

150W, AC-19V_{DC} PFC+LLC Demo Board

UG016

This user's guide covers:

Demo Board#	Description	Part(s) Used
NVE021A-B	150W, AC-19V (PFC+LLC)	NV6115, NV6117



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.

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1. Description:

This demo board uses single iDrive™ GaN Power ICs in a 150W AC-19 V_{DC} CrCM PFC+LLC converter suitable for applications such as large laptop adapters, TV / monitor and ‘All-in-one’ PCs.

The NV6115 is a 650V 160 mΩ eMode GaN Power IC with iDrive™ integrated driver stage, requiring only a low current digital input. The NV6117 is a lower R_{DS(ON)} 110 mΩ (typ) version in the same footprint.

For the datasheet and other information, please refer to www.navitassemi.com or contact info@navitassemi.com.

This board demonstrates high efficiency and high power density performance, enabling customers to develop production-optimized designs with more than double the typical power density of today’s 150W adapters.

The board was co-designed with On Semiconductor and uses a CrCM PFC-LLC-SR control IC chip-set (NCP1615, NCP13992, NCP43080). Thanks go to the teams in Rožnov, Czech Republic and Phoenix, AZ for their collaboration and support.

Thanks also go to Precision Inc. who provided the magnetic components (see BOM section for contact details).

For individual files for schematic, PCB (gerber, .dxf), etc., please contact info@navitassemi.com.

2. Specifications:

Ref.	Parameter	Value	Units
V _{IN}	Input Voltage	90-265	V _{AC}
		50-60	Hz
V _{OUT}	Output Voltage	19	V
I _{OUT}	Output Current (100% load)	8	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)	133 kHz
		PFC (220V, 100% load)	200 kHz
		LLC	300 kHz
η	Efficiency	215V _{AC} , 150W	95.4 %
		115V _{AC} , 150W	94.2 %
P _{STBY}	Standby Power Consumption	120V _{AC}	25 mW
		220V _{AC}	65 mW
PF	Power Factor	0.95	
	Board Dimensions	116 x 55 x 18	mm
	Board Volume (no case)	115	cc
	Power Density (no case)	21.4	W/in ³
		1.3	W/cc

3. Topology: CrCM PFC + LLC + SR

This design uses a Critical Conduction Mode (CrCM) PFC (AC-400 V_{DC}), followed by an LLC DC-DC (400-19 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 1.3 W/cc or 21.4 W/in³ 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 Semiconductor NCP1615 CrCM powering 1xNV6117 GaN Power IC 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 NCP13992 current mode resonant controller (LLC) driving NV6115s. In this implementation, as the NV6115s have monolithically-integrated gate drivers, the NCP13992's drivers are not used and loss is minimized.

For secondary-side synchronous rectification, two NCP43080 controllers are used to drive silicon 60V FETs.

As can be seen 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 datasheet) to adjust EMI signature for compliance testing.

Notes:

- 1) This demo has not been designed / tested for input voltage extremes (safety, surge, and lightning, etc.).

Datasheets:

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

NCP1399: http://www.onsemi.com/pub_link/Collateral/NCP1399-D.PDF

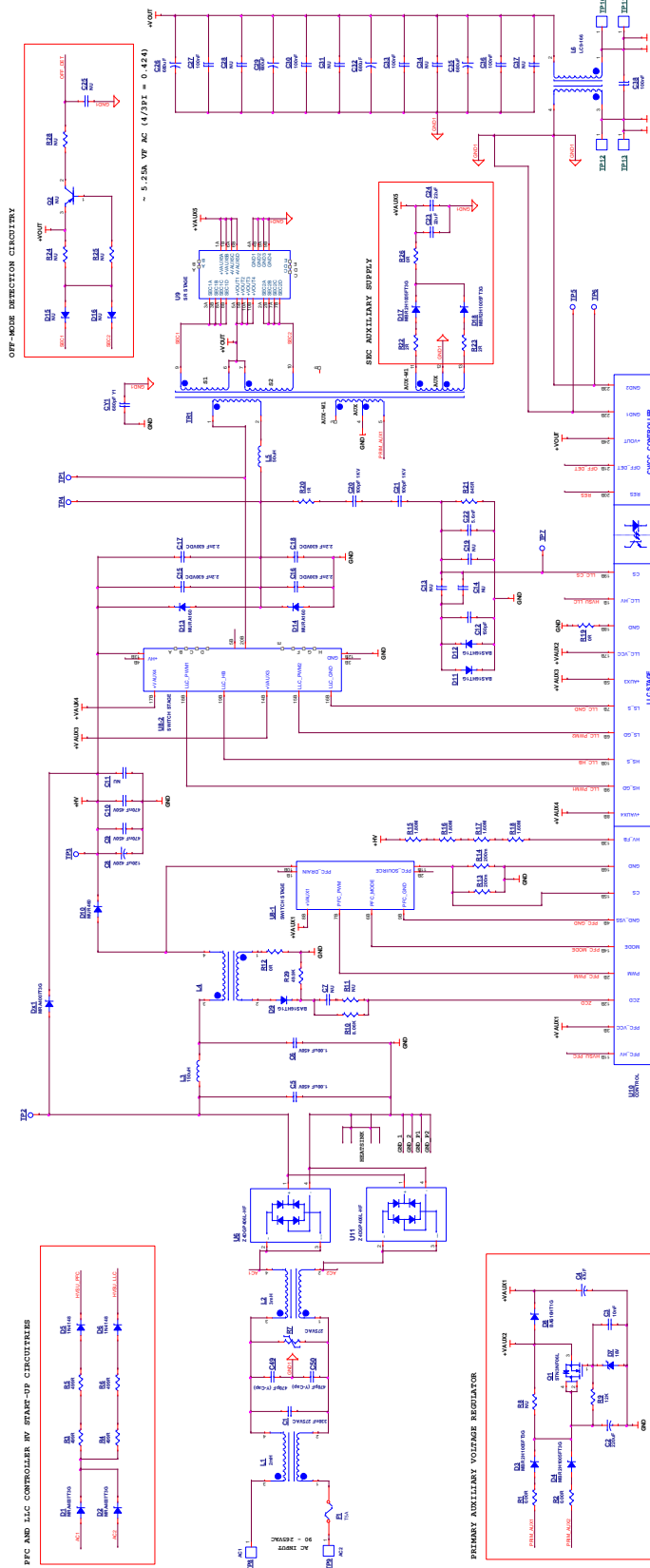
NCP43080: http://www.onsemi.com/pub_link/Collateral/NCP43080-D.PDF

NV6115: <http://navitassemi.com/wp-content/uploads/2015/03/NV6115-datasheet-PRELIMINARY-10-19-16.pdf>
(requires login)

NV6117: <http://navitassemi.com/wp-content/uploads/2015/03/NV6117-datasheet-TARGET-10-19-16-1.pdf>
(requires login)

