LINEAR TECHNOLOGY

# DESIGN NOTES

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# Isolated Power Supplies for Local Area Networks

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## Introduction

Local Area Networks such as Ethernet™ or Cheapernet™, require low cost isolated power supplies with modest line and load regulation. Table 1 summarizes the objective design specifications based on IEEE 802.3 and ECMA 200-V. The LT1072 high efficiency switching regulator can be used in isolated flyback mode to satisfy these requirements with minimal support circuitry.[1]

**Table 1. Power Supply Specifications for Figure 1**

| PARAMETER | VALUE | COMMENTS |
|---|---|---|
| $V_{OUT}$ | −9V | Ethernet $11.4V < V_{IN} < 12.6V$<br>Cheapernet $4.55V < V_{IN} < 5.45V$ |
| Ripple | $V_n < 10mVp\text{-}p$ | |
| $I_{LOAD}$ | 150mA | 40mA Min, 250mA Max |
| Load Reg | 5% | |
| Line Reg | 5% | |
| Efficiency | $e > 70\%$ | |
| Isolation | 3000V<br>500V | Ethernet<br>Cheapernet |

## Circuit Design

Figure 1 illustrates the design approach. In isolated flyback mode, the LT1072 has no electrical connection to the load; instead, the regulator obtains a feedback signal from the transformers flyback voltage during the switch off-time. The voltage sense occurs after a 1.5μs delay, which prevents the internal error amplifier from regulating the voltage spike due to transformer leakage inductance. The LT1072 compares the feedback signal with a reference voltage, which is set at the feedback pin with a resistor to ground. The primary voltage is regulated to $16V + (V_{FB}/R_{FB})7k$. The feedback pin voltage $V_{FB}$, clamps to about 400mV, and the term $(V_{FB}/R_{FB})7k$ is nominally set to 2V, making the total flyback voltage 18V. The circuit is programmed for −9V output by setting the transformer turns ratio to 2 to 1. The feedback resistor $R_{FB}$, includes a 500Ω trim to take into account variations in the clamp voltage and gain within the LT1072.

**Note 1:** LTC's Application Note 19, the LT1070 Design Manual, presents a detailed discussion of isolated flyback mode and general information on switching regulator design.

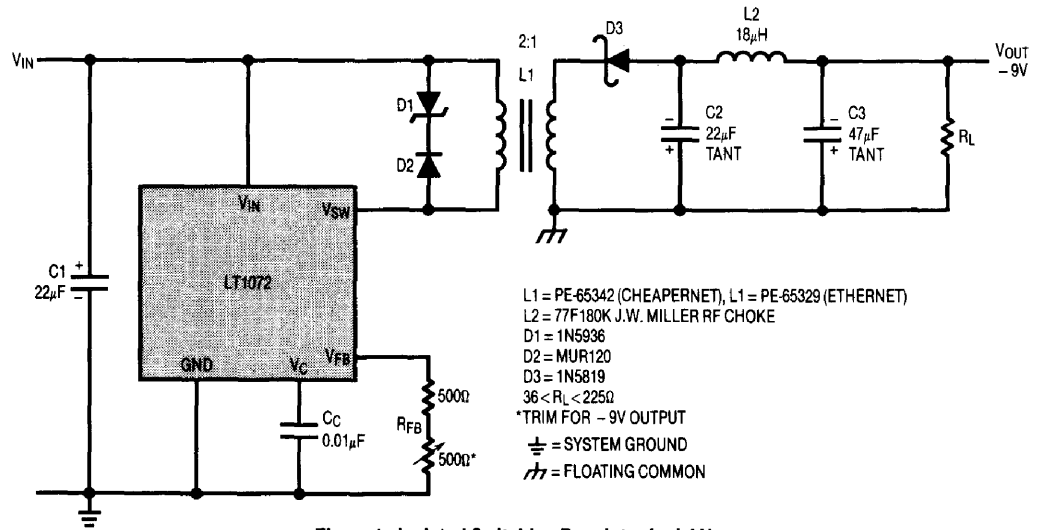


**Figure 1. Isolated Switching Regulator for LAN**

A snubber network consisting of a fast turn-on, high breakdown diode and a 36V Zener diode, limits the magnitude of the leakage inductance spike. This snubber configuration improves efficiency because it minimizes the duration of the inductance spike. A Schottky diode in the secondary reduces the voltage loss to the output and increases efficiency.

