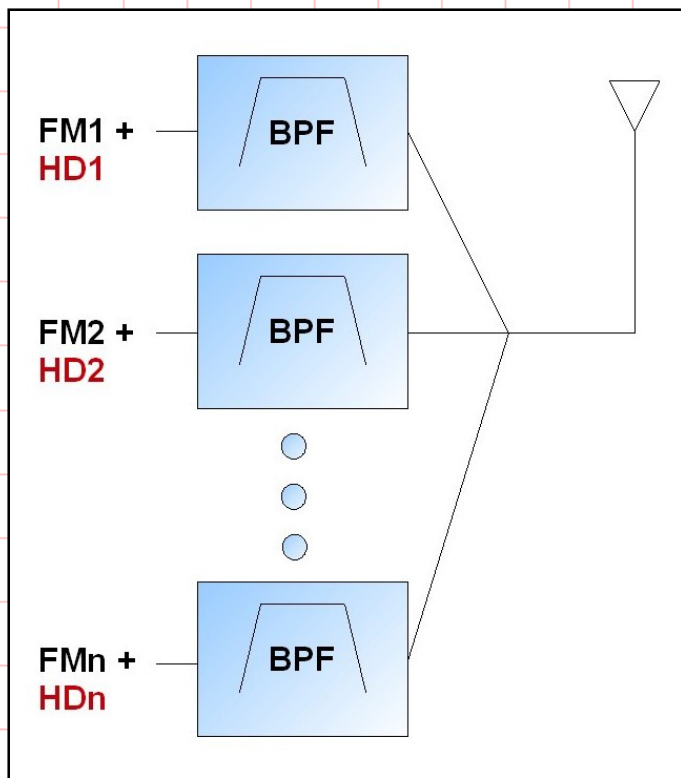
- Which HD Radio implementation options can be used with existing FM combiners?
- Any of the above. If certain criteria met.



Multi-Channel FM Combiner HD Radio Options

- Can use the existing combiner to feed a common antenna

Multi-Channel FM Combiner HD Radio Options



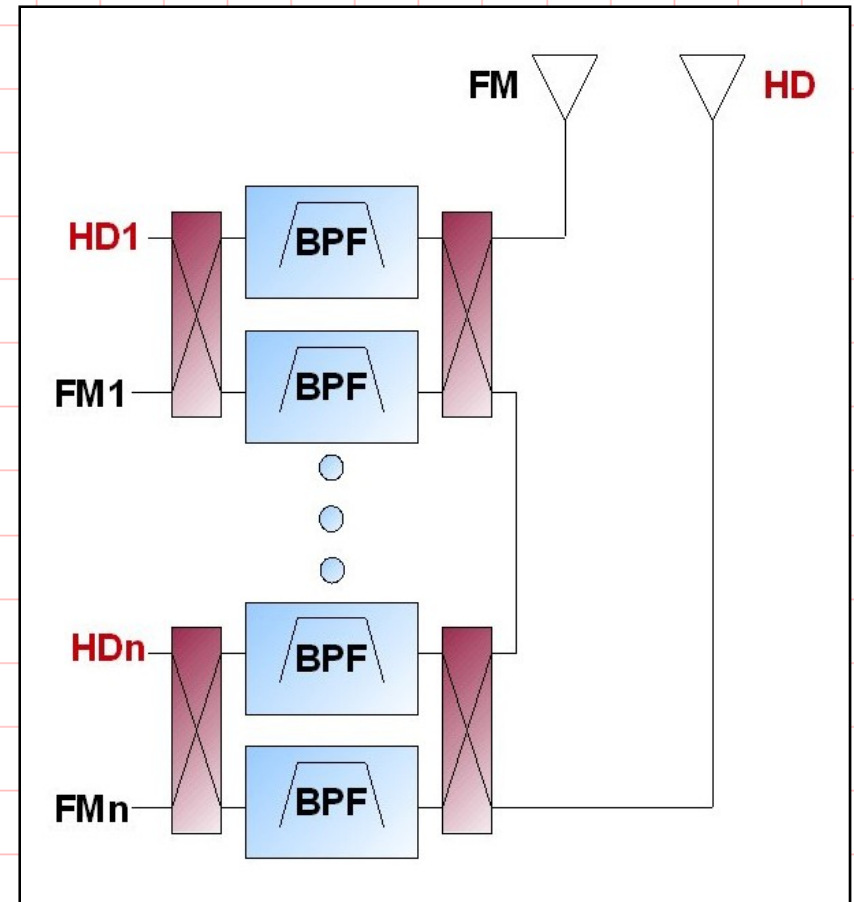


Multi-Channel FM Combiner HD Radio Options

- Can also Back-Feed an existing constant impedance combiner

Multi-Channel FM Combiner HD Radio Options

- "Back Fed"
- Separate Antennas





What are the Concerns?

