

A green rectangular road sign with rounded corners is mounted on a weathered wooden post. The sign contains the text "The eGaN® FET Journey Continues" in white. The background of the entire slide is a desert landscape with a road leading towards a building at sunset. The sky is filled with large, white, fluffy clouds, and the sun is low on the horizon, creating a bright, golden glow. The road is a two-lane asphalt road that recedes into the distance. In the distance, a building with a grid-like facade is visible on the horizon.

The eGaN® FET
Journey Continues

Enabling Envelope Tracking through GaN Transistors

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Agenda



- Overview of Envelope Tracking (ET)
- Example *eGaN*[®] FET Power Stage
- Opportunities in ET
- Conclusions



- World of Radio Frequency Power Amplifiers (RFPA)s is changing.
- Increased efficiency driven by:
 - Improved battery life
 - Reduced cooling
 - Reduced size
 - Lower cost of operation

*Taken from www.open-et.org website

	Standard	Launched	Typ. Carrier BW (MHz)	Typ. Spectral Efficiency (bps/Hz)	Approx. PAPR(dB)
2G cellular	GSM	1991	0.2	0.17	0.0
Digital TV	DVB-H	2007	8	0.28	8.0
2.75G cellular	GSM + EDGE	2003	0.2	0.33	3.5
3G cellular	WCDMA FDD	2001	5	0.51	7.0
Digital TV	DVB-T	1997	8	0.55	8.0
Wi-Fi	IEEE 802.11a/g	2003	20	0.90	9.0
WiMAX	IEEE 802.16d	2004	20	1.20	8.5
Wi-Fi	IEEE 802.11n	2007	20	2.40	9.0
3.5G cellular	HSDPA	2007	5	2.88	8.0
3.9G cellular	LTE	2009	20	8.00	10.0

4G (LTE / OFDM)

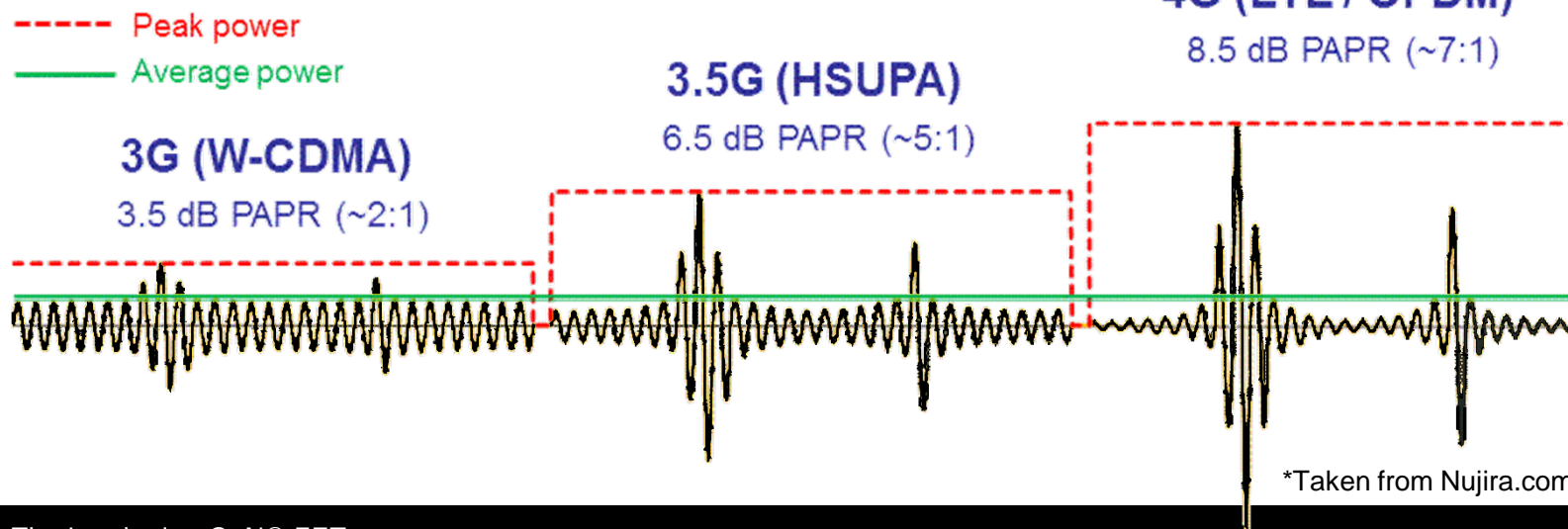
8.5 dB PAPR (~7:1)

3.5G (HSUPA)

