

# Wall Adapter Powers IEEE 802.3af Powered Device

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## ABSTRACT

Power-over-Ethernet is an emerging technology that allows an existing Ethernet connection to carry both data and power. However, today’s powered-device (PD) designers face a dilemma – not all Ethernet connections are wired for power. To operate with these legacy connections, a PD can use a wall adapter, but this capability must be designed into the PD.

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## 1 Introduction

The ability to use a wall adapter increases the versatility of a PD. A wall adapter allows a PD to work with legacy Ethernet, biding time until Power-over-Ethernet is universally adopted. If the Ethernet connection is already wired for power, then the PD can use the adapter and not burden the power-sourcing equipment (PSE). Two independent power sources can provide redundancy in mission-critical applications like security cameras and badge readers; if the adapter fails, then the Ethernet connection provides back-up power, and vice versa.

The increased versatility makes adding an adapter capability a wise design choice. This capability can be built into a PD in many ways. The PD designer should be aware of the tradeoffs for each approach.

## 2 Power Insertion

Auxiliary power can be inserted at the PD controller input, DC/DC converter input, or load as shown in Figure 1. Each insertion point has unique voltage, inrush current, and power hand-off (i.e., hand-off from PSE to the adapter and vice versa) profiles.

The PD controller's identification, classification, and inrush-current limiting functions must meet the IEEE 802.3af standard. An example of such a PD controller is the Texas Instruments TPS23750. Some devices like the TPS23750 integrate the PD controller and the DC/DC power-supply controller onto a single chip.

### 2.1 Inserting Power With a Diode

An obvious way to insert power is to diode-OR the power rails as shown in Figure 1. This method gives priority to the higher supply voltage.

In option 1, the PD controller turns on the DC/DC converter only if the auxiliary voltage rises above 42-V per the IEEE 802.3af standard. A 48-V adapter is a suitable auxiliary power source when using this option. The PD controller limits the inrush current into the DC/DC converter input filter capacitor. If the adapter voltage is higher than the PSE voltage, then the PSE loses the 10-mA Maintain Power Signature (MPS) and removes power to the PD. The PSE subsequently detects an invalid PD and does not apply power to the PD. Once the adapter gains control of the PD, the only way for the PSE to regain control is to disconnect the adapter.

Option 2 bypasses the PD controller, so that the auxiliary voltage can be as low as the minimum operating voltage of the DC/DC converter. For example, if the DC/DC converter can operate down to a 18-V input, then a 24-VDC adapter can provide auxiliary power. Unlike option 1, option 2 does not limit inrush current into the DC/DC converter input filter capacitor. If the auxiliary voltage is higher than the PSE voltage, then the PSE loses MPS and removes power to the PD. The PSE subsequently detects an invalid PD and does not apply 48-V to the PD. Once the adapter gains control of the PD, the only way for the PSE to regain control is to disconnect the adapter.

Option 3 bypasses the PD controller and DC/DC converter and applies auxiliary power to the load through a diode. Common load voltages are 3.3-V, 5-V, 12-V, and 15-V. Therefore, most applications can use a low-voltage adapter. A point-of-load voltage regulator can be used with the adapter if tight load regulation is required. Option 3 does not limit inrush current into the load filter capacitor. If the auxiliary voltage is higher than the DC/DC converter output voltage and the combined bias current of the PD controller and DC/DC converter is below the 10-mA MPS level, then the PSE cycles power to the PD; the PSE removes power to the PD, detects a valid PD, applies power to the PD, loses MPS, removes power to the PD, and repeats this cycle continually. If the bias current is above the MPS level, then the PSE allocates power to the PD at the classified level, even though the auxiliary source powers the PD. Option 3 should be used only if the PSE is able to supply maximum power to all of its ports because optimal power allocation may not be possible.

