NCP1255GEVB

NCP1255 25 W Evaluation Board User's Manual

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EVAL BOARD USER'S MANUAL

The NCP1255 features several novelties compared to the NCP1250 previously released. The key feature of this component lies in its ability to push the switching frequency as the converter experiences a sudden power increase. However, this available extra power delivery can only be maintained for a certain amount of time. Beyond this duration, the controller gives up and enters an auto-recovery mode. This mode is perfectly suited for converters supplying highly variable loads such as Haswell-based notebook adapters or inkjet printers to cite a few possible examples.

General Description

The part is encapsulated in a SOIC−8 package but a reduced-feature set version (no brown-out and timers are internally set), the NCP1254, also exists in a tiny TSOP−6 package. Featuring a low-power BiCMOS process, the die accepts to work with V_{CC} levels up to 35 V, safely clamping the drive voltage below 12 V. With its 15 μA start-up current, a high-value resistive network can be used in offline applications to crank the converter, naturally minimizing the wasted power in high-line conditions. In nominal load operations, the switching frequency of this peak-current mode control circuit is 65 kHz.

When the power demand goes up, the controller increases the peak current setpoint until it reaches the upper limit (0.8 V over R_{sense}, no opp). At this point, the output power demand increase can only be answered by further shifting the switching frequency up until it reaches another limit, 130 kHz. The maximum power is thus obtained at this moment. On the contrary, in light-load operations, the part linearly reduces its switching frequency down to 26 kHz and enters skip cycle as power goes further down. This mode of operation favors higher efficiency from high to moderate output levels and ensures the lowest acoustic noise in the transformer. To improve the EMI signature, a low-frequency modulation brings some dither to the switching pattern. Unlike other circuits, the dither is kept in foldback and peak excursion modes, continuously smoothing the noise signature.

The part hosts several new protection means such as an auto-recovery brown-out circuit. It is adjustable via a resistive divider. A double hiccup on the V_{CC} brings down the average input power while in auto-recovery fault mode.

Board Description

The application schematic that appears in Figure 1 has been optimized to limit the leakage inductance losses and maximize the efficiency. For this purpose, the RDC clamping network has been replaced by a TVS-based circuitry, leaving enough swing to the 800 V MOSFET. Again, a 600 V type could have been used but would have hampered the drain voltage dynamics at turn off. A capacitor in parallel with the TVS limits its peak current at the switch opening and helps softening the radiated noise. Besides its excellent performance in standby, the TVS approach helps to maintain a safe clamping level given the wide output power excursion.

The chip supply is brought in via pin 6. Please note that the start-up resistances, besides cranking the controller, also perform the X2 discharge function for free. Upon start-up, for a voltage less than 18 V (typical), the internal consumption is limited to 15 μA maximum. It suddenly changes to a few mA as the controller starts to drive the 800 V MOSFET at 130 kHz when V_{CC} reaches 18 V. The auxiliary voltage can go down to around 9 V before the controller safely stops the switching pulses. The first V_{CC} capacitor C3 must be sized so that the auxiliary winding takes over before the UVLO is touched. The auxiliary winding is tailored to deliver an auxiliary voltage above 12 V and it drops to 10 V in no-load conditions. This guarantees a good no-load standby power performance as you will read below. A low-valued resistance (R_{13}) limits the voltage excursion on this auxiliary voltage in short circuit situations.

Regulation is ensured by pulling down the dedicated pin via an optocoupler, driven from the secondary side by a NCP431. This new device does not require a 1 mA bias current as it was the case with the classical TL431. The absence of this bias current greatly contributes to reducing the no-load standby power.

