



CPEEC·CPSSC
2023

2023中国电力电子与能量转换大会
暨中国电源学会第二十六届学术年会及展览会
2023 China Power Electronics and Energy Conversion Congress
& The 26th China Power Supply Society Conference and Exhibition

采用无损电流采样的高集成 GaN Sense Control & GaN Sense HalfBridge方案

Reyn.Zhan
高级技术营销经理

广州, 2023.11.13

ir@navitassemi.com

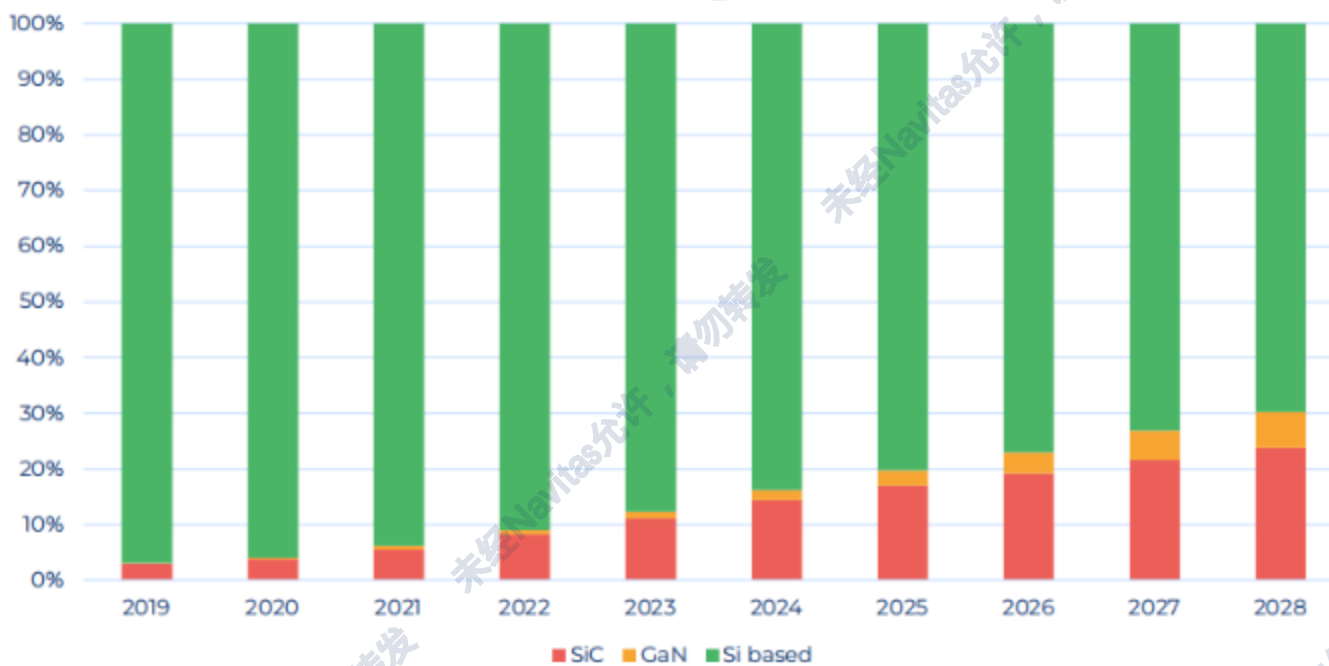


□ **GaN Market Outlook**

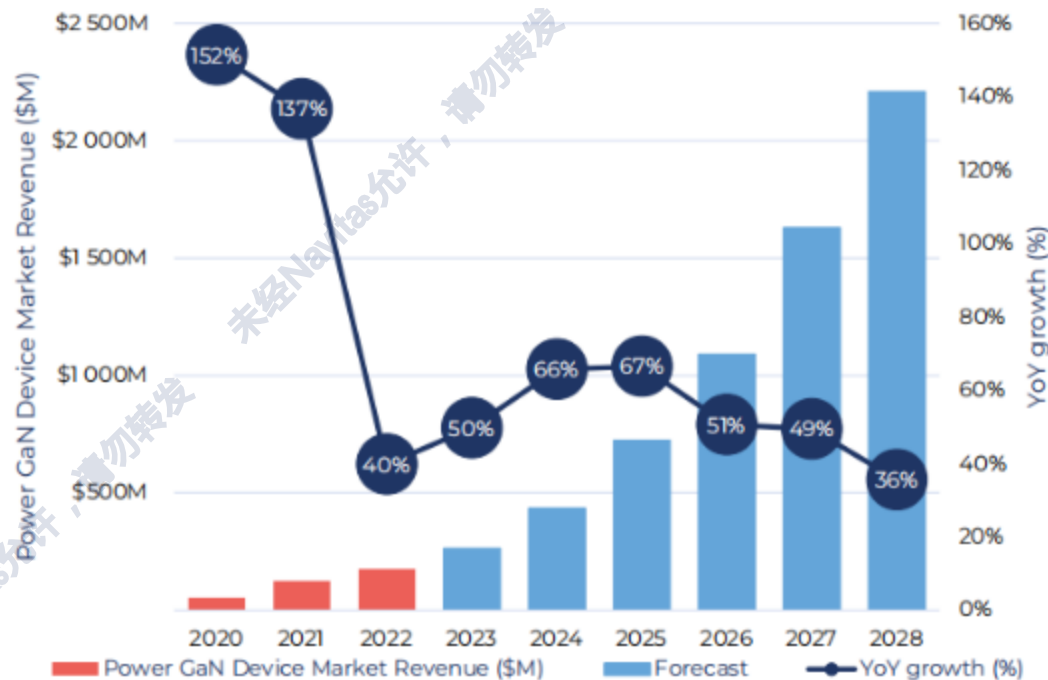
□ **Why Navitas GaNSense**

□ **GaNSense Control**

□ **GaNSense HalfBridge**



■ Power Device Revenue Market Shares : SiC VS. GaN VS. Si



■ Power GaN Device Market

氮化镓行业大规模应用发展方向

过去3-5年

- 手机
- 笔记本电脑

USB
TYPE C



现在

- 手持式设备
- 可充电设备
- 小家电
- 电动工具
- 智能家居



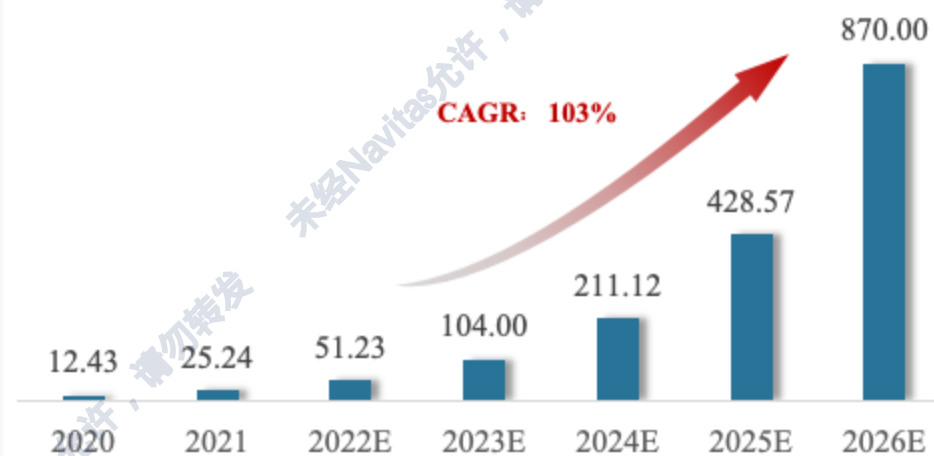
未来2-3年

- 工业
- 通信
- 服务器和数据中心
- 医疗
- 汽车



- 氮化镓功率IC在消费电子中主要用于电源适配器、无线充电、过电压保护 (OVP) 等场景，因氮化镓具有**高能量密度、高转换效率**等优点，可满足高性能消费电子设备的快速充电和充电保护等需求。
- 5G带动手机快充需求量增加，将会加速氮化镓快充渗透手机前后装市场；电源适配器的高功率趋势也会带动GaN功率半导体用量的提升。
- 根据预测，2026年消费电子氮化镓功率市场规模预计可达**8.7亿美元**，2020-2026年均复合增长率达到**103%**。

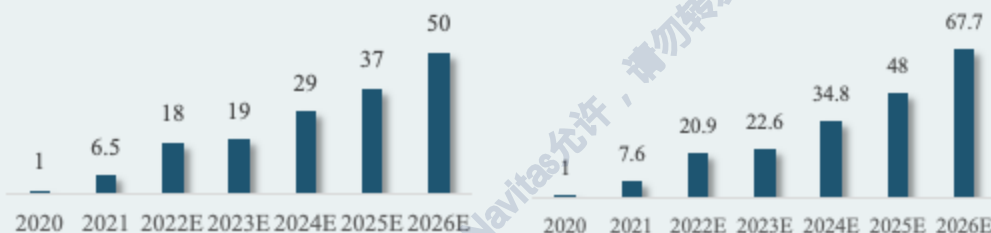
消费电子GaN市场规模 (百万美元)



