



# Implications of Elevated Digital Carrier Levels for HD Radio

**PREC at NAB**

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# Terminology



- Crest Factor: ratio of the peak **voltage** to be amplified to its RMS value.
- PAPR: Peak-to-average **Power** Ratio
- Crest Factor =  $\sqrt{\text{PAPR}}$
- The Crest Factor of a sine wave is 1.41 (3 dB)
- The Crest Factor of an IBOC Digital-only signal is about 2.5:1 (8 dB before compression)

# Transmitter Requirements



	FM	OFDM	-20 dB	-10 dB
<b>Average Power</b>	100%		1%	10%
<b>Crest Factor</b>	1.41:1	2.5:1	1.657	2.09
<b>PAPR</b>	3.01 dB	8 dB	4.387 dB	6.4 dB
<b>Headroom Req.</b>			1.377 dB	3.4 dB
<b>Add'l Average Power</b>			0.04 dB	0.4 dB
<b>Backoff</b>			1.417 dB	3.8 dB

# Vector representation

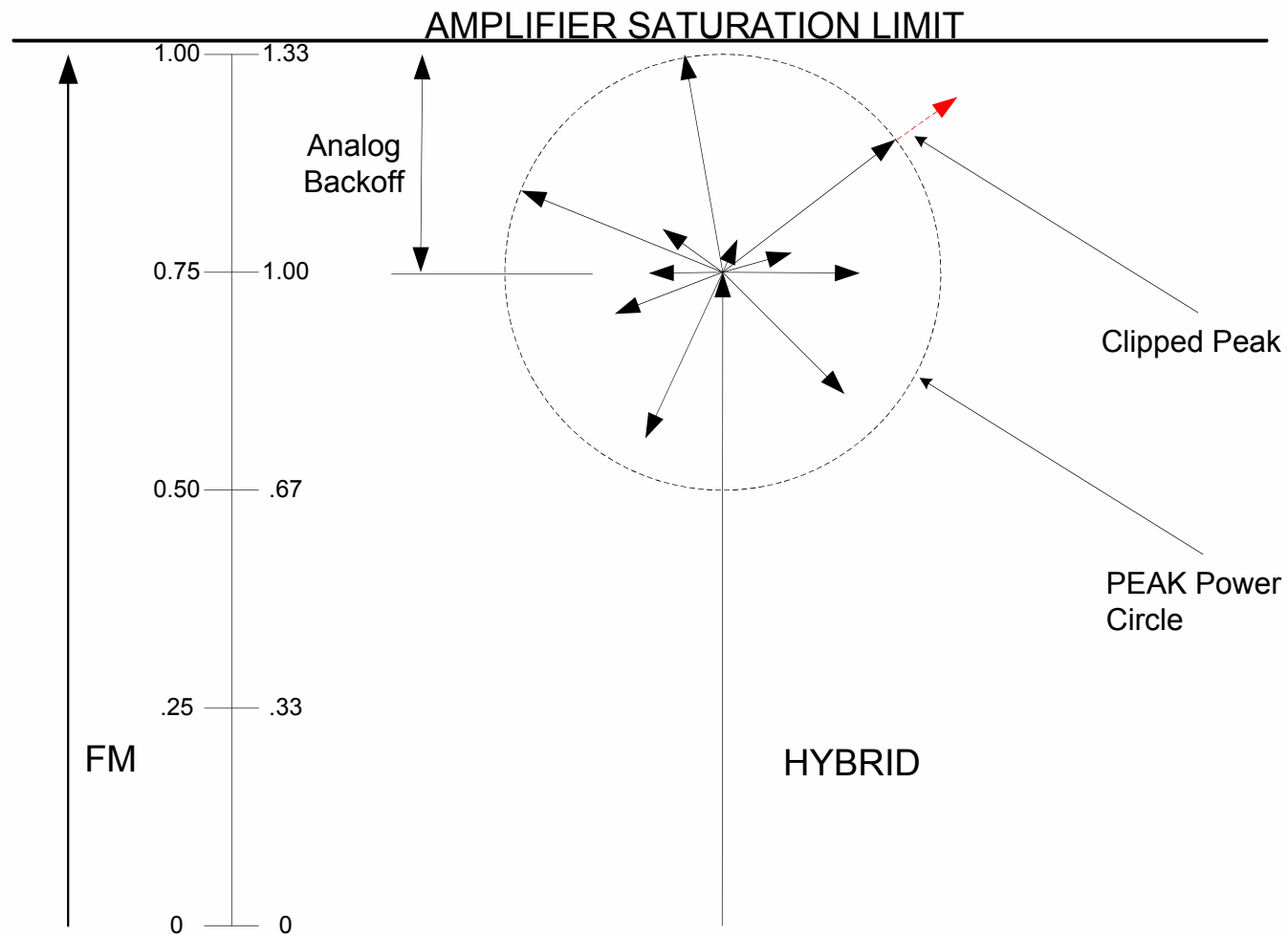
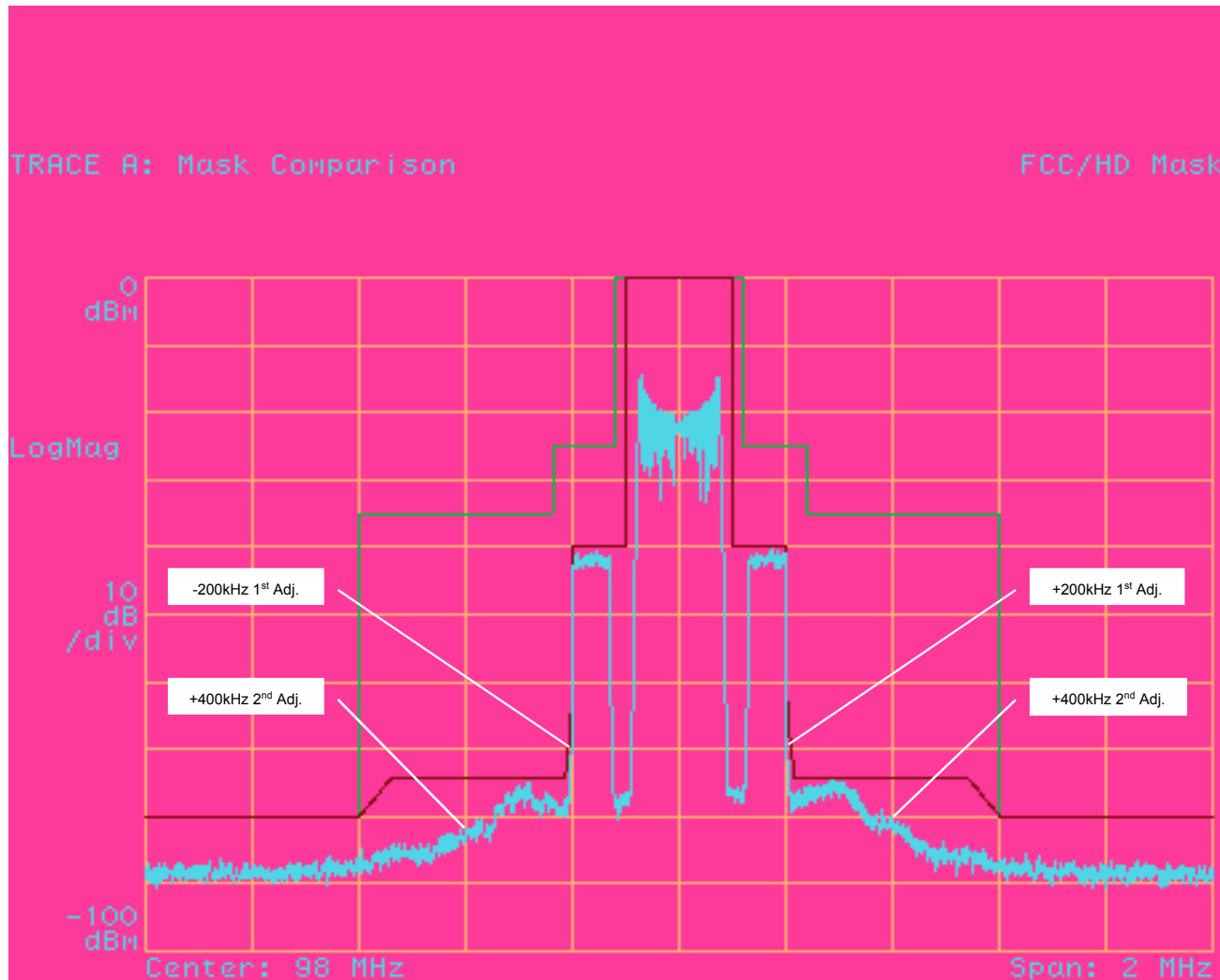
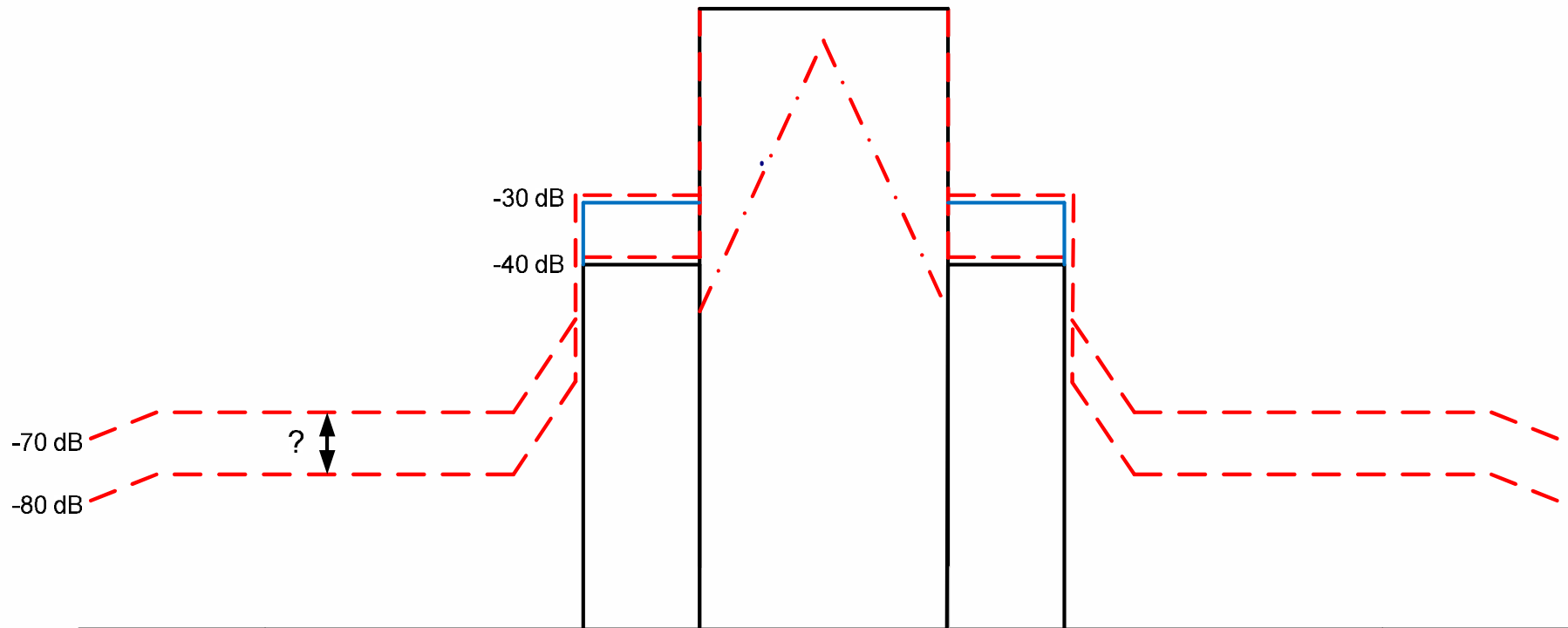


