Efficient Power Conversion Corporation

Agenda

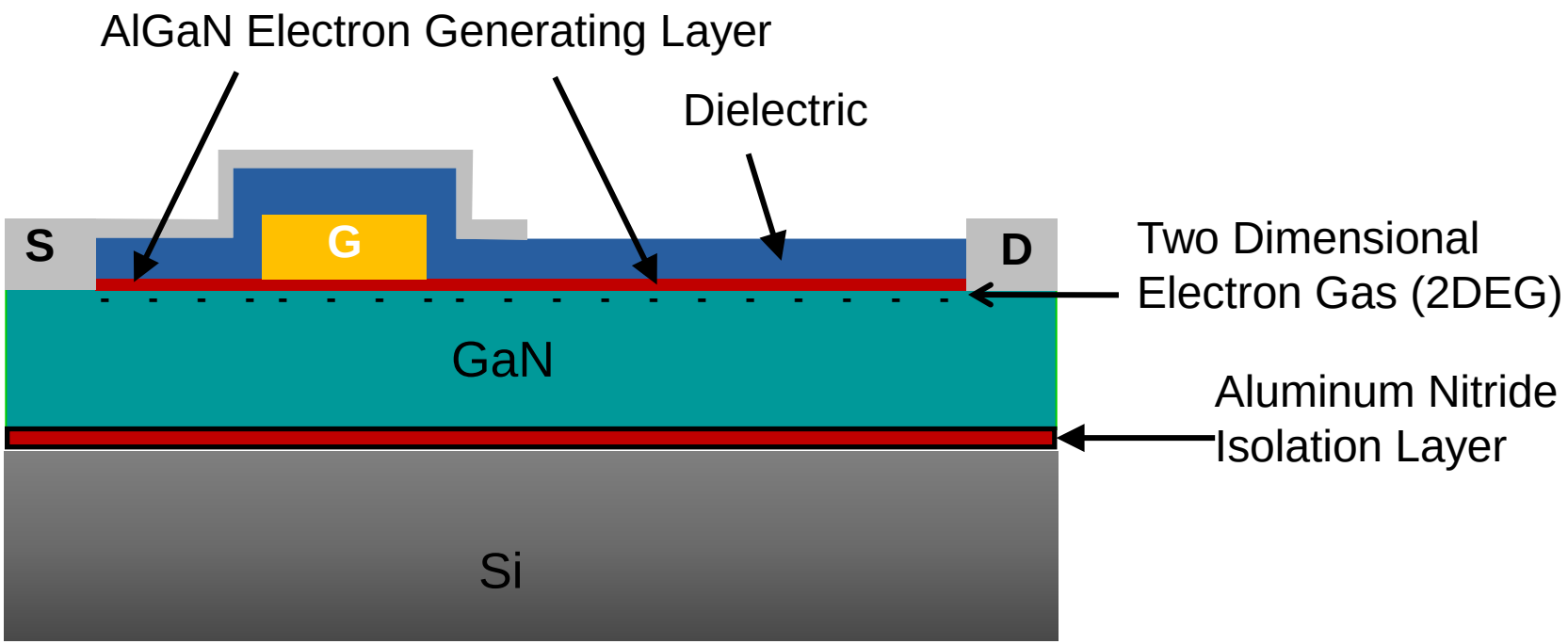
- EPC Update
- Overview of eGaN®FET Technology
- eGaN®FET Ecosystem
- Why Gallium Nitride?
- Isolated and non-isolated converter efficiency
- EPC Roadmap

Status

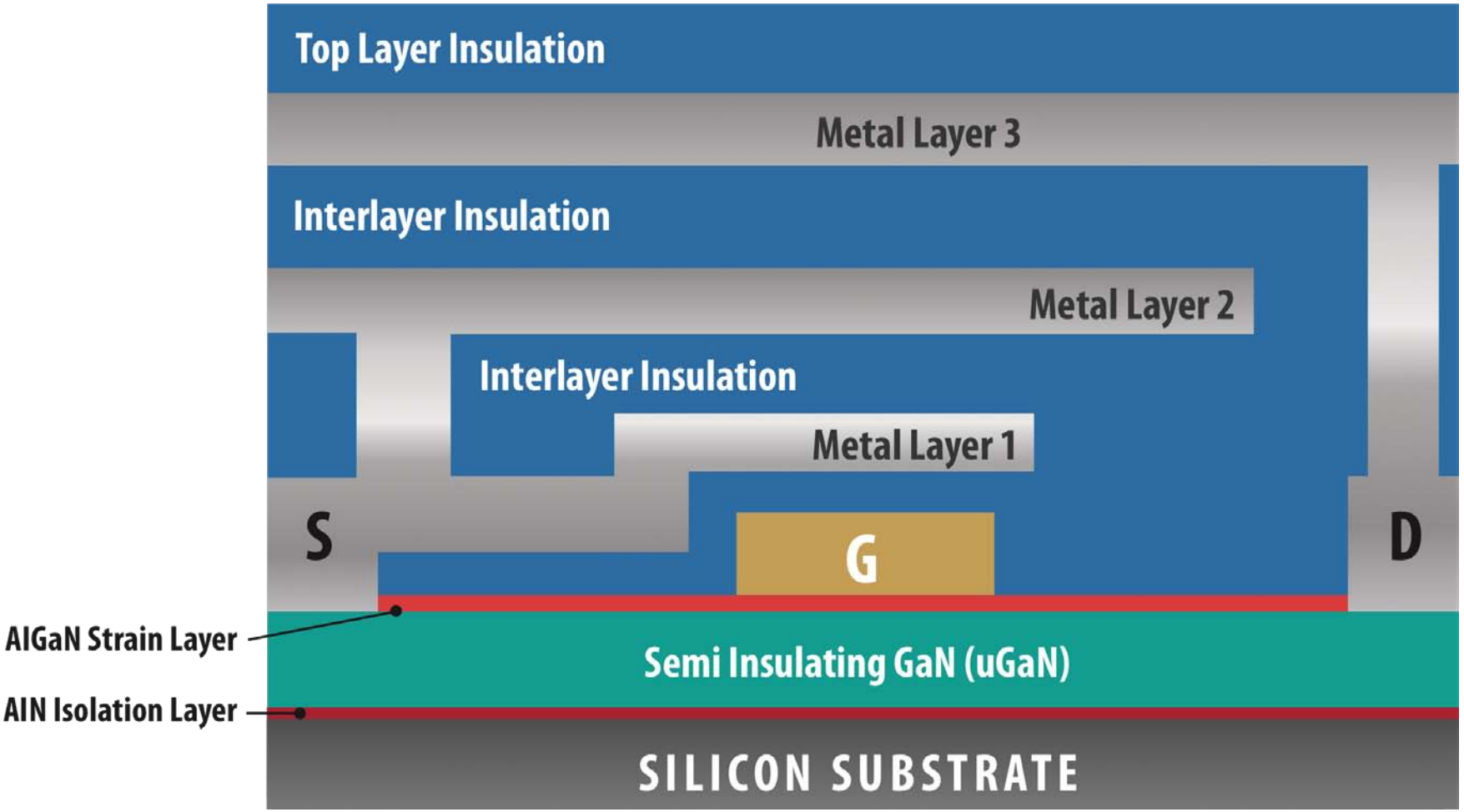
- Enormous capacity already in place
- eGaN FETs shipping to > 350 customers worldwide
- Several major IC companies are developing eGaN optimized drivers – the first of these, the LM5113 by Texas Instruments, was launched in June 2011
- Received ISO9001:2008 Certification in Q3 CY2011
- eGaN FETs have demonstrated that improved efficiency can be obtained now in servers, telecom equipment, solar microinverters, medical equipment, and RF transmission systems

