2022中国电力电子与能量转换大会
暨中国电源学会第二十五届学术年会及展览会
2022 China Power Electronics and Energy Conversion Congress
& The 25th China Power Supply Society Conference and Exhibition

"GaNFast™ Half-Bridge IC and Applications"

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Contact: ir@navitassemi.com
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Pure-Play Next-Gen Power Semiconductors

August 15th, 2022: Navitas Semiconductor, industry-leader in gallium nitride power ICs, acquired GeneSiC Semiconductor, silicon carbide pioneer and industry leader

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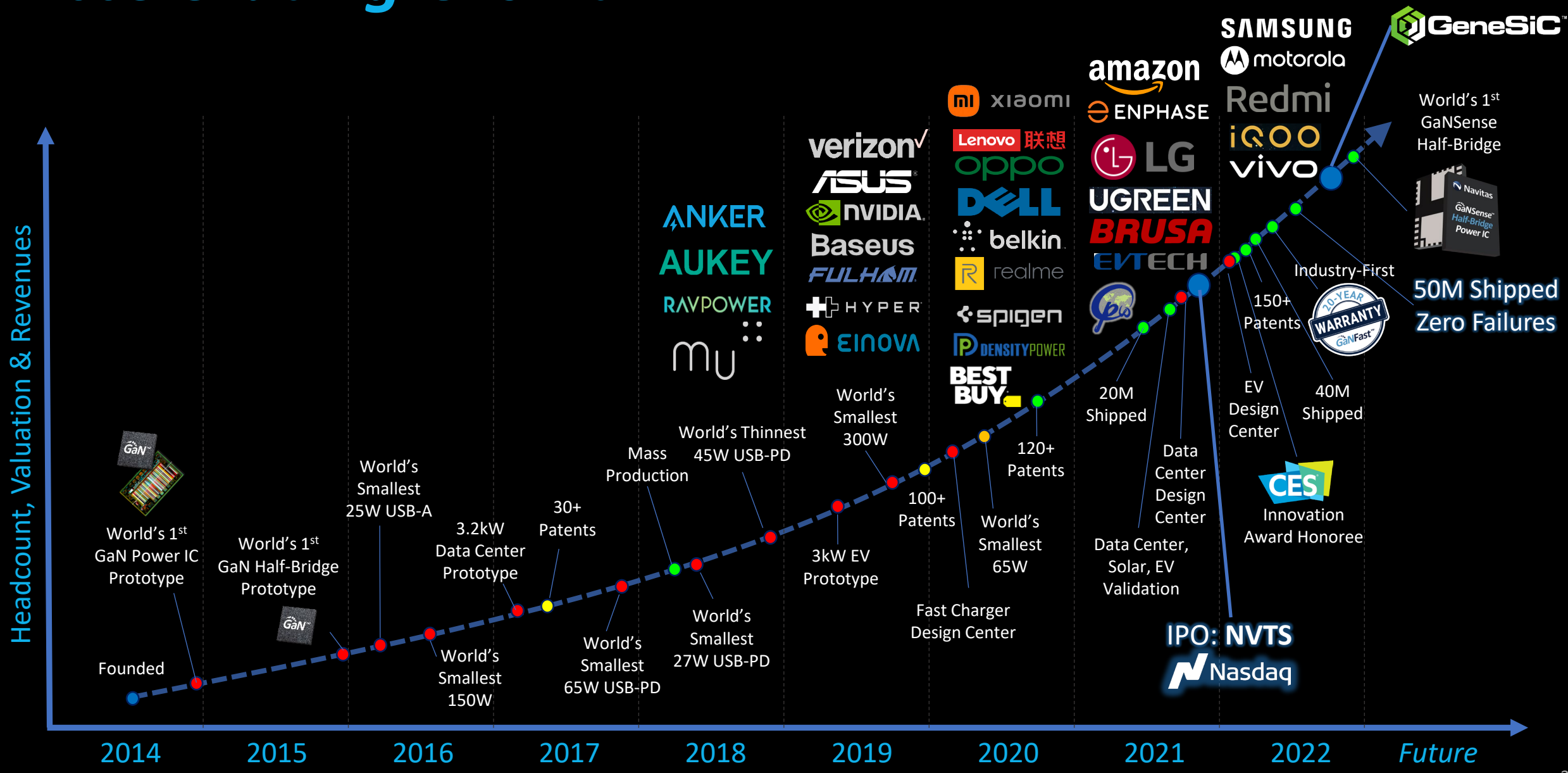
Accelerating Growth



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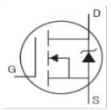
The GaN Revolution: Ultimate Integration

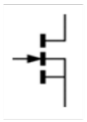
Navitas

Silicon FET



- Old, slow
- High Q_g
- High C_{OSS}
- F_{SW} < 100 kHz

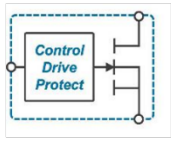
Discrete GaN



- Exposed gate
- External gate drive
- dV/dt sensitivity
- Layout sensitivity
- ESD sensitivity
- Unknown reliability
- Unknown robustness

GaNFast™

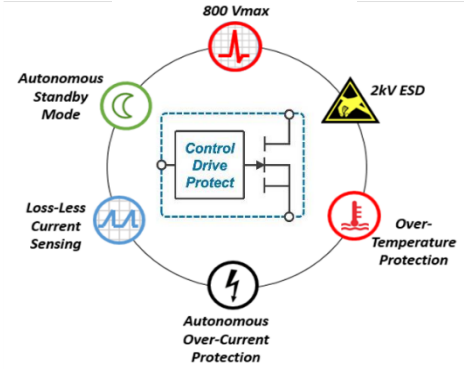
200-300 kHz



- ✓ Internal Gate
- ✓ Integrated Gate Drive
- ✓ dV/dt Immunity
- ✓ Layout Insensitive
- ✓ 2 kV ESD rating
- ✓ Proven Reliability
- ✓ Proven Robustness

GaNSense™

500 kHz

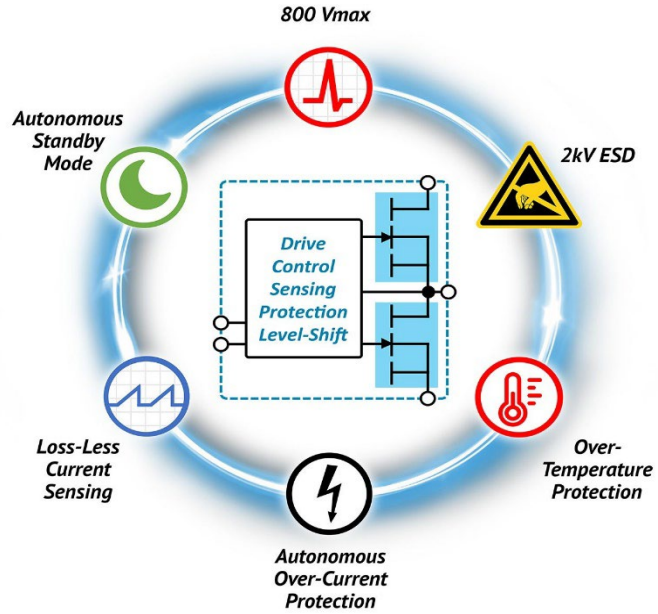


GaNFast plus:

- ✓ Autonomous Standby
- ✓ Autonomous Protection
- ✓ Loss-less Current Sensing
- ✓ High Precision
- ✓ High Efficiency

GaNSense Half-Bridge

1 MHz



GaNSense plus:

- ✓ Highest integration
  - ✓ integrated HS and LS FETs
  - ✓ Integrated level-shift isolation
  - ✓ integrated boot-strap
  - ✓ Shoot-through protection
  - ✓ Enlarged cooling pads
- ✓ Fastest switching
- ✓ Highest efficiency

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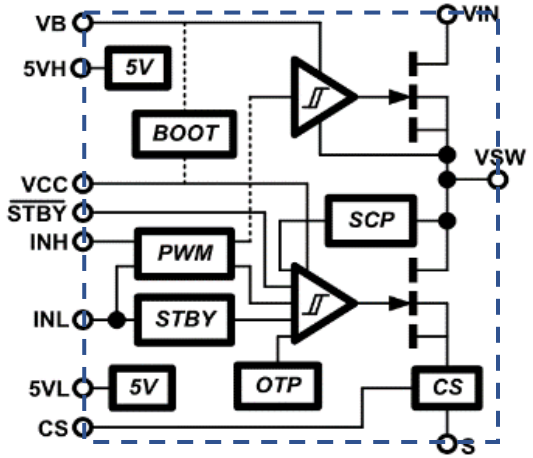
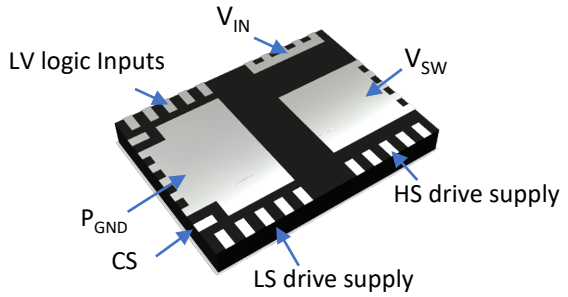
GaNFast Half-Bridge IC with GaNSense

- **GaNSense™ Technology**
  - Integrated loss-less current sensing
  - Over-current protection
  - Over-temperature protection
  - Autonomous low-current standby mode
  - Auto-standby enable input
- **Small, low profile SMT QFN**
  - 6x8 mm footprint, 0.85 mm profile
  - Minimized package inductance
  - Enlarged cooling pads
- **Sustainability**
  - RoHS, Pb-free, REACH-compliant
  - Up to 40% energy savings vs Si solutions
  - System level 4 kg CO_2 Carbon Footprint reduction
- **Product Reliability**
  - 20-year limited product warranty

Simplified schematic



PQFN 6x8



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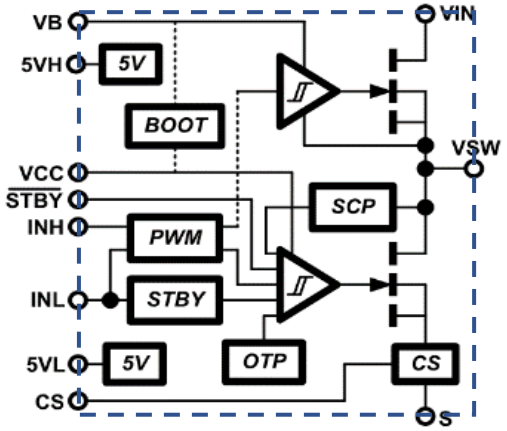
GaNFast Half-Bridge IC with GaNSense

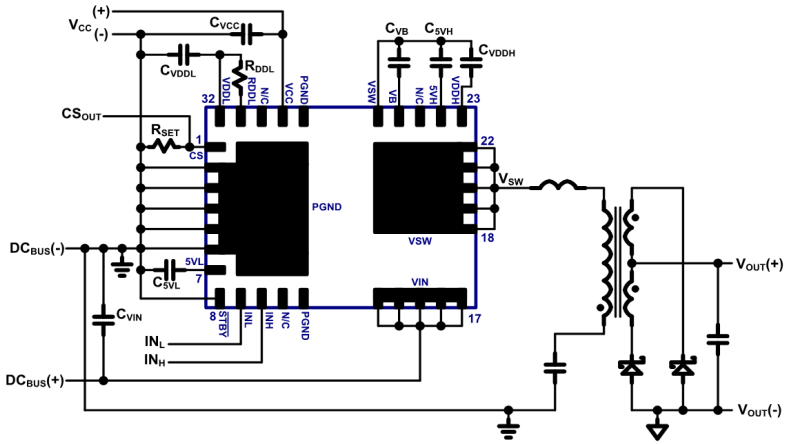
Features

- Two independent logic inputs with hysteresis
- 3.3, 5, 12 V PWM input compatible
- Floating high-side with internal level-shift
- 200 V/ns common mode transient immunity
- Integrated high-side bootstrap
- Shoot-through protection
- Wide V_{CC} range (10 to 20 V)
- Low-side turn-on dV/dt slew-rate control
- 800 V transient voltage rating
- 650 V continuous voltage rating
- 160 mΩ high-side FET, 160 mΩ low-side FET
- Zero reverse-recovery charge
- 2 kV ESD Rating (HBM)
- 2 MHz operation

