# LT4295, LT4321 High Efficiency IEEE 802.3bt (PoE++, Type 4, 62W/71W) PD with Flyback DC/DC Converter and Auxiliary Supply Input

## DESCRIPTION

Demonstration Circuit 2476A is an Ethernet Alliance™ Gen 2 PoE certified IEEE 802.3bt compliant power over ethernet (PoE) powered device (PD). It features the LT®4295 PD interface and switching regulator controller and the LT4321 PoE ideal diode bridge controller.

The LT4295 provides IEEE 802.3af (PoE, Type 1), IEEE 802.3at (PoE+, Type 2), and IEEE 802.3bt (PoE++, Type 3 and 4) compliant interfacing and power supply control. It utilizes an external, low $R_{DS(on)}$ (30mΩ typical) N-channel FET for the hot swap function to improve efficiency. The LT4295 controls a DC/DC converter that utilizes a highly efficient flyback topology with synchronous rectification.

The LT4321 controls eight low $R_{DS(on)}$ (30mΩ typical) N-channel FETs to further improve end-to-end power delivery efficiency and ease thermal design. This solution replaces the eight diodes typically found in a passive PoE rectifier bridge.

The DC2476A-A accepts up to 71.3W of delivered power from a power sourcing equipment (PSE) via the RJ45 connector (J1) or a local 48V DC power supply using the auxiliary supply input. When both supplies are connected, the auxiliary supply input has priority over the PoE input. The DC2476A-A supplies a 24V output at up to 2.7A as a Class 8 (71.3W) PD and up to 2.4A as a Class 7 (62W) PD application.

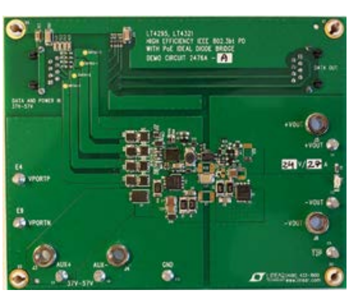
**Design files for this circuit board are available.**



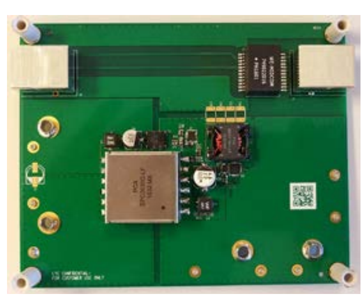
## PERFORMANCE SUMMARY

| PARAMETER | CONDITIONS | VALUE |
|---|---|---|
| Port Voltage ($V_{PORT}$) | At RJ45 | 37V to 57V |
| Auxiliary Voltage | From AUX+ to AUX– Terminals | 37V to 57V |
| Output Voltage ($V_{OUT}$) | | 24V (Typical) |
| Output Current ($I_{OUT}$) | Class 8 (Default)<br>Class 7 (R20 = 80.6Ohm, R19 = 64.9Ohm) | 2.7A (Max)<br>2.4A (Max) |
| Output Voltage Ripple | $V_{PORT}$ = 41.2V, $I_{OUT}$ = 2.7A | 200m$V_{P-P}$ (Typical) |
| Load Regulation | | 0.5% (Typical) |
| Efficiency | $V_{PORT}$ = 50V, $I_{OUT}$ = 2.7A, End-to-End | 91.5% (Typical) |
| Switching Frequency | | 250kHz (Typical) |

