

PD Controller ICs with Integrated Flyback or Forward Controllers Meet Demands of 25.5W PoE+

by Ryan Huff

Introduction

The IEEE 802.3af Power over Ethernet (PoE) standard allows a powered device (PD), such as an internet protocol (IP) telephone, to draw up to 12.95W from an Ethernet cable. When the 802.3af standard was drafted, 12.95W appeared sufficient to cover the immediately imaginable range of PD products (primarily IP phones). Of course, application developers are always far more innovative than standards committees anticipate, so new power-hungry applications for PoE immediately started to appear, such as dual-radio IEEE 802.11a/g and 802.11n wireless access points, security cameras with pan/tilt/zoom motors, and color LCD IP video phones. 12.95W was suddenly not enough. The IEEE committee responded with the 802.3at standard, which raises the available PD power

to 25.5W. The new “at” standard, commonly referred to as PoE+, also adds a “handshaking” communications requirement between PDs and power sourcing equipment (PSEs), while allowing backward compatibility with the legacy “af” standard.

New power control ICs are required to take advantage of these expanded requirements. The DC/DC conversion and control schemes used for legacy “af” PDs are not optimized for the increased power capability and feature requirements of PoE+. For instance, in both standards the 37V to 57V PoE voltage is converted to lower voltages that digital circuitry can tolerate. This DC/DC conversion is handled in the lower power 12.95W standard with a conventionally rectified (i.e., diode rectified) flyback converter. The higher power 25.5W standard is better

served by a synchronously rectified (i.e. MOSFET rectified) flyback or a forward power supply topology.

To meet the new performance requirements of PoE+, including handshaking, Linear Technology offers a new family of PD controller ICs that integrate a front-end PD controller with a high performance synchronously rectified flyback (LTC4269-1) or a forward (LTC4269-2) power supply controller.

Features

Both parts combine a PD controller—which includes the handshaking circuitry, Hot Swap™ FET, and input protection—with a DC/DC power supply controller. While the power supply sections of the two parts are very different, the PD controller in both is identical.