高功率电源需求带动功率器件放量提价

PD 快充 GaN 器件市场规模 (亿元)

PD 快充所需 GaN-on-Si 晶圆 (万片)



“充电”将成为GaN功率器件放量提价的关键。在电源适配器、无线充电应用中，GaN 器件关断速度快、开关频率高、无反向恢复损失、低传导损耗的特点可以得到充分发挥，使得GaN快充产品在**体积、重量、充电速度**等方面实现性能飞跃。预计未来PD快充产品将会大量使用GaN器件及GaN-on-SiC晶圆。

纳微的GaN快充产品实现了性能飞跃

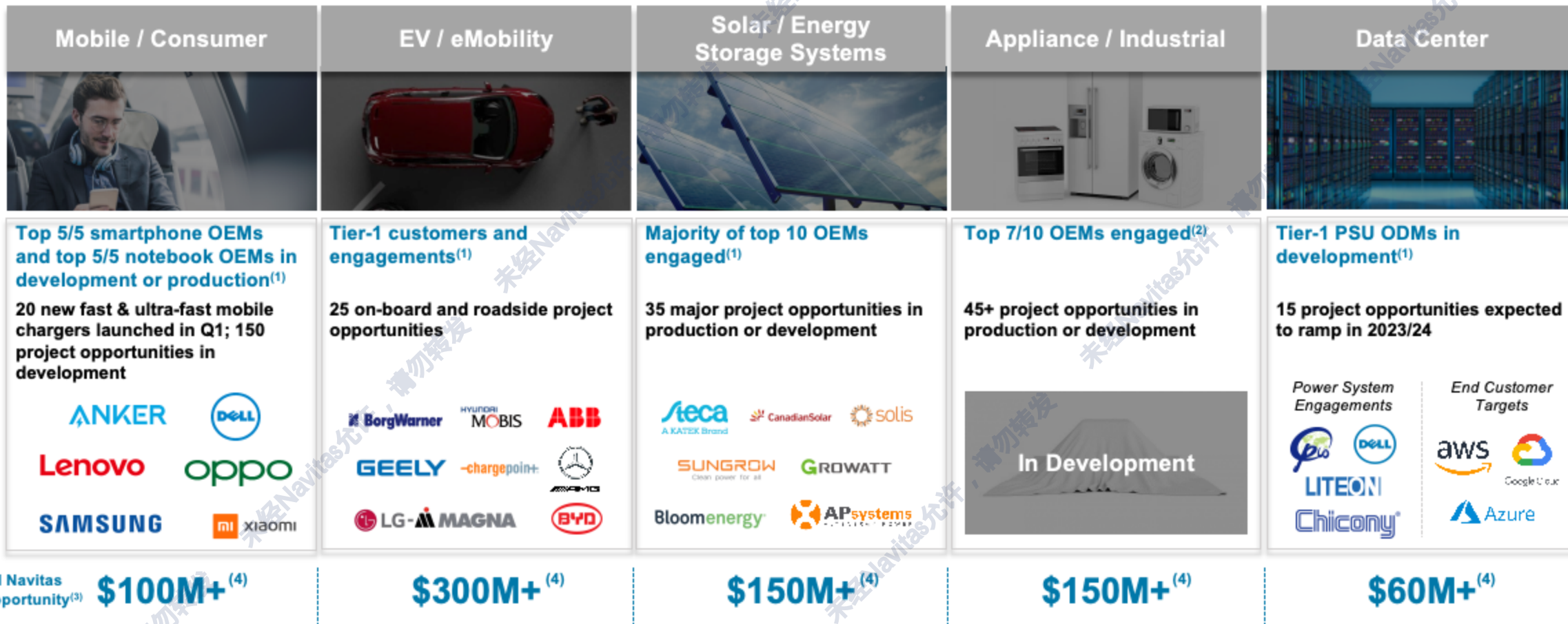


体积与重量减半

充电速度快3倍



Multi-market Growth

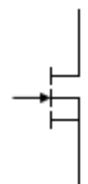


Notes:

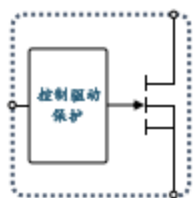
- Based on internal Navitas estimates of top OEMs in each respective market and their existing customer engagements
- Based on internal Navitas estimates of who they believe to be top OEMs in the appliance/industrial segment
- "Pipeline opportunity" reflects estimated potential future business based on interest expressed by potential customers for qualified programs, stated in terms of estimated revenue that may be realized in one or more future periods. Pipeline opportunity is not a proxy for backlog or future revenue or other measure or indicator of financial performance. Rather, Navitas uses customer pipeline as a statistical metric to indicate relative changes in future potential business across various product markets. Time horizons vary accordingly, based on product type and application. Actual business realized depends on ultimate customer selection, program share and other factors
- Based on Navitas internal estimates for potential customer revenue across GaN or SiC in the market stated

GaNFast系列产品突破了分立器件的缺陷，公司依托市场需求持续优化产品性能

分立GaN
器件



GaNFast™



GaNSense™



**GaNSense
Half-Bridge**



**GaNSense
Control**



- 结构脆弱
- 使用难度高
- 可靠性差
- 系统设计要求高

GaNFast 系列:

- ✓ 结构坚实耐用
- ✓ 便于使用
- ✓ 可靠性经过验证

GaNFast plus 系列:

- ✓ 自动保护功能
- ✓ 无损耗电流传感

GaNSense plus 系列:

- ✓ 高边、低边、电平偏移隔离单元一体化集成
- ✓ 全方位保护功能

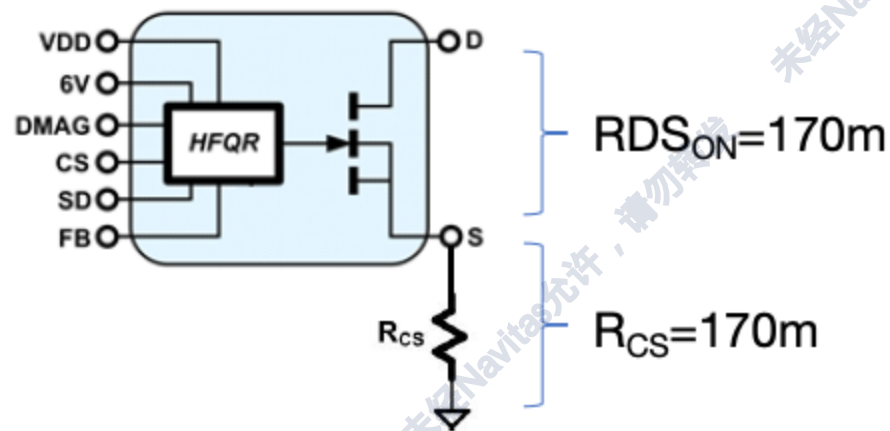
GaNSense plus 系列:

- ✓ 低压硅系统控制器
- ✓ 组件最优化



GaNFast™ HFQR Controller

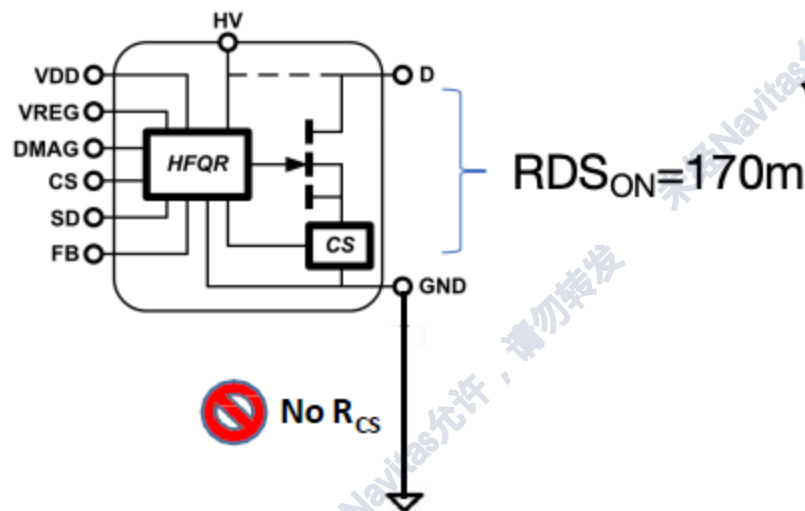
NV9550



$R_{TOTAL}=340m$

GaNSense™ HFQR Controller

NV9580



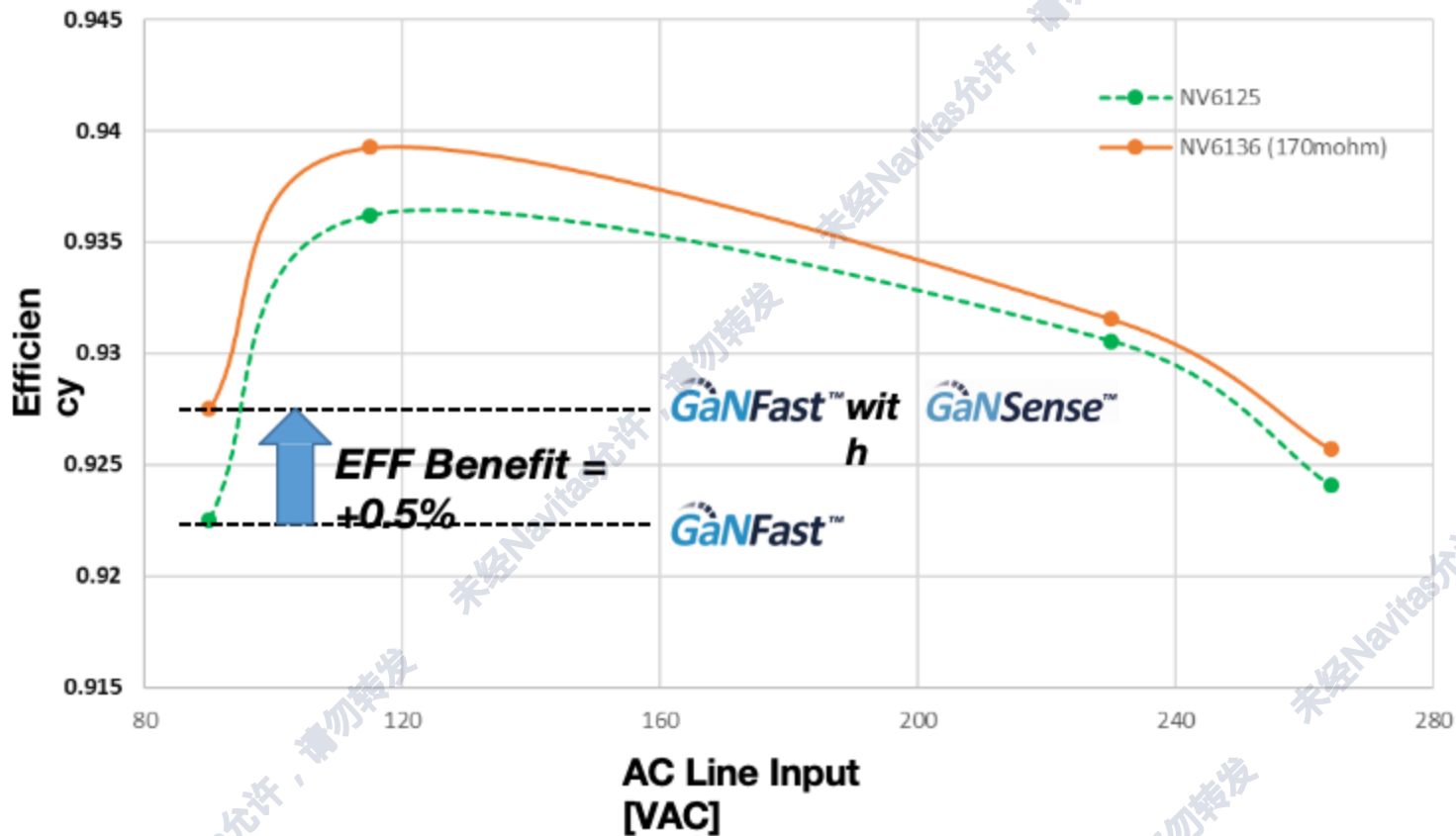
$R_{TOTAL}=170m$

✓ Loss-less current sensing offering higher efficiency

✓ Real time over current detection and protection even CS pin is short

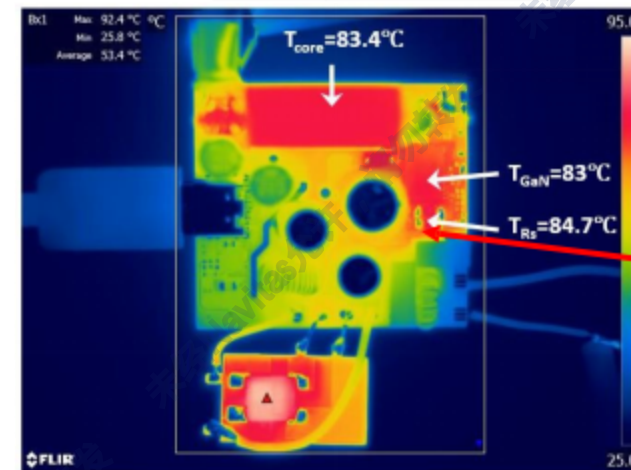
Efficiency Curves (60W HFQR, 20V/3A)

20V 3A Optimized Efficiency



Thermals (60W HFQR, 90VAC, 20V/3A, 1 Hour)

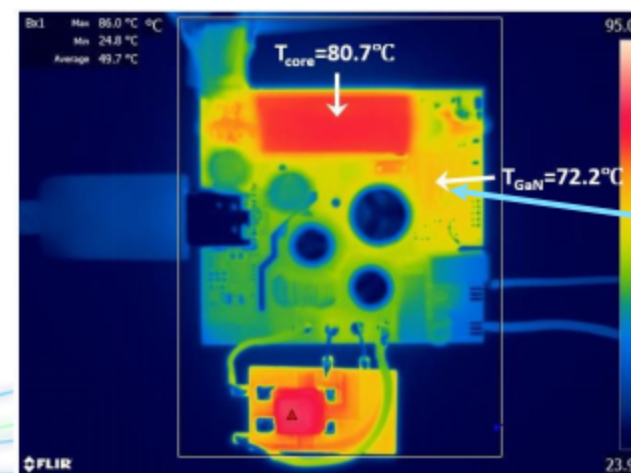
Non-GaNSense



R_{DS ON} = 170m
R_{CS} = 170m

R_{CS} HOTSPOT = 85C!

With GaNSense™



R_{DS ON} = 170m
R_{CS} = 0m

**NO R_{CS} HOTSPOT
T_{GaN} = -10C**

ADVANTAGE

Low Cost & Easy Miniaturization Design

High integration GaN combo solution in smaller size

Smallest BOM with only 40 components for 65W PD power

No bulky additional circuit and simple transformer configuration

Low production cost



High Performance

High peak and average efficiency even at light load and at high/low V_{AC}

Lowest standby power (<20mW)

Full protection to meet in box design requirement

Ture LPS function

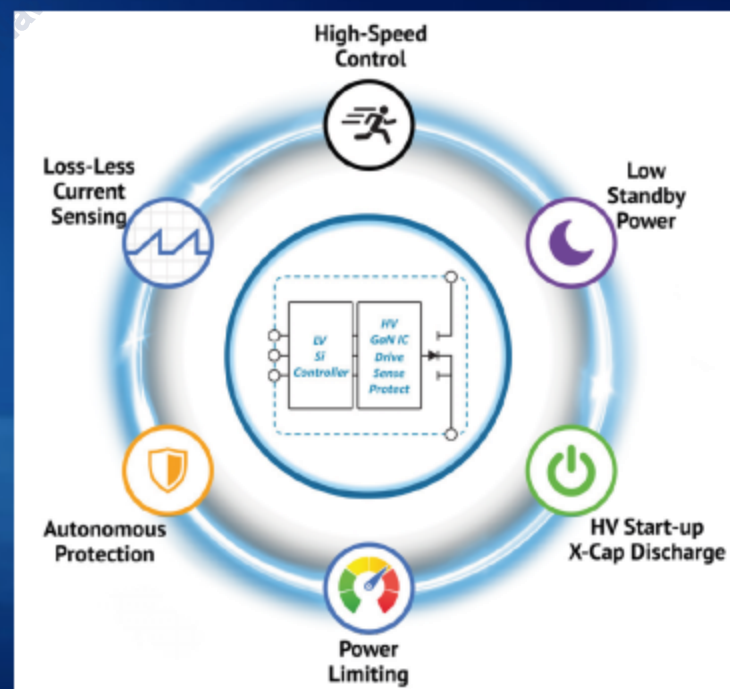


High Reliability

Market proved GaN integrated

DFQ & DFT & DFM design concept

3 lots full reliability qualification under JEDEC standard



Main Controller overview, NV9510(SOIC10), NV9512(SOIC10), NV9550(QFN56)

Value Proposition

The NV9510 (NV9512/NV9550) Flyback Controller is a high performance controller ICs for switched mode power supplies, it supports QR, DCM, CCM and multiple frequency hybrid mode operation. 300kHz/225kHz/129kHz/82kHz frequency option provides flexible design for PCB transformer and wire-wound type of transformer, offering an efficient and compact 20W – 65W charger solution.

