Ideal diode bridge controller efficiently powers MOSFETs

Steve Taranovich - June 12, 2013

Linear Technology Corporation is claiming a major breakthrough with the introduction of the LT4320, an ideal diode bridge controller for 9V to 72V systems that replaces each of the four diodes in a full-wave bridge rectifier with a low loss N-channel MOSFET to significantly reduce the power dissipation and increase available voltage.

This seems like a pretty obvious, straight-forward design choice, that is, to use a MOSFET in a diode bridge instead of a lossy silicon diode—and it is! But the catch here is how to drive those MOSFETs properly with the challenges associated with this idea that may not be very obvious to us.
In a conventional diode bridge, power dissipation is calculated as \(2 \times 0.6V \times I_L\), which yields 1.2W at 1A, 12W at 10A, and 120W at 100A. In many cases this obviously will require heat sinking and forced air.

Designers looked at the following scenario, especially with respect to the Power-over-Ethernet (PoE) market. According to Linear Technology engineers:

“The two diode drop voltage, roughly 1.2V, is only 0.7% of 170V (peak voltage for 120V AC), but 10% of 12V and 13.3% of 9V. In devices such as security cameras, power can be supplied either by 24V AC or 12V DC. Networked cameras may derive power from the Ethernet port at 48V DC (Power over Ethernet or PoE), but also maintain these legacy 24V AC/12V DC auxiliary inputs. Consequently, the downstream power converter has to work over a wide input range. The upper end is 57V, dictated by PoE, while the lower end is set to 10.8V by the 12V±10% input. A diode bridge rectifier on the auxiliary input with its two diode drops further exacerbates the wide range problem, especially at the lower end to 9.6V (= 10.8V – 1.2V). Sometimes the minimum voltage is specified at 9V, which after the diode bridge becomes 7.8V.”

A major challenge was how to make the MOSFET look like a diode! That’s where the design expertise and creativity comes in. There are significant challenges to this process----that’s probably why we have not seen a good solid design for an efficient and robust MOSFET bridge driver architecture until now.

The LT4320 design replaces each of the four diodes in a full-wave bridge rectifier with low loss N-channel MOSFETs and thus significantly lowers power dissipation by at least a factor of 10 and increases available voltage. Power supply size is reduced as the enhanced power efficiency eliminates bulky heat sinks (see figures 1 and 2). Low voltage applications benefit from the extra margin afforded by saving the two diode drops inherent in diode bridges. Compared to the traditional alternative, the MOSFET bridge yields a rectifier design that is highly space- and power-efficient. The controller operates from 9V to 72V systems at input frequencies from DC to 600Hz.
How did the designers achieve their lofty goal?

An example of one challenging design solution during the MOSFET bridge driver design process, crafted by Linear Technology engineers, was the implementation of an internal charge pump that supports an all-NMOS design. This integrated charge pump provides at least 425µA of pull-up current to turn on the top-side N-channel MOSFET gate. No external flying capacitors are required. The strong pull-up current enables rectification for high frequency inputs and high power applications employing large gate charge MOSFETs. This design eliminates the need for larger and more costly PMOS switches. Monitoring internally also detects the power source in the case of a failure or short circuit, and in that case the circuitry implements a fast turn-off to minimize reverse current transients.

Another clever design tactic the designers used was to ensure that the LT4320 switch control smoothly turns on the appropriate two MOSFETs, while keeping the other two off, thus preventing reverse currents.

The choice of MOSFETs offers the greatest flexibility in power levels ranging from one to thousands of watts. The data sheet outlines this important aspect of the design—the selection criteria for the optimum MOSFETs to be used as the bridge element part of this design.

This short video demonstrates the efficiency and power savings in AC/DC rectifier size, cost and heat sinking requirements that demonstrates superiority of the Diode Bridge controller over a
conventional Schottky diode bridge for a similar temperature rise with a 24V AC input and 9A output load current.

The controller is available in two options: the LT4320 is designed for DC to 60Hz voltage rectification and the LT4320-1 that rectifies from DC to 600Hz.

Specified over the −40°C to 85°C industrial temperature ranges, the LT4320 is offered in a compact 8-pin 3mm x 3mm DFN package, and a 12-lead MSOP package with enhanced high-voltage pin spacing.

Prices begin at $2.95 each for 1,000-piece quantities.

Evaluation circuit boards are available.

For more information, visit www.linear.com/product/LT4320.