



ON Semiconductor

# Universal AC Input, 5 or 12 Volt Output, 15 to 24 Watt Power Supply

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1076/77 NCP431	Smart Meters, Electric Meters, White Goods	85 to 270 Vac	15 to 25 W	CCM Flyback	Isolated ( 3 kV)

Output Specification	
Output Voltage	5 Vdc or 12 Vdc
Ripple	200 mV p/p @ full load
Nominal Current	4A/1.75A Amps (5V/12V)
Max Current	4.5/2.0 Amps
Min Current	zero

PFC (Yes/No)	No (Pout < 25W)
Average Efficiency	80% minimum typical at 50% load
Inrush Limiting / Fuse	Inrush resistor (Optional - R1) & Fuse
Operating Temp. Range	0 to +50°C
Cooling Method / Supply Orientation	Convection
Signal Level Control	None

## Circuit Description

This design note describes a simple, low power (25W or less), universal AC input, constant voltage power supply intended for powering utility electric meters or similar industrial equipment or white goods where isolation from the AC mains is required and low cost and high efficiency is essential.

The featured power supply is a simple CCM flyback topology utilizing ON Semiconductor's new NCP1076/1077 series of monolithic switchers in an SOT-223 package. This Design Note provides the complete circuit schematic details and transformer design for 5V/4A and 12V/1.75A power supplies. Other output voltages from 3.3 Vdc up to 28 Vdc are easy to implement by modifying the values (or ratings) of a few of the secondary side output components and the flyback transformer's secondary winding (T1). The simple input EMI filter is adequate to pass Level B for FCC conducted EMI compliance and the NCP431

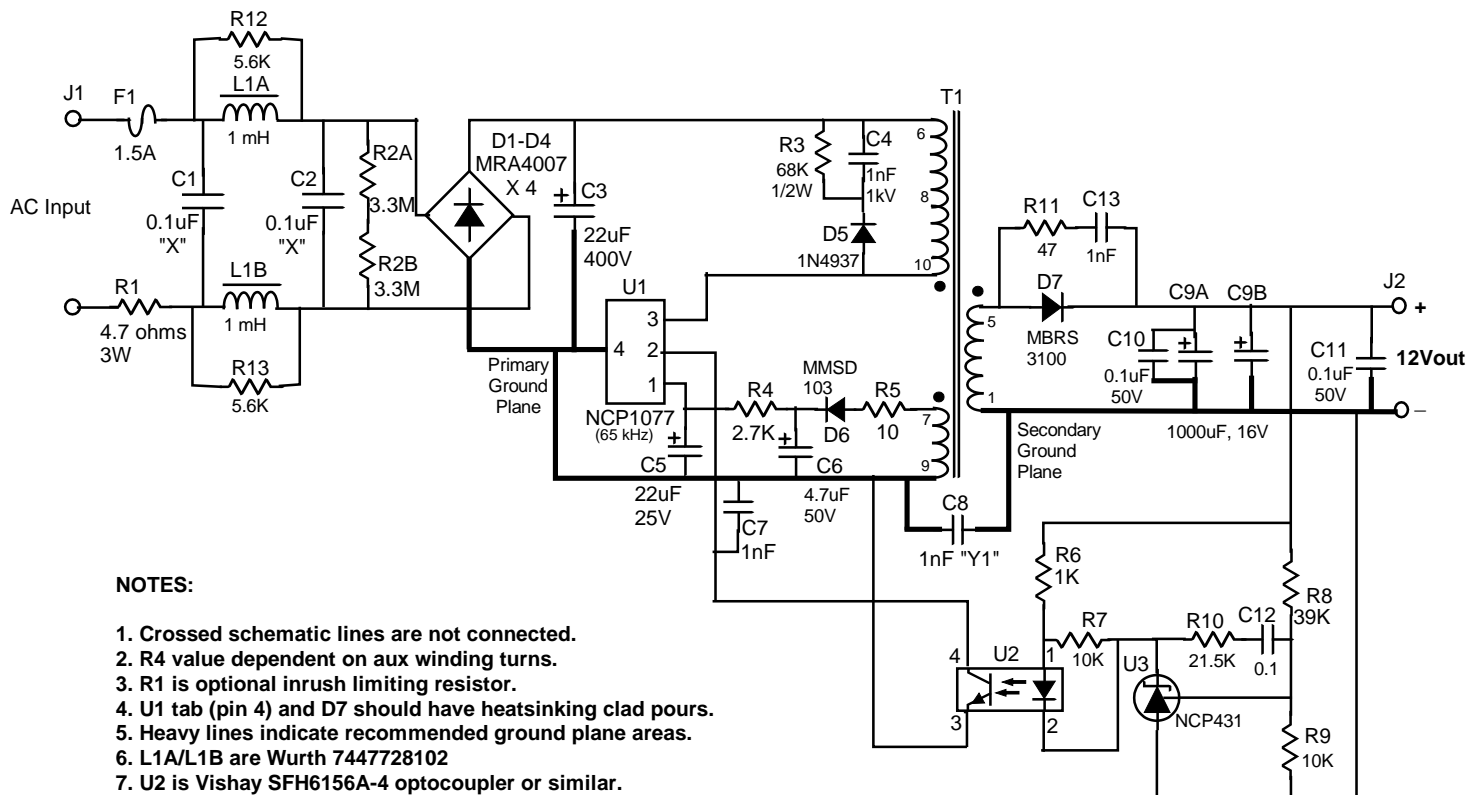
programmable zener plus optocoupler feedback scheme provides for excellent line and load regulation along with high input-to-output isolation.

