When the Flyback Converter Reaches Its Limits

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Galvanically isolated power supplies are used in numerous applications. There are different reasons for this. In some circuits, galvanic isolation is necessary due to safety considerations. In other circuits, functional isolation is used to block any interference on signals.

A galvanically isolated power supply is usually designed with a flyback converter. These regulators have a very simple design. Figure 1 shows a typical design for such a regulator with an ADP1071 flyback controller. We can see that it is a flyback converter because the dots do not match up on the transformer. A primary-side power switch (Q1) is utilized. Also, a secondary-side rectifier circuit is required. This can be executed with a Schottky diode, but for higher efficiencies, an active switch (Q2 in Figure 1) is commonly used. The corresponding ADP1071 controller takes care of controlling the switches and providing the galvanic isolation for the feedback path FB.

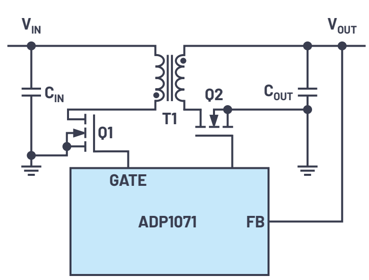

Figure 1. Typical flyback regulator (flyback converter) for power of up to approximately 60 W.

Although flyback converters are very popular, this topology has practical limitations. The transformer T1 in Figure 1 is not actually used as a classic transformer. When Q1 is in the on state, no current flows through the secondary winding of T1. The energy of the primary-side current is nearly completely stored in the transformer core. Similarly to how a buck converter stores energy in a choke (inductor), a flyback converter does this in the transformer. When Q1 is in the off state, a current flow develops on the secondary side of T1. This supplies the output capacitor C_{OUT} and the output with energy. This concept is very easy to implement but has inherent limitations at higher power. The transformer T1 is used as an energy storage element. For this reason, the transformer can also be referred to as a coupled inductor (choke). This requires that the transformer can store the required energy. The higher the energy class of the power supply, the larger and more expensive the transformer. In most applications, the upper limit is at approximately 60 W.

If a galvanically isolated power supply is required for higher power, a forward converter is a suitable choice. The concept is shown in Figure 2. Here, the transformer really is used as a classic transformer. While current flows through Q1 on the primary side, a current flow also develops on the secondary side. The transformer thus does not need to provide any energy storage capacity. In fact, the opposite is true. It must be ensured that the transformer is always discharged during the off-time of Q1 so that it does not inadvertently reach saturation after a few cycles.

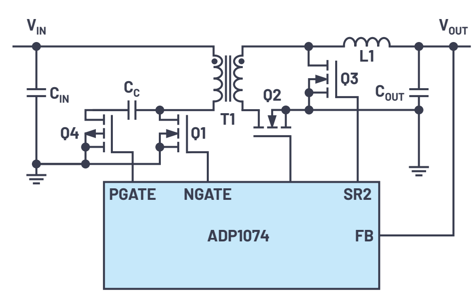

Figure 2. Forward regulator (forward converter) for power of up to approximately 200 W.

For the same power, a forward converter needs a smaller transformer than a flyback converter does. This makes the forward converter practical and sensible for use even at power levels lower than 60 W. One disadvantage is that the transformer core must be freed from unintentionally stored energy with each cycle, which is implemented by the active clamp wiring with switch Q4 and capacitor C_C in Figure 2. A forward converter also usually requires an additional inductor L1 on the output side. However, through this, the output voltage can also have a lower ripple than that of a flyback converter at the same power level.

