

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 IEEE 802.3bt (Draft 2.2) 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 $R_{DS(on)}$ (30m Ω 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 $R_{DS(on)}$ (30m Ω 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 71W 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.

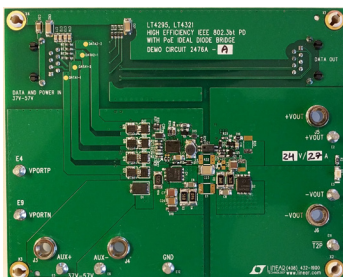
Design files for this circuit board are available at <http://www.linear.com/demo/DC2476A-A>

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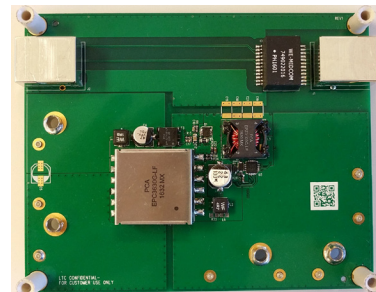
PERFORMANCE SUMMARY

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})		2.7A (Max)
Output Voltage Ripple	$V_{PORT} = 41.2V, I_{OUT} = 2.7A$	200mV _{P-P} (Typical)
Load Regulation		0.5% (Typical)
Efficiency	$V_{PORT} = 50V, I_{OUT} = 2.7A, \text{End-to-End}$	91.5% (Typical)
Switching Frequency		250kHz (Typical)

BOARD PHOTO



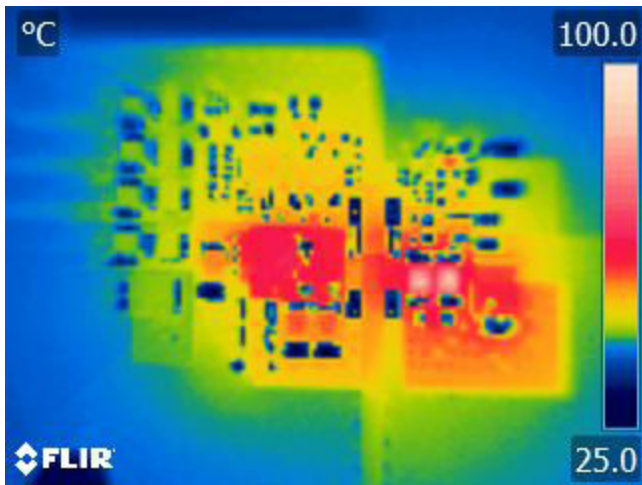
Top Side



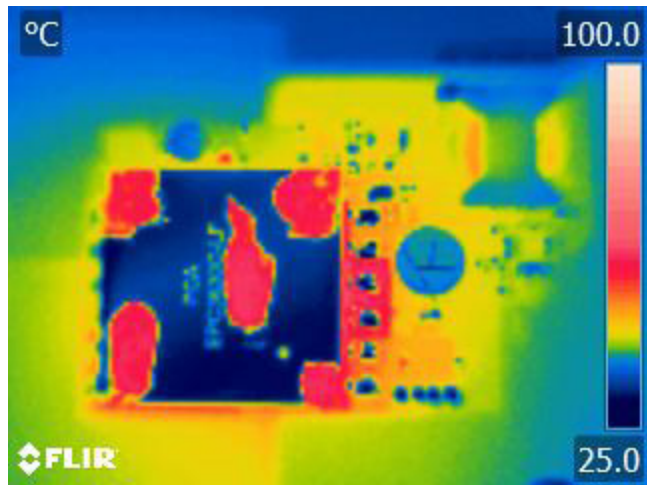
Bottom Side

dc2476aaf

TYPICAL PERFORMANCE CHARACTERISTICS



Top Side



Bottom Side

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

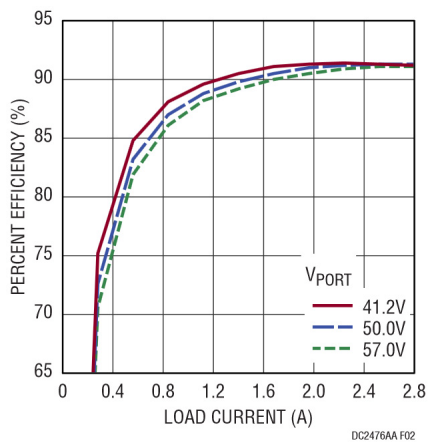


Figure 2. Efficiency (End-to-End)

