
COMARK
Communications Corp.
COMARK

Transmitter choices for the next digital roll out…

What technology is the best fit for your station?

COMARK
Communications

Key factors for the Engineering Manager:

- **Signal Quality – SNR/MER**
- **Cost of Operation – Efficiency**
- **Reliability**
- **Maintenance**
- **Obsolescence**

COMARK Communications

Contents

- **Quick look at SS device progression**
- **Signal Quality – The Key Ingredients**
- **Cost of Operation – Transmitter Efficiency Comparisons versus Power Output**
- **Reliability & Maintenance – System Complexity**
- **Obsolescence – Device stability**

COMARK Communications

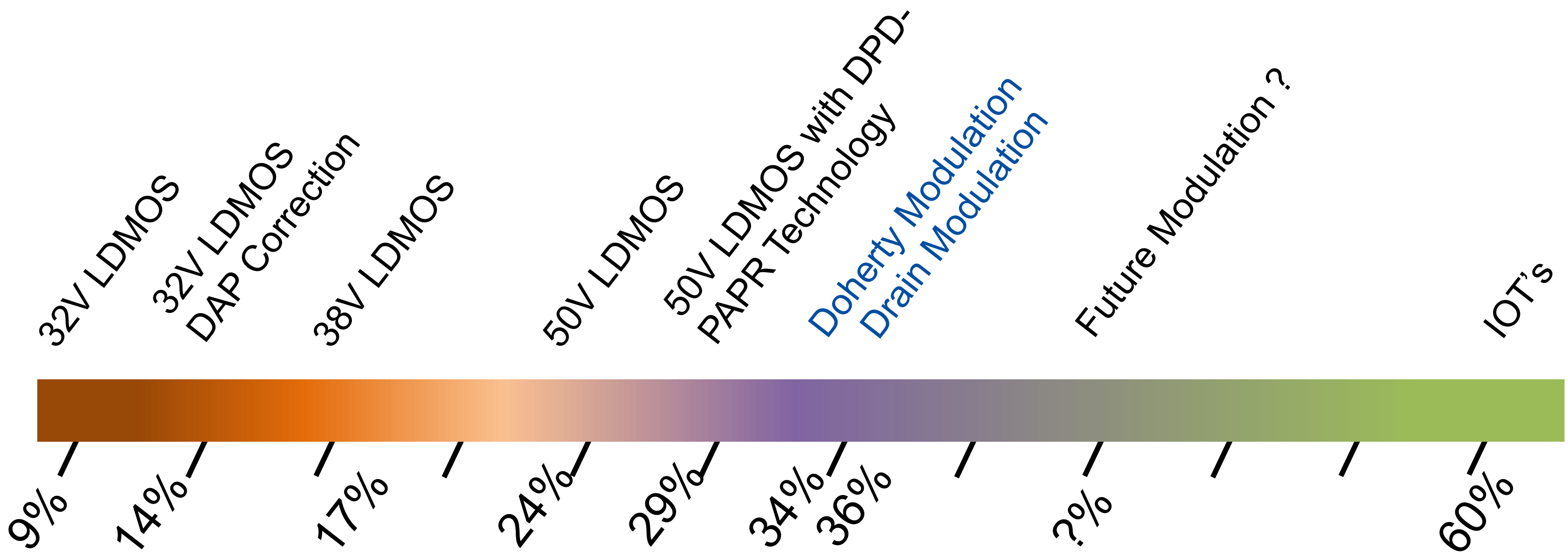
Contents

- ➢ **Quick look at SS device progression**
- ➢ **Signal Quality – The Key Ingredients**
- ➢ **Cost of operation – Transmitter Efficiency Comparisons versus Power Output**
- ➢ **Reliability & Maintenance – System Complexity**
- ➢ **Obsolescence – Device stability**
- ➢ **Space considerations**

SS Device Progression

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

A Brief History….. Of transmitter devises & efficiencies



Contents

- Quick look at SS device progression
- **Signal Quality – The Key Ingredients**
- Cost of operation – Transmitter Efficiency Comparisons versus Power Output
- Reliability & Maintenance – System Complexity
- Obsolescence – Device stability
- Space considerations

COMARK Communications

Signal Quality – Root Causes of Problems

There are several SNR degradations in the link between the transmitter and the receiver starting… with the transmitter