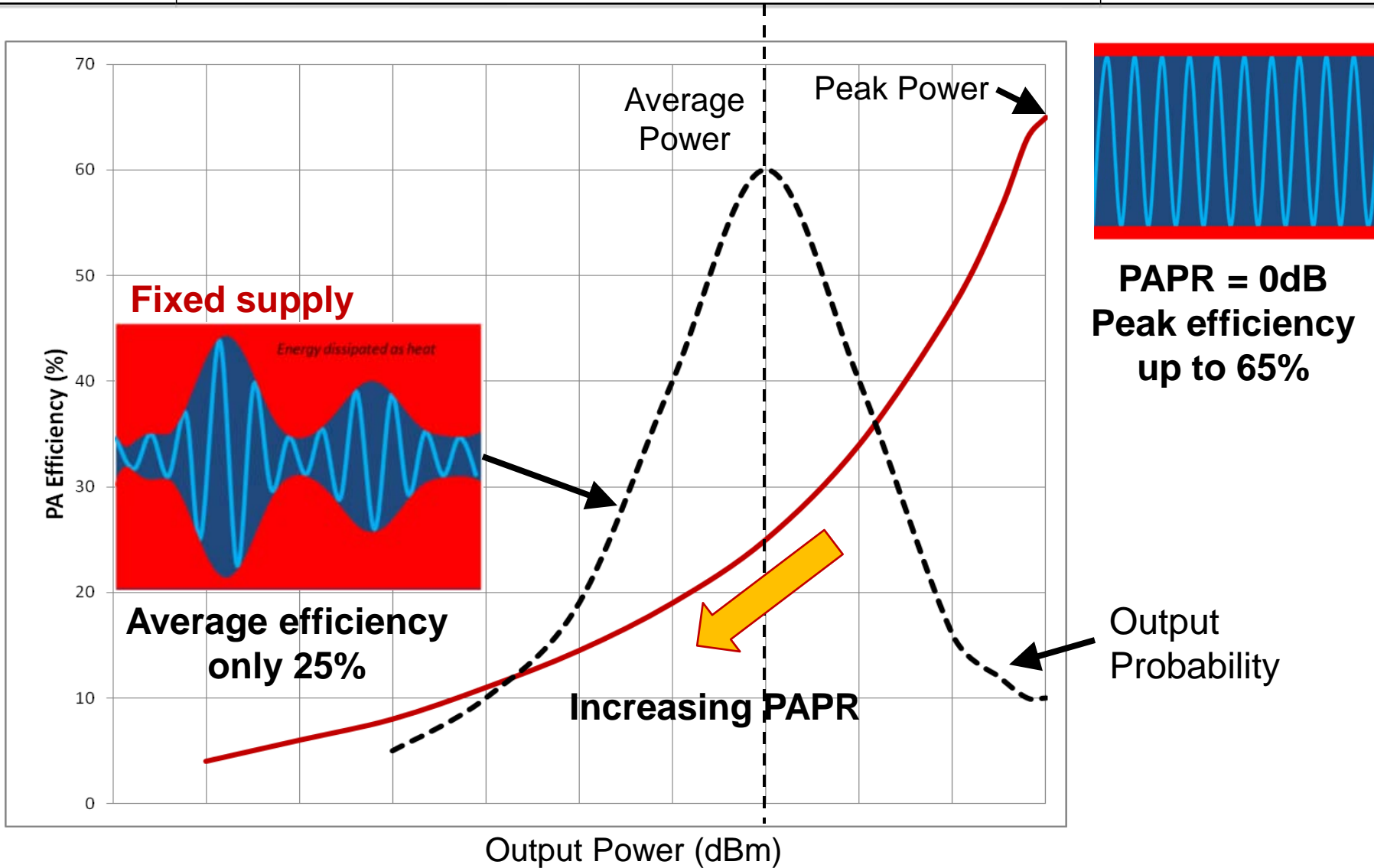
6.5 dB PAPR (~5:1)

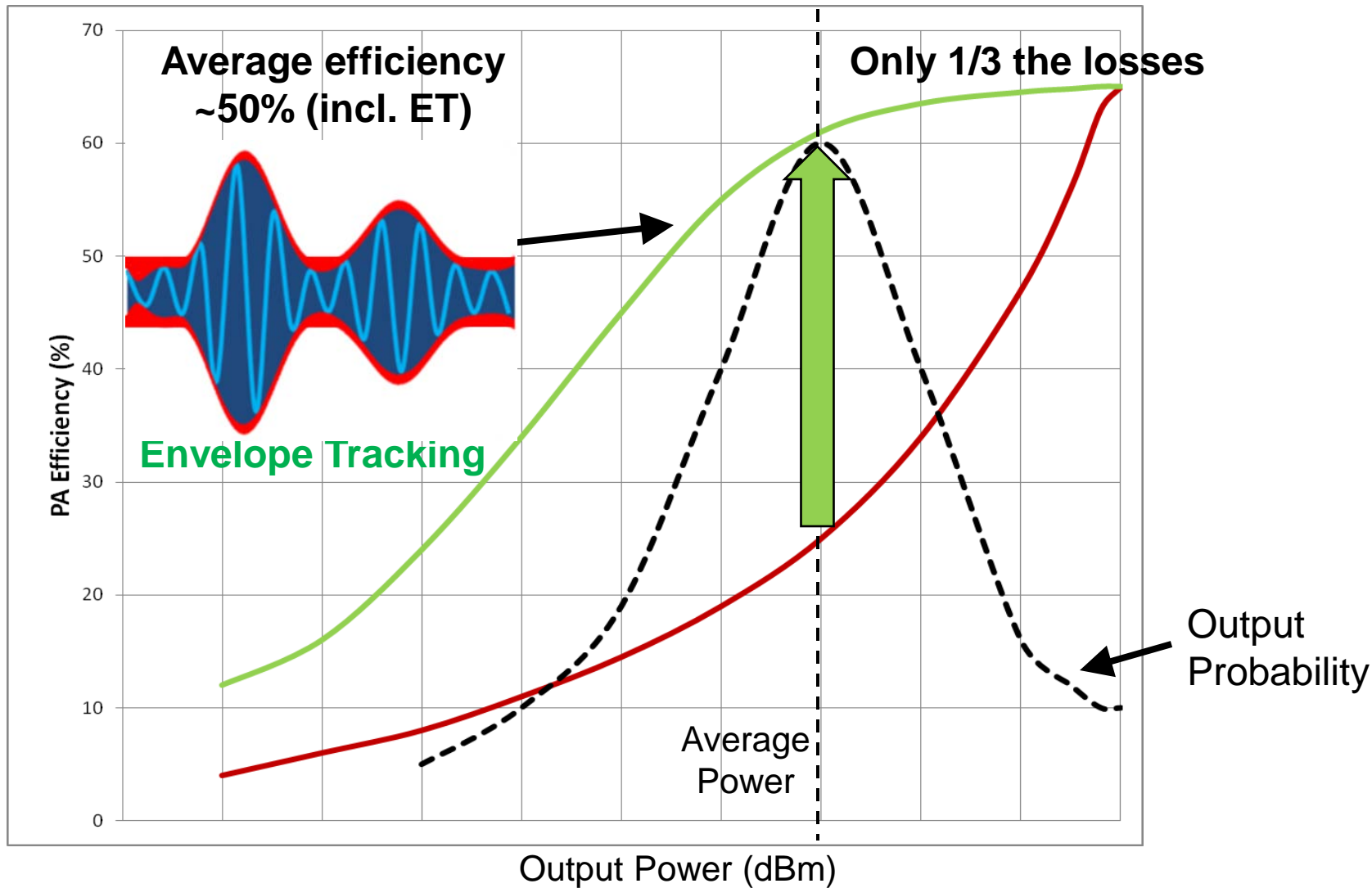
3G (W-CDMA)

