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Design Note – DN05058/D

NCP107X, 12 Vout, Off-line Buck Regulator

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1071 NCP1075 NCP1077	Smart Meters Electric Meters, White Goods	85 to 265 Vac	Up to 6 W at 12 Vout	Off-Line 100 kHz Buck	Non-isolated

	Output Specification
Output Voltage	5 to 36 Vdc depending on selected Z1 zener value
Output Ripple	Less than 1%
Typical Current	100 to 350 mA
Max Current	150 mA with NCP1071, 400 mA with NCP1077 (see matrix below)
Min Current	zero

PFC (Yes/No)	No, Pout < 25 watts
Efficiency	See plots below
Inrush Limiting / Fuse	External fuse required
Operating Temp. Range	0 to +50°C (dependent on U1 heatsinking)
Cooling Method / Supply Orientation	Convection
Signal Level Control	None

Circuit Description

This design note describes a very simple, low power, constant voltage output buck power converter intended for powering electronics for white goods, electrical meters, and industrial equipment where isolation from the AC mains is not required. The switching element in the converter is ON Semiconductor's NCP107x series of monolithic switchers. In this reference design, the NCP1071 is utilized with a 100 kHz switching frequency and a maximum output current of 250 mA.

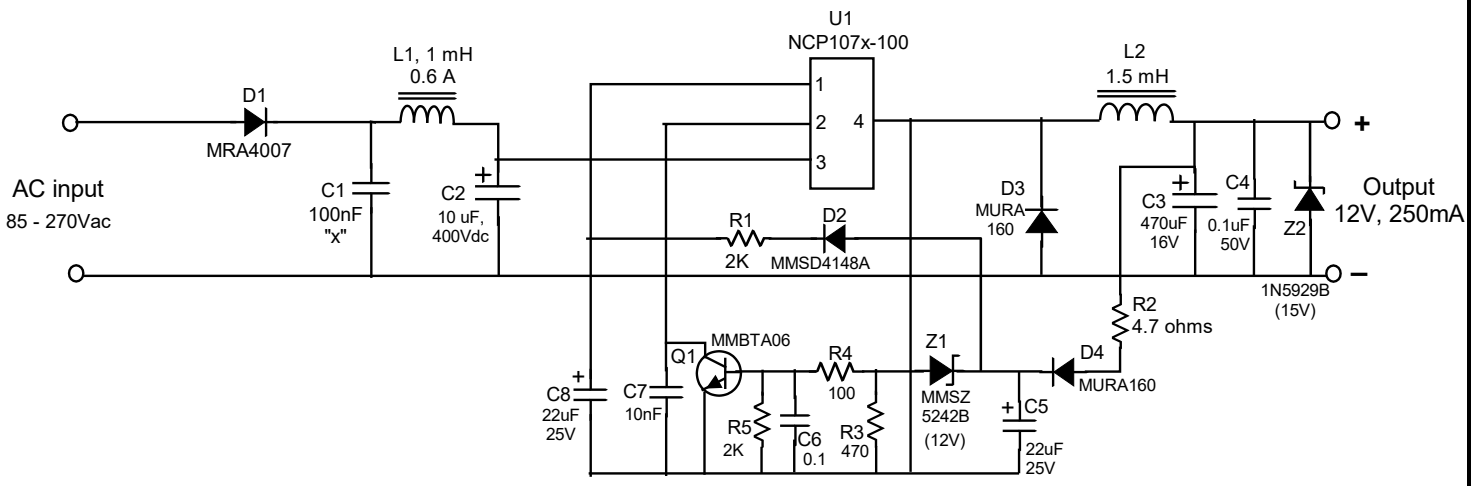
This buck circuit design utilizes a simple charge pump or "bootstrap" type of voltage sensing and regulation scheme composed of D4, C5, Z1, Q1 and the associated passive components. This simple sensing technique eliminates the use of an optocoupler in the feedback loop. Z1 sets the approximate output voltage and Q1 acts as a simple error amplifier. Although the regulation is inferior to that of a conventional TL431 and optocoupler feedback circuit, it is typically adequate for most applications with a regulation of +/- 5% over loads from 100% down to about 1% max rated load. Below 1% the output will rise to the value of the overvoltage clamping zener Z2 across the output. For a 12 volt output, a typical value for this zener will be 15 volts and at no load, the output will be clamped at this level.