- **At the TX Site**
  - **Intermodulation and cross-modulation products with the transmitter**
  - **Noise due to the issues between transmitter and antenna.**
- **Propagation**
  - **Various propagational Interference, natural & man made**
- **At the home**
  - **Co- channel & Adjacent channel interference**
  - **Receiver equalizer adds white noise**

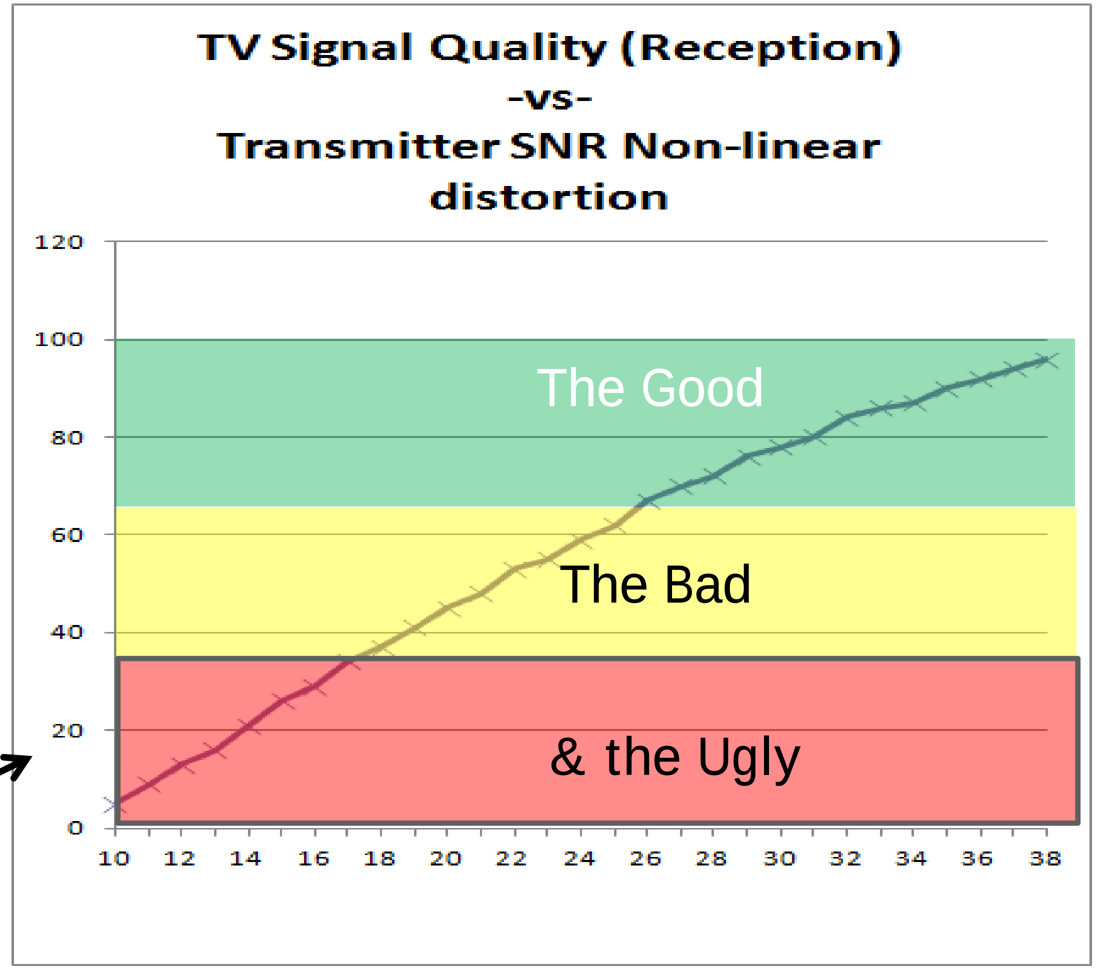
ALL POTENTIALLY DEGRADE THE RECEIVED SNR and DECREASE COVERAGE

COMARK Communications

Signal Quality – Quantitative Definition

As Transmitter Signal to Noise Ratio (T-SNR) decreases the ability to pick up a received signal drops proportionally.

