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 C1 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

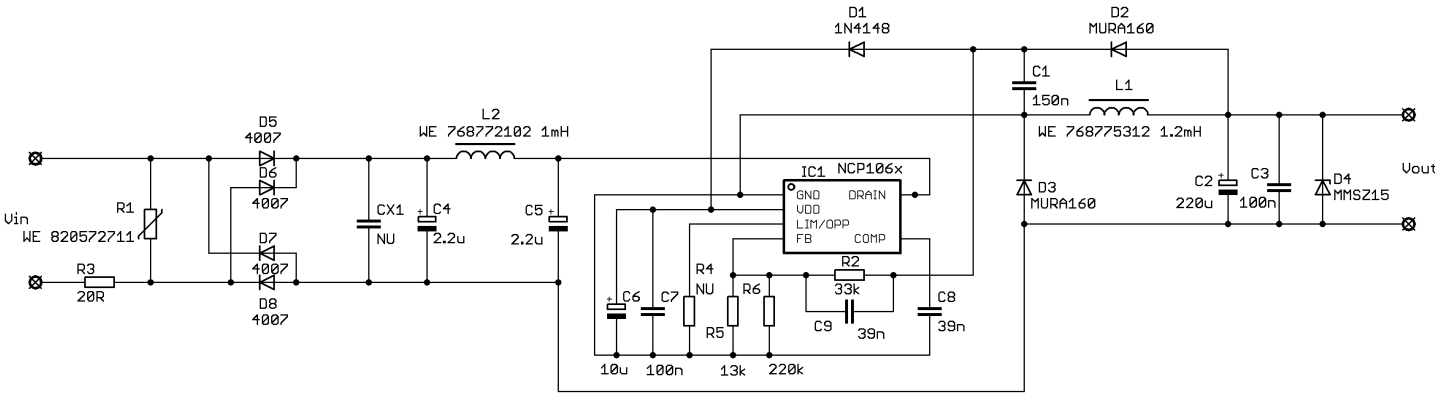


**Figure 1 – Buck converter schematic**

## Output Regulation

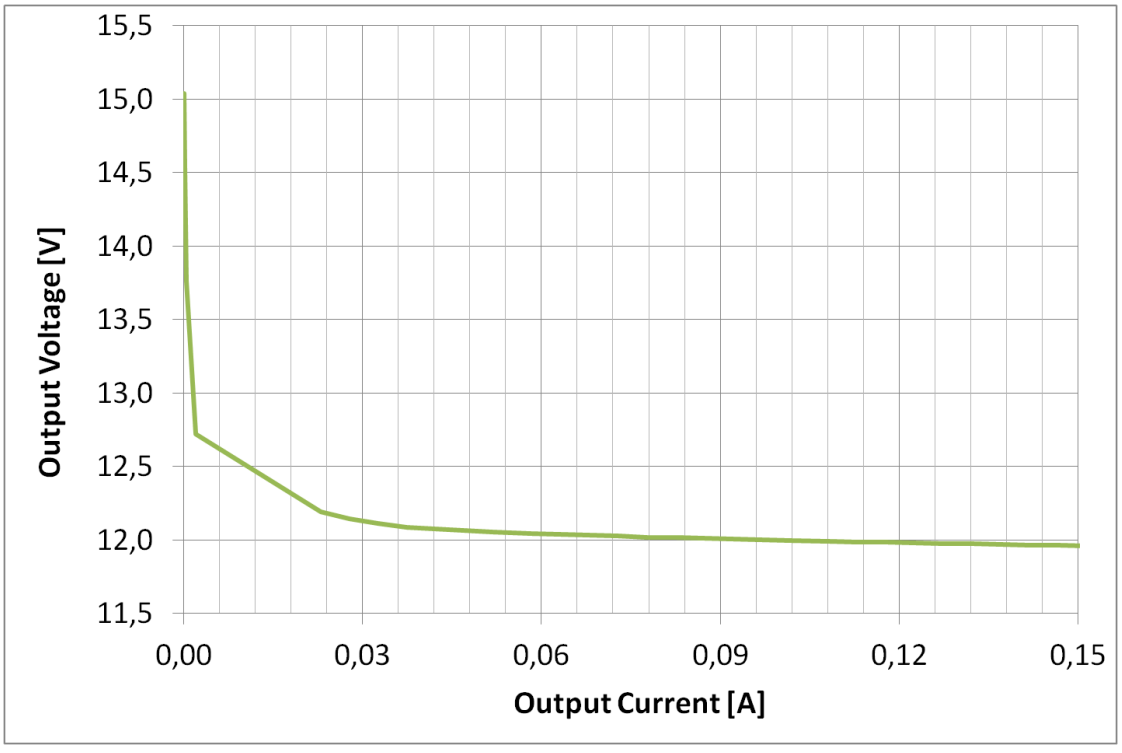