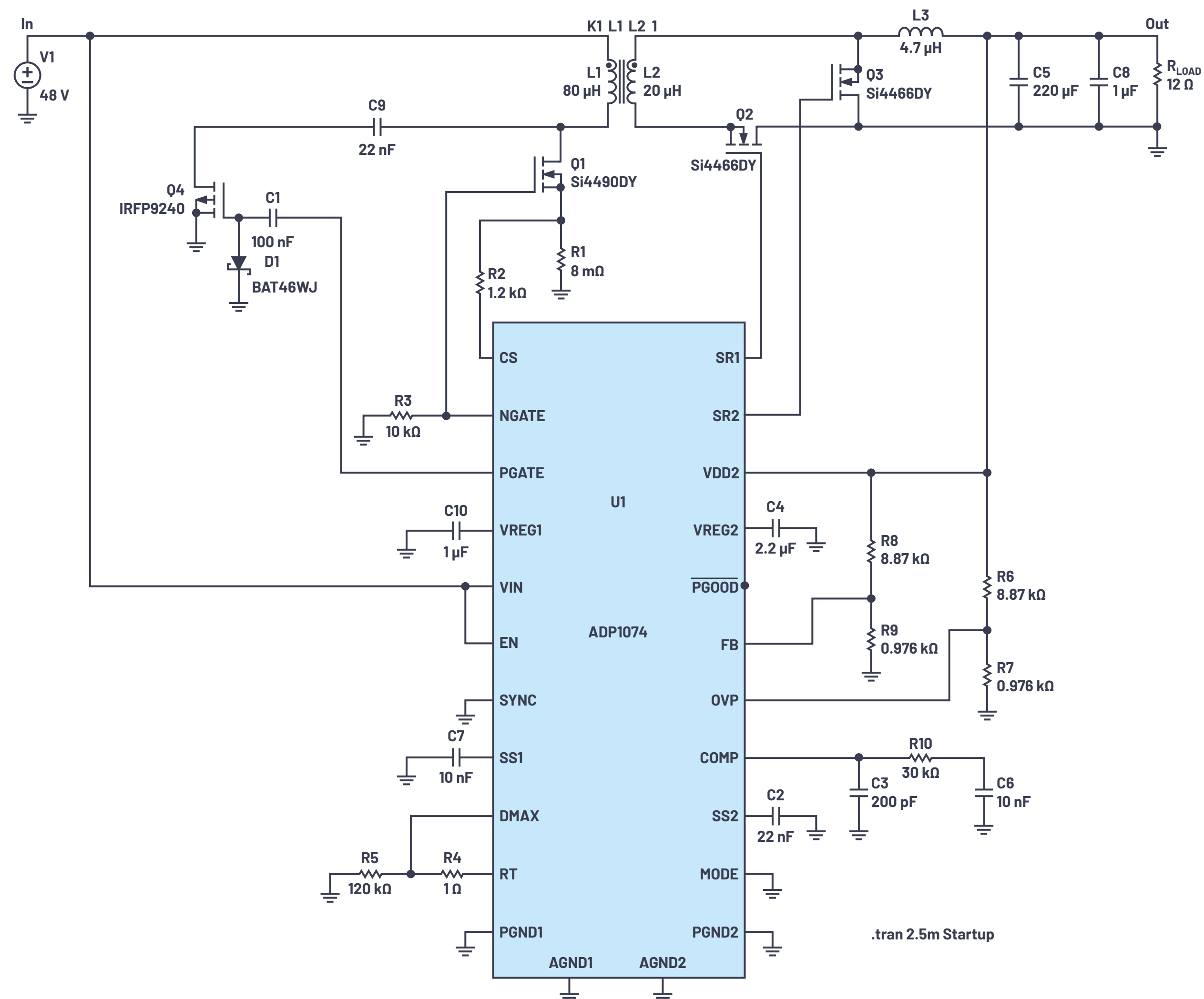

Figure 3. Example of a circuit with an ADP1074 simulated in LTspice®.

Power management ICs such as the ADP1074 from Analog Devices offer a very compact solution for designing a forward converter. This architecture is usually used when power levels higher than approximately 60 W are required. Below 60 W, a forward converter could also be a better choice than a flyback converter based on circuit complexity and achievable efficiencies. For simplifying the decision about which topology to use, simulation with the free circuit simulator LTspice is recommended. Figure 3 shows the simulation schematic of an ADP1074 forward converter circuit in the LTspice simulation environment.

About the Author

Frederik Dostal studied microelectronics at the University of Erlangen in Germany. Starting work in the power management business in 2001, he has been active in various applications positions including four years in Phoenix, Arizona, where he worked on switch-mode power supplies. He joined Analog Devices in 2009 and works as a field applications engineer for power management at Analog Devices in München. He can be reached at frederik.dostal@analog.com.

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