- Bandwidth
- Peak Power Ratings
- Group Delay Variation
- Isolation

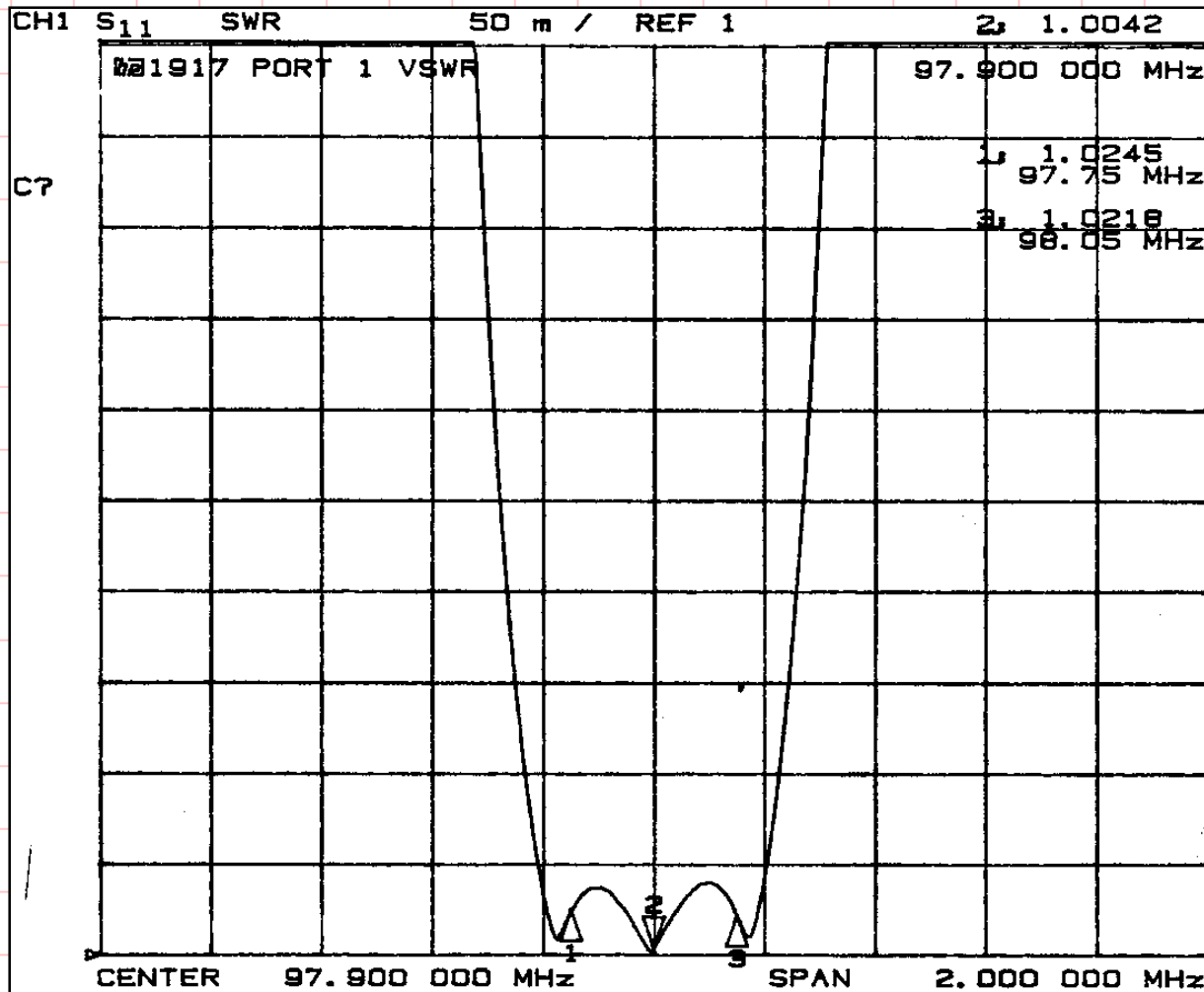


Bandwidth

- Typical FM combiner spec $\pm 150\text{kHz}$
- HD Radio signal requires $\pm 198\text{kHz}$
- Many existing combiners compatible

