Navitas AllGaN™ Energy, Driven

WiPDA 2016

Navitas

Speed Drives Performance

4th IEEE Workshop on Wide Bandgap Power Devices and Applications (WiPDA)
Fayetteville, NC, USA. November 9th 2016.

Gene Sheridan, CEO
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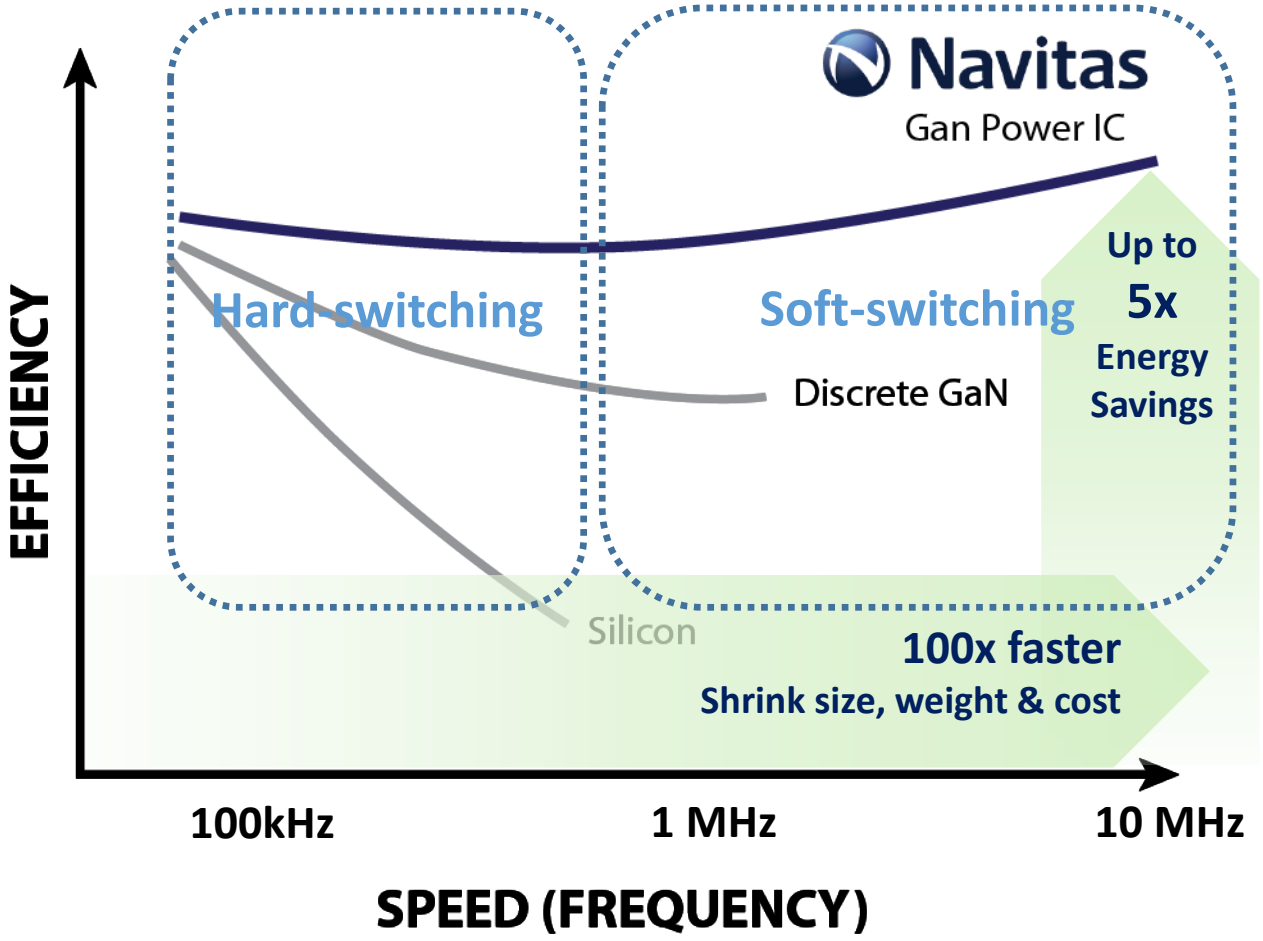
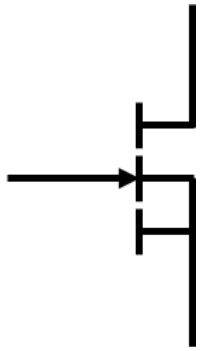
Speed & Efficiency are Key

- **Fast** power devices have ***potential*** to enable high-frequency and high efficiency
- **Frequency** enables ***small size***, ***low-cost*** and ***faster charging***
- **Efficiency** enables ***energy savings***
- With Silicon (or even discrete GaN), you can get one ***or*** the other
- With GaN power ICs, you get ***both at the same time*** with unequaled **Speed & Efficiency**



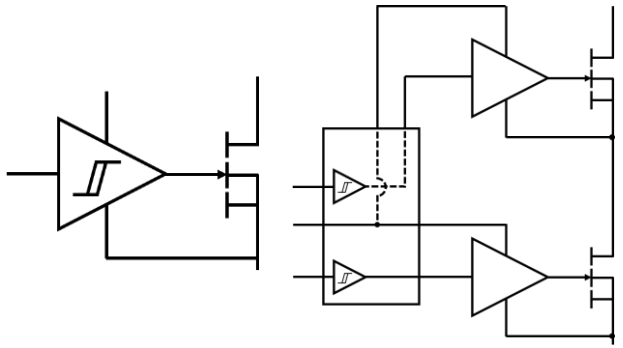
World's First AllGaN™ Power ICs

Fastest, most efficient Hi-V GaN Power FETs



>20x faster than silicon
>5x faster than cascoded GaN
Proprietary design
15+ pending or issued patents

iDrive First & Fastest Integrated GaN Gate Drivers



>3x faster than any other gate driver
Proprietary design
8+ pending patents

World's First AllGaN™ Power IC

Up to 40MHz switching, 5x higher density & 20% lower system cost


Hi-Speed Devices
(V/ns)
200
180
160
140
120
100
80
60
40
20
0
320
340
360
400

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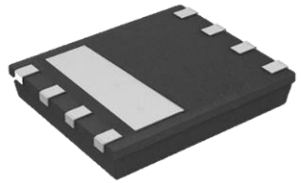
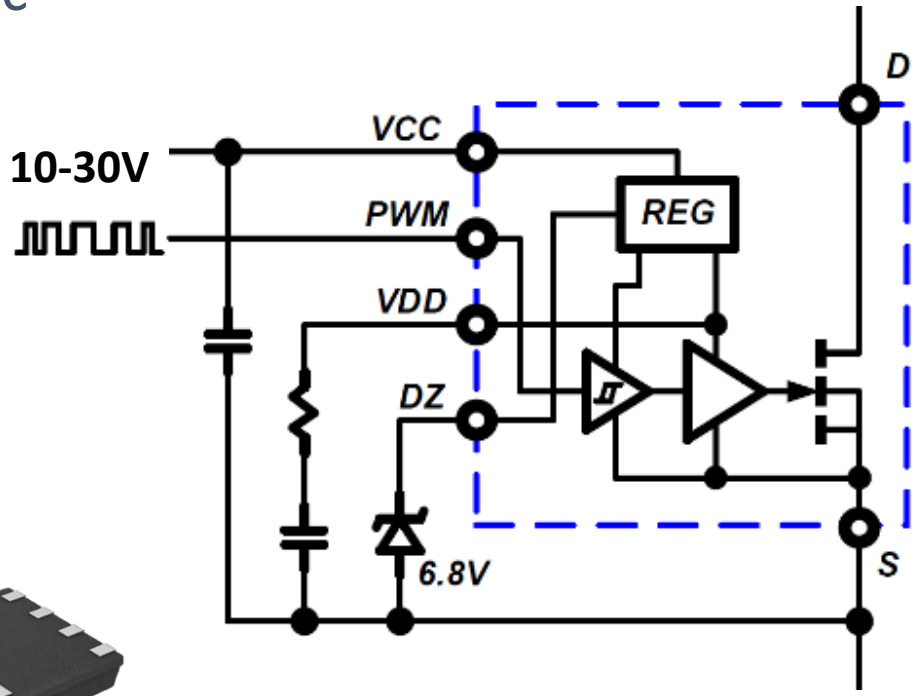
GaN Power IC: Hi-Speed FET, Drivers & More

