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DN05044/D

High Efficiency, <10 mW Standby PFC + QR Adapter

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DESIGN NOTE

Circuit Description

The NCP1937 is a combination controller which integrates a power factor correction (PFC) and quasi-resonant flyback controller in an SO−20 package. It integrates all the functionality necessary to implement a compact and highly efficient Switched Mode Power Supply for an adapter application.

The PFC stage exhibits near-unity power factor while operating in a Critical Conduction Mode (CrM) with a maximum frequency clamp. The circuit incorporates all the features necessary for building a robust and compact PFC stage while minimizing the number of external components.

The quasi-resonant current-mode flyback stage features a proprietary valley-lockout circuitry, ensuring stable valley switching. This system works down to the 4th valley and toggles to a frequency foldback mode with a minimum frequency clamp beyond the 4th valley to eliminate audible noise. Skip mode operation allows excellent efficiency in light load conditions while consuming very low standby power consumption.

Synchronous rectification is implemented on the secondary side for increased efficiency with the NCP4304. The NCP4355B is a secondary side CCCV controller that detects no load conditions and communicates to the primary controller enabling an ultra-low frequency skip mode for reduced standby consumption. This enables the system to achieve < 10 mW no load standby.

Key Features

- High-Voltage Startup Circuit and Active Input Filter Capacitor Discharge Circuitry for Reduced Standby Power
- Integrated High-Voltage Switch Disconnects PFC Feedback Resistor Divider to Reduce Standby Power
- Low Consumption Power Savings Mode for Reduced Standby Power
- Adjustable PFC Disable Threshold Based on Output Power
- Fault Input for Severe Fault Conditions, NTC Compatible (Latch and Auto-Recovery Options)
- Boost Diode Short-Circuit Protection
- Valley Switching Operation with Valley-Lockout for Noise-Free Operation
- Frequency Foldback with Minimum Frequency Clamp for Low Standby Mode
- Minimum Frequency Clamp Eliminates Audible Noise

Table 1. DEVICE DETAILS

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1937 R1 NCP4304 NCP4355	Adapter	90 to 264 Vac	Up to 85 W	PFC + QR Combo	Isolated

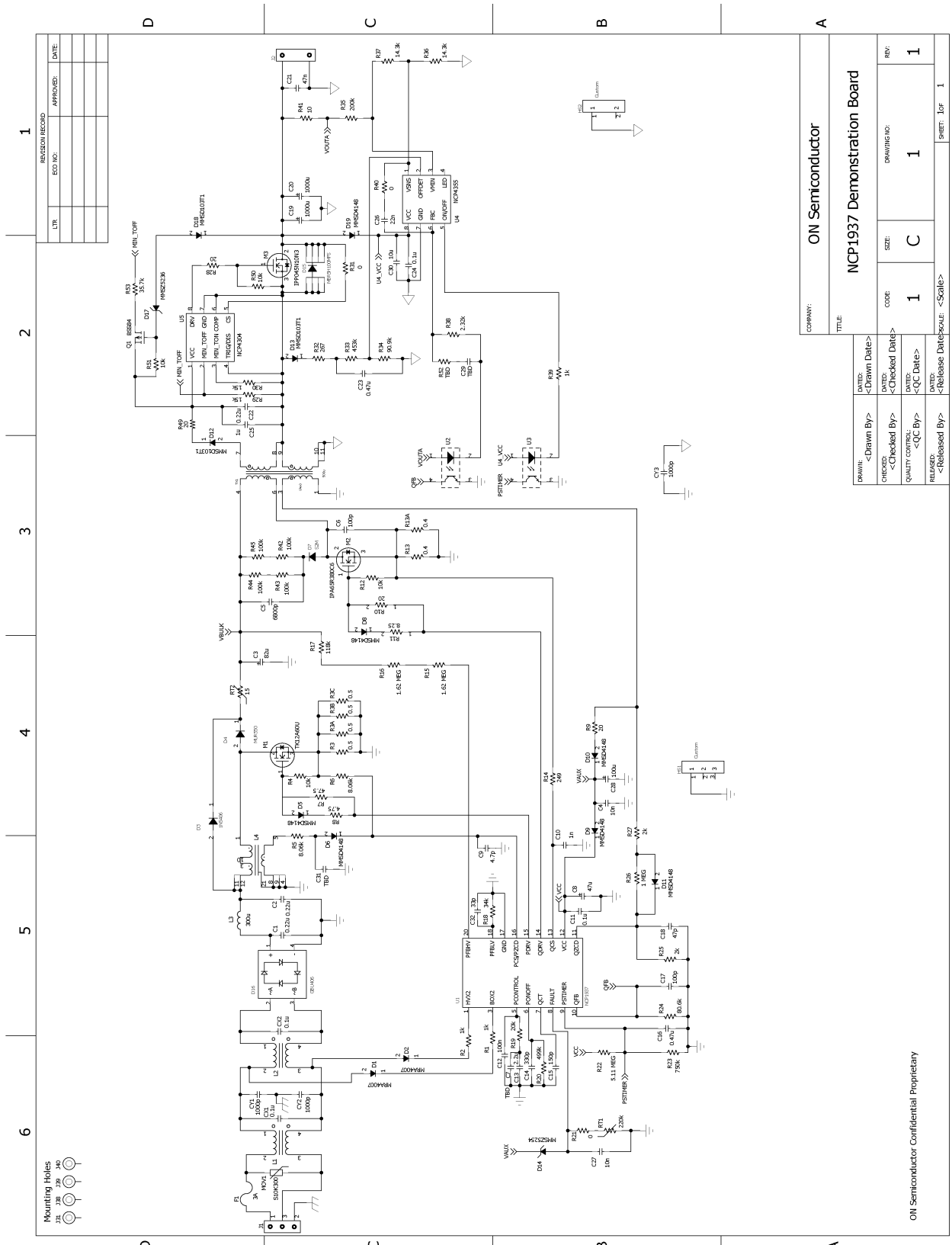
Table 2. OTHER SPECIFICATIONS

	Output Specification
Output Voltage	20 Vdc nominal
Nominal Current	4.25 A
No Load Standby	< 10 mW
Min Current	Zero

