



HD Radio™ Power Increase

What's Happening and What Can We Do?

Wisconsin Broadcasters Association
Broadcasters Clinic
13 October 2009



Timeline

- November 1999, FCC opens Docket 99-325, an NPRM for Digital Broadcasting
- October 2002, FCC approves IBOC for digital broadcasting
- March 2004, FCC approves use of separate antennas for FM
- June 2005, NRSC5 standard introduced and comment period opened
- January 2006, first HD2 channels are officially on-air
- May 2007, Second Report and Order formalizes IBOC rules
- July 2008, joint comment filed by equipment manufacturers and broadcasters requesting an immediate 6dB increase and subsequent 10dB increase
- September 2008, embedded Exporter is released by manufacturers and NAB
- October 2008, FCC opens comment period for HD power increase
- October 2008, iBiquity releases v4.2 software, incorporating several major upgrades
- July 2009, joint comment filed by equipment manufacturers and broadcasters supporting an immediate 6dB increase and subsequent 10dB increase
- July 2009, NAB files comment in support of immediate 10dB increase
- July 2009, iBiquity files comment in support of immediate 6dB increase and subsequent 10dB increase
- July 2009, Best Buy stocks first HD portable
- August 2009, Microsoft incorporates HD capability into Zune
- October 8 2009, NPR files a comment with the FCC supporting a 6dB increase
- November 2009, iBiquity to release v4.3x software, supporting HD4 multicast



NV Modeling

- 8 models from 3.5 kW to 40 kW
- Scalable results
- Test conditions:
 - Operating temp: 50° C
 - VSWR <1.05:1
 - 3 dB clearance of NRSC mask
 - 1 kHz tone 100% modulation
 - MP1 mode
- A conservative factor has been applied to account for VSWR above test conditions



Mask Limited vs. Thermal Limited

- Mask limited – Emissions reach mask limit BEFORE thermal limitations are exceeded. (Most early product releases for HD Radio fell into this category)
- Thermal limited – Thermal limitations are exceeded BEFORE emissions mask limit is reached.
- Nautel NV Series are thermal limited with a conservative factor applied.



Unverified Estimates (40% rule)

Available Analog TPO (kW)

	NV40	NV20	NV10
-20	32.0	16.0	8.0
-18	28.0	14.0	7.0
-16	25.2	12.6	6.3
-14	22.4	11.2	5.6
-12	19.5	9.8	4.9
-10	16.4	8.2	4.1



Estimated vs. Verified Test Results 88.1 MHz (Worst Case) Available Analog TPO (kW)

	NV40		NV20		NV10	
-20	32.0	30.1	16.0	15.2	8.0	7.5
-18	28.0	27.7	14.0	13.8	7.0	6.9
-16	25.2	24.9	12.6	12.4	6.3	6.2
-14	22.4	21.6	11.2	10.8	5.6	5.4
-12	19.5	18.3	9.8	9.1	4.9	4.5
-10	16.4	16.0	8.2	8.0	4.1	4.0



Verified Test Results by Band Segments

Available Analog TPO (kW)

	NV40		NV20		NV10	
	88-92	92-108	88-92	92-108	88-92	92-108
-20	30.1	32.0	15.2	16.0	7.5	8.0
-18	27.7	32.0	13.8	16.0	6.9	8.0
-16	24.9	32.0	12.4	16.0	6.2	8.0
-14	21.6	30.0	10.8	15.0	5.4	7.5
-12	18.3	25.6	9.1	12.8	4.5	6.4
-10	16.0	21.1	8.0	10.5	4.0	5.2



Non-Commercial Educational (NCE) Band (Reserved): 87.9MHz to 91.9MHz

Common Amplification/Hybrid (FM+HD) Mode

Table results are based on NV40 operating at 88MHz, into a VSWR < 1.05:1, 1kHz modulation, and MP1 mode. Limits are based on acceptable Tj at 50°C Ta with 3dB margin under the mask.

These values represent the MAXIMUM power capable (Rated power would be approximately 9% less).

