GaN Transistors – Successes and Challenges Ahead

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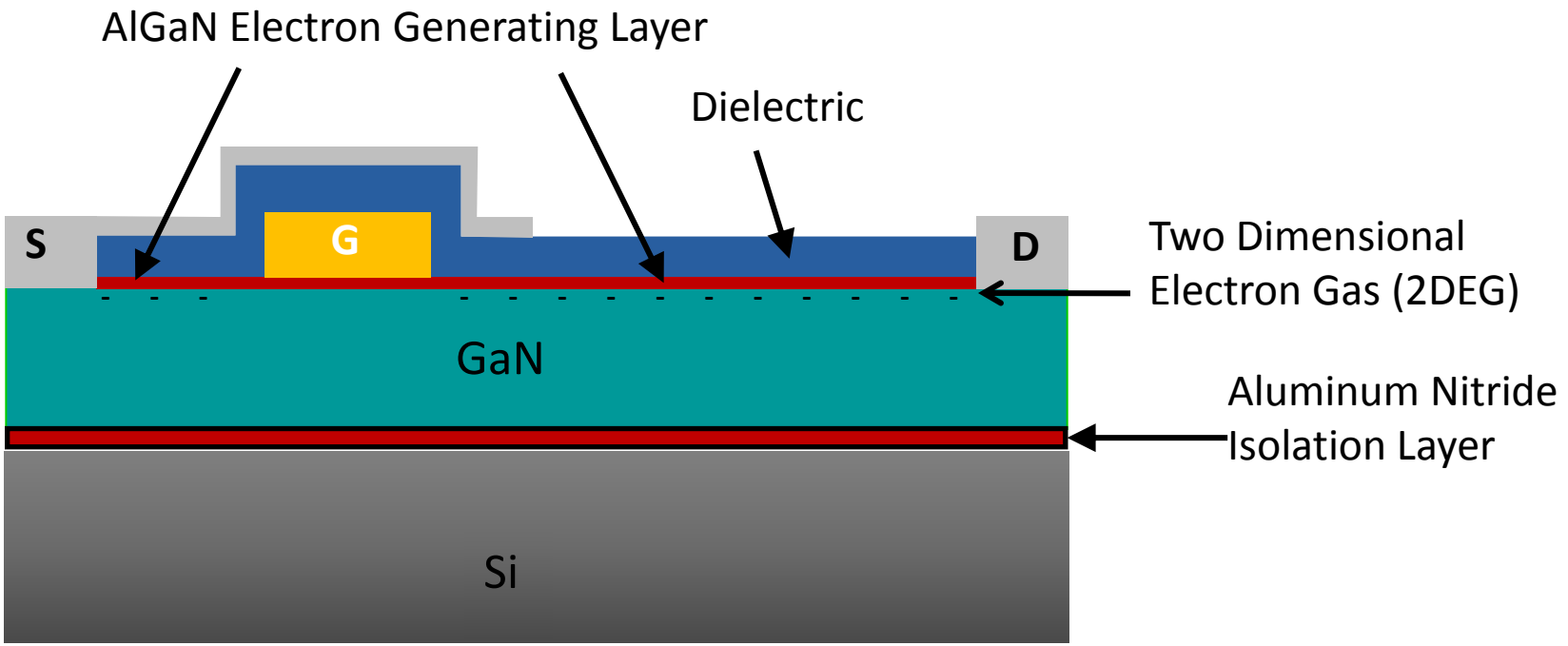
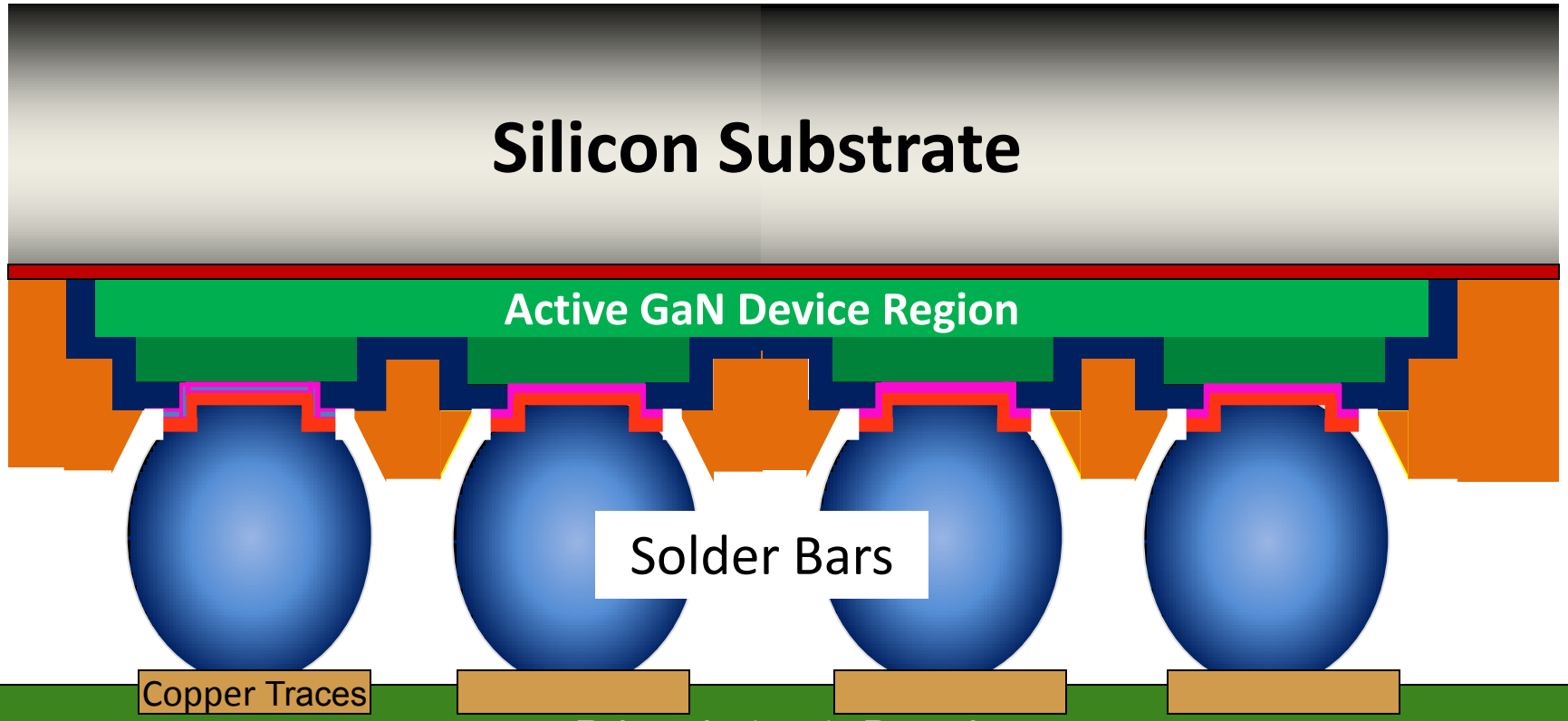
Agenda

