



Navitas

Let's go **GaNFast™**

Delivering Performance, Let's Go GaNFast™

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**POWER ELECTRONICS
CONFERENCE 2018**

December 4, 2018 - Hilton Hotel at Munich Airport

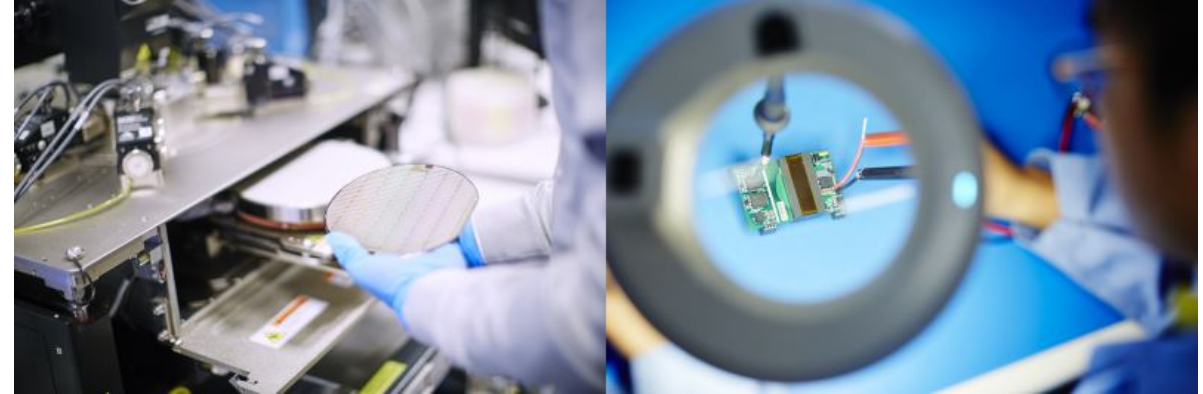
ASPENCORE



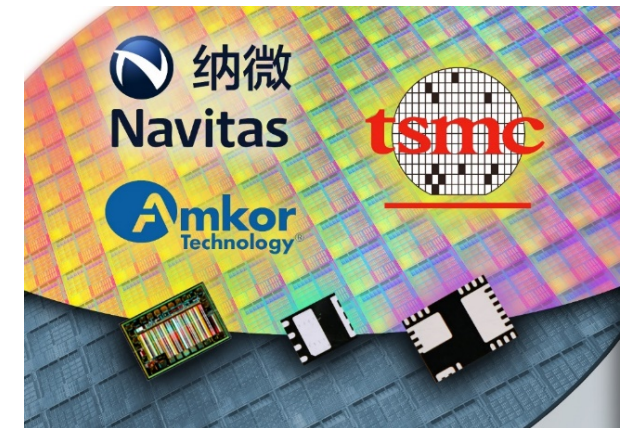
Navitas Semiconductor Inc.



- World's first & only GaN power IC company
 - Production released with fast revenue ramp
- Navitas: Latin for *Energy*
 - **Energy** savings
 - *Bringing a new Energy to power electronics*
- Founded January 2014, HQ El Segundo, CA
- Proven management team, 60+ employees
- Tier 1 manufacturing partners
 - Wafer foundry, packaging
- Strong financial investors (\$1B+ managed capital)



navitas
noun | en·er·gy

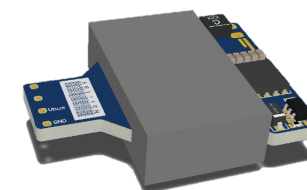
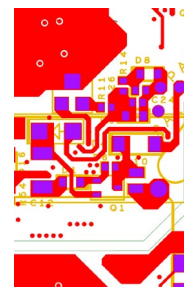
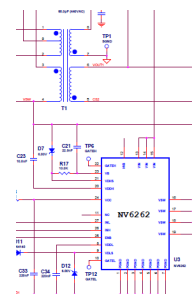
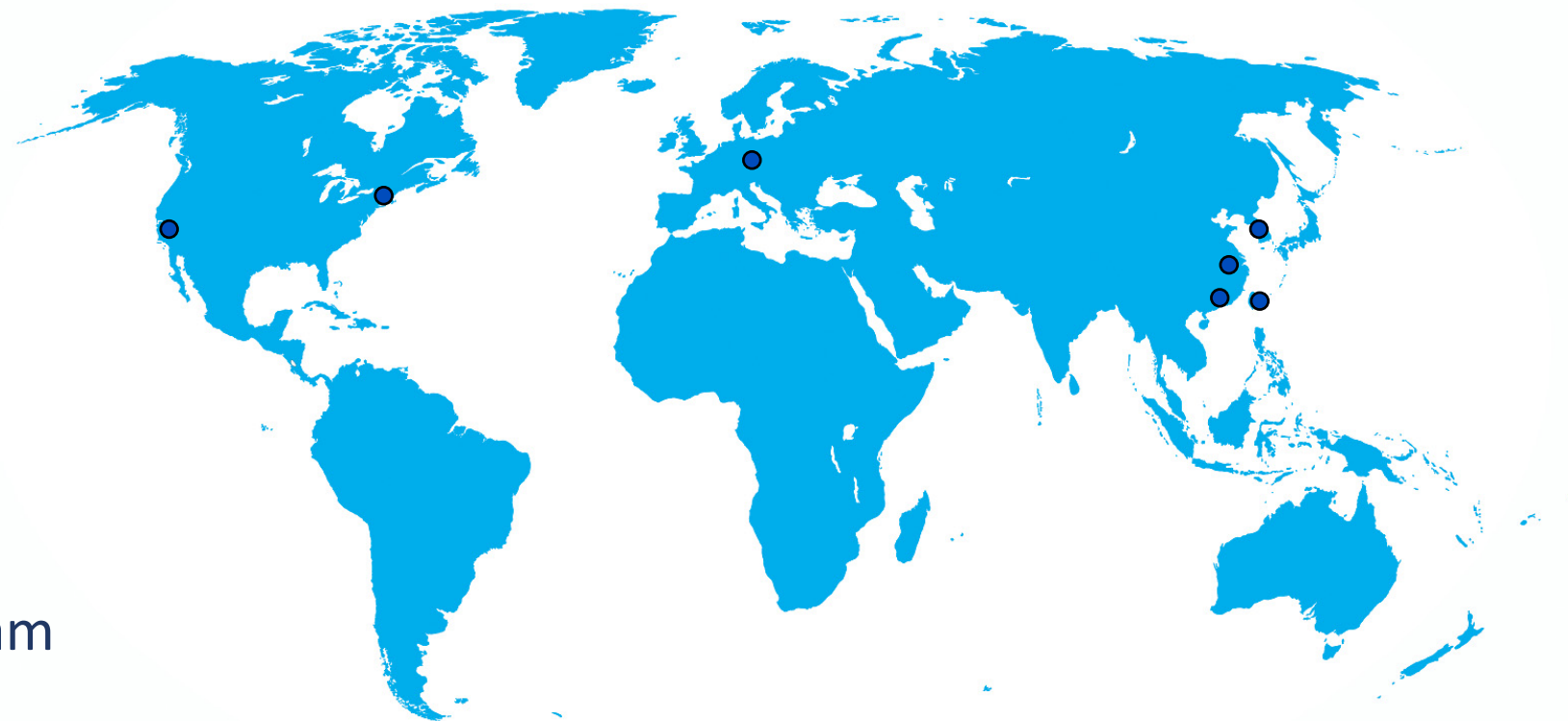




GaNFast Design Support



- Global technical support
 - Direct support
 - Partner support (VAR)
- Strong AE team
- Strong FAE team
- GaNFast Design Support Program
 - From schematic to EMI
 - Components, magnetics, PCB
 - Critical component support
 - System Reliability support

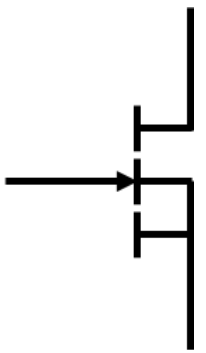




World's First GaNFast™ Power ICs



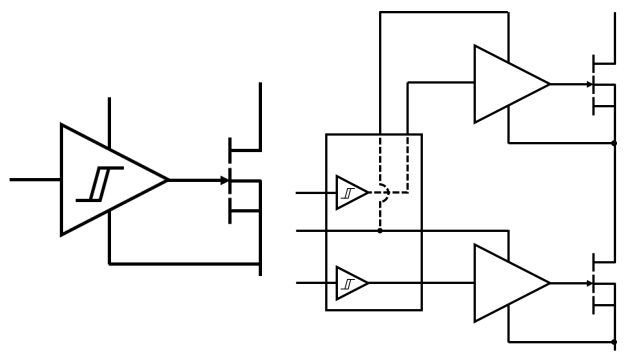
**Fastest, most efficient
GaN Power FETs**



>20x faster than silicon
>5x faster than cascoded GaN
Proprietary design



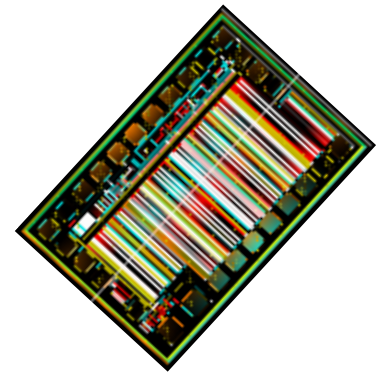
**First & Fastest Integrated
GaN Gate Drivers**



>3x faster than any other gate driver
Proprietary design
30+ patents granted/applied



