ON Semiconductor

Design Note – DN05080/D

NCP1060, 12 Vout, 2W Off-line Buck Regulator

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1060	Smart Meters, Electric Meters, White Goods	85 to 265 V	Up to 2 W at 12 Vout	Off-Line 100 kHz Buck	Non-isolated

	Output Specification
Output Voltage	4 to 16 Vdc depending on selected Z1 zener value
Output Ripple	Less than 1%
Typical Current	100 to 150 mA for 12Vout
Max Current	160 mA
Min Current	0 mA

PFC (Yes/No)	No
Efficiency	See plots below
Inrush Limiting / Fuse	External fuse required
Operating Temp. Range	0 to +50°C (dependent on IC1 cooling)
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 power 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 NCP106x series of monolithic switchers. In this reference design, the NCP1060 is utilized with a 60 kHz switching frequency and a maximum output current of 150 mA.

This buck circuit utilizes a simple charge pump or "bootstrap" type of voltage sensing and regulation scheme composed of D2, C1. This simple sensing technique eliminates the use of an optocoupler in the feedback loop. Thanks an on chip voltage reference and error amplifier no external active components are necessary for regulation. Just simple resistor divider composed of R2, R5 and R6 to bring portion of external voltage to FB pin. This helps to achieve load regulation +/-5% over the loads 100% down to 1% of maximum rated load. Below 1% the output voltage will rise to the value of the overvoltage clamping zener diode D4 across the output. For a 12 V output a typical value for zener diode will be 15 V and at no load the output will be clamped at this level.

The sensed voltage produced on C5 is also used to power the NCP106x controller through D1 once 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.

Although this is low power output converter, full bridge rectifier is used, to lower input peak current. C4, L2 and C5 form a conducted EMI filter.

The 1.2 mH buck output inductor is available in several surface mount or through hole configurations from multiple vendor. This inductor should be designed to handle high voltage.

