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Total Transmission

INNOVATION

SYSTEM EXPERTISE

GREEN POWER TECHNOLOGY

RELIABILITY

TRUST

ENERGY SAVING

Question:
What are TV transmitter design engineers doing to help you save money, and possibly make your life a bit easier?

Answer: see next page…

New Digital TV Correction Techniques
AND
New Amplifier Technology

CONTENTS

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CONTENTS

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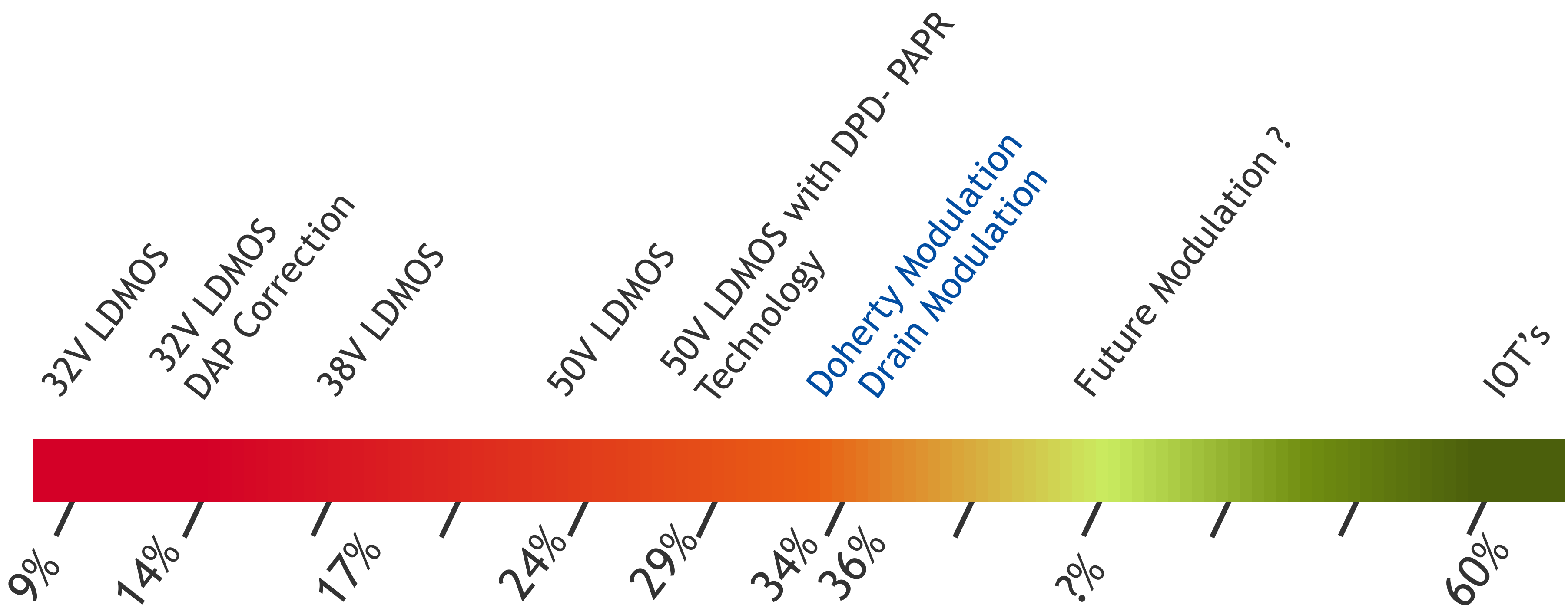
1. Introduction
2. Linearization Fundamentals
3. Digital Pre-Distortion Techniques
4. New Amplifier Designs
5. Conclusion

Digital TV Station objectives

- Reduce Operating **Costs**
- Maintain or Improve **Coverage** within designated coverage area
- Maximize **reliability** of Over The Air (OTA) signal

How “in” efficient is your “green” transmitter?

A Brief History….. Of transmitter efficiencies



INTRODUCTION

In the real world there are several SNR degradations in the link between the transmitter and the receiver starting… with the transmitting antenna.

- Co- channel
- Adjacent channel
- Receiver equalizer adds white noise
- Intermodulation and cross-modulation products
- Noise due to the impedance mismatch between antenna input and tuner.
- Interference from unlicensed devices

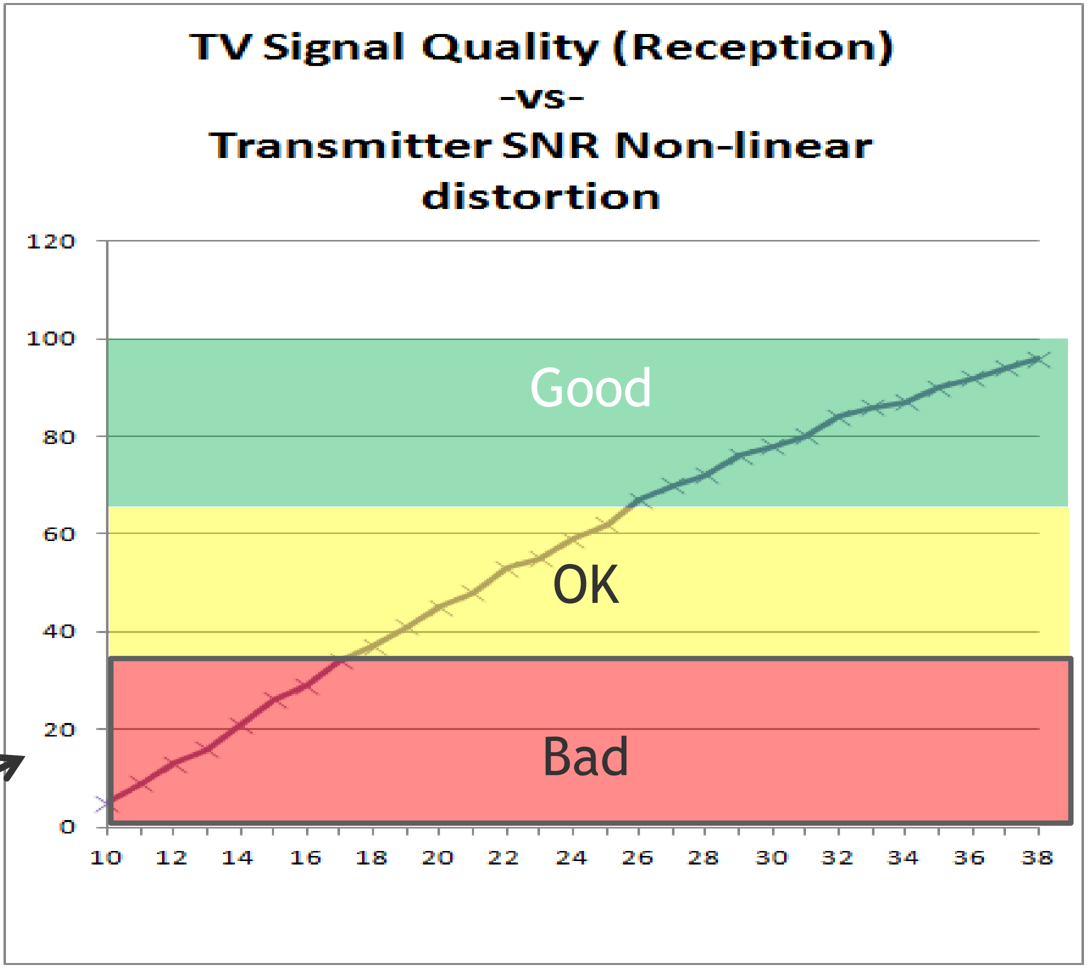
ALL POTENTIALLY DEGRADE THE RECEIVED SNR and DECREASE COVERAGE

INTRODUCTION

- Raising the transmitter SNR can improve the SNR margin at receivers in areas subject to poor propagation
- “Good”
- “OK”
- “Bad”

RCA MOBILE TV DMT270R

- As Transmitter Signal to Noise Ratio (T-SNR) decreases the ability to pick up a received signal drops proportionally.
- "Good" >66% >26dB
- "OK" > 33% >17dB
- "Bad" 33% <17dB



INTRODUCTION

- TV SQ = 94%
- TX T-SNR = 36dB

- TV SQ = 40%
- TX T-SNR = 21dB

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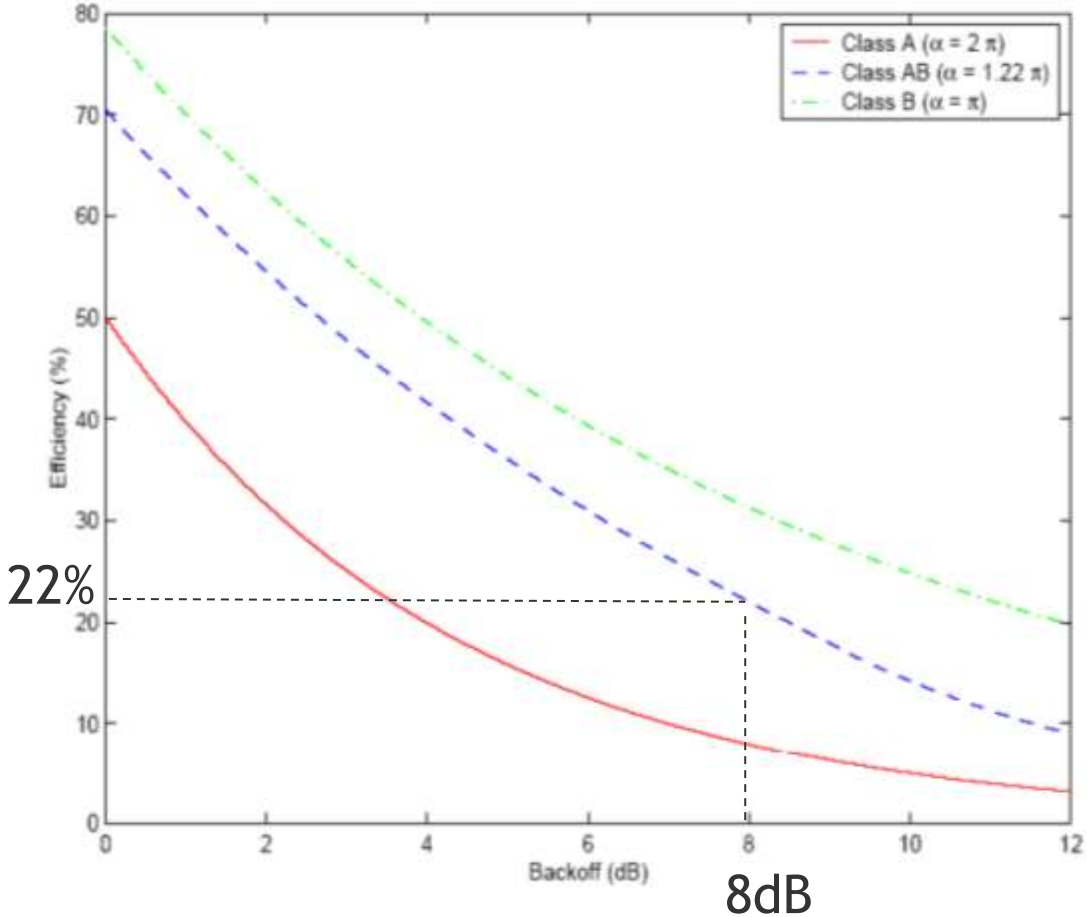
- Power Amplifier (PA) design is a simple trade-off between ***efficiency*** and ***linearity***
- The linearization of the PA reduces back-off, thus increasing efficiency
- PA's in a current broadcast transmitter available today operates at about 8dB back off giving a PA efficiency of 22% and a typical transmitter efficiency of less than 17%



