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Universal AC Input, 5 Volt Output, 10 Watt Power Supply

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1124 NCP431	Smart Meters, Electric Meters, White Goods	85 to 265 Vac	10W	CCM Flyback	Isolated (3 kV)

Output Specification	
Output Voltage	5 Vdc nominal
Ripple	100 mV p/p @ full load
Nominal Current	2 Amps continuous
Max Current	2.2 A maximum
Min Current	zero

PFC (Yes/No)	No(Pout ≤ 10 watts)
Input Protection	Fuse
Operating Temp. Range	0 to +50°C
Cooling Method	Convection
Standby Power	30 mW at 115 Vac 80 mW at 230 Vac

Circuit Description

This design note describes a simple 10 watt, universal AC input, constant output voltage power supply intended for AC adapters, industrial equipment, or white goods, where isolation from the AC mains is required, and low cost, high efficiency, and low standby power are essential.

The featured power supply is a simple CCM flyback topology utilizing ON Semiconductor's new NCP1124 monolithic with with integral 9-ohm, vertical channel MOSFET in a PDIP7 package (U1). This Design Note provides the complete circuit schematic details and BOM for 5V, 2A power supply. The simple input EMI filter (C1, L1) is adequate to pass Level B for FCC conducted EMI compliance. The NCP431 programmable zener is used as an error amplifier (U3), plus an optocoupler feedback scheme (U2) provides for excellent line and load regulation with high input-to-output safety isolation.

Performance characteristics for efficiency, output ripple, and internal MOSFET drain switching characteristics (Vds, Id) are shown in the figures and plots below. Enhanced input transient protection (lightning, etc.) can be accomplished with the addition of an appropriate TVS device across the input of the diode bridge.

