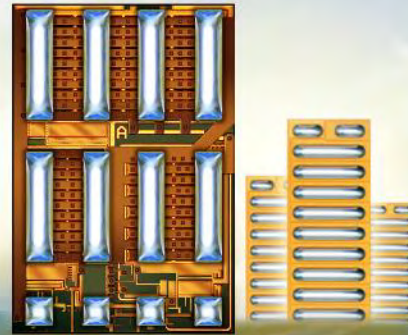


*The eGaN[®] Technology
Journey Continues*



*Harness the Power of eGaN[®] FETs
and ICs for Motor Drives*
Alex Lidow

Agenda

- eGaN Technology Value for 48 V Motor Drives
- Key Applications
- GaN-based BLDC Motor Drive
 - Demonstration from EPC Italy FAE Lab
- Product Portfolio for BLDC Motors

Why BLDC Motors?

BLDC Motors are popular:

- High torque and power density
- Wide speed range capability
- High efficiency
- Brushless ensuring low EMI

Application focus:

- Robotics – Precision control
- Drones – Lightweight
- eBikes – Small size, lightweight

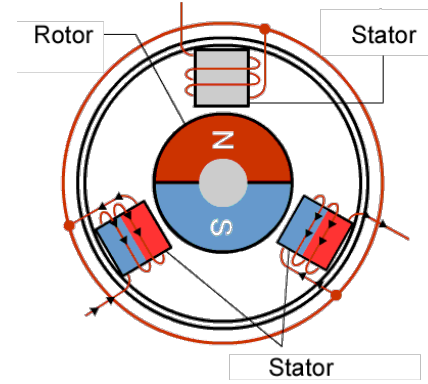


Image courtesy of: Renesas

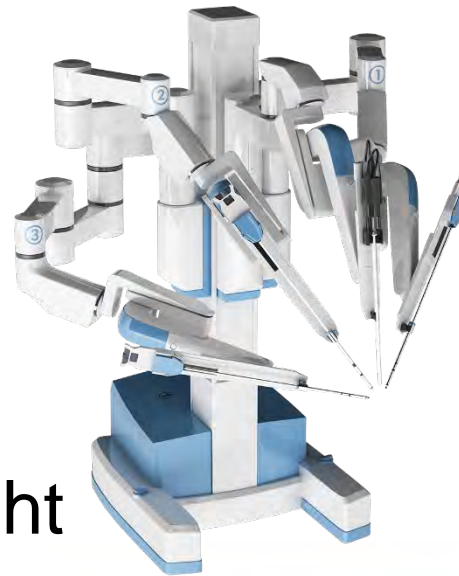
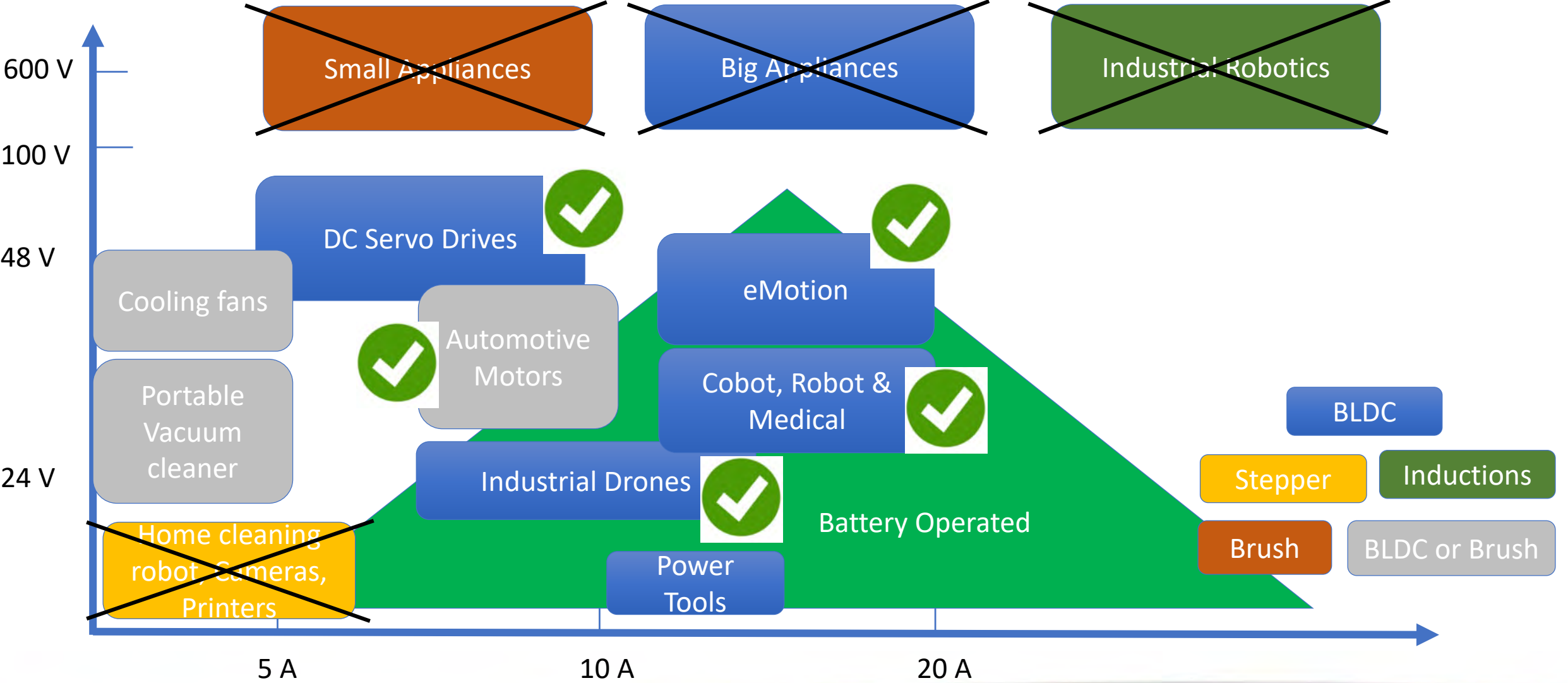


