WBA / SBE Broadcasters Clinic

Methods to Improve HD Radio Coverage

presented by:

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TOPICS TO BE COVERED

- The need to increase HD Radio sideband power
- Optimized 6dB power increase
- RF amplifier linearity challenge
- Combining methods to higher HD Radio sideband levels
- Space Combining
- Common Amplification
- Re-use of existing HD Radio equipment to increase digital sideband levels
- High power Filterplexers
- Sharp tuned RF mask filters
- More HD power with Hybrid Crest Factor Reduction
- Unequal HD Radio sidebands to prevent interference
- HD Radio Gap Filler solutions
- HD Radio Translators
- HD Radio signal quality measurement

GOALS OF INCREASING HD RADIO POWER

- Reliable reception of multicast channels - no analog fall back
- Better building penetration to portable and desktop receivers
- Better mobile reception in suburban areas
- Better reception on portable receivers with poor antennas

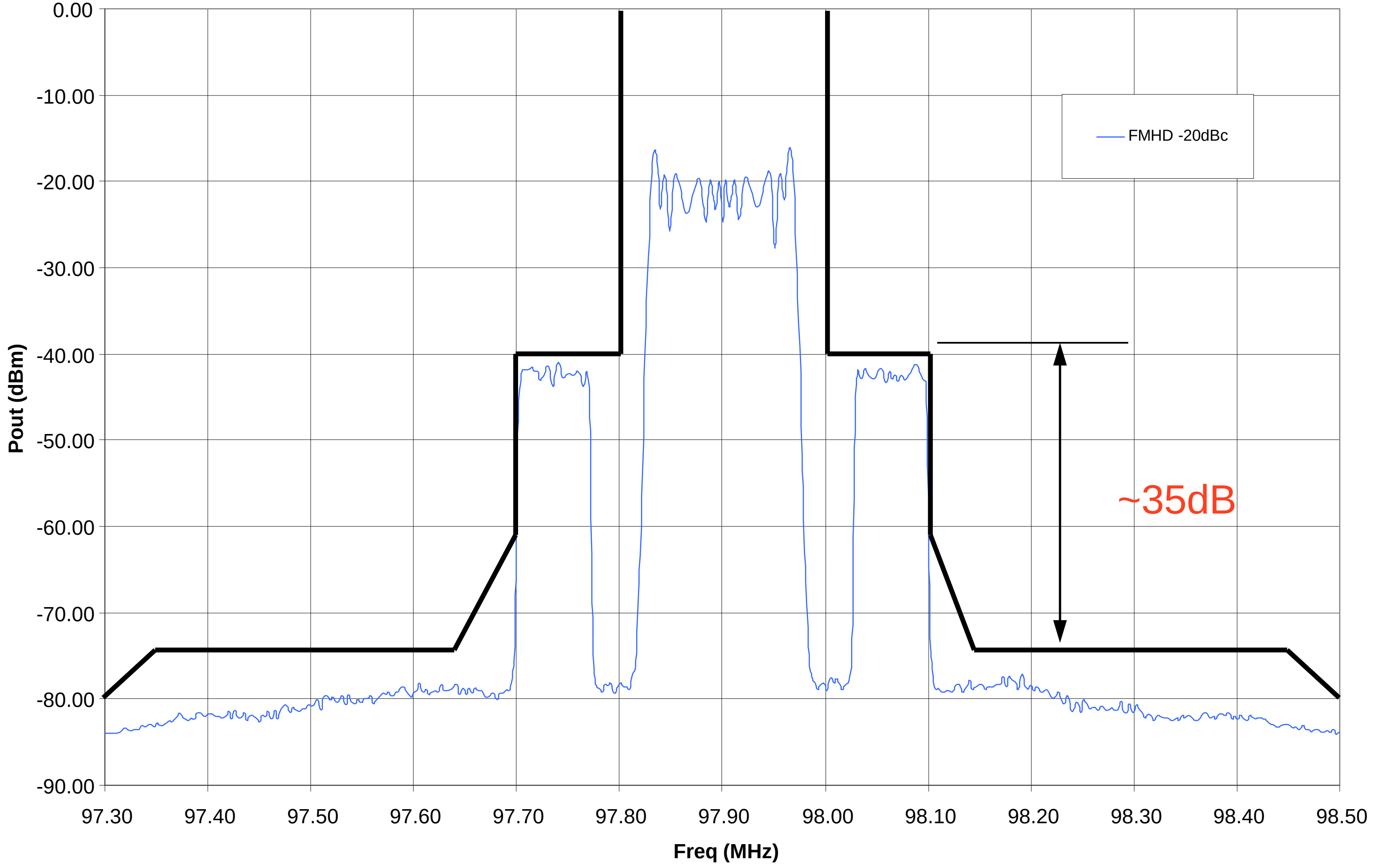
CORRECTLY SIZE TRANSMITTER UPGRADE

- Do I size my transmission plant for -14, -12, or -10dBc?
- Do I size for asymmetrical HD sidebands?
- All FM stations permitted to increase both HD sidebands levels by +6 dB
- Grandfathered, super power stations, may get less
- FCC site at: http://www.fcc.gov/mb/audio/digitalFMpower.html
- Many stations able to increase power of one or both HD sidebands 4dB more with asymmetrical HD sidebands
- Additional power for asymmetrical sidebands needs to be considered in selecting the proper size transmitter
- Estimated 91% commercial band stations and 82% non-commercial band segment stations can increase one HD sideband to -10dBc
- Estimated 58% commercial band stations and 50% non-commercial band segment could increase both HD sidebands to the -10dBc

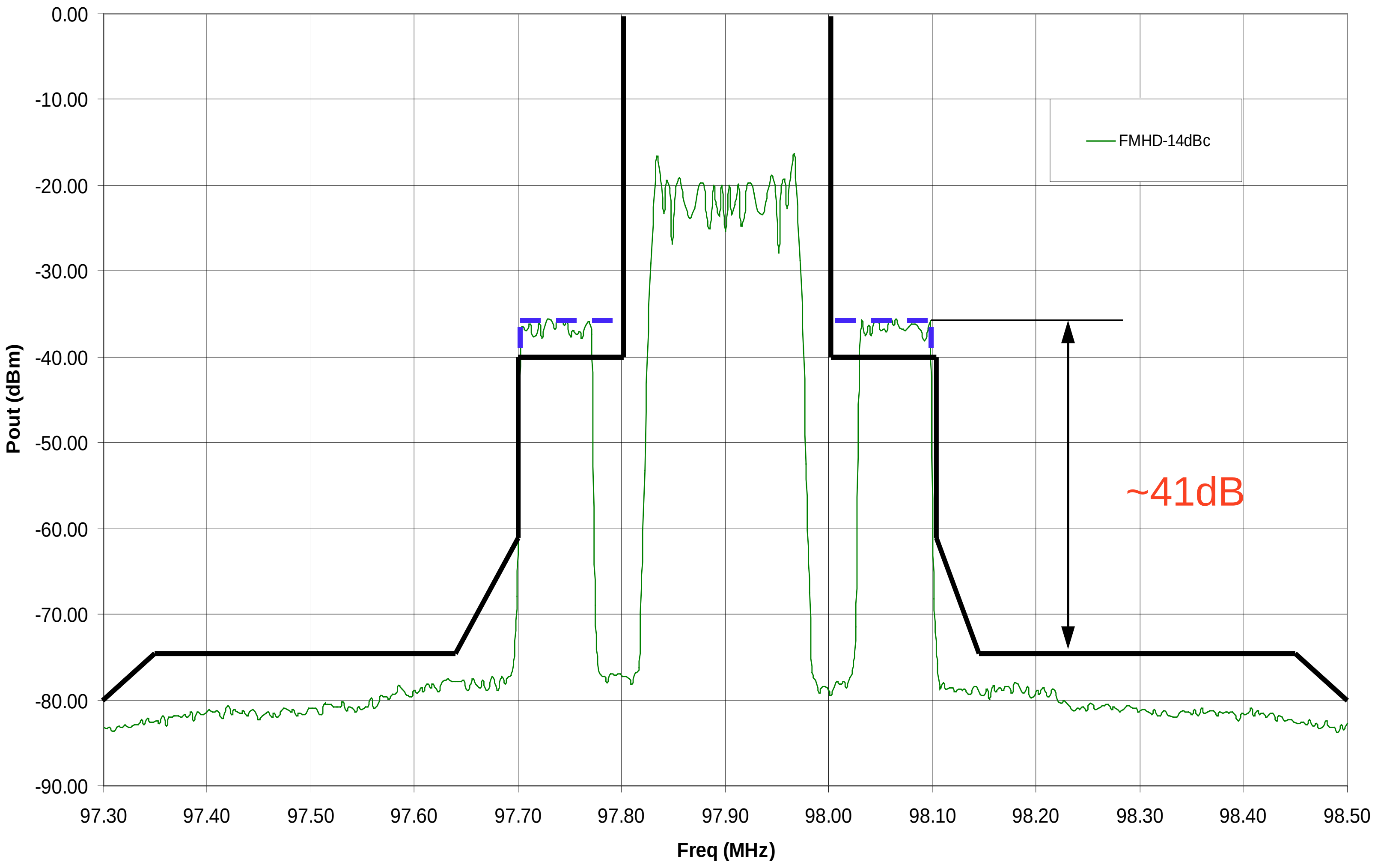
LINEARITY CHALLENGE - HIGHER HD POWER

- Higher AM component of increased IBOC power means common amplification transmitter must be further de-rated from Class ”C” saturated FM operation
- HD-only, separate amplification without linearizing effect of constant envelope analog FM signal - maximum power must be reduced to improve IMD suppression
- At -10dBc (10%) injection, RF IMD must be suppressed additional 10dB at same time power output is increased by 10dB
- 20dB linearity improvement from -20dBc (1%) to maintain the original RF mask compliance