**World's First
GaNFast™
Power ICs**



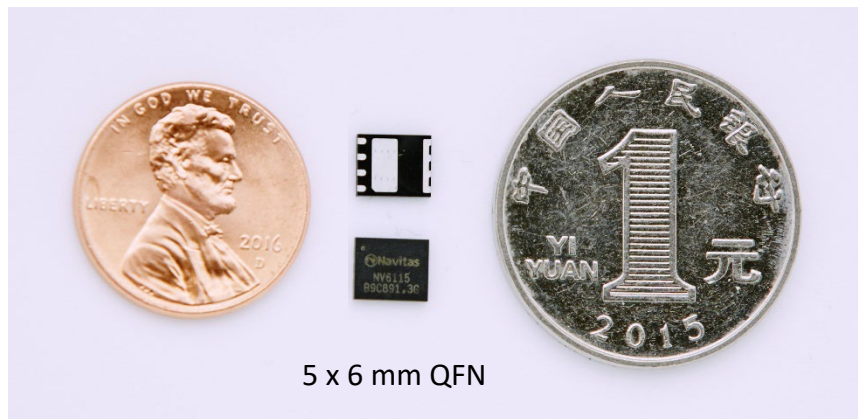
Up to 40MHz switching, 5x higher density & 20% lower system cost



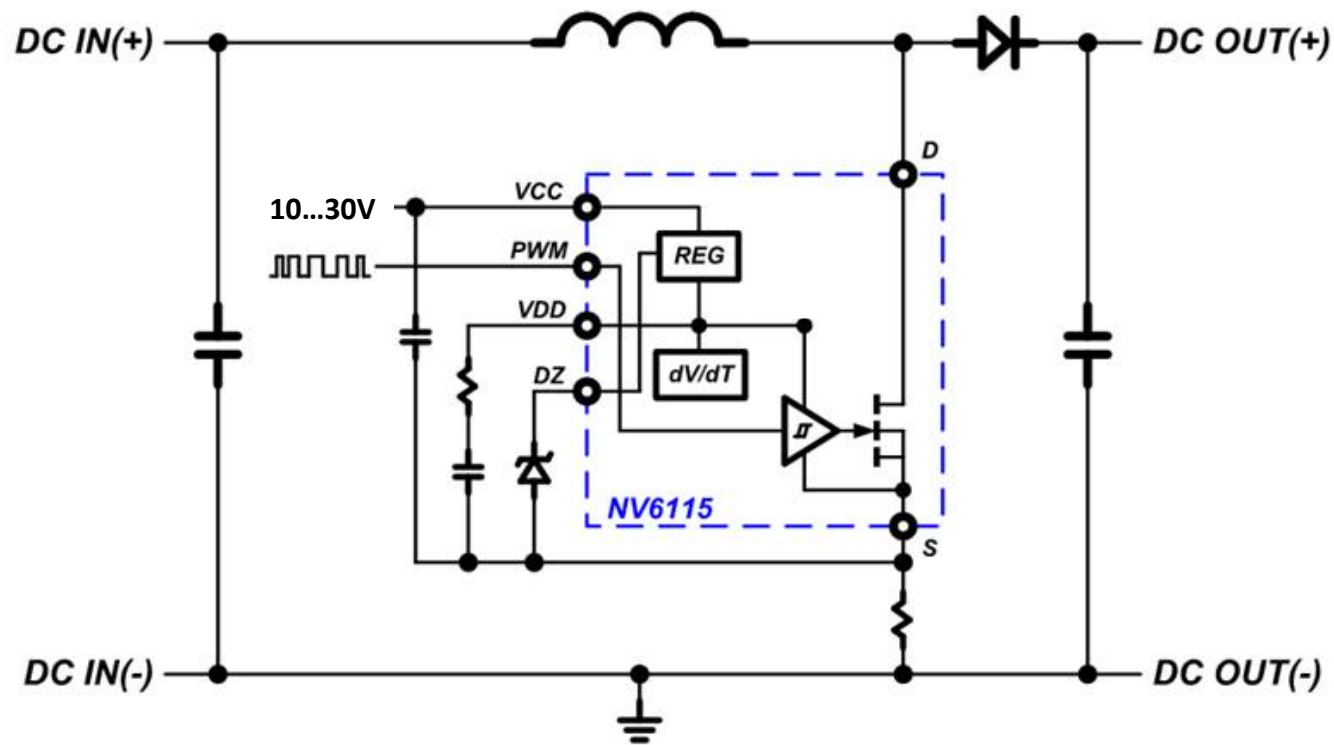
Single GaNFast Power IC



- Monolithic integration, 650V
 - GaN FET
 - GaN Driver
 - GaN Logic
- “Digital In, Power Out”



5 x 6 mm QFN

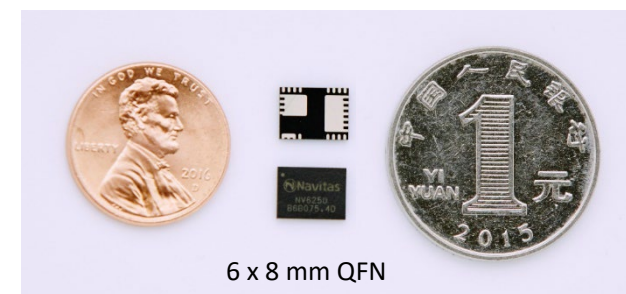
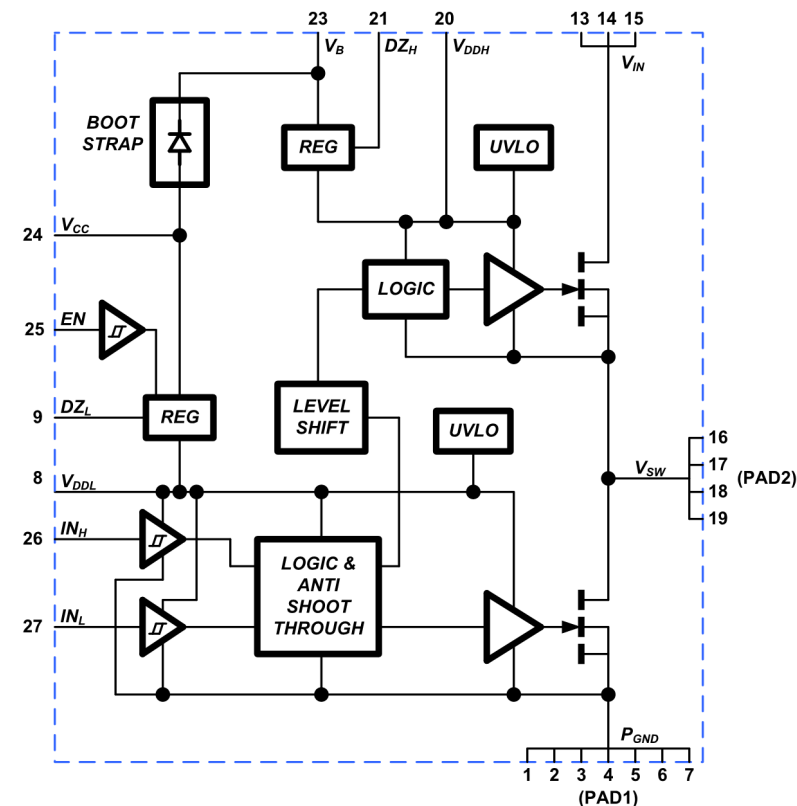
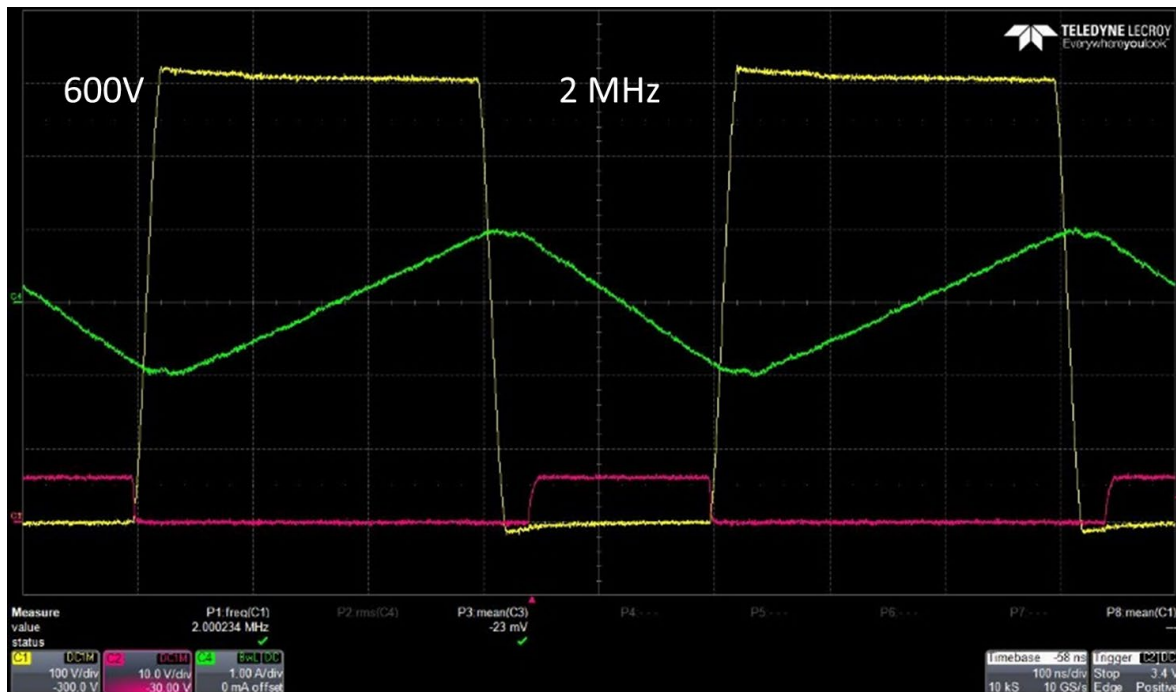