4. Schematics and Board Layers:

Fig. 1a: Overall Schematic



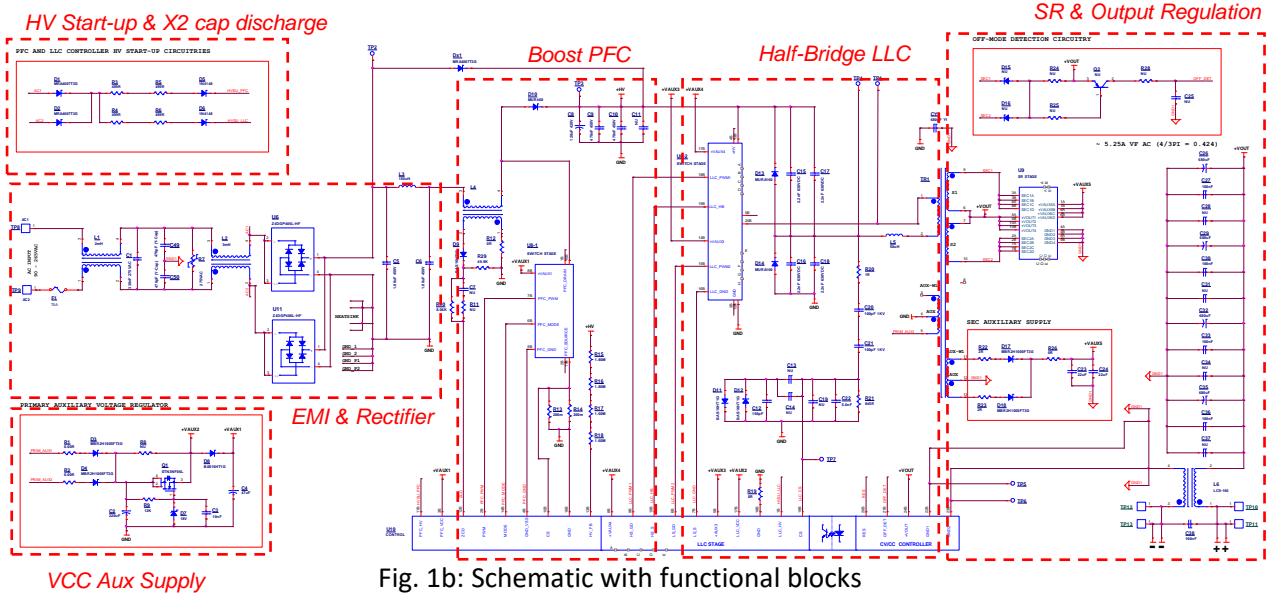


Fig. 1b: Schematic with functional blocks

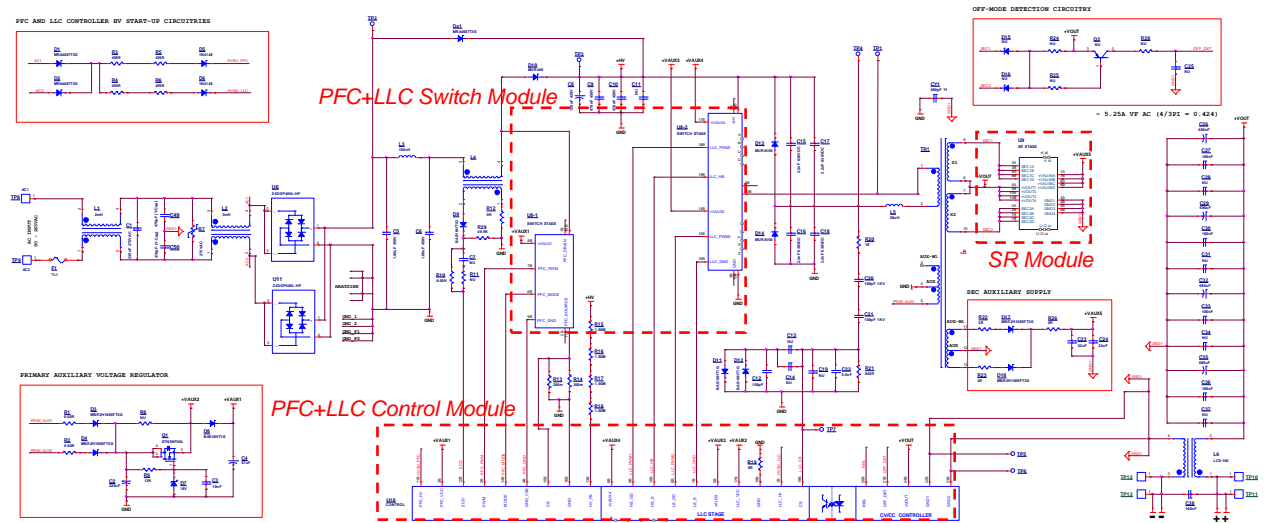


Fig. 1c: Schematic with daughtercard module content

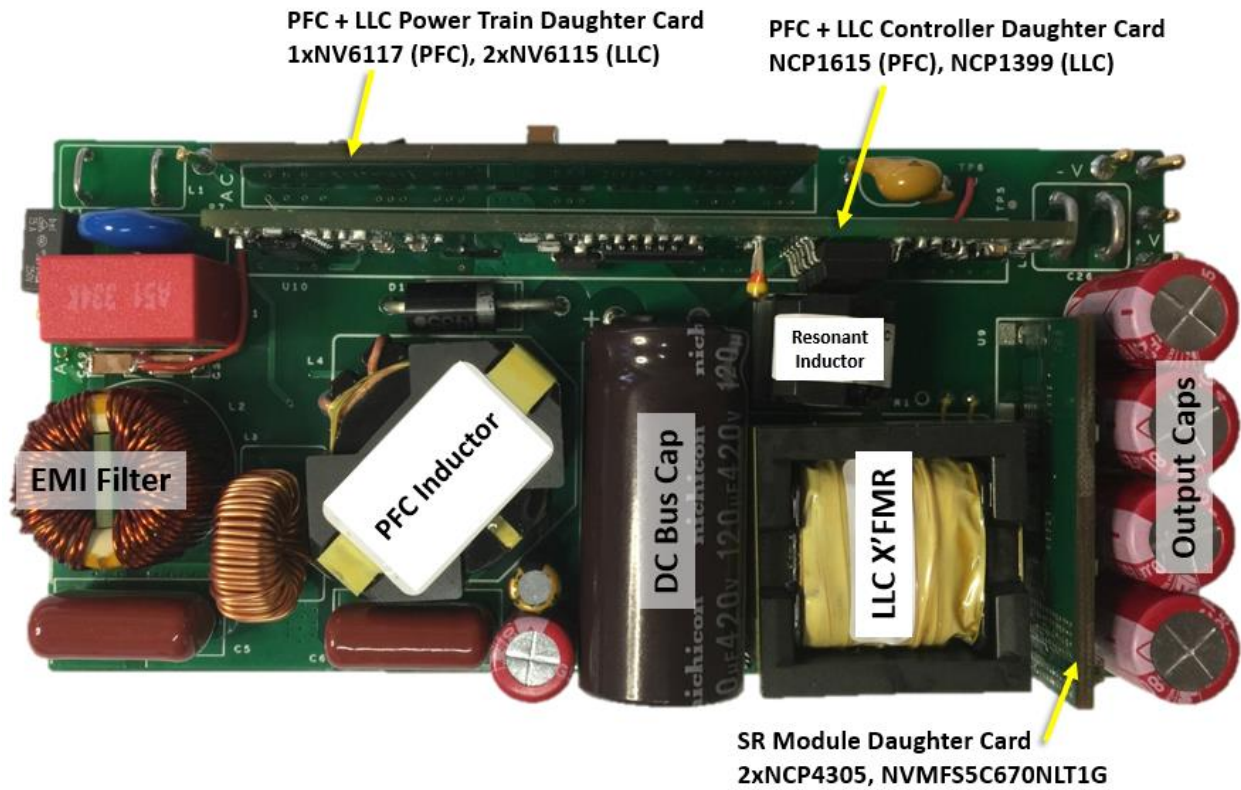


Fig. 2a: Power board top-side components (see BOM, section 12, for most recent part numbers)

