Navitas

Let's go GaNFast™

Delivering Performance, Let's Go GaNFast™

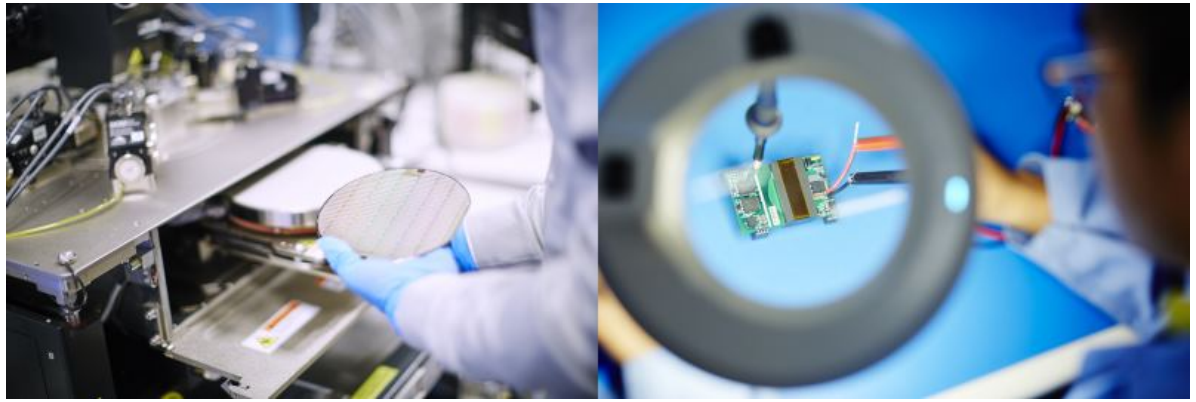
Stephen Oliver, VP Sales & Marketing, stephen.oliver@navitassemi.com

ASPENCORE

Navitas Semiconductor Inc.

GaNFast™

- 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

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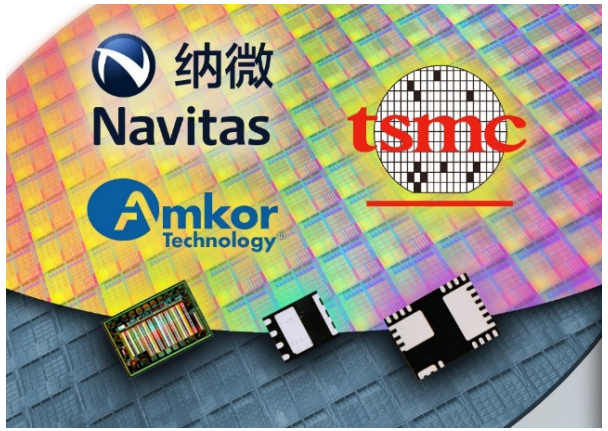
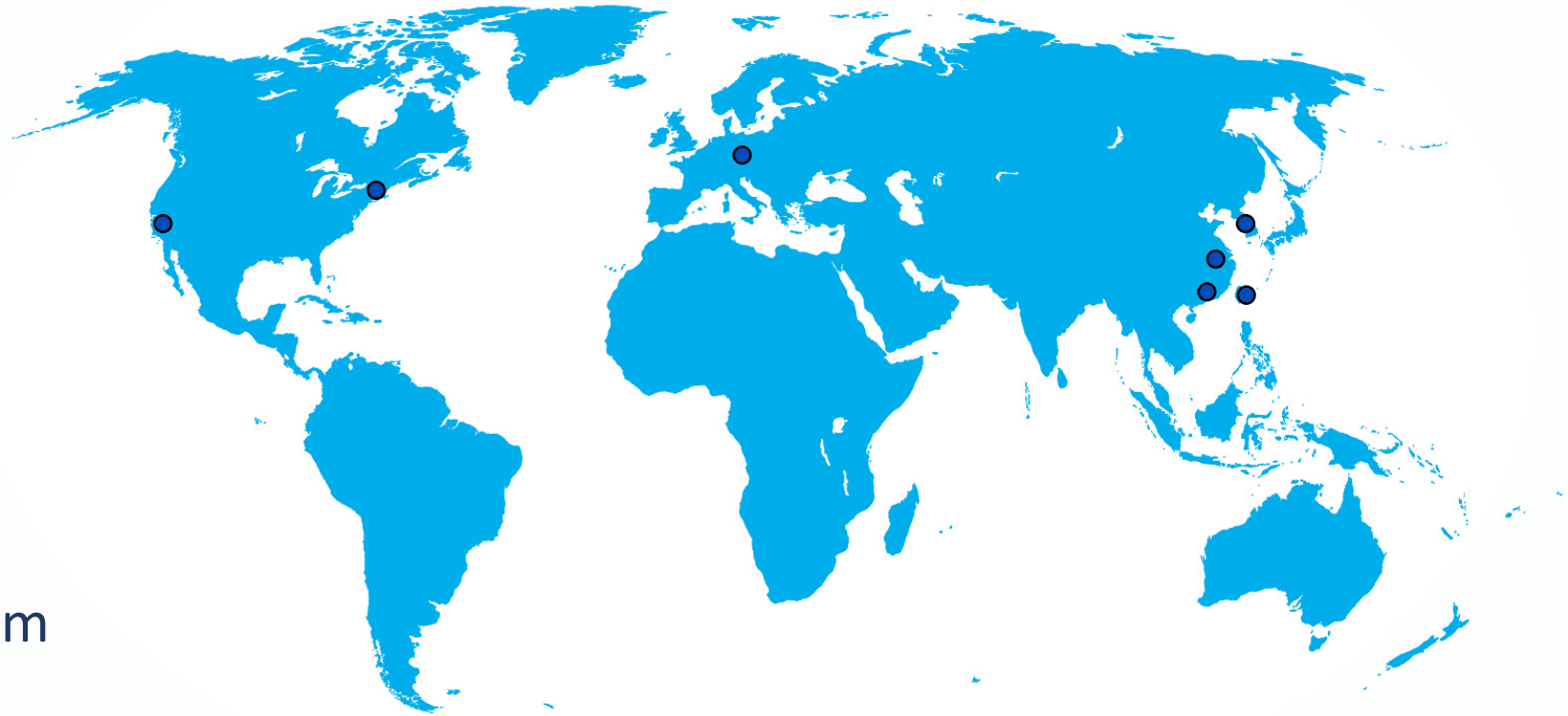
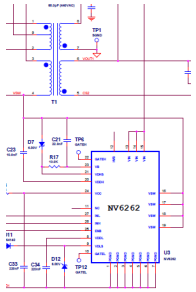
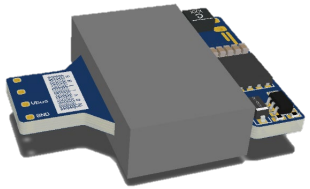


GaNFast Design Support

- 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

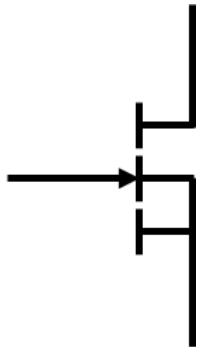






World's First GaNFast™ Power ICs

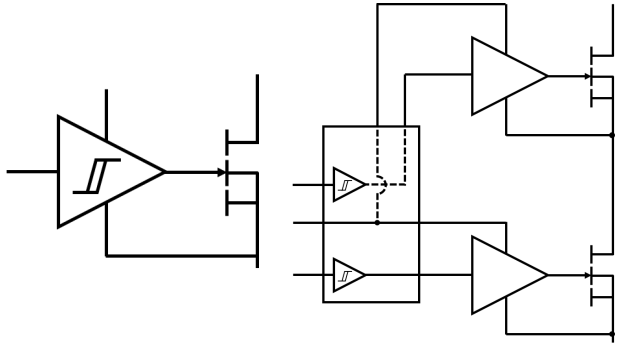
Fastest, most efficient GaN Power FETs



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

+

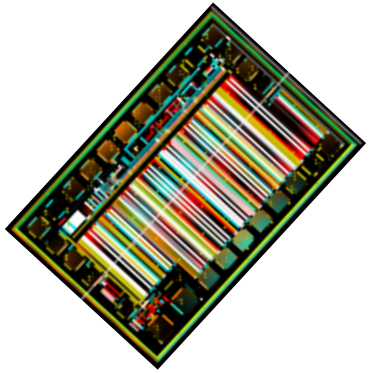
First & Fastest Integrated GaN Gate Drivers