May, 2013 − Rev. 1

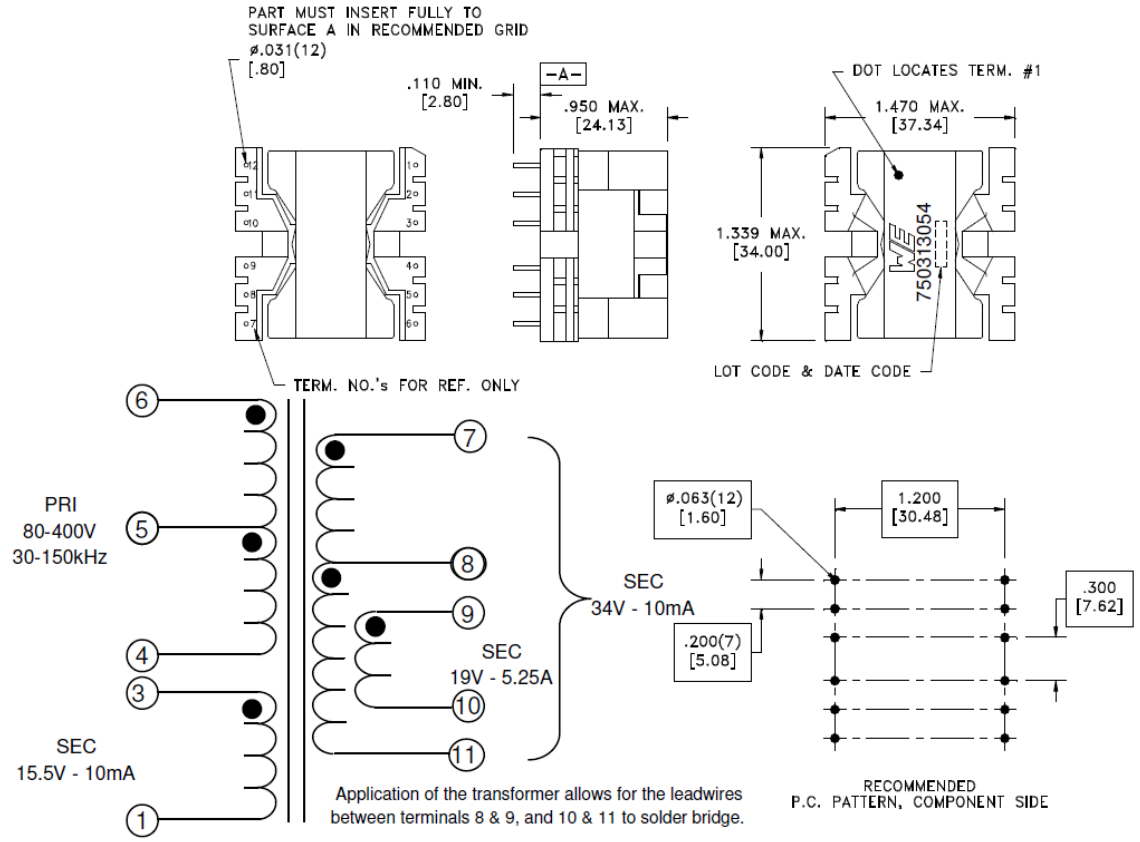
Publication Order Number:
DN05044/D

CIRCUIT SCHEMATIC



MAGNETICS DESIGN – FLYBACK TRANSFORMER

CUSTOMER TERMINAL	RoHS	LEAD(Pb)–FREE
Sn96%, Ag4%	Yes	Yes



ELECTRICAL SPECIFICATIONS @ 25°C unless otherwise noted:

D.C. RESISTANCE (@20°C):	4-6 , 0.300 Ohms ±10%.
	1-3 , 0.050 Ohms ±20%.
	7-8 , 0.028 Ohms max.
	8-11 , 0.020 Ohms max.
	9-10 , 0.020 Ohms max.
DIELECTRIC RATING:	4000VAC, 1 minute tested by applying 4000VAC for 1 second between pins 6-7(tie 3+4, 8+9).
	500VAC, 1 minute tested by applying 625VAC for 1 second between pins 1-6.
INDUCTANCE:	500µH ±10%, 10kHz, 100mVAC, 0mADC, 4-6, Ls.
SATURATION CURRENT:	4.25A saturating current that causes 20% rolloff from initial inductance.
LEAKAGE INDUCTANCE:	3.5µH typ, 7µH max, 100kHz, 100mVAC, 4-6(tie 1+3, 7+8+9+10+11), Ls.
TURNS RATIO:	(6-5):(5-4), (1):(1.00), ±1%.
	(6-4):(3-1), (7.2):(1.00), ±1%.
	(6-4):(7-8), (9):(1.00), ±1%.
	(6-4):(8-11), (6):(1.00), ±1%.
	(6-4):(9-10), (6):(1.00), ±1%.

Designed to comply with the following requirements as defined by IEC60950-1, EN60950-1, UL60950-1/CSA60950-1 and AS/NZS60950.1:
- Basic insulation for a primary circuit at a working voltage of 400VDC.

OPERATING TEMPERATURE RANGE: -40°C to 125°C including temp. rise.

Wire insulation & RoHS status not affected by wire color. Wire insulation color may vary depending on availability.

