

LT4276, LT4321, LT4320

High Efficiency PoE PD Interface with Integrated Switching Regulator and 9-57VDC/24VAC AUX Support

DESCRIPTION

Demonstration circuit 2047A-A is an IEEE802.3at compliant Power over Ethernet (PoE) Powered Device (PD) with support for 9-57VDC and 24VAC auxiliary supply input. It features the [LT®4276](#) PD interface and switching regulator controller, the LT4321 PoE ideal diode bridge controller, and the LT4320 ideal diode bridge controller.

The LT4276 provides IEEE802.3af (PoE, Type 1) and IEEE802.3at (PoE+, Type 2) compliant interfacing and power supply control. It utilizes an external, low $R_{DS(ON)}$ (57m Ω typical) N-channel FET for the hot swap function to improve efficiency. The LT4276 also provides a DC-DC converter configured as a highly efficient flyback topology with synchronous rectification.

The LT4321 controls eight low $R_{DS(ON)}$ (57m 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 LT4320 controls four N-channel FETs (9.6m Ω typical) to replace a diode bridge typically found at the auxiliary supply input. AC rectification and DC polarity correction are provided. This solution reduces voltage drop associated with the diode bridge and enables the power supply operation as low as 9VDC at the auxiliary supply input. This improves end-to-end efficiency and reduces heat.

The DC2047A-A accepts up to 25.5W of delivered power from a Power Sourcing Equipment (PSE) via the RJ45 connector (J1) or a local AC/DC power supply using the auxiliary supply input. When both supplies are connected, the auxiliary supply input has priority over the PoE input. The DC2047A-A supplies a 12V output at up to 1.9A.

Design files for this circuit board are available at <http://www.linear.com/demo/DC2047A-A>

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PERFORMANCE SUMMARY

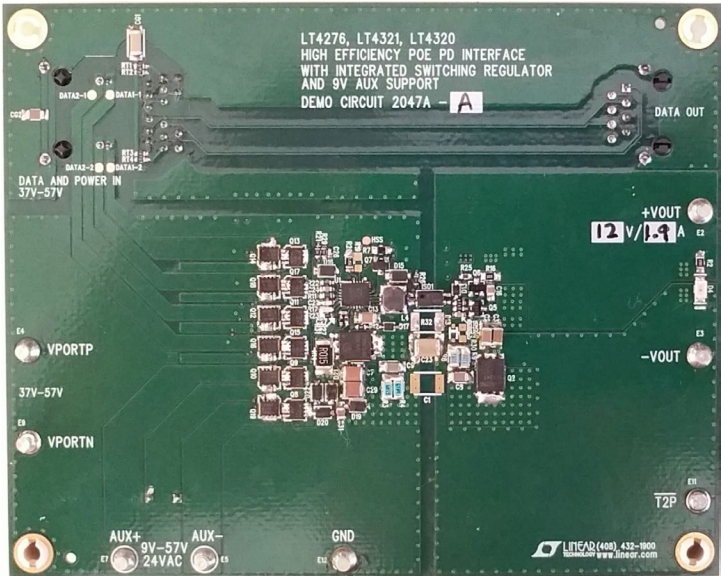
Specifications are at $T_A = 25^\circ\text{C}$

PARAMETER	CONDITIONS	VALUE
Port Voltage (V_{PORT})	At RJ45	37V to 57V
Auxiliary Voltage (V_{AUX})	From AUX+ to AUX- Terminals	9V to 57VDC/24VAC
Output Voltage (V_{OUT})		12V (Typical)
Output Current (I_{OUT})		1.9A (Max)
Output Voltage Ripple	$V_{PORT} = 42.5V$, $I_{OUT} = 1.9A$	90mV _{p-p} (Typical)
Load Regulation		$\pm 0.6\%$ (Typical)
Efficiency	$V_{PORT} = 42.5V$, $I_{OUT} = 1.9A$, End-to-End	88% (Typical)
Switching Frequency		250kHz (Typical)