FIGURE 2

# FM Spectrum



# Mask Impact



An “across the board” raise of the mask level is not likely

# High Level Combining



10 kW TPO Station:

Tx Power required to convert to -10 dB, using HLC

	10 dB	9 dB	8 dB	7 dB	6 dB	5 dB	4 dB
	COUPLING RATIO						
10.0 kW	11.1 kW	11.4 kW	11.8 kW	12.4 kW	13.1 kW	14.1 kW	15.6 kW
1000w	10. kW	8.0 kW	6.3 kW	5.0 kW	4.0 kW	3.1 kW	2.5 kW
Reject Power	10.1 kW	8.4 kW	7.1 kW	6.4 kW	6.1 kW	6.2 kW	7.1 kW

# High Level Combining



10 kW TPO Station: keeps current HD Tx

Additional Injection available by changing only injector:

	10 dB	9 dB	8 dB	7 dB	6 dB	5 dB	4 dB
	<b>C O U P L I N G R A T I O</b>						
100%	111%	114%	118%	124%	131%	141%	156%
	<b>R E Q U I R E D A N A L O G H E A D R O O M</b>						
10% HD Tx	-20 dB	-19 dB <b>+1 dB</b>	-18 dB <b>+2 dB</b>	-17 dB <b>+3 dB</b>	-16 dB <b>+4 dB</b>	-15 dB <b>+5 dB</b>	-14 dB <b>+6 dB</b>
Reject Power	20%	23%	26.4%	32%	38.5%	47.8%	62%