- Proprietary AllGaN™ technology
- **Monolithic** integration of GaN FET, GaN Driver, GaN Logic
- 650 V eMode
- 20x lower drive loss than silicon (<35 mW at 1 MHz)
- Driver impedance matched to power device
- Very fast (prop delay and turn-on/off of 10-20 ns)
- Zero inductance turn-off loop
- High dV/dt immunity (200 V/ns) with control
- Digital input
- Complete layout flexibility



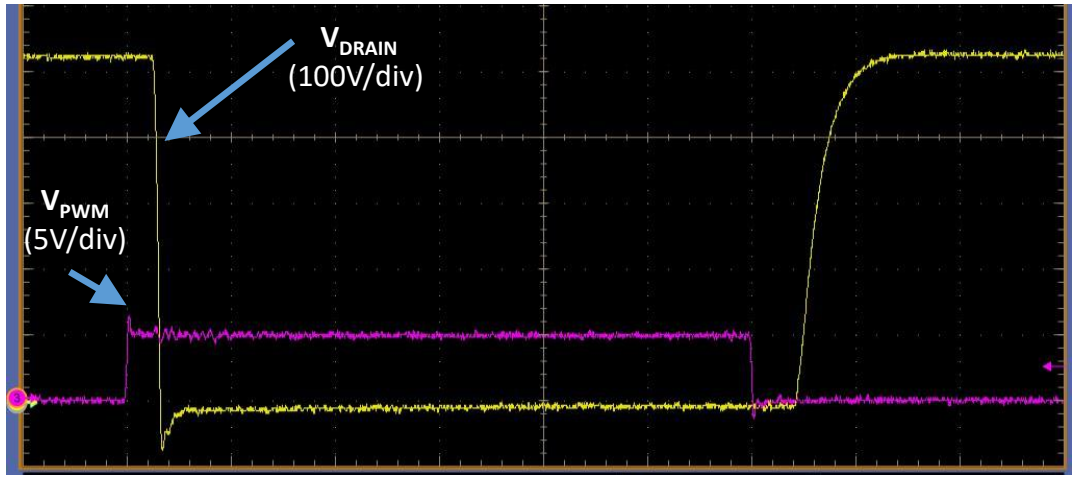
QFN 5x6mm



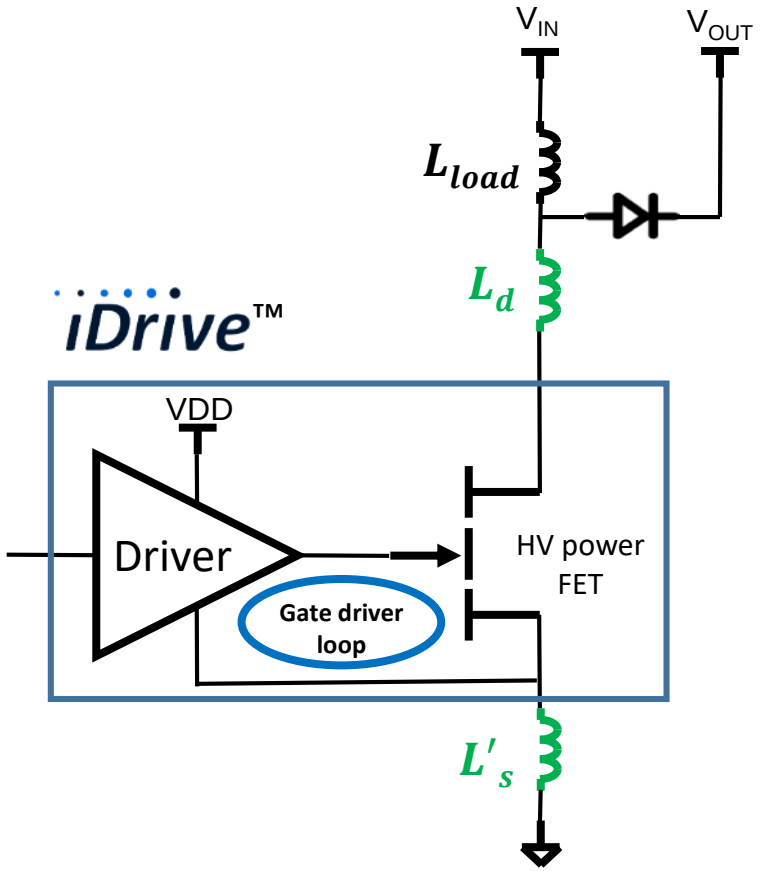
D. Kinzer, S. Oliver "Monolithic HV GaN Power ICs" in *IEEE PELS Power Electronics Magazine*, vol. 3, no. 3, pp. 14-21, September 2016

Fast & Clean High Voltage Transitions

- Prop delays 10-20 ns
  - From PWM input to 10% of FET V_{DS} change
- Turn-on & turn-off times 10-15 ns
- Zero gate loop inductance