- GaN Device Structure
- Envelope Tracking
- Wireless Power
- What is in the future?

eGaN® FET Structure



LGA Construction

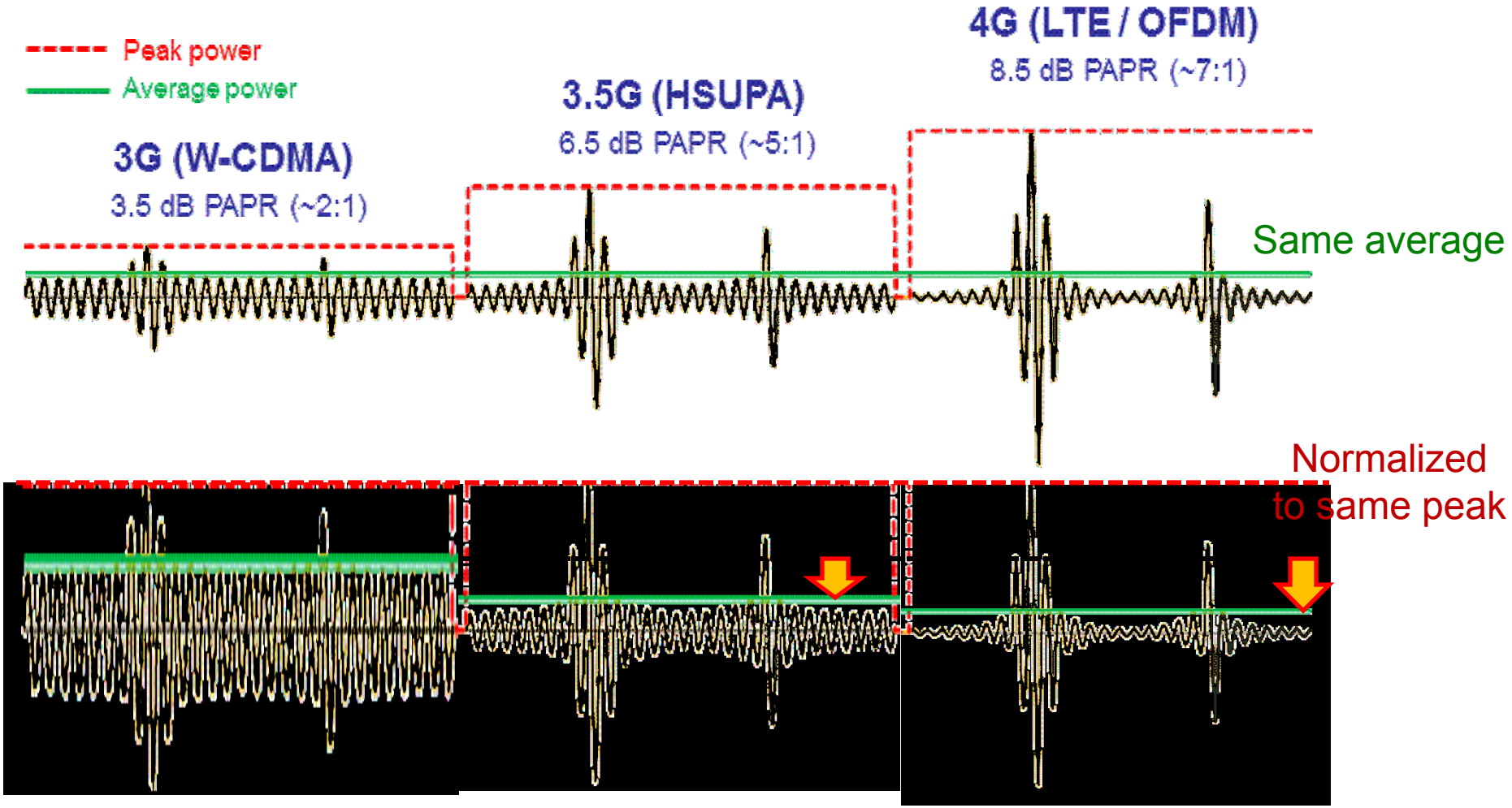


Key Applications

- RF DC-DC “Envelope Tracking”
- Wireless Power Transmission
- RadHard
- Power Over Ethernet
- RF Transmission
- Network and Server Power Supplies
- Point of Load Modules
- Solar Micro-inverters
- Energy Efficient Lighting
- Class D Audio

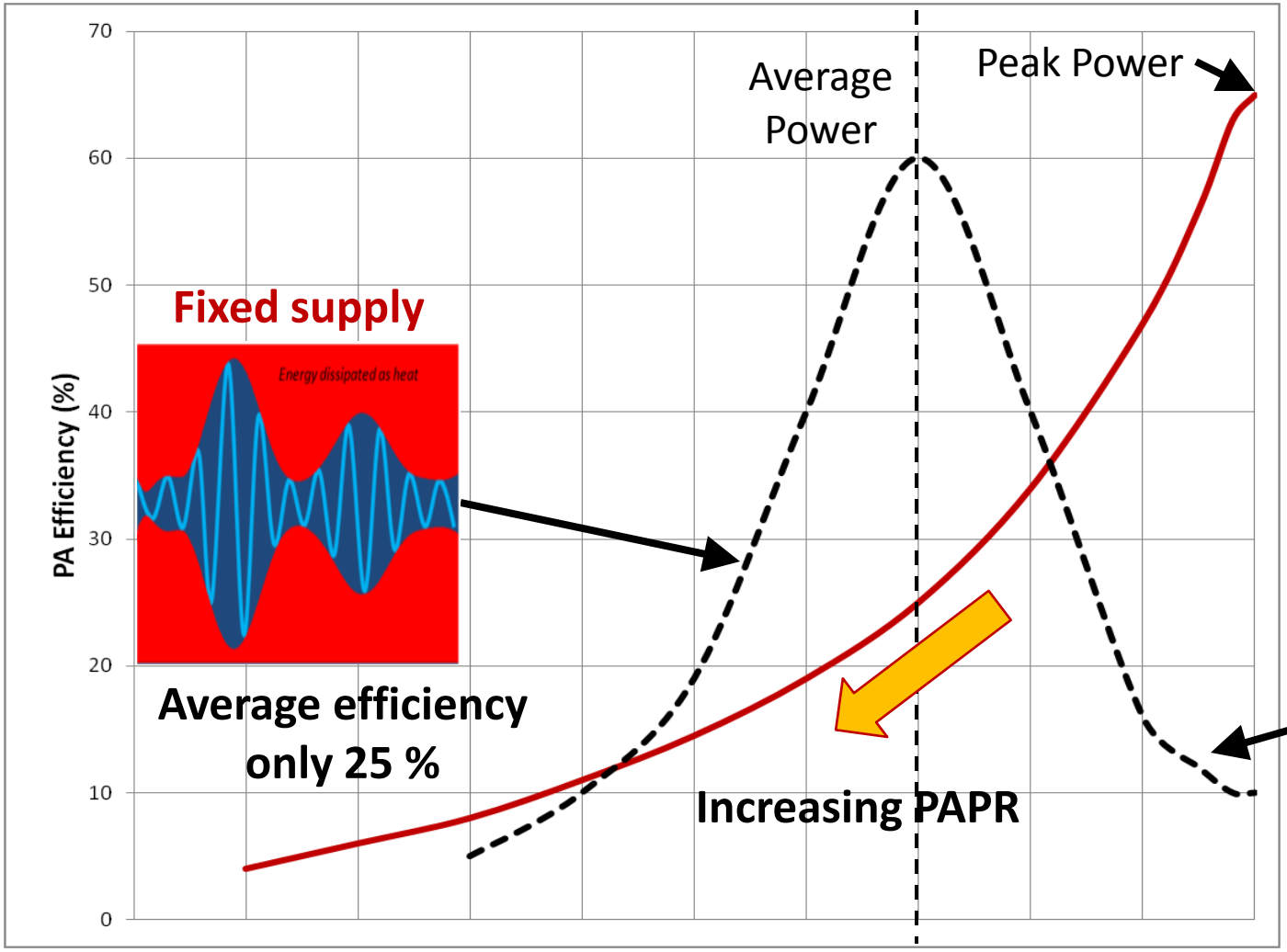
Envelope Tracking (ET)

