
# GaN: Raising the Bar for Power Conversion Performance

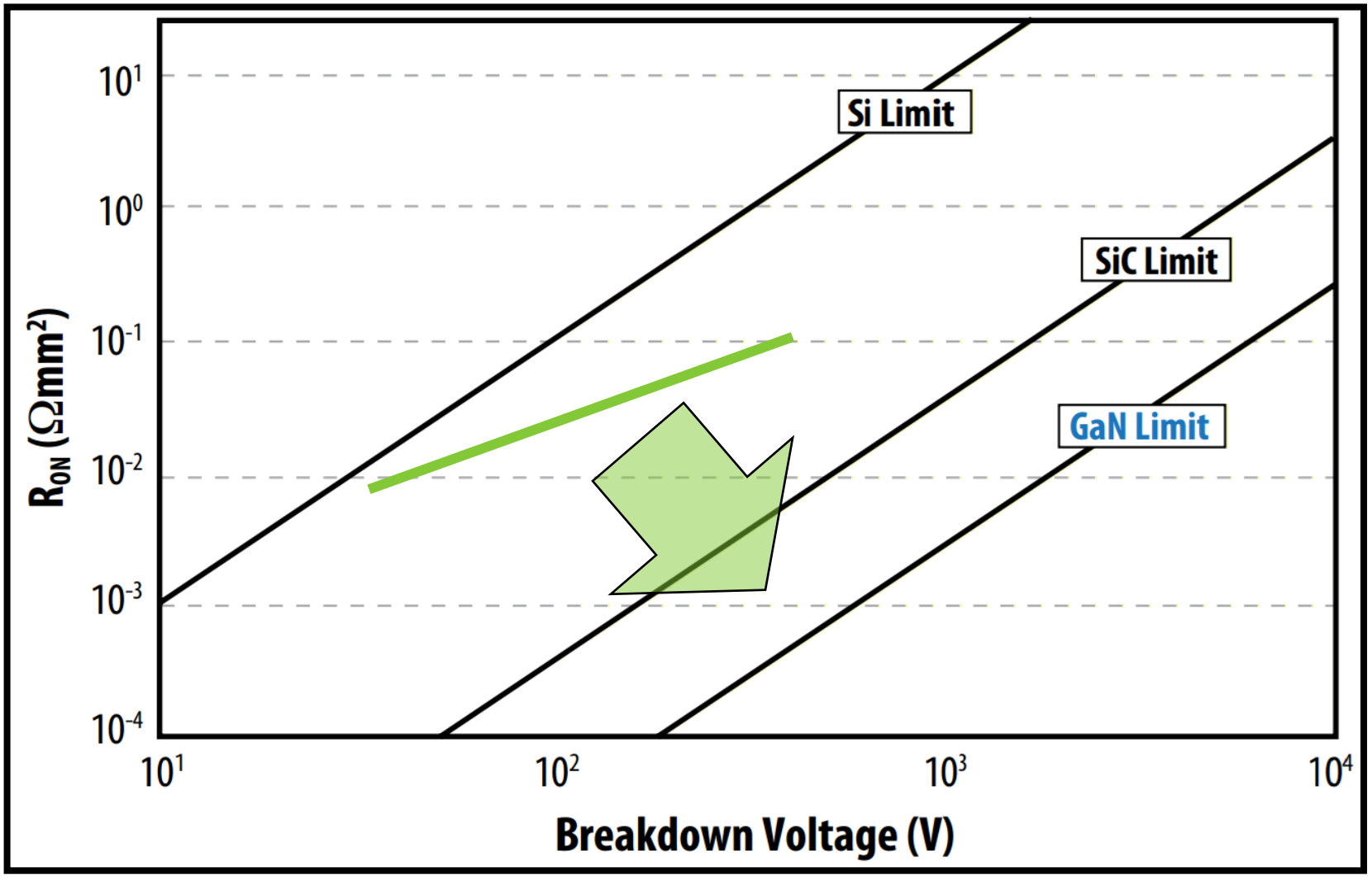
David Reusch and Johan Strydom

*Efficient Power Conversion Corporation*

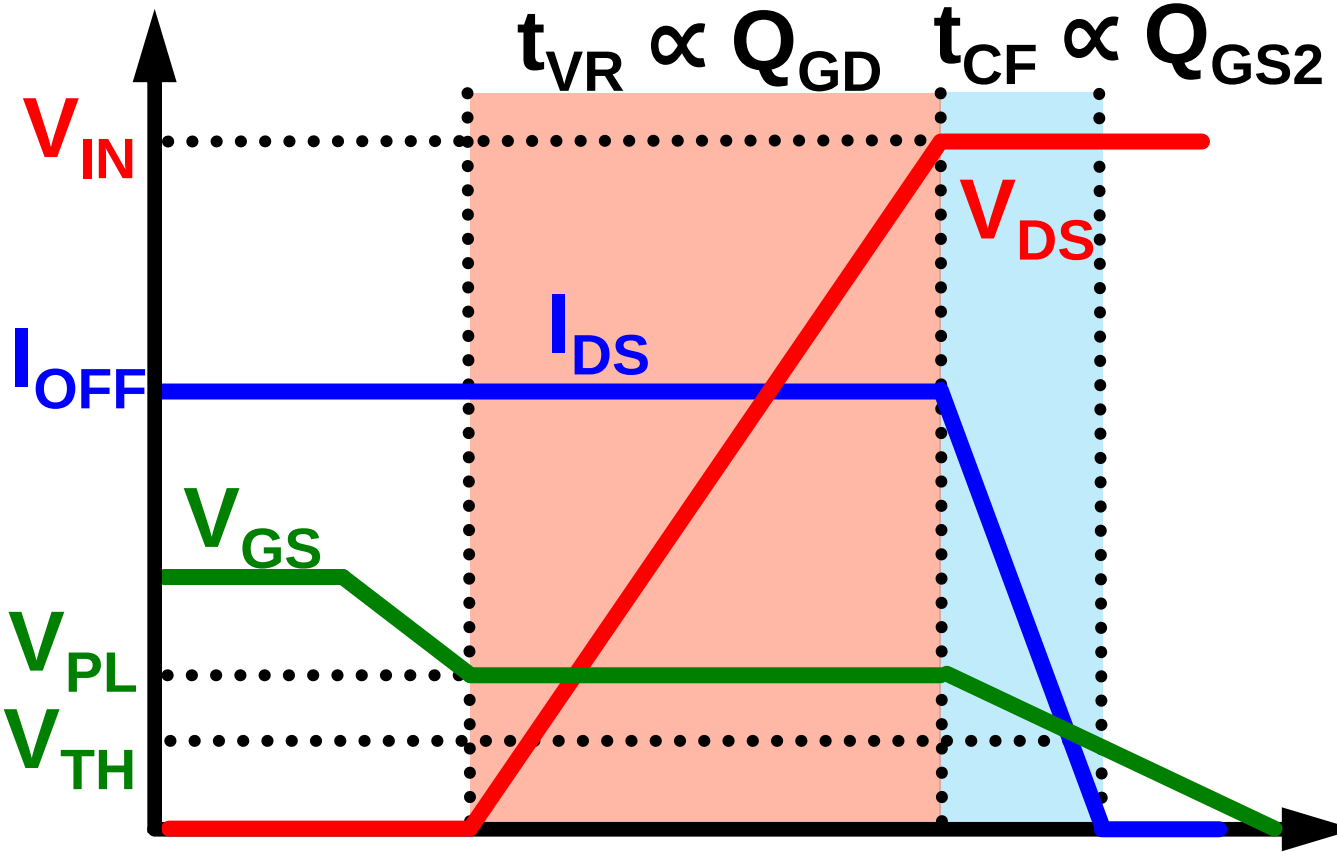
# Agenda

- Why GaN?
- What have we learned?
- Higher current applications
- Higher frequency applications
- Summary

