

DESIGN NOTES

No Design Offline Power Supply – Design Note 62

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Offline Switcher Eliminates Optocoupler Feedback. Low Cost, Simple, 50W, Universal Input Power Supply.

Linear Technology has broken through the “buy-vs-build” barrier for offline power supplies. The new LT11051 current-mode PWM control IC is used to make a simple, triple output power supply (Figure 1). The circuit features low cost, high reliability and customizable footprint. It accepts a universal input of 85VAC-270VAC while providing isolated and regulated output voltages of 5V at 5A, 12V at 1.5A and –12V at 0.5A. MTBF is calculated at >100k hours for full load at 25°C ambient. The power supply contains all necessary components including an input EMI filter. All outputs have continuous short-circuit protection. Figure 2 indicates 5V load regulation performance as a function of input line voltage.

The LT1105 eliminates optocoupler feedback by regulating the flyback voltage of the bootstrap bias winding. This reduces the number of components crossing the isolation barrier to one: the transformer. The transformer is designed to meet international safety standards and is subject to a set of compromises involving efficiency, maximum power output, size, coupling, leakage inductance, interwinding capacitance and ultimately cost. A unique sampling error amplifier incorporated into the LT1105 allows operation in spite of the resultant transformer limitations. The error amplifier provides a feedback term allowing load regulation performance to be set with one external resistor. Thus, $\pm 1\%$ line and load regulation performance is achievable for single output voltage power supplies operating in either continuous or discontinuous mode².

LTC has simplified the magnetics design task by creating a series of off-the-shelf transformers for a variety of applications. New transformer design continues as an area of development. Transformers in power levels of 50W and 100W are presently available and meet international safety standards UL1950 and IEC950. Completed transformers are available from Coiltronics at 305-781-8900.

The LT1105's totem-pole output drives the gate of external high-voltage FET switch Q1. R10 controls switching transition speed. Transition speed is a trade-off between minimizing switch dV/dt common mode current contributions vs minimizing switching losses. FET conduction losses are set by the values of switch “on” resistance and primary current. The FET voltage rating must exceed the sum of the maximum rectified DC input voltage plus the leakage inductance spike. Finally, the external FET is protected from insufficient or excessive gate drive voltage with a drive protection circuit built into the LT1105.

Short-circuit protection is provided by bootstrap operation of the LT1105. Shorting an output results in switch duty cycle “on” time being limited to 500ns. The transformer cannot store sufficient energy to maintain a regulated bias winding voltage. The LT1105 senses this condition and shuts down the power supply. The power supply then returns to start-up mode. Trickle resistor R11 charges input bypass capacitor C8 to the LT1105 start threshold voltage. If the output remains shorted, the LT1105 starts and stops again. This “burp” mode protects the power supply from overload or indicates an incomplete power loop. Sense resistor R22 sets the maximum switch current available. To guarantee “burp” mode operation under fault conditions, C8 must be prevented from peak-detecting the large leakage inductance spike during maximum switch current cycles. Otherwise, the bootstrapped supply voltage would increase under a fault condition thereby leading to catastrophic failure. Resistor R3 along with C8 forms an R-C filter which prevents the diode D2/C8 combination from peak detection. This ensures well defined start cycles.

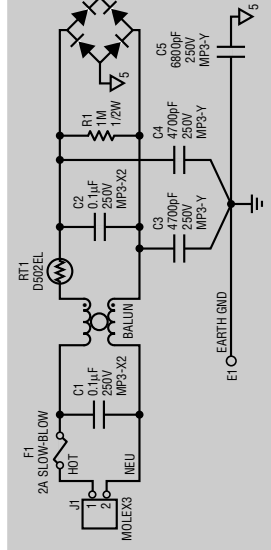
1. Data Sheet, LT1103/LT1105 Offline Switching Regulator, Linear Technology Corporation, Milpitas, CA., March 1992
2. Bonte, A. and Vinsant R., “Offline Switching Regulators Achieve $\pm 1\%$ Regulation in a Flux-Sensed Converter”, Seventh Annual Applied Power Electronics Conference, IEEE-7803-0485-392, p 513-516, 1992

WARNING!

DANGEROUS AND LETHAL POTENTIALS ARE PRESENT IN OFFLINE CIRCUITS!

BEFORE PROCEEDING ANY FURTHER, THE READER IS WARNED THAT CAUTION MUST BE USED IN THE CONSTRUCTION, TESTING AND USE OF OFFLINE CIRCUITS. HIGH VOLTAGE, AC LINE-CONNECTED POTENTIALS ARE PRESENT IN THESE CIRCUITS. EXTREME CAUTION MUST BE USED IN WORKING WITH AND MAKING CONNECTIONS TO THESE CIRCUITS. REPEAT: OFFLINE CIRCUITS CONTAIN DANGEROUS, AC LINE-CONNECTED HIGH VOLTAGE POTENTIALS. USE CAUTION.