50 ns/div



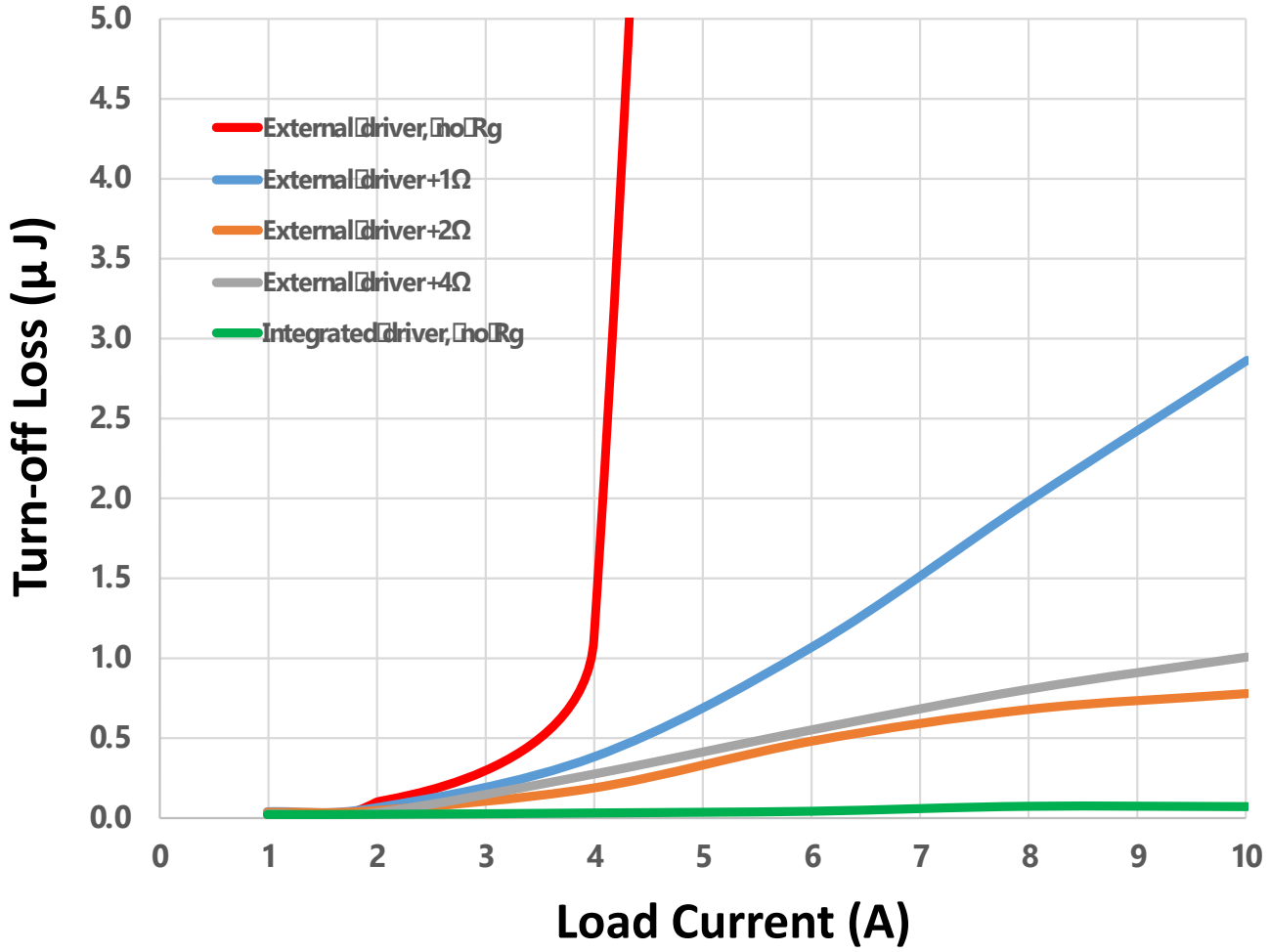
Speed & Integration → Eliminate Turn-off Losses

External drivers

- Significant turn-off losses
- Just 1-2 nH of gate loop inductance can cause voltage spikes that create unintended turn-on of the GaN FET
- Adding a gate resistor reduces spikes but slows down the circuit creating additional losses

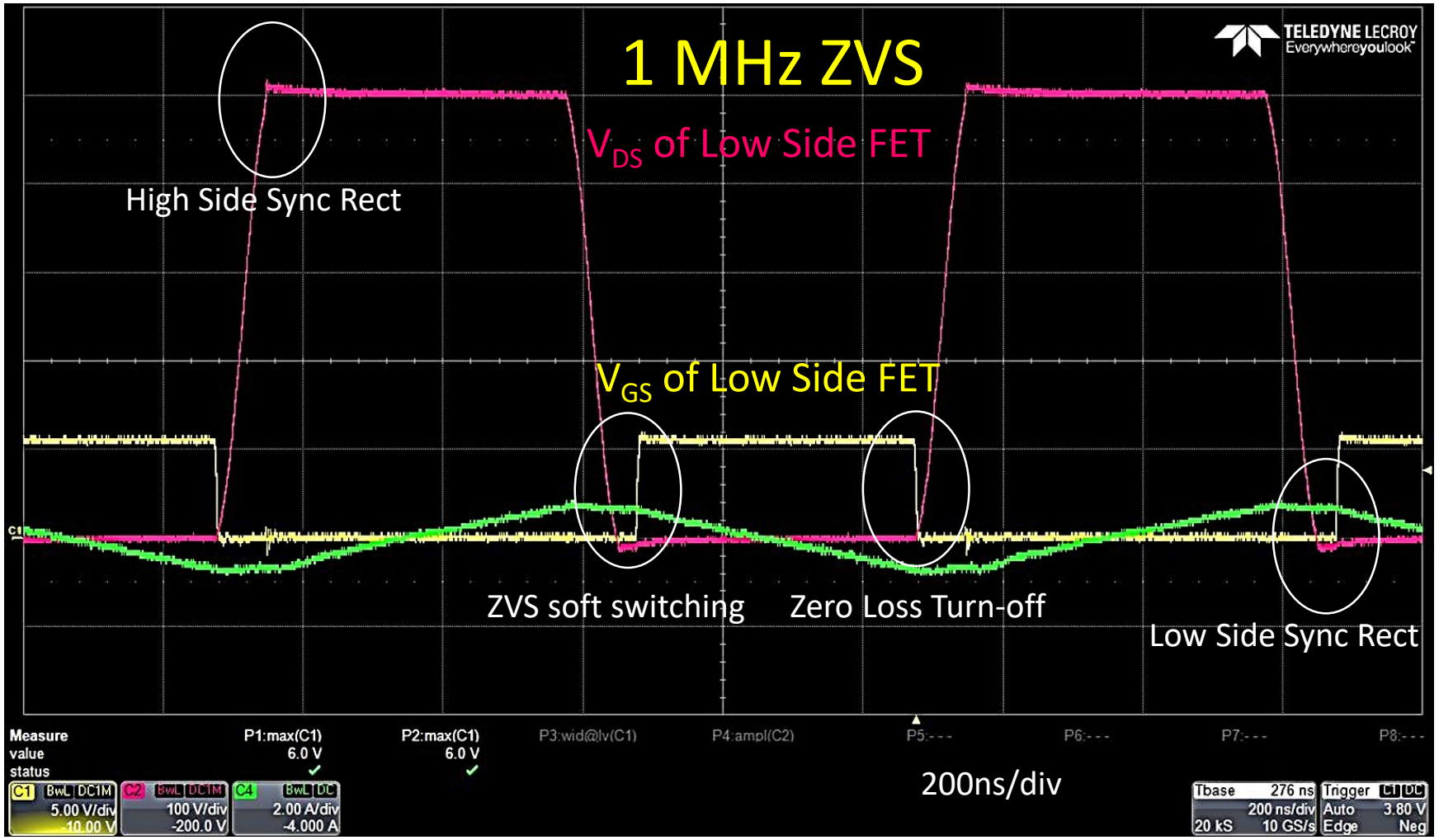
Integrated GaN drivers (iDrive™)