## BOARD PHOTO



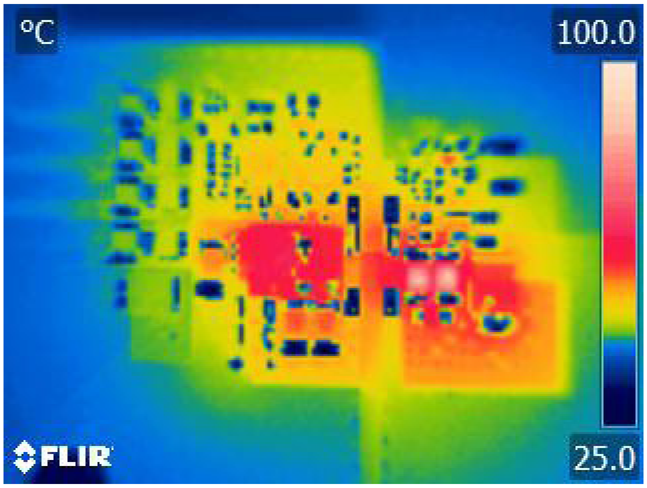
Top Side



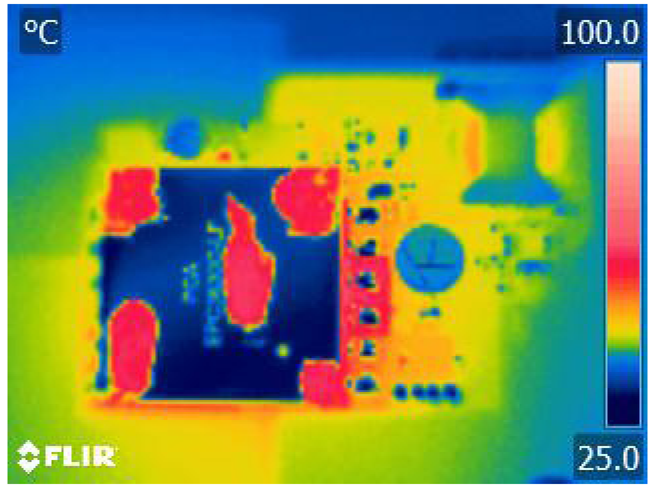
Bottom Side

EA Certified 2.0™

## TYPICAL PERFORMANCE CHARACTERISTICS




Top Side




Bottom Side

**Figure 1. Thermal Pictures (Conditions: $V_{PORT}$ = 57V, $V_{OUT}$ = 24V, $I_{OUT}$ = 2.7A)**

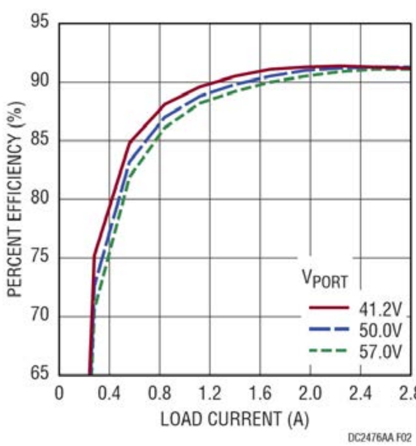



**Figure 2. Efficiency (End-to-End)**

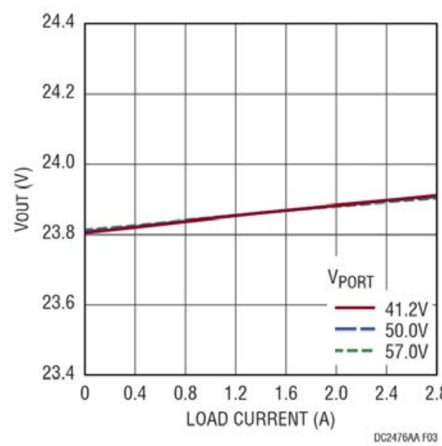