Simplified schematic



Typical Application (LLC)



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GaN Integration Drives Speed, Efficiency, Stability

Navitas

Discrete GaN Half-Bridge

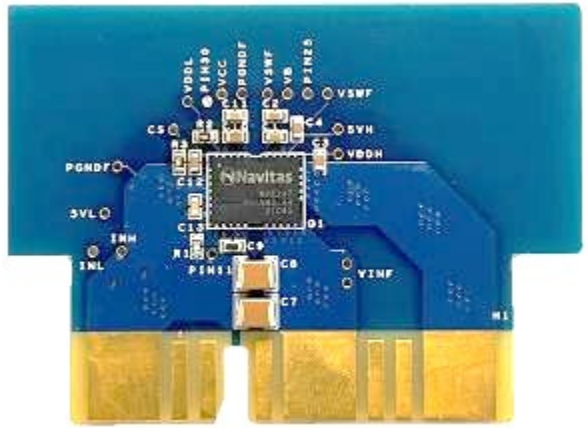
- × 33 components
- × 250 mm² footprint
- × External HB driver HVIC
- × External. HV bootstrap
- × 2x HV bypass diodes
- × 2x external gate drives
- × Exposed gates

61% fewer components

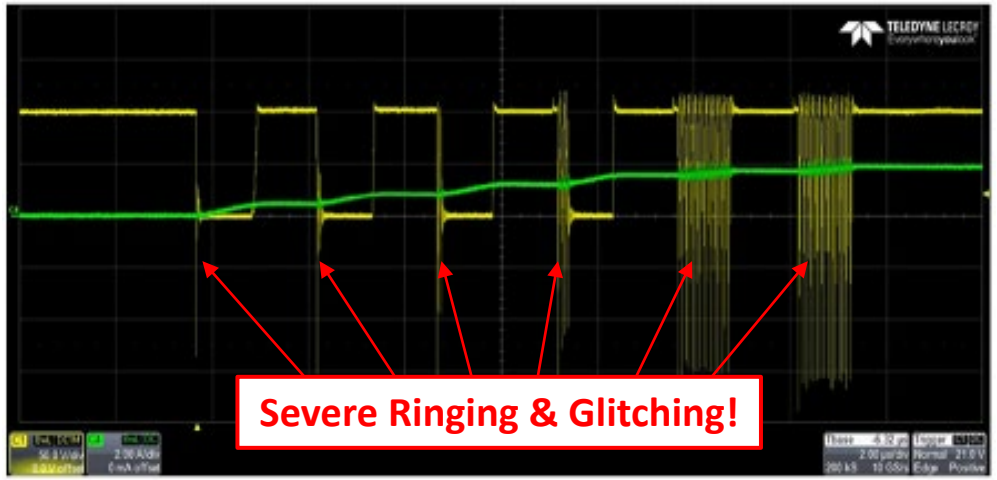
64% smaller footprint

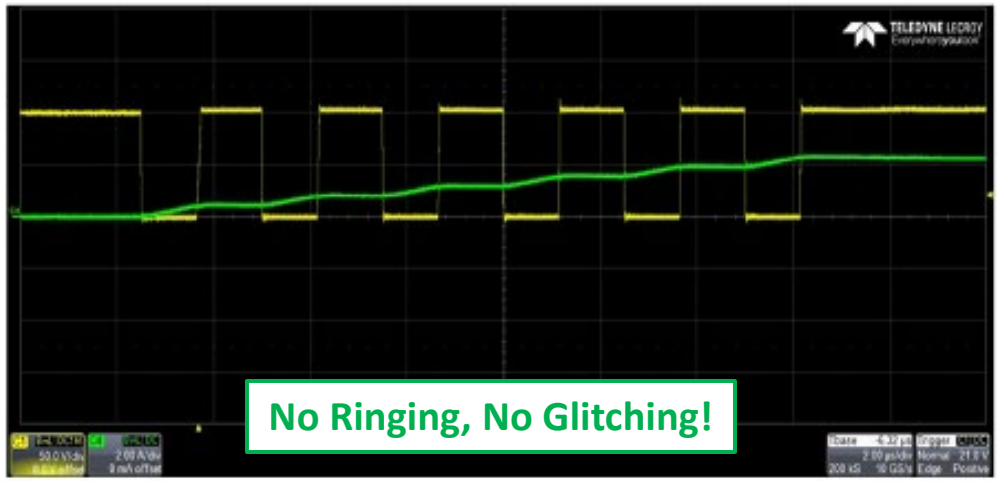
Complete integration

GaNSense Half-Bridge IC



- ✓13 components
- ✓90 mm² footprint
- ✓Level shifters
- ✓Bootstrap
- ✓Gate drivers
- ✓No exposed gates





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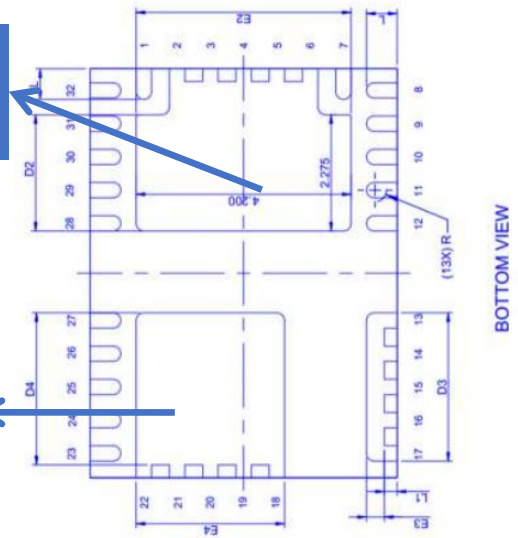
Navitas: Smallest Package, Biggest Thermal Pads

