Next-Generation GaN power ICs Drive Transformer Revolution

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Apple Power Adapter Family

Navitas

State-of-the-Art 70W Adapter -- Apple

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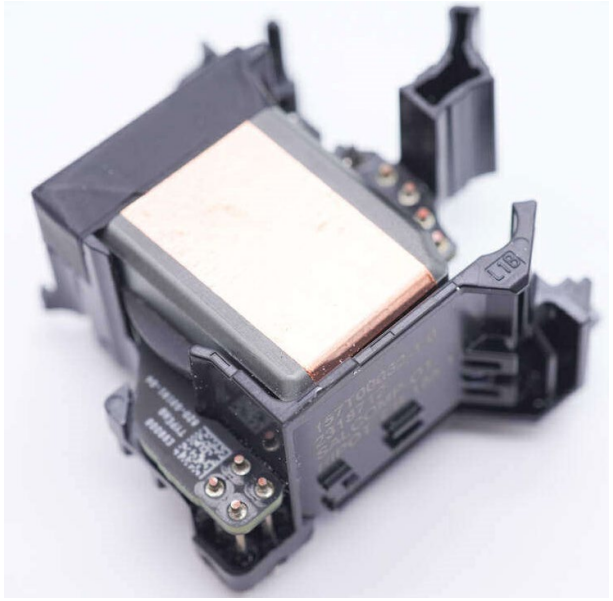
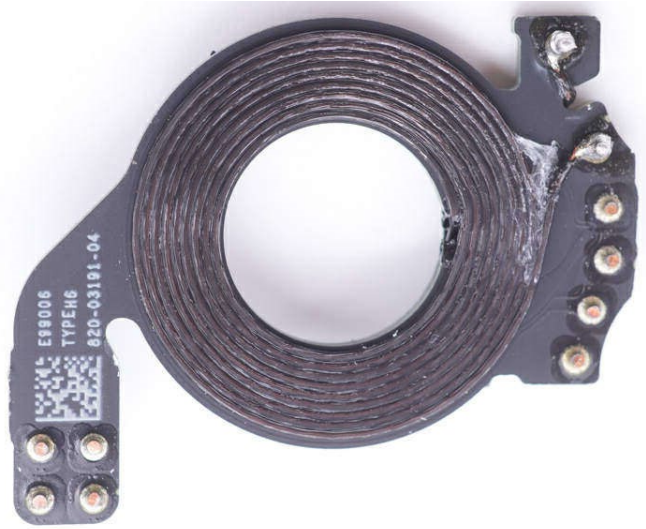
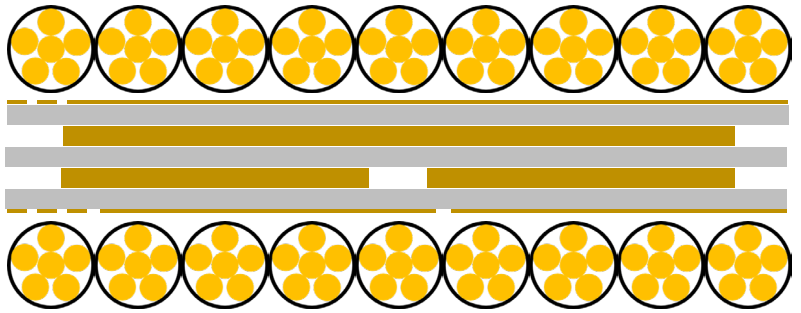
65 x 65 x 28.6 mm







Pri:Sec:Aux1:Aux2=18:3:2:6

Pri winding: 0.13 x 6, DCR=360mohm

Sec winding: 8oz, DCR=6.8mohm

Pros:
- ✓ Low DCR
- ✓ Low fringing loss
- ✓ EMI consistency

Cons:
- ❖ High cost PCB and wire
- ❖ Complicated manufacturing

State-of-the-Art 45W Adapter -- Samsung

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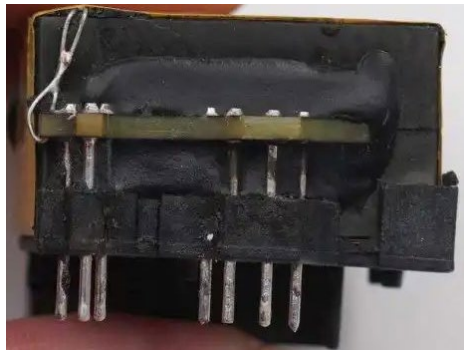
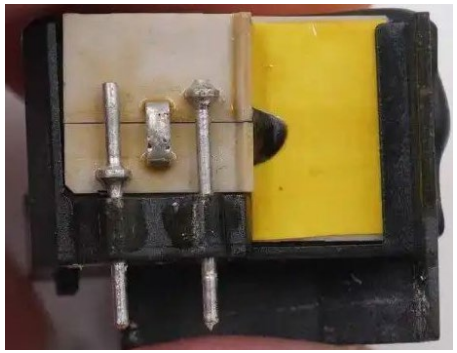
47.7 x 43.6 x 28 mm

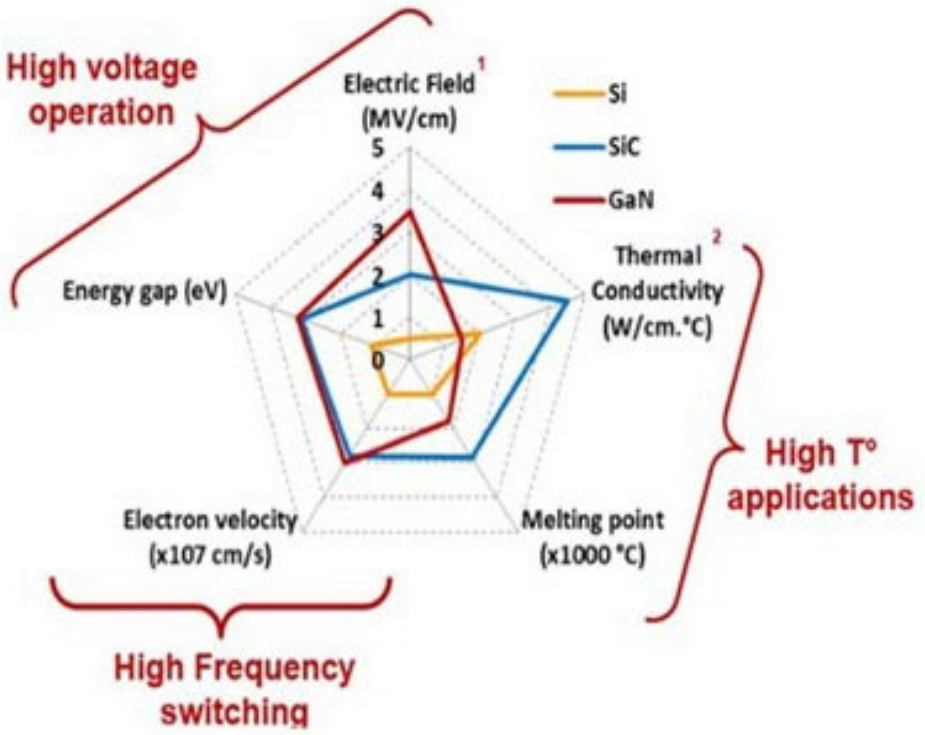




Pros:
- ✓ Low DCR
- ✓ EMI consistency
- ✓ Small footprint

Cons:
- ❖ High cost Cu plate and tooling
- ❖ Complicated manufacturing

Game Changer - GaN



- Pick same R_{ds} device, GaN has 10X smaller die size

Parameters	Si CoolMOS	NV6136
V_{DS}(V)	650	700
R_{DS}(Ω)	0.17	0.17
Q_g(nC)	23	2.4
C_{OSS_tr}(pF)	374	36
Q_{rr}+Q_{COSS} (nC)	5950	16
E_{off} @ 5A (uJ)	> 2	<0.2