ALL TESTING PERFORMED ON AN OFFLINE CIRCUIT MUST BE DONE WITH AN ISOLATION TRANSFORMER CONNECTED BETWEEN THE OFFLINE CIRCUIT'S INPUT AND THE AC LINE. USERS AND CONSTRUCTORS OF OFFLINE CIRCUITS MUST OBSERVE THIS PRECAUTION WHEN CONNECTING TEST EQUIPMENT TO THE CIRCUIT TO AVOID ELECTRIC SHOCK. REPEAT: AN ISOLATION TRANSFORMER MUST BE CONNECTED BETWEEN THE CIRCUIT INPUT AND THE AC LINE IF ANY TEST EQUIPMENT IS TO BE CONNECTED.



- PARTS LIST:**
 C1, C2 = WIMA MP3-X2; METALLIZED PAPER
 C3, C4, C5, C6 = WIMA MP3-Y; METALLIZED PAPER
 C7 = IMEG; 0.5W; CARBON COMPOSITION
 R1 = MIDWEST COMPONENTS NTC THERMISTOR 0502EL
 BALUN = COILTRONICS 121-2-01103
 BR1 = GENERAL INSTRUMENTS GBU4K
 C7 = SPRAGUE 82D221M68K5C2D
 C8 = PANASONIC ECA1VF6890
 C9, C11 = WIMA RKC 2, 250Vdc, OR 100Vdc, POLYCARBONATE FILM
 C10, C13, C14, C15 = WIMA MKS 2, 63Vdc; METALLIZED POLYESTER
 R11 = FOUR 51k, 1/4W IN SERIES
 R16 = BOURNS 3266W-1-202
 R22 = R.G. ALLEN MICRON MGP70
 HS1, HS2 = THERMALLOY HEATSINK 7020U-MT
 O1 = PHILIPS BU426-800A (FULLY INSULATED F-PAK)
 D2, D3 = PHILIPS BAV21
 D7 = GENERAL INSTRUMENT 1.5KE300A
 MUR410, MBR1645, MUR1100E = MOTOROLA
 C17, C18, C19, C20, C21 = UNITED CHEMICON LX39(B)10212.5X30LL
 C25, C26, C27 = WIMA RKP 2, 100Vdc; POLYPROPYLENE FILM

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Figure 1. LT1105 Fully Isolated, Offline Flyback, 100kHz, 50W Converter with Load Regulation Compensation

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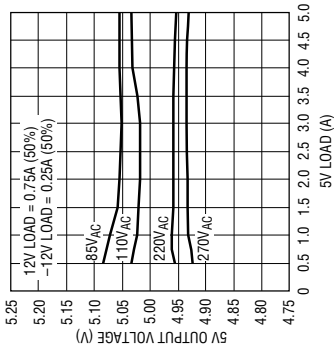
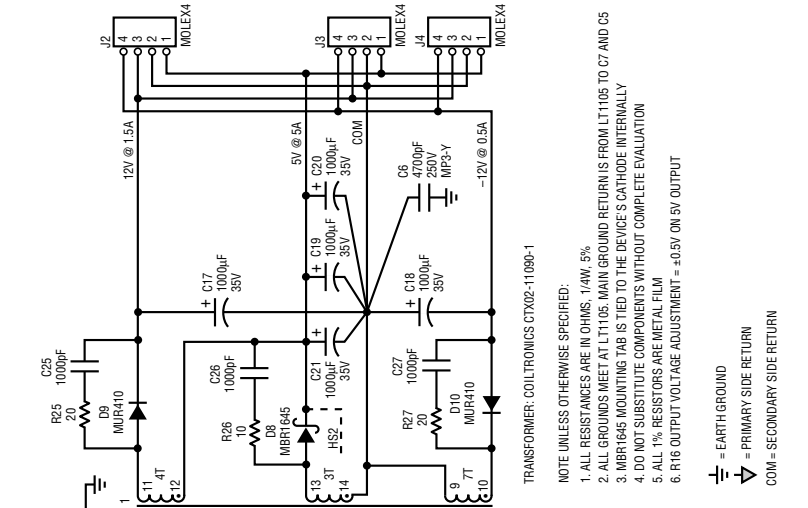


Figure 2. 5V Load Regulation vs Line Voltage



- NOTE UNLESS OTHERWISE SPECIFIED:**
 1. ALL RESISTANCES ARE IN OHMS; 1/4W, 5%
 2. ALL GROUNDINGS MEET AT LT1105. MAIN GROUND RETURN IS FROM LT1105 TO C7 AND C5
 3. MBR1645 MOUNTING TAB IS TIED TO THE DEVICE'S CATHODE INTERNALLY
 4. DO NOT SUBSTITUTE COMPONENTS WITHOUT COMPLETE EVALUATION
 5. ALL 1% RESISTORS ARE METAL FILM
 6. R16 OUTPUT VOLTAGE ADJUSTMENT = +0.5V ON 5V OUTPUT
- ⊥ = EARTH GROUND
 ⇩ = PRIMARY SIDE RETURN
 COM = SECONDARY SIDE RETURN
- TRANSFORMER: COILTRONICS CX02-11090-1