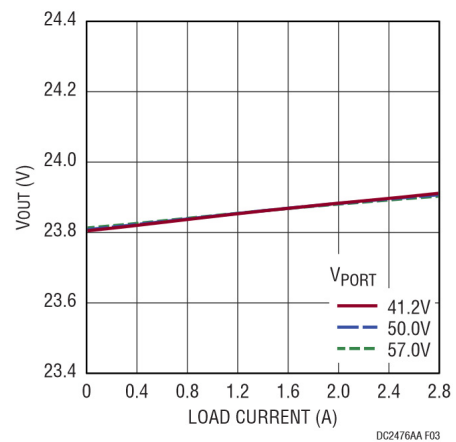


Figure 3. Load Regulation

TYPICAL PERFORMANCE CHARACTERISTICS

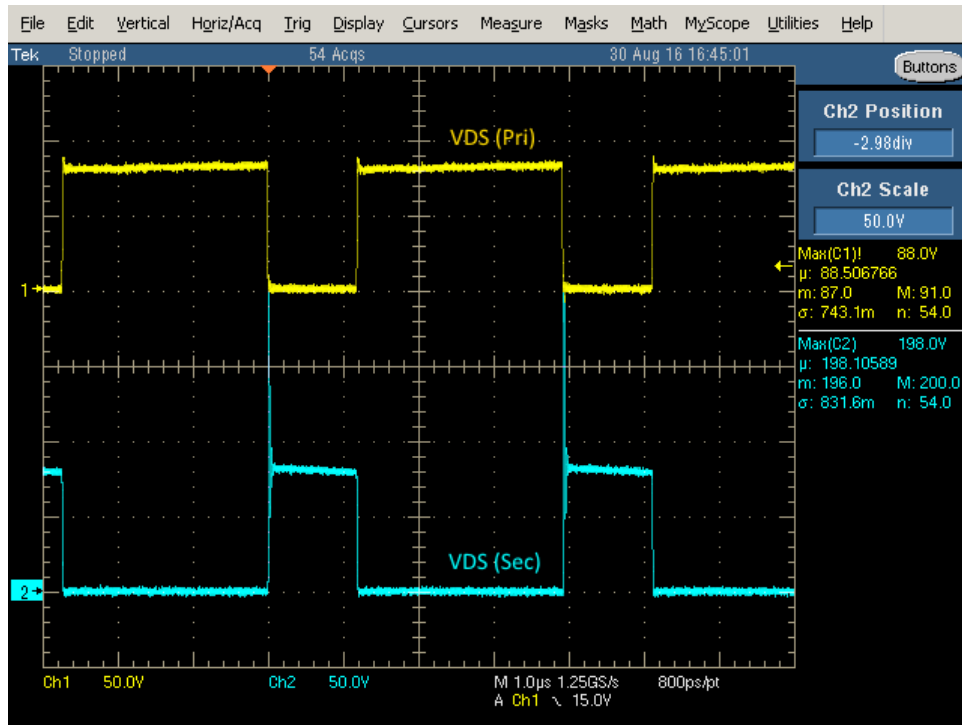


Figure 4. Switch Node Waveforms (Conditions: $V_{PORT} = 57V$, $V_{OUT} = 24V$, $I_{OUT} = 2.7A$)

TYPICAL PERFORMANCE CHARACTERISTICS

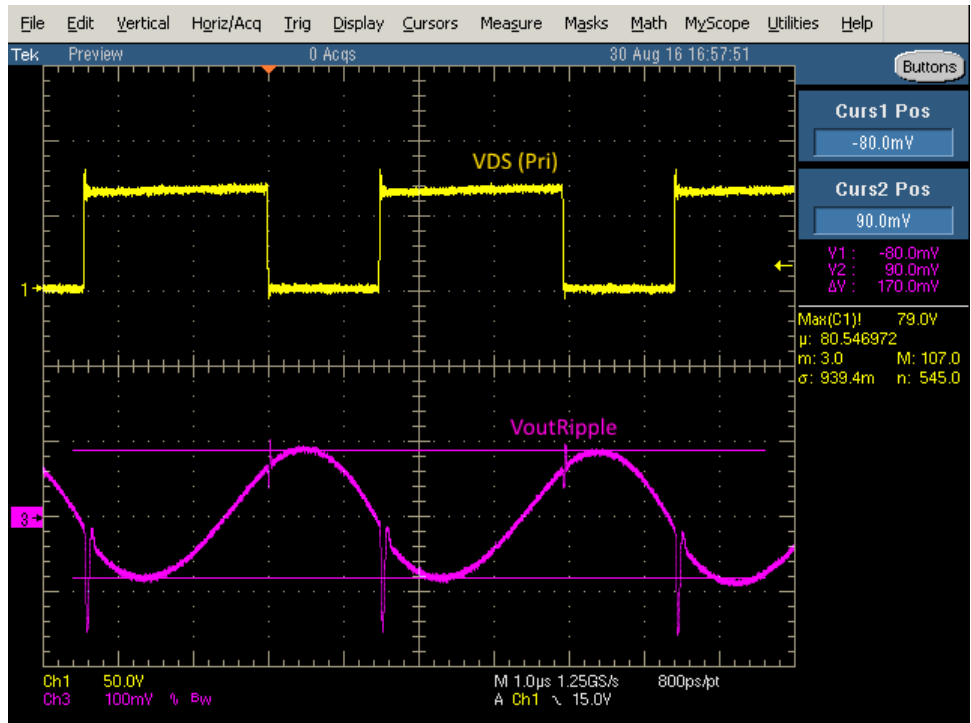


Figure 5. Output Voltage Ripple (Conditions: $V_{PORT} = 41.2V$, $V_{OUT} = 24V$, $I_{OUT} = 2.7A$)