NV6247 QFN6*8
Total 18.5 mm²

P_{GND}
9.5 mm²

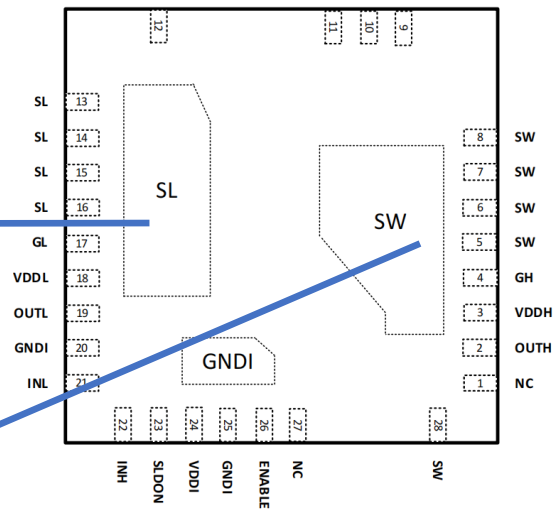
V_{SW}
9 mm²



C* GaN QFN8*8
Total 12.9 mm²

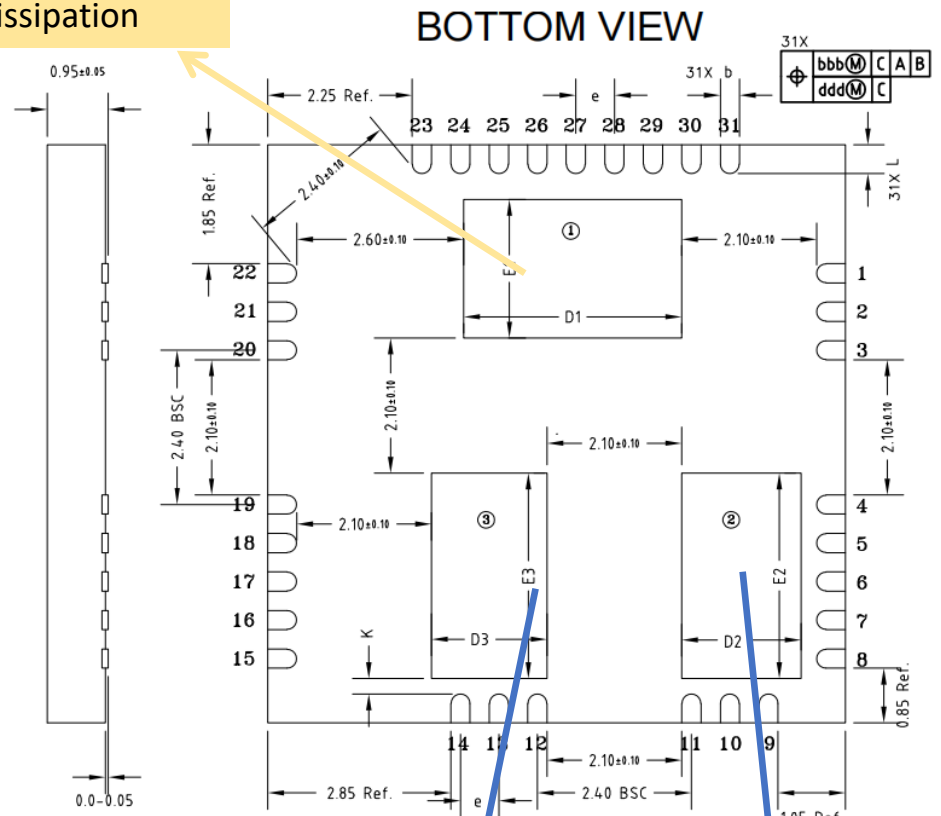
P_{GND}
6.1 mm²

V_{SW}
6.8 mm²



S_{GND}
Nearly no impact to thermal dissipation

M* GaN1 QFN9*9
Total 11.5 mm²



V_{SW}
5.76 mm²

P_{GND}
5.76 mm²

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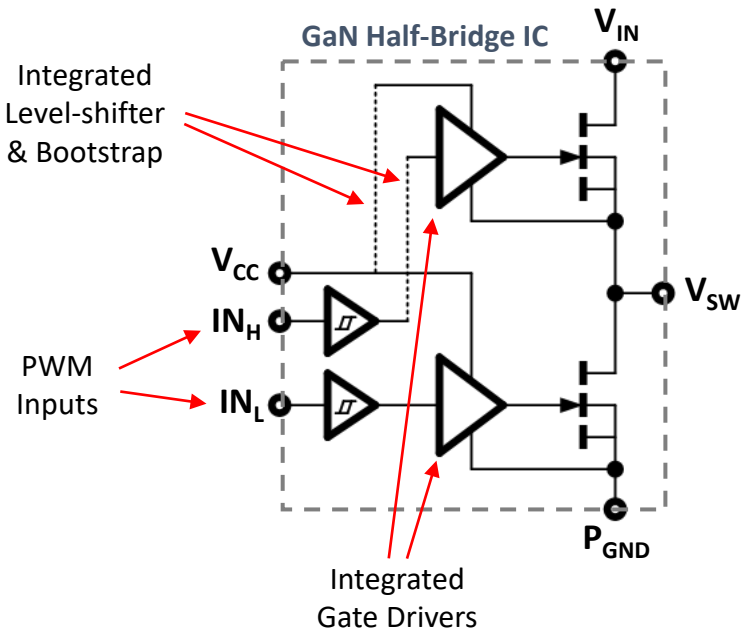
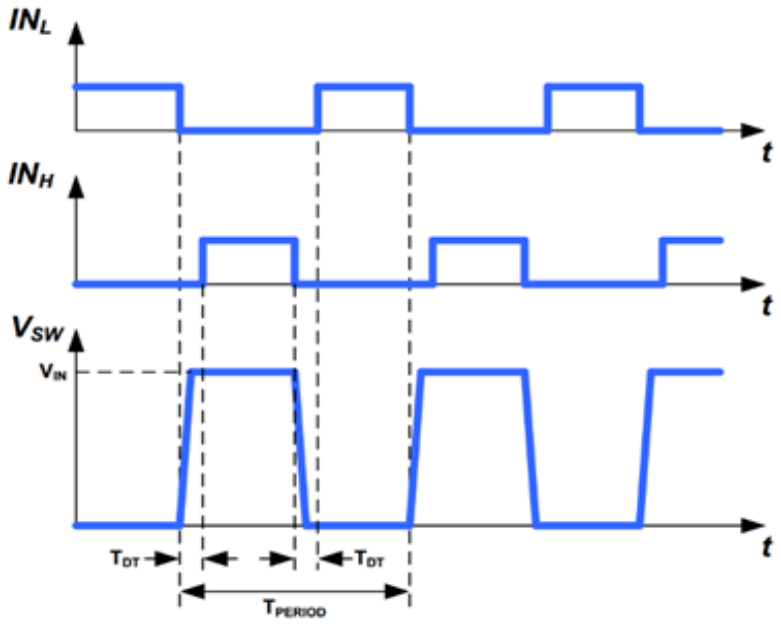
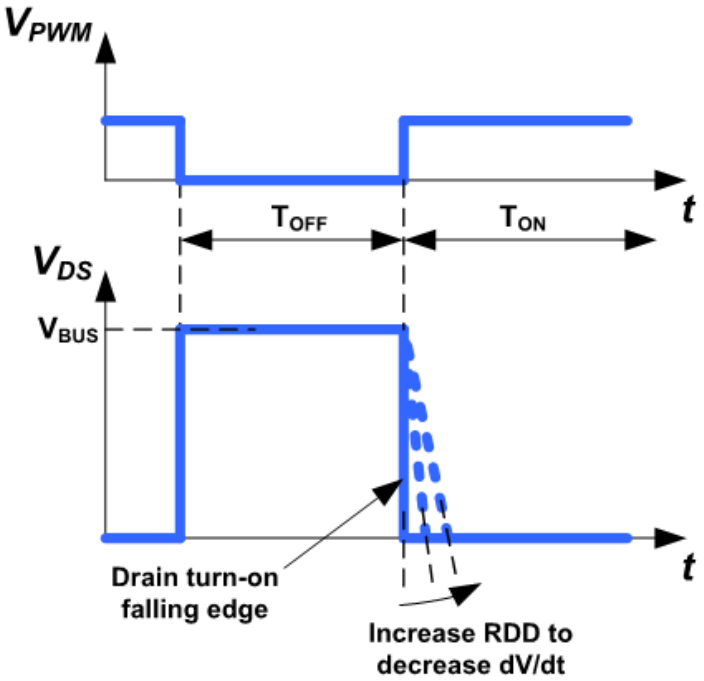
Digital In, Power Out!



GaN Half-Bridge IC Timing Diagram (ZVS Mode)



Turn-on dV/dt slew rate control



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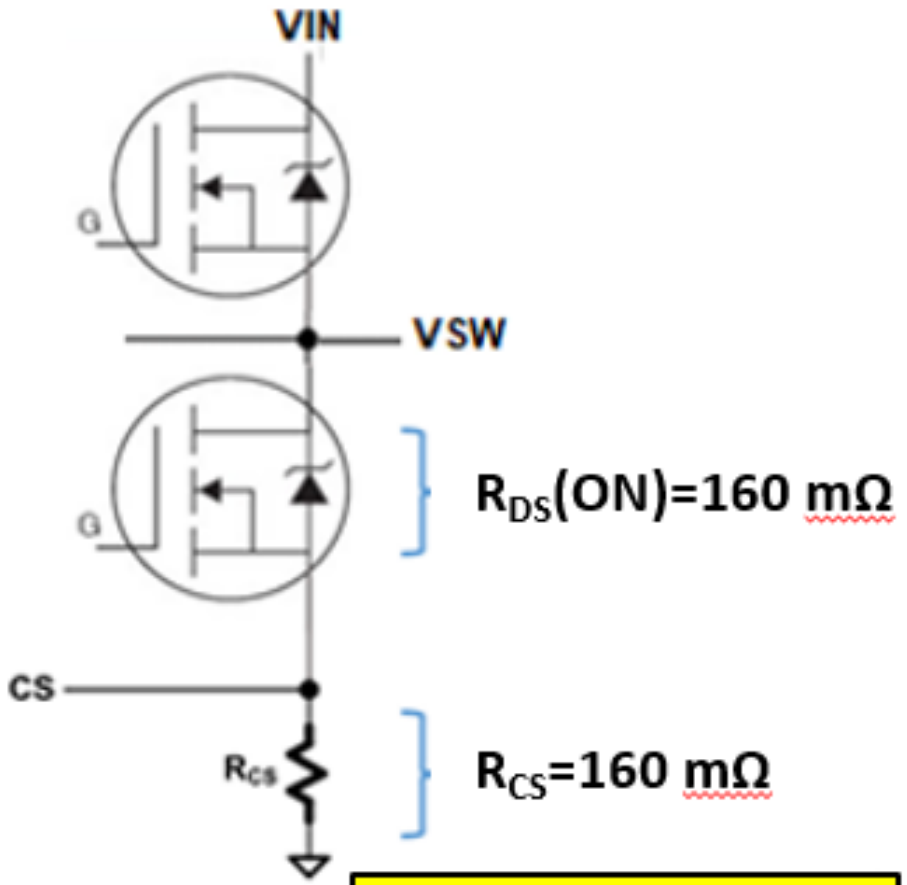
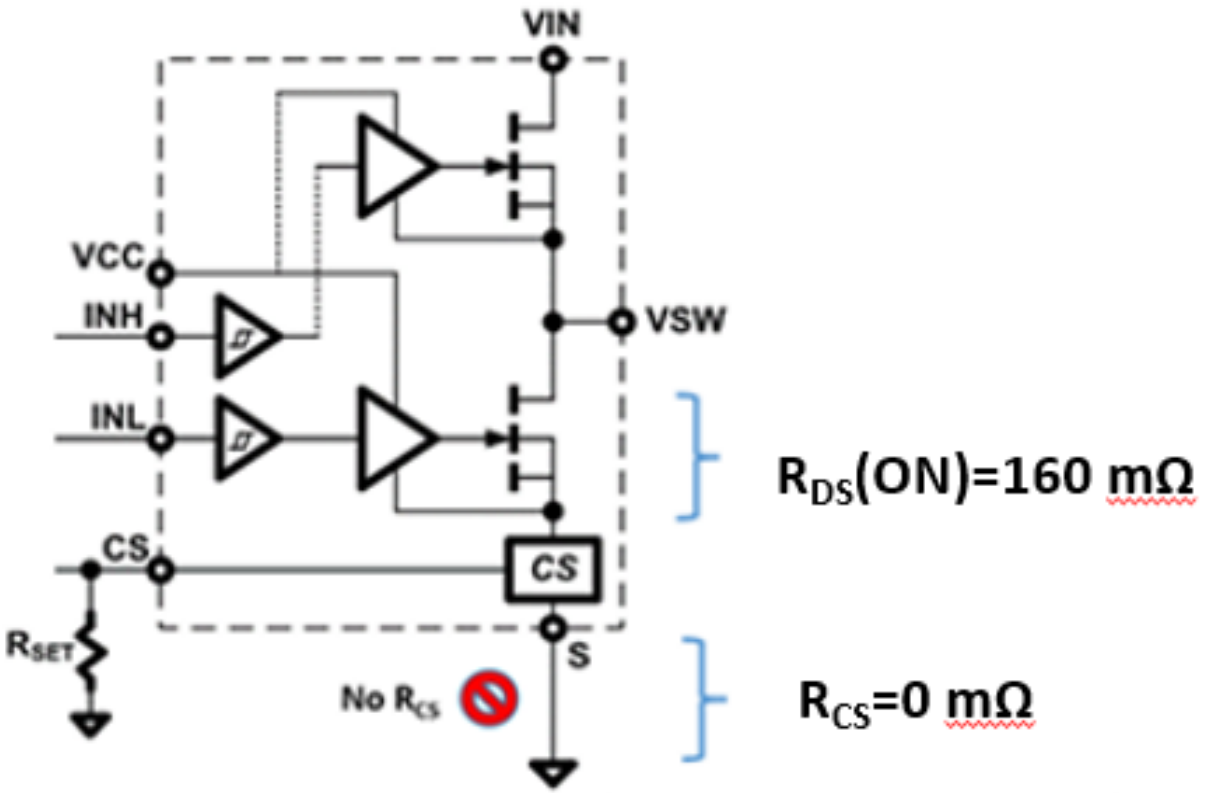
Loss-less Current Sensing





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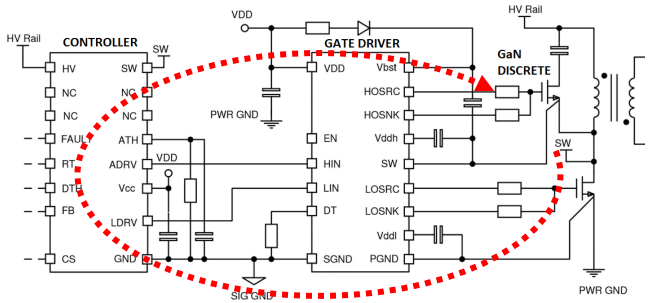
Autonomous Over-Current Protection (OCP)

Discrete GaN Solution

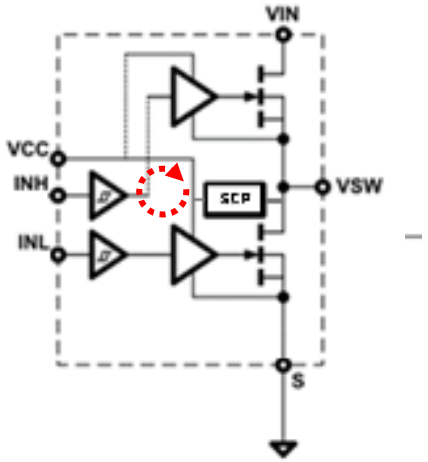


Uses QR controller OCP function

T_{OCP} = 180 ns

- *Existing solutions use ext. R_{CS}*
- *Filter + controller delay slow*

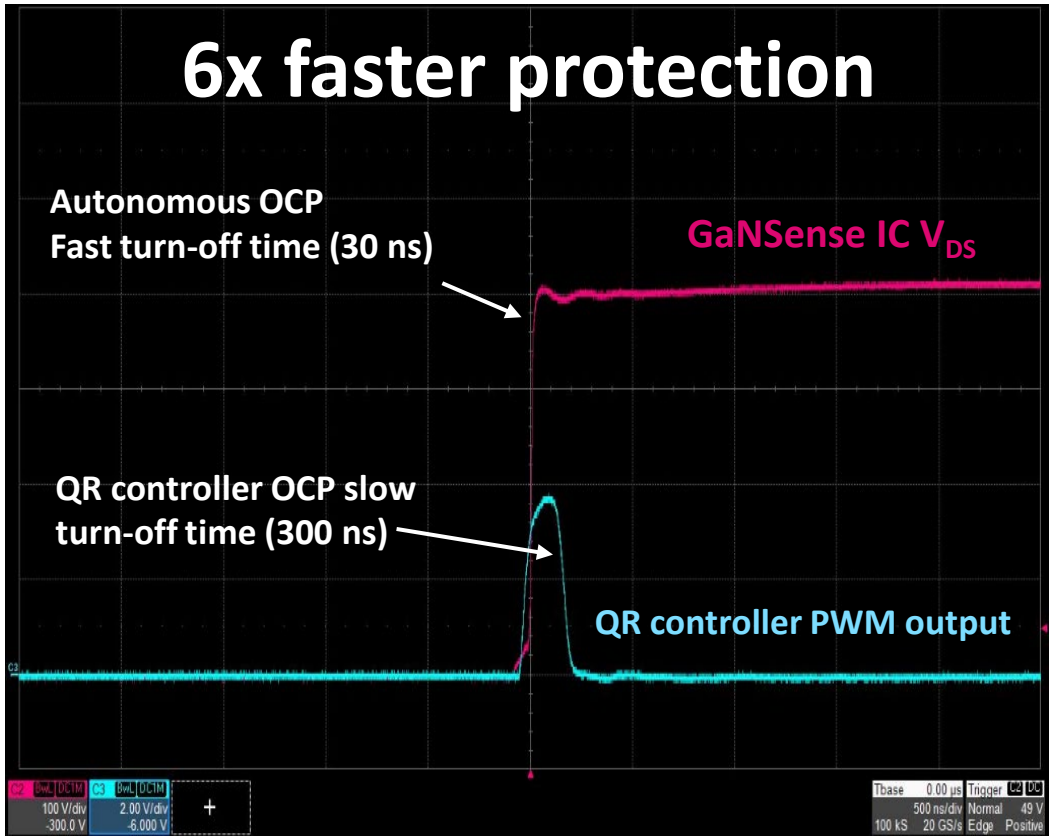
GaNFast™ with GaNSense™



Integrated SCP function

T_{OCP} = 30 ns

- *Autonomous OCP*
- *Fast-acting self-protection*
- *Cycle-by-cycle protection*
- *Excellent robustness*



