# LT4276, LT4321
# PoE PD with Synchronous Flyback and Ideal Diode Bridge

## DESCRIPTION

Demonstration circuit 2046A-F is an Ethernet Alliance™ certified PoE Powered Device (PD) with an isolated power supply using synchronous flyback topology, featuring the LT®4276 and ideal diode bridge controller (LT4321).

The LT4276 provides IEEE802.3af (PoE, Type 1), IEEE802.3at (PoE+, Type 2), and LTPoE++™ PD interfacing and power supply control. When the PD is fully powered, the PD interface switches power over from the Power Sourcing Equipment (PSE) to the switcher through an external, low resistance, high power N-channel FET. The highly integrated LT4276 controls a high power, small-sized power supply that utilizes a highly efficient flyback topology with synchronous rectification. The LT4321 provides further efficiency improvement by minimizing the bridge losses.

The DC2046A-F supplies a 5V output at up to 2.3A. It also demonstrates the use of an optional auxiliary power supply input of 48V. When present, the auxiliary supply becomes the dominant supply over PoE to provide power.

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

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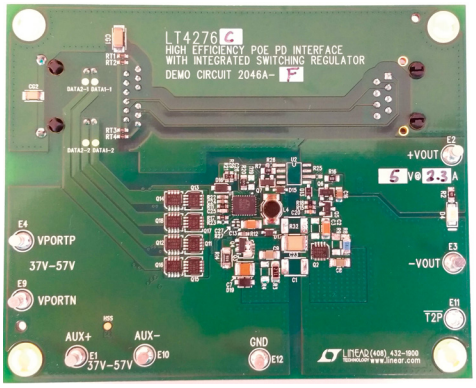
## PERFORMANCE SUMMARY

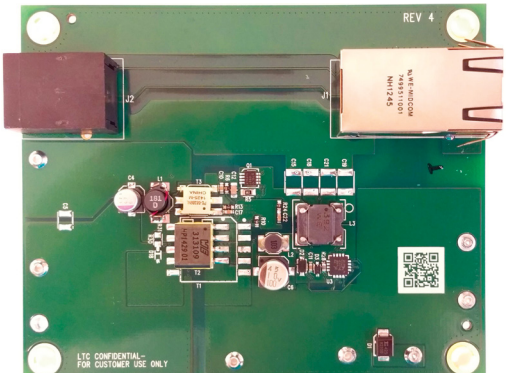
**Specifications are at $T_A$ = 25°C**

| PARAMETER | CONDITIONS | VALUE |
|---|---|---|
| Port Voltage ($V_{PORT}$) | At Ethernet Port | 37V to 57V |
| Auxiliary Voltage | From AUX+ to AUX– Terminals | 37V to 57V |
| Output Voltage | | 5V (Typ) |
| Output Current | | 2.3A (Max) |
| Output Voltage Ripple | $V_{PORT}$ = 37V, $I_{OUT}$ = 2.3A | 30m$V_{P-P}$ (Typ) |
| Output Regulation | | ±0.2% (Typ) |
| Efficiency | $V_{PORT}$ = 48V, $I_{OUT}$ = 2.3A, End to End | 90% (Typ) |
| Switching Frequency | | 250kHz (Typ) |