Performance characteristics for efficiency, output ripple, internal MOSFET drain switching characteristics, and conducted EMI are shown in the figures and plots below.

## Key Features

- Universal AC input range (85 – 270 Vac).
- Input filter (pi-network) for conducted EMI attenuation and input transient protection.
- Very low standby (no load) power consumption.
- Frequency foldback under light load and/or overcurrent conditions.
- Secondary circuit easily configured for different output voltage/current combinations.
- Inherent over-current, over-voltage and over temperature protection.

## 12V Circuit Schematic



**20 Watt NCP1077 Power Supply  
with Universal AC Input (Rev 4)**

## 12 V Transformer Design

12V/2.0A, 65 kHz Version (Wurth Electronics # 750313861 Rev 1)

Core: E25/10/6 (812E250)

Primary A: 55 turns of 0.25mm mag wire

12V Secondary: 22 turns of 0.6mm Triple Insulated Wire (11 TPL, 2 layers)

Aux/Vcc: 22 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)

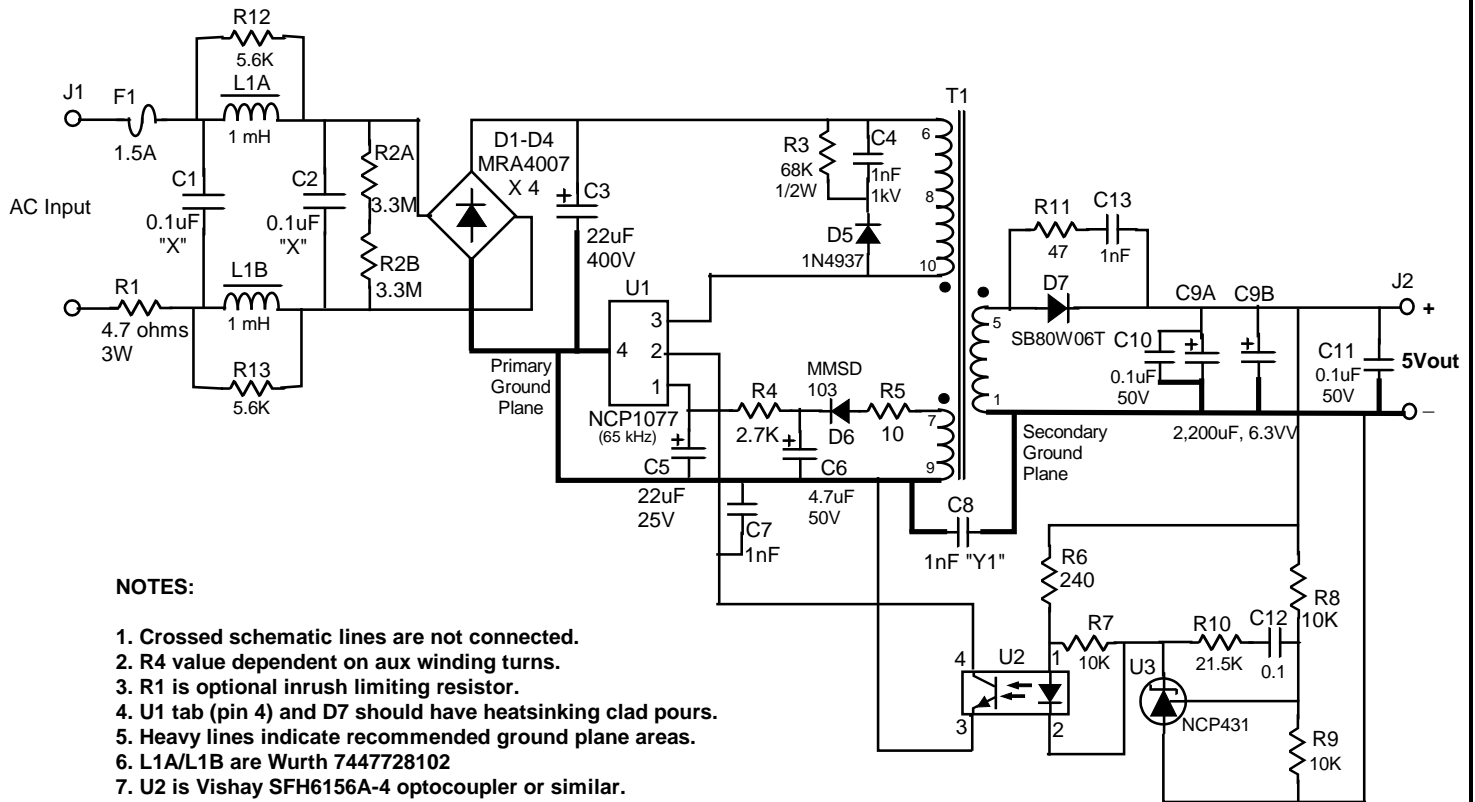
Leakage Inductance (12Vsec & Aux shorted): 30 uH max