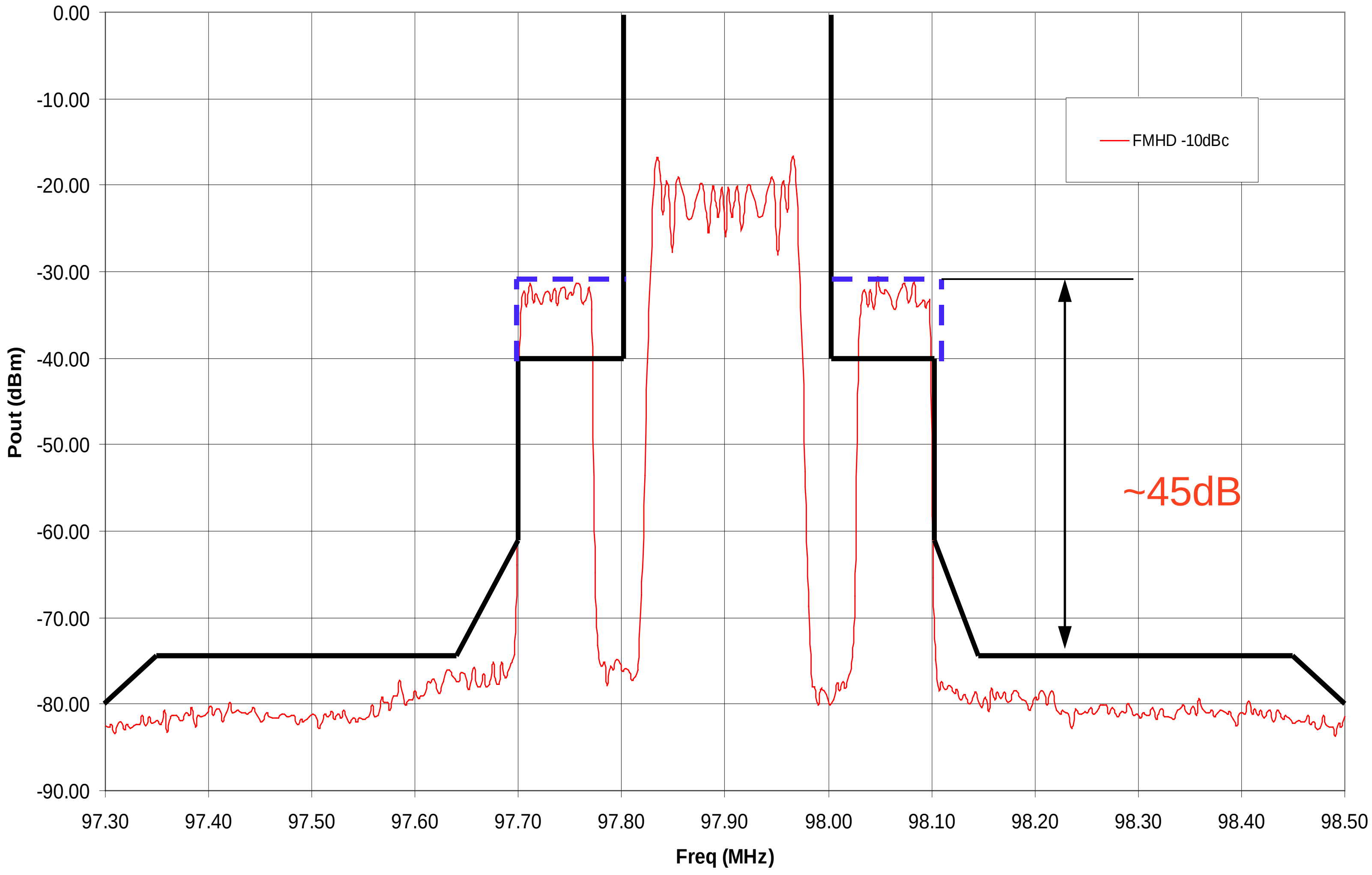
RF MASK FOR -20dBc IBOC SIDEBANDS



RF MASK FOR -14dBc IBOC SIDEBANDS



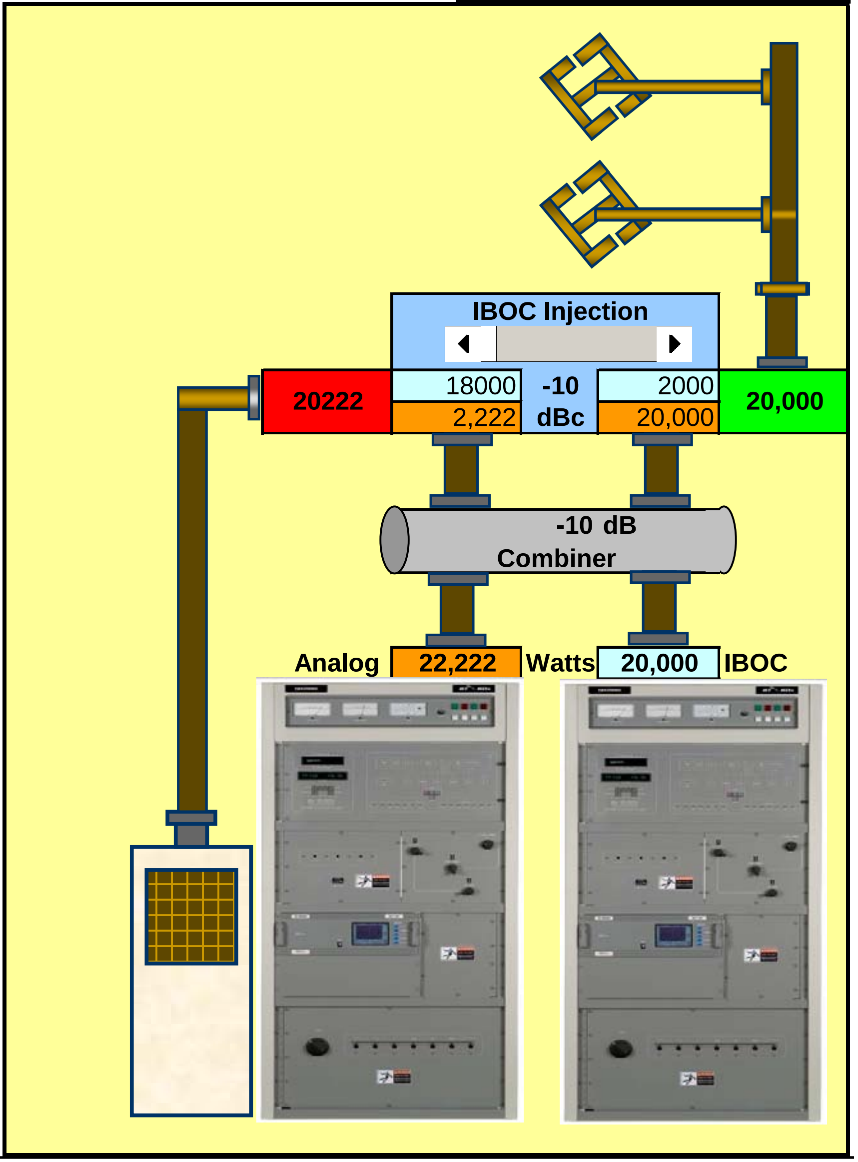
RF MASK FOR -10dBc IBOC SIDEBANDS



10DB HIGH LEVEL COMBINING -20 VS. -10 dBc

Conventional 10dB High-Level combining is not practical in terms of capital expense or operating efficiency for more than 2dB increase in IBOC injection

Lic. TPO 20,000 Watts		Combiner -10 dBc
HD Injection dB	**HD Power Watts**	**Reject Watts**
-20	2,000	4,022
-18	3,170	5,075
-16	5,024	6,744
-14	7,962	9,388
-13	10,024	11,244
-12	12,619	13,579
-10	20,000	20,222



OPTIMIZED +6DB HD POWER INCREASE

- Stations want full +6dB increase in HD power
- Practical choices to increase HD radio power
  - Space combining separate analog and digital transmitters
  - Conversion of split-level systems or high level systems to unequal combining of common amplification transmitters
  - Common amplification of FM + HD through a single transmitter

- High level or split-level combining not practical for HD increase of more than +3dB

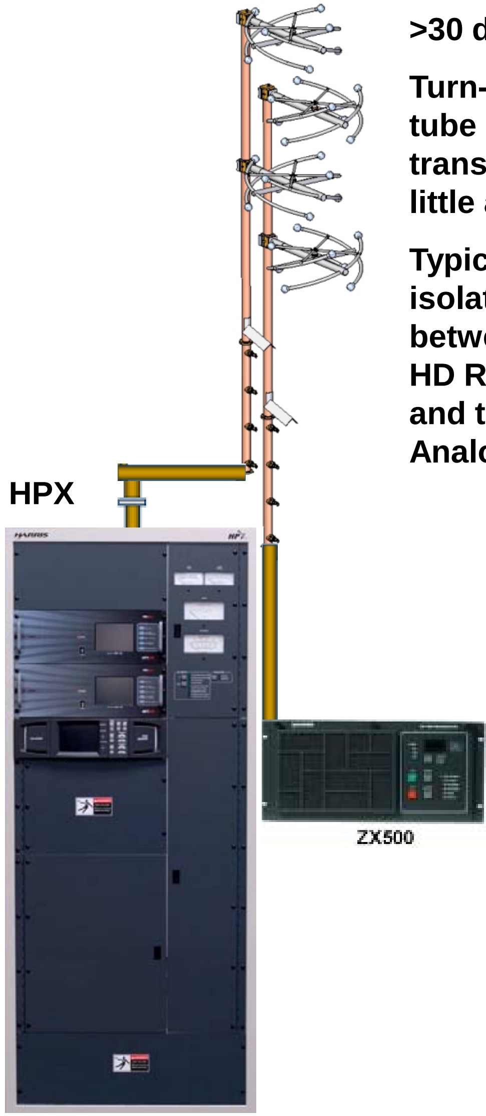
SPACE COMBINING OR COMMON AMPLIFICATION?

- Space combining - most cost effective way to increase the HD power using the existing antennas and analog FM transmitter
- If system isolation + power handling requirements can be met, increasing the digital transmitter power is the only equipment change
- Shortcoming is 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
- Most practical way is common amplification transmitter of both signals in proper ratio

UPGRADING A SPACE COMBINED SYSTEM

- 6dB increase to -14dBc = digital transmitter to 4 x current power
- Some headroom to increase power some number of dB now ??
- Isolation between analog FM transmitter and digital transmitter needs to increase “dB for dB” in direct proportion to the digital transmitter power increase
- Exact isolation requirement will depend on the mixing “turn-around-loss” of both the analog and digital transmitters -> higher “turn-around-loss” requires less isolation
- Limiting factor driving isolation requirement is frequently “turn-around-loss” of high power analog FM transmitter
- Power ratings of multi-station combining system, transmission line, and antenna may need to be upgraded

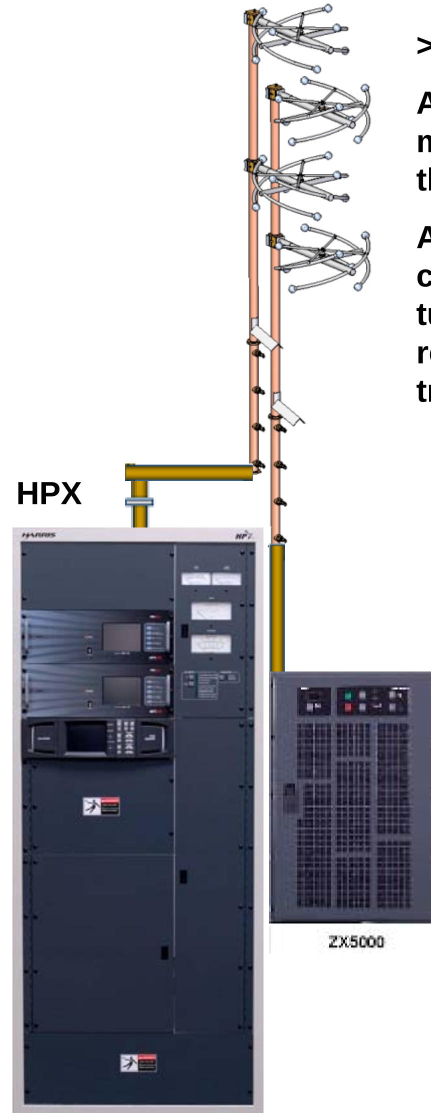
SPACE COMBINING -20 dBc VS. -10 dBc



>30 dB isolation

Turn-around-loss in tube type analog transmitter can be a little as 6dB

Typically 30-40dB isolation is required between a solid-state HD Radio transmitter and the tube type Analog transmitter



>40 dB isolation

A low power circulator may be required on the digital transmitter.

