ON Semiconductor

Is Now

To learn more about onsemi™, please visit our website at
www.onsemi.com

ON Semiconductor

Design Note – DN05038/D Rev 1

Non-Isolated, 8 Watt Dual Output, Off-line Power Supply

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1075 NST45011	White Goods, Industrial Equipment	180 to 270 Vac	8 Watts Nominal	Non-Isolated Flyback	No isolation from mains

Other Specification

	Output 1	Output 2	Output 3	Output 4
Output Voltage	5.0 Vdc +/- 2%	8.5 Vdc +/- 5%	N/A	N/A
Ripple	200 mV p/p	200 mV p/p	N/A	N/A
Nominal Current	1 A	200 mA	N/A	N/A
Max Current	1.25 A	300 mA	N/A	N/A
Min Current	1%	1%	N/A	N/A

PFC (Yes/No)	No
Efficiency	76% at 8 watts output
Inrush Limiting / Fuse	Yes – limiting resistor and fuse
Operating Temp. Range	0 – 50 C
Cooling Method / Supply Orientation	Convection NA
No Load Standby Power	68 mW @ 230 Vac

Others	Optional high regulation sense circuit using NCP431

Circuit Description

This Design Note features an 8 watt, off-line, dual output, flyback power supply intended for powering white goods or industrial equipment circuitry which does not require output isolation from the AC mains. The flyback converter is designed around ON Semiconductor's 100 kHz NCP1075 monolithic switching controller. A simple voltage sensing and feedback scheme utilizing a current mirror transistor pair (Q1), and zener diode (Z1) is utilized for low cost yet effective output regulation for most typical applications.

This particular design example provides output voltages of 5V and 8.5V but these can be tailored to other voltages to accommodate the specific requirements by appropriate transformer turns ratio changes and alterations to voltage setting zener Z1 and resistor R6.

The regulation loop is closed around the 5 volt main output while the 8.5 volt output is configured using a "slave" secondary winding on the transformer. The slave secondary is tightly coupled to the main 5V winding via bifilar winding techniques which assures reasonable load and cross regulation without requiring dedicated regulation circuitry. Other 2nd channel voltages are possible by changing the turns of the slave secondary winding.