## BOARD PHOTOS



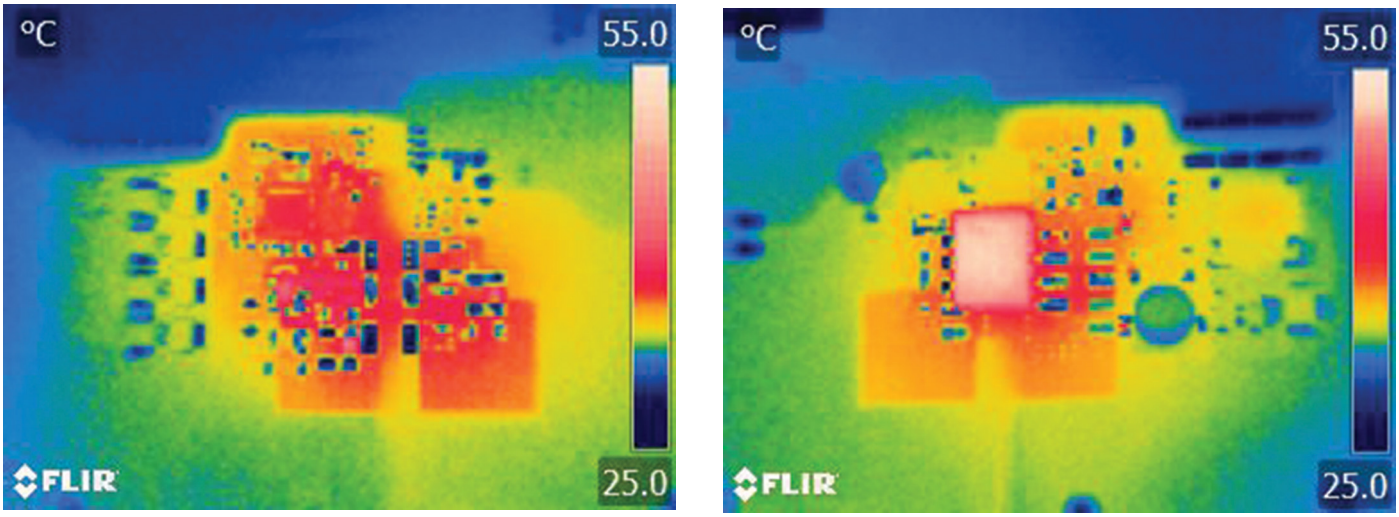

Top Side




Bottom Side

EA Certified™

## TYPICAL PERFORMANCE CHARACTERISTICS




**Top Side** **Bottom Side**

**Figure 1. Thermal Pictures – $V_{PORT}$ = 57V, 5V/2.3A**

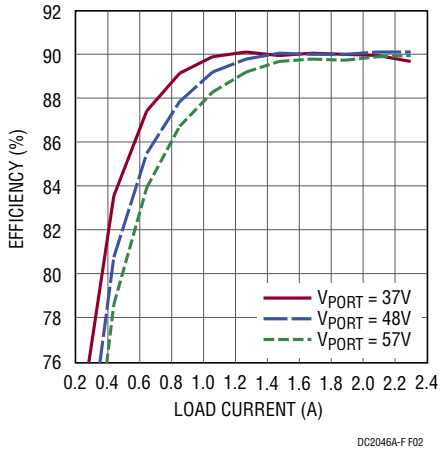



**Figure 2. Efficiency (End to End)**

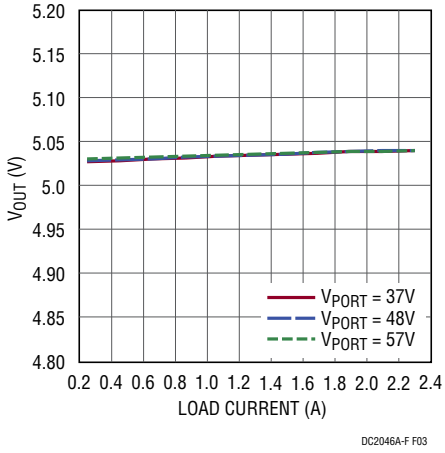



**Figure 3. Output Voltage Regulation**

## TYPICAL PERFORMANCE CHARACTERISTICS

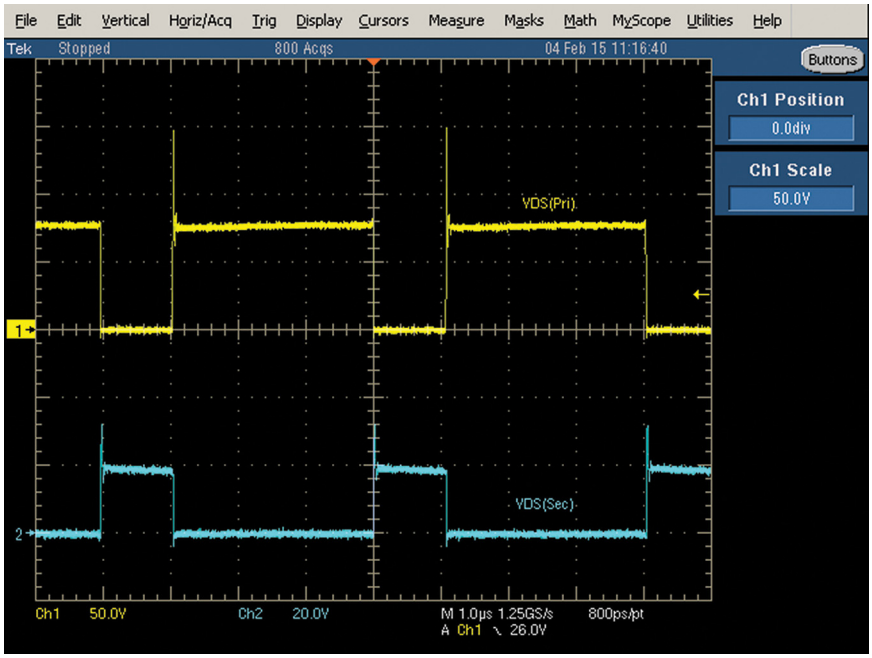



**Figure 4. Stresses ($V_{PORT}$ = 57V, 5V/2.3A)**

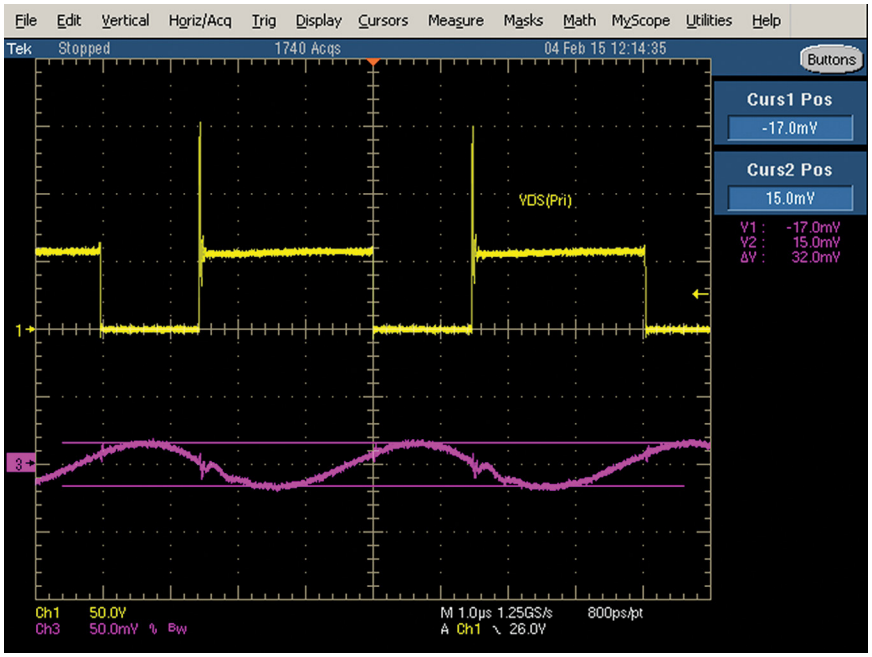



**Figure 5. Output Voltage Ripple ($V_{PORT}$ = 37V, 5V/2.3A)**

## TYPICAL PERFORMANCE CHARACTERISTICS

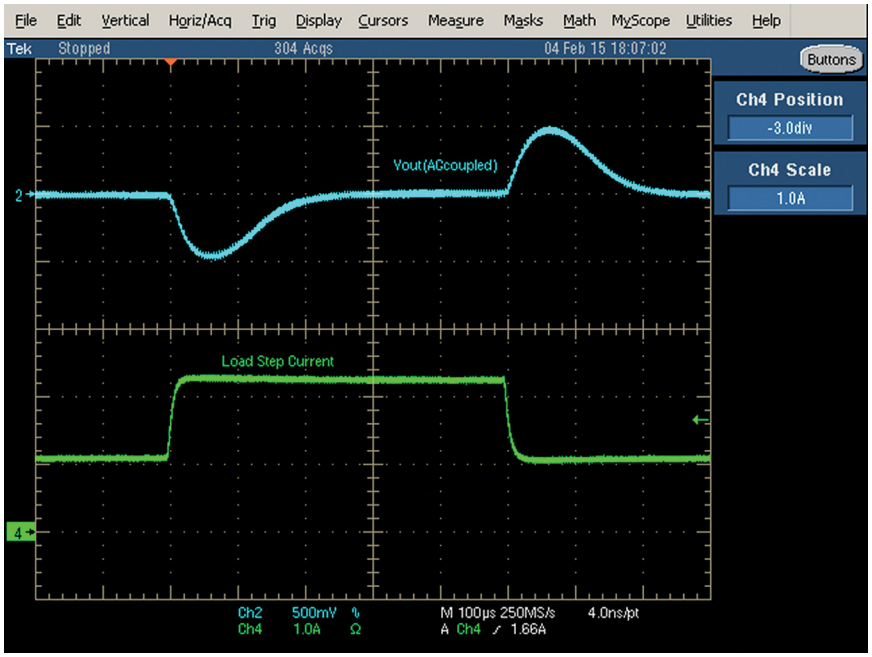