MAGNETICS DESIGN – PFC INDUCTOR

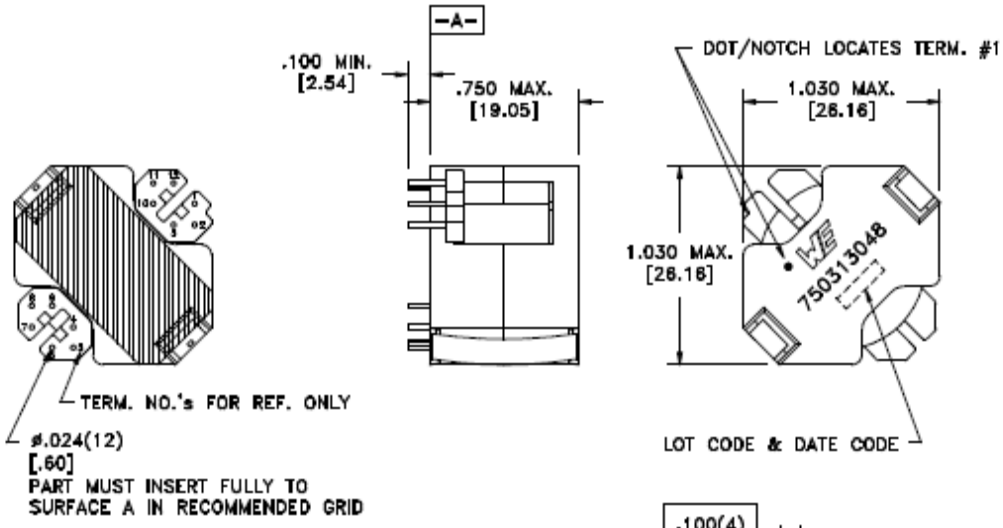
Midcom

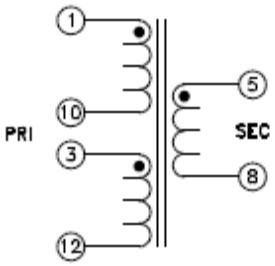
WÜRTH ELEKTRONIK

ELECTRICAL SPECIFICATIONS @ 25°C unless otherwise noted:

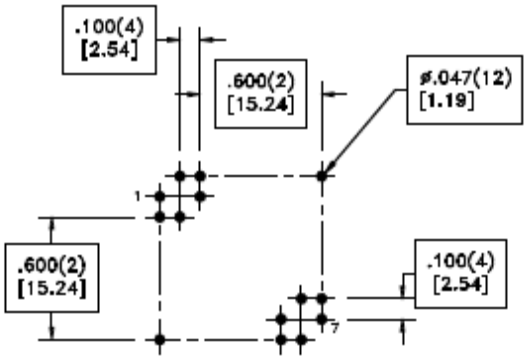
PARAMETER		TEST CONDITIONS	VALUE
D.C. RESISTANCE	1–12	@20°C	.230 ohms Max.
D.C. RESISTANCE	5–8	@20°C	.400 ohm Max.
INDUCTANCE	1–12	10kHz, 100mVAC, Ls Tie(10+3)	390uH ±10%
DIELECTRIC	1–8	1875VAC, 1 second Tie(10+3)	1500VAC, 1 minute
TURNS RATIO		(1–12):(5–8)	10:1, ±2%

GENERAL SPECIFICATIONS:
OPERATING TEMPERATURE RANGE: –40°C to +125°C including temp rise.