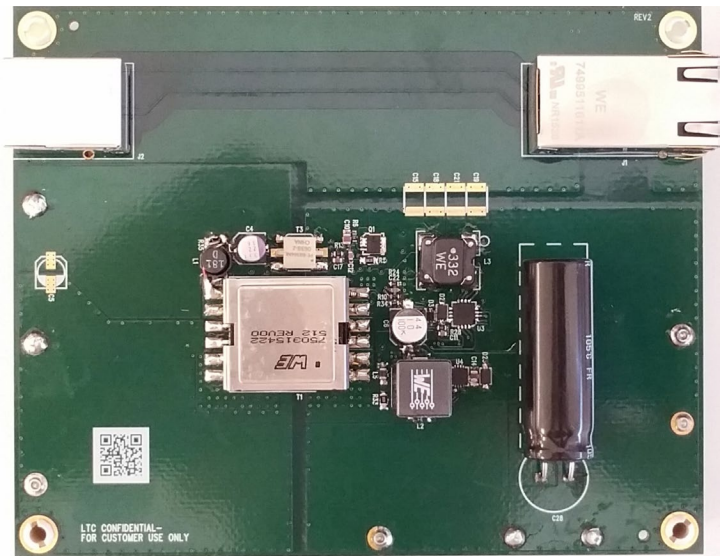
DEMO MANUAL

DC2047A-A

BOARD PHOTO



Top Side



Bottom Side

TYPICAL PERFORMANCE CHARACTERISTICS

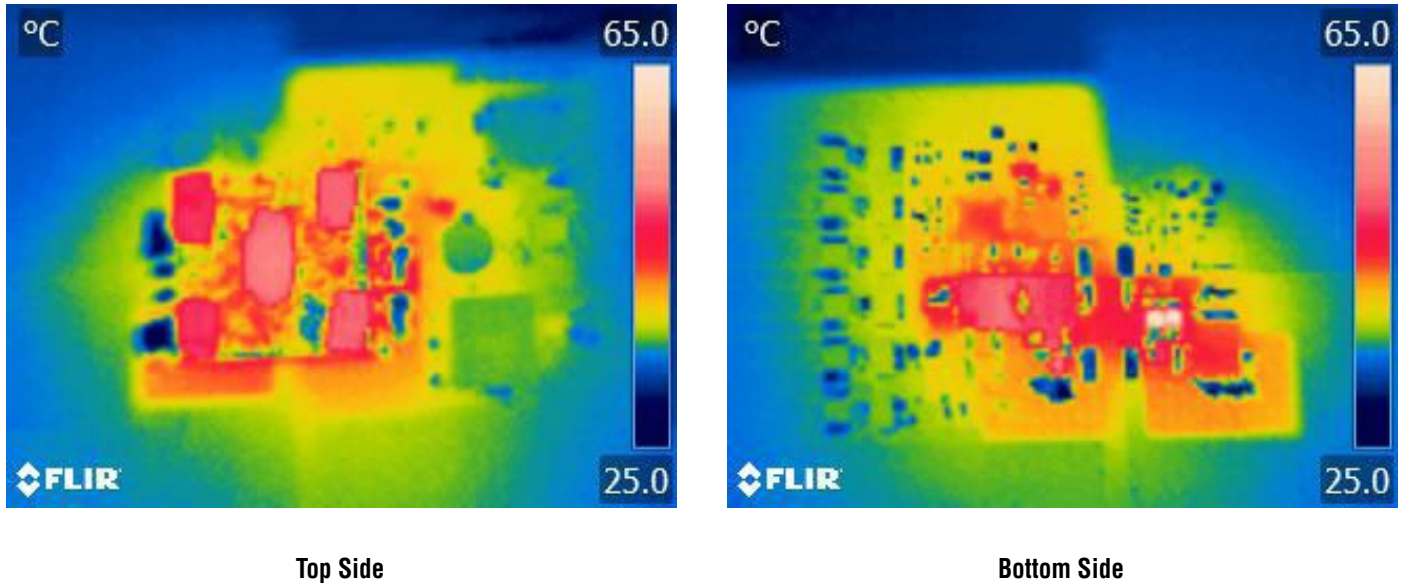


Figure 1. Thermal Pictures (Conditions: $V_{AUX} = 57V$, $V_{OUT} = 12V$, $I_{OUT} = 1.9A$)

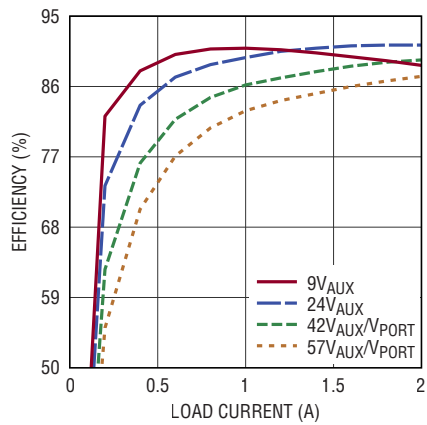


Figure 2. Efficiency (End-to-End)