Model #	-20			-18			-16			-14			-12			-10		
	Comb	FM (TPO)	IBOC	Comb	FM (TPO)	IBOC	Comb	FM (TPO)	IBOC	Comb	FM (TPO)	IBOC	Comb	FM (TPO)	IBOC	Comb	FM (TPO)	IBOC
NV 3.75	2,852	2,824	28	2,644	2,603	41	2,397	2,338	59	2,110	2,029	81	1,829	1,721	109	1,650	1,500	150
NV 5	3,802	3,765	38	3,526	3,471	55	3,196	3,118	78	2,814	2,706	108	2,439	2,294	145	2,200	2,000	200
NV 7.5	5,704	5,647	56	5,289	5,206	83	4,794	4,677	117	4,221	4,059	162	3,658	3,441	217	3,300	3,000	300
NV 10	7,605	7,530	75	7,051	6,941	110	6,392	6,235	157	5,627	5,412	215	4,878	4,588	290	4,400	4,000	400
NV 15	11,407	11,294	113	10,577	10,412	165	9,588	9,353	235	8,441	8,118	323	7,317	6,883	434	6,600	6,000	600
NV 20	15,210	15,059	151	14,103	13,883	220	12,784	12,471	313	11,255	10,824	431	9,756	9,177	579	8,800	8,000	800
NV 30	22,815	22,589	226	21,154	20,824	330	19,176	18,706	470	16,882	16,236	646	14,634	13,765	869	13,200	12,000	1,200
NV 40	30,420	30,118	301	28,205	27,765	440	25,568	24,942	627	22,509	21,648	862	19,511	18,353	1,158	17,600	16,000	1,600

NV30 through NV3.5 are scaled based on NV40 results (test data showed that NV5 was nearly 8 times lower than NV40).

All values are further scaled by the "Conservative" Factor.

Commercial Band (Non-Reserved): 92.0MHz to 108.0MHz

Common Amplification/Hybrid (FM+HD) Mode

Table results are based on NV40 operating at 92 MHz, into a VSWR < 1.05:1, 1kHz modulation, and MP1 mode. Limits are based on acceptable Tj at 50°C Ta with 3dB margin under the mask.

These values represent the MAXIMUM power capable (Rated power would be approximately 9% less).

Model #	-20			-18			-16			-14			-12			-10		
	Comb	FM (TPO)	IBOC	Comb	FM (TPO)	IBOC	Comb	FM (TPO)	IBOC	Comb	FM (TPO)	IBOC	Comb	FM (TPO)	IBOC	Comb	FM (TPO)	IBOC
NV 3.75	3,030	3,000	30	3,048	3,000	48	3,075	3,000	75	2,936	2,824	112	2,551	2,400	151	2,184	1,985	199
NV 5	4,040	4,000	40	4,063	4,000	63	4,101	4,000	100	3,915	3,765	150	3,402	3,200	202	2,912	2,647	265
NV 7.5	6,060	6,000	60	6,095	6,000	95	6,151	6,000	151	5,872	5,647	225	5,103	4,800	303	4,368	3,971	397
NV 10	8,080	8,000	80	8,127	8,000	127	8,201	8,000	201	7,829	7,530	300	6,804	6,400	404	5,824	5,294	529
NV 15	12,120	12,000	120	12,190	12,000	190	12,302	12,000	301	11,744	11,294	450	10,206	9,600	606	8,736	7,941	794
NV 20	16,160	16,000	160	16,254	16,000	254	16,402	16,000	402	15,659	15,059	600	13,608	12,800	808	11,647	10,589	1,059
NV 30	24,241	24,001	240	24,381	24,001	380	24,603	24,001	603	23,488	22,589	899	20,412	19,200	1,211	17,471	15,883	1,588
NV 40	32,321	32,001	320	32,508	32,001	507	32,805	32,001	804	31,317	30,118	1,199	27,216	25,601	1,615	23,295	21,177	2,118