Image courtesy of: <https://electricbikereport.com/>

GaN Applications: 24 V – 150 V BLDC Motor



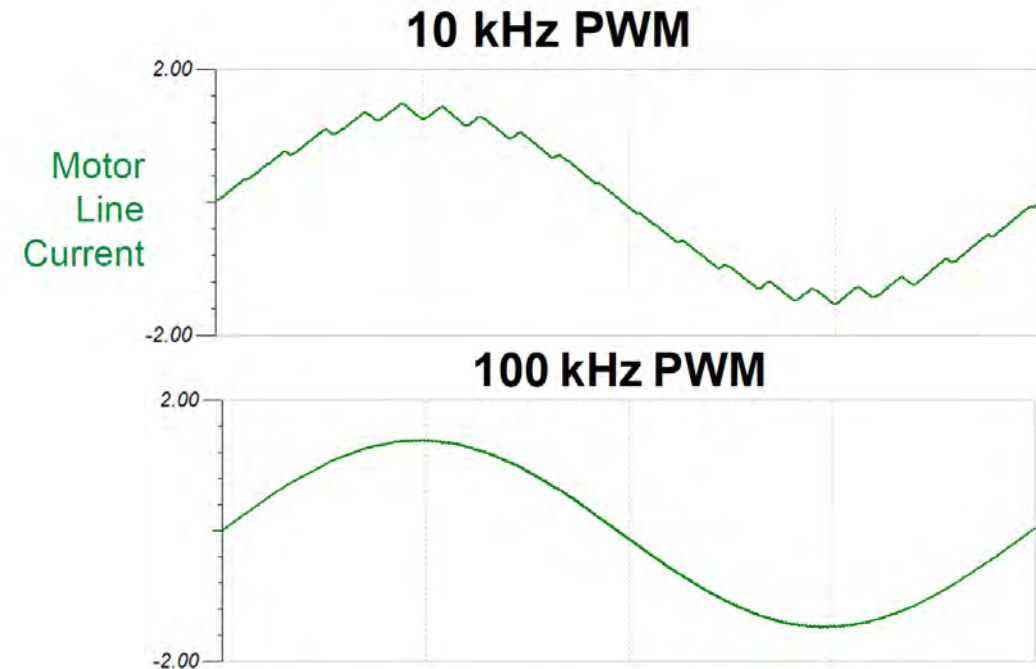
GaN Benefits in Motor Drives

GaN FET/ICs switch fast with no $Q_{RR} = 0$

higher switching frequency

lower dead time

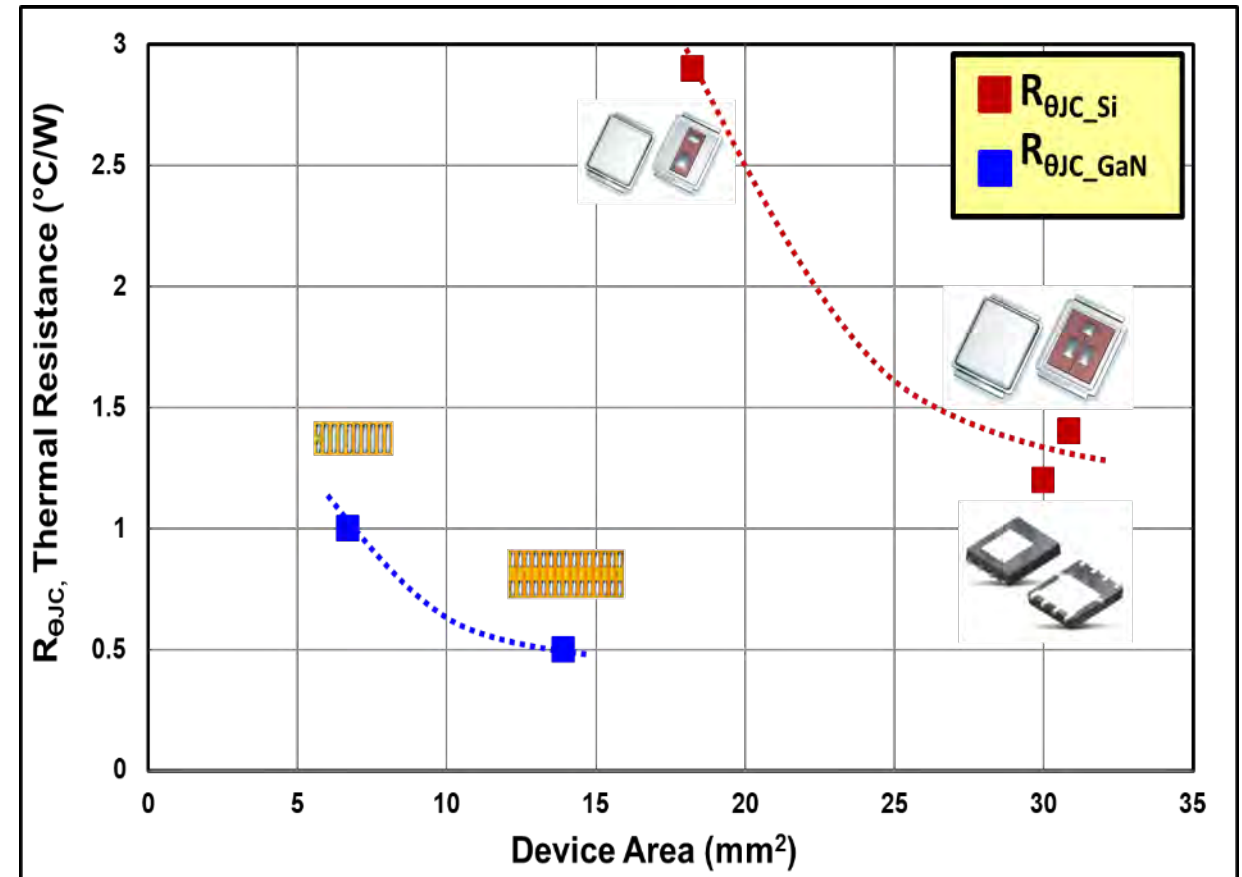
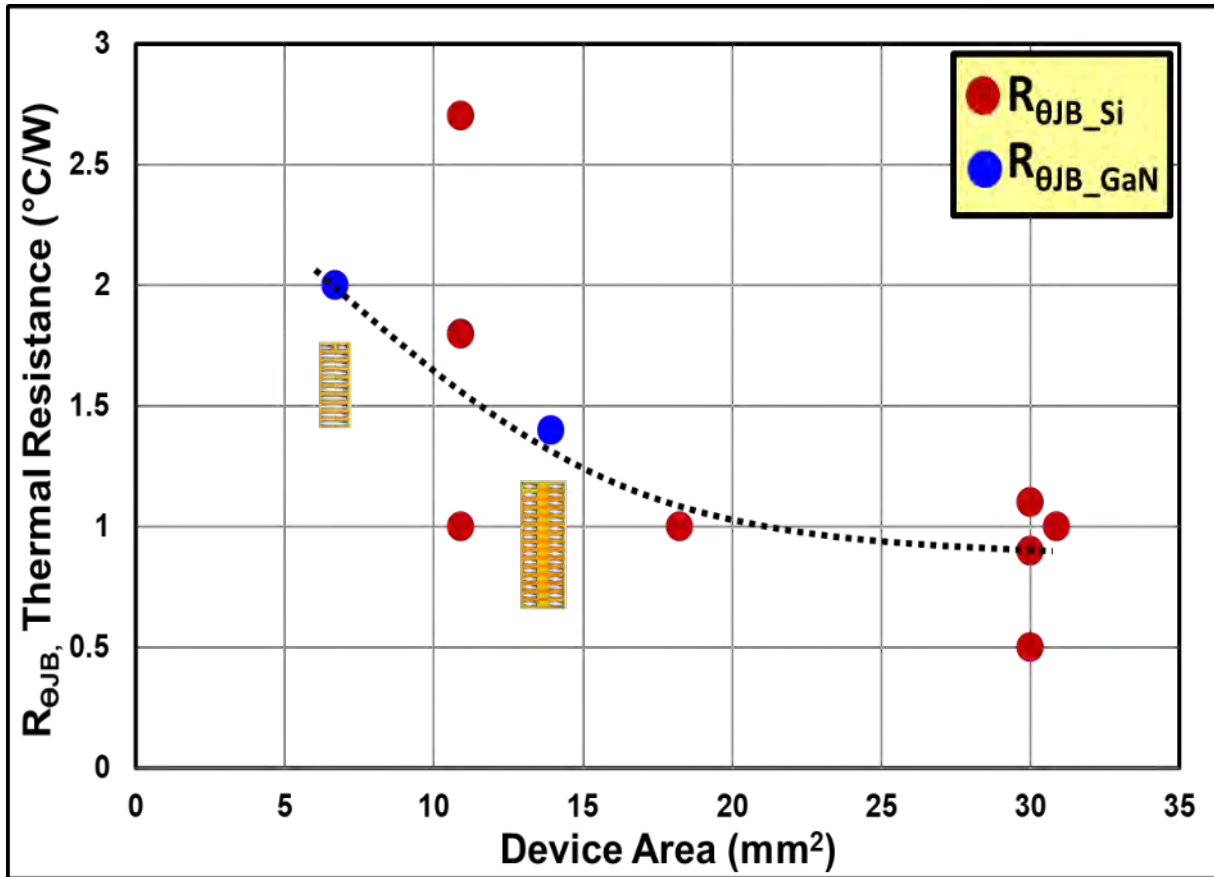
- Lower distortion → lower acoustic noise
- Lower current ripple → reduced magnetic loss
- Lower torque ripple → improved precision
- Lower filtering → lower cost, weight & size
- Supports low inductance motors