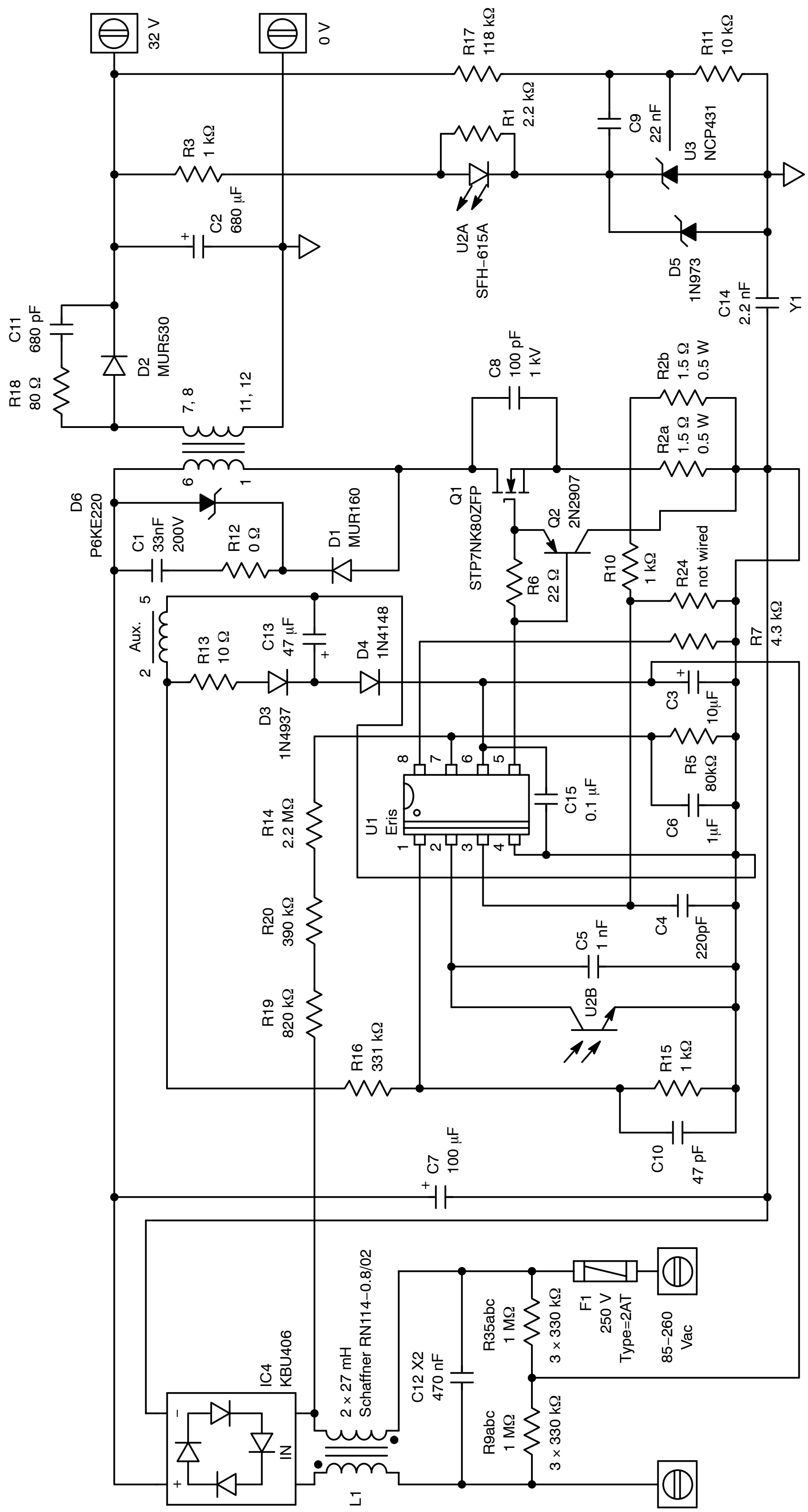


Figure 1. The Typical Implementation of the NCP1255 in an Isolated Flyback Converter Authorizing Peak Power Excursions

The Specifications

The evaluation board must deliver 32 V at a nominal 25 W output power (I_{out} = 0.8 A). When the frequency increases to 130 kHz, the peak power is up to 35 W or a 40% increase compared to the nominal value. The duration of the peak is set by resistance R_7 pulling pin 8 down to ground. When set to 200 ms (t_{OVL}) as in this board, the short circuit duration (t_{SC}) is internally limited to 50 ms: $t_{SC} = t_{OVL}/4$. Should the output current further grow, as the frequency is clamped, the feedback voltage rises up to its open loop value (≈ 4.5 V). In this mode, the delivered power increases to 41 W or a 64% peak compared to the 25 W nominal value.