3.5 dB PAPR (~2:1)



*Taken from Nujira.com website



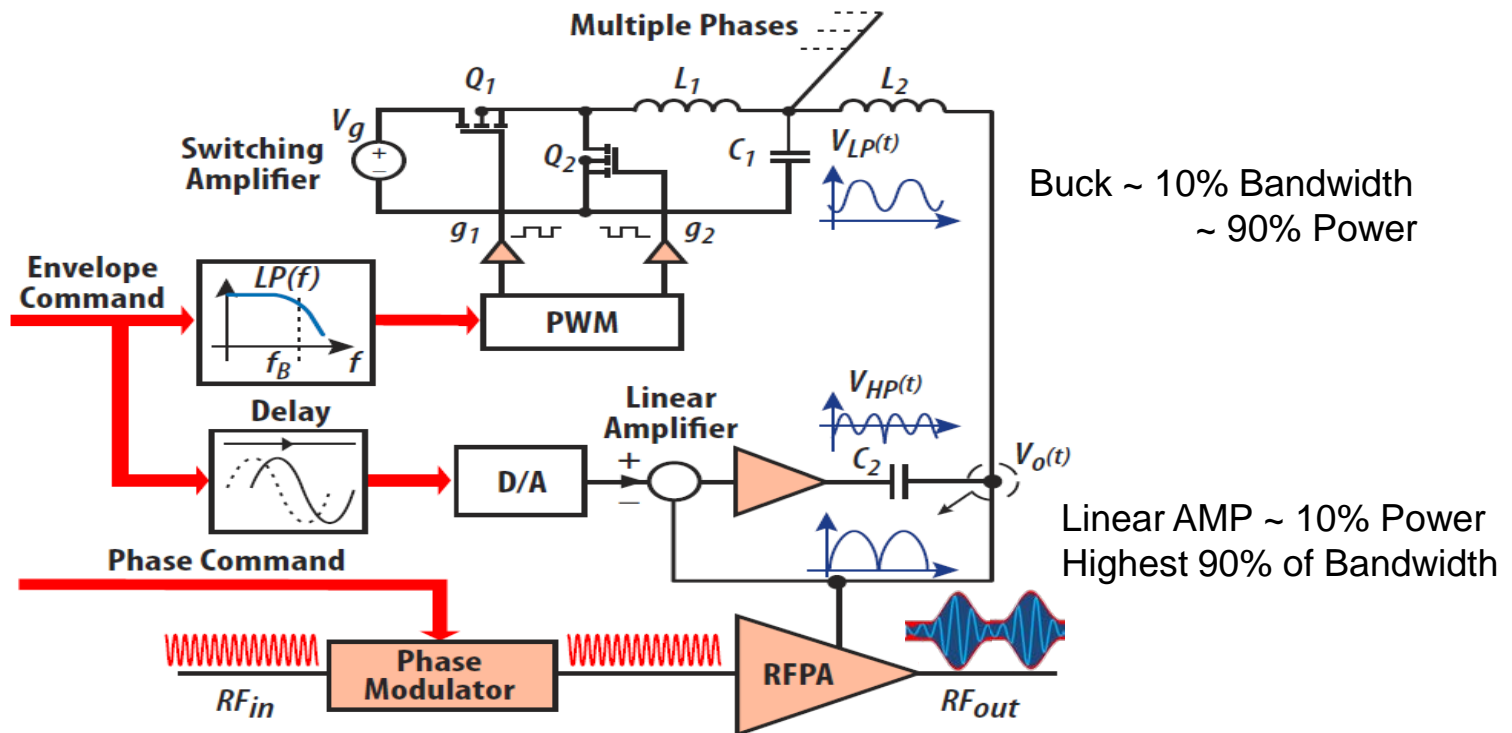


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- Up to 20 MHz Carrier bandwidth required
- Required ET supply BW up to 5x higher if linear control

*Taken from www.open-et.org website

- ET power supply topologies vary
 - Open loop boost – full BW required
 - Closed loop linear-assisted Buck