Schematic

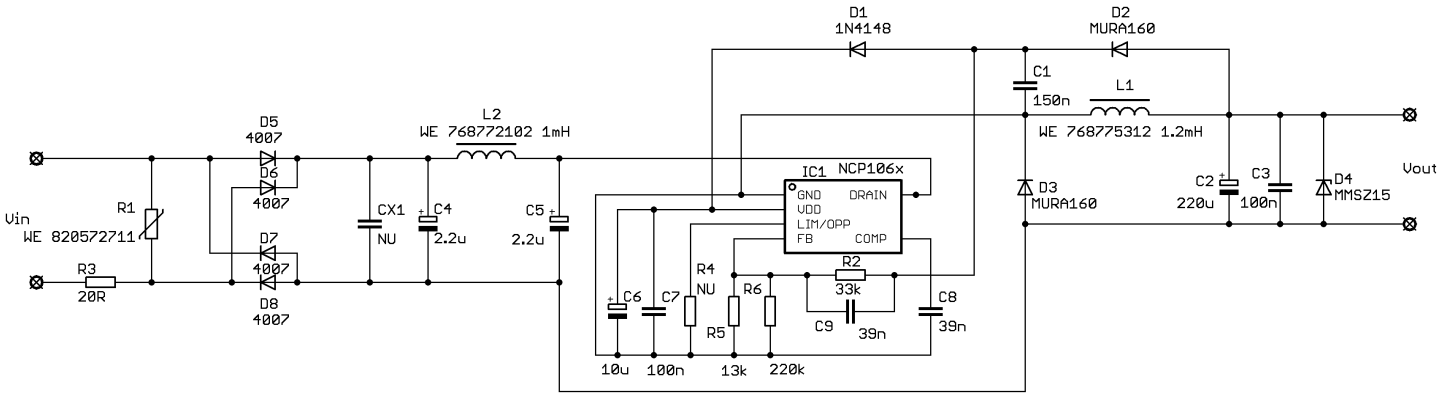

Figure 1 – Buck converter schematic

Output Regulation

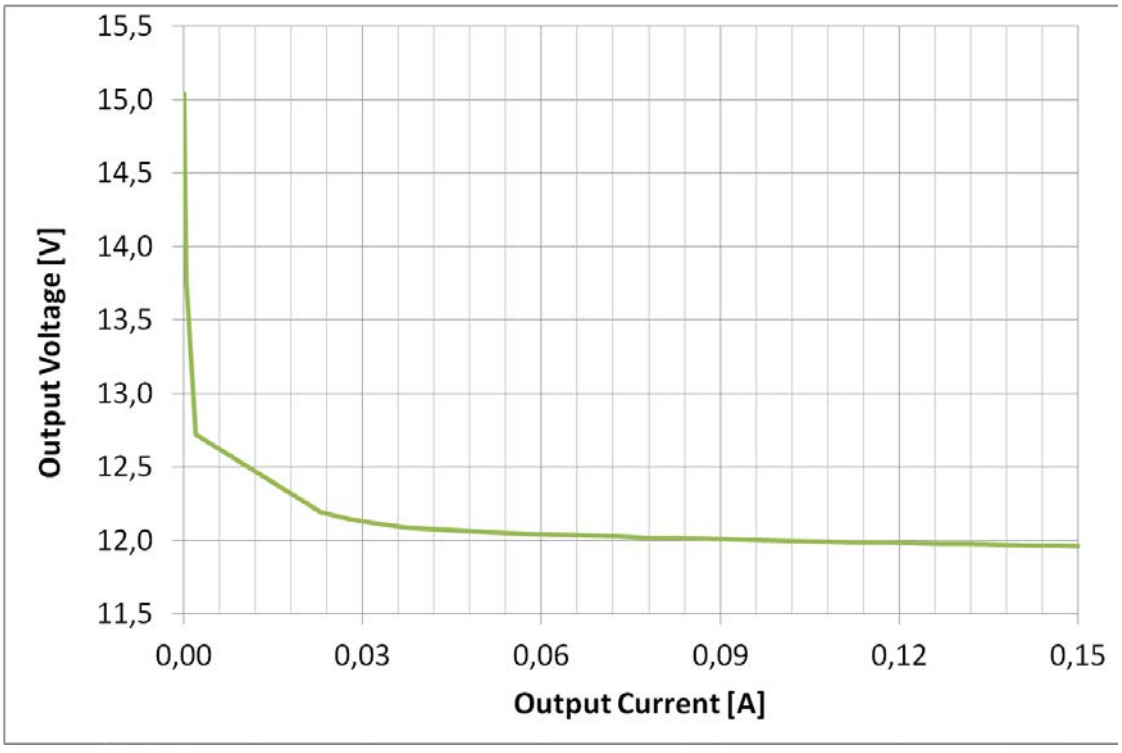

Figure 2 – Output voltage dependency on output current

Typical Efficiency versus Load for 110 V and 230 V

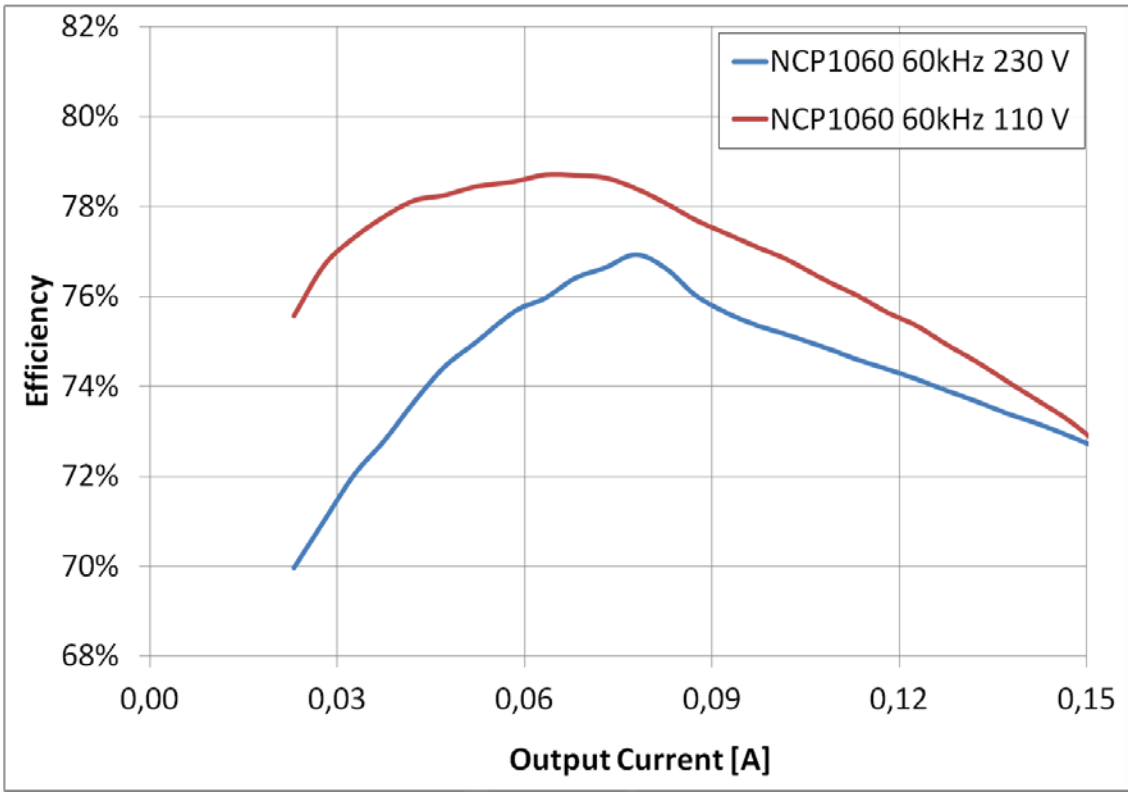

Figure 3 – Efficiency of the Buck Converter