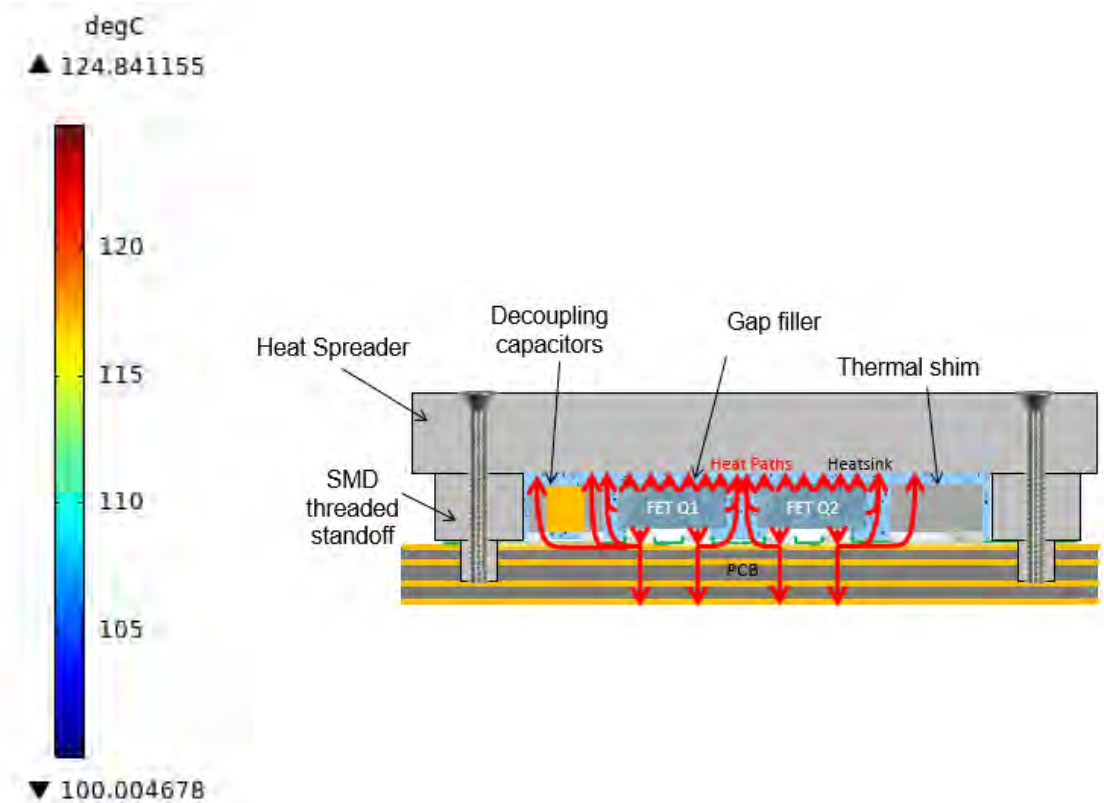
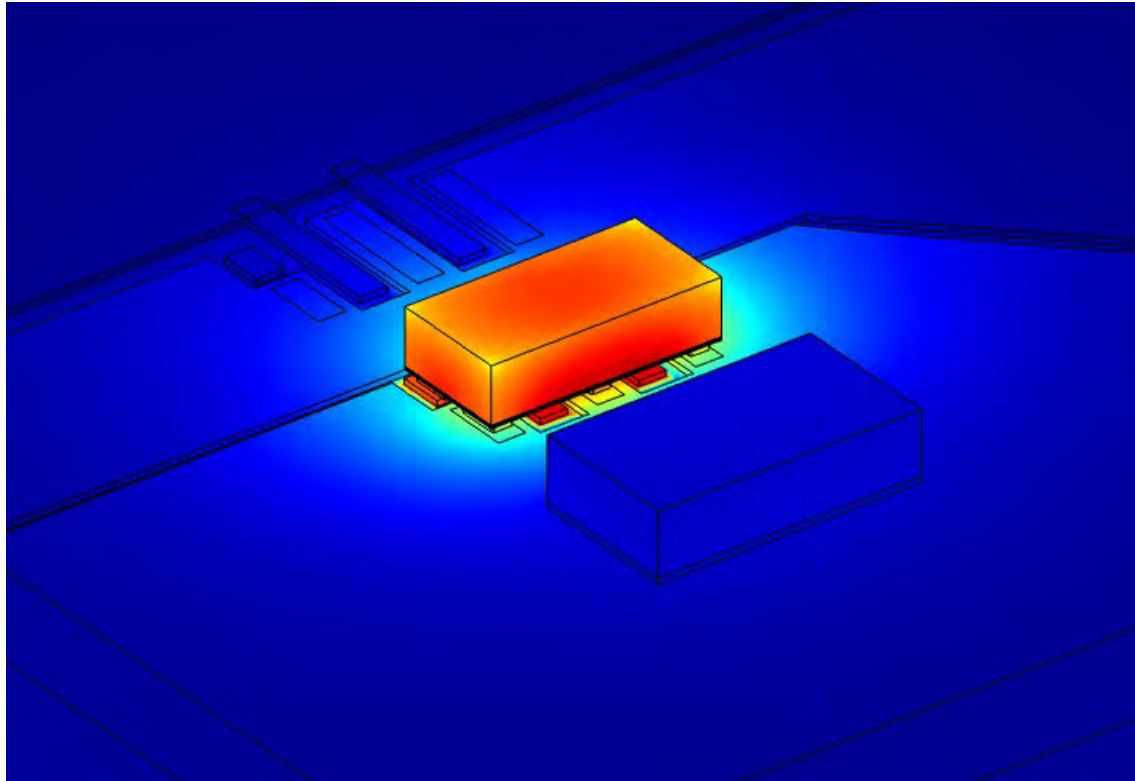
Double-Sided Cooling for eGaN FETs

Heat transfer to PCB $R_{\theta JB_{board}}$

Heat transfer to top Si substrate $R_{\theta JC_{case}}$



Best Thermal Performance – 4 mm² and 3.9°C/W



- 6 W DC power dissipation in the device
- 125°C average T_j with heat spreader at 100 °C
- 1.5 mm x 3 mm x 0.7 mm thermal shim, 6 W/mK gap filler, 0.2 mm spacing to heat spreader

Key Applications

Cobot & Robot

Why GaN?