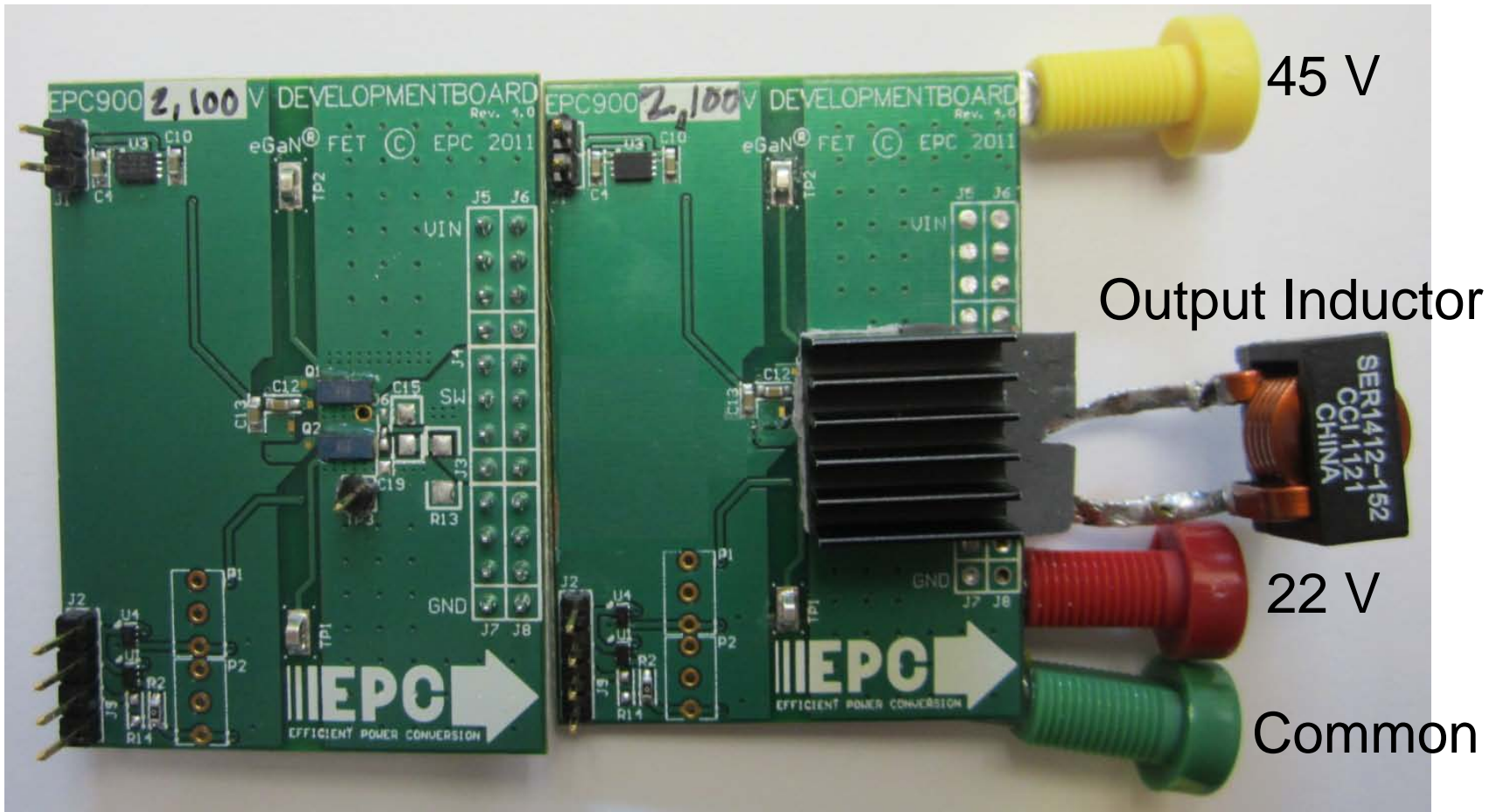


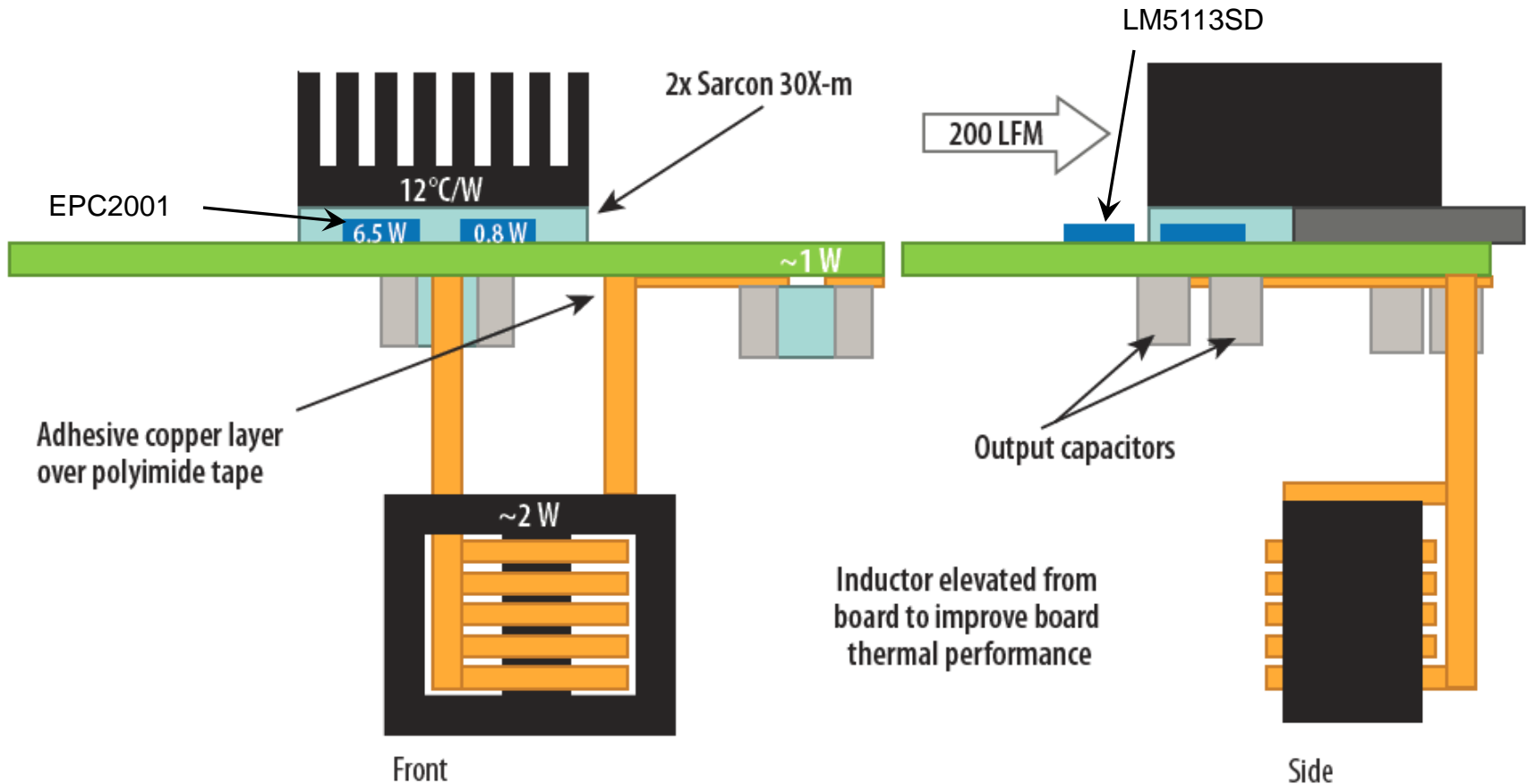
- 1300 W DVB* – 8 MHz BW and 8 dB PAPR
- Linear-assisted Buck for ET
 - 4ϕ x 1 MHz Buck with up to 800 kHz BW
- 45 Vin, 22 Vout/ 15 Aout (Avg)

- Pure Buck option for ET (Push frequency)
 - 10ϕ x 4 MHz Buck with up to 8 MHz BW
- 45 Vin, 22 Vout/ 6 Aout (Avg)

*Representative of a high power ET buck in HV LDMOS, such as that implemented by ET specialist Nujira.