TYPICAL PERFORMANCE CHARACTERISTICS

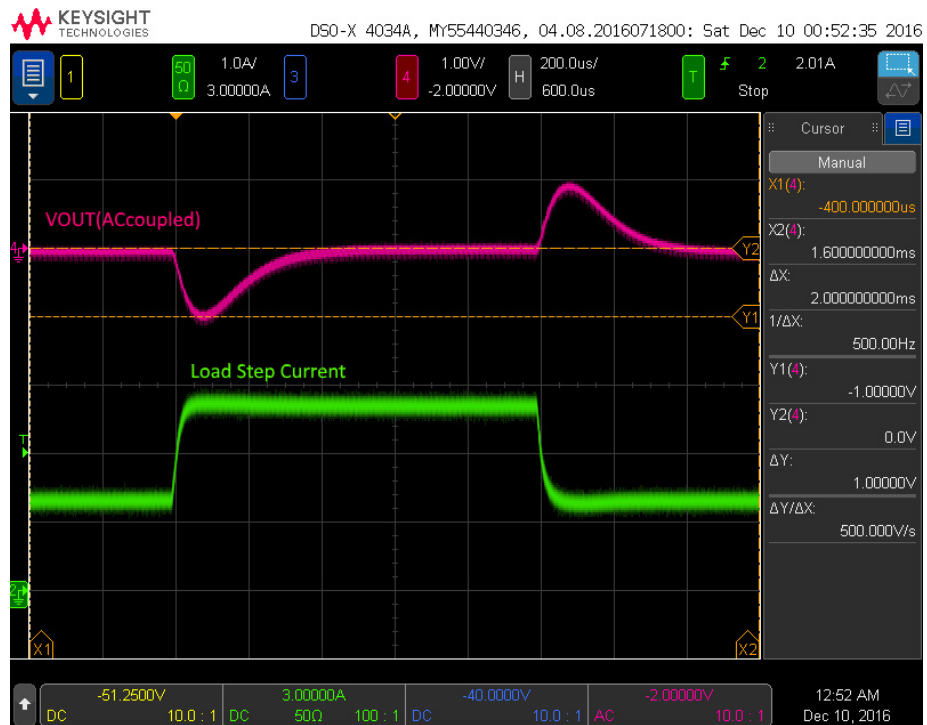


Figure 6. Load Transient Response (Conditions: $V_{PORT} = 41.2V$, Load Step: 1.35A to 2.7A to 1.35A)