Benefits of Integrated GaN Power ICs

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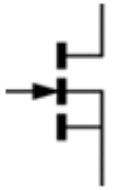
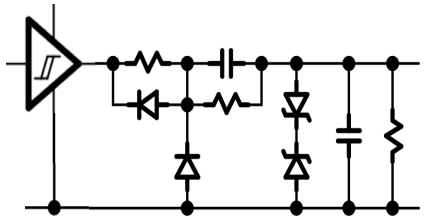
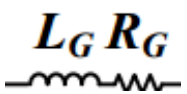
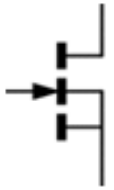
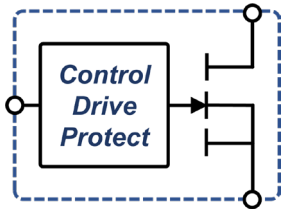
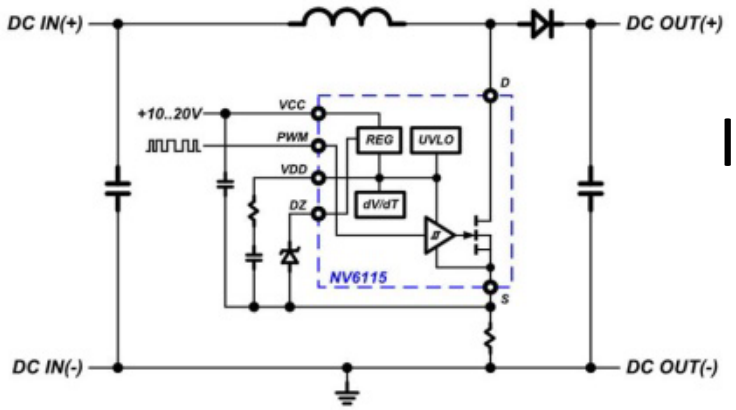
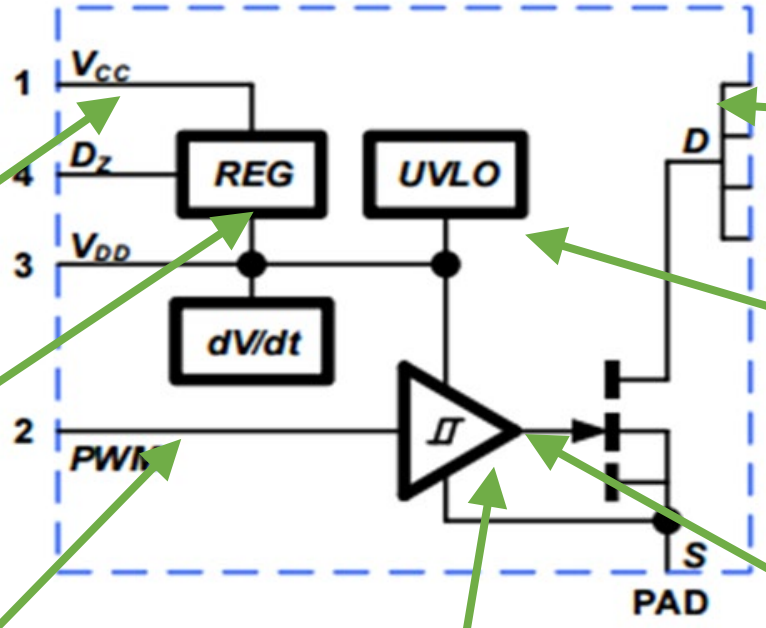
	Gate Driver Drive, control and protection	Parasitic Limitation of switching speed and efficiency	Power Device Si / GaN	Frequency Switching frequency	Power Density Smaller volume, faster charging speed
Discrete Si MOSFET	 *(Included in controllers)*			< 100 kHz	 <0.5 W/cc
Discrete GaN Device	 *(EZ Drive)*			< 200 kHz	 <1 W/cc
Navitas Integrated GaN Power IC				Up to 2 MHz	 >>1 W/cc

1st Gen of Navitas GaN Power IC



Integrated driver → **Simple and reliable**



Wide VCC range (10-30V)

The regulator ensures that the V_{GS} is within the SOA range

PWM hysteresis can suppresses the noise

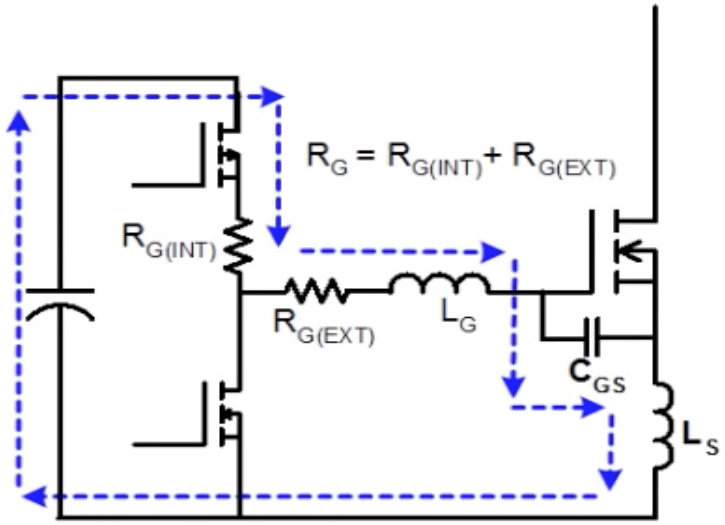
No parasitic inductance or ringing in the gate driving loop

Layout is simple and flexible

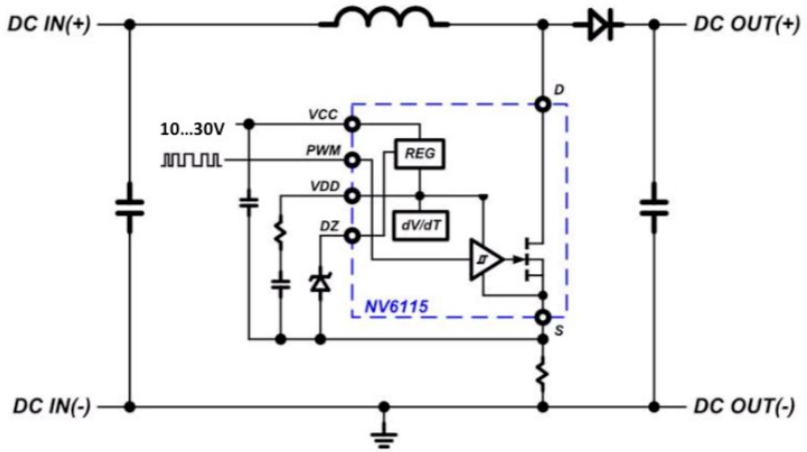
Undervoltage lockout protects the driver and GaN FET even the V_{CC} is not fully charged up