**Figure 3. Load Regulation**

# TYPICAL PERFORMANCE CHARACTERISTICS

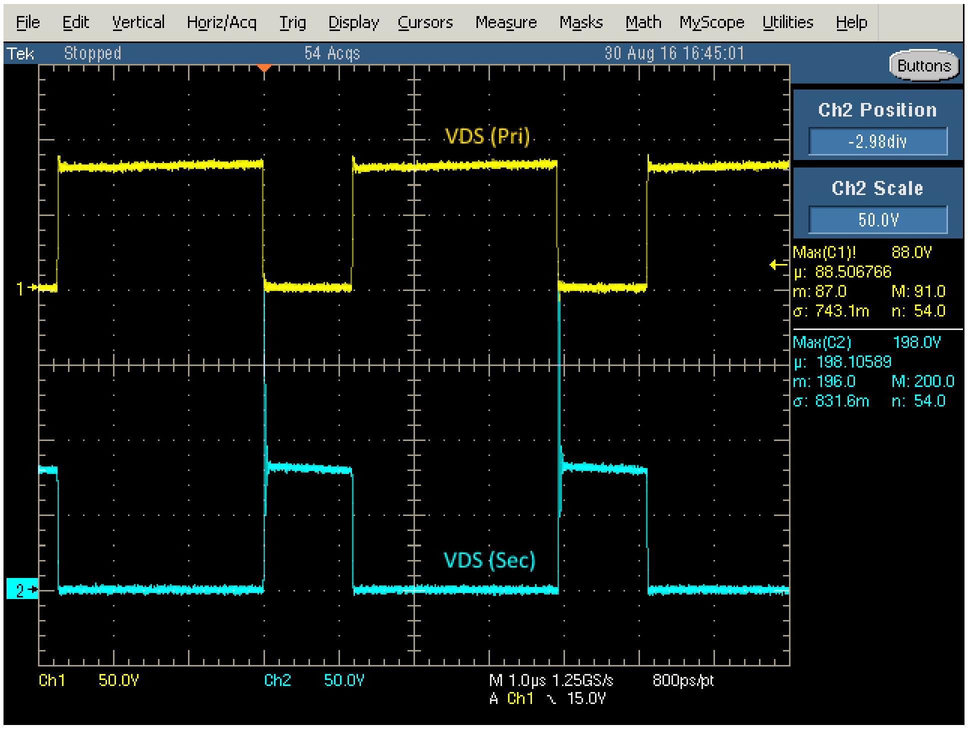



Figure 4. Switch Node Waveforms (Conditions: $V_{PORT}$ = 57V, $V_{OUT}$ = 24V, $I_{OUT}$ = 2.7A)

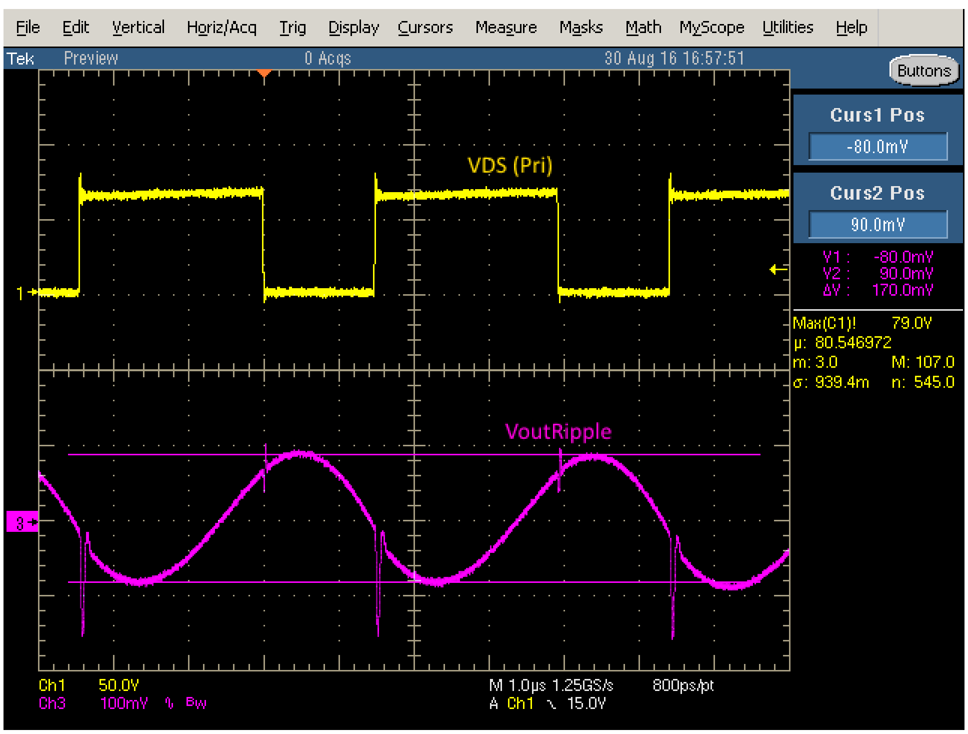



Figure 5. Output Voltage Ripple (Conditions: $V_{PORT}$ = 41.2V, $V_{OUT}$ = 24V, $I_{OUT}$ = 2.7A)