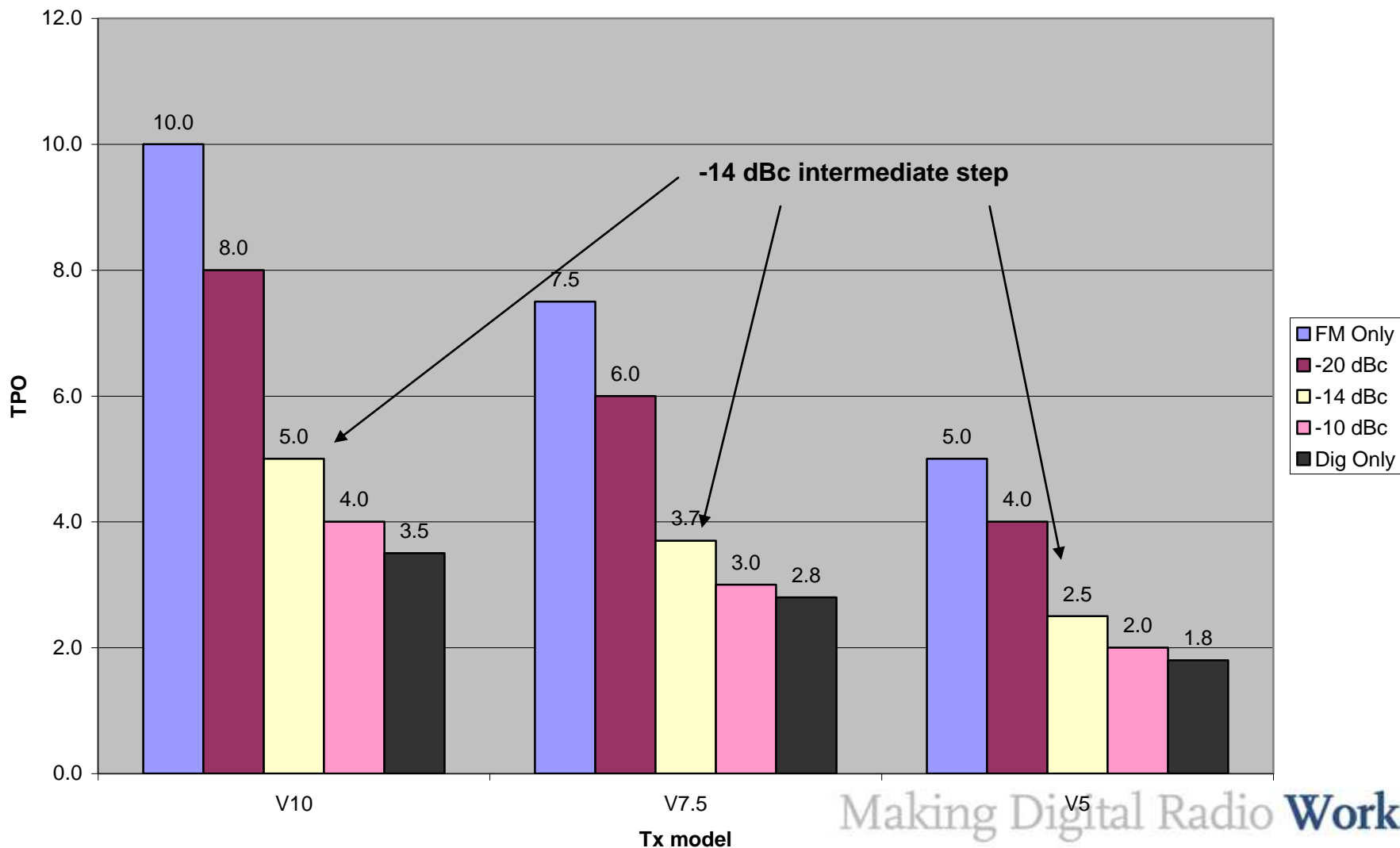
NV30 through NV3.5 are scaled based on NV40 results (test data showed that NV5 was nearly 8 times lower than NV40).