The complete power supply specifications are as follows:

V_{out} = 32 V
V_{in} = 100 − 240 V rms
$I_{out,\ nom}$ = 0.8 A (Continuous Delivery of 25 W)
$I_{out,\ peak}$ = 1.3 A (Peak Power of 41 W)
$F_{sw,\ nom}$ = 65 kHz
$F_{sw,\ max}$ = 130 kHz

The transformer is built on a PQ26/25 type of core and features the following characteristics:

Primary Inductance L_P = 1 mH
Maximum Primary Peak Current at T_A = 70°C = 1.3 A
Turns Ratio, N_p:N_s = 1:0.39
Turns Ratio, N_p:N_{aux} = 1:0.19
Continuous Primary rms Current = 0.8 A
Continuous Secondary rms Current = 1.9 A
IEC−950 Safety Compliant

Electrical Performance

Some efficiency tests were carried on this board. The current was set to its nominal value (0.8 A) and reduced in a 20-step sequence. Efficiency was recorded at every step and collected in Figure 2 graph. As you can see, the nominal efficiency is slightly less than 90% at nominal and maintains above 85% as the output power drops. The average efficiency at a 100 V input is 88.3% and drops slightly less than 85% at high line (230 V rms). Please note that these measurements include a 1.5 m long dc cable. The light and no-load numbers are as follows:

Table 1. LIGHT AND NO-LOAD NUMBERS

Low Line, 100 V rms	High Line, 230 V rms
P_{out} = 0 W, P_{in} = 48.7 mW	P_{out} = 0 W, P_{in} = 100 mW
P_{out} = 0.5 W, P_{in} = 0.690 W	P_{out} = 0.5 W, P_{in} = 0.81 W
P_{out} = 0.6 W, P_{in} = 0.797 W	P_{out} = 0.6 W, P_{in} = 0.92 W
P_{out} = 0.7 W, P_{in} = 0.915 W	P_{out} = 0.7 W, P_{in} = 1.06 W

These numbers are very good, furthermore if we consider a low-voltage IC externally cranked by a resistive network. The brown-out sensing network is another burden that significantly impacts the performance as well. When the start-up/X2 network and the brown-out divider are removed while the converter delivers an unloaded 32 V output, the input consumption is measured at 50 mW with a 230 V rms input voltage.

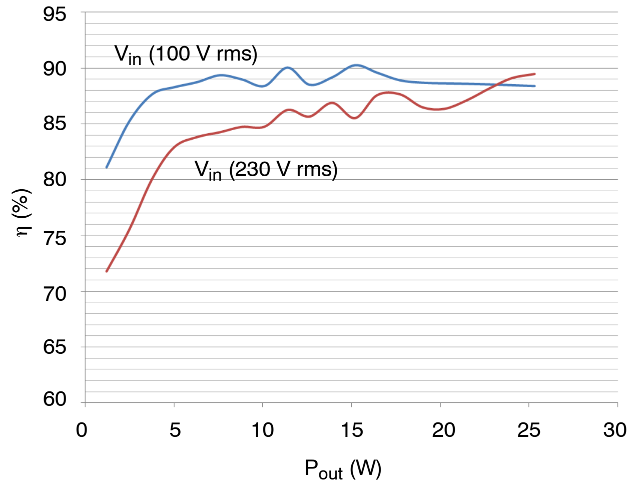


Figure 2. The Efficiency is Maintained in Light-load Conditions Thanks to the Frequency Foldback Technique

Typical Waveforms

Some typical signals have been captured on the operating board. The start-up sequence at a 100 V rms input is clean, exempt from output overshoot (Figure 3):

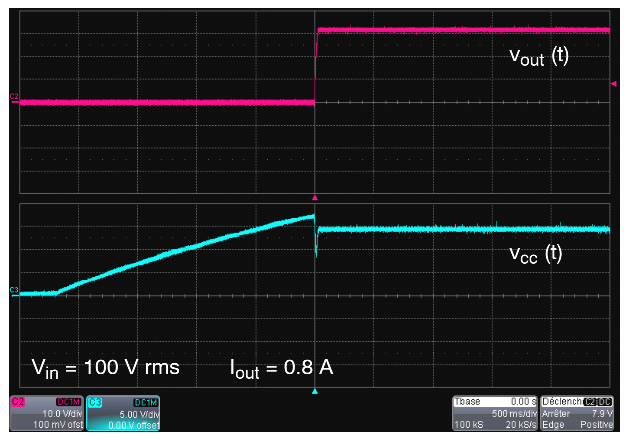


Figure 3. There is No Noticeable Output Voltage Overshoot Upon Start Up at Low Line

