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EPC
EFFICIENT POWER CONVERSION

The eGaN® FET Journey Continues

Performance Comparison for A4WP Class-3 Wireless Power Compliance between eGaN® FET and MOSFET in a Class E Amplifier

Agenda

- Introduction to the A4WP Class-3 Specifications
- Class E Amplifier
- eGaN® FET versus MOSFET Comparison
- Experimental Results
- Summary

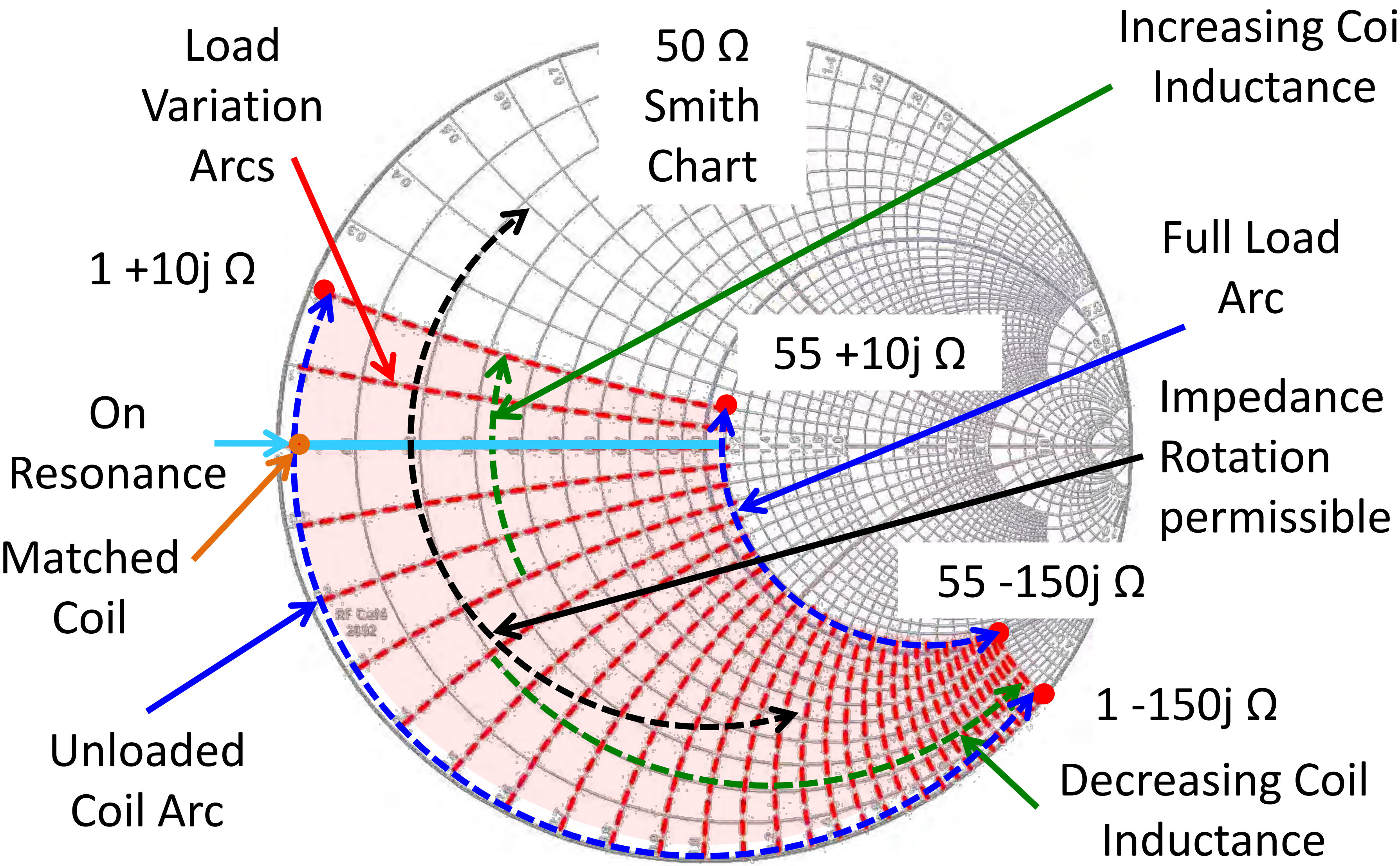
eGaN® is a registered trademark of Efficient Power Conversion Corporation

Introduction

- Wireless power transfer solutions must address convenience-of-use such as:

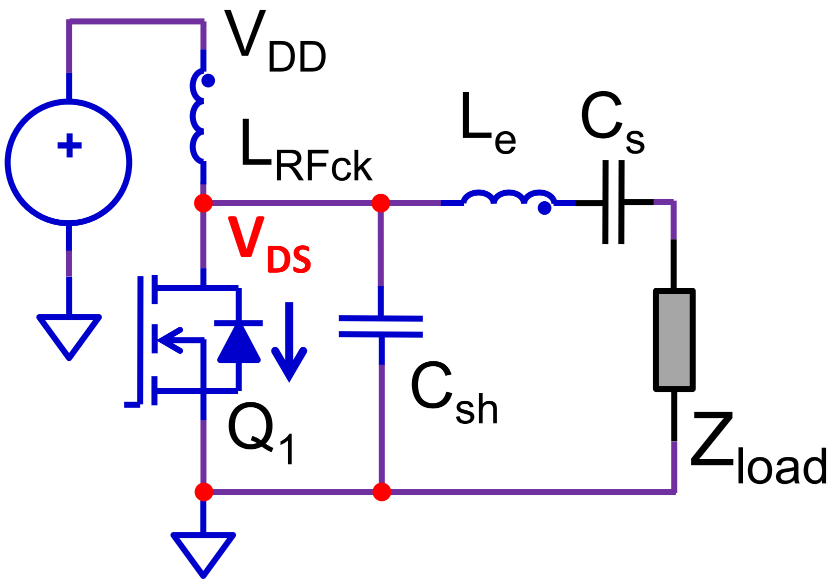
  device orientation and distance, multiple device capability, user simplicity, and power.
- Only the Alliance for Wireless Power (A4WP / Rezence) standard does:
  - Highly resonant (6.78 MHz ISM band)
  - Loosely coupled coils
  - Operation off-resonance
- Class E amplifier will be tested to the Class-3 requirements

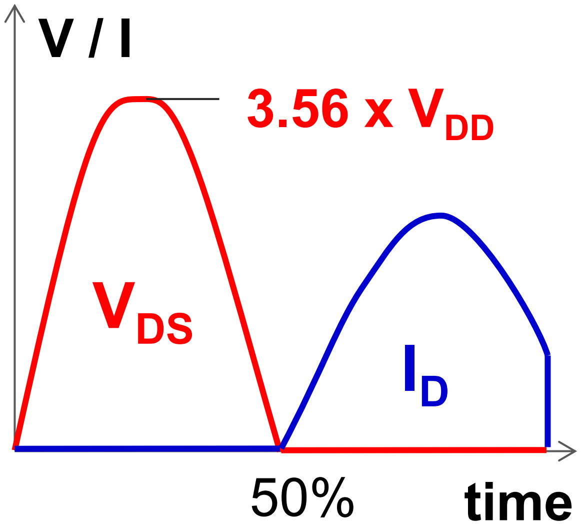
A4WP Class-3 Impedance Requirements



Class E Amplifier

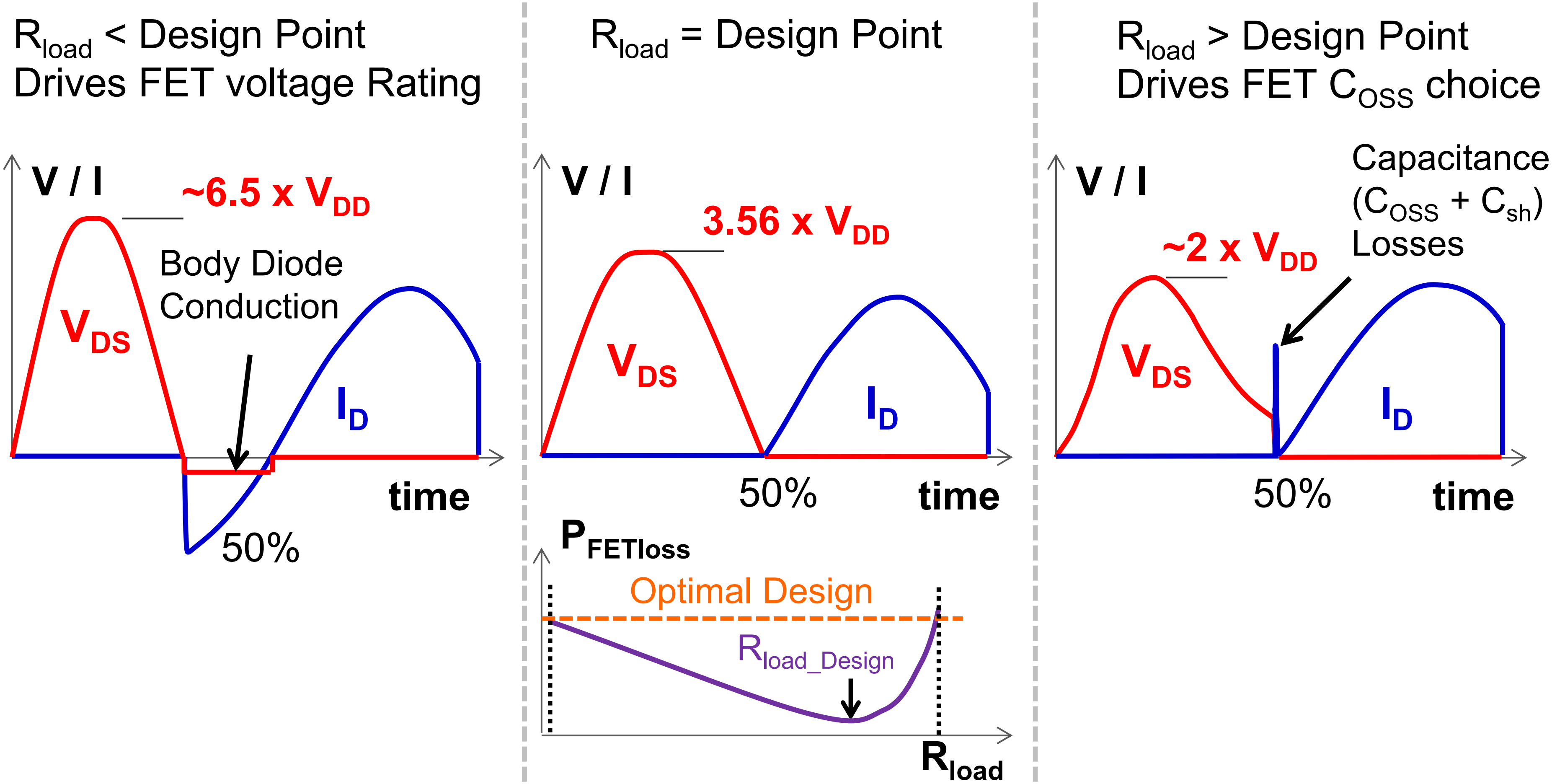
- Switch voltage rating = 3.56·Supply (V_{DD}) ideal operation, but can be up to 6.5 times!
- C_{OSS} "absorbed" into matching network.
- Susceptible to load variation - high FET losses
- Coil Voltage $= \frac{1}{\sqrt{2}} \cdot V_{DD}\ [V_{RMS}]$ (Ideal operation ONLY)