- High frequency / low inductance for precision
- Small size and low weight



UR3e



UR5e



UR10e



UR16e NEW



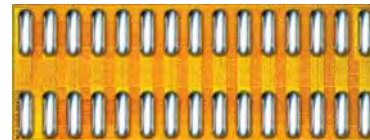
High Precision Motors: *Smooth and Precise Motion*

Everest Net 30/80

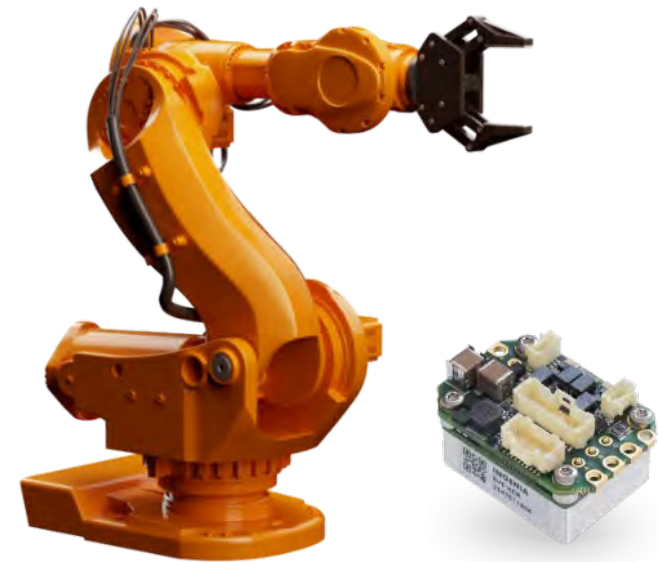
- Miniature size for robotic joints
- High resolution torque sensing
- Smooth Operation

Why GaN?

- Small, low profile footprint
- Lower losses
- Higher efficiency
- High frequency



EPC2022
100 V, 3.2 m Ω
6.1 mm x 2.3 mm



Demonstration provided courtesy of

INGENIA

Medical Motors

- Robotic surgery requires great precision -- Precision can save your life!
- GaN's high frequency & low switching losses = high-resolution and precise control
- Small size, low weight



Surgical Robotics

Industrial Drones

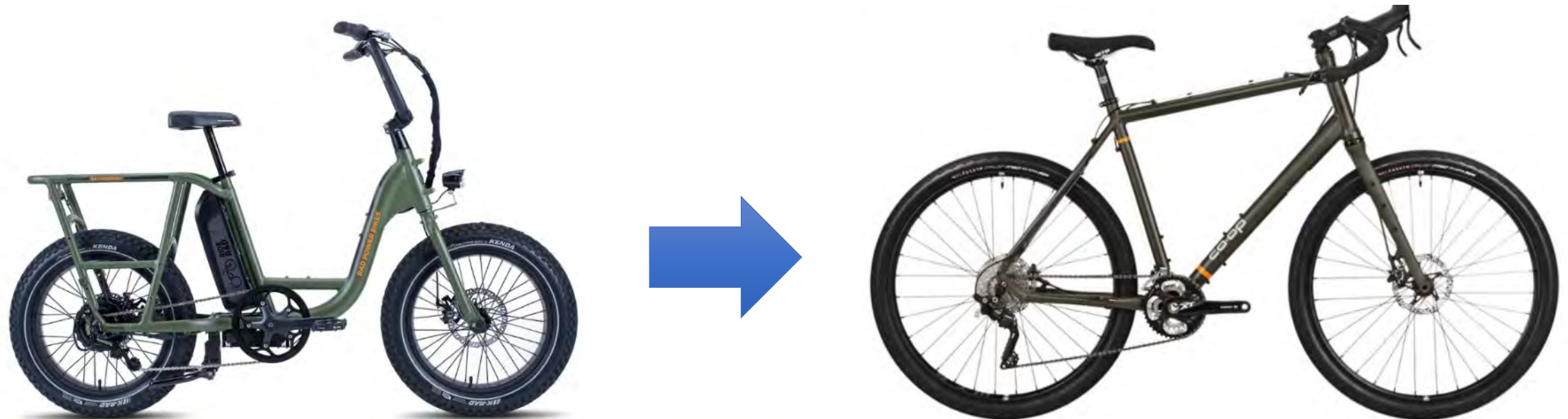
- Smaller
- Lighter
- Higher battery efficiency
- Fly farther



