

LT4295, LT4321 High Efficiency IEEE 802.3bt (PoE++, Type 4, 71W) PD with Forward DC/DC Converter

DESCRIPTION

Demonstration circuit 2584A is an IEEE 802.3bt (Draft 2.1) 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 active-clamp forward converter 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 DC2584A-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 DC2584A-A supplies a 12V output at up to 5.5A.

Design files for this circuit board are available at <http://www.linear.com/demo/DC2584A-A>

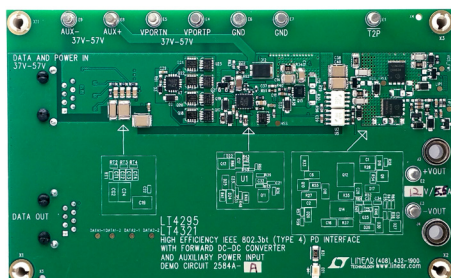
LT, LT, LTC, LTM, Linear Technology, LTPoE++ and the Linear logo are registered trademarks of Analog Devices, Inc. All other trademarks are the property of their respective owners.

PERFORMANCE SUMMARY

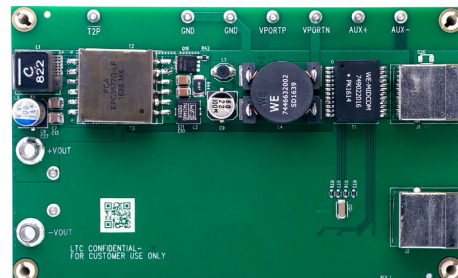
Specifications are at $T_A = 25^\circ\text{C}$

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{PORT}	Port Voltage	At RJ45	37		57	V
	Auxiliary Voltage	From AUX+ to AUX- Terminals	37		57	V
V_{OUT}	Output Voltage			12		V
I_{OUT}	Output Current				5.5	A
	Output Voltage Ripple	$V_{PORT} = 57\text{V}$, $I_{OUT} = 5.5\text{A}$		45		mV _{P-P}
	Load Regulation			0.05		%
	Efficiency	$V_{PORT} = 41\text{V}$, $I_{OUT} = 5.5\text{A}$, End-to-End		93		%
	Switching Frequency			250		kHz

BOARD PHOTO



Top Side



Bottom Side

TYPICAL PERFORMANCE CHARACTERISTICS

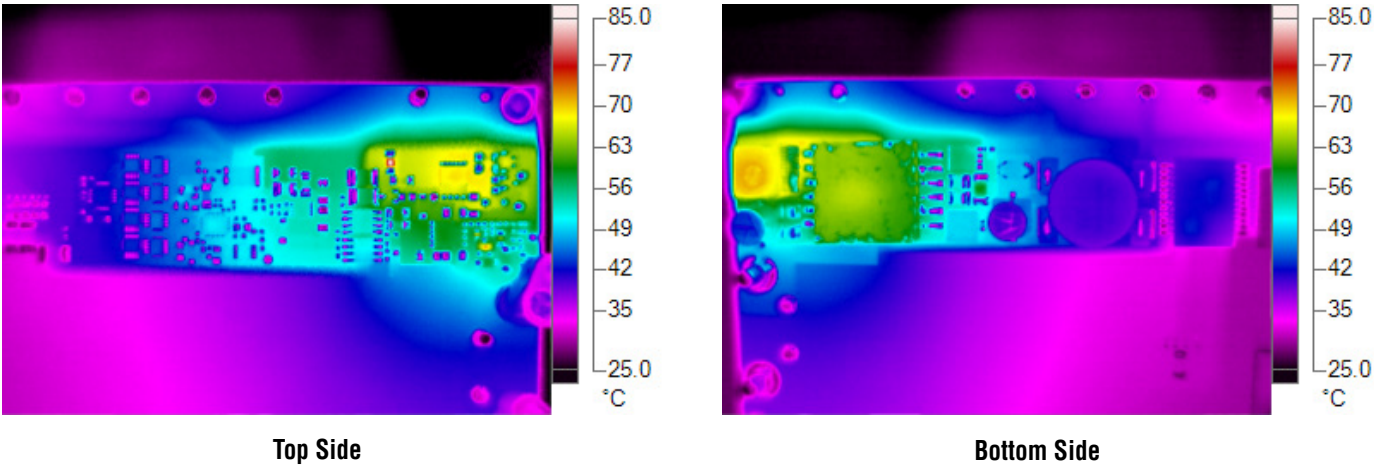


Figure 1. Thermal Pictures (Conditions: $V_{PORT} = 57V$, $V_{OUT} = 12V$, $I_{OUT} = 5.5A$)

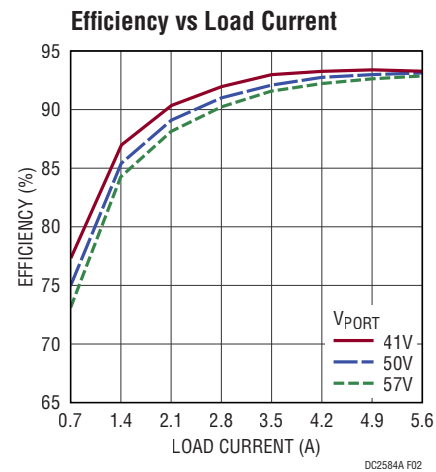


Figure 2. Efficiency (End-to-End)

