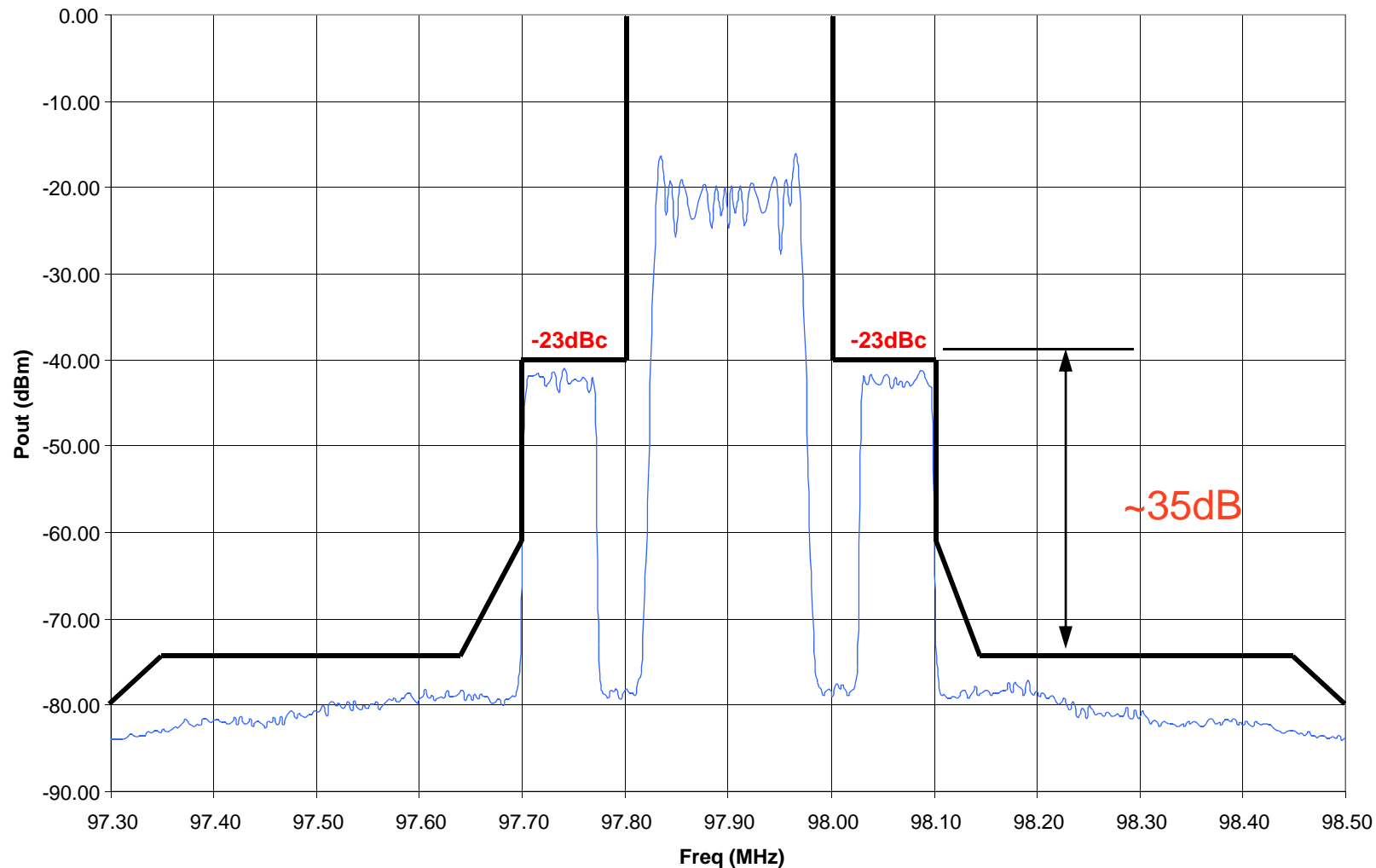


RF MASK FOR -20dBc (1%) IBOC SIDEBANDS

