GaN Half-Bridge ICs Enable Next Gen Mid-Power, Multi-Port, High-Density Charger Topologies

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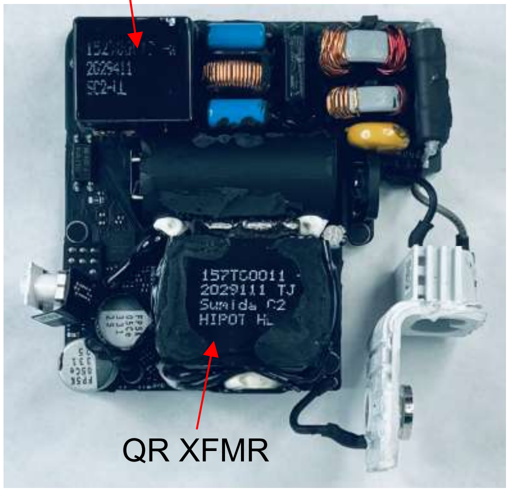
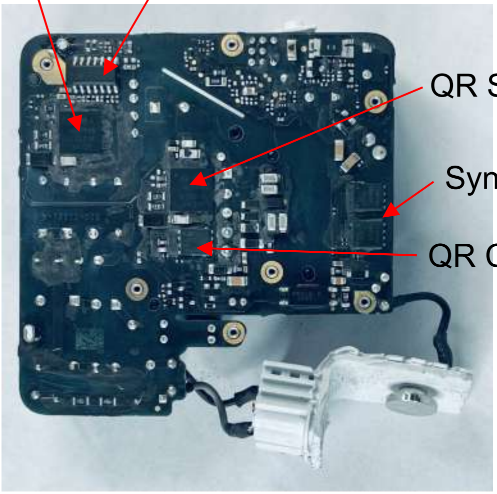
Presentation Outline

- Mid-power charger examples
- Mid-power circuit topologies
- AHB circuit topology
- USB-C PD Mid-power Multi-port block diagram
- 650V GaN Half-Bridge IC
- 140W-1C TTP + AHB charger

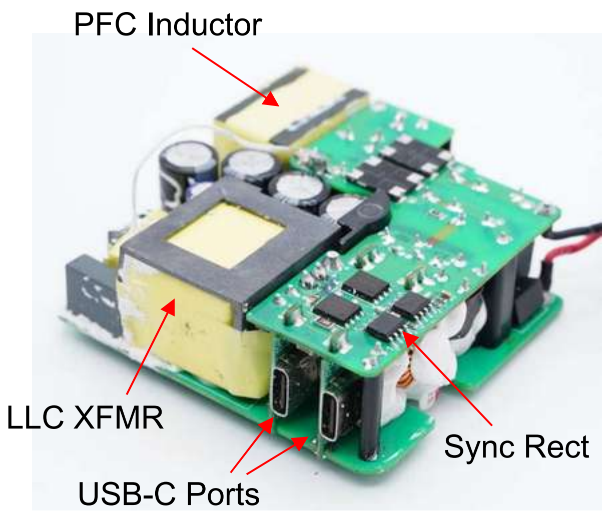
Apple 96W-1C (185cc)

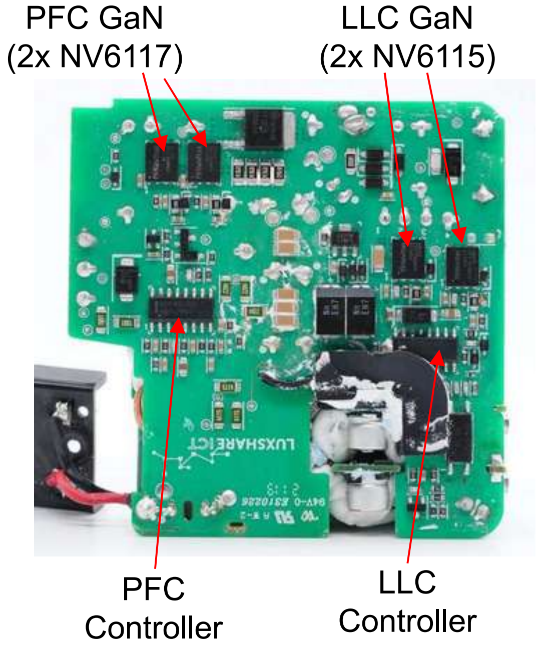




- Topology = PFC + QR Flyback
- Cased Size = 80 x 80 x 29mm = 185cc
- Power Density = 0.52 W/cc
- Frequency = 80 kHz
- Efficiency = 92% @ 90VAC/100%