Source: Background Graph from Texas Instruments

LINEARIZATION FUNDAMENTALS

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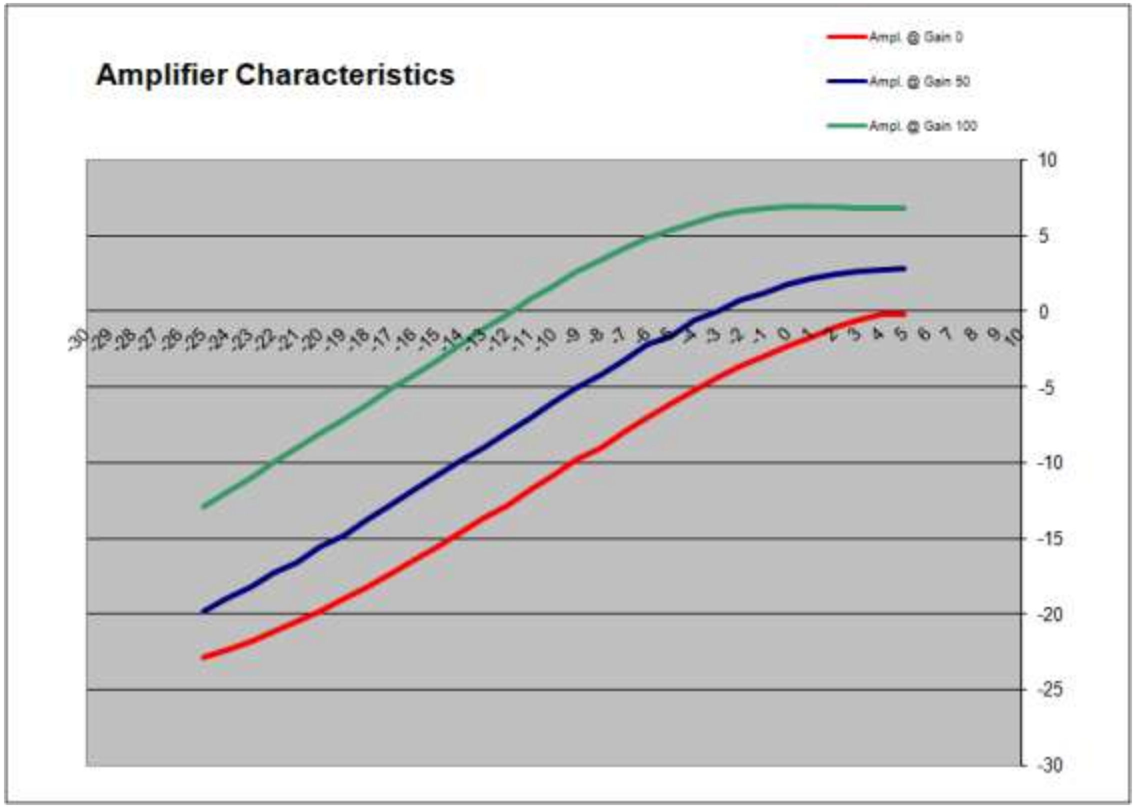
- The closer to saturation a PA operates the more efficient.
- However, the closer to saturation the more non-linear.
- Non-linearity caused by amplifier saturation can **not** be compensated for by the ATSC receiver
- Only Linear distortion can be compensated or equalized by the receiver



Broadcasters who improve SNR will enjoy better coverage in noisy and interference-prone links.

CONTENTS

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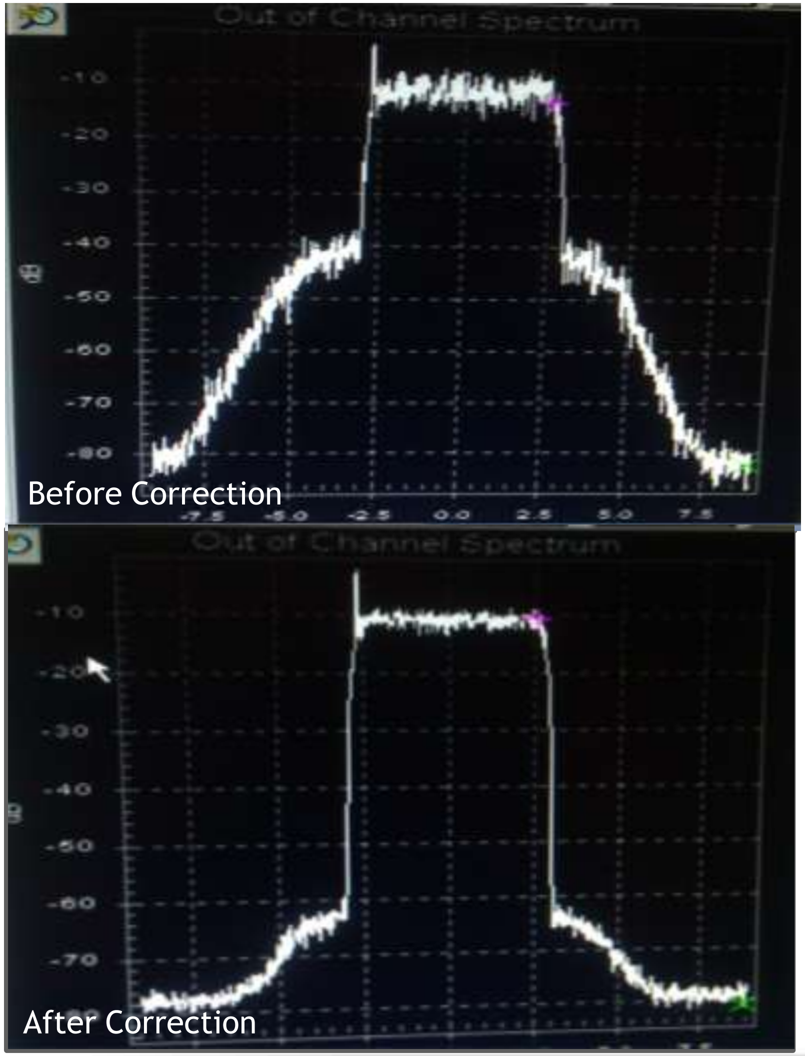
EFFECTS OF NON-LINEARITY

Third harmonic distortion is the most problematic.

3^{rd} H gives rise to Inter-modulation distortion near the bands of the amplifier.

FCC/IC requirement is a minimum of **47dB** at the sides of the spectrum.