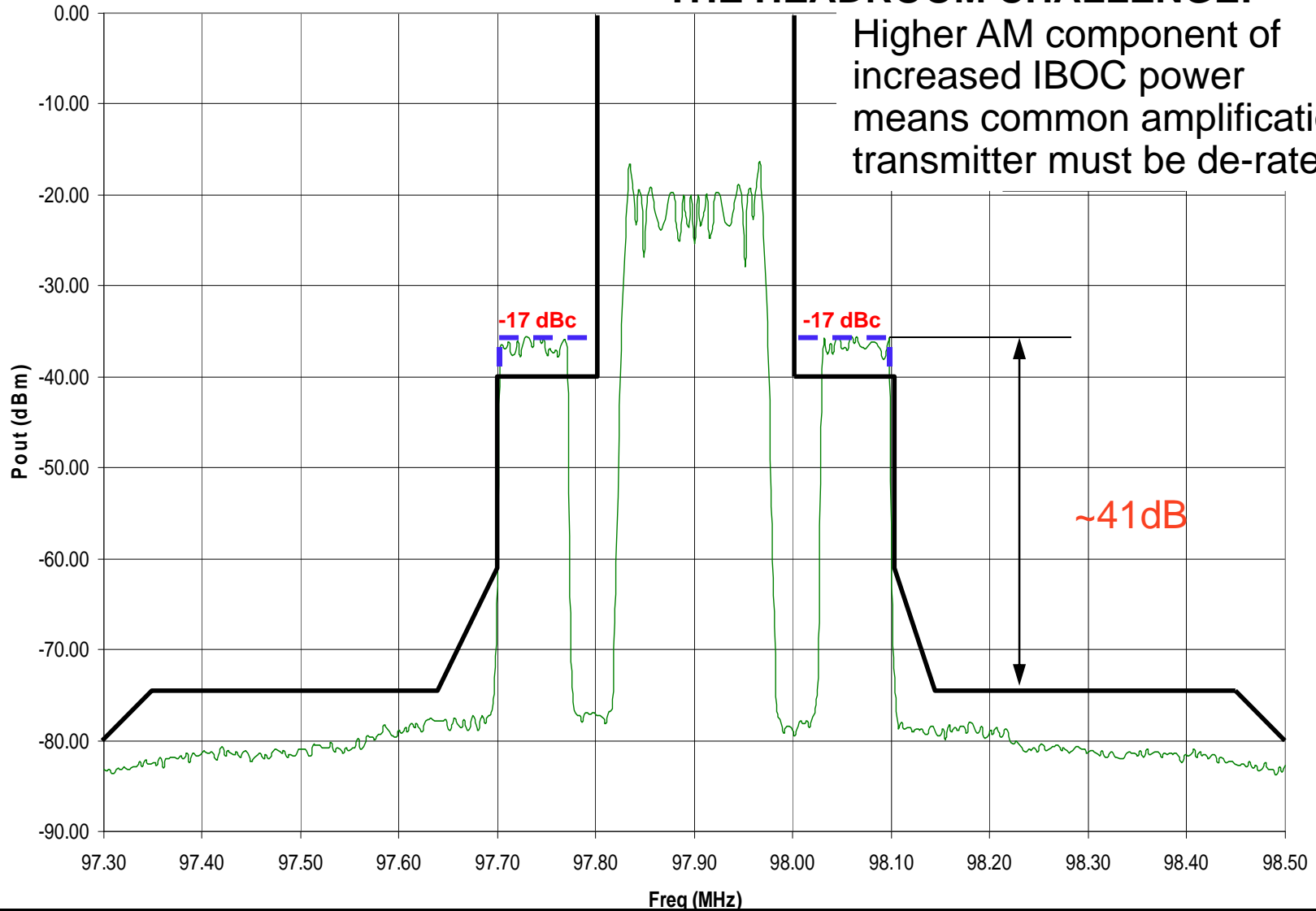


RF MASK FOR -14dBc (4%) IBOC SIDEBANDS



THE HEADROOM CHALLENGE:

