150W, AC-19.5V$_{DC}$ PFC+LLC Demo Board

UG025

This user's guide covers:

Demo Board#	Description	Part(s) Used
NVE055A	150W, AC-19.5V (PFC) PFC min 140 kHz	NV6117
NVE055A	150W, AC-19.5V (LLC) LLC 270 kHz	NV6115

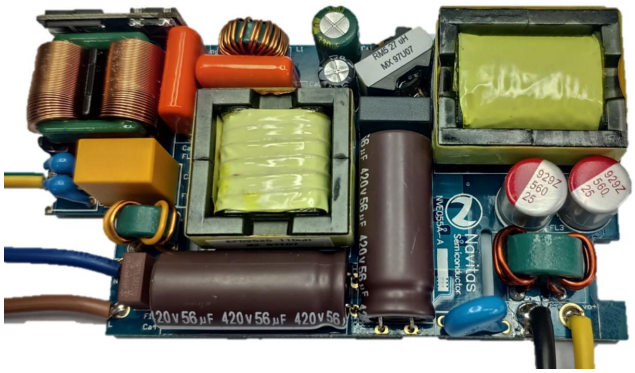


Fig. 1a

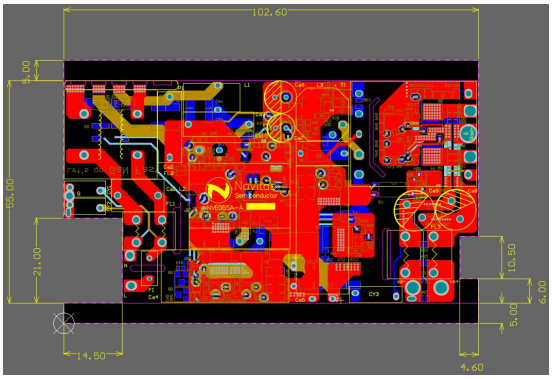


Fig.1b

KEY PERFORMANCE:

93.3% @90Vac, 95.2% @230Vac;
Dimension 103*55*17 96CC;
165mW standby power @230Vac;
EMI PASS, Include CE and RE.

IMPORTANT NOTICE:

Hazardous voltages are present on this demo board. Personal contact with high voltages may result in injury or death. Correct handling and safety procedures must be observed. Boards are for lab bench evaluation only. Not for installation in end-user equipment.

CAUTION:

This product contains parts that are susceptible to damage by electrostatic discharge (ESD). Always follow ESD prevention procedures when handling the product.

1. Specifications:

Ref.	Parameter		Value	Units
V_{IN}	Input Voltage		90-264 47-63	V_{AC} Hz
V_{OUT}	Output Voltage		19.5	V
I_{OUT}	Output Current (100% load)		7.69	A
I_{OUT_LIM}	Output Current Limitation (short-circuit or over-load)		9.5	A
P_{OUT}	Output Power (max)		150	W
F_{SW}	Switching Frequency	PFC (120V, 100% load, CrCM) PFC (220V, 100% load, DCM) LLC	200 100 270	kHz kHz kHz
η	Efficiency	230 V_{AC}, 150 W 90 V_{AC}, 150 W	95.2 93.3	% %
P_{STBY}	Standby Power Consumption	115 V_{AC}	< 145	mW
		230 V_{AC}	< 165	mW
PF	Power Factor		0.95	
EMI_{COND}	Conducted Emissions, EN55032 Class B, 150kHz to 30MHz		PASS	dB
EMI_{RAD}	Radiated Emissions, EN55032 Class B, 30MHz to 1GHz		PASS	dB
	Board Dimensions		103 x 55 x 17	mm
	Board Volume (uncased)		96.3	cc
	Power Density (uncased)		25.5 1.56	W/in^3 W/cc

2. Topology: CrCM PFC + LLC + SR

This design uses a Critical Conduction Mode (CrCM/DCM) PFC (AC-400 V_{DC}), followed by an LLC DC-DC (400-19.5 V_{DC}). For both stages, the switching frequency was increased to the maximum allowed by the off-the-shelf control ICs available. The board is designed to be a 'demonstration' board, and is not yet optimized as a production design. With this design, a power density of 1.56 W/cc or 25.5 W/in^3 is achieved, which is around 2x typical and 40% more than the best-on-class Si-based design today. Customer designs are expected to achieve even higher power density.

