

# LT4295, LT4321

## High Efficiency IEEE802.3bt (PoE++, Type 3, 51W) PD with Flyback DC/DC Converter and Auxiliary Power Input

### DESCRIPTION

Demonstration circuit 2539A is an IEEE802.3bt (Draft 2.1) compliant Power over Ethernet (PoE) Powered Device (PD). It features the [LT<sup>®</sup>4295](#) PD interface and switching regulator controller and the [LT4321](#) PoE ideal diode bridge controller.

The LT4295 provides IEEE802.3af (PoE, Type 1), IEEE802.3at (PoE+, Type 2), and IEEE802.3bt (PoE++, Type 3) compliant interfacing and power supply control. It utilizes an external, low  $R_{DS(ON)}$  (57m $\Omega$  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 $\Omega$  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 DC2539A-A accepts up to 51W of delivered power from a Power Sourcing Equipment (PSE) via the RJ45 connector (J1) or a local 48VDC power supply using the auxiliary supply input. When both supplies are connected, the auxiliary supply input has priority over the PoE input. The DC2539A-A supplies a 12V output at up to 3.9A.

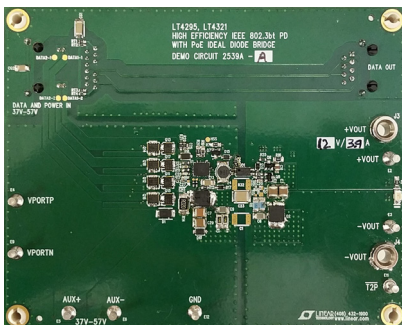
**Design files for this circuit board are available at <http://www.linear.com/demo/DC2539A-A>**

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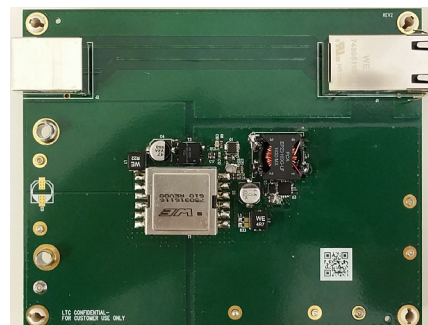
### PERFORMANCE SUMMARY Specifications are at $T_A = 25^\circ\text{C}$

PARAMETER	CONDITIONS	VALUE
Port Voltage ( $V_{PORT}$ )	At RJ45	37V to 57V
Auxiliary Voltage	From AUX+ to AUX- Terminals	37V to 57V
Output Voltage ( $V_{OUT}$ )		12V (Typical)
Output Current ( $I_{OUT}$ )		3.9A (Max)
Output Voltage Ripple	$V_{PORT} = 42.5V, I_{OUT} = 3.9A$	54mV <sub>P-P</sub> (Typical)
Load Regulation		$\pm 0.4\%$ (Typical)
Efficiency	$V_{PORT} = 50V, I_{OUT} = 3A, \text{End-to-End}$	91.5% (Typical)
Switching Frequency		250kHz (Typical)

### BOARD PHOTOS

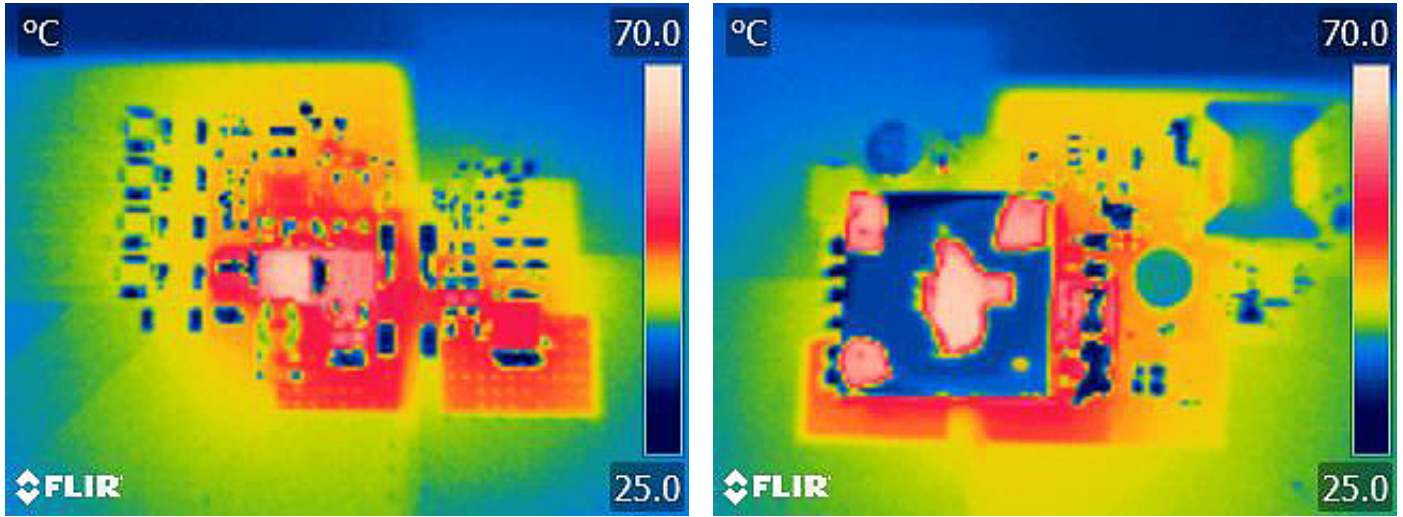


Top Side



Bottom Side

### TYPICAL PERFORMANCE CHARACTERISTICS



Top Side

Bottom Side

Figure 1. Thermal Pictures (Conditions:  $V_{PORT} = 57V$ ,  $V_{OUT} = 12V$ ,  $I_{OUT} = 3.9A$ )