- *QR controller OCP = slow turn-off (180 ns)*
- *NV6136 OCP = fast turn-off (30 ns)*

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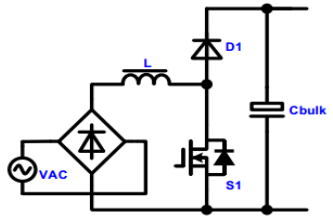
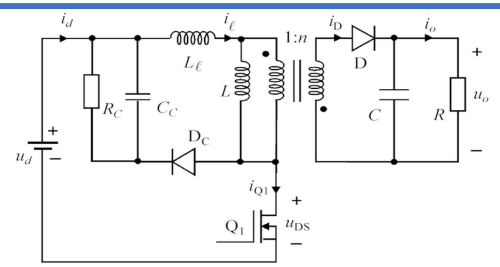
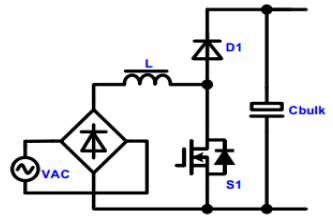
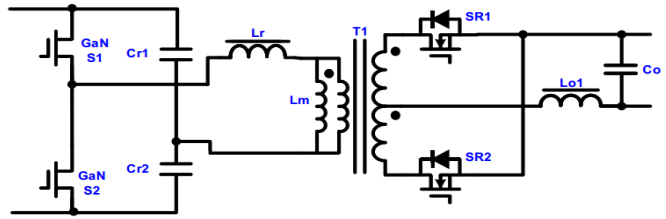
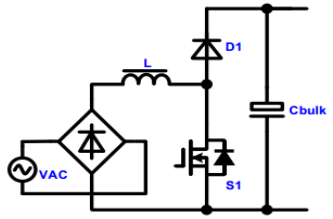
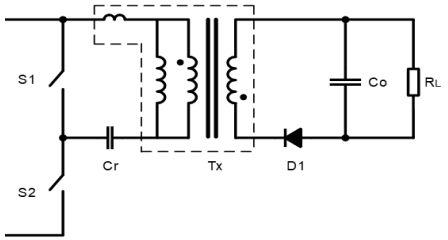
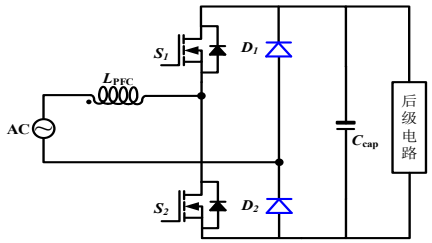
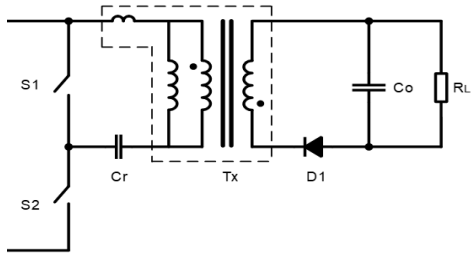
Mid-Power Circuit Topologies

	AC/DC	DC-DC	Adv/Disadv
PFC + QR			• 2x HV Switches • 1x SR Switch • Variable V_{OUT} • Low Power Density • Low Efficiency • Low Cost
PFC + LLC			• 3x HV Switches • 2x SR Switches • Fixed V_{OUT} • High Power Density • High Efficiency • High Cost
PFC + AHB			• 3x HV Switches • 1x SR Switch • Variable V_{OUT} • High Power Density • High Efficiency • Medium Cost
TTP + AHB			• 4x HV Switches • 1x SR Switch • Variable V_{OUT} • Highest Power Density • Highest Efficiency • High Cost

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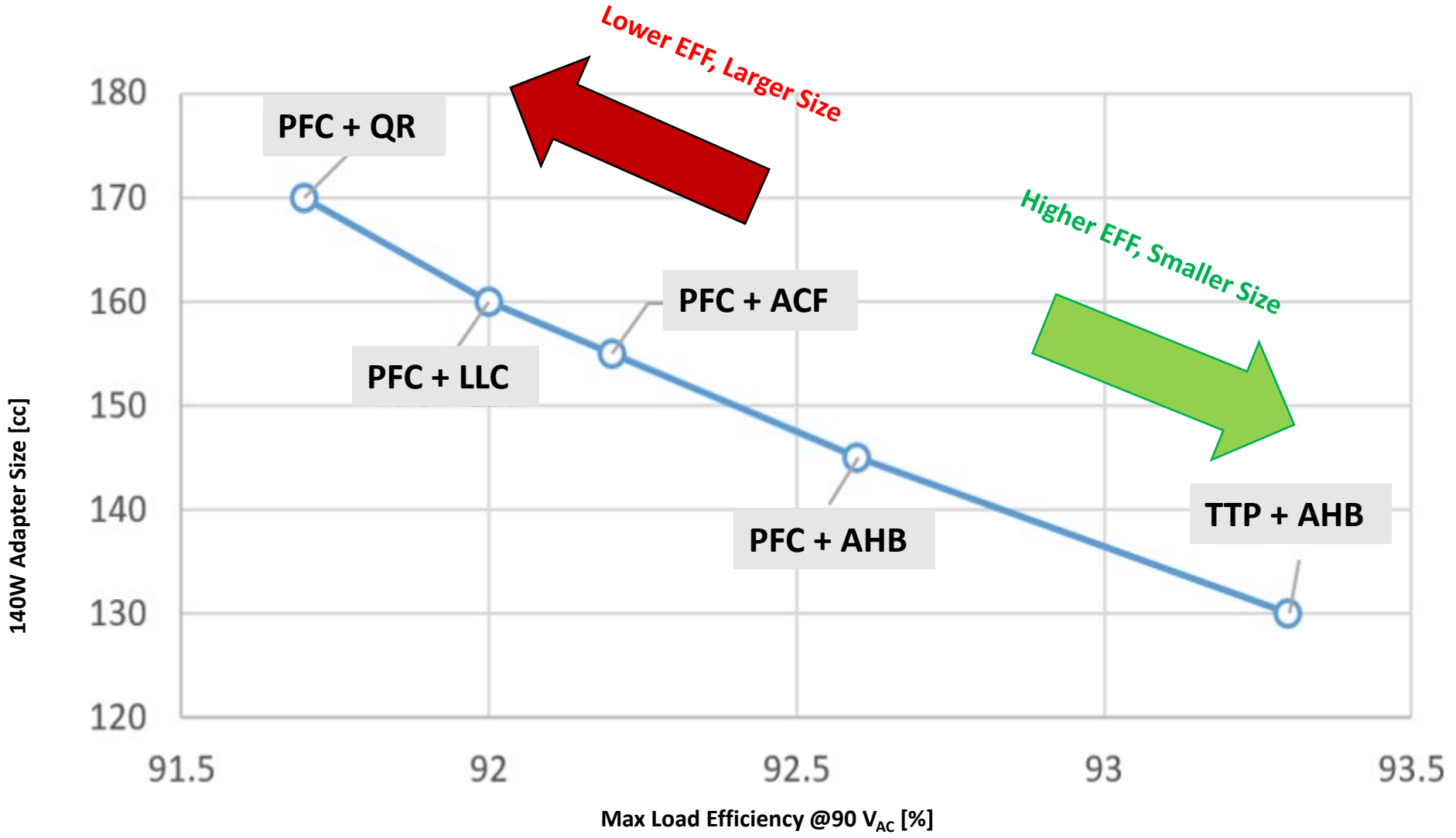
High Efficiency = Small Size



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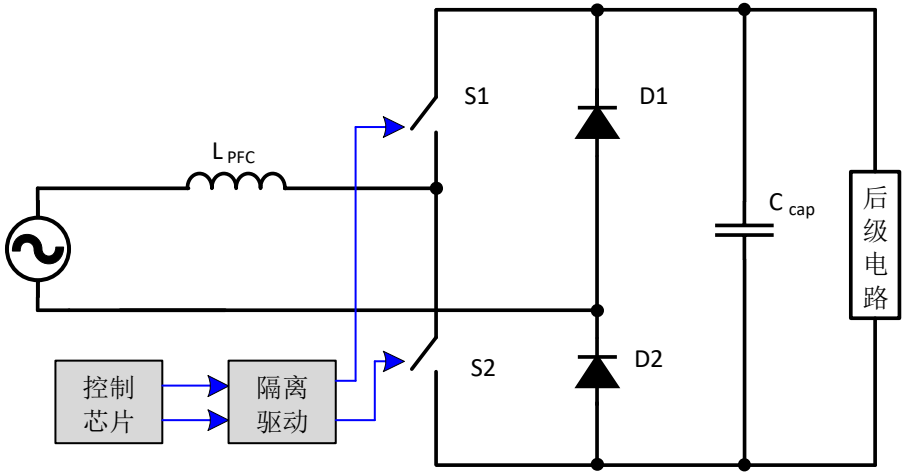
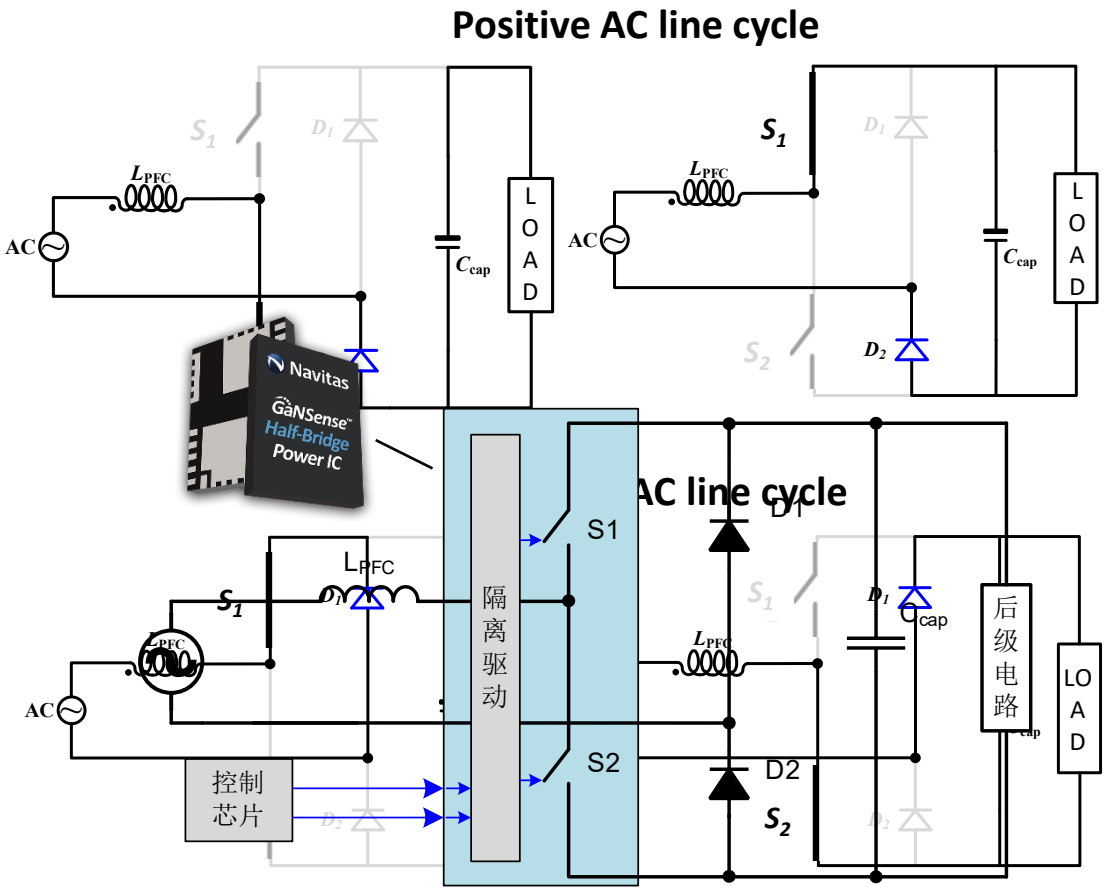
NV62xx in Totem-pole PFC