- "Good" >66% >26dB
- "Bad" > 33% >17dB
- "Ugly" 33% <17dB



COMARK Communications

Signal Quality – Correction Techniques

Look for these technologies in your Exciter

To obtain a balance between maximum efficiency and maximum signal quality:

- Drive the amplifier into saturation to obtain the best efficiency and …
- Correct the signal using the latest correction techniques
  - ***Digital Pre-Distortion*** with "PA modeling"
  - ***Crest Factor Reduction*** (CFR)
  - ***Memory Error Correction*** (MEC)

Signal Quality – Summary

➢New Digital Pre-distortion algorithms significantly improve IMD and SNR

- 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

➢Couple this with new Amplifier design techniques and you very efficient transmitter options

Contents

- Quick look at SS device progression
- Signal Quality – The Key Ingredients
- **Cost of operation – Transmitter Efficiency Comparisons versus Power Output**
- Reliability & Maintenance – System Complexity
- Obsolescence – Device stability
- Space considerations

COMARK Communications

Cost of operation – Efficiency

- **Best choice of technology varies with application**
  - **One size does NOT fit all**
- **SS options include:**
  - **50V device designs – great for low power applications**
  - **Doherty Modulation – best suited for HP up to 30 kW**
    - **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) - complex**
    - **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.**
- **IOT – most efficient for most stations above 30kW**

Doherty Modulation

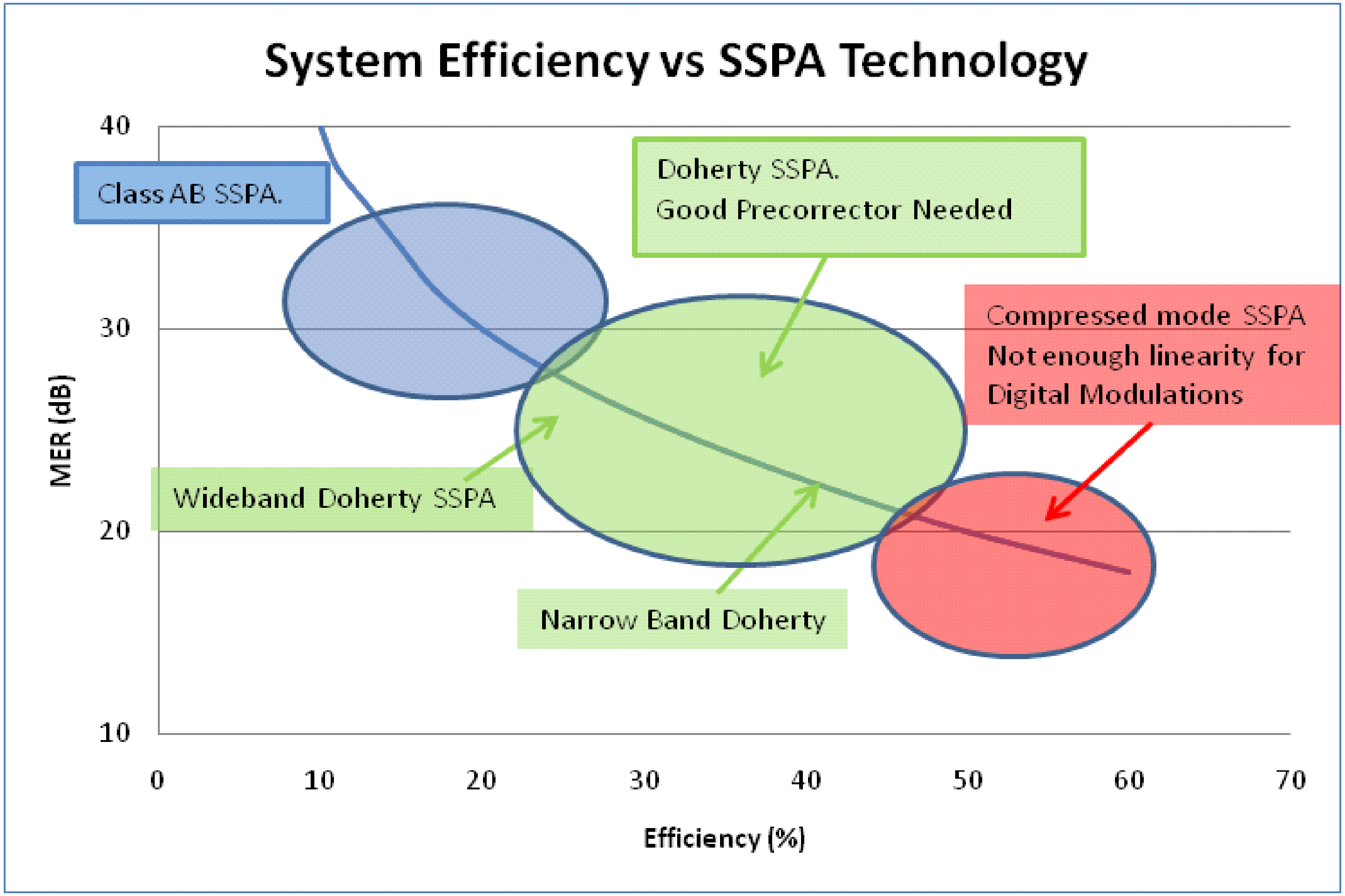
DOHERTY Amplifier design was invented by William Doherty in 1934 by Bell Labs.