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

=

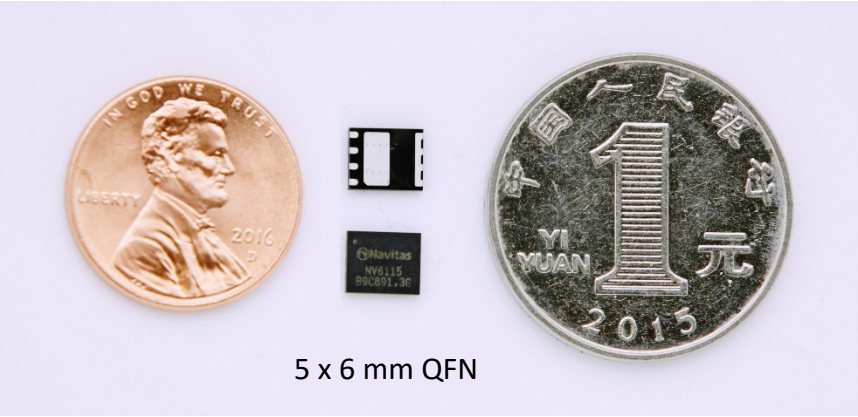
World's First GaNFast™ Power ICs



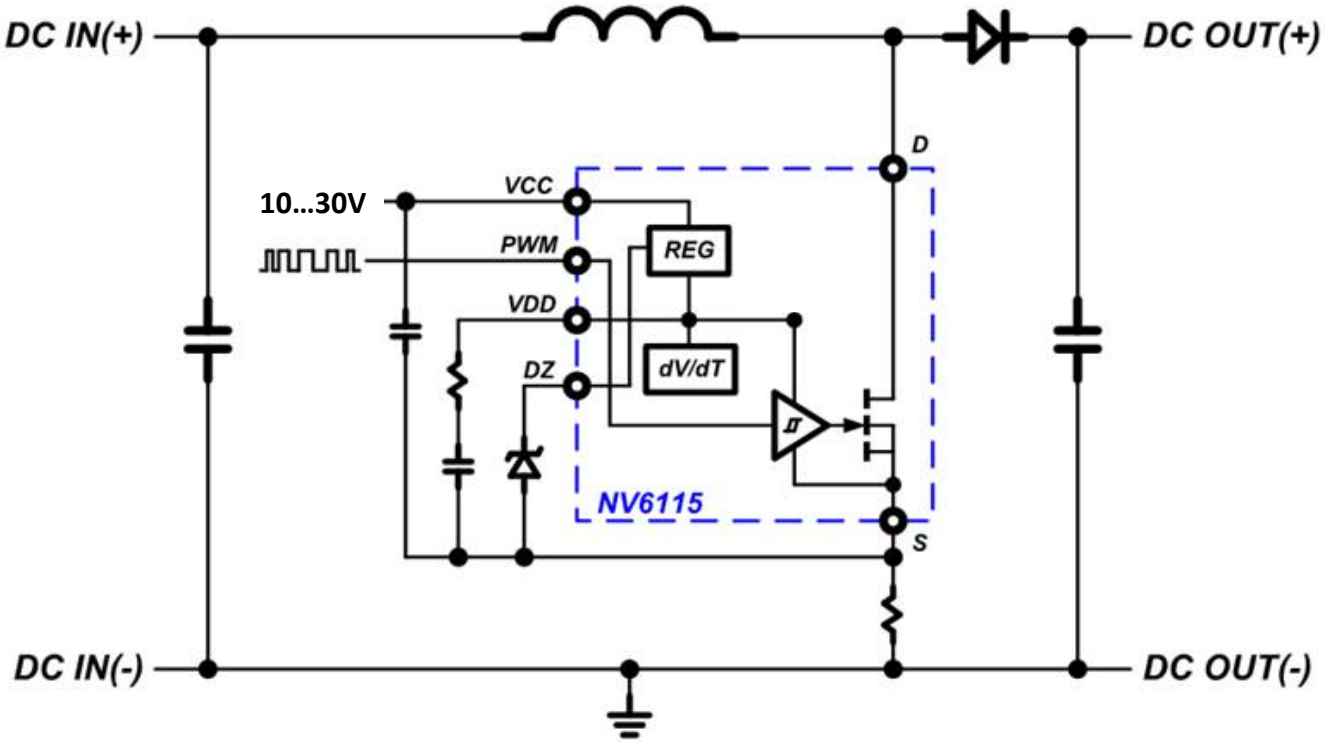
Up to 40MHz switching, 5x higher density & 20% lower system cost