Overview of eGaN® FET Technology

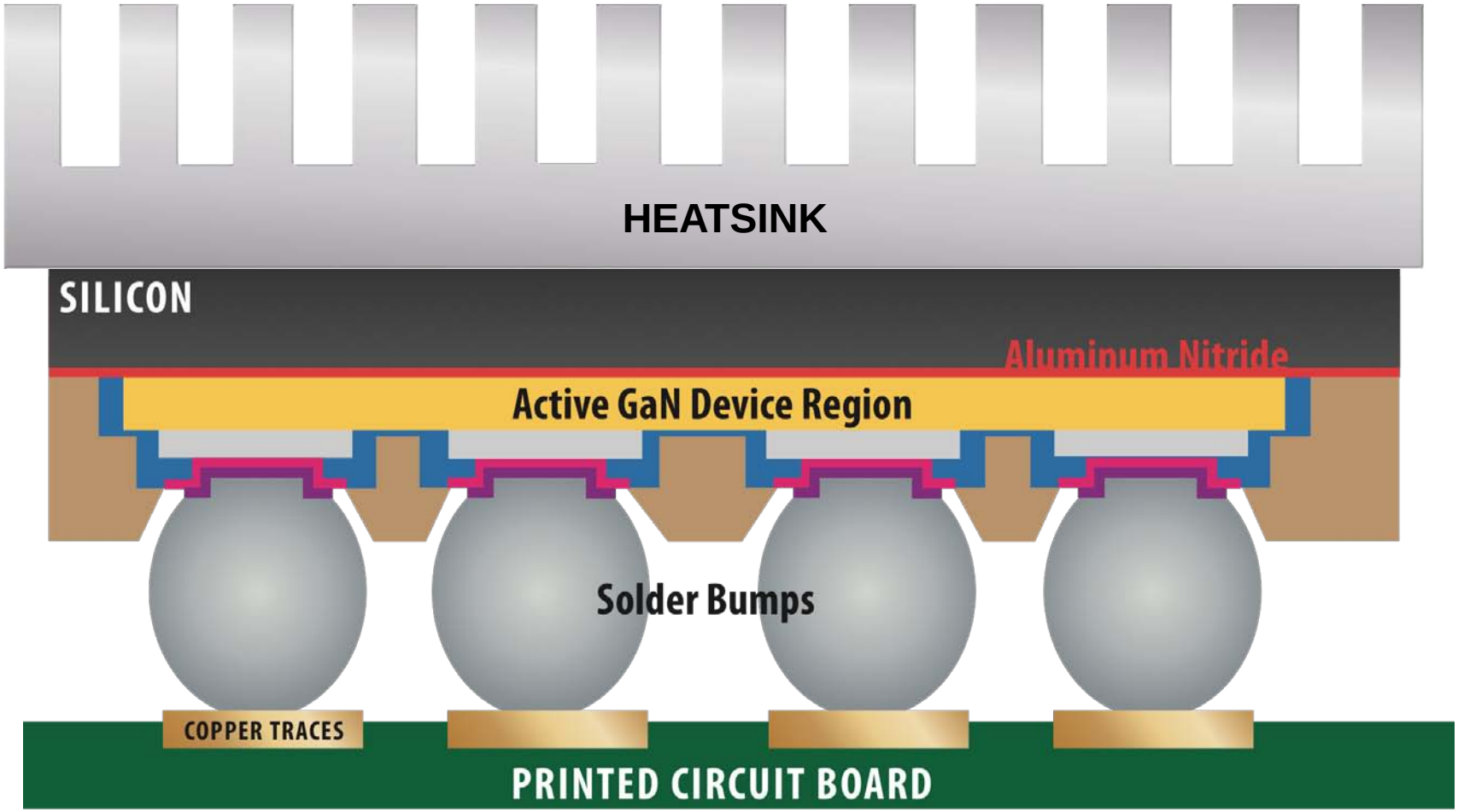
eGaN® FET Structure



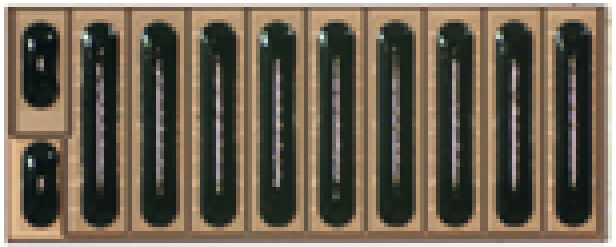
eGaN® FET Structure



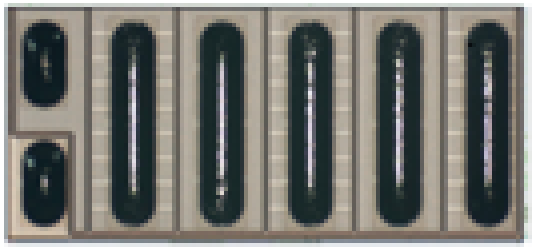
LGA Assembly



EPC *MOSFET Killer* Products



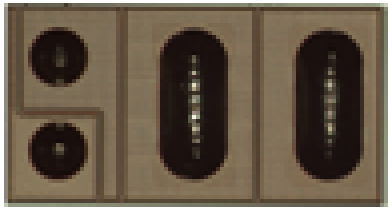
LGA 4.1x1.6 x0.8



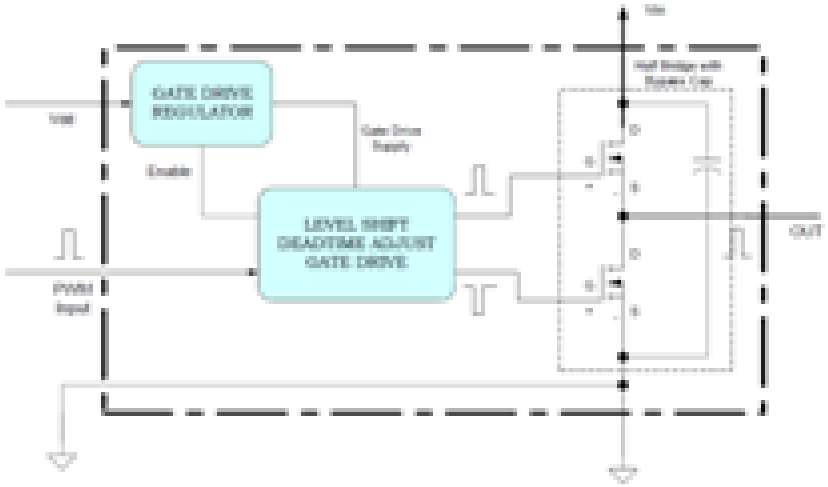
LGA 3.6x1.6 x0.8

Development Board available

LGA 1.7x1.1x0.8



LGA 1.7x0.9x0.8



EPC Shortform

Part Number	Package (mm)	RoHS and Halogen Free	$T_{J(MAX)}$ (°C)	V_{DS}	V_{GS} (max)	Max $R_{DS(ON)}$ (mΩ) @5V_{GS}	Q_G typ (nC)	Q_{GS} typ (nC)	Q_{GD} typ (nC)	Q_{OSS} typ (nC)	V_{TH} typ	Q_{RR} (nC)	I_D (A)
EPC2015	LGA 4.1x1.6	Yes	150	40	6	4	10.5	3	2.2	18.5	1.4	0	33
EPC2014	LGA 1.7x1.1	Yes	150	40	6	16	2.5	0.67	0.48	4.8	1.4	0	10
EPC2001	LGA 4.1x1.6	Yes	125	100	6	7	8	2.3	2.2	35	1.4	0	25
EPC2007	LGA 1.7x1.1	Yes	125	100	6	30	2.1	0.5	0.6	10	1.4	0	6
EPC2010	LGA 3.6x1.6	Yes	125	200	6	25	5	1.3	1.7	40	1.4	0	12
EPC2012	LGA 1.7x0.9	Yes	125	200	6	100	1.5	0.33	0.57	11	1.4	0	3

40V - 200V in mass production, 600V sampling in Q4 2011

Demo Boards

EPC's half bridge development boards simplify the evaluation process of our eGaN FETs by including all the critical components and layout for optimal switching performance on a single board that can be easily connected into any existing converter.

Part Number	Description	V_{DS} (max)	Id (max RMS)	Featured Product	Schematic	Gerber	Bill of Materials	
EPC9001	Half Bridge Plus Driver	40	15	EPC2015				Buy Now
EPC9002	Half Bridge Plus Driver	100	10	EPC2001				Buy Now
EPC9003	Half Bridge Plus Driver	200	5	EPC2010				Buy Now
EPC9004	Half Bridge Plus Driver	200	3	EPC2012				Buy Now
EPC9005	Half Bridge Plus Driver	40	7	EPC2014				Buy Now
EPC9006	Half Bridge Plus Driver	100	5	EPC2007				Buy Now

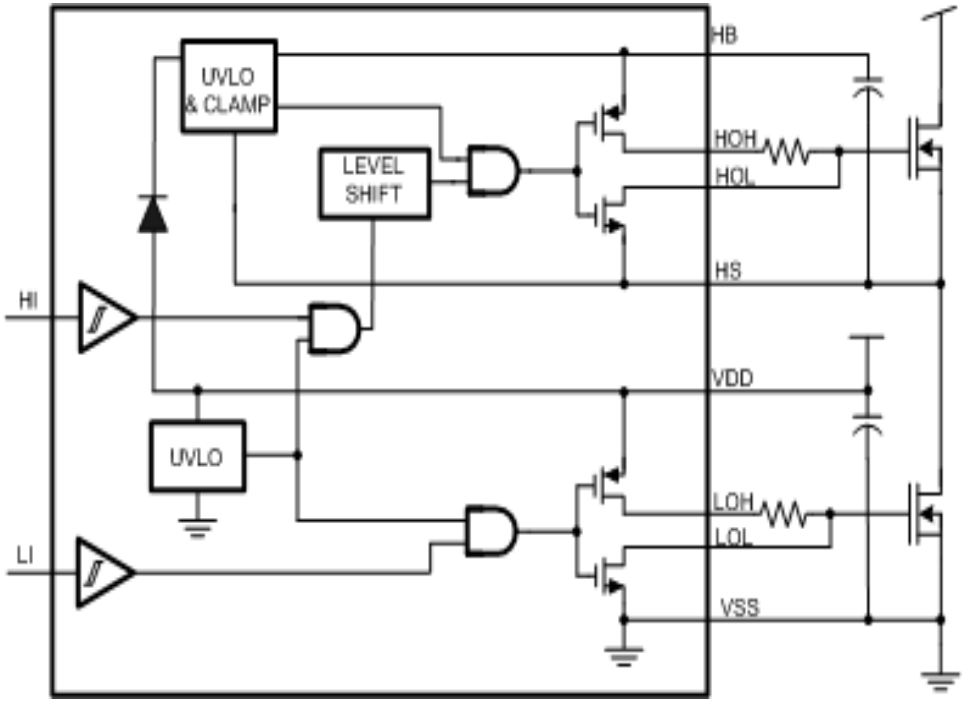
Part Number	Description	Vin	Vout	Iout	Featured Product	Schematic	Gerber	Bill of Materials	
EPC9101	19V to 1.2V Buck Converter	8V-19V	1.2V	18A	EPC2015/EPC2014				Buy Now
EPC9102	48V to 12V 1/8th Brick	36V-60V	12V	15A	EPC2001/EPC2015				Coming Soon

eGaN Ecosystem

LM5113 – Half Bridge Gate Driver Optimized for eGaN FETs

Key Features

- 0.5 Ohm Sink and 2 Ohm Source Capability
- Independent Source and Sink Outputs
- Bootstrap Voltage Clamp
- Vcc UVLO optimized for eGaN FETs (3.5V)
- 100V V_{HS} Rating
- >50V/ns dv/dt Immunity at V_{HS}
- Independent TTL Inputs
- Short Propagation Delays (25ns)
- 4ns Delay Matching Between Channels
- Low Power Consumption (2mA @ 0.5MHz)