Lenovo YOGA 130W-2C (155cc)

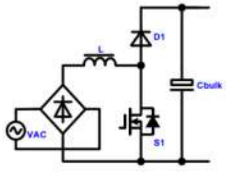
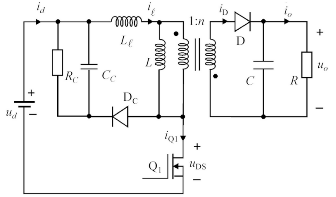
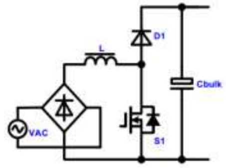
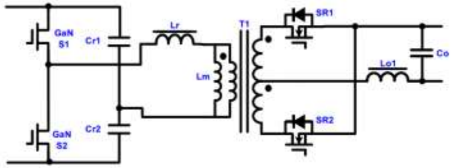
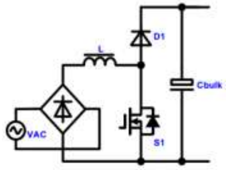
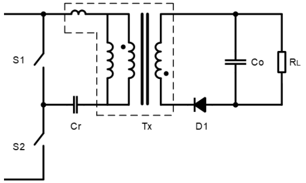
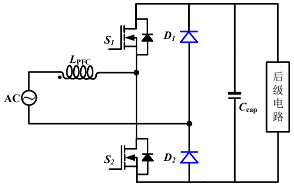
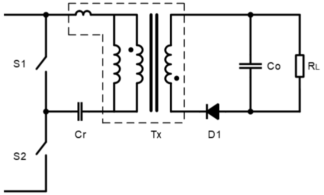




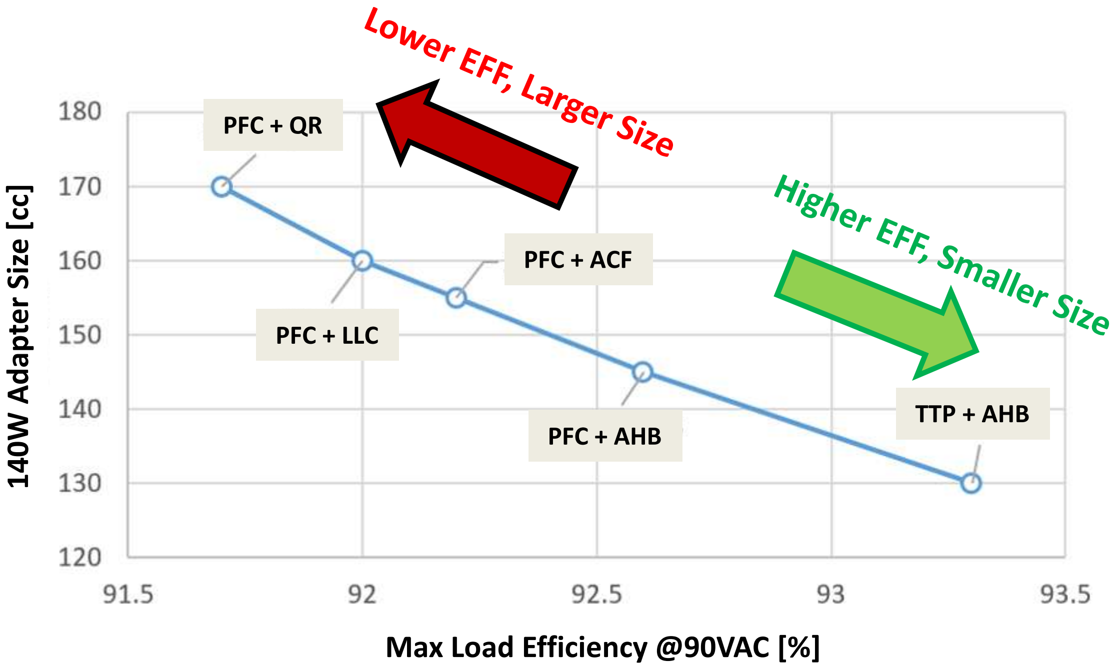
- -16% smaller size
- 2x higher frequency
- +0.5% higher efficiency
- 2x USB-C ports

- Topology = PFC + LLC
- Cased Size = 71 x 71.5 x 30.5mm = 155cc
- Power Density = 0.84 W/cc
- Frequency = 160 kHz
- Efficiency = 92.5% @ 90VAC/100%

