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Design Note – DN06037/D

Low Power, Off-Line, CVCC Power Supply

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1014	LED Driver, Chargers	90 – 260 Vac	Up to 10W	Off-Line Buck	Non-isolated

Other Specifications

Parameter	Output Specification
Output Voltage	5 to 28 Vdc depending on selected Z1 zener value
Ripple	Dependent on L2 inductance and C6 ESR, typically 1%
Nominal Current	50 to 350 mA typical
Max Current	350 mA, set by R3
Min Current	zero

PFC (Yes/No)	No, Pout < 25 watts
Minimum Efficiency	65% (dependent on Vout and Iout 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

Others	For applications where isolation from AC line is not required.

Circuit Description

This Design Note describes a simple, low power (10 W or less), constant voltage, constant current (CVCC) power supply intended for LED strings, battery chargers or similar applications where the CVCC load characteristic is necessary, and isolation from the AC mains is not required. The output voltage can be set from 5 to approximately 28 volts by using the appropriate zener diode for Z1. Output voltage sensing is accomplished by utilizing a level shifting circuit comprised of D7, C8, Z1, Q2 and the associated resistors. In applications where the output negative 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 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.

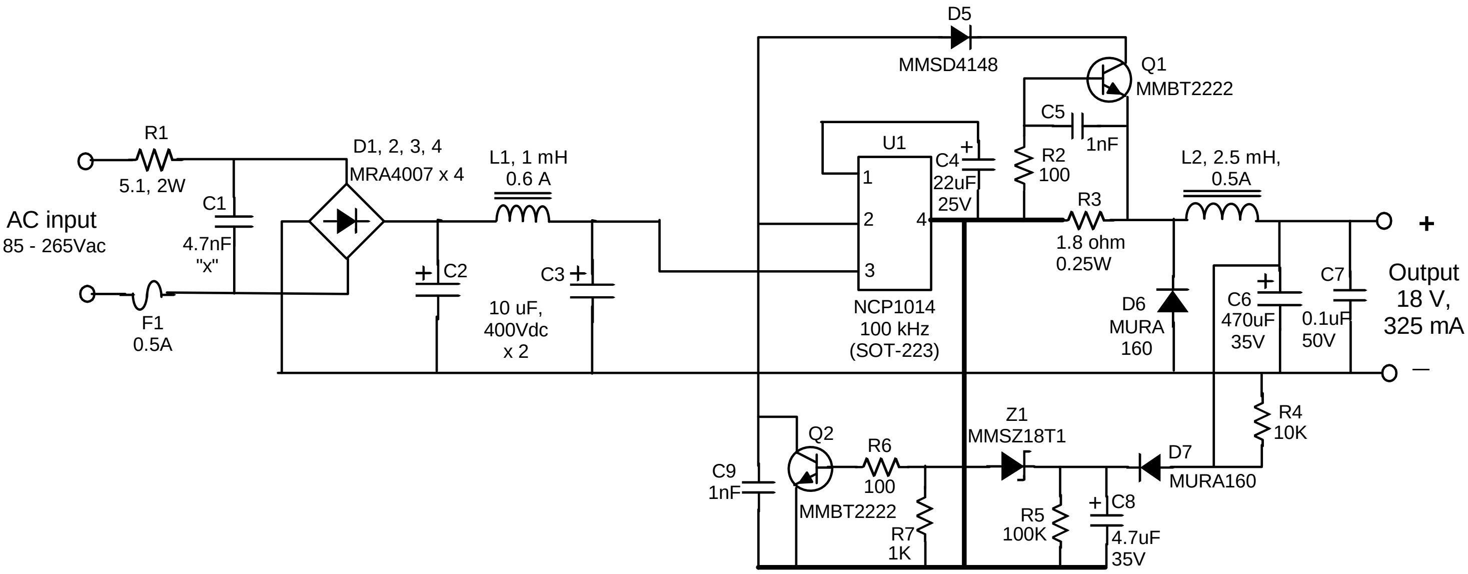
The output current is regulated during the constant current mode by the peak sensing circuit of D5, R3, R2, C5 and Q1. The max current is actually limited by the NCP1014 controller’s internal circuitry to about 450 mA, but is controlled externally by this circuit and the value of R3 by detecting the peak inductor current which is a good representation of the dc output current. Due to the additive magnetizing component of L2, the true load current should be limited to about 350 mA maximum for reliable constant current operation. A lower inductance 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. 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 schematic, V/I plot, and switching waveform are for an 18 volt, 325 mA prototype.