**Figure 2 – Output voltage dependency on output current**

## Typical Efficiency versus Load for 110 V and 230 V

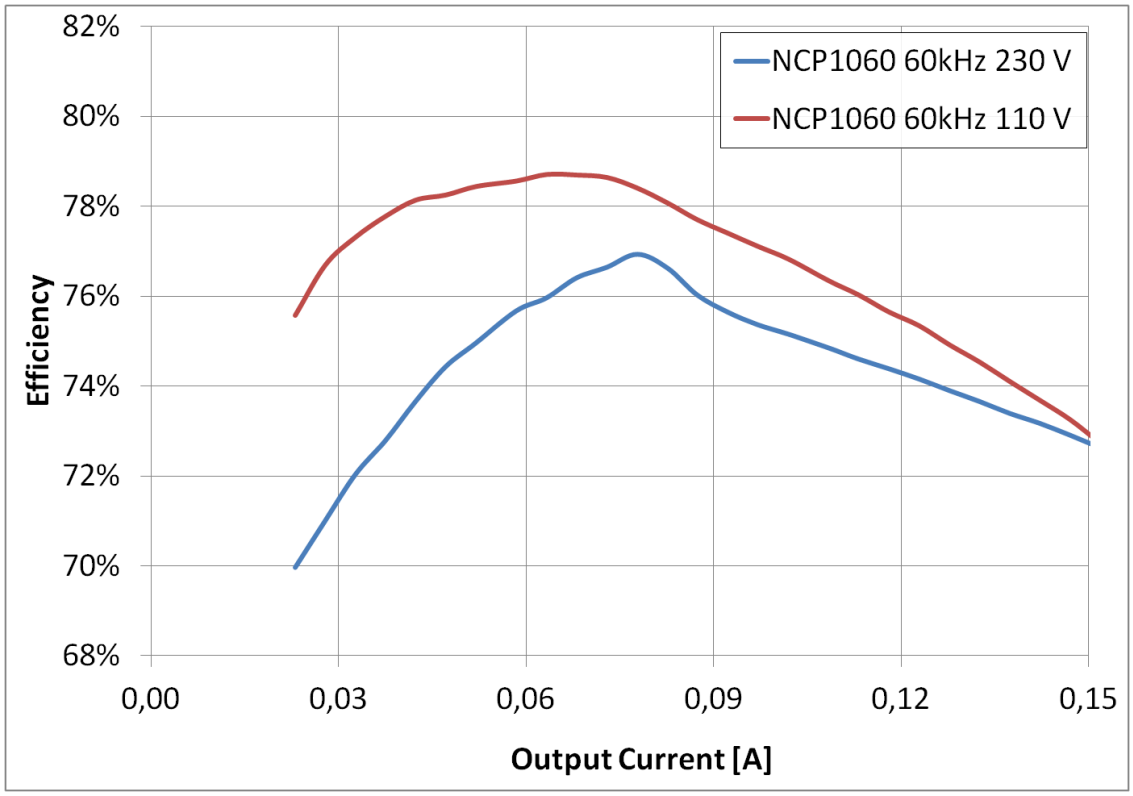


**Figure 3 – Efficiency of the Buck Converter**

## Output Ripple – 150 mA load, 230 Vac