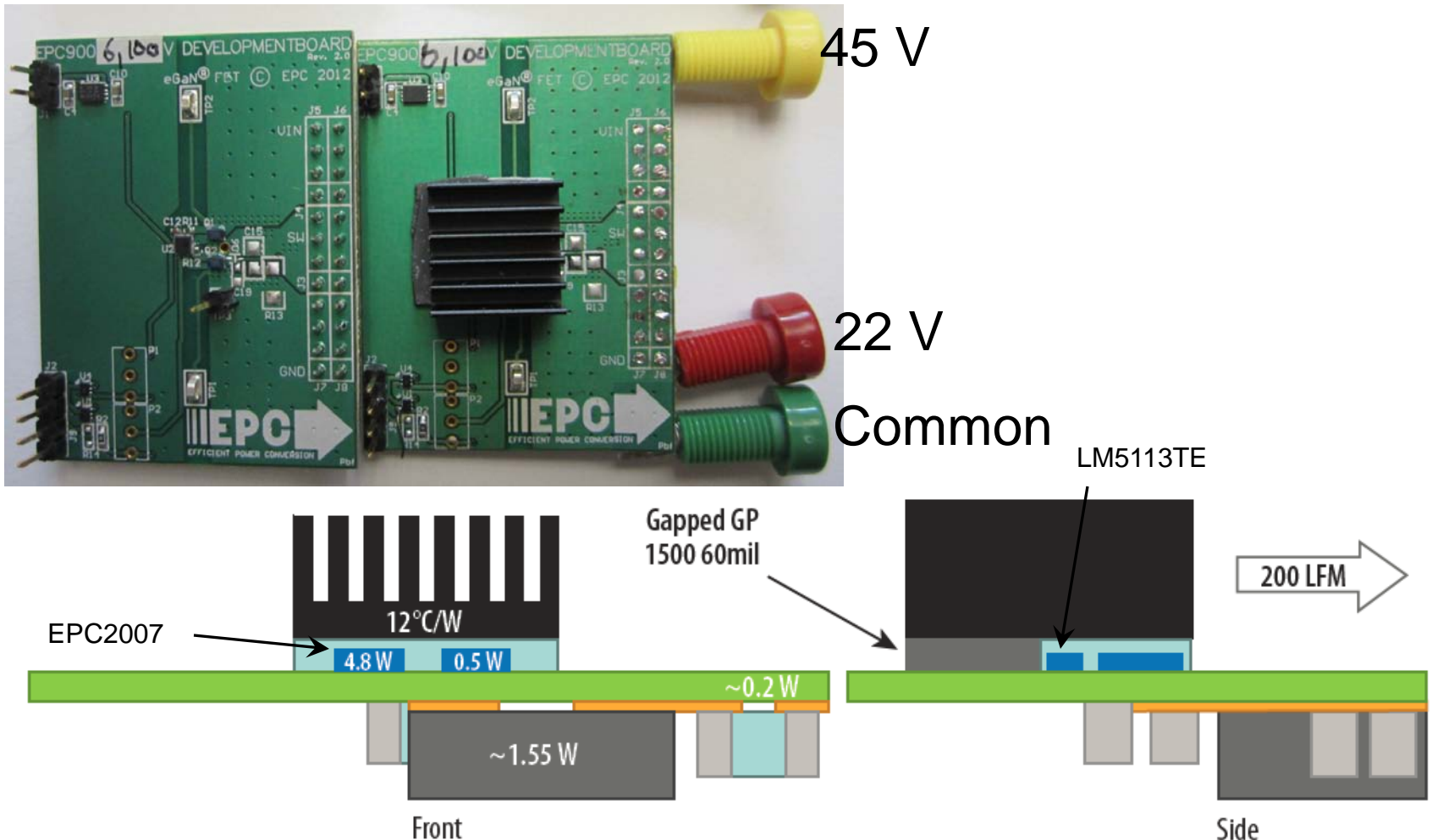
- Modified an EPC9002 development board





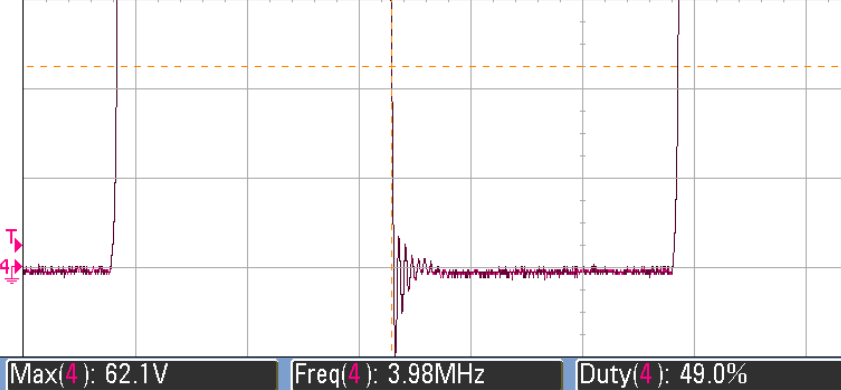
45 V to 22 V, 15 A, 1 MHz buck converter using EPC9002