The PFC section is a standard ON Semi NCP1615 CrCM/DCM powering 2x NV6117 (parallel) GaNFast Power ICs directly. Critical mode PFC (also known as boundary mode) is a soft-switching topology which allows higher frequency operation.

The DC-DC section uses the NCP13992AB current-mode resonant controller (LLC) driving NV6115s. The NV6115s have monolithically-integrated gate drivers, so the NCP13992's drivers are not used and loss is minimized.

For secondary-side synchronous rectification, two NCP4306 controllers are used to drive silicon 60 V FETs.

As shown in the 'scope images – the waveforms are extremely clean, with no overshoot / oscillation. This 'controlled' switching performance is also a key factor in good EMI performance. If required, dV/dt may be programmed using a simple resistor (see NV6115 and NV6117 datasheet) to adjust EMI signature for compliance testing.

Notes:

DO NOT TEST EXTREME INPUT VOLTAGE. The demo is not designed for safety, surge, lightning, etc.

BOARD REQUIRES THERMAL MANAGEMENT. Use fan or heat spreading with copper wrapper.

Datasheets:

NCP1615: http://www.onsemi.com/pub_link/Collateral/NCP1615-D.PDF

NCP13992: http://www.onsemi.com/pub_link/Collateral/NCP13992-D.PDF

NCP4306: http://www.onsemi.com/pub_link/Collateral/NCP4306-D.PDF

NV6115: https://www.navitassemi.com/download/

NV6117: https://www.navitassemi.com/download/

3. Schematics and Board Layers:

Fig. 2a: Power board top-side components (see BOM, for most recent part numbers)

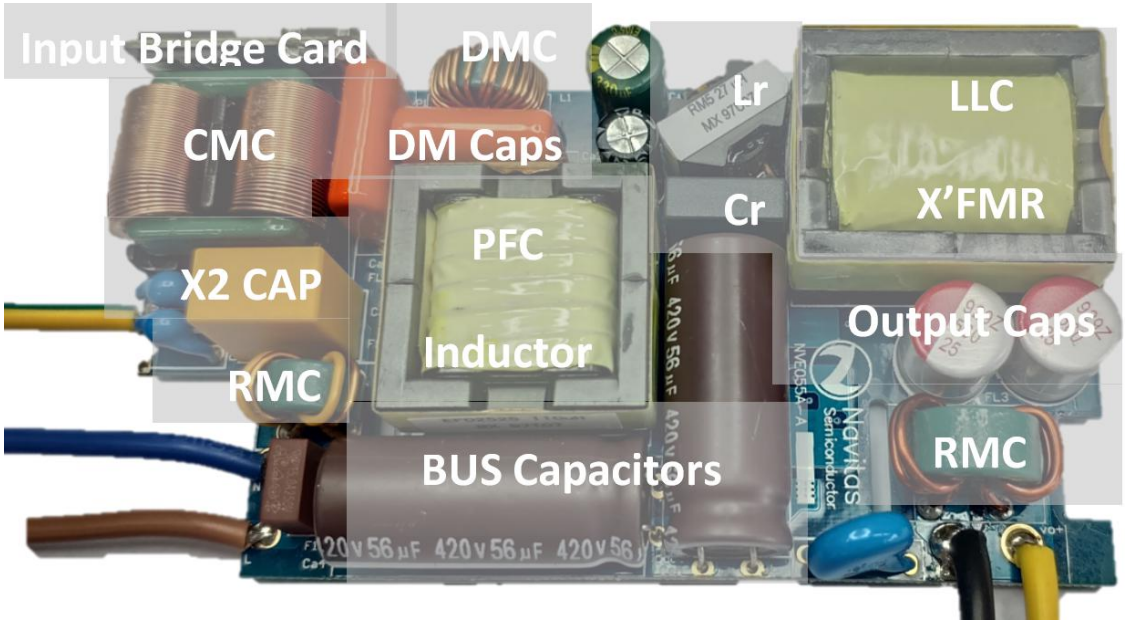
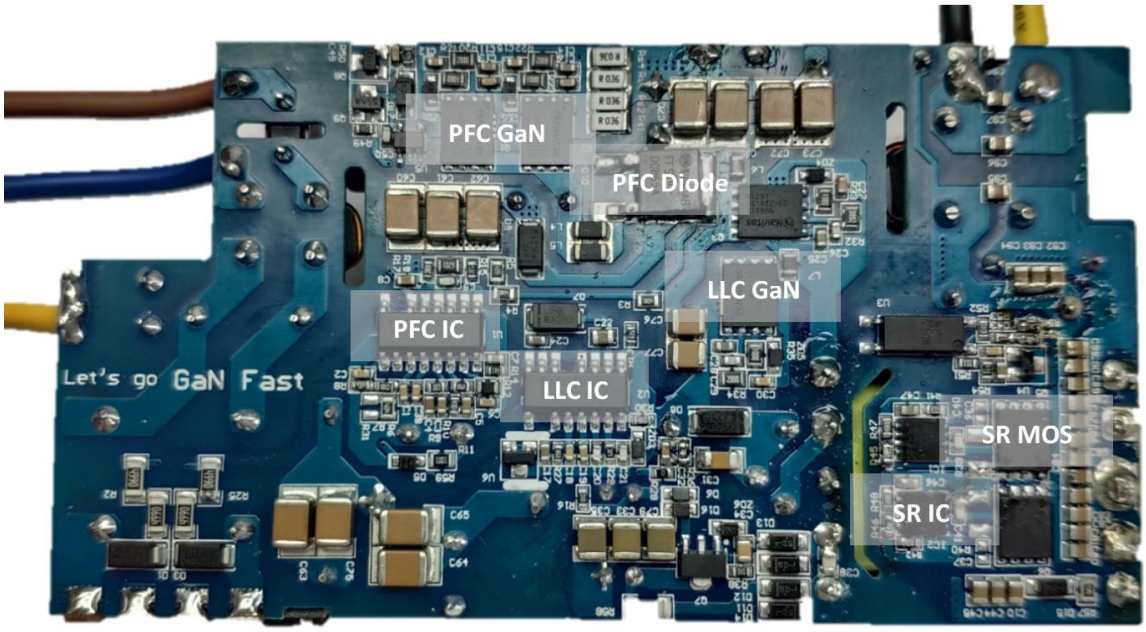