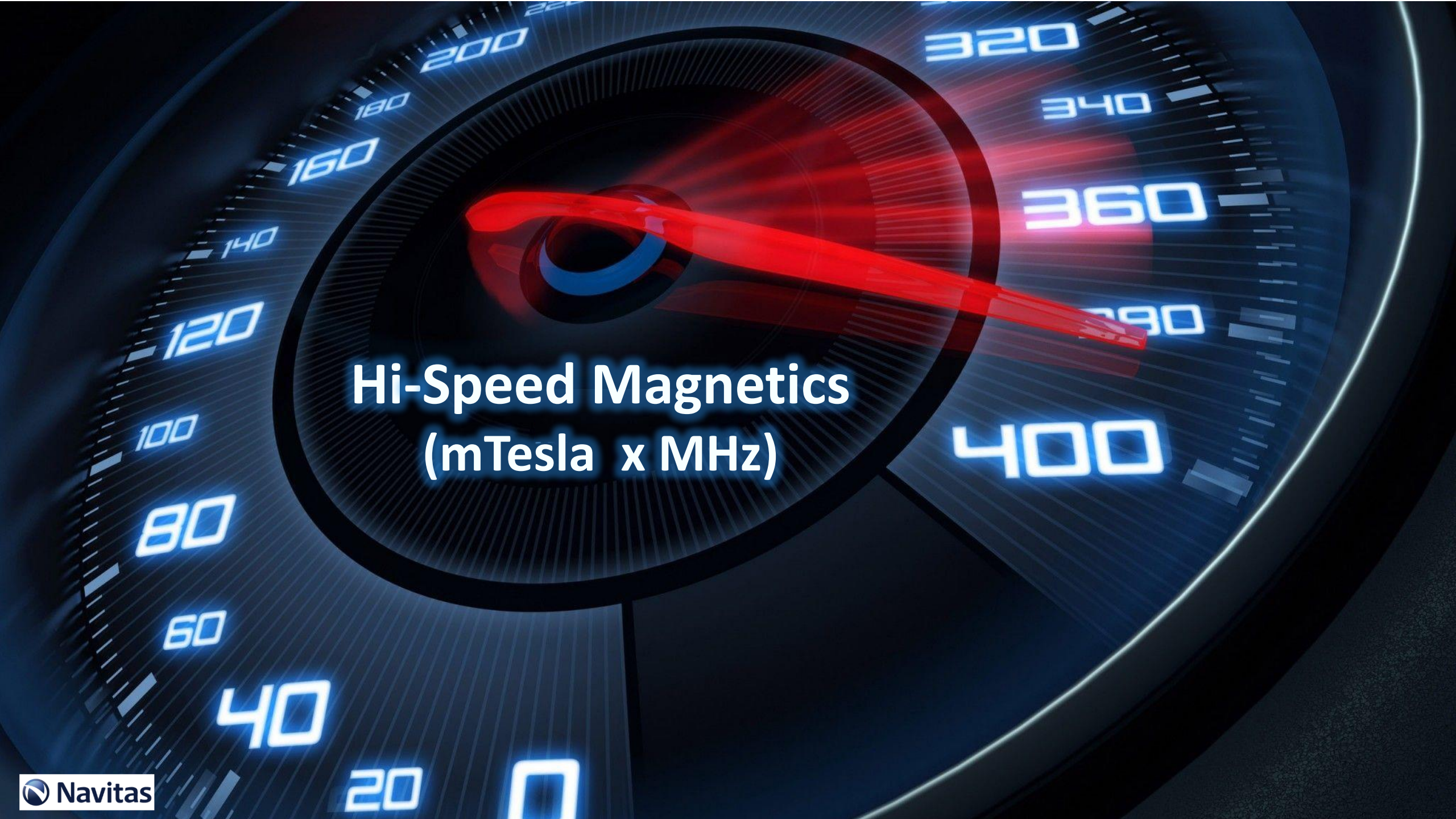
- Eliminate the problem
- Negligible turn-off losses



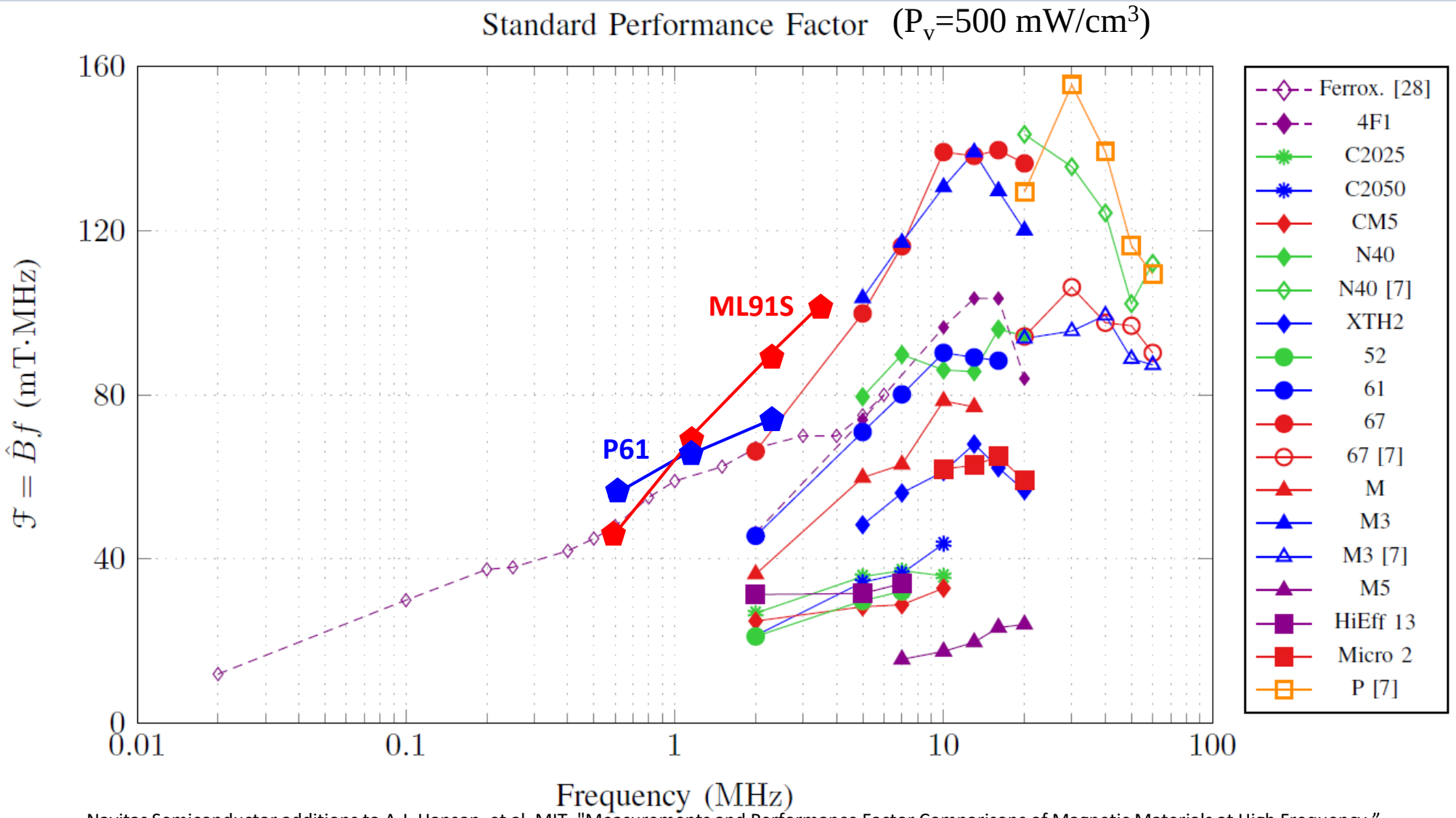
GaN Power IC – *Fast & Efficient*

- 500 V Switching
- No overshoot / spike
- No oscillations
- ‘S-curve’ transitions
- Zero Loss Turn-on
- Zero Loss Turn-off
- Sync Rectification
- High frequency
- Small, low cost magnetics