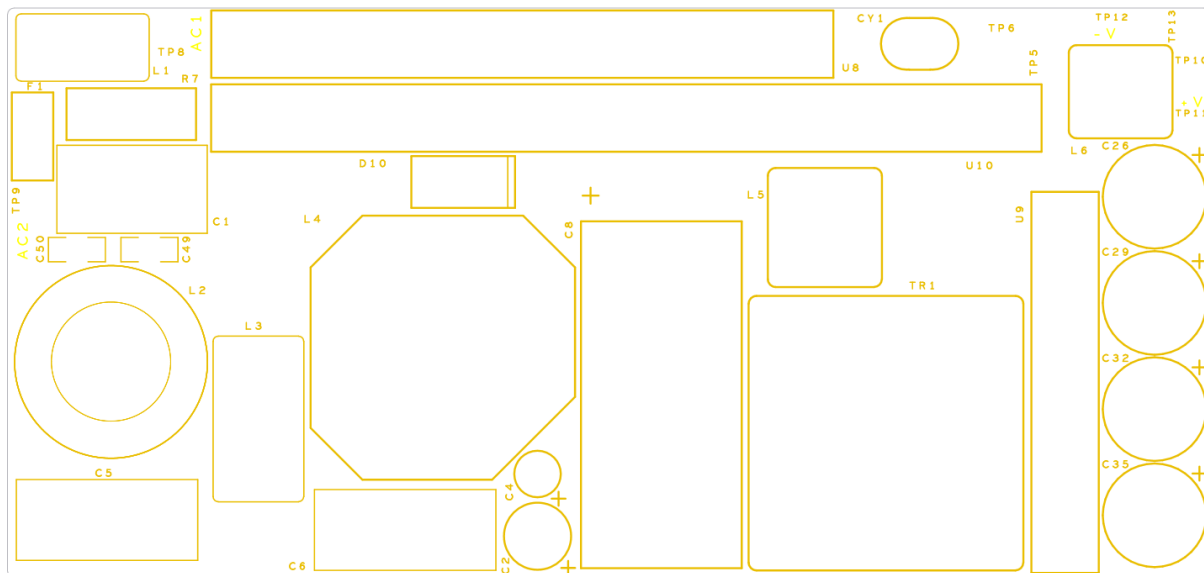


Fig. 2b: Power board top-side silkscreen

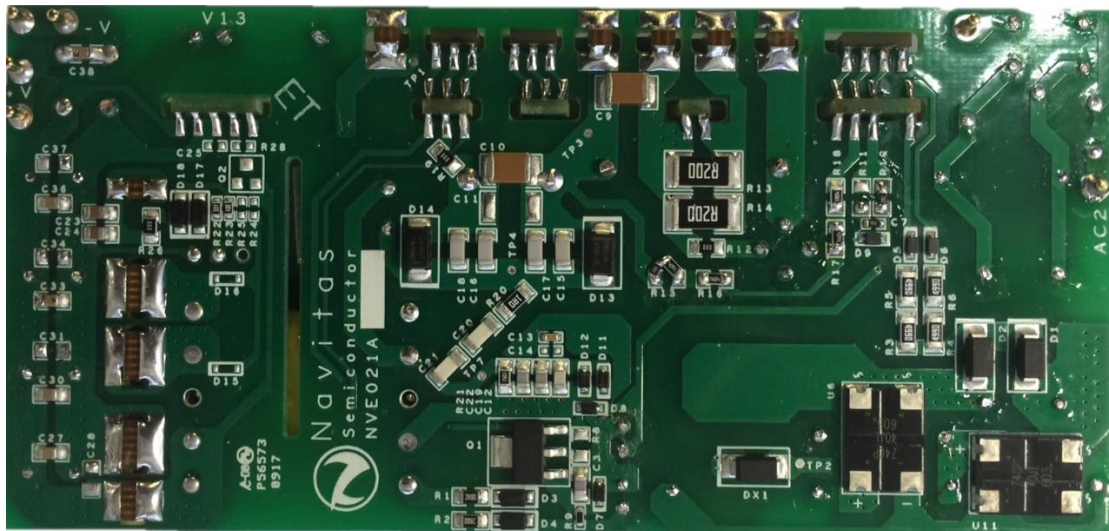


Fig. 2c: Power board bottom-side components

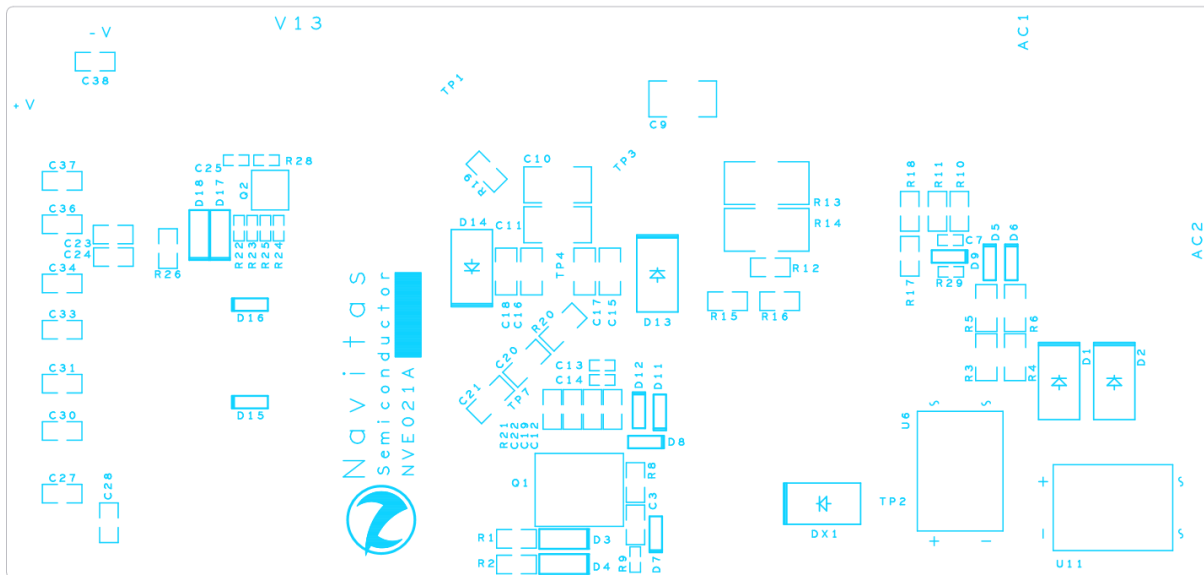


Fig. 2d: Power board bottom-side silkscreen

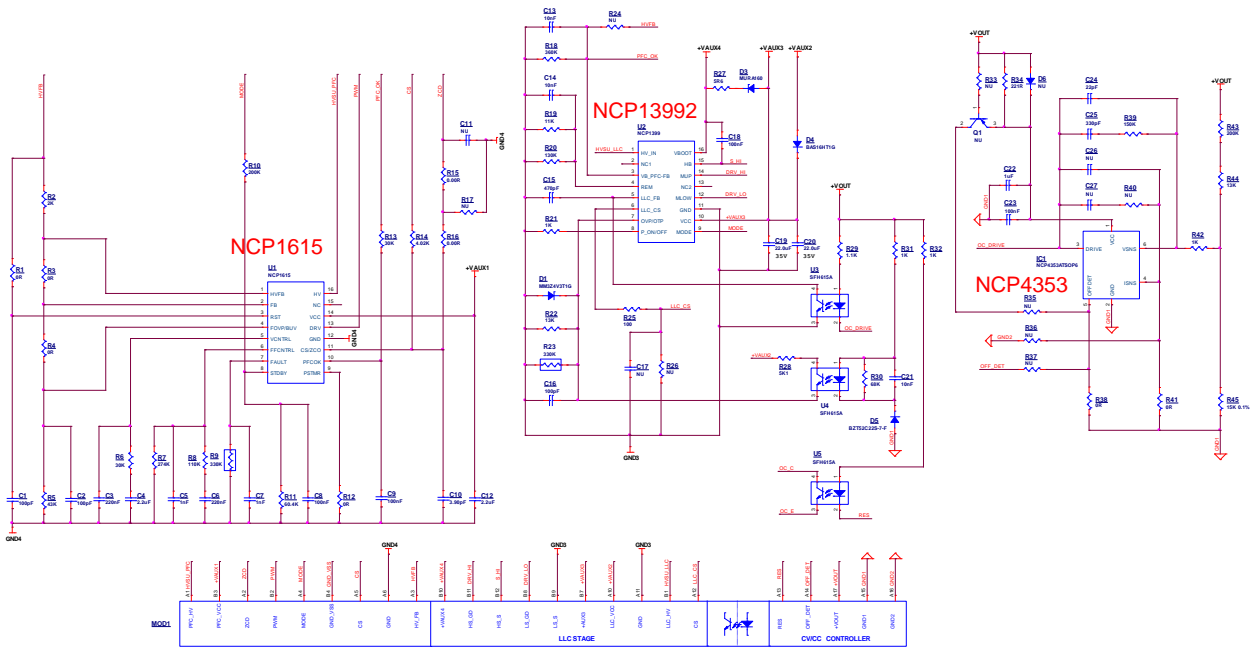


Fig. 3a: PFC, LLC control module daughtercard schematic

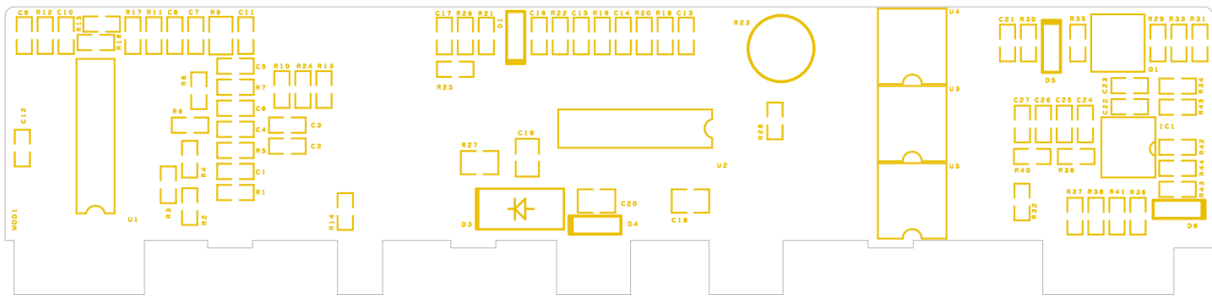


Fig. 3b: PFC, LLC control module daughtercard silkscreen

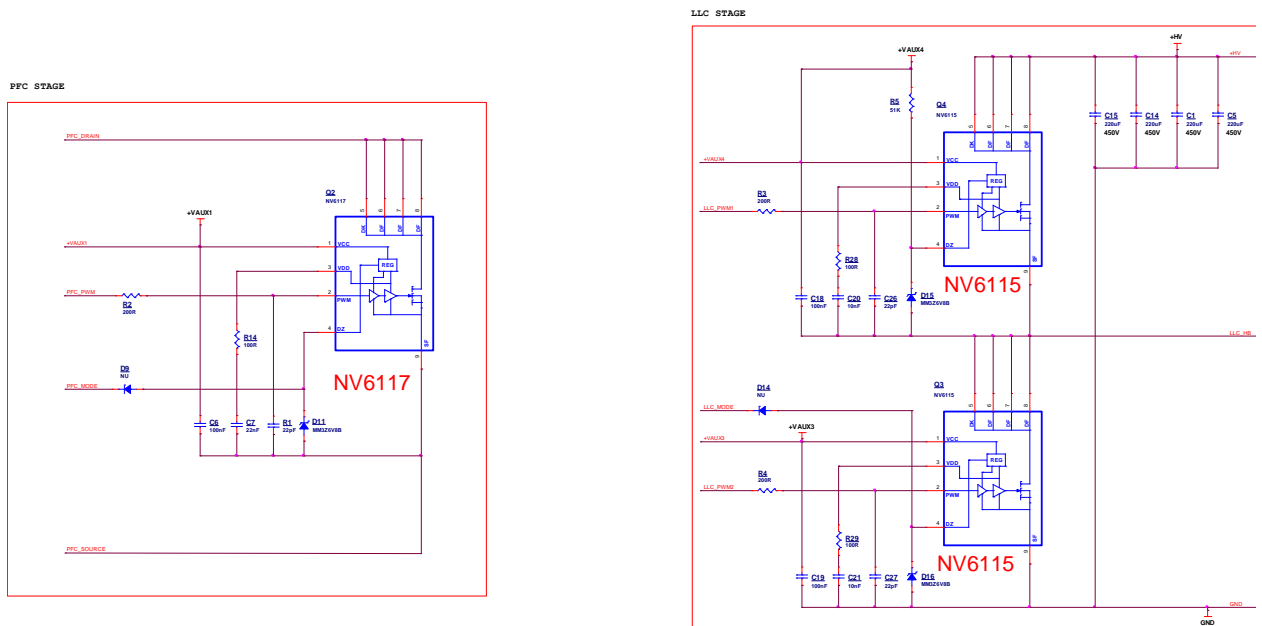


Fig. 4a: PFC, LLC powertrain daughtercard schematic

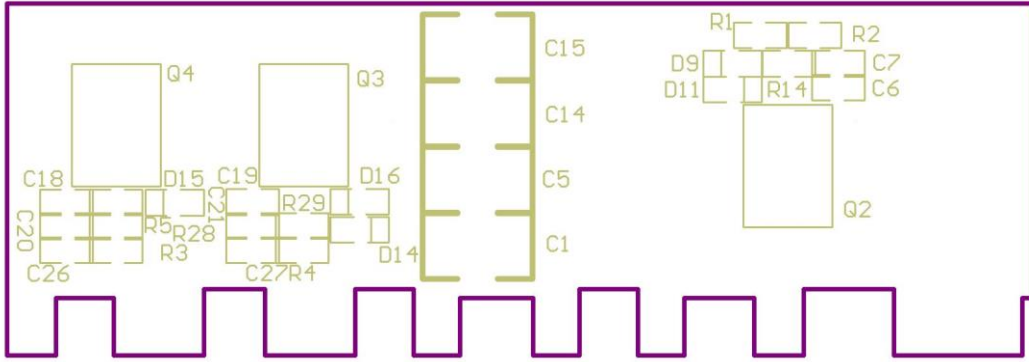


Fig. 4b: PFC, LLC powertrain daughtercard silkscreen

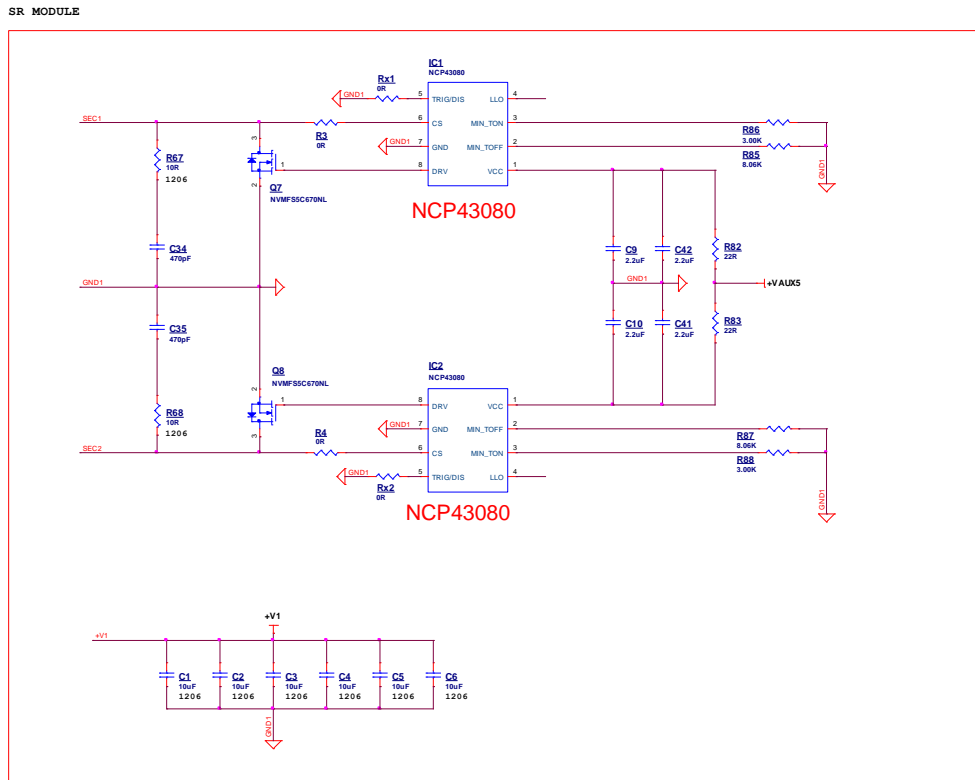


Fig. 5a: Secondary rectifier daughtercard schematic

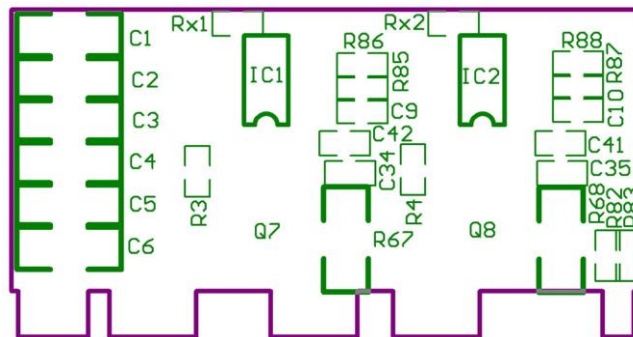


Fig. 5b: Secondary rectifier daughtercard silkscreen

5. PCB Construction:

The demo is constructed using a main board plus daughtercards. This assists evaluation and allows the user to exchange daughtercards for experimentation, plus allows a lower cost for PCB and assembly. PCB material is standard FR4 with 20oz copper. Comprehensive PCB information and design files (gerber, .dxf, etc.) are available from info@navitassemi.com.

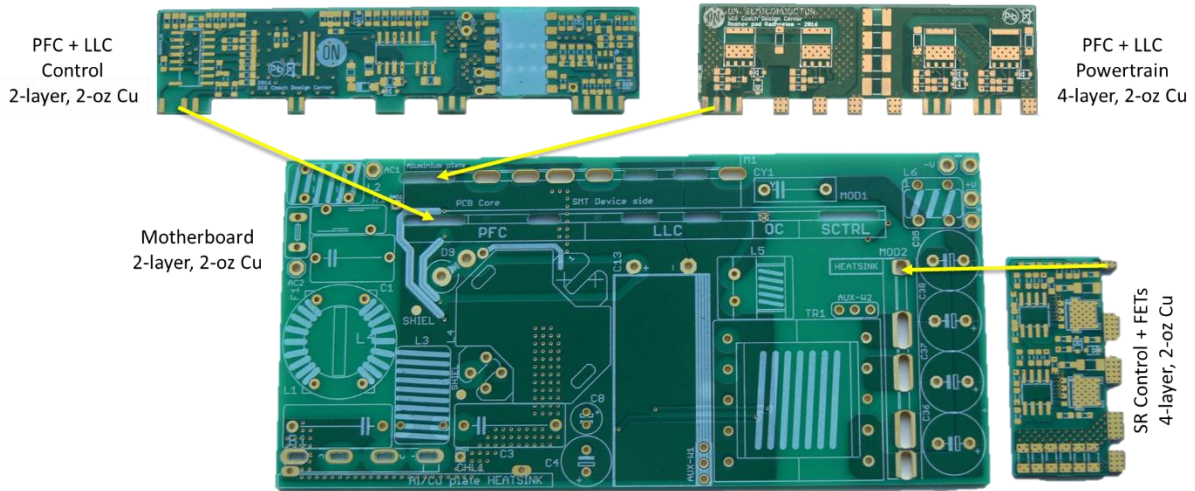


Fig. 6: Power board and daughtercard PCBs (generic construction shown, actual board design may vary)

6. Connections and Start-up Sequence:

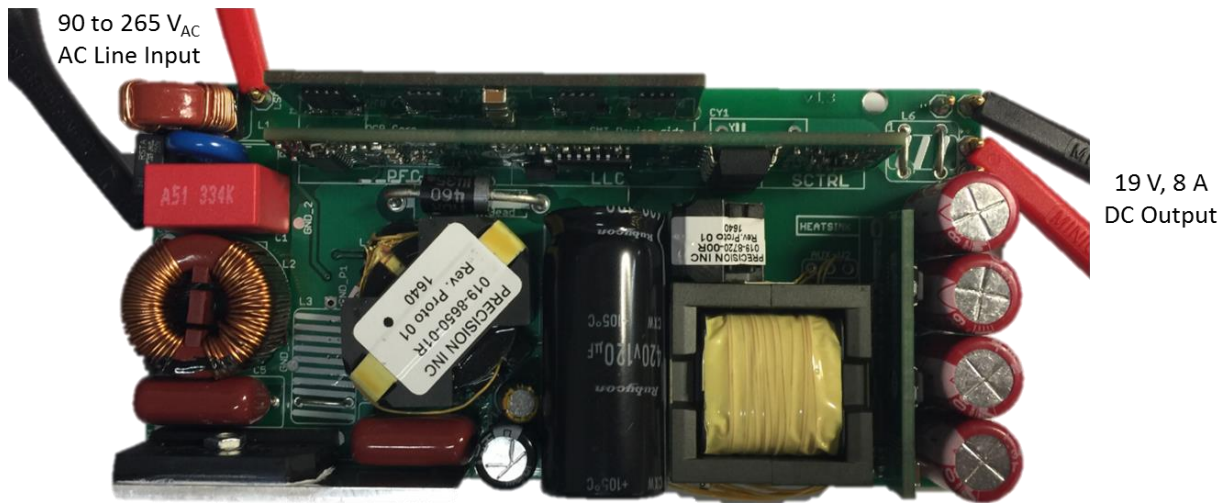


Fig. 7: Connections (generic connection shown, actual board design may vary)

Start-up:

Attention: This board has not been optimized for inrush / lightning strike. Follow the procedure as described below.