The gate is protected from external noises

Clean Gate Drive with NV GaN IC

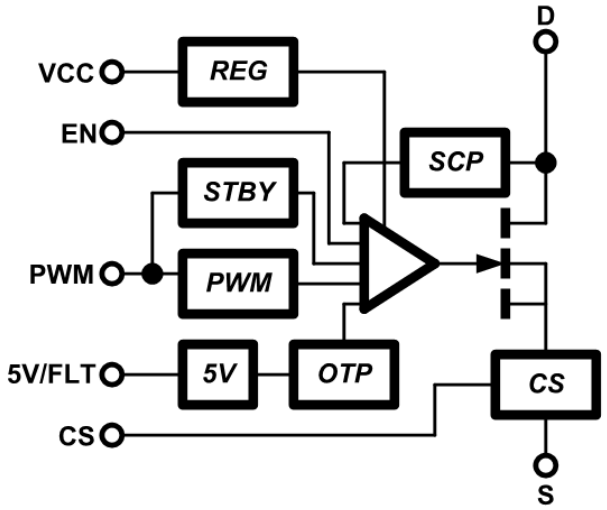


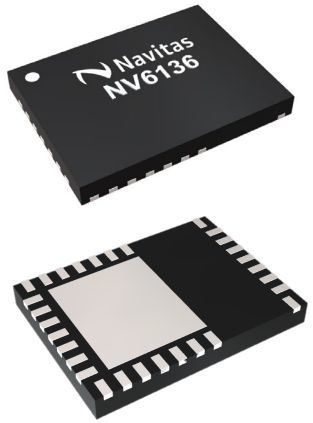
Discrete GaN: direct drive

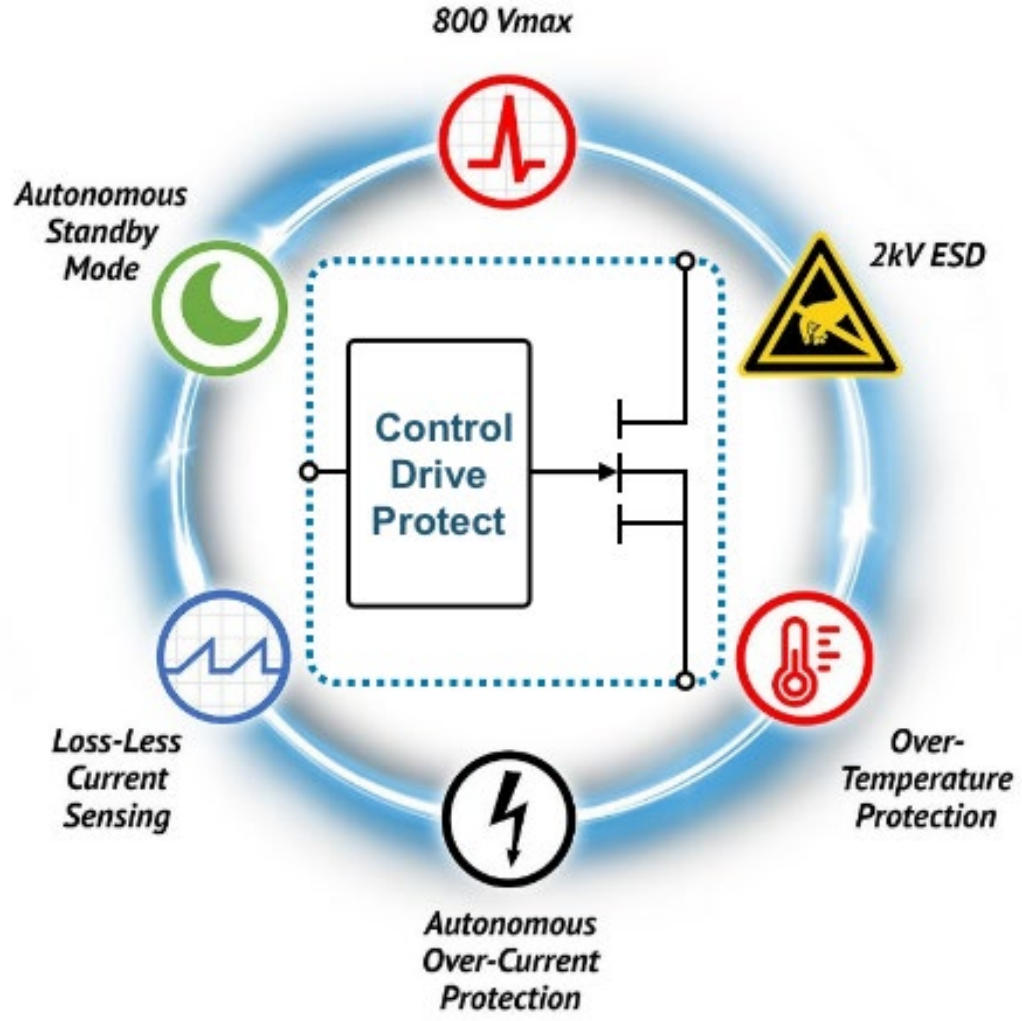


NV GaN: integrated drive

GaNFast with GaNsense Technology





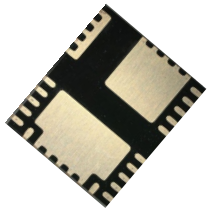


GaNSense™ Technology
• *Fast* • *Autonomous* • *Self-driven* • *Real-time sensing* • *Self-protected* • *Precision* • *Flexible*

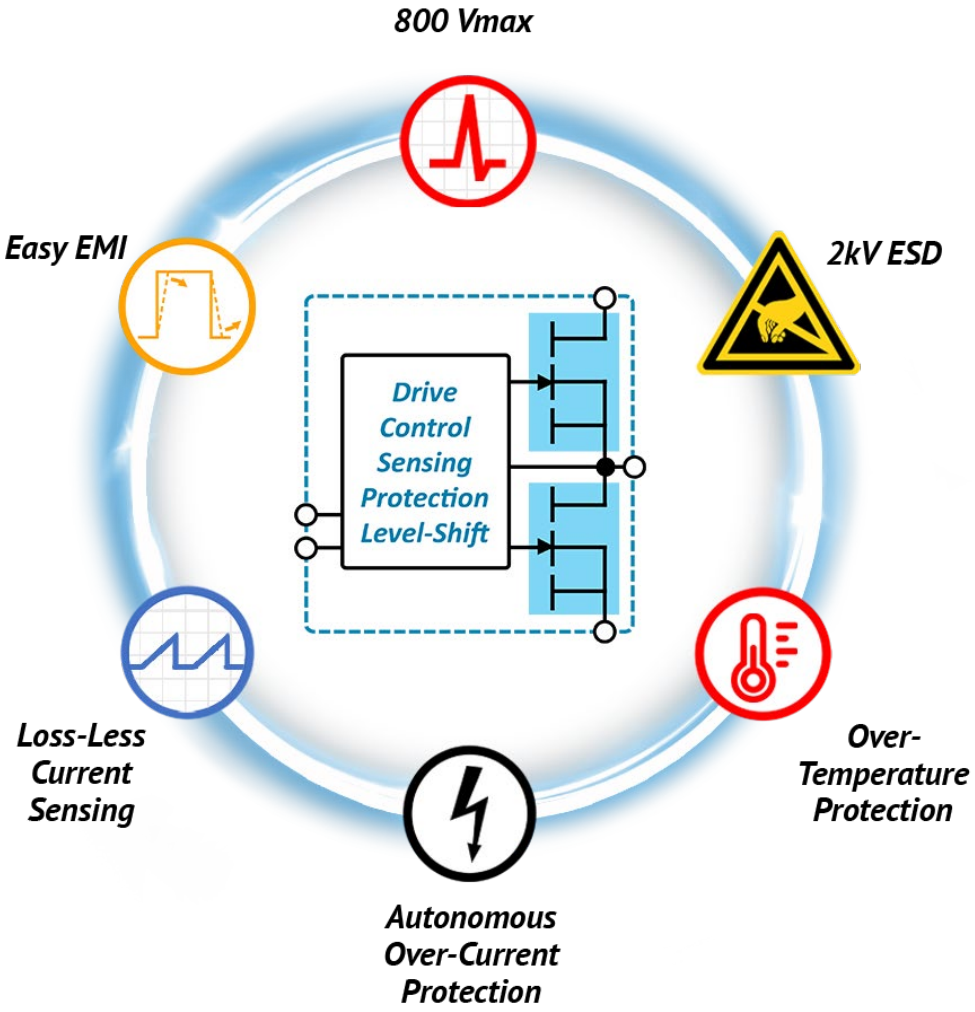
Increased Integration
• *Enable input* • *5V aux output* • *dV/dt control* • *Integrated gate drive* • *Integrated regulator*