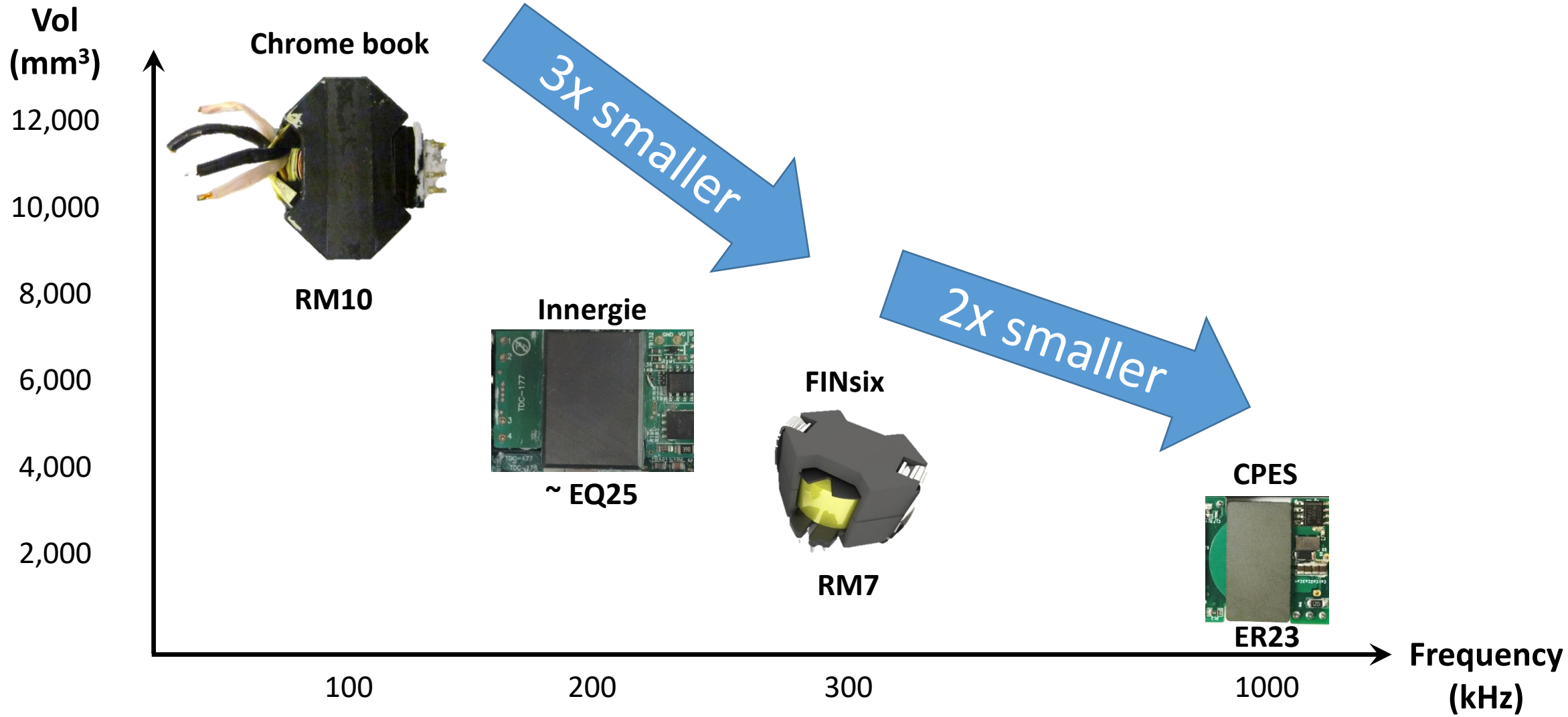

Hi-Speed Magnetics
(mTesla x MHz)
Navitas

New Magnetics, New Speeds



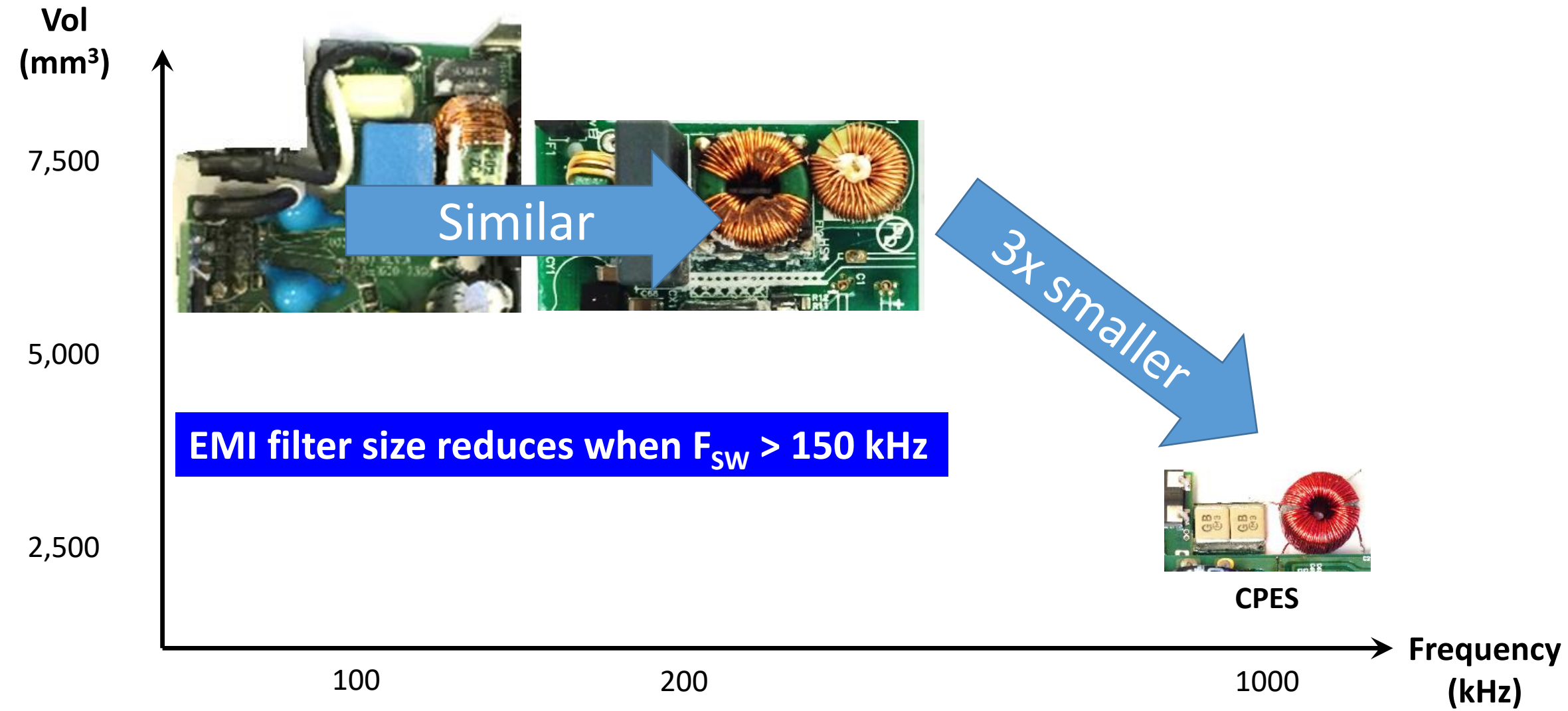
Navitas Semiconductor additions to A.J. Hanson, et al, MIT, "Measurements and Performance Factor Comparisons of Magnetic Materials at High Frequency," in *IEEE Transactions on Power Electronics*, vol. 31, no. 11, pp. 7909-7925, Nov. 2016.