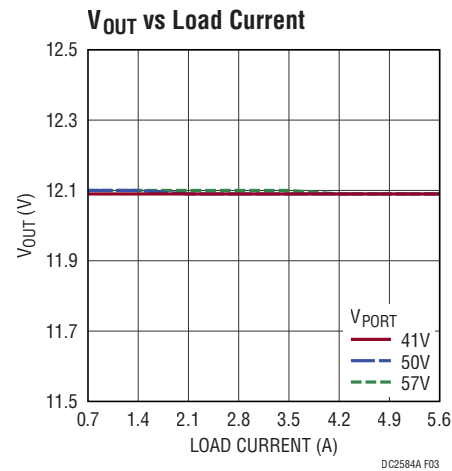


Figure 3. Load Regulation

TYPICAL PERFORMANCE CHARACTERISTICS

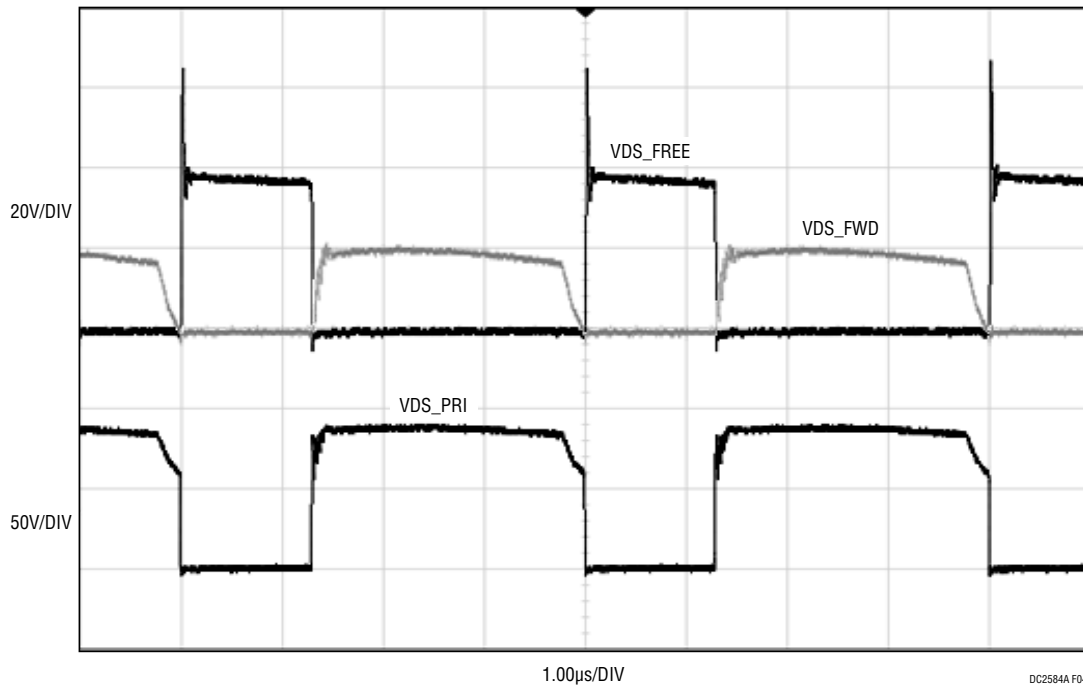


Figure 4. Switch Node Waveforms (Conditions: $V_{PORT} = 57V$, $V_{OUT} = 12V$, $I_{OUT} = 5.5A$)