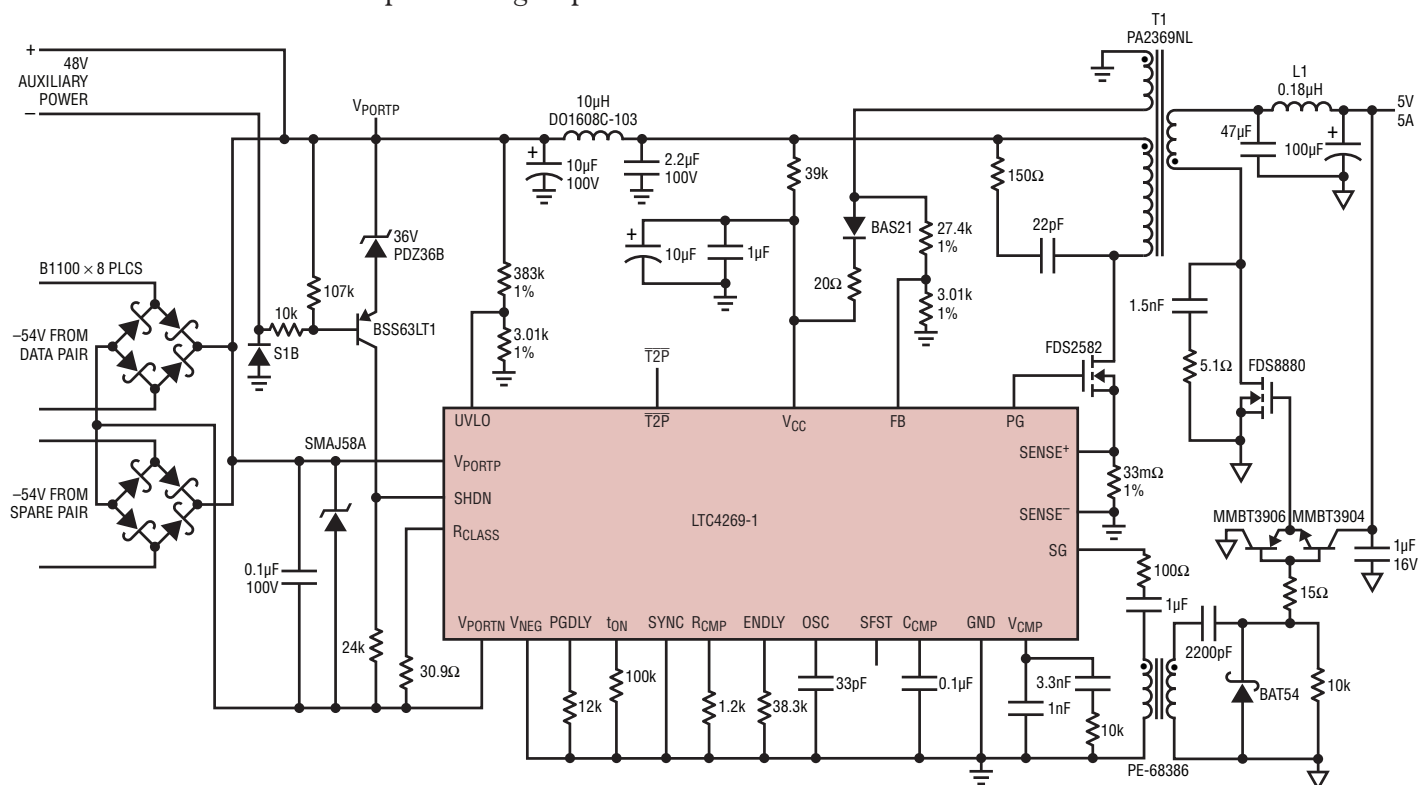


Figure 1. LTC4269-1-based synchronous flyback converter

In the LTC4269, handshaking circuitry, also known as the “High Power Available,” “Two Finger Detect,” or “Ping Pong” indicator, allows the PD to take full advantage of a new PSE’s full 25.5W of available power. Both parts include an integrated Hot Swap MOSFET for a controlled power up of the PD. The switch has a low 700m Ω (typical) resistance and a robust 100V max rating, thus meeting the needs of a wide range of applications. Auxiliary power supplies (“wall warts”) can be accommodated by interfacing to the SHDN pin to disable the PoE power path. Setting a programmable classification current allows different power leveled PDs to be recognized by the PSE. Achieving this is as easy as choosing the proper resistor and placing it from the R_{CLASS} pin to V_{PORTN} pin. The ICs are chock-full of protection features, including overvoltage, undervoltage, and overtemperature to name a few. Finally, complementary power good indicators signal that the PD Hot Swap MOSFET is out of the inrush limit and ready to draw full power.

The power supply controllers of the LTC4269s also share some features. Both offer programmable switching frequency, which allows the designer to optimize the trade-off between efficiency and size, or the designer can choose a specific frequency to meet application specific EMI requirements. The power supply soft-start time is also adjustable to prevent the PSE from dropping out its power due to excessive inrush current and virtually eliminate any power supply