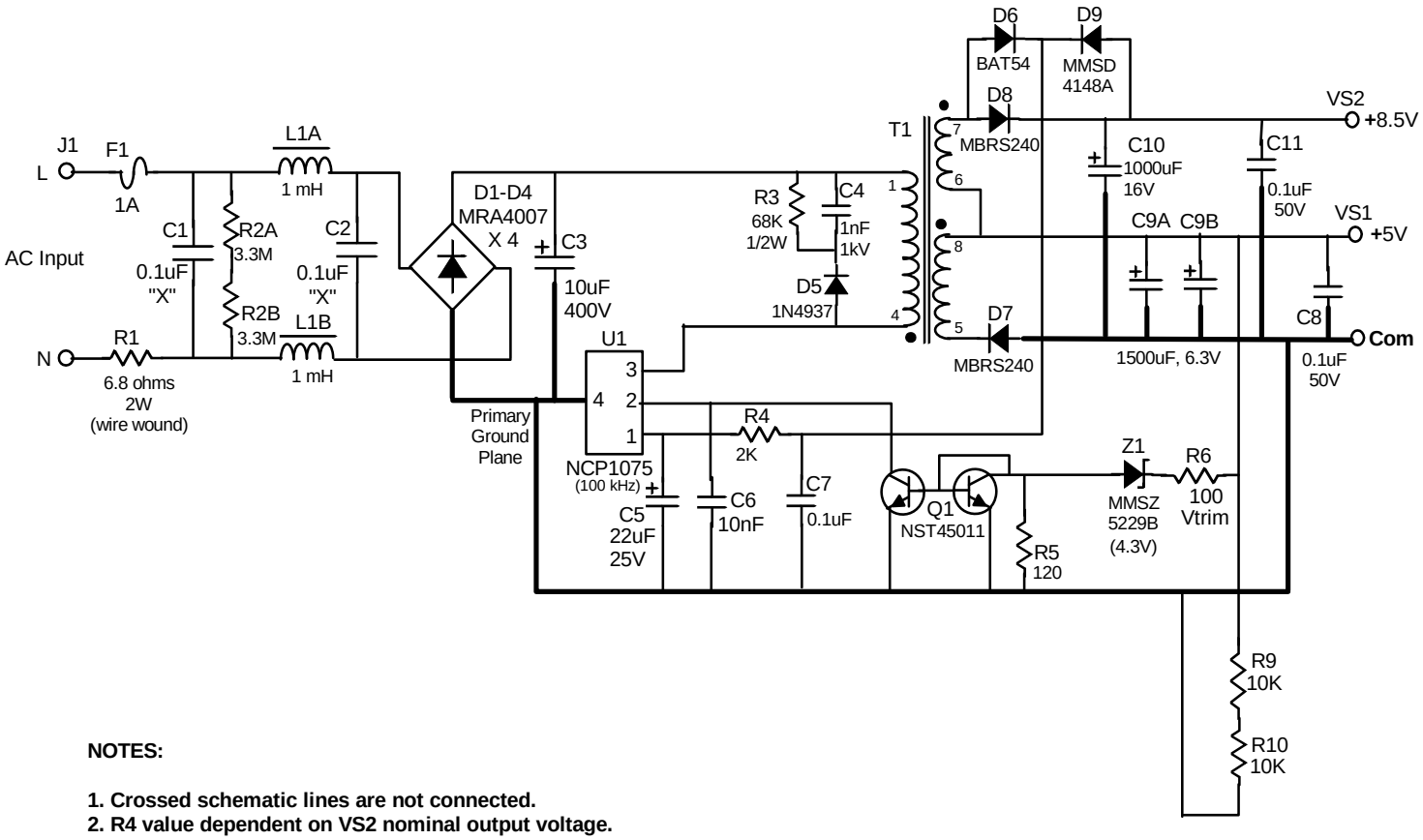
Logic power (Vcc) for the control chip is derived via diode D9 directly from the slave output. Since the control IC needs a minimum of about 8 volts to maintain efficient operation, Schottky D6 is provided as an optional logic Vcc source instead of D9 in the event it is required that the second output is somewhat less than 8 volts. At Vcc voltages less than about 8 volts, the controller will operate in DSS mode and there will be some degradation in overall circuit efficiency.

Although this design is for European mains voltage, a transformer design for a universal AC input version is available on request. A 5V/12V transformer design is also included in the information below.

Key Features

- Schottky diodes (D6, D7) on both outputs for high efficiency
- Dual sensing options depending on desired regulation accuracy
- Input EMI filter for conducted emission compliance
- Input fuse and inrush limiting resistor (R1)
- Good load and cross regulation on 8.5Vout due to secondary winding technique on transformer

Schematic



NOTES:

1. **Crossed schematic lines are not connected.**
2. **R4 value dependent on VS2 nominal output voltage.**
3. **R1 is optional inrush limiting resistor.**
4. **U1 tab (pin 4) should have heatsinking clad pours and be part of a ground plane area for best noise immunity.**
5. **Heavy lines indicate recommended ground plane areas.**
6. **L1A/L1B are Wurth 7447728102.**
7. **Z1 sets nominal 5Vout. R6 can trim Vout upward.**

Non-Isolated, 8 Watt, Dual Output NCP1075 PSU with Universal AC Input (Rev 8)

DN05038/D

MAGNETICS DESIGN DATA SHEET

Project / Customer: ON Semiconductor - NCP1014/1075, 8W dual output PSU

Part Description: 8 watt flyback transformer, 100kHz, 5V/9V outputs (Rev 5 - Euro version)

Schematic ID: T1 Wurth Electronics Part # 750313309 Rev 02

Core Type: EF16 (E16/8/5); 3C90 material or similar

Core Gap: Gap for 5.5 mH +/- 5% inductance across primary (pins 1 - 4)