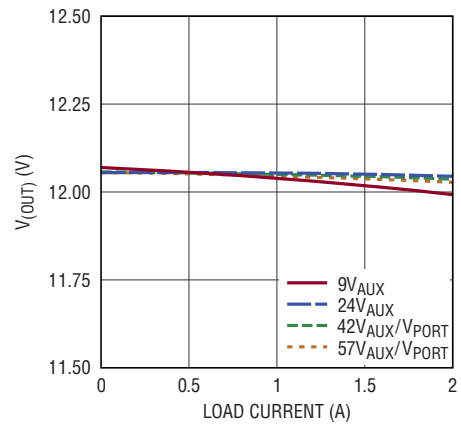


Figure 3. Load Regulation

TYPICAL PERFORMANCE CHARACTERISTICS

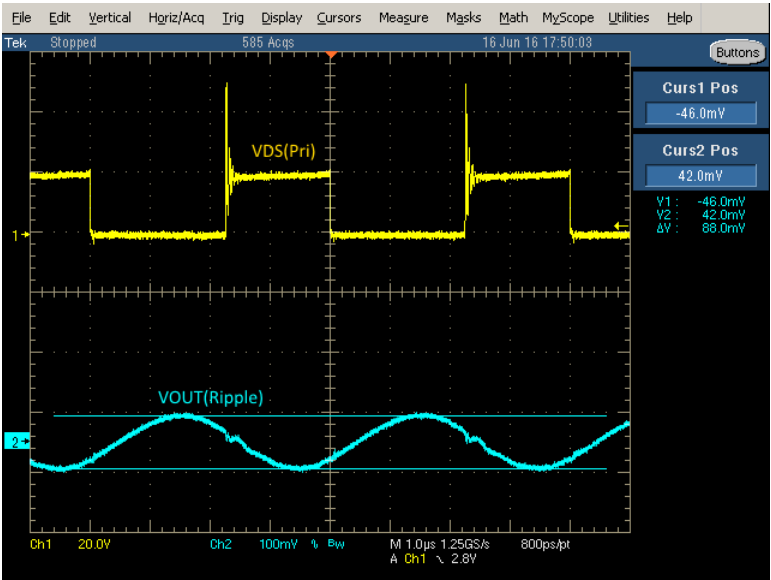


Figure 4. Output Voltage Ripple (Conditions: $V_{AUX} = 9V$, $V_{OUT} = 12V$, $I_{OUT} = 1.9A$)

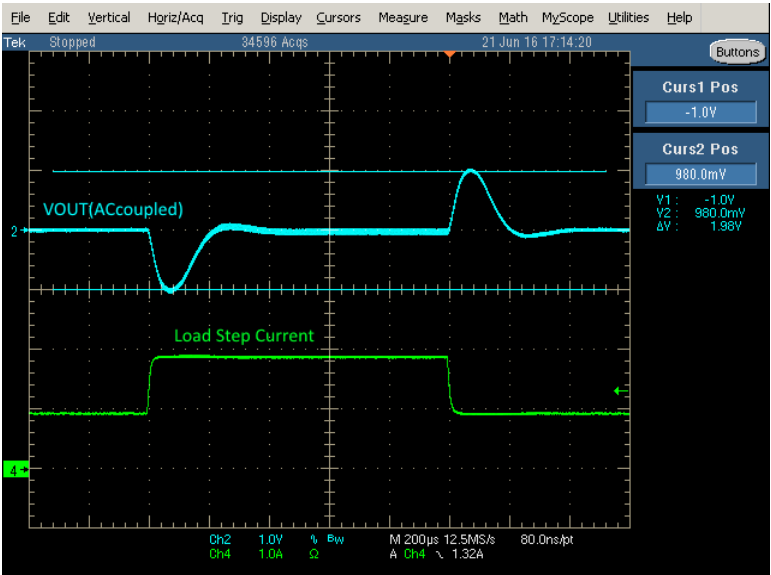


Figure 5. Load Transient Response (Conditions: $V_{AUX} = 9V$, Load Step: 0.95A to 1.9A to 0.95A)