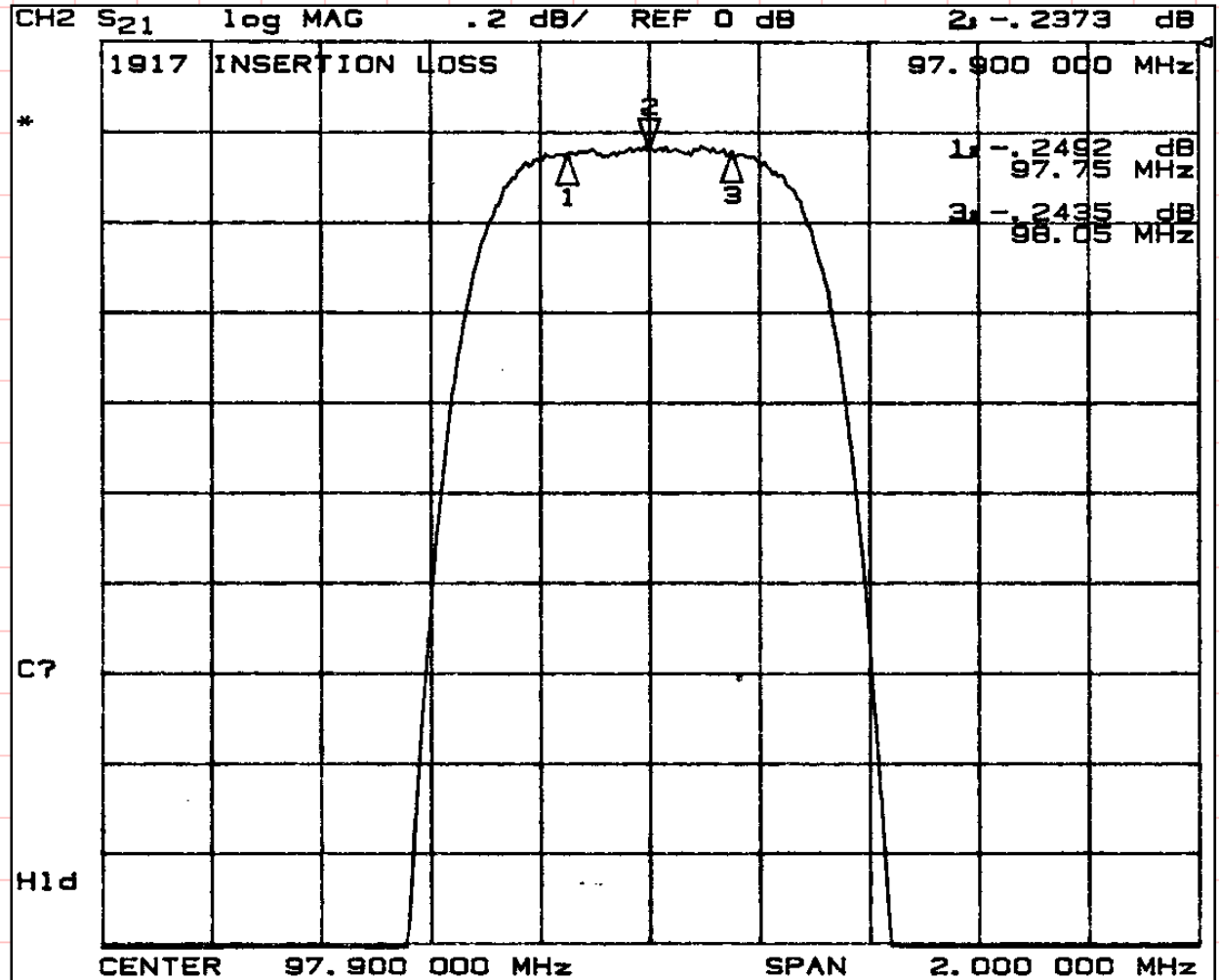
Bandwidth

- Example:



Bandwidth

- Example:





Bandwidth

- Close-Spaced (1 MHz or less) combiners may be a problem
- Solution – Replace filters



Peak Power Handling

- Added HD Radio average power rarely a concern
- HD Radio has 6dB crest factor (PAR)
- In a combined system Peak Power increases rapidly as multiple HD Radio signals are added



Peak Power Handling

- 7x 7kW FM combiner with 3-1/8" Output
- Avg Pwr = 49kW < 50kW Rating
- Pk Pwr = 343kW Pk < 440kW Pk Rating