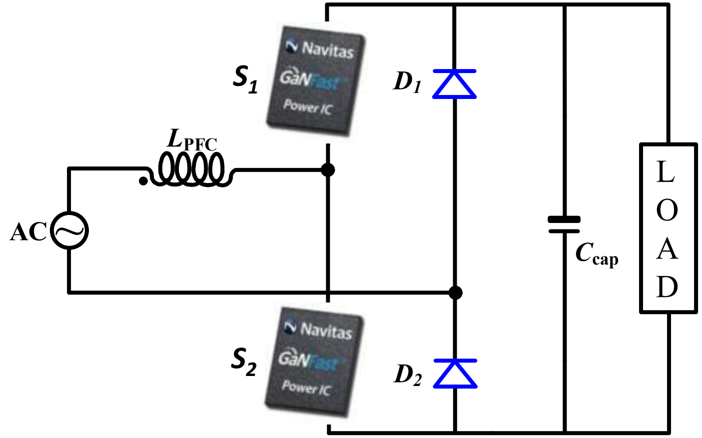
Mid-Power Circuit Topologies

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

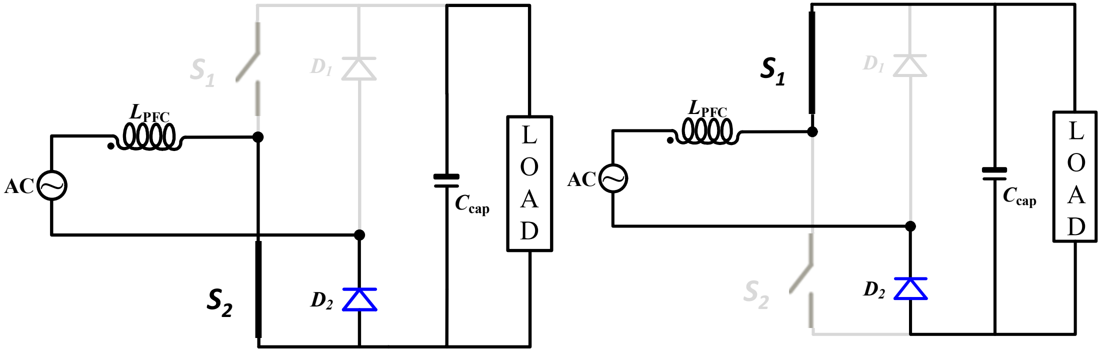
Size & Efficiency Matter



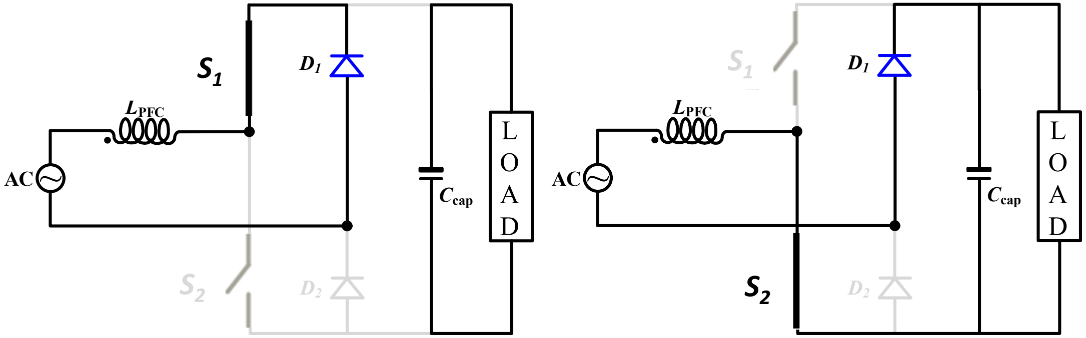
TTP = Totem Pole PFC



Positive AC line cycle



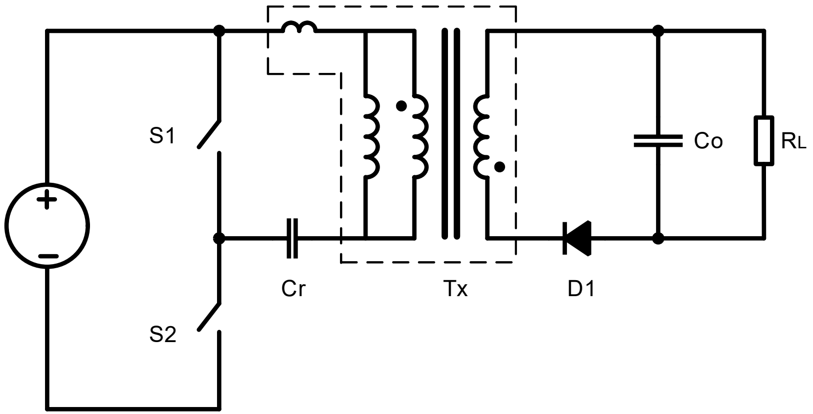