TTP Benefits

- ✓ *Eliminates Input Bridge* → *High efficiency*
- ✓ *GaN Zero Qrr* → *CRM & CCM modes*
- ✓ *GaN High Frequency* → *Small inductor size*

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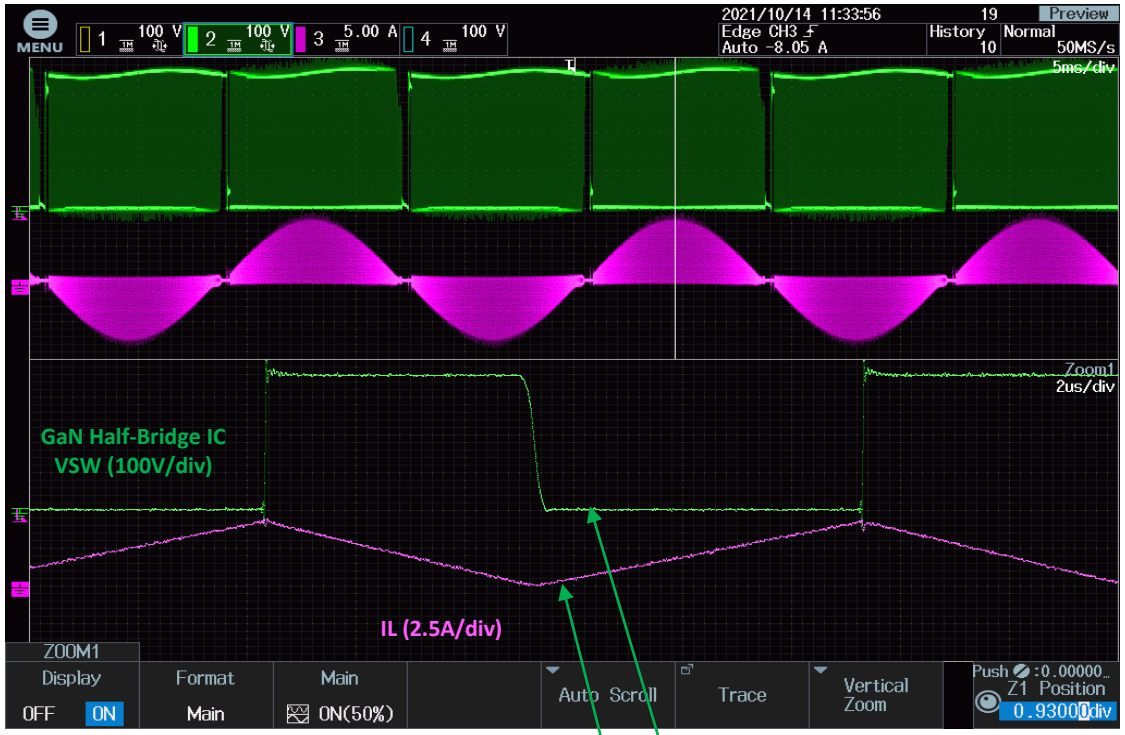
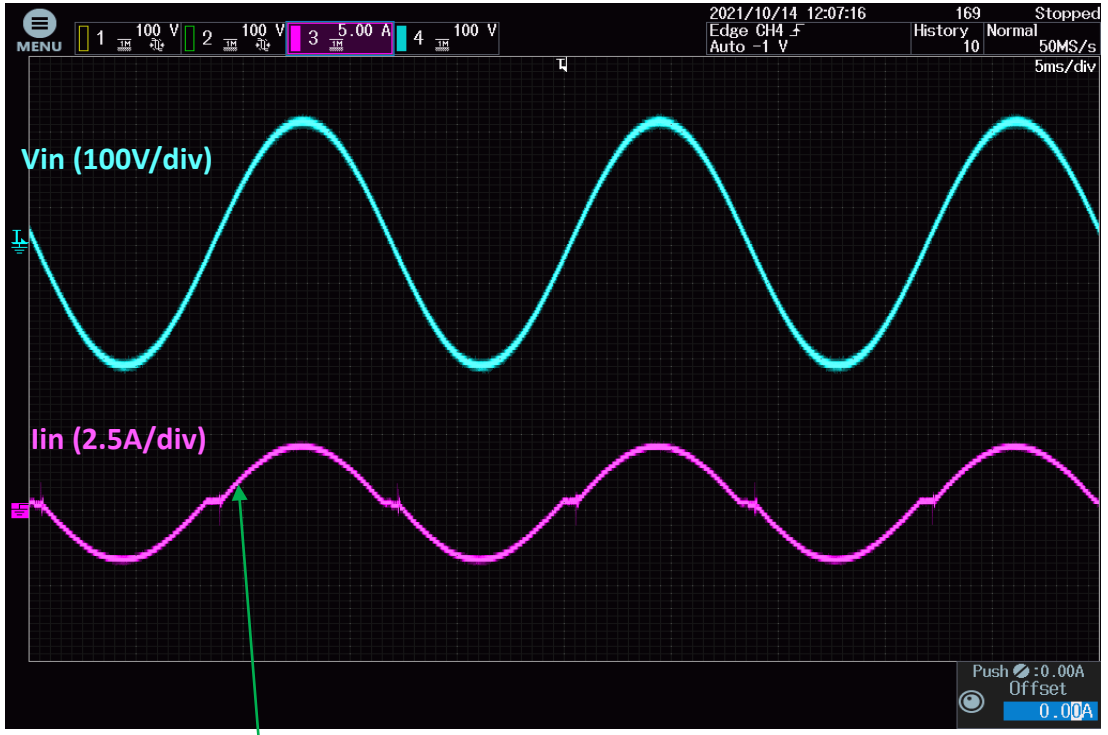
Totem-pole PFC CRM Operation

Boost Circuit Waveforms (V_{IN} = 115 V_{AC}, P_{OUT} = 140 W)



- Clean Boost Circuit Waveforms
- CRM Operating Mode

AC Input Waveforms (V_{IN} = 115 V_{AC}, P_{OUT} = 140 W)



- Sinusoidal Input Current
- High Power Factor = 0.997

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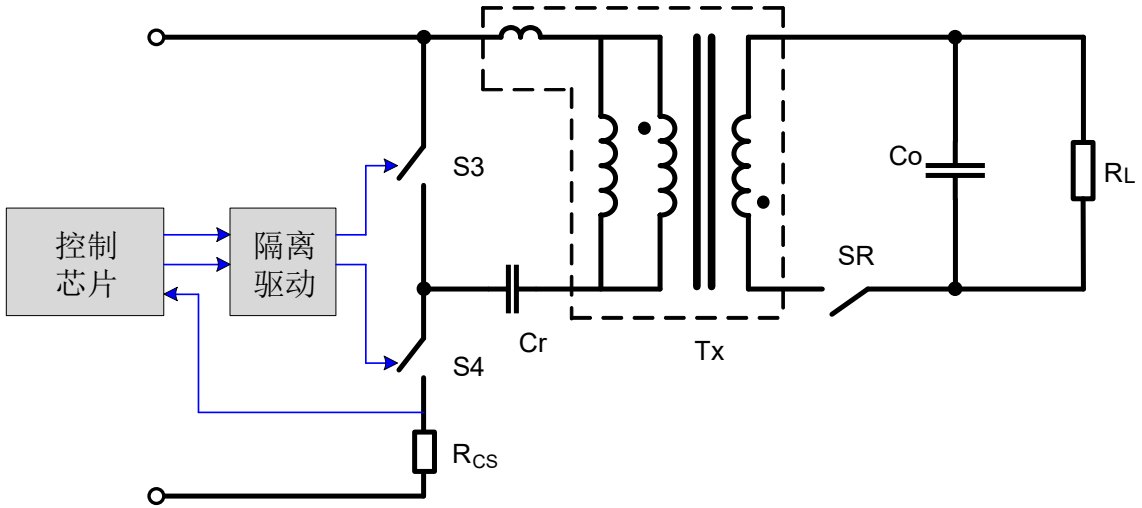
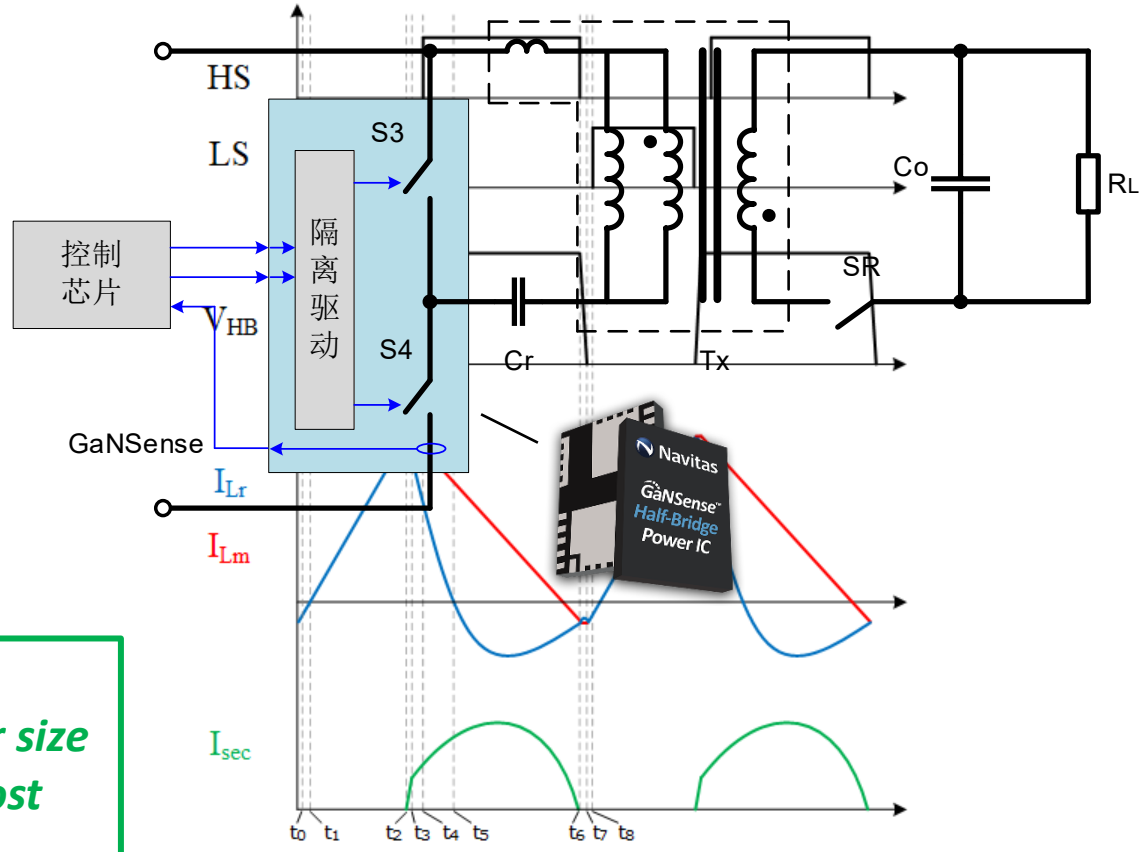
NV62xx in AHB converter