# Why Gallium Nitride?



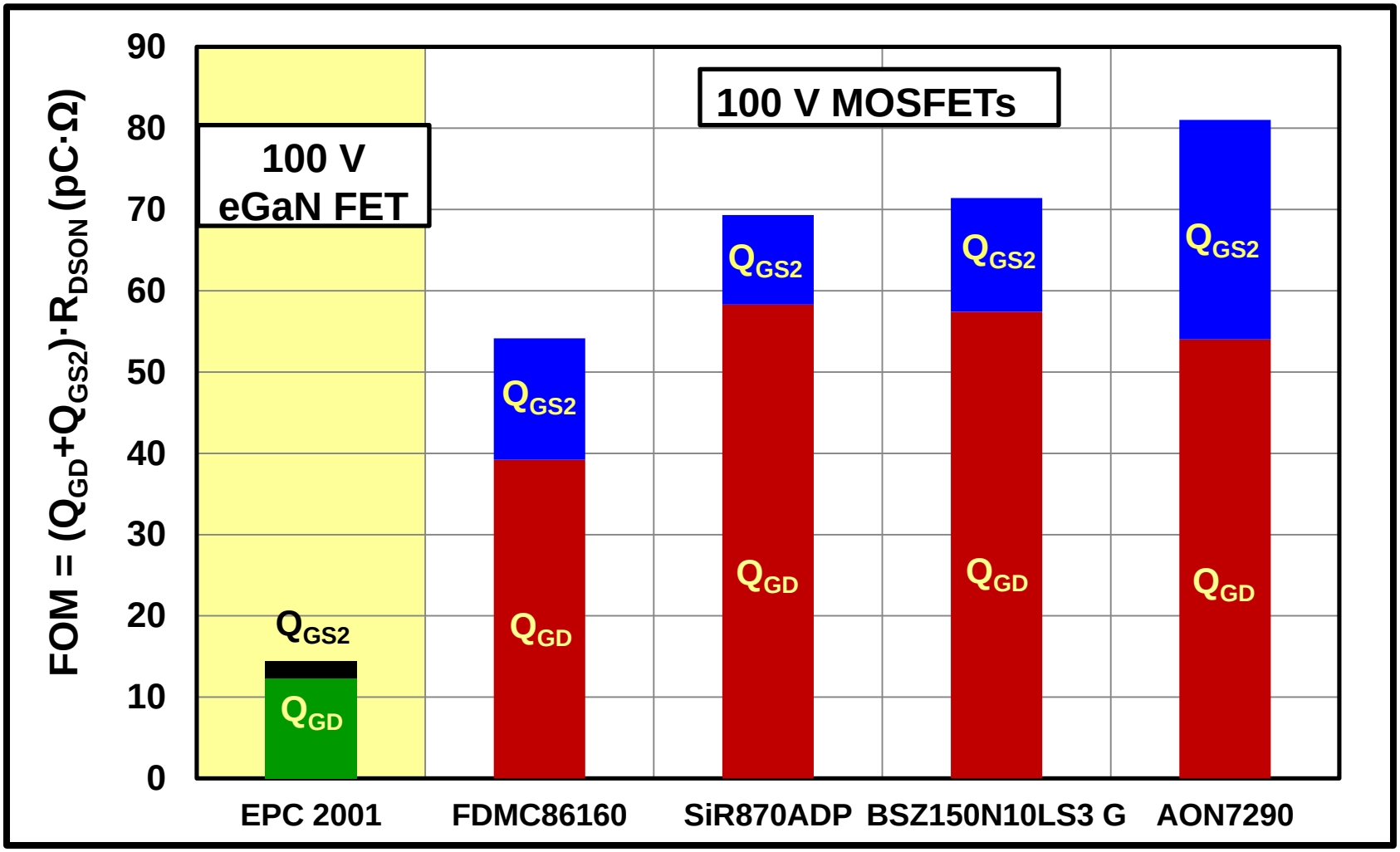
# Ideal Hard Switching




$$P_{t_{VR}} \approx \frac{V_{IN} * I_{OFF} * Q_{GD}}{2 * I_G}$$

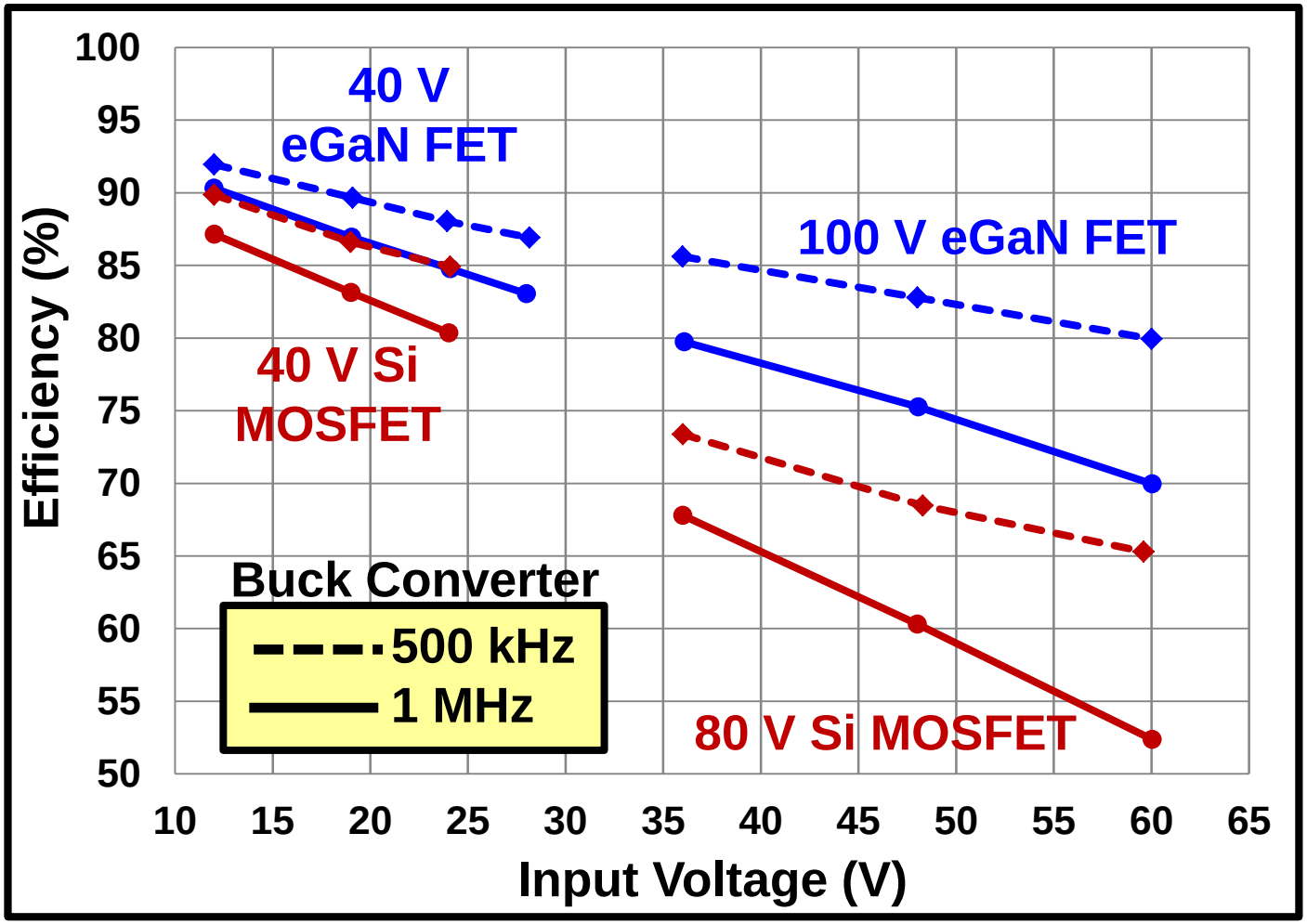
$$P_{t_{CF}} \approx \frac{V_{IN} * I_{OFF} * Q_{GS2}}{2 * I_G}$$