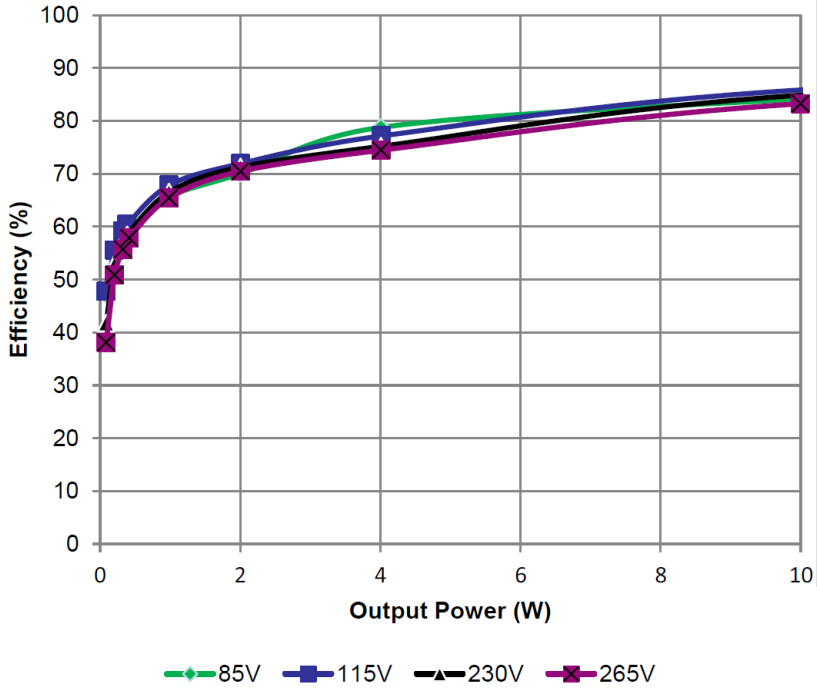
CUSTOMER TO TIE TERMINALS
3+10 INTERNALLY ON PCB



RECOMMENDED
P.C. PATTERN, COMPONENT SIDE

EFFICIENCY PLOTS

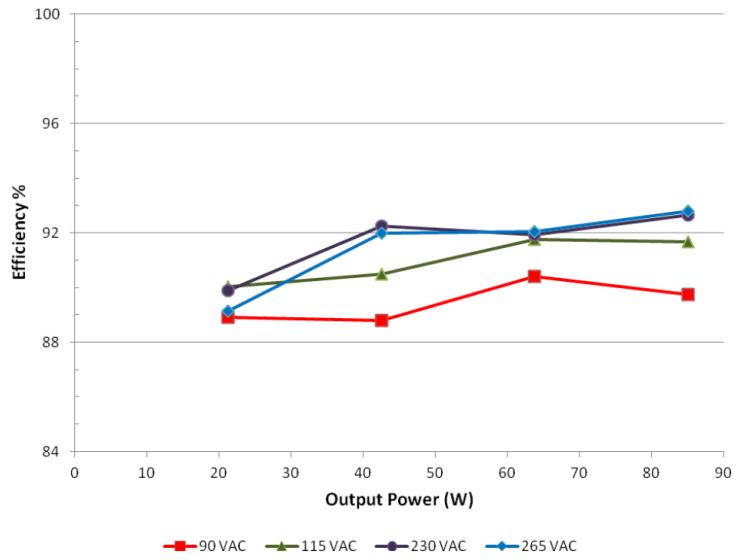
Light Load Efficiency



Vin (VAC)	Pin(W)	Vout (VDC)	Iout (A)	Pout (W)	Eff
85	0.380	19.99	0.010	0.208	54.85
85	0.704	19.99	0.021	0.418	59.45
85	1.503	19.99	0.049	0.987	65.65
85	2.866	19.99	0.100	2.007	70.02
85	5.094	19.99	0.201	4.013	78.78
85	11.889	19.98	0.500	9.999	84.10
115	0.375	19.99	0.010	0.208	55.60
115	0.642	19.99	0.019	0.388	60.41
115	1.455	19.99	0.049	0.987	67.81
115	2.791	19.99	0.100	2.007	71.92
115	5.202	19.99	0.201	4.013	77.14
115	11.651	19.99	0.500	10.002	85.84
230	0.394	19.99	0.010	0.208	52.90
230	0.664	19.99	0.019	0.388	58.43
230	1.483	19.99	0.049	0.987	66.52
230	2.815	19.99	0.100	2.006	71.26
230	5.335	19.99	0.201	4.012	75.20
230	11.788	19.99	0.500	10.002	84.85
265	0.409	19.99	0.0104	0.208	50.86
265	0.722	19.99	0.0209	0.418	57.88
265	1.508	19.99	0.0493	0.986	65.41
265	2.847	19.99	0.1004	2.006	70.47
265	5.387	19.99	0.2007	4.011	74.46
265	12.010	19.98	0.5004	9.998	83.25

Figure 1. Output Power vs. Efficiency – Light Load Efficiency

Average Efficiency



VAC	Po (W)	% Full Load	Efficiency %
90	21.25	25%	88.92
	42.50	50%	88.79
	63.75	75%	90.40
	85.00	100%	89.74
115	21.25	25%	90.04
	42.50	50%	90.50
	63.75	75%	91.75
	85.00	100%	91.68
230	21.25	25%	89.89
	42.50	50%	92.23
	63.75	75%	91.94
	85.00	100%	92.66
265	21.25	25%	89.12
	42.50	50%	91.99
	63.75	75%	92.04
	85.00	100%	92.80

Average efficiency = 90.91%

Figure 2. Output Power vs. Efficiency – Average Efficiency

DESCRIPTION OF KEY FEATURES

Power Savings Mode

The NCP1937 features a low consumption operating mode called Power Savings Mode (PSM). PSM can be used to achieve very low input power dissipation when the application is operating at no load. When the controller enters PSM it stops switching and shuts down much of its functionality enabling the controller to operate with a bias current of < 70 μA. While most of the controller's functions are shut off, the input filter capacitor discharge is required to remain active should the application be unplugged.

In order to provide a bias supply for the capacitor discharge function the controller regulates V_{CC} to 11 V (typical) by alternating turn-on of the high voltage startup circuits. Each startup turns on once every line cycle when its respective HV pin voltage exceeds 30 V (typical) provided that V_{CC} is below 11 V and the complementary startup had turned on during the previous half cycle. The startup circuit will shut off once V_{CC} exceeds 11 V. There is no hysteresis in the internal regulation loop ensuring that V_{CC} will be below its regulation level during the next half cycle. This method of regulating V_{CC} makes it possible to have a low average voltage at the HV pins allowing the application to achieve very low power dissipation.

Power Savings Mode Operation
Ch. 1 (Yellow): BOX2
Ch. 3 (Purple): HVX2
Ch. 4 (Green): V_{CC} (AC Coupled)

Measured data with 2 wire connection
- 4.82 mW at 115 VAC
- 8.68 mW at 265 VAC

Figure 3. Power Saving Mode

Active X2 Capacitor Discharge

The NCP1937 features integrated active input filter (X2) capacitor discharge, eliminating the need for external discharge resistors which are major contributors to the total power dissipation in light load and standby mode operation. The integrated discharge circuit is virtually lossless across all operating modes and only consumes power when it is needed to discharge the X2 capacitors.

The discharge circuit works in the following manner: 1) Line voltage removal is detected at the HVX2 and BOX2 pins when the voltage on those pins becomes static. A line removal timer is then initiated. 2) When the line removal timer expires, drive pulses are halted and the V_{CC} pin is rapidly discharged. 3) Once V_{CC} reaches $V_{CC(off)}$ the high voltage startups are turned on transferring the stored charge from the input filter capacitors onto the V_{CC} capacitor. 4) Being that the V_{CC} capacitor is much larger than the filter capacitors, the voltage on the filter capacitors will quickly discharge to a safe level without restarting the controller.

Figure 4. Active X2 Capacitor Discharge

Adjustable PFC Disable

PFC Disable		PFC Enable	
VAC	I_O	VAC	I_O
90	2.5 A	90	3 A
115	2.5 A	115	2.9 A
230	2.4 A	230	2.8 A
265	2.4 A	265	2.75 A