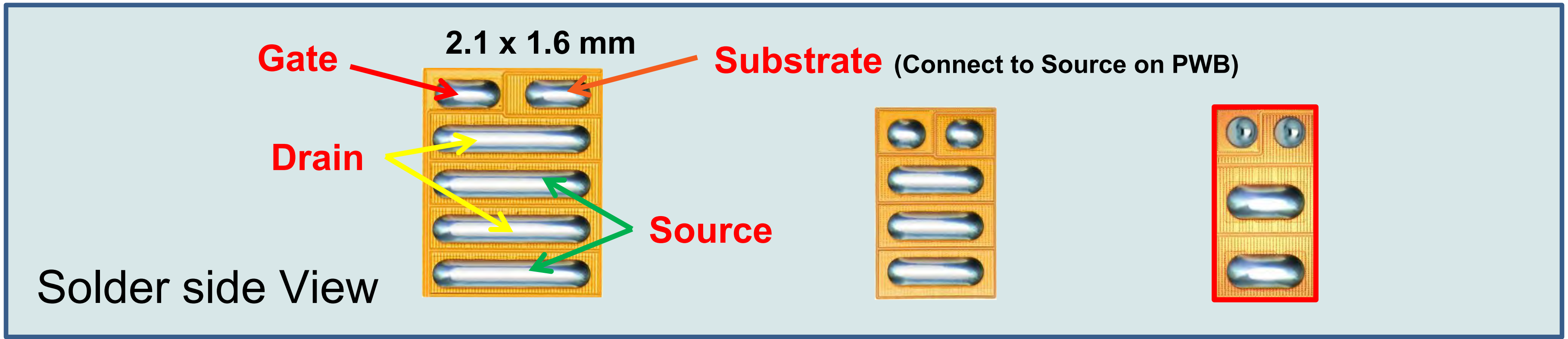
Ideal Waveforms

Impact of Load Resistance on Class E FET



Low Voltage eGaN FETs suitable for wireless power

- Proven in various wireless power transfer amplifiers
- Low C_{ISS}
- Low C_{OSS}
- Zero Q_{RR}