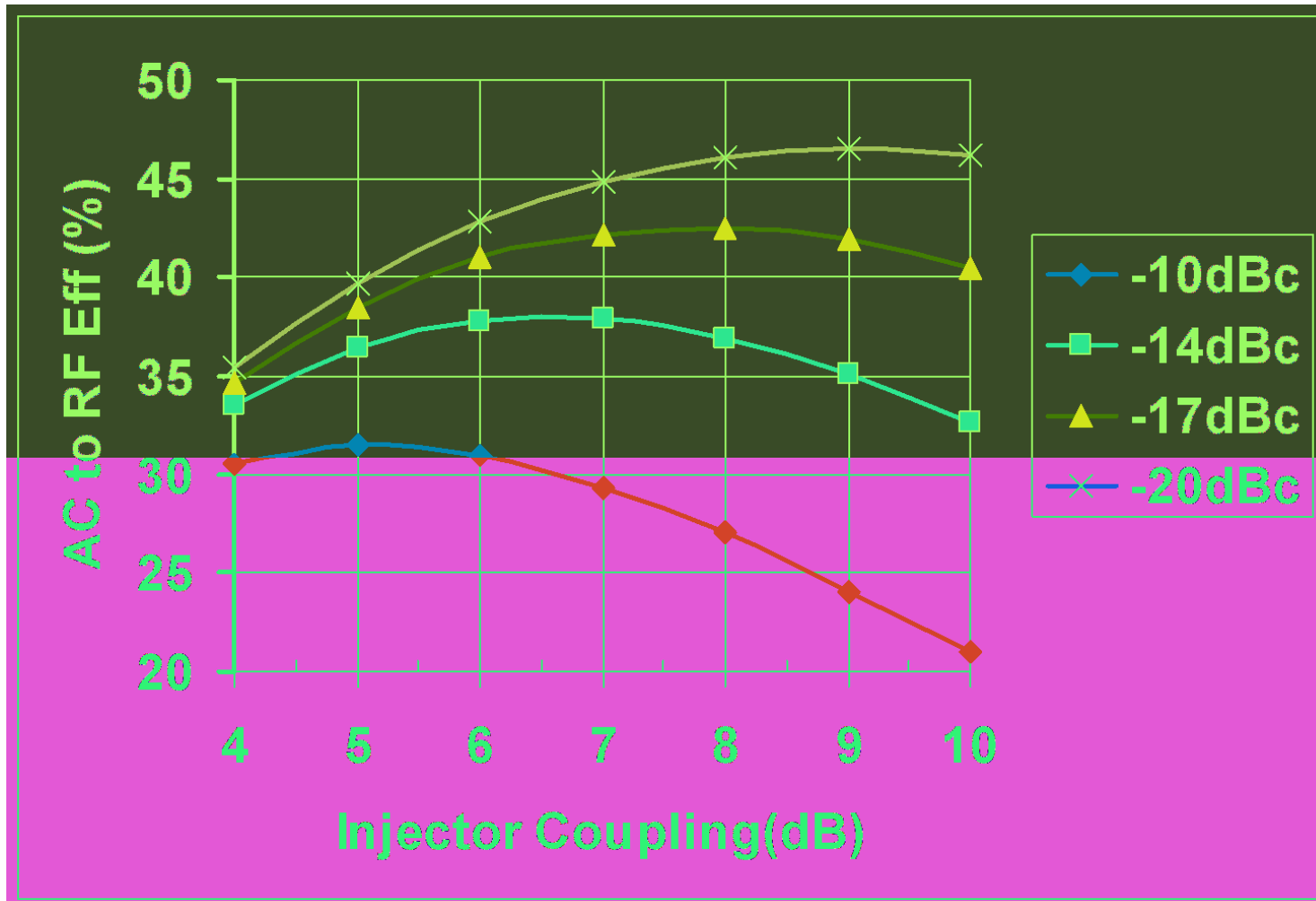
# Variable Coupling Ratios



Coupling Ratio	Licensed TPO	Total Analog Power Required	Digital Power Total	New Digital Power	Boost in dB	Total Reject Power
10	100.00	111.00	10.00	1.00	0	20.00
9	100.00	114.17	10.00	1.26	1	22.92
8	100.00	118.36	10.00	1.58	2	26.78
7	100.00	123.93	10.00	2.00	3	31.94
6	100.00	131.43	10.00	2.51	4	38.92
5	100.00	141.62	10.00	3.16	5	48.46
4	100.00	155.66	10.00	3.98	6	61.68

All power expressed as % of licensed TPO

# Optimized Coupling Ratios



# Conclusions



- Hybrid amplifiers will require further de-rating 4-5 dB from their analog nameplate rating (3-4 dB from -20 dB mode).
- Space combined solutions will become more attractive.
- Isolation of -35 to -40 dB is necessary in any space combined solution-isolators may be required.
- Intermediate power increases may be most cost effective in individual cases.
- High level combined stations can consider changing the injector ratio as a means to increase digital power.
- There are evolving solutions for stations restricted to hybrid amplifiers.

# NAB Engineering Conference



Sunday, April 12 – Radio Technology Advancements, S226-227

- 3:00PM - 3:30PM A New Approach to Peak-to-Average-Power Reduction for FM IBOC Transmission. Presenter: Philipp Schmid, Research Engineer, Nautel

Wednesday, April 16 – Radio RF Transmission Systems, S228

- 3:30PM – 4:00 PM Implications of IBOC Injection Levels Above -20 dB. Presenter: Gary Liebisch, Eastern Regional Sales Manager, Nautel

# Contact Info



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