Negative AC line cycle

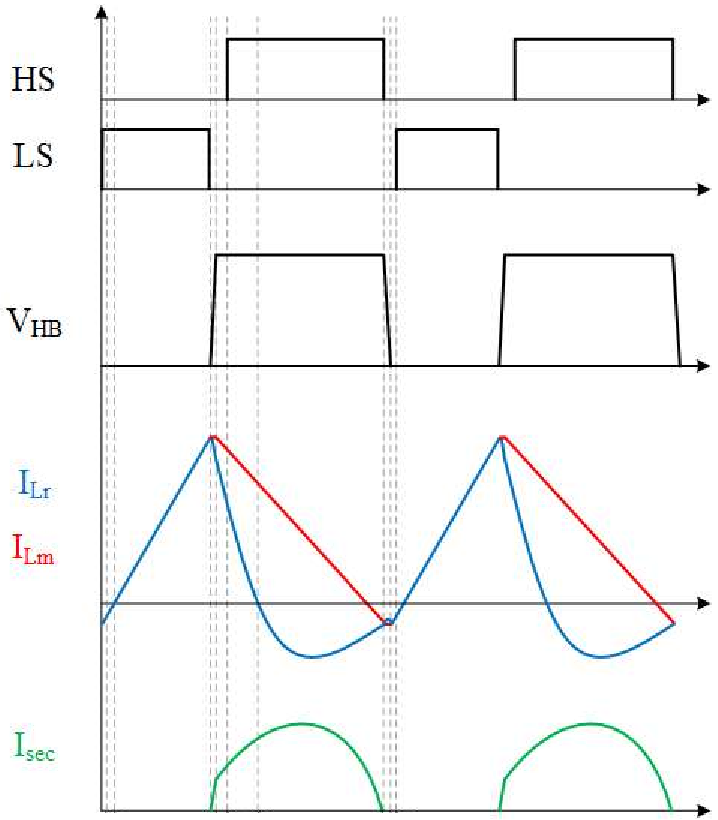


TTP Benefits

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

AHB = Asymmetric Half Bridge

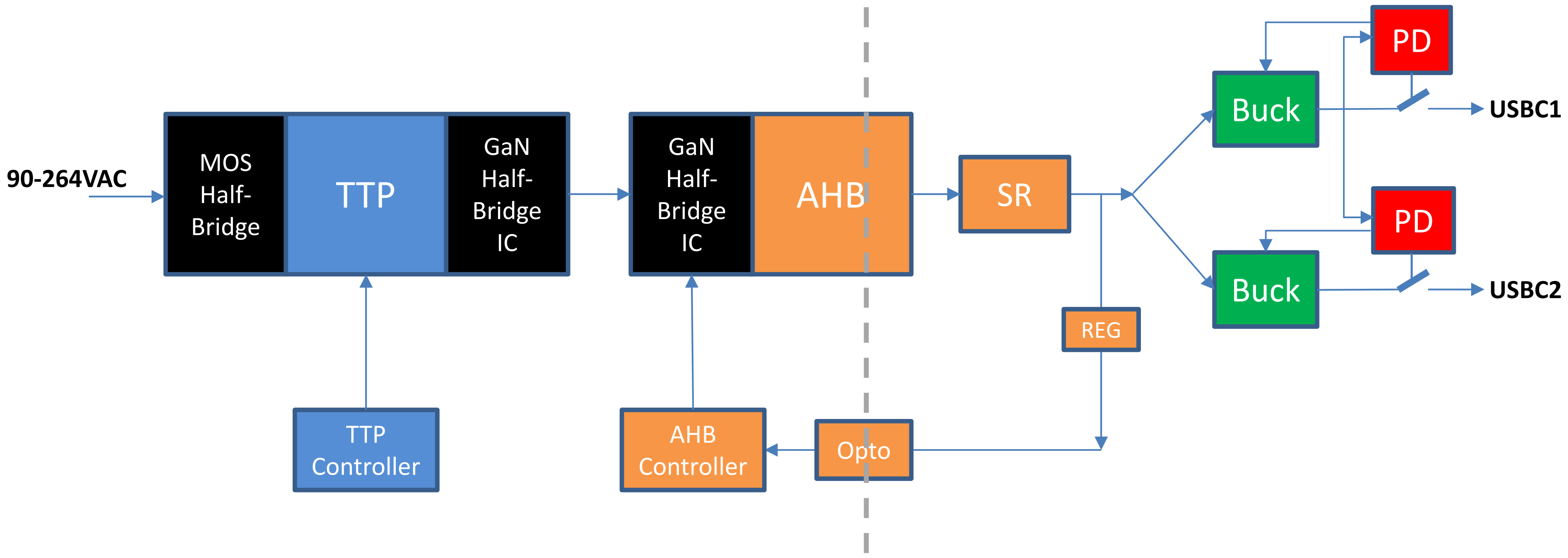




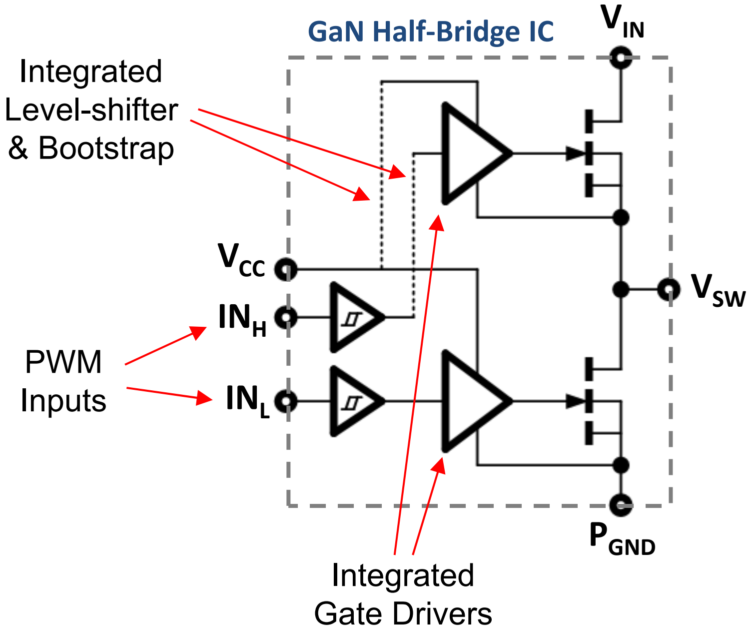
AHB Benefits

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