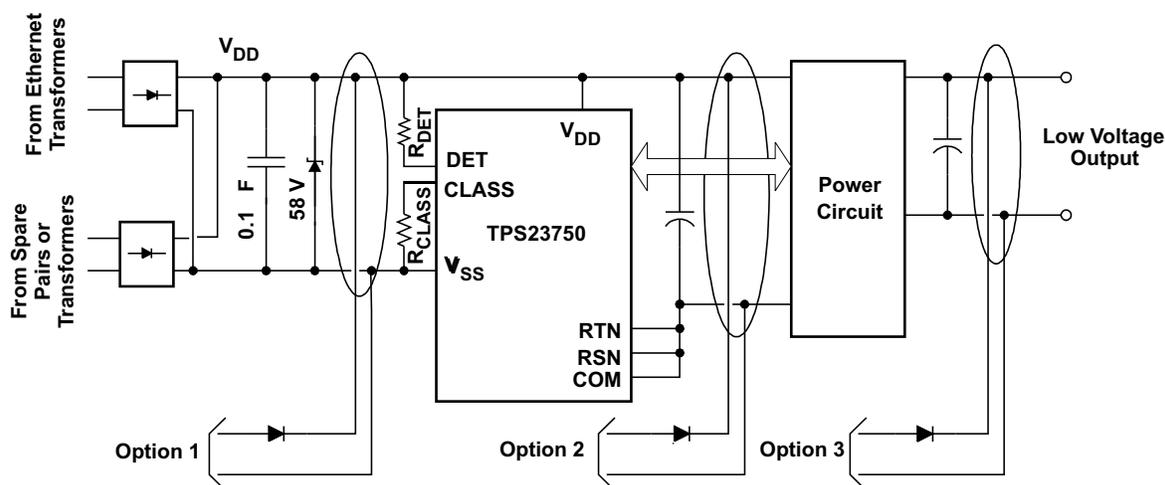


Figure 1. Power Insertion Options Using a Diode

## 2.2 Manual Power-Selector With Adapter Priority

The circuits in [Figure 2](#) through [Figure 5](#) give priority to the wall adapter. The voltage and inrush-current profiles are the same as the diode-ORing approach at the corresponding power insertion point.

Note that plugging the adapter into the DC power jack selects the adapter even *if the adapter output voltage is zero*. This can occur if the adapter is unplugged from the AC outlet. Unplugging the adapter from the jack is necessary to select the PSE. On selecting the PSE, the PD input voltage drops out until the PSE detects, classifies, and turns on power to the PD (see [Figure 6](#)). It is possible that the PSE may not power up the PD if that causes the PSE to exceed its power budget.

Optocouplers U1 and U2 prevent the PSE from cycling power to the PD, assuming that the adapter is plugged into the DC-power jack and AC outlet. U2 reduces the DC/DC converter bias current below the MPS threshold to kick out the PSE while U1 invalidates the PD detection signature to prevent the PSE from re-applying 48-V to the PD.