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## 5V Circuit Schematic



**20 Watt NCP1077 Power Supply  
with Universal AC Input (Rev 4)**

## 5 V Transformer Design

5V/4A, 65 kHz Version (Wurth 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)

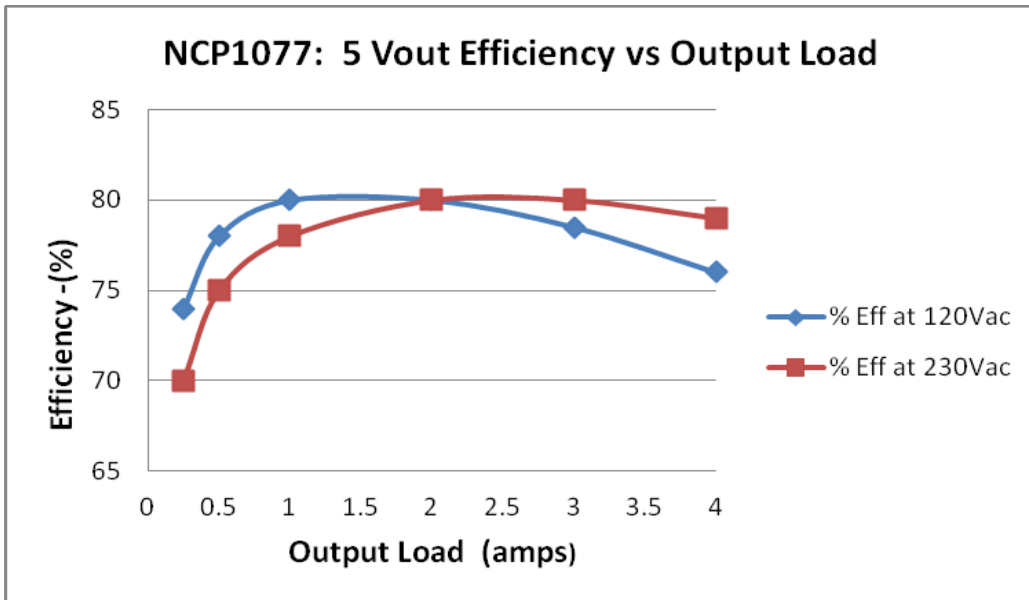
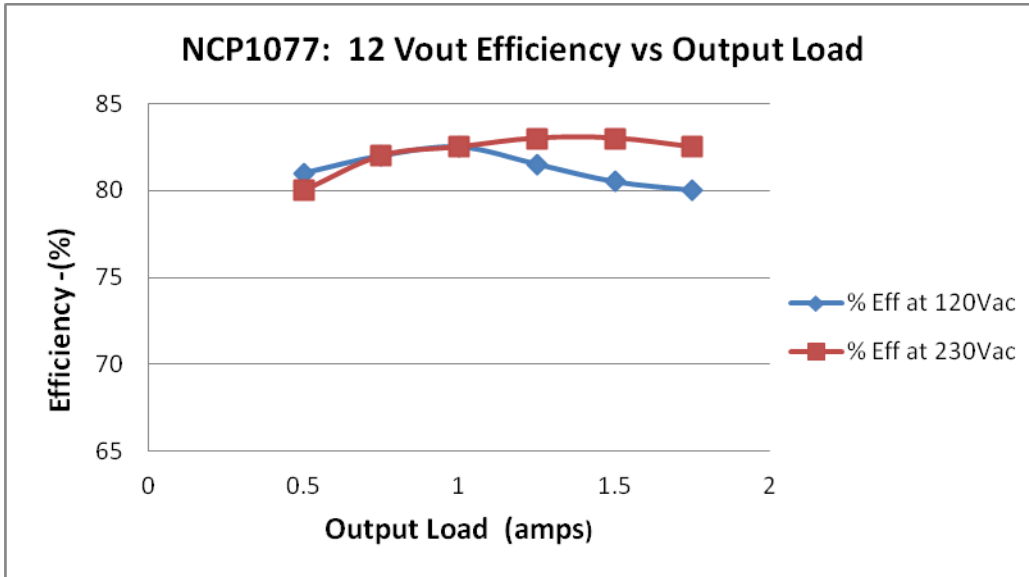
Aux/Vcc: 25 turns of 0.15mm mag wire spiral wound over 1 layer