Motor Drives for High-end e-bike & e-scooters



- Miniaturization enables better aesthetics & light weight



Integrated Motors DC Servo Drive

eGaN devices sweet spot: $10 V_{DC} - 150 V_{DC}$ @ $1 - 2 kW$

- Smaller
- High precision
- No EMI cables and winding shields

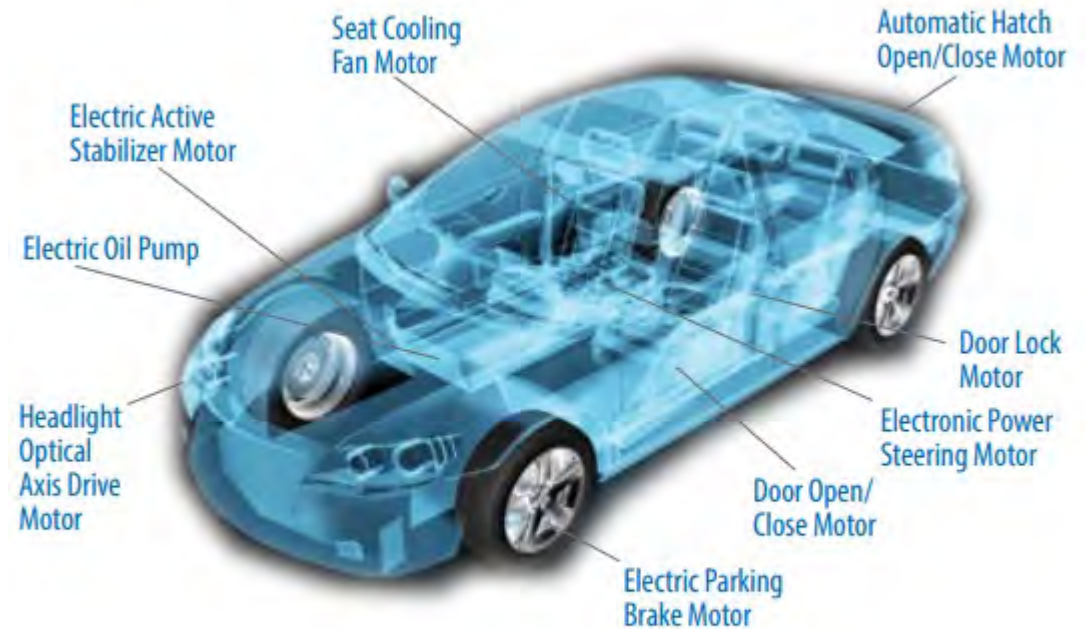


- Integrated motor
- Machine tools
- Packaging, textile



eGaN Value in Automotive Motors

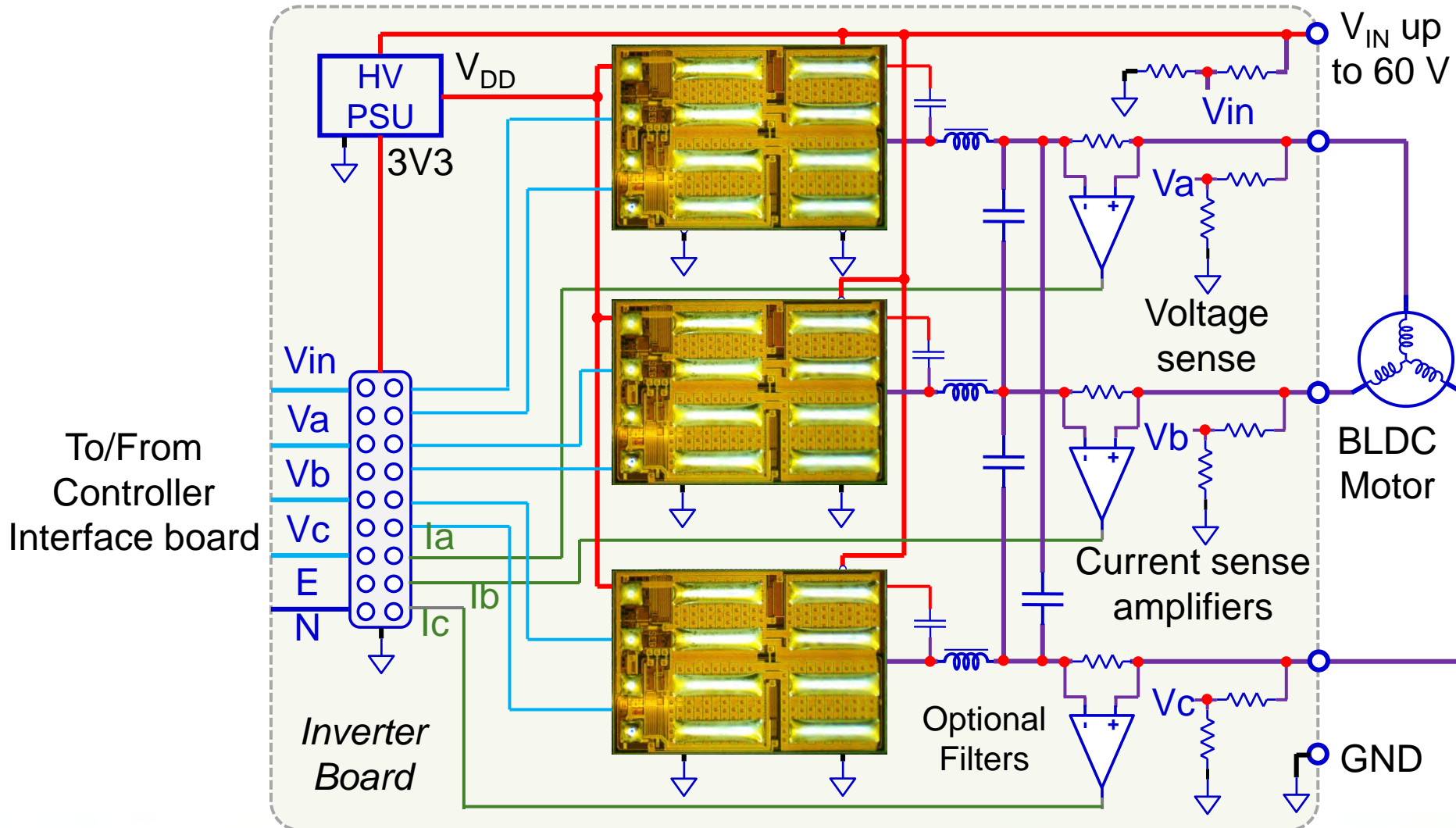
- Smaller and lighter
- No audible noise
- Better torque
- Longer battery life
- Higher efficiency