All values are further scaled by the "Conservative" Factor.



De-ratings for -20,-14,-10 dBc

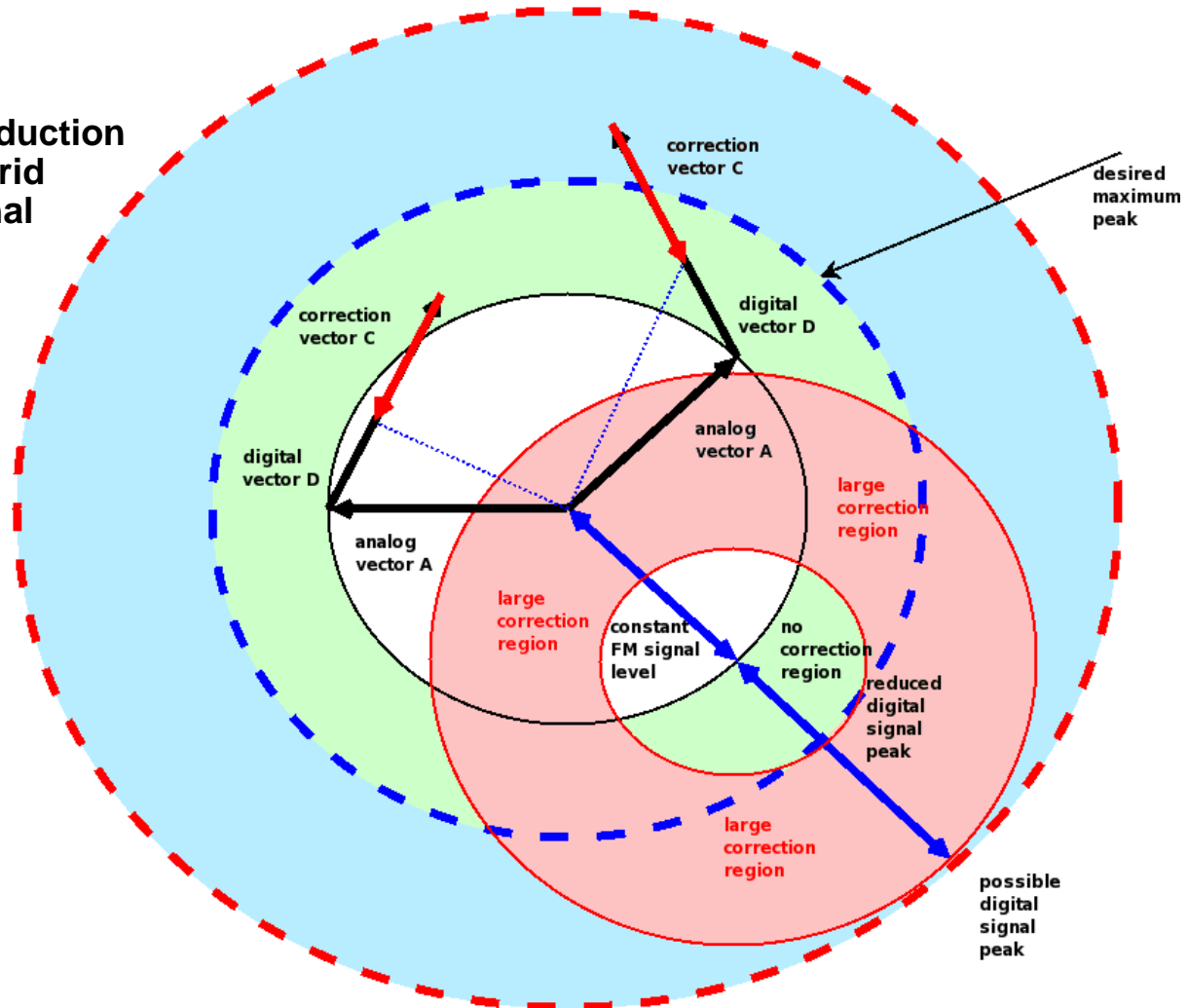