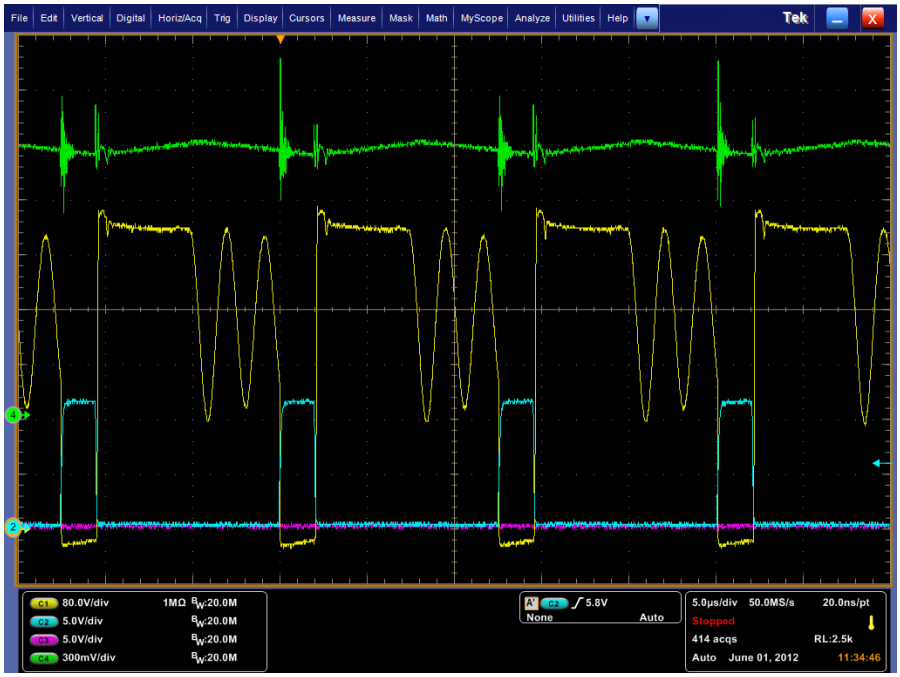
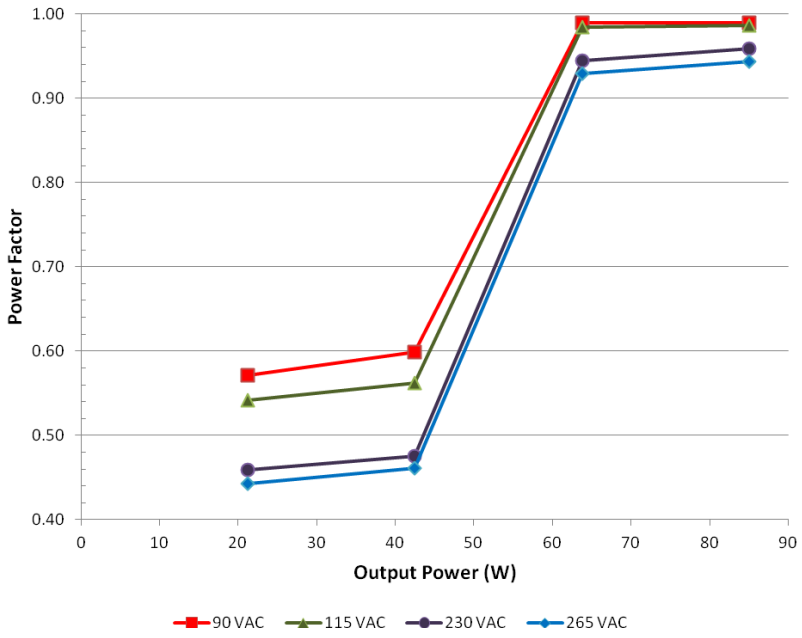


Figure 5. Adjustable PFC Disable

In certain applications it is desired to turn the PFC converter off at lighter loads to optimize the system's overall efficiency. The NCP1937 features integrated circuitry which measures the output power of the flyback converter and outputs a current proportional to the QR flyback's output power from the PONOFF pin. The current proportional to output power is generated with a voltage-to-current (V/I) converter which sets a DC current based on the feedback voltage of the QR flyback. The DC current from the V/I converter is then pulse width modulated with a duty cycle equivalent to the demagnetization period of the QR flyback. External to the controller, a resistor and capacitor scale and average the current output from the PONOFF pin into a voltage proportional to the system's output power. This voltage is then compared internally to a reference voltage to determine when the PFC is enable and disabled. Reference the NCP1937 Design Tool for determining the values of the external resistor and capacitor.

A waveform of the voltage on the PONOFF pin with the flyback switching waveforms is shown above demonstrating the modulation and averaging of the PONOFF current. Performance data from the demonstration board is shown alongside the waveform. In this application it was determined that enabling and disabling the PFC between 50–75% (2.125–3.19 A) of the full rated load provided the best average efficiency across the universal line range.

POWER FACTOR



VAC	Po (W)	% Full Load	Power Factor
90	21.25	25%	0.571
	42.50	50%	0.598
	63.75	75%	0.990
	85.00	100%	0.989
115	21.25	25%	0.541
	42.50	50%	0.562
	63.75	75%	0.984
	85.00	100%	0.986
230	21.25	25%	0.459
	42.50	50%	0.475
	63.75	75%	0.945
	85.00	100%	0.959
265	21.25	25%	0.442
	42.50	50%	0.461
	63.75	75%	0.930
	85.00	100%	0.944