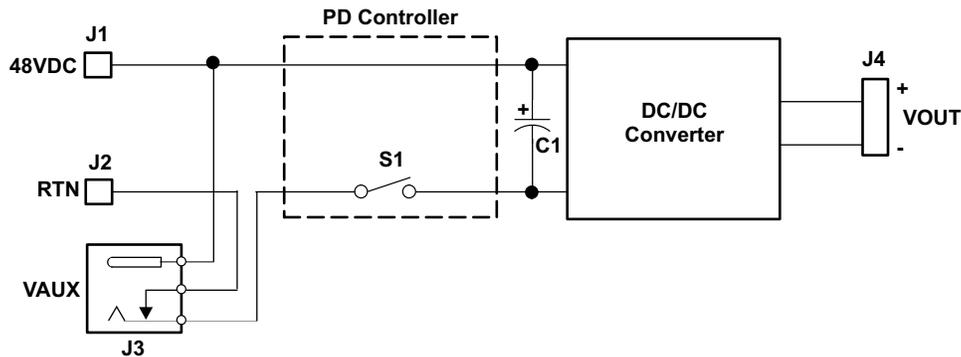


Figure 2. Manual Power-Selector Inserts Power at PD Controller Input

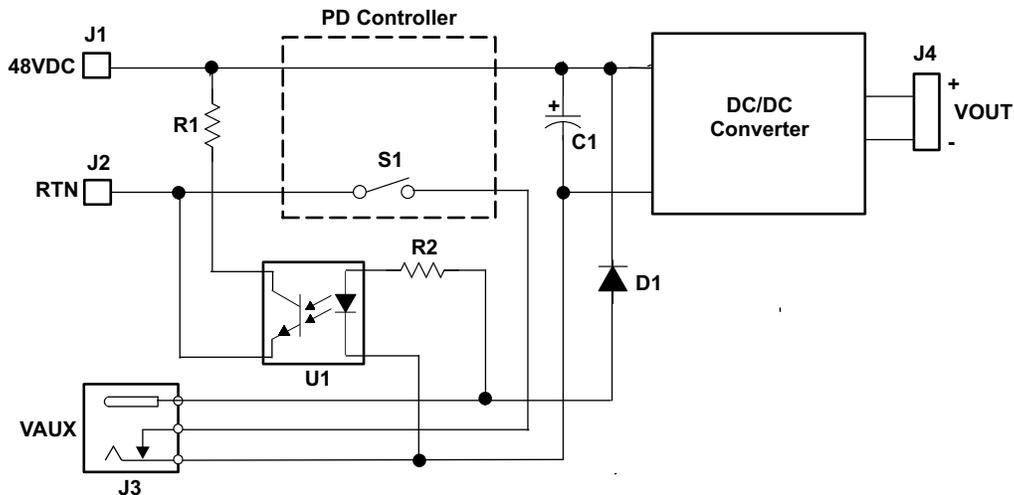


Figure 3. Manual Power-Selector Inserts Power at DC/DC Converter Input

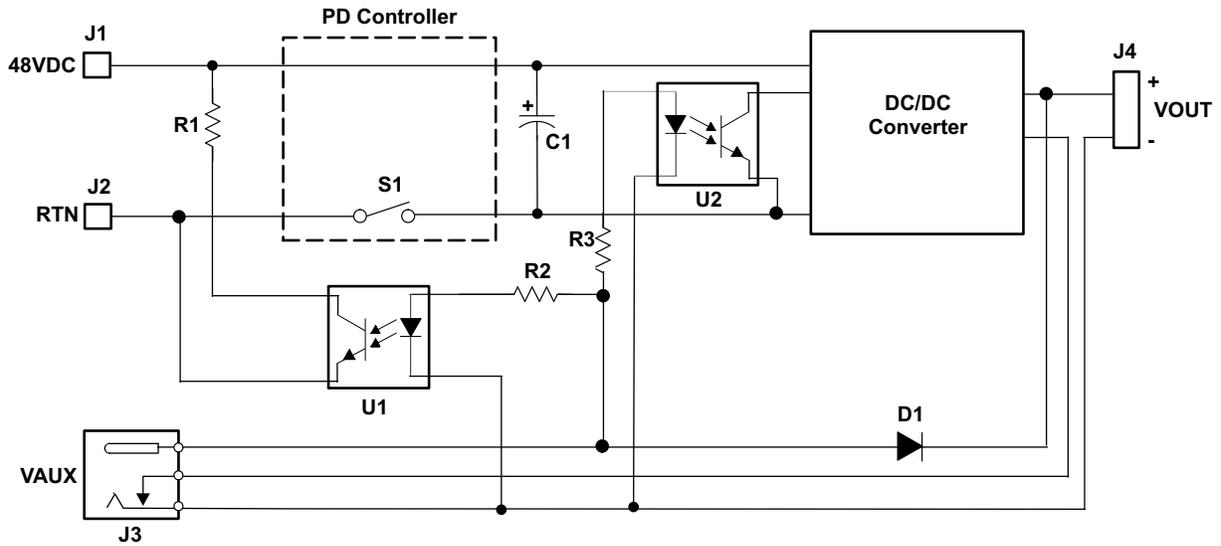


