Performance Evaluation of eGaN® FETs in Low Power High Frequency Class E Wireless Energy Converter

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Agenda

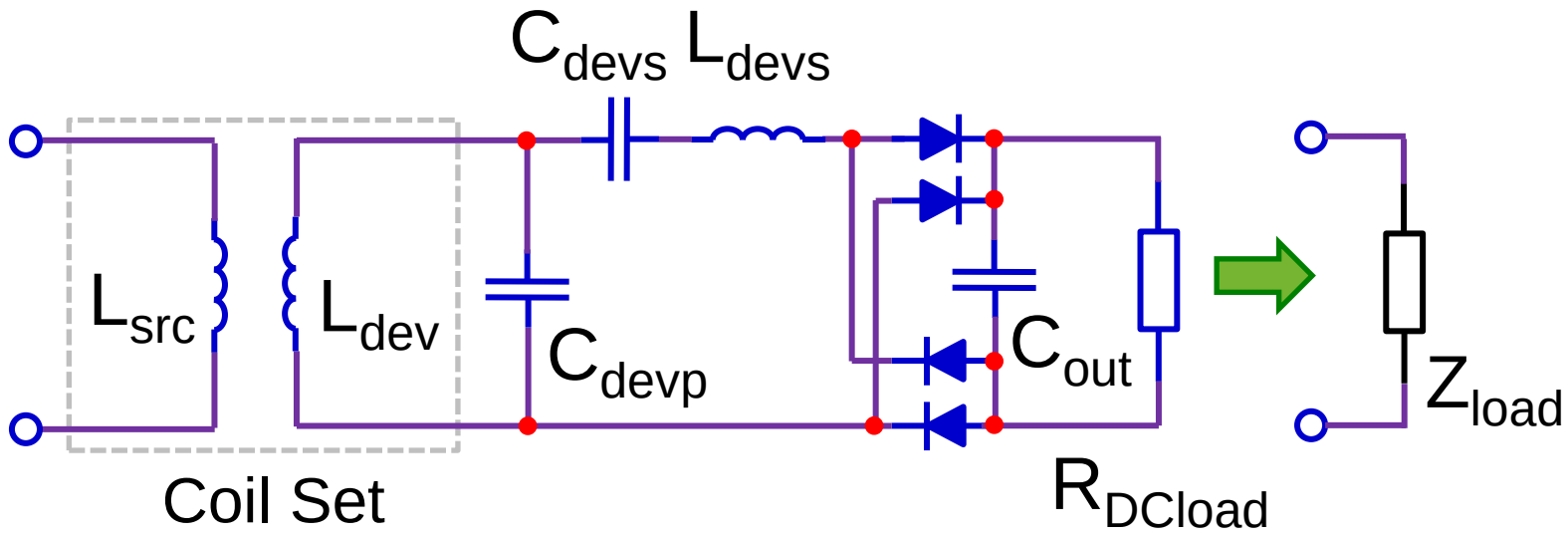
- Why GaN?
- Topologies Evaluated
- Wireless Power Figure of Merit
- Device Comparison
- Experimental Verification
- Summary

Why eGaN FETs for Wireless

- Low C_{ISS} and C_{OSS}
- Low $R_{DS(on)}$ for equal voltage rating
- Low profile
- Gate Drivers available:
  - LM5113
  - LM5114
  - UCC27611

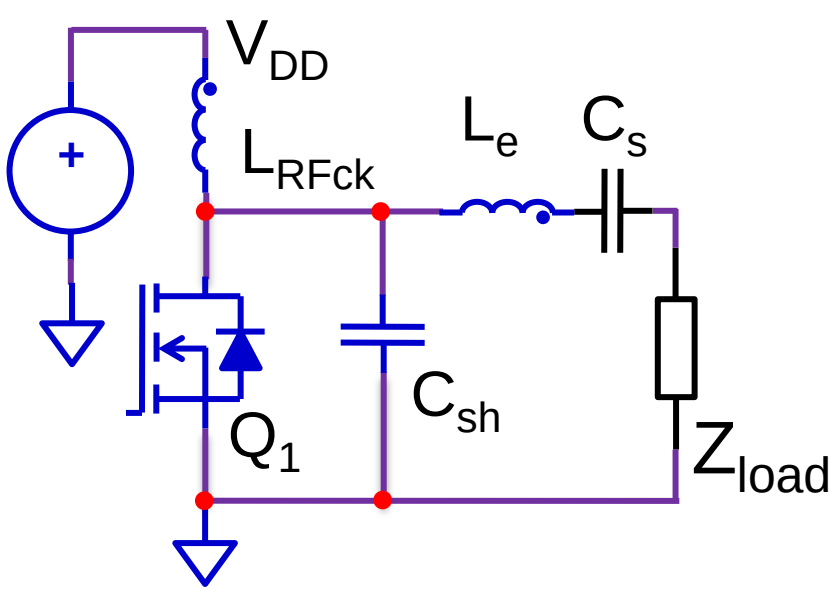
Coil Simplification

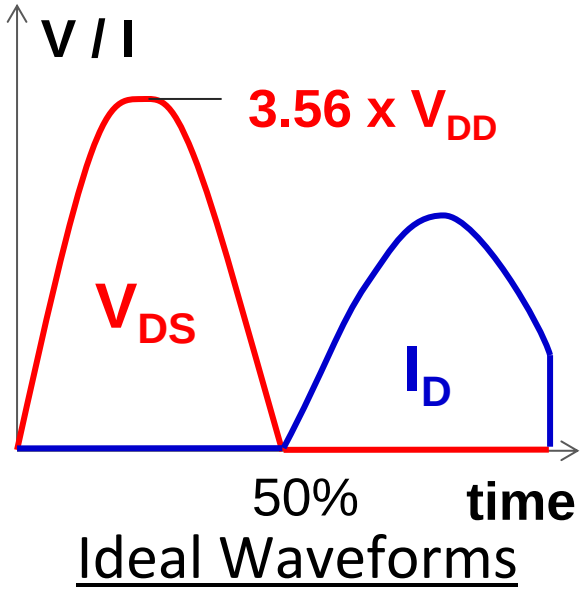
Simplified representation of coil-set for easy comparison between topologies



Single Ended Class E

- Switch voltage rating ≥ 3.56·Supply (V_{DD}).
- C_{OSS} "absorbed" into matching network.
- Susceptible to load variation - high FET losses.
- Coil voltage ≈ 0.707·V_{DD} [V_{RMS}].