Automotive Motors

GaN-Based BLDC Motor Drive

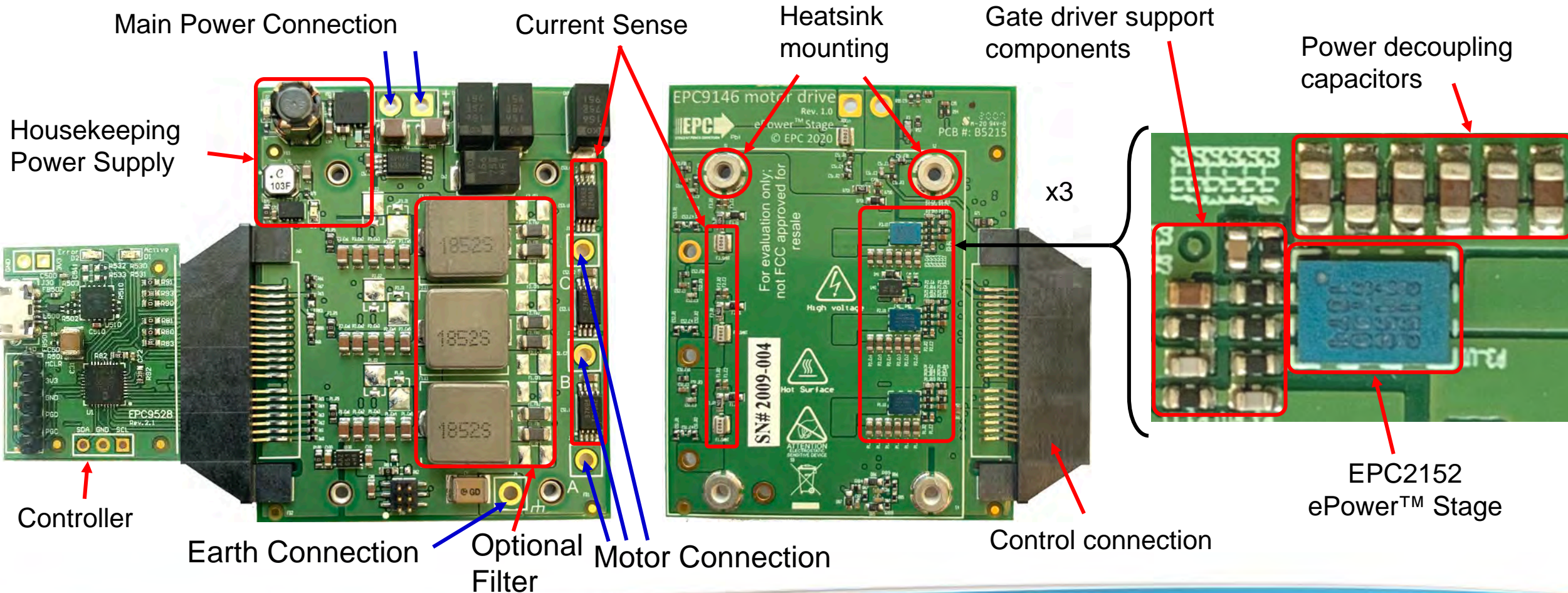
BLDC Motor Drive Overview



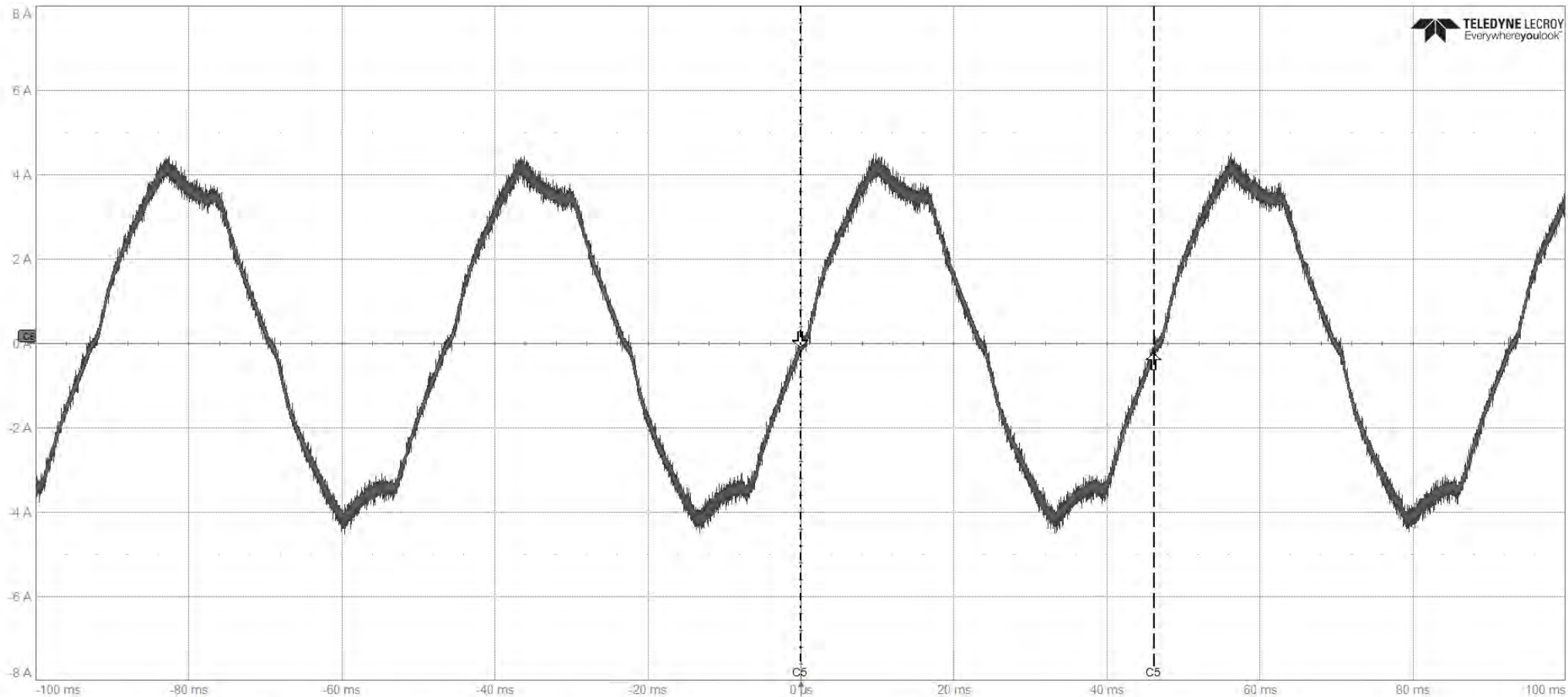
Experimental 3-Phase Motor Drive

- 15 V – 60 V_{DC} supply
- 15 A_{peak} per phase

- Power a 400 W NEMA 34 Motor
- Measures 55 mm x 45 mm



Dead Time = 500 ns @ 40 kHz



Measure	P1.rms(C5)	P2.freq(C5)	P3---	P4---	P5---	P6---	P7---	P8---	P9---	P10---	P11---	P12---
value	2.782 A	21.52165809 Hz										
status	✓	✓										

C5	BWL	DC
2.00 A/div		
0.0 mA offset		
↓ -119.1 mA		
↑ -282.1 mA		
Δ -163.0 mA		

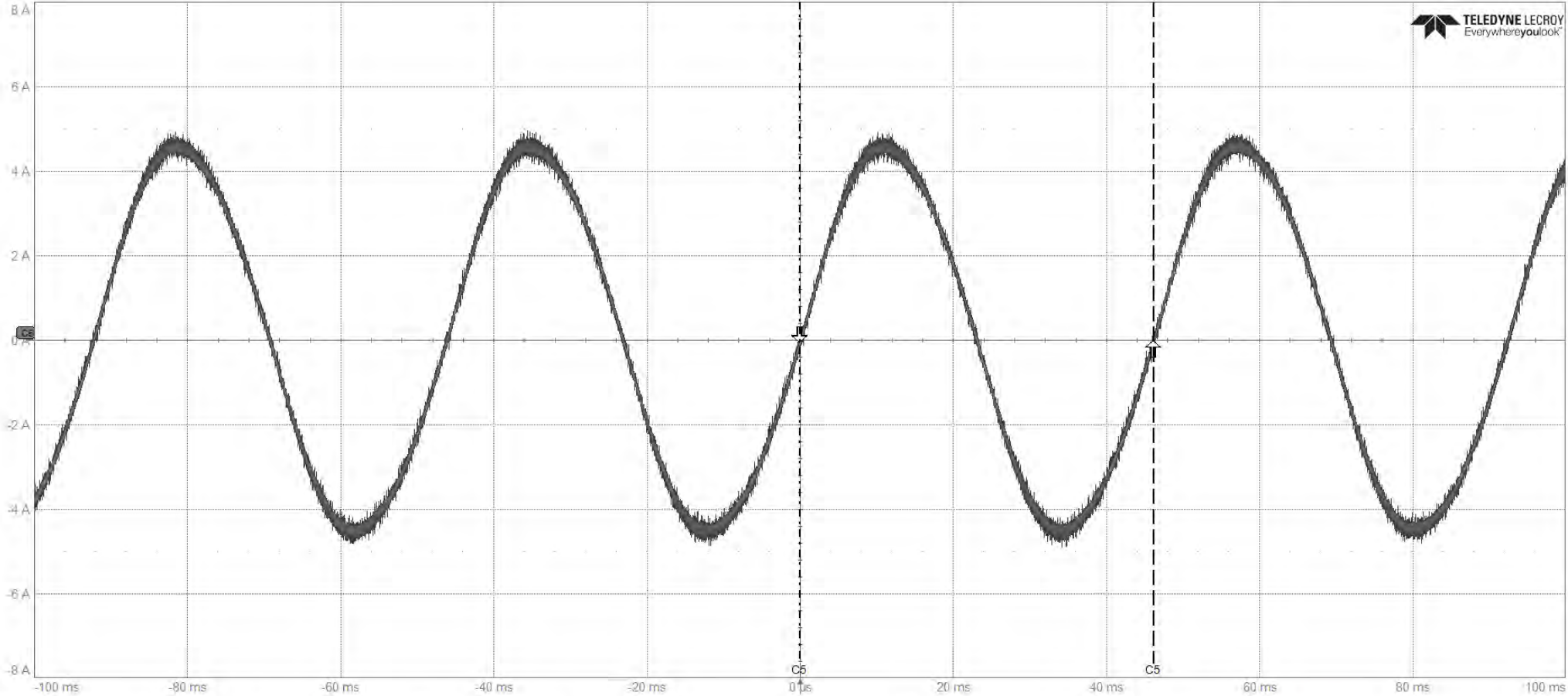
HD	Timebase	0.0 ms	Trigger	C5	HFR
12 Bits	20.0 ms/div	Auto	0.00 A		
	2.5 MS	12.5 MS/s	Edge	Positive	
X1=	-11.92 μs	ΔX=	46.12896 ms		
X2=	46.11704 ms	1/ΔX=	21.67836 Hz		