TYPICAL PERFORMANCE CHARACTERISTICS

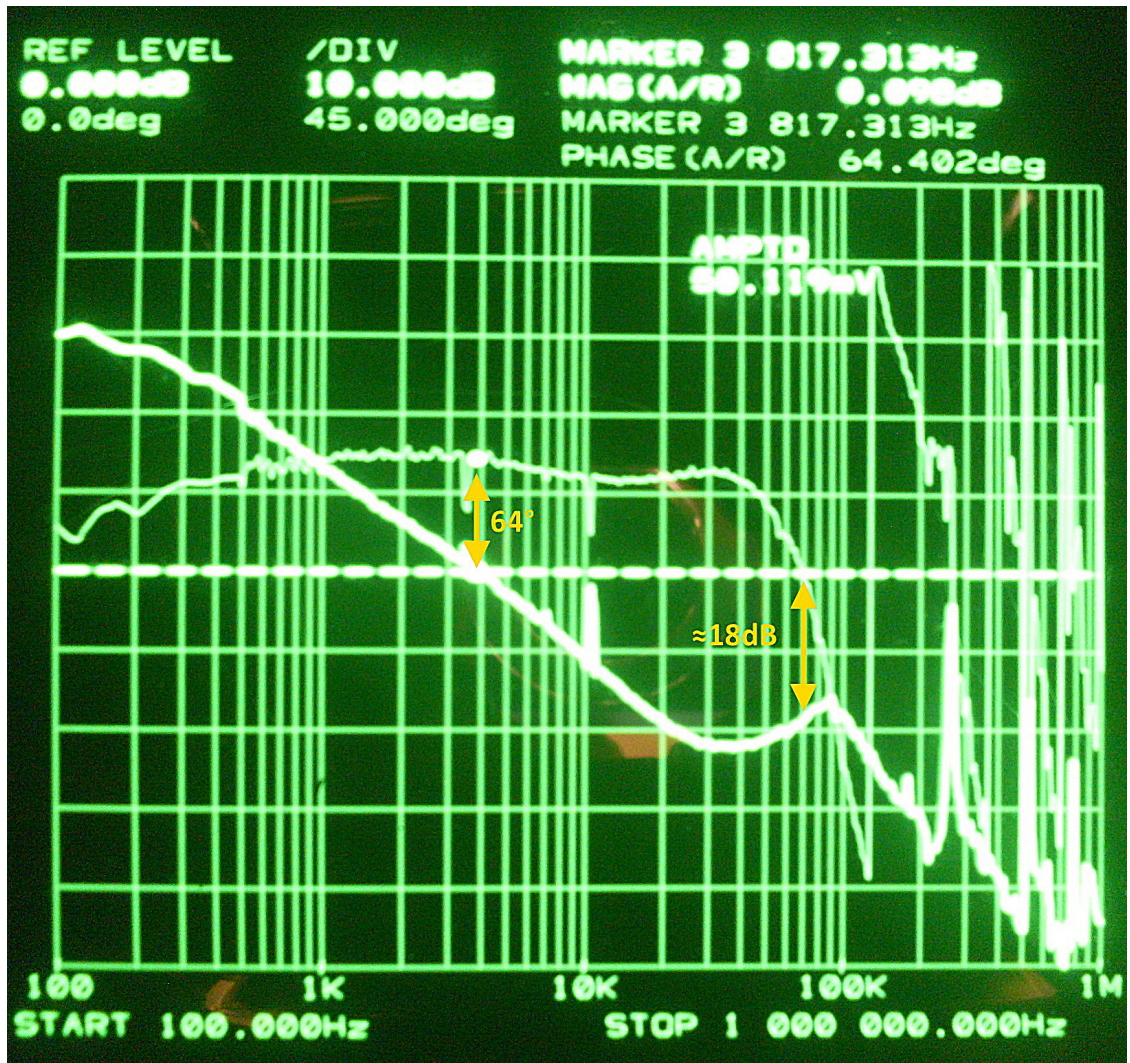


Figure 7. Gain and Phase Margin of the Flyback DC/DC Converter (Conditions: $V_{PORT} = 57V$, $V_{OUT} = 24V$, $I_{OUT} = 2.7A$)

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 DC power supply to the DC1814A-D. Turn on the DC power supply and set its current limit to 2A. Then increase its output voltage to 57V.

Note: An LTPoE++[®] compliant PSE (DC1814A-D) is used to provide power to the DC2476A-A. $\overline{T2P}$ output of the DC2476A-A is shown in Table 1. It is recommended to use an IEEE 802.3bt compliant PSE for the proper

handshaking sequence when such a PSE is available in the market.

5. Connect the output of the DC1814A-D to the RJ45 connector (J1) of the DC2476A using a CAT5e or CAT6 Ethernet cable.
6. After the LED (D4) on the DC2476A is lit, check the output voltage using a voltmeter. Output voltage should be within $24.0V \pm 0.3V$.
7. Turn on the electronic load and increase its load current up to 2.7A. Observe the output voltage regulation, efficiency, and other parameters.
8. Verify $\overline{T2P}$ response with an oscilloscope as shown in Figure 8. The $\overline{T2P}$ response to the type of PSE connected to the DC2476A-A is provided in Table 1.