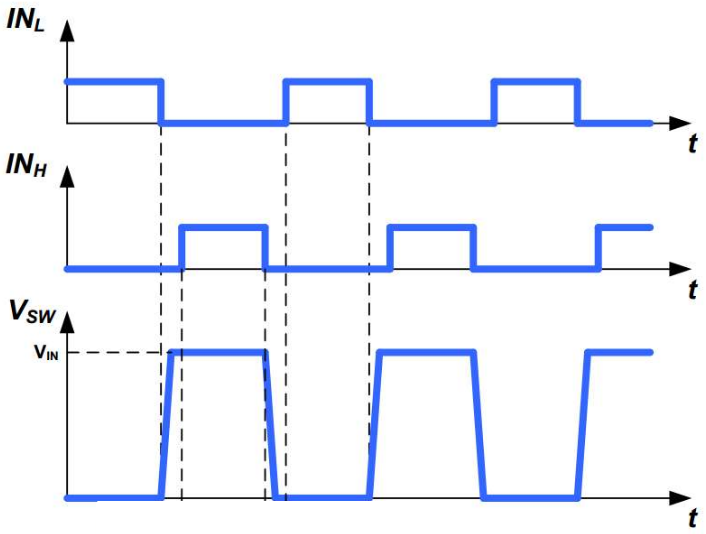
USB-C PD Mid-Power Multi-Port Block Diagram



PWM Signal In, GaN Half-Bridge Out



GaN Half-Bridge IC Timing Diagram (ZVS Mode)

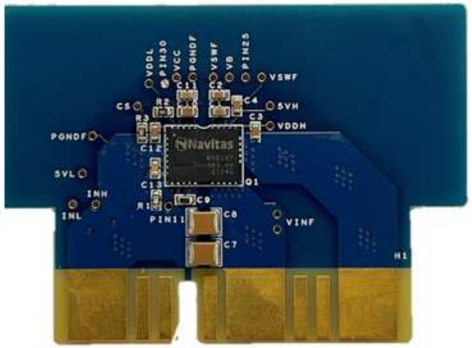


GaN Half-Bridge IC = Smallest PCB Area, Fewest Components, No Ringing, No Glitching