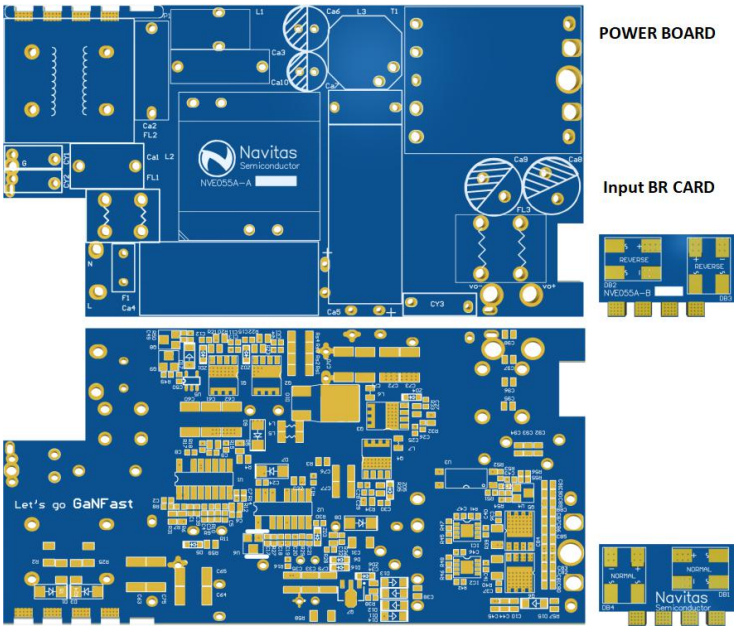
Fig. 2b: Power board bottom-side components



4. PCB Construction:

This demoboard is constructed using 1 main board (4-layer) plus 1 daughtercards (4-layer). This assists evaluation and allows the user to exchange daughtercards for experimentation, plus allows for easy heat sinking and thermal management. PCB material is standard FR4 with 2 oz copper. Comprehensive PCB information and design files (gerber, .dxf, etc.) are available from info@navitassemi.com.