**Figure 6. Load Transient Response ($V_{PORT}$ = 37V, 1.15A to 2.3A to 1.15A)**

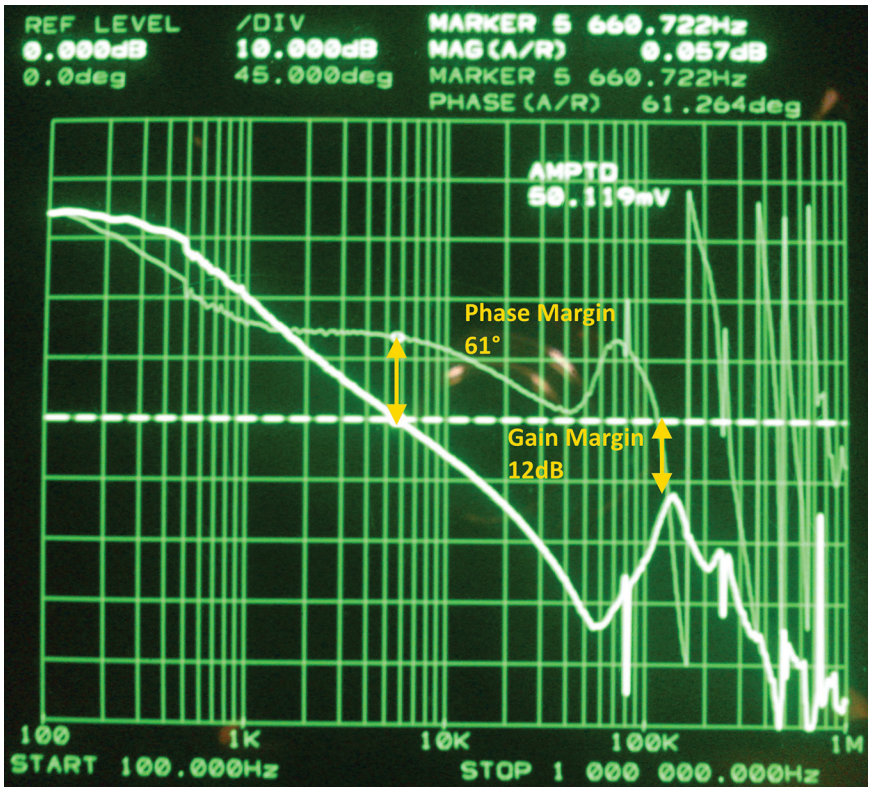



**Figure 7. Gain and Phase Margin of the Flyback Loop ($V_{PORT}$ = 37V, 5V/0.23A)**

## QUICK START PROCEDURE

Demonstration circuit 2046A-F is easy to set up to evaluate the performance of the LT4276 in a PoE+ application. Refer to Figure 8 for proper equipment setup and follow the procedure below.

**NOTE**: When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the output voltage ripple by touching the probe tip and probe ground directly across the +VOUT and –VOUT terminals. See Figure 9 for proper scope probe technique.

1. Place test equipment (voltmeter, ammeter, power supplies, and electronic load) as shown in Figure 8.
2. Input supplies:
   A) Connect a PoE+ capable PSE with a CAT-5 cable to the RJ45 connector, J1. See Figure 8.
   B) Or, connect a 37V to 57V capable power supply (Power Supply in Figure 8) across $V_{PORTP}$ and $V_{PORTN}$.
   C) If evaluating the auxiliary power supply (Auxiliary Supply in Figure 8), connect a 37V to 57V capable power supply across AUX+ to AUX–.
3. Check for the proper output voltage of 5V.
4. Once the proper output voltage is confirmed, adjust the load within the operating range and observe the output voltage regulation, ripple voltage, efficiency, and other parameters.