A high power circulator or a sharp tuned filter may be required on the tube transmitter

MAX HD-ONLY TPO – SEPARATE AMPLIFICATION

HARRIS

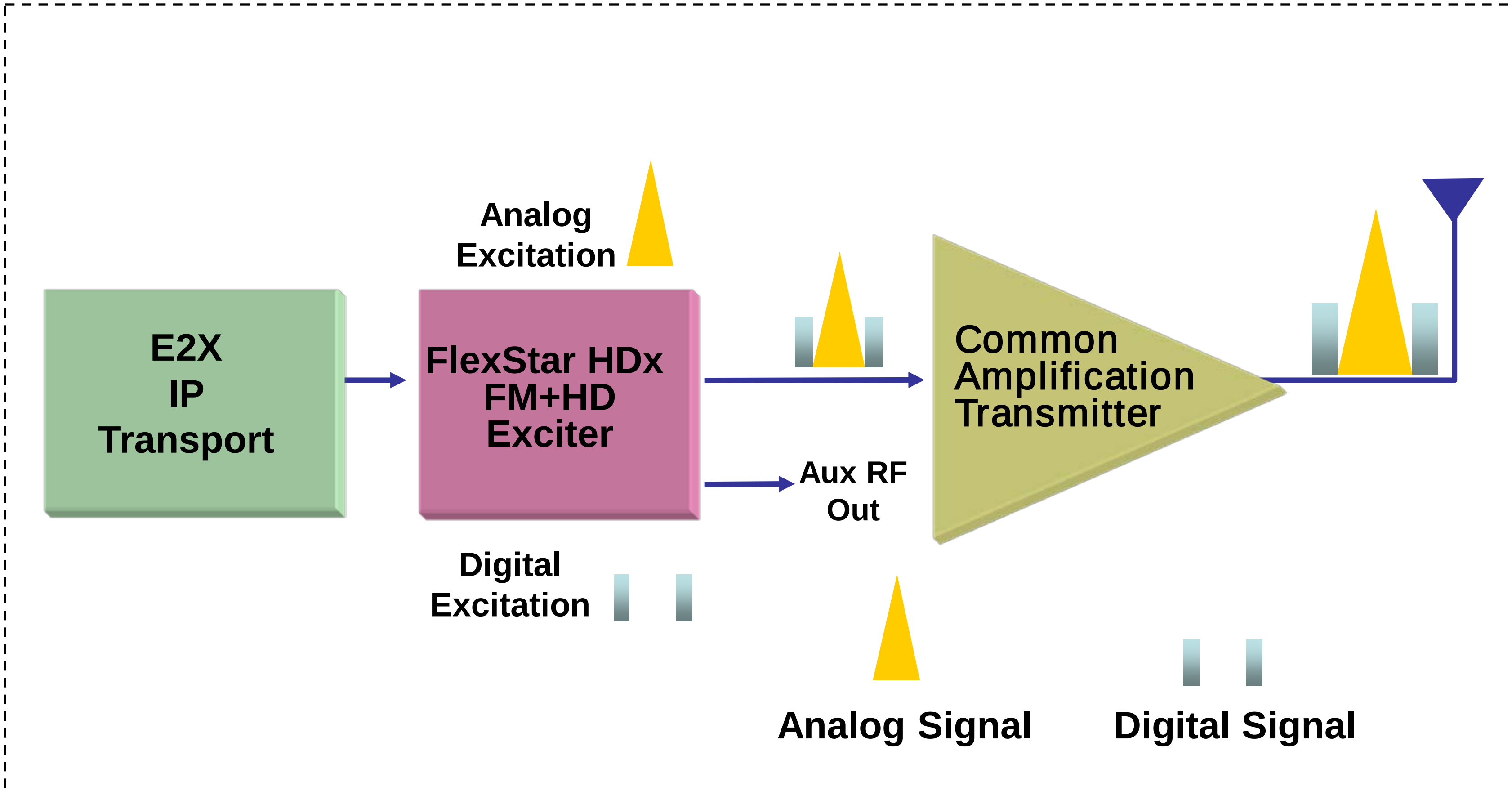
Without the linearizing effect of the constant envelope analog FM signal, the maximum available TPO must be reduced to improve linearity and IMD suppression

As the IBOC sideband power ratio is increased, power output of the IBOC only transmitter is increasing and the RF inter-modulation products need to be further suppressed by the same ratio to maintain original mask compliance.

Harris Transmitter	HD-Only Separate Amplification TPO					
	-20dBc	-18dBc	-16dBc	-14dBc	-12dBc	-10dBc
ZX500	200	198	196	194	183	171
ZX1000	400	396	392	388	366	342
ZX2000	800	792	784	776	732	684
ZX3500	1400	1386	1372	1358	1281	1197
Z4HD+	775	753	711	695	682	664
Z6HD+	1350	1275	1204	1178	1155	1125
ZX5000	2000	1980	1960	1940	1830	1710
Z8HD+	1750	1650	1580	1560	1410	1250
Z12HD+	2600	2550	2408	2355	2310	2250
Z16HD+	3500	3400	3210	3140	3080	3000
ZD24HD+	5200	5100	4815	4710	4620	4500
ZD32HD+	7000	6800	6420	6280	6160	6000
HT/HD+	9400	9100	8600	7800	7400	6800
HT/HD+ (Dual)	18236	17654	16684	15132	14356	13192
HPX20	8400	8100	7600	7000	6600	6100
HPX30	9400	9100	8600	7800	7400	6800
HPX40	9600	9300	8800	8000	7600	7000
HPX80 (Dual HPX40)	18624	18042	17072	15520	14744	13580

This table displays the maximum **IBOC** RF power output, in watts, available from each Harris HD transmitter when operating **Digital Only** for IBOC sideband injection levels from -20 dBc through -10dBc

COMMON AMPLIFICATION



UPGRADING COMMON AMPLIFICATION SYSTEM

- Increasing HD power in FM + HD common amplification system simply involves 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

HIGH POWER COMMON AMPLIFICATION

- Single HPX provides total FM+HD TPO of 17kW at -10dBc

- Single HPX provides total FM+HD TPO of 24kW at -14dBc

- Dual HPX provides total FM+HD TPO of 33kW at -10dBc

- Dual HPX provides total FM+HD TPO of 47kW at -14dBc

Dual HPX- 40 Common Amp
@ -10dBc = 33,000 W Max
@ -14dBc = 47,000 W Max

MAXIMUM TPO FOR COMMON AMPLIFICATION

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Harris Transmitter	FM	FM+HD Common Amplification TPO - IBOC to FM Ratio (dBc) with standard digital only crest factor reduction																	
		-20dBc			-18dBc			-16dBc			-14dBc			-12dBc			-10dBc		
		Com	FM	IBOC	Com	FM	IBOC	Com	FM	IBOC	Com	FM	IBOC	Com	FM	IBOC	Com	FM	IBOC
ZX500	550	413	409	4	390	384	6	350	341	9	314	302	12	286	269	17	267	243	24
ZX1000	1100	852	844	8	780	768	12	700	683	17	628	604	24	572	538	34	534	485	49
ZX2000	2200	1704	1687	17	1560	1536	24	1400	1366	34	1256	1208	48	1144	1076	68	1068	971	97
ZX2500	2750	2130	2109	21	1950	1920	30	1750	1707	43	1570	1510	60	1430	1345	85	1335	1214	121
ZX3500	3850	2800	2772	28	2563	2523	40	2300	2244	56	2064	1985	79	1880	1768	112	1755	1595	160
ZX3750	4125	3195	3163	32	2925	2879	46	2625	2561	64	2355	2265	91	2145	2018	127	2003	1820	182
Z4HD+	5500	2050	2030	20	1925	1895	30	1725	1683	42	1545	1486	59	1405	1322	83	1310	1191	119
Z6HD+	2200	3075	3045	30	2888	2842	45	2588	2524	63	2318	2228	89	2108	1982	125	1965	1786	179
ZX5000	5500	4260	4218	42	3900	3839	61	3500	3414	86	3140	3019	121	2860	2690	170	2670	2427	243
Z8HD+	5250	4100	4059	41	3850	3790	60	3450	3365	85	3090	2971	119	2810	2643	167	2620	2382	238
Z12HD+	7800	6150	6089	61	5775	5685	90	5175	5048	127	4635	4457	178	4215	3965	250	3930	3573	357
Z16HD+	10500	8200	8119	81	7700	7580	120	6900	6731	169	6180	5943	238	5620	5286	334	5240	4764	476
ZD24HD+	15600	12300	12178	122	11550	11370	180	10350	10096	254	9270	8914	357	8430	7930	500	7860	7145	715
ZD32HD+	21000	16400	16238	162	15400	15160	240	13800	13462	338	12360	11885	475	11240	10573	667	10480	9527	953
HT/HD+	35000	25000	24752	248	21700	21361	339	18600	18144	456	14300	13751	550	12300	11570	730	9100	8273	827
HT/HD+ (Dual)	67900	49000	48515	485	42532	41868	664	36456	35563	893	28028	26951	1078	24108	22677	1431	17836	16215	1621
HPX20	21000	19266	19075	191	18727	18435	292	18000	17559	441	17000	16347	654	16200	15239	961	14500	13182	1318
HPX30	31500	26500	26238	262	24759	24372	386	22641	22086	555	20000	19232	769	18000	16932	1068	15500	14091	1409
HPX40	42000	32110	31792	318	30000	29532	468	27434	26762	672	24138	23211	928	20000	18813	1187	16964	15422	1542
HPX80 (Dual HPX40)	81480	62936	62312	623	58800	57883	917	53771	52453	1318	47310	45493	1820	39200	36873	2327	33249	30227	3023