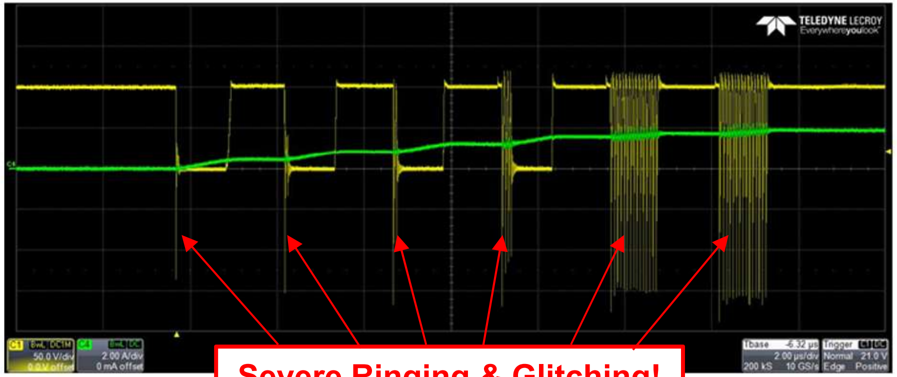
Discrete GaN Half-Bridge

- × 33 components
- × 250mm2 footprint
- × 1x ext. HB driver HVIC
- × 1x ext. HV bootstrap
- × 2x HV bypass diodes
- × 2x gate drive circuits
- × Exposed gates

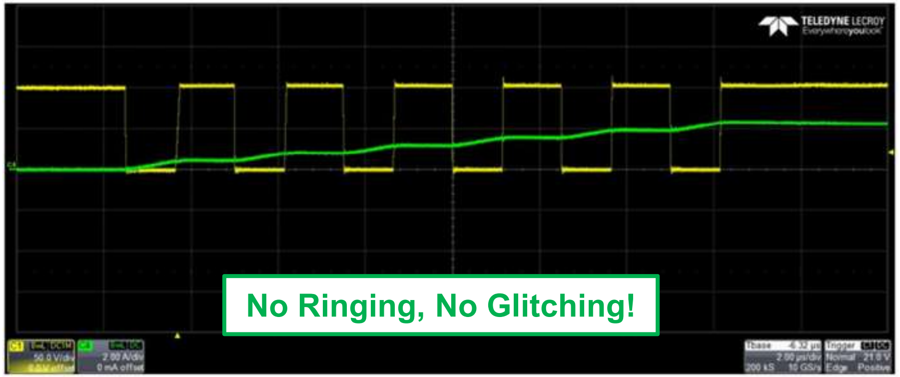
GaN Half-Bridge IC



- ✓ 13 components
- ✓ 90mm2 footprint
- ✓ Int. level shifters
- ✓ Int. bootstrap
- ✓ Int. gate drivers
- ✓ No exposed gates



Severe Ringing & Glitching!



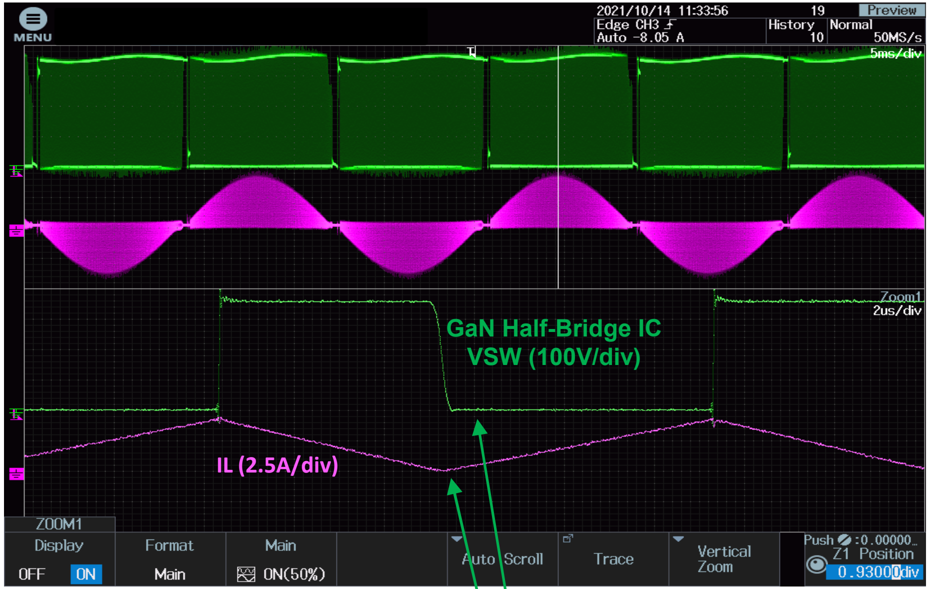
No Ringing, No Glitching!