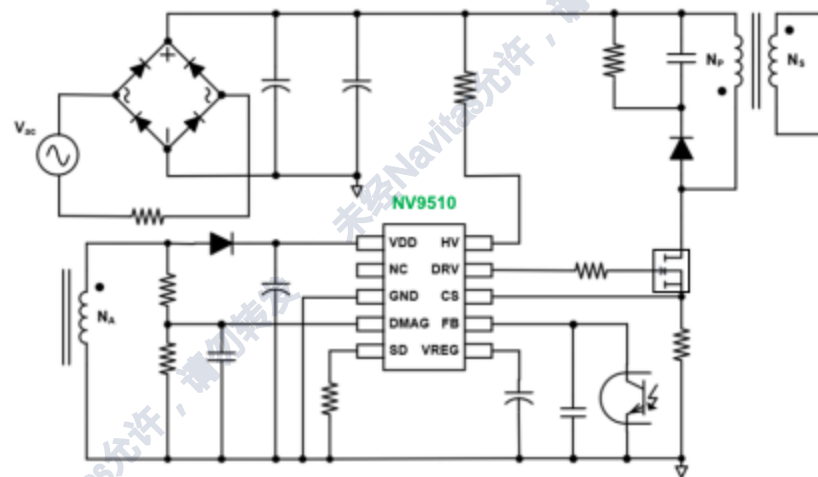
Features

- Incorporated innovated control algorithm
- Smart Frequency control, to provide a more efficient solutions
- Compatible with driving GaN/MOSFET device
- **High VDD voltage up to 80 V**
- High frequency operation up to **300 kHz**
- **Smart driver and frequency hopping for better EMI**
- **High-voltage startup**
- **X-Cap discharge**
- Pseudo-valley switching in ultra-high frequency
- Comprehensive Protections
 - UVLO, VDD_OVP, Brown-in/out, VO_UVP, VO_OVP
 - LPS (CC/PL), External Shut-down Protection
 - Current Sense Limit (VCS_LIM), Cycle by cycle Short Circuit Limit (CSSC), AOCIP

Market & Applications

- AC/DC adapters
- USB-PD PPS adapters and chargers
- Notebook adapters

Typical Application Diagram

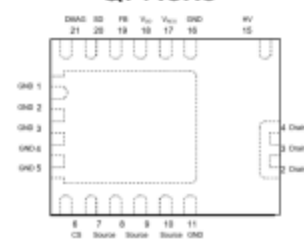


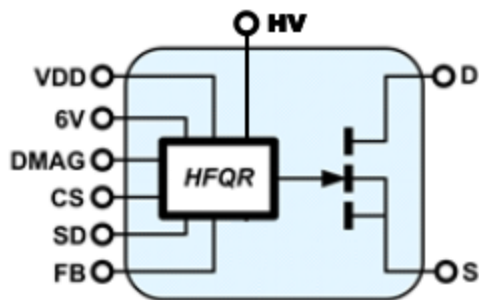
Pins and Package Information

- Available in SOIC10



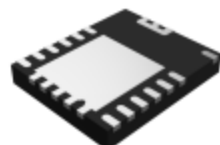
QFN5x6



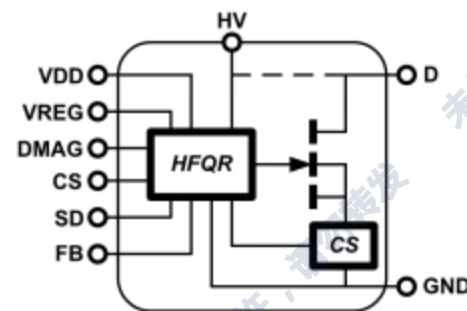


GaNFast™ HFQR Controller
(NV955x)

- Primary HFQR Controller with **GaNFast**
- Multi-mode CCM/DCM + variable freq ctrl
- HV start-up
- < 20mW stby power
- Fewest external components
- Robust protection features
- Small QFN 5x6 package
- SR co-pak chip set

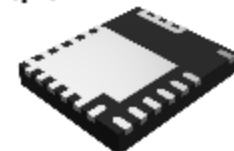


QFN5x6



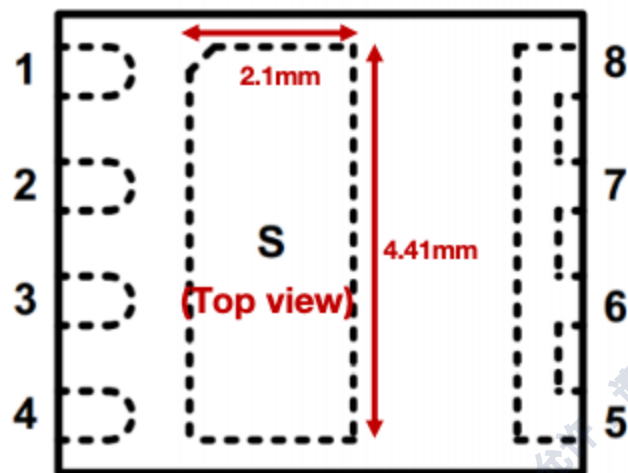
GaNSense™ HFQR Controller
(NV958x)

- Primary HFQR Controller with **GaNSense**
- **Loss-less current sensing (+0.5% efficiency increase)**
- **Over current protection when CS pin short**
- Multi-mode CCM/DCM + variable freq ctrl
- HV start-up
- < 20mW stby power
- Fewest external components
- Robust protection features
- Small QFN 5x6 package
- **Increased cooling pad**
- SR co-pak chip set



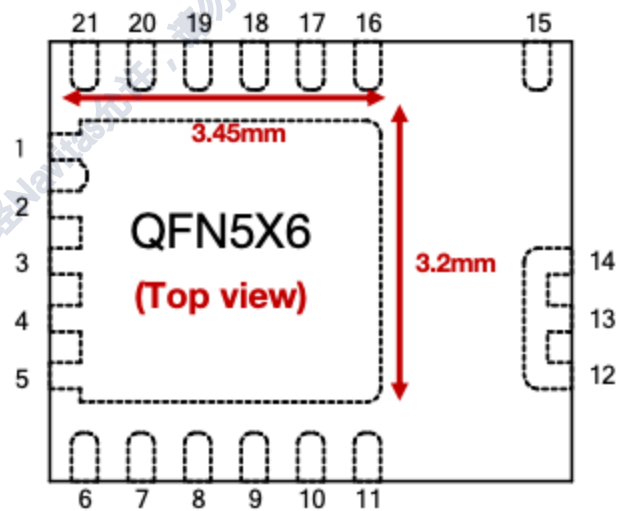
QFN5x6 Super

Package Superiority: from Discrete to GaNSense Control Navitas



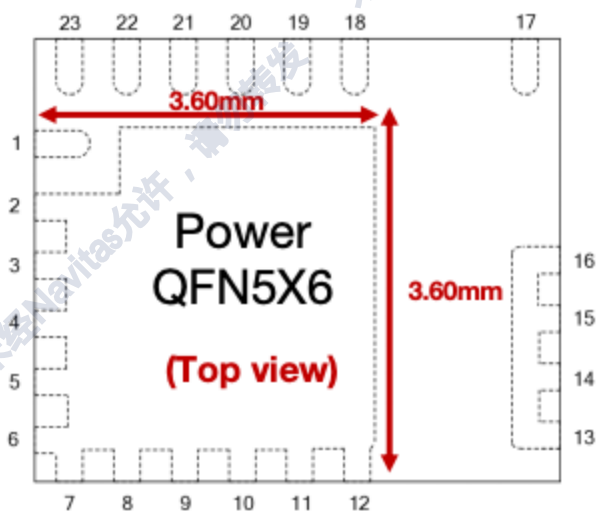
Package Top View

Discrete GAN Solution



NV955x:

- Additional 30% DAP size comparing to conventional 5x6 Discreet GaN solution



NV958x:

- Additional 50% DAP size comparing to conventional 5x6 Discreet GaN solution
- Compatible DAP size to QFN6x8
- Maximize exposed pad
- Flexible PCB layout for power path

GaNFET Co-package IC Performance Comparison Navitas


Feature	A	B	Navitas NV958x
Max Frequency (kHz)	175	150	129/225
Package	PQFN 6x8	InSOP 10x14	PQFN 5x6
HV Startup	Built-in	Built-in	Built-in
Lossless Current Sensing	No	Yes	Yes
V _{CC} Range (V)	7.9 - 40	4 - 6	6.2 - 75
External V _{DD} Regulator	Boost	Linear	Not Required
External Components	+11	+18	+9
PCB Footprint (mm ²)	85	90	50
Thermal Pad	Yes	No	Yes
Hotspot	Yes	No	No
V _{DS} (cont./trans.)	650 / 750	650 / 750	700 / 800
X-cap discharge	Built-in	Additional IC	Built-in
Primary side TSD for RNTC	No	No	Built-in