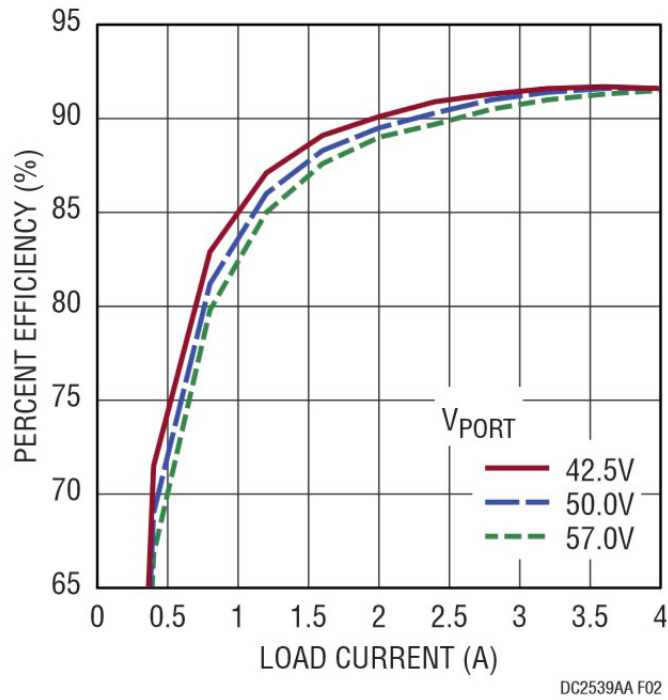


Figure 2. Efficiency (End-to-End)