Availability

- Packages: **LLP-10 (4mm x 4mm), uSMD12 (2mm x 2mm)**
- Production Release: **Oct 2011**

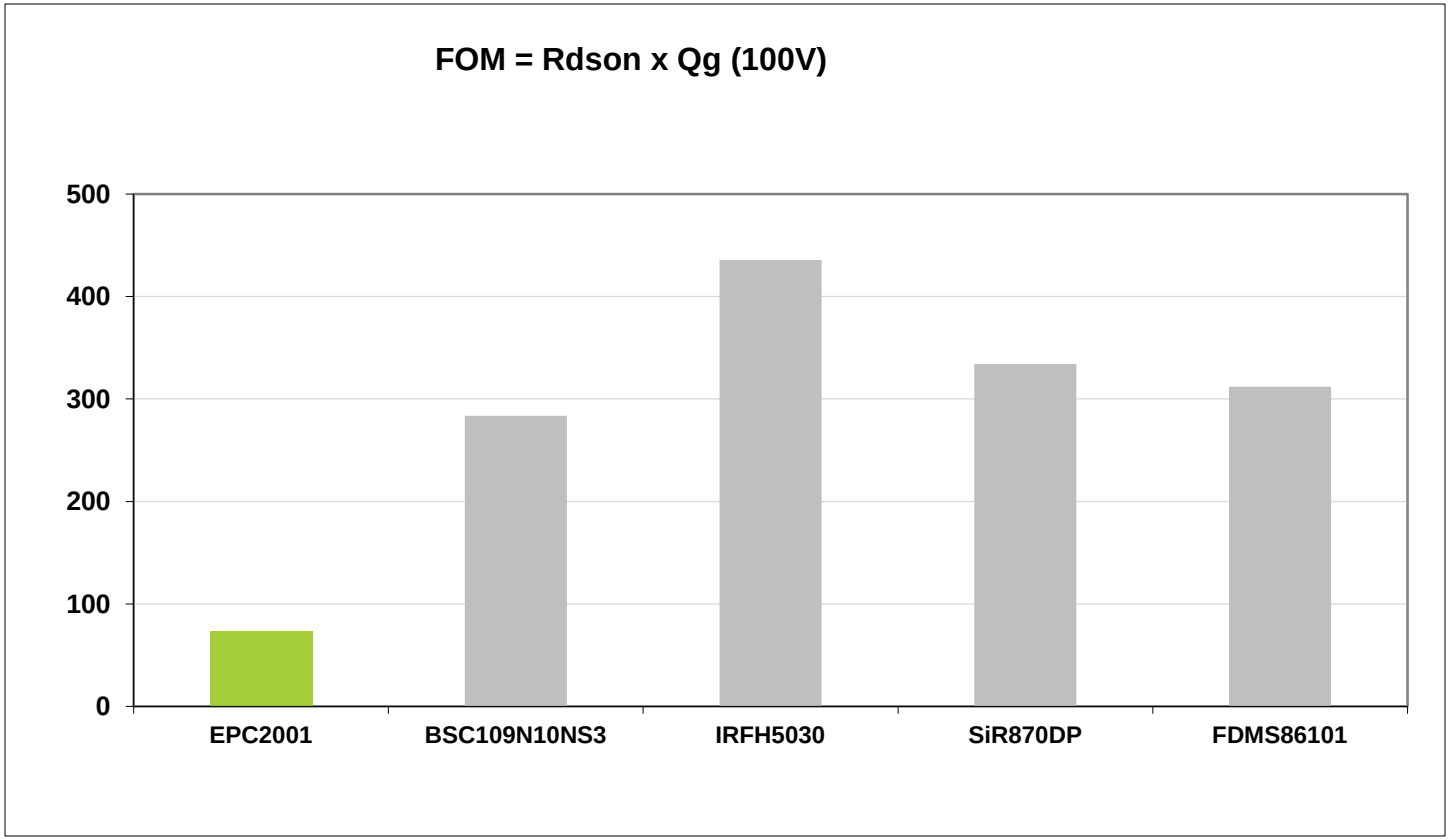
Why Gallium Nitride?

eGaN® FETs are Smaller

200V Silicon Device
(30 milli Ohms)

200V GaN Device
(25 milli Ohms)