140W-1C TTP+AHB = 130cc, 1.1W/cc

- ✓ **PCBA size: 60 x 60 x 25mm = 90cc**
- ✓ **Cased size (est.) = 65 x 65 x 30mm = 130cc**
- ✓ **Power Density = 1.1 W/cc**

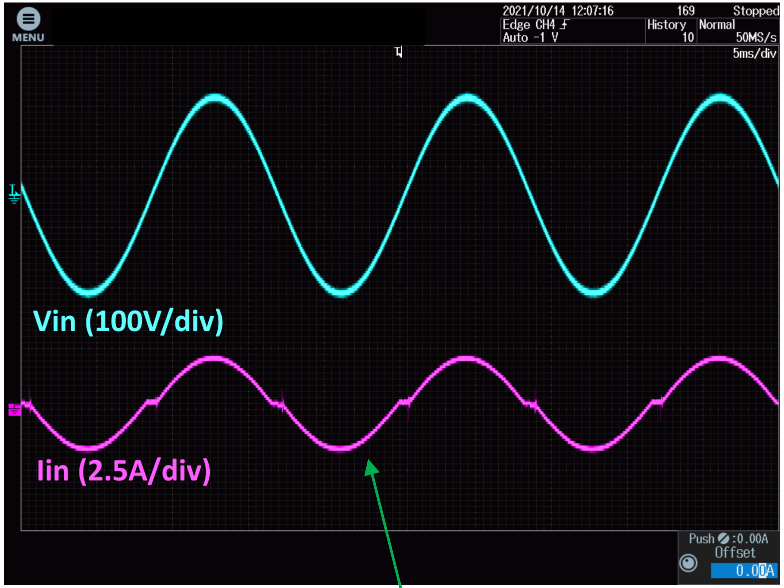
TTP Waveforms CRM Operation

Boost Circuit Waveforms (Vin=115VAC, Po=140W)



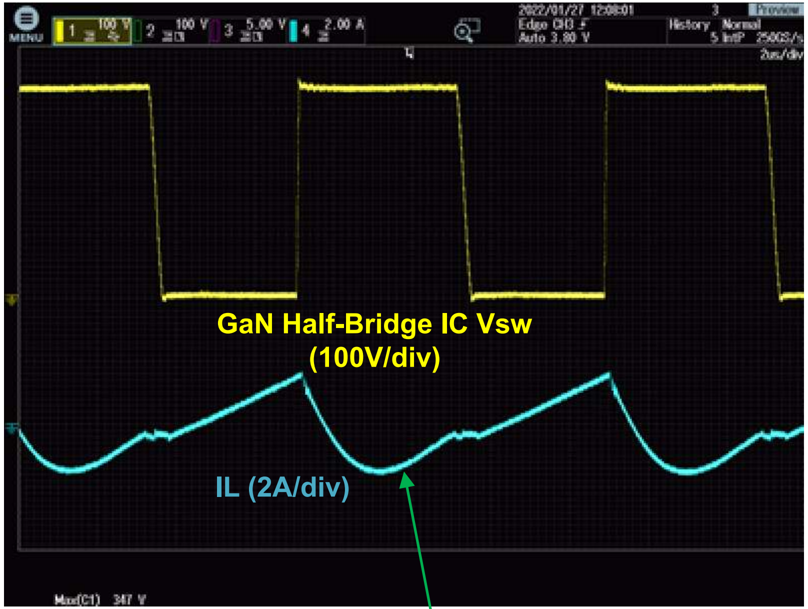
- **Clean Boost Circuit Waveforms**
- **CRM Operating Mode**

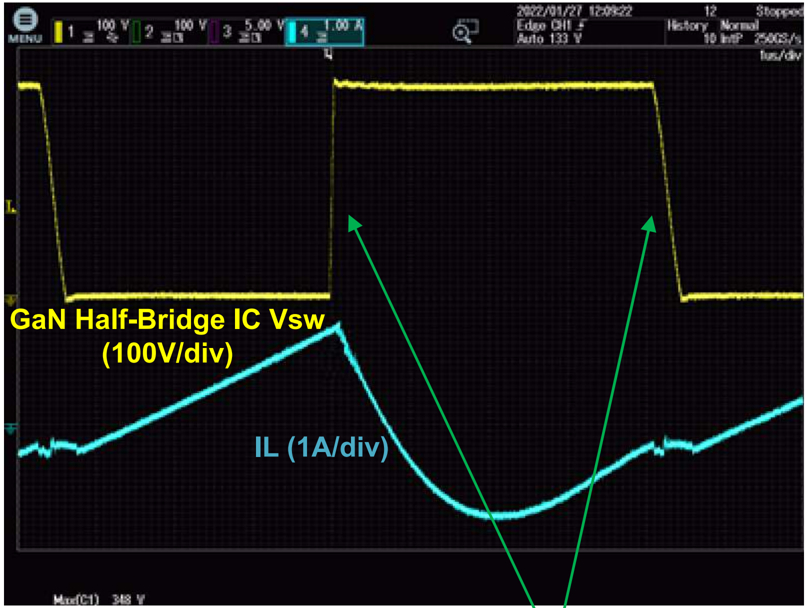
AC Input Waveforms (Vin=115VAC, Po=140W)