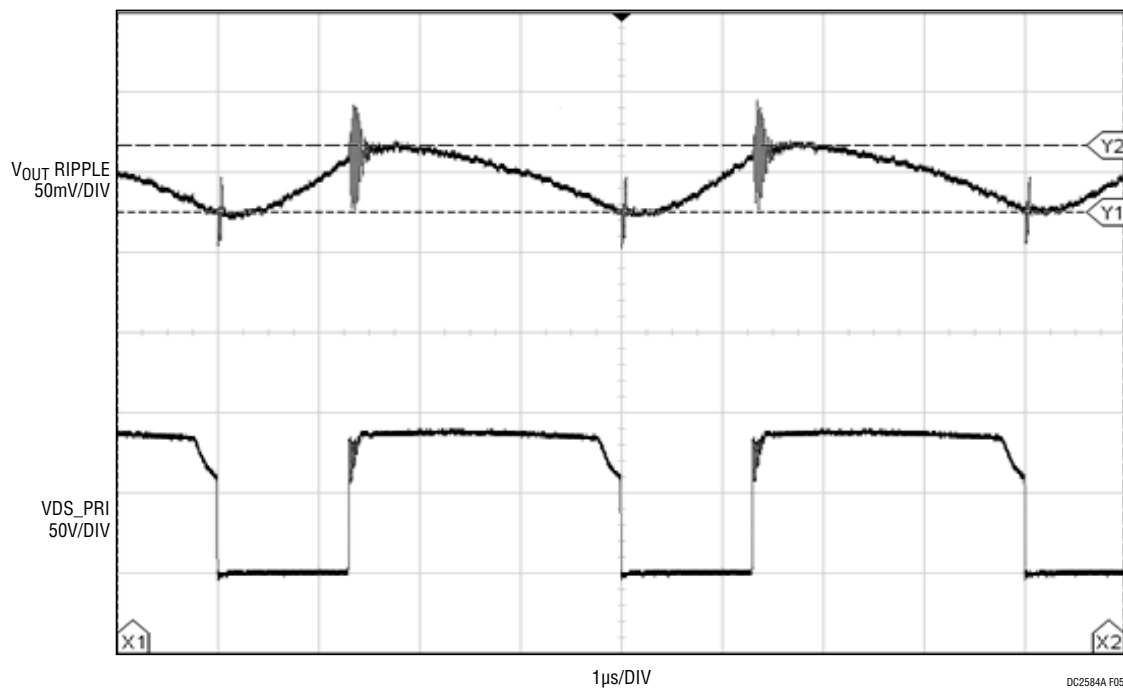


Figure 5. Output Voltage Ripple (Conditions: $V_{PORT} = 57V$, $V_{OUT} = 12V$, $I_{OUT} = 5.5A$)

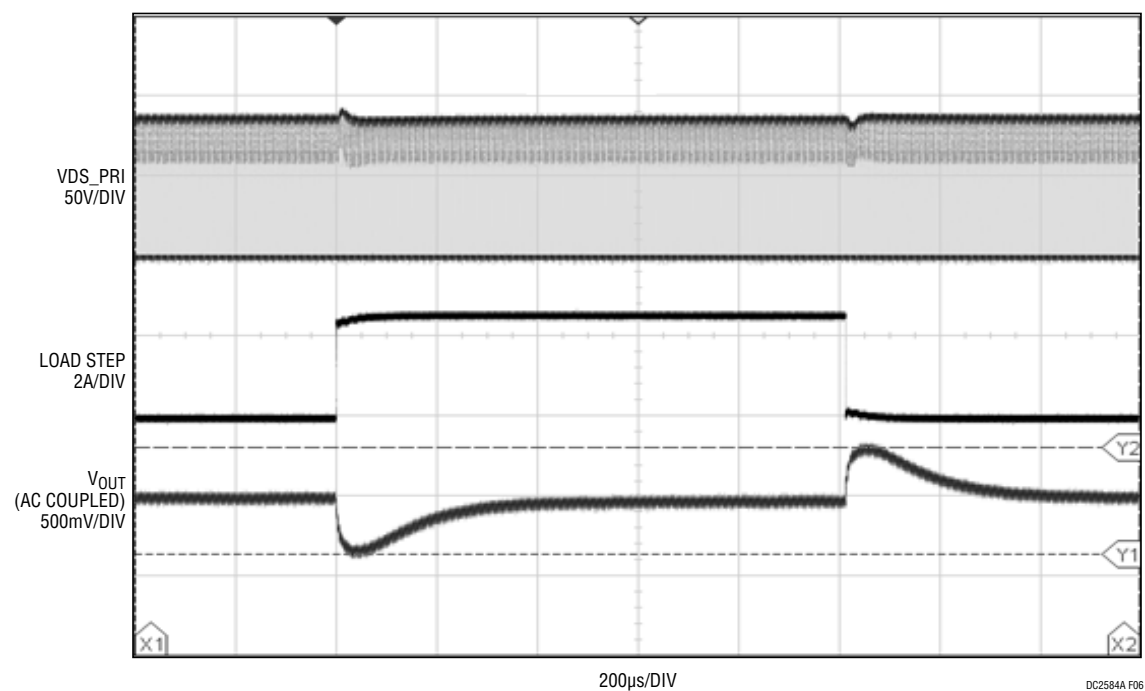


Figure 6. Load Transient Response (Conditions: $V_{PORT} = 57V$, Load Step: 0A to 2.8A with 2.7A DC Load)

QUICK START PROCEDURE

Power Over Ethernet (PoE) Input

1. Disconnect auxiliary supply if it is connected to AUX⁺ and AUX⁻ inputs of the DC2584A-A.
2. Place and connect test equipment (voltmeter, ammeter, oscilloscope, and electronic load) as shown in Figure 7.
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 DC2584A using a CAT5e or CAT6 Ethernet cable. (See note)
5. After the LED (D21) on the DC2584A is lit, check the output voltage using a voltmeter. Output voltage should be within $12.0V \pm 0.2V$.
6. Turn on the electronic load and increase its load current up to 5.5A. Observe the output voltage regulation, efficiency, and other parameters.
7. Verify $\overline{T2P}$ response with an oscilloscope as shown in Figure 7. The $\overline{T2P}$ response to the type of PSE connected to the DC2584A-A is provided in Table 1.

NOTE: An 802.3bt PSE has not yet been released. In the interim, an LTPoE++[®] compliant PSE (DC1814A-D) may be used to provide power to the DC2584A-A. The LTPoE++ classification will not be 802.3bt compliant, but the PSE will provide a compatible detection and power output. Specifically, the $\overline{T2P}$ output of the DC2584A-A is different from the behavior stated in Table 1 and will indicate connection to a Type 2 PSE. Otherwise PD behavior will be unaffected.