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

## Efficiency vs Load Curves



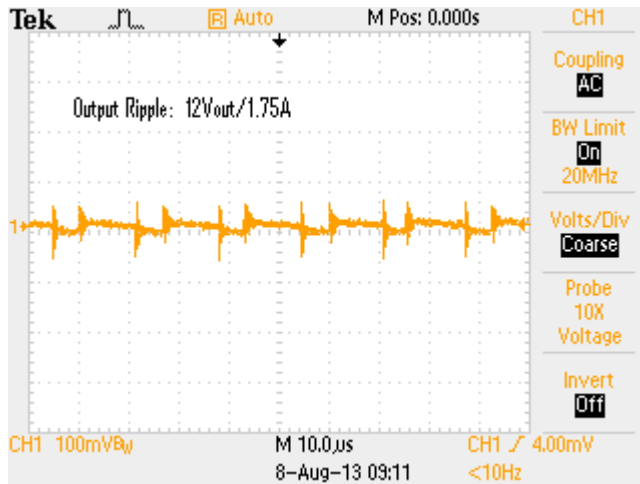
### Typical Standby (no load) Input Power

120 Vac: 30 mW

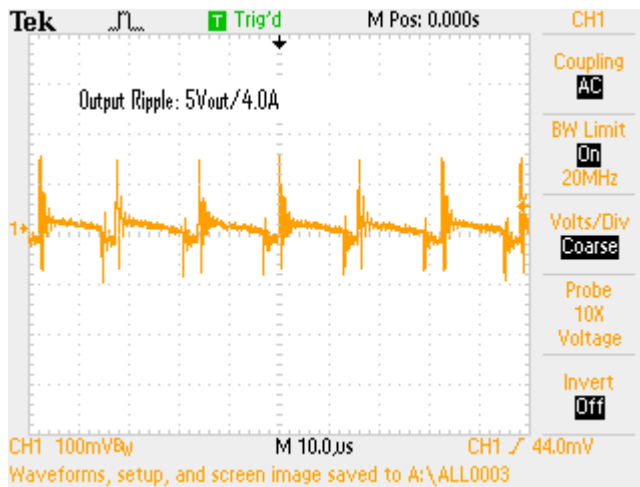
230 Vac: 64 mW

## Full Load Output Ripple @ 120 Vac Input

### 12Vout



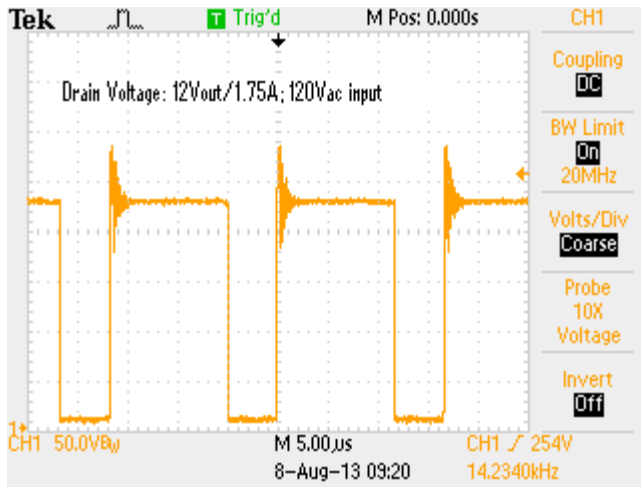
### 5Vout



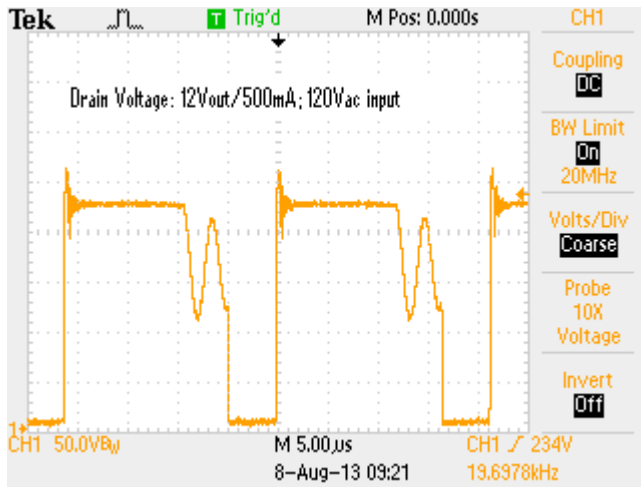
Note: The demo boards under test do not contain an output L/C ripple filter (see schematics above). The output ripple can be further reduced another half-order of magnitude if necessary by the addition of a 4.7 uH inductor followed by a 100 uF capacitor.