Figure 6. Power Factor vs. Output Power

Table 3. BILL OF MATERIALS FOR 20 W NCP1126/1129 FLYBACK

REF DES	Qty.	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer PN	Substi-tution
C1, C2	2	Capacitor, Metallized Polypropylene	0.22 μF, 450 V	5%	Through Hole, 10 mm	Panasonic	ECW−F2W224JAQ	No
C3	1	Capacitor, Electrolytic	82 μF, 450 V	20%	Through Hole, 7.5 mm	United Chemi-Con	EKXG451ELL820MMP1S	No
C4	1	Capacitor, Ceramic, X7R	10 nF, 50 V	10%	SMD, 1206	Vishay	VJ1206Y103KXAAC	Yes
C5	1	Capacitor, Ceramic, X7R	6800 pF, 630 V	20%	SMD, 1206	TDK	C3216X7R2J682M	No
C6	1	Capacitor, Ceramic, X7R	100 pF, 1 kV	10%	SMD, 1206	Johanson's Dielectric	102R18W101KV4E	No
C7	0	PLACEHOLDER	PLACEHOLDER		SMD, 0603	PLACEHOLDER	PLACEHOLDER	Yes
C8	1	Capacitor, Electrolytic	47 μF, 35 V	20%	Through Hole, 2.5 mm	Kemet	ESH476M035AE3AA	No
C9	1	Capacitor, Ceramic, COG	4.7 pF, 50 V	±0.25 pF	SMD, 0603	TDK	C1608COG1H4R7C	Yes
C10	1	Capacitor, Ceramic, X7R	1000 pF, 25 V	10%	SMD, 0603	Vishay	VJ0603Y102KXXCW1BC	Yes
C11, C12, C24	3	Capacitor, Ceramic, X7R	0.1 μF, 50 V	10%	SMD, 0603	Yageo	CC0603KRX7R9BB104	Yes
C13	1	Capacitor, Ceramic, X7R	2.2 μF, 10 V	10%	SMD, 0603	Taiyo Yuden	LMK107B7225KA−T	Yes
C14	1	Capacitor, Ceramic, X7R	330 pF, 50 V	10%	SMD, 0603	Yageo	CC0603KRX7R9BB331	Yes
C15	1	Capacitor, Ceramic, X7R	150 pF, 25 V	10%	SMD, 0603	AVX	06033C151KAT2A	Yes
C16, C23	2	Capacitor, Ceramic, X7R	0.47 μF, 50 V	10%	SMD, 0603	Taiyo Yuden	UMK107B7474KA−TR	Yes
C17	1	Capacitor, Ceramic, X7R	100 pF, 25 V	10%	SMD, 0603	Vishay	VJ0603Y101KXXCW1BC	Yes
C18	1	Capacitor, Ceramic, COG	47 pF, 50 V	10%	SMD, 0603	Vishay	VJ0603A470KXAAC	Yes
C19, C20	2	Capacitor, Electrolytic	1000 μF, 35 V	20%	Through Hole, 5 mm	Panasonic	EEU-FM1V102	No
C21	1	Capacitor, Ceramic, X7R	47 nF, 50 V	10%	SMD, 1206	Xicon	140-CC502B473K−RC	Yes
C22	1	Capacitor, Ceramic, X7R	0.22 μF, 25 V	10%	SMD, 0805	Kemet	C0805C224K3RACTU	Yes
C25	1	Capacitor, Ceramic, X7R	2.2 μF, 25 V	10%	SMD, 0805	TDK	TMK212B7225KG−TR	Yes
C26	1	Capacitor, Ceramic, X7R	22 nF, 50 V	10%	SMD, 0603	TDK	C1608X7R1H223K	Yes
C27	1	Capacitor, Ceramic, X7R	10 nF, 50 V	10%	SMD, 0603	Murata	GRM188R71H103KA01D	Yes
C28	1	Capacitor, Electrolytic	100 μF, 35 V	20%	Through Hole, 2.5 mm	Kemet	ESH107M035AE3AA	Yes
C29	0	Capacitor, Ceramic, X7R	PLACEHOLDER		SMD, 0603	PLACEHOLDER	PLACEHOLDER	Yes
C30	1	Capacitor, Ceramic, X5R	10 μF, 35 V	10%	SMD, 1206	Taiyo Yuden	GMK316BJ106KL−T	Yes
C31	0	Capacitor, Ceramic, X7R	PLACEHOLDER		SMD, 0603	PLACEHOLDER	PLACEHOLDER	Yes
C32	1	Capacitor, Ceramic, COG	33 pF, 50 V	5%	SMD, 0603	Murata	GRM1885C1H330JA01D	Yes
CX1, CX2	2	Capacitor, Metallized Polypropylene	100 nF, 275 VAC	10%	Through Hole, 10 mm	Kemet	PHE840MA6100KA04	Yes
CY1, CY2, CY3	3	Capacitor, Ceramic, X1Y2	1000 pF, 250 VAC	20%	Through Hole, 5 mm	Murata	DE2E3KY102MA2BM01	Yes
D1, D2	2	Diode, Standard Recovery	1000 V, 1 A		SMD, SMA	ON Semiconductor	MRA4007T3G	Yes
D3	1	Diode, Standard Recovery	600 V, 3 A		Through Hole, Axial, DO−201AA	ON Semiconductor	1N5406G	No

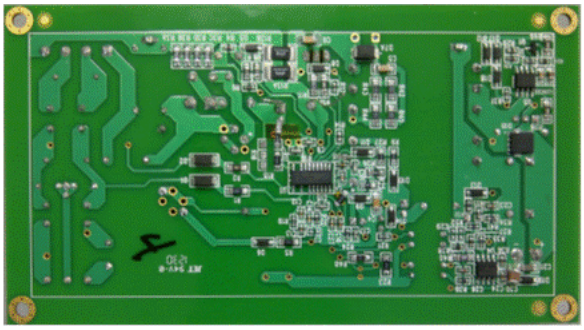
Table 3. BILL OF MATERIALS FOR 20 W NCP1126/1129 FLYBACK (continued)