Tx De-Rating incl -14 dBc





Standard PAPR Reduction

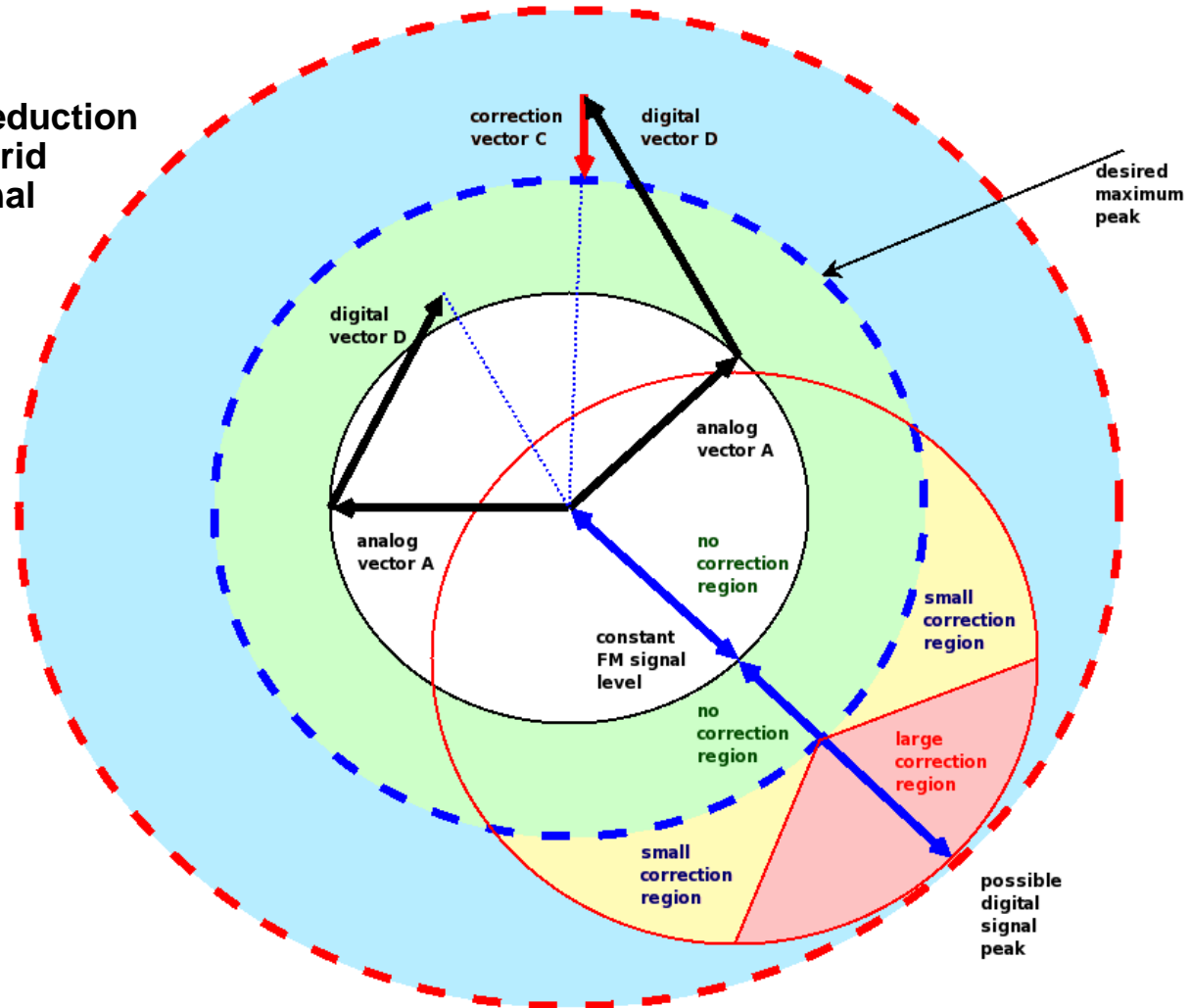
Standard PAPR reduction applied to hybrid FM+IBOC signal