# MOSFET Drain Voltage

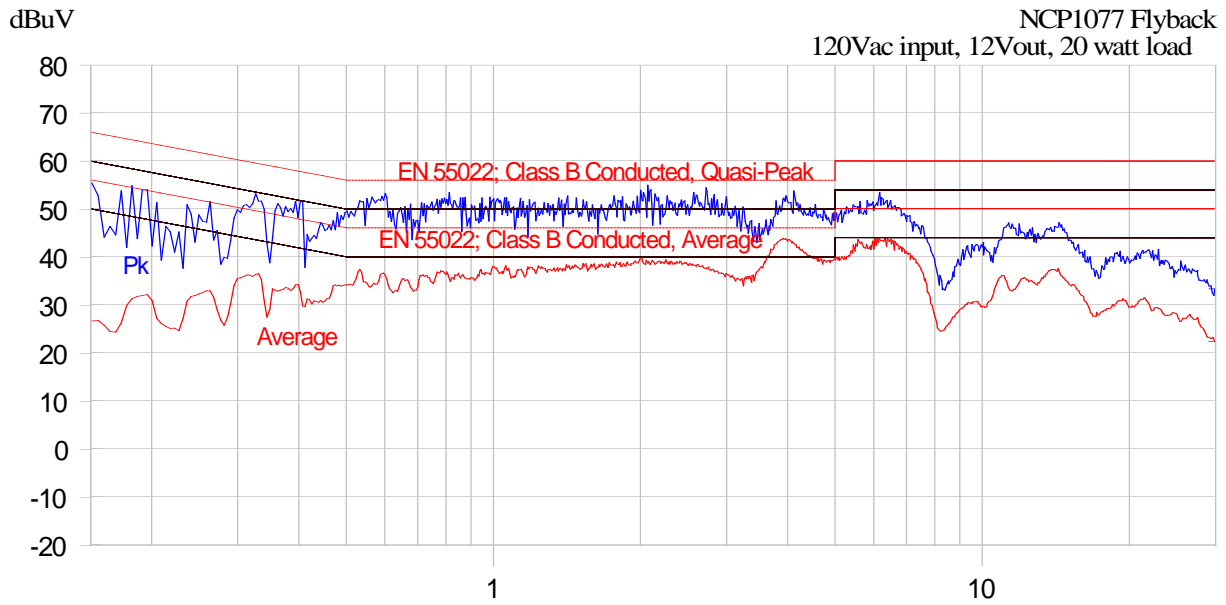
## Full Load – 120Vac Input



## Light Load – 120 Vac Input

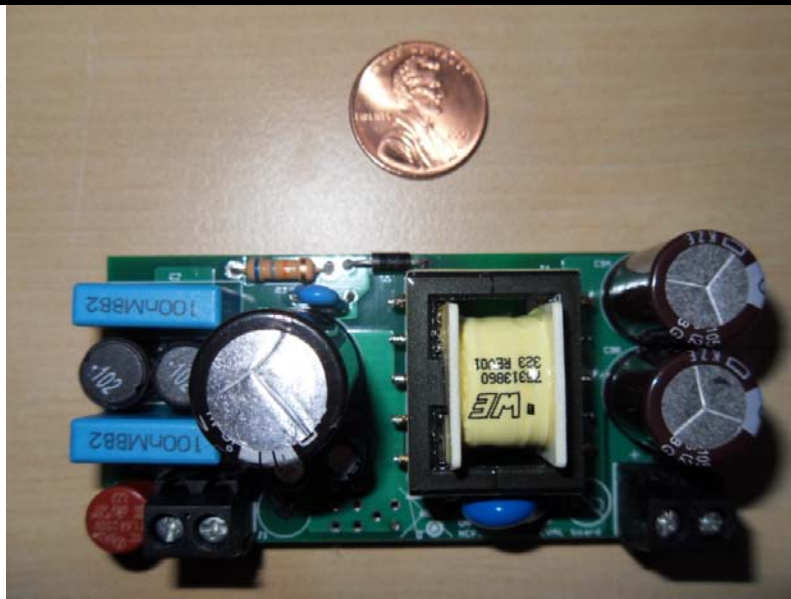