In short circuit, the double hiccup (Figure 4) nicely reduces the duty cycle in burst mode to less than 3%. This greatly helps to reduce the average input power while in fault mode.

The peak power behavior was also tested as shown in Figure 5. In the left side, the peak power is 35 W and lasts 100 ms. The feedback voltage is around 4 V, the controller considers an overload transient. The output voltage drop is well contained in the allowable limits (±5%). If the transient load duration is reduced to slightly below 50 ms but the power increased to 41 W, the controller lets the voltage drop while authorizing the peak excursion. Should the duration exceeds 50 ms, the power supply would protect itself and enter hiccup mode.

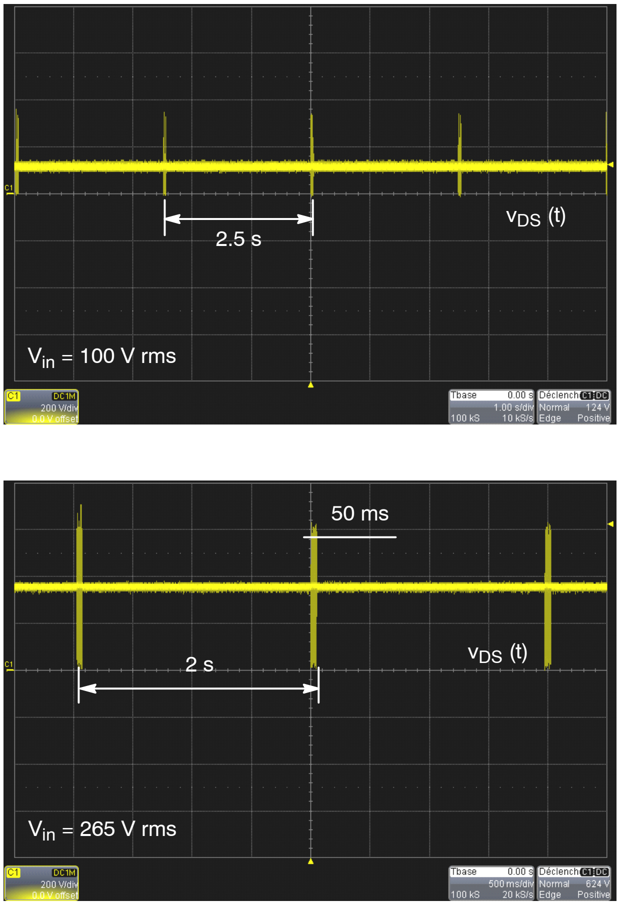


Figure 4. The Double Hiccup Nicely Limits the Input Average Power while in Burst

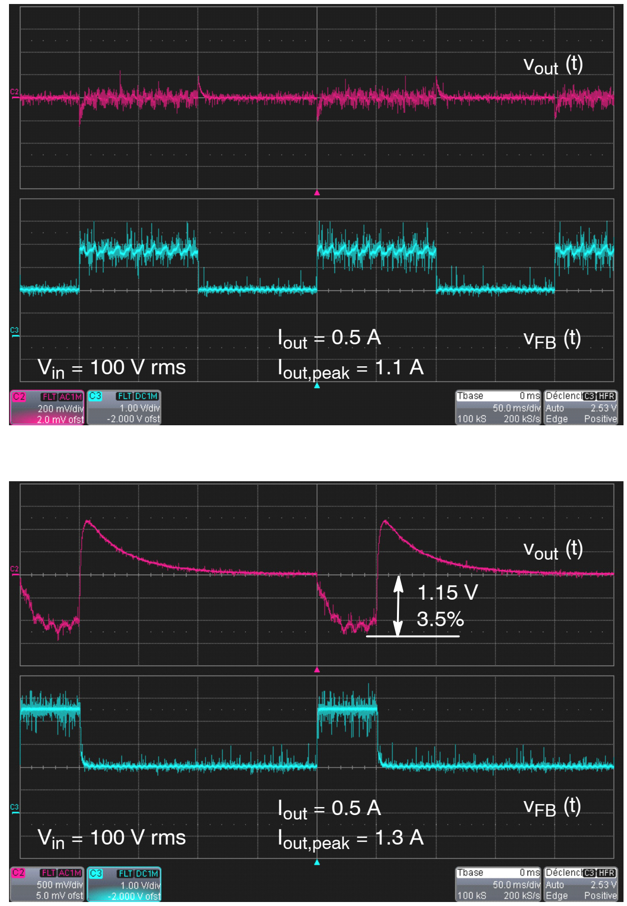


Figure 5. By Increasing the Switching Frequency Up to 130 kHz, the Controller Authorizes Peak Power for a Certain Amount of Time

Conclusion

This evaluation board user's manual shows the peak power capability offered by the NCP1255 and the overall good efficiency brought by the frequency foldback technique. The frequency excursion offers a nice means of transiently increasing the power capability without affecting the transformer as the peak current remains constant. Packed with a wealth of features, this SOIC package will let you build safe and rugged power converters with a limited count of surrounding components.

Table 2. BILL OF MATERIAL FOR THE NCP1255 EVALUATION BOARD

Designator	Qty.	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Comments
R1	1	Resistor	2.2 kΩ	1%	SMD0805	Multicomp	MCHP05W4F2201T5E	Yes	Not Wired
R2a, R2b	2	Resistor	1.5 Ω, 0.5 W	1%	SMD2510	Panasonic	ERJ1TRQF1R5U	Yes	0.5 W
R3	1	Resistor	1 kΩ	1%	SMD0805	Multicomp	MCHP05W4F1001T5E	Yes	–
R4a, R4B	2	Resistor	15 kΩ	1%	Through-hole	Vishay BC Components	MRS25000C1503FCT00	Yes	0.6 W
R5	1	Resistor	80.6 kΩ	0.1%	SMD0805	TE Connectivity/ Holsworthy	RP73D2A80K6BTG	Yes	–
R6	1	Resistor	22 Ω	1%	SMD0805	Multicomp	MCHP05W4F220JT5E	Yes	–
R7	1	Resistor	4.3 kΩ	1%	SMD0805	Multicomp	MCHP05W4F2202T5E	Yes	–
R9a, R9b, R9c	3	Resistor	330 kΩ	1%	SMD0805	Multicomp	MCHP05W4F3303T5E	Yes	–