Output Ripple – 150 mA load, 230 Vac Input

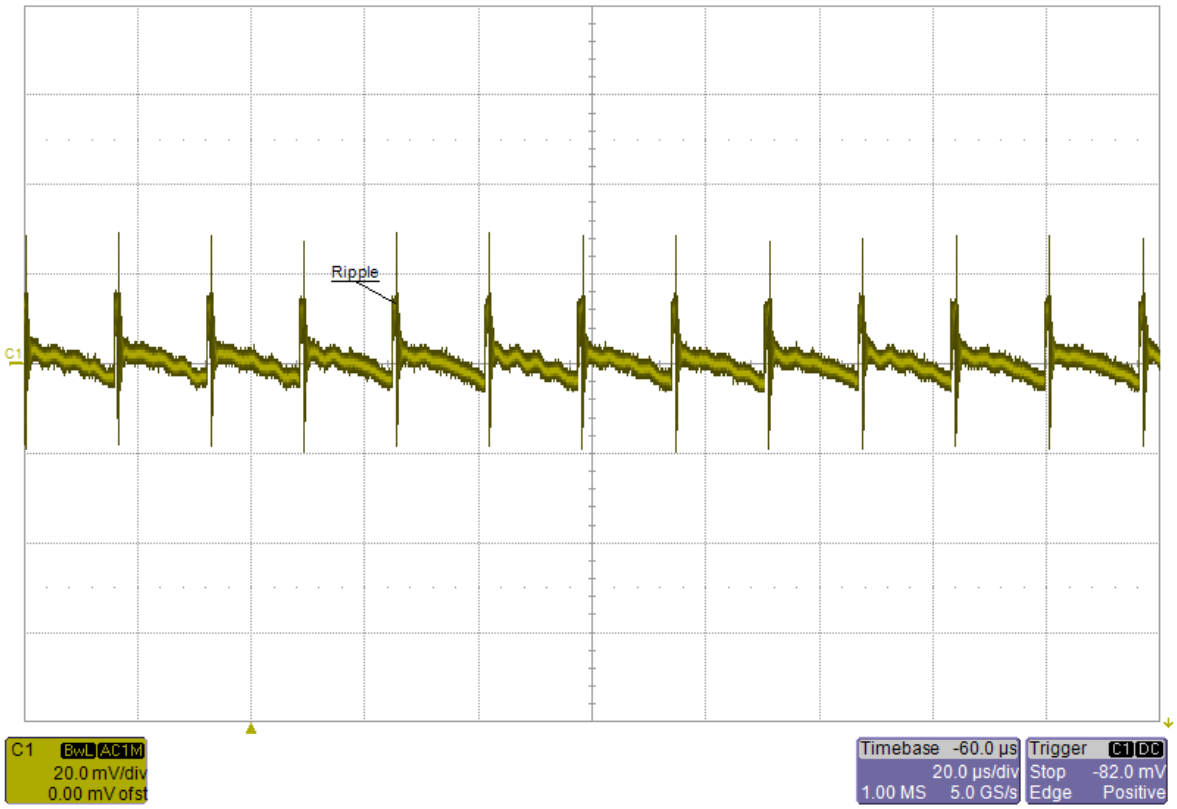

Figure 4 – Output Voltage Ripple at Full Load

References:

ON Semiconductor Application Notes: AND8318, AND8328
ON Semiconductor Design Notes: DN05014, DN06011, DN06052, DN05058
ON Semiconductor NCP1060 High-Voltage Switcher for low Power offline SMPS.