Fig. 3: Power board and daughtercard PCBs (generic construction shown, actual board design may vary)

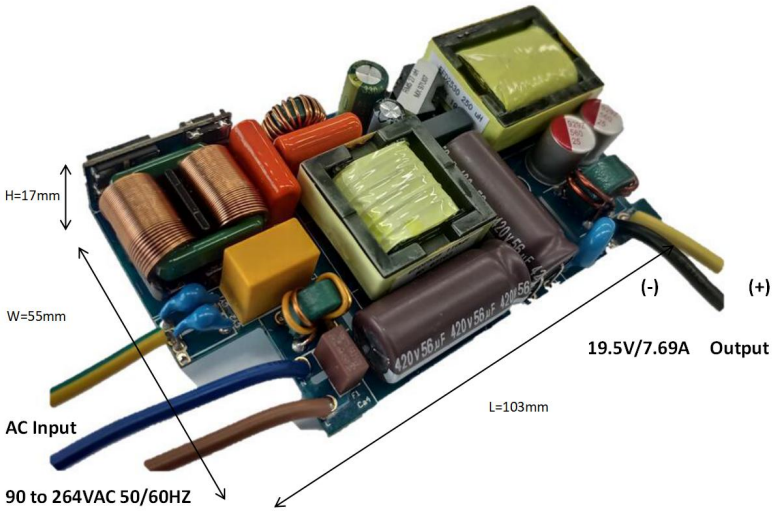


5. Connections and Start-up Sequence:

DO NOT TEST EXTREME INPUT VOLTAGE. The demo is not designed for safety, surge, lightning, etc.

BOARD REQUIRES THERMAL MANAGEMENT. Use fan or heat spreading with copper plate.

Fig. 4: AC input and DC output connections



Start-up:

DO NOT TEST EXTREME INPUT VOLTAGE. The demo is not designed for safety, surge, lightning, etc.

BOARD REQUIRES THERMAL MANAGEMENT. Use fan or heat spreading with copper plate.

1. Set AC line to 0 V_{AC}
2. Set AC line to OFF
3. Connect AC line input
4. Connect DC load at the output
5. Set AC line input to 120 V_{AC}
6. Turn AC line input to ON
7. Measure DC output voltage (19.5 V)
8. Increase output load current and monitor output voltage

Power-down sequence:

1. Turn off AC power supply
2. Turn off the load

6. Switching Waveforms:

CrCM PFC Boost Stage

Fig. 5a: CrCM PFC Boost at 90 V_{AC}, 400 V_{OUT}, 150 W, 139 kHz (peak of AC line)

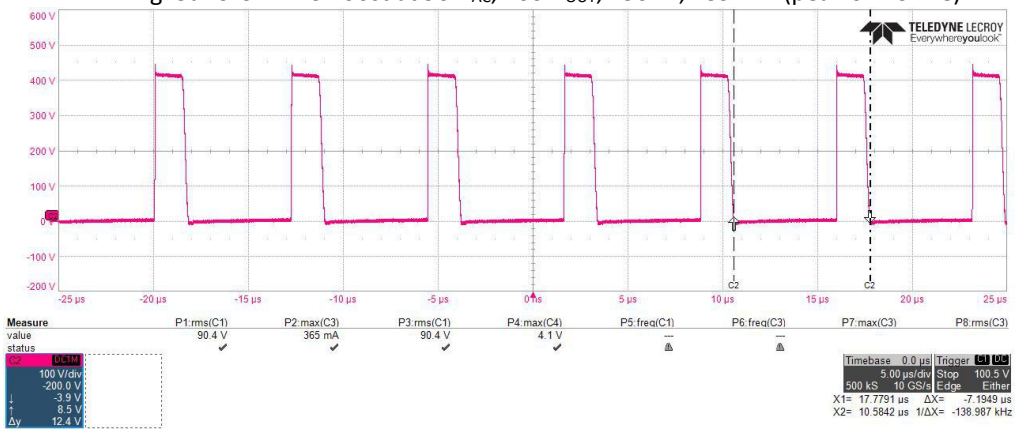
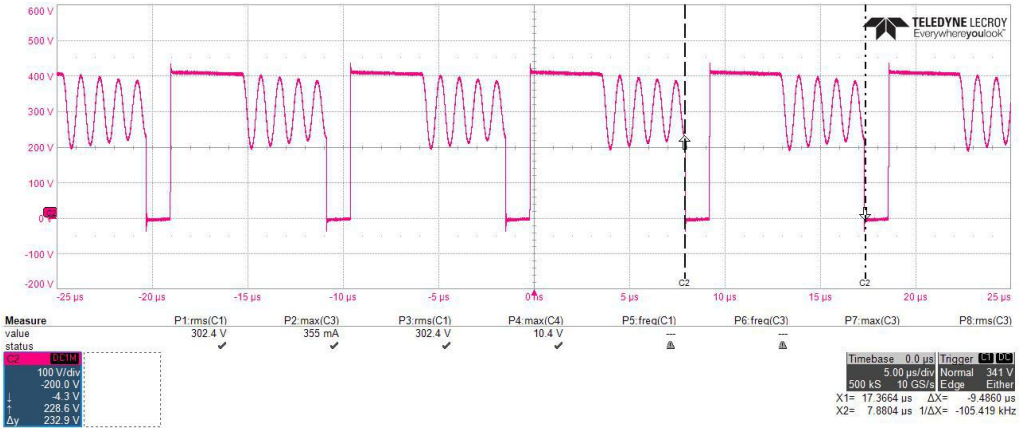