## TYPICAL PERFORMANCE CHARACTERISTICS

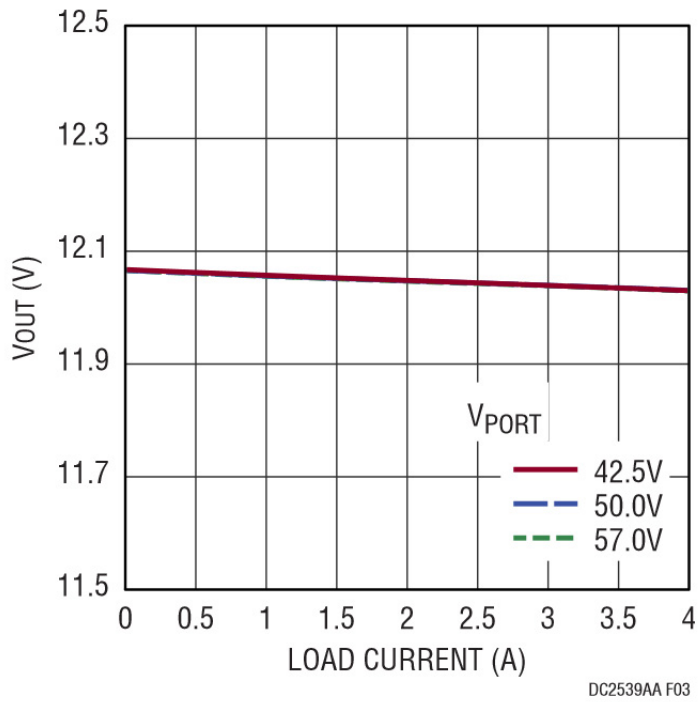


Figure 3. Load Regulation

## TYPICAL PERFORMANCE CHARACTERISTICS

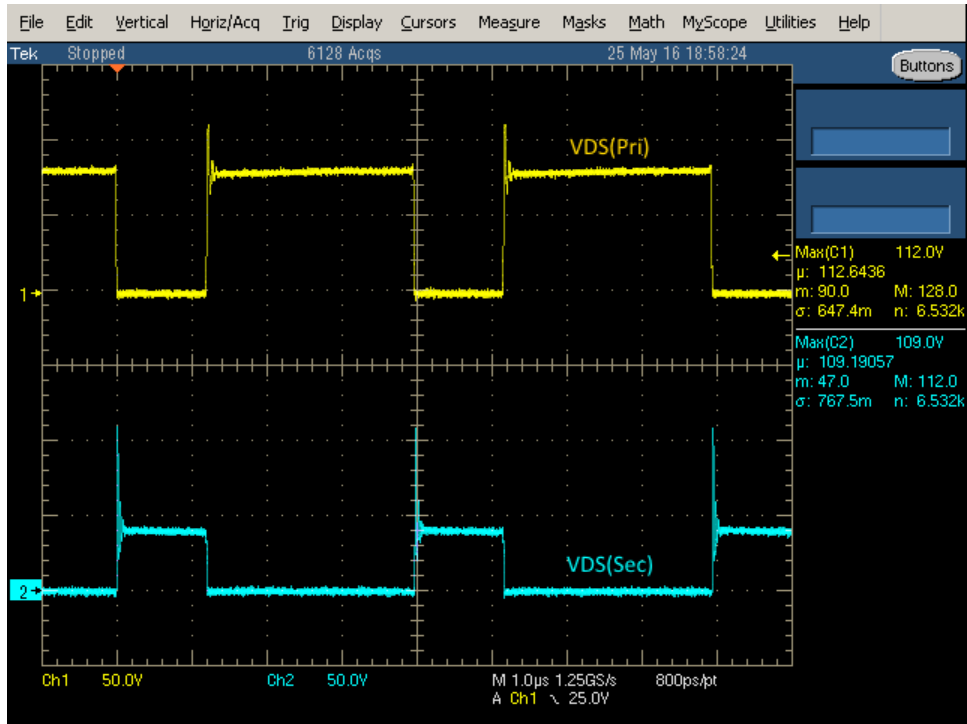


Figure 4. Switch Node Waveforms (Conditions:  $V_{PORT} = 57V$ ,  $V_{OUT} = 12V$ ,  $I_{OUT} = 3.9A$ )

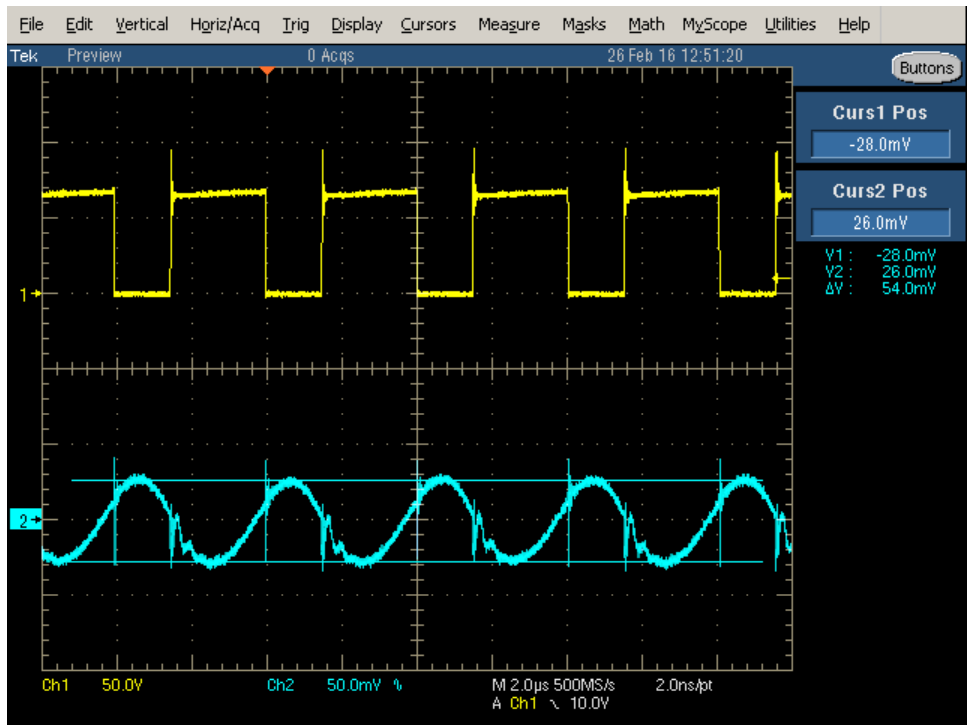


Figure 5. Output Voltage Ripple (Conditions:  $V_{PORT} = 42.5V$ ,  $V_{OUT} = 12V$ ,  $I_{OUT} = 3.9A$ )