1. Set AC line to 0V_{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 120V_{AC}
6. Turn AC line input to ON
7. Measure DC output voltage (19V)
8. Increase output load current and monitor output voltage

Power-down sequence:

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

7. Switching Waveforms: CrCM PFC Boost Stage

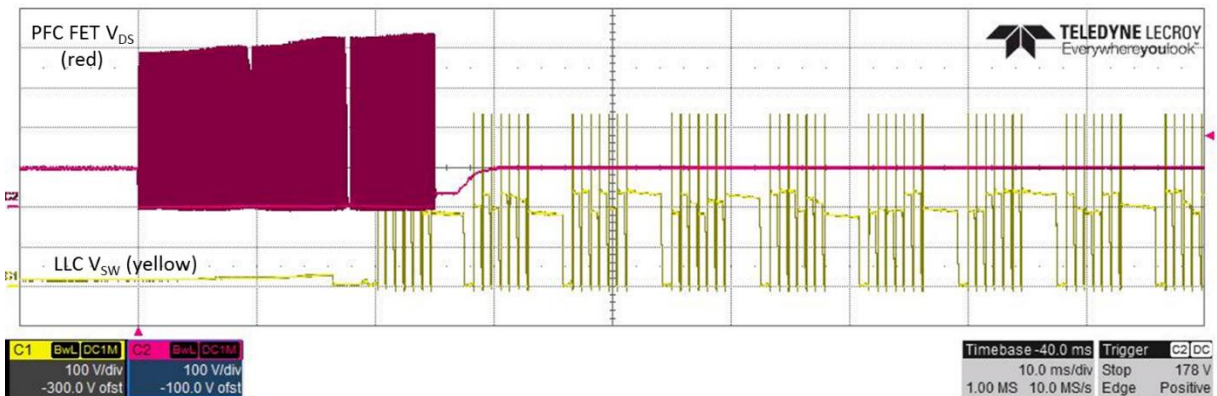


Fig. 8a: PFC FET V_{DS}, LLC V_{Sw} at start-up

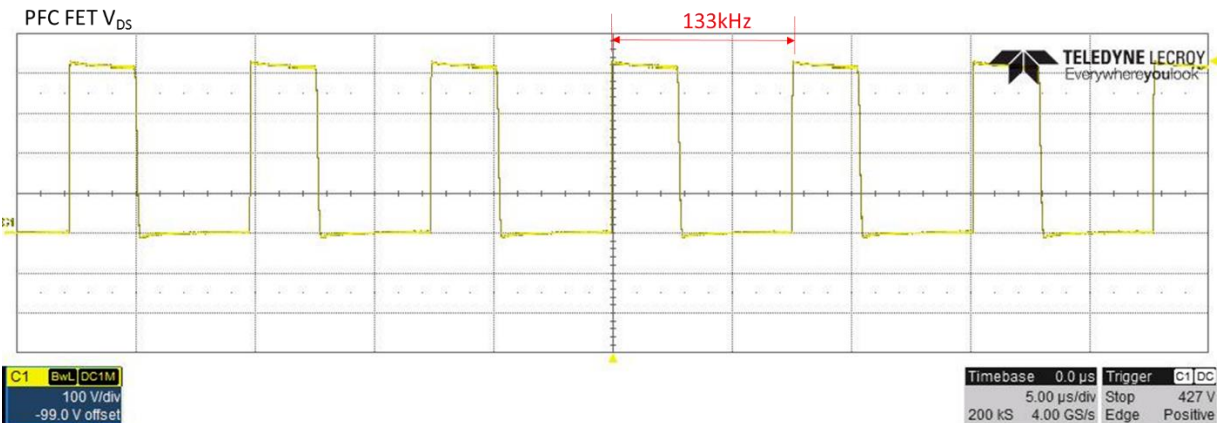


Fig. 8b: CrCM PFC Boost 120V_{IN}, 400V_{OUT}, 150W (peak of AC line)

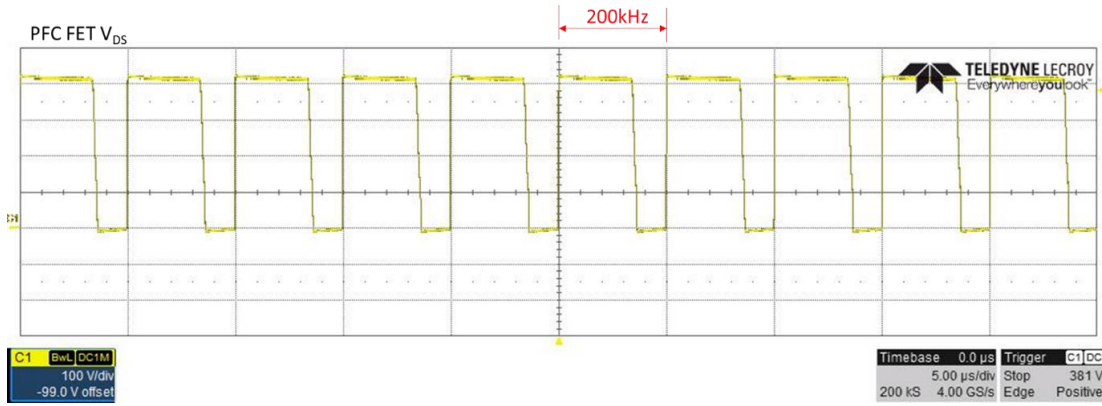


Fig 8c: CrCM PFC Boost at 220V_{AC}, 150W (peak of AC line)

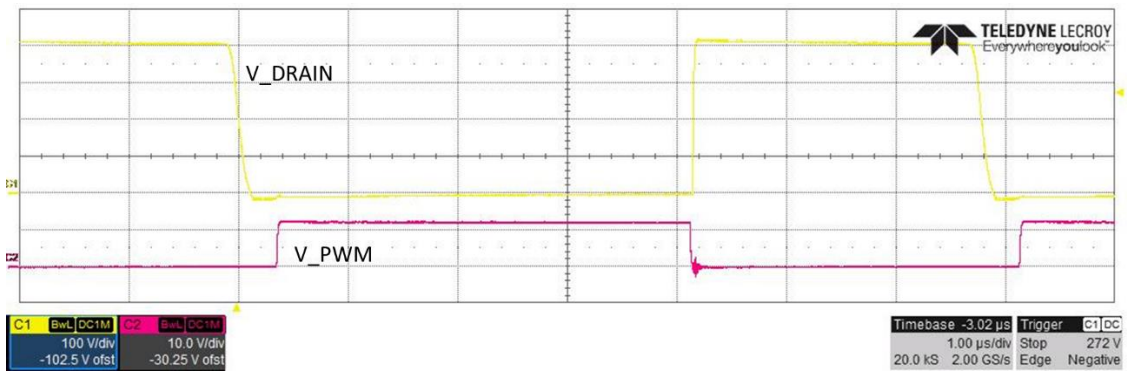


Fig. 8d: PFC switching (zoom), 220V_{AC}, 150W

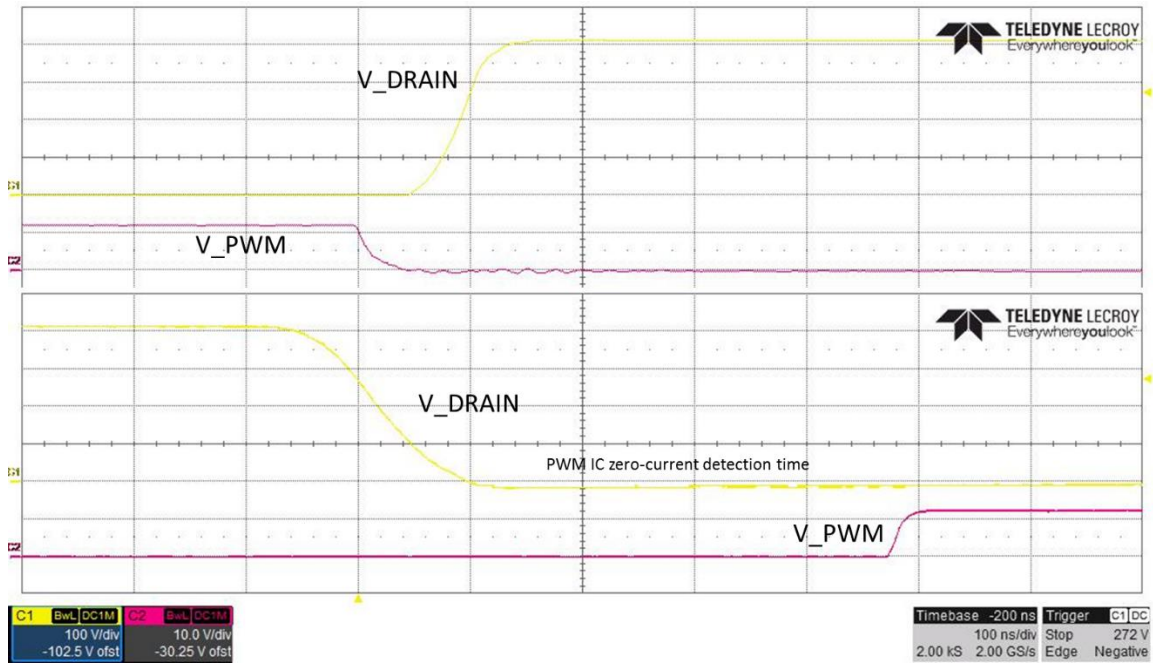
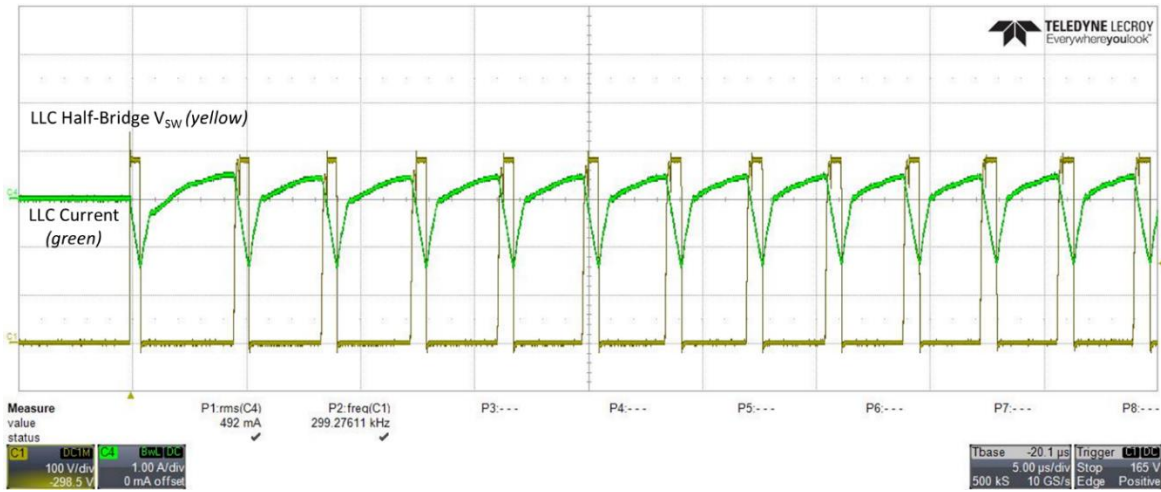
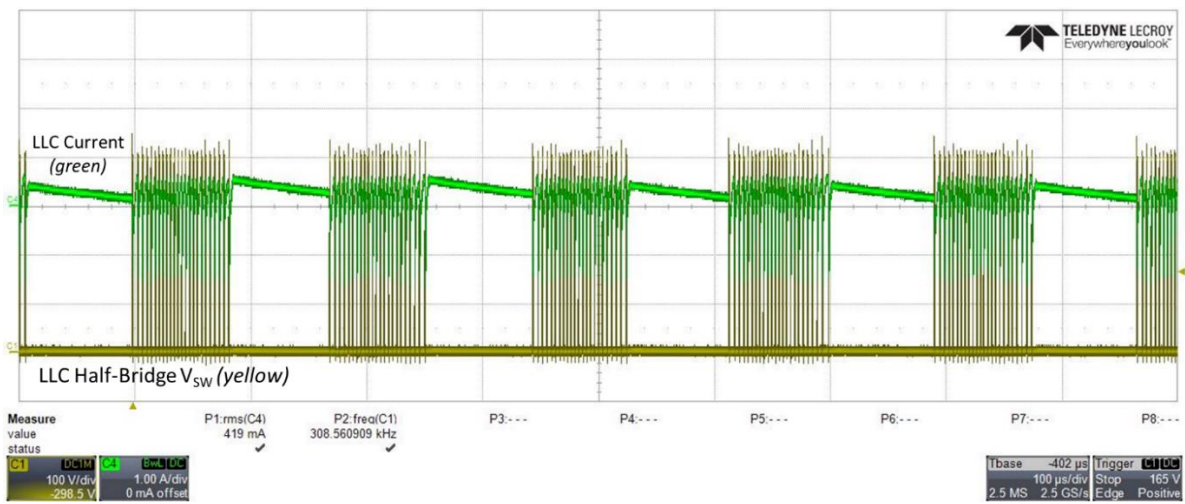