Inductance: 5 to 6 mH when measuring from pin 1 to pin 4

Bobbin Type: 8 pin horizontal mount for EF16

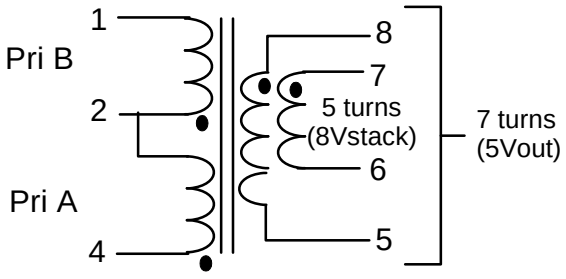
Windings (in order):

Winding # / type	Turns / Material / Gauge / Insulation Data
Primary A (4 - 2)	78 turns of #38 mag wire wound over 1 layer. Insulate with Mylar tape for at least 1kV breakdown.
5V/8.5V Secondaries (8,5 - 7,6)	7 turns of two pieces of #26 magnet wire (different colors) spiral wound bifilar over one layer. Remove two turns so winding terminating to pins 7/6 has only 5 turns. Triple Insulated wire can also be used if desired. Self-leads to pins.
Primary B (2 - 1)	Same as primary A.

Varnish assembly

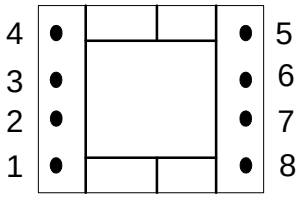
Hipot: 1 kV from primary to secondary - no agency primary/secondary insulation requirements

Schematic



Lead Breakout / Pinout

(Bottom View - facing pins)



DN05038/D

MAGNETICS DESIGN DATA SHEET

Project / Customer: ON Semiconductor - NCP1014/1075, 8W dual output PSU

Part Description: 8 watt flyback transformer, 100kHz, 5V/12V outputs (Rev 1 - Euro version)

Schematic ID: T1

Core Type: EF16 (E16/8/5); 3C90 material or similar

Core Gap: Gap for 5.5 mH +/- 5% inductance across primary (pins 1 - 4)

Inductance: 5 to 6 mH when measuring from pin 1 to pin 4

Bobbin Type: 8 pin horizontal mount for EF16

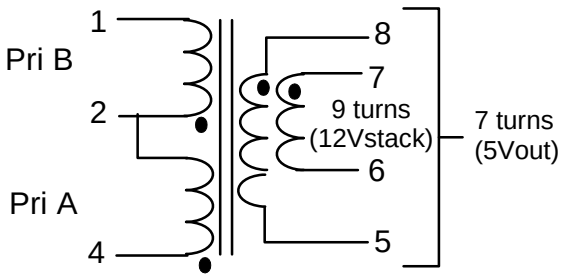
Windings (in order):

Winding # / type	Turns / Material / Gauge / Insulation Data
Primary A (4 - 2)	78 turns of #38 mag wire wound over 1 layer. Insulate with Mylar tape for at least 1kV breakdown.
5V/12V Secondaries (8,5 - 7,6)	7 turns of two pieces of #26 magnet wire (different colors) spiral wound bifilar over one layer. Add two more turns so the winding terminating to pins 7/6 has 9 turns total (12V stack). Triple Insulated wire can also be used if desired. Self-leads to pins.
Primary B (2 - 1)	Same as primary A.

Varnish assembly

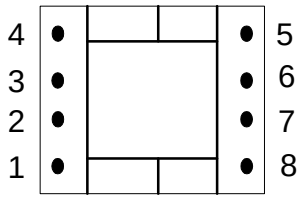
Hipot: 1 kV from primary to secondary - no agency primary/secondary insulation requirements