Frequency Drives Size: Transformer (65 W)

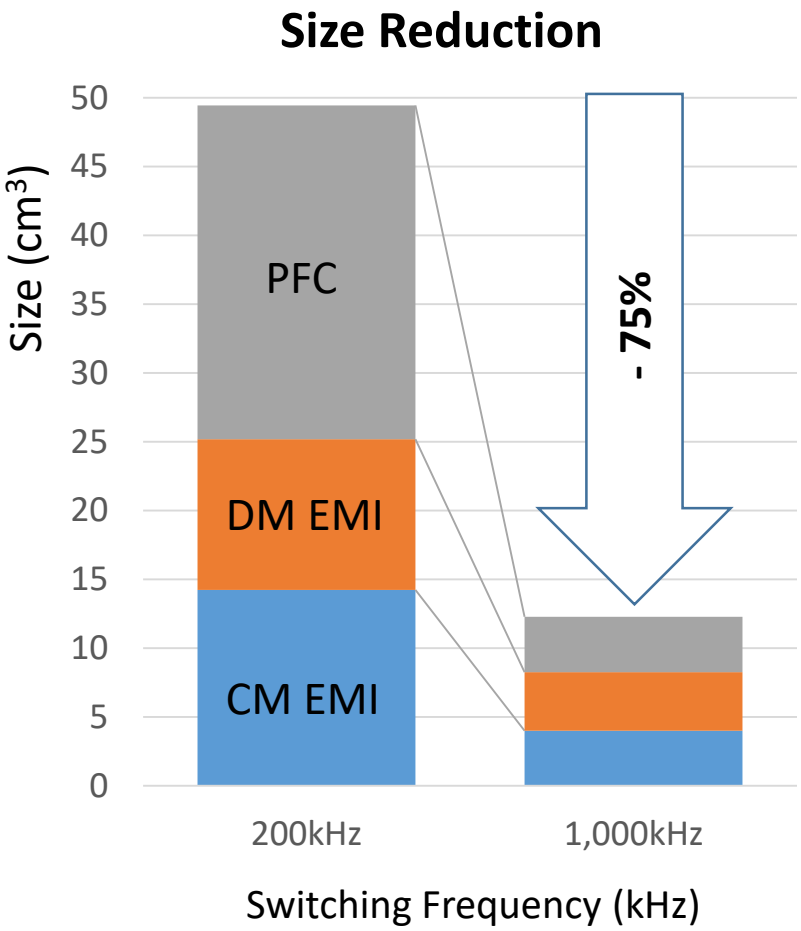


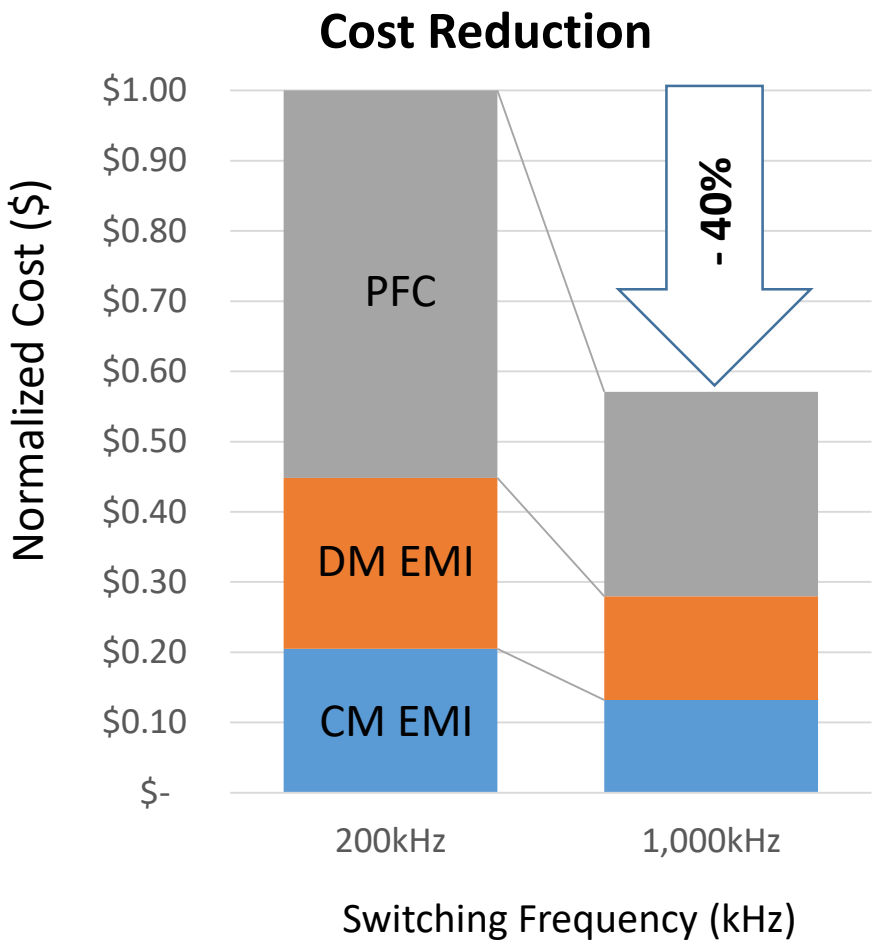
Frequency Drives Size: EMI Filter

Conductive frequency range: 150 kHz - 30 MHz



High Frequency → Small Size → Low Cost





Magnetics & EMI Filters


Hi-Speed Systems
(MHz → W/in³)
Navitas

GaN Power ICs enable Hi-Density Adapters

3x Higher Density with 50% Energy Savings

Existing Si-based 150W

100 kHz
5-10 W/in³
88%

AllGaN™ 2016 150W

2x Higher Density

300-500 kHz
17 W/in³
>93%

AllGaN™ 2017 150W

3x Higher Density

>1 MHz
26.5 W/in³
>95%

Ultra-thin LED TV

All-in-One PCs

Next-Gen Gaming Consoles

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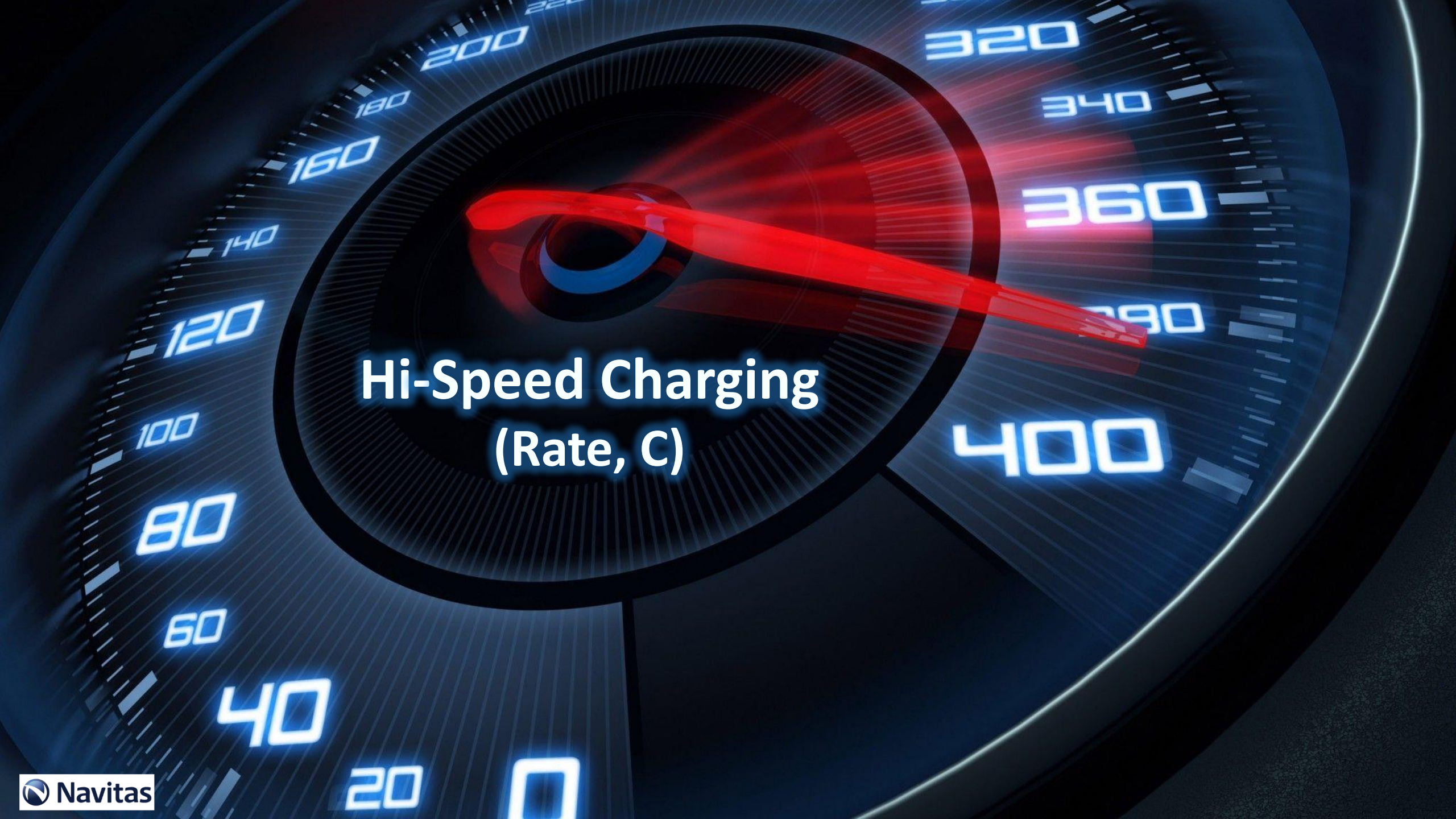
2016: Navitas + On Semiconductor; **2017**: Xiucheng Huang, "High Frequency GaN Characterization and Design Considerations," Ph.D Dissertation, Dept. Electr. Eng., Virginia Tech., Blacksburg, VA, USA, 2016.


Hi-Speed Charging
(Rate, C)
200
180
160
140
120
100
80
60
40
20
0
320
340
360
400

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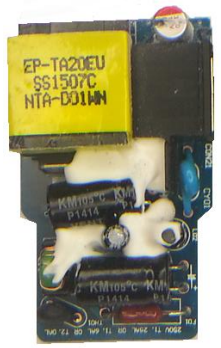
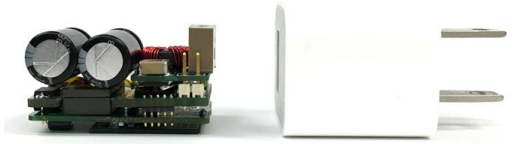