GaNSense Half-Bridge IC

GaNSense Half-Bridge + Smart dv/dt technology



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



GaNSense Control: PWM + GaN Integration

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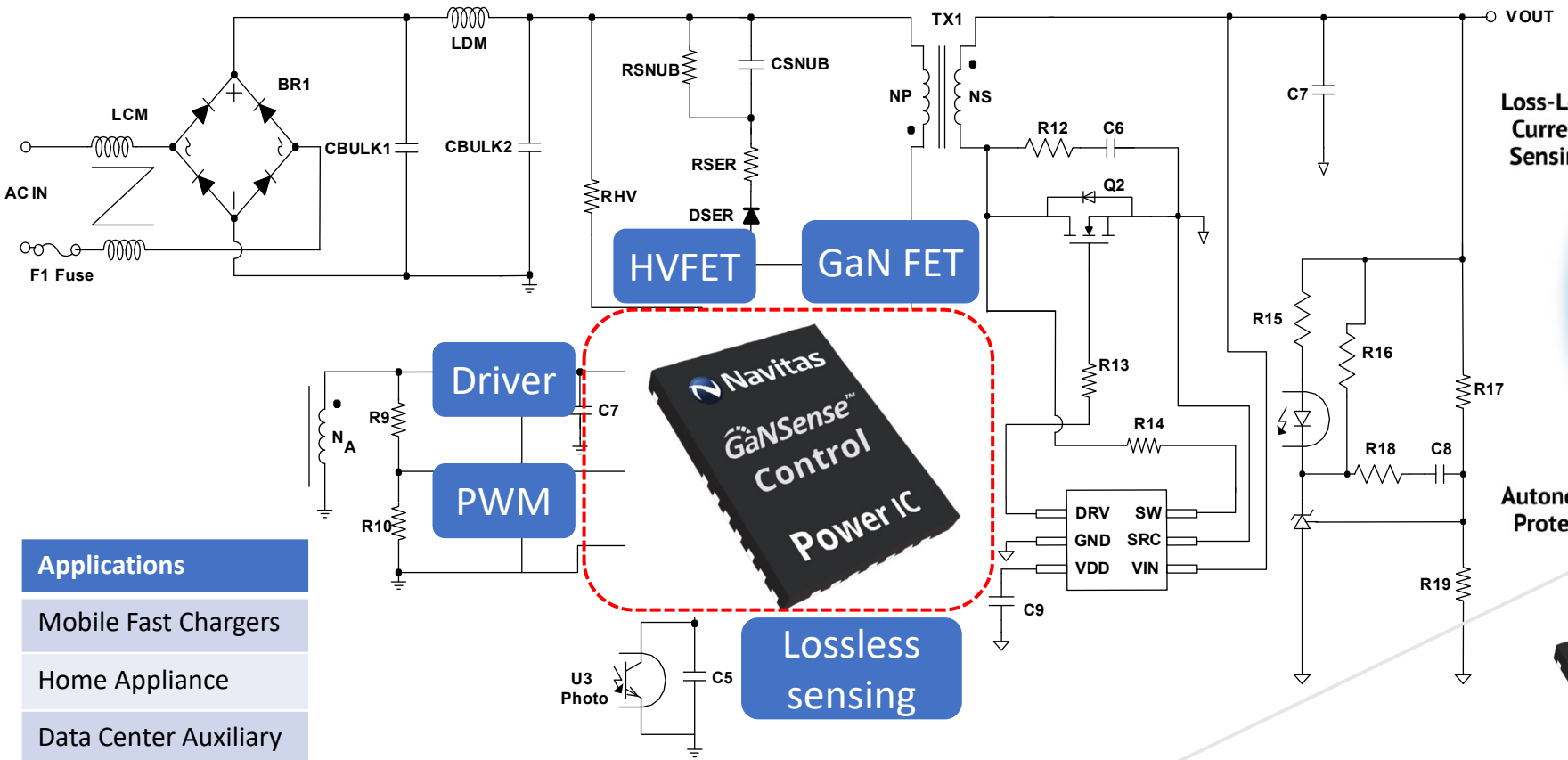

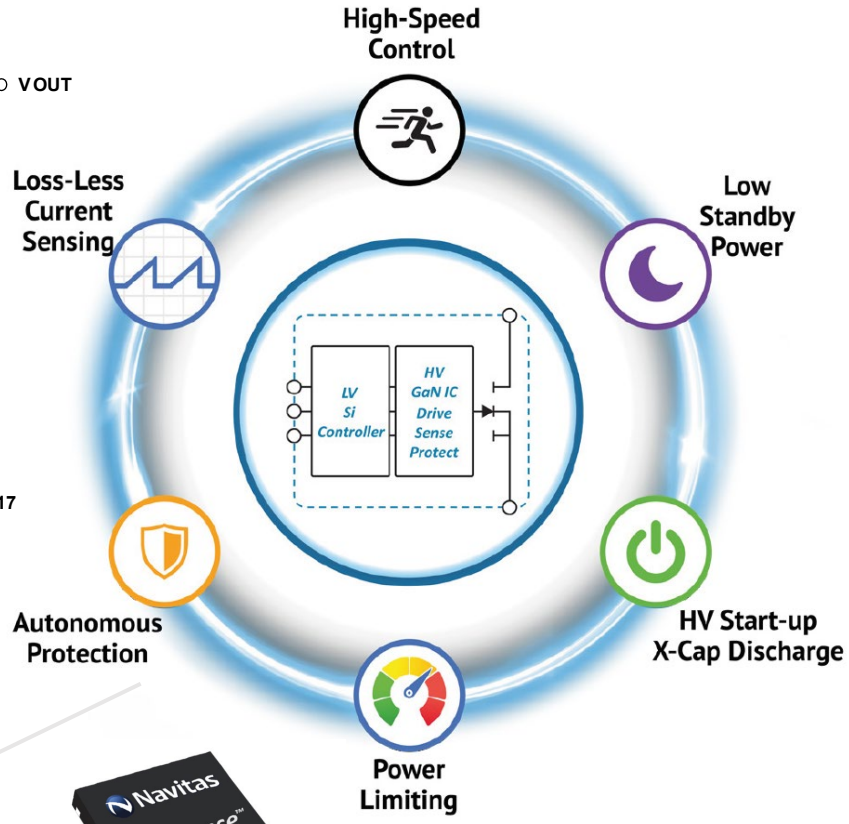

Applications
Mobile Fast Chargers
Home Appliance
Data Center Auxiliary
Industrial Auxiliary
Consumer
Point-of-Sale

GaNFast™ Technology Leader, Market Leader

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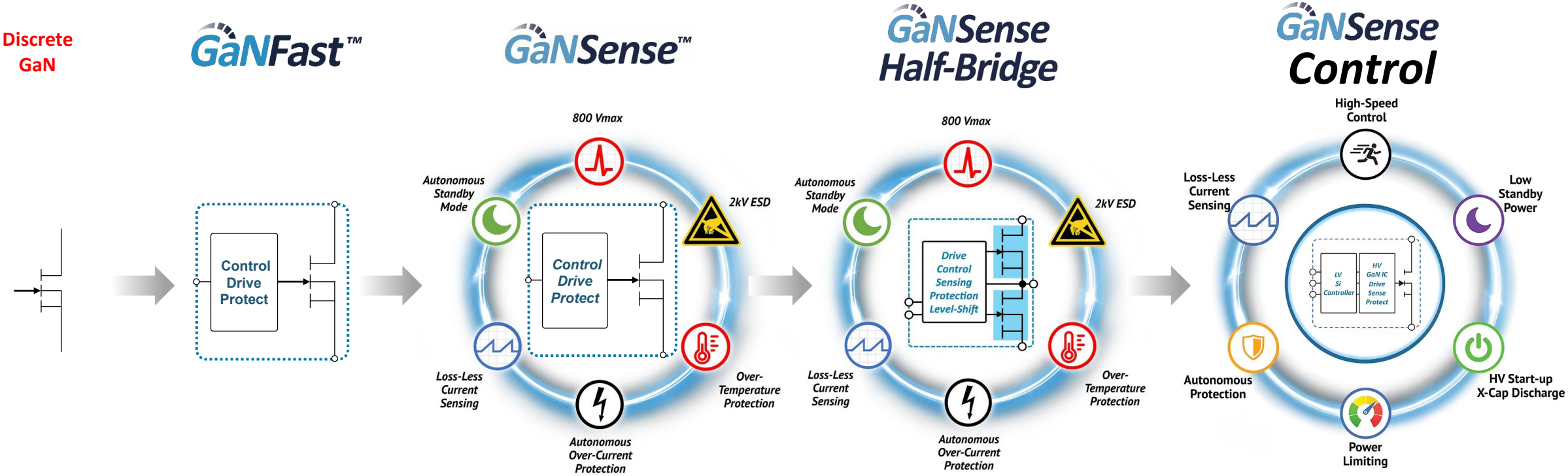