Higher Efficiency
Higher Power Density

Higher Reliability

Built-in protections

GaNSense Control Product Family

Product Family	Part#	Package	$R_{DS(ON)}$ (typ, m Ω)	Samples	MP	Typical Applications
GaNFast Control	NV9550	QFN 5 x 6	170	Now	Now	HFQR Flyback
	NV9552		260	Now	Now	
	NV9554		450	Now	Now	
GaNSense Control	NV9580	 QFN 5 x 6 Super	170	Now	Now	HFQR Flyback
	NV9581		210	Now	Q4'23	
	NV9582		260	Now	Now	
	NV9583		330	Now	Q4'23	
	NV9584		520	Now	Now	
	NV9586		600	Now	Q4'23	
HFQR Controller	NV9510/12	SOIC-10	N/A	Now	Now	HFQR Flyback
SR Controller	NV9701	SOT-23-5L	N/A	Now	Now	Sync Rec
SR Controller + Power	NV9750	QFN 5 x 6	14	Now	Now	Sync Rec

65W EVB w/ NV9580+NV9701

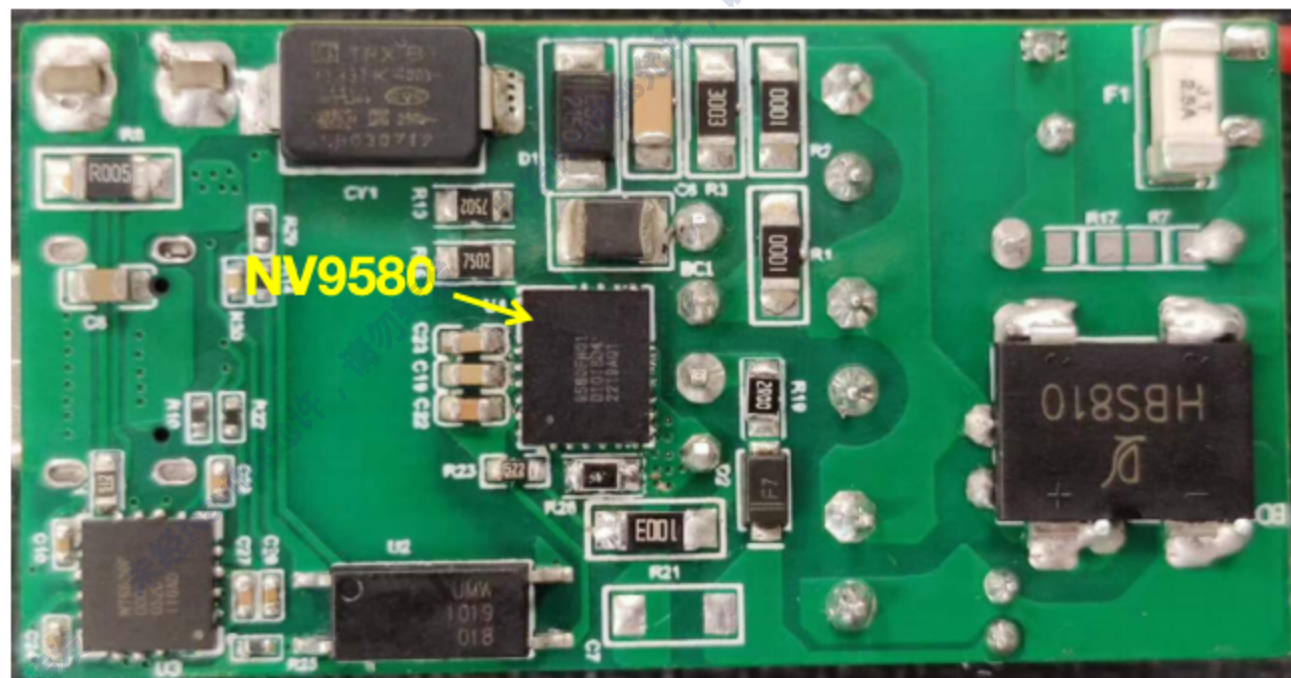
EVB size: Length 50mm x Width 25.7mm x Height 20mm

40 components Only for power stage

Top View

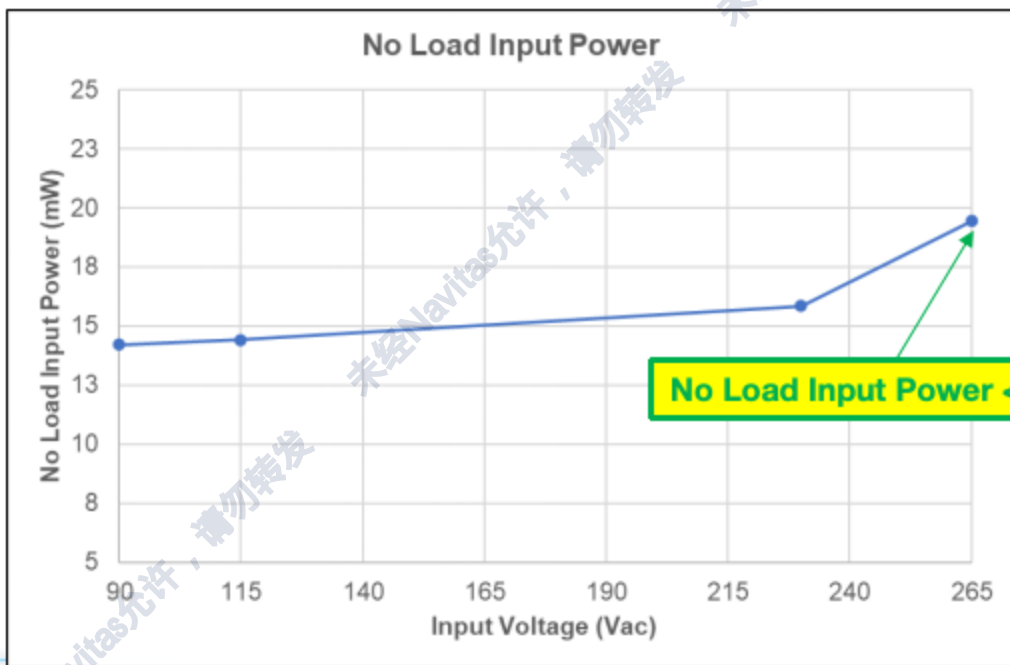


Bottom View



Standby Power

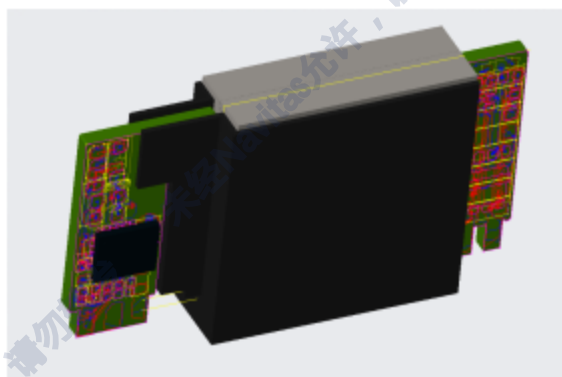
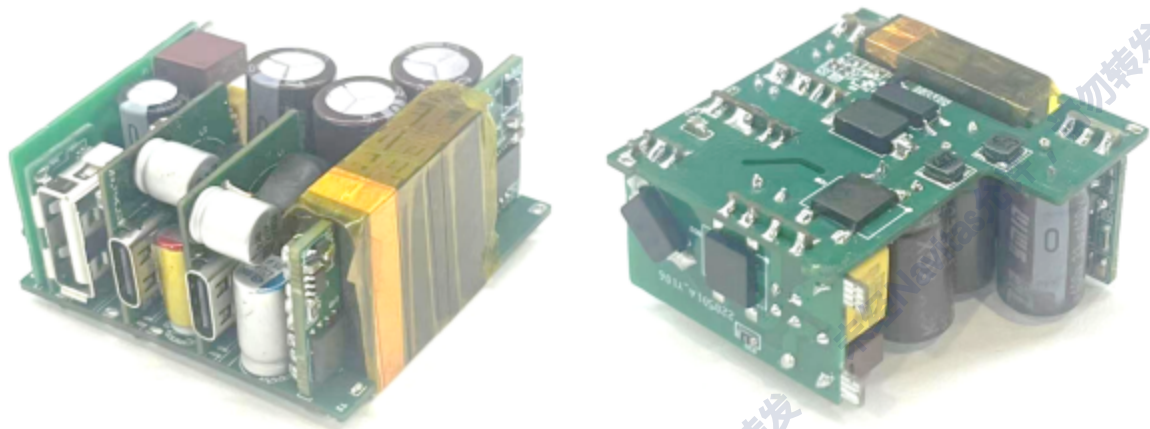
	90Vac	115Vac	230Vac	264Vac
Standby Power	13.5mW	13.5mW	15.85mW	19.45mW