Three color coded columns in this table show the maximum **FM Analog**, **Combined**, and **IBOC** RF power output, in watts, available from each Harris FM+HD transmitter with IBOC sideband injection levels from -20dBc through -10dBc. Possible 30% increase above these power levels at -10dBc with FM+HD Hybrid Crest Factor signal processing

Power Measurements and Actual FM Power

- All figures assume a minimum of 3 dB of headroom below the NRSC RF mask of -74.4 dBc with the FM analog carrier modulated 100% using a 1kHz monaural tone

- All ratings are stated as measured (or interpolated) with a calorimetric power meter measuring the integrated (RMS) power of both the analog and digital RF components

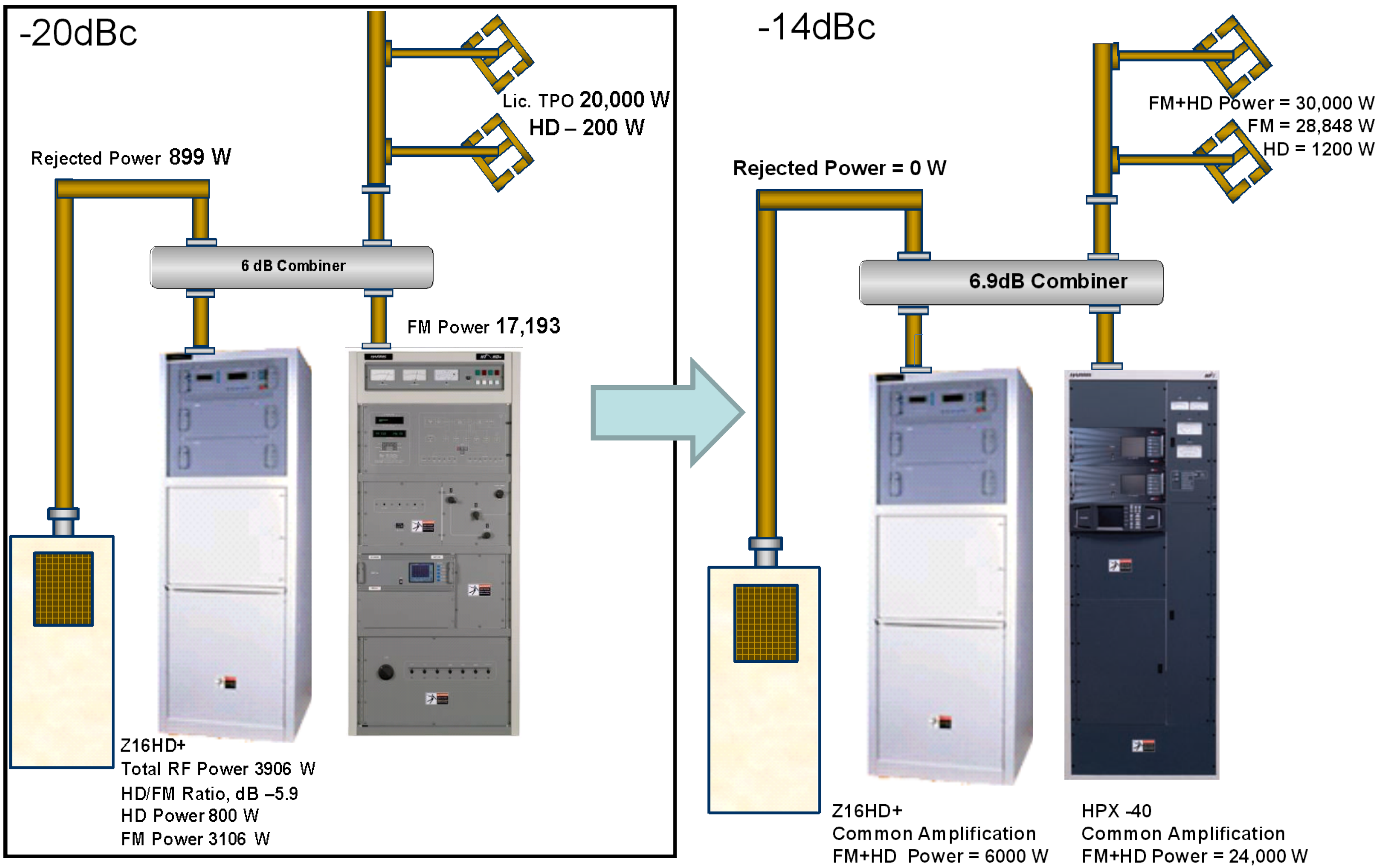
- At -20 dBc IBOC sideband injection, a transmitter rated at 10,000 watts is providing 9,901 watts of analog and 99 watts of digital. This is not significant in terms of power measurement and transmitter selection for a given TPO

- At -10 dBc, the transmitter rated at 10,000 watts is providing 9,091 watts of analog and 909 watts digital. This **DOES** become significant in terms of power measurement and transmitter selection for a given TPO. The transmitter would need to be rated at 11,000 watts to achieve a licensed TPO of 10,000 watts analog FM plus 1000 watts of IBOC using common amplification

SPLIT-LEVEL TO COMMON AMP CONVERSION

- Existing investment in a split-level system may be re-configured into an unequally combined, common amplification system
- Analog FM transmitter is replaced with FM + HD
- Both transmitters run FM+HD in same ratio
- Typical combining ratio is 6dB instead of 3dB
- Negligible reject load power dissipation
- RTAC can correct two different types of transmitters when combined for common amplification
- Existing tube or solid state common amplification transmitters can be used with HPX to reach to higher power levels at -14dBc or -10dBc HD Radio sideband levels

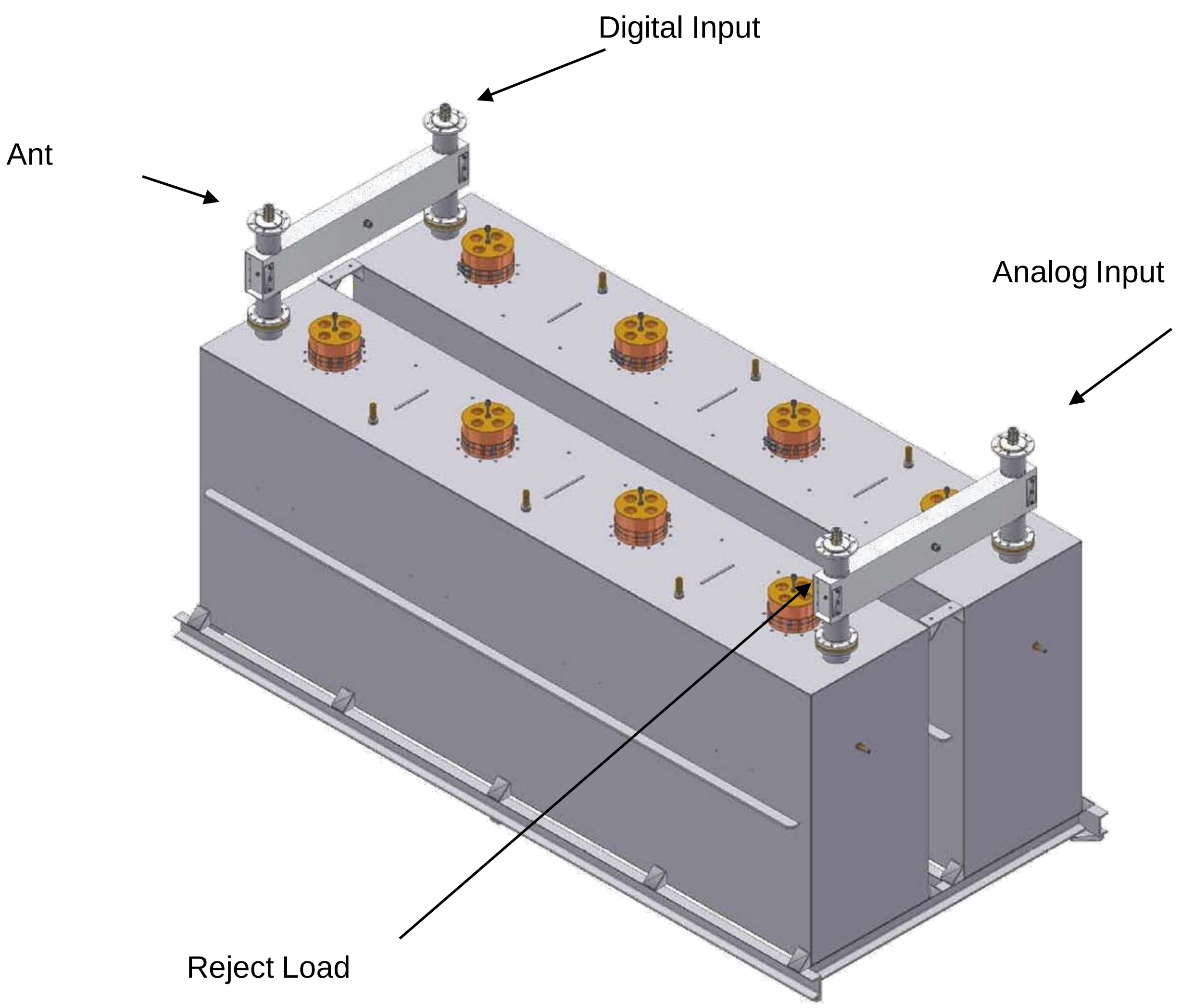
Convert Split Level to Common Amplification



HIGH-LEVEL TO COMMON AMP CONVERSION

- Existing investment in a high-level system may be re-configured into an equally or unequally combined, common amplification system
- Both transmitters run FM+HD in same ratio
- Typical combining ratio is 6dB instead of 3dB
- Negligible reject load power dissipation
- RTAC can correct two different types of transmitters when combined for common amplification
- Existing tube or solid state common amplification transmitters can be used with HPX to reach to higher power levels at -14dBc or -10dBc HD Radio sideband levels

HIGH POWER FILTERPLEXER COMBINING



HIGH POWER FILTERPLEXER COMBINING

- High power, sharp tuned, filterplexer can do high level combining if analog FM transmitter has ~11% headroom for insertion loss
- Typical insertion loss for HD signal in MP1 mode is 1.4dB or ~ 38% of the digital power
- Application where existing FM transmitter has headroom to allow combining moderate size digital transmitter for HD Radio injection levels of -14dBc or higher
- FM signal requires time delay, digital pre-correction to compensate linear distortion