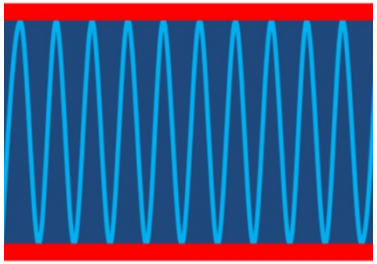
Peak to Average Power Ratio



Reference: Nujira.com website

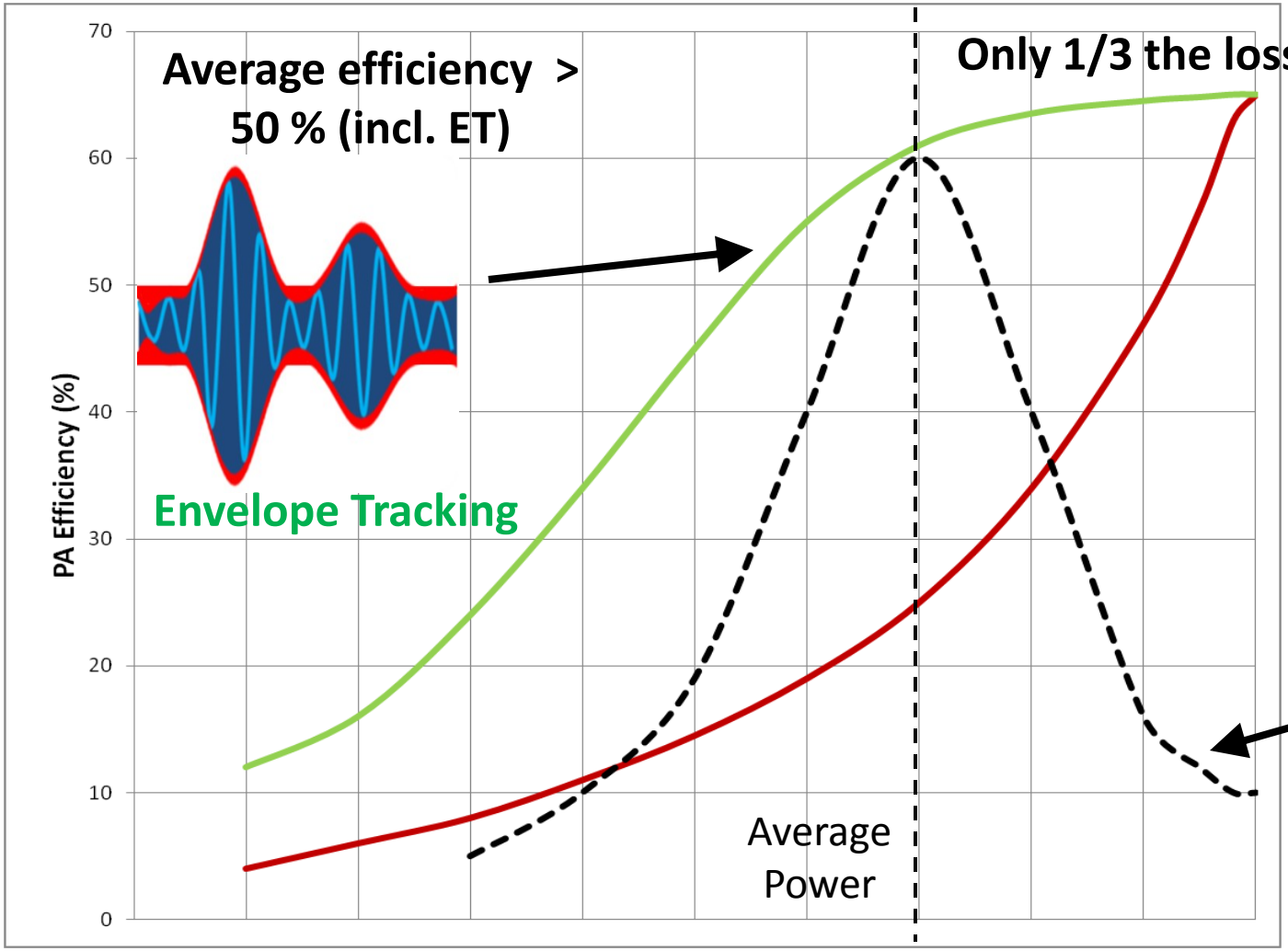
Effect of PAPR



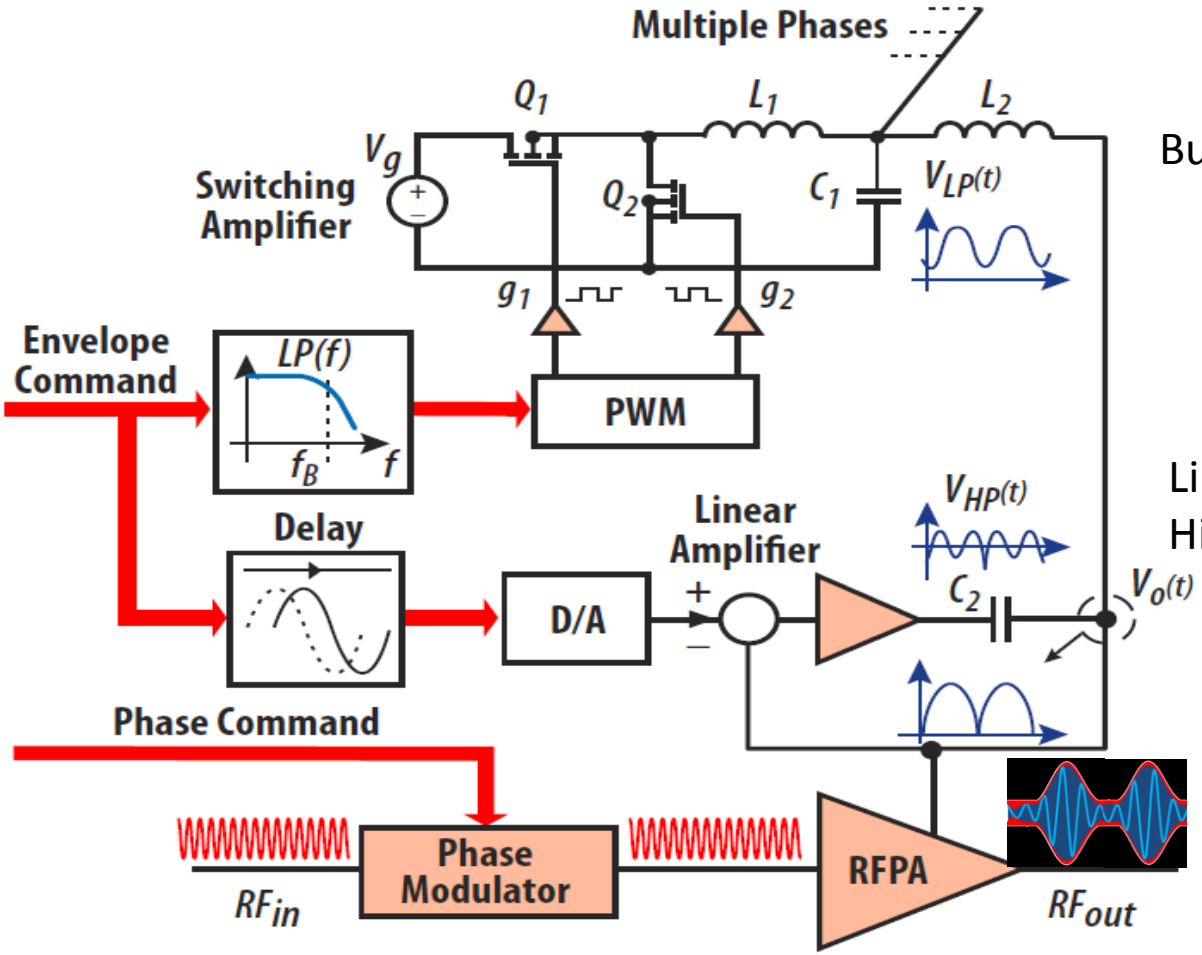


PAPR = 0dB
Peak efficiency up to 65%

Effect of Envelope Tracking



Envelope Tracking Supply