Schematic

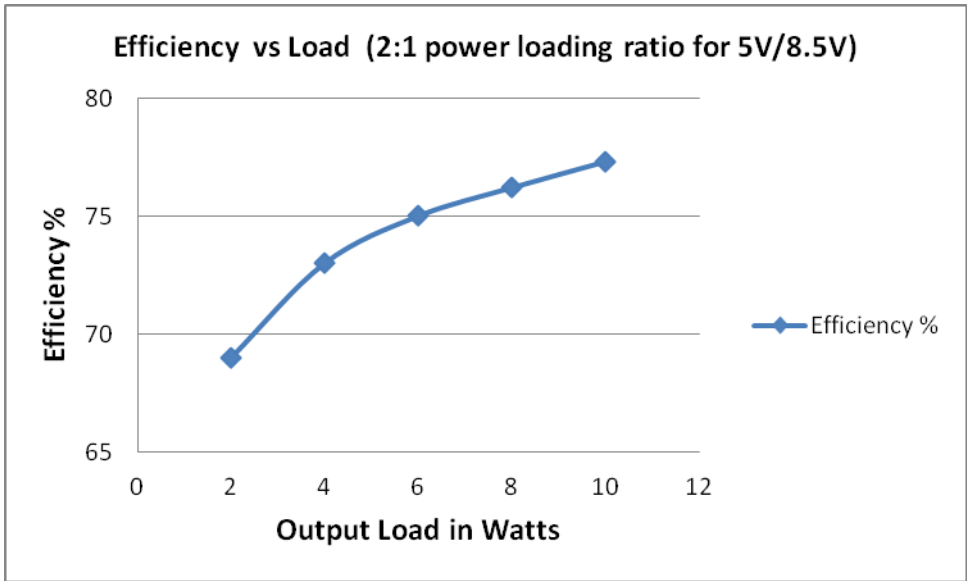


Lead Breakout / Pinout

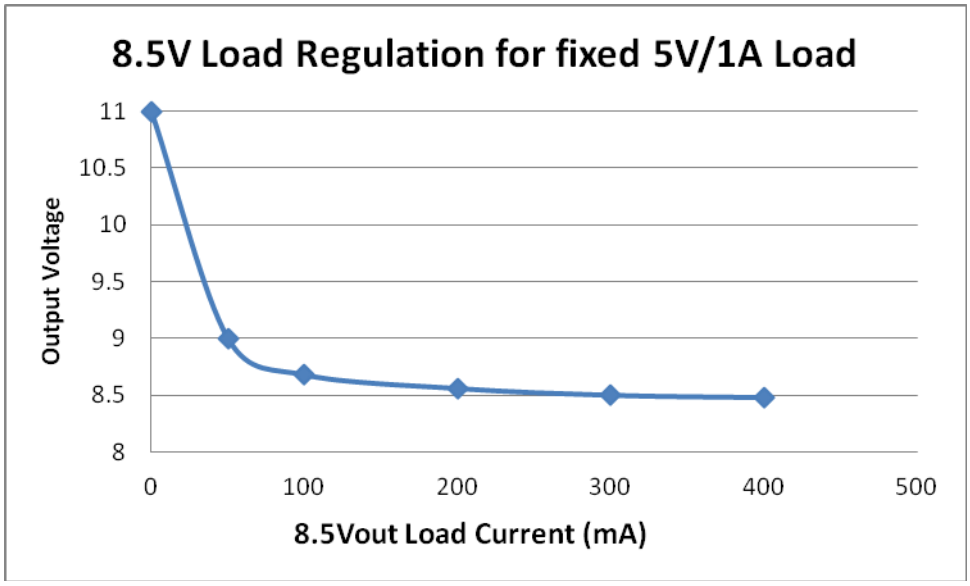
(Bottom View - facing pins)