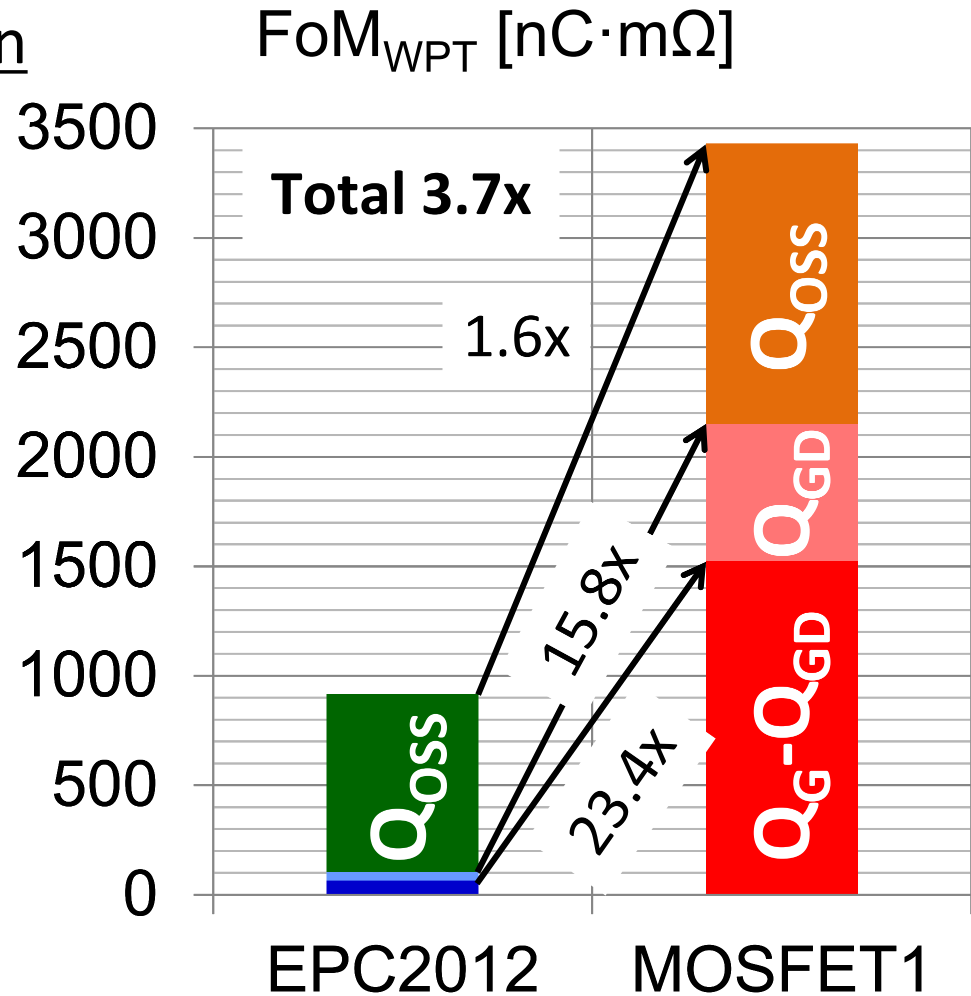


Part Number	Package (mm)	V_{DS} (V)	V_{GS} (V)	$R_{DS(on)}$ @5V (mΩ)	Q_G @5 V Typ. (nC)	Q_{GS} Typ. (nC)	Q_{GD} Typ. (nC)	R_G Typ. (Ω)	V_{th} Typ. (V)	Q_{RR} (nC)	I_D (A)	T_J Max. (°C)
EPC2014C	LGA 1.7x1.1	40	6	16	2.0	0.7	0.3	0.6	1.4	0	10	150
EPC2016C	LGA 2.1x1.6	100	6	16	3.4	1.1	0.55	0.6	1.4	0	18	150
EPC2007C	LGA 1.7x1.1	100	6	30	1.6	0.6	0.3	0.6	1.4	0	6	150
EPC2012C	LGA 1.7x0.9	200	6	100	1.0	0.3	0.2	0.6	1.4	0	5	150