- Modified an EPC9006 development board

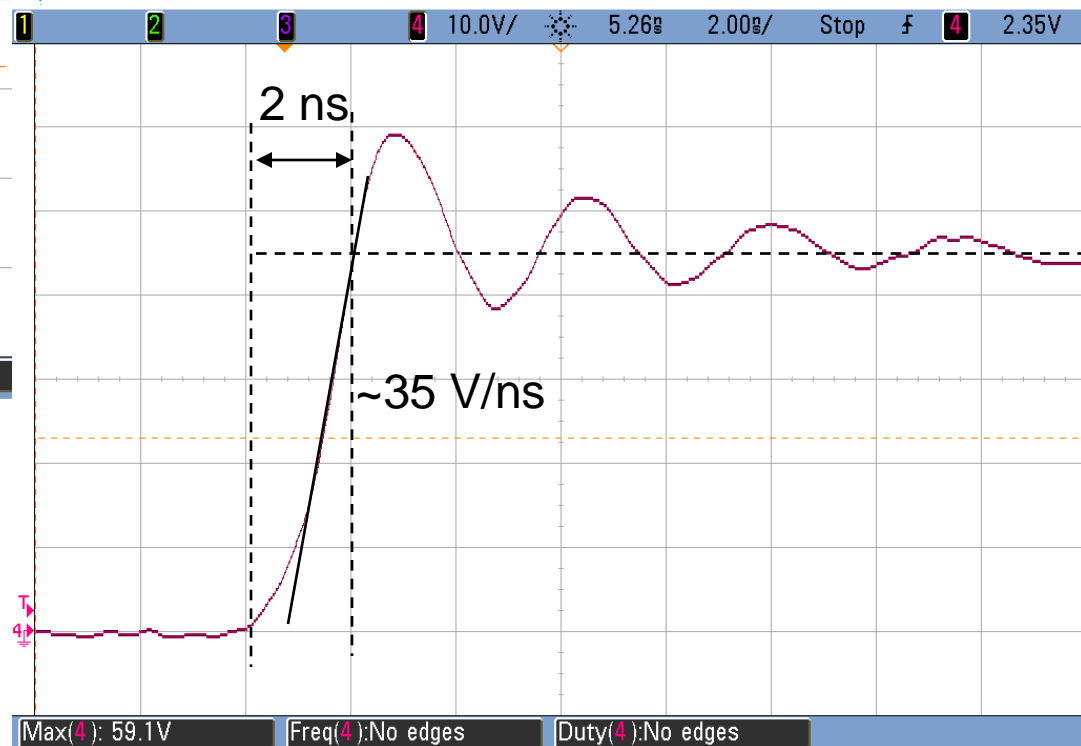


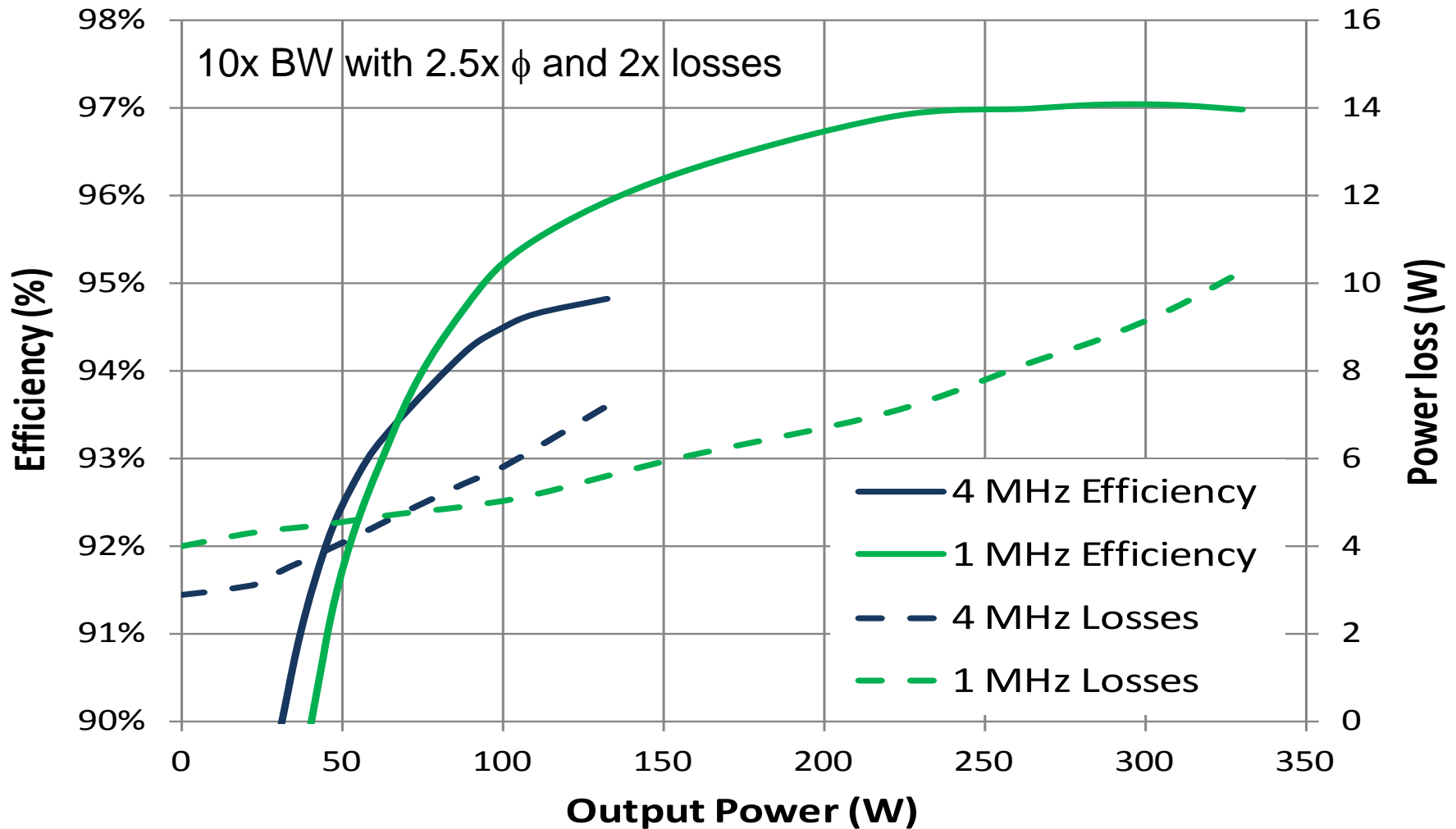