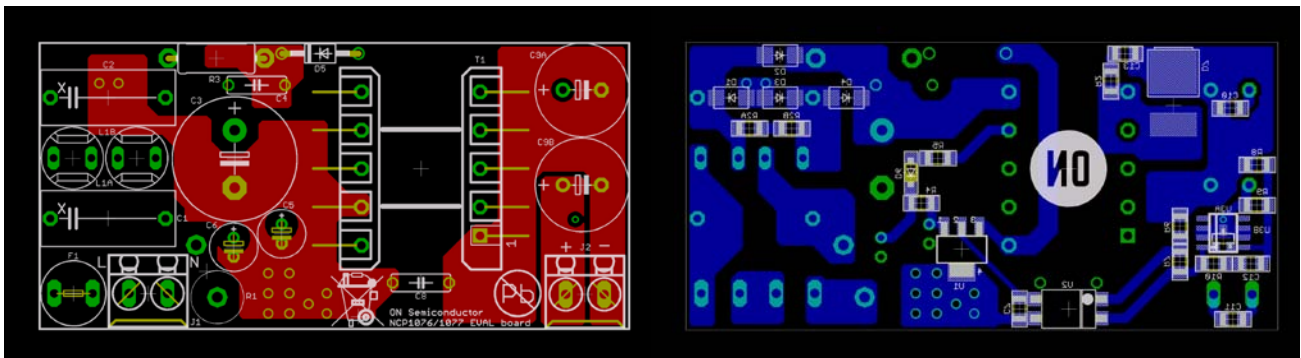


# EMI Profile - Quasi-peak (blue) and Average (red)



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(Start = 0.15, Stop = 30.00) MHz