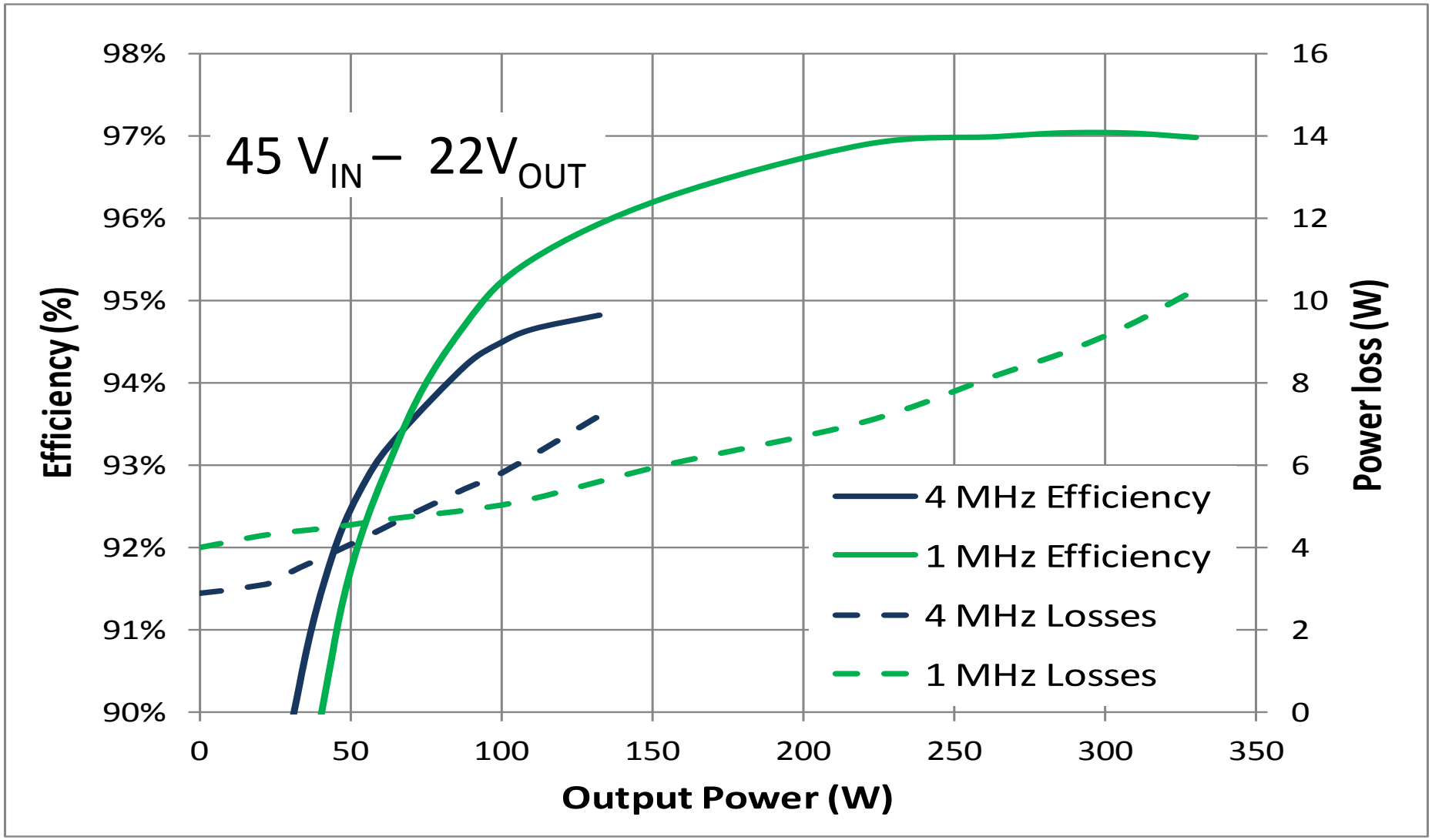


Buck ~ 10% Bandwidth
~ 90% Power

Linear AMP ~ 10% Power
Highest 90% of Bandwidth

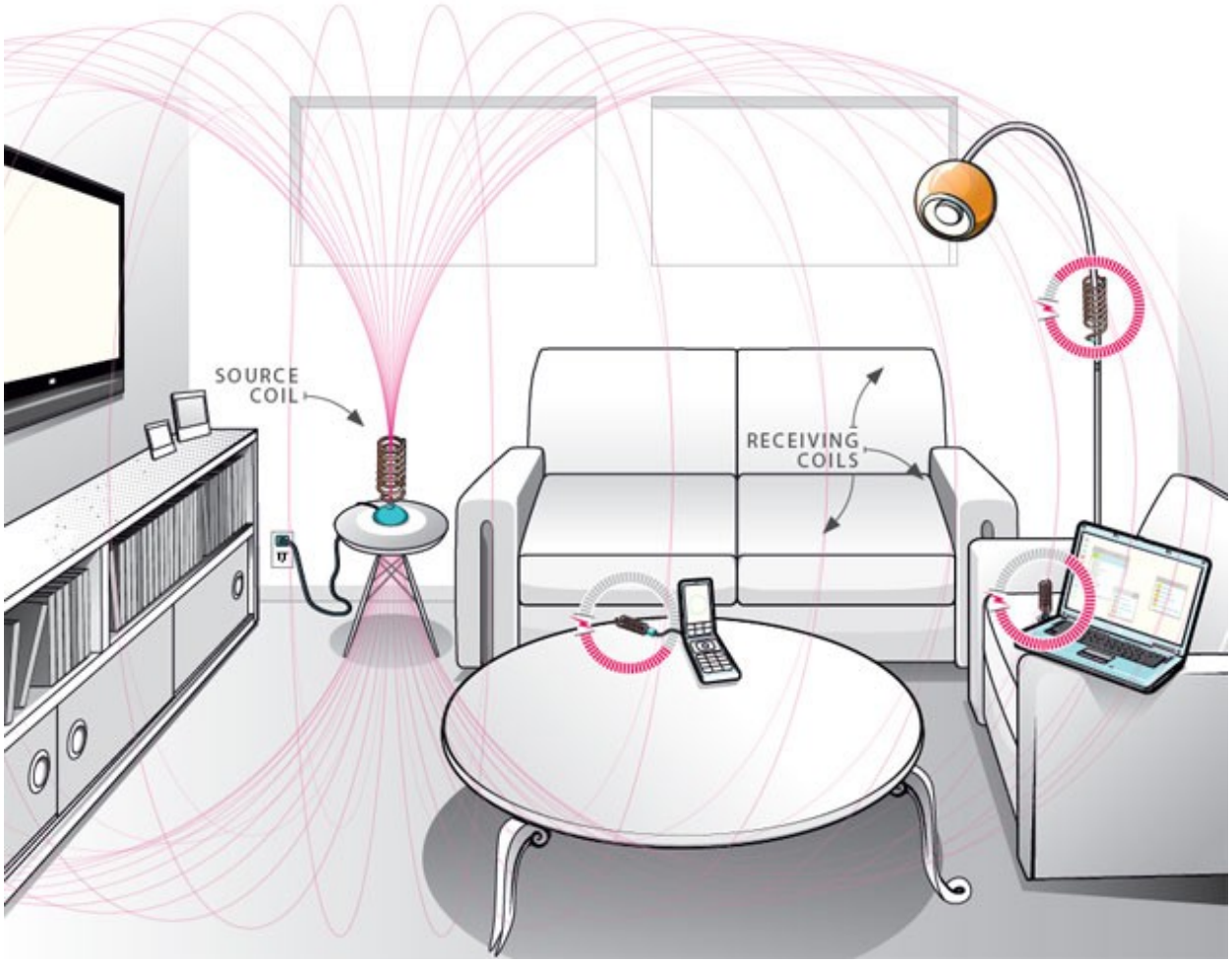
*Reference: V. Yousefzadeh, et al, Efficiency optimization in linear-assisted switching power converters for envelope tracking in RF power amplifiers, ISCAS 2005