Figure 4. Manual Power-Selector Inserts Power at Load

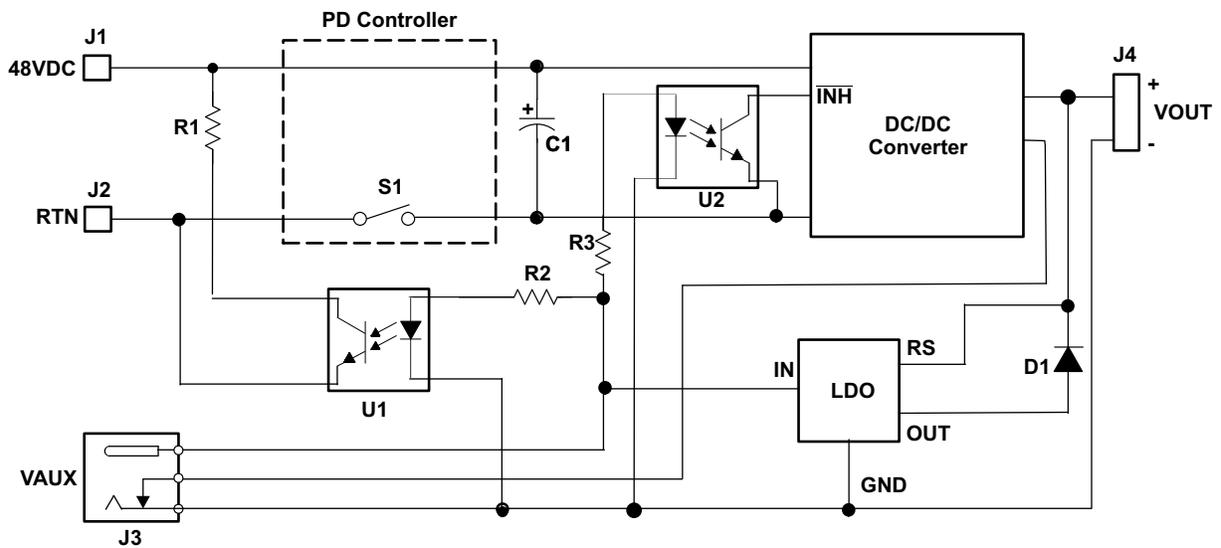
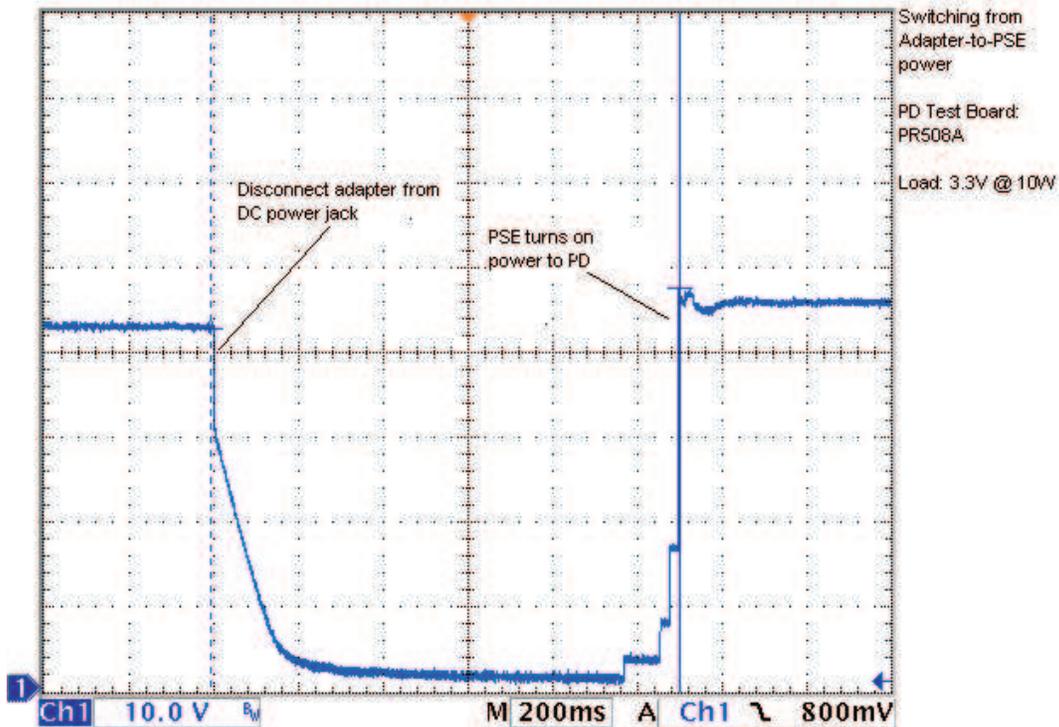


Figure 5. Manual Power-Selector Inserts Power at Load. An LDO is Used for Tight Load Regulation.