Fig. 8e: PFC switching (zoom), 220V_{AC}, 150W

Switching Waveforms: DC-DC (LLC) Stage

 Fig. 9a: LLC V_{sw} , open load, 19V_{OUT}

 Fig. 9b: LLC V_{sw} , skip mode, 19V_{OUT}, 1A

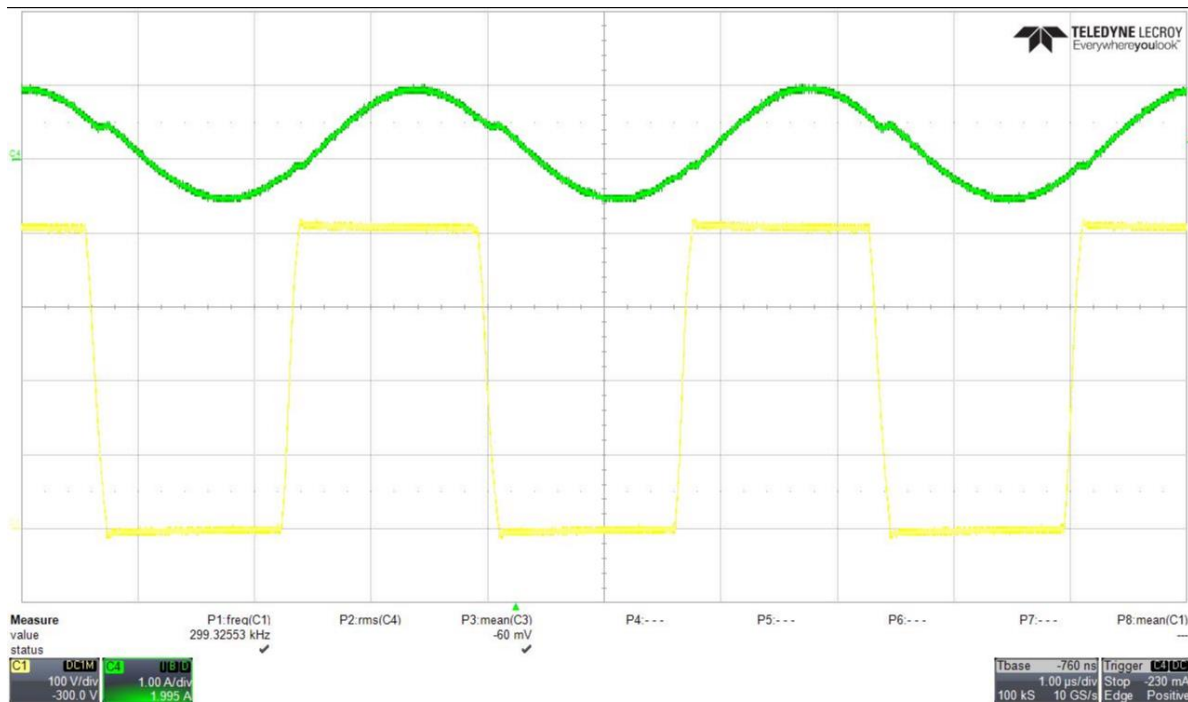


Fig. 9c: LLC V_{sw}, I_L, 19V_{out}, 4A_{out}

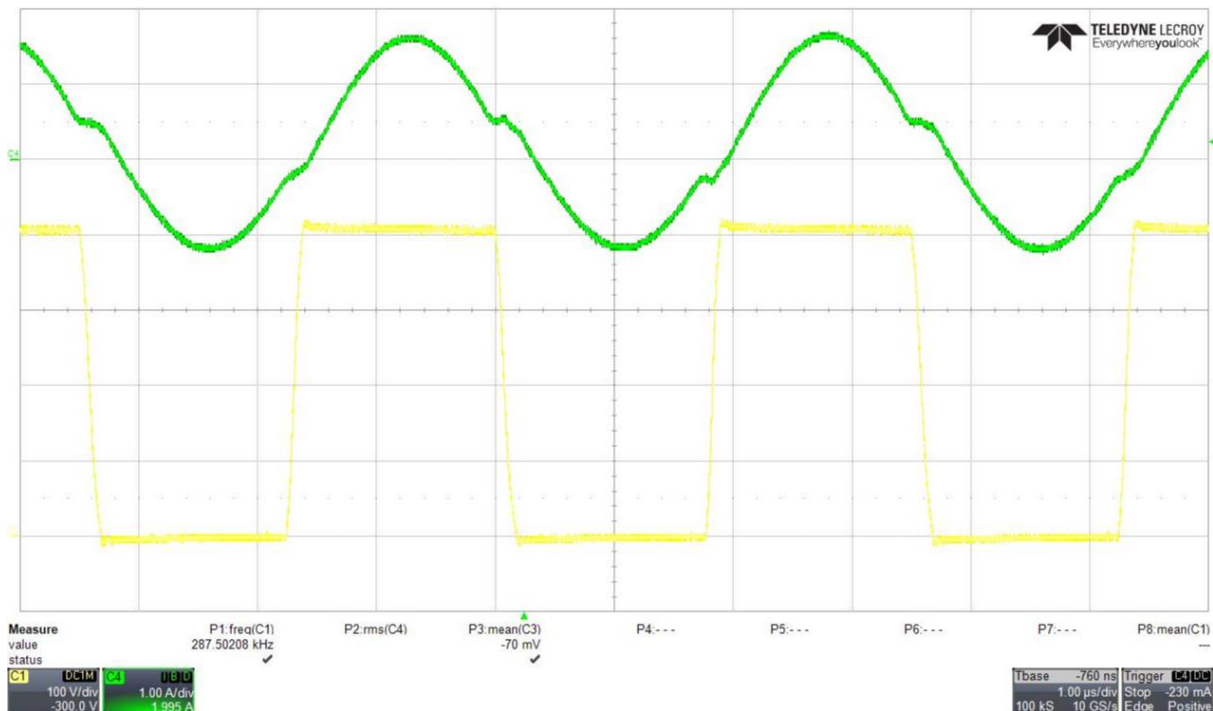


Fig. 9d: LLC V_{sw}, I_L, 19V_{out}, 8A

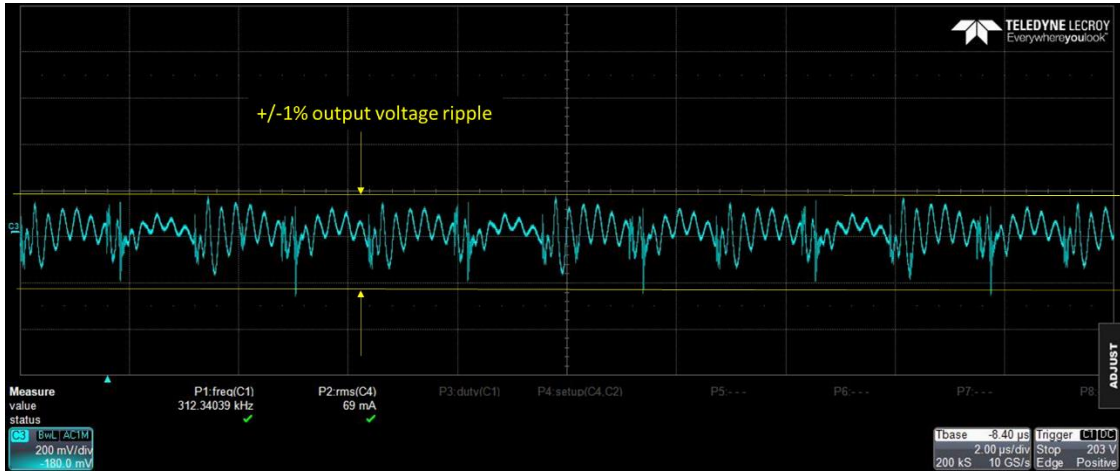


Fig. 9e: Output Voltage Ripple (19V_{OUT}, 8A). +/- 200mV on 19V.

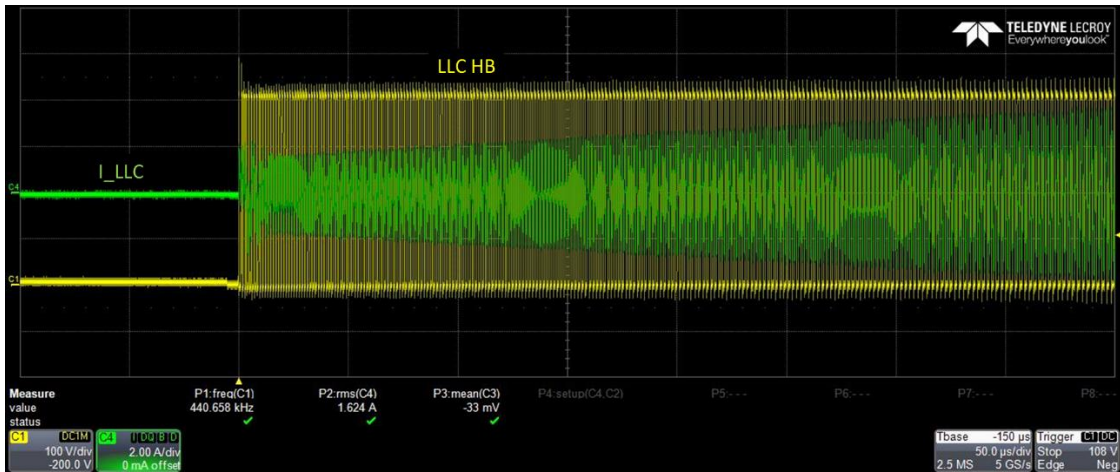


Fig. 9f: Start-up into full load

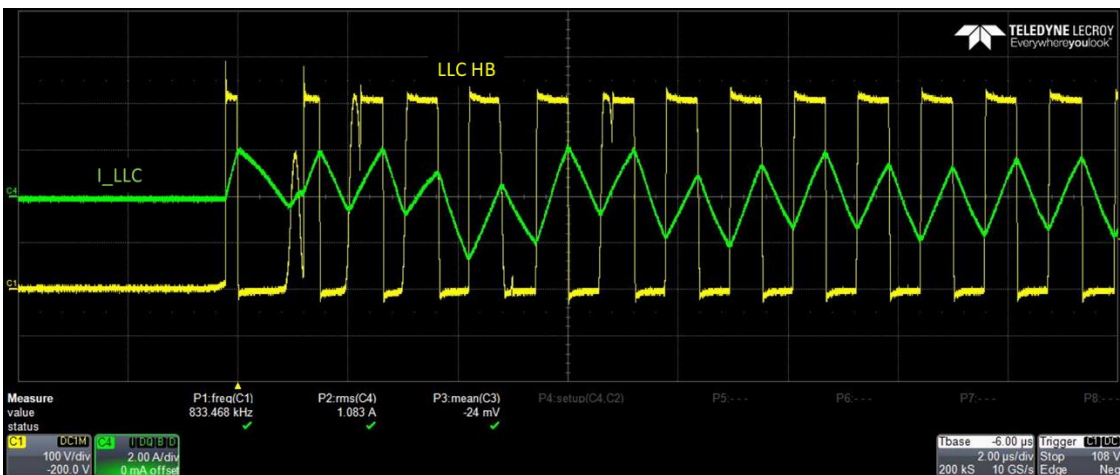


Fig. 9g: Start-up into full load (zoom), showing the first pulses of high-side soft-start using increasing pulse-width turn-on technique.