Fast Chargers … *going "GaN Fast"*

3x Fast Charging with 50% Energy Savings

Existing Si-based 15W	AllGaN™ 2016 25W	AllGaN™ 2017 25W
	2x Faster Charging	*3x Faster Charging*
		 25W 5W
100 kHz Up to 6.5 W/in³ 88%	300-500 kHz 11 W/in³ >92%	>1 MHz 17.5 W/in³ >95%

Smartphones & Tablets

Fast-charging Drones

AR / VR & Wearables

2016: Navitas; **2017**: Xiucheng Huang, "High Frequency GaN Characterization and Design Considerations," Ph.D Dissertation, Dept. Electr. Eng., Virginia Tech., Blacksburg, VA, USA, 2016.

Accelerating Wireless Power

Existing Silicon-based multi-stage wireless power

AirFuel™ Alliance

- Multi-stage Efficiency: 77%
- GaN-enabled single stage: 90%
- 20% lower system cost
- 3x faster charging

AC-DC Adapter
88% Efficiency

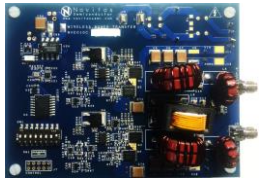
DC-DC
94% Efficiency

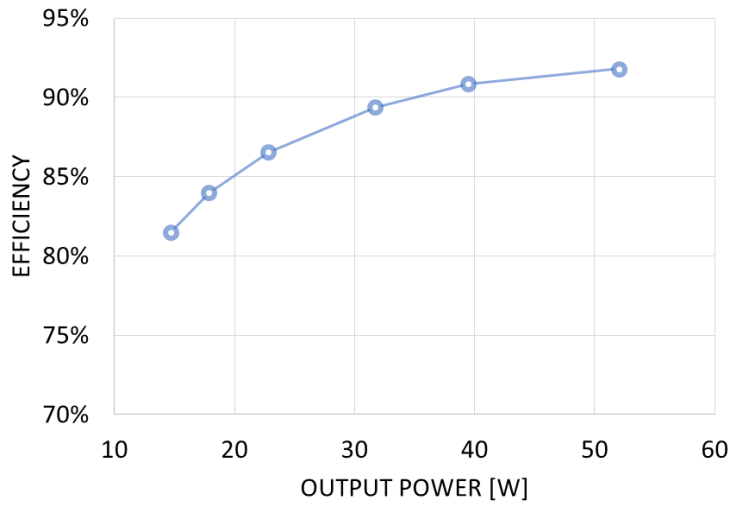
Power Amplifier
93% Efficiency

Wireless Transfer
90% Efficiency

Single-Stage Amplifier
90% Efficiency

- 650 V GaN Power ICs
- 3-stages integrated in 1-stage
- 6.78 MHz Operation
- High-Efficiency





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Hi-Speed Adoption
($B/yr)
0
20
40
60
80
100
120
140
160
180
200
320
340
360
400