Dead Time = 50 ns @ 40 kHz

Only GaN CaN Do This!



TELEDYNE LECROY
Everywhere you look



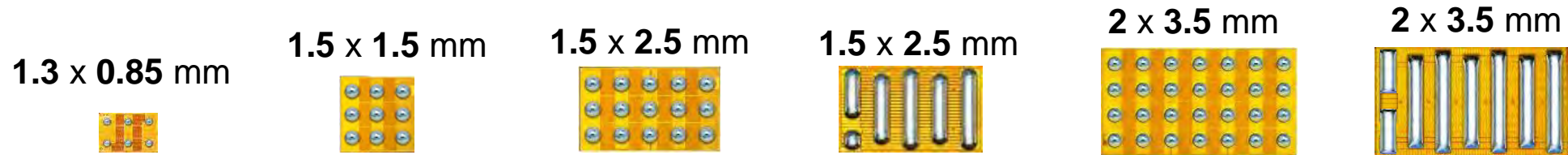
Measure	P1.rms(C5)	P2.freq(C5)	P3----	P4----	P5----	P6----	P7----	P8----	P9----	P10----	P11----	P12----
value	3.162 A	21.56804361 Hz										
status	✓	✓										

C5	BWL	DC
2.00 A/div		
0.0 mA offset		
↓ -74.3 mA		
↑ -68.6 mA		
Δ 5.7 mA		

HD	Timebase	0.0 ms	Trigger	C5	HFR
12 Bits	2.5 MS	12.5 MS/s	Auto	0.00 A	
X1=	-11.92 μs	ΔX=	46.12896 ms		
X2=	46.11704 ms	1/ΔX=	21.67836 Hz		

Product Portfolio for BLDC Motors

100 V Products



Parameter	EPC2051 (@ 5 V _{GS})	EPC2052 (@ 5 V _{GS})	EPC2045 (@ 5 V _{GS})	EPC2204 (@ 5 V _{GS})	EPC2053 (@ 5 V _{GS})	EPC2218 (@ 5 V _{GS})
R_{DS(on)} typ	20 mΩ	10 mΩ	5.6 mΩ	4.5 mΩ	3.2 mΩ	2.5 mΩ
R _{DS(on)} max	25 mΩ	12.5 mΩ	7 mΩ	5.6 mΩ	3.8 mΩ	3.2 mΩ
Q _G typ	1.7 nC	3.7 nC	5.9 nC	6.4 nC	12 nC	11.8 nC
Q_{GD} typ (1)	0.3 nC	0.5 nC	0.8 nC	0.9 nC	1.5 nC	1.6 nC
Q _{OSS} typ(1)	7.3 nC	13 nC	25 nC	25 nC	45 nC	46 nC
Q _{rr} typ	0 nC	0 nC	0 nC	0 nC	0 nC	0 nC
R _g typ	0.8 Ω	0.7 Ω	0.6 Ω		0.6 Ω	
Area	1.11 mm²	2.25 mm²	3.75 mm²	3.75 mm²	7 mm²	7 mm²

(1) at V_{DS} = 50 V

EPC Devices vs. Competition

	V _{DS} max [V]	V _{GS} typ [V]	Max R _{DS(on)} [mohm]	Q _G typ [nC]	Q _{GD} typ [nC]	Q _{OSS} typ [nC]	Q _{RR} typ [nC]	Dimensions [mm ²]
NTMFS6B03	100	10	4.8	58	17	95 ...	120	30
BSC035N10	100	10	3.5	70	14	91	122	30
BSC030N08	80	10	3.0	61	13	73	94	30
EPC2053	100	5	3.8	11.4	1.5	45	0	7
EPC2045	100	5	7	6	0.8	16	0	3.75
EPC2052	100	5	13.5	3.5	0.5	13	0	2.25

At low PWM Frequency (20 kHz – 40 kHz)