Table 1. $\overline{T2P}$ Response

PSE	$\overline{T2P}$ Response	Negotiated PD Input Power
IEEE	Logic High	13W
	Logic Low	25.5W
	50% Logic High/50% Logic Low, Toggle at 976Hz $\pm 7\%$	51W
	75% Logic High/25% Logic Low, Toggle at 976Hz $\pm 7\%$	71W
LTPoE++, 90W	Logic Low	71W

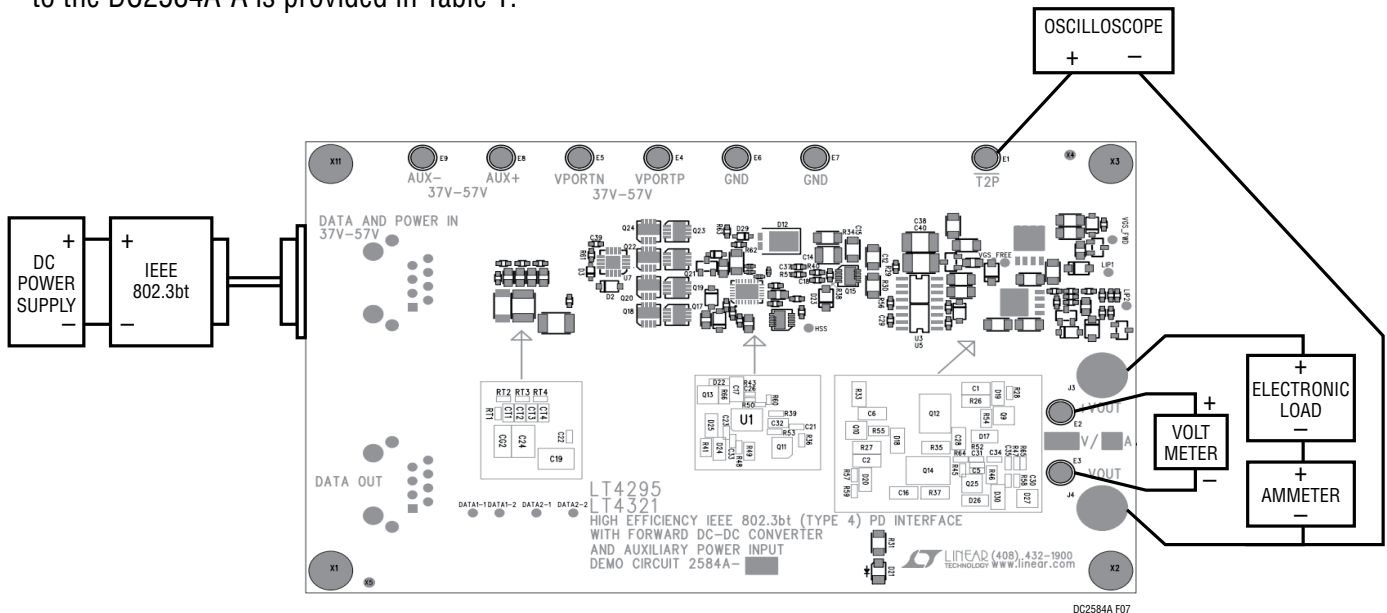


Figure 7. Setup Diagram for PoE Input

QUICK START PROCEDURE

Auxiliary Supply Input

1. Place and connect test equipment (voltmeter, ammeter, oscilloscope, and electronic load) as shown in Figure 8.
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 DC2584A as shown in Figure 8. Turn on the auxiliary supply and set its current limit to 2A. Then increase its output voltage to 48V.
4. Once the LED (D21) on the DC2584A is lit, check the output voltage using a voltmeter. Output voltage should be within $12.0V \pm 0.2V$.
5. Turn on the electronic load and increase its load current up to 5.5A. Observe the output voltage regulation, efficiency, and other parameters.
6. Verify $\overline{T2P}$ response with an oscilloscope as shown in Figure 8. The $\overline{T2P}$ response during auxiliary power operation is: 75% Logic High/25% Logic Low, Toggle at $976Hz \pm 7\%$.