AHB Benefits

- ✓ *High efficiency → Reduces losses, enables small charger size*
- ✓ *ZVS operation → Enables HF, reduce component size/cost*
- ✓ *Variable V_{OUT} → Enables USB-C PD3.1*

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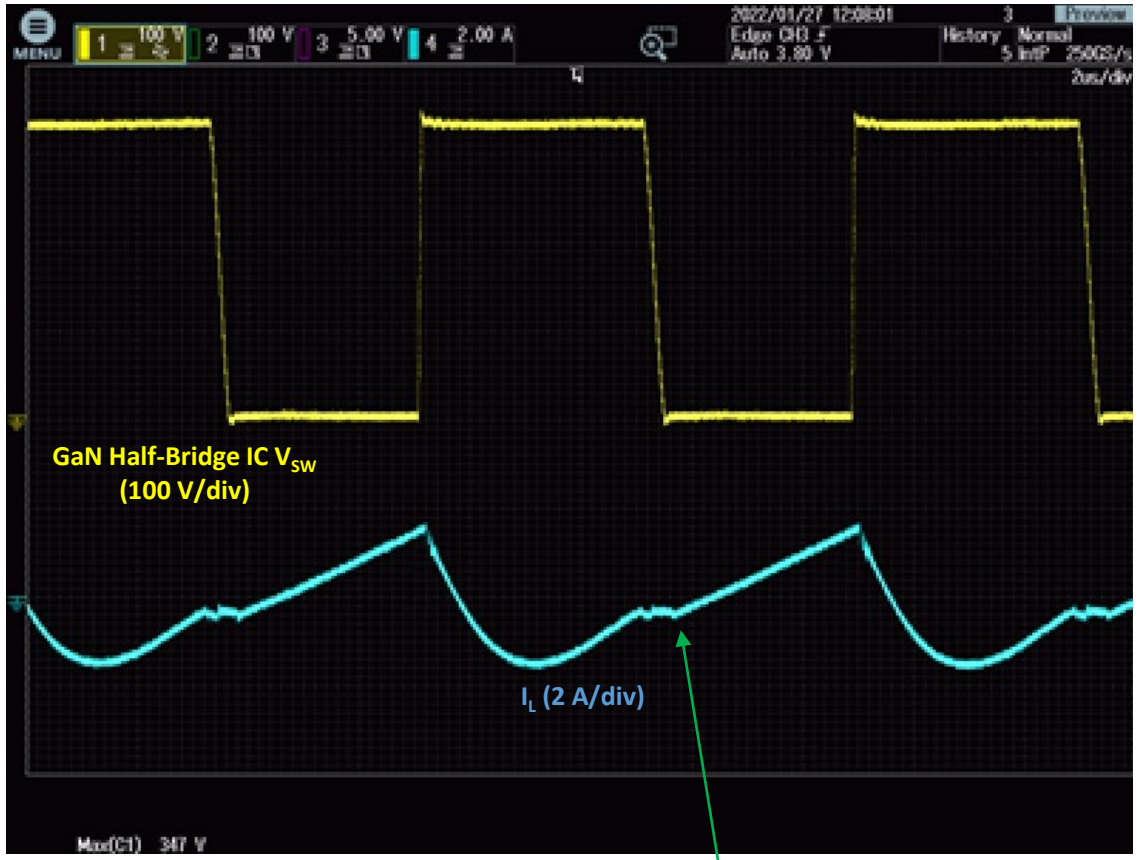
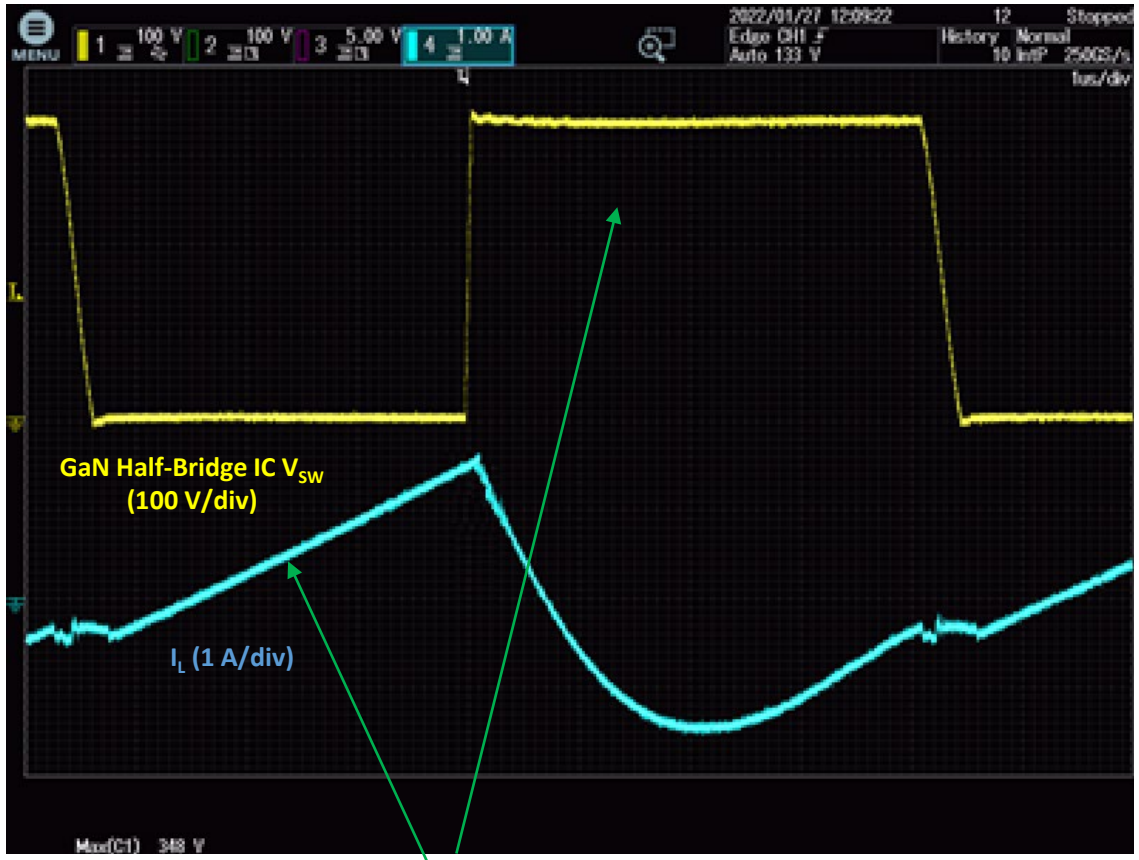
AHB Resonant ZVS Switching



- AHB Tank Current
- Resonant Mode Operation



- GaN Half-Bridge Switched Node
- Resonant ZVS Switching

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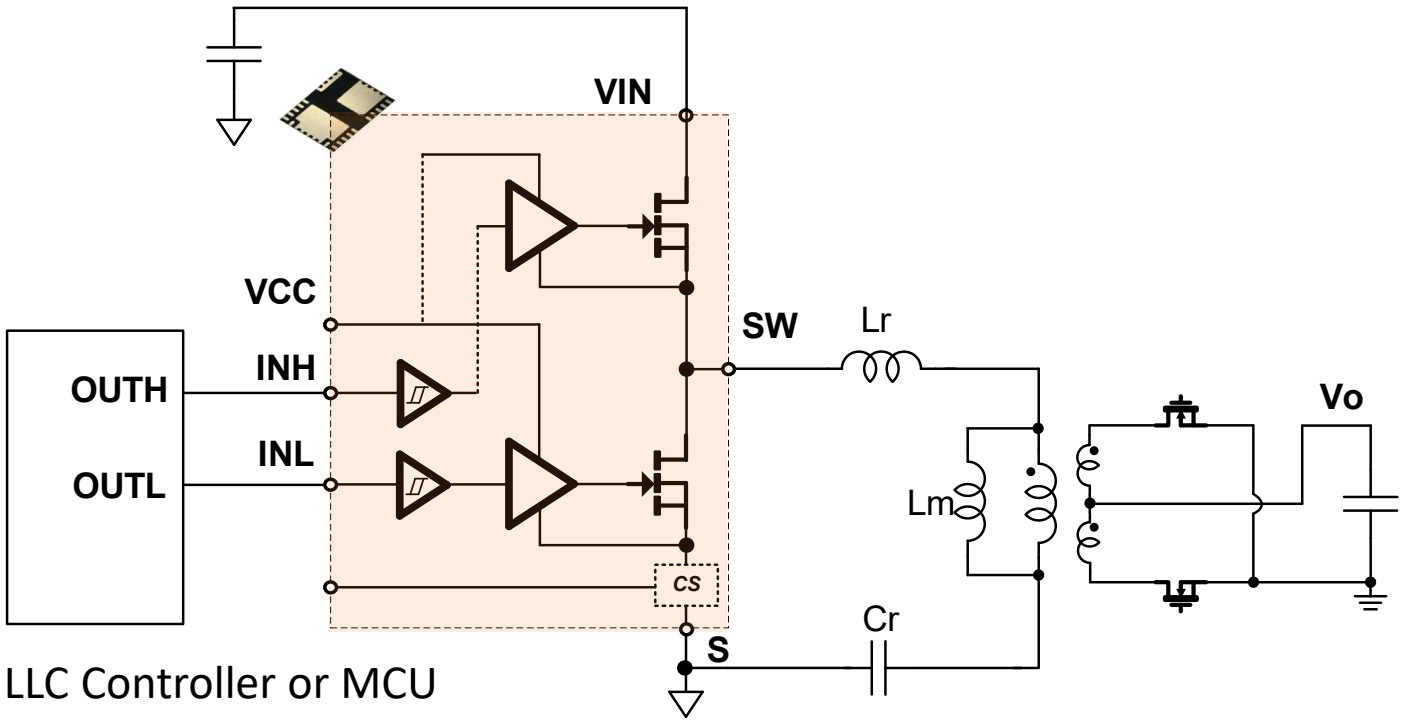
NV62xx in LLC converter



- LLC Controller or MCU

- Integrated gate driver
- Few peripheral devices
- Simplified system
- Small critical loop area