# 100 V Device Comparison



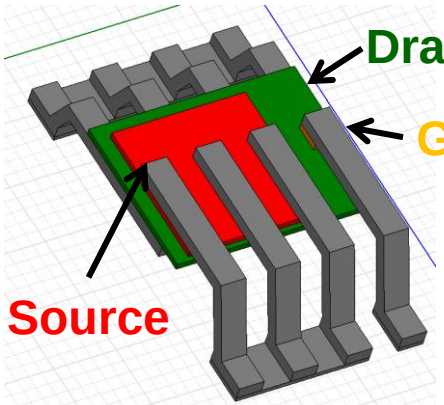

$V_{DS}$=0.5*$V_{DS}$, $I_{DS}$= 10 A

# eGaN FET vs MOSFET

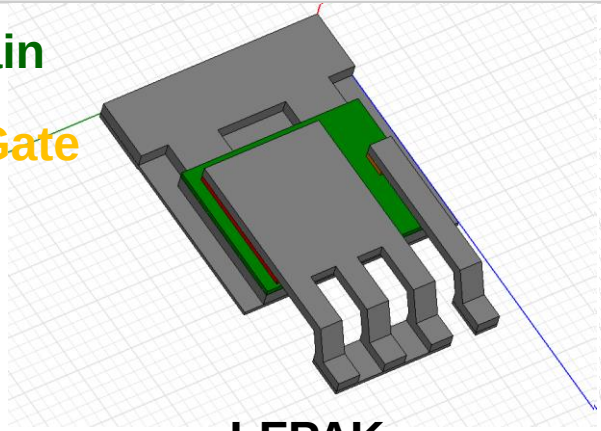



**Measured Efficiency** $V_{OUT}$=1.2 V $I_{OUT}$=10 A

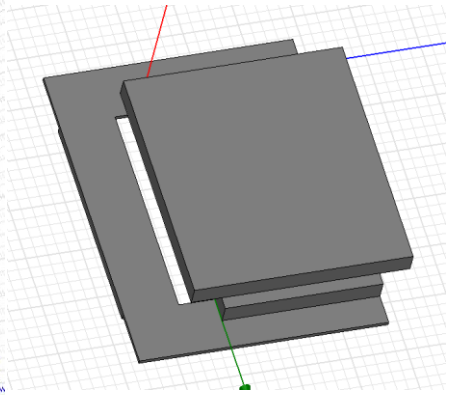
# Package Impact on Efficiency




SO-8

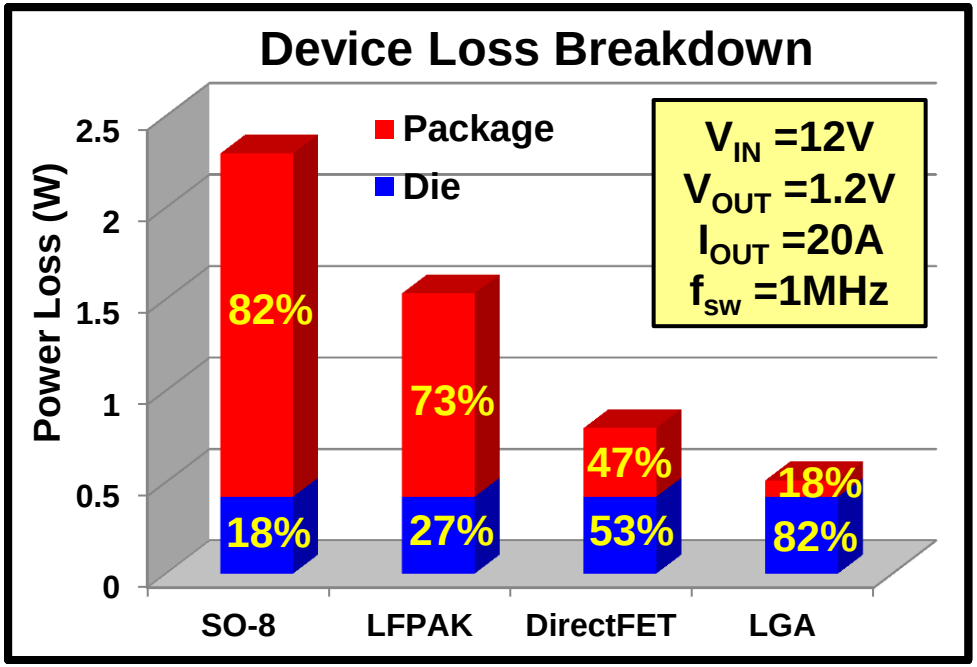


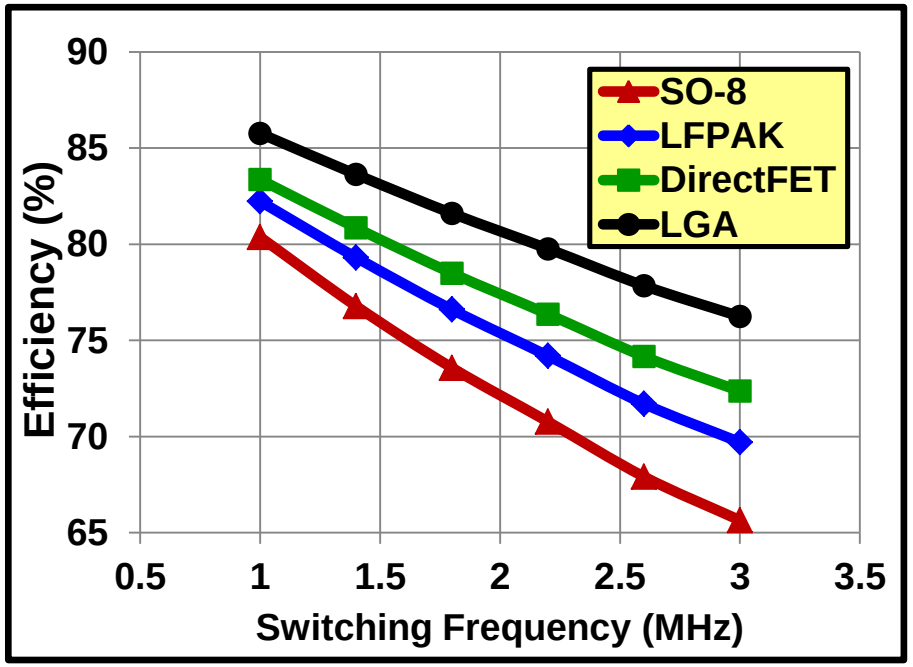
LFPAK



DirectFET

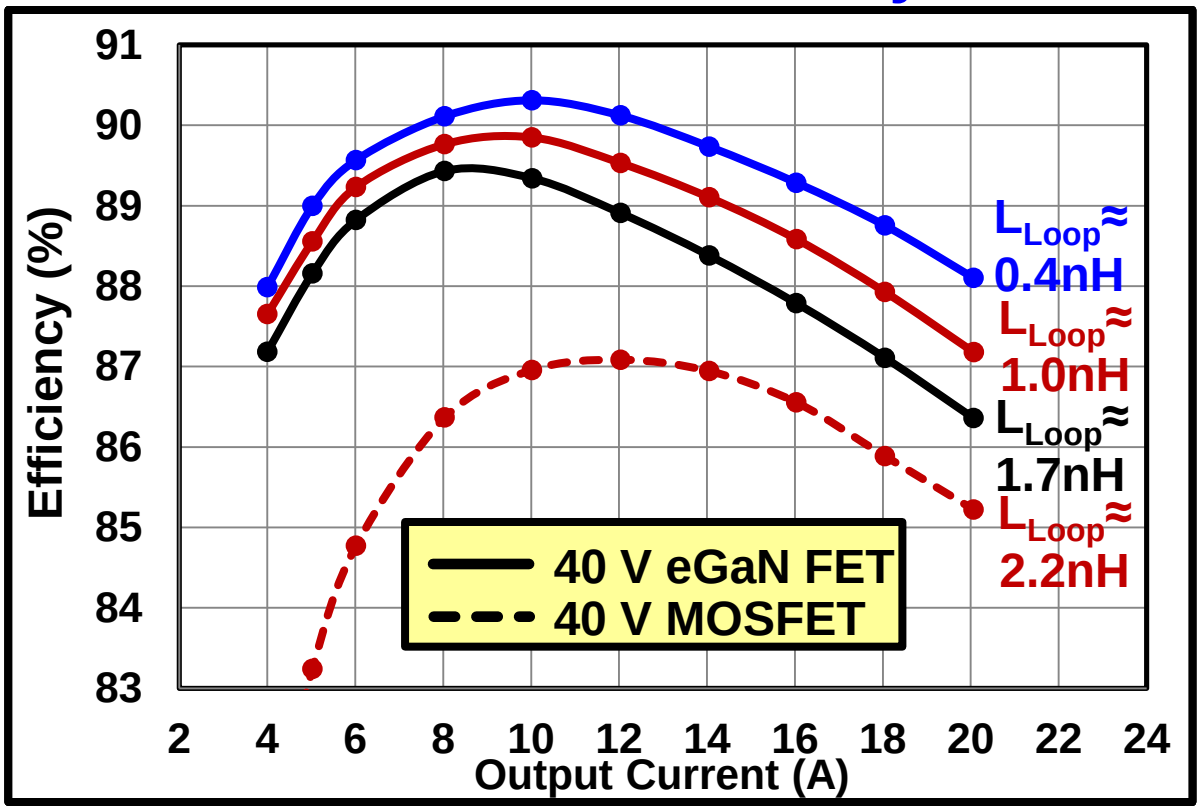