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

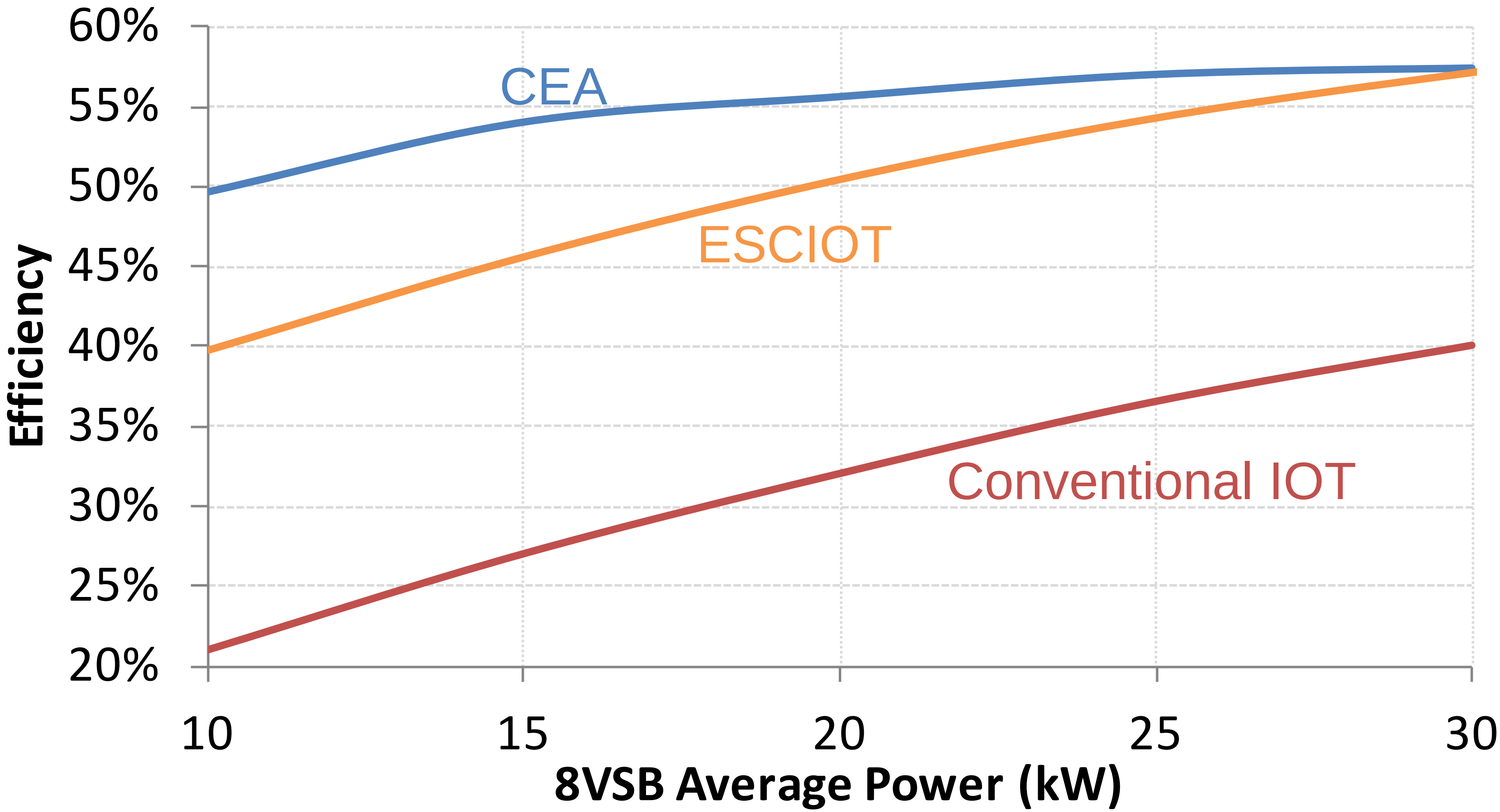
NXP semiconductors and Freescale both have released transistors "optimized" for Doherty amplifier applications.