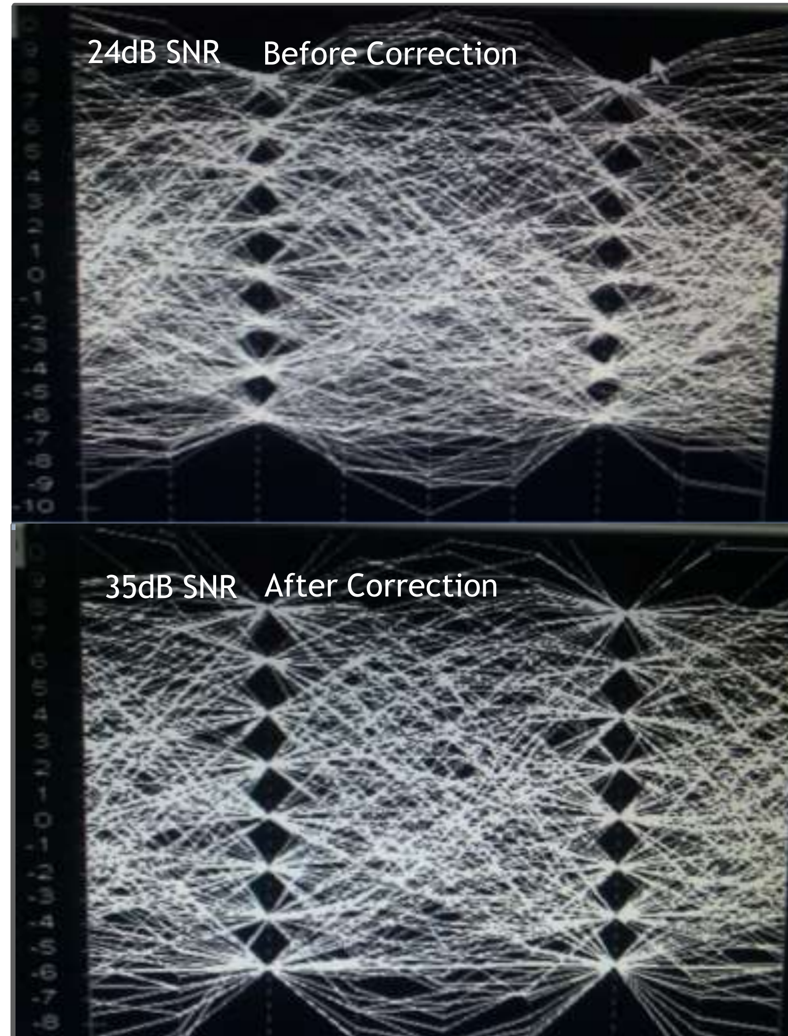


EFFECTS OF NON-LINEARITY

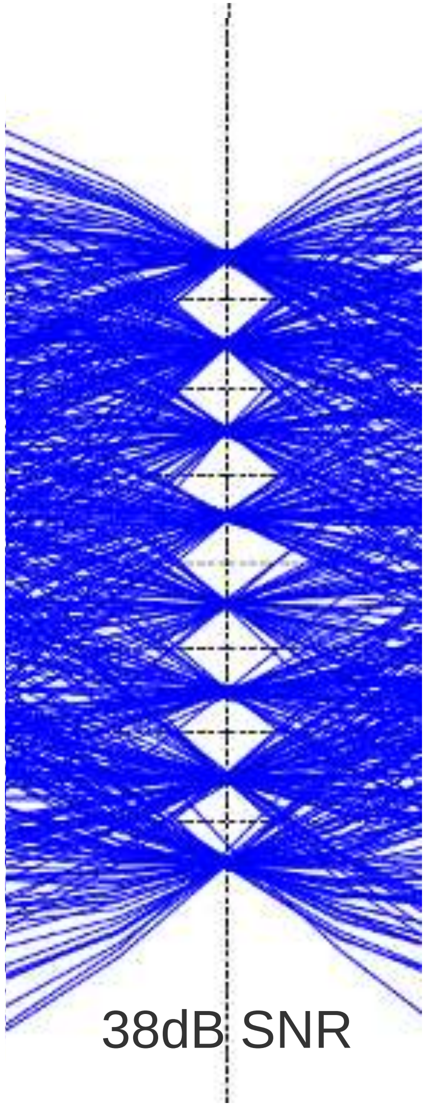
Inter-modulation decreased the in-band noise hence degrading the Signal to Noise (SNR) or Modulation Error Ratio (MER).

This can be seen from the ATSC measurement known as the EYE DIAGRAM.

FCC/IC recommendation is a minimum of **27dB** SNR



EFFECTS OF NON-LINEARITY



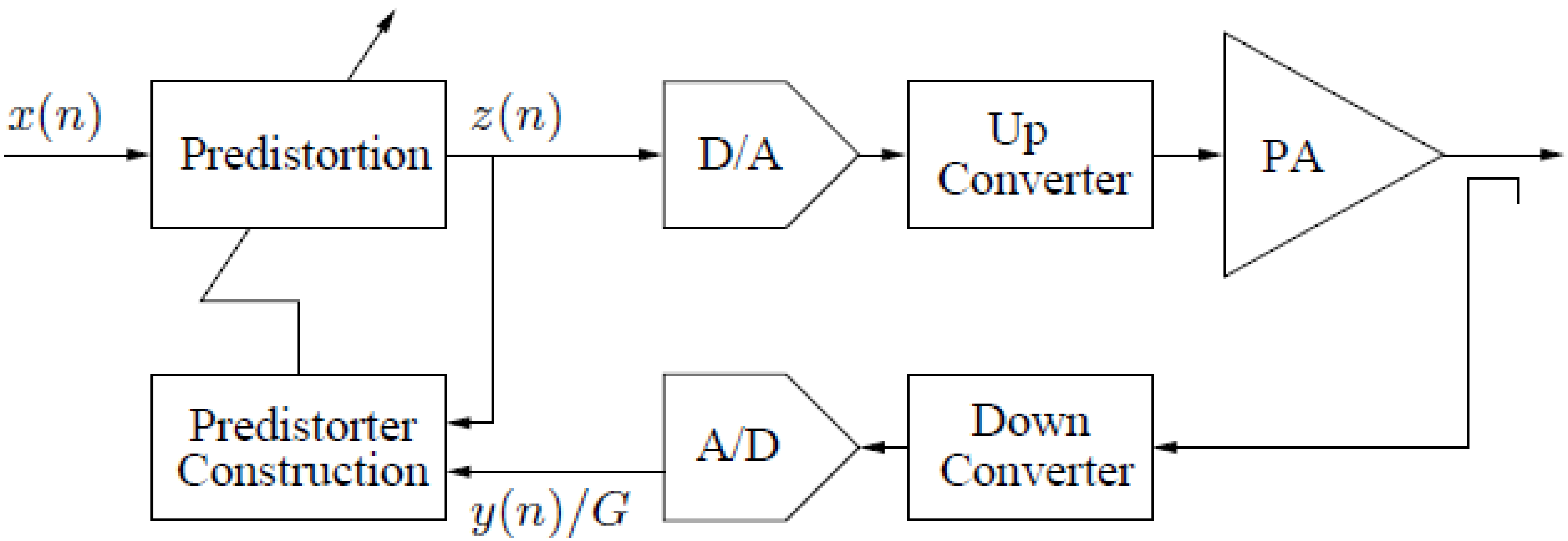
DIGITAL PRE-DISTORTION TECHNIQUES

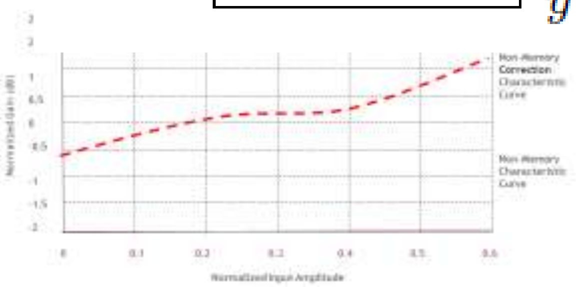
To obtain both high efficiency and keep the performance metrics within requirements

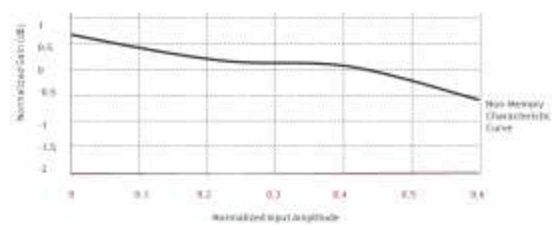
- Drive the amplifier hard into saturation to obtain the best efficiency and use the latest DPD techniques..

- ***Digital Pre-Distortion*** with “PA modeling”
- ***Crest Factor Reduction*** (CFR)
- ***Memory Error Correction*** (MEC)

Digital Pre-Distortion with PA modeling







Source: Lei Ding – Digital Pre-Distortion techniques

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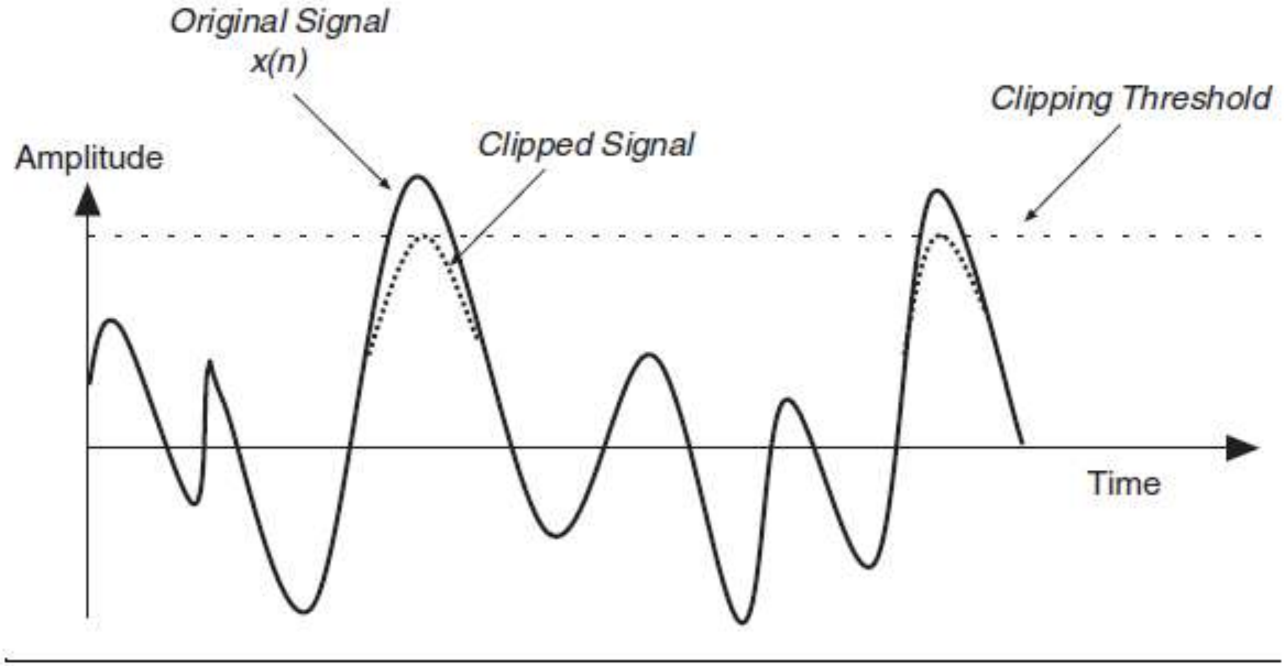
Crest Factor Reduction



Source: Altera Application note 396

Memory Error Correction

Definition:

- gain is dependent on input power *and* on input signal past history
- Memory is also called ***dynamic*** distortion; it is time dependent.

Cause: bias coupling, unmatched networks, instantaneous variation of junction temperature, feedback coupling, etc.

Effect: more spectral regrowth or intermodulation.