R10	1	Resistor	1 kΩ	1%	SMD0805	Multicomp	MCHP05W4F1001T5E	Yes	–
R11	1	Resistor	10 kΩ	1%	SMD0805	Multicomp	MCHP05W4F1002T5E	Yes	–
R12	1	Resistor	0 Ω	1%	Through-hole	Vishay BC Components	MRS25000C2209FCT00	Yes	Strapped
R13	1	Resistor	10 Ω	1%	Through-hole	Vishay BC Components	MRS25000C1509FCT00	Yes	–
R14	1	Resistor	2.2 MΩ	1%	Through-hole	Vishay BC Components	MRS25000C2204FCT00	Yes	0.6 W
R15	1	Resistor	1 kΩ	1%	SMD0805	Multicomp	MCHP05W4F1001T5E	Yes	–
R16	1	Resistor	330 kΩ	1%	SMD0805	Multicomp	MCHP05W4F3303T5E	Yes	–
R17	1	Resistor	118 kΩ	0.1%	SMD0805	Multicomp	MCTC0525B1183T5E	Yes	–
R18	1	Resistor	80.6 kΩ	1%	Through-hole	Vishay BC Components	MRS25000C8069FCT00	Yes	0.6 W
R19	1	Resistor	820 kΩ	1%	Through-hole	Vishay BC Components	MRS25000C8203FCT00	Yes	0.6 W
R20	1	Resistor	390 kΩ	1%	Through-hole	Vishay BC Components	MRS25000C3903FCT00	Yes	0.6 W
R24	1	Resistor	22 kΩ	1%	SMD0805	Multicomp	MCHP05W4F2202T5E	Yes	Not Wired
R35a, R35b, R35c	3	Resistor	330 kΩ	1%	SMD0805	Multicomp	MCHP05W4F3303T5E	Yes	–
C1	1	Capacitor	33 nF/250 V	10%	Through-hole	Vishay	MKT 1822–333//405	Yes	–
C2	1	Electrolytic Capacitor	680 μF/35 V	20%	Through-hole	Rubycon	35ZL680MEFC12.5X20	Yes	–
C3	1	Capacitor	10 μF/50 V	10%	Radial	Panasonic	ECA1HHG100	Yes	–
C4	1	Capacitor	220 pF	5%	SMD0805	Multicomp	MCCA000335	Yes	–
C5	1	Capacitor	1 nF	5%	SMD0805	Multicomp	MCCA000351	Yes	–
C5a	1	Capacitor	470 pF	5%	SMD0805	Multicomp	MCCA000342	Yes	–
C6	1	Electrolytic Capacitor	1 μF/16 V	20%	Radial	Murata	MURGRM31MR71C105K A01L	Yes	–
C7	1	Electrolytic Capacitor	100 μF/400 V	20%	Through-hole	Nichicon	UCY2G101MHD	Yes	–
C8	1	Capacitor	100 pF/1 kV	20%	Through-hole	Vishay	F101K25S3NN63J5R	Yes	–
C9	1	Capacitor	22 nF	10%	SMD0805	Multicomp	MCCA000374	Yes	–
C10	1	Capacitor	47 pF	5%	SMD0805	Multicomp	MCCA000326	Yes	–
C11	1	Capacitor	680 pF/100 V	10%	Through-hole	Vishay BC Components	D681K20Y5PH63L2R	Yes	–
C12	1	Capacitor	470 nF	10%	Radial	Epcos	B32923C3474K	Yes	X2
C13	1	Capacitor	47 μF/25 V	20%	Radial	Panasonic	ECEA1HN470U	Yes	–
C14	1	Capacitor	2.2 nF/250 V	20%	Radial	Murata	DE1E3KX222MA5B	Yes	Y1
C15	1	Capacitor	0.1 μF	10%	SMD0805	AVX	08051C104K4T2A	Yes	–
D1	1	Ultra-fast Diode	MUR160	–	Axial	ON Semiconductor	MUR160RLG	Yes	–
D2	1	Rectifier	MURD530	–	DPAK–4	ON Semiconductor	–	No	–