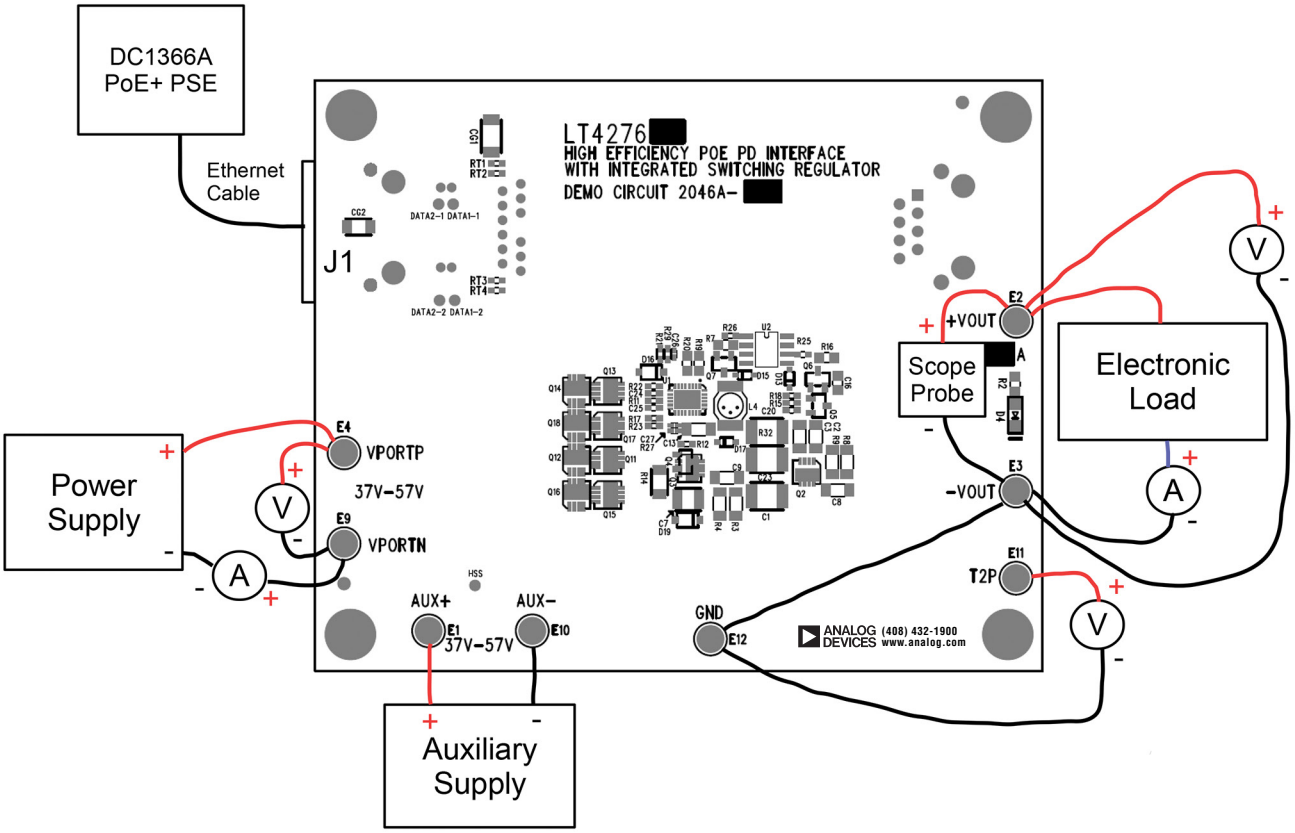



**Figure 8. Proper Measurement Equipment Setup**

## QUICK START PROCEDURE

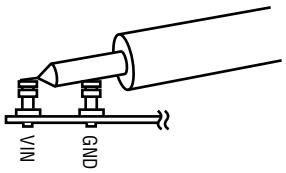



**Figure 9. Measuring Output Ripple**

## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURE/PART # |
|---|---|---|---|---|
| **DC2046A General BOM** | | | | |
| 1 | 1 | CG1 | Cap, Cer, X7R 1000pF 2KV 10% 1808 | Murata GR442QR73D102KW01L |
| 2 | 1 | CG2 | Cap, Cer, X7R 0.01µF 100V 20% 1206 | AVX 12061C103AT2A |
| 3 | 0 | C1 | Cap, Cer, Opt 2kV 1812 | Opt |
| 4 | 0 | C5 | Cap, Cer, X7U Opt 6.3V 10% 1210 | Opt |
| 5 | 1 | C6 | Cap, Elec, 10µF 100V 10% 6.3x7.7 | SunCon 100CE10BS |
| 6 | 1 | C7 | Cap, Cer, X7R 2.2µF 100V 10% 1210 | Murata GRM32ER72A225KA35 |
| 7 | 1 | C10 | Cap, Cer, X7R 10nF 100V 20% 0603 | Murata GRM188R72A103KA01D |
| 8 | 1 | C11 | Cap, Cer, X7R 0.047µF 100V 20% 0603 | Kemet C0603C473M1RACTU |
| 9 | 1 | C12 | Cap, Cer, X7R 0.047µF 100V 10% 0805 | Murata GRM21BR72A473KA01L |
| 10 | 1 | C13 | Cap, Cer, X7R 10µF 10V 10% 1206 | Murata GRM31CR71A106KA01L |
| 11 | 0 | C15, C18, C19, C21 | Cap, Cer, X5R Opt 2kV 20% 1812 | Opt |
| 12 | 1 | C17 | Cap, Cer, X7R 1µF 25V 10% 0603 | Murata GRM188R71E105KA12 |
| 13 | 1 | C20 | Cap, Cer, X7R 2.2nF 25V 10% 0603 | Murata GRM188R71E222KA01 |
| 14 | 1 | C23 | Cap, Cer, X7R 4.7nF 2kV 10% 1812 | Murata GR443DR73D472KW01L |
| 15 | 1 | C26 | Cap, Cer, X5R 100pF 16V 10% 0402 | AVX 0402YC101KAT2A |
| 16 | 0 | C27 | Cap, Cer, X7R Opt 6.3V 10% 0402 | Opt |
| 17 | 1 | D1 | Diode, Schottky, B2100 100V SMB | Diodes Inc. B2100-13-F |
| 18 | 1 | D2 | Diode, TVS, PTVS58VS1UR 58V SOD123 | NXP PTVS58VS1UR |
| 19 | 1 | D3 | Diode, Zener, MMSZ5252BS 24V SOD323 | Diodes Inc. MMSZ5252BS |
| 20 | 1 | D4 | Diode, Led Green | ROHM SML-010FTT86L |
| 21 | 1 | D13 | Diode, Schottky, NXP, BAT46W 100V SOD323 | NXP BAT46WJ,115 |
| 22 | 1 | D15 | Diode, Diodes Inc., BAV19WS 120V SOD323 | Diodes Inc. BAV19WS |
| 23 | 1 | D16 | Diode, TVS, PTVS58VS1UR 58V SOD123 | NXP PTVS58VS1UR |
| 24 | 1 | D17 | Diode, Schottky, BAT54WS 30V SOD323 | Diodes Inc. BAT54WS |
| 25 | 1 | D19 | Diode, TVS, PTVS58VS1UR 58V SOD123 | NXP PTVS58VS1UR |
| 26 | 7 | E1, E2, E3, E4, E9, E10, E12 | TP, Turret, PAD150-094 0.094 | Mill-Max 2501-2-00-80-00-00-07-0 |
| 27 | 1 | J1 | Conn, Integrated Jack, 7499511001 | Würth 7499511001 |
| 28 | 1 | J2 | Conn, RJ45 Jack, SS-6488-NF-K1 | Stewart Connector SS-6488-NF-K1<br>Alternate: SS-6488S-A-NF |
| 29 | 1 | L2 | Ind, 10µH | Coilcraft DO1608C-103 |
| 30 | 1 | L4 | Ind, 100µH | Coilcraft DO1608C-104 |
| 31 | 9 | Q1, Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18 | MOSFET, N-CH, PSMN075-100MSE 100V LFPAK33 | NXP PSMN075-100MSE |
| 32 | 1 | Q5 | Tran, PNP, MMBT3906 40V SOT23 | Fairchild MMBT3906 |
| 33 | 1 | Q6 | Tran, NPN, MMBT3904 40V SOT23 | Fairchild MMBT3904 |
| 34 | 1 | Q7 | Tran, PNP, FMMT723 100V SOT23 | Diodes Inc. FMMT723TA |
| 34 | 0 | Q7 (Alternate) | Tran, PNP, PBSS9110T 100V SOT23 | NXP PBSS9110T |