- Unbalanced shoulders : symptom of memory non-linearity which means the non-linearity is frequency dependent
- Memory effects can be short term (nano seconds) or long term (micro seconds). It happens due to thermal (junction temperature) or electric (bias and matching networks) effects

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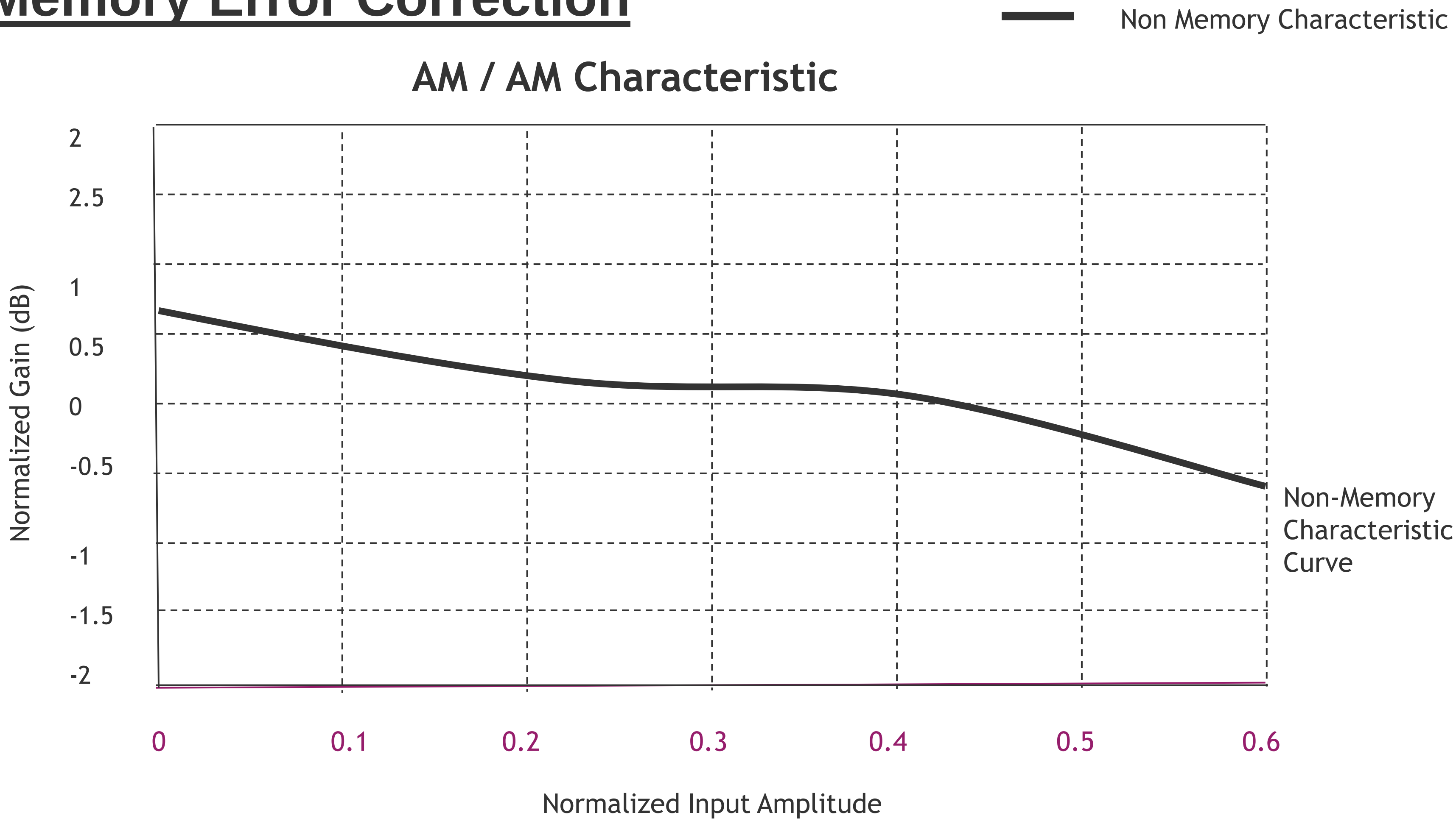
Memory Error Correction



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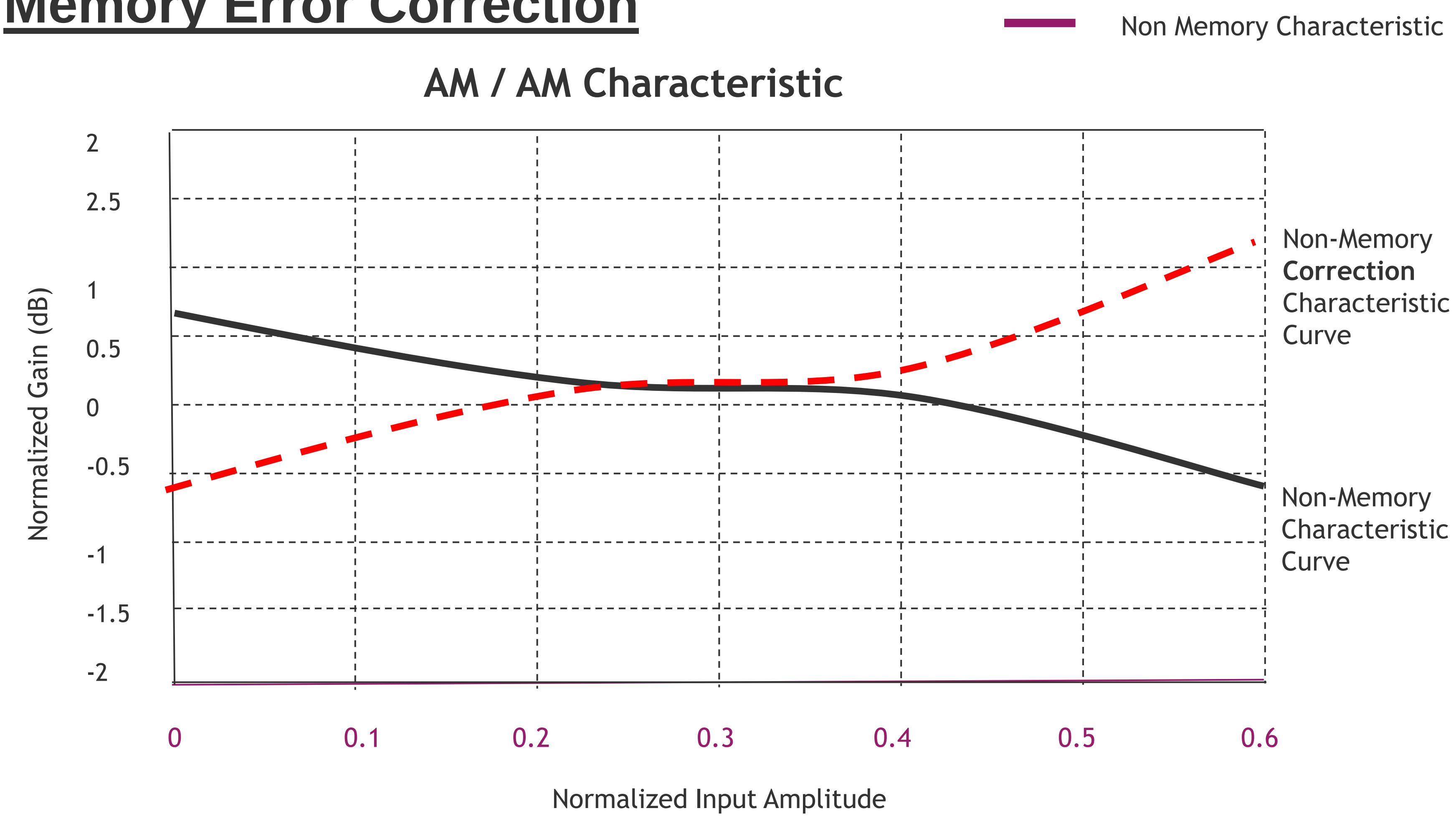
Memory Error Correction