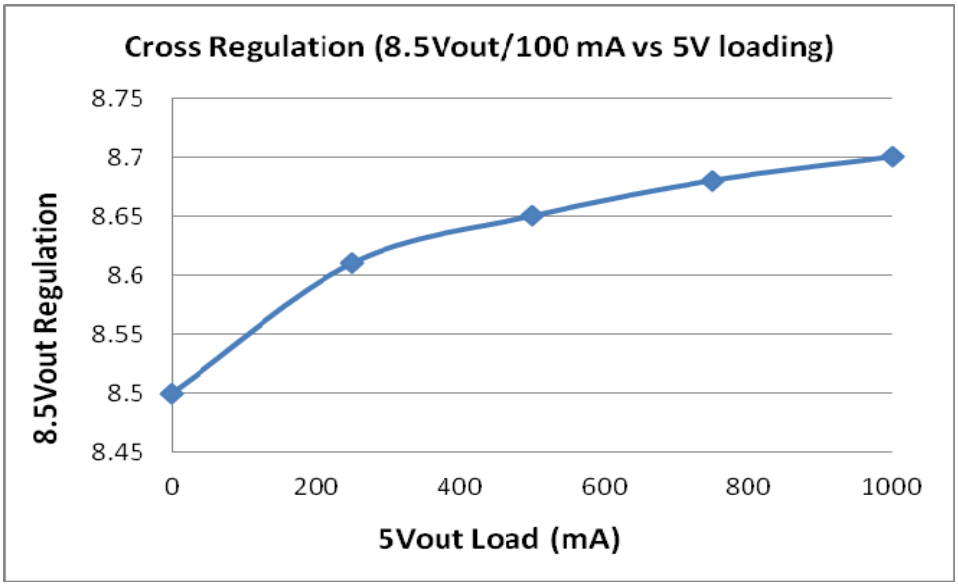
Efficiency versus Pout (5V:8.5V = 2:1 Loading Ratio Respectively)



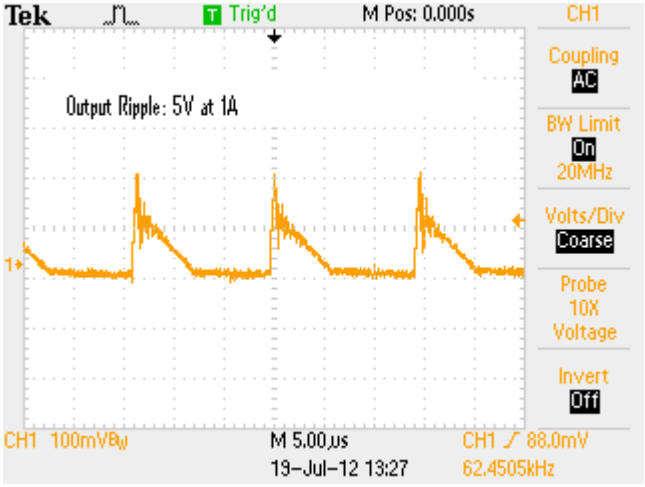
8.5 Vout Load Regulation (5 Vout set to 1A Load)



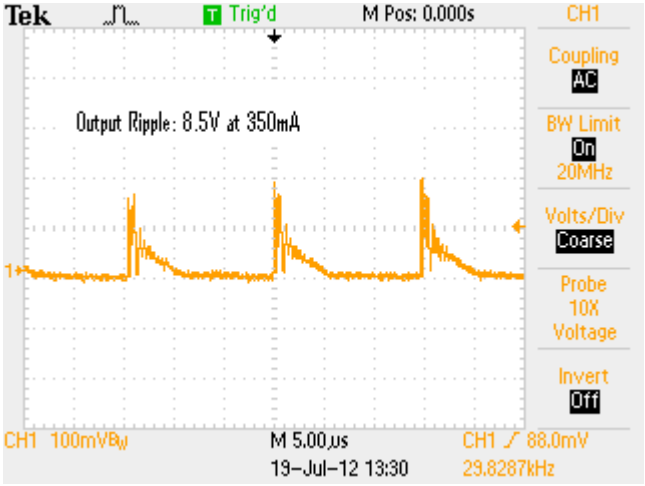
Cross Regulation (8.5Vout loaded at 100mA)