## TYPICAL PERFORMANCE CHARACTERISTICS


**Figure 6. Load Transient Response (Conditions: $V_{PORT}$ = 41.2V, Load Step: 1.35A to 2.7A to 1.35A)**

## TYPICAL PERFORMANCE CHARACTERISTICS

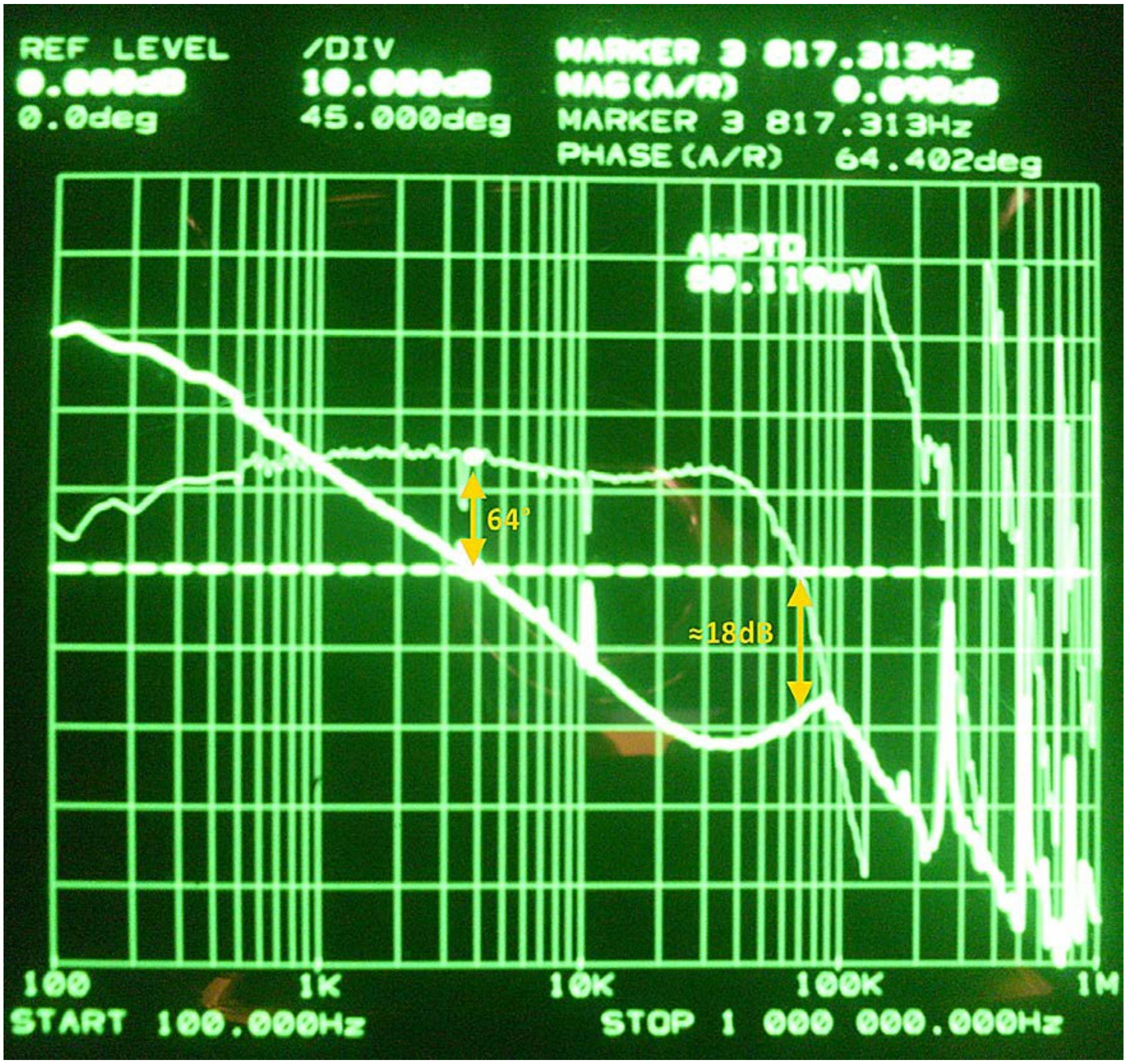



Figure 7. Gain and Phase Margin of the Flyback DC/DC Converter (Conditions: $V_{PORT}$ = 57V, $V_{OUT}$ = 24V, $I_{OUT}$ = 2.7A)

| CROSSOVER FREQUENCY | GAIN MARGIN | PHASE MARGIN |
|---|---|---|
| 3.8kHz | 18dB | 64° |

# QUICK START PROCEDURE

**Power over Ethernet (PoE) Input**

1. Disconnect auxiliary supply if it is connected to AUX+ and AUX– inputs of the DC2476A-A.
2. Place and connect test equipment (voltmeter, ammeter, oscilloscope and electronic load) as shown in Figure 8.
3. Turn down the electronic load to a minimum value and turn off the electronic load.
4. Connect the output of the IEEE 802.3bt compliant PSE to the RJ45 connector (J1) of the DC2476A using a CAT5e or CAT6 Ethernet cable. (See Note.)
5. After the LED (D4) on the DC2476A is lit, check the output voltage using a voltmeter. Output voltage should be within 24.0V ±0.3V.
6. Turn on the electronic load and increase its load current up to 2.7A. Observe the output voltage regulation, efficiency, and other parameters.
7. Verify $\overline{\text{T2P}}$ response with an oscilloscope as shown in Figure 8. The $\overline{\text{T2P}}$ response to the type of PSE connected to the DC2476A-A is provided in Table 1.