Half-Bridge GaNFast Power IC

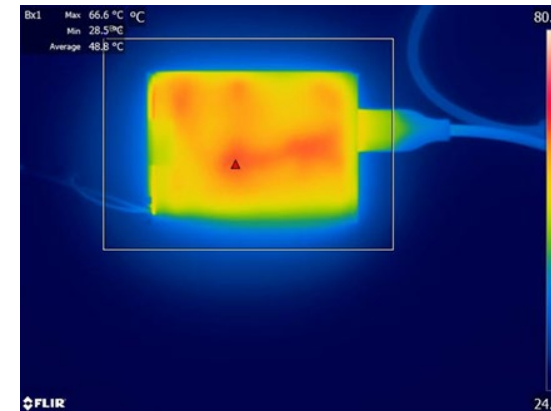
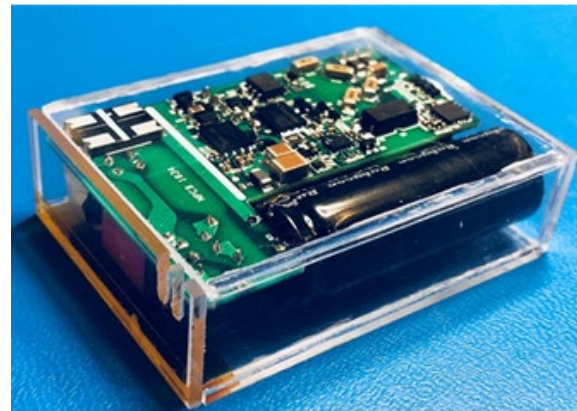
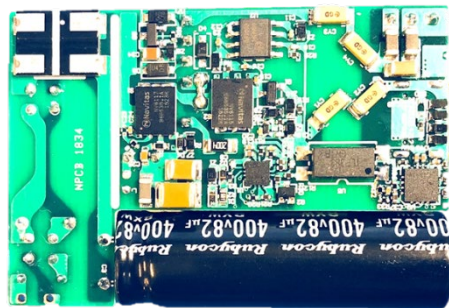
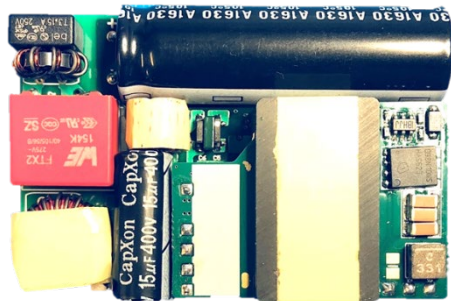
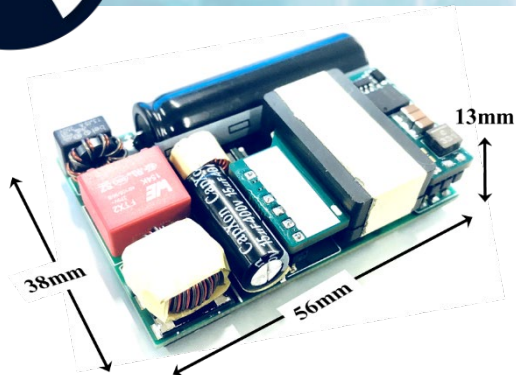


- Monolithic integration, 650V
 - 2x GaN FETs
 - 2x GaN drivers
 - GaN Logic (level-shift, bootstrap, UVLO, shoot-through, ESD)
- “Digital In, Power Out”



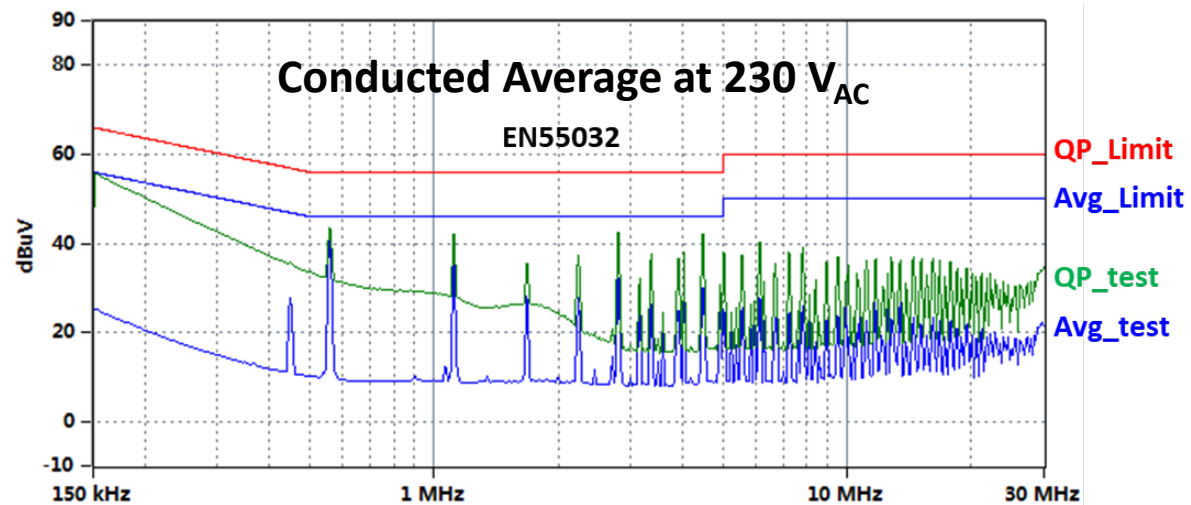
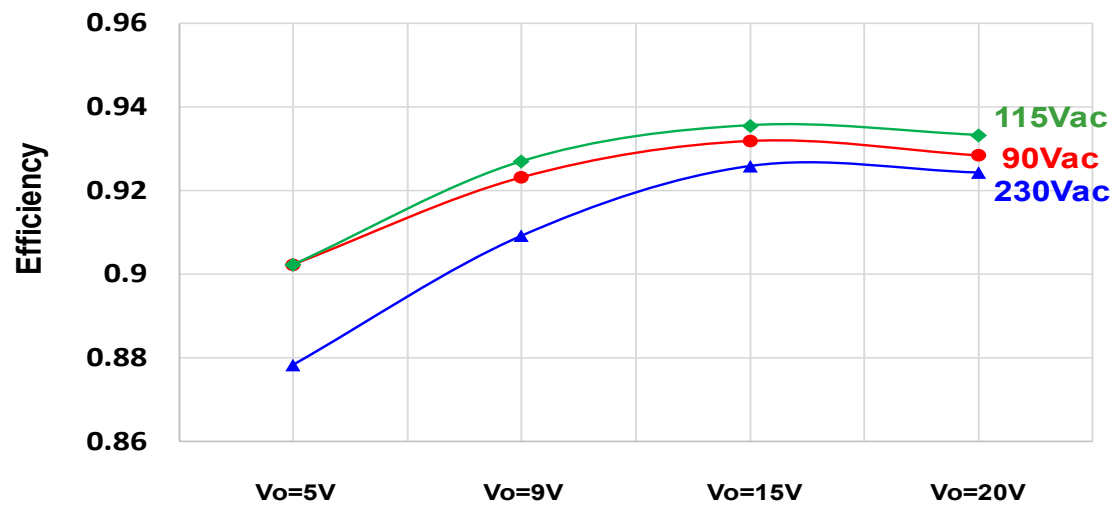


World's Smallest 65W USB-PD



Power, Output	65 W USB-PD
Topology	ACF with NV6115, NV6117 GaNFast Power ICs
Frequency	600 kHz
Size	27 cc (45 cc with case)
Density	2.4 W/cc (39 W/in ³) uncased 1.5 W/cc (24 W/in ³) cased
Efficiency	93.3% peak (115 V _{AC}) 93.2% at 90 V _{AC} , full load DoE Level VI, Euro CoC (EuP) Tier 2

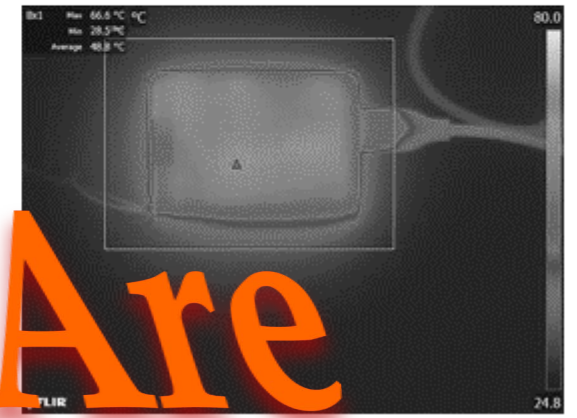
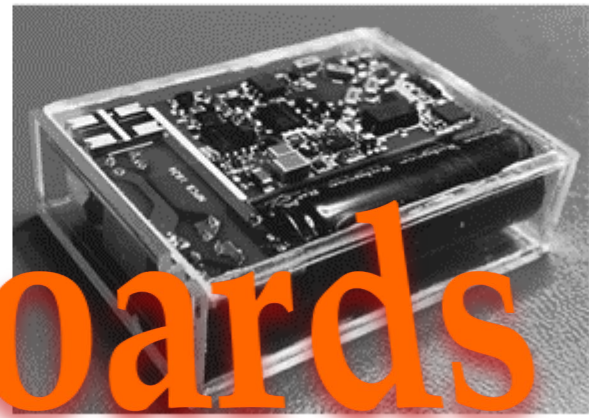
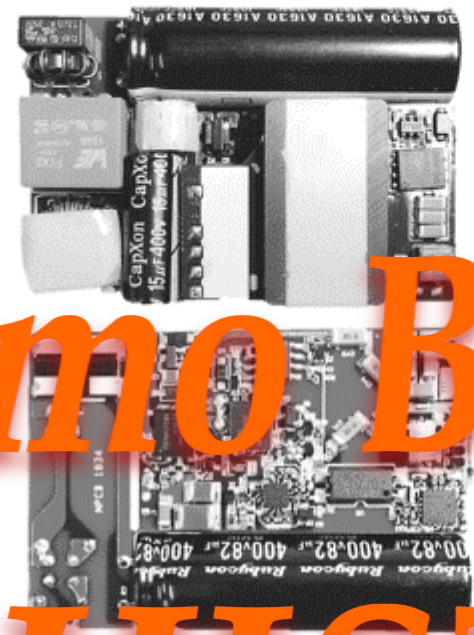
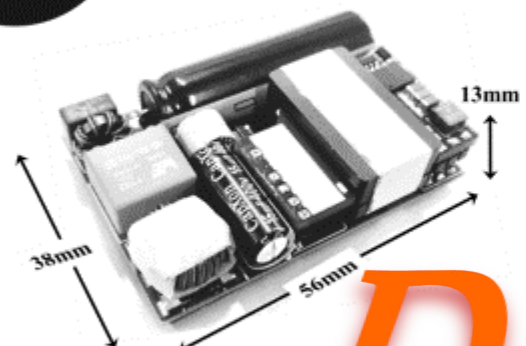
115 V_{AC}, 20 V / 3.25 A, 25°C ambient, no case, no airflow, no heatsink
20mins steady state operation. Maximum case <70°C