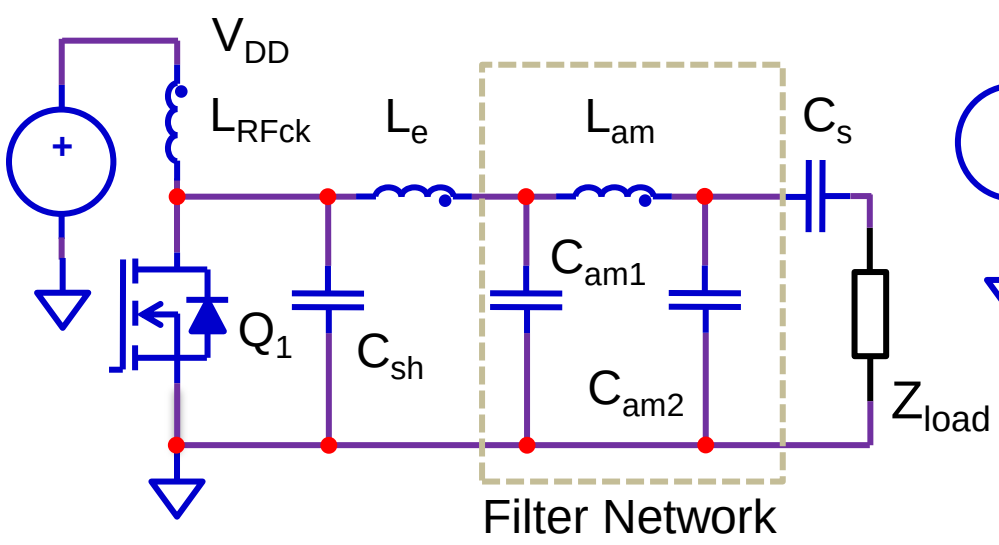


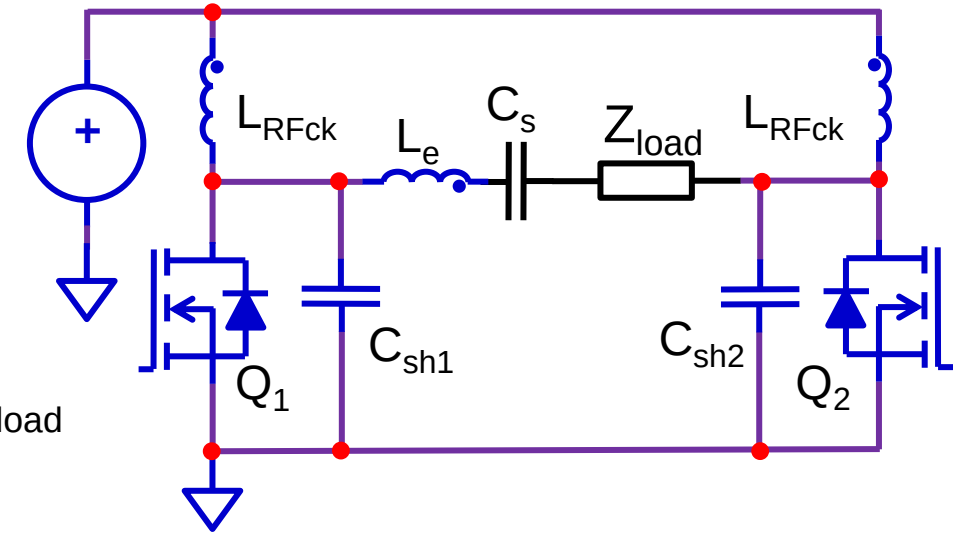


Ideal Waveforms

Class E Topology Variations

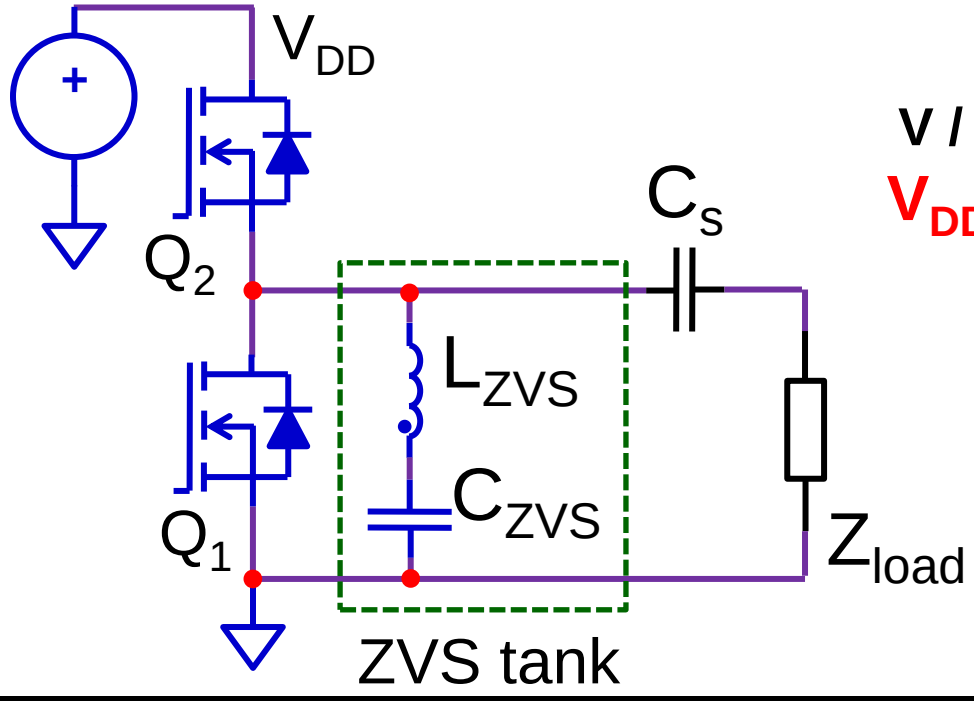
- Impedance matching filter for load variations.
- Differential mode:
  - Increases output power.
  - Reduced voltage harmonics.
  - Coil voltage ≈ $1.414 \cdot V_{DD}$ [V_{RMS}].

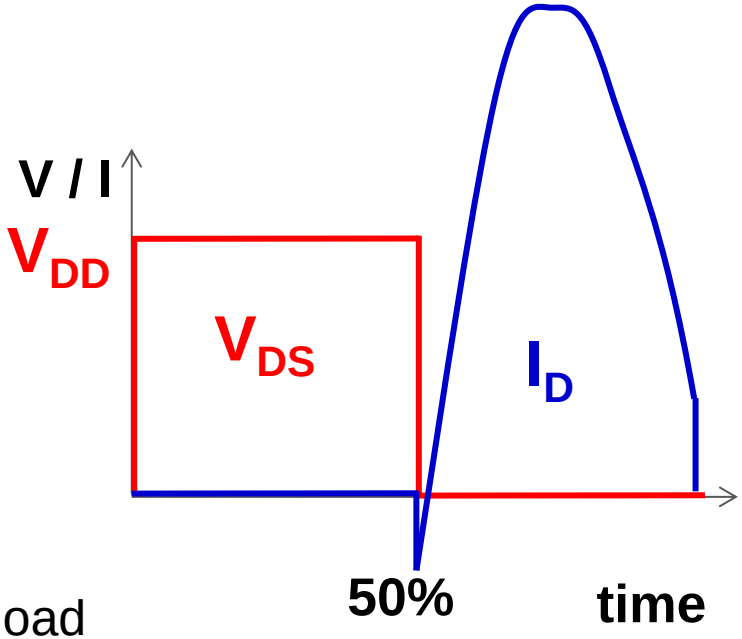




ZVS Class D

- Switch voltage rating = Supply (V_{DD}).
- C_{OSS} voltage is transitioned by the ZVS tank .
- ZVS tank circuit does not carry load current.
- Coil voltage = ½·V_{DD} [V_{RMS}].