LGA



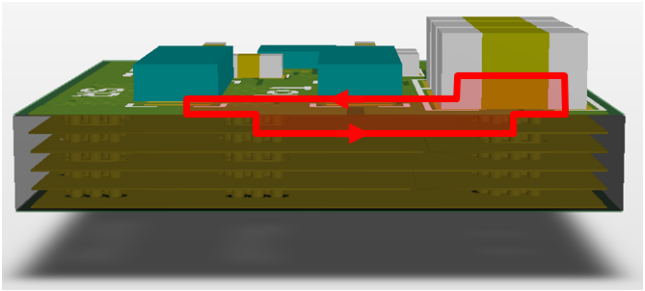
# Layout Impact on Efficiency

## Measured Efficiency



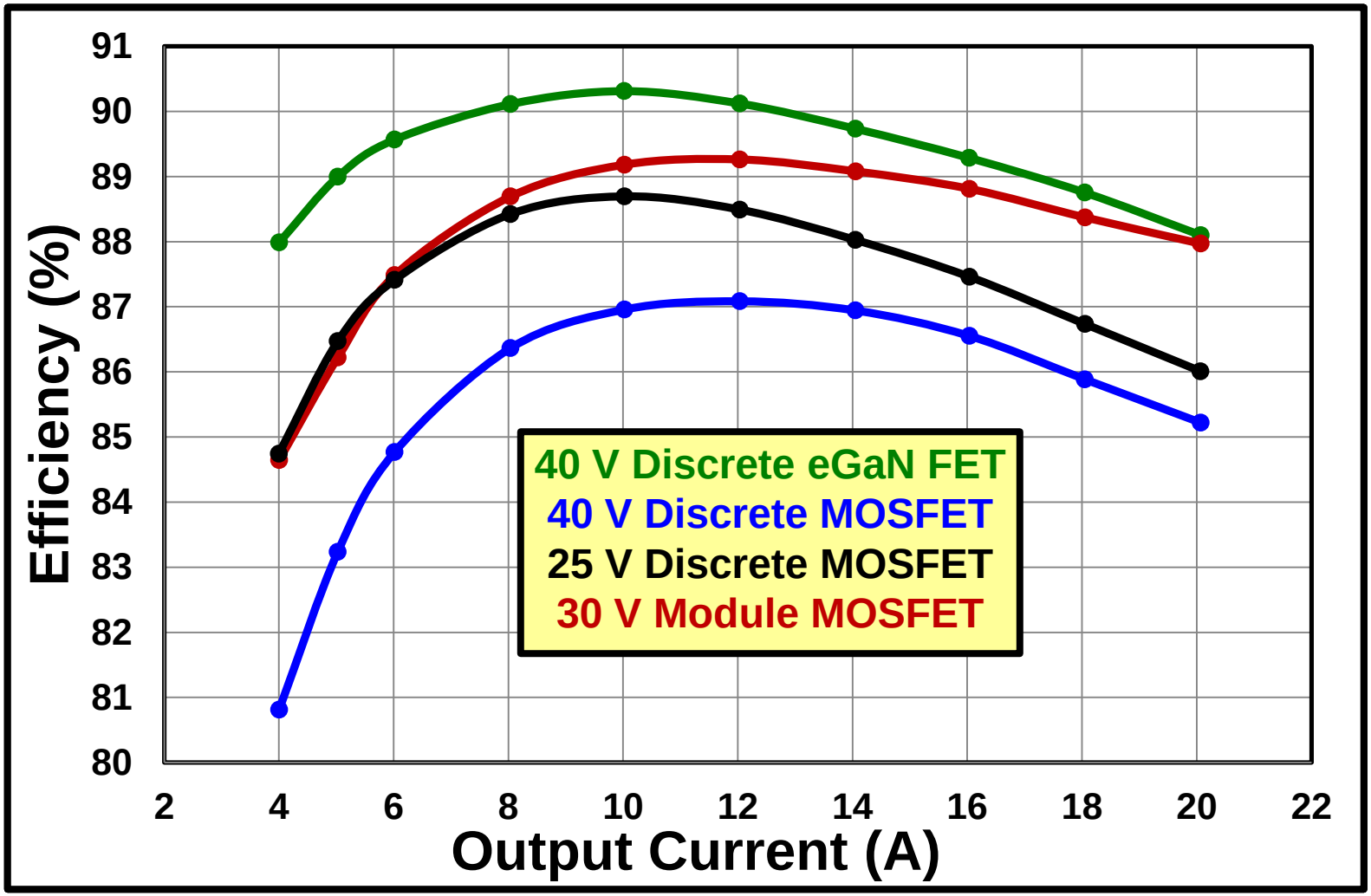

$V_{IN}$=12 V, $V_{OUT}$=1.2 V, $f_{sw}$=1 MHz, L=300 nH

## EPC Optimal Layout



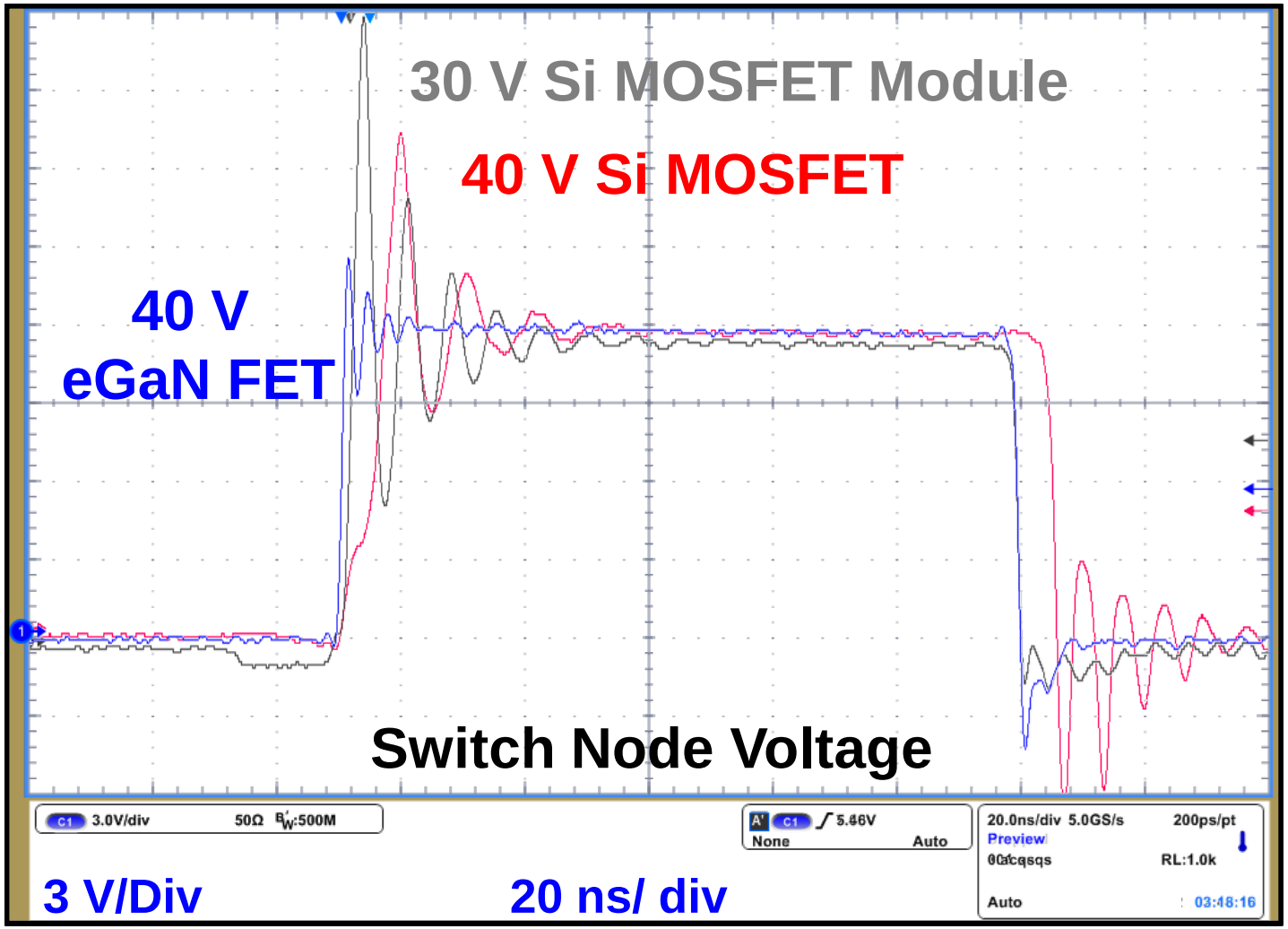
Ref: D. Reusch, J. Strydom, "Understanding the Effect of PCB Layout on Circuit Performance in a High Frequency Gallium Nitride Based Point of Load Converter," APEC 2013