## TYPICAL PERFORMANCE CHARACTERISTICS

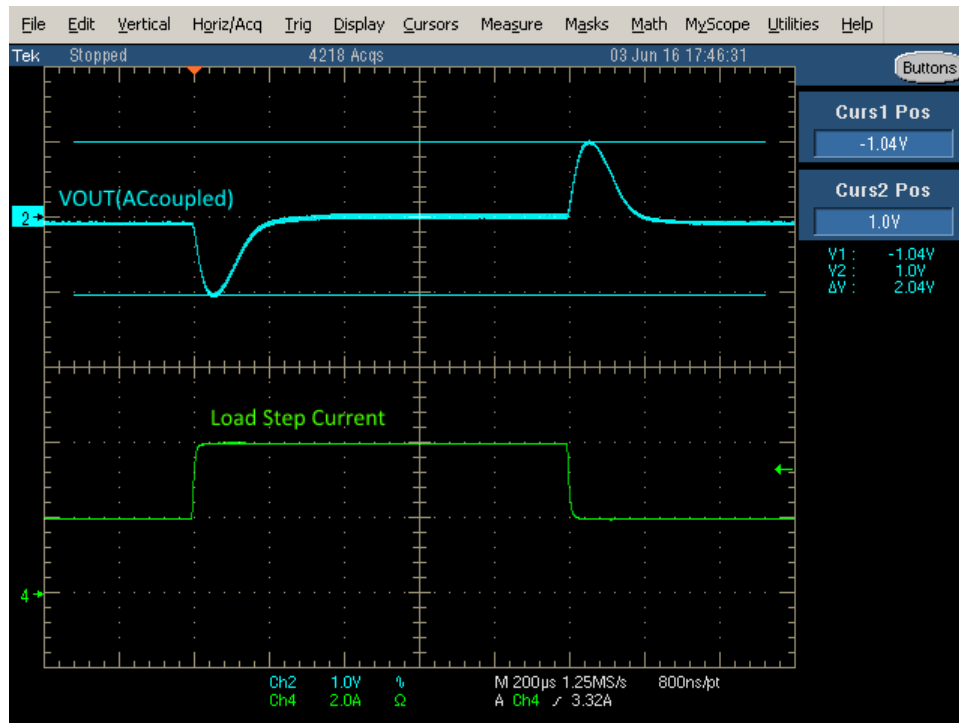


Figure 6. Load Transient Response (Conditions:  $V_{PORT} = 42.5V$ , Load Step: 2A to 4A to 2A)



## TYPICAL PERFORMANCE CHARACTERISTICS

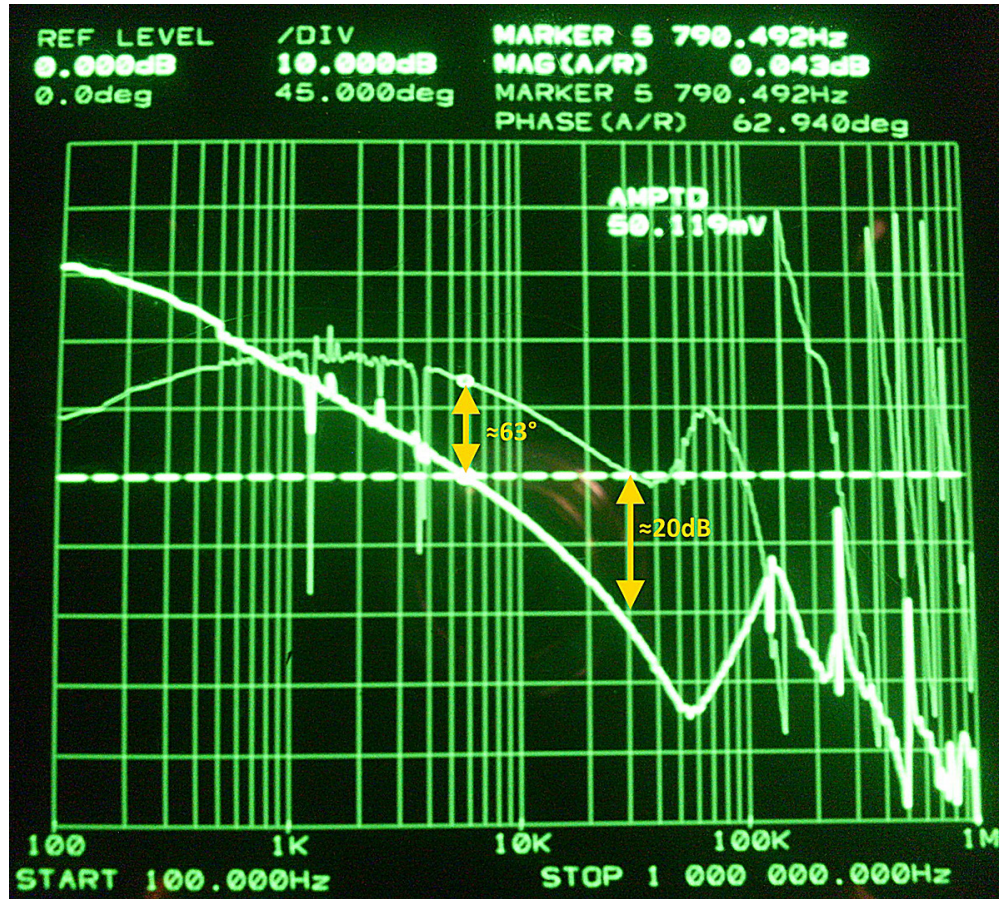


Figure 7. Gain and Phase Margin of the Flyback DC/DC Converter (Conditions:  $V_{PORT} = 57V$ ,  $V_{OUT} = 12V$ ,  $I_{OUT} = 3.9A$ )

CROSSOVER FREQUENCY	GAIN MARGIN	PHASE MARGIN
~5.8kHz	~20dB	~63°

### QUICK START PROCEDURE

#### Power Over Ethernet (PoE) Input

- 1 Disconnect auxiliary supply if it is connected to AUX+ and AUX- inputs of the DC2539A-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 DC2539A using a CAT5e or CAT6 Ethernet cable. (See note.)
- 5 After the LED (D4) on the DC2539A 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 3.9A. Observe the output voltage regulation, efficiency, and other parameters.
- 7 Verify  $\overline{T2P}$  response with an oscilloscope as shown in Figure 8. The  $\overline{T2P}$  response to the type of PSE connected to the DC2539A-A is provided in Table 1.