- Vulnerable
- Difficult to use
- Unknown reliability

- ✓ Robust
- ✓ Easy to use
- ✓ Proven reliability

GaNFast plus:
- ✓ Autonomous protection
- ✓ Loss-less current sensing

GaNSense plus:
- ✓ Integrated HS, LS, level-shift isolation
- ✓ Complete protection

GaNSense plus:
- ✓ LV silicon system controller
- ✓ Fewest components

Efficiency

Reliability

Speed

Integration

Traditional Bobbin Transformer

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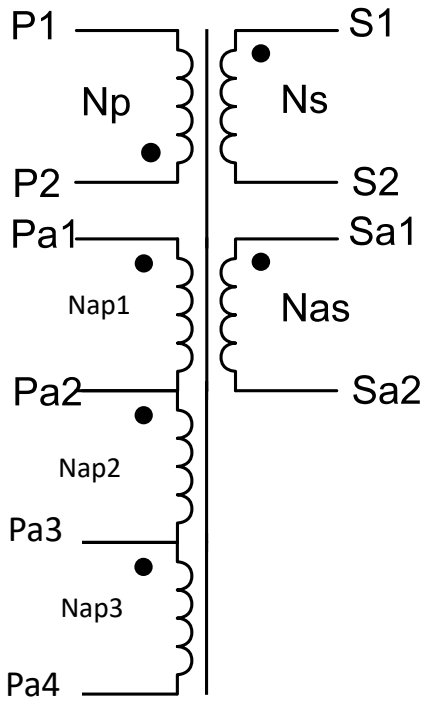
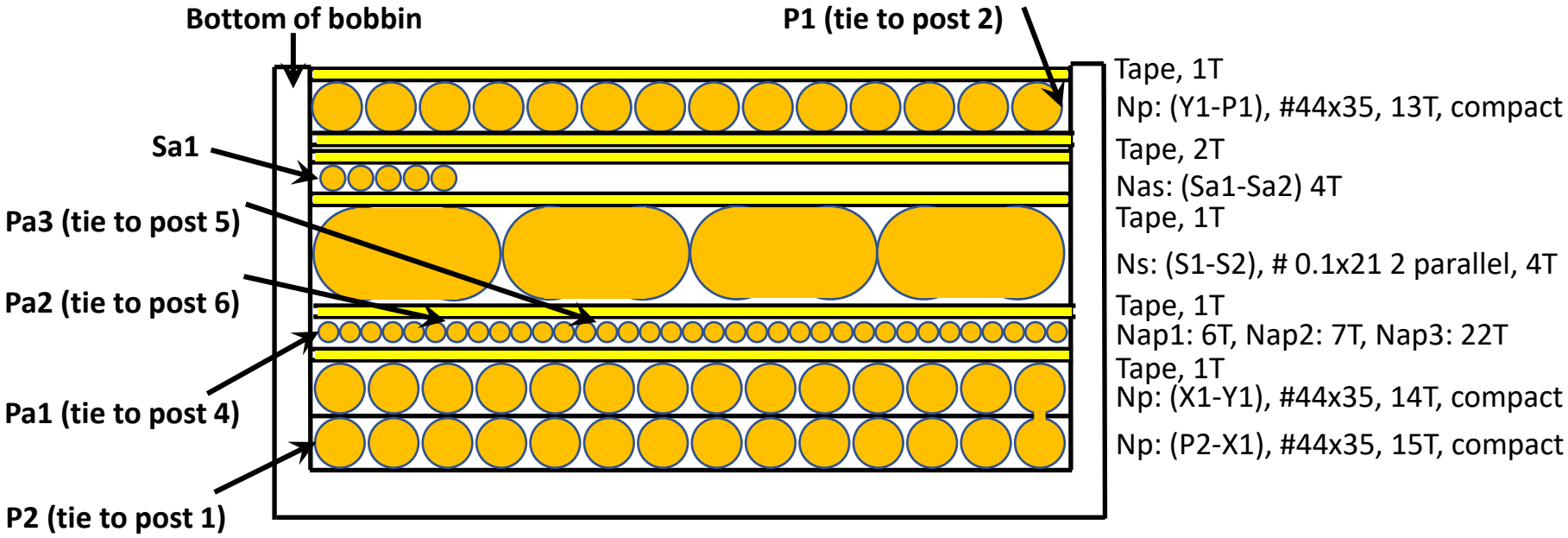
Apple61W

Razor 120W

Complicated Structure of Bobbin Transformer





Parameters	Wire
Primary main (Np)	Litz #44 x 35
Secondary main (Ns)	Triple insulated Litz 0.1 x 21 2 in parallel
Primary Aux (Nap1 & Nap2)	Solid wire AWG 36
Secondary Aux (Nas)	Triple insulated wire Thinner than AWG 34