The output power will also be thermally limited, so for power levels above 5 watts, the ground tab on U1 (SOT223 package) should be soldered to a sufficient spread 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 current, constant voltage output regulation with minimal components and no optocoupler for feedback.
- NCP1014 monolithic current mode controller with internal 700V Mosfet for maximum simplicity (see data sheet at www.onsemi.com.
- Circuit easily configured for different output voltage and current requirements.
- Inherent short circuit and over-temperature protection.
- No optocoupler required for voltage sensing.

Schematic

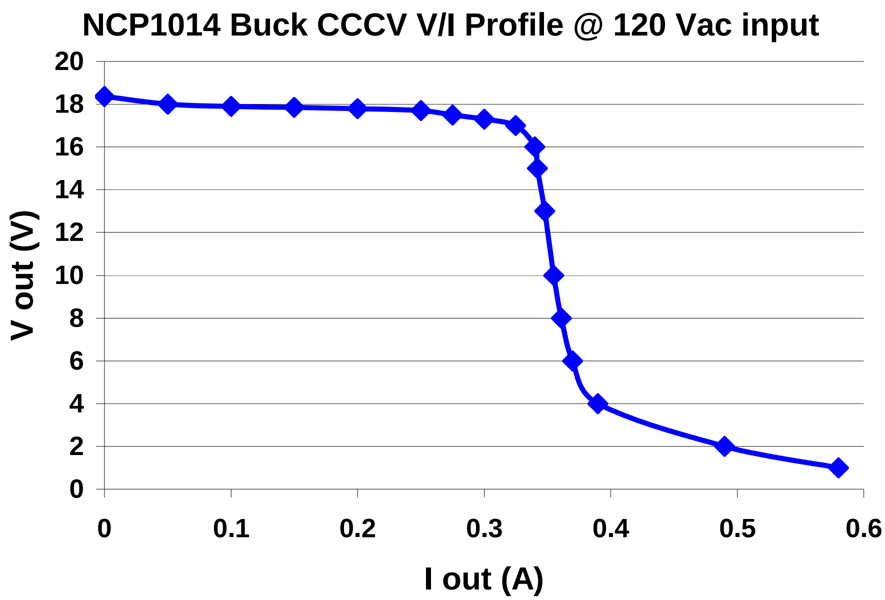


Notes:

1. Vout set by Z1 (Vout = Vz)
2. I out set by R3 (Iout = 0.65/R3); Imax = 350 mA
3. L1 is Coilcraft MSS1260-105KL or similar.
4. Thick lines indicate recommended ground plane area
5. U1 should be heatsunk via ground tab to copper clad area
6. Crossed schematic lines are not connected

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 gapping the core to achieve an inductance of 2.5 mH when measured across the winding.

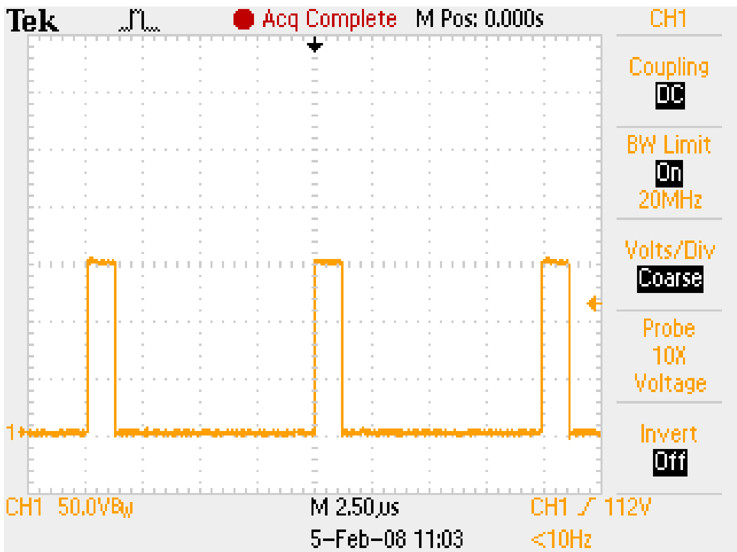


Note the "current tail" below 5 volts output due to the very short pulse width and the subsequent propagation delay effects in the controller. This sets a lower useful output level to the supply when in the CVCC mode to about 5 volts.

Efficiency:

18 volts, 275 mA output (CV mode): 77%
17 volts, 325 mA output (CVCC knee): 76%
14 volts 375 mA output (CC mode): 74%

Input Voltage to Choke (Cathode of D6) During Operation at CVCC Knee (120 Vac input):



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