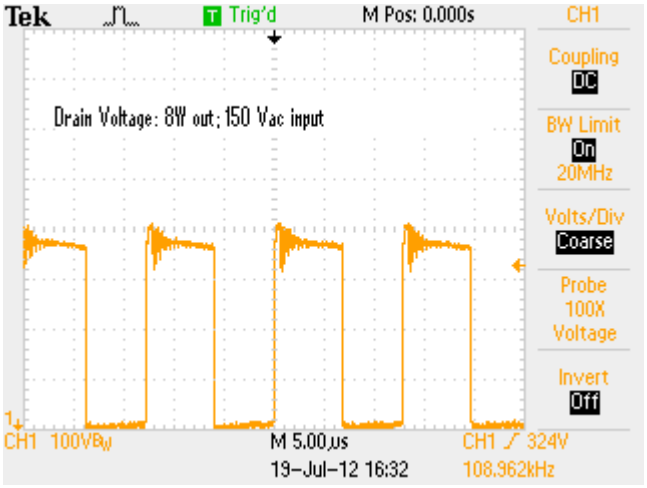
Output Ripple – 5 Vout at 1 Amp



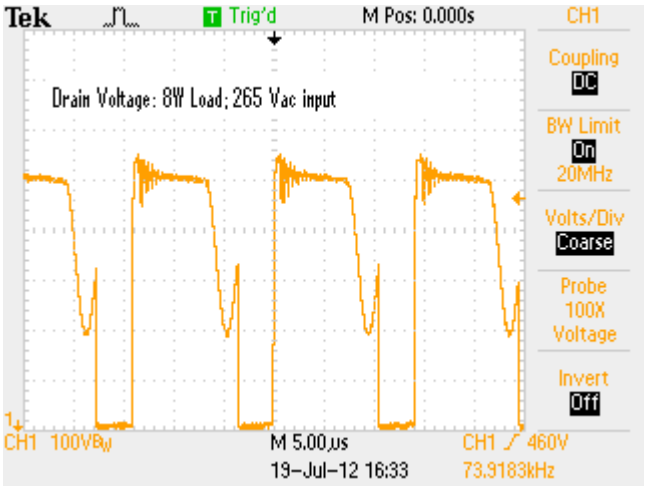
Output Ripple – 8.5 Vout at 350 mA



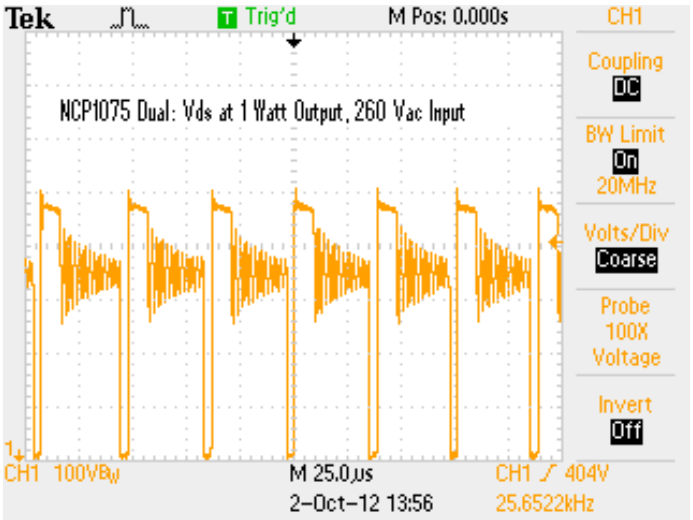
Mosfet Drain Voltage at 150 Vac Input and 8 Watt Load