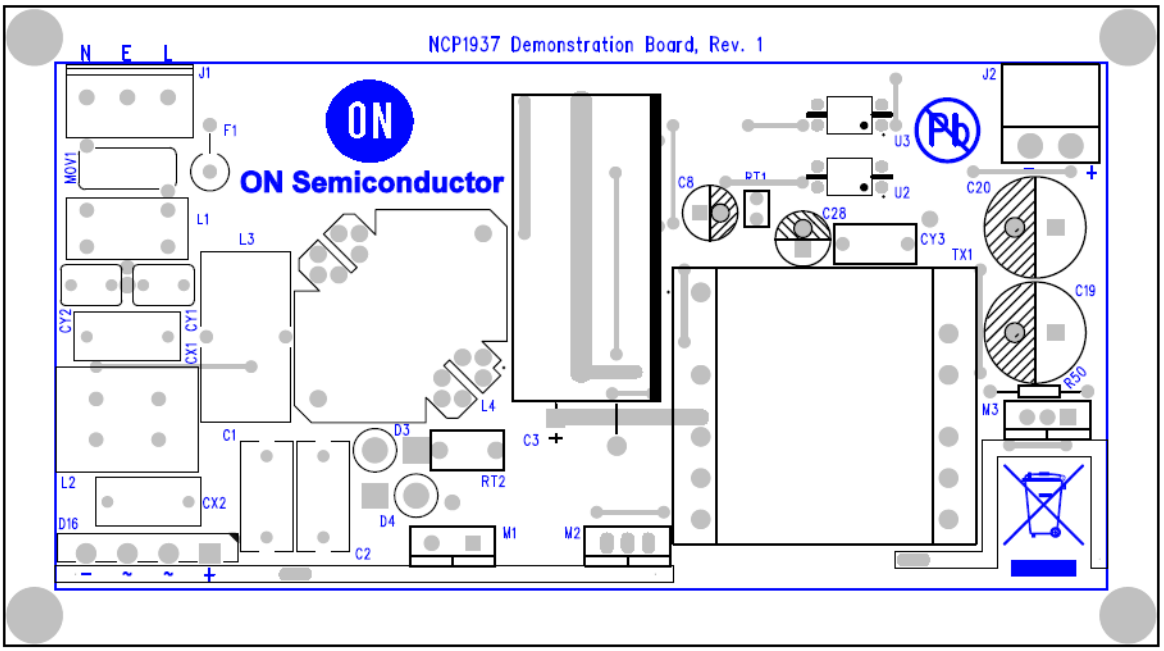
REF DES	Qty.	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer PN	Substi-tution
D4	1	Diode, Switchmode Rectifier	520 V, 5 A		Through Hole, Axial, DO−201AA	ON Semiconductor	MUR550APFG	No
D5, D6, D8, D9, D10, D11, D19	7	Diode, Switching	100 V, 200 mA		SMD, SOD−123	ON Semiconductor	MMSD4148T1G	Yes
D7	1	Diode, Standard Recovery	1000 V, 1.5 A		SMD, SMB	Vishay	S2M-E3/52T	No
D12, D13, D18	3	Diode, Switching	250 V, 100 mA		SMD, SOD−123	ON Semiconductor	MMSD103T1G	Yes
D14	1	Diode, Zener	27 V, 500 mW		SMD, SOD−123	ON Semiconductor	MMSZ5254BT1G	Yes
D15	1	Diode, Schottky,	100 V, 5 A		SMD, SO−8FL	ON Semiconductor	MBR5H100MFST1G	No
D16	1	Diode, Bridge Rectifier	600 V, 4 A		Through Hole, GBU	Diodes Inc	GBU406	Yes
D17	1	Diode, Zener	7.5 V, 500 mW		SMD, SOD−123	ON Semiconductor	MMSZ5236BT1G	Yes
F1	1	Fuse	250 VAC, 3 A		Through Hole	Littelfuse	0224003.HXP	No
J1	1	Terminal Block, 3 pos, in-line	250 V, 16 A		Through Hole, 5mm	On Shore Technology	OSTTA030161	Yes
J2	1	Header, 2 pos, in-line, right angle	250 V, 12 A		Through Hole, 5mm	Phoenix Contact	1757475	Yes
J2A	1	Terminal Block, 2 pos, plug	250 V, 12 A		N/A	Phoenix Contact	1754449	Yes
L1	1	Inductor, Common mode choke	4 mH, 1.5 A		Through Hole	Wurth Electronics	744 821 240	No
L2	1	Inductor, Common mode choke	20 mH, 0.5 A		Through Hole	Wurth Electronics	744 822 120	No
L3	1	Inductor, Differential choke	300 μH, 2 A		Through Hole	Wurth Electronics	744 706 0	No
L4	1	Inductor, PFC boost	390 μH, 3.5 A		Through Hole, RM10, Custom	Wurth Electronics	750313048 rev2	No
M1	1	MOSFET, PFC Switch	600 V, 12 A		TO−220FP	Toshiba	TK12A60U	No
M2	1	MOSFET, QR Switch	650 V, 10.6 A		TO−220FP	Infineon	IPA65R380C6	No
M3	1	MOSFET, Synchronous Rectifier	100 V, 100 A		TO−220	Infineon	IPP045N10N3	No
MOV1	1	MOV	300 VAC, 2.5 kA		Through Hole, 10 mm	Epcos	S10K300	Yes
Q1	1	MOSFET, Small signal	PMOS, 50 V		SMD, SOT23−3	ON Semiconductor	BSS84LT1G	Yes
R1, R2	2	Resistor, 1/4 W	1 kΩ	1%	SMD, 1206	Stackpole	RMCF1206FT1K00	Yes
R3, R3A, R3B, R3C	4	Resistor, 1/2 W	0.5 Ω		SMD, 1206	Stackpole	CSR1206FKR500	Yes
R4, R12, R51	3	Resistor 1/10 W	10 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT10K0	Yes
R5	1	Resistor, 1/4 W	8.06 kΩ	1%	SMD, 1206	Stackpole	RMCF1206FT8K06	Yes
R6	1	Resistor 1/10 W	8.06 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT8K06	Yes
R7	1	Resistor, 1/8 W	47.5 Ω	1%	SMD, 0805	Stackpole	RMCF0805FT47R5	Yes
R8	1	Resistor, 1/8 W	4.75 Ω	1%	SMD, 0805	Stackpole	RMCF0805FT4R75	Yes
R9	1	Resistor, 1/8 W	20 Ω	1%	SMD, 0805	Stackpole	RMCF0805FT20R0	Yes
R10, R28, R49	3	Resistor, 1/4 W	20 Ω	1%	SMD, 1206	Stackpole	RMCF1206FT20R0	Yes
R11	1	Resistor, 1/4 W	8.25 Ω	1%	SMD, 1206	Yageo	RC1206FR-078R25L	Yes
REF DES	QTY	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer PN	Substit ution

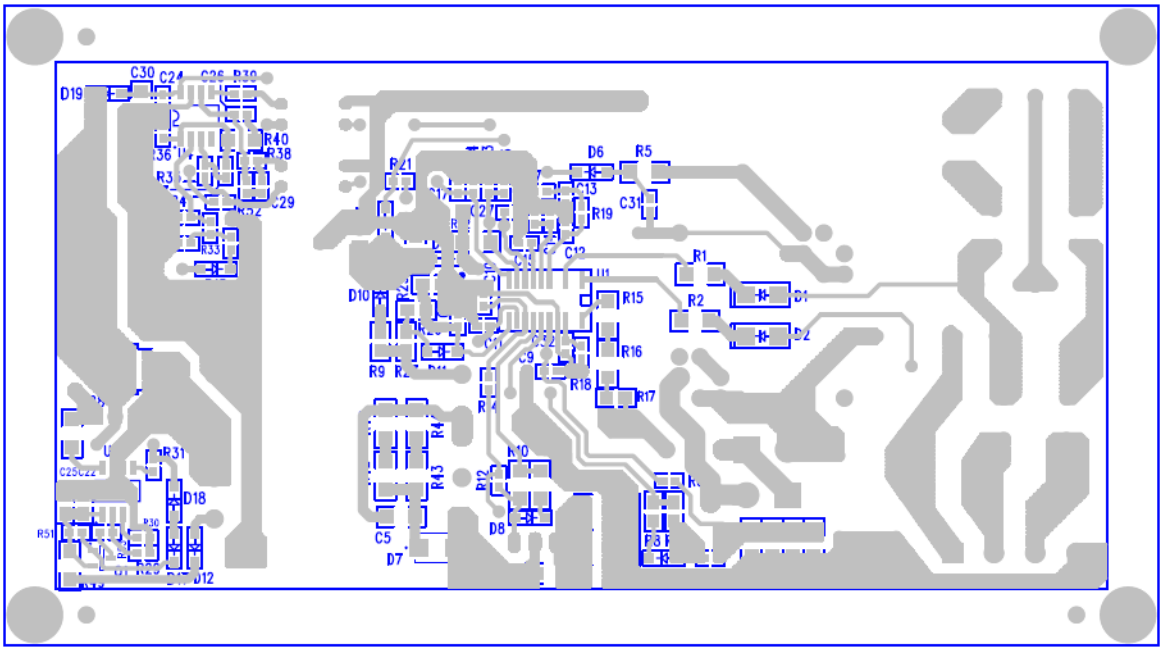
Table 3. BILL OF MATERIALS FOR 20 W NCP1126/1129 FLYBACK (continued)