GaN IC Enables High Frequency Planar TX

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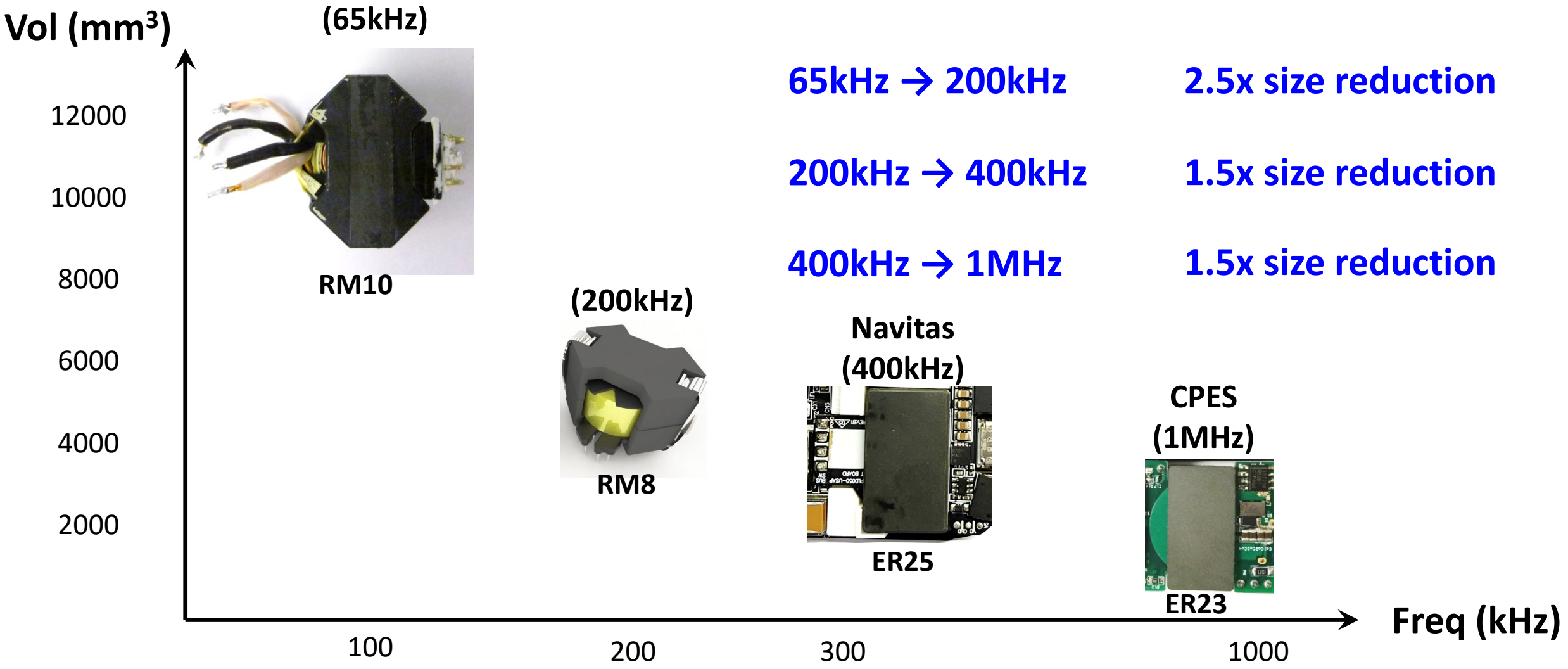
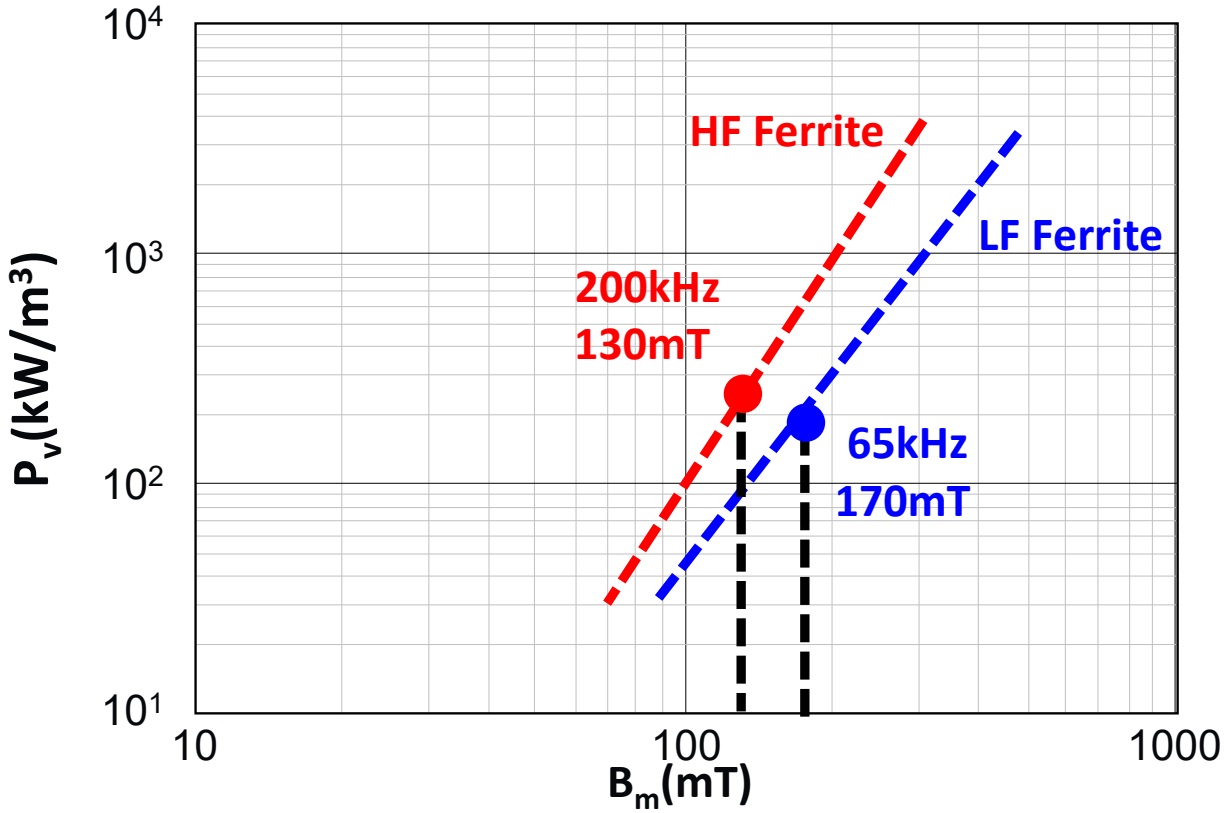


65kHz → 200kHz 2.5x size reduction

200kHz → 400kHz 1.5x size reduction

400kHz → 1MHz 1.5x size reduction

Transformer Size Reduction



$$u = \frac{N_S \cdot Ae \cdot B_{pk-pk}}{\Delta t}$$

$$\underbrace{N_S \cdot Ae}_{\text{Transformer volume}} = \frac{V_O \cdot (1 - D)}{2 \cdot \Delta B \cdot f_s}$$

$N_S \cdot Ae$: 2.4x Reduction

Integrated Power Devices onto PCB Winding

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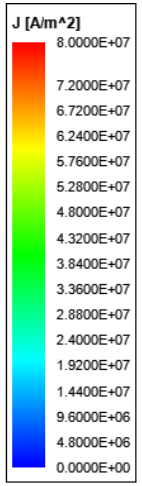
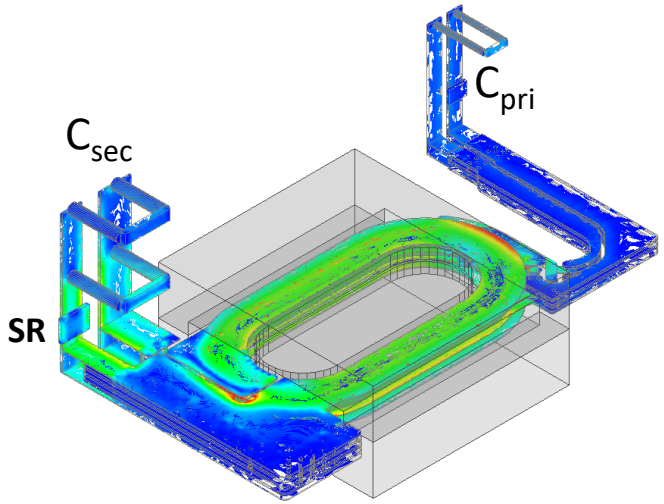
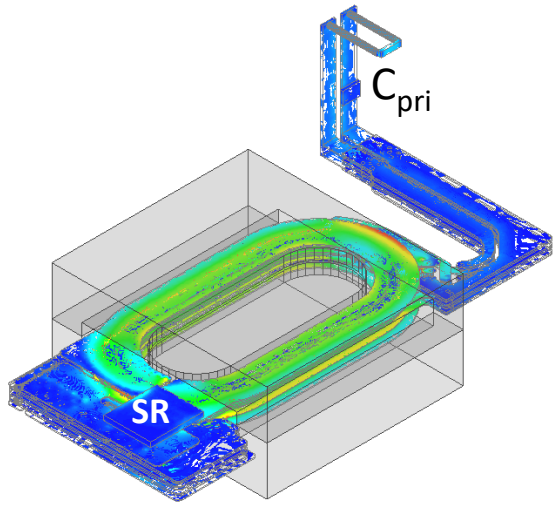
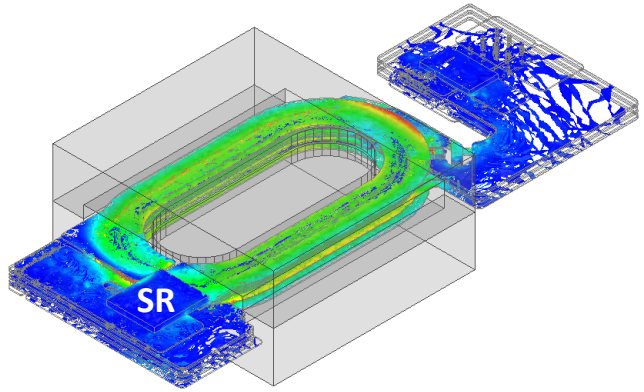