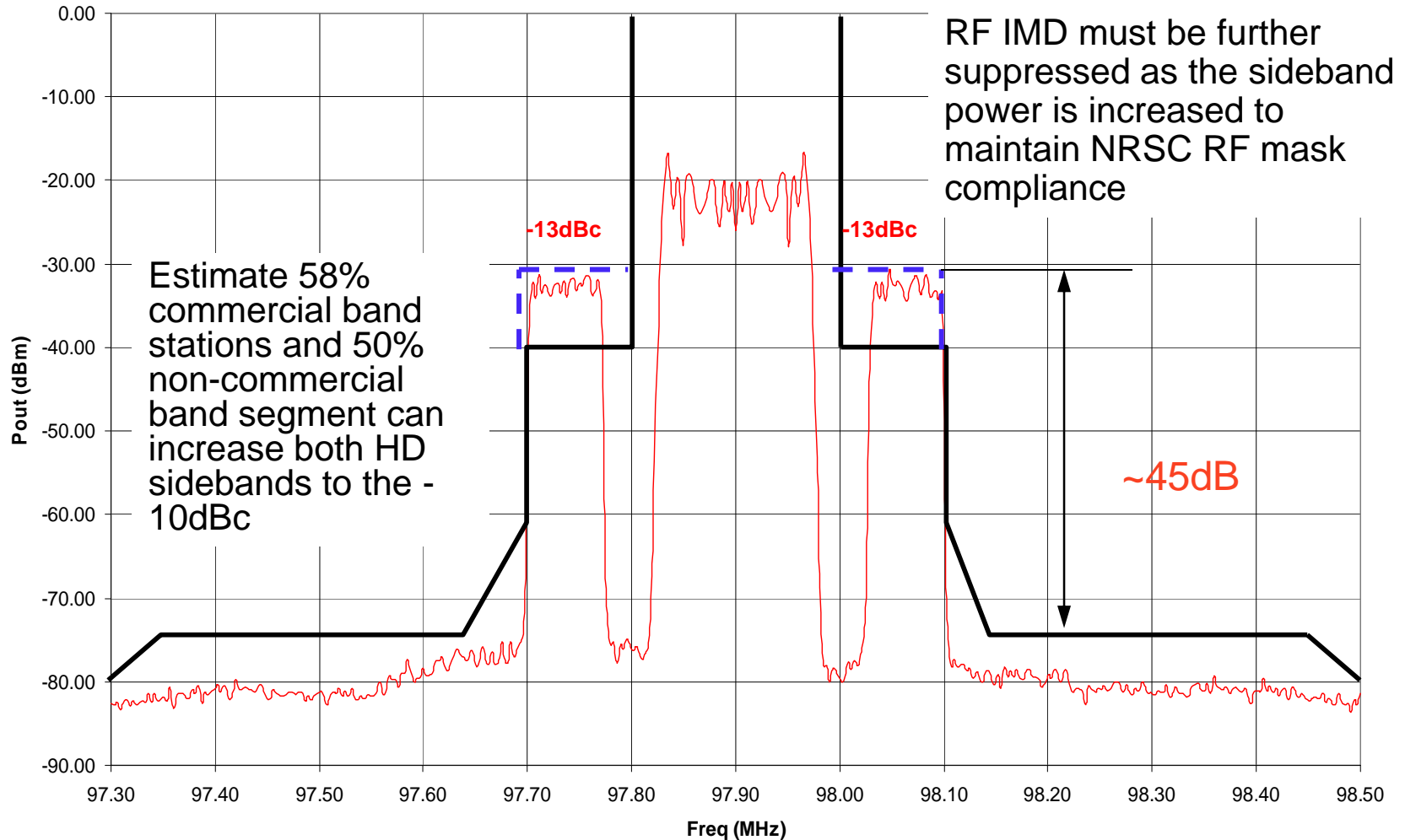
Higher AM component of increased IBOC power means common amplification transmitter must be de-rated



RF MASK FOR -10dBc (10%) IBOC SIDEBANDS



THE LINEARITY CHALLENGE:



HYBRID CREST FACTOR REDUCTION



HD Operating Mode	HD Carrier Injection (dBc)	PAR (dB) @ 0.01% with SCFR	PAR (dB) @ 0.01% with HCFR	PA Utilization Improvement
MP1	-20	1.49	1.11	+9%
MP3	-20	1.65	1.22	+10%
MP1	-14	2.64	2.04	+15%
MP3	-14	2.87	2.22	+16%
MP1	-10	3.75	2.58	+31%
MP3	-10	3.96	2.72	+33%

- HD Radio signal has high Crest Factor or Peak to Average power Ratio (PAR) compared to constant envelope FM
- Transmitter amplification system must have sufficient headroom to pass the high PAR of HD signal
- To improve RF power amplifier utilization, the (PAR) of HD Radio signal must be reduced by intelligent clipping techniques