Wireless Power Transfer Figure of Merit

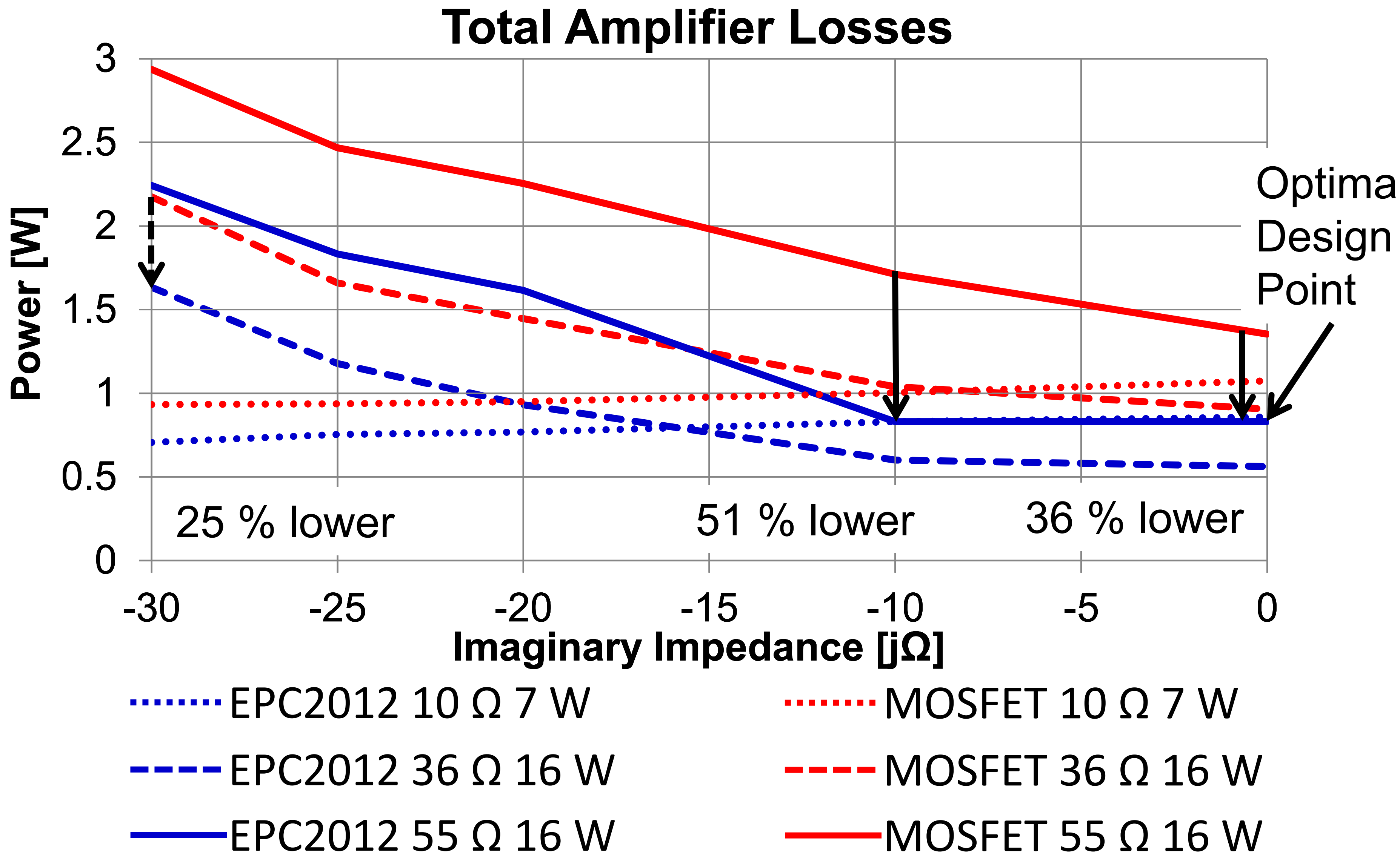
<u>Best-In-Class MOSFET comparison</u>

- ZVS: $Q_G - Q_{GD}$, except Partial ZVS mode ($R_{load} > R_{design}$)
- C_{OSS} "absorbed" in matching, still important:
  - Drives off resonance losses
  - Determines design-ability
- Q_{RR} ignored – poorly defined, ZVS, & device turned on after diode conduction.