Input

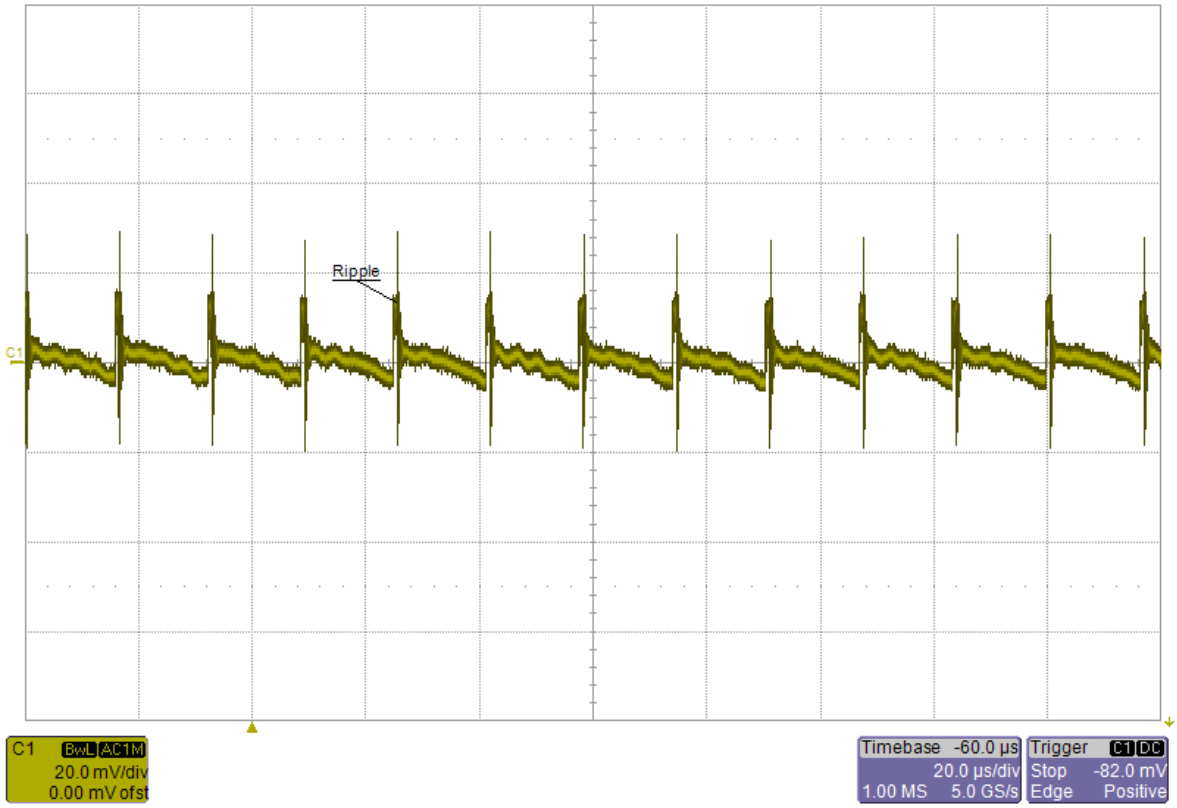


**Figure 4 – Output Voltage Ripple at Full Load**

## 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:

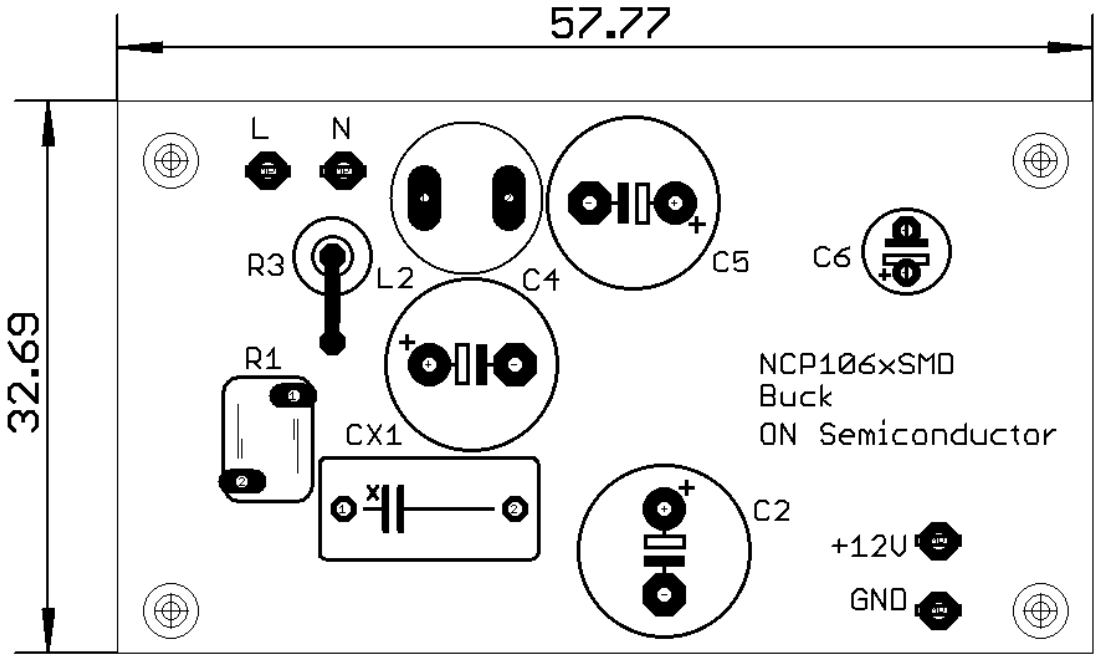


**Figure 5 - components position on PCB (top side)**