Peak Power Handling

- Now add 7x 70W HD Radio to FM combiner
- Avg Pwr = 49.49kW < 50kW Rating
- Pk Pwr = 493.5kW Pk > 440kW Pk Rating
- Solution: Replace under-rated components in combining system

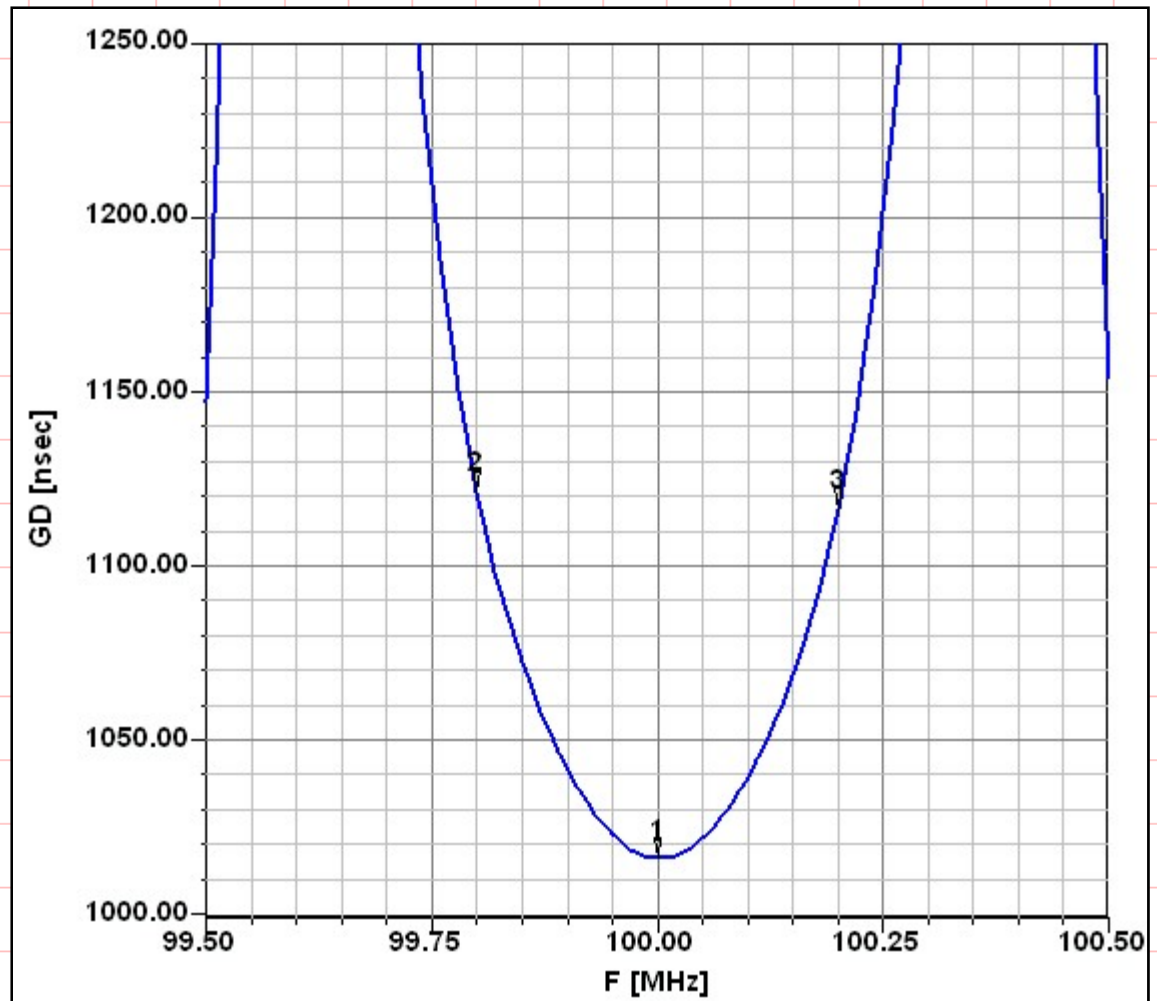


Group Delay Variation

- iBiquity Spec = 600ns peak to peak over $\pm 200\text{kHz}$
- Typically only a problem in closely spaced combiners ($< 1\text{ MHz}$)
- What are the sources of Group Delay Variation?