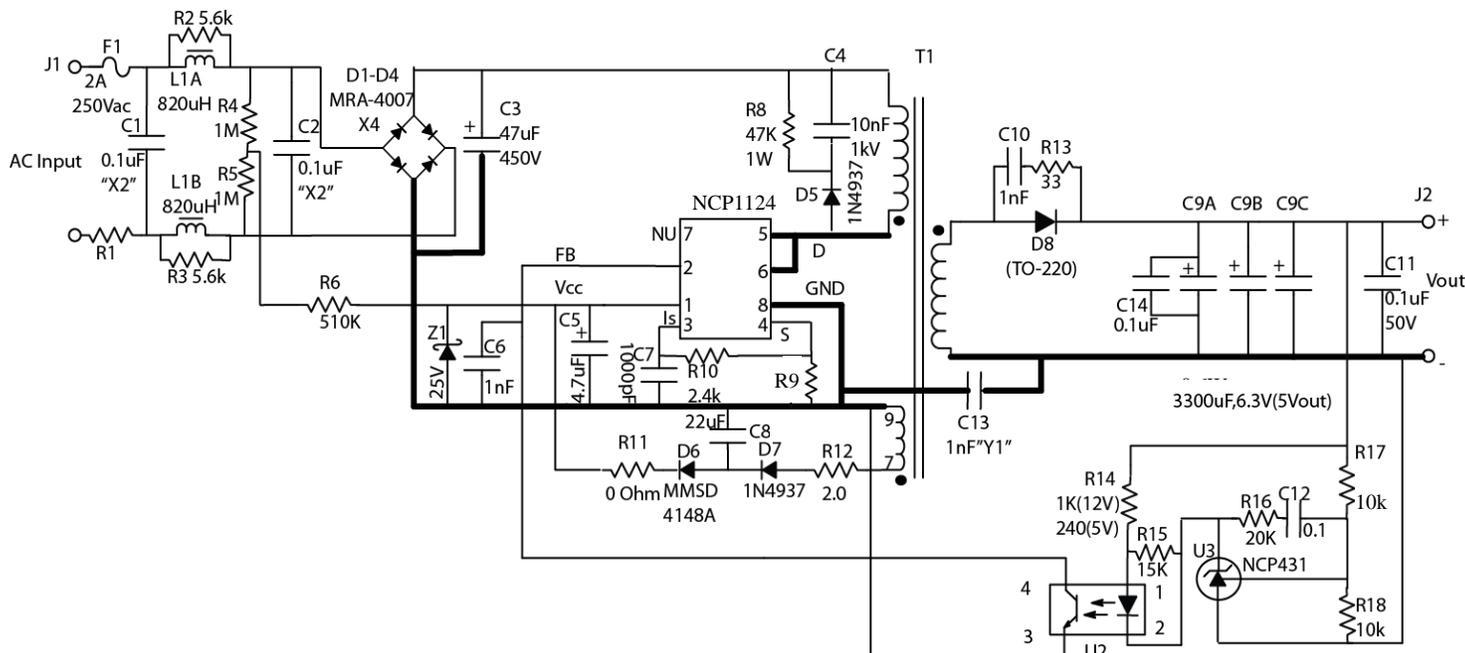
Key Features

- Universal AC input range (85 – 265 Vac).
- Input filter for conducted EMI attenuation.
- 650V Avalanche rated MOSFET.
- Input filter for conducted EMI attenuation.
- Very low standby (no load) power consumption.
- Frequency foldback under light load.
- Inherent over-current, over-voltage and over temperature protection.

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For optimum thermal characteristics, the printed circuit board should be laid out to include clad "pours" around pins 5 and 6 of the DIP8 package (MOSFET drain pins). Resistors 9 sets the peak current limit point for the internal overcurrent protection circuit of U1 and can be adjusted for desired max output current. For output voltages other than 5 volts, typical circuit changes include the transformer turns ratio for both the secondary and the primary aux winding, the value of R17 in the output voltage sense divider, and selecting appropriate voltage ratings for output rectifier D8 and output capacitors C9A, B & C. Depending on the transformer aux winding characteristics, it may be necessary to change R11 to a higher value resistance value to adjust the nominal Vcc voltage. Z1 can be added as an option in the event that the compliance range of the Vcc over the output load range exceeds the OVP trip point on pin 1 of U1 (28 volts). Such a scenario would be the result of a transformer with high leakage inductance.

Circuit Schematic



NOTES:

1. Crossed lines on schematic are NOT connected.
2. U2 is NEC PS2561L-1 or equivalent optocoupler(CTR>50%).
3. R1 is optional for increased inrush limiting- use wire wound only.
4. L1A/L1B are Wurth #7447728215 inductors (820uH, 500mA).
5. Output caps(C9A/B/C) are radial lead, low impedance types(UCC LXV series or similar).
6. R11 is for Vcc trimming(<28Vmax), typically zero ohms.
7. R9A/B sets max output current.
8. Heavy schematic lines indicate recommended ground plane areas.

10 Watt NCP 1124 Power Supply With Universal AC Input

Circuits Optimized for 650V 9ΩMOSFET (compared to MOSFET NCP1126/NCP1129)

A single 0.6 W, 1.5Ω resistor with 1% tolerance is used to limit the maximum current flowing through the MOSFET, instead of paralleling two 1.8Ω, 1/2W resistors with 5% tolerance.

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T1 Transformer Designs (Available from ICE Components Inc. and Würth Electronics)

5V/2A, 65 kHz Version (ICE # TO0915-1, Würth Electronics #750313860 Rev 01)

Core: E25/10/6 (812E250)

Primary A: 55 turns of 0.25mm mag wire

5V Secondary: 11 turns bifilar of 0.6mm Triple Insulated Wire (2 layers)