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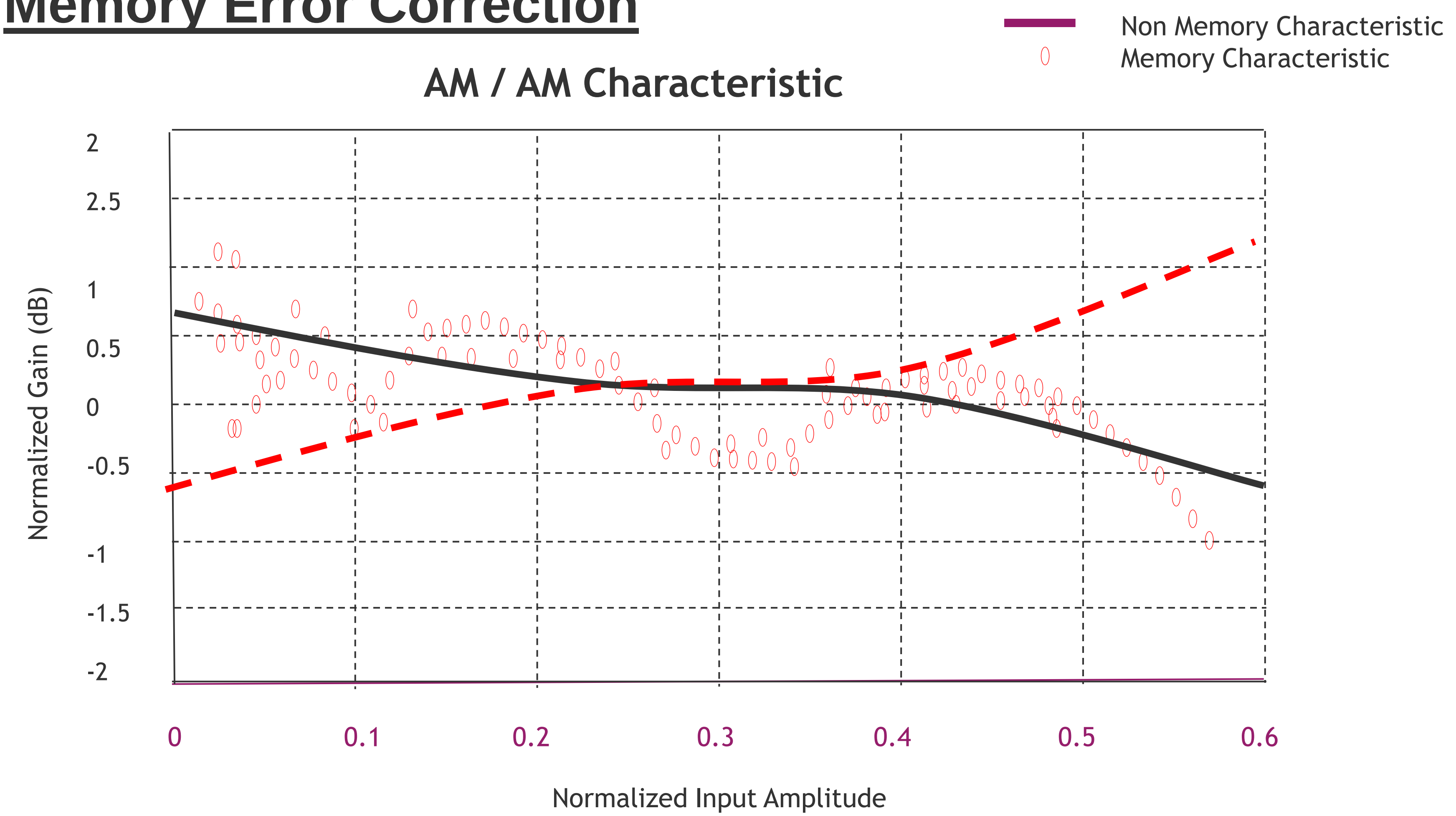
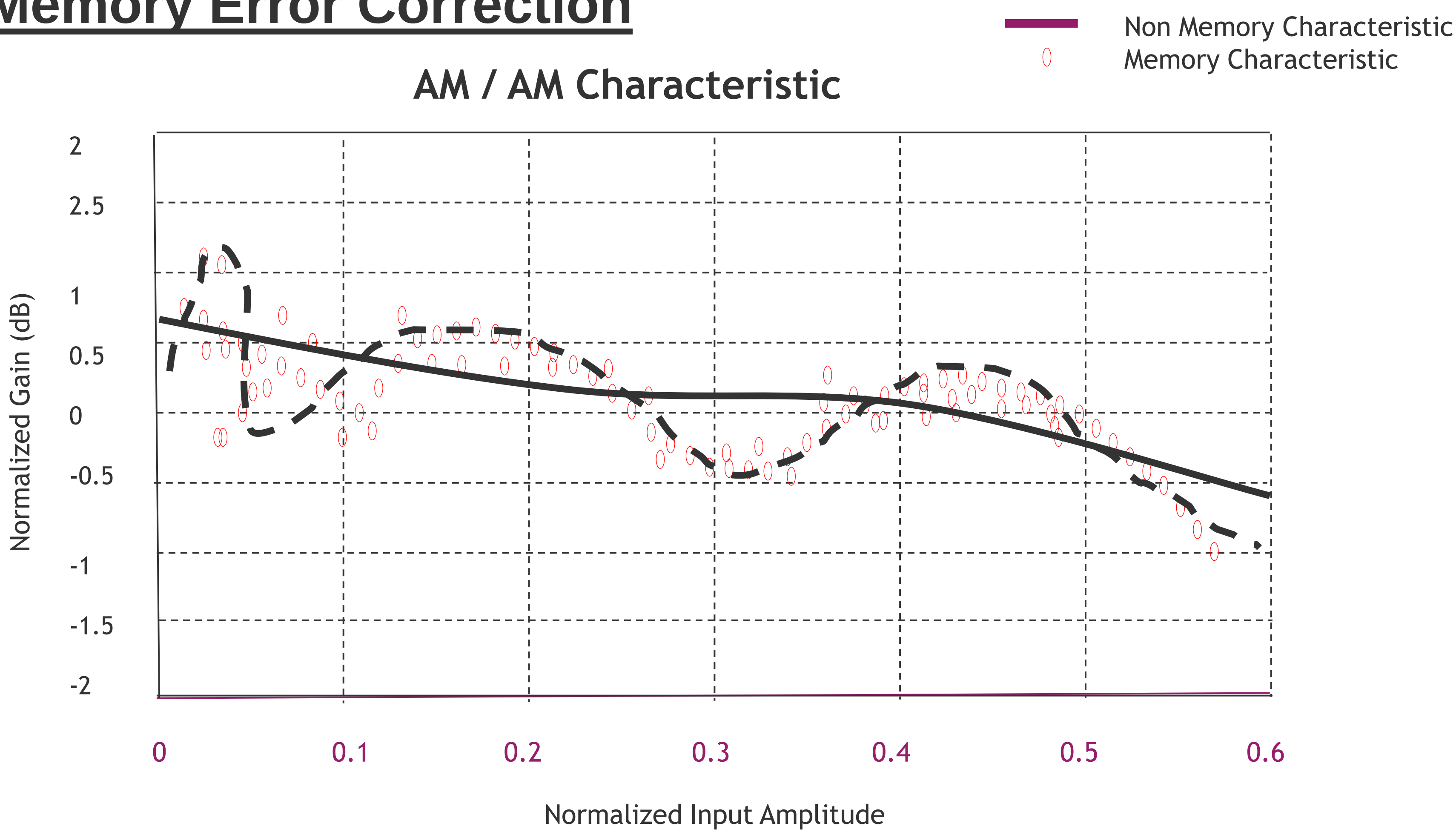
Memory Error Correction



Memory Error Correction



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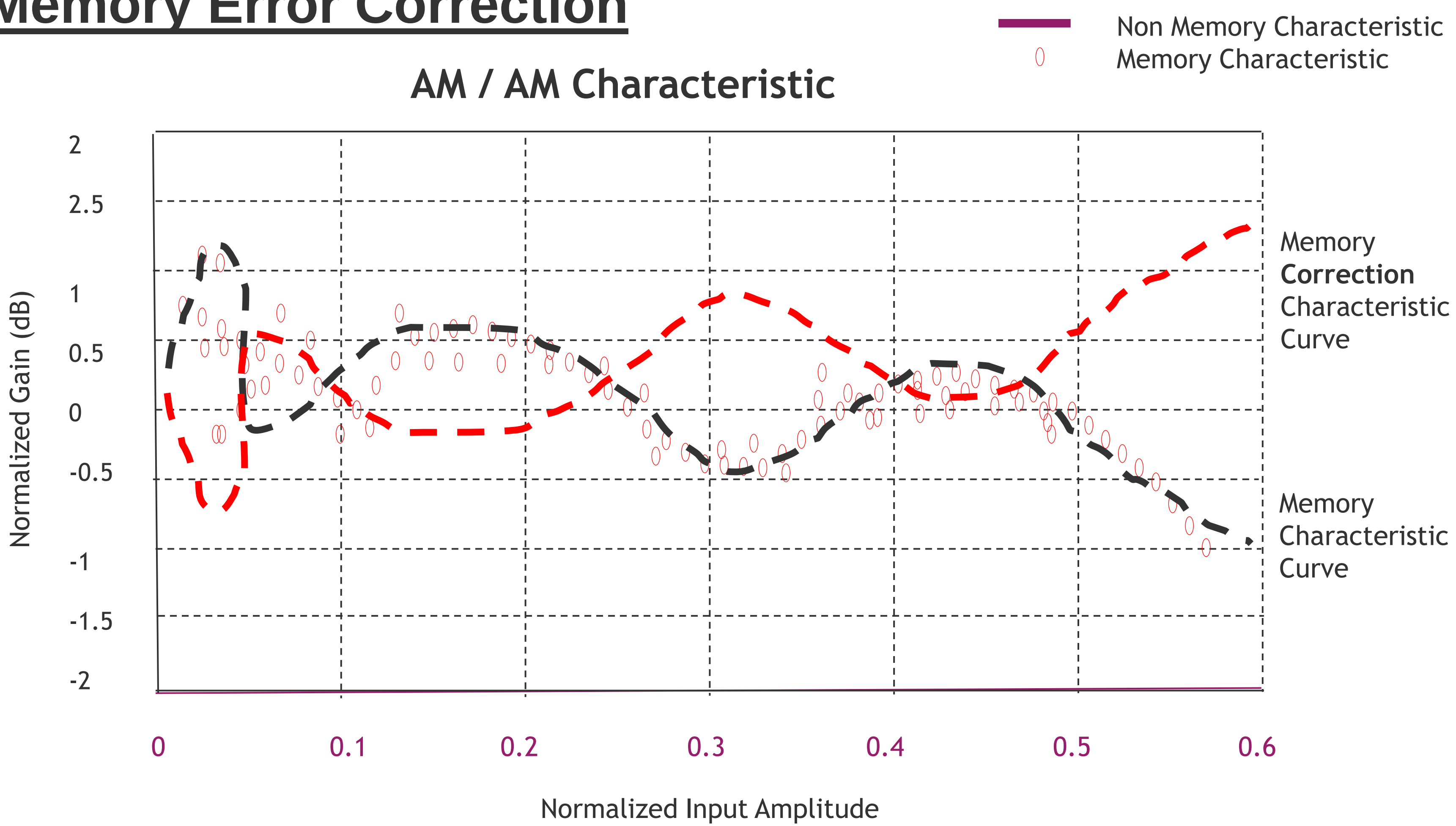
Memory Error Correction



Conclusion

New Digital Pre-distortion algorithms such as has
- Mathematical PA modeling
- Crest Factor Reduction
- Memory Error Correction

Significantly improves IMD and SNR

-These techniques can almost DOUBLE the efficiency of a modern transmitter to obtain TRANSMITTER efficiencies up to 28%.

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New Amplifier Designs being investigated

Doherty Modulation

Paralleling two amplifiers devices; first operating in Class AB which amplifies the average power level, and the second operates in Class C amplifying just the peaks of the waveform. Output of two devices are combined with a matched transformer.

Drain Modulation (or Envelope Tracking)

Operates by modulating the DRAIN of a FET amplifier with the input signal so that the Power Supply voltage follows the level of the input signal. The amplifier operates near the high-efficiency saturation point over a significant portion of the envelope depth.