Input Power and Eff. at Ultra Light Load Condition

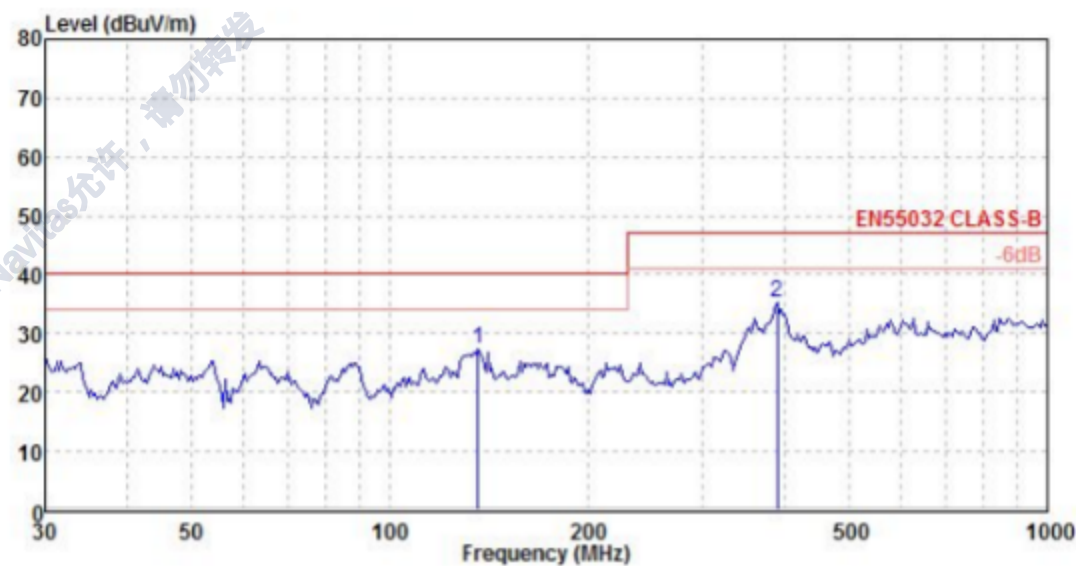
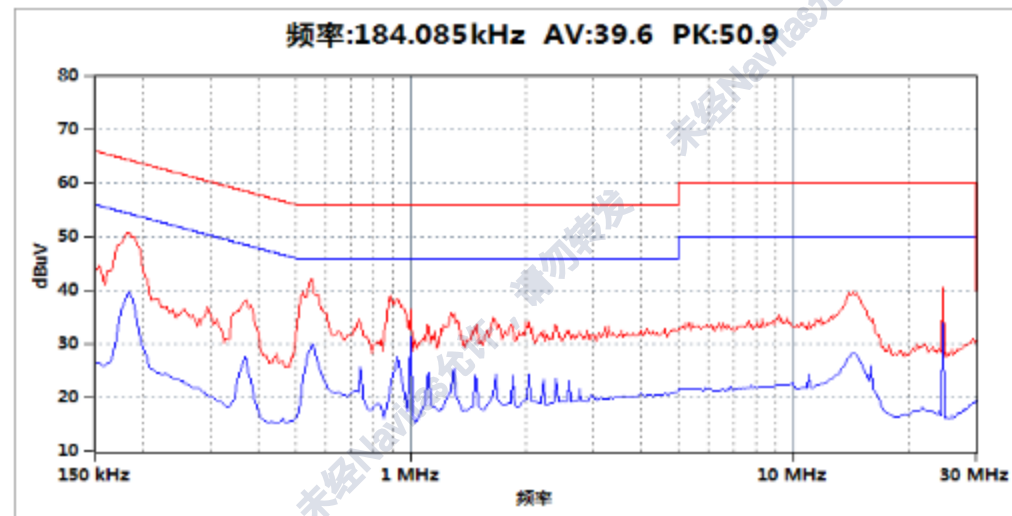
Input	Output		Input Power (W)	Eff. (%)
	Vo (V)	Power (W)		
115Vac /60Hz	5	0.24	0.278	86.33
		0.1	0.113	88.50
	9	0.24	0.272	88.24
		0.1	0.127	78.74
230Vac /50Hz	5	0.24	0.3	80.00
		0.1	0.12	83.33
	9	0.24	0.288	83.33
		0.1	0.134	74.63

65W 2C + 1A Key Electrical Spec



PCBA : 43 x 43 x 24mm³ (44CC)

92.9% efficiency @90Vac 20.8V/3A, acdc only



Features	Simplified Schematic	Package
<p>GaNFast™ Power IC</p> <ul style="list-style-type: none"> Two independent logic inputs with hysteresis 3.3, 5, 12 V PWM input compatible Floating high-side with internal level shift Integrated high-side bootstrap Shoot-through protection Wide V_{CC} range (10 to 24 V) Hi & Lo-side turn-on dV/dt slew rate control Super slow turn-off speed (M versions) <p>GaN Power FETs</p> <ul style="list-style-type: none"> 275/275 mΩ version (NV6245C/M) 150/150 mΩ version (NV6247C/M) Zero reverse recovery charge 800 V Transient voltage rating 650 V Continuous voltage rating <p>GaNSense™ Technology</p> <ul style="list-style-type: none"> Integrated loss-less current sensing Over-current protection Over-temperature protection Autonomous low-current standby mode <p>Small, low-profile SMT PQFN</p> <ul style="list-style-type: none"> 6x8 mm footprint Minimized package inductance Large cooling pads 		<p>QFN 6x8 QFN 8x10</p>
<h3>Typical Application Schematic (AHB)</h3>		

GaN Half-Bridge Comparisons - Features



	Feature	Navitas GSHB	S	I
Gate Drive	Regulated Gate Voltage	Internal LDOs (2x caps)	Integrated gate drive supply	Requires ext. 8V supply
	Integrated bootstrap	Integrated bootstrap 6 ohm	Integrated bootstrap 150 ohm	Requires ext Rboot + Dboot (+17mm ²)
Protection	Loss-Less Current Sensing (LLCS)	Eliminate RCS, Lower RON(TOT) No PCB hot-spot (-85C) No RCS footprint (-20mm ²) No Source inductance	Requires ext. RCS (3pcs) RCS PCB hot-spot (+85C) RCS PCB footprint (+20mm ²) Source inductance	Requires ext. RCS (3pcs) RCS PCB hot-spot (+85C) RCS PCB footprint (+20mm ²) Source inductance
	Fast Short-Circuit Protection (SCP)	Integrated SCP (50nsec) Fast, self-protect	Uses controller OCP (300nsec) Too slow for SCP	Uses controller OCP (300nsec) Too slow for SCP
	Over-Temperature Protection (OTP)	Integrated OTP (160/100)	Integrated OTP (175/155)	No OTP
On/Off Control	Turn-on dV/dt control	Ext. RDD resistor (LS only, HS metal)	Internal set resistors	Ext. source resistors
	Turn-off dV/dt control	Internally fixed (soft pull down option)	Internal set resistors	Ext. sink resistors
Package	Pkg type/size	QFN 6x8	QFN 9x9	QFN 8x8
	PCB Footprint (incl. ctrl)	84 mm ²	122 mm ²	148 mm ²
	Thermal PAD Size	LS=9.6mm ² , HS=8.6mm ²	LS=6.2mm ² , HS=6.2mm ²	LS=6.5mm ² , HS=6.1mm ²
Robustness	ESD Rating	2 KV	Not listed	TBD
	VDSmax-tran	800 V	Not listed	Not listed
	VDSmax-cont	850 V	620Vmax/520Vcc	600 V
	VGS range	10 to 80 V	6 V to 11 V	22 V
No Load	I-STBY	275 uA (typ) ASTBY	830 uA (typ) SD=5V	1.4 mA (typ)
Switching	Prop delay	35ns/35ns	46ns/46ns	47ns/47ns