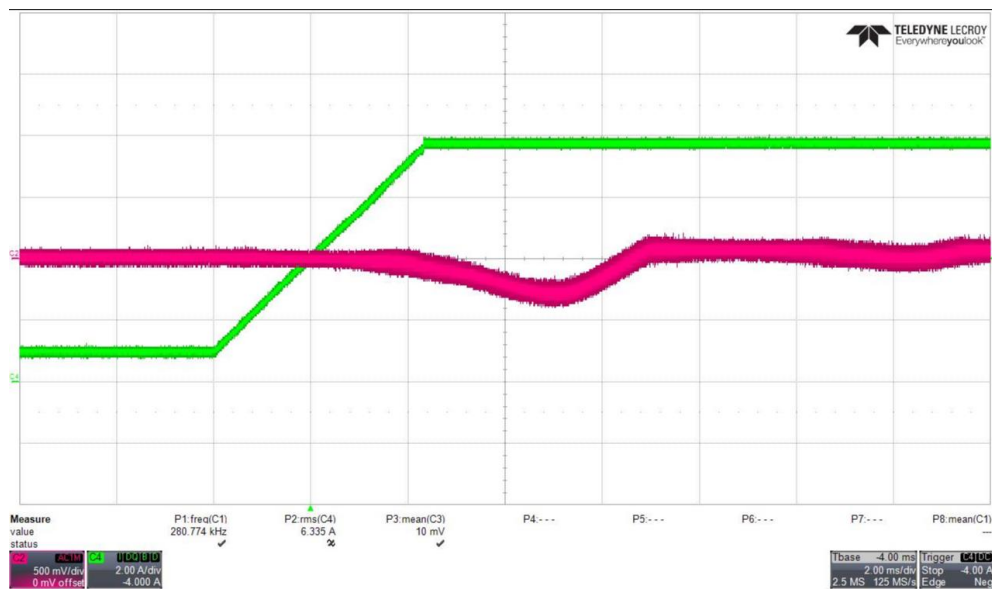


Fig. 9h: Load step waveforms (1A to 8A, output current green, AC coupled output voltage red).

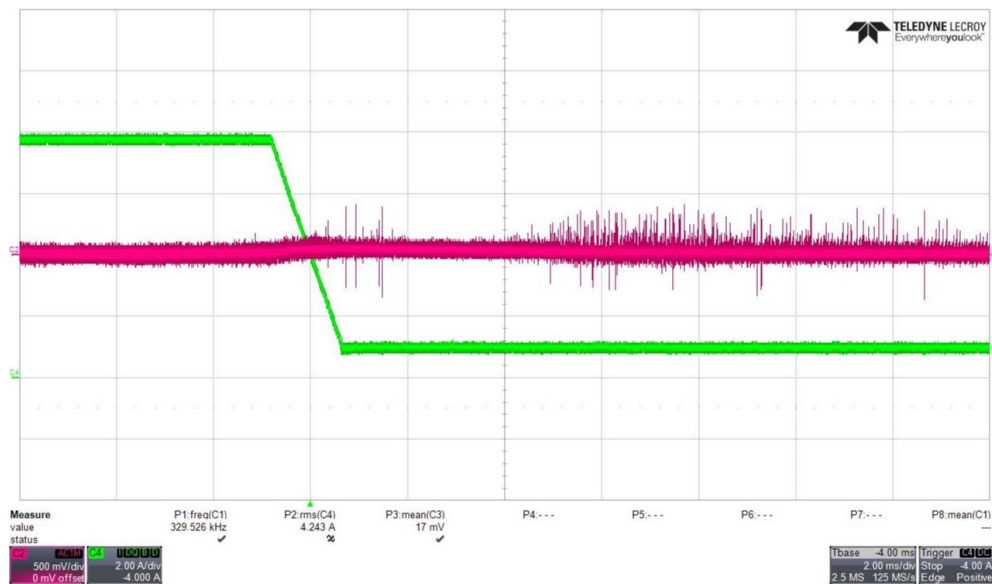


Fig. 9i: Load step waveforms (8A to 1A, output current green, AC coupled output voltage red).

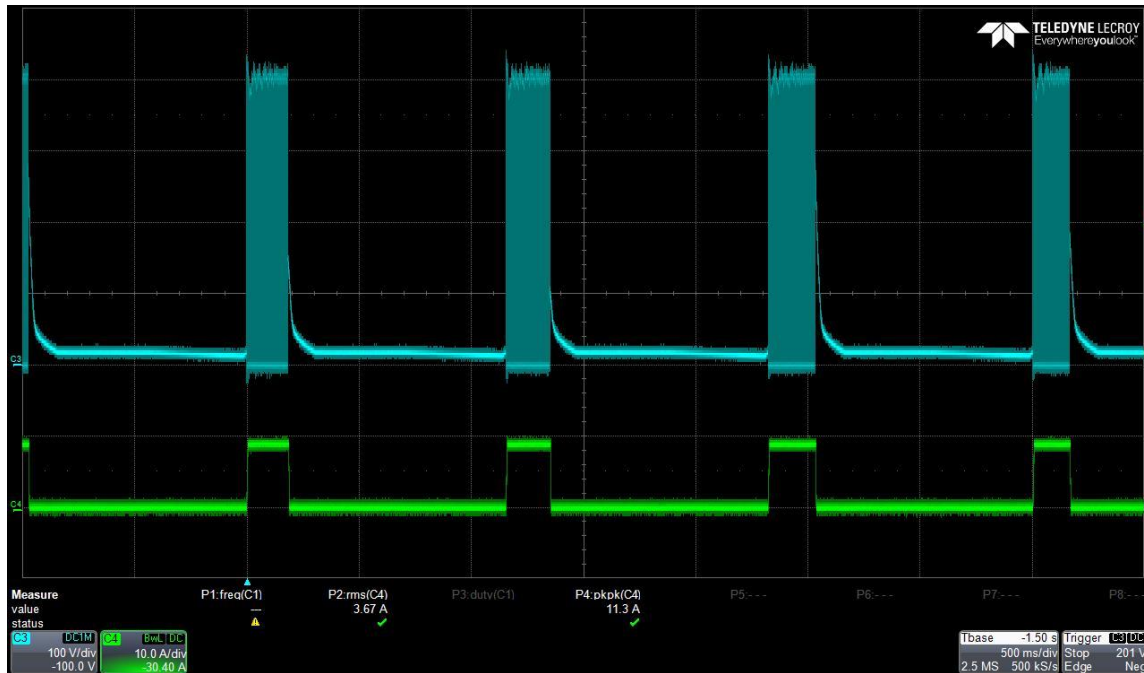


Fig. 9j: Over-current limitation (output short-circuit, output current green, half-bridge switch node blue).

8. Efficiency Curves:

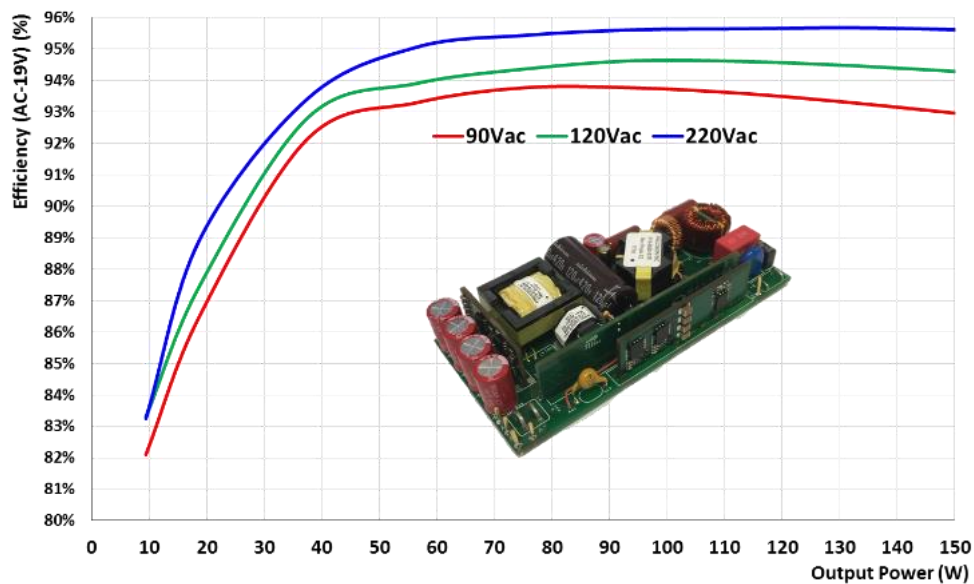


Fig. 10: Efficiency vs. load, AC line voltage (no heatsink, no airflow, room ambient)

Standby power consumption <100mW (120V_{AC} = 25mW, 220V_{AC} = 65mW).

9. Power Factor:

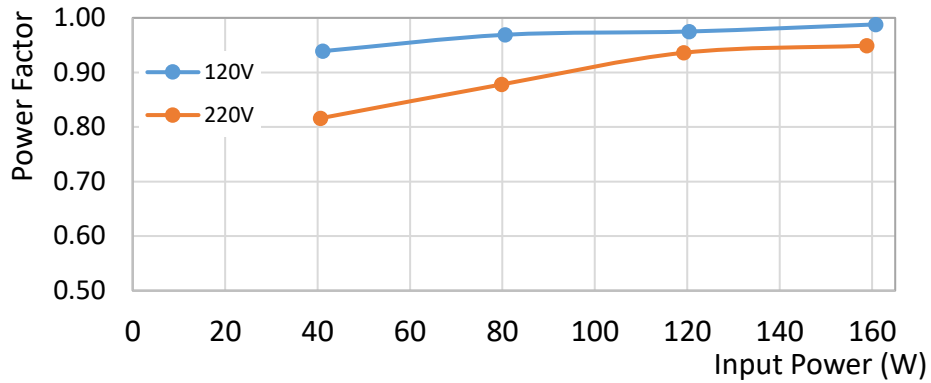


Fig. 11: Power factor vs. load

10. Thermal Performance:

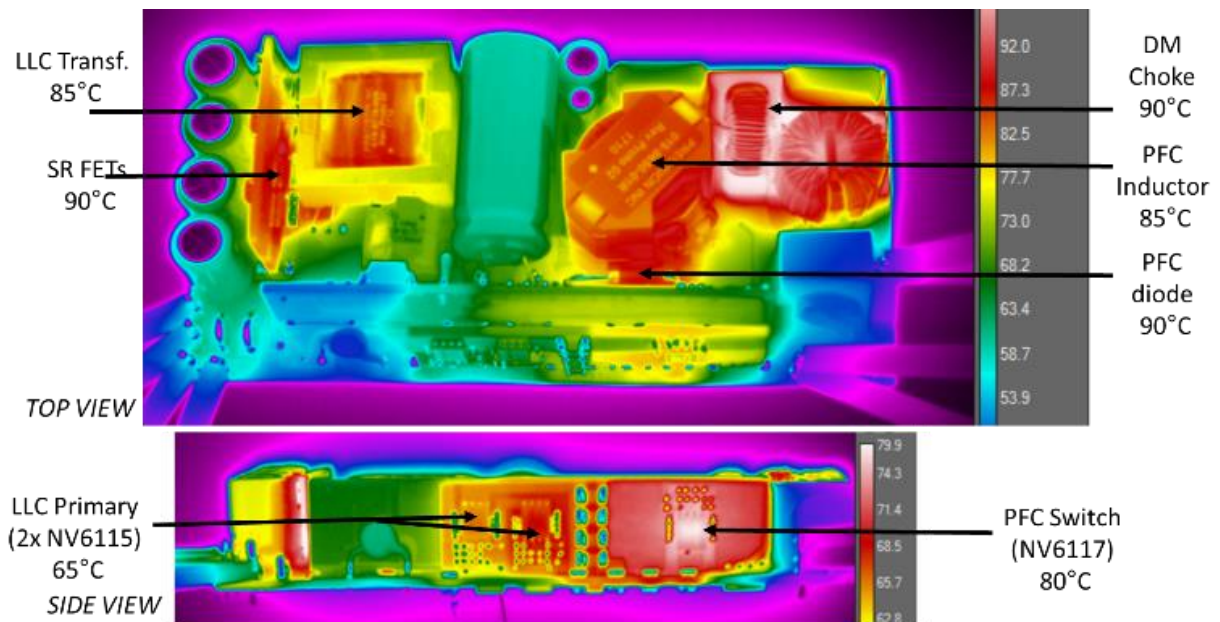


Fig. 12: Top view and side view, 90V_{AC}, 100% Load (no airflow, 25°C). AC rectifiers on bottom side (100°C not shown).

11. EMI Measurements:

(Quasi-Peak and Average modes, 120VAC, 150W. Performance as shipped.)