Note: An 802.3bt PSE has not yet been released. In the interim, an LTPoE++<sup>®</sup> compliant PSE (DC1814A-B) may be used to provide power to the DC2539A-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 DC2539A-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.

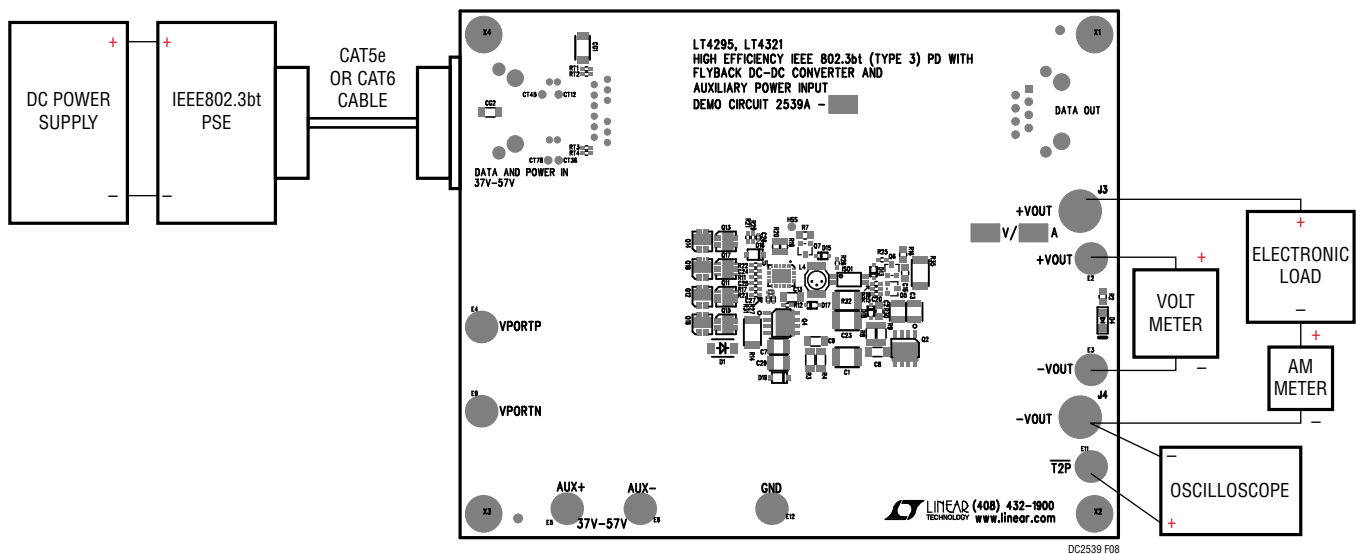


Figure 8. Setup Diagram for PoE Input

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
LTPoE++, 52.7W	Logic Low	51W

### 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 DC2539A 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 DC2539A 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 3.9A. 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  $976Hz \pm 7\%$