Specifications for power supply filters are application dependent. When noise levels of 150mV are tolerable, a single 100µF tantalum capacitor is a suitable supply filter. When output noise below 10mV is required, the use of large output capacitors is often impractical. An LC filter is an appropriate recourse. The optional LC filter in Figure 1 contains an RF choke L2, and tantalum filter capacitors C1 and C2. These components have low effective series resistance (ESR) which helps maintain 5% load regulation.

Figure 2 shows the voltage on the switch pin, trace A, and the current flowing through the inductor, trace B. Trace C is a magnified view of trace A, which more clearly shows regulation of the primary voltage after the switch off-time. Figure 3 shows the voltage and current noise at the output.

**Transformer Design**

The circuit design for 12V to −9V (Ethernet) and 5V to −9V (Cheapernet) circuits are identical except for the transformer specifications. Both circuits develop a regulated 18V primary voltage, but the available input voltage determines the required primary inductance.

$$L_{PRI} = \frac{V_{IN}}{(\Delta I)(f)(1 + V_{IN}/V_{PRI})}$$

$$= \frac{5V}{(0.3A)(40kHz)(1 + 5/18)}$$

$$= 326\mu H \text{ (Minimum)}$$

Where,

$\Delta I$ = Magnetizing Current
$f$ = Switching Frequency
$V_{IN}$ = Input Voltage
$V_{PRI}$ = Primary Voltage

Ethernet requires a larger primary inductance than Cheapernet, which implies a larger transformer. Increased isolation also mandates a larger core to accommodate additional insulation. The transformers used in both applications are shown in Figure 4. The PE-65329 for Ethernet (right) achieves 3700V isolation, while the PE-65342 for Cheapernet (left) provides 500V isolation.[Note 2] These transformers are constructed with low loss core material and low resistance wire, to further improve efficiency.

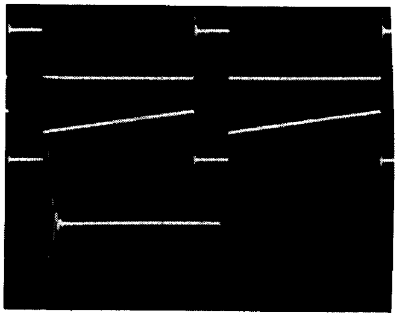


**Figure 2. Switching Waveforms**

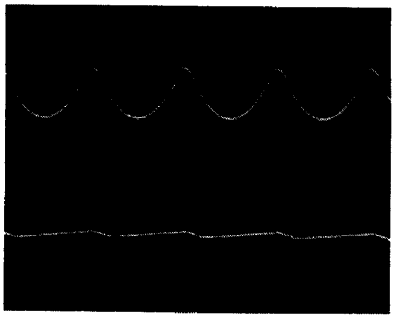


**Figure 3. Voltage and Current Noise**

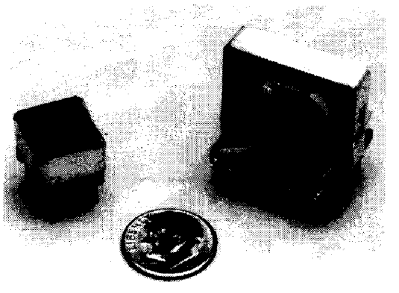

**Figure 4. LAN Transformers. PE-65342 (Left), PE-65329 (Right)**

For additional literature on switching regulators, call **(800) 637-5545.** For applications help, call (408) 432-1900, Ext. 445.

**Note 2:** A 500V version of the Ethernet transformer (PE-65330) is available in the 0.5 inch package in Figure 4.