DOHERTY MODULATION

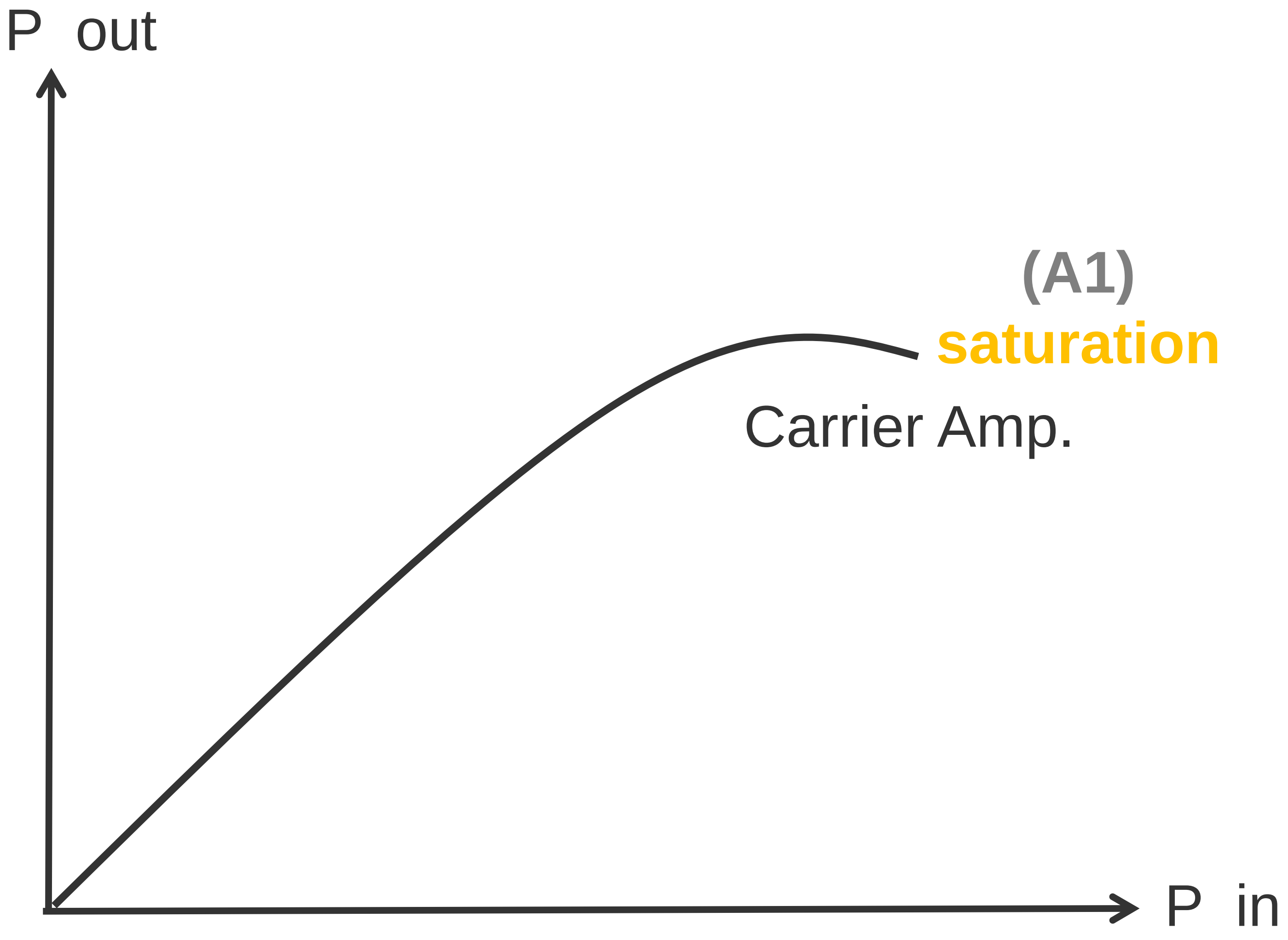
DOHERTY Amplifier design was invented by William Doherty in 1934 by Bell Labs.

Carrier amplifier: Class AB (saturates at high power input)
Peak Amplifier: Class C (Turns on at high power input

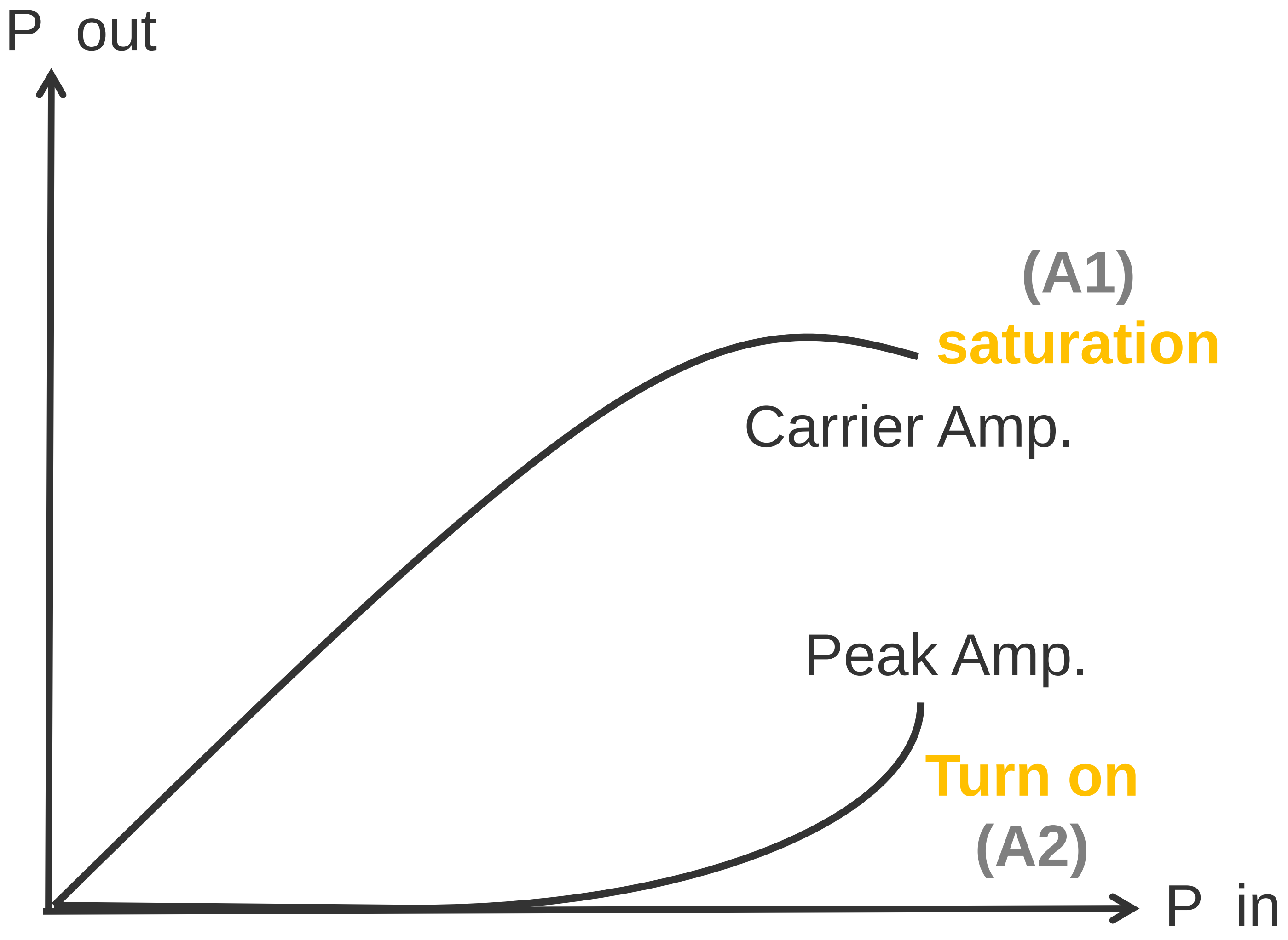
DOHERTY Configuration improves linearity at the high power input by complementing the saturation of the carrier amplifier with the turn on characteristics of the peak amplifier

In 2008 NXP semiconductors (founded by Philips) released a transistor "optimized" for Doherty amplifier applications. It has since been improved and commonly available… Example BLF888.