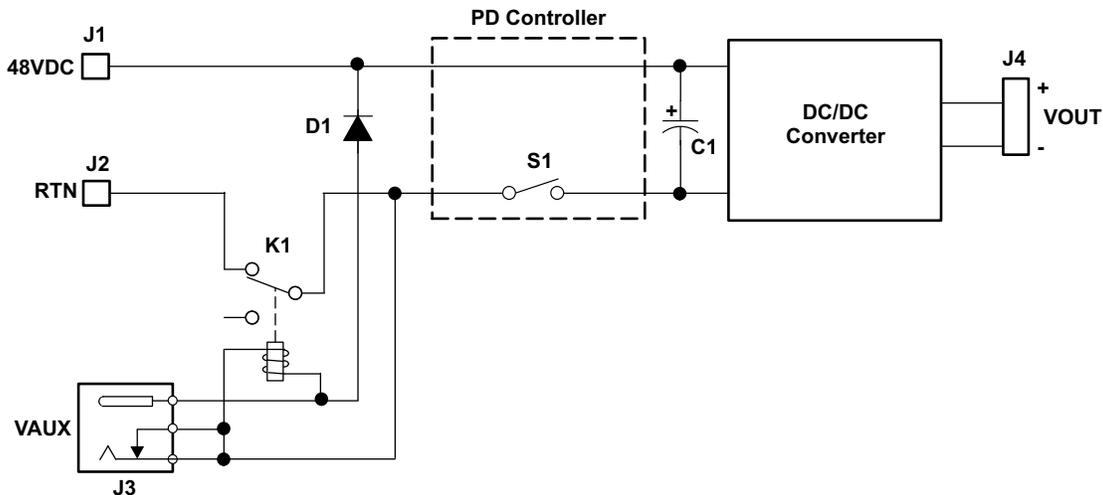


**Figure 6. Typical PD-Controller Input Voltage When Circuit in Figure 2 Switches From Adapter to PSE Power.**

### 2.3 Automatic Power-Selector with Adapter Priority

The circuits in Figure 7 through Figure 10 use a relay to select the power source and give priority to the adapter. The relay automatically selects the PSE if the adapter is unplugged from the DC power jack or AC outlet. The relay presents the appropriate maintain power signature and detection signature when the adapter is selected to prevent the PSE from cycling power to the PD. The voltage and inrush-current profiles are the same as the corresponding circuits in Figure 2 through Figure 5.

On selecting the PSE, the PD input voltage drops out until the PSE detects, classifies, and turns on power to the PD (see Figure 6). It is possible that the PSE may not power up the PD if that causes the PSE to exceed its power budget.



**Figure 7. Automatic Power-Selector Inserts Power at PD Controller Input.**

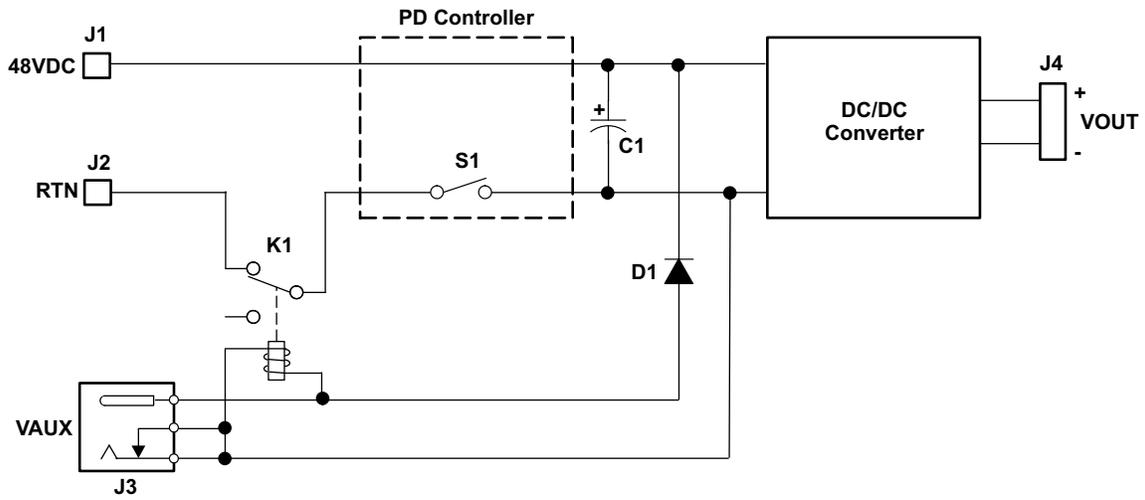


Figure 8. Automatic Power-Selector Inserts Power at DC/DC Converter Input.