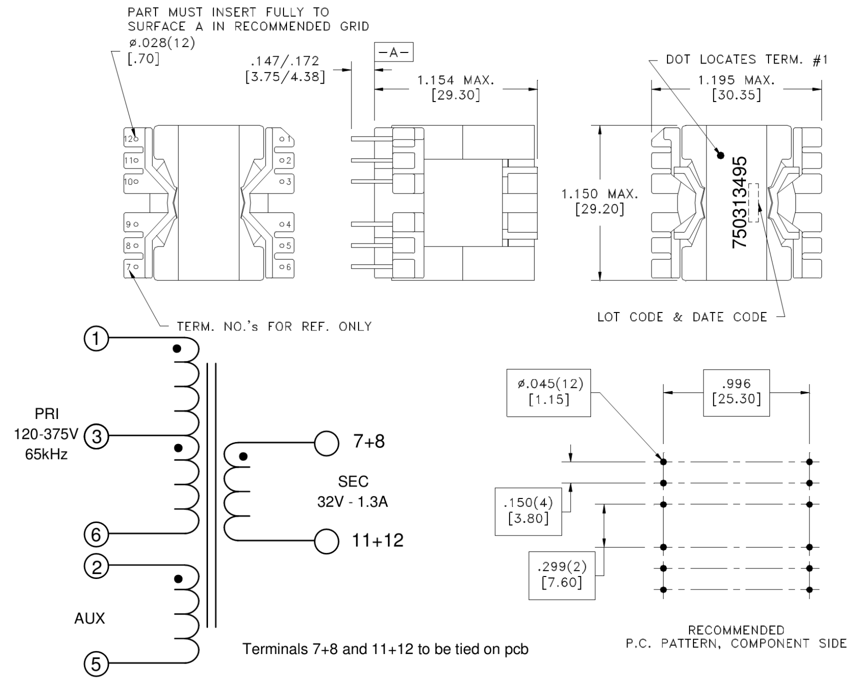
Table 2. BILL OF MATERIAL FOR THE NCP1255 EVALUATION BOARD (continued)