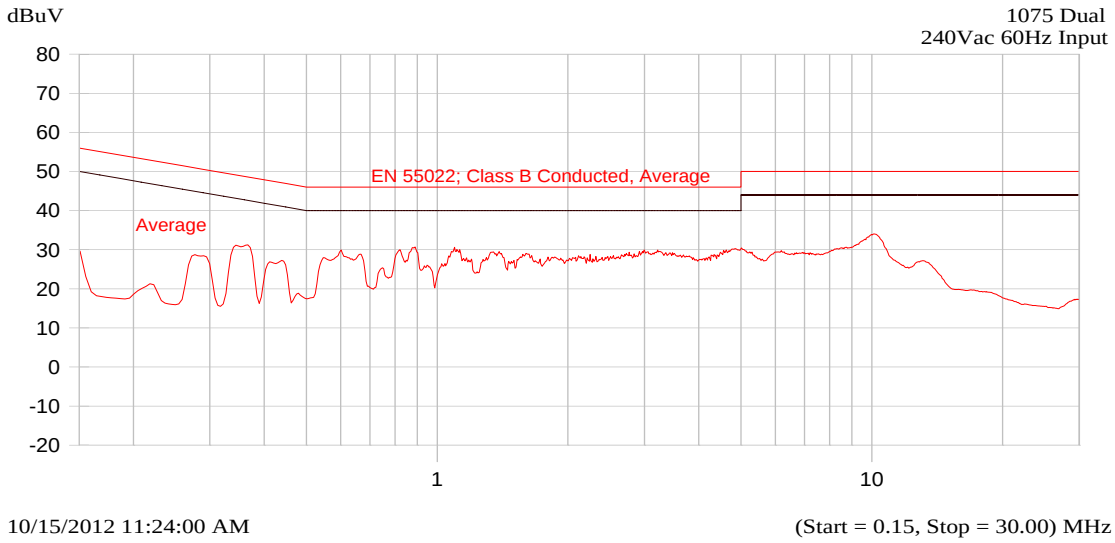
Mosfet Drain Voltage at 265 Vac Input and 8 Watt Load



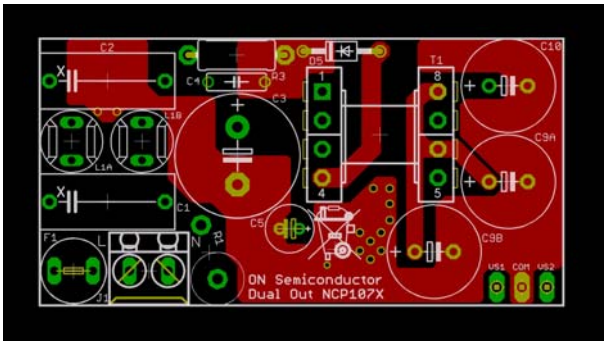
Mosfet Drain Voltage at 260 Vac Input and 1 Watt Load

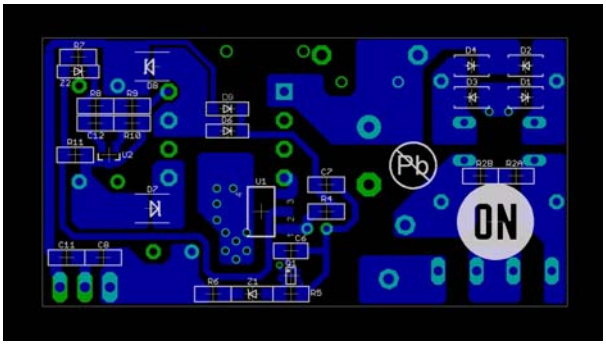


Conducted EMI Scan with 8 Watt Load (EN55022, Level B; Average)