PC Board:

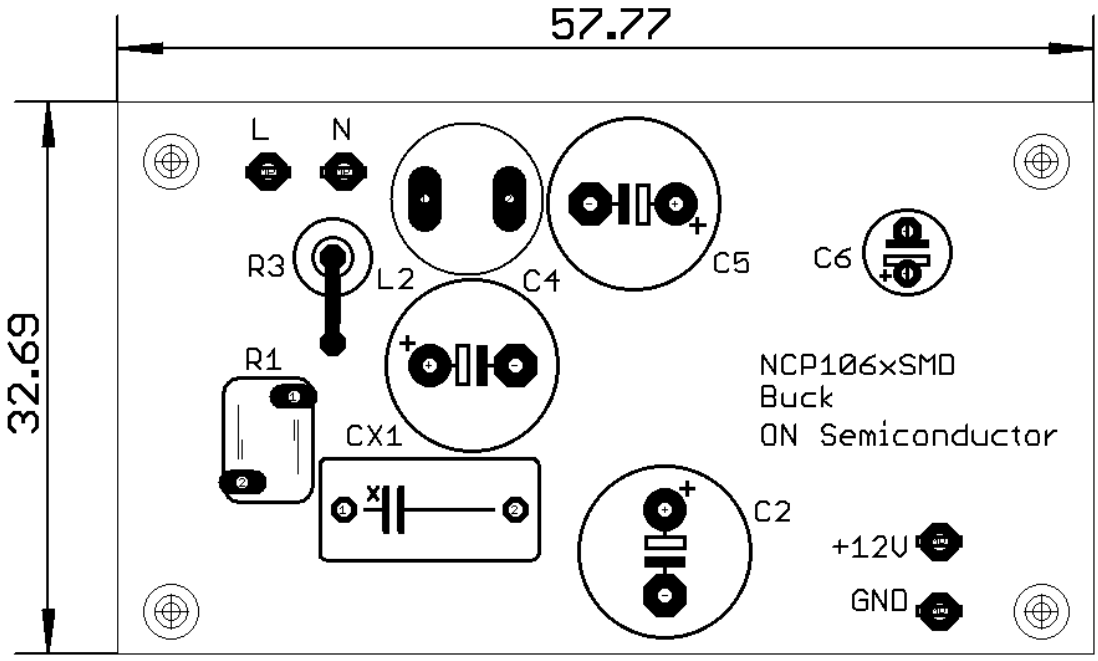

Figure 5 - components position on PCB (top side)