TYPICAL PERFORMANCE CHARACTERISTICS

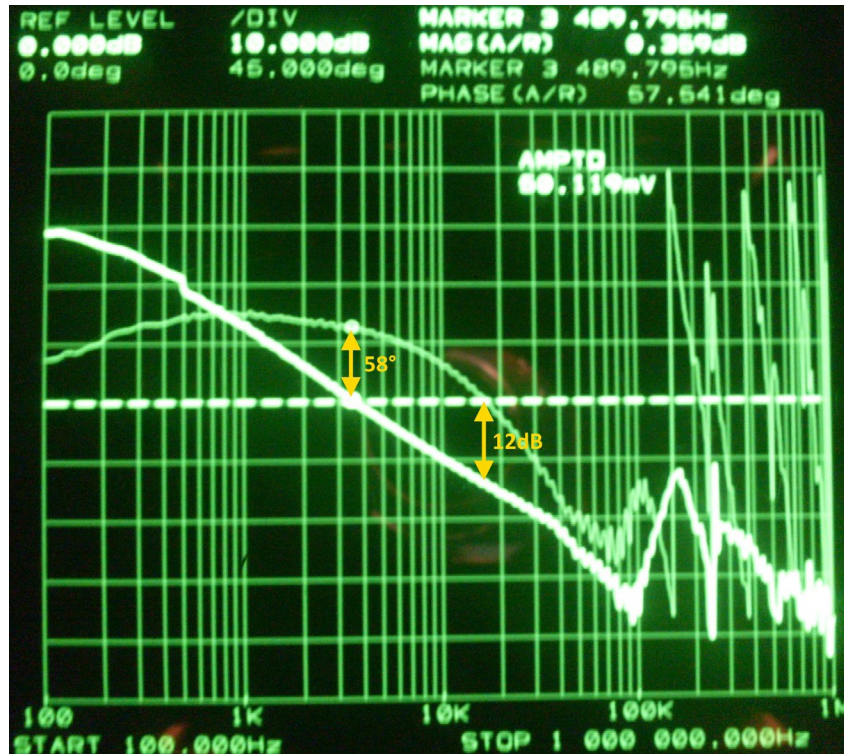


Figure 6. Gain and Phase Margin of the Flyback DC/DC Converter (Conditions: $V_{AUX} = 9V$, $V_{OUT} = 12V$, $I_{OUT} = 1.9A$)

CROSSOVER FREQUENCY	GAIN MARGIN	PHASE MARGIN
3.5kHz	12dB	58°

QUICK START PROCEDURE

Power over Ethernet (PoE) Input

1. Disconnect auxiliary supply if it is connected to AUX+ and AUX- inputs of the DC2047A-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 DC power supply to the DC1567A. Turn on the DC power supply and set its current limit to 1A. Then increase its output voltage to 57V.

5. Connect the output of the DC1567A to the RJ45 connector (J1) of the DC2047A using a CAT5e or CAT6 Ethernet cable.
6. After the LED (D4) on the DC2047A is lit, check the output voltage using a voltmeter. Output voltage should be within 12.0V \pm 0.2V.

7. Turn on the electronic load and increase its load current up to 1.9A. Observe the output voltage regulation, efficiency, and other parameters.

8. Verify $\overline{T2P}$ response with a voltmeter as shown in Figure 7. The $\overline{T2P}$ response to the type of PSE connected to the DC2047A-A is provided in Table 1.