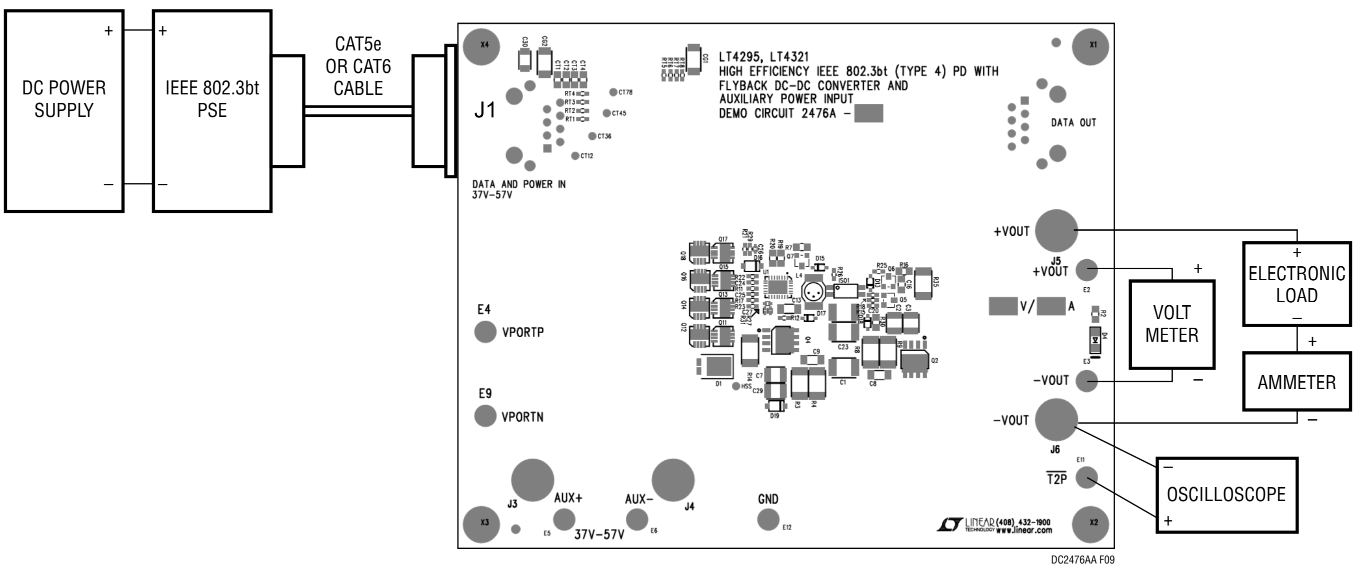



**Figure 8. Setup Diagram for PoE Input**

**Table 1. $\overline{\text{T2P}}$ Response**

| PSE | $\overline{\text{T2P}}$ Response | Negotiated PD Input Power |
|---|---|---|
| IEEE | Logic High | 13W |
| | Logic Low | 25.5W |
| | 50% Logic High/50% Logic Low, Toggle at 976Hz ±7% | 51W |
| | 75% Logic High/25% Logic Low, Toggle at 976Hz ±7% | 71.3W |
| LTPoE++, 90W | Logic Low | 71.3W |

# QUICK START PROCEDURE

### Auxiliary Supply Input

1. Place and connect test equipment (voltmeter, ammeter, oscilloscope and electronic load) as shown in Figure 9.
2. Turn down the electronic load to a minimum value and turn off the electronic load.
3. Connect the output of the auxiliary supply to the DC2476A as shown in Figure 9. Turn on the auxiliary supply and set its current limit to 2A. Then increase its output voltage to 48V.
4. Once the LED (D4) on the DC2476A is lit, check the output voltage using a voltmeter. Output voltage should be within 24.0V ±0.3V.
5. Turn on the electronic load and increase its load current up to 2.7A. Observe the output voltage regulation, efficiency, and other parameters.
6. Verify $\overline{T2P}$ response with an oscilloscope as shown in Figure 9. The $\overline{T2P}$ response during auxiliary power operation is: 75% Logic High/25% Logic Low, Toggle at 976Hz ±7%.