Efficiency Results



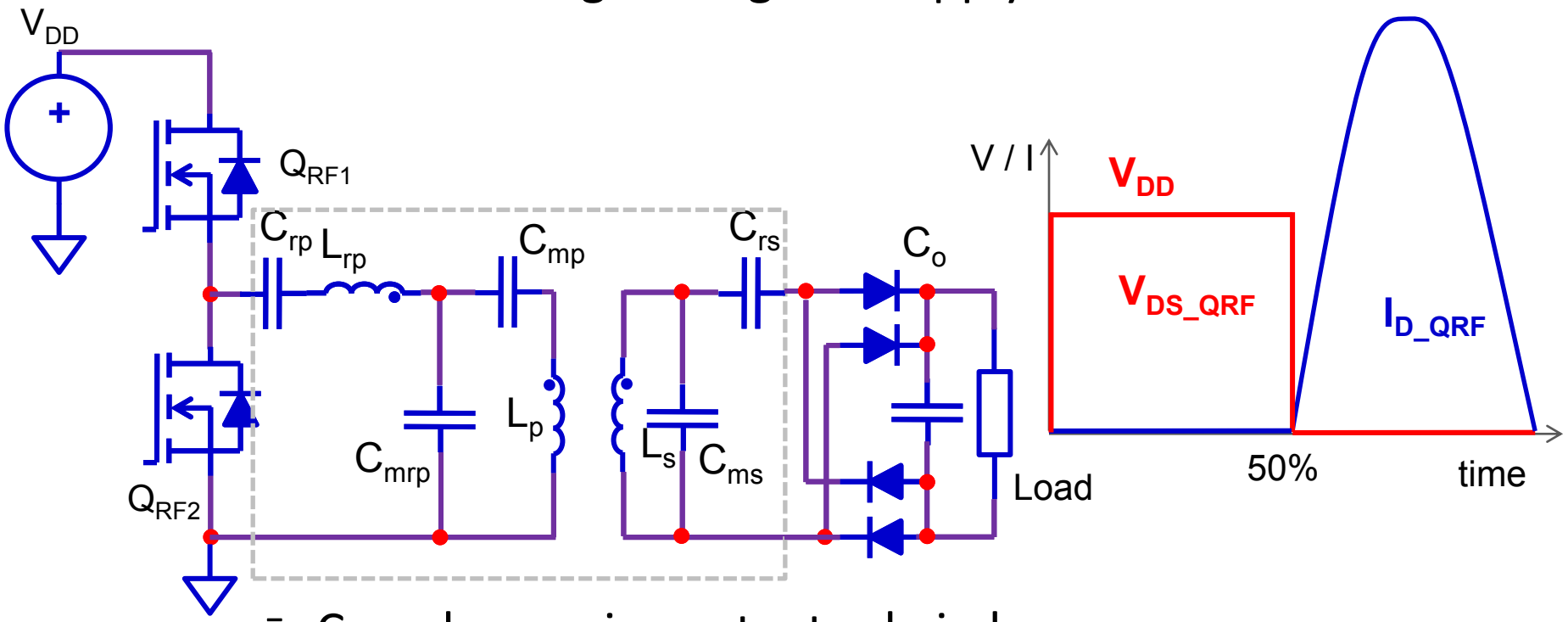
Wireless Power

Wireless Power



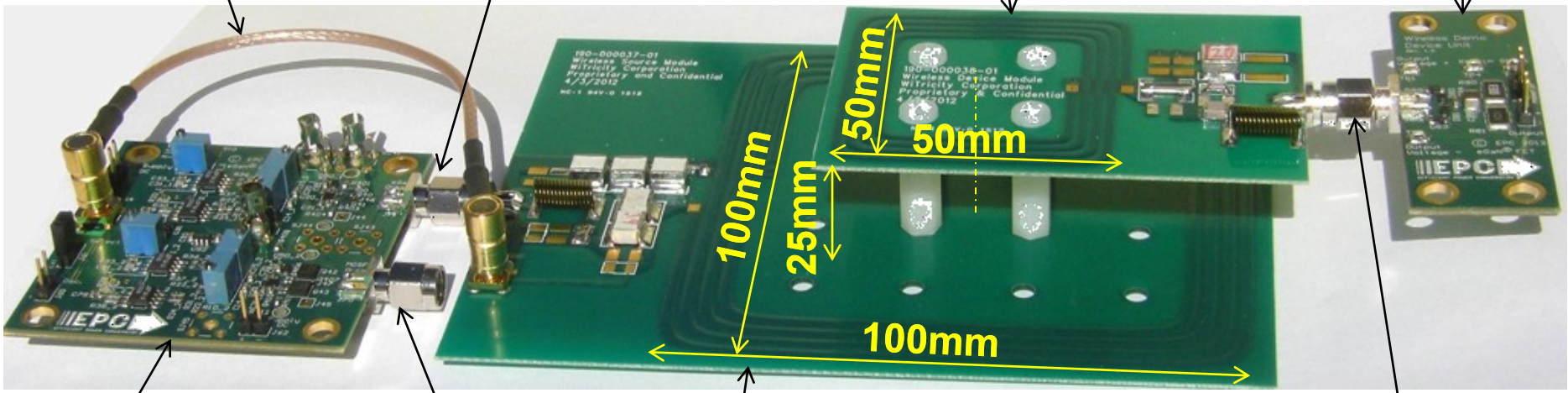
Class D Wireless Power

+ Resonant design is in the coil set
+ Switch voltage rating = to supply value

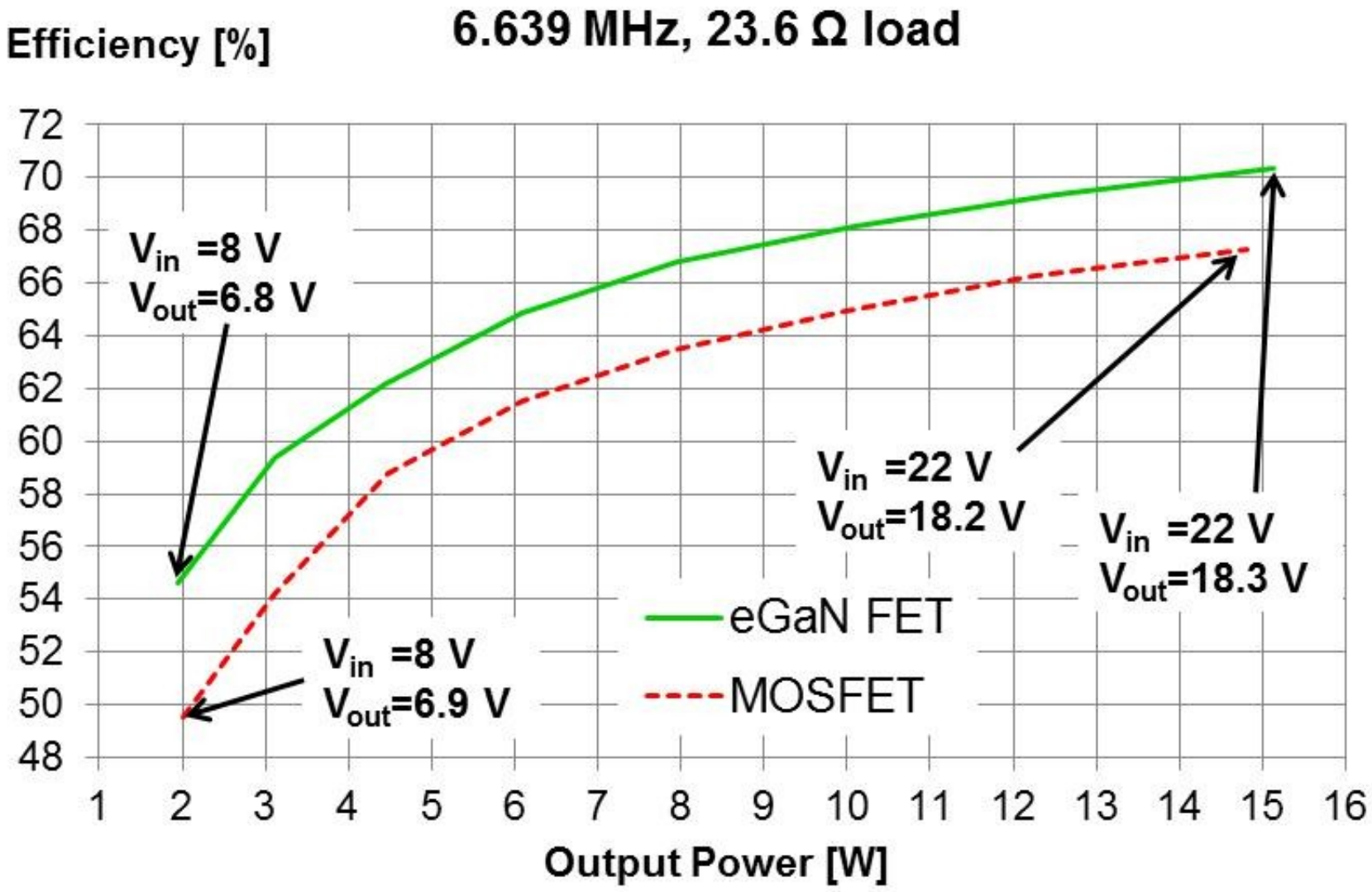


- C_{OSS} plays an important role in losses

System Setup



Efficiency


6.639 MHz, 23.6 Ω load
Efficiency [%]
72
70
68
66
64
62
60
58
56
54
52
50
48
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Output Power [W]
Vin =8 V
Vout=6.8 V
Vin =8 V
Vout=6.9 V
Vin =22 V
Vout=18.2 V
Vin =22 V
Vout=18.3 V
eGaN FET
MOSFET

What's in the Future?