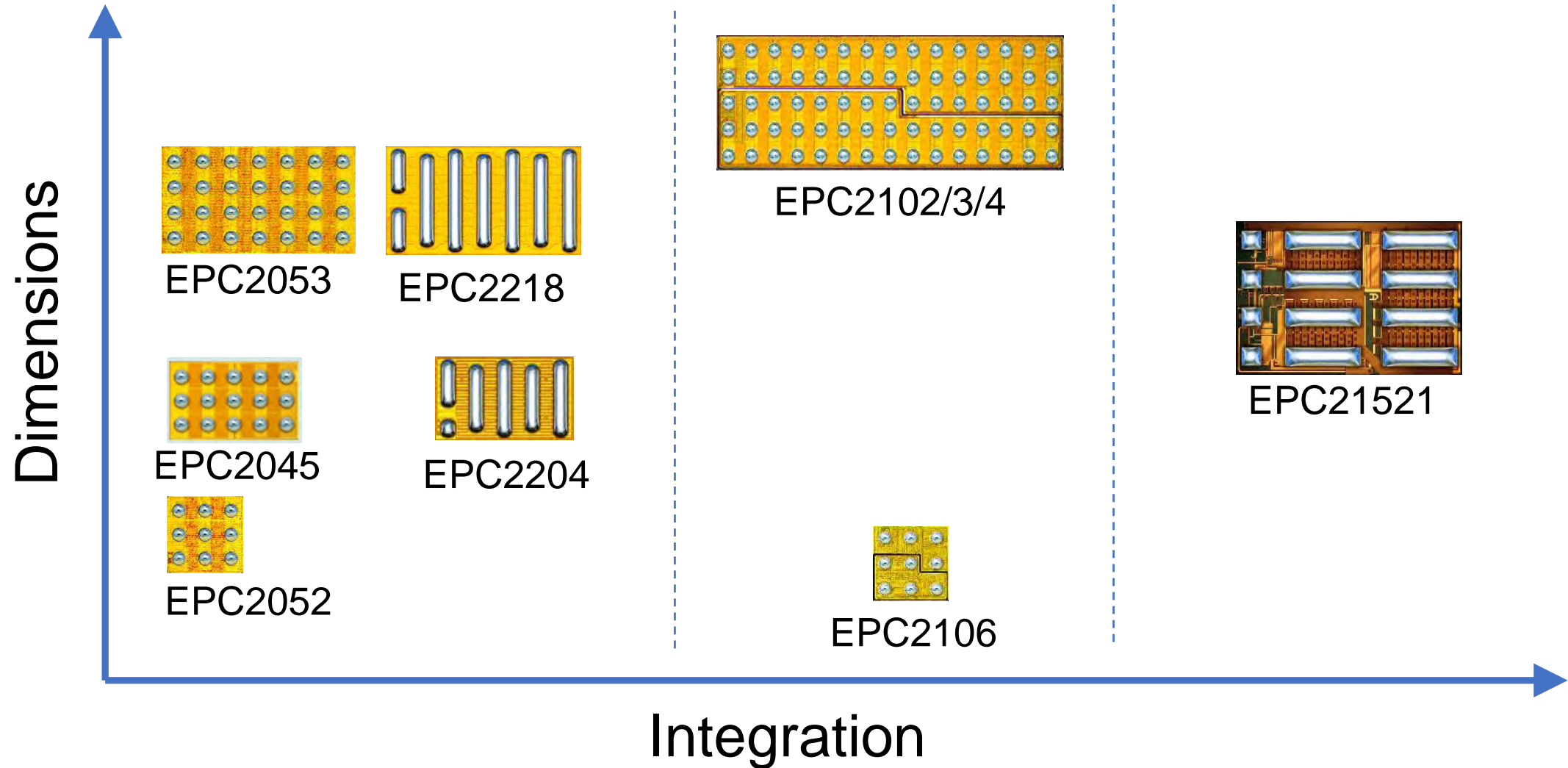
- 30% lower area vs. competitive benchmark
- No reverse recovery
- Enables minimum deadtime



EPC GaN devices enable miniaturization

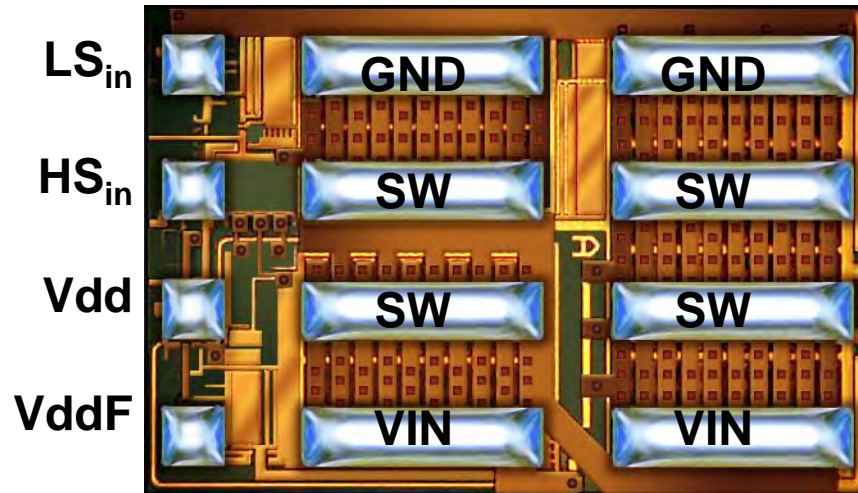
At higher PWM frequency (40 kHz – 100 kHz) significant size reduction

Integrated Solutions



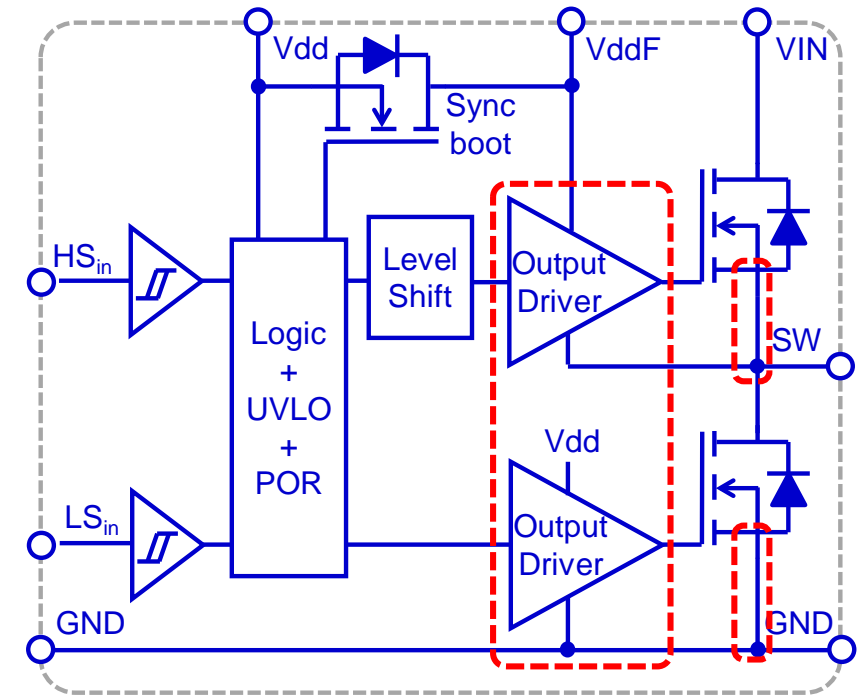
The Integrated Power Stage

EPC21521



- Near zero common source inductance
- Driver matched to FETs
- Thermal balancing
- Layout friendly

$80 \text{ V}_{\text{DSmax}}$, $R_{\text{DS(on)}_typ} = 10 \text{ m}\Omega$



Summary

- EPC devices allows smaller, lighter and more accurate motor drives
- Given same $R_{DS(on)}$, EPC eGaN devices
 - Are smaller
 - Have lower switching dissipation
 - Have no reverse recovery
- ePower™ Stage Digital In and Power Out family simplifies design and will further reduce size

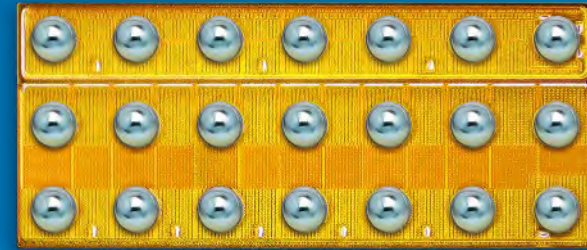


How To GaN Video Series

epc-co.com



3rd Edition Textbook



eGaN[®] FETs and ICs

Evaluation
Kits