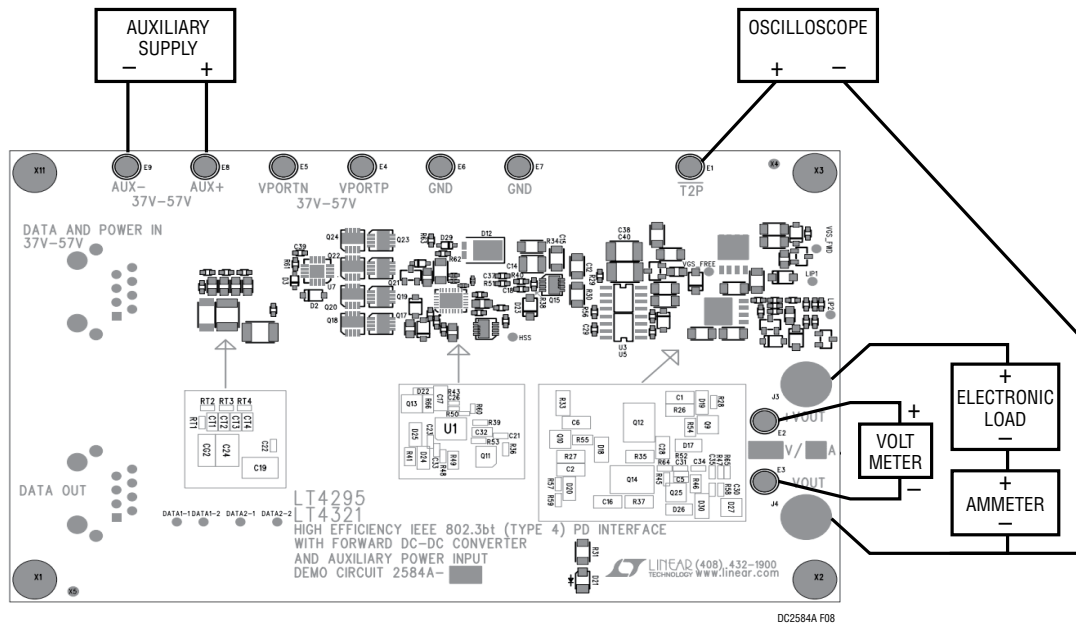


Figure 8. Setup Diagram for Auxiliary Supply Input

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
DC2584A 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	1	C9	CAP, ELEC, 22µF 100V 20% 8 X 10.2	SUNCON, 100CE22KX
4	2	C10, C11	CAP, CER, X7R 2.2µF 100V 10% 1210	MURATA, GRM32ER72A225KA35
5	0	C20	CAP, CER, X7R OPT 250V 10% 1206	OPT
6	1	C17	CAP, CER, X7R 10µF 10V 10% 1206	MURATA, GRM31CR71A106KA01
7	4	C5, C18, C29, C31	CAP, CER, X7R 0.1µF 50V 20% 0603	MURATA, GRM188R71H104MA93
8	4	C19, C24, C38, C40	CAP, CER, X7R 2.2nF 2kV 10% 1812	MURATA, GR443QR73D222KW01L
9	1	C21	CAP, CER, X7R 10nF 100V 10% 0603	MURATA, GRM188R72A103KA01D
10	1	C22	CAP, CER, X7R 1nF 100V 10% 0603	MURATA, GRM188R72A102KA01
11	2	C23, C39	CAP, CER, X7R 0.047µF 100V 10% 0603	KEMET, C0603C473K1RACTU
12	0	C26	CAP, CER, X7R OPT 50V 20% 0402	OPT
13	1	C33	CAP, CER, X7R 100pF 50V 10% 0603	AVX, 06035C101KAT2A
14	1	C37	CAP, CER, X7R 100pF 50V 10% 0603	AVX, 06035C101KAT2A
15	3	D2, D24, D25	DIODE, TVS, PTVS58VS1UR 58V SOD123	NXP, PTVS58VS1UR
16	1	D3	DIODE, ZENER, MMSZ5252BS 24V SOD323	DIODES INC, MMSZ5252BS
17	1	D12	DIODE, SCHOTTKY, PDS5100H 100V PowerDI5	DIODES INC, PDS5100H
18	1	D21	DIODE, LED, 1208, GREEN	ROHM, SML-010FTT86L
19	1	D22	DIODE, SILICON, BAV19WS 120V SOD-323	DIODES INC., BAV19WS
20	1	D23	DIODE, SCHOTTKY, CMMSH1-40L 40V SOD-123F	CENTRAL SEMI., CMMSH1-40L
21	1	D27	IC, REFERENCE, ZR431F01TA SOT23	DIODES INC, ZR431F01TA
22	1	D29	DIODE, SCHOTTKY, BAT54WS 30V SOD323	DIODE INC, BAT54WS
23	9	E1, E2, E3, E4, E5, E6, E7, E8, E9	TP, TURRET, PAD150-094 0.094"	MILL-MAX, 2501-2-00-80-00-00-07-0
24	2	J1, J2	CONN, RJ-45, SS-6488-NF-K1	STEWART CONNECTOR, SS-6488-NF-K1
25	2	J3, J4	CONN, BANANA, 575-4 0.175"	KEYSTONE, 575-4
26	1	L3	IND, 100µH DO1608	COILCRAFT, DO1608C-104
27	1	L4	IND, CMC, 2.2mH WE-LF	WURTH ELEKTRONIK, 7446632002
28	1	Q11	MOSFET, N-CH, PSMN040-100MSE 100V LPAK33	NXP, PSMN040-100MSE
29	1	Q13	TRANSISTOR, PNP, FMMT723 100V SOT23	DIODES INC., FMMT723
30	1	Q15	MOSFET, P-CH, FDMC2523P 150V POWER33	FAIRCHILD, FDMC2523P
31	8	Q17, Q18, Q19, Q20, Q21, Q22, Q23, Q24	MOSFET, N-CH, PSMN075-100MSE 100 LPAK33	NXP, PSMN075-100MSE
32	8	RT1, RT2, RT3, RT4, RT5, RT6, RT7, RT8	RES, CHIP, 75Ω 5% 0603	NIC, NRC06J750TRF