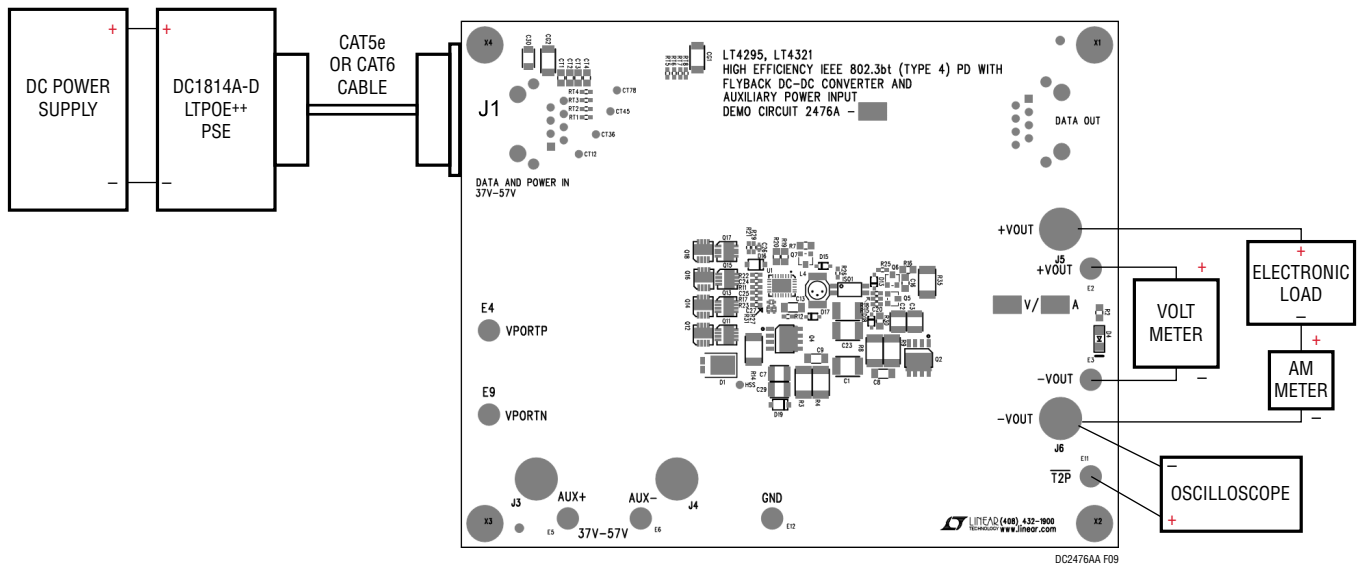


Figure 8. Setup Diagram for PoE Input

Table 1. Response vs PSE Type

PSE	$\overline{T2P}$ Response	PD Input Power	Max PD Output Power
Type 1 (PoE, "af")	Logic High	13W	10.8W
Type 2 (PoE+, "at")	Logic Low	25.5W	22.8W
Type 3 (PoE++, "bt")	50% Logic High/50% Logic Low, Toggle at 976Hz $\pm 7\%$	51W	46.0W
Type 4 (PoE++, "bt")	75% Logic High/25% Logic Low, Toggle at 976Hz $\pm 7\%$	71W	64.8W
LTPoE++, 90W	Logic Low	90W	64.8W

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 $24.0V \pm 0.3V$.
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 $976Hz \pm 7\%$.