# DN05049/D

## Bill of Materials for 15W/20W NCP1076/1077 Flyback (Rev4)

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Designator	Qty	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free	Comments
D7 (12Vout)	1	Schottky diode	3A, 100V		SMC	ON Semi	MBR3100	No		
D7 (5Vout)	1	Schottky diode	8A, 60V		DPak	ON Semi	SB80W06T or MBRD660CT	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	Signal diode	100mA, 250V		SOD-123	ON Semi	MMSD103	No		
U3	1	Programmable zener	2.5V		SOIC8 / SOT23	ON Semi	NCP431A	No		
U2	1	Optocoupler	CTR $\geq$ 0.5		4-pin	Vishay or NEC	Digikey P/N = PS2561BL-1	Yes		
U1	1	Switcher IC - NCP1077/1076	65 kHz		SOT223	ON Semi	NCP1077ST65	No		
C1, C2	2	"X" cap, box type	100nF, X2		LS = 15 mm	Rifa, Wima	Digi-Key P/N = 399-5426-ND	Yes		
C8	1	"Y1" cap, disc type	1nF, Y1		LS = 7.5 mm	Rifa, Wima	Digikey P/N = BC2374-ND, Mouser P/N = 75-WKP102MCPEJ0KR	Yes		
C4	1	Ceramic cap, disc	1 nF, 1kV	5%	LS = 7.5 mm	Rifa, Wima	Digi-Key P/N = 478-4227-ND	Yes		
C7, C13	2	Ceramic cap, monolithic	1 nF, 100V	10%	1206	AVX, Murata	TBD	Yes		
C10, 11, 12	3	Ceramic cap, monolithic	100nF, 50V	10%	1206	AVX, Murata	Digi-Key P/N = 311-1179-1-ND	Yes		
C3	1	Electrolytic cap	22uF, 400/450V	10%	LS=7.5mm, D=16mm	UCC, Panasonic	Digikey P/N = P5877-ND	Yes		
C6	1	Electrolytic cap	4.7uF, 50Vdc	10%	LS=2.5 mm, D=6.3mm	UCC, Panasonic	Digi-Key P/N = 565-1105-ND	Yes		
C5	1	Electrolytic cap	22uF, 25V	10%	LS=2.5mm, D=6.3mm	UCC, Panasonic	Digi-Key P/N = 565-1056-ND			
C9A,B (12V)	2	Electrolytic cap	1000uF, 16V	10%	LS=5mm, D=12.5mm	UCC, Panasonic	Digi-Key P/N = 565-1664-ND	Yes		12V version
C9A,B (5V)	2	Electrolytic cap	2200 or 3300uF, 6.3V	10%	LS=5mm, D=12.5mm	UCC, Panasonic	TBD			
R1	1	Resistor, 3W, Wire wound	Use jumper wire	10%	LS=7.5mm, D=7mm	Ohmite, Dale	Digi-Key P/N = 4.7AECT-ND	Yes		
R3	1	Resistor, 0.5W, metal film	68K, 0.5W	10%	Axial lead; LS=12.5mm	Ohmite, Dale	Mouser = 71-FP01/268K0G5605EK	Yes		
R2A,R2B	2	Resistor, 1/4W SMD	3.3 Meg	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-3.30MFCT-ND	Yes		
R10	1	Resistor, 1/4W SMD	21.5K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-21.5KFCT-ND			
R11	1	Resistor, 1/4W SMD	47 ohms	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-47.0FCT-ND			
R5	1	Resistor, 1/4W SMD	10 ohms	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-10.0FCT-ND	Yes		
R4	1	Resistor, 1/4W SMD	2.7K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-2.70KFCT-ND			
R7, R9	2	Resistor, 1/4W SMD	10K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-10.0KFCT-ND	Yes		
R12, R13	2	Resistor, 1/4W SMD	5.62K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-5.62KFCT-ND			
R6 (12Vout)	1	Resistor, 1/4W SMD	1K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-1.00KFCT-ND	Yes		
R6 (5Vout)	1	Resistor, 1/4W SMD	240 ohms	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-240FCT-ND	Yes		
R8 (12Vout)	1	Resistor, 1/4W SMD	38.3K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-38.3KFCT-ND	Yes		
R8 (5Vout)	1	Resistor, 1/4W SMD	10K	1%	SMD 1206	AVX, Vishay, Dale	Digi-Key P/N = 541-10.0KFCT-ND	Yes		
F1	1	Fuse, TR-5 style	1.5A		TR-5, LS=5mm	Minifuse	Digi-Key P/N = WK4253BK-ND	Yes		
L1A/B	1	Inductor (EMI choke)	1 mH, 500 mA		See Wurth Drawing	LS=5mm, D=8mm	7447728102	Yes		
T1 (12Vout)	1	Transformer	E25/10/6 core		See Mag Drawing	Wurth Magnetics	750313861 Rev 1	Yes		
T1 (5Vout)	1	Transformer	E25/10/6 core		See Mag Drawing	Wurth Magnetics	750313860 Rev 1			
J1, J2	2	Screw Terminal			LS = 0.2"	DigiKey	# 281-1435-ND	Yes		

Blue indicates part change with Vout change



## References

ON Semiconductor data sheet for NCP1076/1077 monolithic switcher.

ON Semiconductor Design Notes DN05018, DN05043, DN05048

ON Semiconductor Application Note AND8489/D

ON Semiconductor Flyback Transformer Design Tool:

(<http://www.onsemi.com/PowerSolutions/supportDoc.do?type=tools&rpn=NCP1075>)

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