PC Board Layout/Photo





DN05038/D

Designator	Qty	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free	Comments
D7, D8	2	Schottky diode	3A, 40V		SMB	ON Semi	MBRS240L (or MBRS2040L)	No		
D1, 2, 3, 4	4	Diode - 60 Hz,	1A, 800V		SMA	ON Semi	MRA4007	No		
D5	1	Diode - fast recov	1A, 600V		axial lead	ON Semi	1N4937	No		
D6	1	Schottky diode	200mA, 30V		SOD-123	ON Semi	BAT54	No		
D9	1	Signal diode	100mA, 100V		SOD-123	ON Semi	MMSD4148A	No		For 12Vout and higher
Z1	1	Zener diode	4.3V, 500 mA		SOD-123	ON Semi	MMSZ5229B	No		
Z2	1	Zener diode	2.7V, 500 mA		SOD-123	ON Semi	MMSZ5223B	No		
Q1	1	Dual NPN matched xstr	45V, 100 mA		SOT-363	ON Semi	NST45011	No		
U2	1	Programmable zener	2.5V		SOIC8 / SOT23	ON Semi	NCP431A	No		
U1	1	Switcher IC - NCP1075	100 kHz		SOT223	ON Semi	NCP1075ST100	No		
C1, C2	2	"X" cap, box type	100nF, X2		LS = 15 mm	Rifa, Wima	TBD	Yes		
C4	1	Ceramic cap, disc	1 nF, 1kV	5%	LS = 7.5 mm	Rifa, Wima	TBD	Yes		
C6	1	Ceramic cap, monolythic	1 nF, 50V	10%	1206	AVX, Murata	TBD	Yes		
C7, 8, 11	3	Ceramic cap, monolythic	100nF, 50V	10%	1206	AVX, Murata	TBD	Yes		
C12	1	Ceramic cap, monolythic	100nF, 50V	10%	1206	AVX, Murata	TBD			
C3	1	Electrolytic cap	10uF, 400/450V	10%	LS=7.5mm, D=16mm	UCC, Panasonic	TBD	Yes		
C10	1	Electrolytic cap	1000uF, 16V	10%	LS=5 mm, D=12.5mm	UCC, Panasonic	TBD	Yes		
C5	1	Electrolytic cap	22uF, 25V	10%	LS=2.5mm, D=6.3mm	UCC, Panasonic	TBD			
C9A, C9B	2	Electrolytic cap	1,500uF, 6.3V	10%	LS=5mm, D=12.5mm	UCC, Panasonic	TBD	Yes		12V version
R1	1	Resistor, 2W, Wire wound	6.8 ohm, 2W	10%	LS=7.5mm, D=7mm	Ohmite, Dale	TBD	Yes		
R3	1	Resistor, 0.5W, metal film	68K, 0.5W	10%	Axial lead; LS=12.5mm	Ohmite, Dale	TBD	Yes		
R2A,R2B	2	Resistor, 1/4W SMD	3.3 Meg	5%	SMD 1206	AVX, Vishay, Dale	TBD	Yes		
R5	1	Resistor, 1/4W SMD	120 ohms	1%	SMD 1206	AVX, Vishay, Dale	TBD	Yes		
R4	1	Resistor, 1/4W SMD	2.0K	1%	SMD 1206	AVX, Vishay, Dale	TBD			
R9, R10	2	Resistor, 1/4W SMD	10K	1%	SMD 1206	AVX, Vishay, Dale	TBD	Yes		
R7	1	Resistor, 1/4W SMD	10K	1%	SMD 1206	AVX, Vishay, Dale	TBD	Yes		
R6	1	Resistor, 1/4W SMD	100 ohms	1%	SMD 1206	AVX, Vishay, Dale	TBD	Yes		
R8	1	Resistor, 1/4W SMD	1 Meg	1%	SMD 1206	AVX, Vishay, Dale	TBD	Yes		
R11	1	Resistor, 1/4W SMD	4.7K	1%	SMD 1206	AVX, Vishay, Dale	TBD	Yes		
F1	1	Fuse, TR-5 style	1A		TR-5, LS=5mm	Minifuse		Yes		
L1A/B	1	Inductor (EMI choke)	1 mH, 500 mA		See Wurth Drawing	LS=5mm, D=8mm	7447728102	Yes		
T1 (5/8.5Vout	1	Transformer	E20/10/6 core		See Mag Drawing	Wurth Magnetics	750313309 Rev 02	Yes		
J1	1	Screw Terminal			LS = 0.2"	DigiKey	# 281-1435-ND	Yes		

Yellow indicates parts for standard Vout sense scheme
Green indicates parts for alternate Vout sense scheme.

References:

NCP1075 data sheet: http://www.onsemi.com/pub_link/Collateral/NCP1072-D.PDF

NCP1075 Design Note: http://www.onsemi.com/pub_link/Collateral/DN05018-D.PDF

NCP1072 EVAL Board Documents:
http://www.onsemi.com/PowerSolutions/supportDoc.do?type=boards&rpn=NCP1072

Design note created by Frank Cathell, e-mail: f.cathell@onsemi.com