World's Smallest 65W USB-PD

GaNFast™

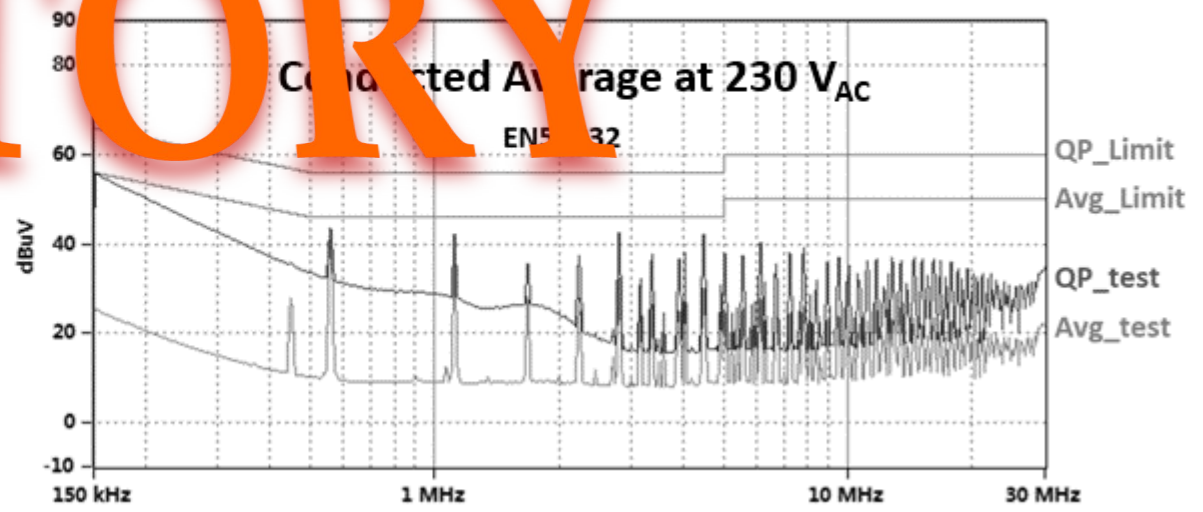
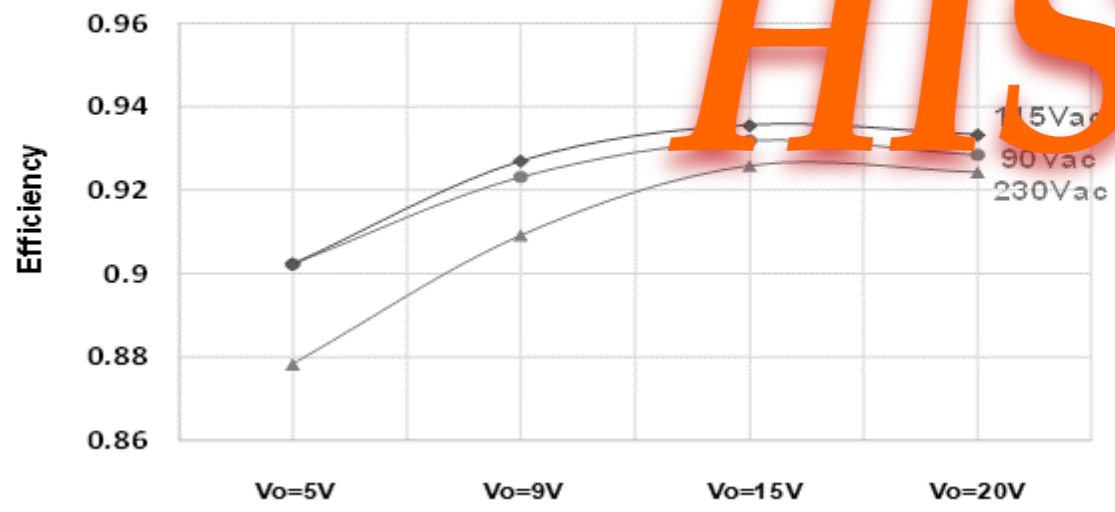


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Density	2.4 W/cc (39 W/in ³) uncased 1.5 W/cc (24 W/in ³) cased
Efficiency	93.3% peak (115 V _{AC}) 93.2% at 90 V _{AC} full load DoE Level VI, Euro CoC (EuP) Tier 2

Demo Boards Are

115 V_{AC} 20 V / 3.25 A, 25°C ambient, no case, no airflow, no heatsink
20mins steady state operation. Maximum case <70°C

HISTORY





- GaNFast power ICs:
 - Capability
 - Voltage, power, system performance
 - Reliability
 - 'Time-zero', lifetime
 - Availability
 - Capacity (M's/month), leadtime (12 weeks)
 - Cost-competitive

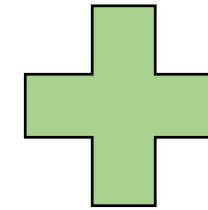


'Beyond' JEDEC Qualification



GaN-Based Qual Plan

	Reference	Test Conditions	Duration	Lots	S.S.
Package Stress	JESD22-A113 J-STD-020	Preconditioning (MSL1): Moisture Preconditioning + 3x reflow: HAST, UHAST, TC & PC	N/A	3	308
	JESD22-A104	Temperature Cycle: -55°C / 150°C	1,000cy	3	77
	JESD22-A122	Power Cycle: Delta T _j = 100°C	10,000cy	3	77
	JESD22-A110	Highly Accelerated Stress Test: 130°C / 85%RH / 100V V _{DS}	96hrs	3	77
Die Stress	JESD22-A108	High Temperature Reverse Bias: 150°C / 520V V _{DS}	1,000hrs	3	77
	JESD22-A108	High Temperature Gate Bias: 150°C / 6V V _{GS}	1,000hrs	3	77
	JESD22-A108	High Temperature Operating Life	1,000hrs	3	77
	JS-001-2014	Human Body Model ESD	N/A	1	3
	JS-002-2014	Charged Device Model ESD	N/A	1	3



Lifetime Models
(HTOL, HTRB)

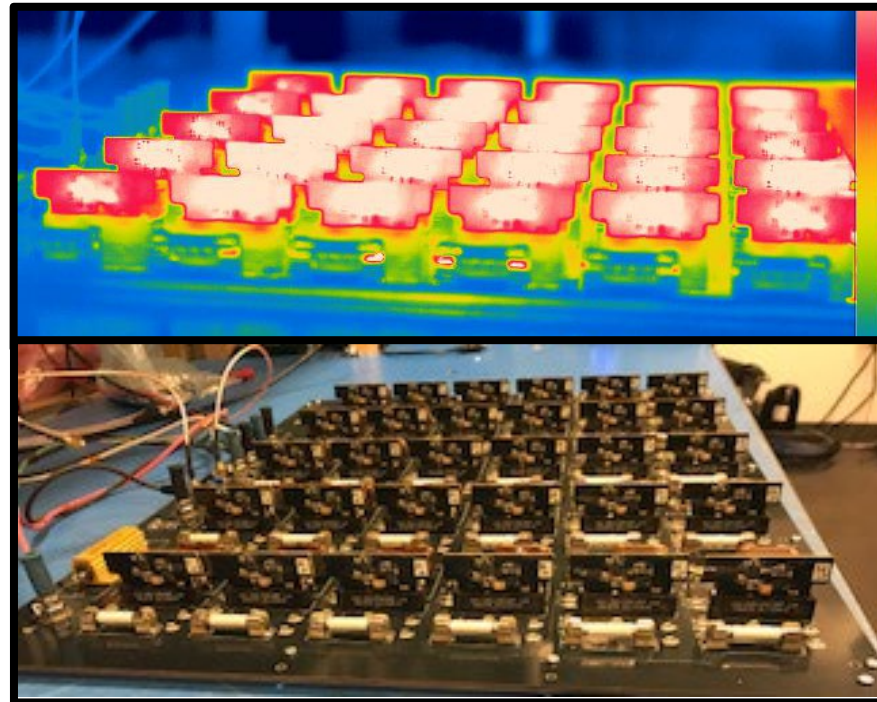
Failure Modes
Established

Application Specific HTOL Test Bench



HTOL Mother Board

- Matches all elements of application profile
 - FET & IC
- Many cells in parallel
 - Statistical sample sizes
- Low total power consumption
- Conditions changeable to develop lifetime and acceleration models