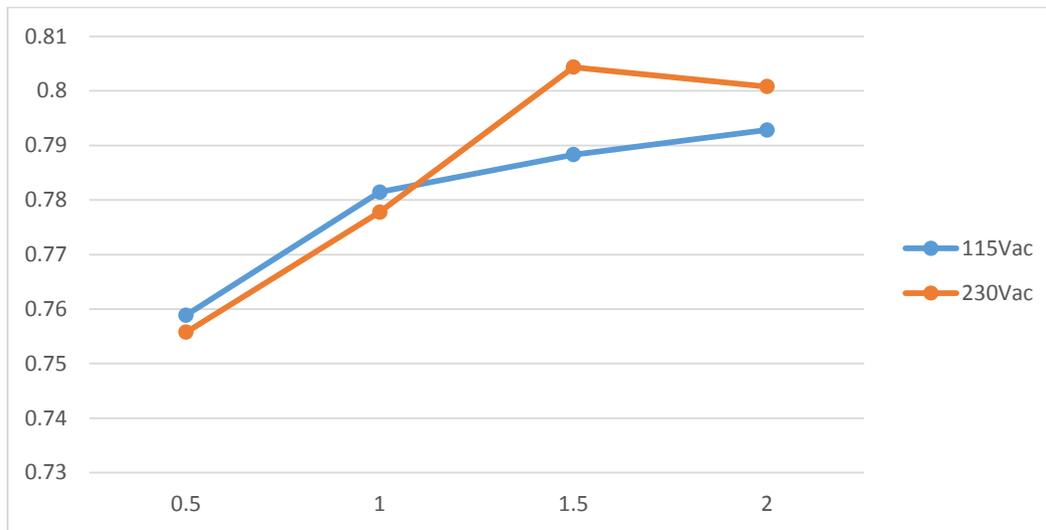
Aux/Vcc: 25 turns of 0.15mm mag wire spiral wound over 1 layer

Primary B: 55 turns of 0.25mm mag wire

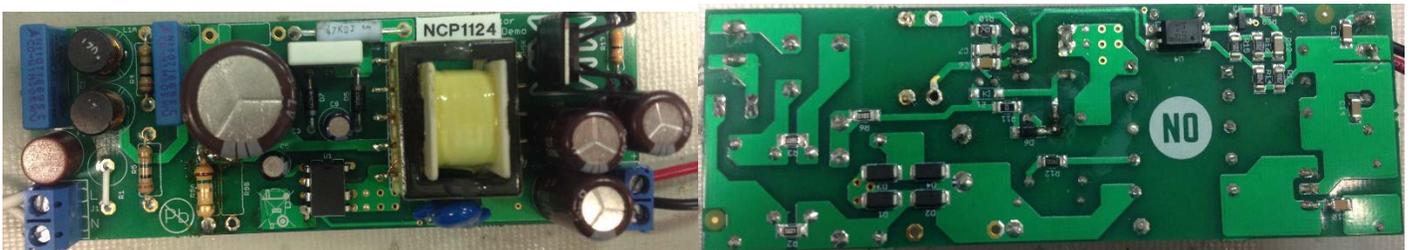
Primary Inductance (Pri A and B in series): 2 mH +/- 10% (gap in center leg)