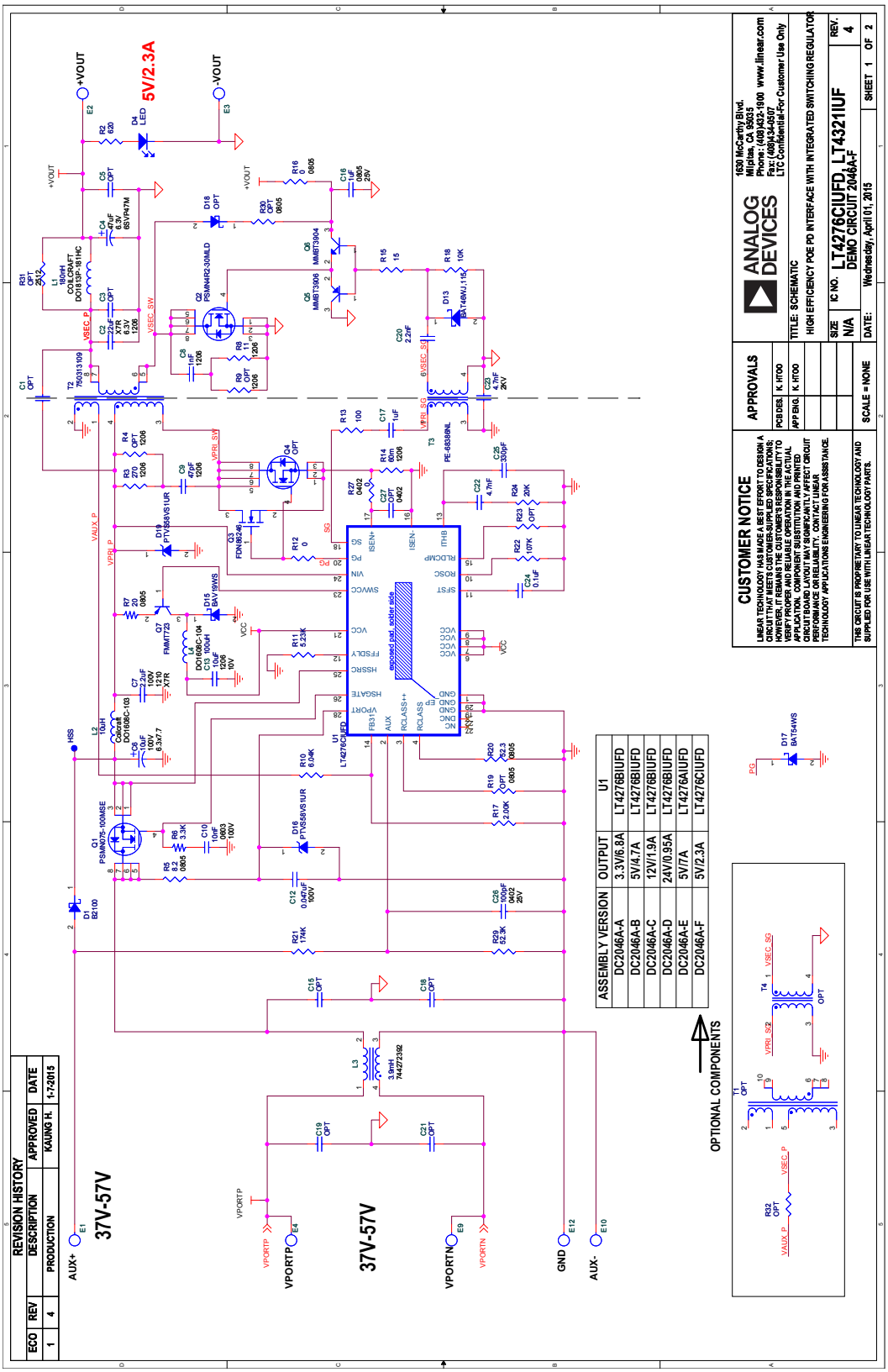
## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURE/PART # |
|---|---|---|---|---|
| 35 | 4 | RT1, RT2, RT3, RT4 | Res, Chip, 75Ω 5% 0603 | NIC NRC06J750TRF |
| 36 | 1 | R5 | Res, Chip, 8.2Ω 5% 0805 | NIC NRC10J8R2TRF |
| 37 | 1 | R6 | Res, Chip, 3.3k 5% 0603 | NIC NRC06J332TRF |
| 38 | 1 | R7 | Res, Chip, 20Ω 5% 0805 | Vishay CRCW080520R0JNEA |
| 39 | 1 | R12 | Res, Chip, 0Ω 5% 0603 | NIC NRC06ZOTRF |
| 40 | 1 | R13 | Res, Chip, 100Ω 5% 0603 | Vishay CRCW0603100RFKEA |
| 41 | 1 | R15 | Res, Chip, 15Ω 5% 0603 | NIC NRC06J150TRF |
| 42 | 1 | R17 | Res, Chip, 2.00k 1% 0603 | NIC NRC06F2001TRF |
| 43 | 1 | R18 | Res, Chip, 10k 5% 0603 | Yageo RC0603JR-0710KL |
| 44 | 1 | R21 | Res, Chip, 174k 1% 0603 | Vishay CRCW0603174KFKEA |
| 45 | 1 | R22 | Res, Chip, 107k 1% 0603 | NIC NRC06F1073TRF |
| 46 | 1 | R27 | Res, Chip, 0Ω 5% 0402 | NIC NRC04ZOTRF |
| 47 | 1 | R28 | Res, Chip, 0Ω 5% 0603 | NIC NRC06ZOTRF |
| 48 | 1 | R29 | Res, Chip, 52.3k 1% 0603 | Vishay CRCW060352K3FKEA |
| 49 | 0 | R32 | Res, Chip, Opt 5% 1812 | Opt |
| 50 | 1 | T3 | XFMR, SMD Gate Drive, PE-68386NL | Pulse PE-68386NL |
| 50 | 0 | T3 (Alternate) | XFMR, SMD Gate Drive, EPA4271GE | PCA EPA4271GE |
| 51 | 0 | T4 | XFMR, SMD Gate Drive, Opt | Opt |
| 52 | 1 | U3 | IC, PoE Ideal Bridge Controller, LT4321IUF QFN16 | Analog Devices LT4321IUF |