# Lower Voltage Comparison



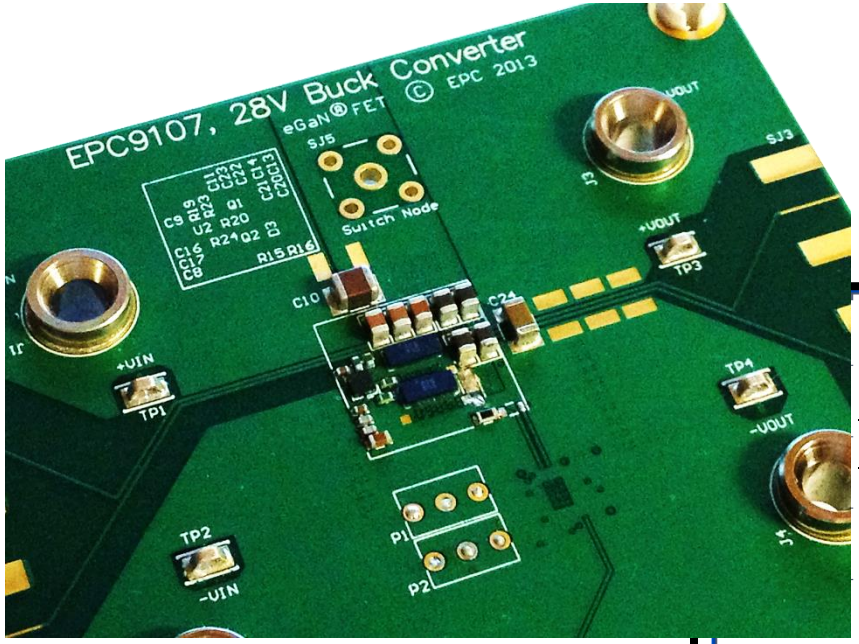

$V_{IN}$=12 V $V_{OUT}$=1.2 V $f_{sw}$=1 MHz L=300 nH

# Switching Comparison

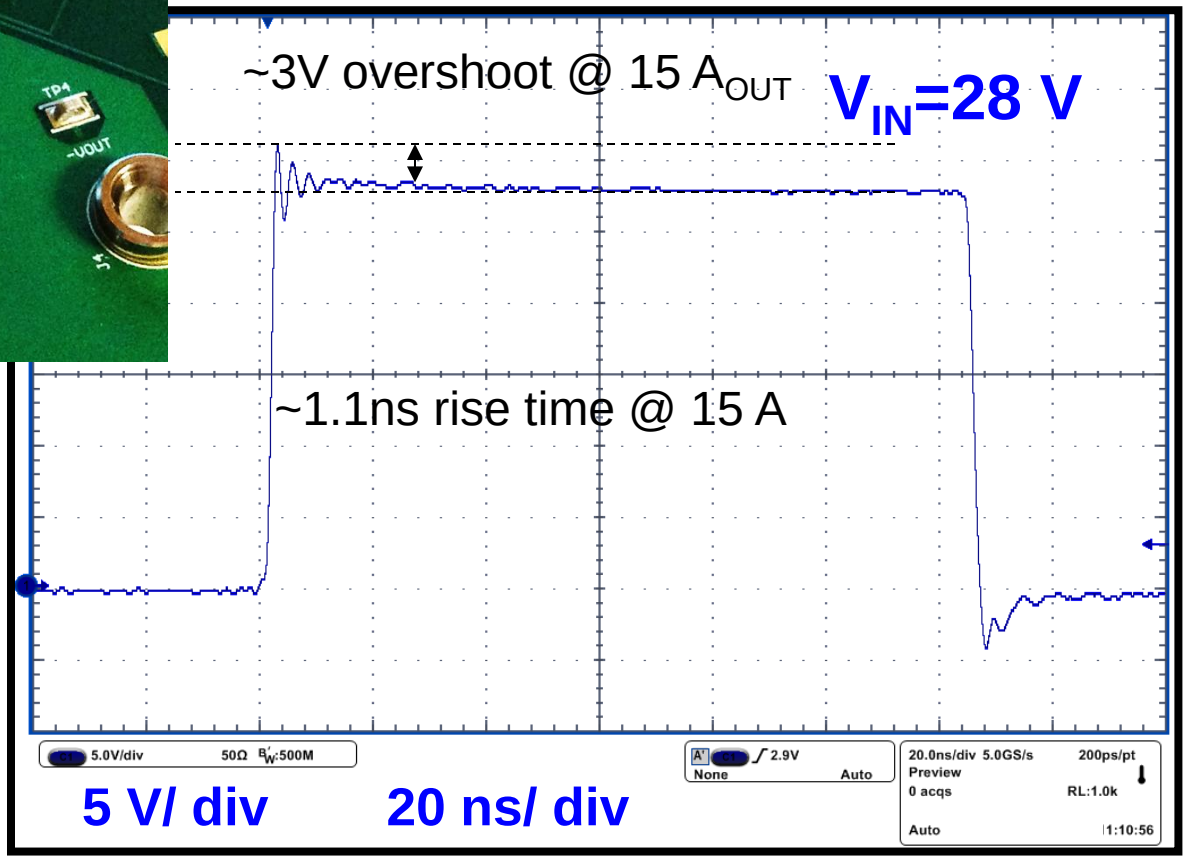



$V_{IN}$=12 V $V_{OUT}$=1.2 V $I_{OUT}$=20 A $f_{sw}$=1 MHz L=300 nH

# Extended Operating Range



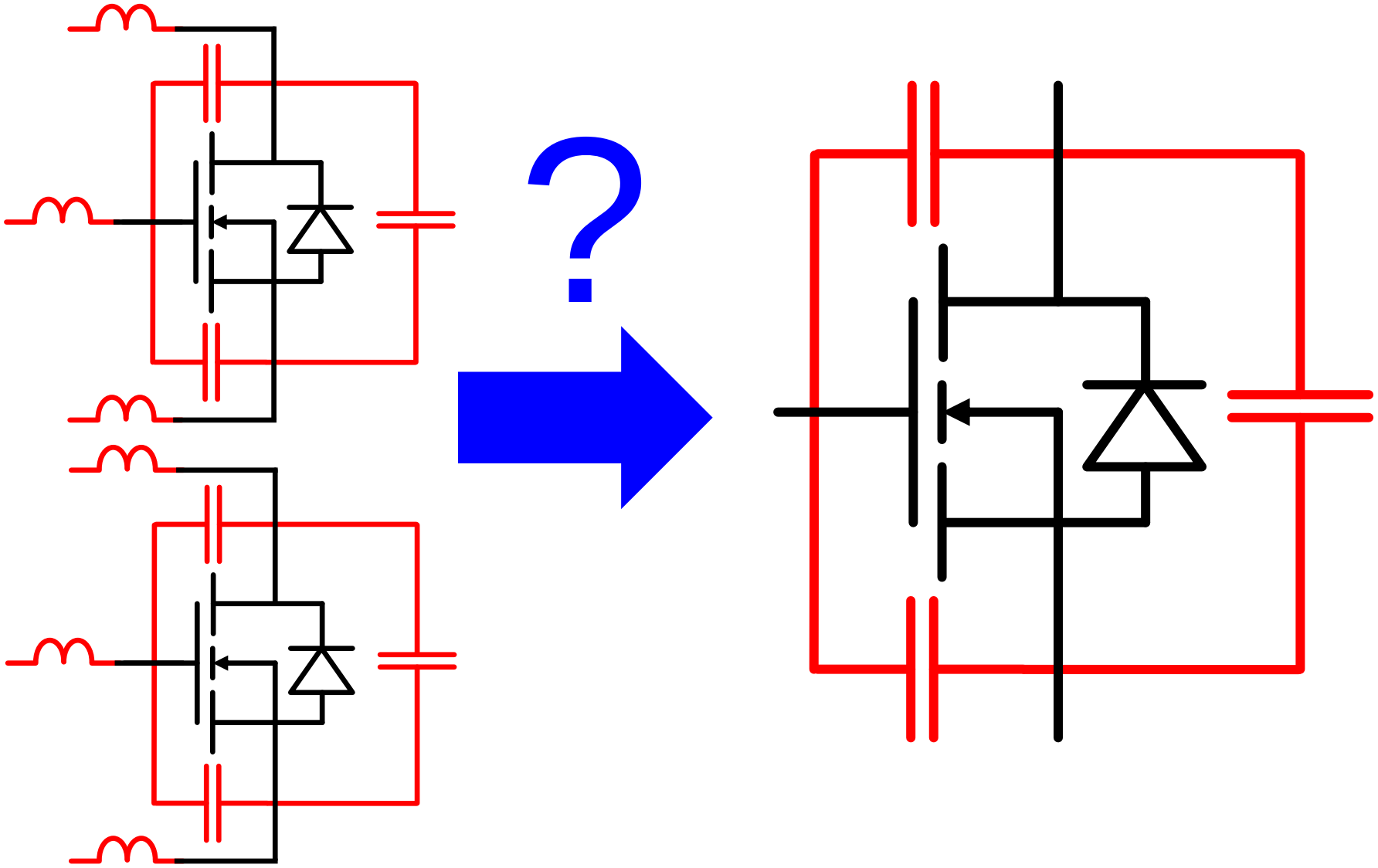