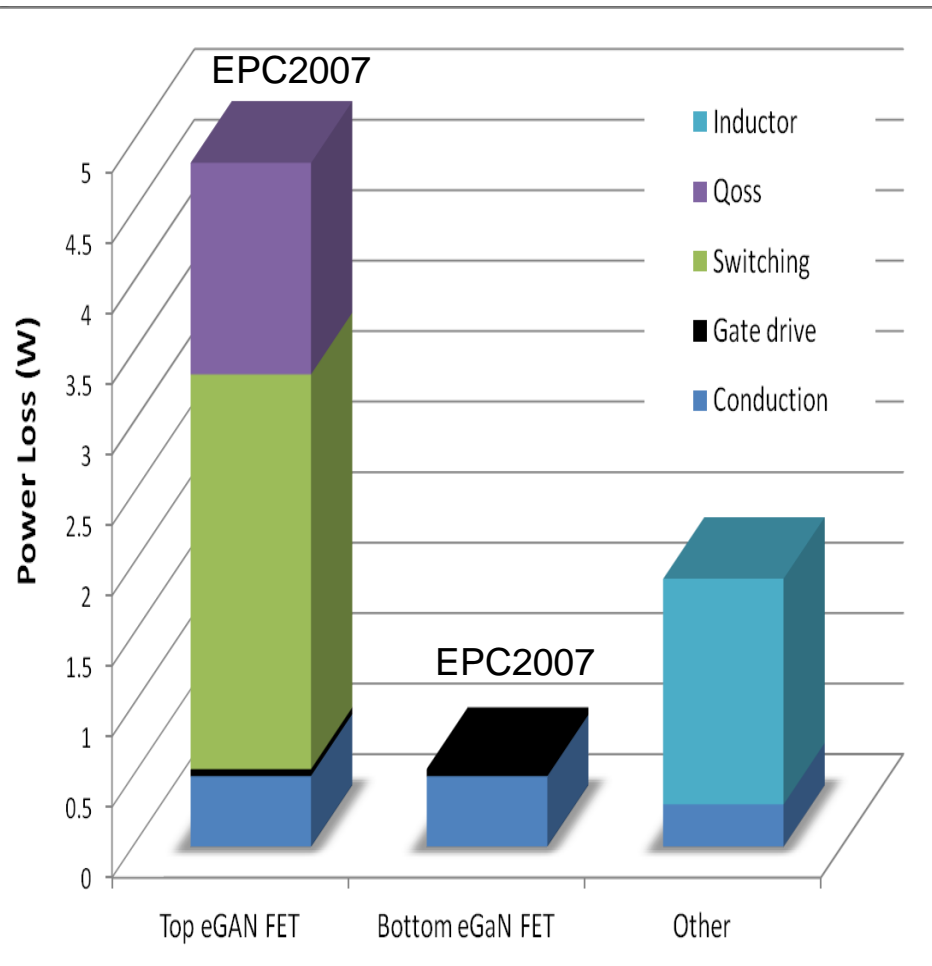
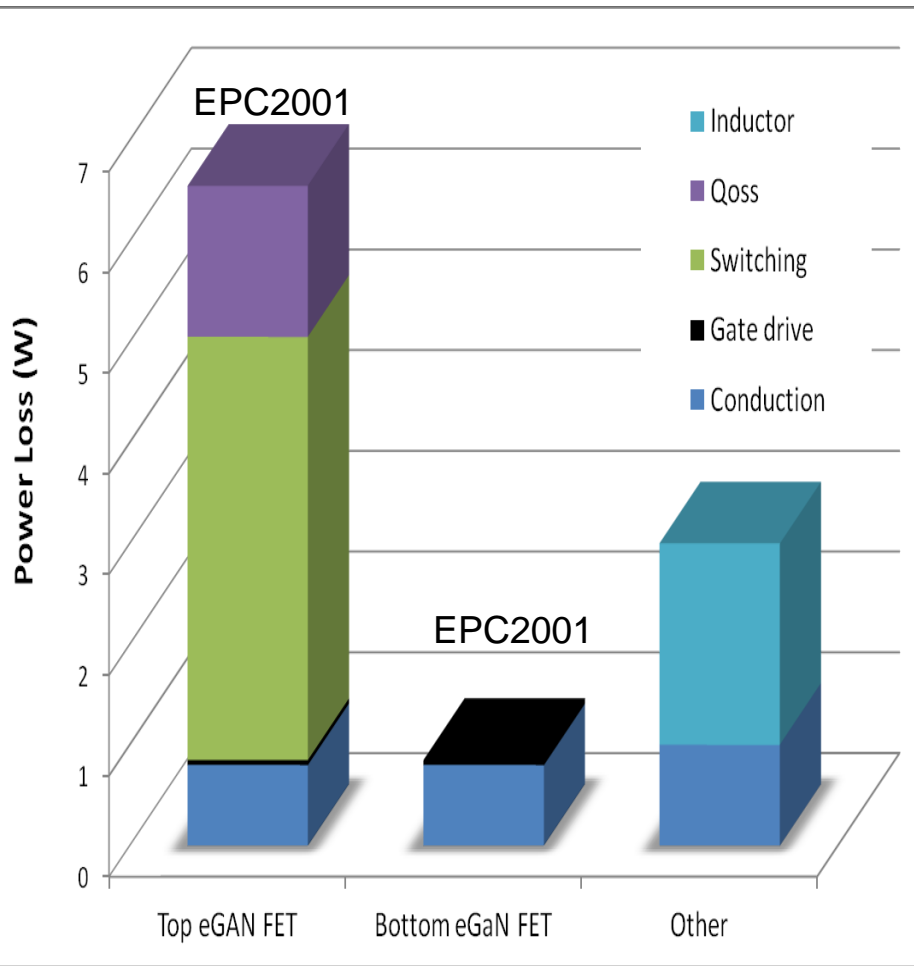
Switching Waveforms