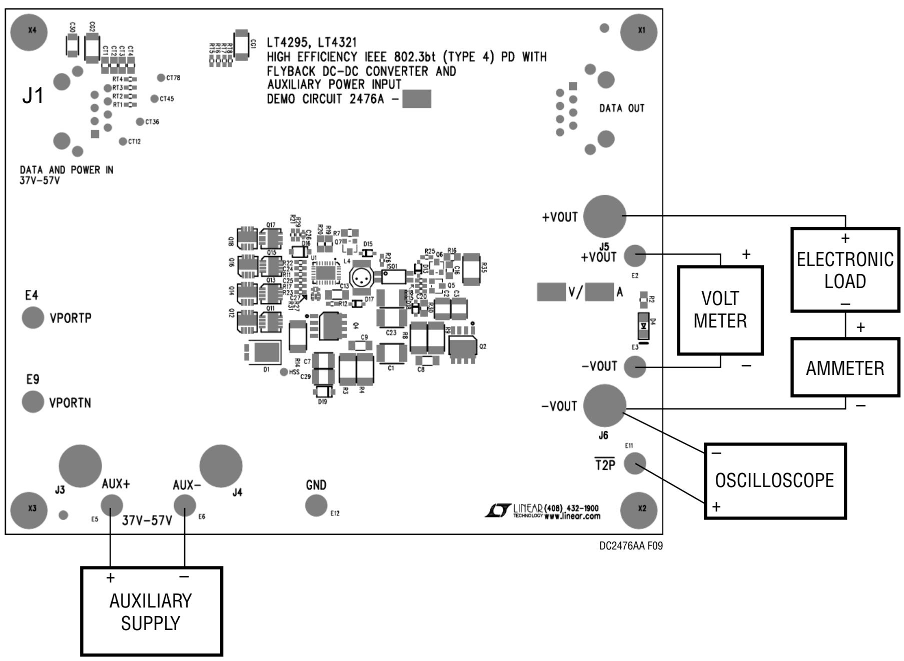
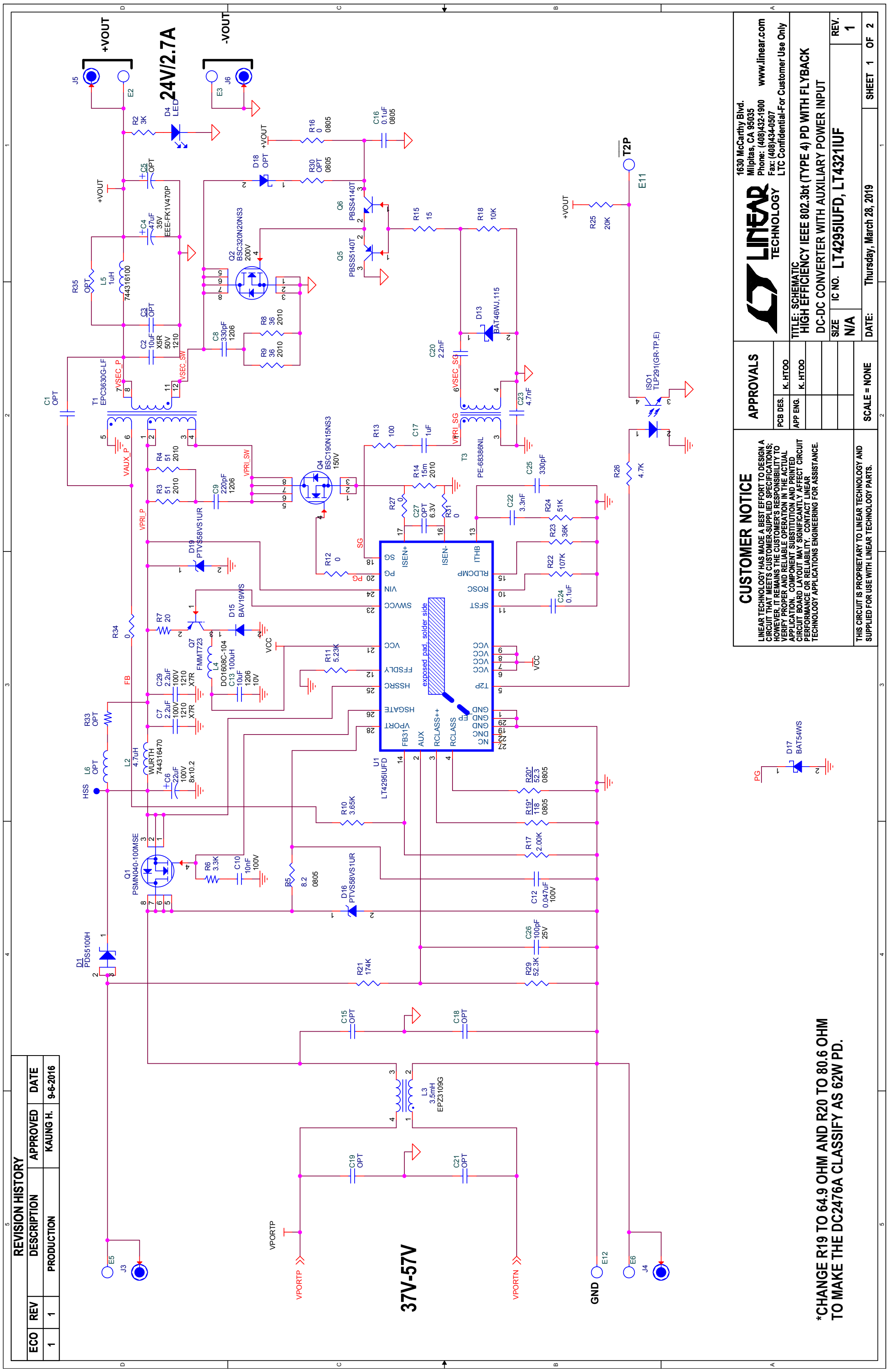
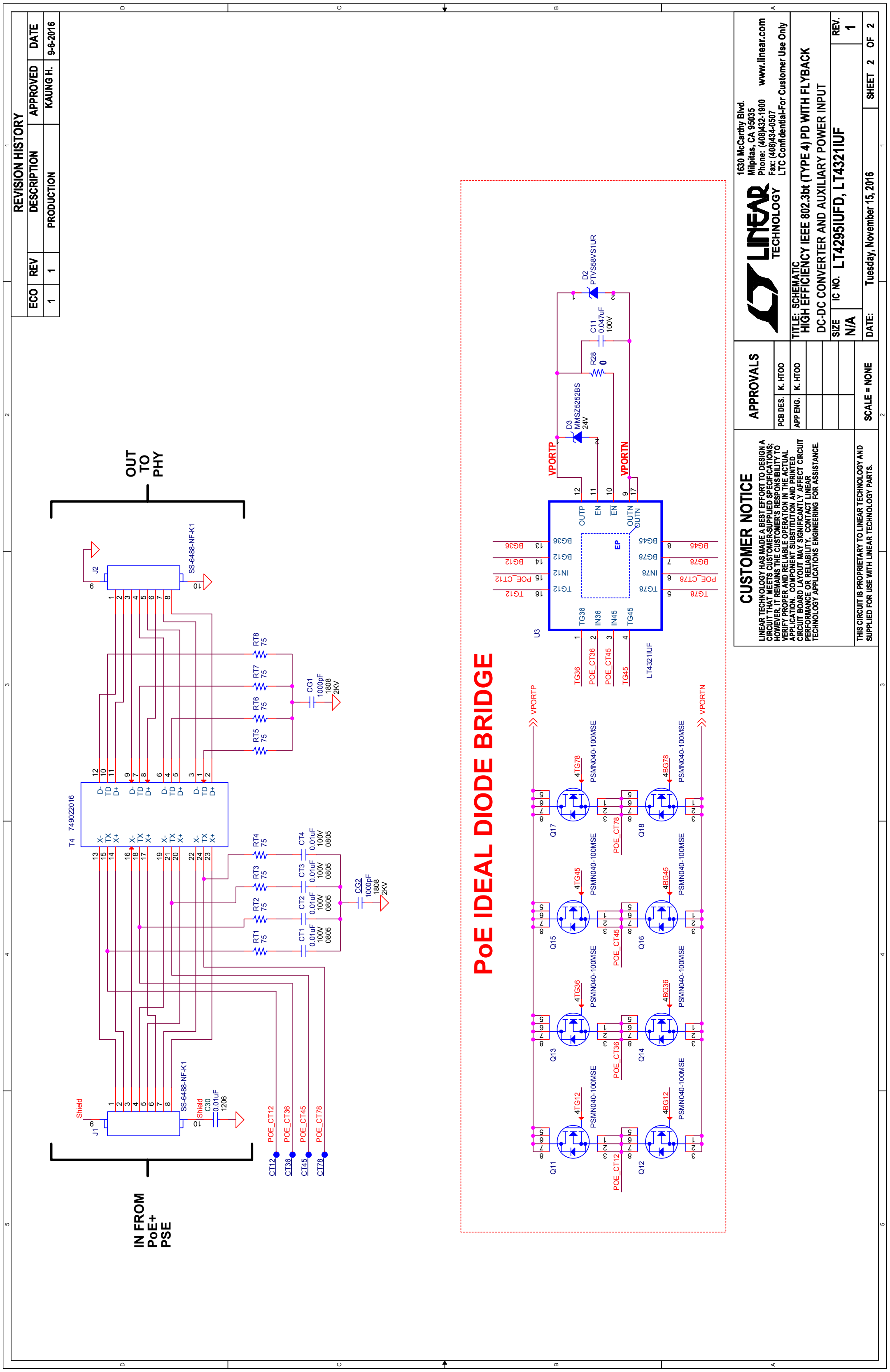



**Figure 9. Setup Diagram for Auxiliary Supply Input**

# SCHEMATIC DIAGRAM



# SCHEMATIC DIAGRAM



**ESD Caution**

**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

**Legal Terms and Conditions**

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NONINFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS ($100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.