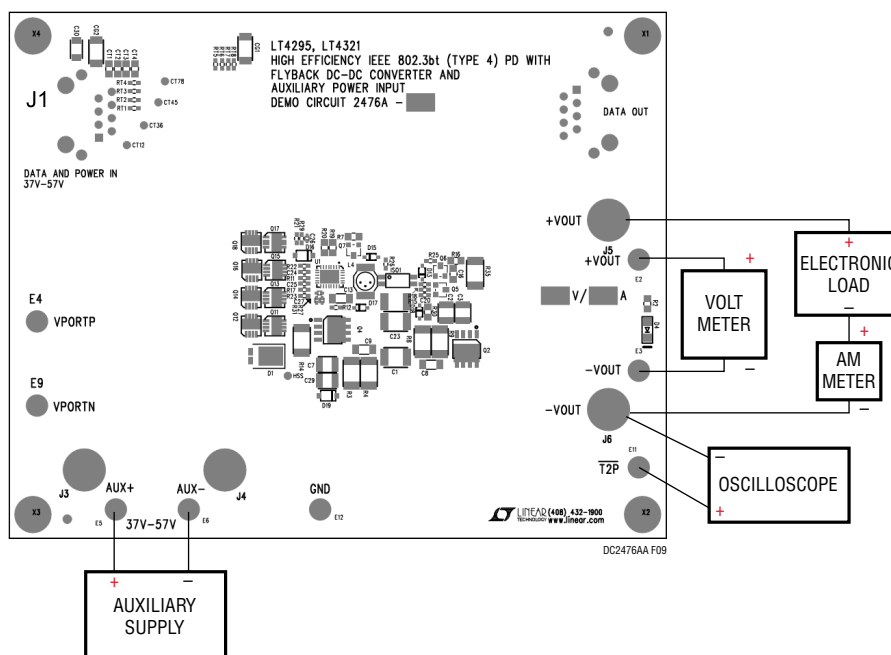


Figure 9. Setup Diagram for Auxiliary Supply Input

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
DC2476A General BOM				
1	2	CG1, CG2	CAP, CER, X7R 1000pF 2kV 10% 1808	MURATA, GR442QR73D102KW01L
2	4	CT1, CT2, CT3, CT4	CAP, CER, X7R 0.01µF 100V 20% 0805	MURATA, GRM21BR72A103MA01L
3	0	C1	CAP, CER, OPT 2kV 1812	OPT
4	1	C6	CAP, ELEC, 22µF 100V 10% 8x10.2	SUNCON, 100CE22KX
5	2	C7, C29	CAP, CER, X7R 2.2µF 100V 10% 1210	MURATA, GRM32ER72A225KA35
6	1	C10	CAP, CER, X7R 10nF 100V 20% 0603	MURATA, GRM188R72A103KA01D
7	1	C11	CAP, CER, X7R 0.047µF 100V 20% 0603	KEMET, C0603C473M1RACTU
8	1	C12	CAP, CER, X7R 0.047µF 100V 10% 0805	MURATA, GRM21BR72A473KA01L
9	1	C13	CAP, CER, X7R 10µF 10V 10% 1206	MURATA, GRM31CR71A106KA01L
10	0	C15, C18, C19, C21	CAP, CER, X5R OPT 2kV 20% 1812	OPT
11	1	C17	CAP, CER, X7R 1µF 25V 10% 0603	MURATA, GRM188R71E105KA12
12	1	C20	CAP, CER, X7R 2.2nF 25V 10% 0603	MURATA, GRM188R71E222KA01
13	1	C24	CAP, CER, X7R 0.1µF 25V 20% 0603	MURATA, GRM188R71E104KA01D
14	1	C26	CAP, CER, X7R 100pF 16V 10% 0402	AVX, 0402YC101KAT2A
15	0	C27	CAP, CER, X7R OPT 6.3V 10% 0402	OPT
16	1	C30	CAP, CER, X7R OPT 250V 10% 1206	AVX, 12061C103MAT2A
17	1	D1	DIODE, SCHOTTKY, PDS5100H 100V POWERDI5	DIODES INC, PDS5100H
18	3	D2, D16, D19	DIODE, TVS, PTVS58VS1UR 58V SOD123	NXP, PTVS58VS1UR
19	1	D3	DIODE, ZENER, MMSZ5252BS 24V SOD323	DIODES INC, MMSZ5256BS
20	1	D13	DIODE, SCHOTTKY, BAT46WJ, 115 100V SOD323	NXP, BAT46WJ, 115
21	1	D15	DIODE, BAV19WS 120V SOD323	DIODES INC, BAV19WS
22	1	D17	DIODE, SCHOTTKY, PMEG1020EA 10V SOD323	NXP, PMEG1020EA
23	8	E2, E3, E4, E5, E6, E9, E11, E12	TP, TURRET, PAD150-094 0.094"	MILL-MAX, 2501-2-00-80-00-00-07-0
24	1	ISO1	OPTO, TLP291(GR-TP, E)	TOSHIBA, TLP291(GR-TP, E)
25	2	J1, J2	CONN, RJ-45, SS-6488-NF-K1	STEWART CONNECTOR, SS-6488-NF-K1
26	4	J3, J4, J5, J6	CONN, BANANA JACK	KEYSTONE, 575-4
27	1	L2	IND, 4.7µH	WURTH, 744316470
28	1	L3	IND, CMC, 3.5mH,	PCA, EPZ3109G-LF
29	1	L4	IND, 100µH	COILCRAFT, D01608C-104MLB
30	0	L6	IND, OPT	OPT