DEMO MANUAL DC2584A-A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
33	1	R28	RES, CHIP, 10k 5% 0603	NIC, NRC06J103TRF
34	1	R29	RES, CHIP, 4.7k 5% 0603	NIC, NRC06J472TRF
35	2	R38, R57	RES, CHIP, 10k 5% 0603	NIC, NRC06J103TRF
36	1	R36	RES, CHIP, 3.3k 5% 0603	NIC, NRC06J332TRF
37	3	R40, R42, R65	RES, CHIP, 0 Ω 5% 0603	NIC, NRC06Z0TRF
38	1	R41	RES, CHIP, 8.2 Ω 5% 0805	NIC, NRC10J8R2TRF
39	3	R43, R50, R60	RES, CHIP, 0 Ω 5% 0402	NIC, NRC04Z0TRF
40	1	R51	RES, CHIP, 100k 5% 0603	NIC, NRC06J104TRF
41	1	R53	RES, CHIP, 107k 1% 0603	NIC, NRC06F1073TRF
42	1	R56	RES, CHIP, 750 Ω 5% 0603	NIC, NRC06J751TRF
43	1	R61	RES, CHIP, 0 Ω 5% 0603	NIC, NRC06Z0TRF
44	1	R62	RES, CHIP, 52.3k 1% 0603	NIC, NRC06F5232TRF
45	1	R63	RES, CHIP, 174k 1% 0603	NIC, NRC06F1743TRF
46	1	R66	RES, CHIP, 20 Ω 5% 0805	NIC, NRC06F20R0TRF
47	1	T1	TRANSFORMER, ETHERNET, 749022016	WURTH ELEKTRONIK, 749022016
48	0	T1 (ALTERNATE)	TRANSFORMER, ETHERNET, ETH1-460LD	COILCRAFT, ETH1-460LD
49	0	T1 (ALTERNATE)	TRANSFORMER, ETHERNET, EPG4260S-LF	PCA, EPG4260S-LF
50	2	U3, U5	OPTO, MOC207M SOIC-8	FAIRCHILD, MOC207M
51	1	U7	IC, PoE IDEAL DIODE BRIDGE CONTROLLER, LT4321IUF QFN16	LINEAR TECH., LT4321HUF
52	4	MH1, MH2, MH3, MH4	STANDOFF, SNAP ON, .625"	KEYSTONE, 8834
53	2		STENCIL (TOP & BOTTOM)	STENCIL, DC2584A

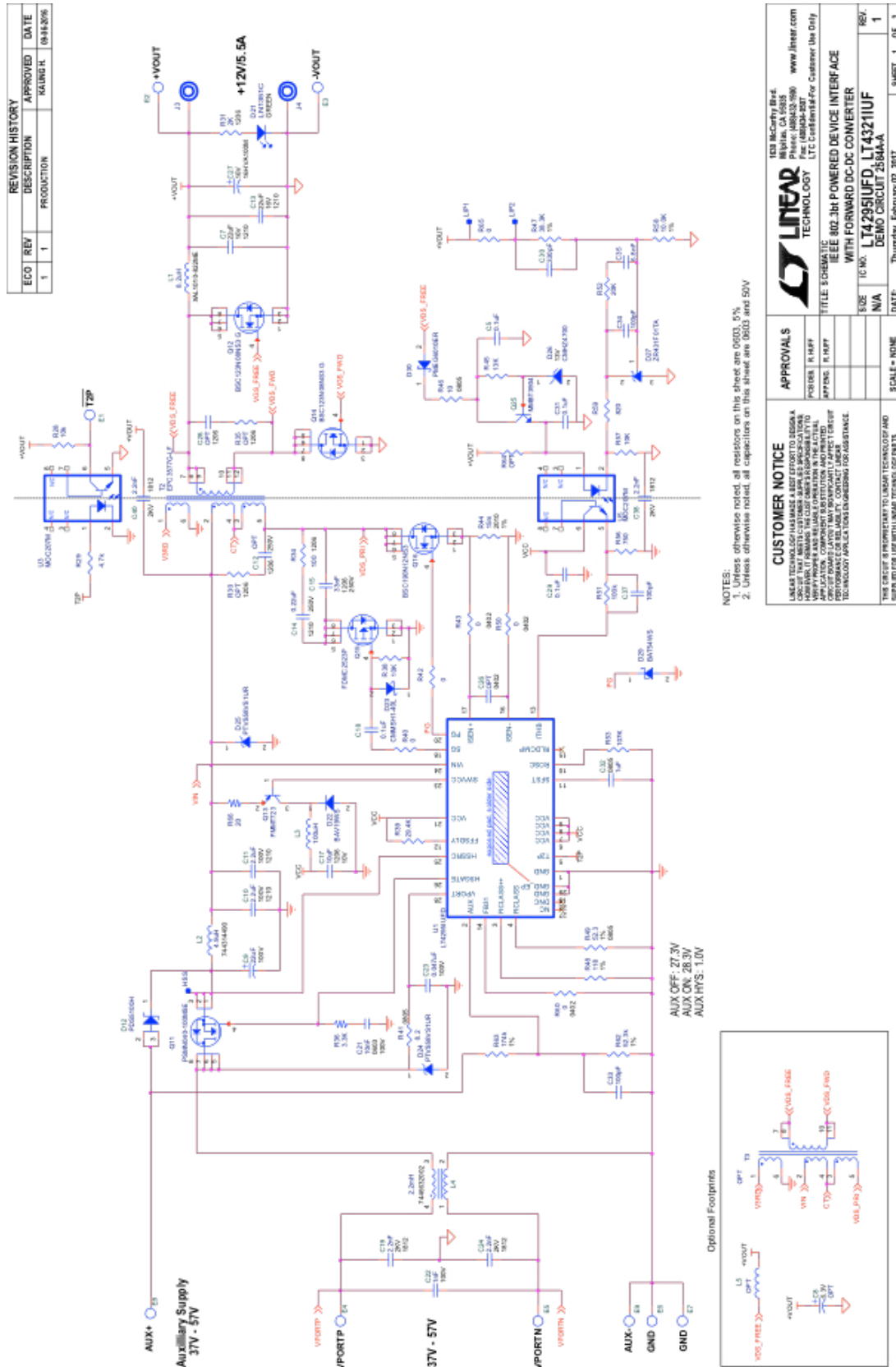
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
DC2584A-A				
1	2	C1, C2	CAP, CER, NP0/COG 100pF 100V 1206	AVX, 12061A101KAT2A
2	0	C16	CAP, CER, X7R OPT 1206	OPT
3	1	C6	CAP, CER, NP0/COG 820pF 100V 1206	AVX, 12061A821JAT2A
4	2	C7, C13	CAP, CER, X5R 22μF 16V 20% 1210	MURATA, GRM32ER61C226ME20
5	0	C8	CAP, ELEC, OPT 6.3 X 6.0	OPT
6	0	C12, C28	CAP, CER, X7R OPT 1206	OPT
7	1	C14	CAP, CER, X7R 0.22μF 250V 10% 1210	MURATA, GRM32DR72E224KW01
8	1	C15	CAP, CER, X5R 33nF 250V 1206	MURATA, GRM31CR72E333KW03
9	1	C27	CAP, ELEC, 100μF 16V 20% 8 X 10.5	SUNCON, 16HVA100M
10	1	C30	CAP, CER, X7R 330pF 50V 10% 0603	AVX, 06035A331KAT2A
11	1	C32	CAP, CER, X7R 1μF 10V 10% 0805	MURATA, GRM21BR71A105KA01L
12	1	C34	CAP, CER, X7R 100pF 50V 10% 0603	AVX, 06035C101KAT2A
13	1	C35	CAP, CER, X7R 6.8nF 50V 10% 0603	MURATA, GRM188R71H682KA01D
14	1	D26	DIODE, ZENER, CMHZ4700 13V SOD-123	ON-SEMI, MMSZ4700T1G
15	2	D17, D18	DIODE, SCHOTTKY, CMMSH1-100 100V SOD-123F	CENTRAL SEMI., CMMSH1-100
16	2	D19, D20	DIODE, ZENER, CMHZ5236B 7.5V SOD-123	CENTRAL SEMI., CMHZ5236B
17	1	D30	DIODE, SCHOTTKY, PMEG6010ER 60V SOD-123W	NXP, PMEG6010ER
18	1	L1	IND, 8.2μH XAL1010-822ME	COILCRAFT, XAL1010-822ME
19	0	L1 (ALTERNATE)	IND, 8.2μH 74439369082	WURTH ELEKTRONIK, 74439369082
20	1	L2	IND, 4.9μH 744314490	WURTH ELEKTRONIK, 744314490
21	0	L5	IND, OPT	OPT
22	2	Q9, Q10	TRANSISTOR, NPN, FMMT624 50V SOT23	DIODES INC., FMMT624
23	2	Q12, Q14	MOSFET, N-CH, BSC123N08NS3 80V PG-TDSON-8	INFINEON, BSC123N08NS3
24	1	Q16	MOSFET, N-CH, BSC190N12NS3 120V PG-TDSON-8	INFINEON, BSC190N12NS3
25	1	Q25	TRANSISTOR, NPN, MMBT3904 40V SOT23	DIODES INC., MMBT3904
26	2	R26, R27	RES, CHIP, 5.1k 5% 1206	NIC, NRC12J512TRF
27	1	R52	RES, CHIP, 20k 5% 0603	NIC, NRC06J203TRF
28	0	R30	RES, CHIP, OPT 5% 1206	OPT
29	1	R31	RES, CHIP, 2k 5% 1206	NIC, NRC12J202TRF
30	0	R35	RES, CHIP, OPT 5% 1206	OPT
31	1	R33	RES, CHIP, 7.5Ω 5% 1/2W 1206	PANASONIC, ERJ-8BQJ7R5V
32	1	R34	RES, CHIP, 100Ω 5% 1206	NIC, NRC12J101TRF
33	0	R37	RES, CHIP, OPT 5% 1206	OPT