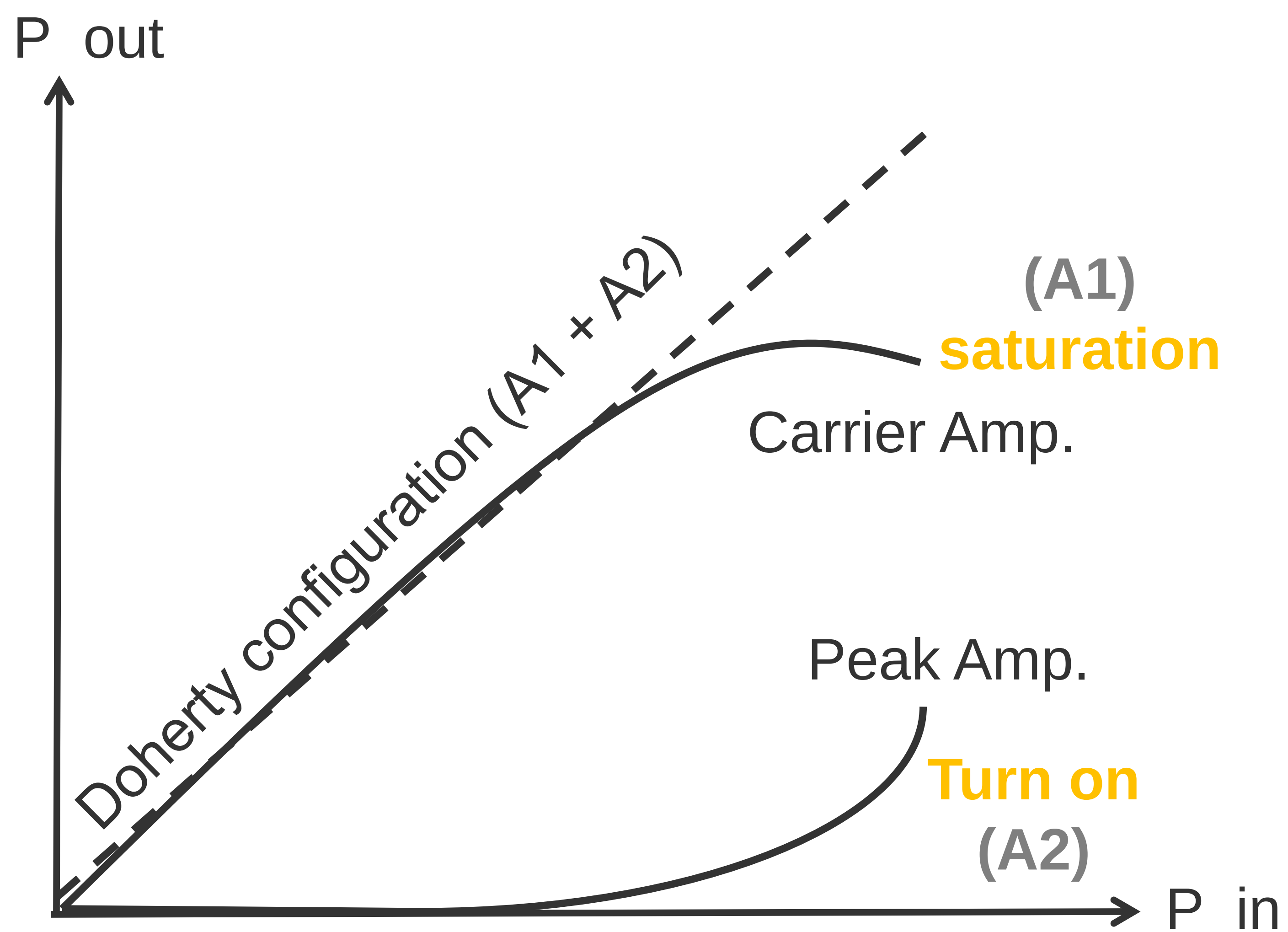
DOHERTY MODULATION



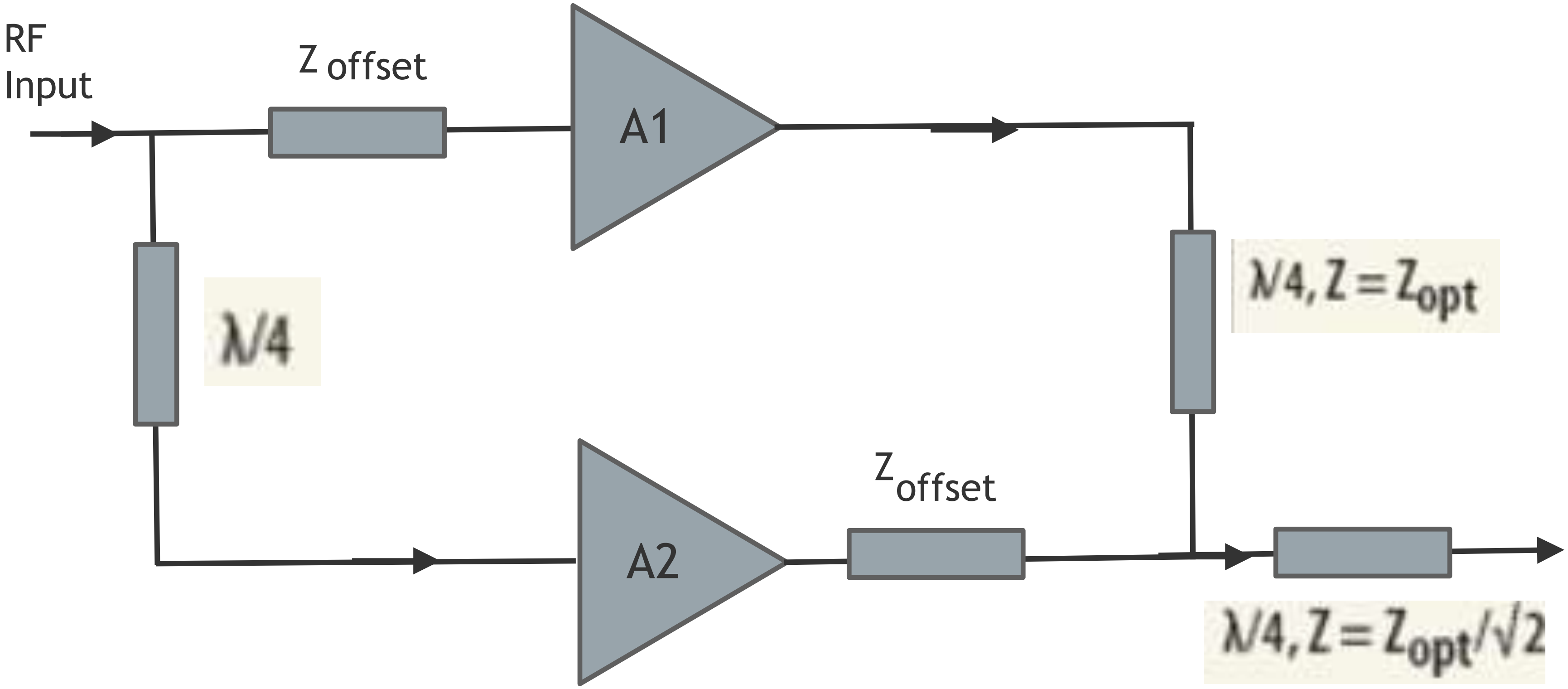
DOHERTY MODULATION



DOHERTY MODULATION



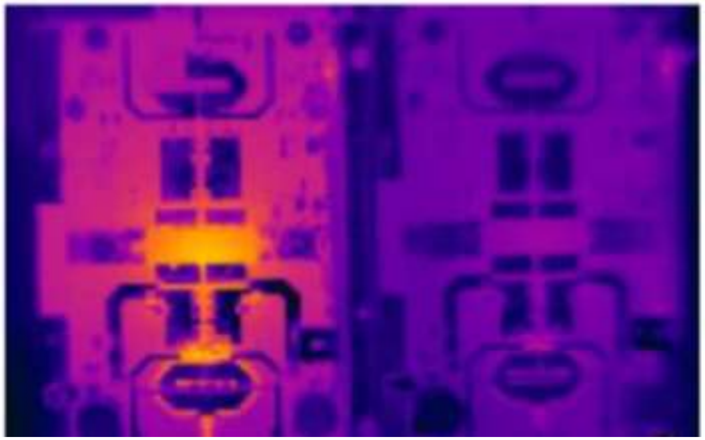
DOHERTY Amplifier Basic Operation



A basic ***DOHERTY*** architecture contains a carrier amplifier biased to operate in Class AB mode (A2) and a peaking amplifier biased to operate in Class C mode (A1).

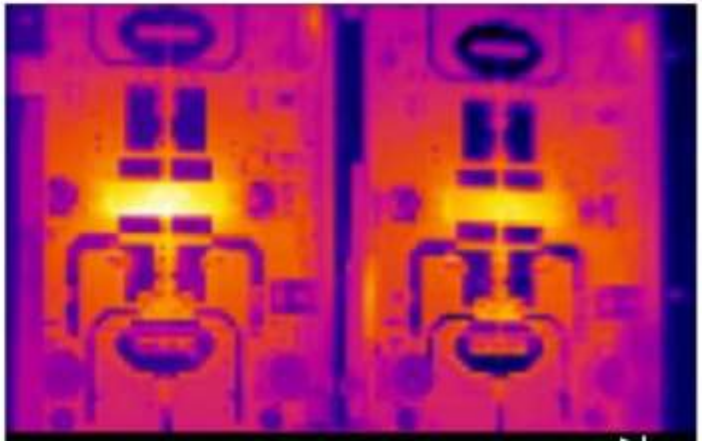
DOHERTY MODULATION

Temperatures of Doherty Amplifier transistors compared to standard Fixed Drain Class A/B