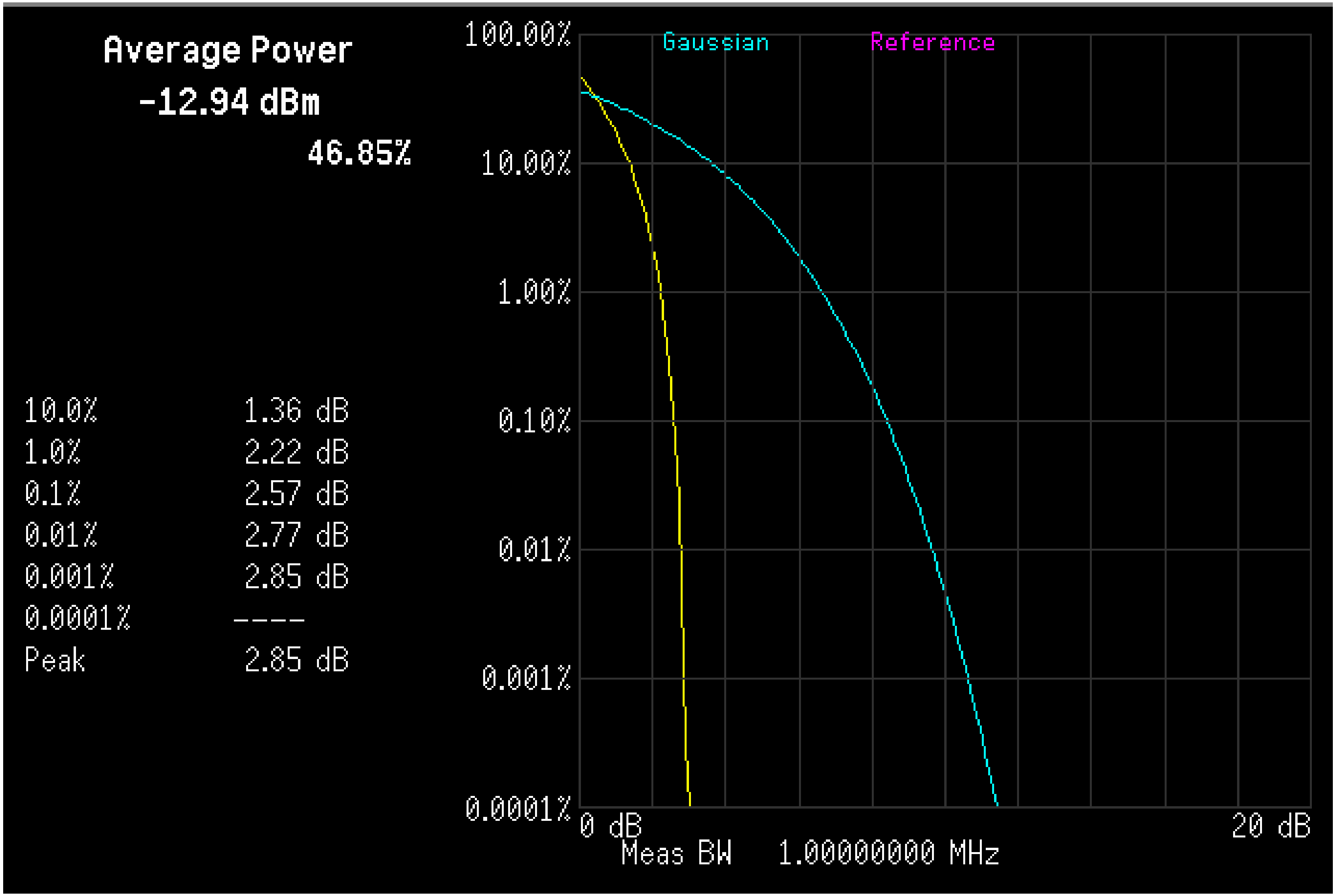
HIGH POWER, SHARP TUNED, MASK FILTER

- Additional power out of common amplification by allowing transmitter to go out of mask and then filter
- Sharp tuned around FM+HD hybrid signal to remove RF intermodulation products
- Transmitter output can exceed mask by up to 8dB and brought back into compliance at antenna feed point
- FM+HD insertion loss of this filter is typically about 12%

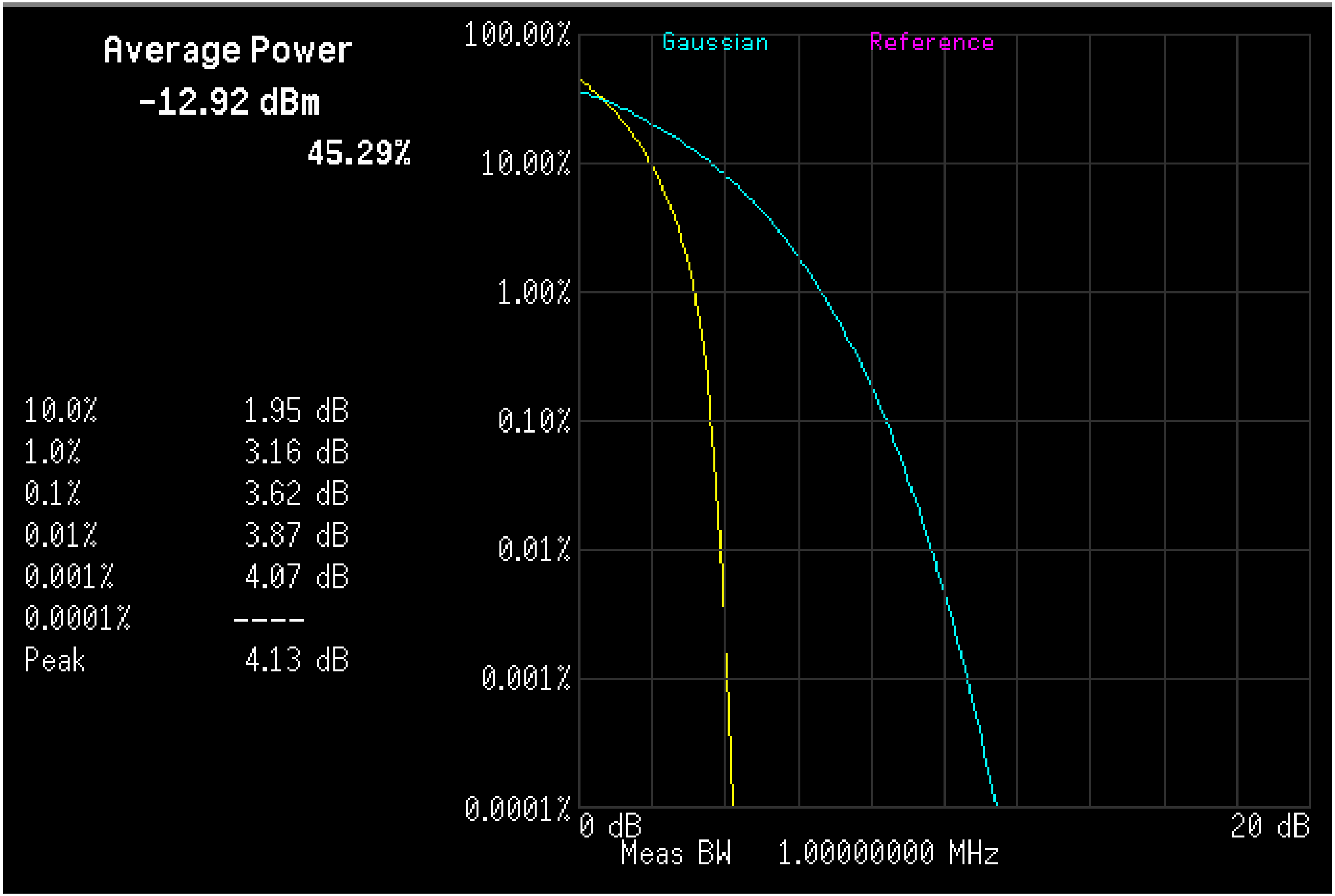
HD RADIO CREST FACTOR

- HD Radio signal has high Crest Factor or Peak to Average power Ratio (PAR) compared to constant envelope FM
- AM component requires linear amplification instead non-linear “Class-C” amplification used for constant envelope FM
- Digital only transmitter used in separate amplification system must have sufficient headroom to pass the high PAR of this HD signal
- To improve RF power amplifier utilization, the (PAR) of HD Radio signal must be reduced by intelligent clipping techniques followed by restoration of amplitude and phase of reference carriers that guide receiver equalizer
- Average PAR of combined FM + HD Radio signal is determined by statistical process called Complementary Cumulative Distribution Function (CCDF)
- Instantaneous peaks are averaged over a number of samples
- PAR determines RMS power capability of transmitter to meet the RF mask based on peaks that occur 0.01% of the time

PAR for -14dBc OFDM pattern generator HD + FM with standard CFR



PAR for -10dBc OFDM pattern generator HD + FM with standard CFR



HYBRID CREST FACTOR REDUCTION

- Common amplification systems must have additional peak power capability to pass PAR of combined, hybrid signal
- PAR required depends on mix ratio of HD with FM and HD mode
- Standard Crest Factor Reduction (CFR) applied to HD Radio (OFDM) signal within Exgine doesn't take into account vector summation of HD with FM in common amplification transmitter
- Hybrid Crest Factor Reduction (HCFR) can be applied to the digital signal accounting for vector addition with the FM analog signal
- Depending on the ratio of HD power combined with the FM
  - **Up to 33% improvement in average transmitter power output at -10dBc**
  - **Up to 16% improvement at a -14dBc injection level**
- HCFR applies only to common amplification – not digital only
- HD Radio carrier injection level should be increased to make-up for RMS power removed by HCFR
- Imposes further stress on the PA and reduces the overall net gain in PA utilization

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%

- PAR of combined HD+FM signals for standard crest factor reduction (SCFR) and hybrid crest factor reduction (HCFR) at 0.01% statistical probability for various FM to HD mix ratios and HD operating modes.