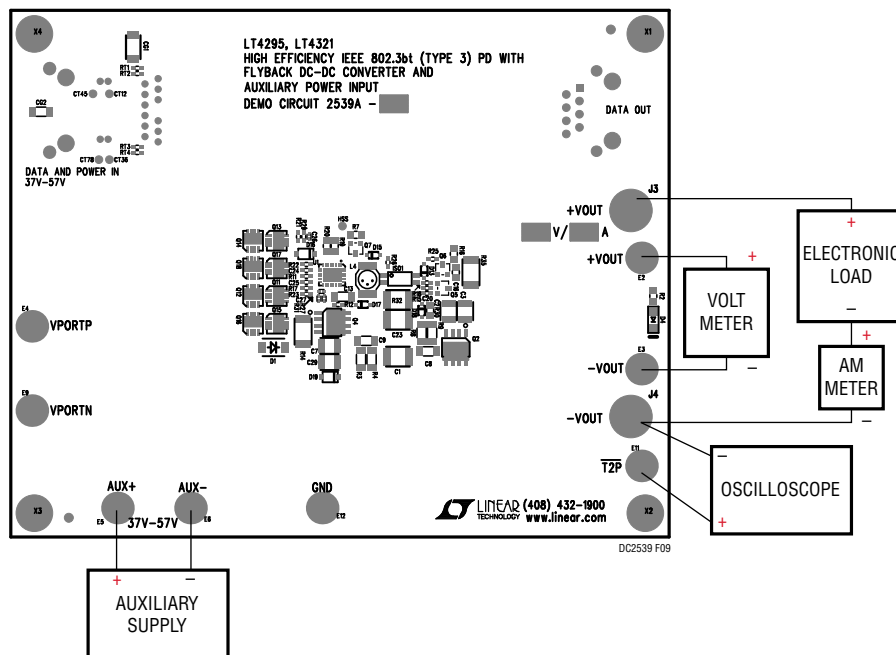


Figure 9. Setup Diagram for Auxiliary Supply Input



## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>DC2539A General BOM</b>				
1	1	CG1	CAP, CER, X7R 1000pF 2kV 10% 1808	MURATA GR442QR73D102KW01L
2	1	CG2	CAP, CER, X7R 0.01μF 100V 20% 1206	AVX 12061C103MAT2A
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 20% 6.3 × 7.7	SUNCON 100CE10KX
6	1	C7, C29	CAP, CER, X7R 2.2μF 100V 10% 1210	MURATA GRM32ER72A225KA35
7	1	C10	CAP, CER, X7R 10nF 100V 20% 0603	MURATA GRM188R72A103KA01D
8	2	C11, C12	CAP, CER, X7R 0.047μF 100V 10% 0603	KEMET C0603C473K1RACTU
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	C23	CAP, CER, X7R 4.7nF 2kV 1812	MURATA GR443DR73D472KW01L
14	1	C26	CAP, CER, X7R 100pF 16V 0402	AVX, 0402YC101KAT2A
15	0	C27	CAP, CER, X7R OPT 6.3V 10% 0402	OPT
16	1	D1	DIODE, SCHOTTKY, PMEG10020 100V SOD128	NXP PMEG10020AELPX
17	3	D2, D16, D19	DIODE, TVS, PTVS58VS1UR 58V SOD123	NXP PTVS58VS1UR
18	1	D3	DIODE, ZENER, MMSZ5252BS 24V SOD323	DIODES INC MMSZ5252BS
19	1	D4	DIODE, LED GREEN	ROHM SML-010FTT86L
20	1	D13	DIODE, SCHOTTKY, NXP, BAT46W 100V SOD323	NXP BAT46WJ,115
21	1	D15	DIODE, DIODE INC, BAV19WS 120V SOD323	DIODE 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	J1	CONN, INTEGRATED JACK, 7499511001A	WURTH 7499511001A
25	1	J2	CONN, RJ45 JACK, SS-6488-NF-K1	STEWART CONNECTOR SS-6488-NF-K1
26	2	J3, J4	CONN, BANANA, 575-4 0.175"	KEYSTONE 575-4
27	1	L2	IND, 4.7μH	WURTH 744316470
28	1	L4	IND, 100μH	COILCRAFT DO1608C-104
29	0	L5	IND, OPT	OPT
30	9	Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18	MOSFET, N-CH, PSMN075-100MSE 100 LFPK33	NXP PSMN075-100MSE
31	1	Q1	MOSFET, N-CH, PSMN040-100MSE 100 LFPK33	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 FMMT723TA
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 NRC06Z0TRF

# DEMO MANUAL

## DC2539A-A

### PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
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	2	R27, R31	RES, CHIP, 0Ω SHUNT 0402	NIC NRC04ZOTRF
47	1	R28	RES, CHIP, 0Ω SHUNT 0603	NIC NRC06ZOTRF
48	1	R29	RES, CHIP, 52.3k 1% 0603	VISHAY CRCW060352K3FKEA
49	0	R32	RES, CHIP, OPT 5% 1812	OPT
50	0	R33	RES, CHIP, OPT 5% 0805	OPT
51	1	T3	XFMR, SMD GATE DRIVE, EPA4271GE	PCA EPA4271GE
52	0	T3 (ALTERNATE)	XFMR, SMD GATE DRIVE, PE-68386NL	PULSE PE-68386NL
53	1	U3	IC, POE IDEAL BRIDGE CONTROLLER LT4321IUF QFN16	LINEAR TECH LT4321IUF
54	2		STENCIL (TOP & BOTTOM)	STENCIL DC2539A