eGaN® FETs are Faster



Source: Infineon, International Rectifier, Siliconix, and Fairchild data sheets

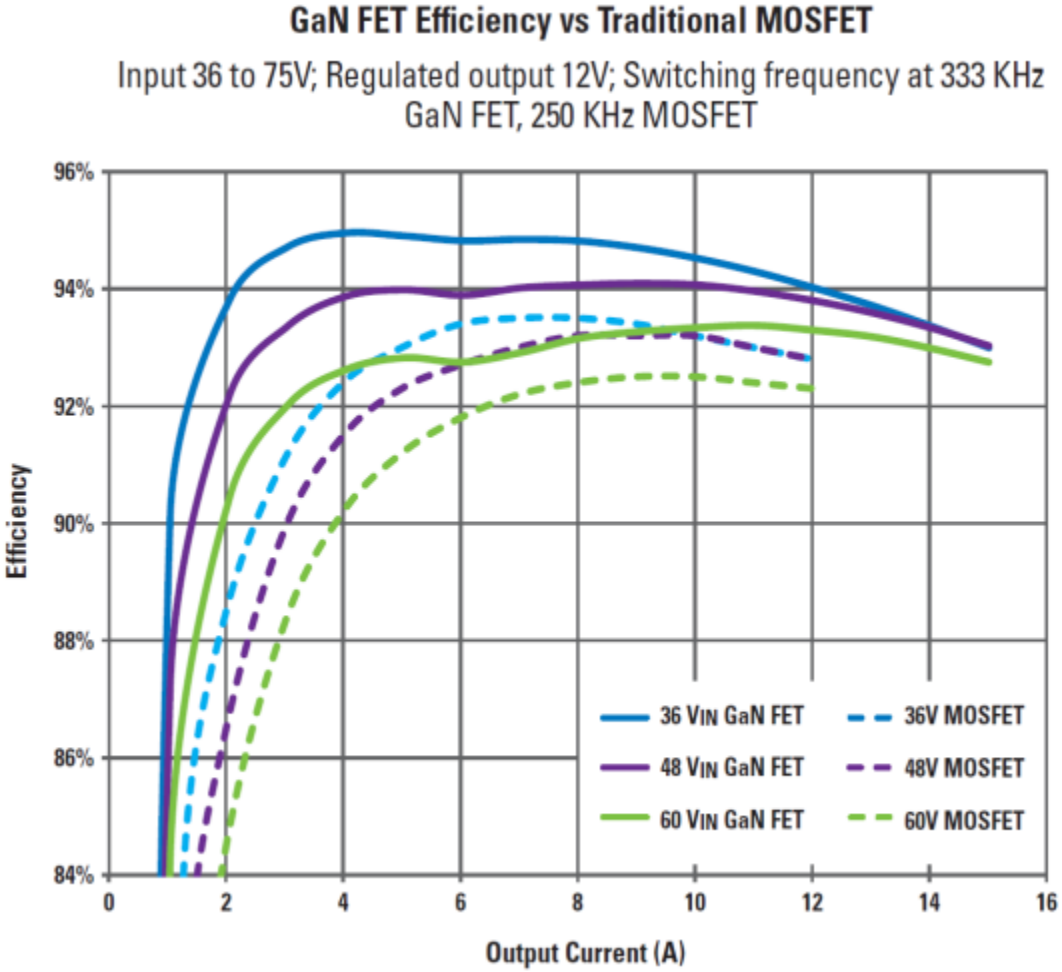
eGaN® FETs Can Be Cheaper

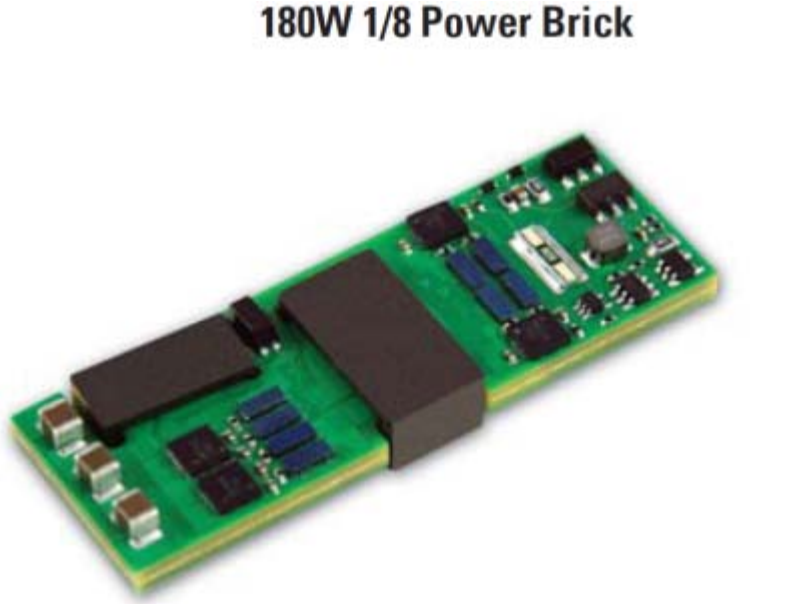
	2010	2015
Starting Material	same	same
Epi Growth	**higher**	**same**
Wafer Fab	same	lower
Test	same	same
Assembly	lower	lower
OVERALL	**higher**	**lower**

Source: EPC

Isolated DC-DC Converter

eGaN FET vs. MOSFET Performance Comparison

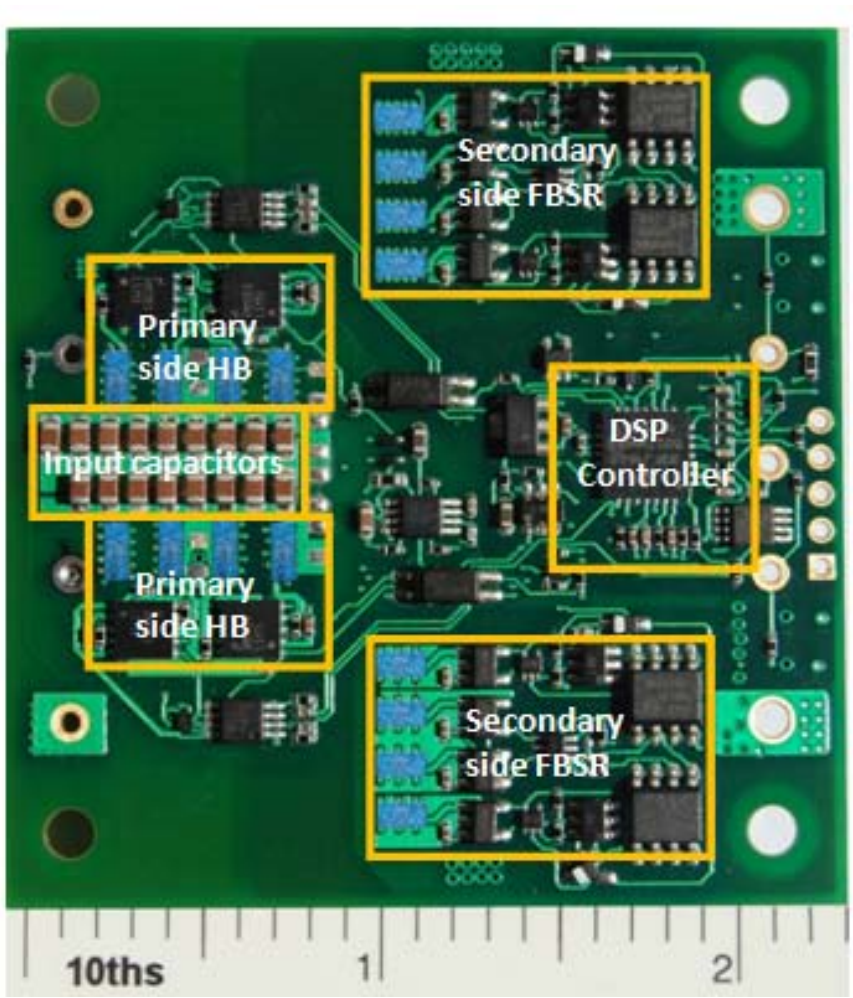


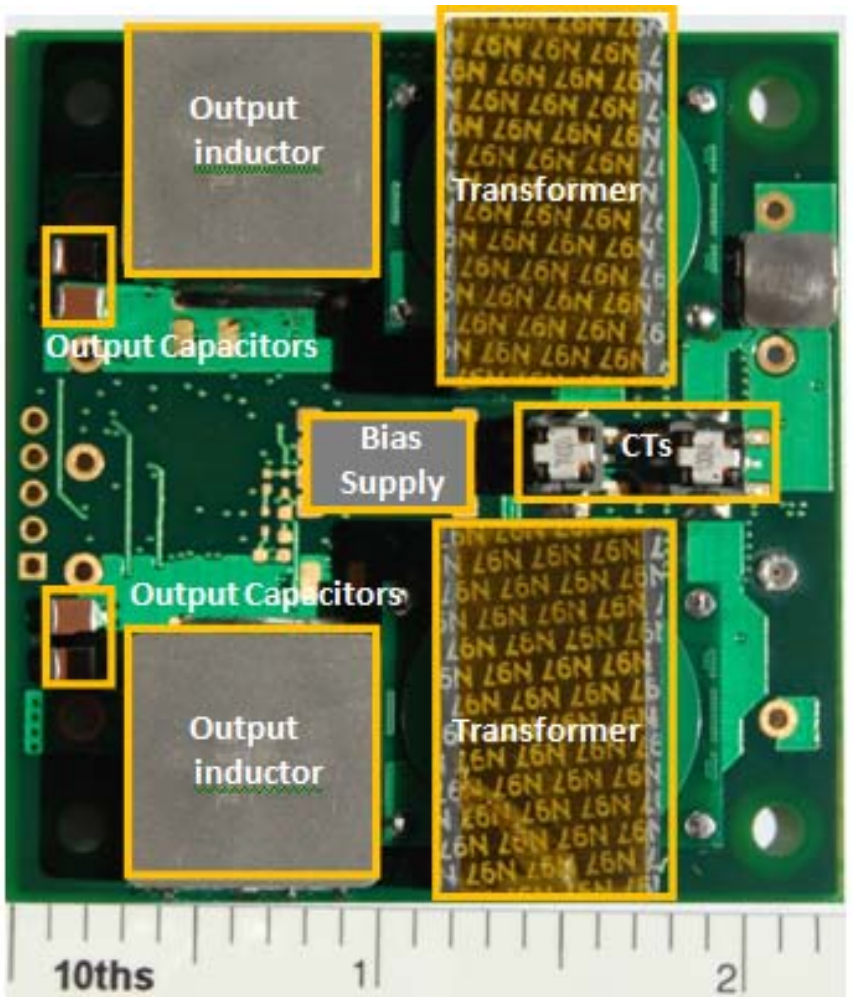


1/8 power brick featuring the EPC2001 eGaN FET and LM5113 GaN FET driver.