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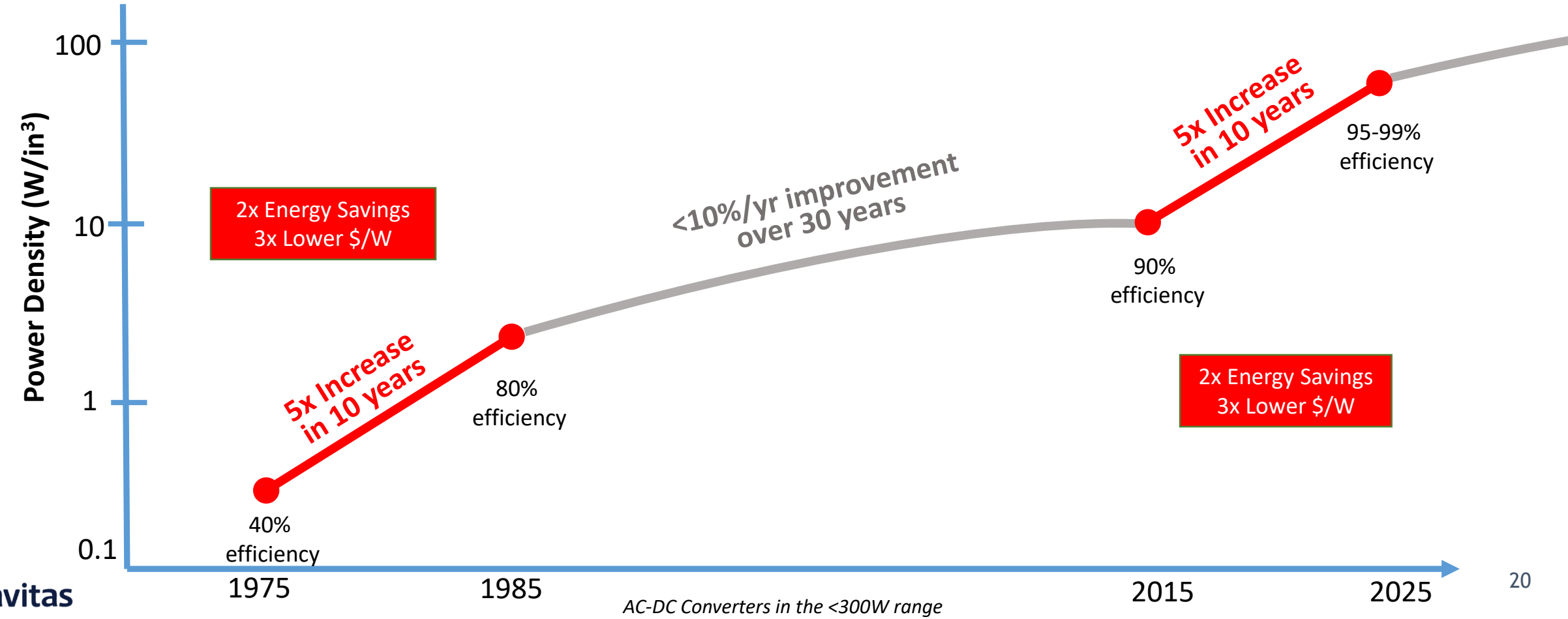
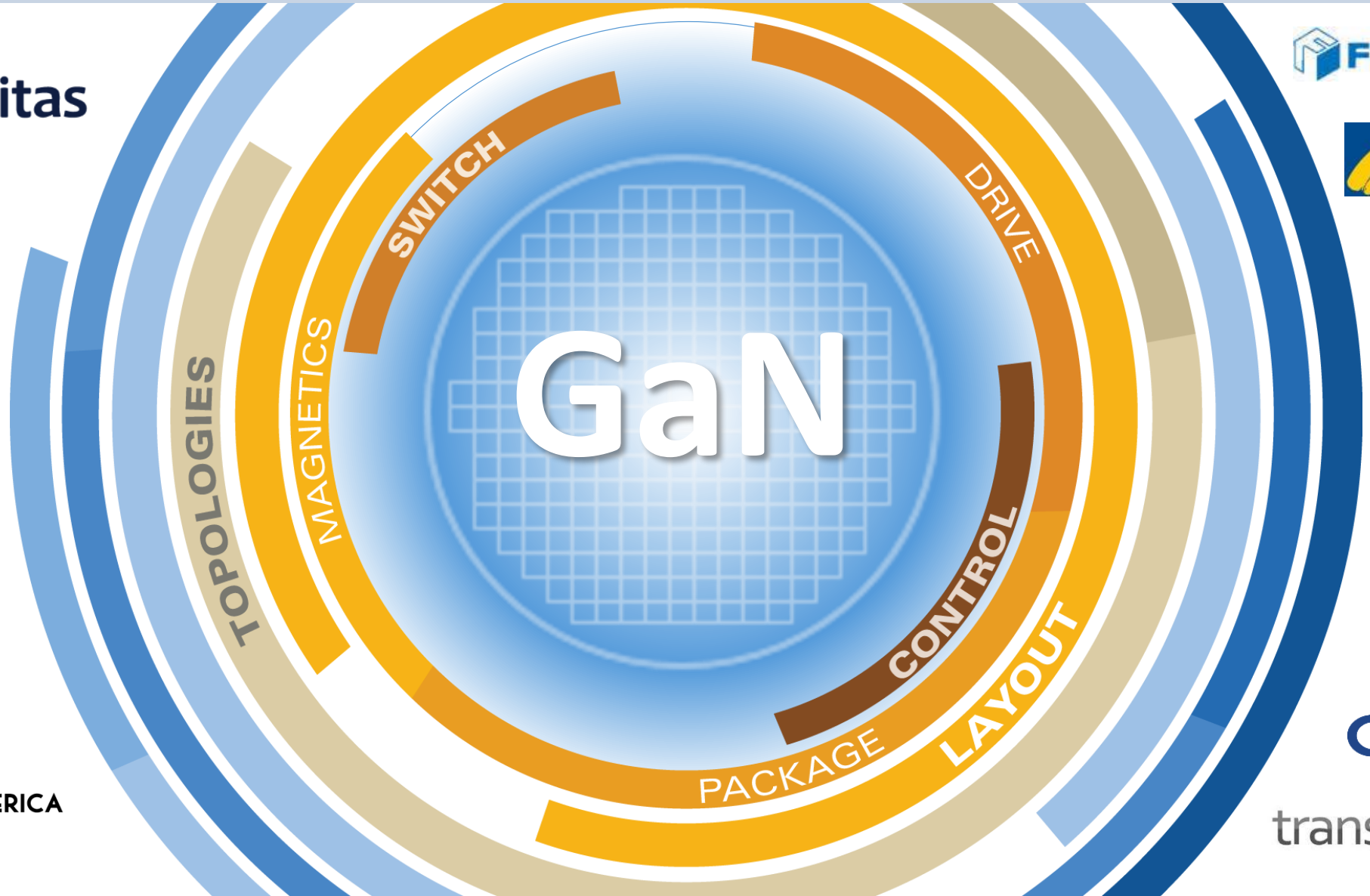
A Hi-Speed Disruption in Power...

Linear Regulators → Switching Regulators → Switching Regulators → HF Switching Regulators



AC-DC Converters in the <300W range

Join the High-Speed Revolution



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Texas Instruments

ON Semiconductor

Infineon

Analog Devices

PowerAmerica

FERROXCUBE
A YAGEO COMPANY

ACME

Materials Magic
Hitachi Metals

PRECISION INCORPORATED

TDK

WÜRTH ELEKTRONIK

EPC
EFFICIENT POWER CONVERSION

GaN Systems

transphorm


Start Your
Engines
MHz+
320
340
360
200
180
160
140
120
100
80
60
40
20
0