Efficiency Comparisons



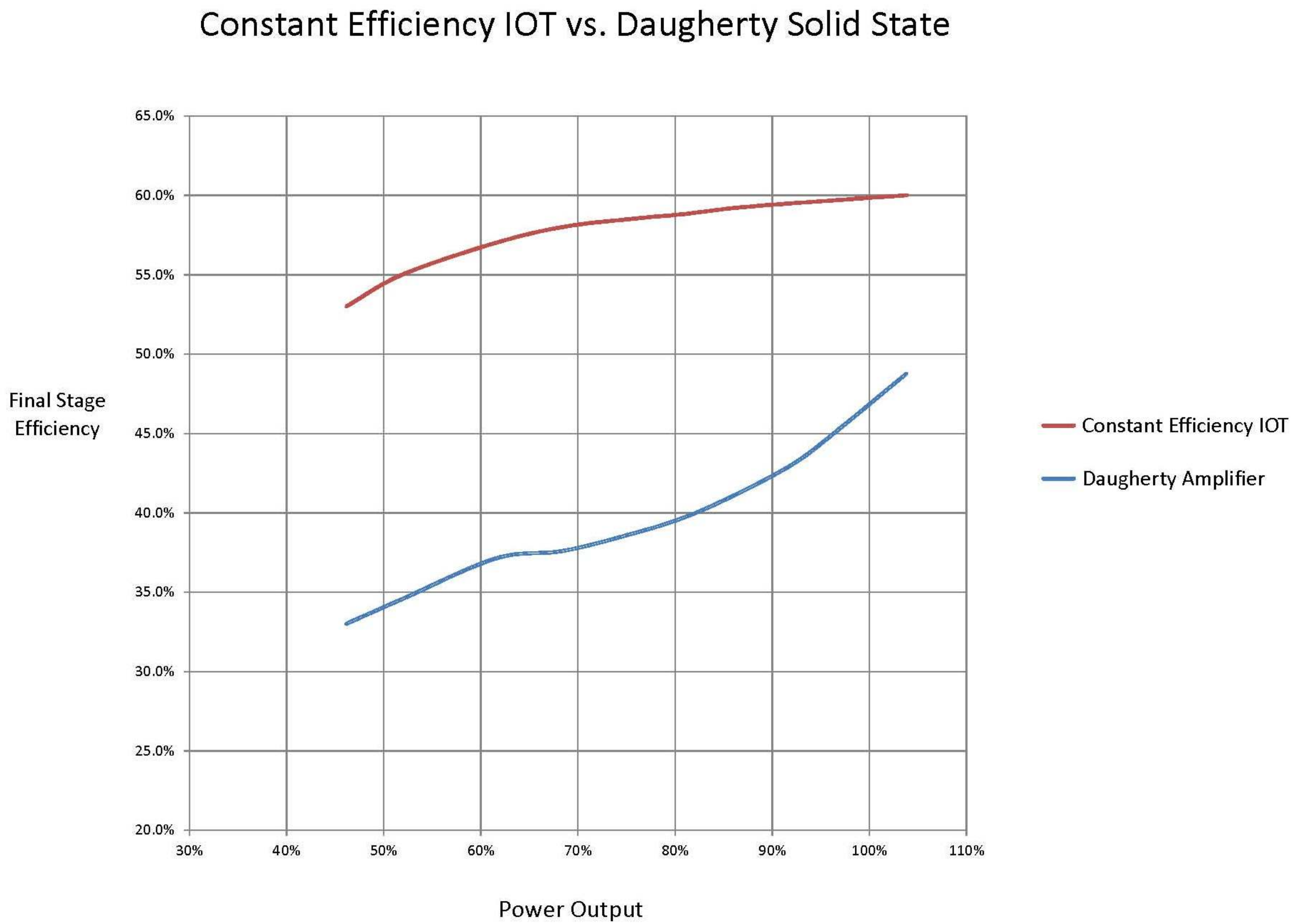
COMARK Communications

Efficiency Comparisons



COMARK Communications

Efficiency Comparisons



COMARK Communications

Cost of Operation – Efficiency Comparison at 10kW

Amplifier Type		32V	50V	Doherty / Drain	MSDC-IOT
Transmitter Power Output - kW		10	10	10	10
Amplifier Efficiency		18%	27%	42%	50%
Transmitter Efficiency		15%	21%	35%	26%
Transmitter Consumption		66.7	47.6	28.6	38.5
Cost of Energy at $/kW/Hr	$ 0.10	$ 58,400	$ 41,714	$ 25,029	$ 33,692

Compared to Doherty					$ (8,664)
Compared to 50V Basic				$ 16,686	$ 8,022
Compared to 32V			$ 16,686	$ 33,371	$ 24,708
CAPEX		N/A	$ 280,000	$ 300,000	N/A
Over 5 Years			**$ 83,429**	**$ 166,857**	**$ 123,538**

COMARK Communications

Cost of Operation – Efficiency Comparison at 20kW

Amplifier Type		32V	50V	Doherty / Drain	MSDC-IOT
Transmitter Power Output - kW		20	20	20	20
Amplifier Efficiency		18%	27%	42%	57%
Transmitter Efficiency		15%	21%	35%	37%
Transmitter Consumption		133.3	95.2	57.1	54.1
Cost of Energy at $/kW/Hr	$ 0.10	$ 116,800	$ 83,429	$ 50,057	$ 47,351

Compared to Doherty				$ 2,706
Compared to 50V Basic			$ 33,371	$ 36,077
Compared to 32V		$ 33,371	$ 66,743	$ 69,449
CAPEX	N/A	$ 400,000	$ 470,000	$ 525,000
Over 5 Years		**$ 166,857**	**$ 333,714**	**$ 347,243**

COMARK Communications

Cost of Operation – Efficiency Comparison at 30kW