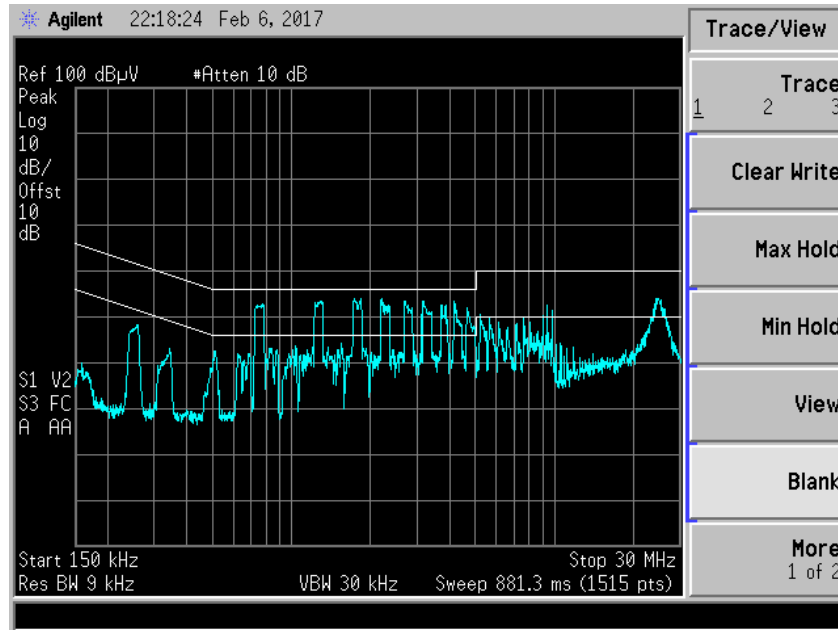


Fig. 11a: Conducted EMI (quasi-peak)

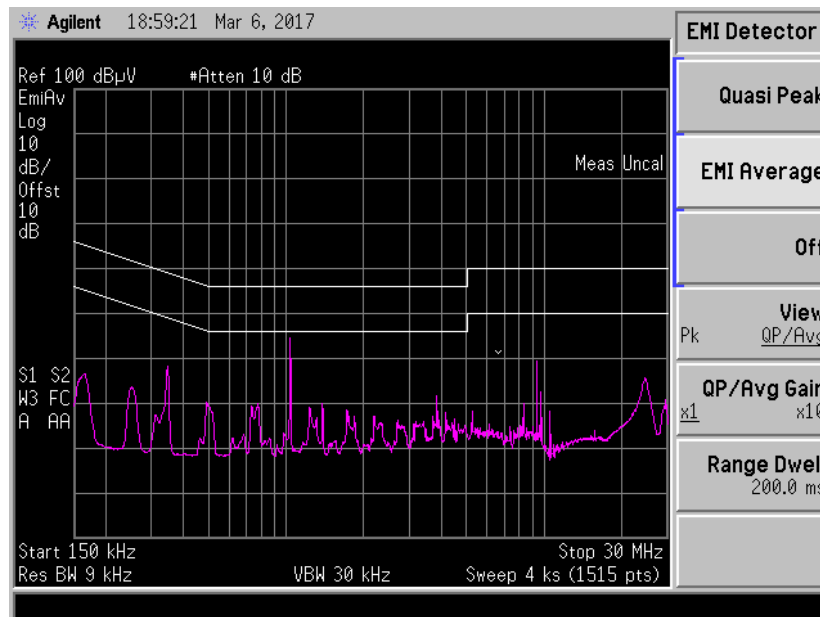


Fig. 11b: Conducted EMI (average).

12. Bill of Materials: Power Board

For Precision Inc. magnetics, please refer to:

Asia: Samuel Yu (余先生), ASEAN / Asia Business Dev. Manager, Samuel.Yu@precision-inc.com, (+86) 139 16581576

USA: Welly Chou, Design Engineering Manager, Welly.Chou@precision-inc.com, (+1) 763-852-6743

ITEM	QTY	REFERENCE	DESCRIPTION	VALUE	PACKAGE	VOLTAGE	TOL.	MFGR. NAME	MFGR. PART #
1	1	C1	CAP FILM 0.33UF 10% 275VAC RAD	330nF	Thru-hole	275V	±10%	Wurth	890324024003
2	2	C10, C9	CAP CER 0.47UF 450V X7T 1812	470nF	1812	450V	±20%	Panasonic	C4532X7T2W474M230KE
3	25	C11, C14, C25, C28, C31, C34, C37, C7, D15, D16, L1, L6, Q2, R11, R24, R25, R28, R8, TP1, TP2, TP3, TP4, TP5, TP6, TP7	Open component	Open	-	-	-	-	-
4	1	C12	CAP CER 150PF 50V NPO 0805	150pF	0805	50V	-55°C ~ 125°C	Yageo	CC0805JRNPO9BN151
5	1	C13	0.022µF ±5% 50V Ceramic Capacitor X7R 0603	22.0nF	0603	50V	±5%	AVX Corp	06035C223JAT2A
6	4	C15, C16, C17, C18	CAP CER 2200PF 630V C0G 1206	2.20nF	1206	630V	-55°C ~ 125°C	TDK Corp	C3216C0G2J222115AA
7	2	C19, C3	CAP CER 10000PF 50V C0G 0805	10.0nF	0805	50V	-55°C ~ 125°C	TDK Corp	C2012C0G1H103J060AA
8	1	C2	CAP ALUM 220UF 20% 35V RADIAL	220uF	Thru-hole	35V	-40°C ~ 105°C	Wurth	860020574012
9	2	C20, C21	CAP CER 100PF 1KV NPO 1206	100pF	1206	1000V	-55°C ~ 125°C	Yageo	CC1206JKNPOCBN101
10	1	C22	CAP CER 1800PF 50V C0G 0805	1.80nF	0805	50V	±5%	TDK Corp	C2012C0G1H182J060AA
11	2	C23, C24	22µF 25V Ceramic Capacitor X5R 0805	22.0uF	0805	25V	±20%	Samsung EM, Inc.	CL21A226MAQNNNE
12	4	C26, C29, C32, C35	CAP ALUM 680UF 20% 25V RADIAL	680uF	Thru-hole	25V	±20%	Wurth	860020475016
13	5	C27, C30, C33, C36, C38	CAP CER 0.1UF 50V X7R 0805	100nF	0805	50V	±5%	AVX Corp	08055C104JAT2A
14	1	C4	CAP ALUM 47UF 20% 35V RADIAL	47.0uF	Thru-hole	35V	±20%	Nichicon	UFW1V470MDD1TD
15	2	C49, C50	Ceramic Disc Capacitors 470pF X1:440Vac Y2:300Vac	470pF	Thru-hole	300VAC	-25°C ~ 125°C	TDK Corp	CS75-B2GA471KYNKA
16	2	C5, C6	CAP FILM 1UF 10% 450VDC RADIAL	1.00uF	Thru-hole	450V	±10%	Panasonic	ECW-FD2W105K
17	1	C8	CAP ALUM 120UF 20% 420V RADIAL	120uF	Thru-hole	420V	-25°C ~ 105°C	Nichicon	UCPW6121MHD
18	1	CY1	CAP CER 680PF 760VAC Y5U RADIAL	680pF	Thru-hole	760VAC	-40°C ~ 125°C	Vishay	VY1681M29Y5UC63V0
19	3	D1, D2, Dx1	DIODE GEN PURP 1KV 1A SMA	Diode	DO214	1000V, 1.0A	-65°C ~ 175°C	ON Semi	MRA4007T3G
20	1	D10	DIODE GEN PURP 600V 4A DO201AD	Diode	Thru-hole	600V, 4.0A	-65°C ~ 175°C	ON Semi	MUR460RLG

Bill of Materials: Power Board (cont.)

ITEM	QTY	REFERENCE	DESCRIPTION	VALUE	PACKAGE	VOLTAGE	TOL.	MFGR. NAME	MFGR. PART #
21	4	D11, D12, D8, D9	DIODE GEN PURP 100V 200MA SOD323	Diode	SOD323	100V, 150mW	-55°C ~ 150°C	ON Semi	BAS16HT1G
22	2	D13, D14	DIODE GEN PURP 600V 2A SMA	Diode	DO214	600V, 2.0A	-65°C ~ 175°C	ON Semi	MURA160T3G
23	4	D17, D18, D3, D4	DIODE SCHOTTKY 100V 2A SOD123FL	Diode	SOD123	100V, 2.0A	-65°C ~ 175°C	ON Semi	MBR2H100SFT3G
24	2	D5, D6	DIODE GEN PURP 250V 200MA SOD323	Diode	SOD323	250V, 200mA	-55°C ~ 150°C	ON Semi	BAS21AHT1G
25	1	D7	DIODE ZENER 18V 300MW SOD323	Diode	SOD323	18V, 300mW	-65°C ~ 150°C	ON Semi	MM3Z18VT1G
26	1	F1	FUSE 5A 250/277V RADIAL	Fuse	Thru-hole	250V, 5A	-55°C ~ 125°C	Bel Fuse Inc.	RSTA 5 BULK
27	1	L2	CM Filter, 10mH/2A/125mΩ	10mH	Thru-hole	250V, 2A	-	Würth	744823210
28	1	L3	DM Filter 0.15mH/2.4A/100mΩ	150uH	Thru-hole	250V, 2.4A	-	Würth	7447018
29	1	L4	PFC INDUCTOR - RM10-3	150uH	Thru-hole	-	-	Precision	019-8650-01R
30	1	L5	RESONANT INDUCTOR 50uH	50uH	Thru-hole	-	-	Precision	019-8720-00R
31	1	Q1	MOSFET N-CH 60V 4A SOT223	FET	SOT223	60V, 100mW	-55°C ~ 150°C	STMicro	STN3NF06L
32	2	R1, R2	RES SMD 2 OHM 1% 1/8W 0805	2.00R	0805	125mW	±1%	Yageo	RC0805FR-072RL
33	1	R10	RES SMD 8.06K OHM 1% 1/10W 0603	8.06K	0603	100mW	±1%	Yageo	RC0805FR-078K06L
34	3	R12, R19, R26	RES SMD 0.0 OHM JUMPER 1/8W 0805	0.00R	0805	125mW	±1%	Vishay	CRCW08050000Z0EA
35	2	R13, R14	RES SMD 0.2 OHM 1% 2W 2512	0.20R	2512	2W	±1%	Stackpole Elect.	CSRN2512FKR200
36	2	R15, R16	RES SMD 1.8M OHM 1% 1/8W 0805	1.80M	0805	125mW	±1%	Panasonic	ERJ-6ENF1804V
37	2	R17, R18	RES SMD 1.6M OHM 1% 1/8W 0805	1.60M	0805	125mW	±1%	Panasonic	ERJ-6ENF1604V
38	1	R20	RES SMD 1 OHM 1% 1/4W 1206	1.00R	1206	250mW	±1%	Panasonic	ERJ-8RQF1R0V
39	1	R21	RES SMD 1.5K OHM 1% 1/8W 0805	1.50K	0805	125mW	±1%	Panasonic	ERJ-6ENF1501V
40	2	R22, R23	RES SMD 2 OHM 1% 1/10W 0603	2.00R	0603	100mW	±1%	Yageo	RC0603FR-072RL
41	1	R29	RES SMD 49.9K OHM 1% 1/10W 0603	49.9K	0603	100mW	±1%	Vishay	CRCW060349K9FKEA
42	4	R3, R4, R5, R6	RES SMD 499 OHM 1% 1/4W 1206	500R	1206	250mW	±1%	Panasonic	ERJ-8ENF4990V
43	1	R7	VARISTOR 470V 2.5KA DISC 10MM	Varistor	Thru-hole	470V, 2.5KA	-40°C ~ 85°C	EPCOS	S10K300
44	1	R9	RES SMD 12K OHM 1% 1/10W 0603	12.0K	0603	100mW	±1%	Panasonic	ERJ-3EKF1202V
45	6	TP10, TP11, TP12, TP13, TP8, TP9	CONN PC PIN CIRC 0.048DIA GOLD	Hardware	0.150 x 0.250"	-	-	Mill-Max Man. Corp.	0600-0-05-15-00-00-01-0
46	1	TR1	LLC TRANSFORMER	-	Thru-hole	-	-	Precision	019-8719-00R
47	1	U10	CONTROL BOARD	-	Thru-hole	-	-	Navitas	CONTROL BOARD
48	2	U11, U6	Bridge Rectifier Single Phase 600V 4A	Diode	SMD4	600V, 4.0A	-55°C ~ 175°C	Comchip	Z4DGP406L-HF
49	1	U8	SWITCH BOARD	-	Thru-hole	-	-	Navitas	SWITCH BOARD
50	1	U9	SR BOARD	-	Thru-hole	-	-	Navitas	SR BOARD