Single GaNFast Power IC

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

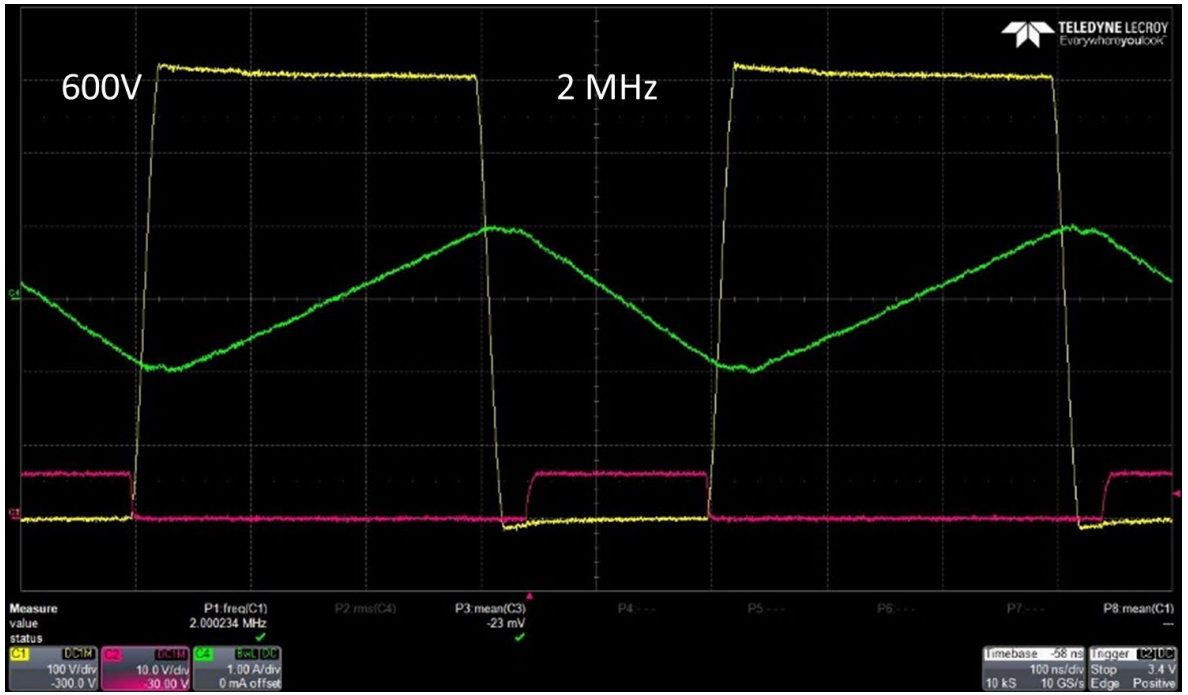


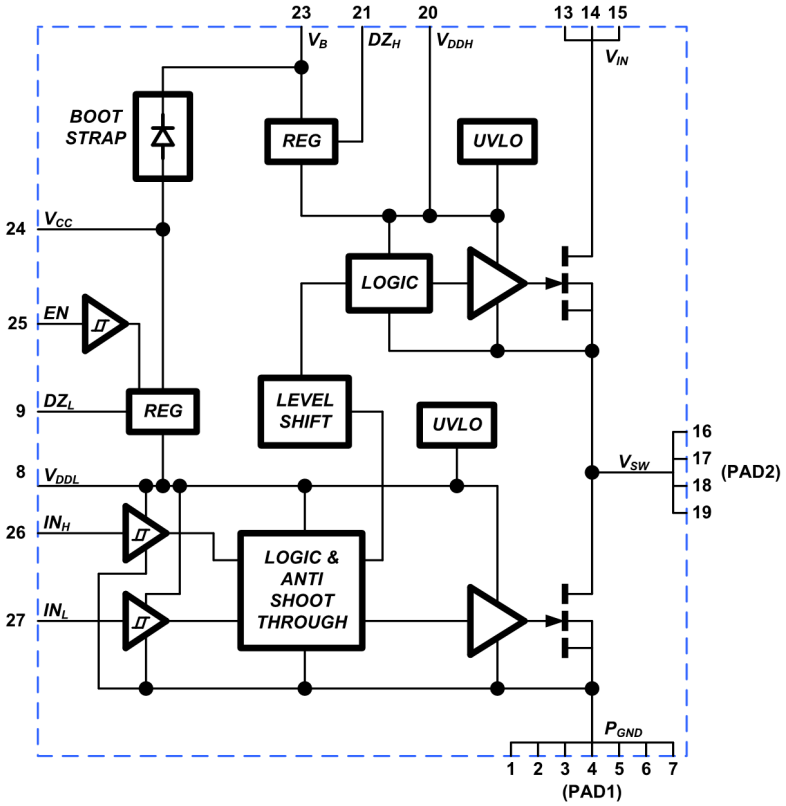
5 x 6 mm QFN

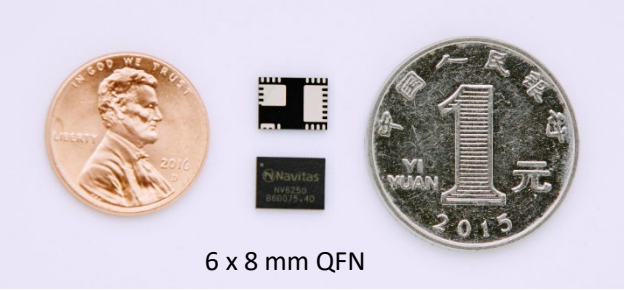


Half-Bridge GaNFast Power IC

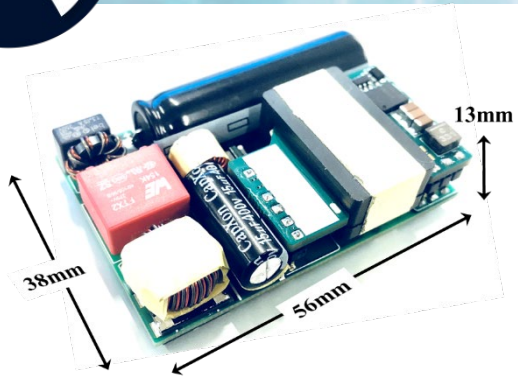
- Monolithic integration, 650V
  - 2x GaN FETs
  - 2x GaN drivers
  - GaN Logic (level-shift, bootstrap, UVLO, shoot-through, ESD)
- “Digital In, Power Out”

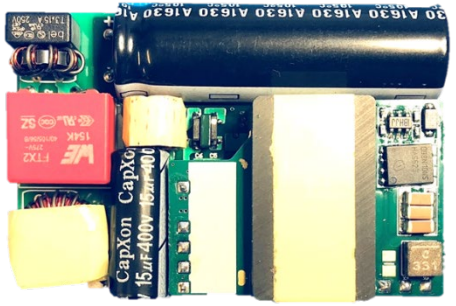


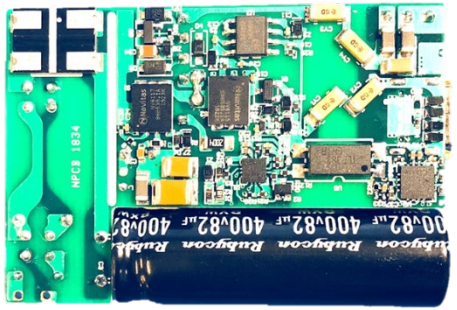




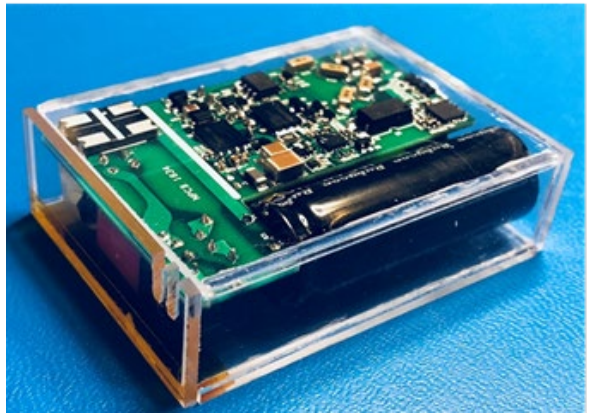
World's Smallest 65W USB-PD

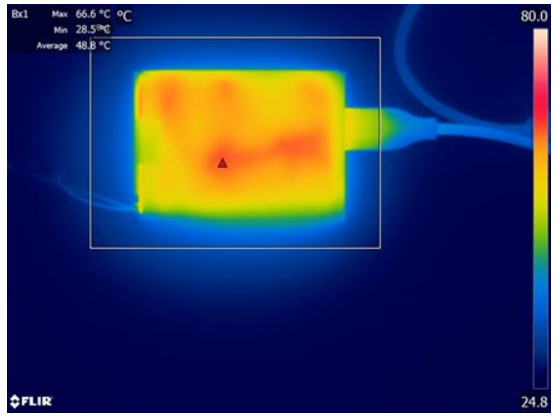




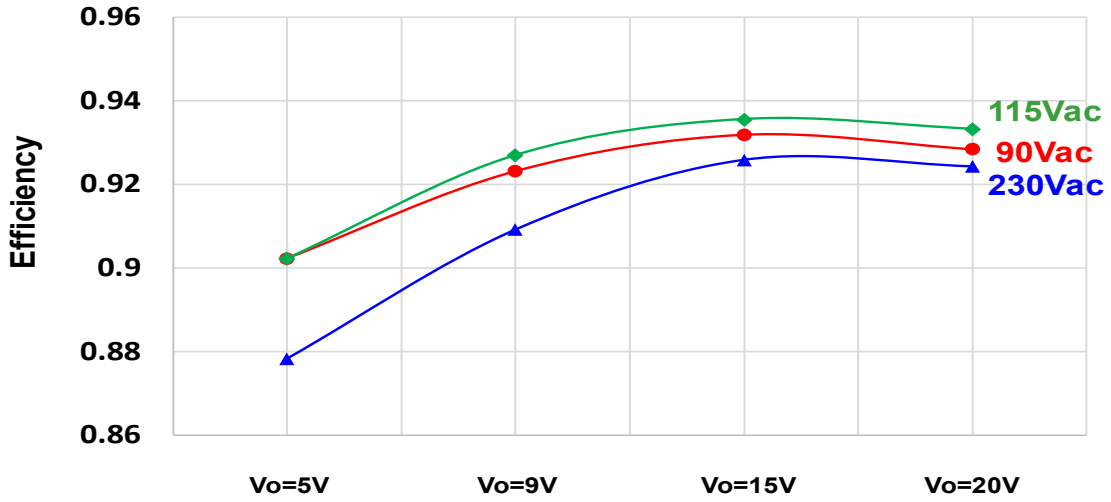


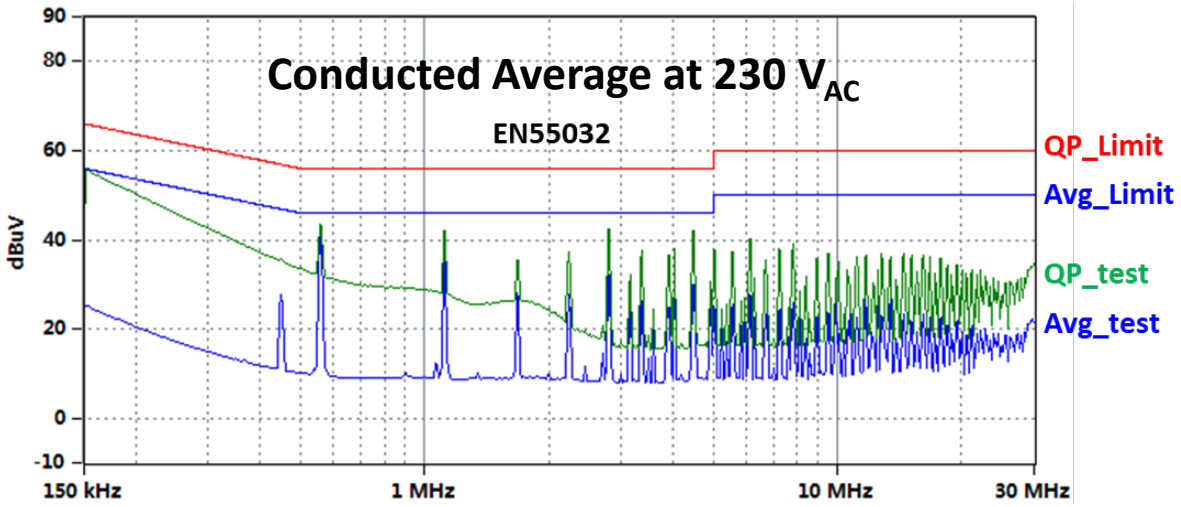
Power, Output	65 W USB-PD
Topology	ACF with NV6115, NV6117 GaNFast Power ICs
Frequency	600 kHz
Size	27 cc (45 cc with case)
Density	2.4 W/cc (39 W/in^3) uncased 1.5 W/cc (24 W/in^3) cased
Efficiency	93.3% peak (115 V_{AC}) 93.2% at 90 V_{AC}, full load DoE Level VI, Euro CoC (EuP) Tier 2