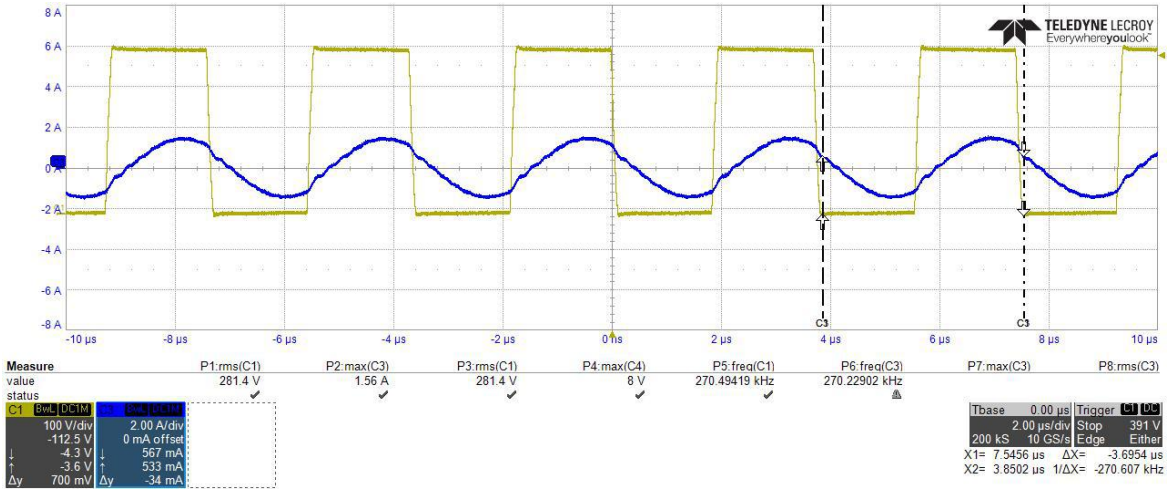
Fig 5b: PFC Boost at 230 V_{AC}, 150 W (peak of AC line, DCM mode)



Switching Waveforms:

DC-DC (LLC) Stage

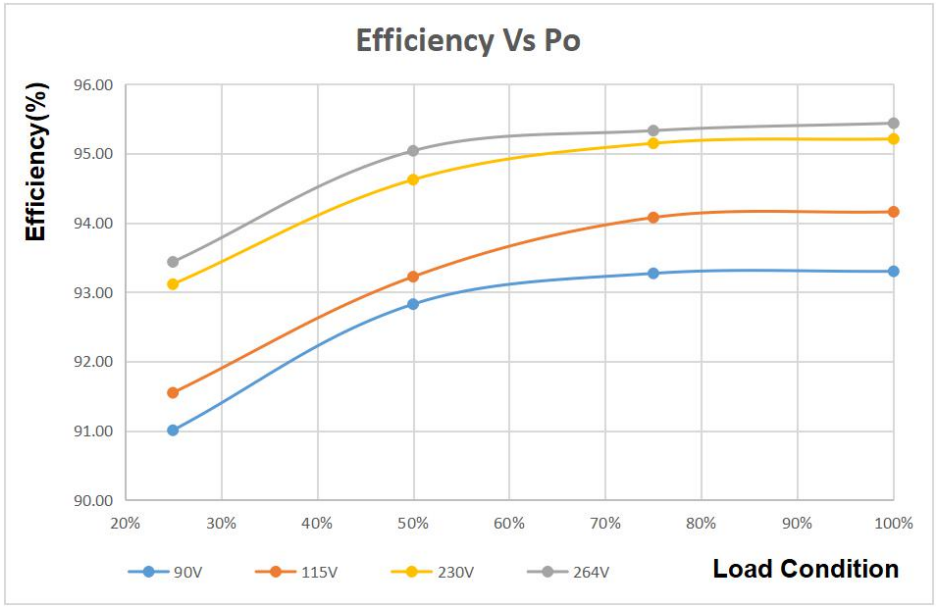
Fig. 6: LLC V_{SW}, I_L, 19.5 V_{OUT}, 7.69 A