$V_{IN}$=12-28 V $V_{OUT}$=3.3 V
$I_{OUT}$=15 A $f_{sw}$=1 MHz
2 x EPC2015



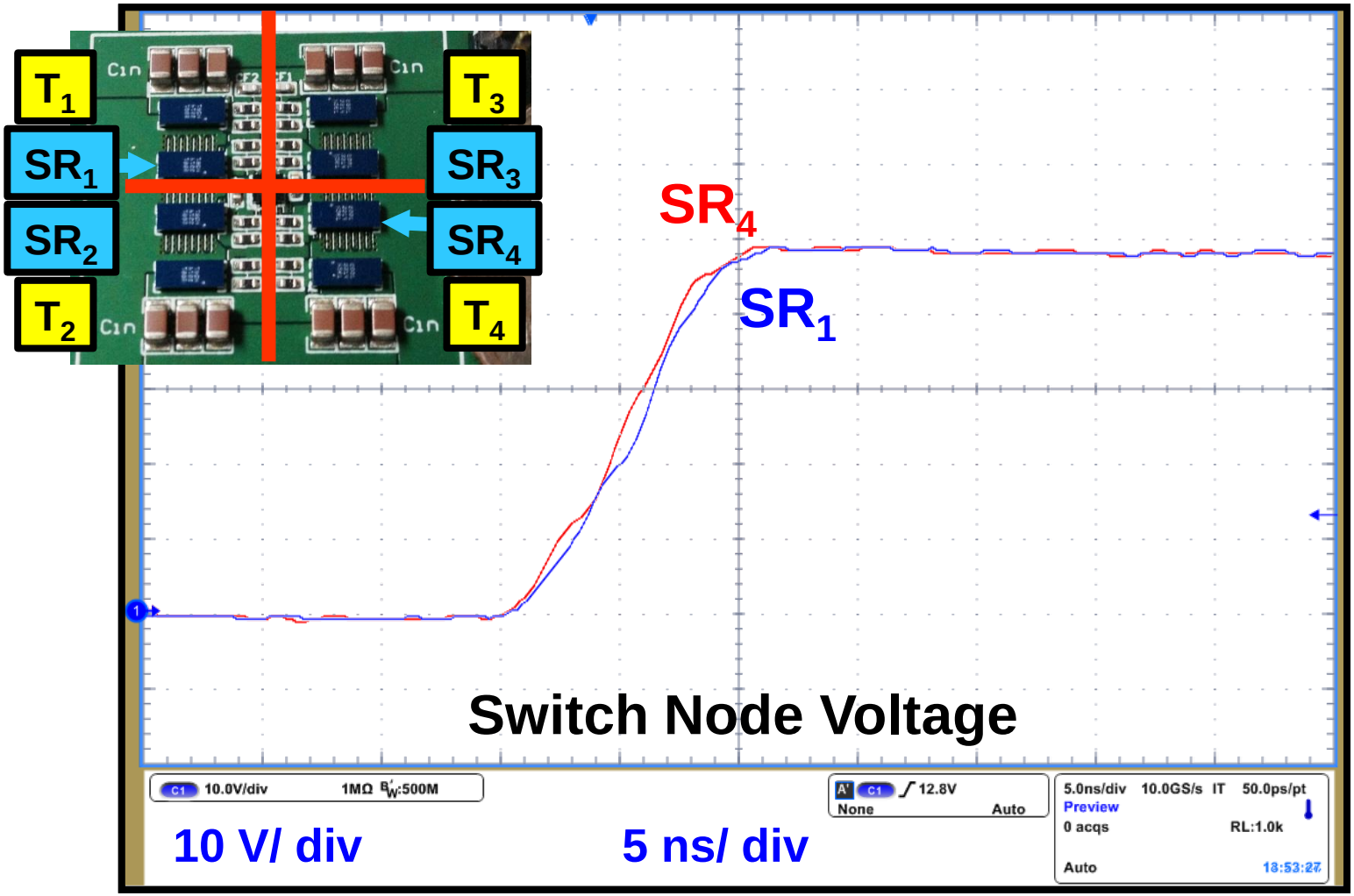

## EPC9107 Switching Node Voltage

$V_{IN}$=28 V $I_{OUT}$=15 A

# Parallel Power Devices

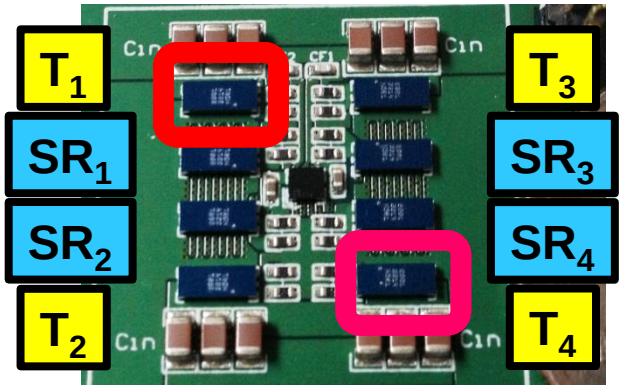


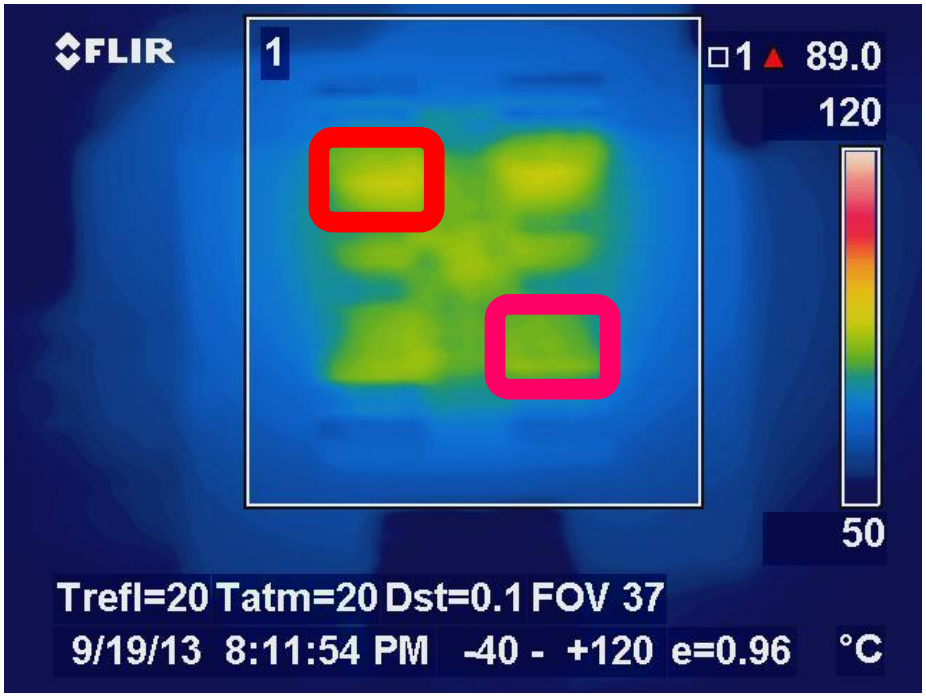
