Technical Article

Power Tips: Bias Your Controller in USB Type-C AC/DC Applications

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The USB Type-C standard allows for an adjustable output voltage that can range from 5V to 20V, and a load current up to 3A using the standard cable. With power levels as high as 60W, the flyback remains a good choice for the topology. However, providing bias power to the primary-side controller can pose some challenges.

An auxiliary winding on the flyback transformer typically provides power to the controller on the primary side of the isolation boundary. The voltage generated by this winding is proportional to the output voltage. With a 4-to-1 range on the output voltage, the bias voltage will also vary by a factor of 4-to-1. In reality, the actual range is wider, considering peak charging of the bias capacitor due to ringing.

You must set the turns ratio from the output winding to the auxiliary winding so that the bias voltage is high enough to effectively drive the primary MOSFET when the output is only 5V. A ratio of 1-to-2.5 (output-to-auxiliary) can be a good choice for providing around 12V of drive. However, this means that when the output voltage is 20V, the auxiliary voltage will be over 50V. Clearly, you must do something to protect the controller from overvoltage damage.

Adding a simple clamping circuit, as shown in Figure 1, offers a good solution. The transistor (Q1) must have a fairly high gain to ensure that the bias voltage does not droop when the output is 5V. The clamping voltage is set by the Zener value (D10). The base resistor (R27) must be set low enough to provide the necessary base current when the output is 5V, but not too low. An excessively low value for the base resistor will lead to unnecessary losses.

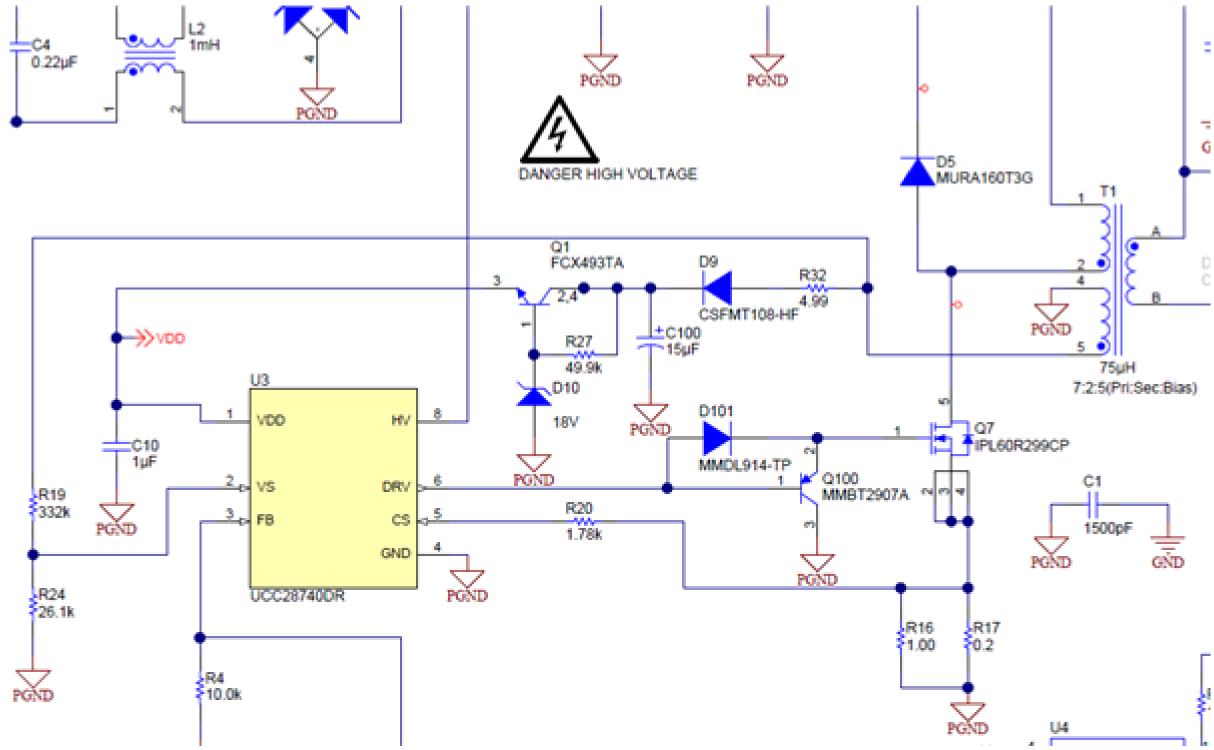

Figure 1. A Clamping Circuit Is Necessary to Limit the Voltage on the Bias Rail

At first glance, it might appear that this clamping circuit will significantly increase the standby (no-load) power losses. However, at no load with the USB Type-C cable unplugged, the output voltage defaults to 5V. When the output is 5V, the clamping circuit adds virtually no additional power loss. Even with this added clamp, it is fairly simple to keep standby losses well below 50mW.

There are many other things to consider when designing an AC/DC adapter for USB-C power delivery; check out the Additional Resources section to learn more.

Additional Resources

- I discuss a few more details about AC/DC adapters in my latest Power Tips post on EE Times.
- Find previous TI Power Tips posts.
- The TI Designs USB-C DFP, 20V/3A Out, Universal AC Input Reference Design is for a 60W adapter for USB Type-C power delivery.

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