The sensed voltage produced on C5 is also used to power the NCP1071 controller through D2 and limiting resistor R1 once the converter has started. This auxiliary Vcc to run the chip improves the overall efficiency of the circuit and prevents the controller from running in DSS mode under normal load conditions.

Because of the low power output, a simple half-wave input rectifier/filter circuit is used comprised of D1 and C2. C1 and L1 form a conducted EMI filter that easily meets CE and UL level B requirements. C2 can be reduced to ½ the specified capacitance if a full-wave bridge rectifier circuit is used on the input.

The 1.5 mH buck output inductor is available in several surface mount configurations from multiple vendors.

Schematic

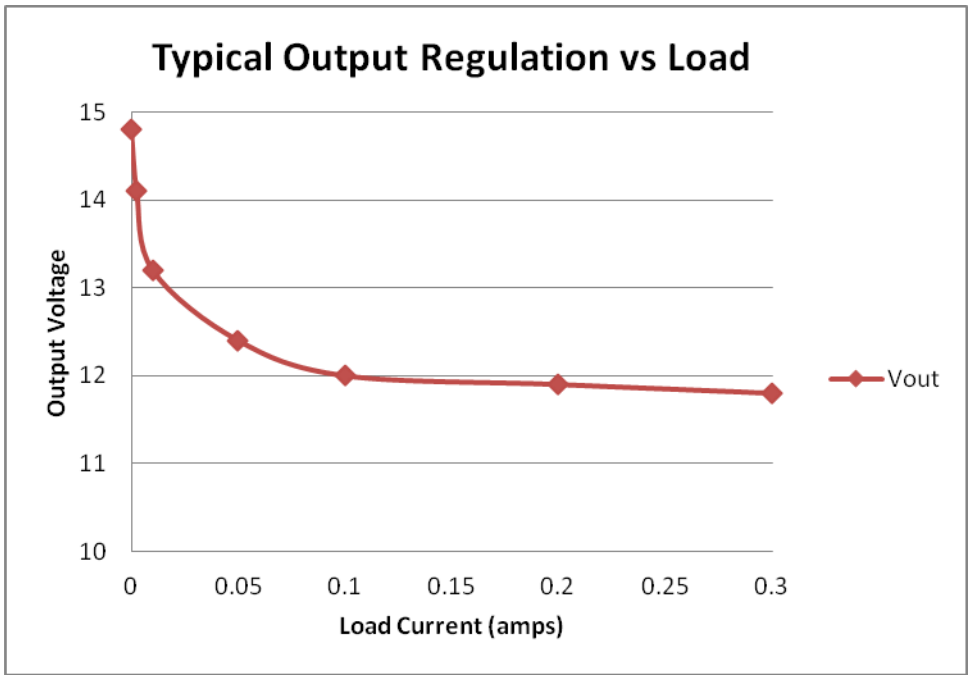


Notes:

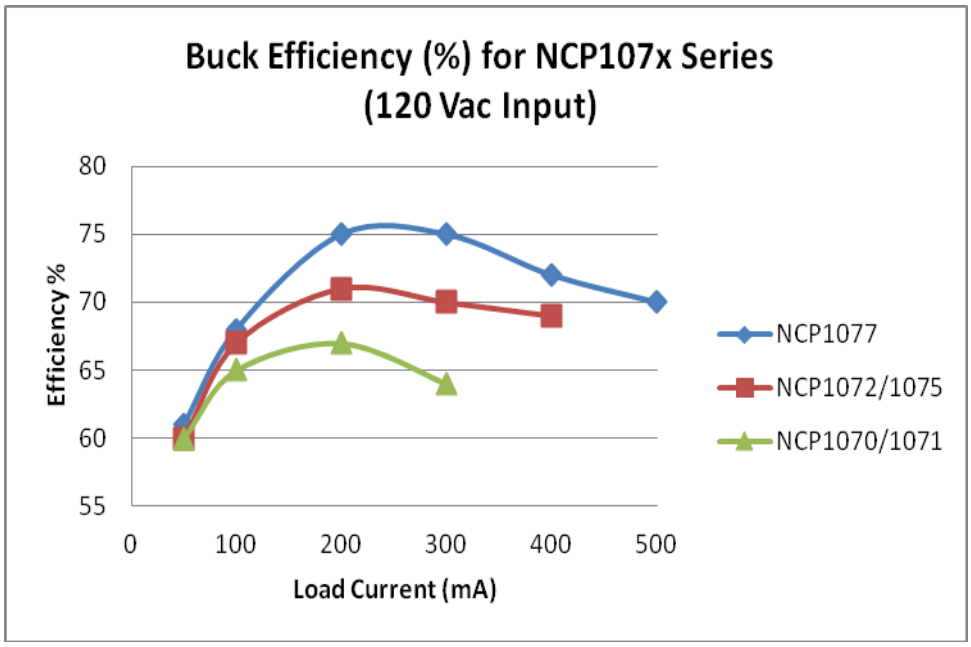
1. Vout set by Z1 (Vout = Vz + 0.5V approx - adjust with R5).
2. L1 is Wurth 744732102.
3. Z2 is optional output OVP zener (15V).
4. R1 sets Vcc max current to avoid OVP trip.
5. L2 is Wurth 7687709152 (1.5 mH, 500 mA)
6. Crossed schematic lines are not connected.

Off-Line Buck Converter Using NCP1070
With Charge Pump Voltage Sensing (R4)

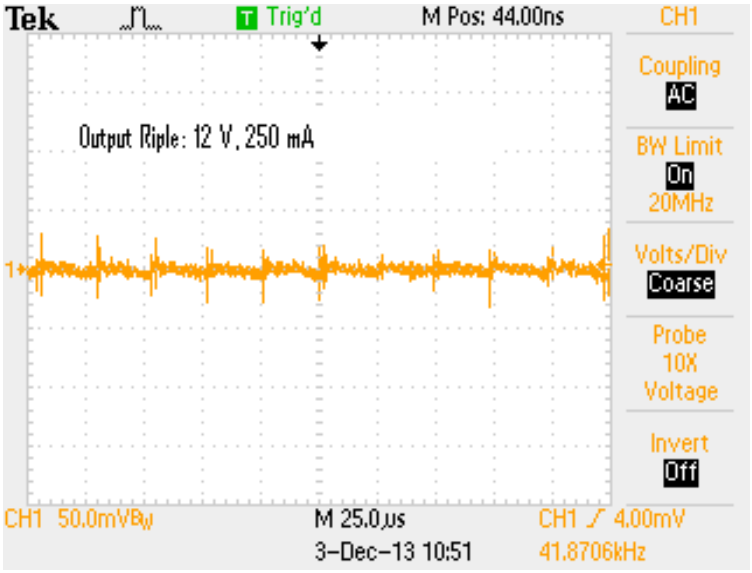
Output Regulation



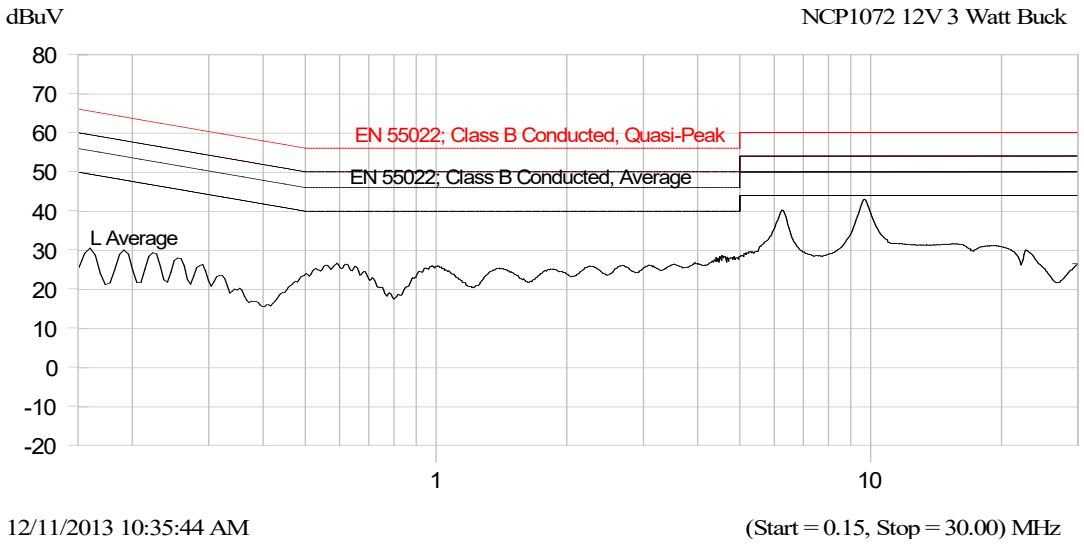
Typical Efficiency vs Load at 120 Vac Input for NCP107x Series