DEMO MANUAL DC2476A-A

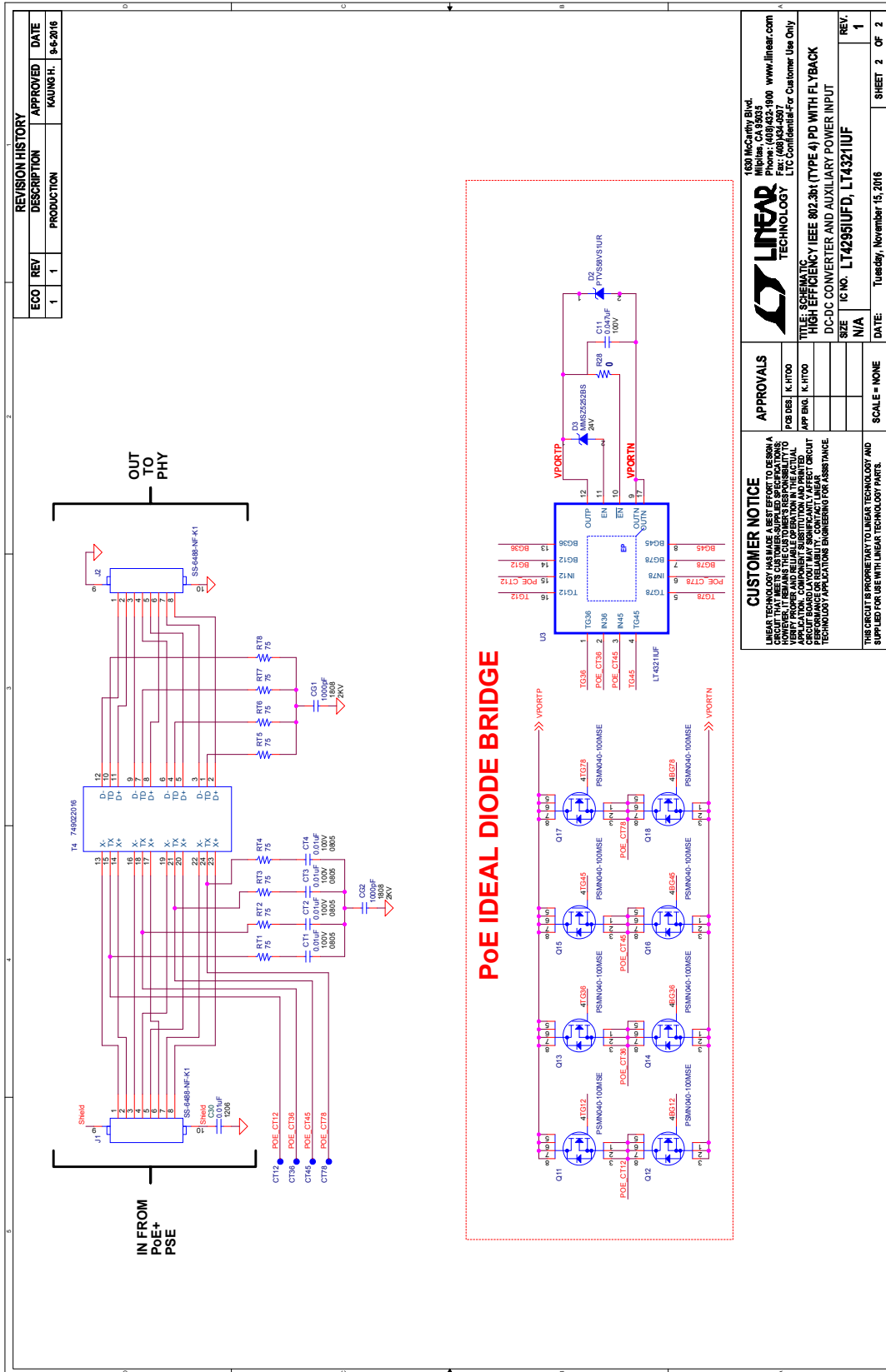
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
31	1	Q1	MOSFET, N-CH, PSMN040-100MSE 100V LFPAK33	NXP, PSMN040-100MSE
32	1	Q5	TRANSISTOR, PNP, PBSS5140T 40V SOT23	NXP, PBSS5140T
33	1	Q6	TRANSISTOR, NPN, PBSS4140T 40V SOT23	NXP, PBSS4140T
34	1	Q7	TRANSISTOR, PNP, FMMT723 100V SOT23	DIODES INC, FMMT723
35	8	Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18	MOSFET, N-CH, PSMN040-100MSE 100V LFPAK33	NXP, PSMN040-100MSE
36	8	RT1, RT2, RT3, RT4, RT5, RT6, RT7, RT8	RES, CHIP, 75Ω 5% 0603	PANASONIC, ERJ-3GEYJ750V
37	1	R5	RES, CHIP, 8.2Ω 5% 0805	PANASONIC, ERJ-P6WJ8R2J
38	1	R6	RES, CHIP, 3.3K 5% 0603	VISHAY, CRCW06033K30FKEA
39	1	R7	RES, CHIP, 20Ω 5% 0805	VISHAY, CRCW080520R0JNEA
40	2	R12, R28	RES, CHIP, 0 5% 0603	PANASONIC, ERJ-3GEY0R00V
41	1	R13	RES, CHIP, 100Ω 5% 0603	PANASONIC, ERJ-3GEYJ101V
42	1	R15	RES, CHIP, 15Ω 5% 0603	VISHAY, CRCW060315R0FKEA
43	1	R17	RES, CHIP, 2.00K 1% 0603	VISHAY, CRCW06032K00FKEA
44	1	R18	RES, CHIP, 10K 5% 0603	VISHAY, CRCW060310K0JNEA
45	1	R21	RES, CHIP, 174K 1% 0603	VISHAY, CRCW0603174KFKEA
46	1	R22	RES, CHIP, 107K 5% 0603	VISHAY, CRCW0603107KFKEA
47	2	R27, R31	RES, CHIP, 0Ω SHUNT 0402	VISHAY, CRCW04020000Z0EA
48	1	R29	RES, CHIP, 52.3K 1% 0603	PANASONIC, ERJ-3EKF5232V
49	0	R32	RES, CHIP, OPT 1% 1812	OPT
50	0	R33	RES, CHIP, OPT 5% 0805	OPT
51	1	R34	RES, CHIP, 0Ω SHUNT 0603	PANASONIC, ERJ-3GEY0R00V
52	1	T3	XFMR, SMD GATE DRIVE, PE-68386NL	PULSE, PE-68386NL
53	0	T3 (ALTERNATE)	XFMR, SMD GATE DRIVE, EPA4271GE-LF	PCA, EPA4271GE-LF
54	1	T4	TRANSFORMER, ETHERNET, 749022016	WURTH, 749022016
55	0	T4 (ALTERNATE)	TRANSFORMER, ETHERNET, ETH1-460LD	COILCRAFT, ETH1-460LD
56	0	T4 (ALTERNATE)	TRANSFORMER, ETHERNET, CSG4260S-LF	PCA, CSG4260S-LF
57	1	U1	IC, PD & SWITCHER CONTROLLER, LT4295IUFD QFN28	LINEAR TECH, LT4295IUFD#PBF
58	1	U3	IC, POE IDEAL BRIDGE CONTROLLER, LT4321IUF QFN16	LINEAR TECH, LT4321IUF#PBF
59	4	MH1-MH4	STAND-OFF, NYLON 0.50" TALL (SNAP ON)	KEYSTONE, 8833
60	2		STENCILS (TOP & BOTTOM)	STENCIL, DC2476A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