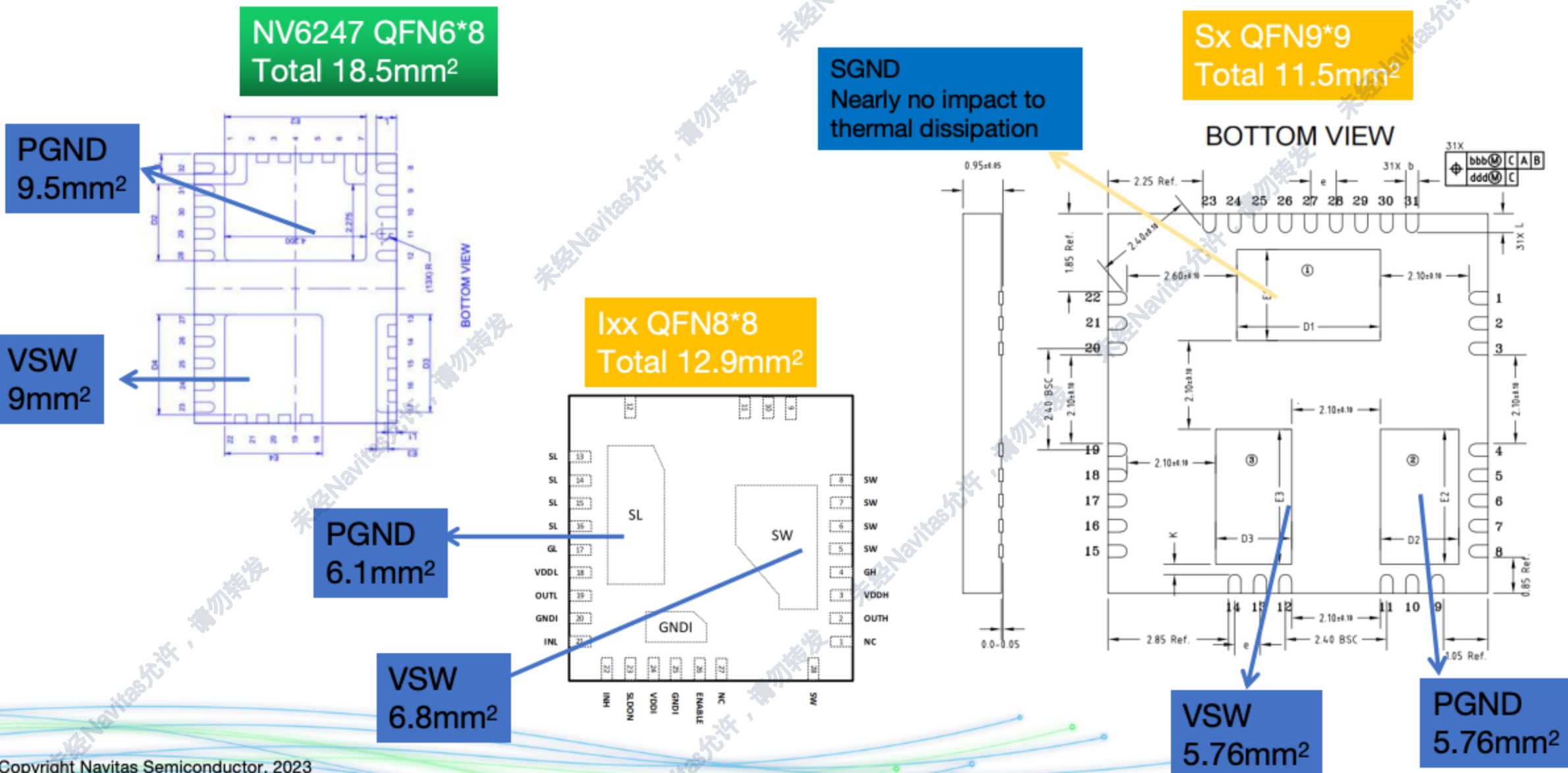
Higher Eff Cooler

Smart EMC


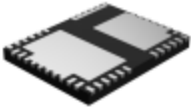
Safer Operation

Faster Switching

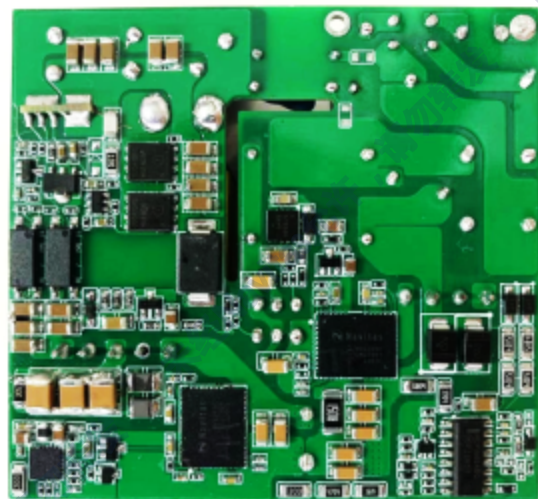
GaN Half-Bridge Comparisons - Thermal Pad



GaNSense Half-Bridge IC Product Family

Family	Part#	Package QFN (mm)	$R_{DS(ON)}$ (typ, m Ω)	Samples	MP	Typical Applications
GaNSense Half-Bridge	NV6245C	 6 x 8	275 + 275	Now	Now	Power supply
	NV6245M		275 + 275	Q1'24	Q2'24	Motor
	NV6247C		150 + 150	Now	Now	Power supply
	NV6247M		150 + 150	Now	Q4'23	Motor
	NV6267C	 8 x 10	150 + 150	Now	Q4'23	Power supply
	NV6267M		150 + 150	Now	Q4'23	Motor
	NV6269C		70 + 70	Now	Q4'23	Power supply
	NV6269M		70 + 70	Now	Q4'23	Motor

240W TTP + AHB w/ GaNSense HalfBridge



NV6269C for both PFC&AHB GaN

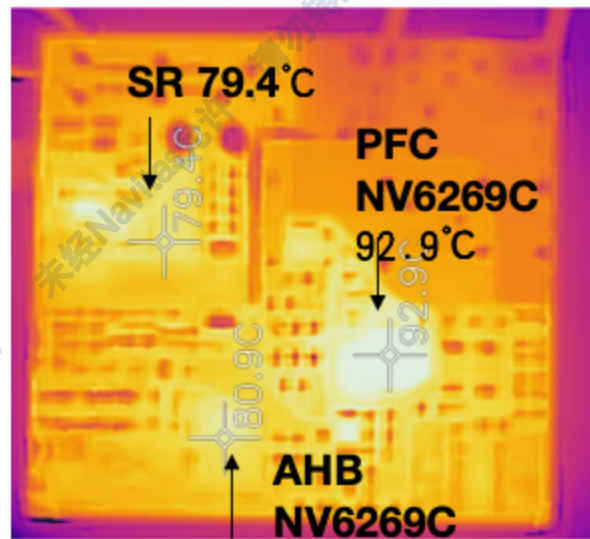
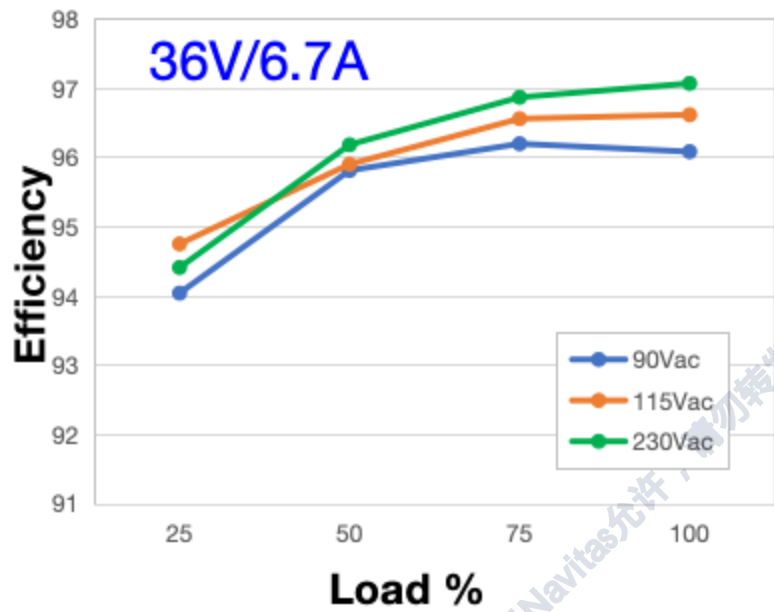
96% efficiency @ 90Vac @36V/6.7A