ASYMMETRICAL HD RADIO SIDEBANDS



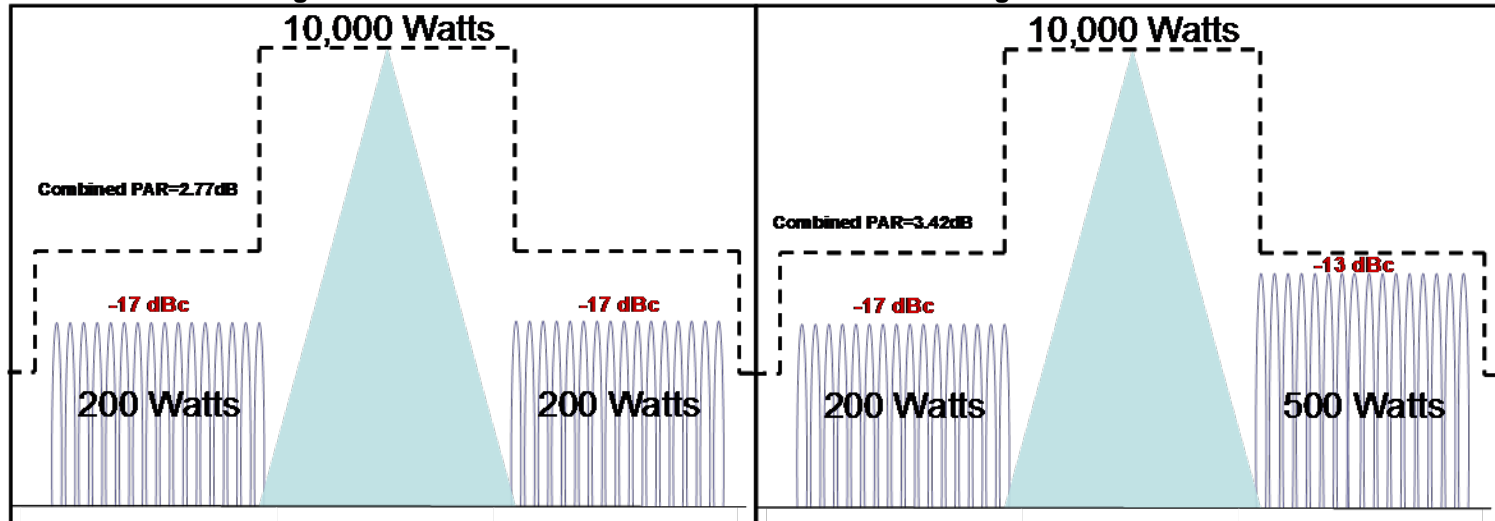
Unequal HD Radio sidebands can allow many stations to increase HD power above -14dBc on one side of channel while protecting adjacent channel on other side

HD Sideband-1 dBc	HD Sideband-2 dBc	Combined dBc	HD Power %	Combined PAR dB	% of -14dBc Power Rating
-14.0 (-17)	-14.0 (-17)	-14.0	4.0	2.77	100
-13.0 (-16)	-14.0 (-17)	-13.5	4.5	2.90	97
-12.0 (-15)	-14.0 (-17)	-12.9	5.2	3.06	94
-11.0 (-14)	-14.0 (-17)	-12.2	6.0	3.23	90
-10.0 (-13)	-14.0 (-17)	-11.5	7.0	3.42	86

Estimated over 90% of the stations in commercial FM band segment and over 80% of stations in the non-commercial band could increase one of the HD Radio sidebands to equivalent -10dBc level

-14 dBc lower and -14 dBc upper sideband power
Total Integrated Power 14 dBc or 4%