7. Efficiency:

a. Full load

Fig. 7: Efficiency vs. load, AC line voltage (w/copper wrapper, room ambient)

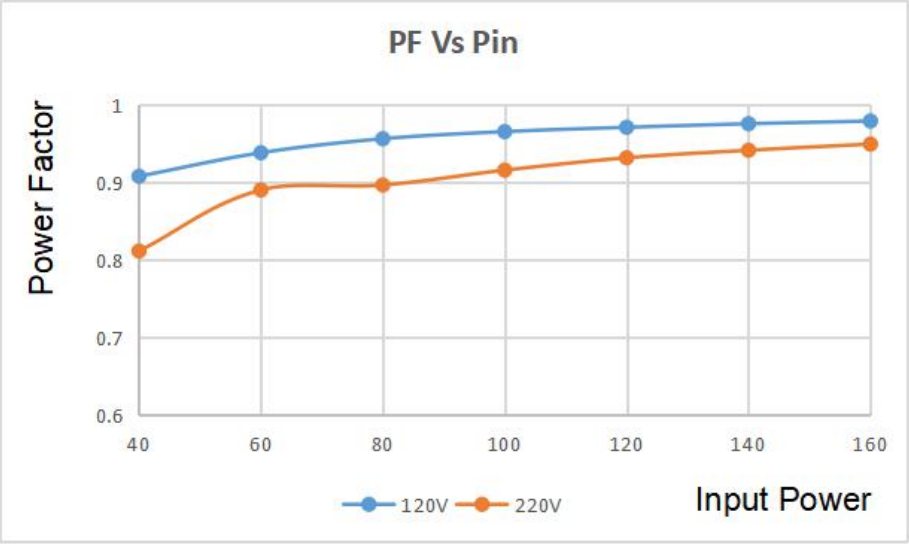


b. Light load / Standby

Load Condition	Pout/Efficiency Vin = 230 VAC
No Load	165 mW
250 mW	55.6 %
500 mW	61.4 %

8. Power Factor:

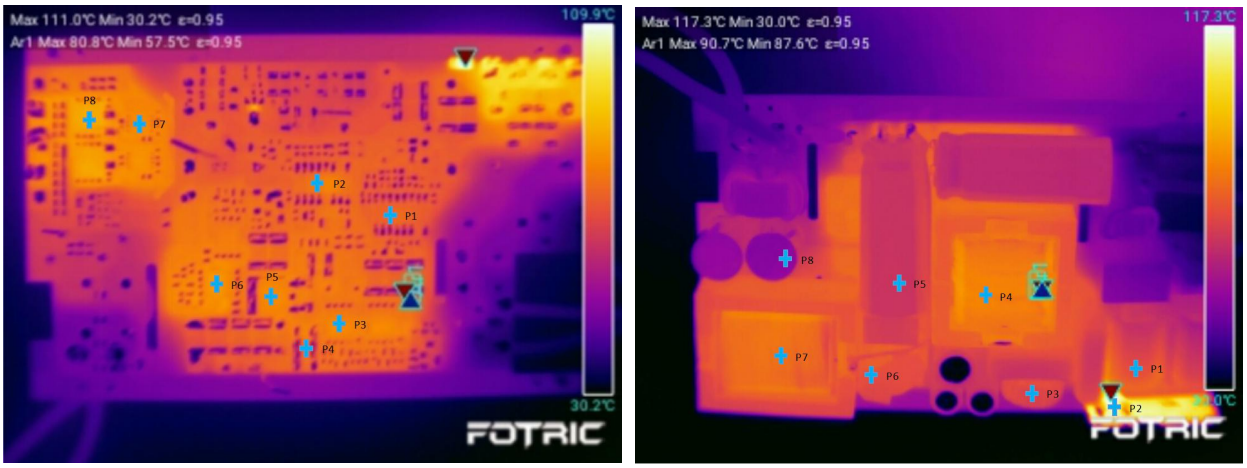
Fig. 8: Power factor vs. load



9. Thermal Performance:

Note: BOARD REQUIRES THERMAL MANAGEMENT. Use fan or heat spreading with copper wrapper.