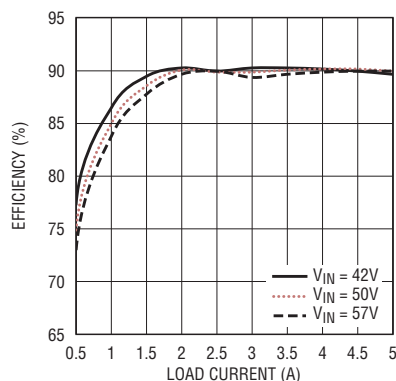


Figure 2. Efficiency of the circuit in Figure 1

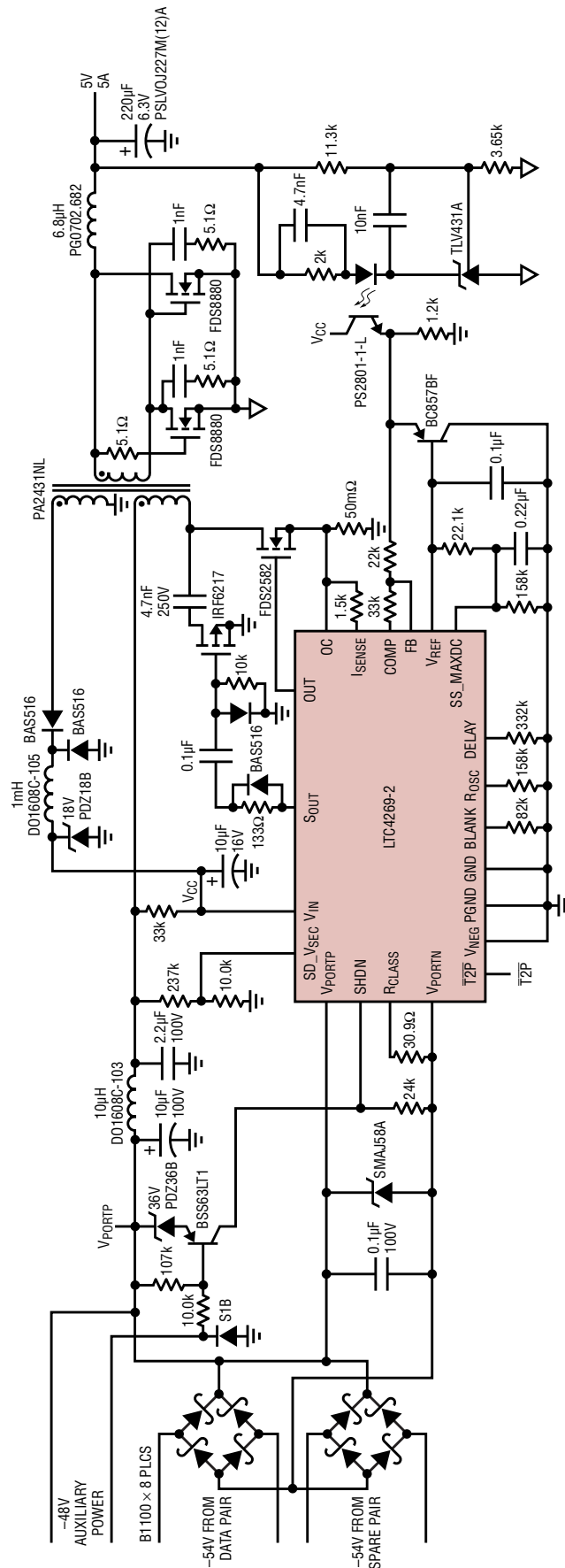


Figure 3. LTC4269-2-based self-driven synchronous forward converter

output voltage overshoot. Both parts include short circuit protection with automatic restart.

LTC4269-1 Synchronous Flyback for Optimized Combination of Efficiency, Simplicity, Size and Cost

A synchronous flyback supply utilizing the LTC4269-1 offers the best combination of efficiency, simplicity, size and cost. See Figures 1 and 2 for the schematic and efficiency curves, respectively, for an LTC4269-1-based PD power supply capable of a 5V output voltage at 5A.

The flyback parts count is low for a few reasons. There is no need for the large output inductor that a forward converter (see Figure 3) needs, for this function is rolled into the isolation transformer (T1). A small, inexpensive second-stage filter inductor (L1) is used in the flyback in order to reduce output voltage ripple, but it should not be confused with a traditional output inductor.

In the case of the LTC4269-1, neither a secondary side reference nor an optocoupler are needed to transmit the output voltage regulation information across the isolation boundary. This is because the IC uses the third (bias) winding on the transformer, T1, to get the output voltage information across the boundary. Finally, the synchronous flyback topology requires half of the switching MOSFETs (only two) needed by the forward converter.