# Higher Output Current




$V_{IN}$=48 V $V_{OUT}$=12 V $I_{OUT}$=30 A $f_{sw}$=300 kHz L=3.3 µH GaN FET T/SR: 100 V EPC2001

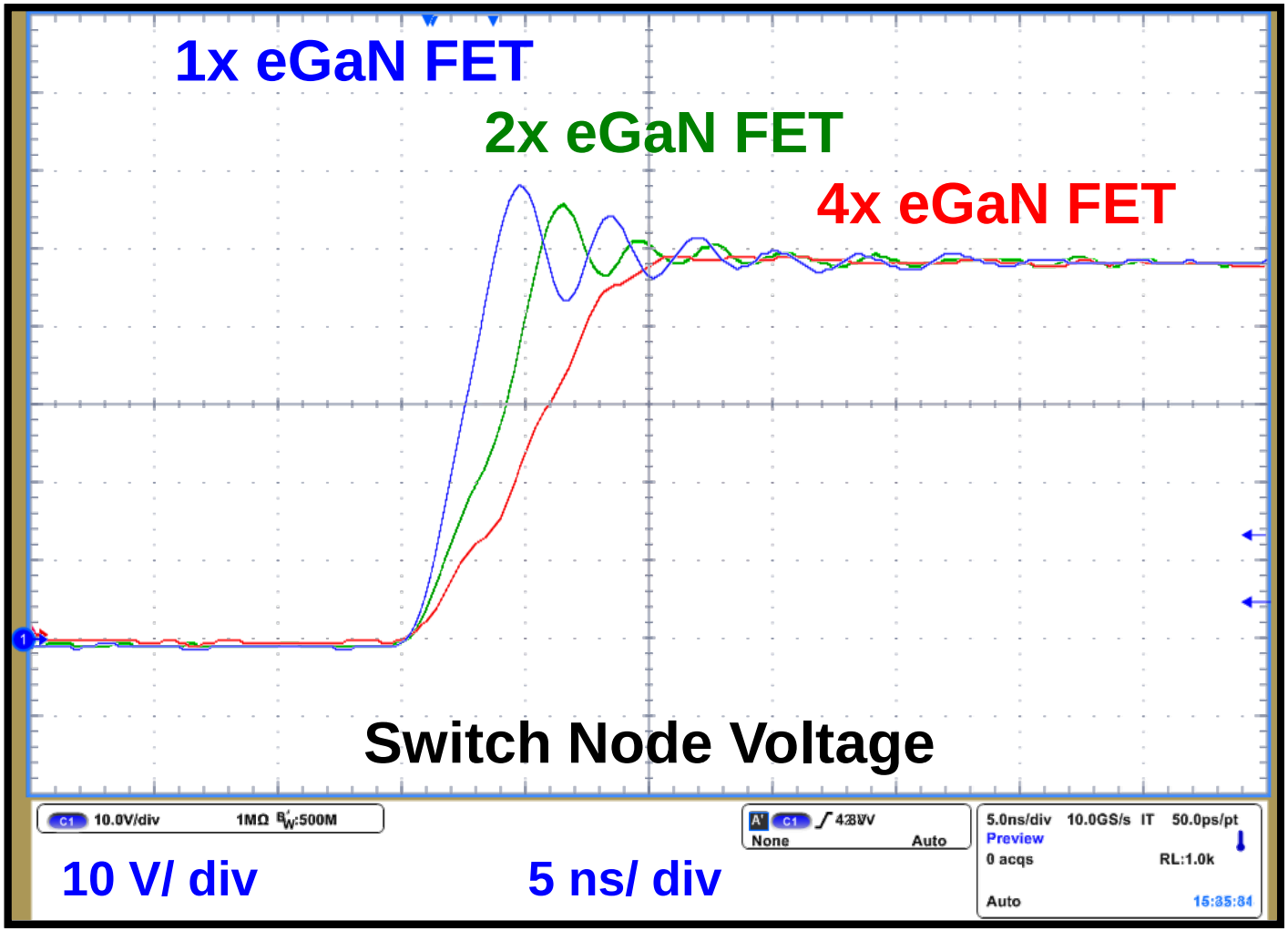
# Paralleling eGaN FETs



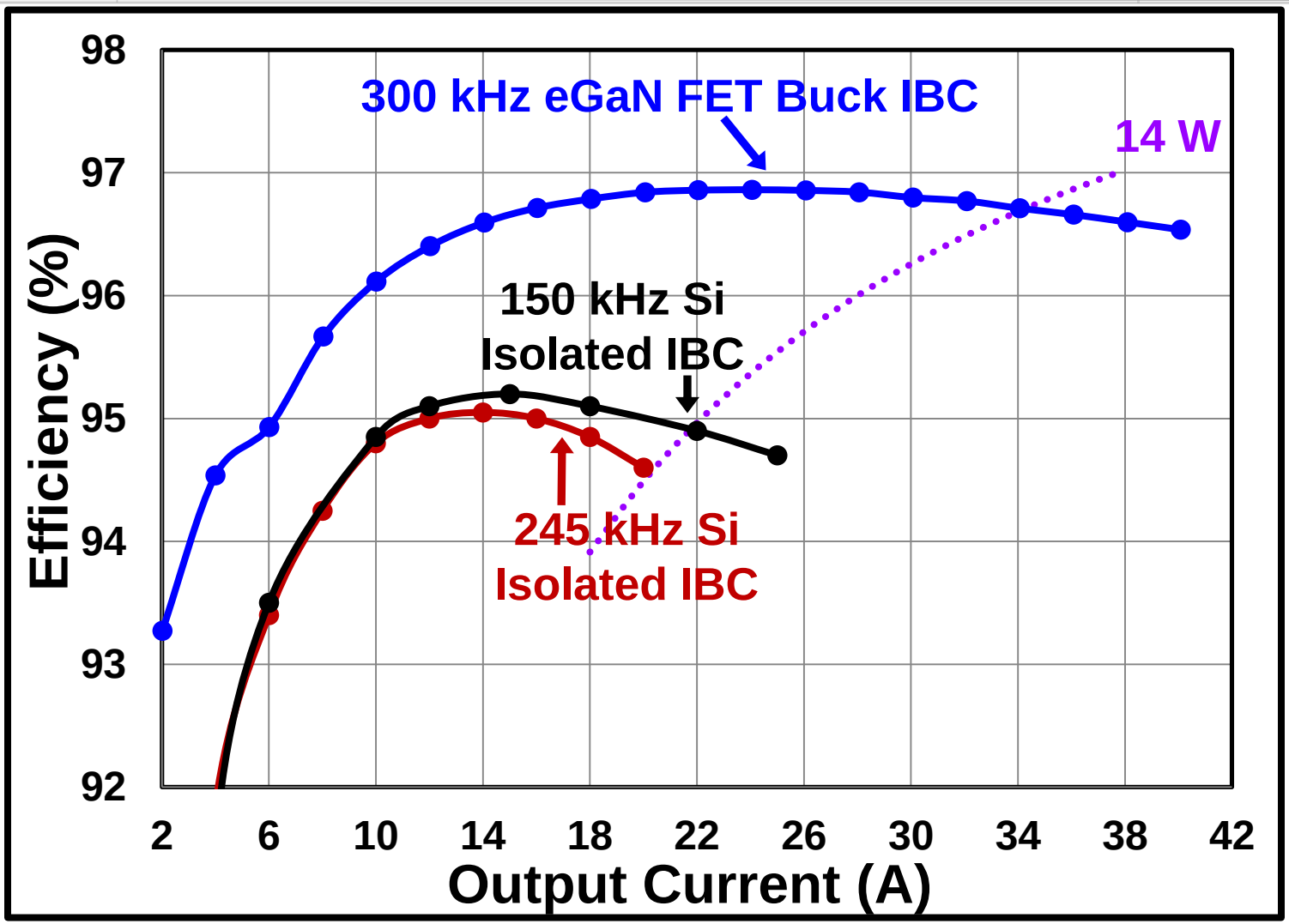

$V_{IN}$=48 V $V_{OUT}$=12 V $I_{OUT}$=30 A $f_{sw}$=300 kHz L=3.3 µH Fan Speed=200 LFM
GaN FET T/SR: 100 V EPC2001