Fig. 9: Bottomside/Topside thermals, 90 V_{AC}, 100% Load (Open frame）



P1:	PFC IC ——	80℃	CMC ——	82℃
P2:	LLC IC ——	82℃	Bridge ——	117℃
P3:	PFC GaN ——	84℃	DMC ——	78℃
P4:	PFC CS ——	84℃	Inductor ——	92℃
P5:	PFC Diode ——	86℃	BUS E-CAP ——	76℃
P6:	LLC GaN ——	85℃	Resonant Inductor ——	79℃
P7:	SR IC ——	85℃	Transformer ——	88℃
P8:	SR MOS ——	90℃	Secondary E-CAP ——	65℃

10. EMI Measurements:

This demo board is optimized for EMI conducted emissions (CE) and radiated emissions (RE). Once final customer specification / form-factor has been decided, Navitas may assist in component placement, PCB layout, and additional shielding as required.

Note: Additional shielding is needed for RE test .

Fig. 10a: Conducted EMI (Quasi-Peak green/red and AVG blue/blue, Vin = 230 VAC L&N, Pout = 150 W)

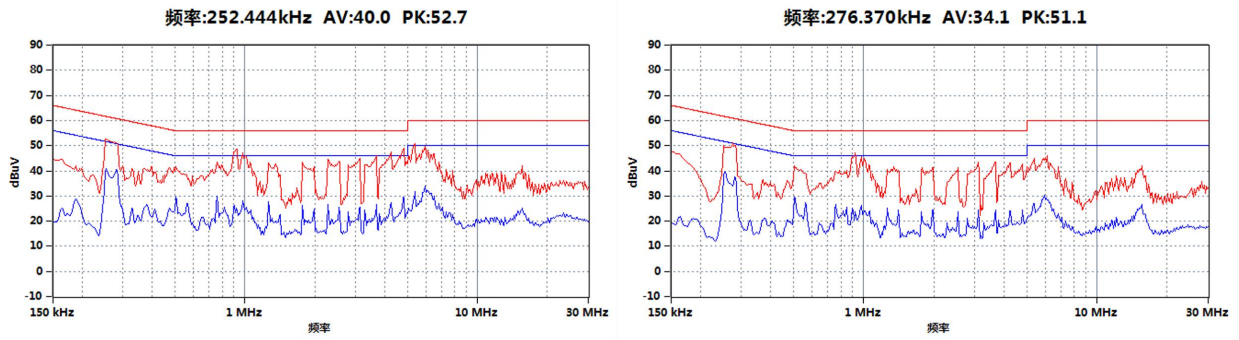


Fig. 10b: Conducted EMI (Quasi-peak green/red and AVG blue/blue, Vin = 110 VAC L&N, Pout = 150 W)

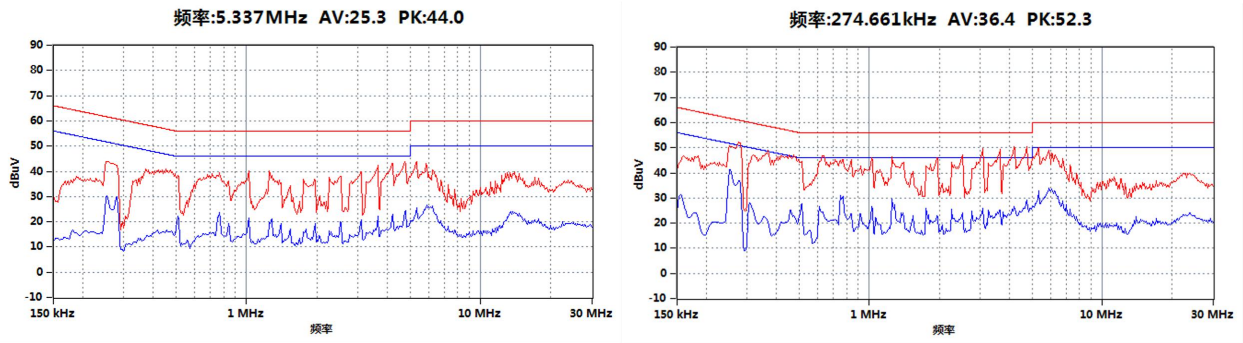


Fig. 10c: Horizontal/Vertical Radiated EMI (Vin = 115 VAC, Pout = 150 W)