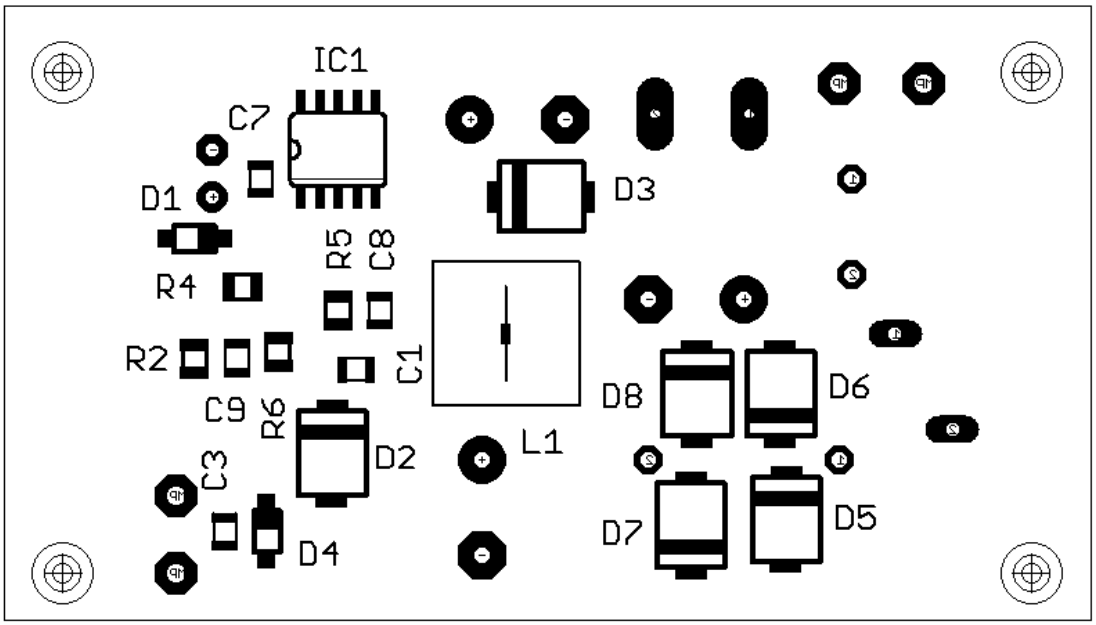

Figure 6 - components position on PCB (bottom side)