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





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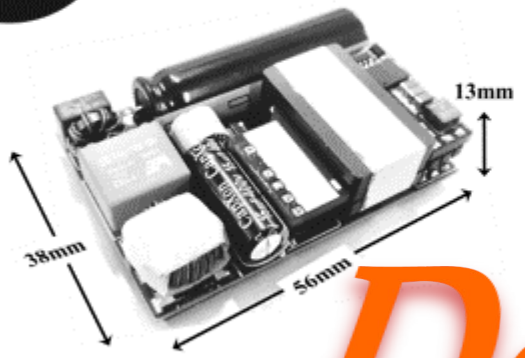
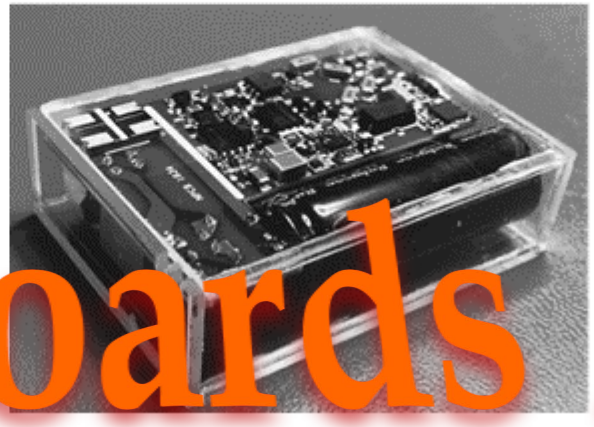
GaNFast™





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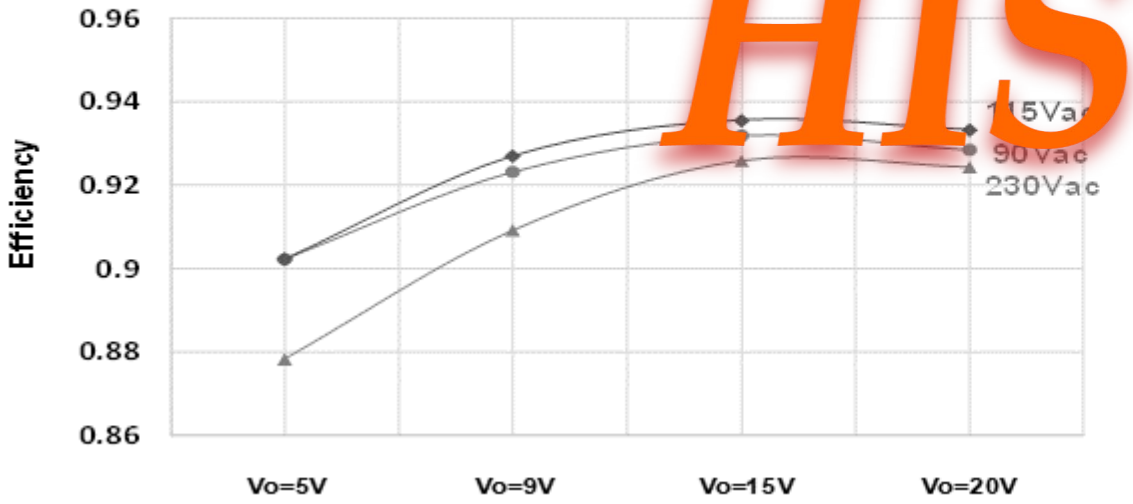
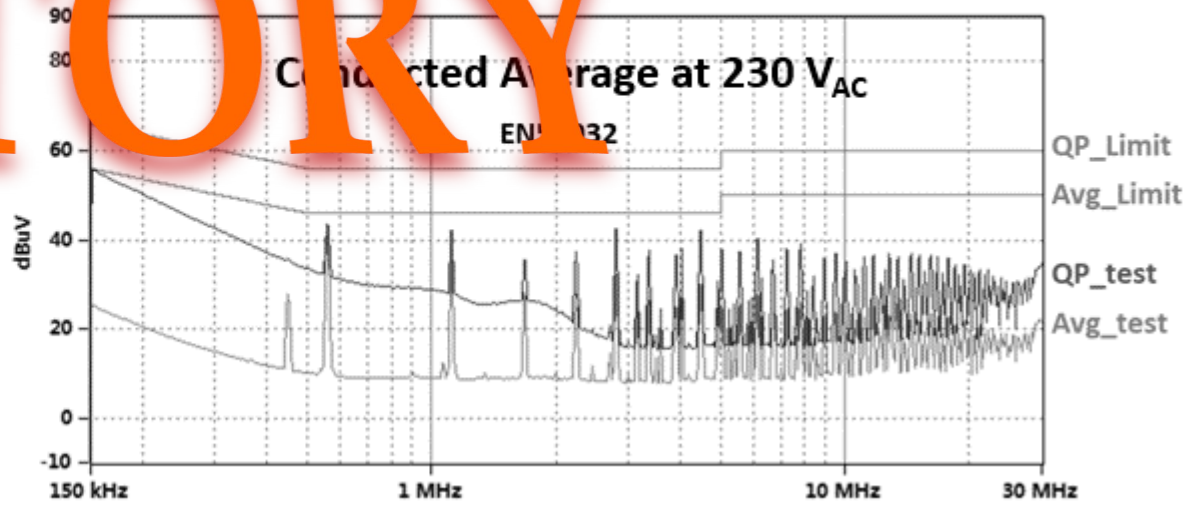
Demo Boards Are HISTORY





Customer Mass Production

- 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

GaNFast™

GaN-Based Qual Plan

Package Stress

Die Stress

Reference	Test Conditions	Duration	Lots	S.S.
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 Tj = 100°C	10,000cy	3	77
JESD22-A110	Highly Accelerated Stress Test: 130°C / 85%RH / 100V V_{DS}	96hrs	3	77
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