Breaking Down the Barriers

- Does it enable significant new capabilities?
- Is it easy to use?
- Is it VERY cost effective to the user?
- Is it reliable?

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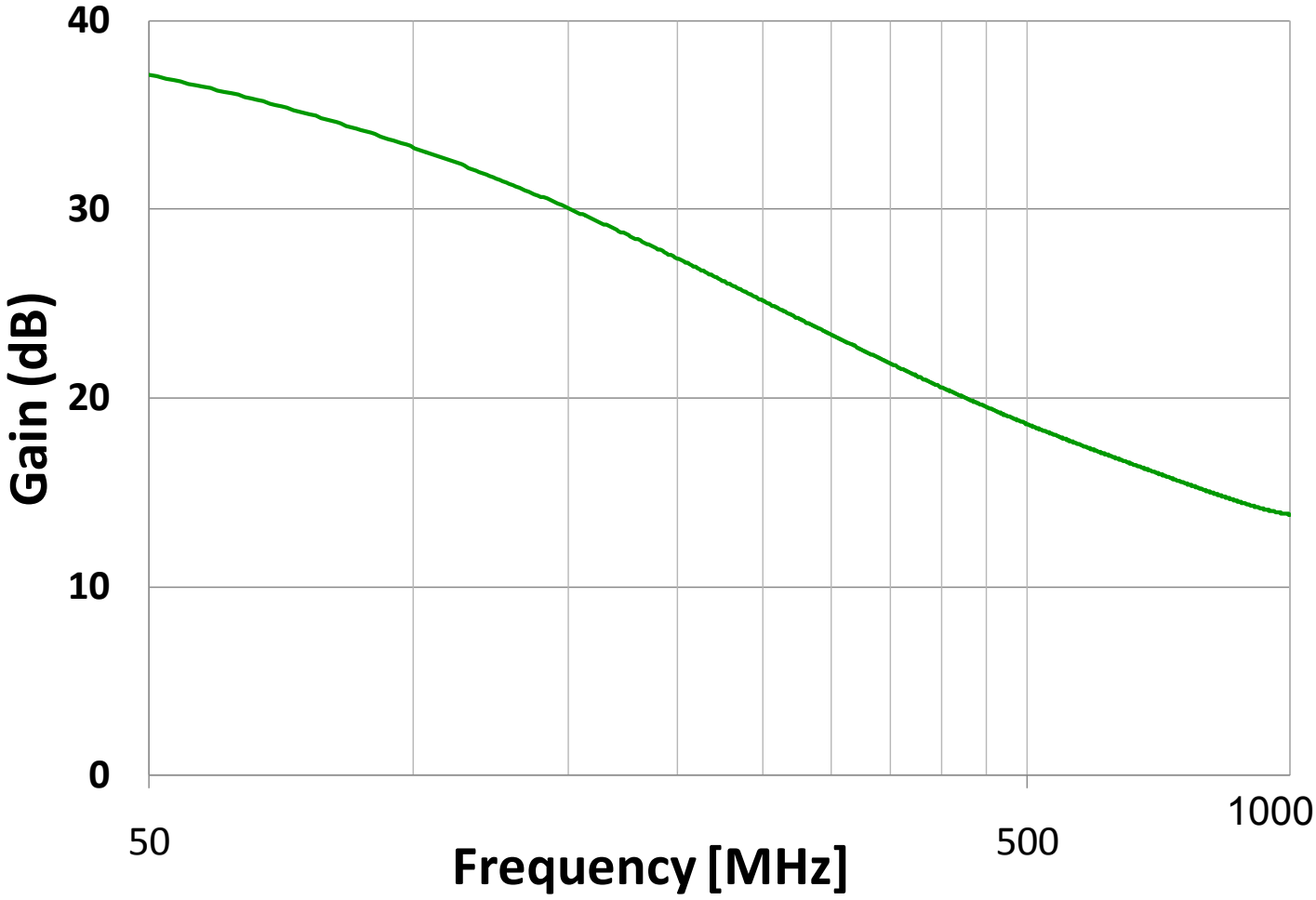
High Frequency High Voltage *and* High Power

EPC 2012 Maximum Gain vs Frequency 200 V eGaN FETs



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Is an eGaN FET Easy to Use?

It's just like a MOSFET

except

The high frequency capability makes circuits using eGaN FETs sensitive to layout

The lower $V_{G(MAX)}$ of 6 V makes it advisable to have V_{GS} regulation in your gate drive circuitry

What Other Advances are Needed?

- High speed digital controller ICs and integrated controller/driver ICs.
  - Application specific controllers to reduce time-to-market
  - Dynamic deadtime control with ~1 ns resolution
  - Envelope Tracking Controllers
- Improved measurement systems

Breaking Down the Barriers

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- Is it easy to use?
- Is it VERY cost effective to the user?
- Is it reliable?

Silicon vs. eGaN Wafer Costs

	2012	2015
Starting Material	same	same
Epi Growth	***higher***	***~same?***
Wafer Fab	same	lower
Test	same	same
Assembly	lower	lower
OVERALL	**higher**	***lower!***