Leakage Inductance (5Vsec & Aux shorted): 40 uH max

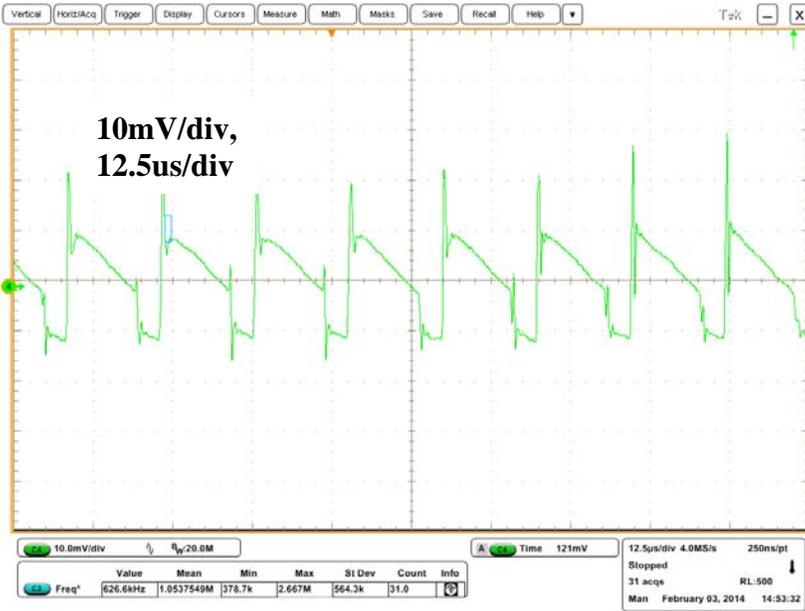
5 Volt Efficiency vs Output Load Curves



Board Picture

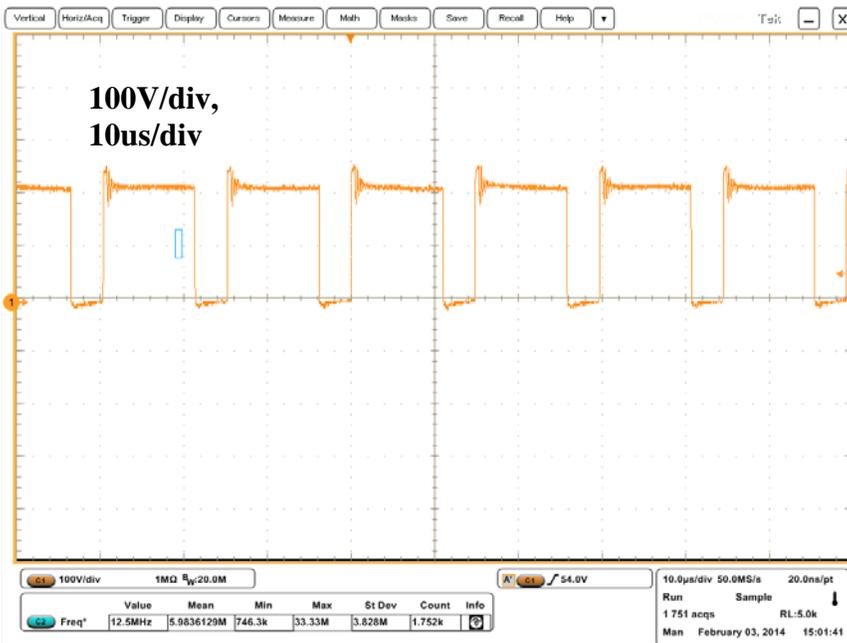


Full Load Output Ripple @ 120 Vac Input

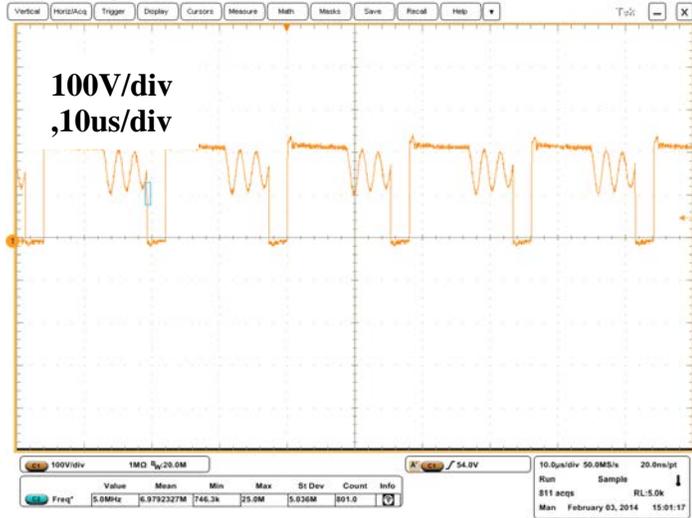


MOSFET Drain Voltage (120 Vac Input)