Qualification

3 Lots
x 77

Lifetime Models

Voltage
Current
Frequency
Temperature

Early Life
Failure Rate

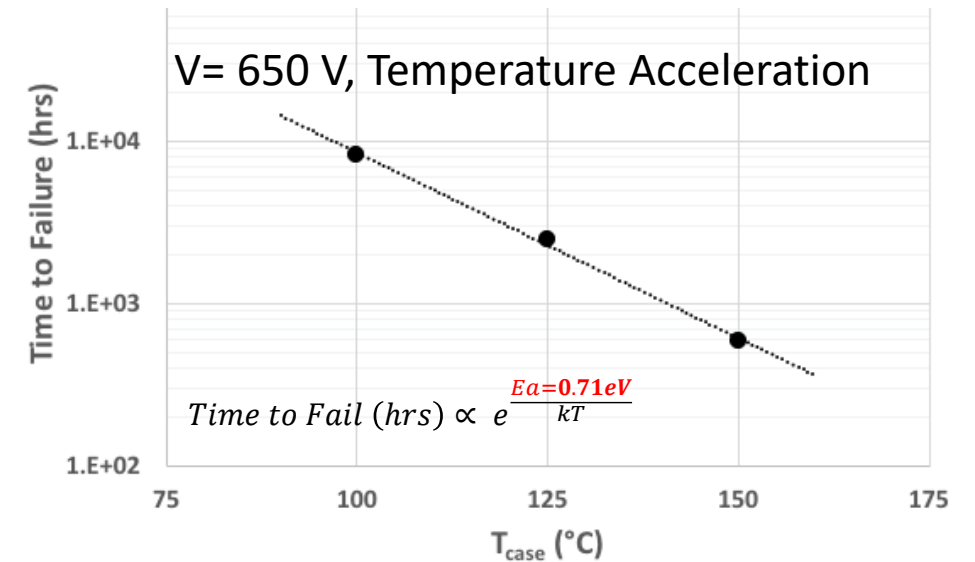
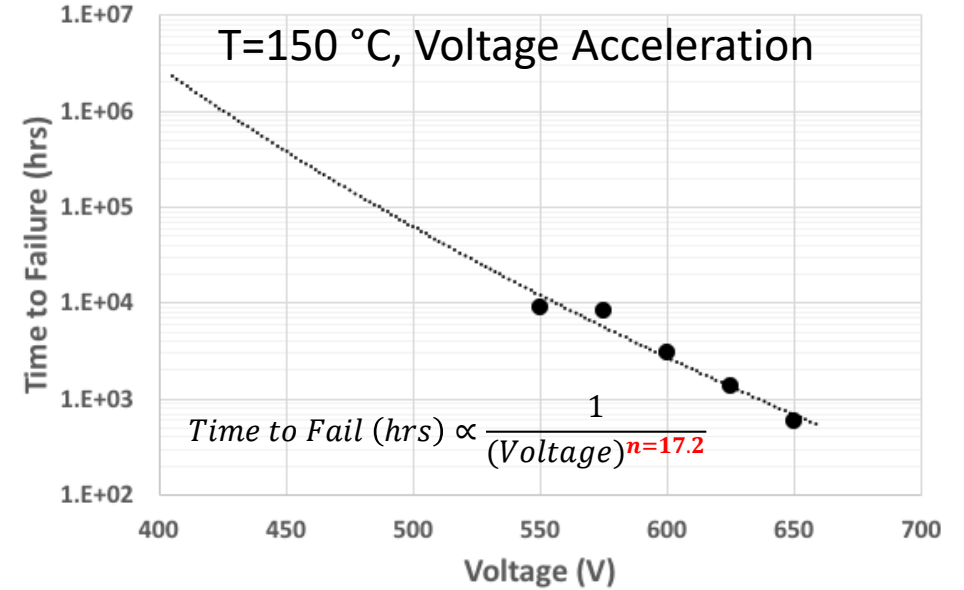
3 Lots
x 1,000



HTOL-based Lifetime Model



Voltage/ Temperature	100	125	150
550			✓
575			✓
600			✓
625			✓
650	✓	✓	✓





Lifetime Estimation: ACF Charger



$$\text{Temperature Acceleration Factor}(AF_{temp}) = e^{\frac{E_a}{k} \times (\frac{1}{T_{application}} - \frac{1}{T_{reliability}})}$$

$E_a = 0.71\text{eV}$

$$\text{Voltage Acceleration Factor}(AF_{voltage}) = (\frac{V_{reliability}}{V_{application}})^n$$

$n = 17.2$

$$\text{Total Acceleration Factor}(AF_{Total}) = AF_{TEMP} \times AF_{VOLTAGE}$$

$$\text{Lifetime estimate in application} = AF_{Total} \times \text{Time to failure in reliability} (TTF_{reliability})$$

ACF Charger
Full-Power
Profile →

AC line Voltage (V)	Rectified AC voltage (V)	Reflected Voltage (V)	Switch Voltage (V)	Full power Temp (°C)
120	170	120	290	85
240	340	120	460	85

$$\text{Lifetime} = AF_{Total} \times TTF_{reliability} = \mathbf{233 \text{ years}} @ 240V AC input$$

- Predicted lifetime exceeds 10yr lifetime requirement



Baseline: "The Mu"

2x **1.2 AMP**

2x1.2 AMP / 2x6 WATT
DUAL USB PORT

PATENTED
FOLD-FLAT DESIGN

14MM



COMPATIBLE WITH ALL
TABLETS & SMARTPHONES
*SLOW CHARGE FOR TABLETS

AUTHENTIC DETECT FOR SAFE
& EFFICIENT IOS CHARGING



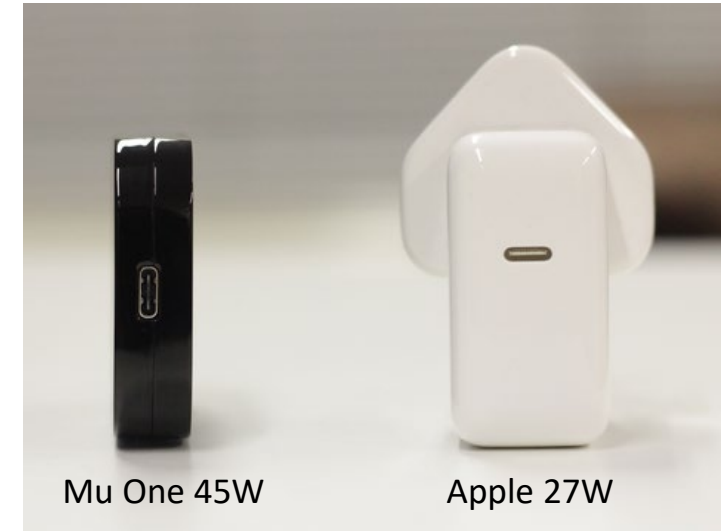
- 14 mm profile
- CE, UL, etc.



- 90-264 V_{AC} input
- 2 x 6 W = 12 W (Type A)



Challenge: “Mu One”

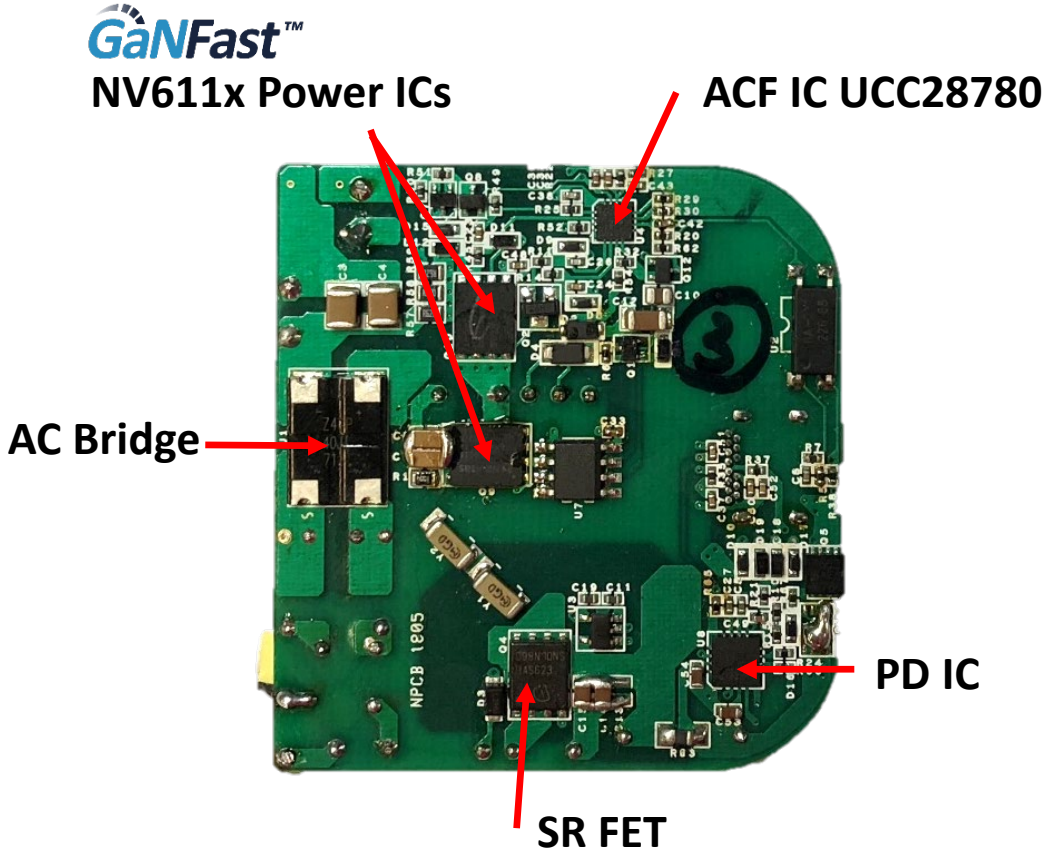
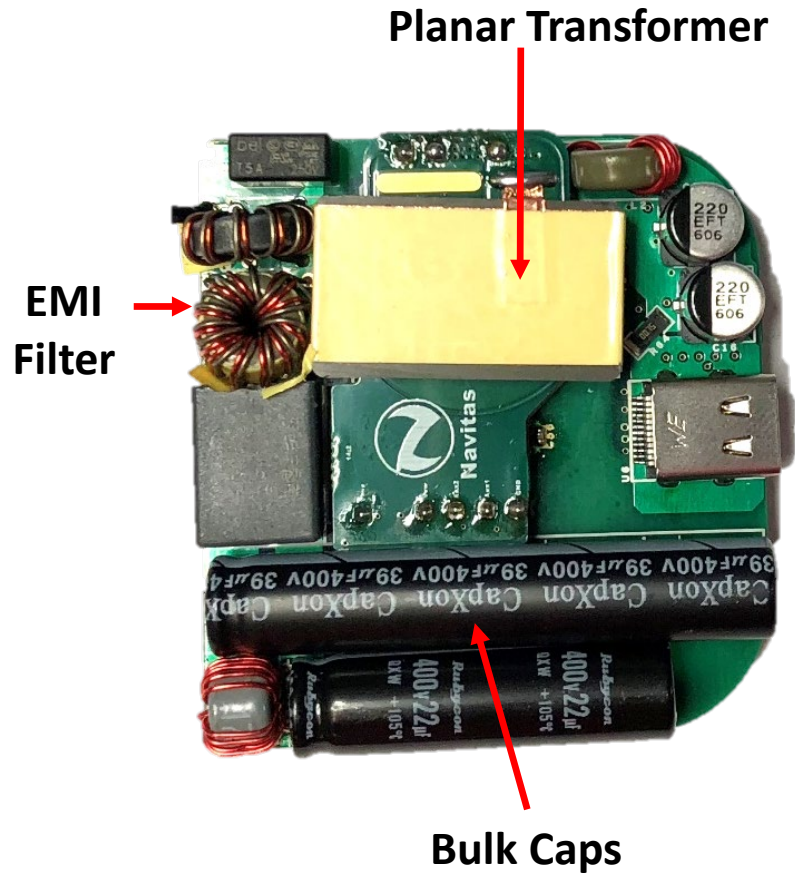