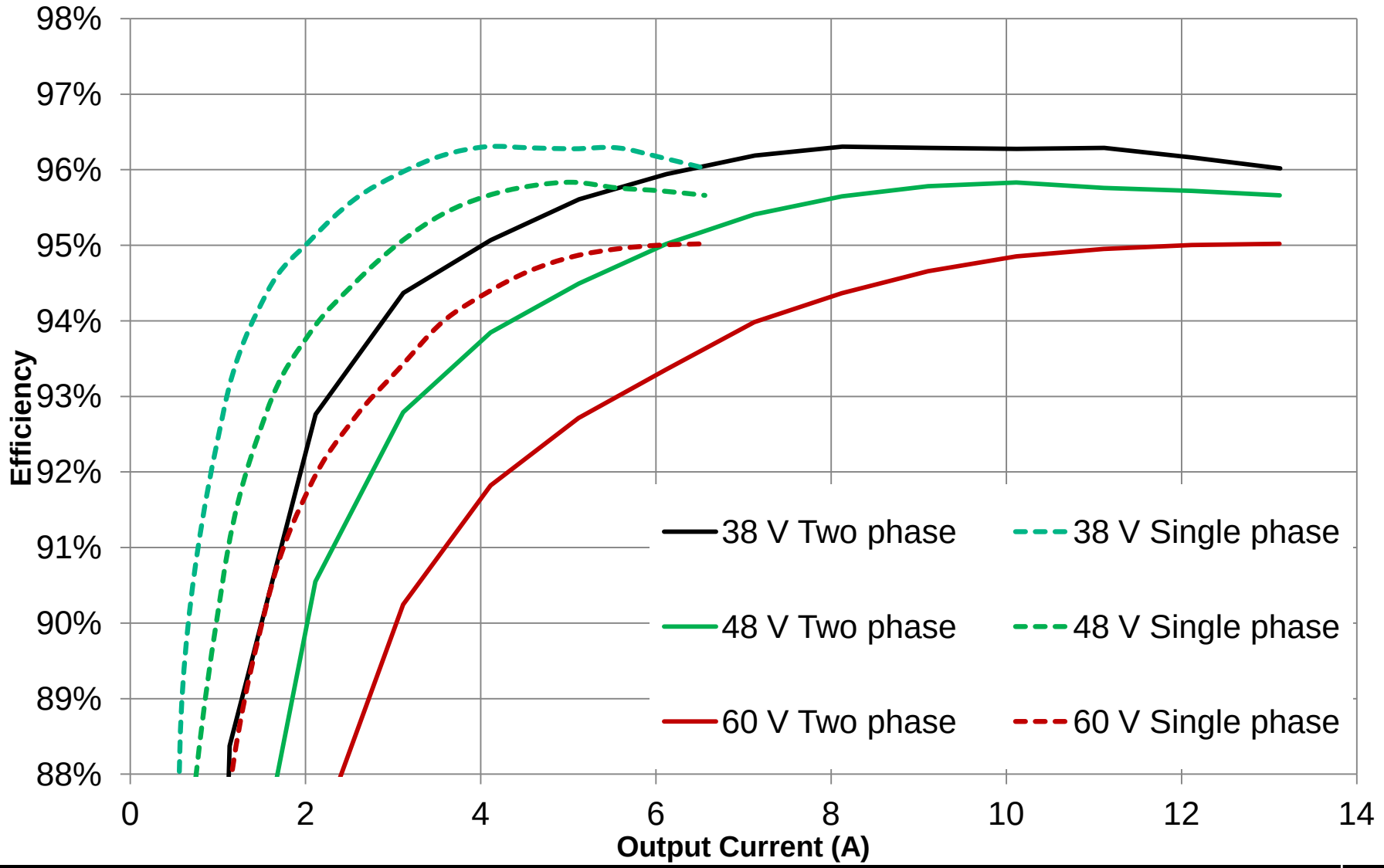
Isolated 1/8th Brick, Regulated 12 Vout

eGaN FET half-brick PSE

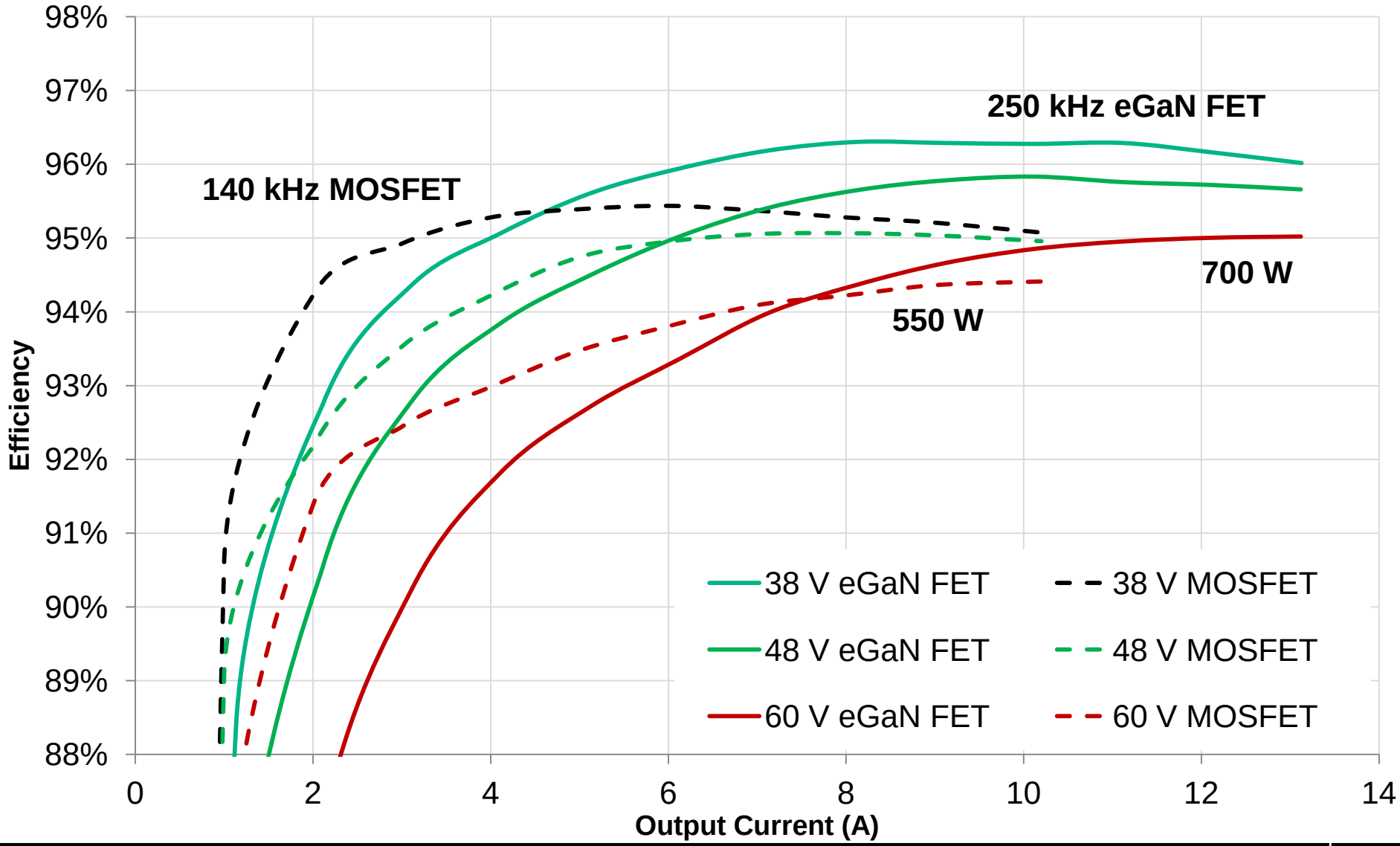




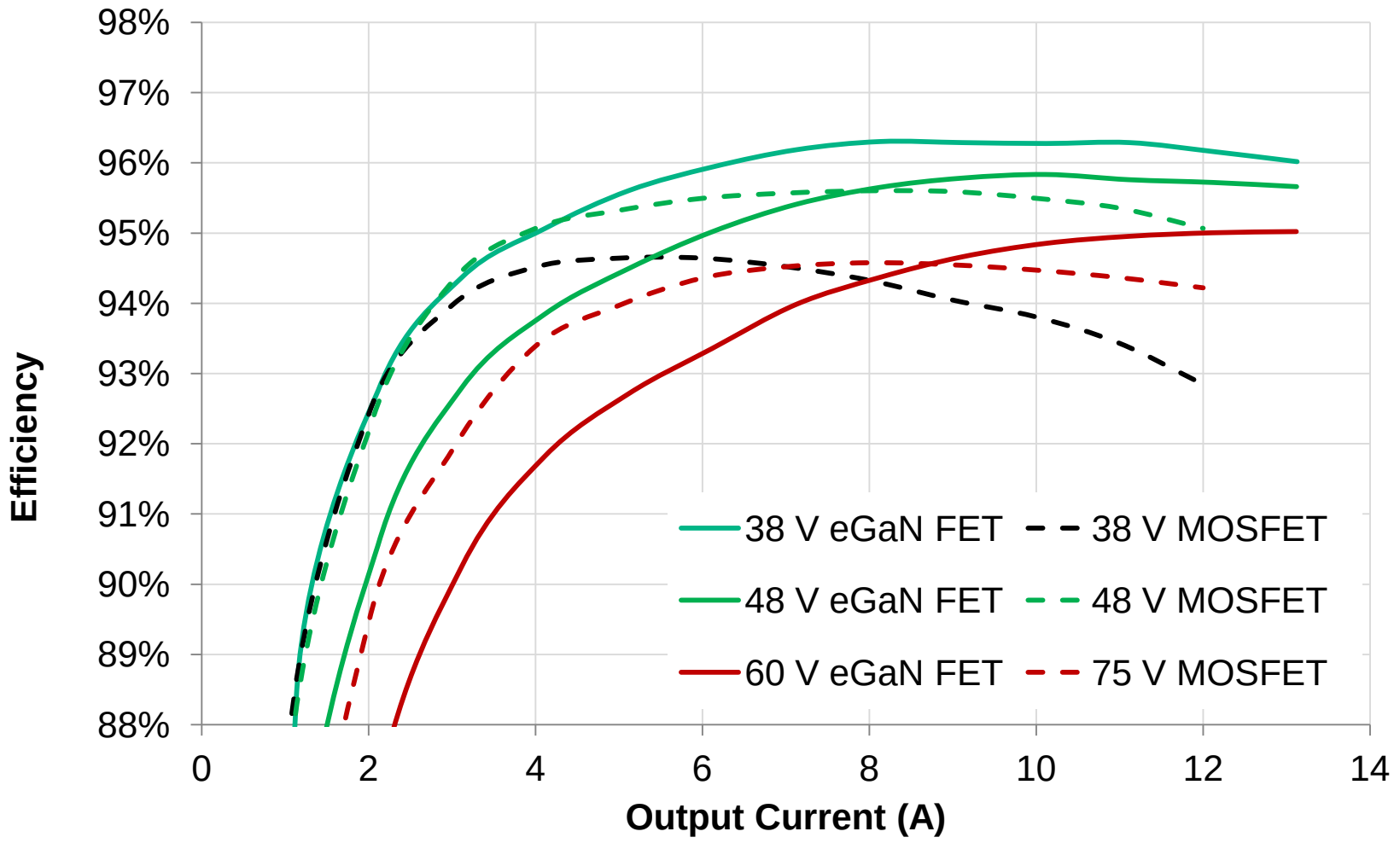
Single Phase Vs Two Phase



Efficiency Comparison

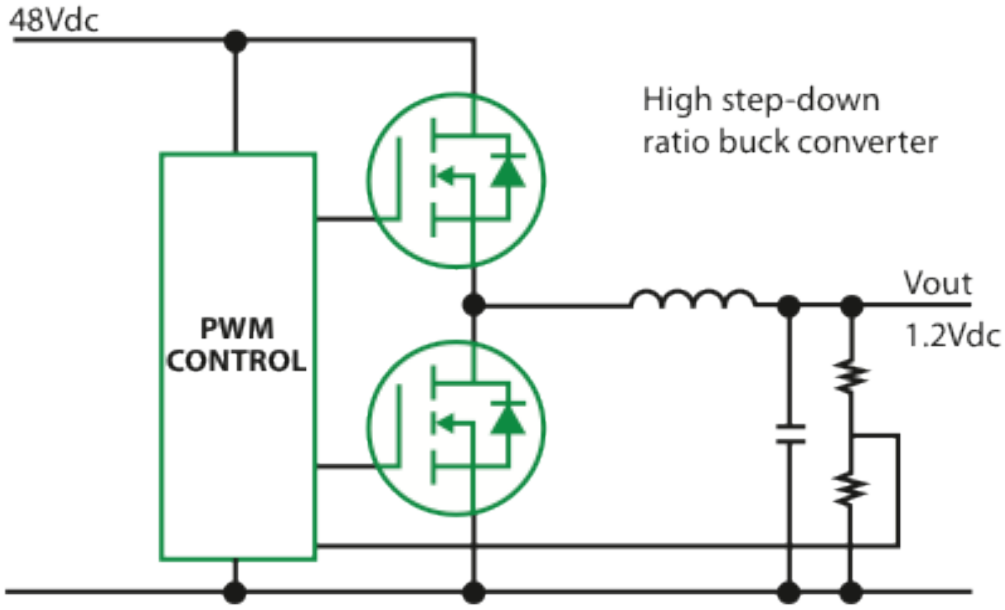


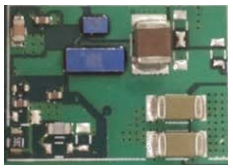
Efficiency Comparison



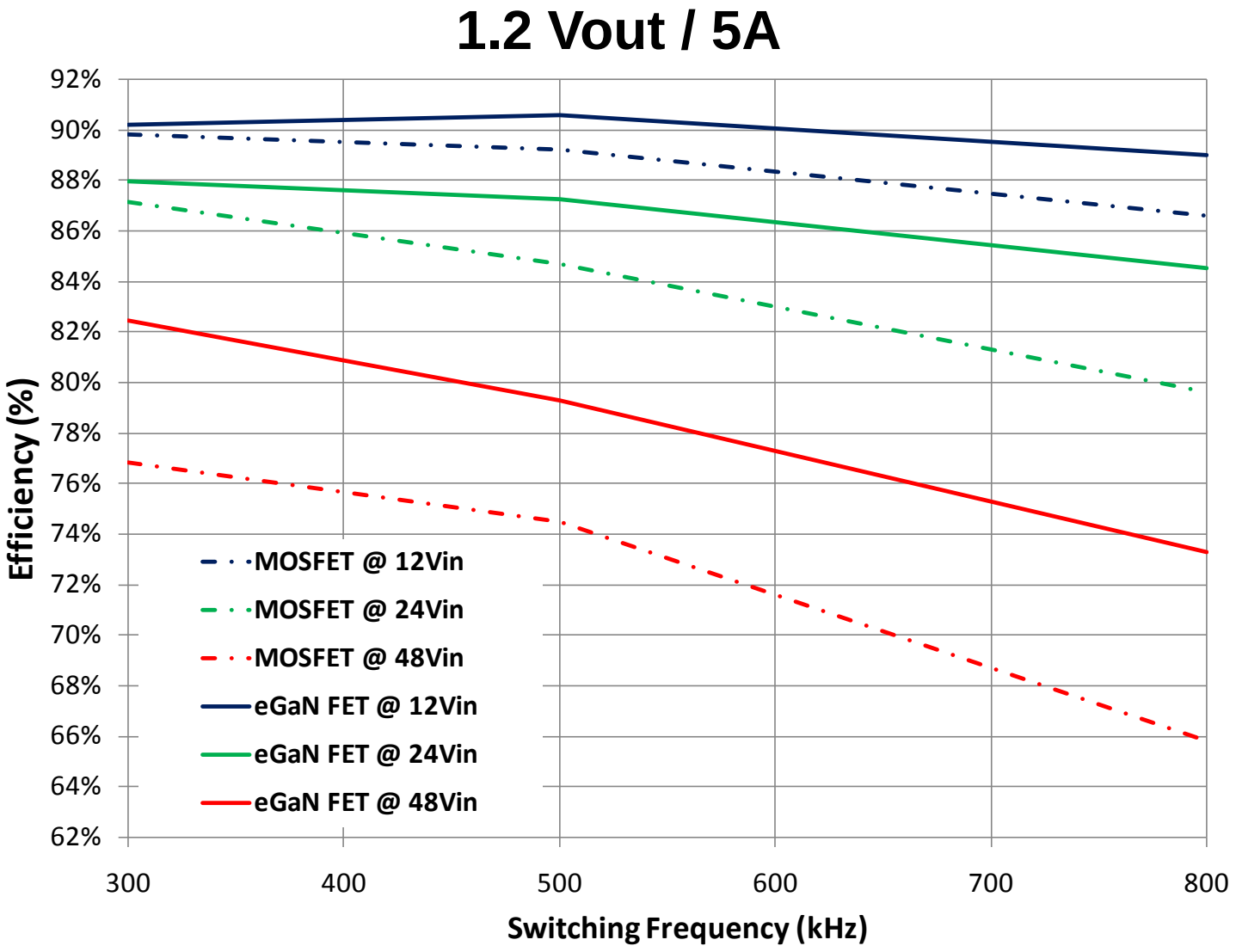
Non-Isolated DC-DC Converter

Buck Converter



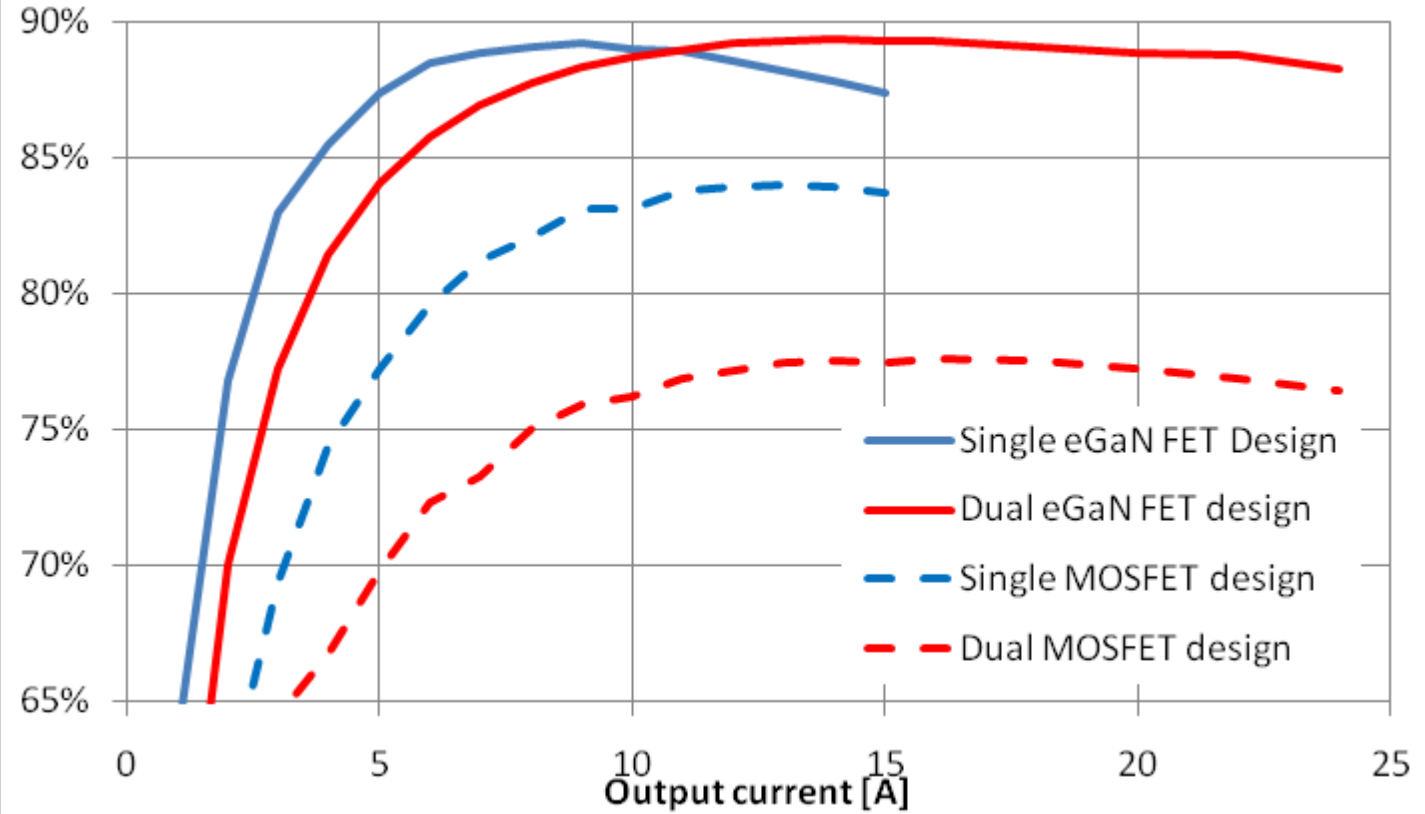