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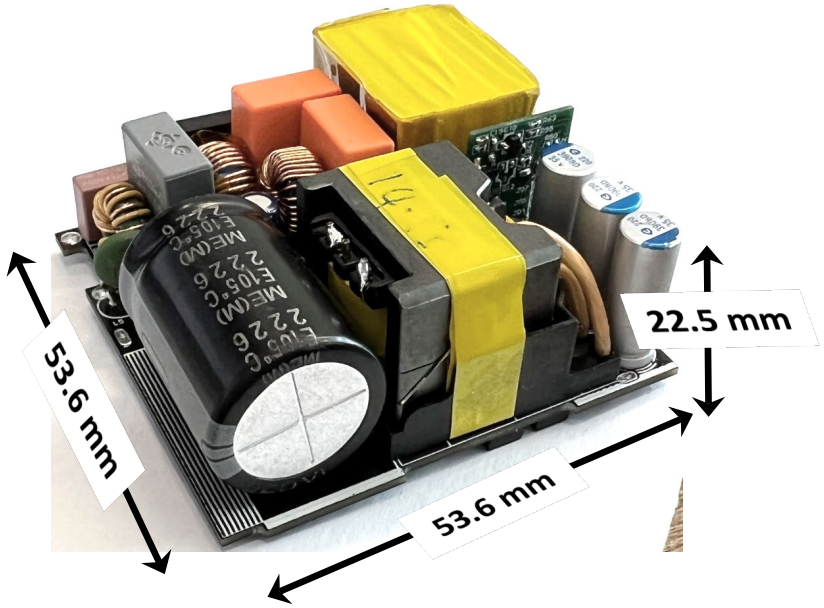
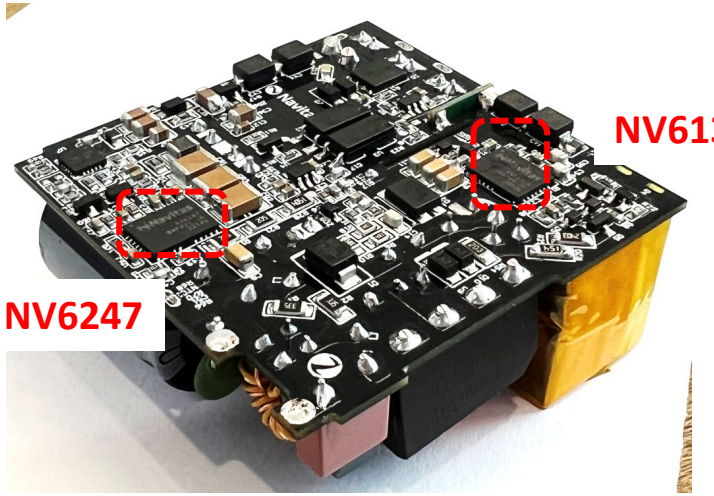
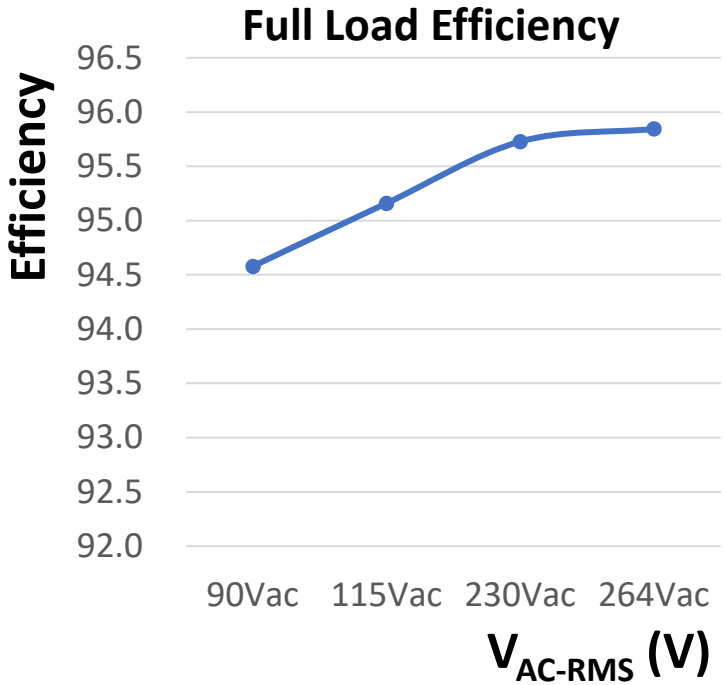
PD 140 W PFC+AHB







- Output : 28 V / 5 A, 20 V / 5 A, 15 V / 3 A, 9 V / 3 A, 5 V / 3 A
- PCBA : 53.6 x 53.6 x 23 mm (66 cc) = 2.1 W/cc
- Cased : 58 x 58 x 29 mm (98 cc) (estimate) = 1.4 W/cc

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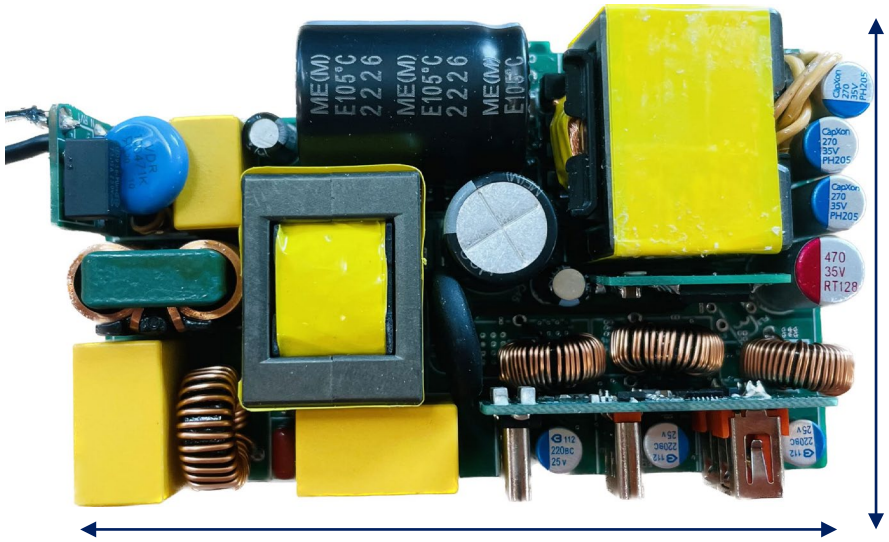
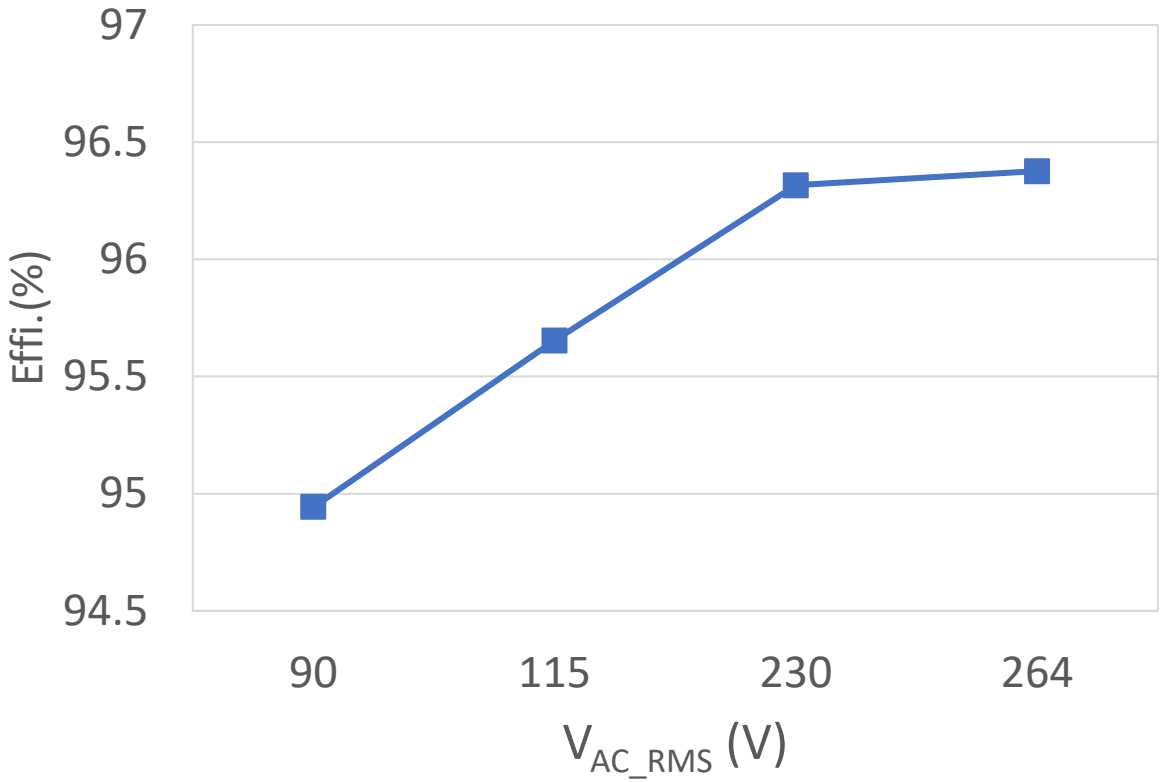
200 W 2C1A

- TPFC+AHB+DCDC



PCBA = 104 cc = 1.92 W/cc

- Full load AC-DC Effi. (28V) *excluding NTC



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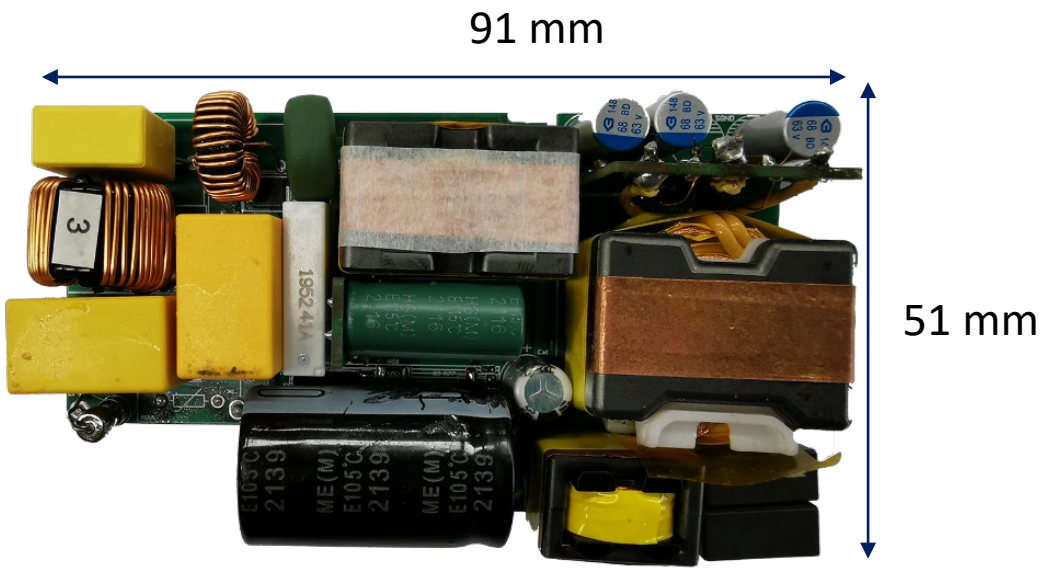
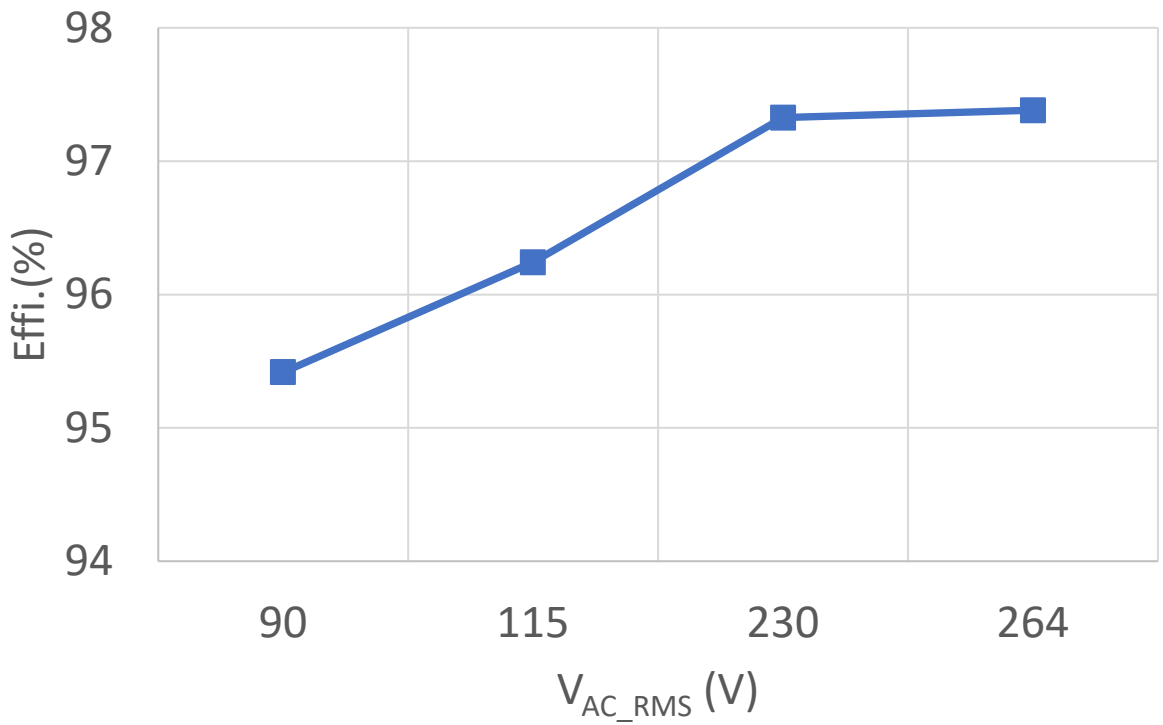
240 W AC-DC PD3.1