Amplifier Type		32V	50V	Doherty / Drain	MSDC-IOT
Transmitter Power Output - kW		30	30	30	30
Amplifier Efficiency		18%	27%	42%	57%
Transmitter Efficiency		15%	21%	35%	43%
Transmitter Consumption		200.0	142.9	85.7	69.8
Cost of Energy at $/kW/Hr	$ 0.10	$ 175,200	$ 125,143	$ 75,086	$ 61,116

Compared to Doherty				$ 13,969
Compared to 50V Basic			$ 50,057	$ 64,027
Compared to 32V		$ 50,057	$ 100,114	$ 114,084
CAPEX	N/A	N/A	$ 670,000	$ 550,000
Over 5 Years		**$ 250,286**	**$ 500,571**	**$ 570,419**

Cost of Operation – Efficiency Comparison at 40kW

Amplifier Type		32V	50V	Doherty / Drain	MSDC-IOT
Transmitter Power Output - kW		40	40	40	40
Amplifier Efficiency		18%	27%	42%	57%
Transmitter Efficiency		15%	21%	35%	48%
Transmitter Consumption		266.7	190.5	114.3	83.3
Cost of Energy at $/kW/Hr	$ 0.10	$ 233,600	$ 166,857	$ 100,114	$ 73,000

Compared to Doherty				$ 27,114
Compared to 50V Basic			$ 66,743	$ 93,857
Compared to 32V		$ 66,743	$ 133,486	$ 160,600
CAPEX	N/A	N/A	$ 915,000	$ 850,000
Over 5 Years		**$ 333,714**	**$ 667,429**	**$ 803,000**

COMARK Communications

Cost of Operation – Efficiency Comparison at 60kW

Amplifier Type		32V	50V	Doherty / Drain	MSDC-IOT
Transmitter Power Output - kW		60	60	60	60
Amplifier Efficiency		18%	27%	42%	62%
Transmitter Efficiency		15%	21%	35%	54%
Transmitter Consumption		400.0	285.7	171.4	111.1
Cost of Energy at $/kW/Hr	$ 0.10	$ 350,400	$ 250,286	$ 150,171	$ 97,333