ASYMMETRICAL HD RADIO SIDEBANDS

- Unequal HD Radio sidebands can be used to prevent adjacent channel interference
- Redundant information in upper and lower digital sidebands makes HD receivable even if sidebands are unequal
- Operating asymmetrical digital sidebands can allow many stations to increase HD power above -14dBc on one side of channel while protecting adjacent channel on other side
- Power increase in only one sideband does not bring full improvement that raising both sidebands would bring
- Benefit to coverage depends on multipath and fading, but a +4dB increase in one sideband could provide improvement of increasing both sidebands by ~ +2dB
- 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
- Asymmetrical sideband generation occurs within the Exgine OFDM modulation process and has already been implemented by Harris

ASYMMETRICAL HD RADIO SIDEBANDS

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

- FM+HD transmitter power ratings for typical asymmetrical sideband configurations
- Sideband-1 and sideband-2 levels are scaled to agree with NPR Labs IBOC Power Allowance Calculator presentation
- Actual individual sideband RMS powers are 3dB less as shown in parentheses, but together they add up to the combined RMS power shown
- PAR values are for an average between operating modes MP-1 and MP-3 with standard, iBiquity, crest factor reduction
- Improvements will also be required to the digital only, CFR to accommodate asymmetrical sideband operation

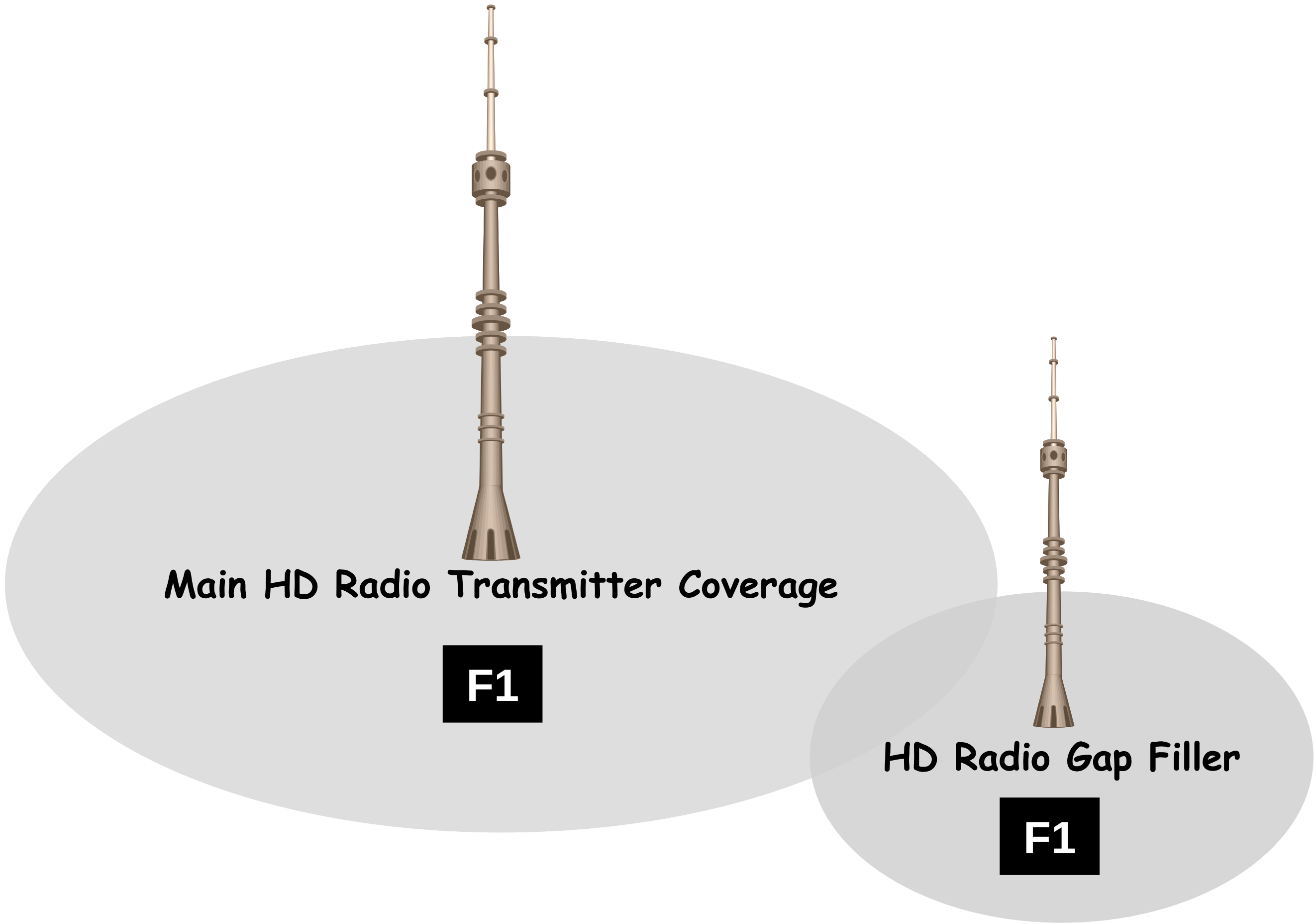
ON CHANNEL GAP FILLERS AND TRANSLATORS

- Single Frequency, on channel, Gap fillers and two frequency translators offer another tool to improve HD coverage without interference to others

- Both Gap fillers and translators can be HD only or hybrid FM + HD

- Asymmetrical sideband techniques can be used with Gap fillers and translators

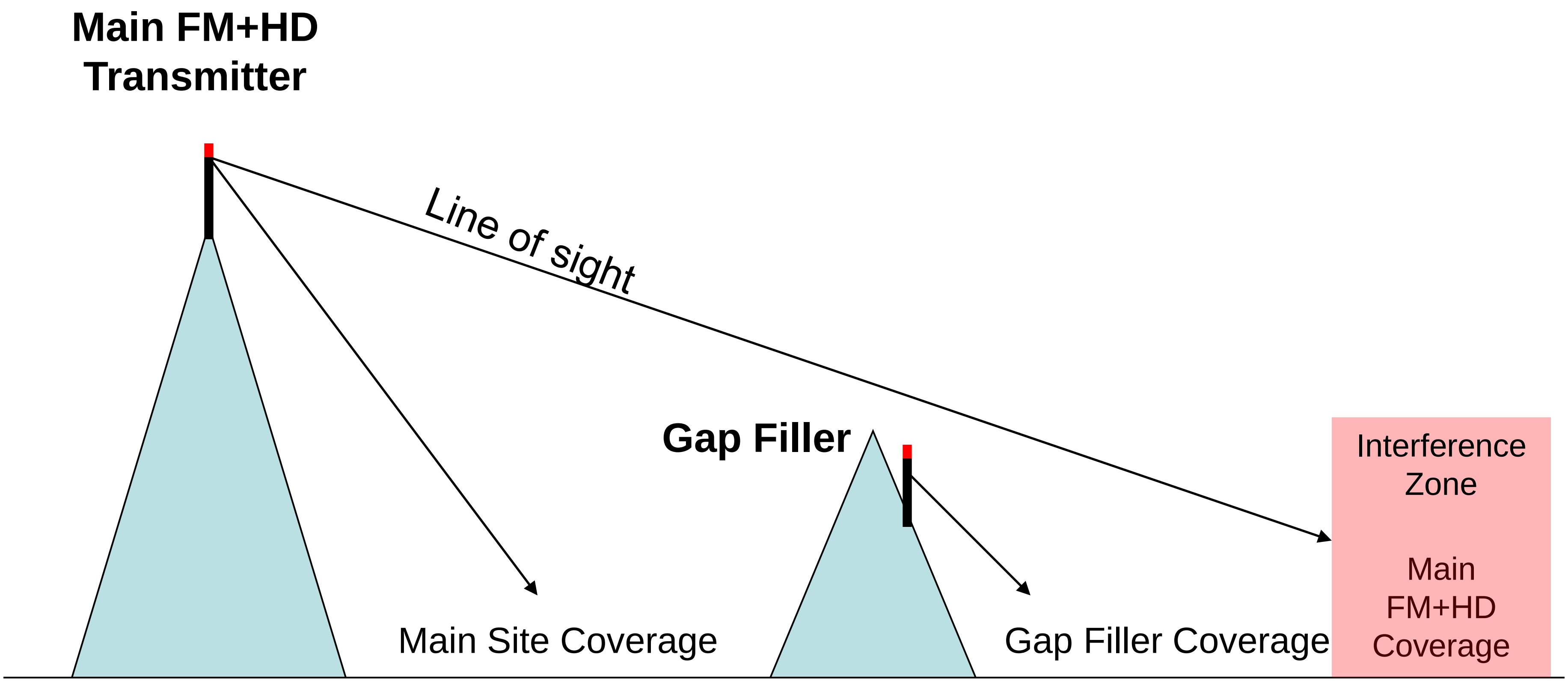
ON CHANNEL HD RADIO GAP FILLER



GUARD INTERVAL REQUIREMENT

- Perfect reception of OFDM signals can be maintained in areas where the original digital and secondary signals are equal
- Differential delay between two signals is maintained within guard interval of digital signaling system
- HD Radio guard interval is ~ 75uS differential delay
- Guard interval requirement must be met until the relative strengths of the two signals are more than 4dB apart
- If more than 4dB difference in strength between HD signals, guard interval no longer needs to be met for HD radio reception
- Effect is somewhat like capture ratio effect for analog FM reception between two stations on the same frequency
- HD Radio gap fillers must be located with antenna patterns so guard interval is met in areas where the primary, secondary (and/or tertiary) signals are all within 4dB of each other
- Location of gap fillers that take advantage of terrain shielding and directional antennas can expand the area over which HD reception is possible even outside of the guard interval

ON CHANNEL HD RADIO GAP FILLER



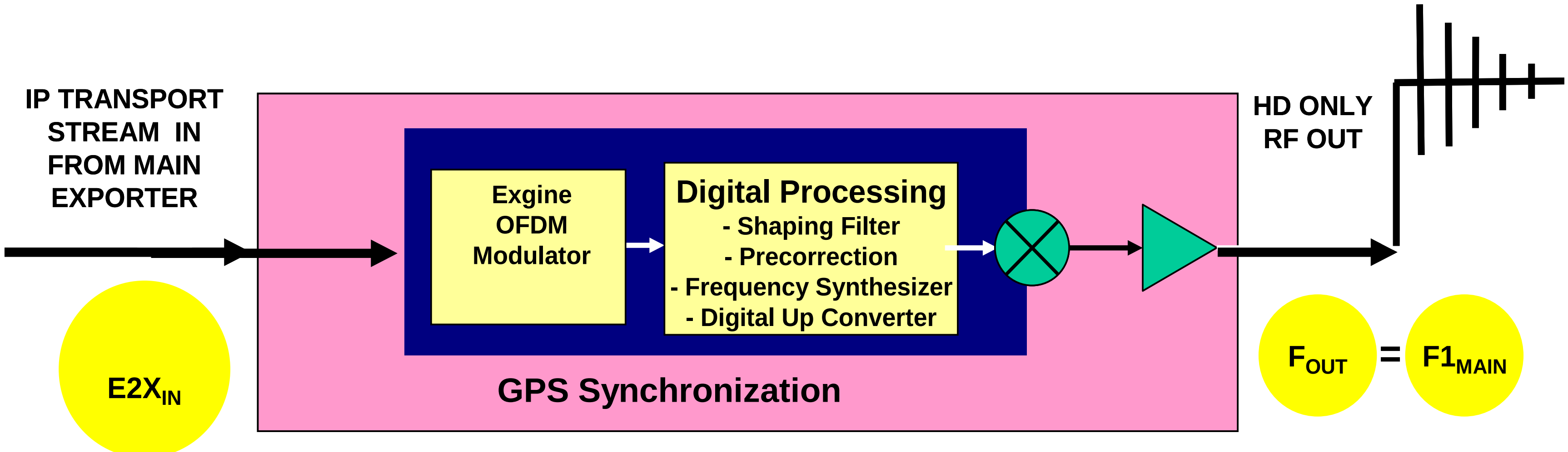
HD ONLY GAP FILLERS

- HD only gap fillers where is insufficient terrain shielding to protect primary, main, transmitter FM signal from interference by secondary FM analog signal radiated by gap filler
- Even with precise time, amplitude, and modulation alignment of main FM signal to gap filler secondary FM signal, it's impossible to eliminate significant multipath distortions to FM reception where two signals overlap and are equal in strength at the receiver
- Gap fillers transmitting HD signal only without analog FM may help solve this problem
- Another problem is created for analog FM reception near the digital only gap filler, because digital signal will be far above normal FM to HD ratio which can cause digital to host analog FM interference
- Recent tests indicate that some analog FM receivers can withstand up to +10dB of digital overdrive before FM reception is compromised
- Individual receiver differences play a large role in determining how successful the deployment of digital only gap fillers can be
- Harris begins field tests of different HD gap filler methods this year