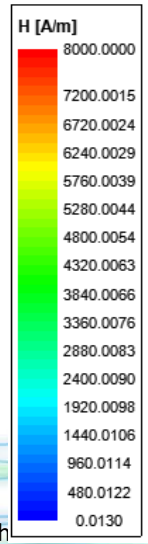
- L_k: 2.6uH
- $P_{Winding}$: 1.8W

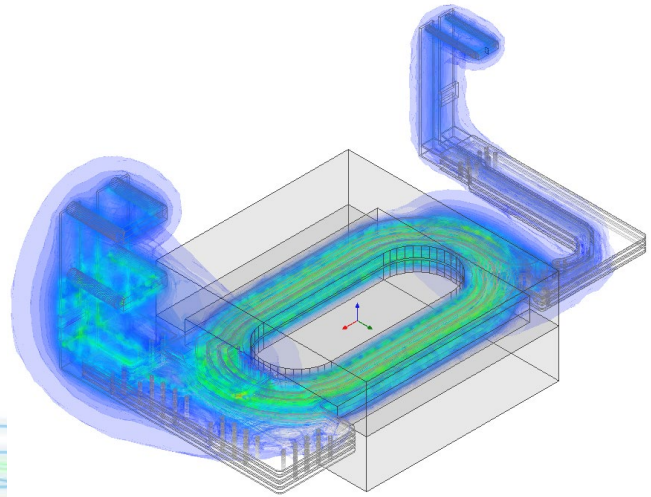


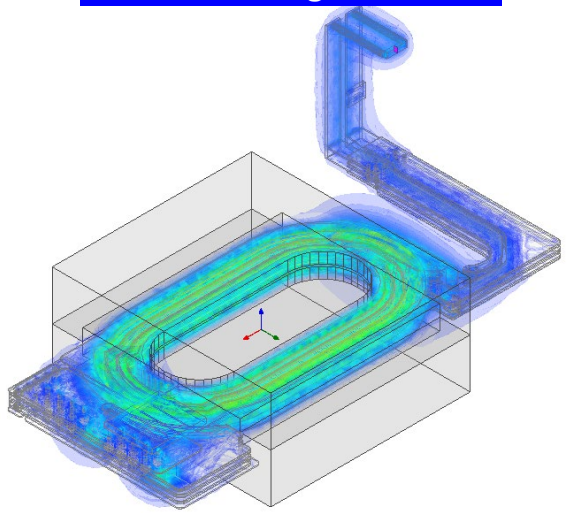
- L_k: 1.9uH
- $P_{Winding}$: 1.2W

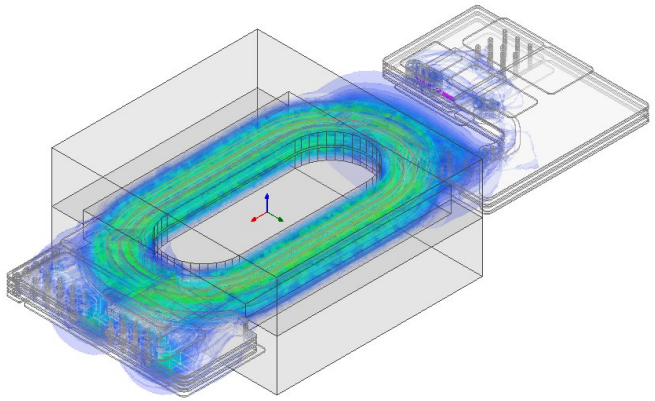


- L_k: 1.8uH
- $P_{Winding}$: 1.1W

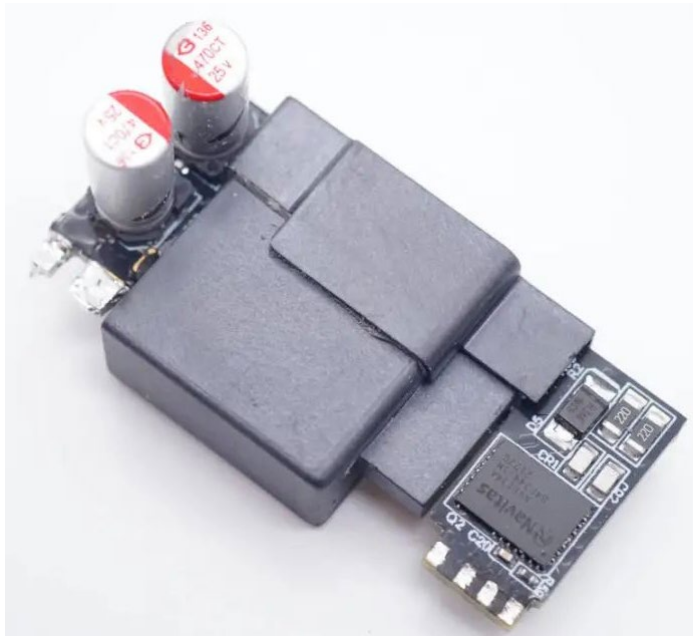








State-of-the-art 120W Charger



- ✓Lowest voltage stress on both primary and secondary switches
- ✓Lowest switching noise across the PCB board
- ✓Highest efficiency and manufacturability