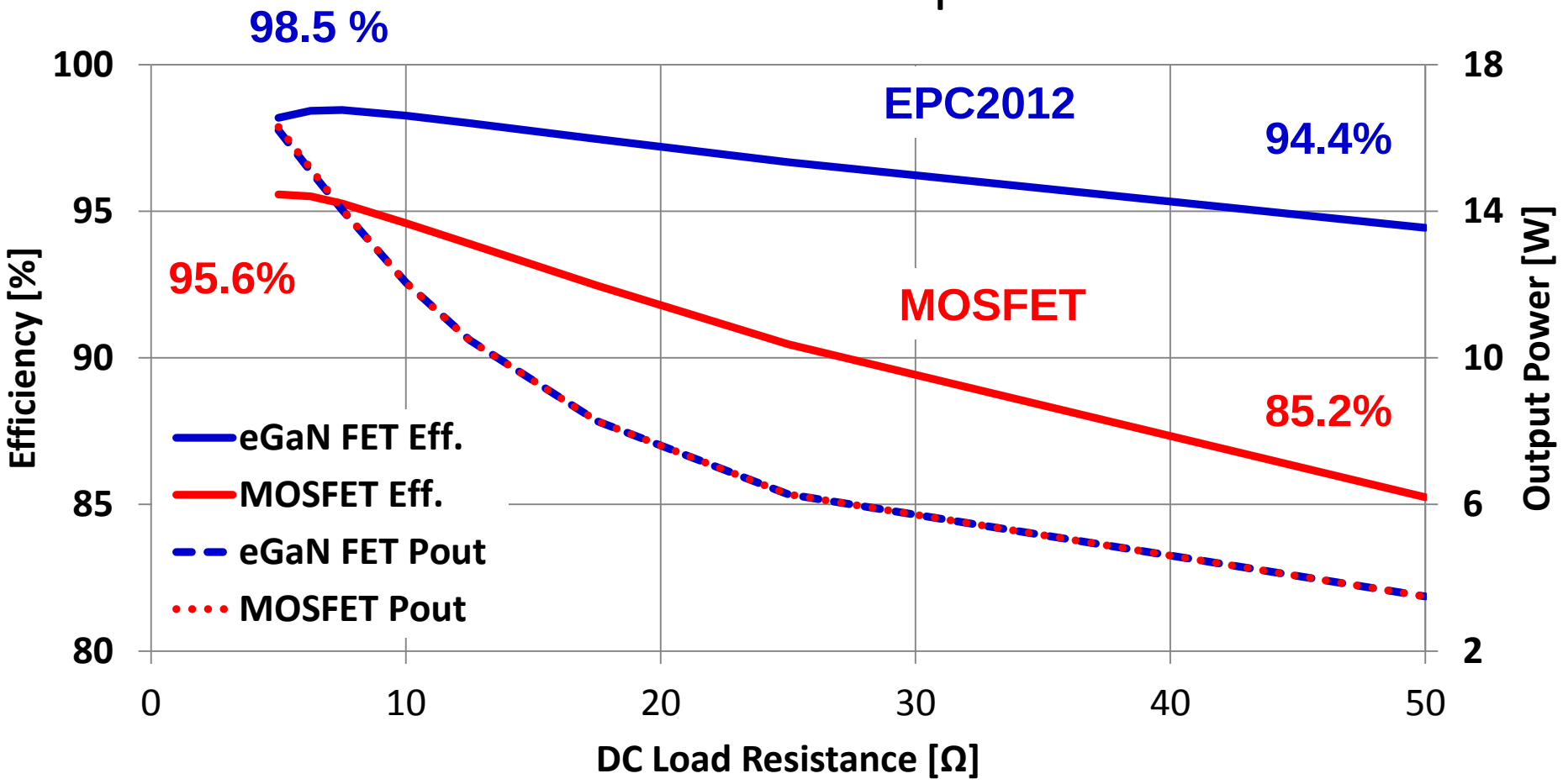




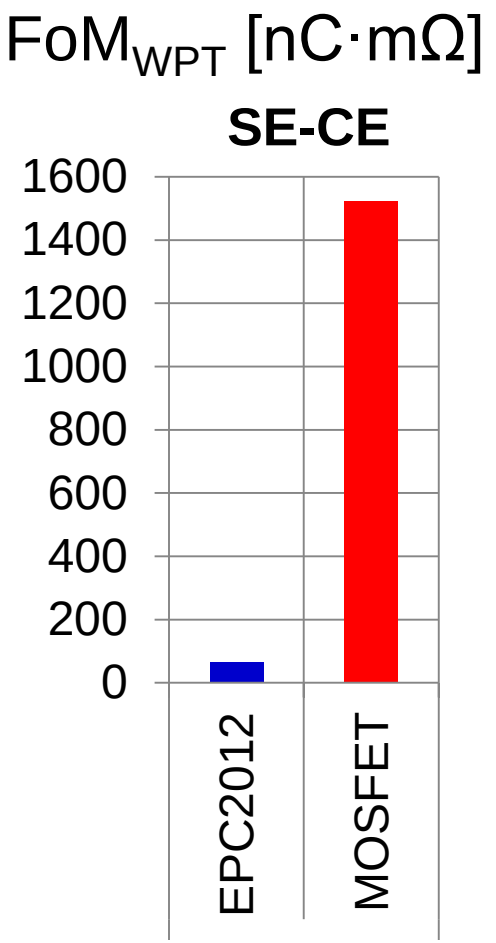
Ideal Waveforms

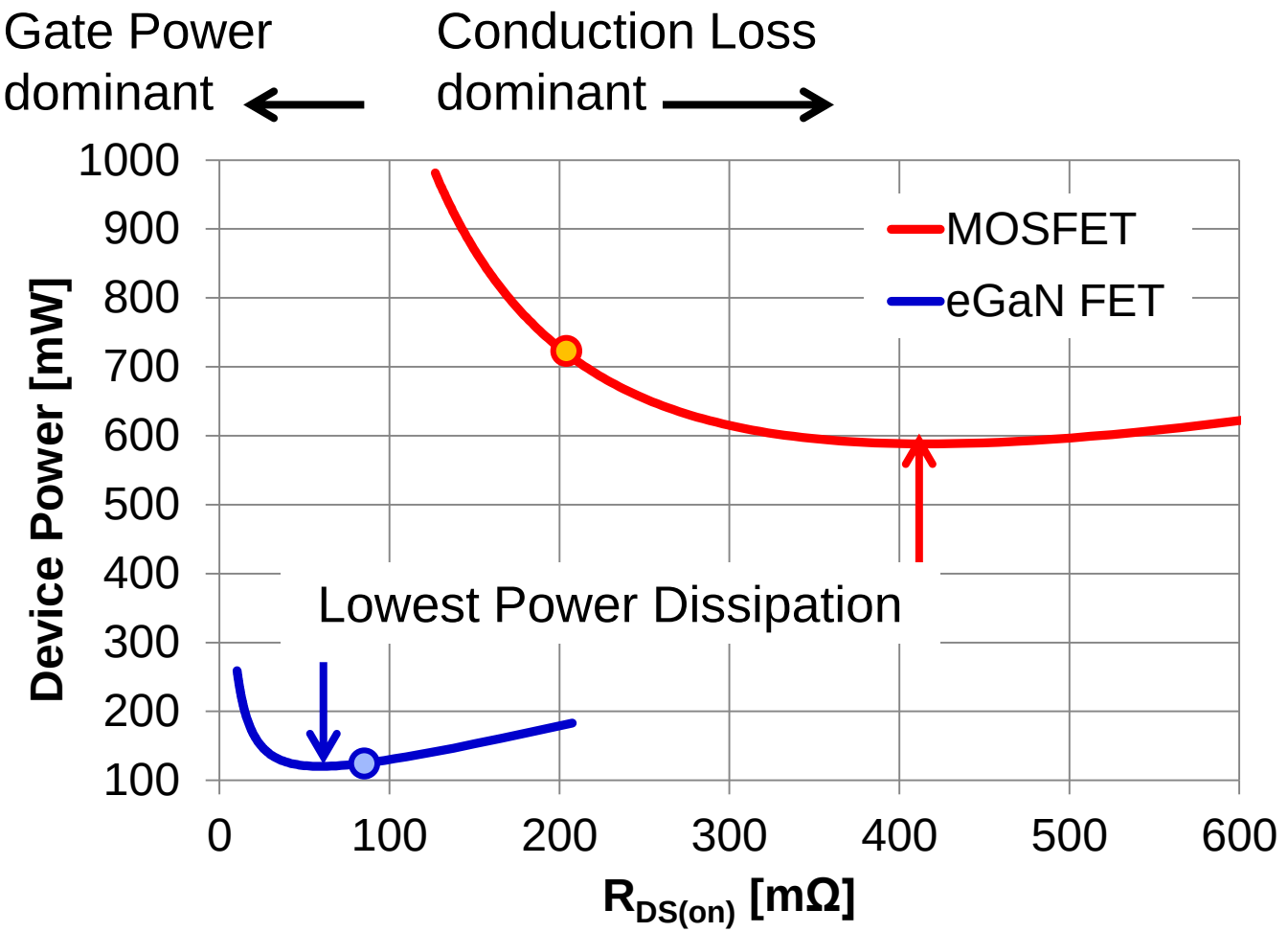
Class E Analysis Comparison

Peak Power Device losses = 279 mW
No Heat-Sink Required



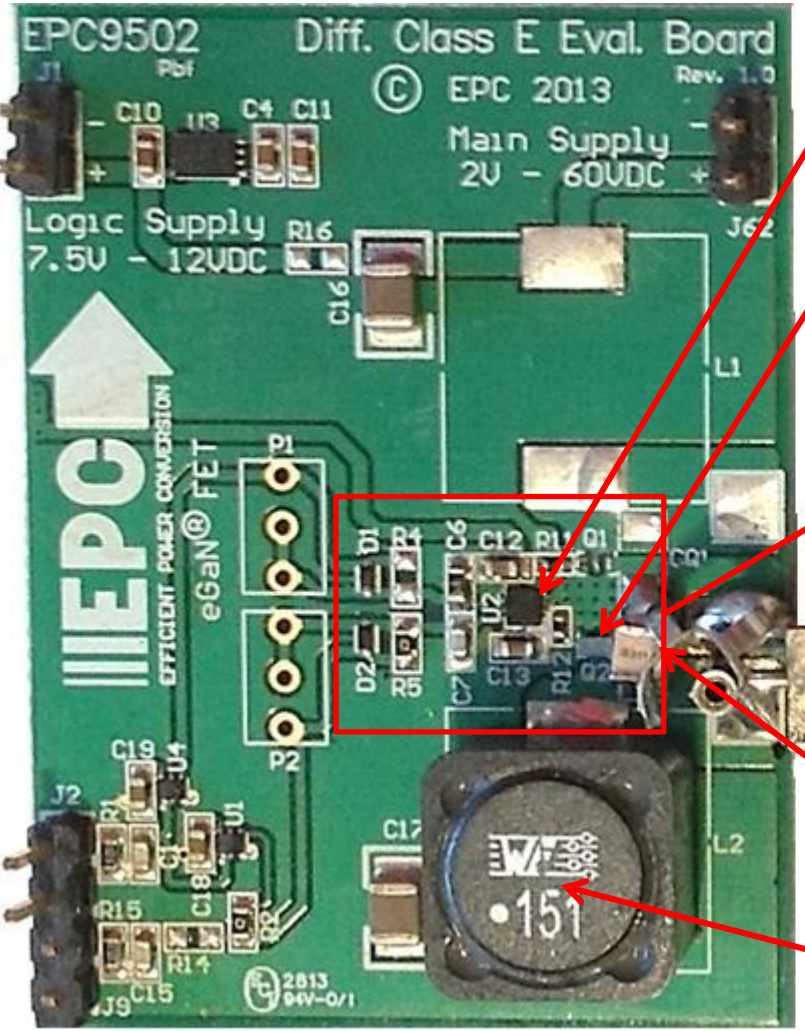
Class E Device Comparison