Efficiency vs Frequency



Parallel eGaN FET Buck Converter

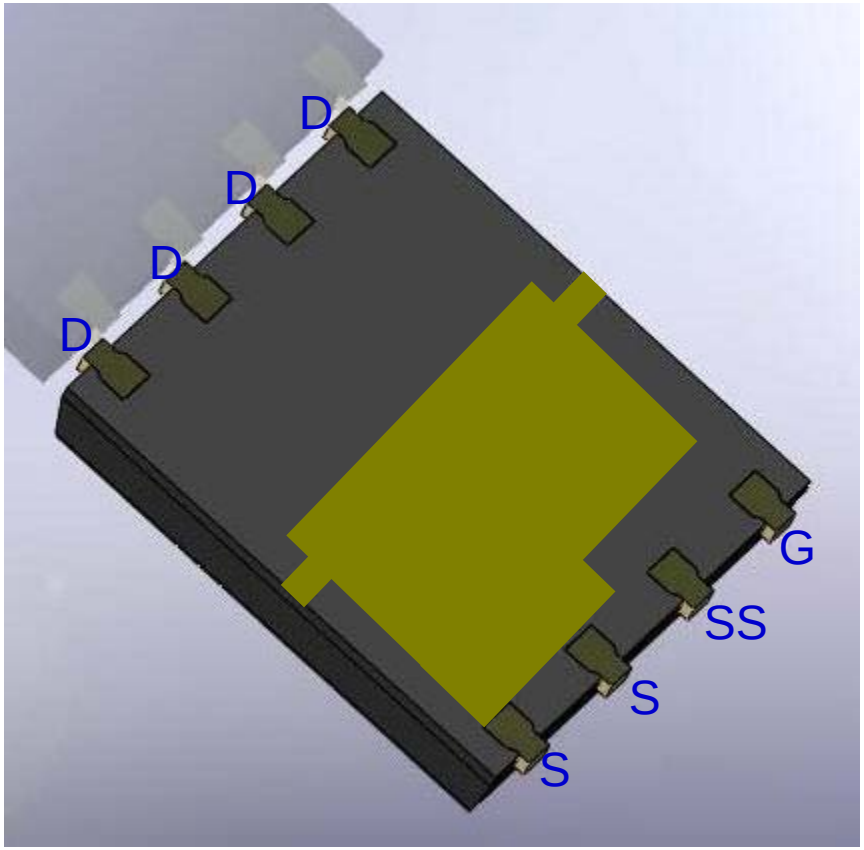
Efficiency at 1 MHz



$12\ V_{IN} – 1.2\ V_{OUT}$

EPC Product Plans

5x6 mm PQFN Package (GaNPAK)



GaNPAK for 600V eGaN devices
Available 2011

EPC3019 Key Specifications*:

$V_{DS(MAX)}$	600V
$R_{DS(ON)(MAX)}$ @25°C	100mΩ
$I_{D(DCMAX)}$	5A
$Q_{GS(typ)}$	0.3 nC
$Q_{GD(typ)}$	4 nC
$V_{TH(typ)}$	1.4V

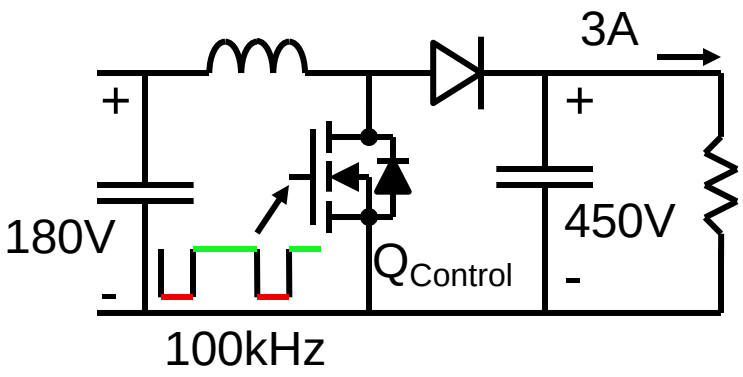
* All key specification limits are preliminary and subject to change without notice