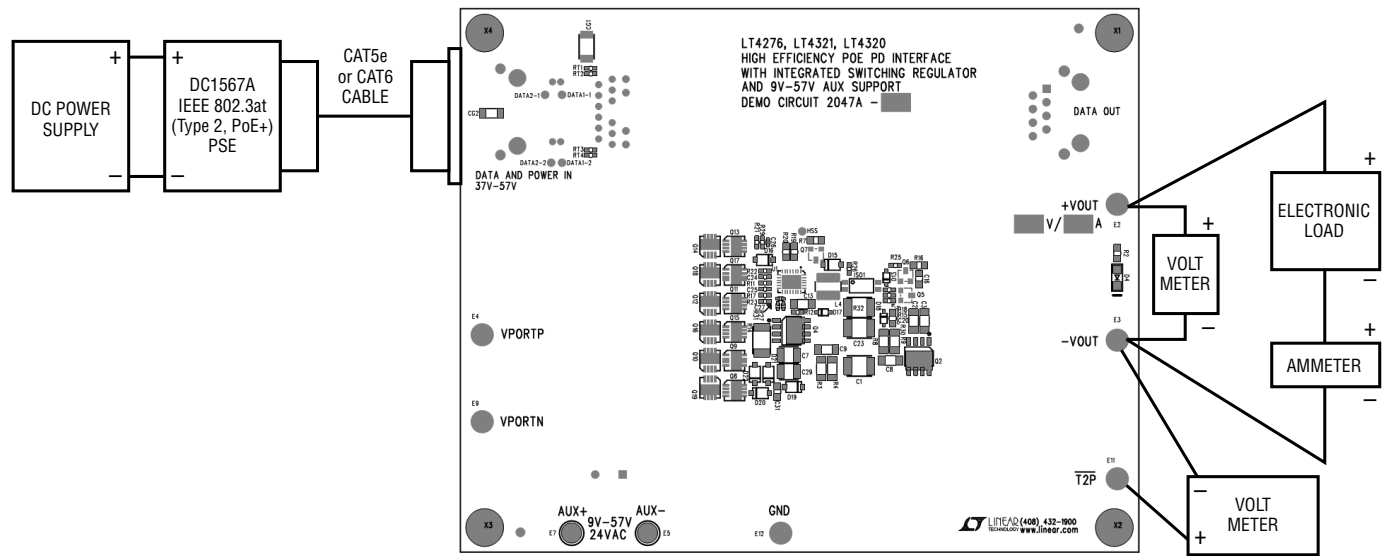


Figure 7. Setup Diagram for PoE Input

Table 1. $\overline{T2P}$ Response vs PSE Type

PSE	$\overline{T2P}$ RESPONSE	NEGOTIATED PD INPUT POWER
IEEE	Logic High	13W
	Logic Low	25.5W

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 DC2047A as shown in Figure 8. Turn on the auxiliary supply and set its current limit to 1A. Then increase its output voltage to 48V.
4. Once the LED (D4) on the DC2047A 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 1.9A. Observe the output voltage regulation, efficiency, and other parameters.
6. Verify $\overline{T2P}$ response with a voltmeter as shown in Figure 8. The $\overline{T2P}$ response during auxiliary power operation is: Logic Low.