2.3W/cc Power density

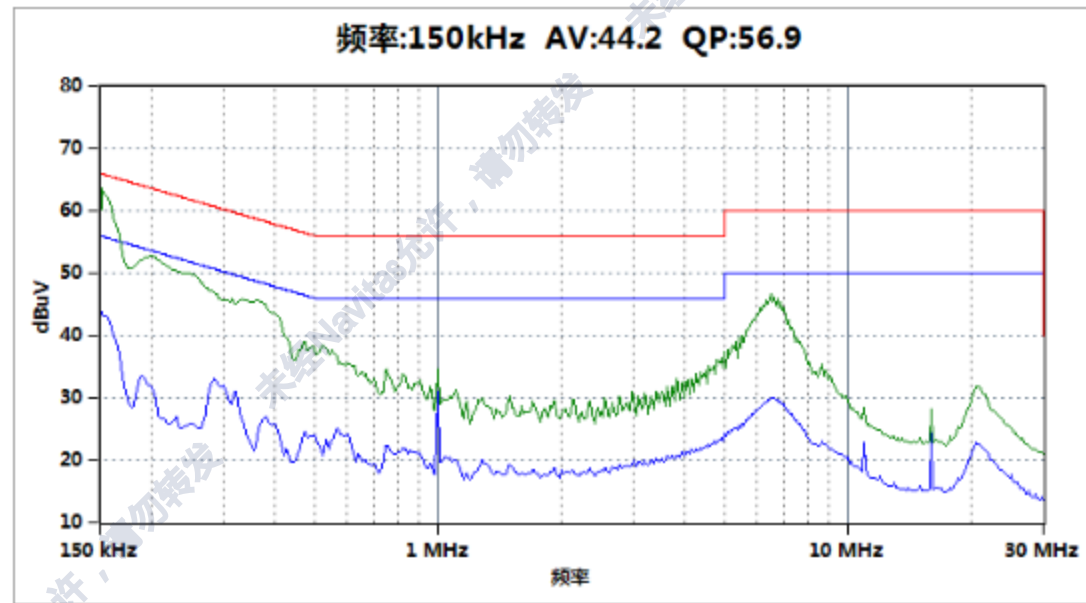
Pass thermal test & EMI test

PCB size: 70mm*65mm*23mm

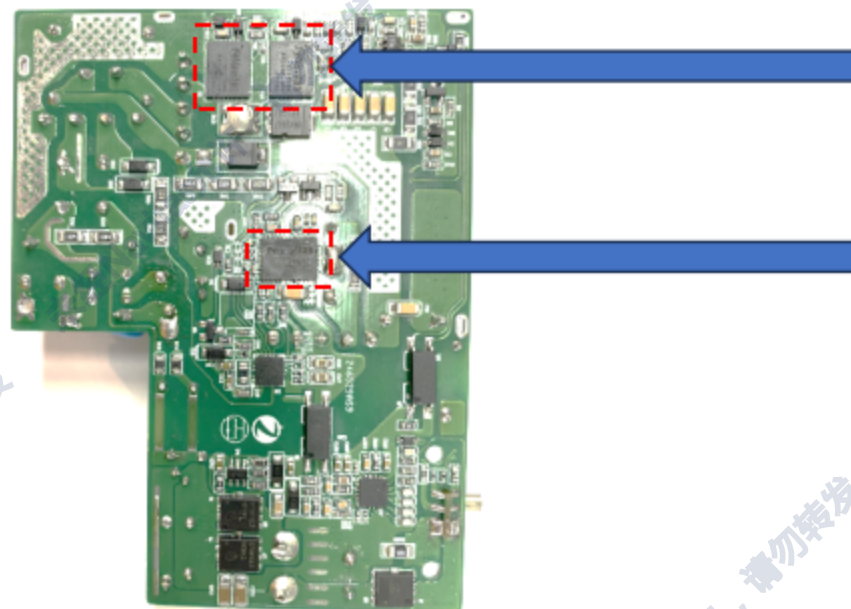
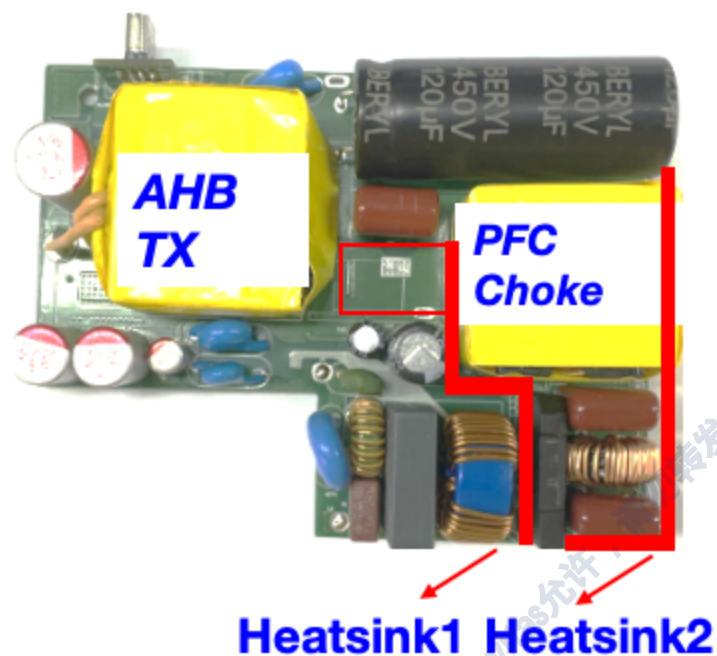
240W Key Electrical Spec



90Vac, 15min Burning,
Ta=25°C



180W BFPFC + AHB



PFC stage
GaNSense Single
NV6136C

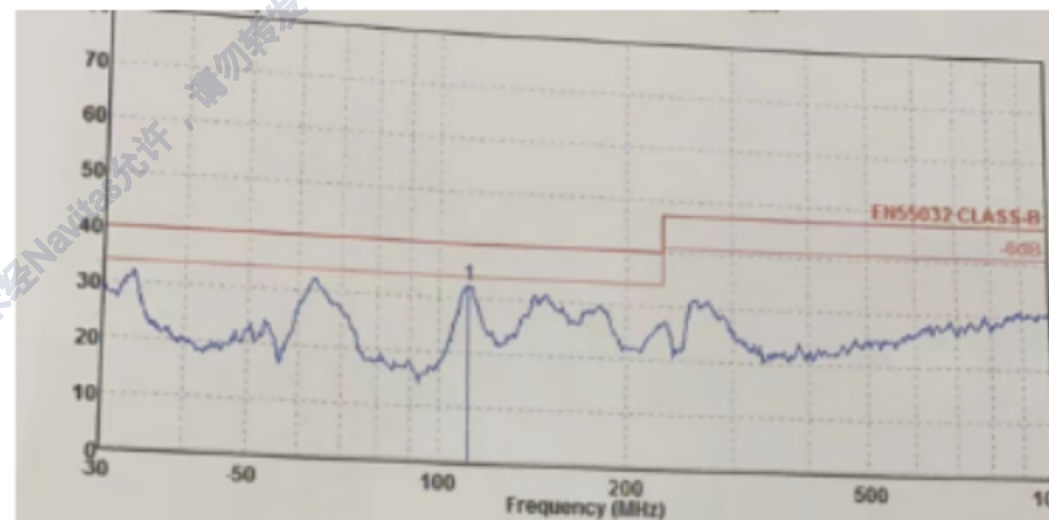
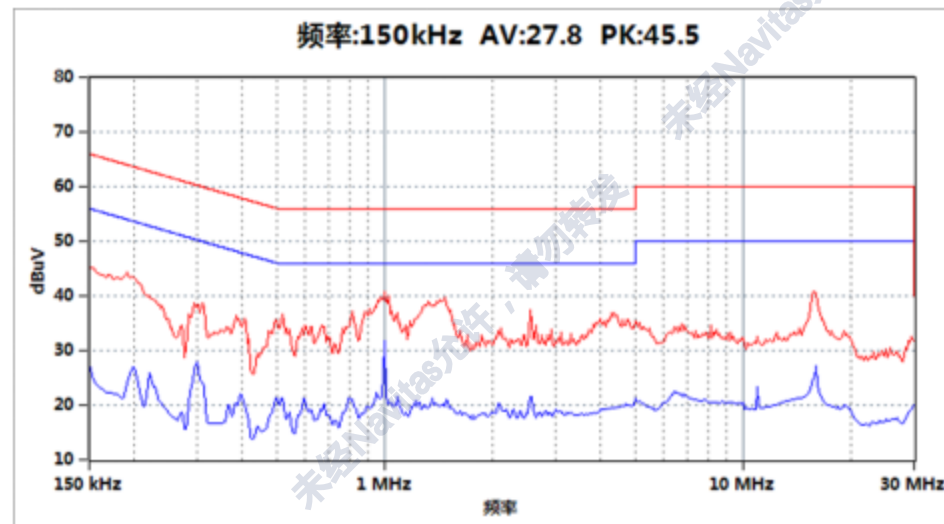
PFC stage
GaNSense HB
NV6247C

Maximum Load : 36V/5A

Cased : 96mmx75mmx28.5mm(205cc);

180W Key Electrical Spec

Vin	Pin(w)	Iout(A)	Vout(v)	Pout(w)	Eff
90Vac/60Hz	190.97	4.98	36.31	180.82	94.685%
115Vac/60Hz	189.59	4.9791	36.326	180.87	95.401%
	141.68	3.7378	36.163	135.17	95.405%
	94.087	2.4816	36.049	89.459	95.081%
	47.314	1.2403	35.937	44.573	94.207%
				Average	95.024%
	19.088	0.49406	35.837	17.706	92.76%
230Vac/50Hz	187.99	4.9781	36.335	180.88	96.218%
	140.73	3.7359	36.174	135.14	96.028%
	93.572	2.4816	36.06	89.486	95.633%
	47.123	1.2394	35.936	44.539	94.516%
				Average	95.6%
	19.078	0.49219	35.864	17.652	92.53%
264Vac/50Hz	187.72	4.9772	36.339	180.87	96.351%



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