LINEAR TECHNOLOGY DESIGN NOTES

Inductor Selection for Switching Regulators

Design Note 8

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A common problem area in switching regulator design is the inductor, and the most common difficulty is saturation. An inductor is saturated when it cannot hold any more magnetic flux. As an inductor arrives at saturation it begins to look more resistive and less inductive. Under these conditions current flow is limited only by the inductor's DC copper resistance and the source capacity. This is why saturation often results in destructive failures.

While saturation is a prime concern, cost, heating, size, availability and desired performance are also significant. Electromagnetic theory, although applicable to these issues, can be confusing, particularly to the non-specialist.

Practically speaking, an empirical approach is often a good way to approach inductor selection. It permits real time analysis under actual circuit operating conditions using the ultimate simulator—a breadboard. If desired, inductor design theory can be used to augment or confirm experimental results.

Figure 1 shows a typical flyback regulator utilizing the LT®1070 switching regulator. A simple approach may be employed to determine the appropriate inductor. A very useful tool is the #845 inductor kit* shown in Figure 2. This kit provides a broad range of inductors for evaluation in test circuits such as Figure 1.

Figure 3 was taken with a 450μH value, high core capacity inductor installed. Circuit operating conditions

*Available from Pulse Engineering, Inc., P.O. Box 12235, San Diego, CA 92112, 619-268-2400

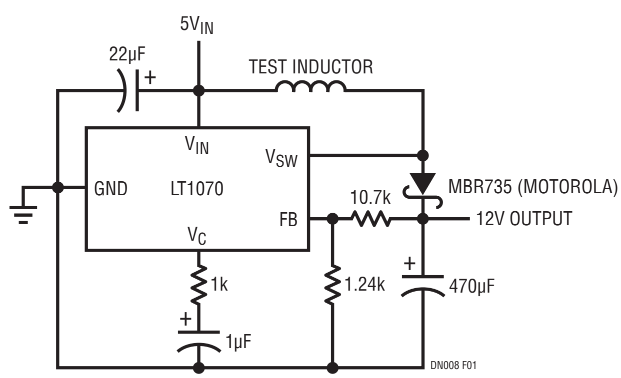

Figure 1. Basic LT1070 Flyback Regulator Test Circuit

such as input voltage and loading are set at levels appropriate to the intended application. Trace A is the LT1070's V_{SWITCH} pin voltage while trace B shows its current. When V_{SWITCH} pin voltage is low, inductor current flows. The high inductance means current rises relatively slowly, resulting in the shallow slope observed. Behavior is linear, indicating no saturation problems. In Figure 4, a lower value unit with equivalent core characteristics is tried. Current rise is steeper, but saturation is not encountered. Figure 5's selected inductance is still lower, although core characteristics are similar. Here, the current ramp is quite pronounced, but well controlled. Figure 6 brings some informative surprises. This high value unit, wound on a low capacity core, starts out well but heads rapidly into saturation, and is clearly unsuitable.

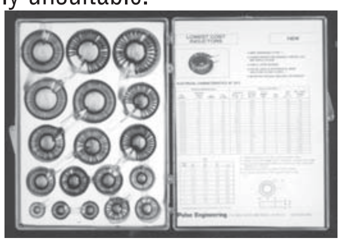

Figure 2. Model 845 Inductor Selection Kit from Pulse Engineering, Inc. (Includes 18 Fully Specified Devices)

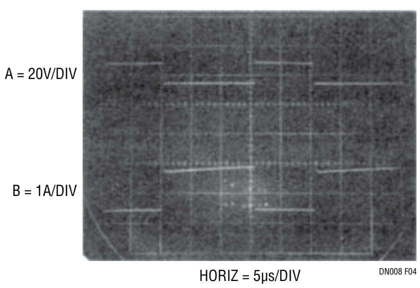

Figure 4. Waveforms for 170μH, High Capacity Core Unit

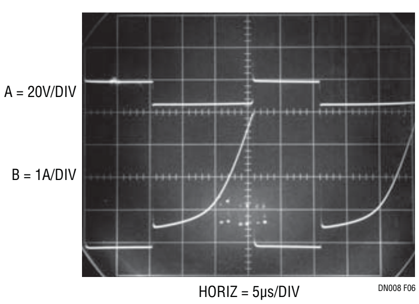

Figure 6. Waveforms for 500μH, Low Capacity Core Inductor (Note Saturation Effects)

The described procedure narrows the inductor choice within a range of devices. Several were seen to produce acceptable electrical results, and the "best" unit can be further selected on the basis of cost, size, heating and other parameters. A standard device in the kit may suffice, or a derived version can be supplied by the manufacturer.

Using the standard products in the kit minimizes specification uncertainties, accelerating the dialogue between user and inductor vendor.

References

AN-25 "Switching Regulators for Poets", Jim Williams, Linear Technology Corporation.

AN-19 "LT1070 Design Manual", Carl Nelson, Linear Technology Corporation.

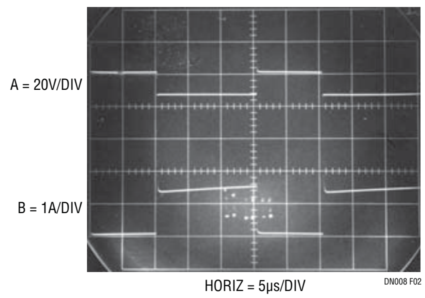

Figure 3. Waveforms for 450μH, High Core Capacity Unit

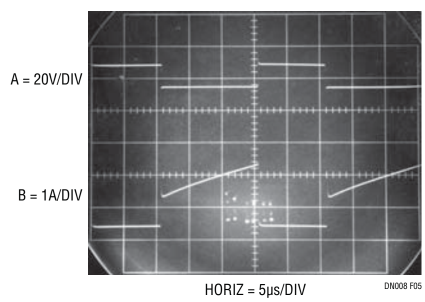

Figure 5. Waveforms for 55μH, High Capacity Core Unit

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