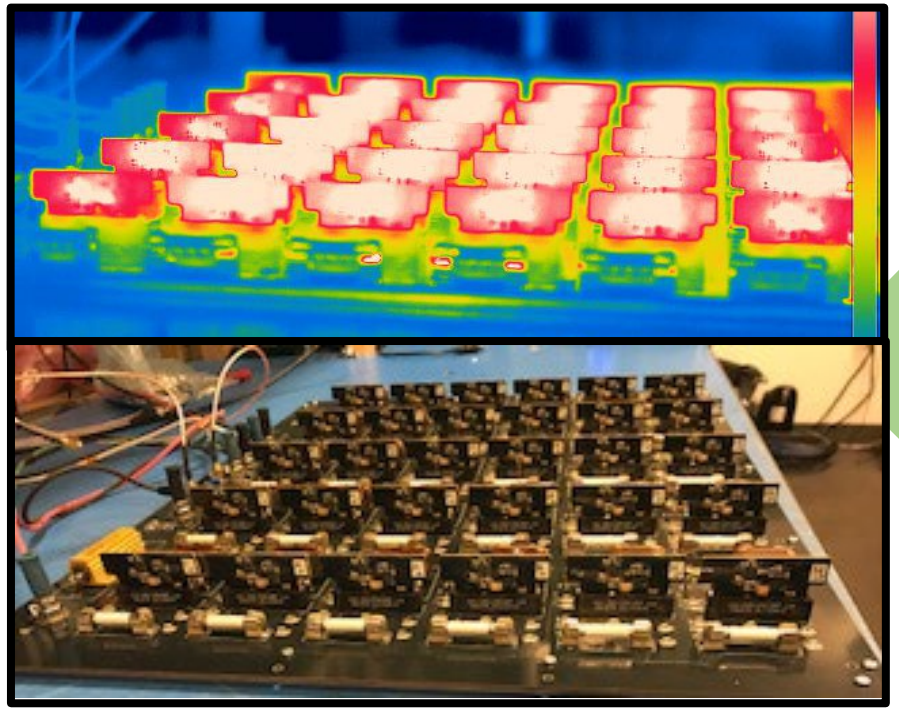
Application Specific HTOL Test Bench

ZVS HTOL at Statistical Sample Sizes

GaNFast™

- 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

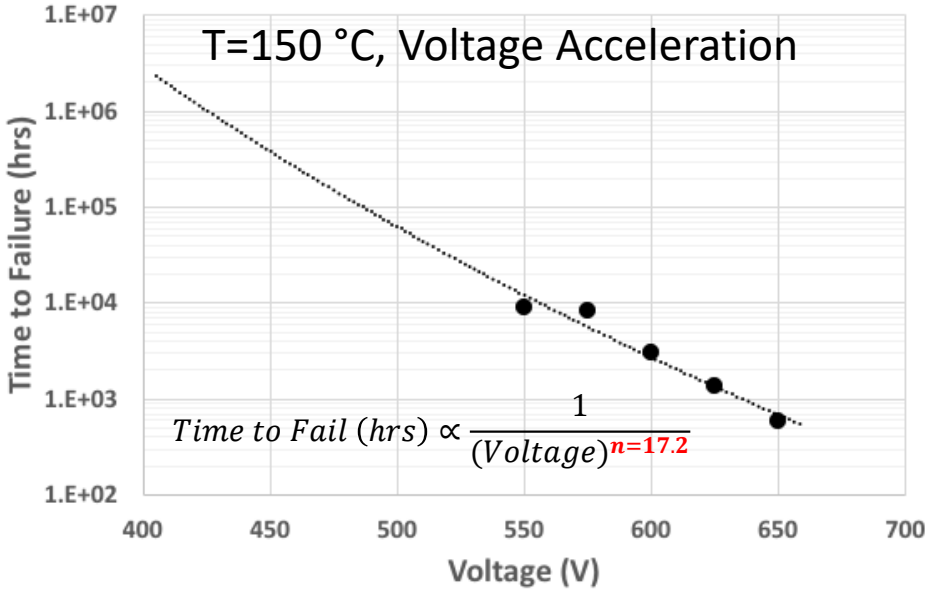
HTOL Mother Board

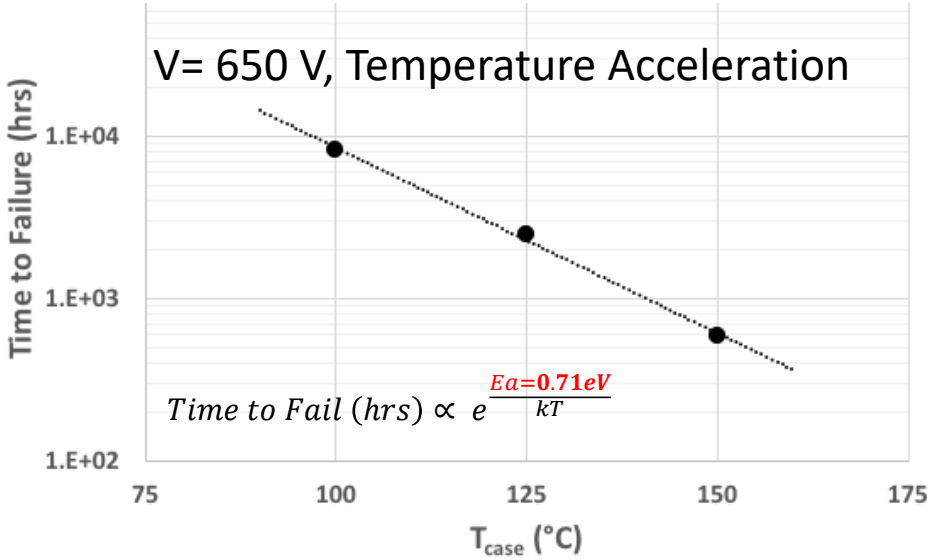


Qualification	3 Lots x 77
Lifetime Models	Voltage Current Frequency Temperature
Early Life Failure Rate	3 Lots x 1,000

HTOL-based Lifetime Model

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





Lifetime Estimation: ACF Charger

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

$E_a = 0.71eV$

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

$n = 17.2$

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

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

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

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

- Predicted lifetime exceeds 10yr lifetime requirement

Baseline: “The Mu”

- 14 mm profile
- CE, UL, etc.

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

Images courtesy Made-in-Mind

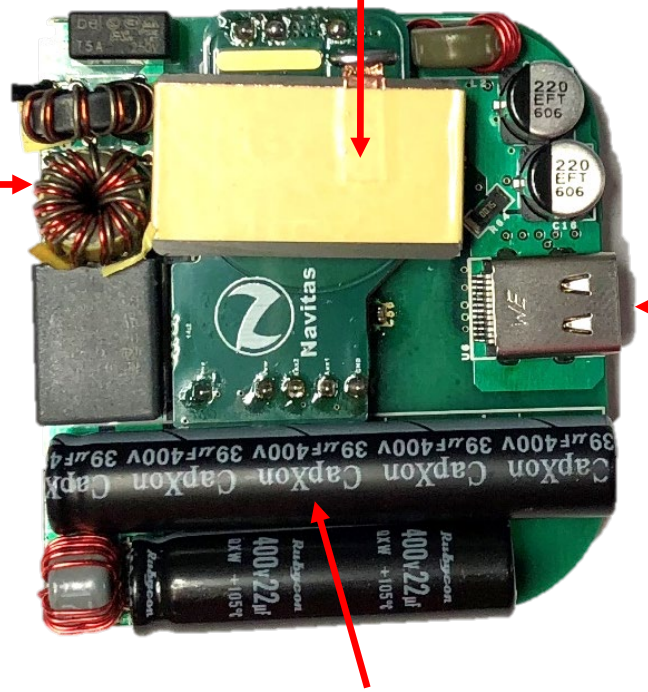
Challenge: “Mu One”

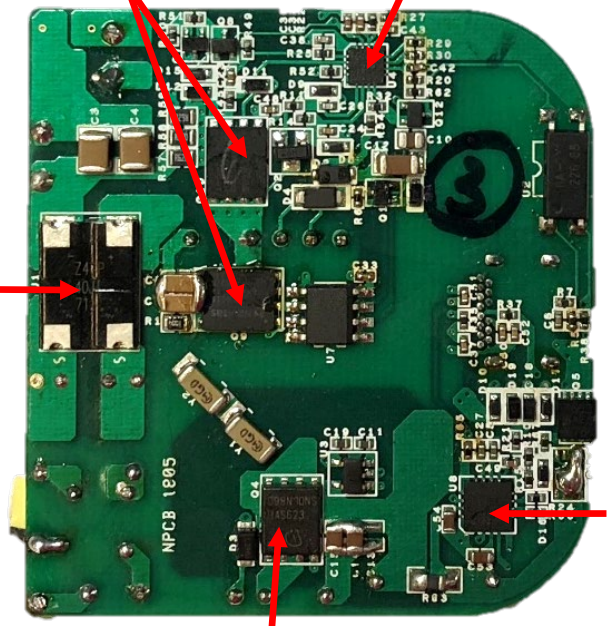
- 14 mm profile
- CE, UL, etc.