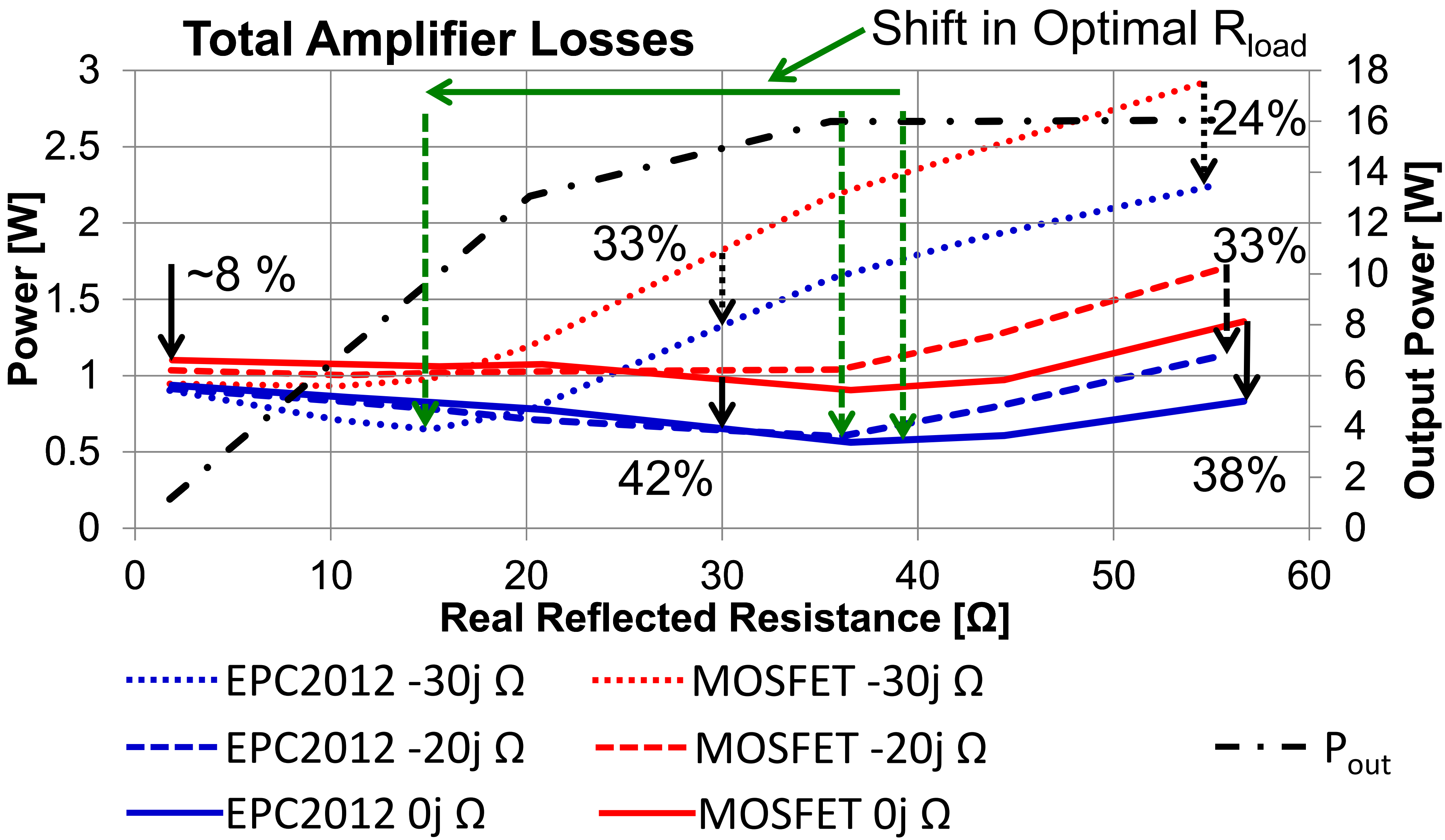


$$FOM_{WPT} = R_{DS(on)} \cdot (Q_G - Q_{GD} + Q_{OSS})$$

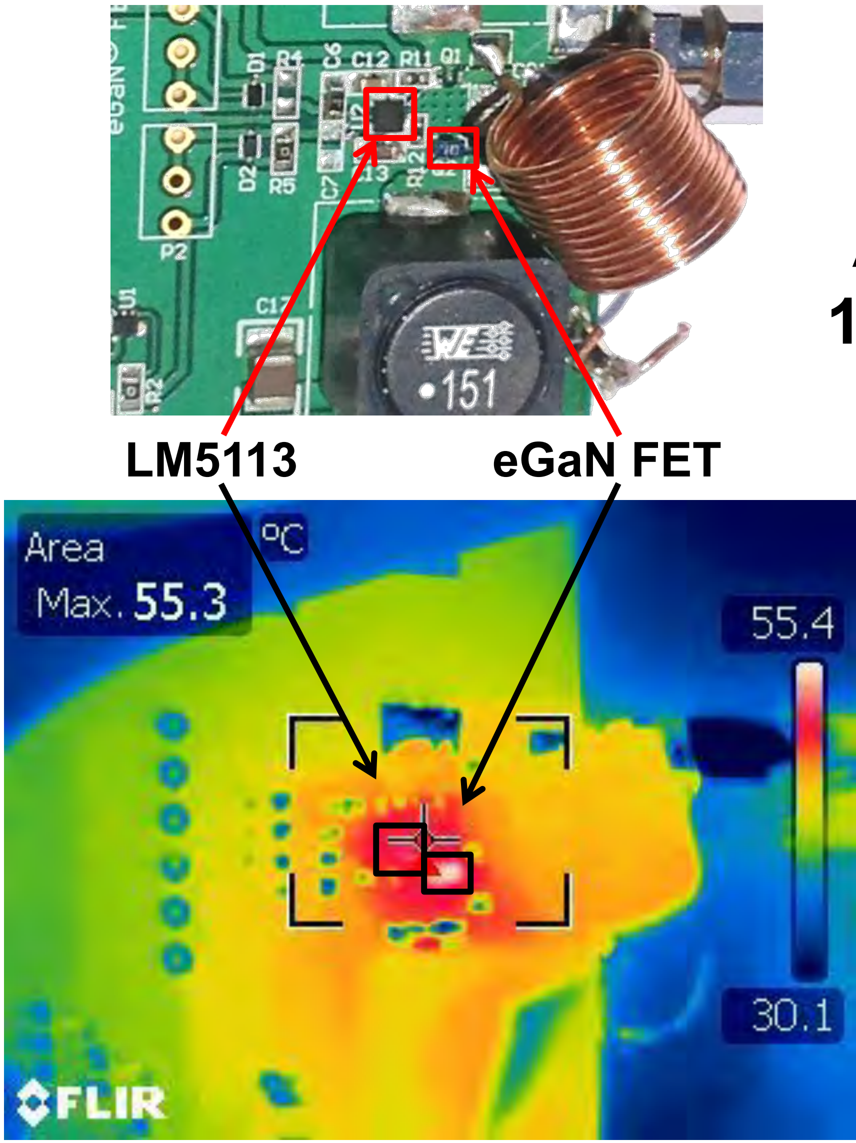
Load Variation (jΩ) Results



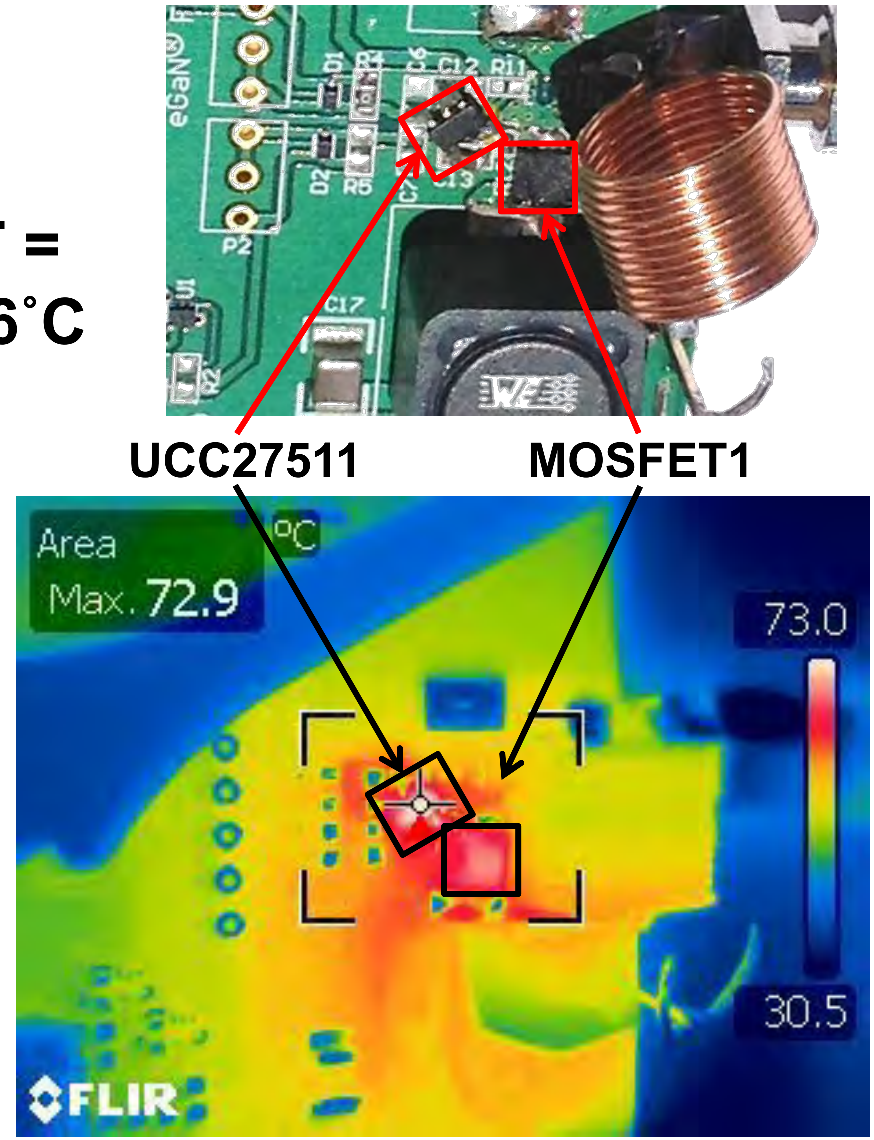
Load Variation (Ω) Results



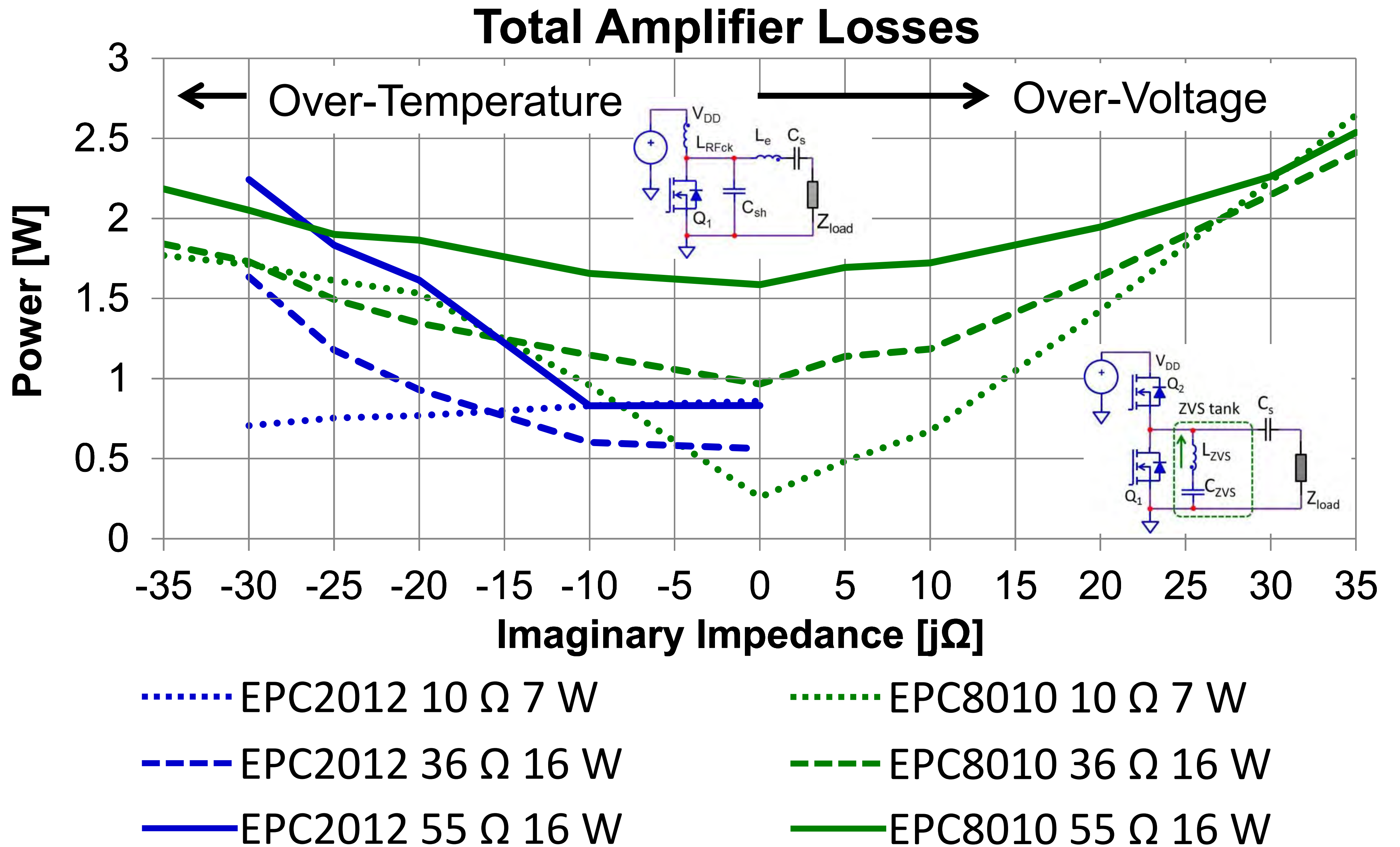
Thermal Performance Comparison