Compared to Doherty				$ 52,838
Compared to 50V Basic			$ 100,114	$ 152,952
Compared to 32V		$ 100,114	$ 200,229	$ 253,067
CAPEX	N/A	N/A	$ 1,200,000	$ 920,000
Over 5 Years		**$ 500,571**	**$ 1,001,143**	**$ 1,265,333**

COMARK Communications

Contents

- Quick look at SS device progression
- Signal Quality – The Key Ingredients
- Cost of operation – Transmitter Efficiency Comparisons versus Power Output
- **Reliability & Maintenance – System Complexity**
- Obsolescence – Device stability
- Space considerations

COMARK
Communications

Reliability & Maintenance

- **Reliability ~ All HP DTV transmitters will have failures!!!**
  - **Solid State requires on average 1 replacement PA module per year**
  - **MSDC-IOT expected device life of >87,600 hours (10 years)**
  - **Normal wear items affect both (fans, pumps, etc.)**

- **Maintenance ~ All HP DTV transmitters require maintenance!!!**
  - **Air cooling (not typically used >5kW) has to be kept clean and cool**
  - **Liquid cooling systems need the coolant monitored, flushed periodically**
  - **Long term stability of new SS designs not yet known**

- **IOT based transmitters have specific needs and skill sets:**
  - **The HV compartment needs to be kept clean / safety considerations**
  - **Safety interlocks should be checked**
  - **Filament management for the highest device life expectancy**

Reliability & Maintenance – System Complexity Comparison

Comparison	Fixed DRAIN	DOHERTY	MSDC-IOT
Efficiency Amplifier Efficiency Transmitter	28 - 30% 20 - 22%	44 - 46% 28 - 29%	57 - 62% 37 - 54%
Broadband	YES	NO	YES
Reliability	GOOD	VERY GOOD *	GOOD **
Complexity	GOOD	Unknown*	AVERAGE
Active Redundancy	GOOD	MEDIUM	GOOD **
Performance at Reduced Power	MEDIUM	POOR	EXCELLENT

* Adequate field data is still being complied by vendors
** Assumes a dual HPA IOT design used