- **Sinusoidal Input Current**
- **High Power Factor = 0.997**

Clean & Smooth AHB Resonant ZVS Switching

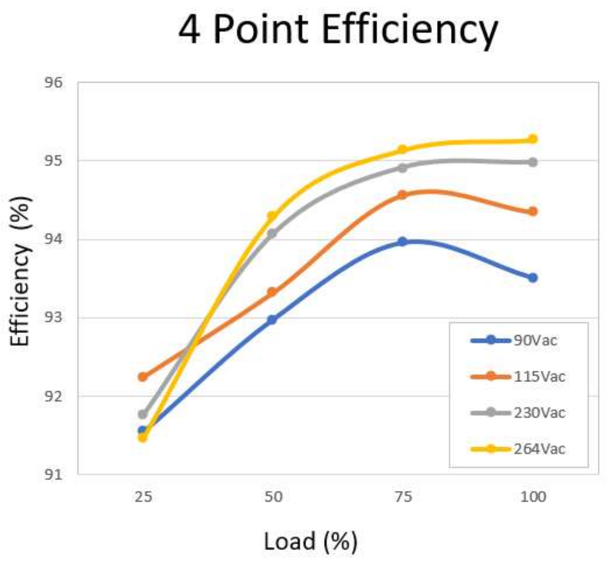


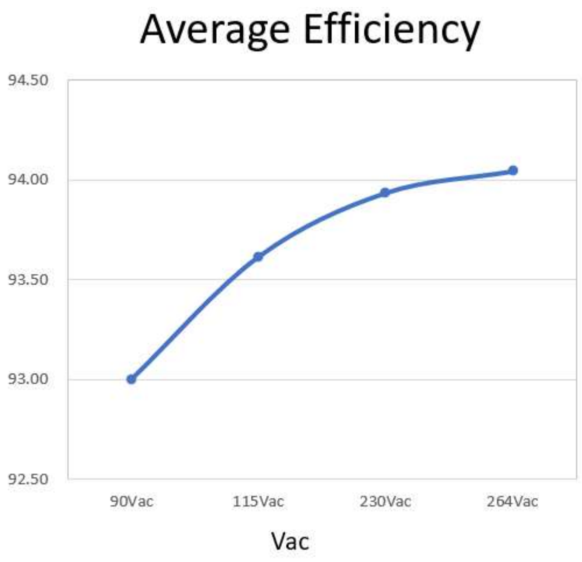


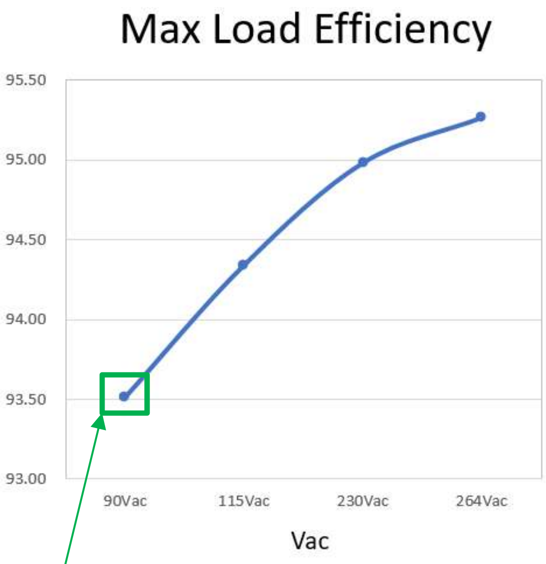
- AHB Tank Current
- Resonant Mode Operation

- GaN Half-Bridge Switched Node
- Resonant ZVS Switching

Highest Efficiency = Lowest Losses = Smallest Size







- ➢ **EFF = 93.5% @ 90VAC/140W/20V/7A**
- ➢ **+1% EFF increase vs existing solutions!**

Acknowledgements & Questions

Special Thanks To:

- ***Xiucheng Huang (Navitas)***
- ***Guoxing Zhang (Navitas)***