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

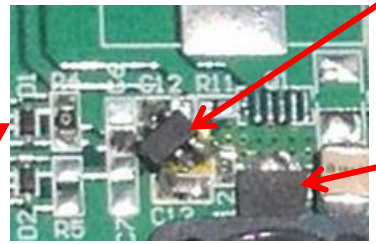
Class E Experimental Setup



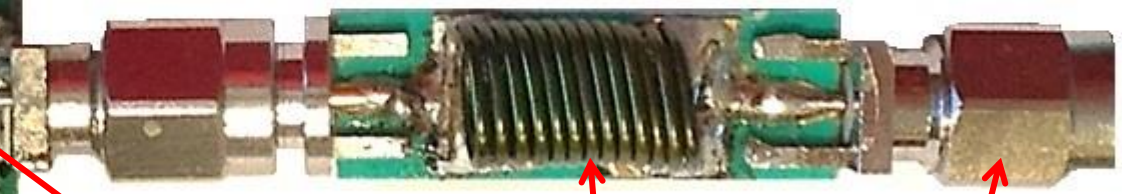
Gate Driver LM5113

eGaN® FET EPC2012

Gate Driver



MOSFET



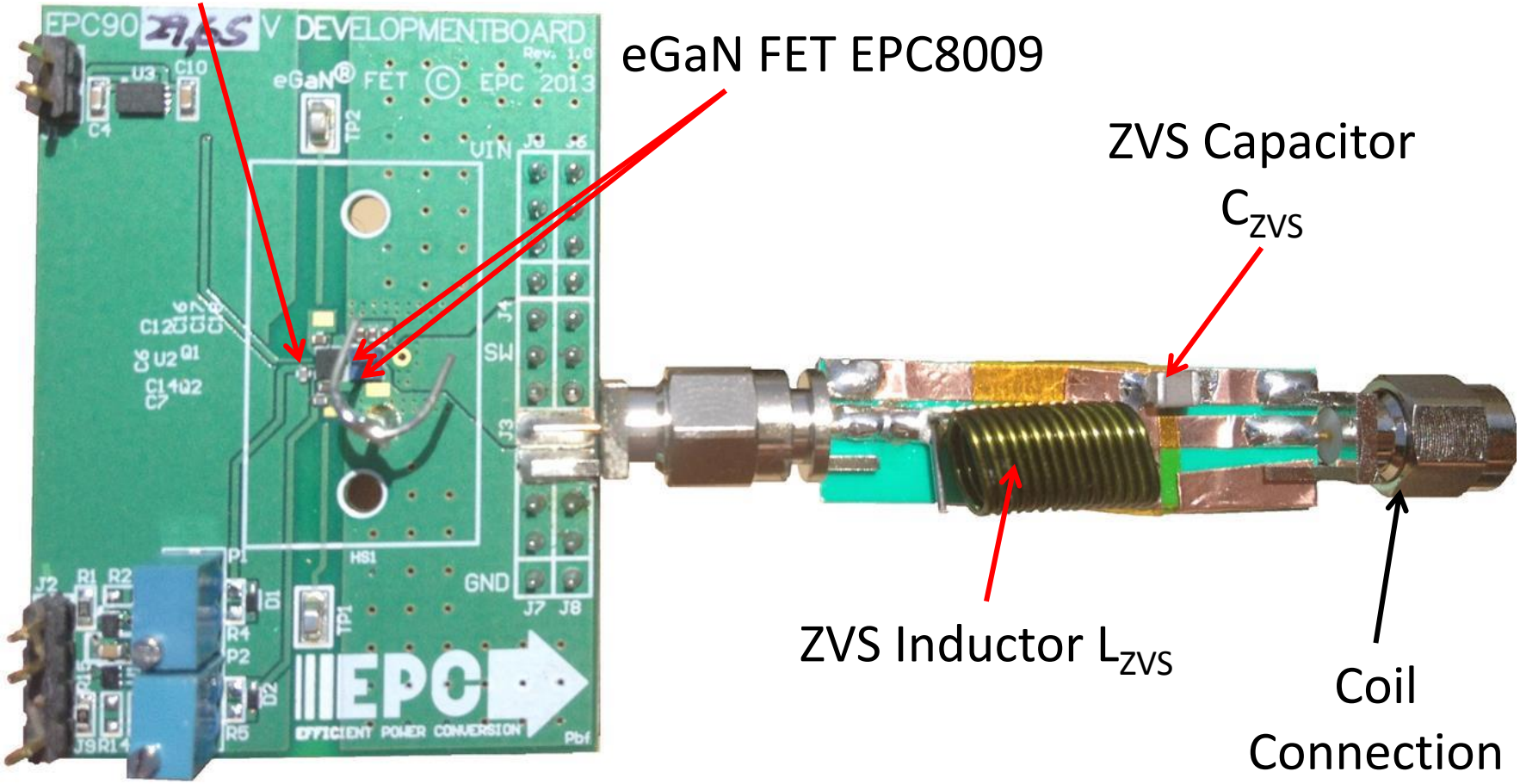
Shunt Capacitor C_{sh}