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

Images courtesy Made-in-Mind

45 W in 11 mm = HF Planar ACF





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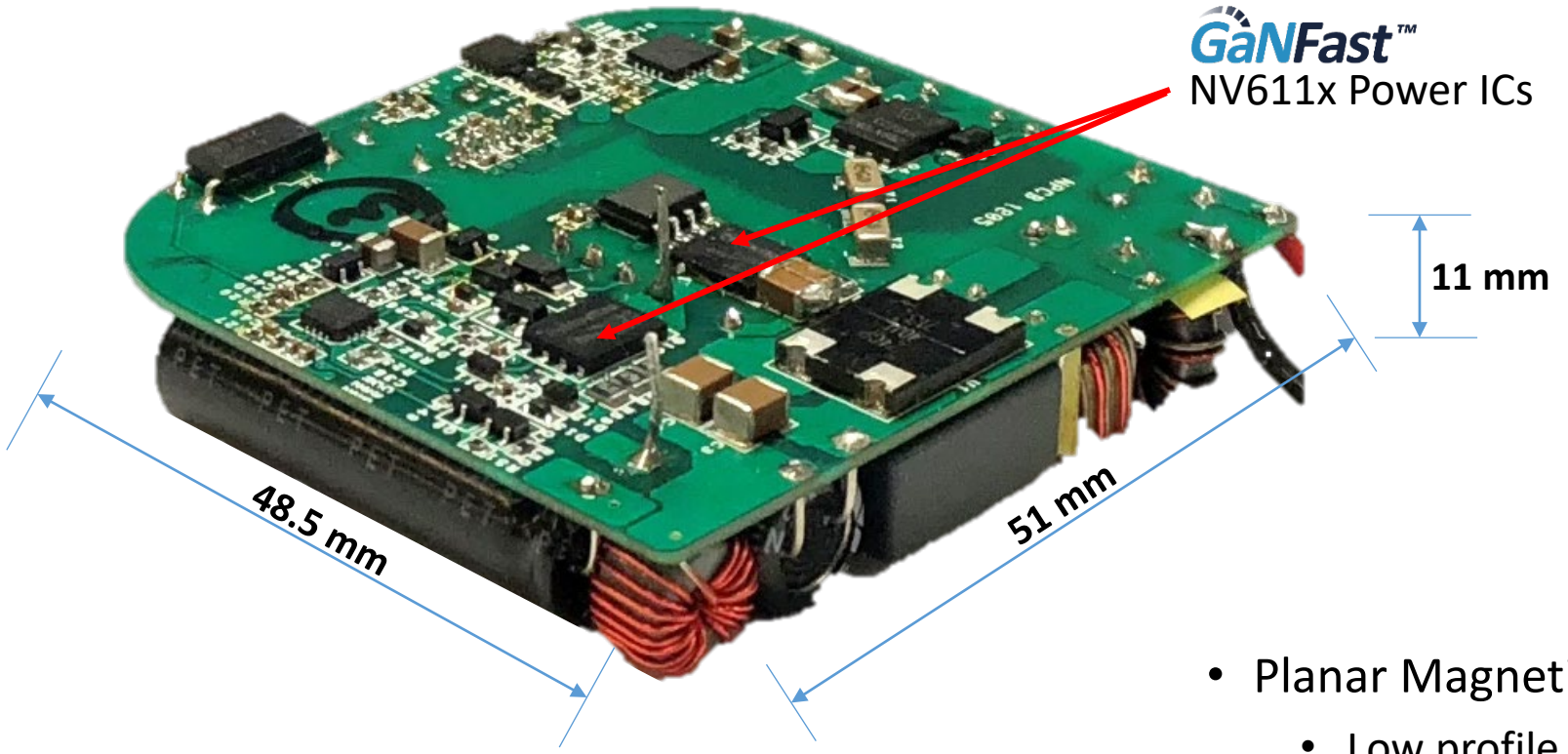
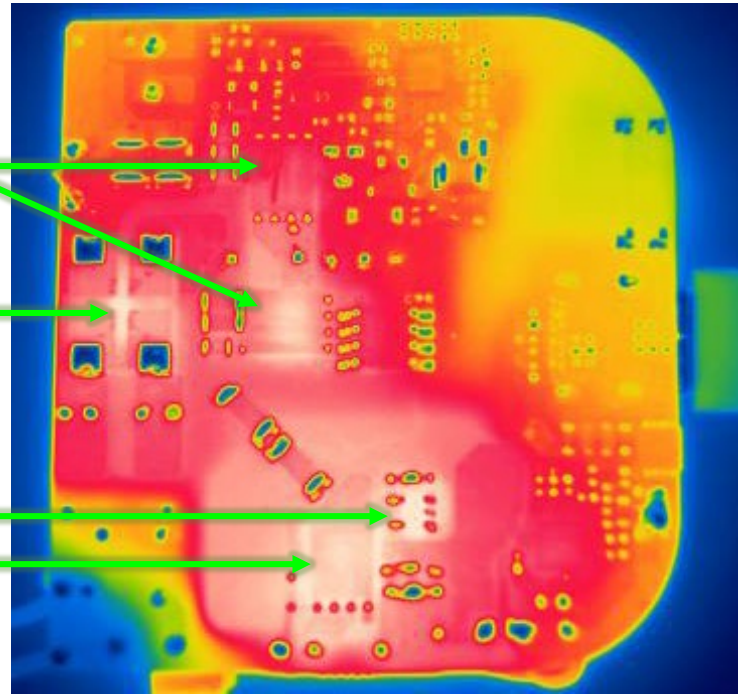


- Size : 29 cc (41 cc with case)
- Density : 1.7 W/cc (27 W/in^3), 1.1 W/cc (18 W/in^3) cased

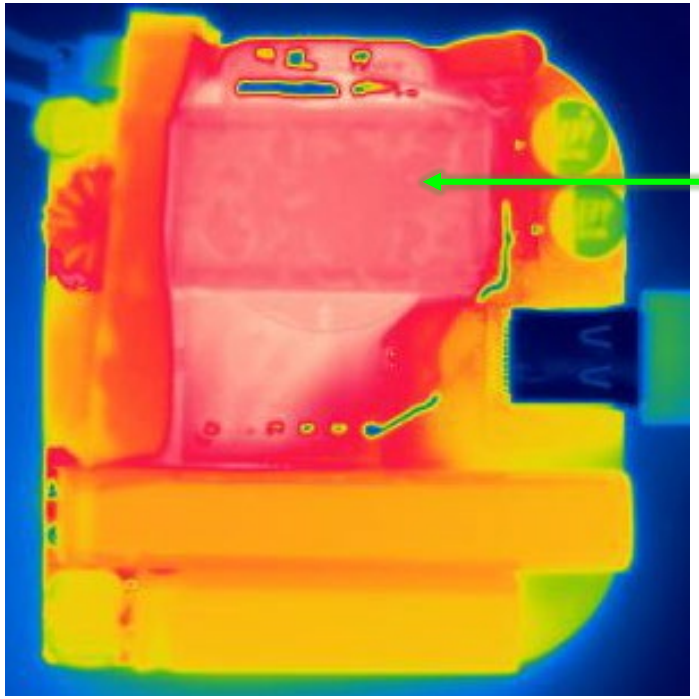
- Planar Magnetics:
  - Low profile
  - Automated assembly
  - Predictable performance
  - High yield