Output Ripple – 250 mA Load, 120 Vac Input



Conducted EMI Profile (12Vout @ 250 mA)



NCP107x Buck Converter Maximum Output Current Matrix

Part	Continuous Limit	Peak Transient Limit
NCP1070	100 mA	1500 mA
NCP1071	150 mA	200 mA
NCP1072	150 mA	200 mA
NCP1075	250 mA	300 mA
NCP1076	300 mA	350 mA
NCP1077	400 mA	500 mA

References:

ON Semiconductor Application Notes: AND8318, AND8328
ON Semiconductor Design Notes: DN05014, DN05023, DN5053, DN06011, DN06052
ON Semiconductor NCP1070, NCP1075 and NCP1077 monolithic switcher data sheets.

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

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Designator	Qty	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number
D3, D4	2	Ultra−fast rectifier	1 A, 600 V		SMA	ON SEMI	MURA160
D1	1	Diode − 60 Hz	1 A, 800 V		SMA	ON SEMI	MRA4007
D2	1	Signal Diode	100 mA, 100 V		SOD−123	ON SEMI	MMSD4148A
Z1	1	Zener Diode	12 V		SOD−123	ON SEMI	MMSZ5242B
Z2	1	Zener Diode	15 V/5 W		Axial lead	ON SEMI	1N5352B or 1N5929B
U1	1	Controller − NCP1070/1072	100 kHz		SOT223	ON SEMI	NCP1070−100
Q1	1	NPN transistor	60 V, 500 mA		SOT23	ON SEMI	MMBTA06T1G/ MMBT2222A
C1	1	“X” cap, box type	100 nF, X2		LS = 10 mm	Rifa, Wima, Wurth Elektronik	890324023023CS
C7	1	Ceramic cap, monolythic	10 nF, 50 V	10%	805	AVX, Murata	TBD
C4, C6	2	Ceramic cap, monolythic	100 nF, 50 V	10%	805	AVX, Murata	TBD
C2	1	Electrolytic cap	10 uF, 400 or 450 V	10%	LS = 5 mm, 12 mm x 15.5 mm	UCC, Wurth Elektronik	860241478003
C5, C8	2	Electrolytic cap	22 uF, 50 Vdc	10%	LS = 2.5 mm, D = 5 mm	Panasonic − ECG, Wurth Elektronik	860080672001
C3	1	Electrolytic cap	470 uF, 25 V	10%	7.5 mm x 15 mm, LS = 3.5 mm	UCC, Panasonic, Wurth Elektronik	860020374012
R2	1	Resistor, ⅛ W SMD	4.7 ohms	5%	SMD 805	AVX, Vishay, Dale	TBD
R3	1	Resistor, ⅛ W SMD	470 ohms	5%	SMD 805	AVX, Vishay, Dale	TBD
R4	1	Resistor, ⅛ W SMD	100 ohms	5%	SMD 805	AVX, Vishay, Dale	TBD
R1, R5	2	Resistor, ⅛ W SMD	2 K	5%	SMD 805	AVX, Vishay, Dale	TBD
L1	1	Inductor (EMI choke)	820 uH or 1 mH		LS = 5 mm, Dia = 7.5 mm	Wurth Magnetics	7447728215
L2	1	Output Inductor	1.5 mH, 500 mA		12 mm x 12 mm SMD	Wurth	7687709152