EPC9006 @ 2 A / 4 MHz



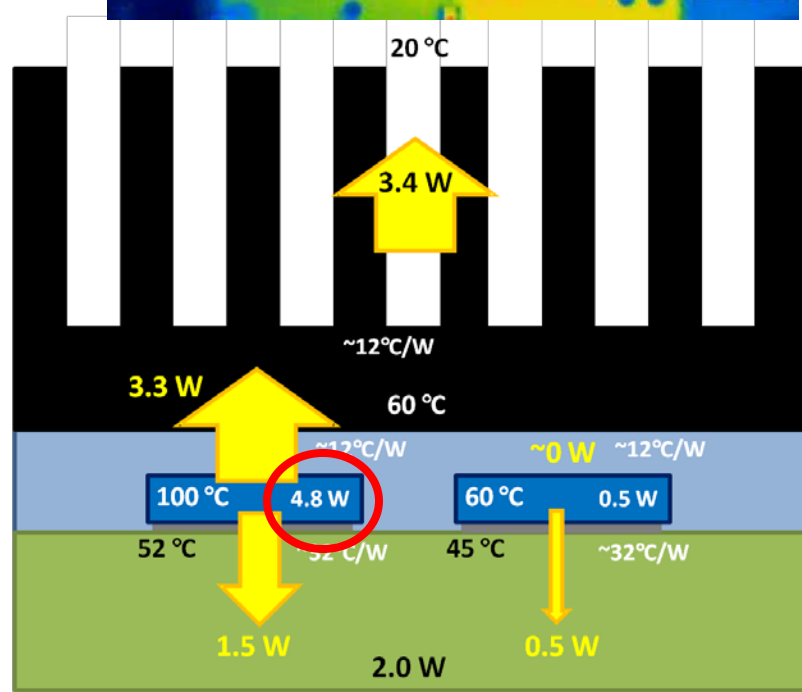
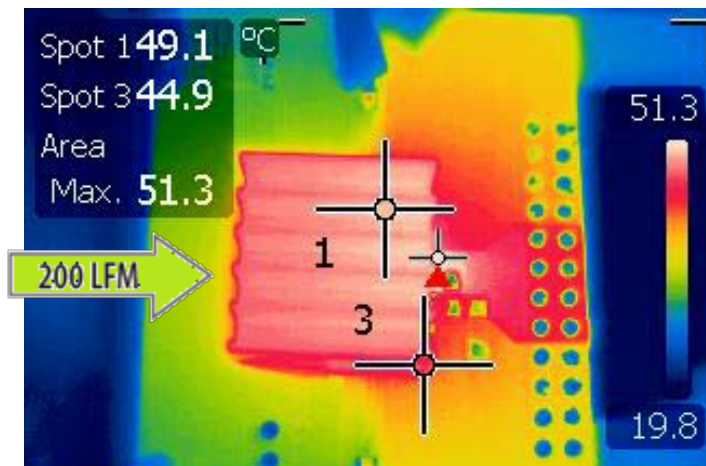
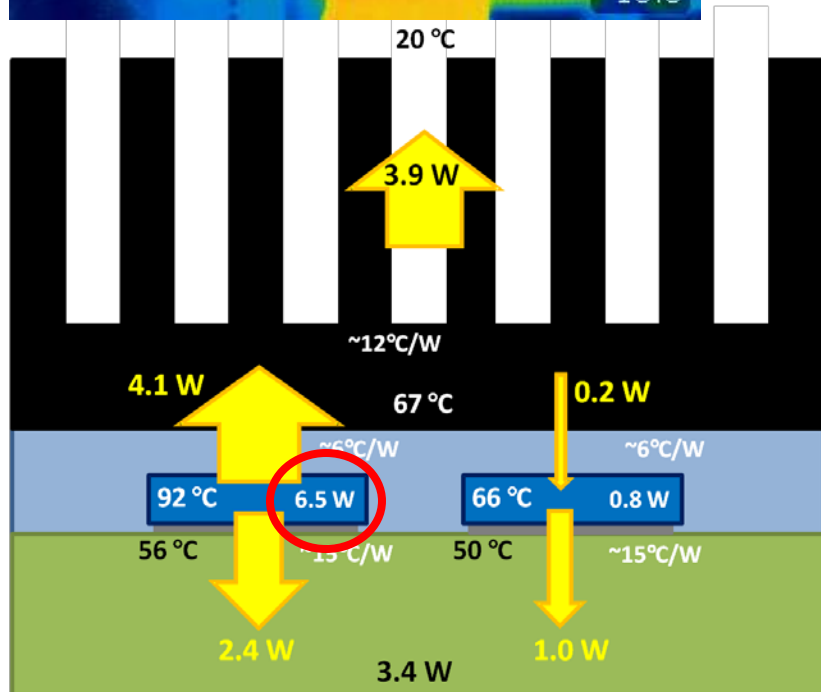
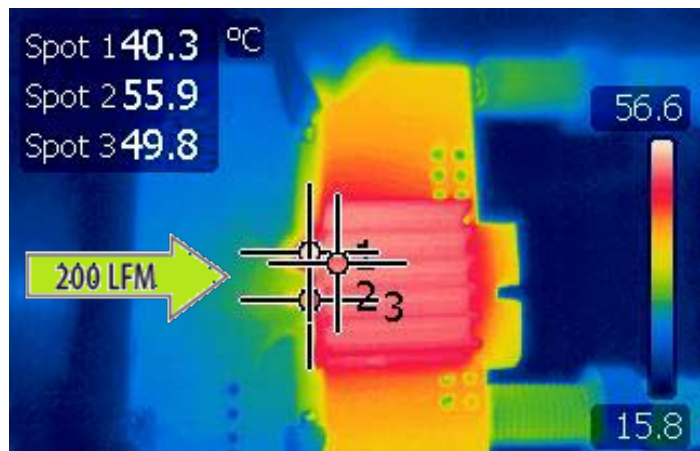




1 MHz EPC9002

4 MHz EPC9006

Future die size optimization possible



- eGaN FET switching times not limiting factor
 - < 1 ns delay / 2-3 ns switching time.
- 20 MHz BW require loop delay < 12 ns (90 deg)
 - Possible with pure buck requiring level-shifter?
- Linear assisted buck 'cleans up' Buck distortion.
 - Relaxes controller delay requirements

- eGaN FETs are an enabling technology for ET
 - Low charge reduce delay and switching times
 - Thermally possible with dual sized cooling
- Results are representative, but not optimized
 - Improve inductor selection
 - Improve thermal design
 - Reduce HS peak device temp. by reducing LS device size / Q_{OSS} losses
- Power and number of phases application specific



*The end of the road
for silicon.....*

*is the beginning of
the eGaN FET
journey!*