Cool Operation

Top

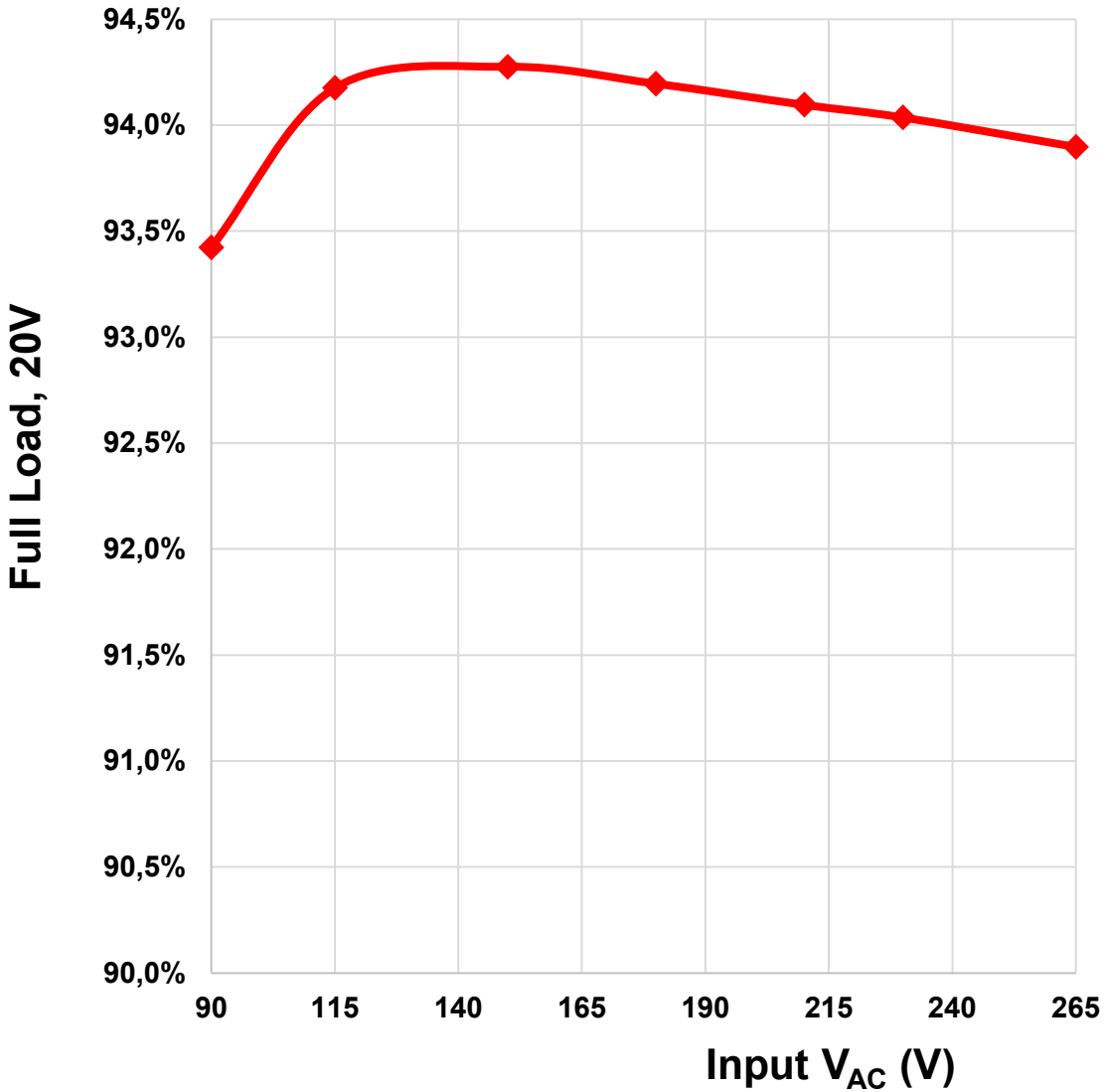


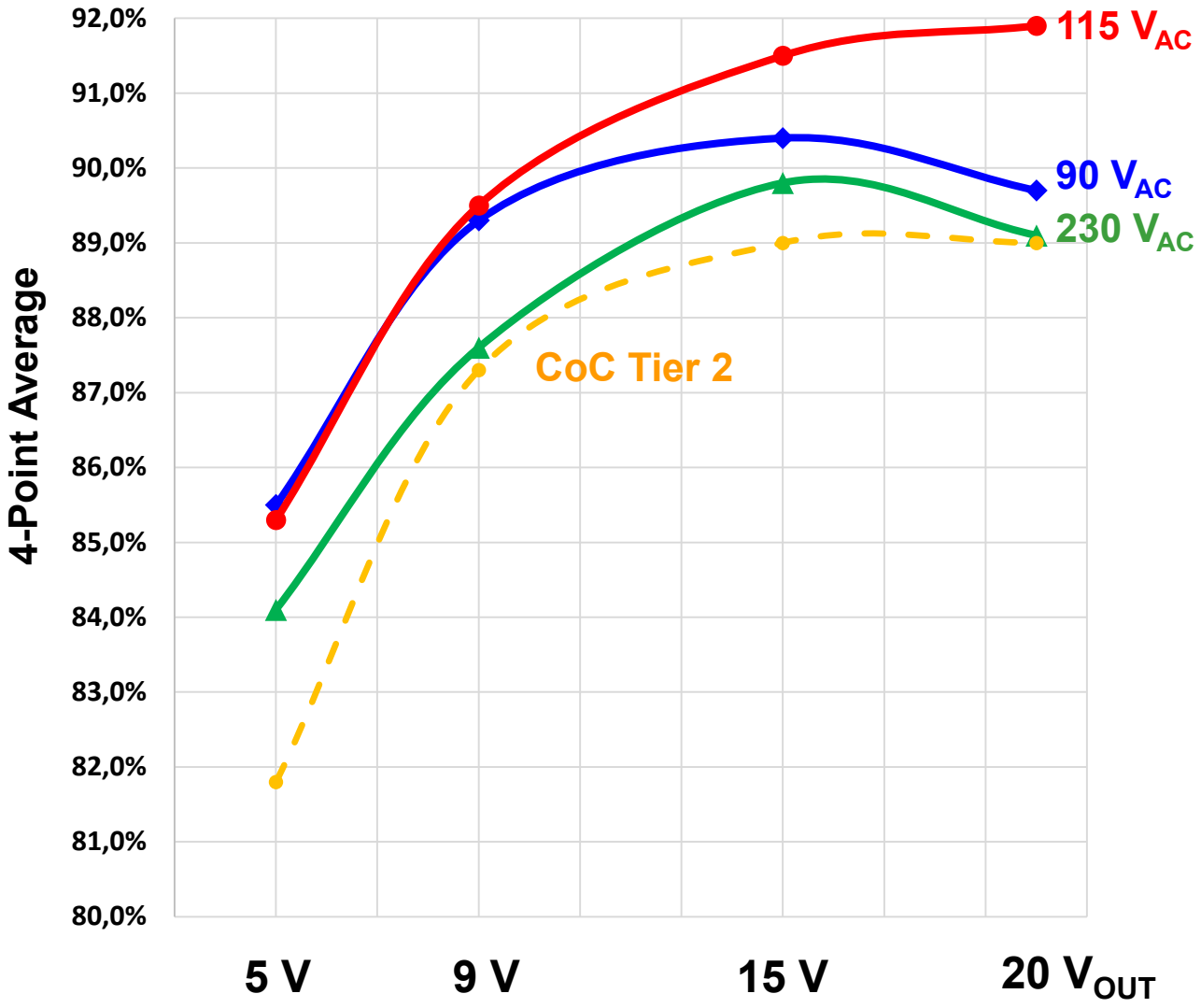
Bottom



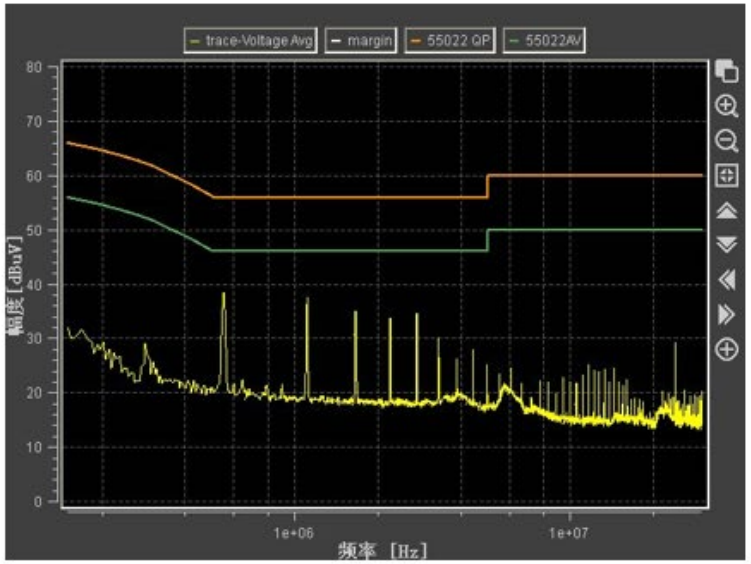
90 V_{AC}, 45 W, 25 °C, uncased, no airflow,
no thermal compound / heatsinking