Proposed PAPR Reduction

Proposed PAPR reduction applied to hybrid FM+IBOC signal

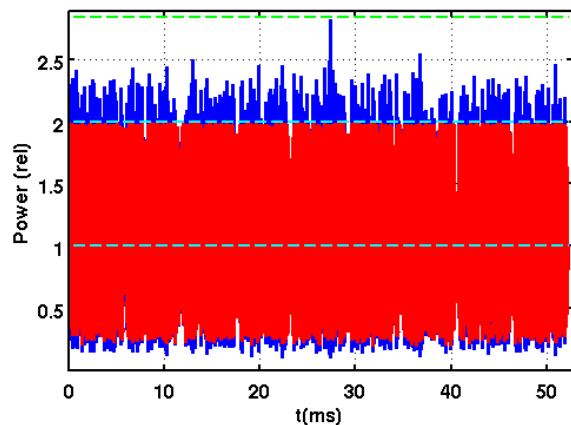




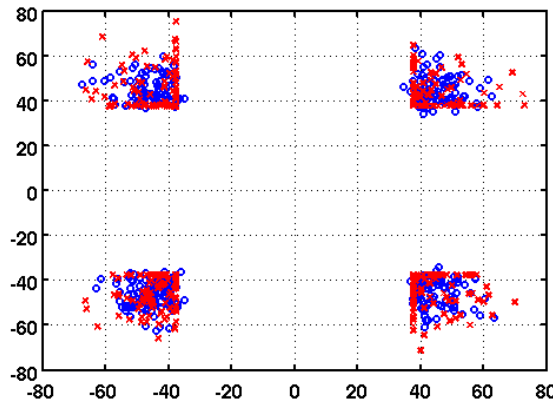
Simulation Results

Basic PAPR Reduction Mode

Standard vs Proposed: Peak to Average Power - 4.51dB -> 3.19dB

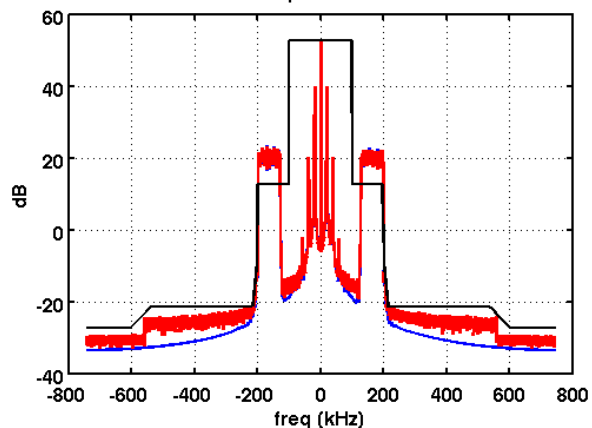


Signal Constellation

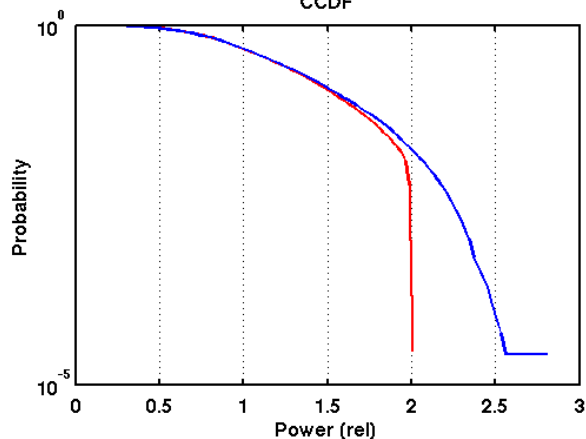


comparable signal constellation

Spectrum



CCDF



For -10dBc carriers:

1.3 dB improvement over standard PAPR reduction

32% increased transmitter output power

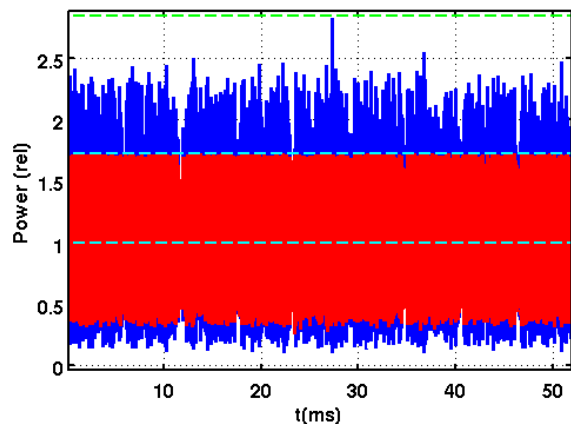


Simulation Results

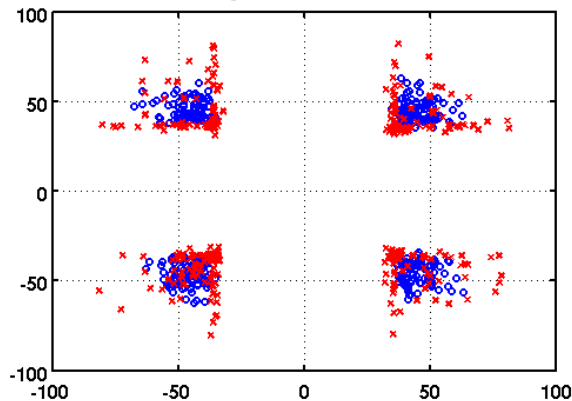
Aggressive PAPR Reduction Mode

targeted at existing peak power limited installations

With Extended Spectrum: Peak to Average Power - 4.51dB -> 2.53dB



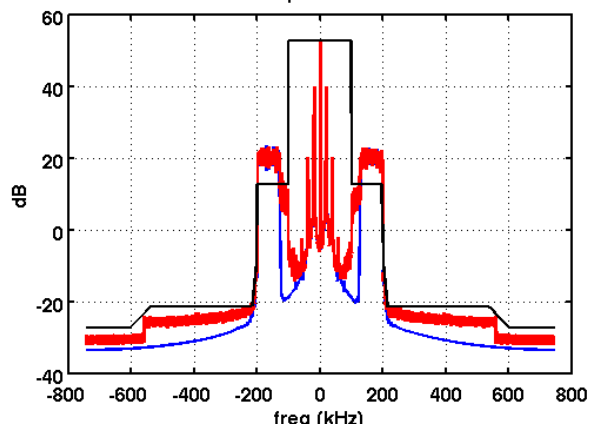
Signal Constellation



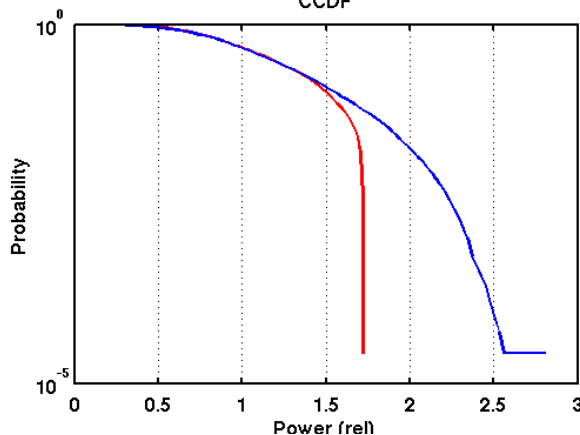
allows small degradation in **signal** constellation

around 1.65 dB drop in noise performance

Spectrum



CCDF



For -10dBc carriers:

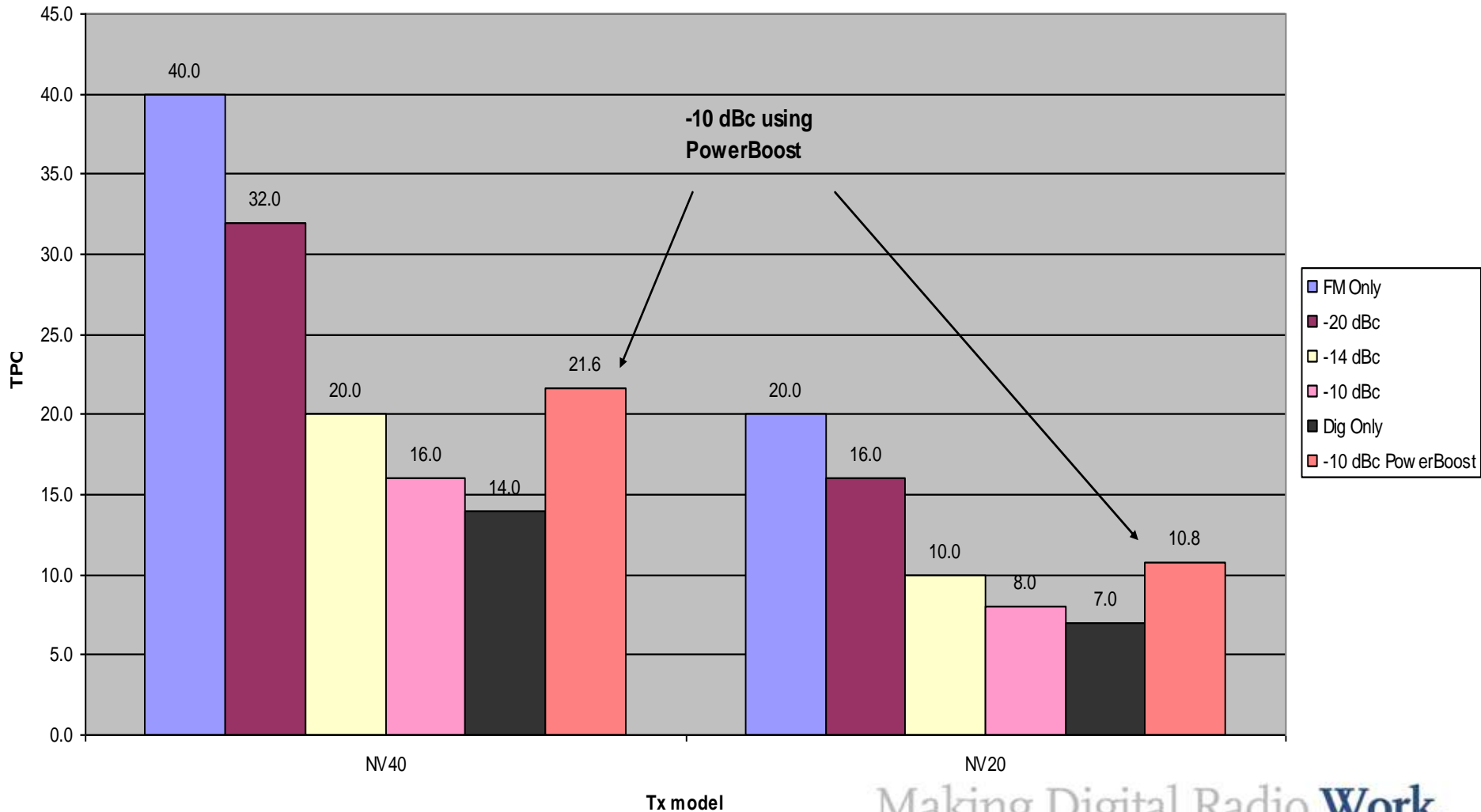
2 dB improvement over standard PAPR reduction

58% increased transmitter output power



Nautel PowerBoost™

Adding Power Boost to NV





What's Next?

- Improvements in NCE band results—Ongoing improvements will bring NCE band results closer to commercial band.
- Additional de-rating for extended hybrid modes
- V Series Tests – Anticipate results to parallel those obtained on the NV Series
- Power Boost – still on Nautel radar for 16% to 23% improvement in available analog TPO.