DEMO MANUAL DC2584A-A

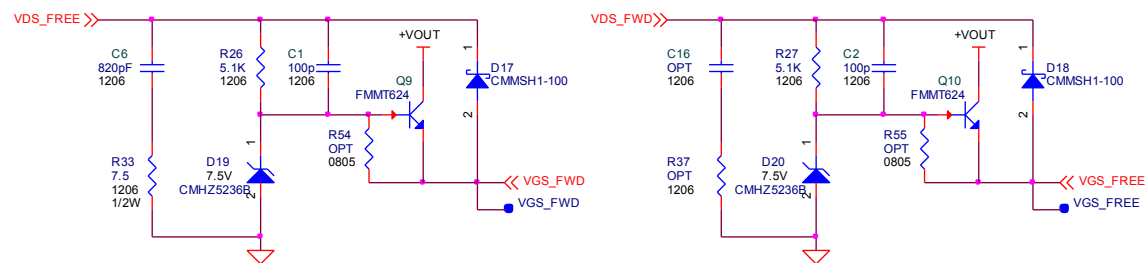
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
34	1	R39	RES, CHIP, 29.4k 1% 0603	VISHAY, CRCW060329K4FKEA
35	1	R44	RES, CHIP, 15m 1% 2010	VISHAY, WSL2010R0150FEA
36	1	R45	RES, CHIP, 13k 5% 0603	NIC, NRC06J133TRF
37	1	R46	RES, CHIP, 10 Ω 5% 0805	NIC, NRC06J100TRF
38	0	R64	RES, CHIP, OPT 5% 0603	OPT
39	1	R47	RES, CHIP, 38.3k 1% 0603	NIC, NRC06F3832TRF
40	1	R48	RES, CHIP, 118 Ω 1% 0603	NIC, NRC06F1180TRF
41	1	R49	RES, CHIP, 52.3 Ω 1% 0805	NIC, NRC10F52R3TRF
42	0	R54, R55	RES, CHIP, OPT 1% 0805	OPT
43	1	R58	RES, CHIP, 10.0k 1% 0603	NIC, NRC06F1002TRF
44	1	R59	RES, CHIP, 820 Ω 5% 0603	NIC, NRC06J821TRF
45	1	T2	TRANSFORMER, FORWARD, EPC3577G-LF EFD20	PCA, EPC3577G-LF
46	0	T3	TRANSFORMER, FORWARD, OPT	OPT
47	1	U1	IC, PD INTERFACE & FORWARD/FLYBACK CONTROLLER, LT4295 QFN28	LINEAR TECH., LT4295IUFD
48	1		FAB, PRINTED CIRCUIT BOARD	DEMO CIRCUIT 2584A