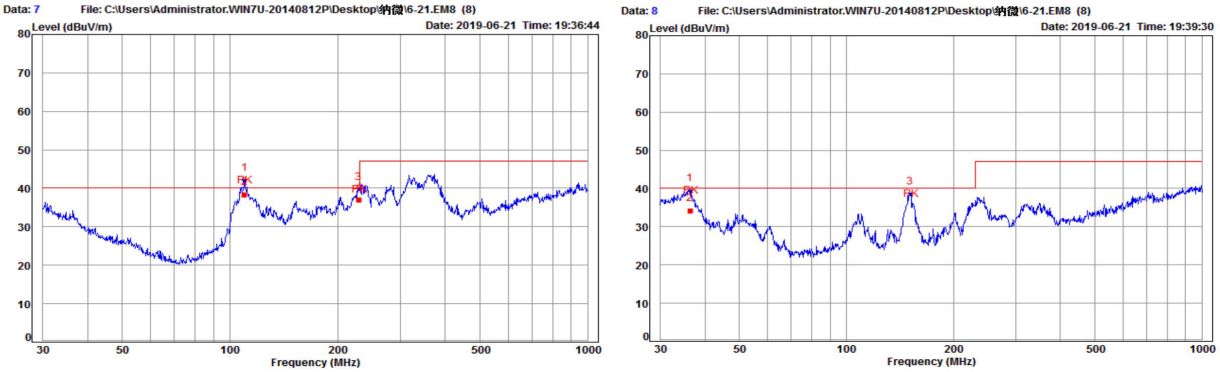
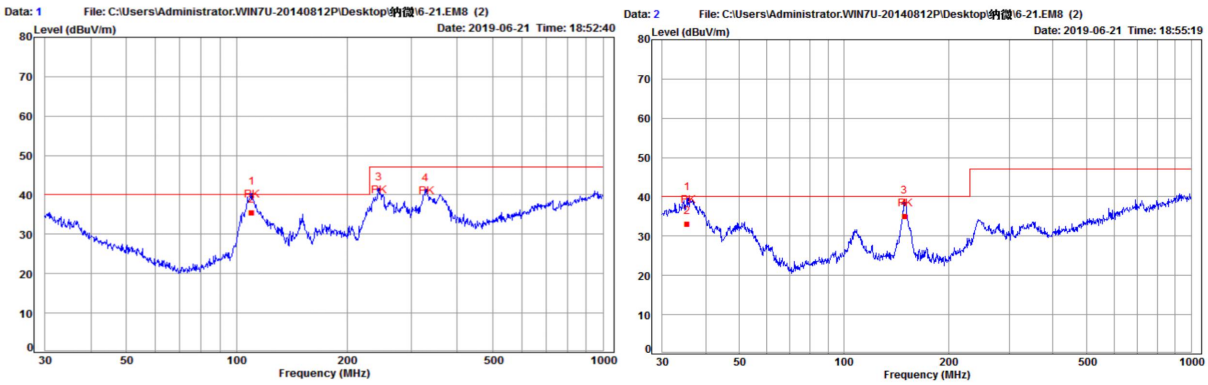


Fig. 10d: Horizontal/Vertical Radiated EMI (Vin = 230 VAC, Pout = 150 W)



Revision History:

Date	Status	Notes
September 24， 2019	Preliminary	NVE055A (Blue PCB)

11. Additional Information:

DISCLAIMER Navitas Semiconductor Inc. (Navitas) reserves the right to modify the products and/or specifications described herein at any time and at Navitas' sole discretion. Pre-production (engineering sample) performance may deviate from the target specifications. All information in this document, including descriptions of product features and performance, is subject to change without notice. Performance specifications and the operating parameters of the described products are determined in the independent state and are not guaranteed to perform the same way when installed in customer products. The information contained herein is provided without representation or warranty of any kind, whether express or implied. This document is presented only as a guide and does not convey any license under intellectual property rights of Navitas or any third parties.

Navitas products are not intended for use in applications involving extreme environmental conditions or in life support systems.

Products supplied under Navitas Terms and Conditions.

Navitas Semiconductor, Navitas, GaNFast and associated logos are registered trademarks of Navitas Semiconductor.

Navitas Semiconductor Inc., 2101 E. El Segundo Blvd, Suite 201, El Segundo, California 90245, USA.

Contact info@navitassemi.com