Designator	Qty.	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substi-tution Allowed	Comments
D3	1	Rectifier	1N4937	–	Axial	ON Semiconductor	1N4937RLG	No	–
D4	1	Rectifier	1N4148	–	Axial	Fairchild Semiconducotr	FDLL4148	Yes	–
D5	1	Zener Diode	1N973	–	SMDSOD80	NTE Electronics	1N973B	No	33 V Zener
D6	1	TVS	P6KE220A	–	DO15	Fairchild Semiconducotr	P6KE220A	Yes	–
F1′	1	Socket forUse	PCB TR5 TE5	–	Radial	Wickmann	5590000000	–	–
F1	1	Fuse	2 A/250 V–T	–	Radial	Schurter	0034.6618 1 (Note 1)	Yes	–
U1	1	PWM Controller	NCP1255	–	SOIC8	ON Semiconductor	– (Note 1)	No	–
U2	1	Optocoupler	SF615A–2	–	SMD	Vishay Semiconductor	SFH615A–4 (Note 1)	No	–
U3	1	Shunt Regulator	NCP431	–	SMD	–	NCP431ACSNT1G	No	SOT–23
U4	1	Diode Bridge	KBU4K	–	Through-hole	Multicomp	KBU4K	Yes	–
TR1	1	Transformer	750313495	–	Through-hole	Würth Electronic Midcom	750313495	No	PQ2625
J1	1	Line Input Connector	C8 SNAP IN 2P	–	Through-hole	Schurter	4300.0099	–	–
J2	1	Output Voltage Connector	–	–	Through-hole	Taiwan Semiconductor	KBU406	–	–
Q1	1	HV MOSFET	STP7NK80ZFP	–	TO220	ST Microelectronics	STP7NK80ZFP	–	–
Q2	1	PNP Transistor	PMBT2907A	–	SOT23	NXP	PMBT2907A	–	–
L1	1	Self 2×27 mH	RN114–0.8–02	–	Through-hole	Schaffner	RN114–0.8–02	–	–
J2	1	PCB Terminal Block	CTB5000/2	–	Through-hole	Camden	CTB5000/2	–	–
Holes	4	Plastic Feet	SFCBS–M4–16M–01	–	Through-hole	Richco	SFCBS–M4–16M–01	–	–

1. This is a Pb-free device.

TRANSFORMER SPECIFICATIONS

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



ELECTRICAL SPECIFICATIONS @ 25°C unless otherwise noted:

D.C. RESISTANCE (@20°C):	1-6 , 0.700 Ohms ±10%.
	2-5 , 0.160 Ohms ±10%.
	7-11 (7+8,11+12), 0.130 Ohms max.
DIELECTRIC RATING:	2000VAC, 1 minute tested by applying 2500VAC for 1 second between pins 1-7(2+6,11+12).
	500VAC, 1 minute tested by applying 625VAC for 1 second between pins 1-2.
INDUCTANCE:	1.00 mH ±10%, 10kHz, 100mVAC, 0mADC, 1-6, Ls.
SATURATION CURRENT:	2.5A saturating current that causes 20% rolloff from initial inductance.
LEAKAGE INDUCTANCE:	6.0μH typ., 12.0μH max., 100kHz, 100mVAC, 1-6(7+8+11+12), Ls.
TURNS RATIO:	(1-6):(7-11), (2.583):(1.00), tie(7+8,11+12), ±1%.
	(1-6):(2-5), (5.166):(1.00), ±1%.
	(1-3):(3-6), (1):(1.00), ±1%.

Designed to meet Class 2 requirements

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

Unless otherwise specified, tolerances are as follows: Angles: ±1° Fractions: ±1/64 Decimals:±.005(.127mm)

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