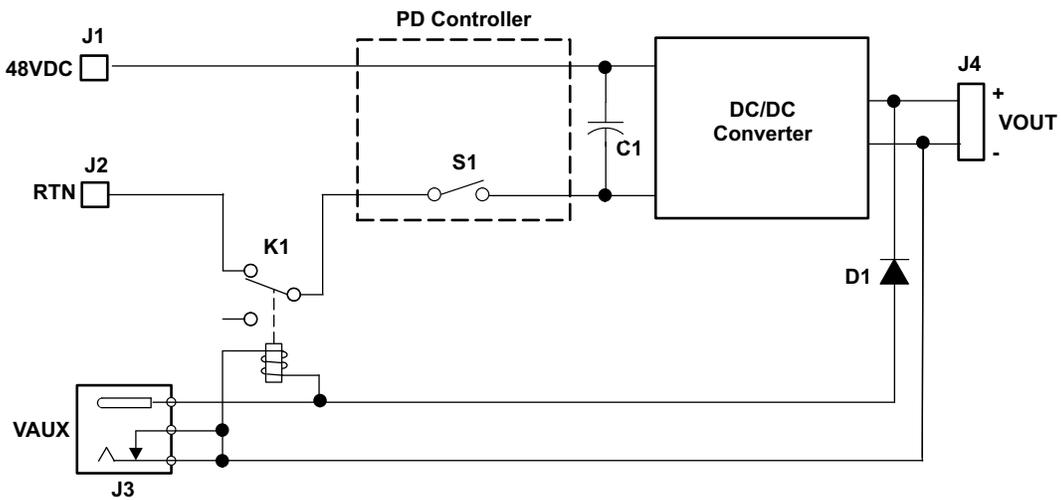
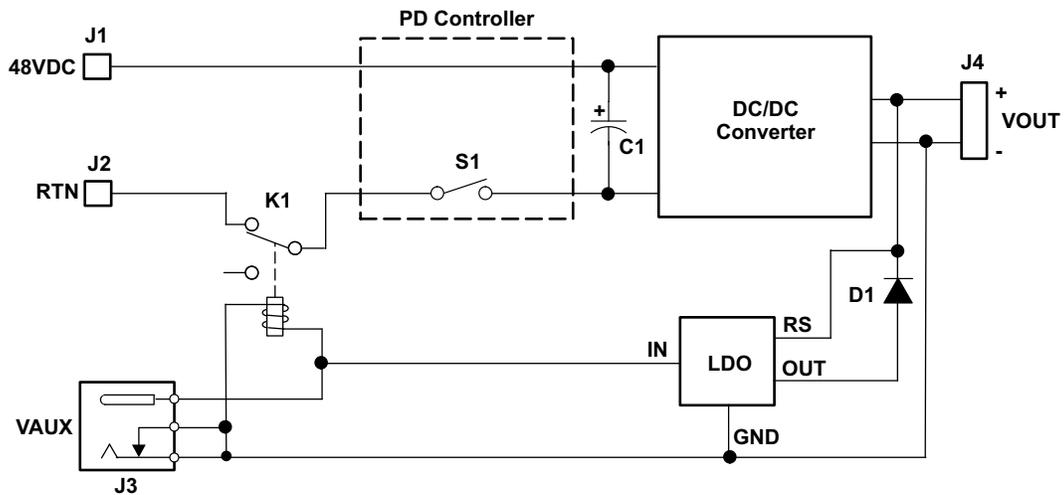


Figure 9. Automatic Power-Selector Inserts Power at Load.



**Figure 10. Automatic Power-Selector Inserts Power at the Load. An LDO is Used for Tight Load Regulation**

## 2.4 Automatic Power-Selector Design Examples

Figure 11 adds the circuit inside the dashed box to a conventional TPS23750 PD design to implement the block diagram in Figure 7. Relay K1 allows a 48-V adapter to power the PD.

Figure 12 adds the circuit inside the dashed box to a conventional TPS23750 PD design to implement the block diagram in Figure 5. Unlike the circuit in Figure 5, the circuit in Figure 11 does not use the built-in switch in the DC power jack. The power selector operates in automatic instead of manual mode with this slight modification.