Comparison vs. Traditional Si Solution

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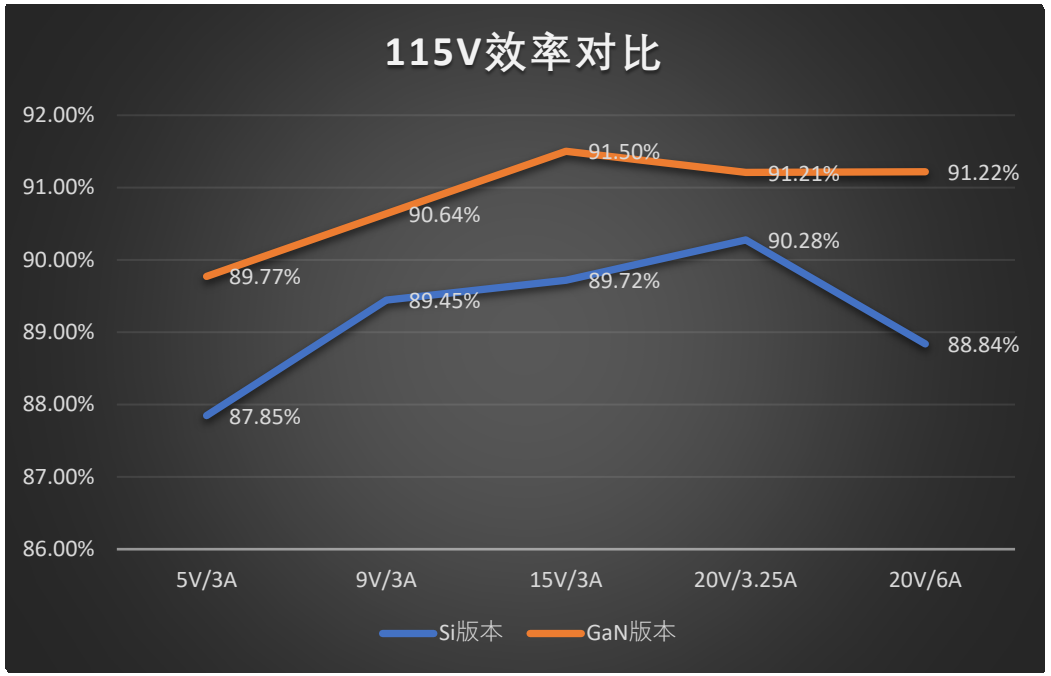
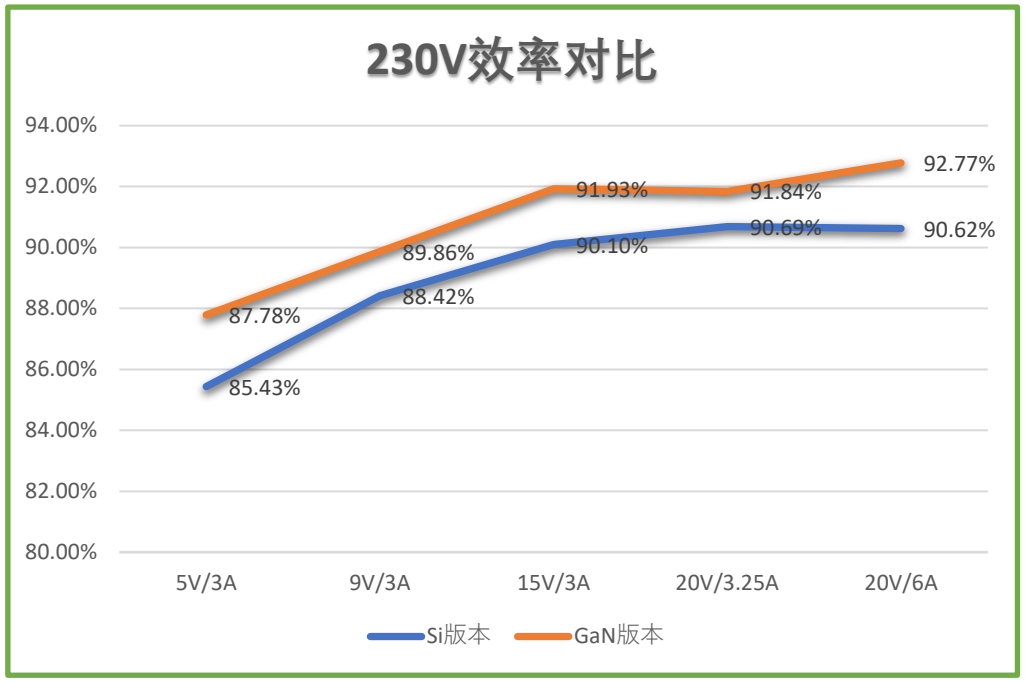
GaN

	GaN	Si
Case size	55.59*55.67*28.35mm	63.54*60.36*28.22mm
Power Density	1.36W/cm³	1.11W/cm³

Si

Efficiency Comparison





- ✓Lower case temp rise
- ✓Shorter 0-100% battery charging time
- ✓Power saving $5x10^{-4}$ kWh per charge assuming 5000mA battery

State-of-the-art 240W Charger

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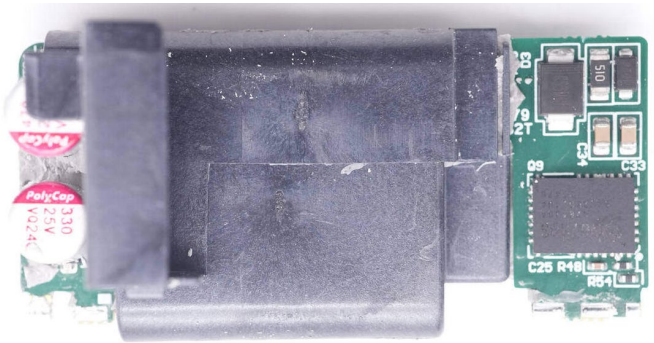

Other Applications

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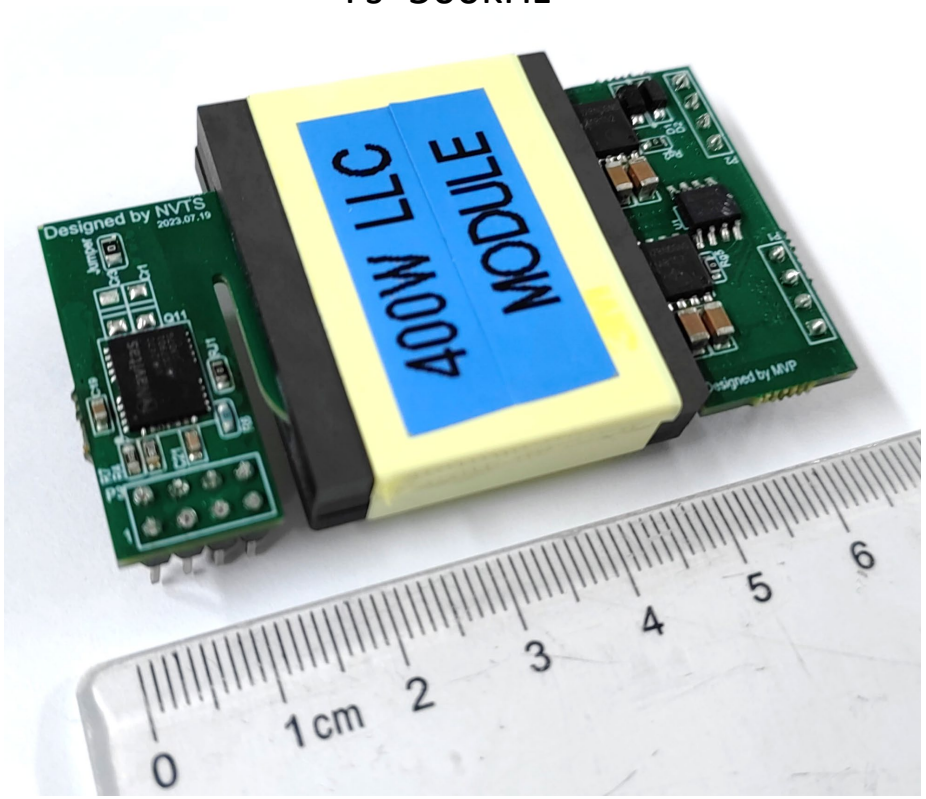
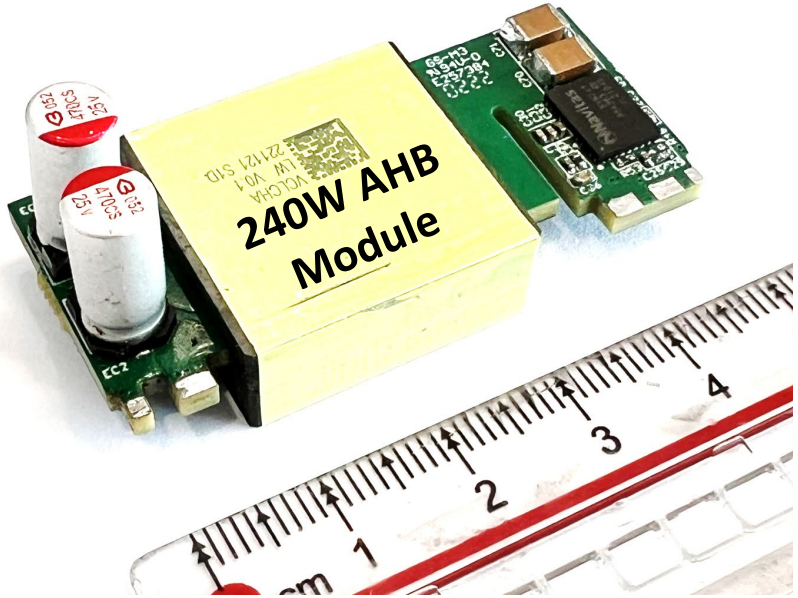
Fs=500kHz



Fs=300kHz



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