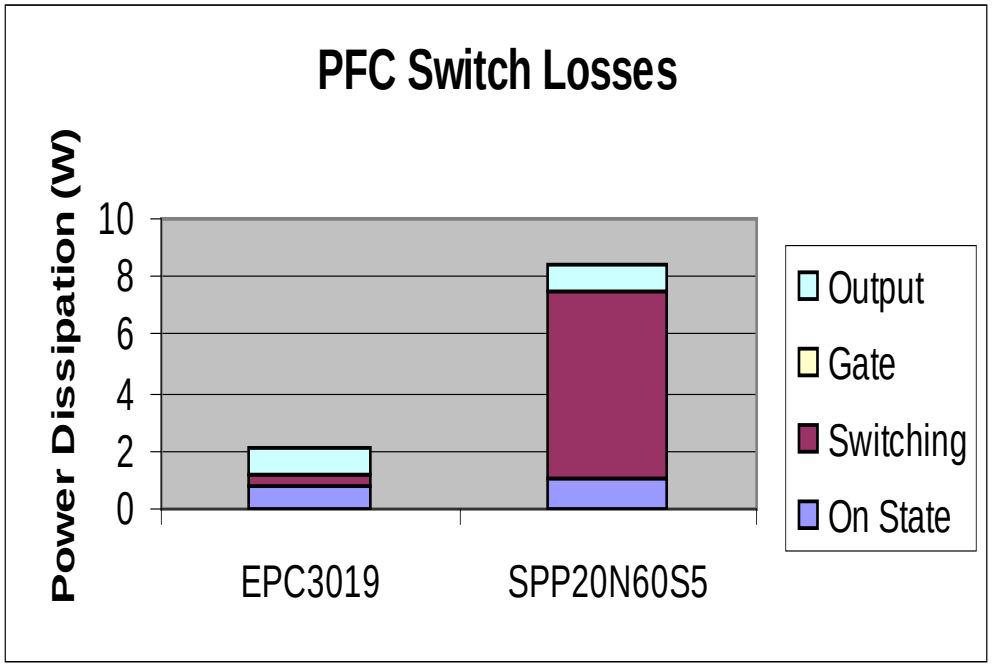
Hard Switched PFC

GaN Transistor Selection

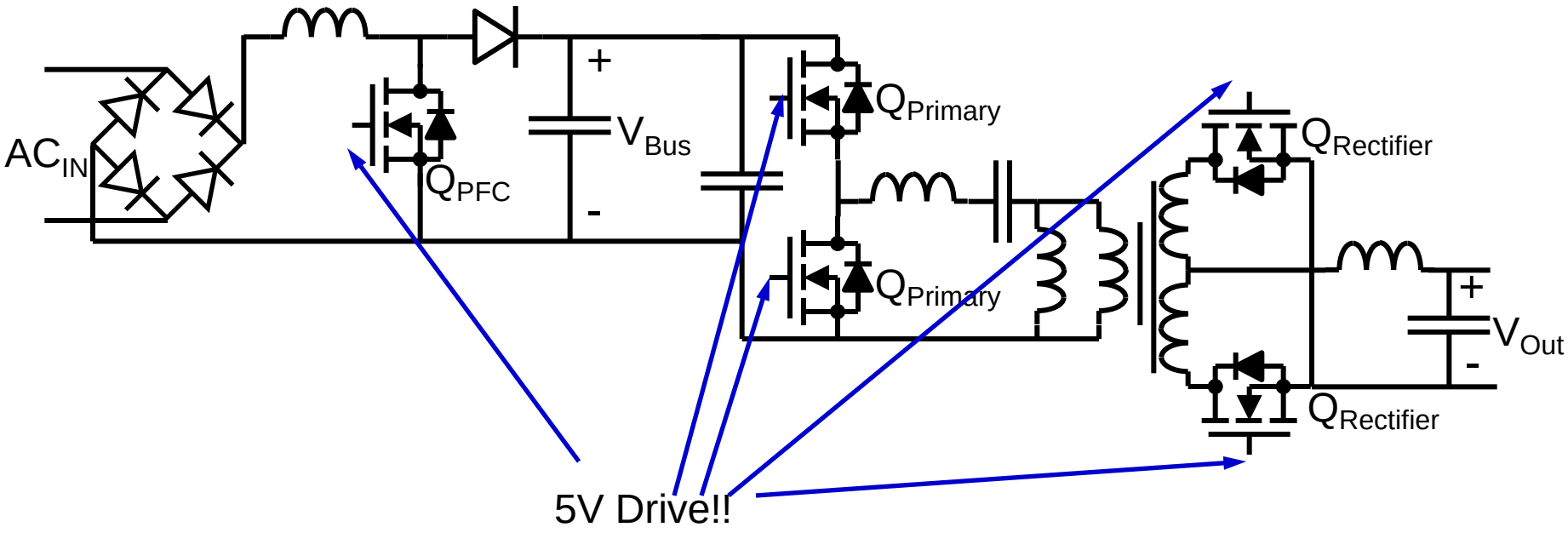
Clear All

Part Number	Package	Mode Ch	Configuration	Vds	Vgs	Rdson (mΩ) 5V	Rdson (mΩ) 100C	Q5 (nC)	Qgs (nC)	Qgd (nC)	Vgth (V)	Rg (Ω)	Qrr (nC)	Qoss (nC)	Id (A)	FOM (RxQ)	Info
Add Manufacturer																	EPC
EPC3019																	
EPC3019	SON 5x6	EN	Single	600	6	100	101.6	5.8	0.3	4	1.4	2	0	47	5	580	Dev 12/15/2010