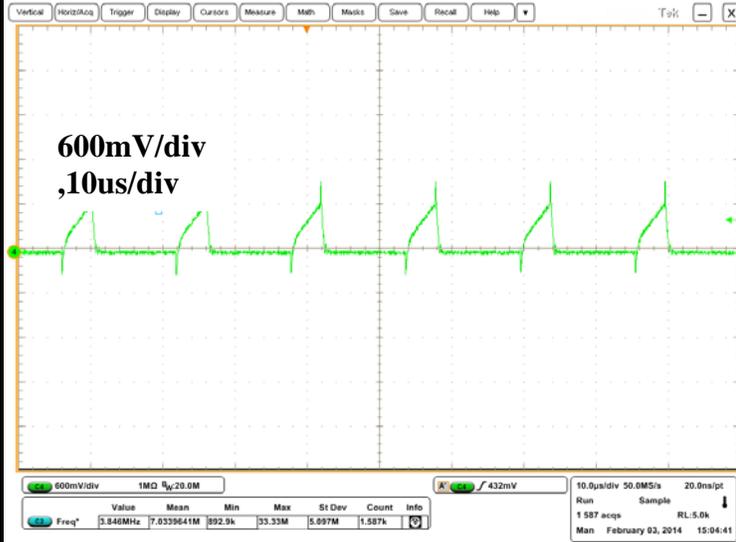
Full Load



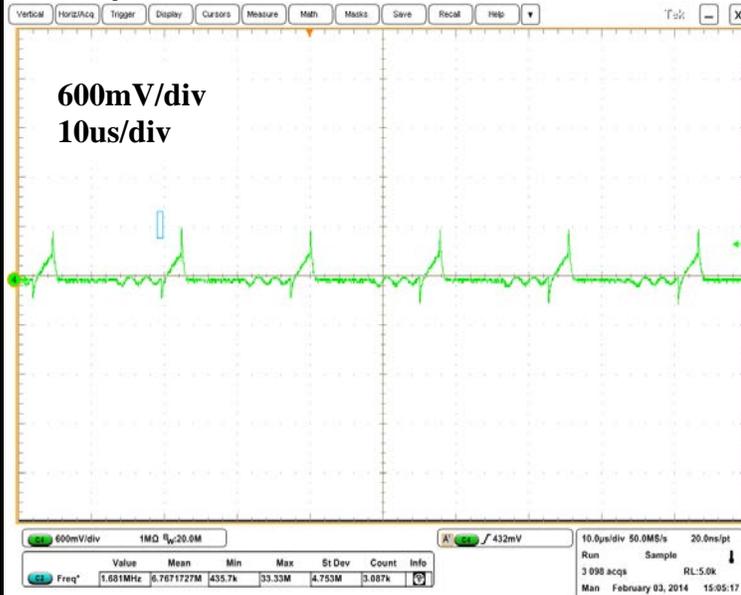
0.5 Amp Load



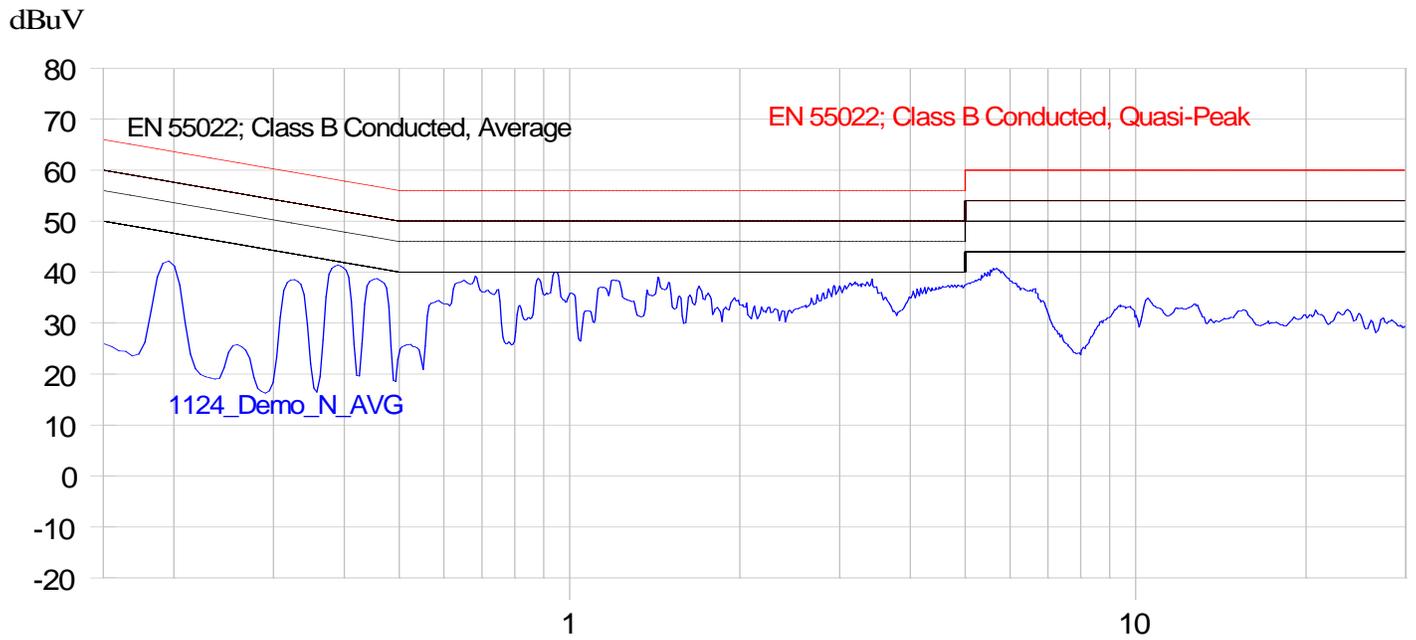
Mosfet Drain Current (120 Vac Input)
Full Load



0.5 Amp Load



Conducted EMI Plot



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(Start = 0.15, Stop = 30.00) MHz