Breaking Down the Barriers

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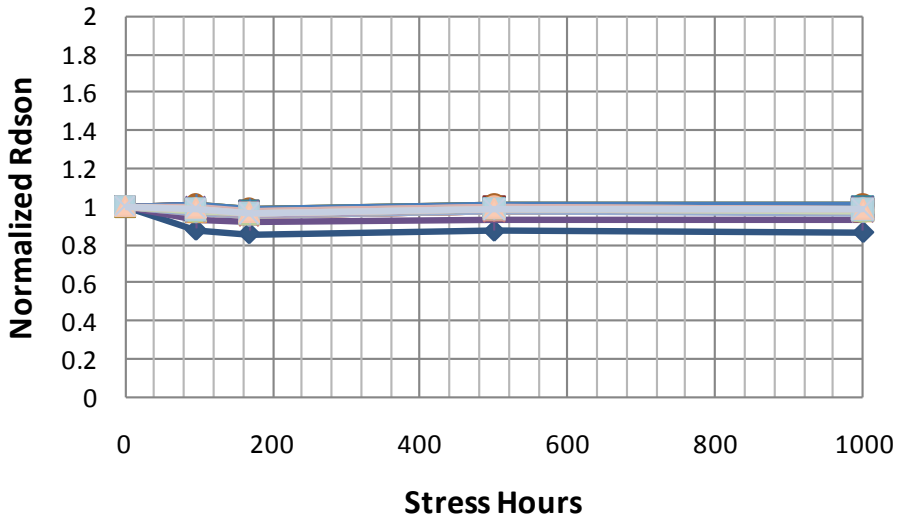
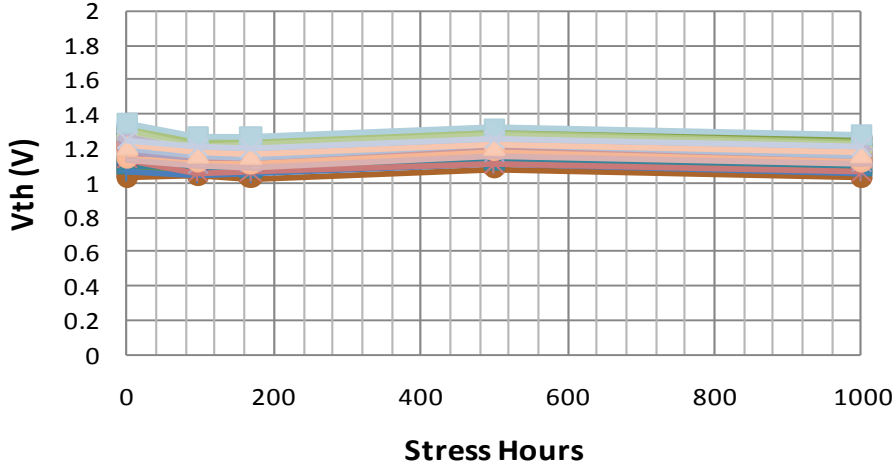
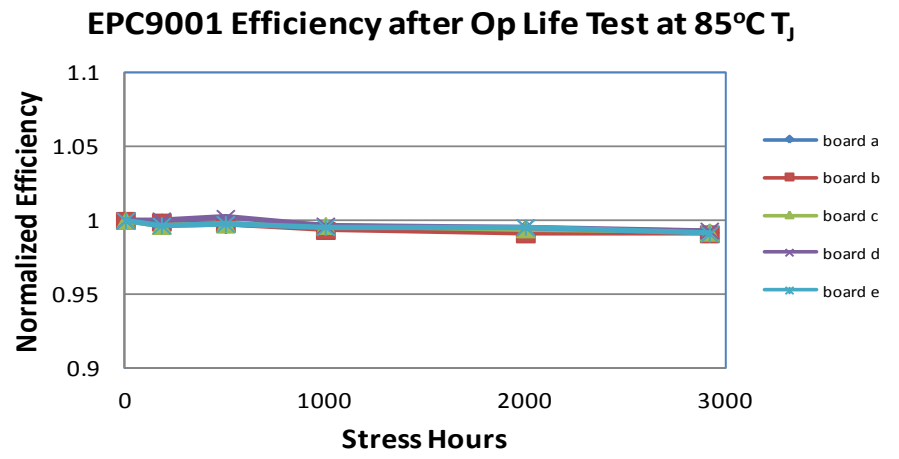
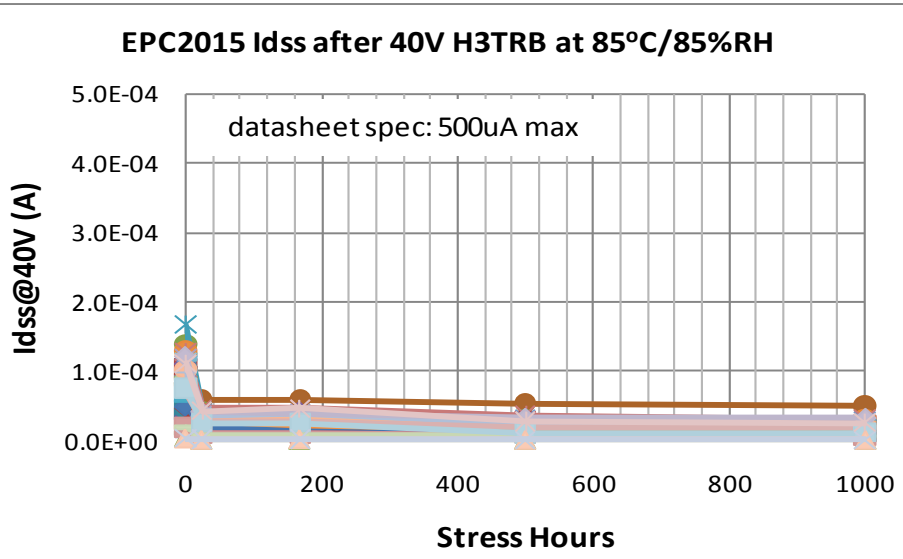
eGaN FETs are Reliable



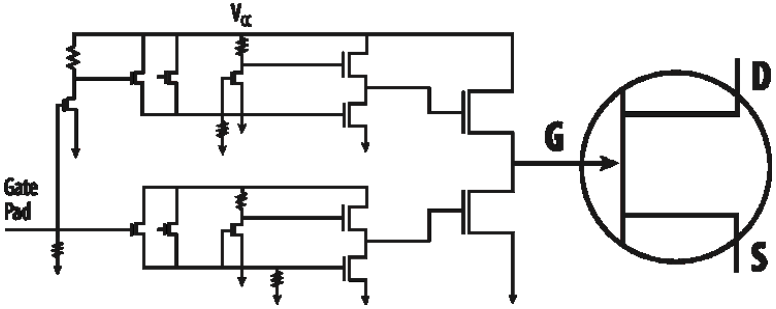




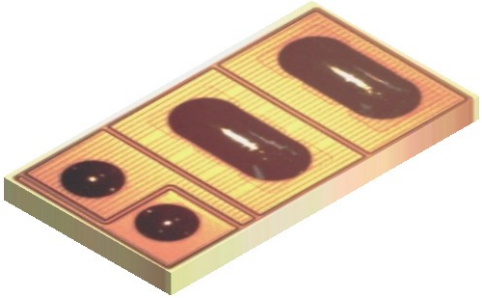


Beyond Discrete Devices

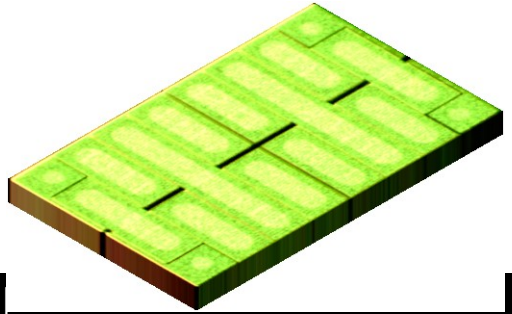
Driver On Board



Discrete FET with Driver



Full-Bridge with Driver and Level Shift



Summary

- GaN transistors improve efficiency compared with power MOSFETs in power conversion.
- eGaN FETs are straightforward to use, but you can't just drop them into a MOSFET socket.
- GaN transistors enable exciting new applications such as RF Envelope Tracking and Wireless Power Transmission.

EPC
EFFICIENT POWER CONVERSION

The end of the road for silicon…..

is the beginning of the eGaN FET journey!