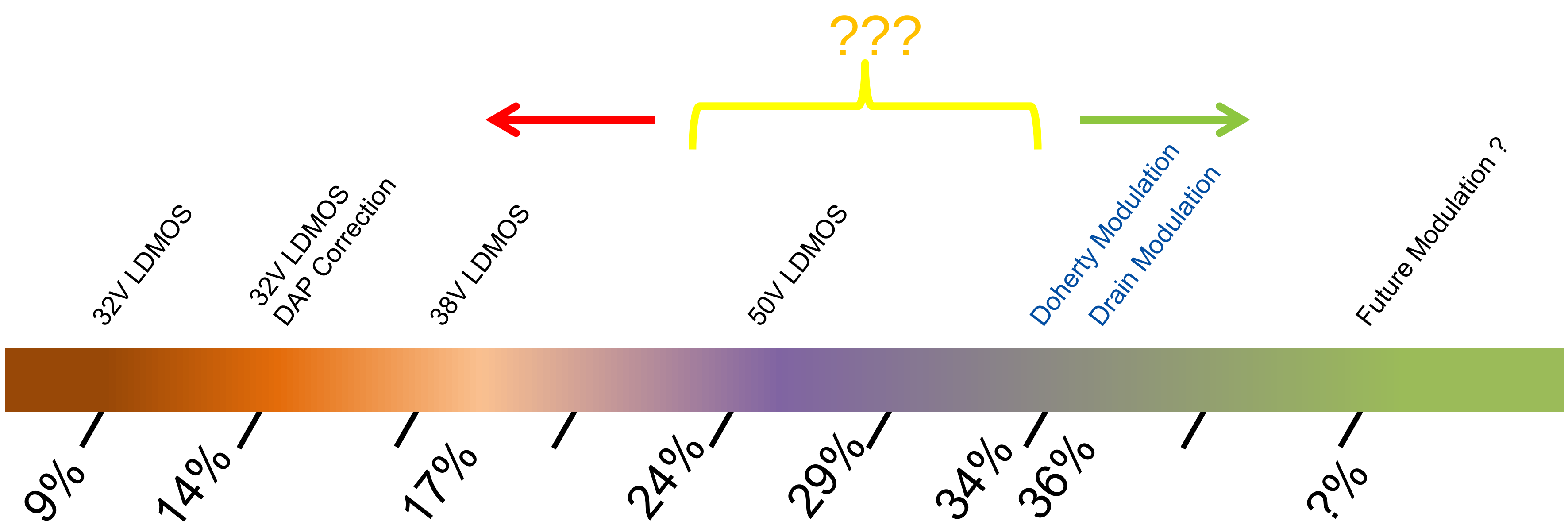
COMARK Communications

Contents

- Quick look at SS device progression
- Signal Quality – The Key Ingredients
- Cost of operation – Transmitter Efficiency Comparisons versus Power Output
- Reliability & Maintenance – System Complexity
- **Obsolescence – Device stability**
- Space considerations

Evolution Leading to Device Obsolescence

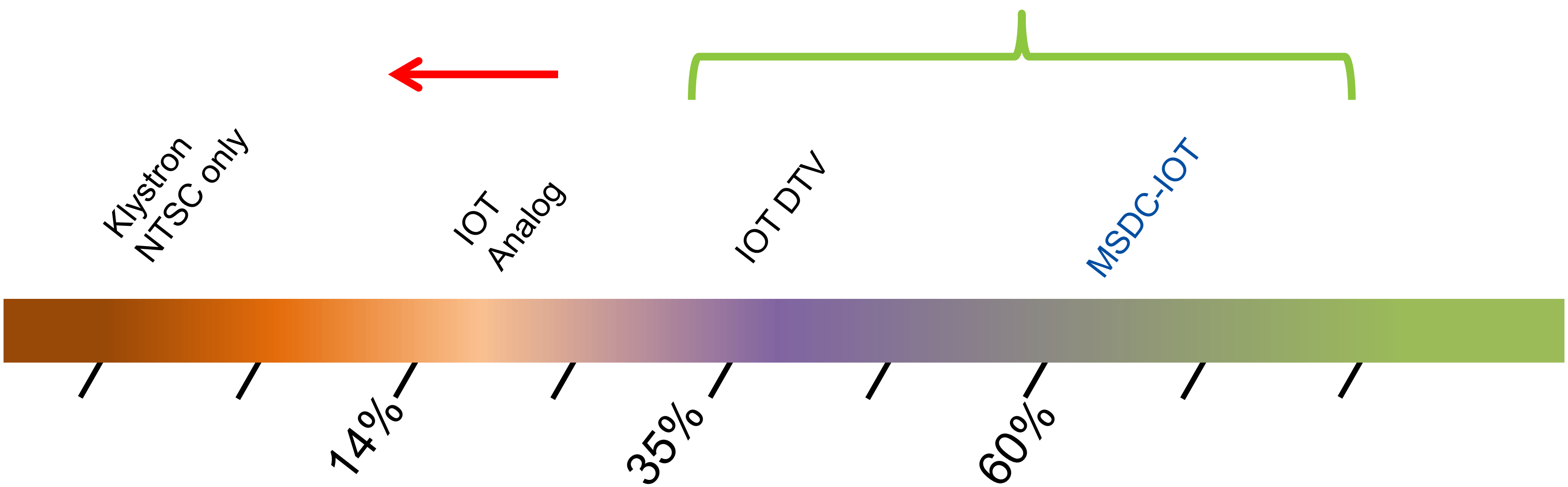
- **Solid State devices continue to evolve and improve:**
  - **Bipolar to LDMOS**
  - **Higher supply voltages (28, 32, 38, 50 VDC….)**
  - **Higher power capability per transistor**
  - **Higher efficiencies (<10% → >35%)**
- **As devices evolve, older series quickly become obsolete….**
- **Where are you on the technology curve?**



COMARK Communications

Tube based amplifiers had 3 major evolutions

- **Klystron → IOT → MSDC-IOT**
  - **Klystrons not used in DTV**
  - **IOT and MSDC-IOT both widely used and available**
- **Tube Vendors continue to support traditional IOT**
- **Tube Vendors continue to service and sell Klystrons for the Scientific / Medical / Industrial markets**



COMARK
Communications

THANK YOU

More information?

Michael Roosa
mroosa@comarktv.com
413 998 1528

COMARK Communications
104 Feeding Hills Road
Southwick MA, 01077, USA
CUSTOMER SERVICE
TOLL FREE # 1 800 345 9295

COMARK Communications