SCHEMATIC DIAGRAM



DEMO MANUAL DC2584A-A

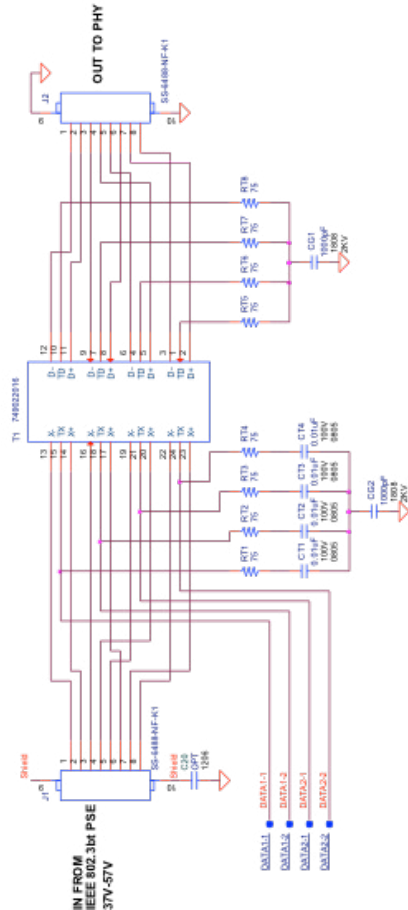
SCHEMATIC DIAGRAM



CUSTOMER NOTICE LINEAR TECHNOLOGY HAS MADE A BEST EFFORT TO DESIGN A CIRCUIT THAT MEETS CUSTOMER-SUPPLIED SPECIFICATIONS; HOWEVER, IT REMAINS THE CUSTOMER'S RESPONSIBILITY TO VERIFY PROPER AND RELIABLE OPERATION IN THE ACTUAL APPLICATION. COMPONENT SUBSTITUTION AND PRINTED CIRCUIT BOARD LAYOUT MAY SIGNIFICANTLY AFFECT CIRCUIT PERFORMANCE OR RELIABILITY. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE.	APPROVALS		 1630 McCarthy Blvd. Milpitas, CA 95035 Phone: (408)432-1900 www.linear.com Fax: (408)434-0507 LTC Confidential-For Customer Use Only	
	PCB DES.	K. HTOO		
	APP ENG.	K. HTOO	TITLE: SCHEMATIC IEEE 802.3bt POWERED DEVICE INTERFACE WITH FORWARD DC-DC CONVERTER	
			SIZE N/A	IC NO. LT4295IUFD, LT4321IUF DEMO CIRCUIT 2584A-A
	THIS CIRCUIT IS PROPRIETARY TO LINEAR TECHNOLOGY AND SUPPLIED FOR USE WITH LINEAR TECHNOLOGY PARTS.		DATE: Monday, February 27, 2017	REV. 1
SCALE = NONE		SHEET 3 OF 3		

SCHEMATIC DIAGRAM

REVISION HISTORY			
ECO	REV	DESCRIPTION	DATE
1	1	PRODUCTION	09-06-2016



DEMO MANUAL DC2584A-A

DEMONSTRATION BOARD IMPORTANT NOTICE

Linear Technology Corporation (LTC) provides the enclosed product(s) under the following **AS IS** conditions:

This demonstration board (DEMO BOARD) kit being sold or provided by Linear Technology is intended for use for **ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY** and is not provided by LTC for commercial use. As such, the DEMO BOARD herein may not be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including but not limited to product safety measures typically found in finished commercial goods. As a prototype, this product does not fall within the scope of the European Union directive on electromagnetic compatibility and therefore may or may not meet the technical requirements of the directive, or other regulations.

If this evaluation kit does not meet the specifications recited in the DEMO BOARD manual the kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY THE SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THIS INDEMNITY, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user releases LTC from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge. Also be aware that the products herein may not be regulatory compliant or agency certified (FCC, UL, CE, etc.).

No License is granted under any patent right or other intellectual property whatsoever. **LTC assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or any other intellectual property rights of any kind.**

LTC currently services a variety of customers for products around the world, and therefore this transaction **is not exclusive**.

Please read the DEMO BOARD manual prior to handling the product. Persons handling this product must have electronics training and observe good laboratory practice standards. **Common sense is encouraged.**

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

Copyright © 2004, Linear Technology Corporation