#### DC2539A-A

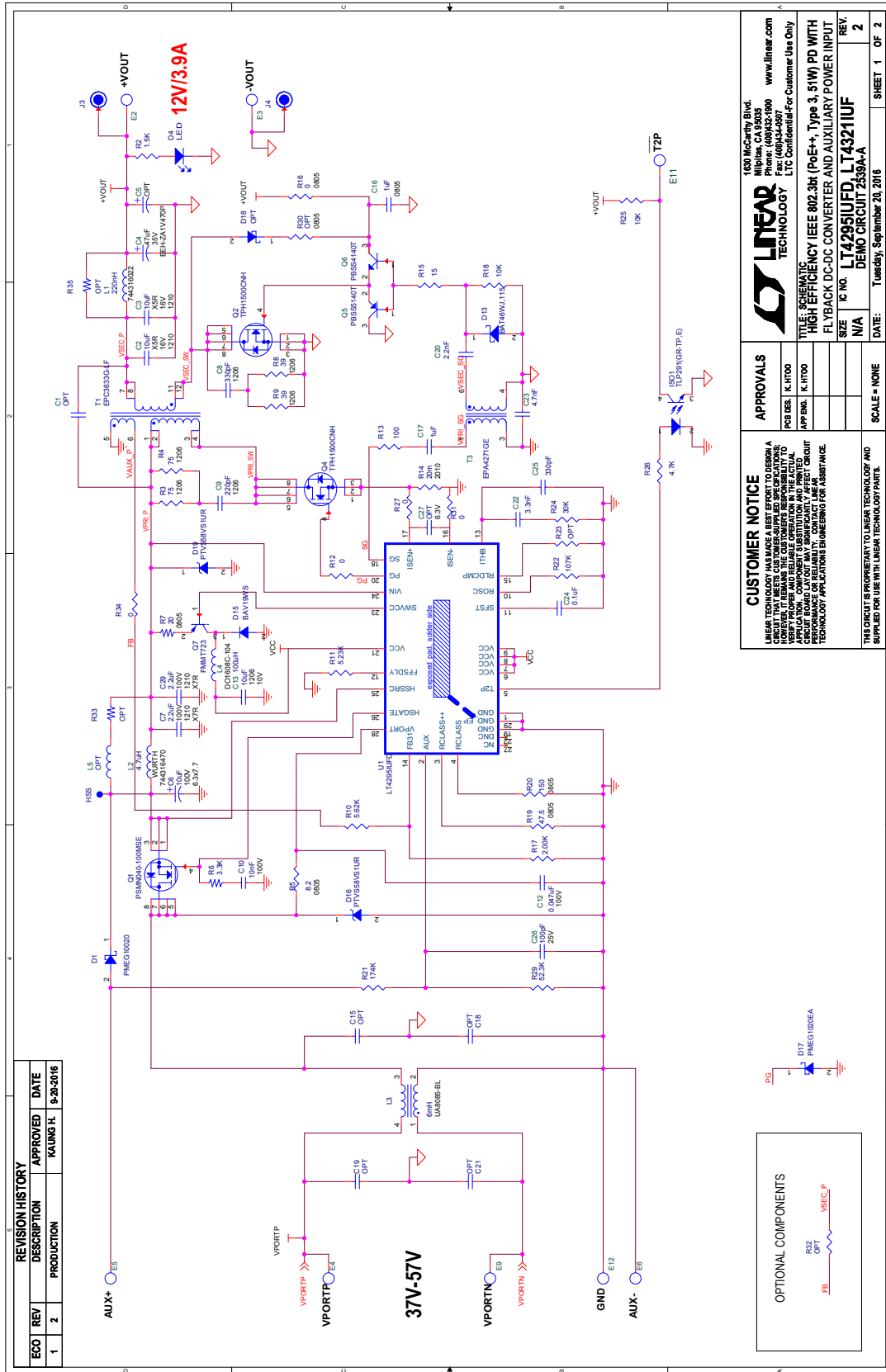
1	1	C2	CAP, CER, X5R 10μF 16V 10% 1210	MURATA GRM32DR61C106KA01
2	1	C3	CAP, CER, X5R 10μF 16V 10% 1210	MURATA GRM32DR61C106KA01
3	1	C4	CAP, ELEC, 47μF 35V 20% 6.0X5.8	PANASONIC EEH-ZA1V470P
4	1	C8	CAP, CER, U2J 330pF 630V 5% 1206	MURATA GRM31A7U2J331JW31
5	1	C9	CAP, CER, U2J 220pF 630V 5% 1206	MURATA GRM31A7U2J221JW31
6	1	C16	CAP, CER, X7R 1μF 25V 10% 0805	MURATA GRM21BR71E105KA99L
7	1	C22	CAP, CER, X7R 3.3nF 25V 10% 0603	AVX 06033C332KAT2A
8	1	C24	CAP, CER, X7R 0.1μF 25V 20% 0603	MURATA GRM188R71E104KA01D
9	1	C25	CAP, CER, X7R 330pF 25V 10% 0603	AVX 06033C331KAT2A
10	0	D18	DIODE, OPT 40V SOD323	OPT
11	1	L1	IND, 220nH	WURTH 744316022
12	1	L3	IND, CMC, 6mH,	COILCRAFT UA8085-AL
13	1	Q2	MOSFET, N-CH, 150V SOP ADVANCE	TOSHIBA TPH1500CNH
14	1	Q4	MOSFET, N-CH, 150V SOP ADVANCE	TOSHIBA TPH1500CNH
15	1	R2	RES, CHIP, 1.5k 5% 0805	NIC NRC10J152TRF
16	1	R3	RES, CHIP, 75Ω 5% 1206	VISHAY CRCW120675R0JNEA
17	1	R4	RES, CHIP, 75Ω 5% 1206	VISHAY CRCW120675R0JNEA
18	1	R8	RES, CHIP, 39Ω 5% 1206	VISHAY CRCW120639R0JNEA
19	1	R9	RES, CHIP, 39Ω 5% 1206	VISHAY CRCW120639R0JNEA
20	1	R10	RES, CHIP, 5.62k 1% 0603	VISHAY CRCW06035K62FKEA
21	1	R11	RES, CHIP, 5.23k 1% 0603	YAGEO RC0603FR-075K23L