DN05064/D

Bill of Materials

Designator	Qty	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free
D8 (5Vout)	1	Schottky diode	20A, 100V		TO-220	ON Semi	NTST20100CTG	No	
D1, 2, 3, 4	4	Diode - 60 Hz,	1A, 800V		SMA	ON Semi	MRA4007	No	
D5, D7	2	Diode - fast recov	1A, 600V		axial lead	ON Semi	1N4937	No	
D6	1	Signal diode	100mA, 100V		SOD-123	ON Semi	MMSD4148A	No	
Z1	1	Zener diode	27V		SOD-123	ON Semi	MMSZ5254B		
U3	1	Programmable zener	2.5V		SOT23	ON Semi	NCP431A	No	
U2	1	Optocoupler	CTR >= 0.5		4-pin	Vishay or NEC	SFH6156A-4 or PS2561L-1	Yes	
U1	1	Controller - NCP1124	65 kHz		DIP8	ON Semi	NCP1124BP65G	No	
C1, C2	2	"X" cap, box type	100nF, X2		LS = 15 mm	Rifa, Wima	TBD	Yes	
C13	1	"Y1" cap, disc type	1nF, Y1		LS = 7.5 mm	Rifa, Wima	TBD	Yes	
C4	1	Ceramic cap, box	10 nF, 1kV	10%	13x4 mm, LS=10 mm	Vishay	MKT1822310635	Yes	
C6	1	Ceramic cap, monolythic	1 nF, 50V	10%	1206	AVX, Murata	TBD	Yes	
C11, 12, 13	3	Ceramic cap, monolythic	100nF, 50V	10%	1206	AVX, Murata	TBD	Yes	
C7	1	Ceramic cap, monolythic	100pF, 50V	10%	1206	AVX, Murata	TBD	Yes	
C10	1	Ceramic cap, monolythic	1 nF, 200V	10%	1206	AVX, Murata	TBD	Yes	
C3	1	Electrolytic cap	47uF, 450V	10%	LS=7.5mm, D=18mm	UCC	EKXG401ELL470MM20S	Yes	
C5	1	Electrolytic cap	4.7uF, 50Vdc	10%	LS=2.5mm, D=5mm	UCC, Panasonic	TBD	Yes	
C8	1	Electrolytic cap	22uF, 50Vdc	10%	LS=2.5mm, D=6.3mm	Panasonic - ECG	ECA-1HM220	Yes	
C9A,B,C (5V)	2	Electrolytic cap	1,200uF, 10V	10%	10x20mm, LS=5mm	UCC	EKZE100ELL122MJ20S	Yes	
R1	1	#22 bare wire jumper	(wire jumper)		LS=7.5mm, D=7mm			Yes	
R8	1	Resistor, 2W, metal film	47K, 1W	10%	Axial lead; LS=18mm	Panasonic - ECG	ERG-2SJ473A	Yes	
R4, R5	2	Resistor, 1/2W metal film	1 Meg, 1/2W	10%	Axial lead; LS=12.5mm	Ohmite, Dale	TBD	Yes	
R9	2	Resistor, 1/2W metal film	1.5 ohm, 0.6W	1%	Axial lead; LS=12.5mm	AVX, Vishay, Dale	TBD		
R13	1	Resistor, 1/4W metal film	33 ohms, 1/4W	10%	Axial lead; LS=10mm	AVX, Vishay, Dale	TBD		
R2, R3	2	Resistor, 1/4W SMD	5.6K	5%	SMD 1206	AVX, Vishay, Dale	TBD		
R6	1	Resistor, 1/4W SMD	510K	5%	SMD 1206	AVX, Vishay, Dale	TBD	Yes	
R10	1	Resistor, 1/4W SMD	2.4K	5%	SMD 1206	AVX, Vishay, Dale	TBD	Yes	
R11	1	Resistor, 1/4W SMD	TBD (0 ohms)	5%	SMD 1206	AVX, Vishay, Dale	TBD		
R12	1	Resistor, 1/4W SMD	2.0 ohms	5%	SMD 1206	AVX, Vishay, Dale	TBD		
R15	1	Resistor, 1/4W SMD	15K	5%	SMD 1206	AVX, Vishay, Dale	TBD		
R16	1	Resistor, 1/4W SMD	20K	5%	SMD 1206	AVX, Vishay, Dale	TBD		
R18	1	Resistor, 1/4W SMD	10K	5%	SMD 1206	AVX, Vishay, Dale	TBD		
R14 (5Vout)	1	Resistor, 1/4W SMD	240 ohms	5%	SMD 1206	AVX, Vishay, Dale	TBD	Yes	
R17 (5Vout)	1	Resistor, 1/4W SMD	10K	5%	SMD 1206	AVX, Vishay, Dale	TBD	Yes	
F1	1	Fuse, TR-5 style	2A		TR-5, LS=5mm	Minifuse	TBD	Yes	
L1A/B	1	Inductor (EMI choke)	820 uH, 500 mA		See Wurth Drawing	Wurth Magnetics	7447728215	Yes	
T1 (5Vout)	1	Transformer	E20/10/6 core		See Mag Drawing	ICE Magetics	TO09151-1	Yes	
J1, J2	2	Screw Terminal			LS = 0.2"	DigiKey	# 281-1435-ND	Yes	
D8 Heatsink	1	Clip-on Heatsink	(TO-220)		0.52" x 0.52" x 0.75"H	Mouser (Aavid)	532-576802B00 or equiv.		
Blue indicates part change with Vout change									

References

ON Semiconductor data sheet for NCP1126, 1129 monolithic switcher.

ON Semiconductor Design Notes DN05012, DN05017, DN05018, DN05028, DN05029, DN05043/D

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