DC2476A-A				
1	1	C2	CAP, CER, X5R 10µF 50V 10% 1210	MURATA, GRM32ER61H106KA12
2	0	C3	CAP, CER, X5R OPT 50V 10% 1210	OPT
3	1	C4	CAP, ELEC, 47µF 35V 20%	PANASONIC, EEE-FK1V470P
4	0	C5	CAP, ELEC, OPT 35V 20%	OPT
5	1	C8	CAP, CER, U2J 330pF 630V 5% 1206	MURATA, GRM31A7U2J331JW31
6	1	C9	CAP, CER, U2J 220pF 630V 5% 1206	MURATA, GRM31A7U2J221JW31
7	1	C16	CAP, CER, X7R 0.1µF 25V 10% 0805	MURATA, GRM21BR71E104KA01L
8	1	C22	CAP, CER, X7R 3.3nF 25V 10% 0603	MURATA, GRM188R71E332KA01D
9	1	C23	CAP, CER, X7R 4.7nF 2kV 1812	MURATA, GR443DR73D472KW01L
10	1	C25	CAP, CER, X7R 330pF 25V 10% 0603	AVX, 06033C331KAT2A
11	0	D18	DIODE, DIODE INC, OPT 30V SOD323	OPT
12	1	L5	IND, 1µH	WURTH, 744316100
13	1	Q2	MOSFET, N-CH, BSC320N20NS3 200V SUPERS08	INFINEON, BSC320N20NS3
14	1	Q4	MOSFET, N-CH, BSC190N15NS3 150V SUPERS08	INFINEON, BSC109N10NS3 G
15	2	R3, R4	RES, CHIP, 51Ω 5% 2010	VISHAY, CRCW201051R0JNEF
16	2	R8, R9	RES, CHIP, 36Ω 5% 2010	PANASONIC, ERJ-12ZYJ360U
17	1	R10	RES, CHIP, 3.65K 1% 0603	VISHAY, CRCW06033K65FKEA
18	1	R11	RES, CHIP, 5.23K 5% 0603	VISHAY, CRCW06035K23FKEA
19	1	R14	RES, CHIP, 15mΩ 1% 2010	VISHAY, WSL2010R0150FEA
20	1	R16	RES, CHIP, 0Ω SHUNT 0805	VISHAY, CRCW08050000Z0EA
21	1	R19	RES, CHIP, 118Ω 1% 0805	PANASONIC, ERJ-6ENF1180V
22	1	R20	RES, CHIP, 52.3 1% 0805	VISHAY, CRCW080552R3FKEA
23	1	R23	RES, CHIP, 36K 5% 0603	VISHAY, CRCW060336K0FKEA
24	1	R24	RES, CHIP, 51K 5% 0603	VISHAY, CRCW060351K0JNEA
25	1	R25	RES, CHIP, 20K 5% 0603	PANASONIC, ERJ-3EKF2002V
26	1	R26	RES, CHIP, 4.7K 5% 0603	YAGEO, RC0603JR-074K7L
27	0	R30	RES, CHIP, OPT 5% 0805	OPT
28	0	R35	RES, CHIP, OPT 5% 2010	OPT
29	1	T1	XFMR, PWR TRAN, EPC3630G-LF	PCA, EPC3630G-LF
30	0	T1 (ALTERNATE)	XFMR, PWR TRAN, 750316231	WURTH, 750316231
31	1		FAB, PRINTED CIRCUIT BOARD	DEMO CIRCUIT 2476A

SCHEMATIC DIAGRAM



DEMO MANUAL DC2476A-A

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This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

Mailing Address:

Linear Technology
1630 McCarthy Blvd.
Milpitas, CA 95035

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