## PARTS LIST

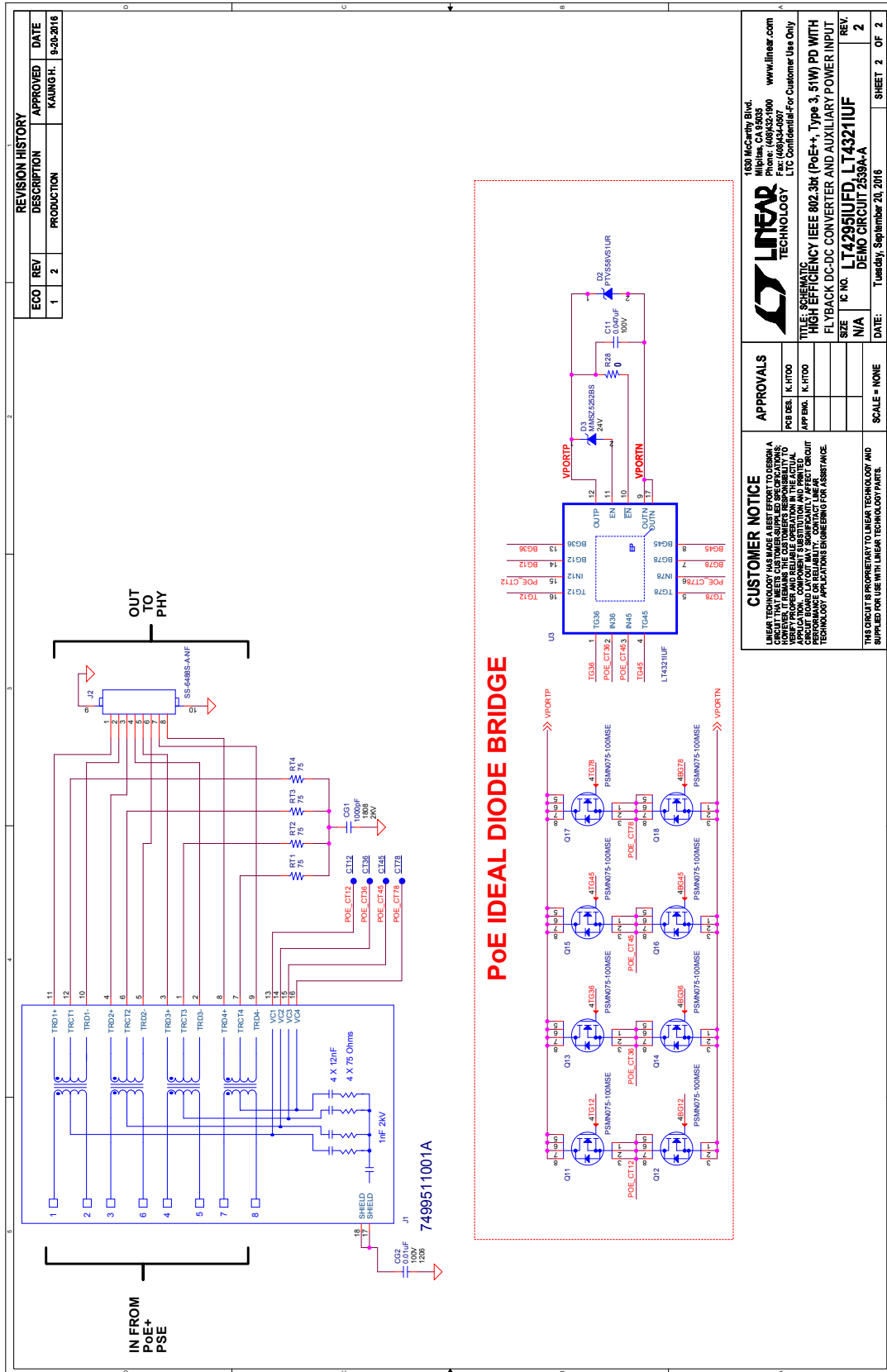
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
22	1	R14	RES, CHIP, 20m $\Omega$ 1% 2010	VISHAY WSL2010R0200FEA
23	1	R16	RES, CHIP, 0 $\Omega$ , Shunt, 0805	VISHAY CRCW08050000Z0EA
24	1	R19	RES, CHIP, 47.5 $\Omega$ 1% 0805	VISHAY CRCW080547R5FKEA
25	1	R20	RES, CHIP, 150 $\Omega$ 1% 0805	VISHAY CRCW0805150RFKEA
26	0	R23	RES, CHIP, OPT 5% 0603	OPT
27	1	R24	RES, CHIP, 30k 5% 0603	VISHAY CRCW060330K1JNEA
28	1	R25	RES, CHIP, 10k 5% 0603	YAGEO RC0603JR-0710KL
29	1	R26	RES, CHIP, 4.7k 5% 0603	NIC NRC06J472TRF
30	0	R30	RES, CHIP, OPT 5% 0805	OPT
31	1	T1	XFMR, FLYBACK TRANSFORMER, EPC3633G	PCA EPC3633G
32	0	T1 (ALTERNATE)	XFMR, FLYBACK TRANSFORMER, 750316116	WURTH 750316116
33	1	U1	IC, PD & SWITCHER CONTROLLER, LT4295IUF QFN28	LINEAR TECH LT4295IUF
34	1	ISO1	IC, TRANSISTOR OUTPUT OPTOCOUPLER, SO4	TOSHIBA TLP291(GR-TPSE)
35	4	MH1-MH4	STAND-OFF, NYLON 0.50" TALL (SNAP ON)	KEYSTONE 8833
36	1		FAB, PRINTED CIRCUIT BOARD	DEMO CIRCUIT 2539A

# DEMO MANUAL DC2539A-A

## SCHEMATIC DIAGRAM



**SCHEMATIC DIAGRAM**



# DEMO MANUAL

## DC2539A-A

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Mailing Address:

Linear Technology  
1630 McCarthy Blvd.  
Milpitas, CA 95035

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