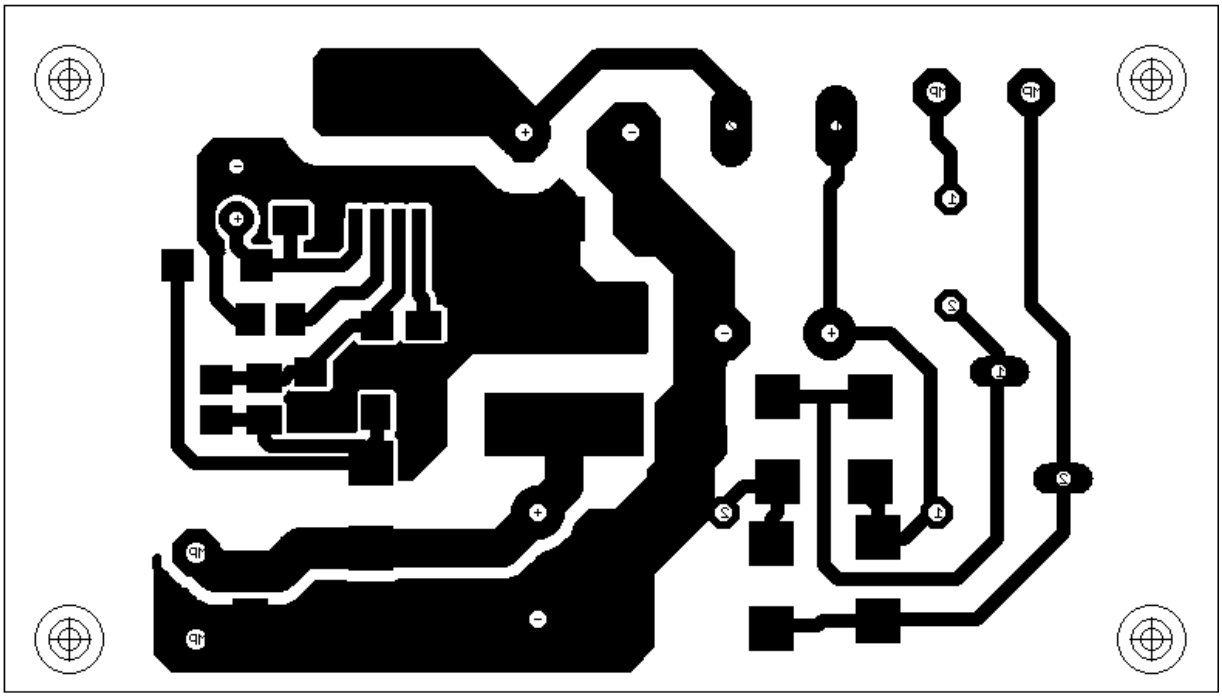

Figure 7 – PCB's bottom side

Table 1– Bill of materials

Designator	Quantity	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number
C1	1	CAPACITOR	150 nF	10%	0805	Kemet	C0805C154K5RACTU
C2	1	ELECTROLYTIC CAPACITOR	220 µF / 35 V	20%	THROUGH HOLE	Koshin	KZH-35V221MG4
C3, C7	2	CAPACITOR	100 nF	10%	0805	Kemet	C0805C104K5RACTU
C4, C5	2	ELECTROLYTIC CAPACITOR	2.2 uF / 450 V	20%	THROUGH HOLE	United Chemi-Con	EKMG451ELL2R2MJC5S
C6	1	ELECTROLYTIC CAPACITOR	10 µF / 25 V	20%	THROUGH HOLE	Koshin	KLH025V100ME3
C8, C9	2	CAPACITOR	39 nF	10%	0805	Kemet	C0805C393K5RACTU
CX1	1	CAPACITOR X2	NU	-	THROUGH HOLE	-	-
D1	1	DIODE	MMSD4148	-	SOD123	ON Semiconductor	MMSD4148T1G
D2, D3	2	DIODE	MURA160	-	SMA	ON Semiconductor	MURA160T3G
D4	1	ZENER DIODE	MMSZ15	5%	SOD123	ON Semiconductor	MMSZ15T1G
D5, D6, D7, D8	4	DIODE	MRA4007	-	SMA	ON Semiconductor	MRA4007T3G
IC1	1	SWITCHER	NCP1060	-	SOIC10	ON Semiconductor	NCP1060AD060R2G
L1	1	INDUCTOR	1.2 mH	10%	SMD/SMT	Würth Elektronik	768775312
L2	1	INDUCTOR	1.0 mH	10%	THROUGH HOLE	Würth Elektronik	768772102
(L,N,+12V,GND)	4	TERMINAL PIN	1.0 mm	-	THROUGH HOLE	Ettinger	13.14.119
R1	1	VARISTOR	820572711	-	THROUGH HOLE	Würth Elektronik	820572711
R2	1	RESISTOR	33 kΩ	1%	0805	Rohm Semiconductor	MCR10ERTF3302
R3	1	RESISTOR	20 Ω	5%	0613	VIshay BC Components	AC03000002009JAC00
R4	1	RESISTOR	NU	-	0805	-	-
R5	1	RESISTOR	13 kΩ	1%	0805	Rohm Semiconductor	MCR10ERTF1302
R6	1	RESISTOR	220 kΩ	1%	0805	Rohm Semiconductor	MCR10ERTF2203

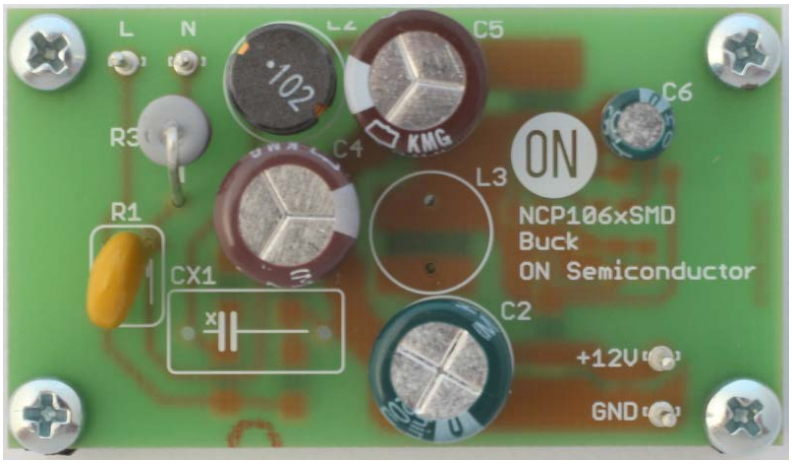

Figure 8 – PCB's top side

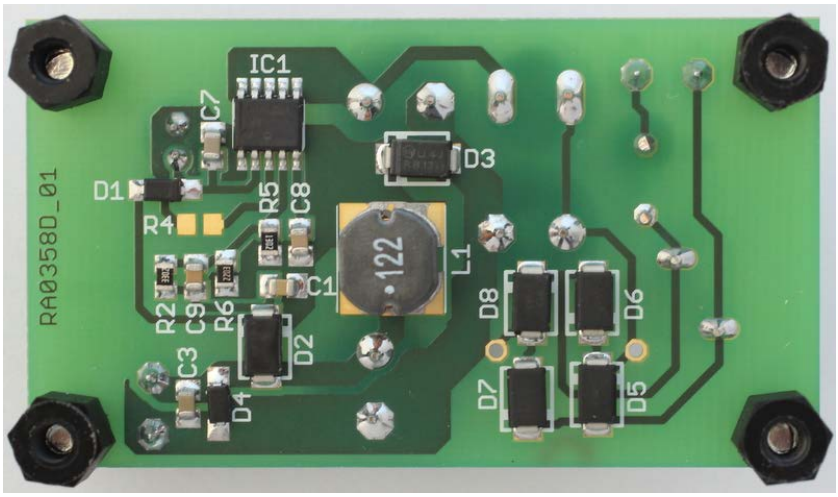

Figure 9 – PCB's bottom side

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