| **DC2046A-F BOM** | | | | |
| 1 | 1 | C2 | Cap, Cer, X7R 22µF 6.3V 10% 1206 | Murata GRM31CR70J226KE19 |
| 2 | 0 | C3 | Cap, Cer, Opt | Opt |
| 3 | 1 | C4 | Cap, Elec, 47µF 6.3V 20% 5.0X5.3 | Panasonic 6SVP47M |
| 4 | 1 | C8 | Cap, Cer, U2J 1nF 630V 5% 1206 | Murata GRM31A7U2J102JW31 |
| 5 | 1 | C9 | Cap, Cer, U2J 47pF 630V 5% 1206 | Murata GRM31A7U2J470JW31 |
| 6 | 1 | C16 | Cap, Cer, X7R 1µF 25V 10% 0805 | Murata GRM21BR71E105KA99L |
| 7 | 1 | C22 | Cap, Cer, X7R 4.7nF 25V 10% 0603 | Murata GRM18871E472KA01D |
| 8 | 1 | C24 | Cap, Cer, X7R 0.1uF 25V 20% 0603 | Murata GRM188R71E104KA01D |
| 9 | 1 | C25 | Cap, Cer, X7R 330pF 25V 10% 0603 | AVX 06031C331KAZ2A |
| 10 | 0 | D18 | Diode, Diodes Inc., Opt 40V SOD323 | Diodes Inc. Opt |
| 11 | 0 | E11 | TP, Turret, Opt 0.094" | Opt |
| 12 | 1 | L1 | Ind, 180nH | Coilcraft DO1813P-181HC |
| 13 | 1 | L3 | Ind, CMC, 3.9mH | Würth 744272392 |
| 14 | 1 | Q2 | MOSFET, N-CH, PSMN4R2-30MLD 30V LFPAK33 | NXP PSMN4R2-30MLD |
| 15 | 1 | Q3 | MOSFET, N-CH, FDN86246 100V SOT23 | Fairchild FDN86246 |
| 16 | 0 | Q4 | MOSFET, N-CH, Opt | Opt |
| 17 | 1 | R2 | Res, Chip, 620Ω 5% 0805 | NIC NRC10J621TRF |
| 18 | 1 | R3 | Res, Chip, 270Ω 5% 1206 | NIC NRC12J271TRF |
| 19 | 0 | R4 | Res, Chip, Opt | Opt |
| 20 | 1 | R8 | Res, Chip, 11Ω 5% 1206 | Vishay CRCW120611R0JNEA |