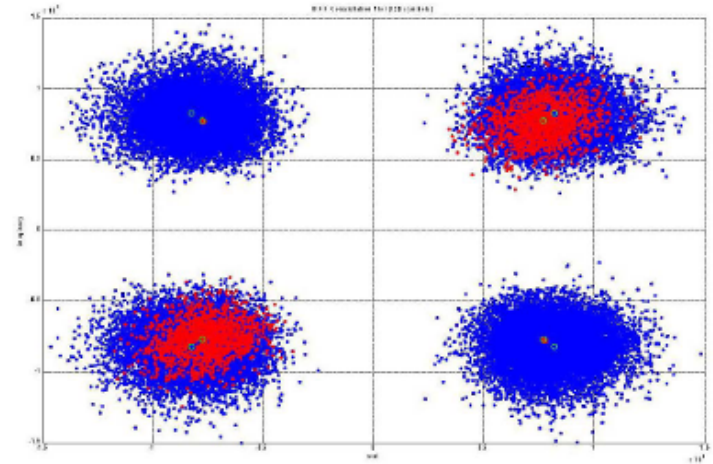
-14 dBc lower and -10 dBc upper sideband power
Total Integrated Power 11.55 dBc or 7%



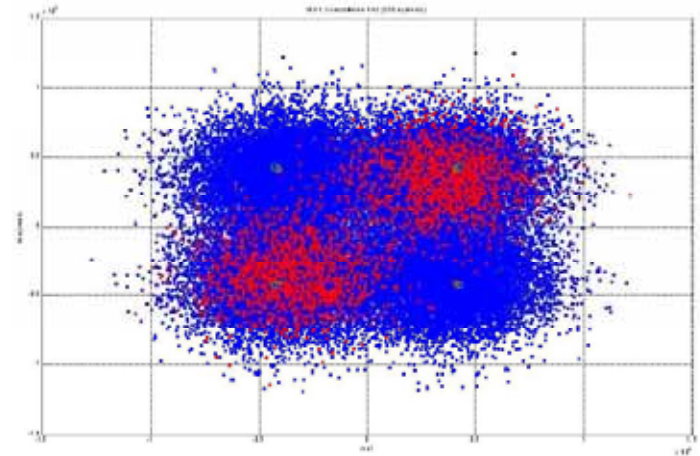
HD RADIO SIGNAL QUALITY MEASUREMENT



- MER (Modulation Error Ratio) allows station engineer to adjust system to minimize distortion to transmitted signal, thereby preserving equalization/correction margin in the receiver
- MER gives “grayscale” diagnostic view of system problems – Becomes important as Crest Factor Reduction techniques are employed
- MER measurement of the digital signal-to-noise ratio for data bearing carriers and the reference carriers within HD Radio OFDM sidebands
- MER averaged across all reference carriers > 14 dB measured at output of the transmission system including any RF filters or combiners feeding the antenna system



MER ~ 14dB IBOC Constellation Cd/No = 68dB-Hz



MER ~ 4dB IBOC Constellation Cd/No = 56dB-Hz

SEPARATE AMPLIFICATION - SPACE COMBINED



- Most cost effective way to increase the HD power
- Higher isolation >40dB and higher “turn around loss” in transmitters required
- If system isolation + power handling requirements can be met, increasing the digital transmitter power is the only equipment change
- Space Combining requires up to 10x more HD power and 10dB improvement in RF IMD suppression
- Mis-tracking between analog FM and HD signal levels due to differences in radiation patterns of two antennas
- Single array with opposite circular polarizations for FM + HD still has mis-tracking where multi-path polarizations add up differently
- FM / HD tracking important to avoid digital to host interference at higher HD power levels
- Only way for FM and HD signals track perfectly - radiate together from single antenna with identical radiation pattern and polarization Requires FM + HD mixed in single transmission line to the antenna



HIGH POWER COMMON AMPLIFICATION



- Increasing HD power in FM + HD common amplification system requires additional headroom in transmitter to handle increased peak to average ratio of the hybrid signal
- Key advantage is ability to use existing, single, antenna providing identical radiation patterns and polarization
FM+HD - Nearly perfect signal tracking of FM + HD radio signals at all locations
- Power rating of Tx increasing HD power -20dBc to -14dBc with standard crest factor reduction will be approximately (70%) of the -20dBc rating and approximately (85%) of the -20dBc rating with hybrid crest factor reduction
- If common amplification transmitter does not have headroom to go to -14dBc or -10dBc, addition of second transmitter combined with a 3dB hybrid offers several advantages
- Combined system provides full back-up of FM + HD Radio
- Nearly full FM analog power possible on either transmitter alone by reducing the HD sideband power level back to -20dBc



Single HPX40: 27 kW Analog @ -14 dBc
Dual HPX40: 52.7 kW Analog @ -14dBc