ΔT = 17.6˚C



Comparison with ZVS Class D

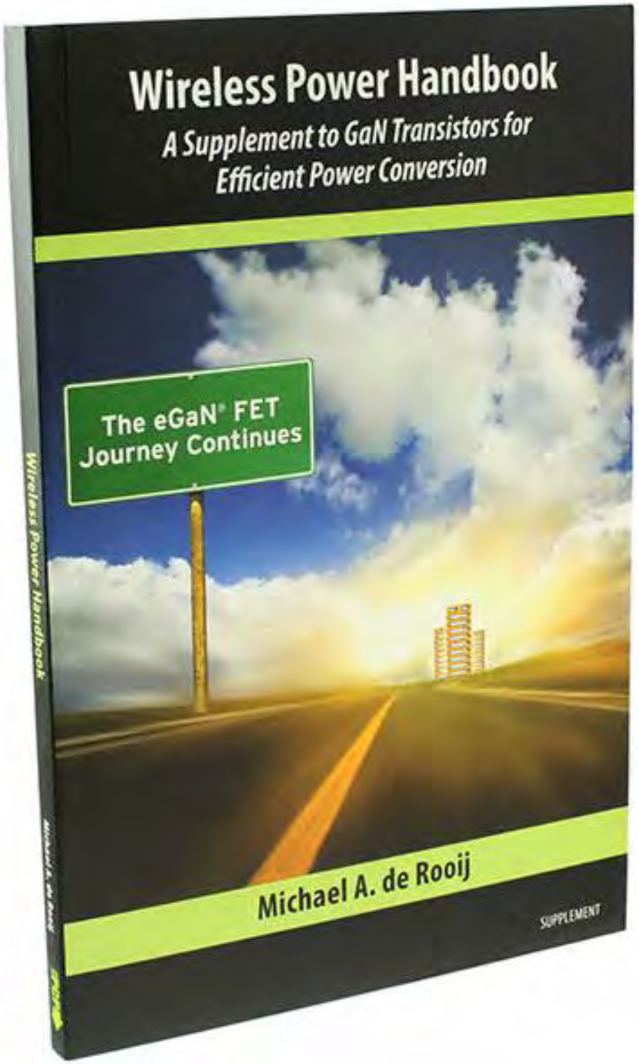


Summary

eGaN FETs in a Class E amplifier were tested to the A4WP Class-3 specifications :

- eGaN FETs always yield higher efficiency than best-in-class MOSFETs
- eGaN FETs operate at lower temperature than best-in-class MOSFETs
- eGaN FET's lower C_{ISS} reduces gate driver power consumption
- eGaN FETs reduce board space by 50 %
- Additional performance can be achieved using ZVS Class D

Handbook on wireless power that covers this work and much more – available at Digi-Key (917-1098-ND)



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Where is GaN going…