- 14 mm profile
- CE, UL, etc.

- 90-264 V_{AC} input
- ~~2 x 6 W = 12 W (Type A)~~
45 W (USB-PD Type C)

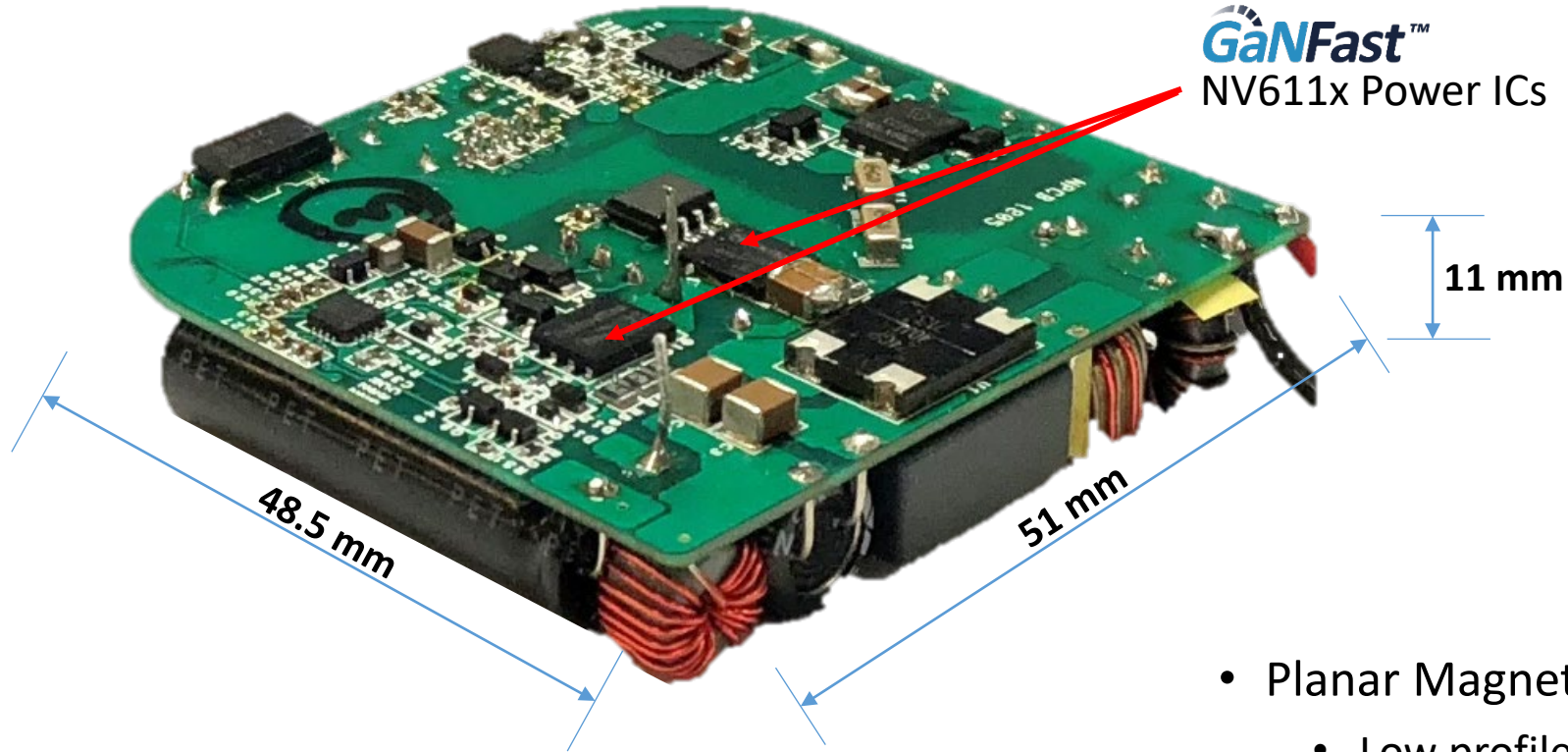


45 W in 11 mm = HF Planar ACF





45 W in 11 mm = HF Planar ACF



- Size : 29 cc (41 cc with case)
- Density : 1.7 W/cc (27 W/in³), 1.1 W/cc (18 W/in³) cased

- Planar Magnetics:
 - Low profile
 - Automated assembly
 - Predictable performance
 - High yield