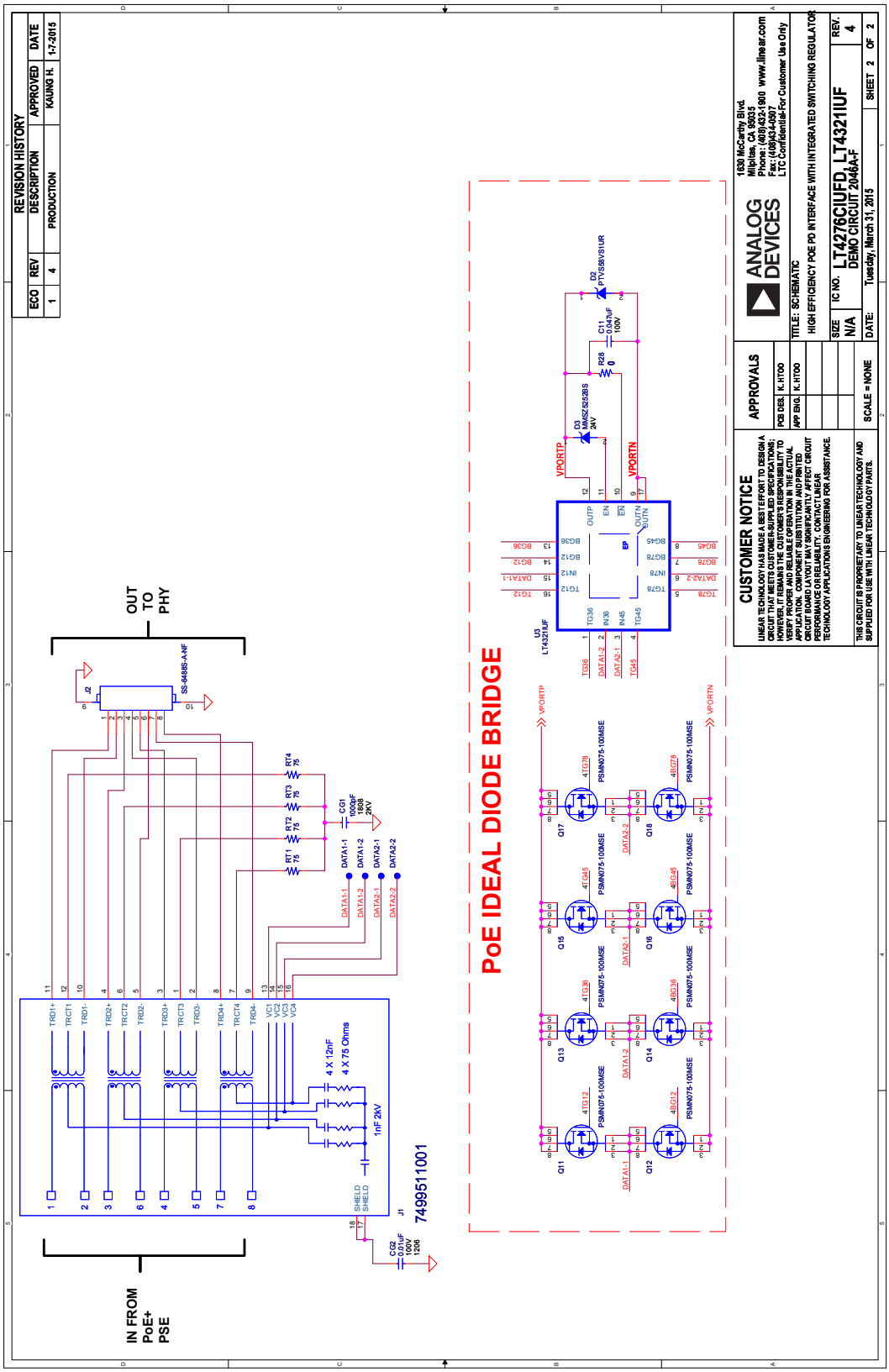
## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURE/PART # |
|---|---|---|---|---|
| 21 | 0 | R9 | Res, Chip, Opt 5% 1206 | Opt |
| 22 | 1 | R10 | Res, Chip, 6.04k 1% 0603 | Vishay CRCW06036K04FKEA |
| 23 | 1 | R11 | Res, Chip, 5.23k 1% 0603 | Vishay CRCW06035K23FKEA |
| 24 | 1 | R14 | Res, Chip, 60mΩ 1% 1206 | Vishay WSL1206R0600FEA |
| 25 | 1 | R16 | Res, Chip, 0Ω, Shunt, 0805 | Vishay CRCW08050000Z0EA |
| 26 | 0 | R19 | Res, Chip, Opt 1% 0805 | Opt |
| 27 | 1 | R20 | Res, Chip, 52.3Ω 1% 0805 | Vishay CRCW080552R3FKEA |
| 28 | 0 | R23 | Res, Chip, Opt 5% 0603 | Opt |
| 29 | 1 | R24 | Res, Chip, 20k 5% 0603 | TBD CRCW060320K0FKEA |
| 30 | 0 | R25 | Res, Chip, Opt 5% 0603 | Opt |
| 31 | 0 | R26 | Res, Chip, Opt 5% 0603 | Opt |
| 32 | 0 | R30 | Res, Chip, Opt 5% 0805 | Opt |
| 33 | 0 | R31 | Res, Chip, Opt, Shunt, 2512 | Opt |
| 34 | 0 | T1 | XFMR, Flyback Tran, Opt | Opt |
| 35 | 1 | T2 | XFMR, Flyback Tran, 750313109 | Würth 750313109 |
| 36 | 1 | U1 | IC, PD & Switcher Controller, LT4276CIUFD QFN28 | Analog Devices LT4276CIUFD |
| 37 | 0 | U2 | Opto, Opt SO8 | Fairchild MOC207M |
| 38 | 1 | | Fab, Printed Circuit Board | Demo Circuit 2046A |

## SCHEMATIC DIAGRAM



# SCHEMATIC DIAGRAM



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