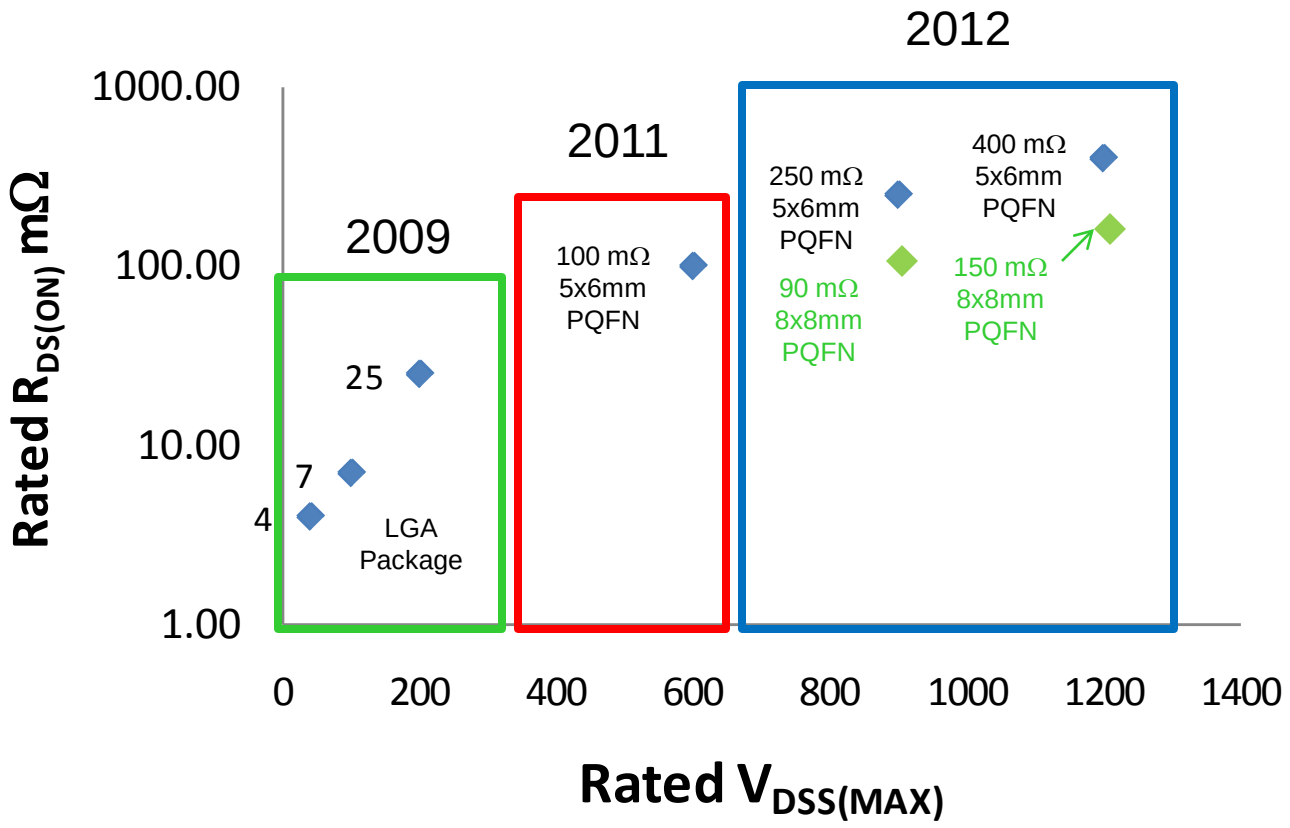


AC/DC - Half Bridge LLC



Socket	Part Number	Channel	Vds	Vgs	Rdson	Qg	Qgs	Qgd	Rg	Qrr	Qoss	Package
PFC	**EPC3019**	EN	600	6	**100**	7.1	0.53	**4**	2	0	**47**	SON 5x6
Primary	**EPC3019**	EN	600	6	**100**	**7.1**	0.53	4	2	0	**47**	SON 5x6
12V Out Rectifier	**EPC1015**	EN	40	6	**3.2**	**11.6**	3.8	2.2	0.6	0	**18.5**	LGA 4.1x1.6
48V Out Rectifier	**EPC1010**	EN	200	6	**18**	**7.5**	1.5	3.5	0.6	0	**40**	LGA 3.6x1.6

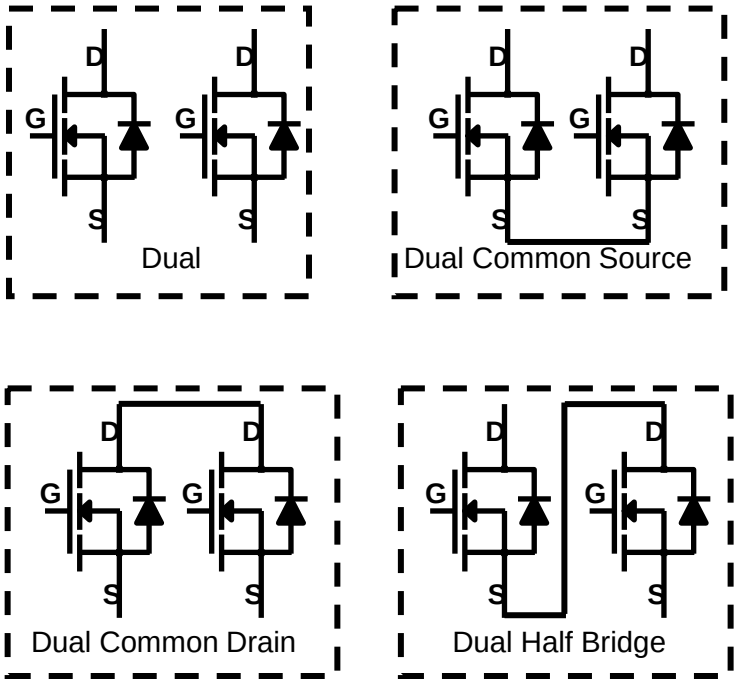
Beyond 600 Volts



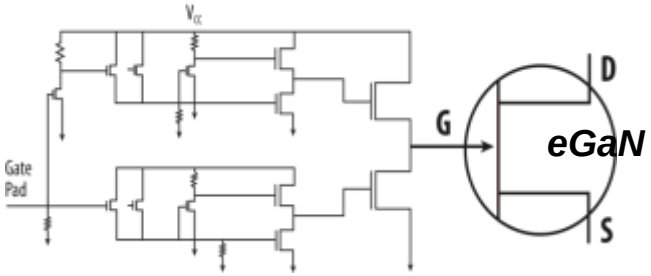
EPC's eGaN FET products will extend to 600V in 2011 and to 900V and 1200V in 2012 if there is adequate customer interest

Beyond Discrete Devices

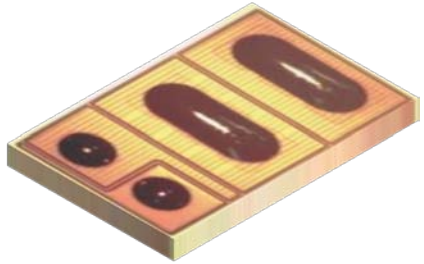
Multiple devices on the same eGaN wafer



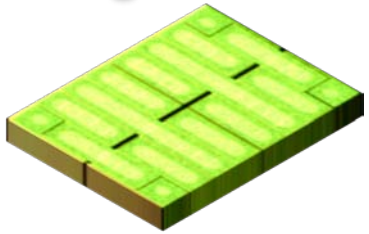
Driver On Board



Discrete FET with Driver



Full-Bridge with Driver



Conclusion

- After almost two years on the market, eGaN FETs have replaced MOSFETs in many high performance applications
- Several major IC companies are developing eGaN FET optimized drivers
- 600 V product will be available soon

EPC
EFFICIENT POWER CONVERSION

The end of the road for silicon…..

is the beginning of the eGaN FET journey!