GAP FILLERS - THREE APPROACHES

- Separate, synchronous, Exgine modulation at each site with transport of E2X stream to each site
- Separate, synchronous, digital up-conversion at each site with transport of high bandwidth, digital IF
- Independent receive and re-transmission at each site without the need for any external data connection

E2X TRANSPORT TO EXGINE MODULATOR



E2X TRANSPORT TO EXGINE MODULATOR

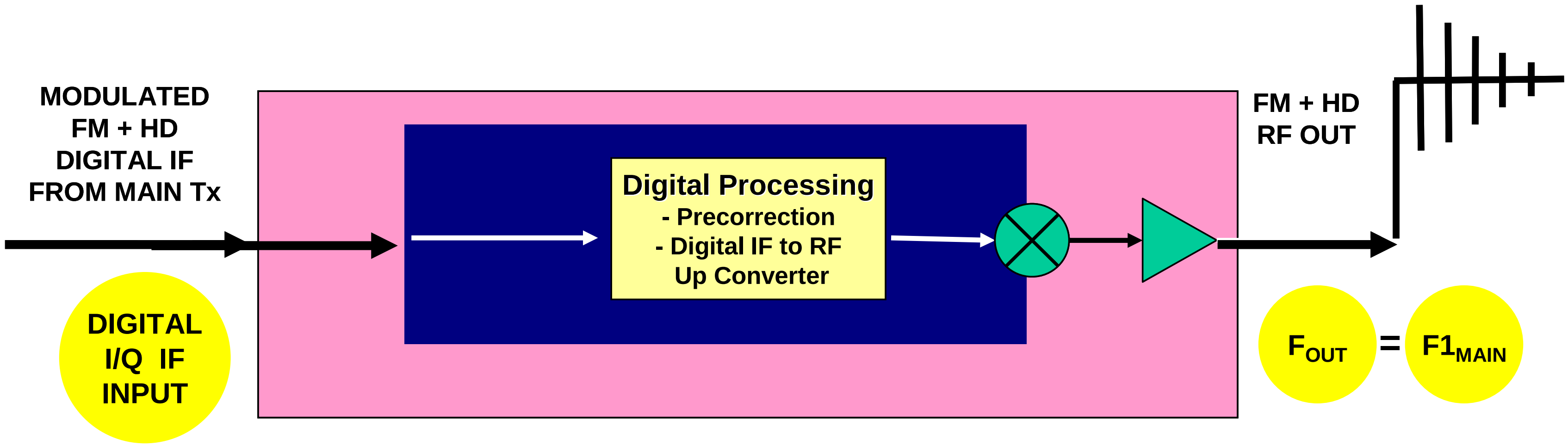
Advantages:

- Host vs. gap fillers can be time aligned to maximize the guard interval protected area
- Fresh digital modulation and error correction at each site

Disadvantages:

- Cost of transporting the E2X stream to each site
- GPS Synchronization at each site
- Possible licensing requirement for additional Exgine modulators at each site
- Additional transport cost to add FM analog for hybrid FM+HD output, unless host audio extraction is used
- Hardware cost

SEPARATE DIGITAL IF UP-CONVERSION



SEPARATE DIGITAL IF UP-CONVERSION

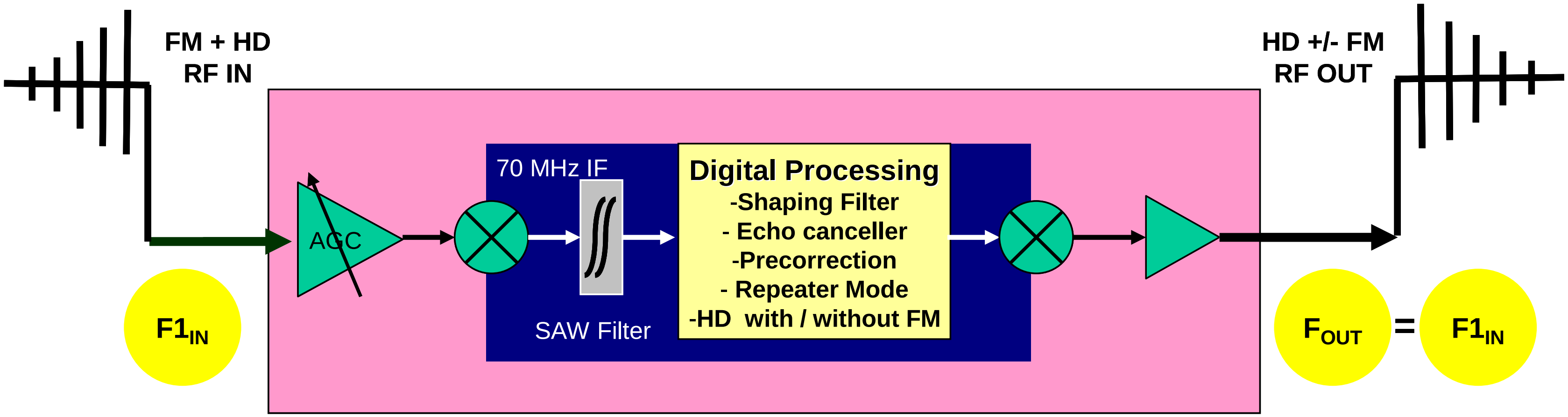
Advantages:

- Host and gap fillers can be time aligned to maximize the guard interval protected area
- No need to license additional Exgine modulators at each site
- Ability to provide hybrid FM+HD gap fillers in same ratio as main, host, transmitter

Disadvantages:

- Higher cost of transporting high bandwidth (~45MBpS) , digital IF signal to each gap filler site
- Additional cost of extra bandwidth for second digital IF signal to provide FM+HD ratio different than main host transmitter
- Hardware cost

ON CHANNEL RECEIVE / RE-TRANSMIT



ON CHANNEL RECEIVE / RE-TRANSMIT

HARRIS

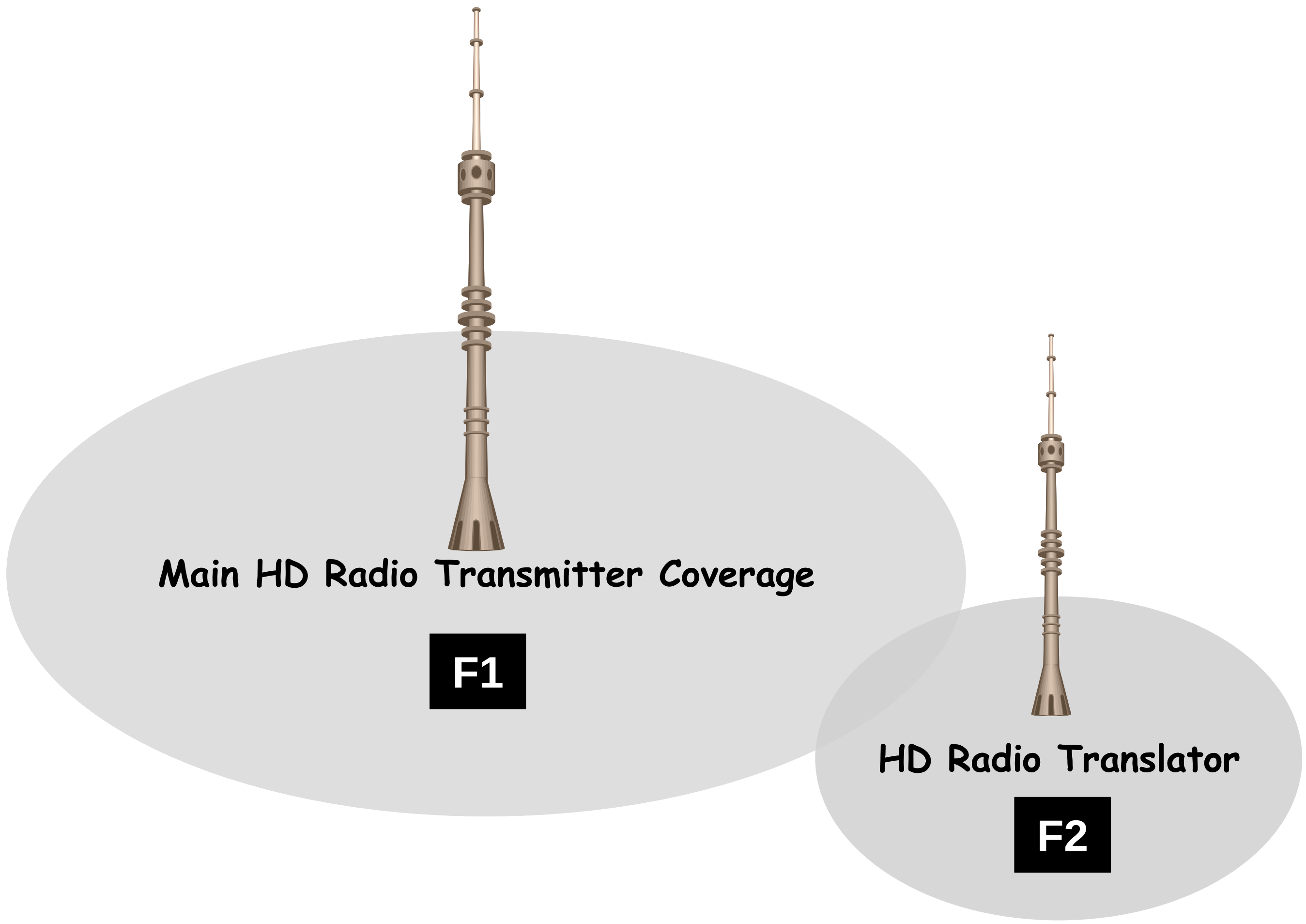
Advantages:

- Simplicity – only AC power required at each site
- Frequency synchronization without GPS or other external reference
- Ability to adjust ratio of FM to HD individually at each site
- Ability to pass asymmetrical HD sidebands
- Lower hardware cost

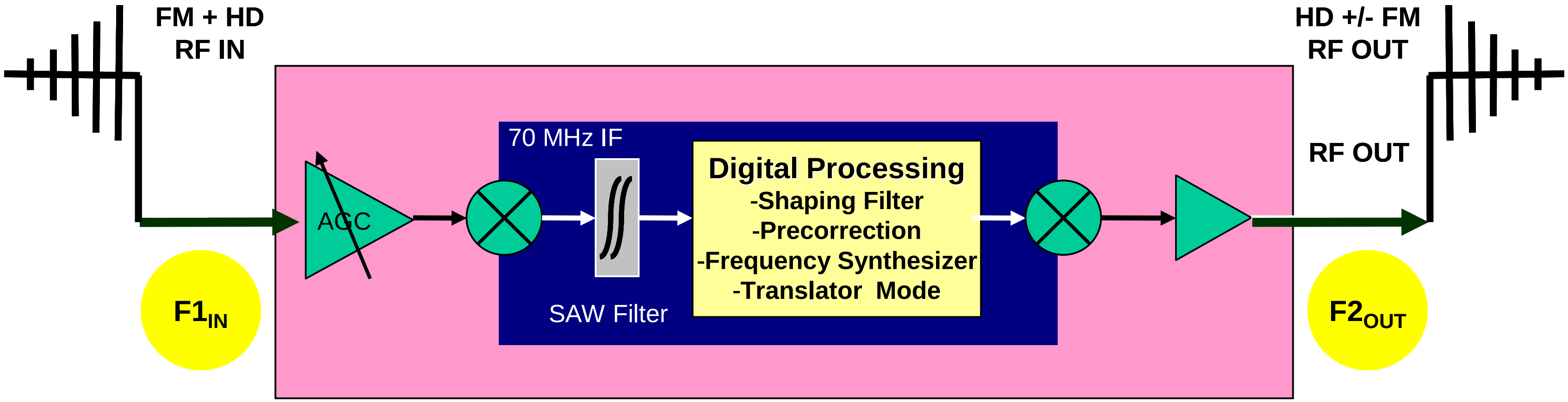
Disadvantages:

- Time alignment offset reduces guard interval protected area
- Time alignment impact on analog FM reception
- May or may not require FCC licensing

HYBRID AND HD ONLY TRANSLATORS



HYBRID AND HD ONLY TRANSLATORS



HYBRID AND HD ONLY TRANSLATORS

Advantages:

- Simplicity – only AC power required at each site
- Ability to adjust ratio of FM to HD individually at each site
- Ability to do asymmetrical HD sidebands individually at each site
- Low hardware cost

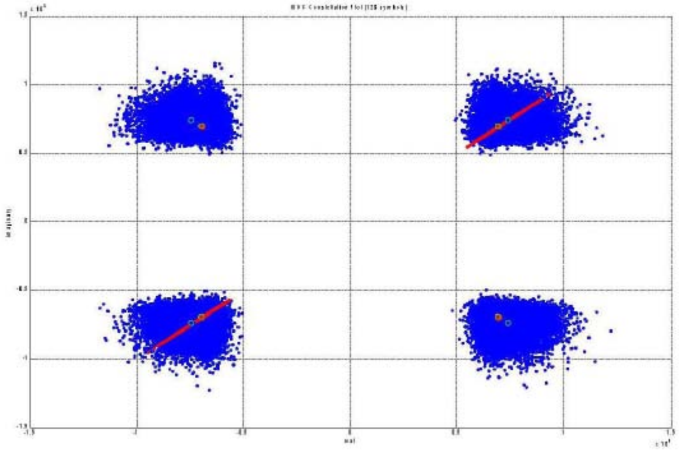
Disadvantages:

- Needs good receive SNR
- Requires FCC licensing

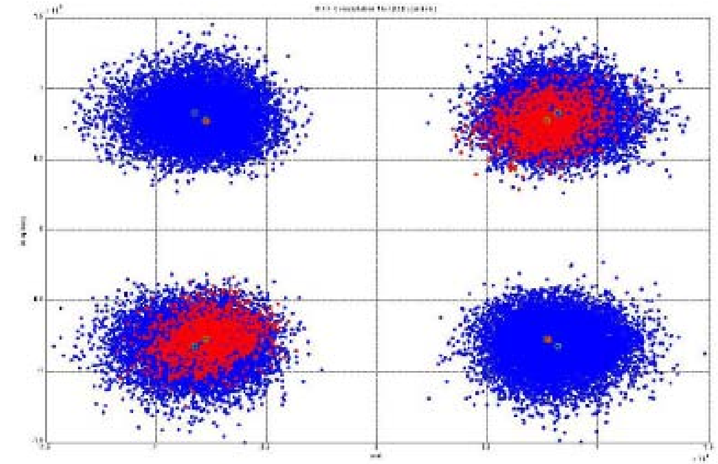
HD RADIO SIGNAL QUALITY MEASUREMENT

- MER (Modulation Error Ratio) measurement of the digital signal-to-noise ratio for data bearing carriers and the reference carriers within HD Radio OFDM sidebands
- MER gives "grayscale" diagnostic view of system problems
- More useful than abrupt failure seen in BER measurement
- 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 allows station engineer to adjust system to minimize distortion to transmitted signal, thereby preserving equalization/correction margin in the receiver

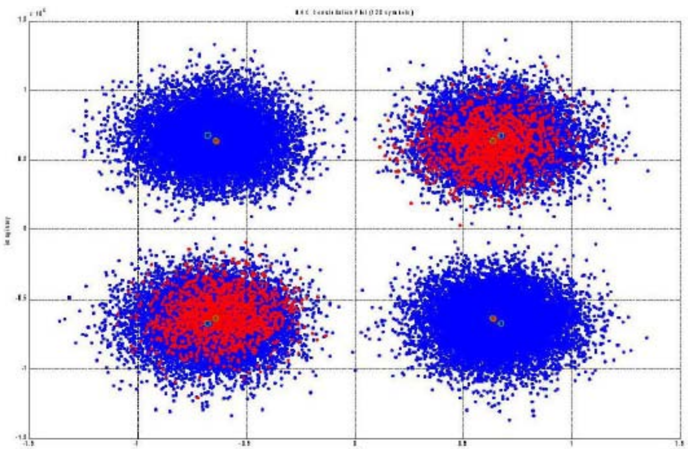
HD RADIO SIGNAL CONSTELLATIONS vs. MER



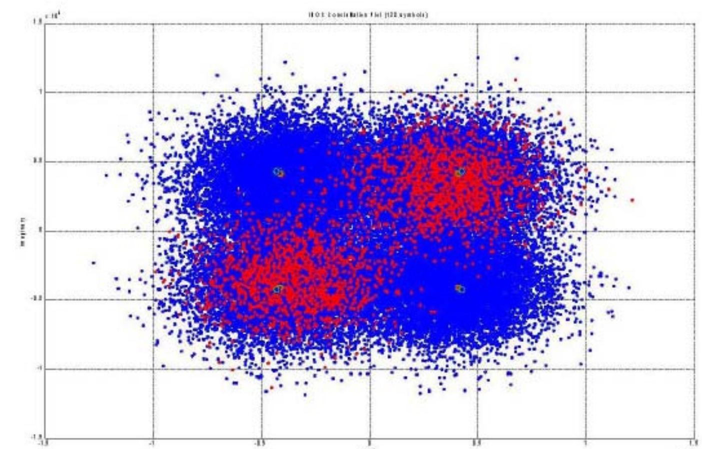
MER ~ 22dB IBOC Constellation PAR – No Noise



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



MER ~ 12dB IBOC Constellation Cd/No = 64dB-Hz



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

HD RADIO SIGNAL MER vs. Cd/No

Test File Name	Service Mode	PAPR Reduction On/Off	Cd/No dB-Hz	MER(ref)Avg	MER(ref)Worst Case / Subcarrier Index	MER(dat)Avg	MER(dat)Worst Case / Partition Index	P1 Channel BER
MP1_PAROn_52dB	MP1	On	52	1.0	0.54	4.6	4.4	1.10E-02
MP1_PAROn_54dB	MP1	On	54	2.6	2.2	4.8	4.7	6.80E-05
MP1_PAROn_56dB	MP1	On	56	4.4	4.0	5.5	5.3	5.70E-08
MP1_PAROn_58dB	MP1	On	58	6.3	5.8	6.6	6.4	0
MP1_PAROn_60dB	MP1	On	60	8.1	7.6	8.0	7.8	0
MP1_PAROn_62dB	MP1	On	62	10.0	9.5	9.6	9.3	0
MP1_PAROn_64dB	MP1	On	64	11.8	11.3	11.2	10.9	0
MP1_PAROn_66dB	MP1	On	66	13.6	13.1	12.6	12.3	0
MP1_PAROn_68dB	MP1	On	68	15.2	14.7	13.9	13.6	0
mp1_PARon_noAnalog	MP1	On	No noise	21.6	21.0	18.0	17.5	0

SUMMARY

- High Level / Split–Level Combining not practical for more than +3dB increase in HD power
- Lower Loss Filterplexer Combining Feasible for +10dB increase in HD power
- Space Combining requires up to 10x more HD power and 10dB improvement in RF IMD suppression
- Higher isolation >40dB and higher “turn around loss” in transmitters important

SUMMARY

- Common Amplification requires power back-off from -20dBc to -14dBc or -10dBc
- RTAC combined with (HCFR) reduces back-off up to 33%
- Split-Level or High-Level systems can be converted to combined common amplification
- Common amplification with two combined transmitters
  - Full back-up of FM + HD Radio
  - Full power possible on either transmitter at -20dBc HD power level

SUMMARY

- Asymmetrical sidebands permit maximum HD power without interference
- On-channel HD Radio gap fillers allow spot area coverage improvements without causing adjacent channel interference
- Digital FM + HD translators offer new opportunities to serve areas now served with analog only translators
- HD Radio quality measurement (MER) will assure transmitted signal leaves enough headroom for receiver equalizer

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Questions ?

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