# Parallel eGaN FET Swithcing



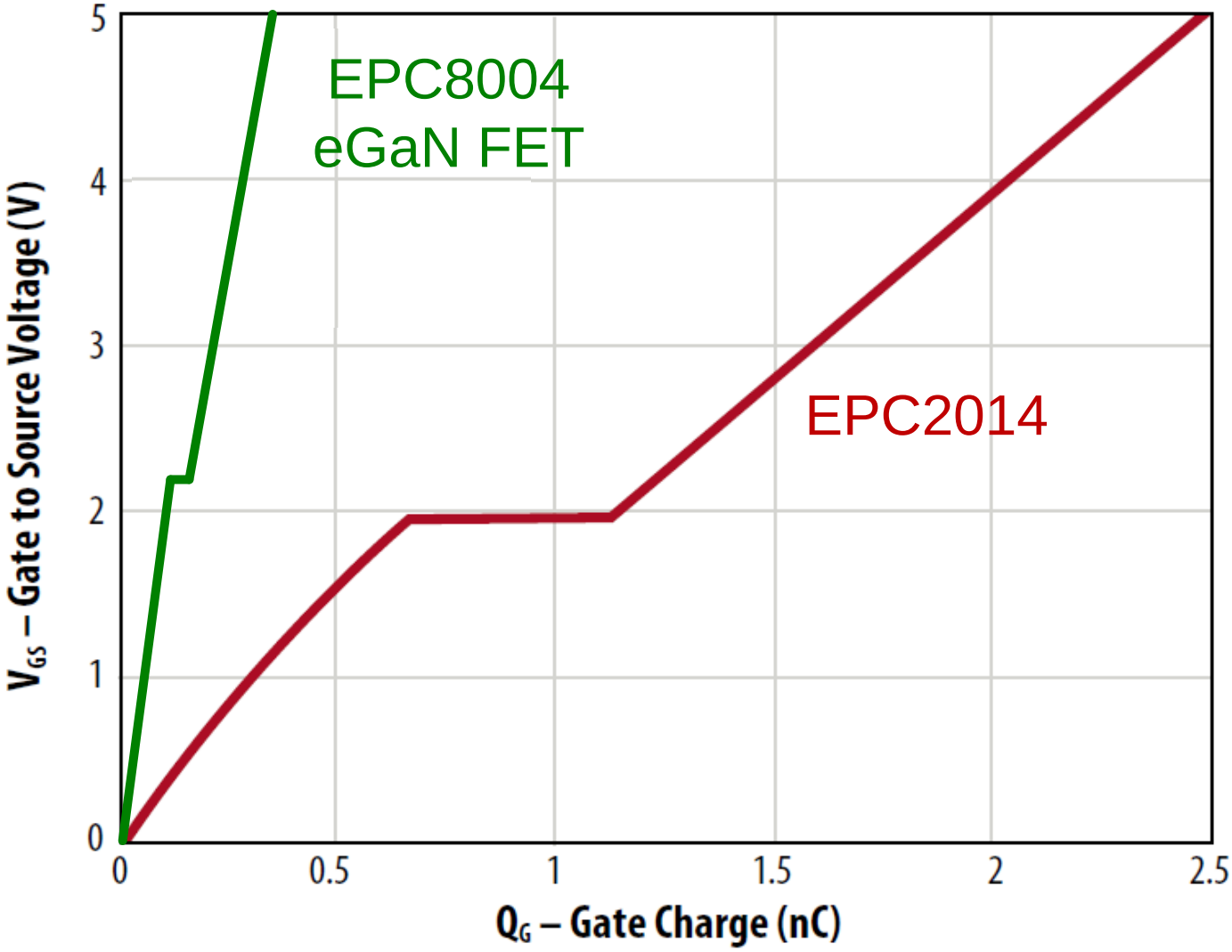

$V_{IN}$=48 V $V_{OUT}$=12 V $I_{OUT}$=30 A/ number of devices $f_{sw}$=300 kHz GaN FET T/SR: 100 V EPC2001

# High Current Applications

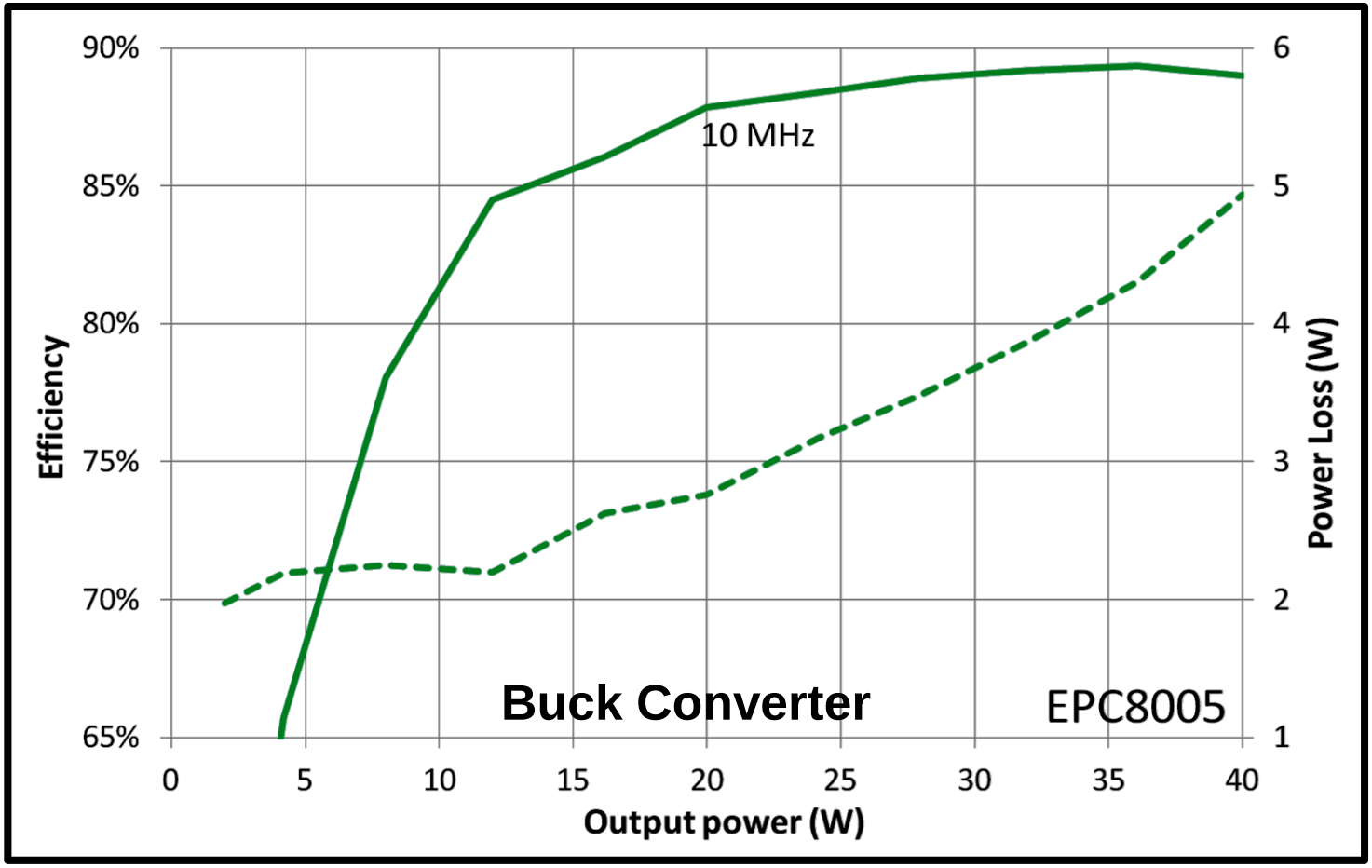



$V_{IN}$=48 V $V_{OUT}$=12 V Fully Regulated IBC

# Pushing to Higher Frequency



# Ultra High Frequency

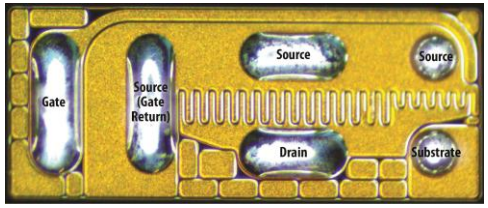



$V_{IN}$=42 V $V_{OUT}$=20 V $f_{sw}$=10 MHz eGaN FET T/SR: EPC8005

**See High Frequency Talk Today in Session T30!**

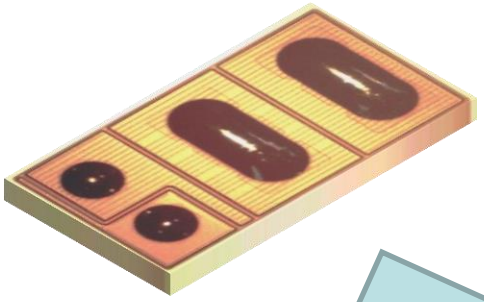
# GaN in the Future

**Ultra High Frequency Family**
**1 - 3 GHz**
Launched Sept 2013



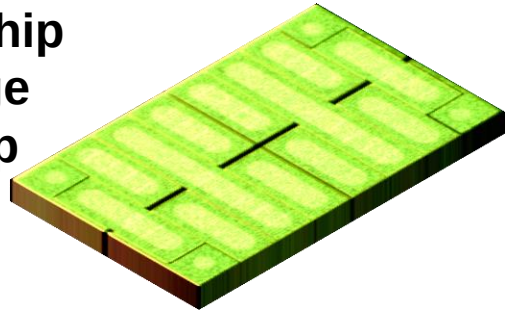

**Mass Production**
**40 V - 200 V**
**~500 MHz**

**Higher Current**
**45 A**



**Higher Voltage**
**600 V**

**More functions on a chip**
**Monolithic half bridge**
**Driver on power chip**



**Next Generation Devices**
**2 x FOM Improvement**

# Summary

eGaN FETs continue to raise the bar for power conversion performance

- **Better FOM's**
- **Better Packaging**
- **Improved PCB Layout Techniques**
  - **Better In-Circuit Performance**
  - **Good Parallel Performance**
- **Higher Frequency Devices**

**Thank You For Your Time ! Questions?**


EFFICIENT POWER CONVERSION

*The end of the road for silicon…..*

*is the beginning of the eGaN FET journey!*