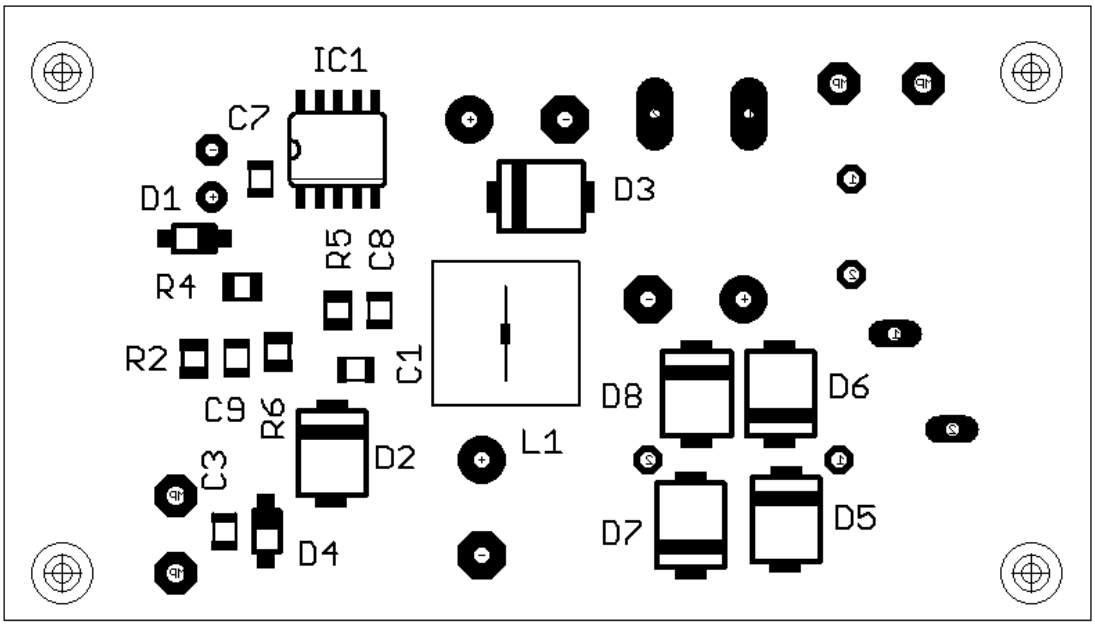


**Figure 6 - components position on PCB (bottom side)**

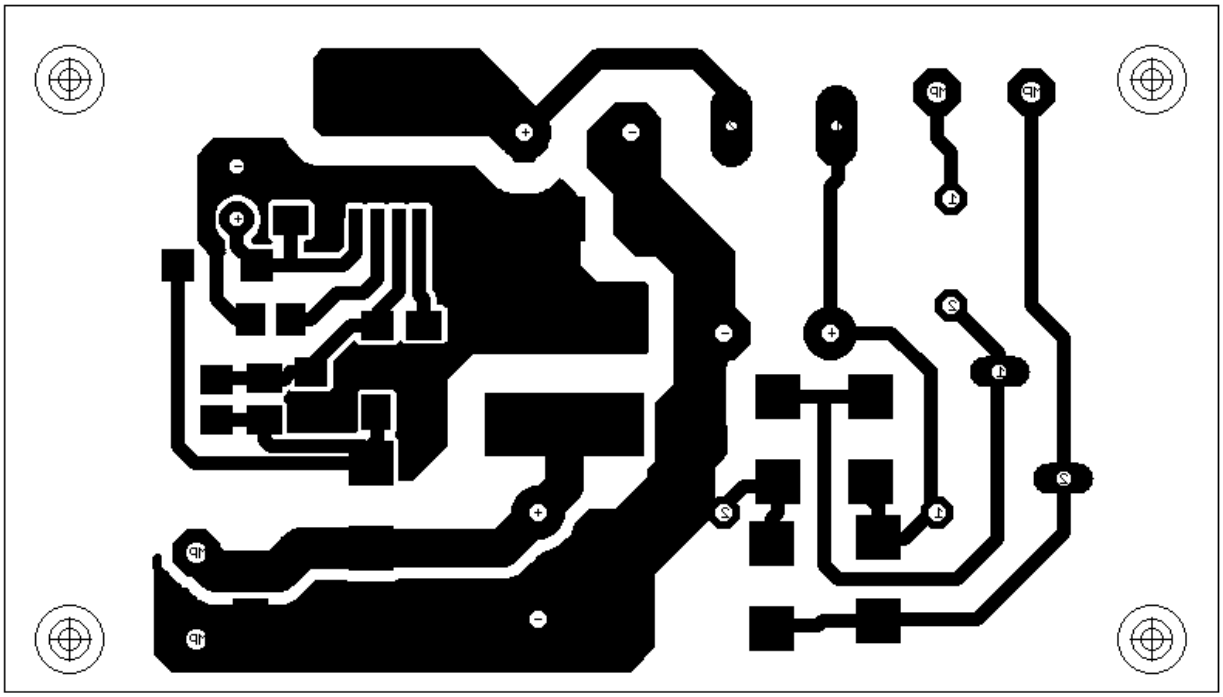

**Figure 7 – PCB's bottom side**

## 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 | Vlshay 