REF DES	Qty.	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer PN	Substi-tution
R13, R13A	2	Resistor, 1 W	0.4 Ω	1%	SMD, 2512	Yageo	PT2512FK−070R4L	No
R14	1	Resistor, 1/10 W	249 Ω	1%	SMD, 0603	Stackpole	RMCF0603FT249R	Yes
R15, R16	2	Resistor, 1/4 W	1.62 MΩ	1%	SMD, 1206	Yageo	RC1206FR-071M62L	Yes
R17	1	Resistor, 1/8 W	118 kΩ	1%	SMD, 0805	Stackpole	RMCF0805FT118K	Yes
R18	1	Resistor, 1/10 W	34 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT34K0	Yes
R19	1	Resistor, 1/10 W	20 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT20K0	Yes
R20	1	Resistor, 1/10 W	499 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT499K	Yes
R21, R31	2	Resistor, 1/10 W	0 Ω		SMD, 0603	Yageo	RC0603JR−070RL	Yes
R22	1	Resistor, 1/4 W	5.11 MΩ	1%	SMD, 1206	Yageo	RC1206FR−075M11L	Yes
R23	1	Resistor, 1/10 W	750 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT750K	Yes
R24	1	Resistor, 1/10 W	80.6 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT80K6	Yes
R25, R27	2	Resistor, 1/8 W	2 kΩ	1%	SMD, 0805	Stackpole	RMCF0805FT2K00	Yes
R26	1	Resistor, 1/8 W	1 MΩ	1%	SMD, 0805	Stackpole	RMCF0805FT1M00	Yes
R29, R30	2	Resistor, 1/10 W	15 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT15K0	Yes
R32	1	Resistor, 1/10 W	267 Ω	1%	SMD, 0603	Yageo	RC0603FR−07267RL	Yes
R33	1	Resistor, 1/10 W	453 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT453K	Yes
R34	1	Resistor, 1/10 W	90.9 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT90K9	Yes
R35	1	Resistor, 1/10 W	200 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT200K	Yes
R36, R37	2	Resistor, 1/10 W	14.3 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT14K3	Yes
R38	1	Resistor, 1/10 W	2.32 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT2K32	Yes
R39	1	Resistor, 1/10 W	1 kΩ	1%	SMD, 0603	Yageo	RC0603FR−071KL	Yes
R40	1	Resistor, 1/4 W	0 Ω		SMD, 1206	Yageo	RC1206JR−070RL	Yes
R41	1	Resistor, 1/10 W	10 Ω	1%	SMD, 0603	Stackpole	RMCF0603FT10R0	Yes
R42, R43, R44, R45	4	Resistor, 1/4 W	100 kΩ	1%	SMD, 1206	Stackpole	RMCF1206FT100K	Yes
R50	1	Resistor, 1/8W	10 kΩ	5%	Through Hole	Stackpole	CF18JT10K0	Yes
R52	0	Resistor 1/10 W	PLACEHOLDER		SMD, 0603	PLACEHOLDER	PLACEHOLDER	Yes
R53	1	Resistor 1/10 W	35.7 kΩ	1%	SMD, 0603	Stackpole	RMCF0603FT35K7	Yes
RT1	1	NTC Thermistor	220 K, 500 mW	5%	Through Hole, 2.54 mm	Vishay	NTCLE100E3224JB0	No
RT2	1	NTC Inrush Current Limiter	15 Ω		Through Hole, 10 mm	Epcos	B57153S0150M000	Yes
TX1	1	Flyback Transformer	500 μH, 4 A		Through Hole, PQ32, Custom	Wurth Electronics	750313054 rev02	No
U1	1	Controller, PFC - QR Combo			SMD, SOIC−20NB, 1 mm	ON Semiconductor	NCP1937A	No
U2	1	Optocoupler	120 V, 60 mA		Through Hole, PDIP4	NEC	PS2513−1−A	No
U3	1	Optocoupler	70 V, 30 mA		Through Hole, PDIP4	NEC	PS2561A−1	Yes
U4	1	Controller, Secondary side			SOIC−8	ON Semiconductor	NCP4355B	No
U5	1	Synchronous rectification driver			SOIC−8	ON Semiconductor	NCP4304A	No

DEMO BOARD




NCP1937 Demonstration Board, Rev. 1
ON Semiconductor
J1
J2
F1
MOV1
L1
L3
L4
C1
C2
C3
C8
C19
C20
C28
CY1
CY2
CY3
CX1
CX2
D3
D4
D16
RT1
RT2
TX1
U2
U3
M1
M2
M3
R50


D19
C30
R40
R38
C29
R21
D6
R5
C31
R19
R1
R2
D1
D2
R15
R16
R18
R17
D10
R31
D18
D8
D7
C5

REFERENCES

[1] Data Sheet NCP1937/D

[2] Data Sheet NCP4355/D

[3] Data Sheet NCP4304/D

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