Cool Operation

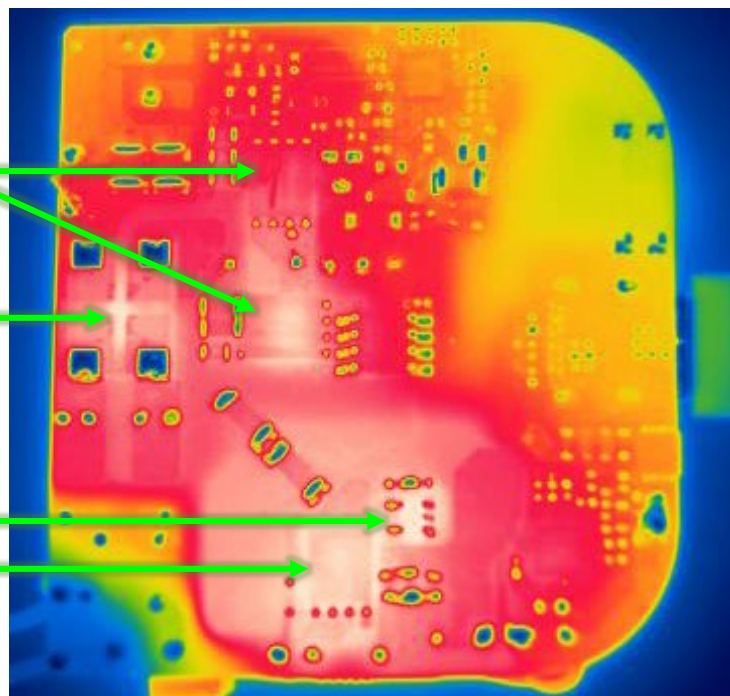
Top

Bottom

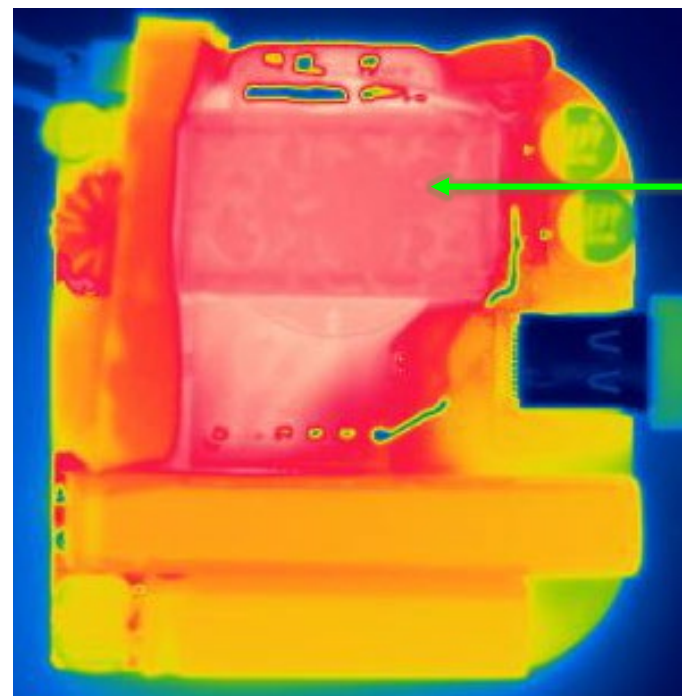
GaNFast
Power IC 75°C, 80°C

AC Bridge 80°C

SR IC 85°C
SR FET 85°C



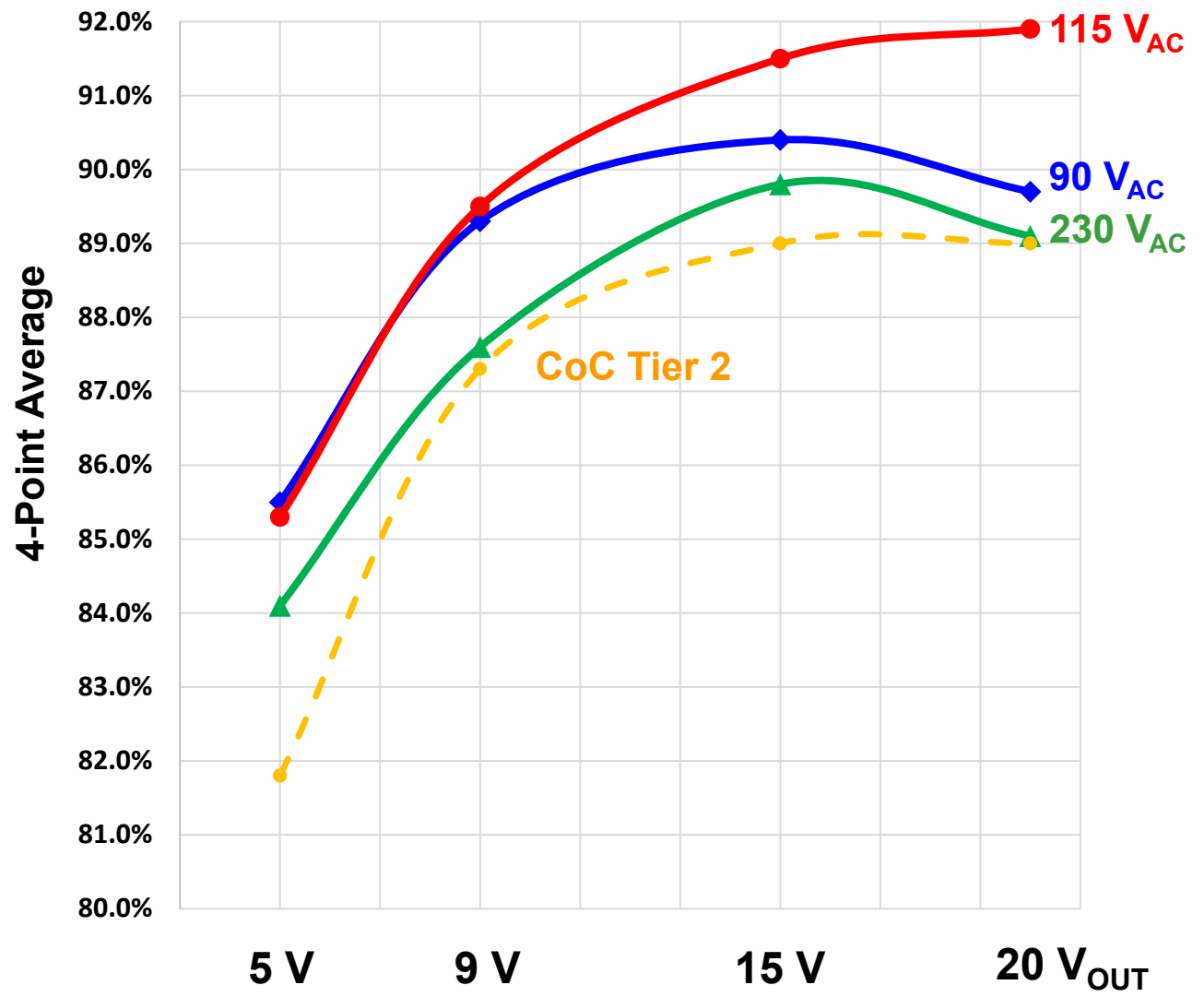
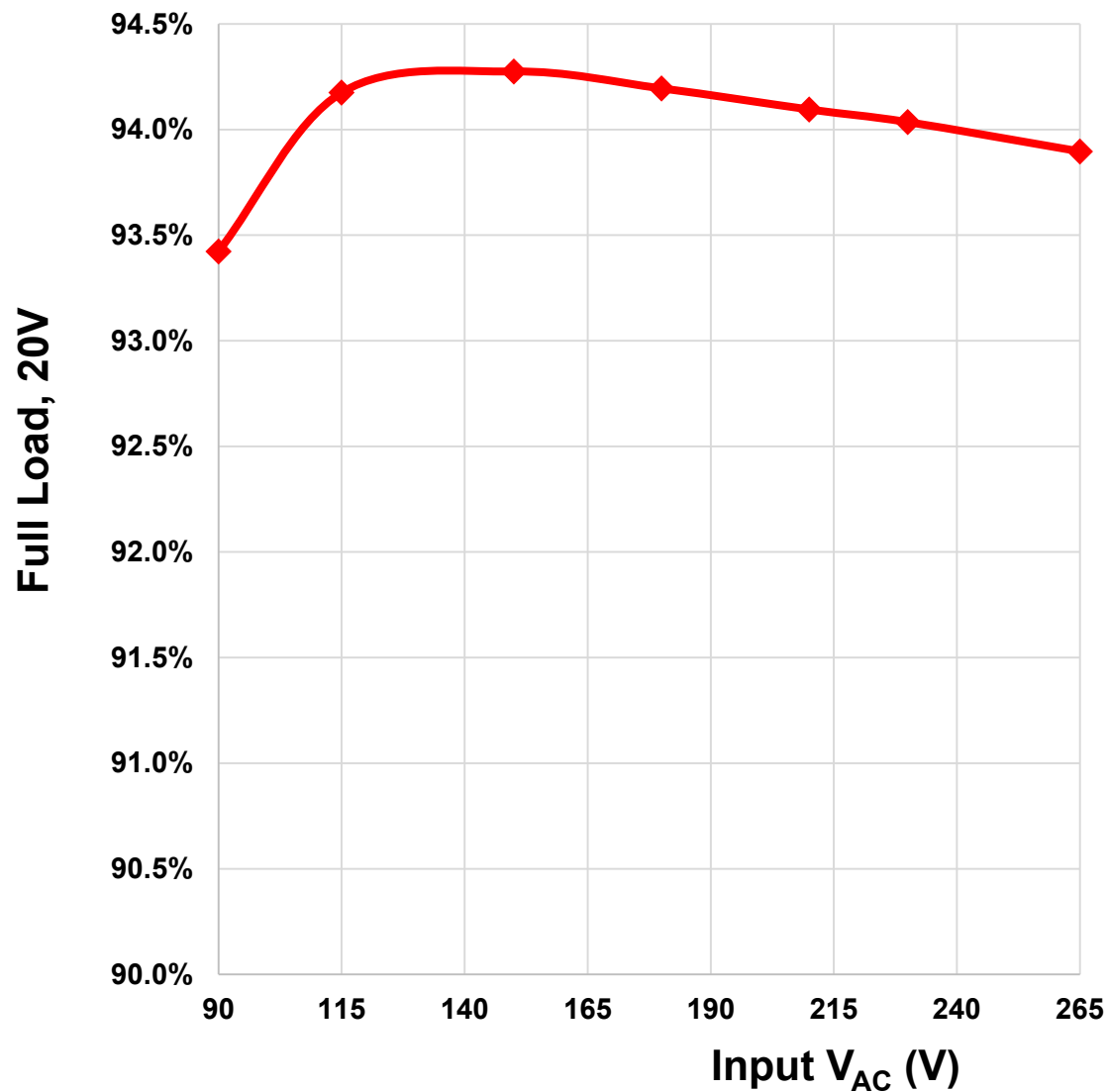
Transformer 80°C