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 |

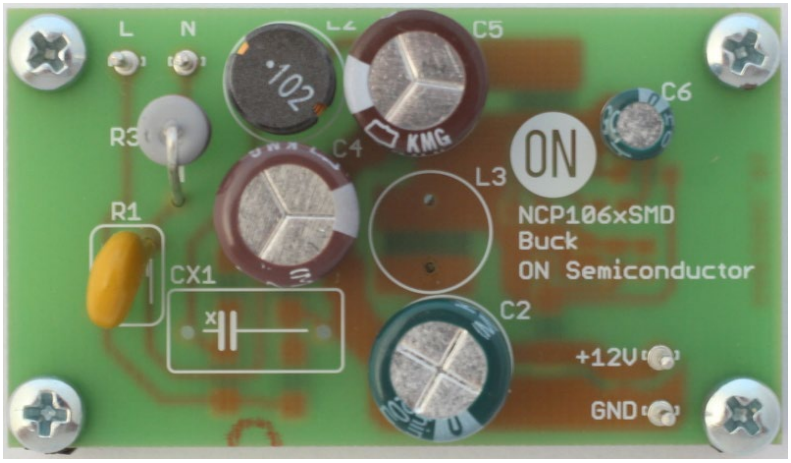


**Figure 8 –** PCB's top side

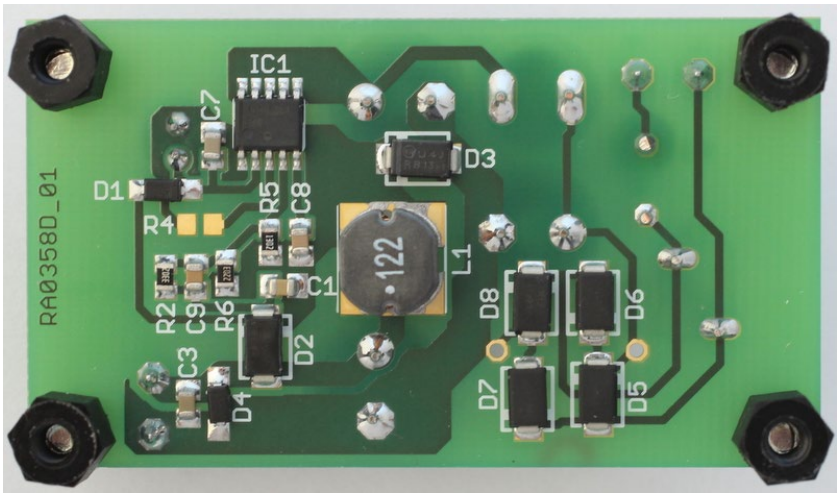


**Figure 9 –** PCB's bottom side



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