Extra Inductor L_e

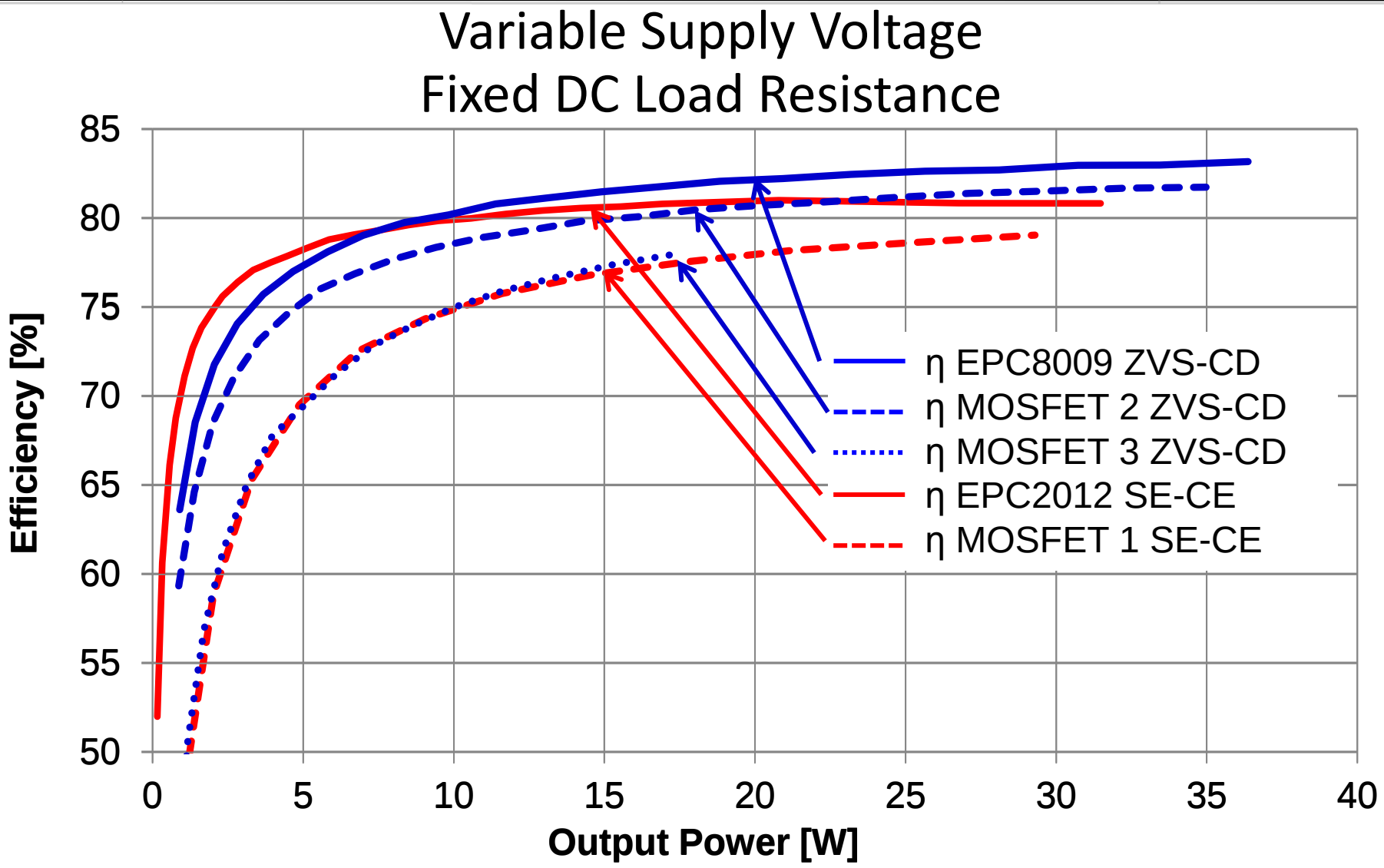
Coil Connection

RF Choke L_{RFck}

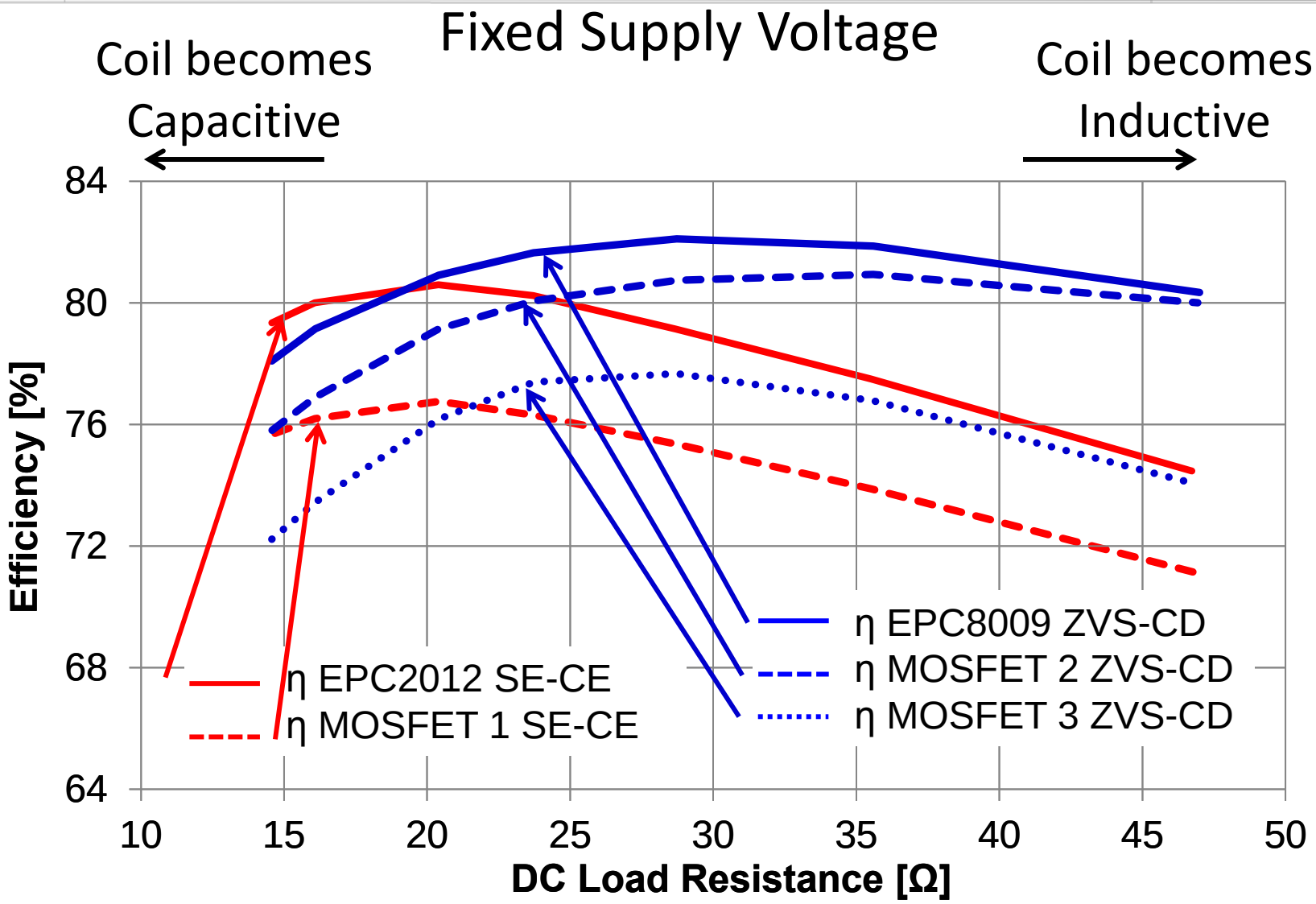
ZVS Class D Experimental Setup



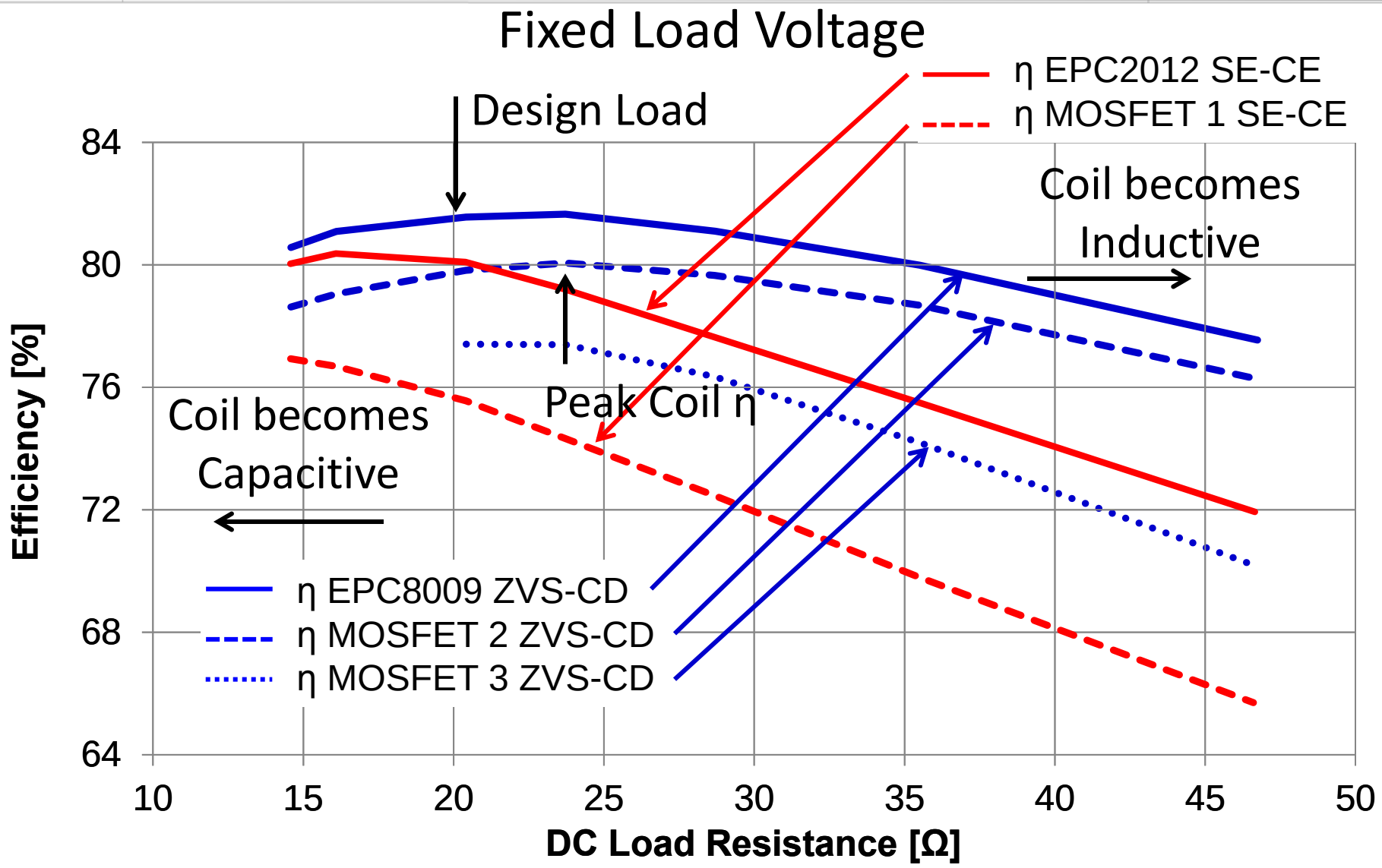
Peak Performance Results



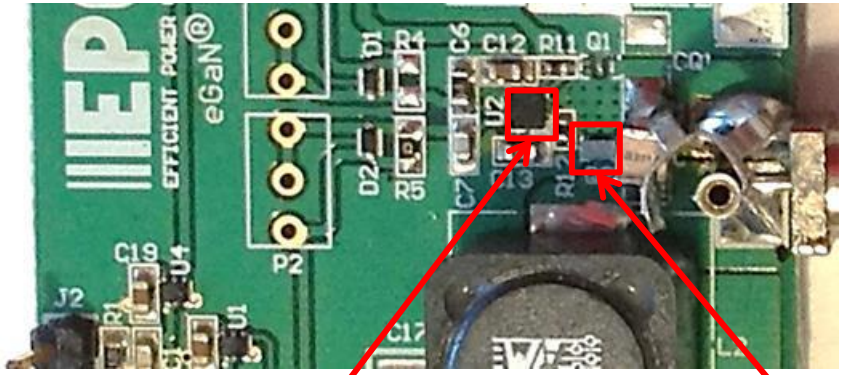
Load Variation Results