- TPFC+LLC, Single 48 V Output



PCBA = 104 cc = 2.3 W/cc

- Full load AC-DC Effi. *excluding NTC



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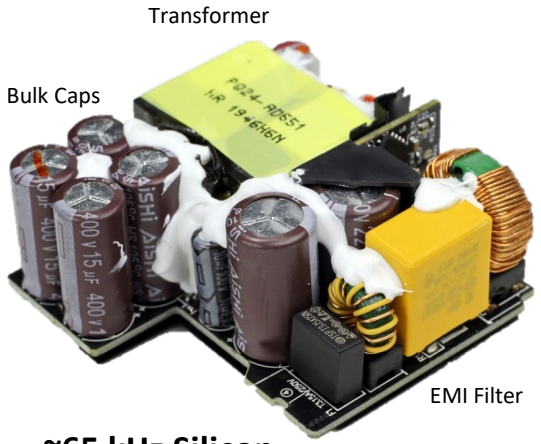
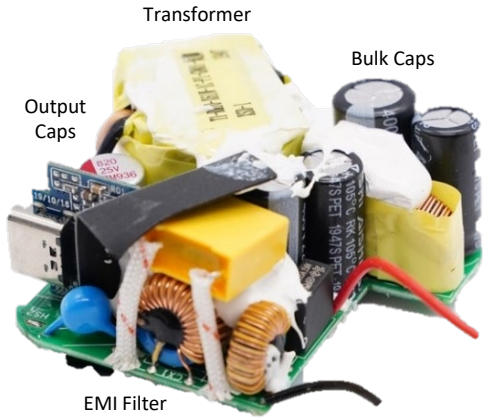
High Speed Shrinks Passive Components

Typically, slow-speed designs have ~70% of volume used by transformer, capacitors, EMI filter, etc.

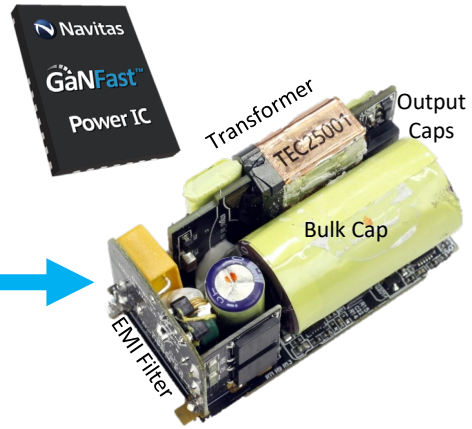


~65 kHz Silicon
65 W 43 cc



~75 kHz GaN Discrete / MCM
65 W, 46 cc

High-speed GaN IC designs **shrink** 'passive' components by **~50%**(1)



~400 kHz GaN IC
65 W, 31 cc

Half-Bridge IC delivers **~2x** the power, or **~2x** faster charging in the **same size**(1)

~750 kHz peak Half-Bridge GaN IC
120 W, 44 cc

~2x faster charging!

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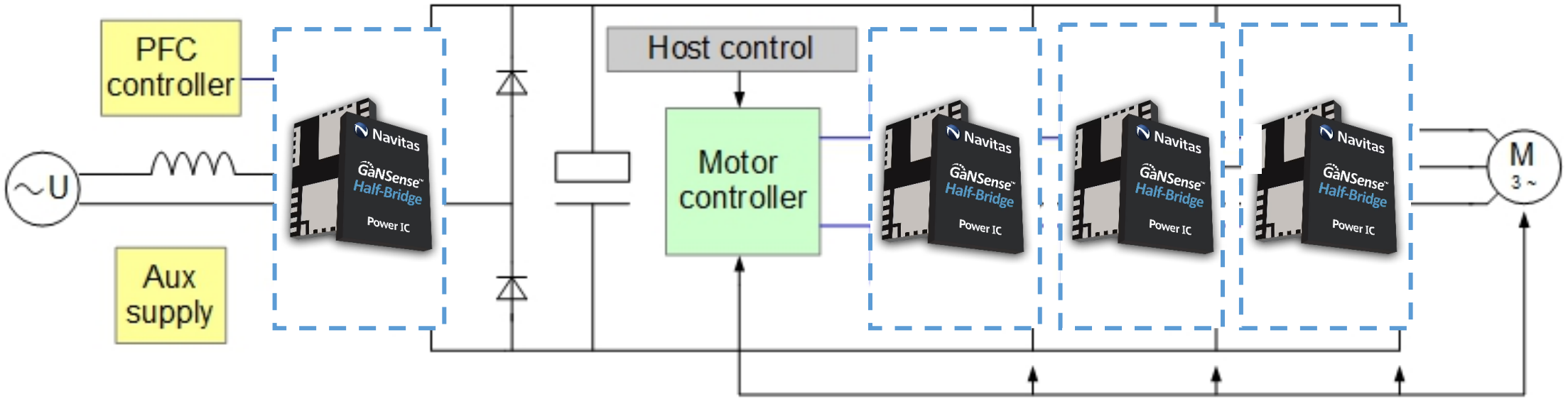
(1) Sep'22 Navitas survey of 20 publicly-available Navitas and MCM example chargers and reference designs 65W - 200W. Nominal 100 cc charger size selected, power capability determines charging speed

GaNSense for Motor Drives



GaNSense half-bridges in:

- Motor Drive: Compact, highly efficient inverter stages with significantly reduced thermal management, elimination of per-phase current sense resistor
- TTP PFC: Highest efficiency, fewest components and smallest footprint
- Aux Supply: Compact, efficient HFQR topology

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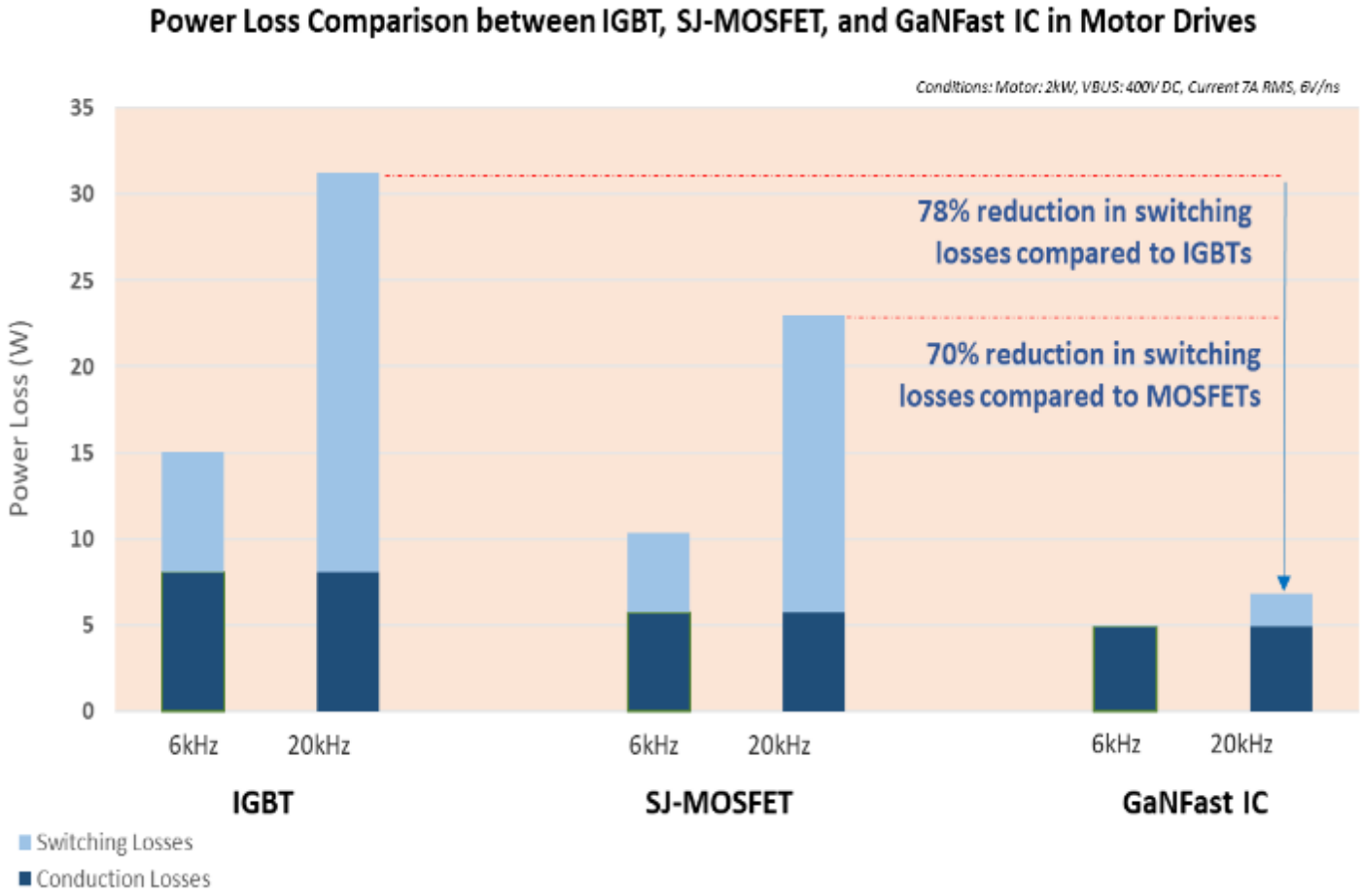
GaNSense ICs Deliver 50% Energy Savings

- 2 kW motor-drive inverter
  - Efficiency increases 2.5% (96%→ 98.5%)
  - Total losses reduced 50% (15W→6,8W)
- Significant reduction in cost, weight and size of thermal management
  - heatsink, fans, other thermal components
- Benefits increase with higher switching frequency



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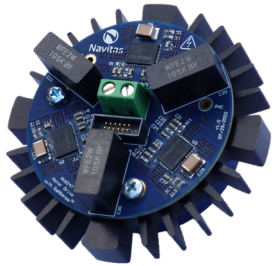
50-300W Motors – going GaNFast!

Legacy Si-Based GE Brush-less DC (BLDC)
Motor & Inverter for Washing Machine
(~80% efficiency)



Navitas 300W 3-phase Platform
for Inverter-Motor Integration

- **2x higher frequency**
- **>60% fewer components, PCB area**
- **95-97% efficiency**
- **80% energy savings vs Silicon BLDC**
- **90% energy savings vs AC motors**
- **High reliability**
- **Fast time to market**

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GaNFast Power ICs

Family	Part #	Type	$V_{DS(CONT)}$ (V)	$V_{DS(TRAN)}$ (V)	$R_{DS(ON)}$ (mΩ, typ)	Package (PQFN)
GaNFast™	NV6113	Single	650	800	300	5x6
	NV6115				170	
	NV6117				120	
	NV6123				300	6x8
	NV6125				175	
	NV6127				125	
	NV6128				70	
GaNFast™ with GaNSense™	NV6152	Single	700	800	450	5x6
	NV6153				330	
	NV6154				260	
	NV6156				170	
	NV6158				120	
	NV6132x				450	6x8
	NV6133x				330	
	NV6134x				260	
	NV6136x				170	
	NV6138x				120	
	NV6169	Single	650	800	45	8x8
	NV6247	Half-Bridge	650	800	160/160	6x8
	NV6245C				275/275	

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Datasheets, electrical (SPICE) and mechanical (.stp) models available at: https://navitassemi.com/download/

2022中国电力电子与能量转换大会
暨中国电源学会第二十五届学术年会及展览会
2022 China Power Electronics and Energy Conversion Congress
& The 25th China Power Supply Society Conference and Exhibition

"GaNFast™ Half-Bridge IC and Applications"

Qin Wei, Zhang Guoxing, Lin Dong

谢谢！

© Navitas Semiconductor, November 4th-7th 2022
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