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DN06066/D

Low Power, Off-Line, Constant Voltage Power Supply

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DESIGN NOTE

Table 1. DEVICE DETAILS

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1014	Smart Meters, Electric Meters	85 to 265 Vac	Up to 10 W	Off-Line Buck	Non-Isolated

Characteristic	Output Specification
Output Voltage	10 to 28 Vdc Depending on Selected Z1 Zener Value
Ripple	Dependent on L2 Inductance and C6 ESR, Typically 1% Max
Nominal Current	50 to 325 mA Typical
Max Current	350 mA Maximum
Min Current	Zero

PFC (Yes/No)	No, (P_{OUT} < 25 W)
Minimum Efficiency	75% (Dependent on V_{OUT} and I_{OUT} Combination)
Inrush Limiting/Fuse	Inrush Resistor (R1)
Operating Temp. Range	0 to +60°C (Dependent on U1 Heatsinking)
Cooling Method/Supply Orientation	Convection
Signal Level Control	None

Circuit Description

This design note describes a simple, low power (10 W or less), constant voltage power supply intended for powering electronics for white goods, electrical meters, industrial equipment or lighting applications where isolation from the AC mains is not required. The output voltage can be set from 10 to approximately 28 V by using the appropriate zener diode for Z1. Output voltage sensing is accomplished by utilizing a level shifting ("bootstrap") circuit comprised of D7, C8, Z1, Q2 and the associated resistors. In applications where the output negative terminal must be common with the input bulk capacitor negative, voltage sensing of the output directly is not possible. This is because the ground node of the controller is switched between the peak input dc voltage and the common line. In order to sense the voltage without an optocoupler in the feedback path, the level shifting "bootstrap" circuit acts as a sample and hold network which stores a sample of the output voltage on C8 (through D7) when the MOSFET in U1 is in the off state. During the on-time, U1's ground reference is shifted up to the input voltage level of choke L2, and sense diode D7 is back biased. When the voltage on C8 exceeds Z1's breakdown level and the B-E drop on Q2, then the feedback pin of U1 (pin 2) is pulled down to achieve regulation. It should be noted that this type of level shifted voltage sensing is not compatible with the tapped inductor type of buck.

Due to the additive magnetizing component of L2, the true load current should be limited to about 350 mA maximum to avoid over-current limiting in U1. An inductance smaller than approximately 2.5 mH for L2 will probably lower the effective usable output current, so a minimum inductance value of 2.5 mH is recommended to keep the choke's magnetizing current low. Commercially available chokes should be rated for an output current of 0.5 A to assure best efficiency. For lower currents and/or output voltages, some compromises can be made on the maximum inductance value; however, lower values could also impact the output ripple if output capacitor C6 has high ESR.

The output power will also be thermally limited, so for power levels above 5 W, the ground tab on U1 (SOT–223 package) should be soldered to a sufficient area of copper pc board clad to assure that the internal over-temperature circuit is not activated.

Key Features

- Input Filter (Pi-Network) for Conducted EMI Attenuation
- Constant Voltage Output Regulation with Minimal Components and No Optocoupler for Feedback
- NCP1014 Monolithic Current Mode Controller with Internal 700 V MOSFET for Maximum Simplicity
- Circuit Easily Configured for Different Output Voltages
- Inherent Short Circuit and Over-temperature Protection

SCHEMATIC
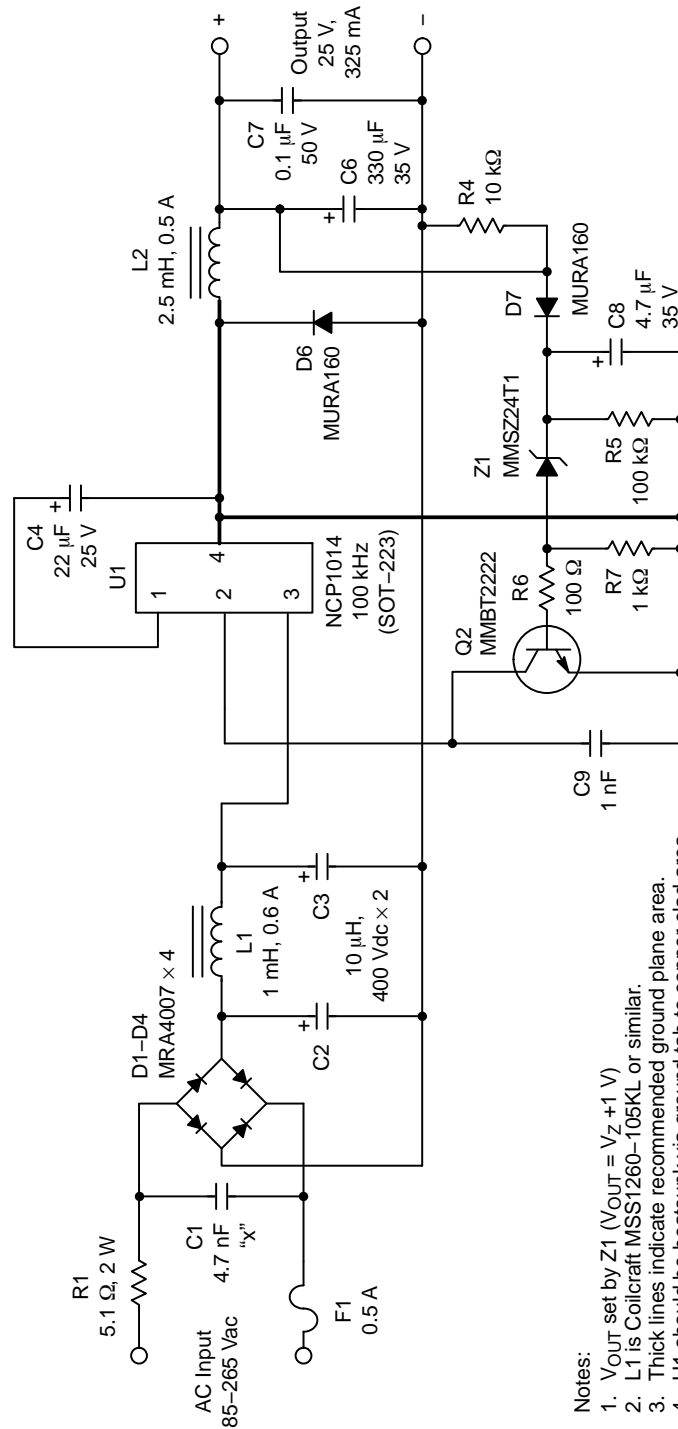
Notes:
1. V_{OUT} set by Z1 ($V_{OUT} = V_Z + 1$ V).
2. L1 is Coilcraft MSS1260–105KL or similar.
3. Thick lines indicate recommended ground plane area.
4. U1 should be heatsunk via ground tab to copper clad area.
5. Crossed schematic lines are not connected.

Figure 1. Circuit Schematic

Output Choke Design

L2 can be constructed by winding 200 turns of #28 magnet wire on the bobbin of an EF−16 (E16/8/5) ferrite core with a cross sectional area (Ae) of 0.2 square centimeters (or similar ferrite core and bobbin), and gaping the core to achieve an inductance of 2.5 mH when measured across the winding. Another, but less efficient option would be to use two "off-the-shelf" Coilcraft RFB1010−122L inductors in series.

References

[1] ON Semiconductor Design Note DN06037/D: Low Power, Off-Line Buck, CVCC Power Supply
[2] Data Sheet NCP1014/D