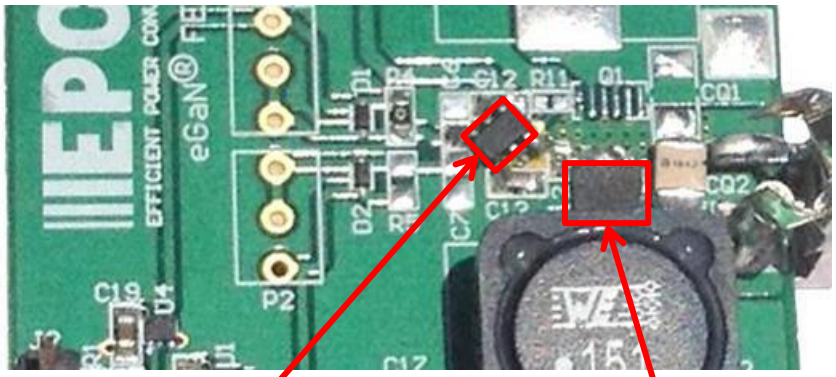


Load Regulation Results



Class E Thermal Performance



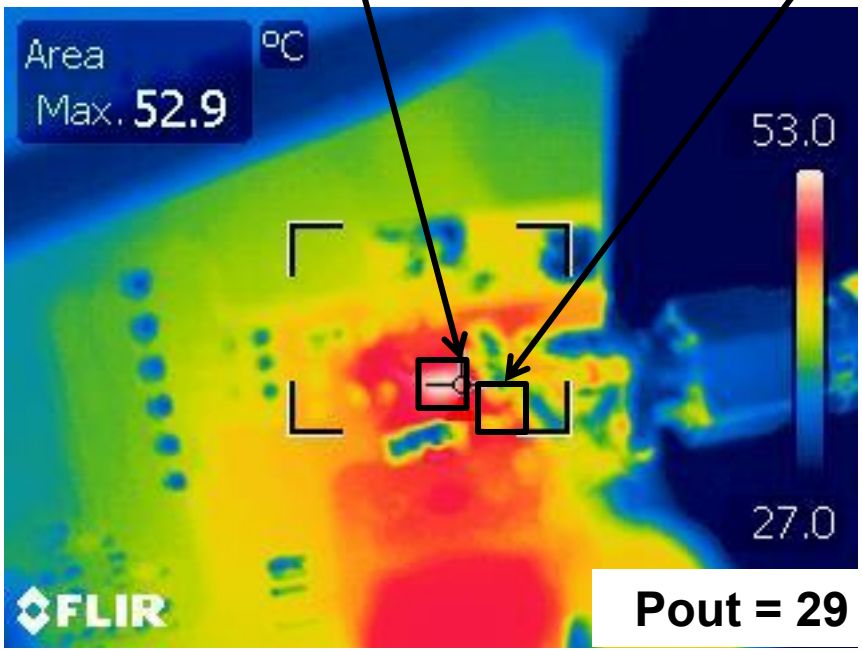


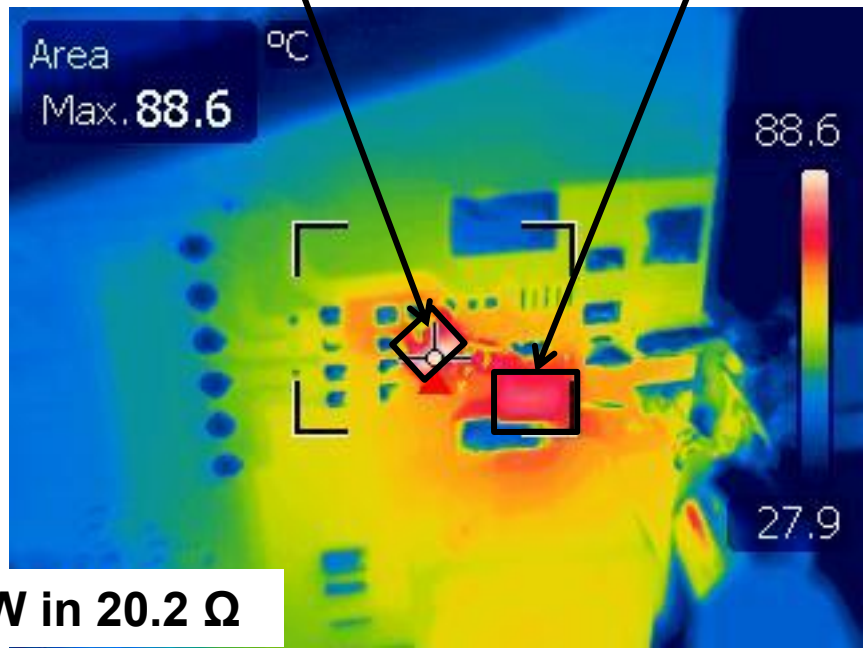
LM5113

eGaN FET

UCC27511

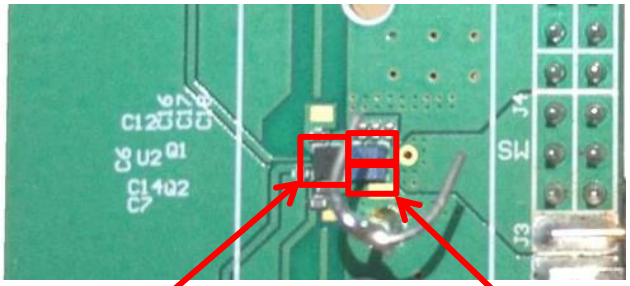
MOSFET

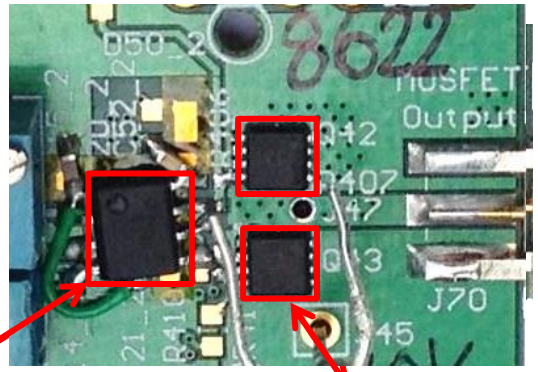