Performance, in terms of efficiency, tops out at above 90% for the

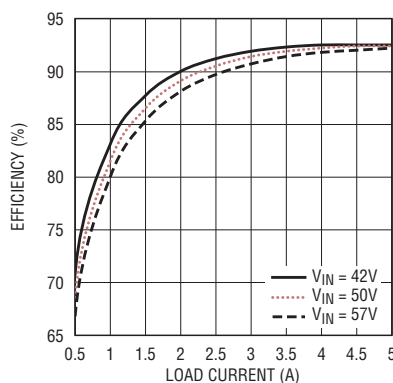


Figure 4. Efficiency of the circuit in Figure 3

LTC4269-1 synchronous flyback. As a contrast, typical PoE efficiencies at the "af" power level for a conventionally rectified flyback were in the lower half of the 80%'s. This higher efficiency is due to the IC's well-controlled implementation of the synchronous rectifier's gate drive. This efficiency is not attainable with an uncontrolled self-driven synchronous rectification scheme that is sometimes used.

Regulation over the full PoE+ input voltage range and 0A to 5A output current range for the LTC4269-1 is better than $\pm 1\%$. Output voltage ripple for the fundamental switching frequency is less than 30mV peak-to-peak.

LTC4269-2 Synchronous Forward to Maximize Efficiency

If the efficiency of a PoE+ power supply is paramount, an LTC4269-2-based synchronous forward supply is the answer at 92.5% efficiency. The increased efficiency comes with the trade-off of increased circuit size and complexity.


Figure 3 shows a complete PD power supply. Figure 4 shows efficiency, and Figure 5 compares the physical size of the flyback (LTC4269-1) versus the forward (LTC4269-2). The forward supplies 5V at 5A.

The increase in the forward's efficiency comes about in part from decreased RMS currents in the secondary side MOSFETs and in part from separating the transformer and output inductor. Both of these changes from the flyback reduce resistive losses. The forward supply uses twice the number of MOSFETs as a flyback so each switch handles just a portion of the current that the switches in the flyback do, thus reducing the I^2R power losses. By separating the isolation transformer and output inductor, instead of using the transformer for both as in the flyback, the same power is processed through two components instead of one. The net effect is more copper, thus less resistance and lower resistive losses.

The cost of the circuit obviously increases with the addition of larger and more expensive power path components. Complexity also goes up with the need to control twice as many MOSFETs. Also, the forward topology does not lend itself to the third winding feedback method. This means extra complexity in the design and compensation of a secondary side reference and opto-coupler circuitry.

Other than the ultra high efficiency of the LTC4269-2's synchronous forward, the solution has similar performance to the flyback. The output ripple of the fundamental switching frequency is about 40mV peak-to-peak. The regulation over the entire input voltage and load current range is well under $\pm 1\%$.

Conclusion

Two new highly integrated PD controller ICs are fully compliant with, and take full advantage of, the upcoming IEEE 802.3at PoE+ standard. The LTC4269 family of parts support the preferred high performance power supply topologies for use in the new standard. 

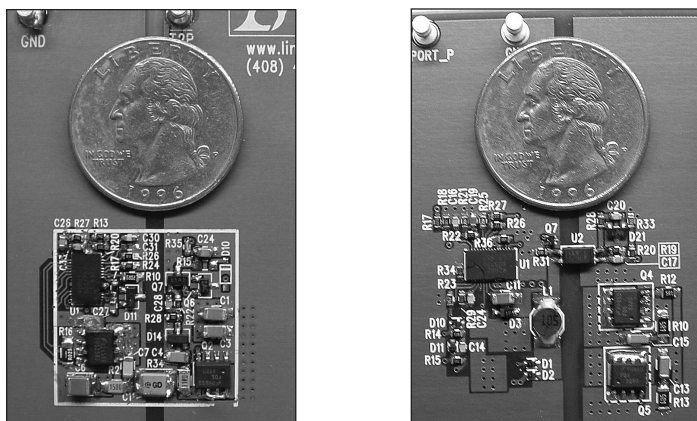


Figure 5. LTC4269-1 and -2 solutions