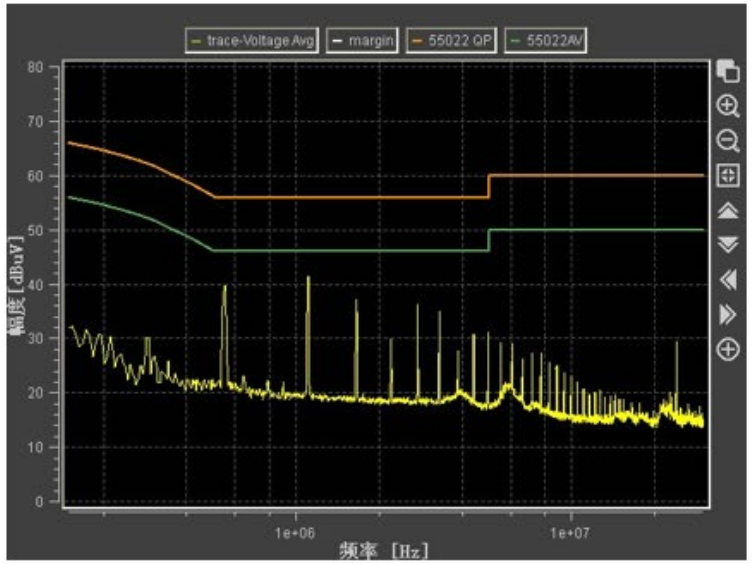
High Efficiency

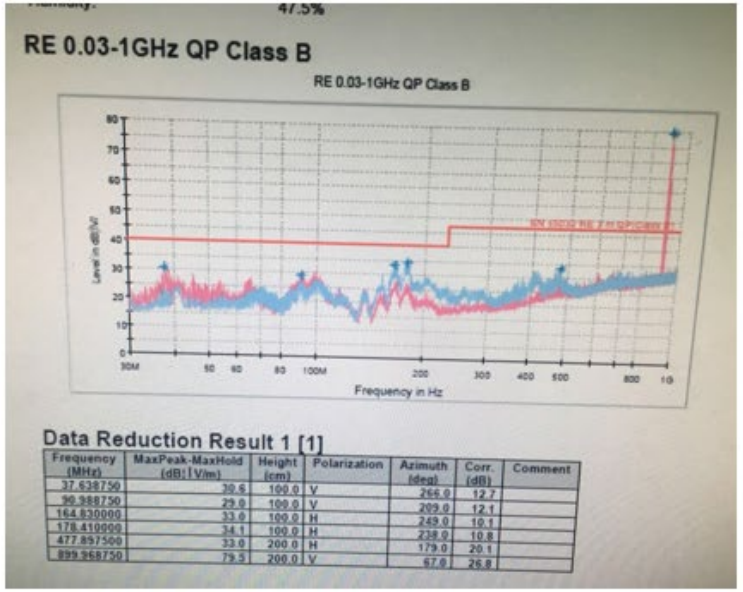




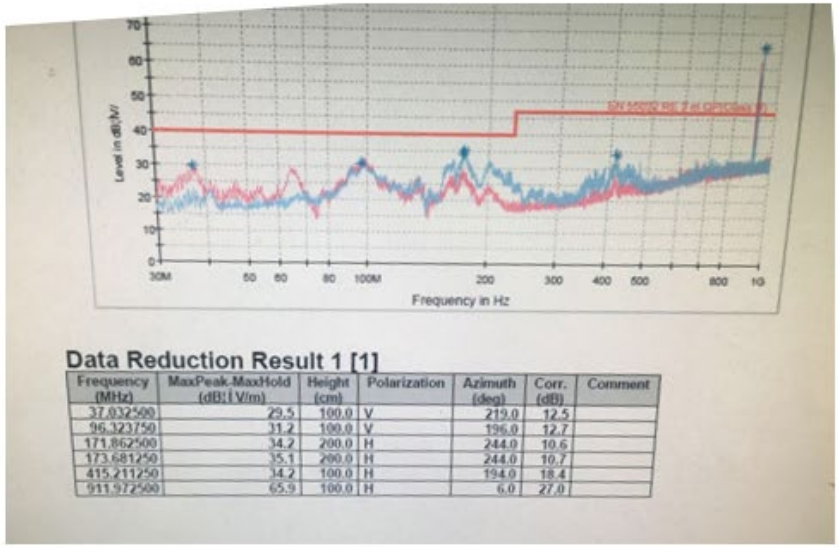
Quiet EMI (Conducted, Radiated)





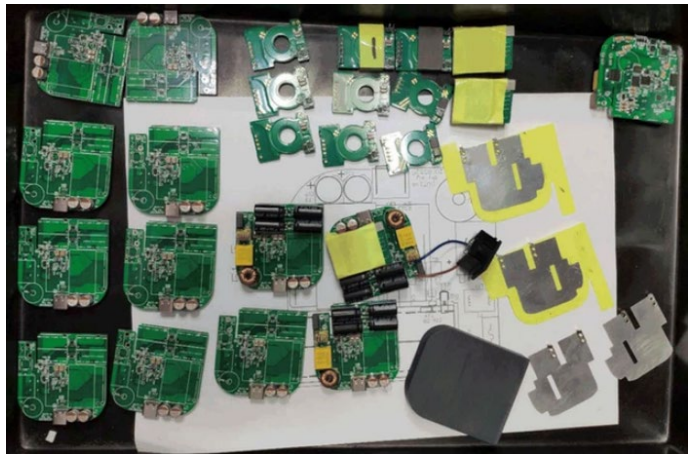


Frequency (MHz)	MaxPeak-MaxHold (dBµV/m)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Comment
37.638750	30.6	100.0	V	266.0	12.7	
90.988750	29.0	100.0	V	209.0	12.1	
164.830000	33.0	100.0	H	249.0	10.1	
178.410000	34.1	100.0	H	238.0	10.8	
477.897500	33.0	200.0	H	179.0	20.1	
899.968750	79.5	200.0	V	67.0	26.8	



Frequency (MHz)	MaxPeak-MaxHold (dBµV/m)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Comment
37.032500	29.5	100.0	V	219.0	12.5	
96.323750	31.2	100.0	V	196.0	12.7	
171.862500	34.2	200.0	H	244.0	10.6	
173.681250	35.1	200.0	H	244.0	10.7	
415.211250	34.2	100.0	H	194.0	18.4	
911.972500	65.9	100.0	H	6.0	27.0	

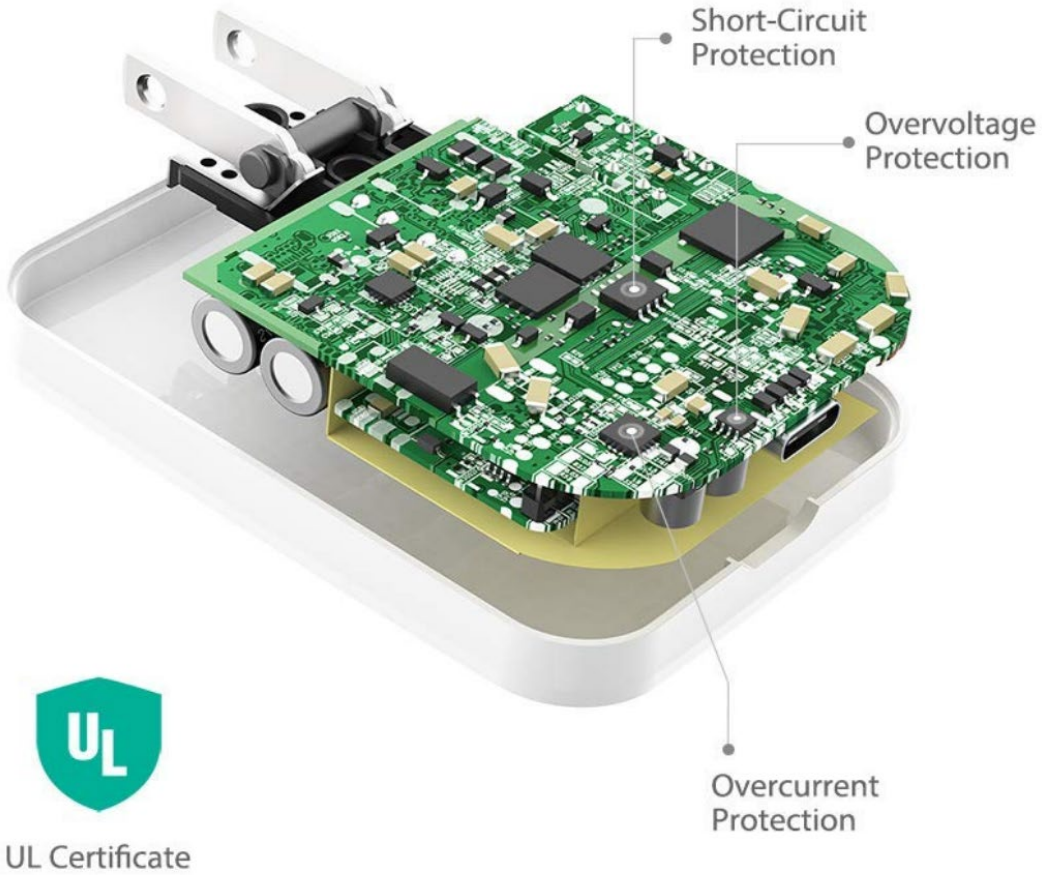
Mu One: From Prototype to Mass Production



- 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

Images courtesy Made-in-Mind

RAVPower 45W USB-C PD



RAVPOWER RAVPOWER New Logo. New Image. A Leap In Power Like Never Before.

- Available now on www.amazon.com

Images courtesy RAVPower

AUKEY 24W, 27W, 30W

- Available now on www.amazon.fr

Images courtesy AUKEY

Let's go GaNFast™!