Doherty Class AB and Class C

T1 = 62.9 C
T2 = 54.6 C

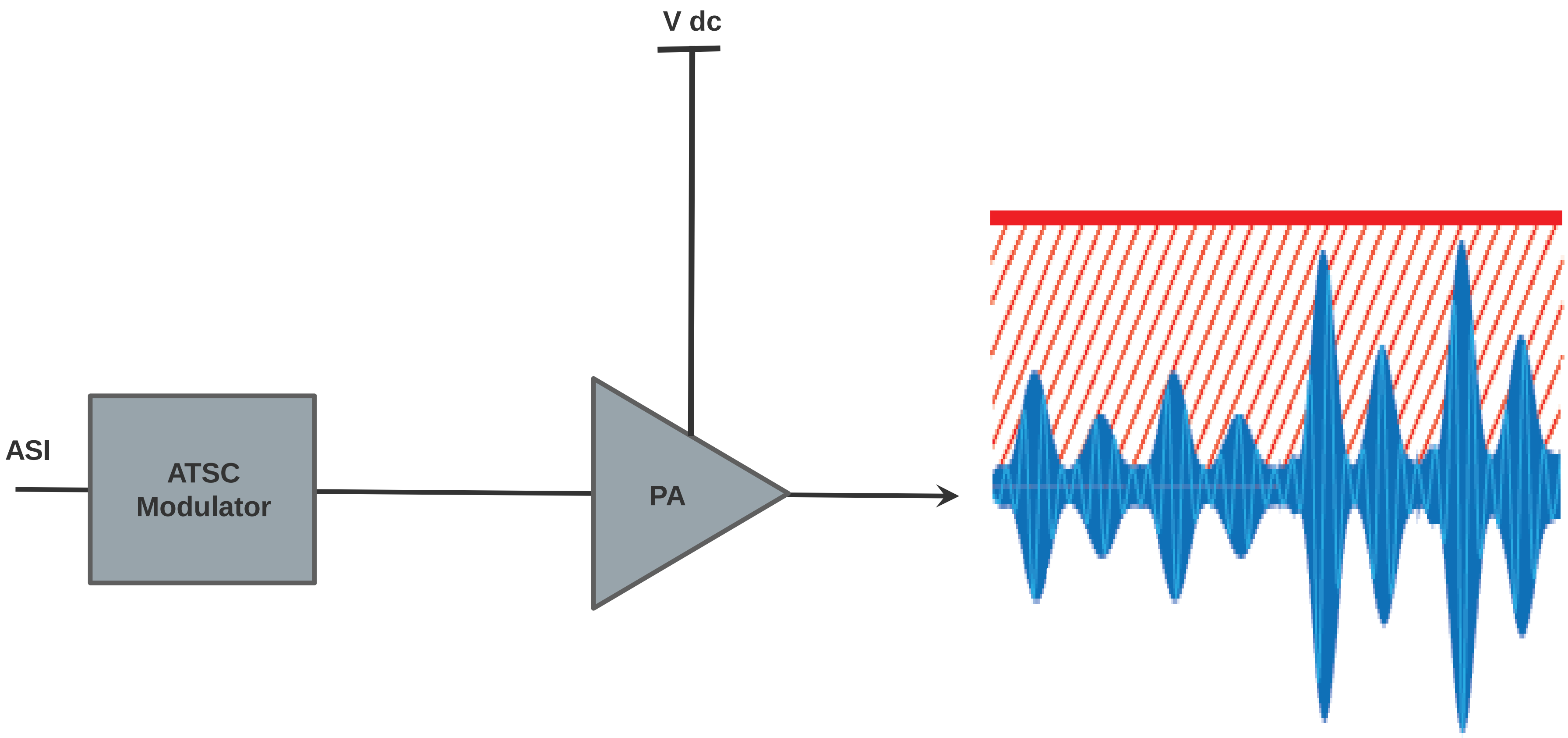


Standard Dual Class AB

T1 = 75.7 C
T2 = 75.5 C

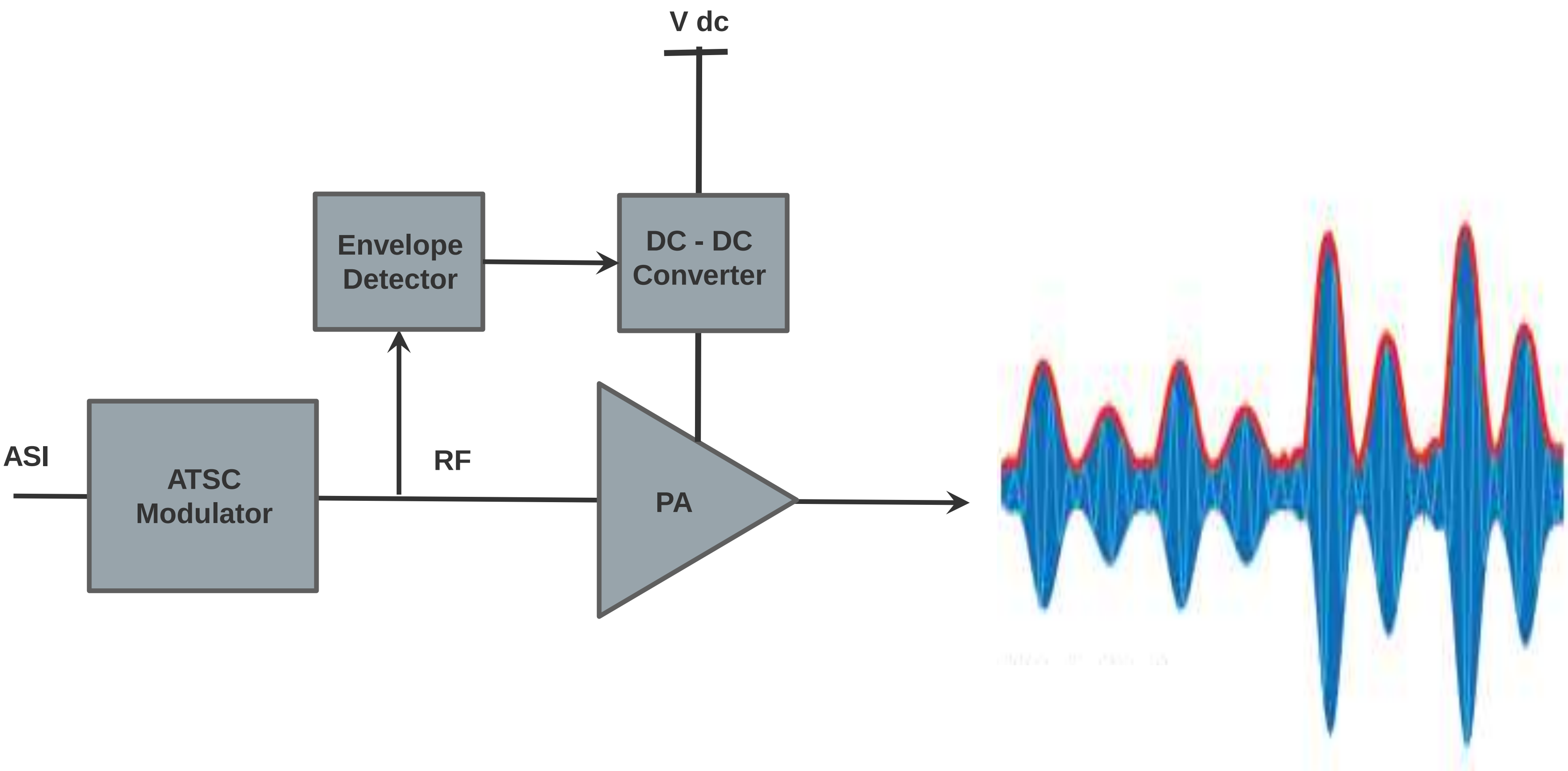
A 22% (average) reduction in temperature

DRAIN MODULATION



Source: OPEN ET Alliance

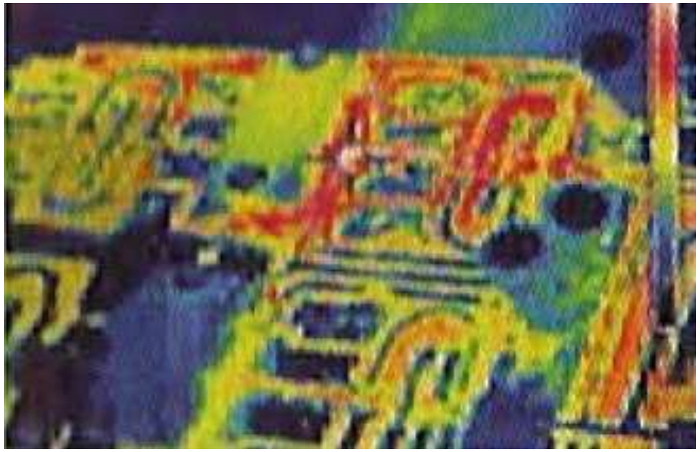
DRAIN MODULATION



Source: OPEN ET Alliance

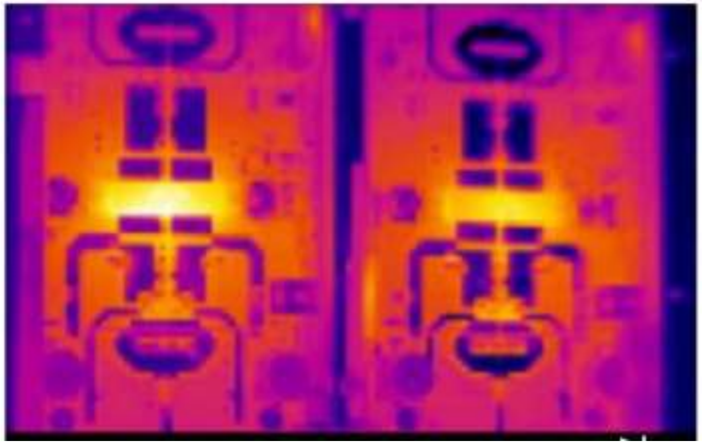
DRAIN MODULATION

Temperatures of Drain Modulation Amplifier transistors compared to standard Fixed Drain Class A/B



Drain Modulation Transistor

T1 = 58.9 C



Standard Dual Class AB

T1 = 75.7 C
T2 = 75.5 C

A 20% reduction in temperature

SUMMARY

Comparison	Fixed DRAIN	DRAIN MODULATION	DOHERTY
Efficiency Amplifier Efficiency Transmitter	28 - 30% 20 - 22%	46 - 48% 29 - 30%	44 - 46% 28 - 29%
Broadband	YES	YES	NO *
Reliability	GOOD	GOOD	VERY GOOD
Complexity	Simple - GOOD	COMPLEX - BAD	SIMPLE - GOOD
Flexibility	GOOD	GOOD	MEDIUM
Active Redundancy	GOOD	GOOD	MEDIUM
Performance at Reduced Power	MEDIUM	GOOD	MEDIUM

* Channel change time approx 30 minutes per 1kW

SUMMARY

Transmitter Type		32V	50V Basic	50V ADPD	Doherty / Drain
Transmitter Power Output - KW		10	10	10	10
Amplifier Efficiency		18	25	29	45
Transmitter Efficiency		16	19	22	29
Transmitter Consumption		67	52	46	34.06
Cost of Energy at - $/kW/Hr	$0.10	$58,692	$45,552	$40,296	$29,837

Compared to 50V ADPC				$10,459
Compared to 50V Basic			$5,256	$15,715
Compared to 32V		$13,140	$18,396	$28,855
Over 5 Years		$65,700	$91,980	$144,277

Pays for up to 75% of the capital cost of a new transmitter in five years !

CONCLUSION

Tremendous strides in Digital Pre-Distortion (DPD) and Amplifier design via ***Doherty*** and ***Drain Modulation*** make the latest designs of Solid State TV transmitter:

- Efficient reducing operating costs
- Potentially more reliable due to lower operating temperatures of amplifiers and cabinets
- Improved performance due to better SNR / IMD

When buying a new solid state transmitter consider

- Efficiency (; Cost savings)
- Operating temperature (; Reliability)
- Definitive SNR and IMD (; Coverage)

CONCLUSION

MPTV-8000-U from **THOMSON**

Lower cost of operation
Less heat into room
Smaller footprint
Operates at lower temperature
Higher redundancy (more PSU’s)
Simpler to operate
Supported from the USA (MA)
2 Year warranty

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THANK YOU

More information?

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