Pout = 29 W in 20.2 Ω

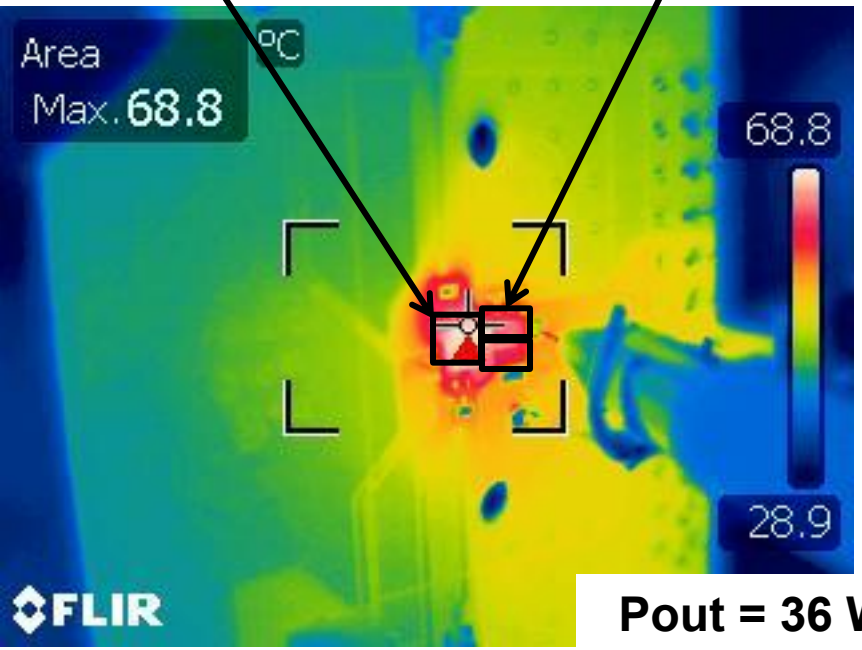
Class D Thermal Performance

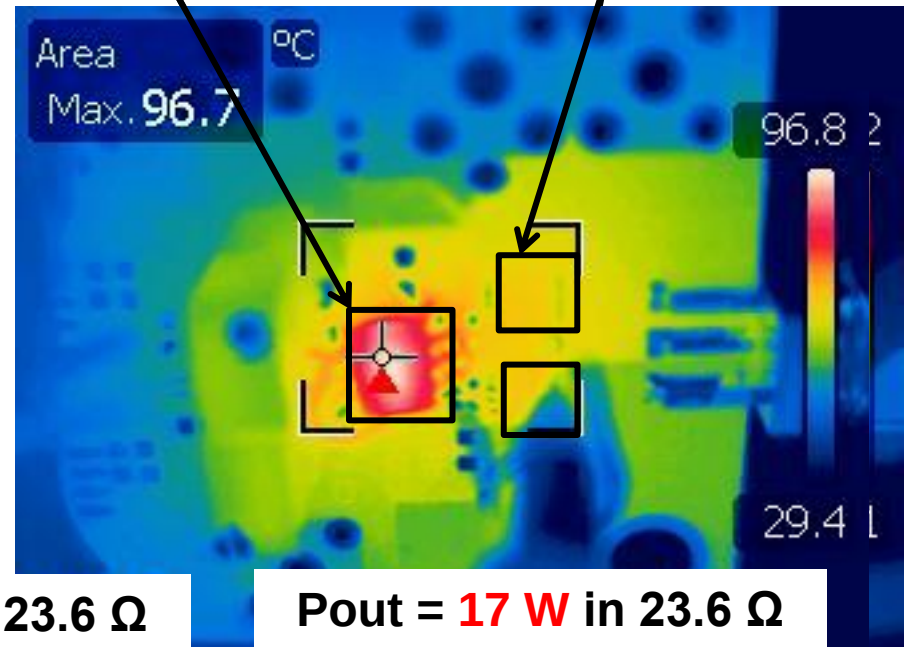




LM5113 EPC8009

LM5107 MOSFET 3





Pout = 36 W in 23.6 Ω

Pout = 17 W in 23.6 Ω

Summary

eGaN® FETs are disruptive in wireless energy:

- Enable wireless power
- Yield higher efficiency than MOSFETs
- Can operate at 6.78 MHz and 13.56 MHz
- Are low profile
- Easy to use
- Drive new topologies e.g. ZVS Class D
- Growing support e.g. gate drivers and products use them.

EFFICIENT POWER CONVERSION

The end of the road for silicon…..

is the beginning of the eGaN FET journey!