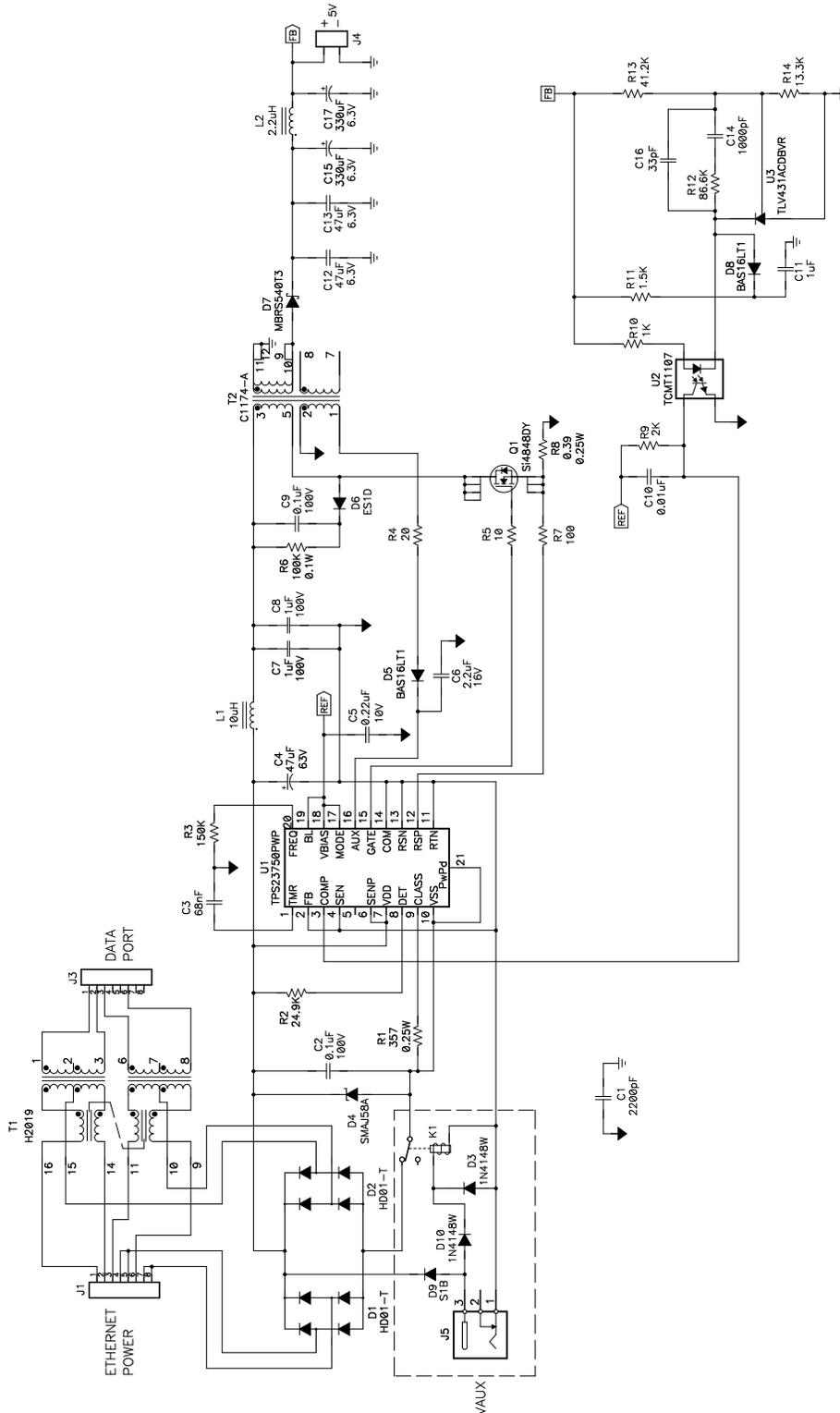


Figure 11. Automatic Power-Selector PD Design Using a Relay. Power is Inserted at PD Controller Input



### **3 Summary**

The ability to accept power from a wall adapter can add value to a powered device. This application report shows several ways to add this capability to a powered device. Low-side power insertion is shown but high-side power insertion is also possible. The PD designer should understand the electrical characteristics and the PSE behavior at the three power insertion points.

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