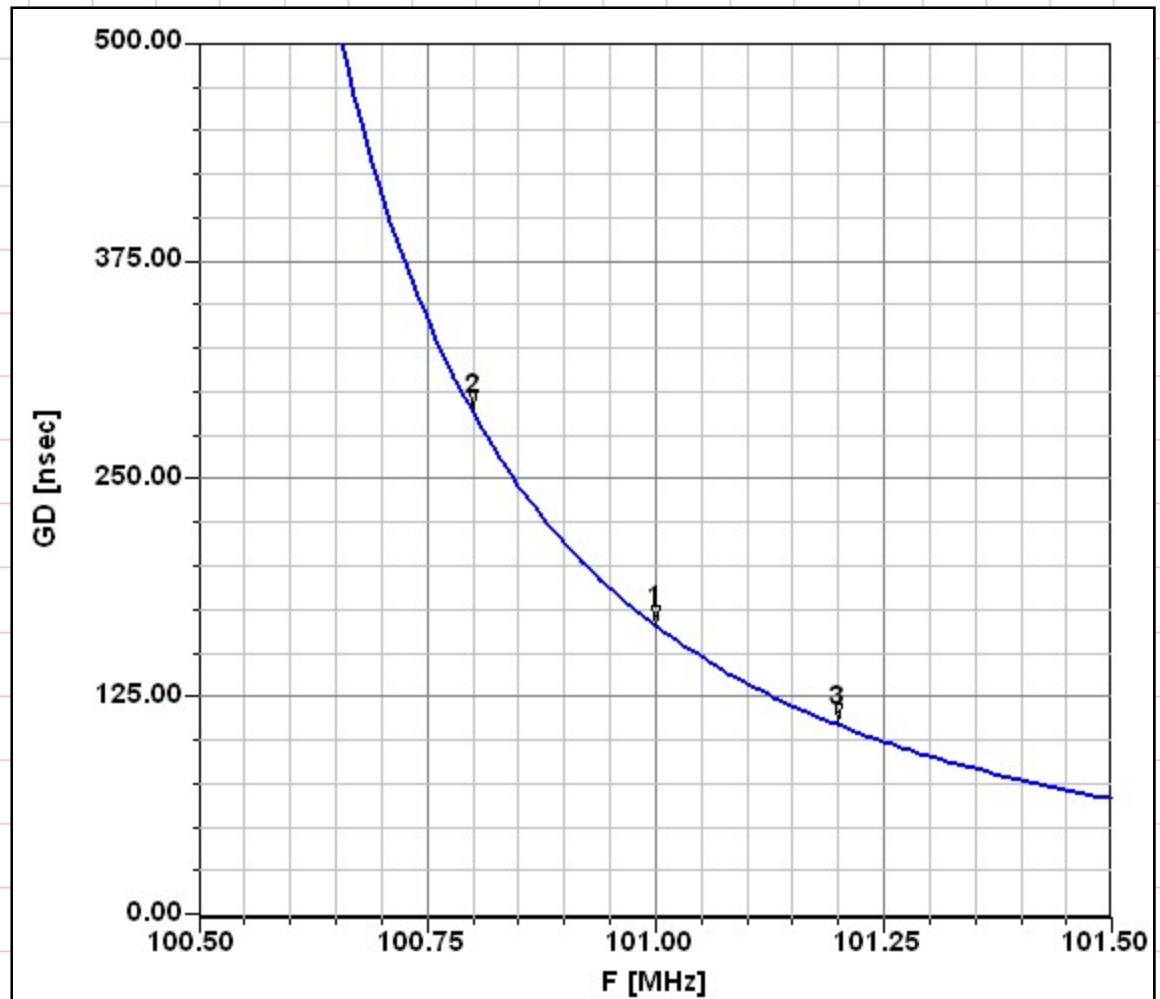
Group Delay Variation

- Passing through filters



Group Delay Variation

- Passing other modules in combiner chain





Group Delay Variation

- Combination of passing through filters and passing by modules
- Solution: Pre-correction in transmitter OR add group delay compensation module for HD Radio input



Isolation

- $> 40\text{dB}$ desired
- Can be a concern if back feeding constant impedance combiners
- Typical isolation 30 to 35dB
- Solution: Isolator on HD input adds $>20\text{dB}$



Conclusion

- Adding HD Radio to combined FM systems requires extra attention.
- Closely spaced frequencies
- 4 or more frequencies combined



Conclusion

- Consult original manufacturer early in the planning process
- Theoretical component performance can give rough estimate of possible changes needed
- Verify with complete combiner measurements



Thank You

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