Bill of Materials: Control Module Daughtercard

ITEM	QTY	REFERENCE	DESCRIPTION	VALUE	PACKAGE	VOLTAGE	TOL.	MFGR. NAME	MFGR. PART #
1	3	C1, C16, C2	MLCC - SMD/SMT 0603 100pF 50volts COG 5%	100pF	0603	50V	±5%	TDK Corporation	C1608COG1H10J1080AA
2	1	C10	CAP CER 3.9PF 50V NPO 0603	3.90pF	0603	50V	±10%	AVX Corporation	06035A3R9CAT2A
3	15	C11, C17, C26, C27, D6, MOD1, Q1, R17, R24, R26, R33, R35, R36, R37, R40	Open component	Open	-	-	-	-	-
4	2	C12, C4	2.2µF ±20% 16V Ceramic Capacitor X7R 0603	2.20uF	0603	100mW	±1%	Taiyo Yuden	EMK107BB7225MA-T
5	3	C13, C14, C21	CAP CER 10000PF 50V 10% X7R 0603	10.0nF	0603	50V	±10%	AVX Corporation	06035C103KAT2A
6	1	C15	CAP CER 470PF 25V 10% X7R 0603	470pF	0603	25V	±10%	Kemet	C0603C471K3RACTU
7	1	C18	CAP CER 0.1UF 50V X7R 0805	100nF	0805	50V	±5%	AVX Corporation	08055C104JAT2A
8	2	C19, C20	CAP CER 22UF 35V 10% X5R 0805	22.0uF	0805	16V	±10%	TDK Corporation	C2012X5R1V226M125AC
9	1	C22	1µF ±10% 50V Ceramic Capacitor X7R 0603	1.00uF	0603	50V	±10%	Taiyo Yuden	UMK107AB7105KA-T
10	3	C23, C8, C9	CAP CER 0.1UF 25V 10% X7R 0603	100nF	0603	25V	±10%	AVX Corporation	0603C104KAT4A
11	1	C24	CAP CER 22PF 50V 5% NPO 0603	22.0pF	0603	50V	±5%	AVX Corporation	06035A220JAT2A
12	1	C25	CAP CER 330PF 50V NPO 0603	330pF	0603	50V	±5%	Yageo	CC0603JRN9P09B331
13	2	C3, C6	MLCC - SMD/SMT 0603 25volts 0.22uF X7R 10%	220nF	0603	25V	±10%	TDK Corporation	C1608X7R1E224K080AC
14	2	C5, C7	CAP CER 1000PF 25V 1% NPO 0603	1.00nF	0603	25V	±1%	Kemet	C0603C102F3GACTU
15	1	D1	DIODE ZENER 4.3V 300MW SOD323	Diode	SOD323	4.3V, 300mW	-65°C ~ 150°C	ON Semiconductor	MM324V3T1G
16	1	D3	DIODE GEN PURP 600V 2A SMA	Diode	SMA	600V, 2A	-65°C ~ 175°C	ON Semiconductor	MURA160T3G
17	1	D4	DIODE GEN PURP 100V 200MA SOD323	Diode	SOD323	100V, 150mW	-55°C ~ 150°C	ON Semiconductor	BAS16HT1G
18	1	D5	DIODE ZENER 22V 200MW SOD323	Diode	SOD323	22V, 200mW	-65°C ~ 150°C	Diodes Incorporated	BZT52C22S-7-F
19	1	IC1	IC SECONDARY CTRLR SMPS	Controller	SOT23-6	36V	0°C ~ 125°C	ON Semiconductor	NCP4353ASNT1G
20	8	R1, R12, R15, R16, R3, R38, R4, R41	Thick Film Resistors - SMD 0603 Zero Ohms	0.00R	0603	100mW	±1%	Panasonic	ERJ-3GEY0R00V
21	2	R10, R43	RES SMD 200K OHM 1% 1/10W 0603	200K	0603	100mW	±1%	Panasonic	ERJ-3EKF2003V
22	1	R11	RES SMD 60.4K OHM 1% 1/10W 0603	60.4K	0603	100mW	±1%	Yageo	RC0603FR-0760K4L
23	2	R13, R6	RES SMD 30.1K OHM 1% 1/10W 0603	30.1K	0603	100mW	±1%	Panasonic	ERJ-3EKF3012V
24	1	R14	RES SMD 4.02K OHM 1% 1/10W 0603	4.02K	0603	100mW	±1%	Yageo	RC0603FR-074K02L
25	1	R18	RES SMD 360K OHM 1% 1/10W 0603	360K	0603	100mW	±1%	Panasonic	ERJ-3EKF3603V
26	1	R19	RES SMD 11K OHM 1% 1/10W 0603	11.0K	0603	100mW	±1%	Panasonic	ERJ-3EKF1102V
27	1	R2	RES SMD 2K OHM 1% 1/10W 0603	2.00K	0603	100mW	±1%	Panasonic	ERJ-3EKF2001V
28	1	R20	RES SMD 130K OHM 1% 1/10W 0603	130K	0603	100mW	±1%	Vishay	CRCW0603130KFKEA
29	4	R21, R31, R32, R42	RES 1K OHM 1/10W 1% 0603 SMD	1.00K	0603	100mW	±1%	Panasonic	ERJ-3EKF1001V
30	2	R22, R44	RES SMD 13K OHM 1% 1/10W 0603	13.0K	0603	100mW	±1%	Panasonic	ERJ-3EKF1302V
31	1	R23	NTC THERMISTOR 330K OHM 5% BEAD	330K	Thru-hole	500mW	±5%	Vishay	NTCLE100E3334JB0
32	1	R25	Thick Film Resistors - SMD 0603 100ohms 1% Tol	100R	0603	100mW	±1%	Panasonic	ERJ-3EKF1000V
33	1	R27	RES SMD 5.6 OHM 1% 1/8W 0805	5.60R	0805	125mW	±1%	Panasonic	ERJ-6RQF5R6V
34	1	R28	RES SMD 5.1K OHM 1% 1/10W 0603	5.10K	0603	100mW	±1%	Yageo	RC0603FR-075K1L
35	1	R29	RES SMD 1.1K OHM 1% 1/10W 0603	1.10K	0603	100mW	±1%	Panasonic	ERJ-3EKF1101V
36	1	R30	RES SMD 68.1K OHM 1% 1/10W 0603	68.1K	0603	100mW	±1%	Panasonic	ERJ-3EKF6812V
37	1	R34	RES SMD 221 OHM 1% 1/10W 0603	221R	0603	100mW	±1%	Panasonic	ERJ-3EKF2210V
38	1	R39	RES SMD 150K OHM 1% 1/10W 0603	150K	0603	100mW	±1%	Vishay	CRCW0603150KFKEA
39	1	R7	RES SMD 274K OHM 1% 1/10W 0603	274K	0603	100mW	±1%	Yageo	RC0603FR-07274KL
40	1	R45	RES SMD 15K OHM 1% 1/10W 0603	15.0K	0603	100mW	±1%	Panasonic	ERJ-3EKF1502V
41	1	R5	RES SMD 43K OHM 1% 1/10W 0603	43K	0603	100mW	±1%	Panasonic	ERJ-3EKF4302V
42	1	R8	RES SMD 110K OHM 1% 1/10W 0603	110K	0603	100mW	±1%	Vishay	CRCW0603110KFKEA
43	1	R9	NTC THERMISTOR 330K OHM 5% 0805	330K	0805	210mW	±5%	Vishay	NTCS0805E3334JHT
44	1	U1	IC CTRLR PFC HV ACTIVE X2 16SOIC	IC analog	SO16	28V	-40°C ~ 125°C	ON Semiconductor	NCP1615CDR2G
45	1	U2	IC OFFLN CONV HALF-BRIDGE 16SOIC	IC analog	SO16	60V	-55°C ~ 150°C	ON Semiconductor	NCP13992AADR2G
46	3	U3, U4, U5	OPTOISOLATOR 5.3KV TRANS 4SMD	IC analog	SMD4	70V, 50mA	-30°C ~ 100°C	Isocom Components	SFH615A-2XSMT/R

Bill of Materials: Powertrain Daughtercard

ITEM	QTY	REFERENCE	DESCRIPTION	VALUE	PACKAGE	VOLTAGE	TOL.	MFGR. NAME	MFGR. PART #
1	4	C1, C14, C15, C5	0.22 μ F \pm 10% 450V Ceramic Cap X7T 1210	0.22uF	1210	450V	\pm 10%	Panasonic	C3225X7T2W224K20 0AA
2	3	C18, C19, C6	CAP CER 0.1UF 25V 10% X7R 0603	0.10uF	0603	25V	\pm 10%	AVX Corp	06033C104KAT4A
3	2	C20, C21	CAP CER 10000PF 50V 10% X7R 0603	10.0nF	0603	50V	\pm 10%	AVX Corp	06035C103KAT2A
4	3	C26, C27, R1	22pF \pm 5% 50V COG, NPO Ceramic Capacitor	22.0pF	0603	50V	\pm 5%	Murata	GQM1885C1H220JB0 1D
5	1	C7	0.022 μ F \pm 5% 50V Ceramic Cap X7R 0603 (1608)	22.0nF	0603	50V	\pm 5%	AVX Corp	06035C223JAT2A
6	3	D11, D15, D16	DIODE ZENER 6.8V 200MW SOD323F	Diode	SOD323	6.8V, 200mW	-65°C ~ 150°C	ON Semi	MM3Z6V8B
7	2	D14, D9	Open component	Open	-	-	-	-	-
8	2	Q3, Q4	Navitas Semiconductor GaN Power IC	IC	QFN- 5x6mm	650V, 160m Ω	-	Navitas	NV6115
9	1	Q2	Navitas Semiconductor GaN Power IC	IC	QFN- 5x6mm	650V, 110m Ω	-	Navitas	NV6117
10	3	R14, R28, R29	Thick Film Res - SMD 0603 100ohms 1% Tol	100	0603	100mW	\pm 1%	Panasonic	ERJ-3EKF1000V
11	3	R2, R3, R4	RES SMD 200 OHM 1% 1/10W 0603	200	0603	100mW	\pm 1%	Panasonic	ERJ-3EKF2000V
12	1	R5	51k Ohm \pm 1% 0.1W, 1/10W Chip Resistor 0603	51.0K	0603	100mW	\pm 1%	Vishay	CRCW060351K0FKEA

Bill of Materials: Synchronous Rectification Daughtercard

DESCRIPTION	VALUE	PACKAGE	VOLTAGE	TOL.	MFGR. NAME	MFGR. PART #
CAP CER 10UF 35V X7R 1206	10.0uF	1206	35V	\pm 10%	Taiyo Yuden	GMK316AB7106KL-TR
2.2 μ F \pm 20% 16V Ceramic Capacitor X7R 0603	2.20uF	0603	100mW	\pm 1%	Taiyo Yuden	EMK107BB7225MA-T
CAP CER 470PF 25V 10% X7R 0603	470pF	0603	25V	\pm 10%	Kemet	C0603C471K3RACTU
IC SECONDARY SIDE CTRLR 8SOIC	IC analog	SO8	35V	-40°C ~ 125°C	On Semi	NCP43080DDR2G
MOSFET N-CH 60V 71A SO8FL	IC analog	SO8	60V, 71A	-55°C ~ 175°C	On Semi	NVMFS5C670NLT1G
Thick Film Resistors - SMD 0603 Zero Ohms	0.00R	0603	100mW	\pm 1%	Panasonic	ERJ-3GEY0R00V
RES SMD 10 OHM 1% 1/4W 1206	10.0R	1206	250mW	\pm 1%	Yageo	RC1206FR-0710RL
22 Ohm \pm 1% 0.1W, 1/10W Chip Resistor 0603	22.0R	0603	100mW	\pm 1%	Yageo	RC0603FR-0722RL
RES SMD 8.06K OHM 1% 1/10W 0603	8.06K	0603	100mW	\pm 1%	Vishay	CRCW06038K06FKEA
RES SMD 3K OHM 1% 1/10W 0603	3.00K	0603	100mW	\pm 1%	Panasonic	ERJ-3EKF3001V

13. Revision History:

Date	Status	Notes
11-15-16	RELEASED	NVE019A-A first publication
12-5-16	RELEASED	NVE019A-B = Update for PFC controller 'long on-time' - change R13, R14 NVE019B-A = Version with 1x NV6117 for PFC
12-23-16	RELEASED	Added: Thermal images with 1x NV6117 PFC, start-up into full load, output ripple waveforms. BOM updates.
1-4-17	RELEASED	Added magnetics contacts, added TR1 (LLC transformer part#)
3-24-17	RELEASED	NVE021A = Updated board images, schematics, layout images, waveforms, thermals, efficiency curves, BOM.
6-27-17	RELEASED	Board part no. update: NVE021A-B Added: Over-current limitation spec (Page 4), over-current limitation waveforms (Fig 9j). Schematic updates: Updated schematics (Figs 1a, 1b, 1c, 3a) BOM updates: Changed component values/part no. for R7, R8, R10, C19, C20, U2. LLC controller part number updated to NCP13992.

Additional Information:

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