90 V_{AC}, 45 W, 25 °C, uncased, no airflow,
no thermal compound / heatsinking

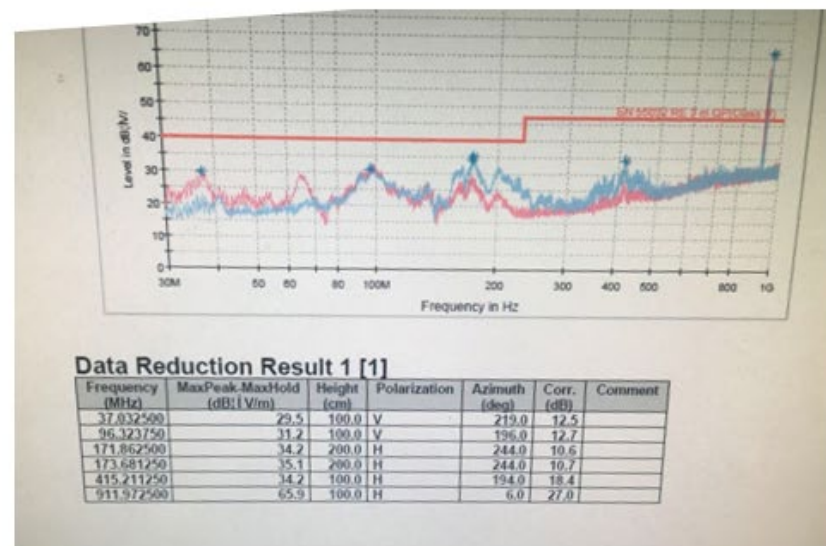
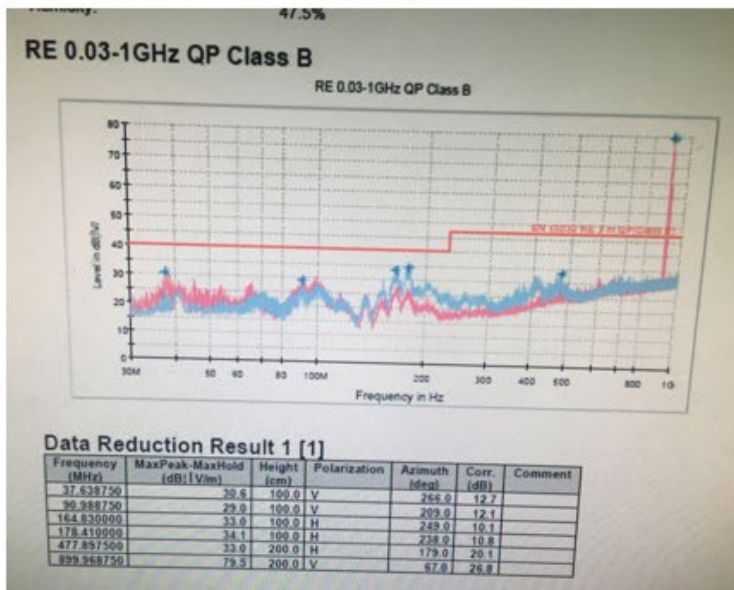
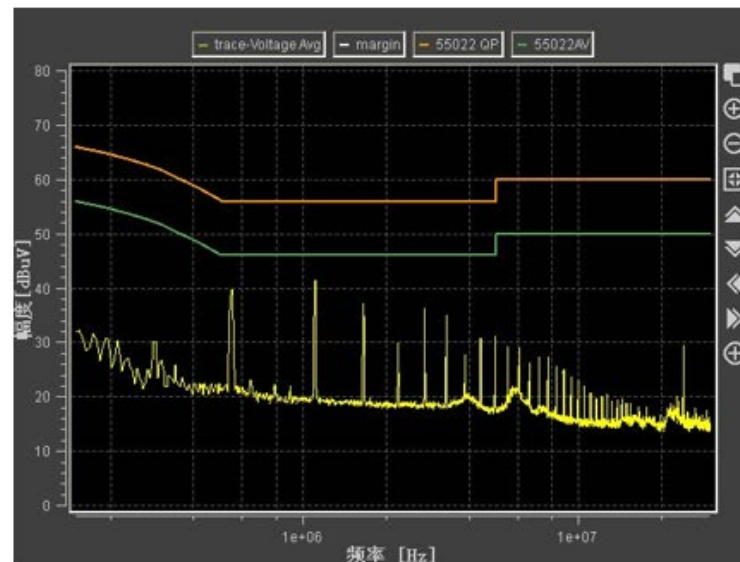
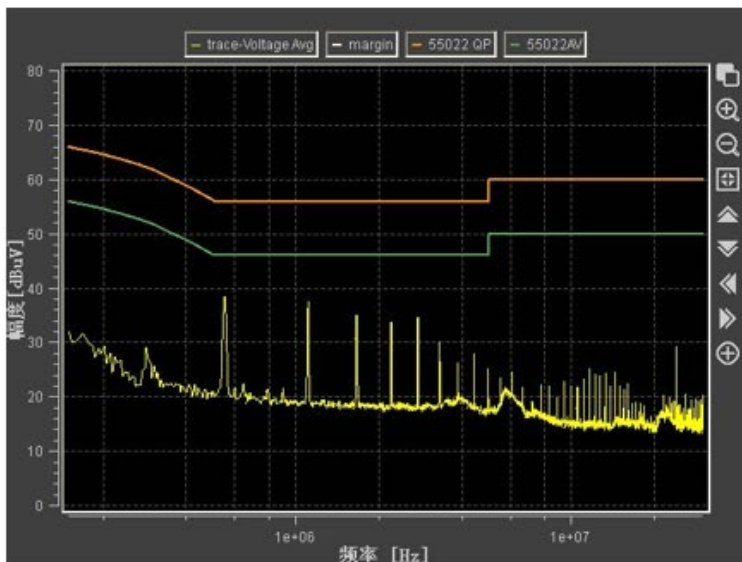


High Efficiency



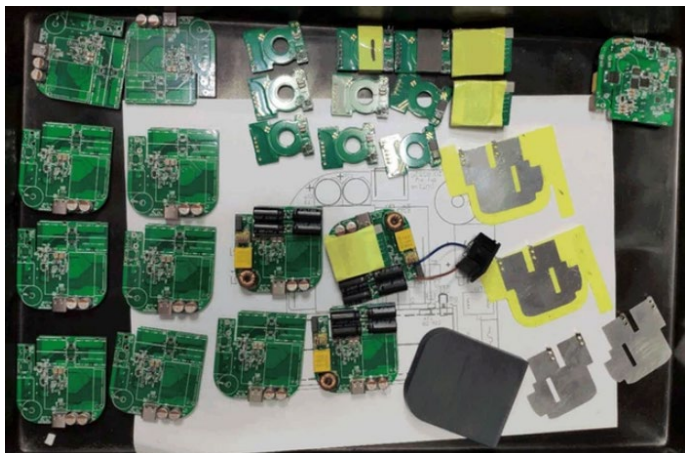


Quiet EMI (Conducted, Radiated)





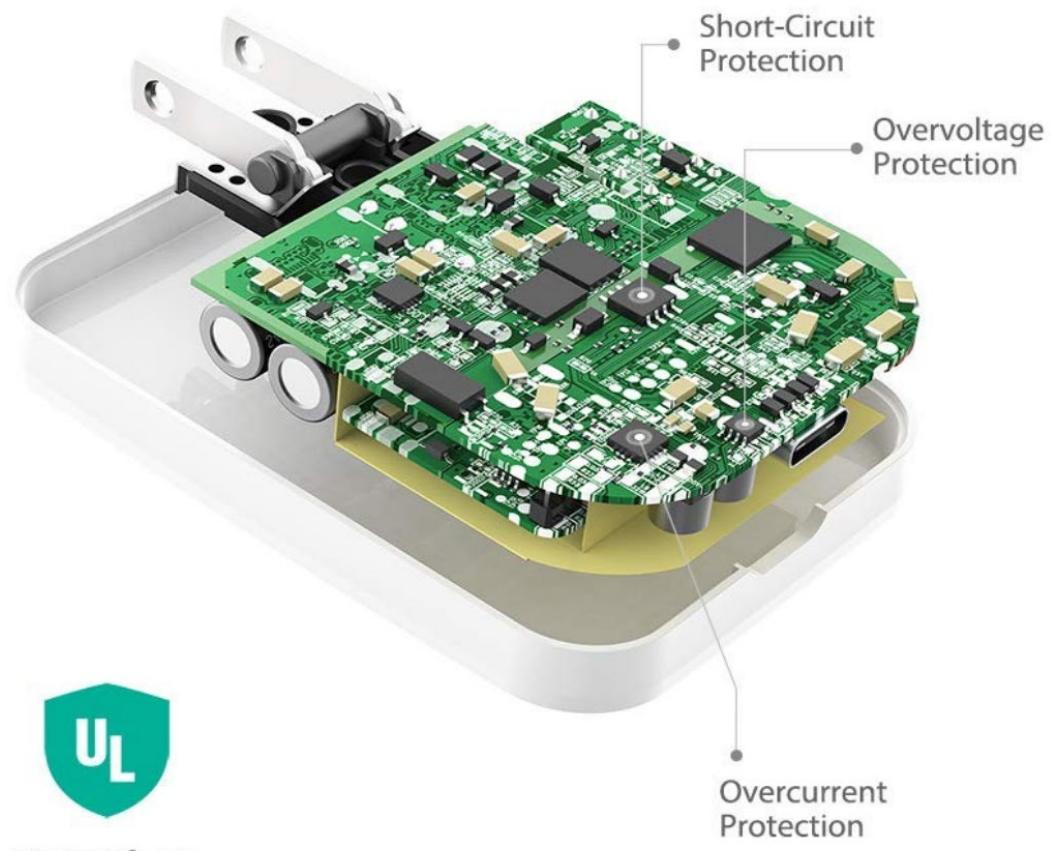
Mu One: From Prototype to Mass Production



- Thanks to Matt Judkins, CEO of Made-in-Mind (Mu)
- Available via www.kickstarter.com now, and via www.amazon.com and airport stores in January



RAVPower 45W USB-C PD



• Available now on www.amazon.com

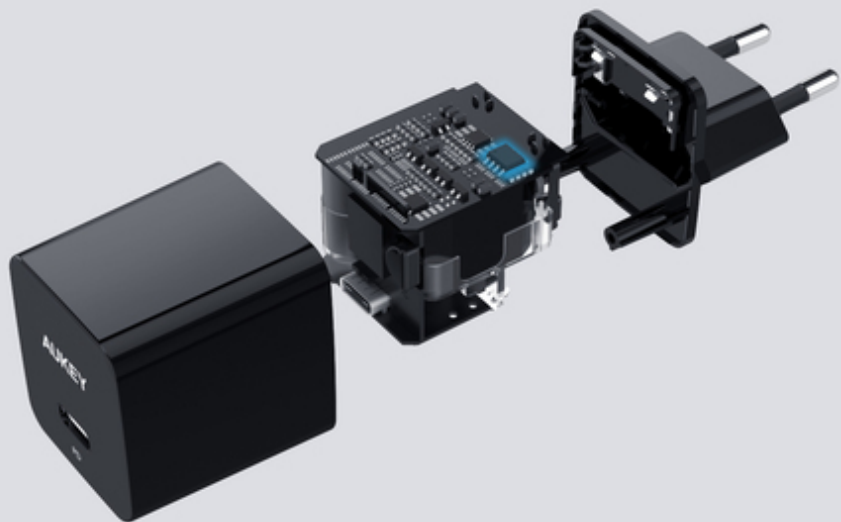


AUKEY 24W, 27W, 30W



AUKEY | **GaNFast™**

Up to 3x faster charging with half the size and weight for unparalleled mobility.



27W USB-C PD



27W USB-C PD



2 x 12W USB-A



30W USB-C PD

- Available now on www.amazon.fr



Let's go **GaNFast™**