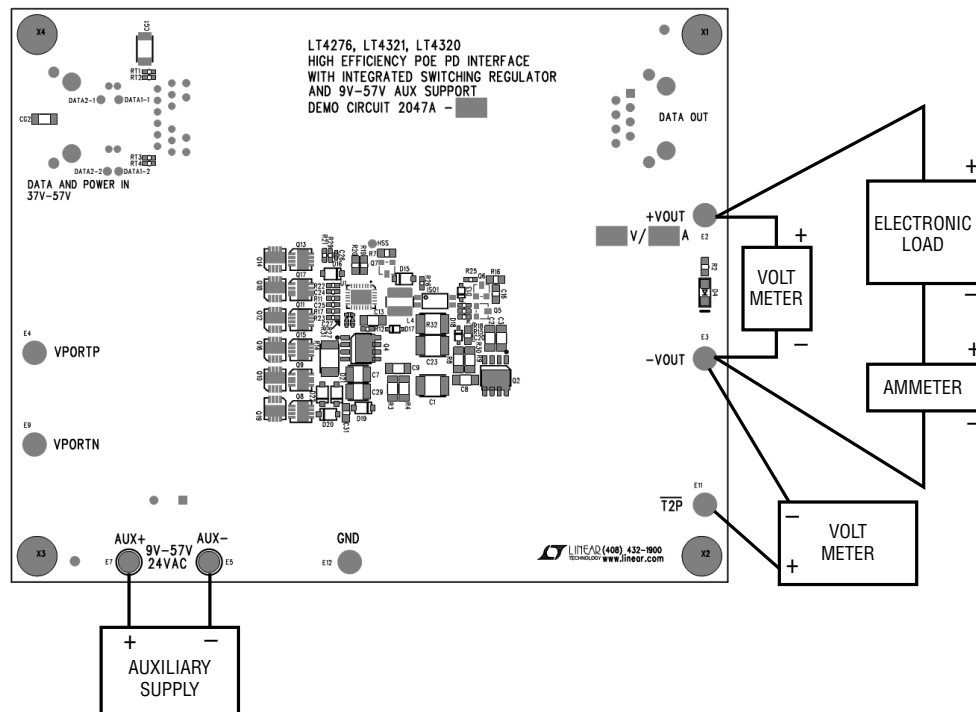


Figure 8. Setup Diagram for Auxiliary Supply Input

DEMO MANUAL

DC2047A-A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
DC2047A 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 12061C103MAT2A
3	0	C1	CAP, CER, OPT 2kV 1812	OPT
4	0	C5	CAP, ELEC, OPT 5.0×5.9	OPT
5	1	C6	CAP, ELEC, 10μF 100V 10% 6.3×7.7	SUNCON 100CE10BS
6	2	C7, C29	CAP, CER, X7S 4.7μF 100V 10% 1210	TDK C3225X7S2A475K200AB
7	1	C10	CAP, CER, X7R 100nF 100V 10% 0805	TDK C2012X7R2A104K125AE
8	2	C11, C12	CAP, CER, X7R 0.047μF 100V 10% 0603	KEMET C0603C473K1RACTU
9	1	C13	CAP, CER, X7R 22μF 10V 20% 1206	MURATA GRM31CR71A226ME15
10	1	C14	CAP, CER, X7R 1μF 100V 10% 0805	MURATA GRJ21BC72A105KE1L
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 1812	MURATA GR443DR73D472KW01L
15	1	C26	CAP, CER, X7R 100pF 16V 10% 0402	AVX 0402YC101KAT2A
16	1	C27	CAP, CER, X7R 4.7nF 6.3V 10% 0402	MURATA GRM155R70J472KA01D
17	1	C28	CAP, ELEC, 680μF 63V 20% 12.5×25	PANASONIC EEU-FR1J681L
18	1	C31	CAP, CER, X7R 0.1μF 100V 10% 0805	MURATA GRM188R72A104KA35
19	4	D2, D16, D19, D23	DIODE, TVS, PTVS58VS1UR 58V SOD123	NXP PTVS58VS1UR
20	1	D3	DIODE, ZENER, MMSZ5252BS 24V SOD323	DIODES INC MMSZ5256BS-7-F
21	1	D4	DIODE, LED	ROHM SML-010FTT86L
22	1	D13	DIODE, SCHOTTKY, BAT46WJ,115 100V SOD323	NXP BAT46WJ,115
23	1	D15	DIODE, SCHOTTKY, PMEG10010ELRX 100V SOD123	NXP PMEG10010ELRX
24	1	D17	DIODE, SCHOTTKY, BAT54WS 30V SOD323	DIODE INC BAT54WS-7-F
25	3	D20, D21, D22	DIODE, SILICON, MM5D4148 100V SOD123	FAIRCHILD SEMI MM5D4148
26	8	E2, E3, E4, E5, E7, E9, E11, E12	TP, TURRET, MILL-MAX-2501 0.094"	MILL-MAX 2501-2-00-80-00-00-07-0
27	1	J1	CONN, INTEGRATED JACK, 7499511611A	WURTH 7499511611A
28	1	J2	CONN, RJ45 JACK, SS-6488S-A-NF	STEWART CONNECTOR SS-6488S-A-NF
29	1	L2	IND, 8.2μH	WURTH 7443330820
30	1	L3	IND, CMC, 3.3mH	WURTH 744272332
31	1	L3 (ALTERNATE)	IND, CMC, 3.3mH	PCA ELECTRONICS EPA4411-LF
32	1	L4	IND, 22μH	BOURNS PM43-220M-RC
33	1	L5	IND, 2.2μH 0805	MURATA LQM21PN2R2NGCD
34	9	Q1, Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18	MOSFET, N-CH, PSMN075-100MSE 100V LFPK33	NXP PSMN075-100MSE
35	1	Q4	MOSFET, N-CH, BSC109N10NS3 G 100V SUPERSO8	INFINEON BSC109N10NS3 G
36	1	Q5	TRANSISTOR, PNP, PBSS5140T 40V SOT23	NXP PBSS5140T
37	1	Q6	TRANSISTOR, NPN, PBSS4140T 40V SOT23	NXP PBSS4140T
38	1	Q7	TRANSISTOR, PNP, FM7T23 100V SOT23	DIODES INC FM7T23TA
39	4	Q8, Q9, Q10, Q19	MOSFET, N-CH, PSMN011-60MS 60V LFPK33	NXP PSMN011-60MS

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
40	4	RT1, RT2, RT3, RT4	RES, CHIP, 75Ω 5% 0603	NIC NRC06J750TRF
41	1	R5	RES, CHIP, 8.2Ω 5% 0805	NIC NRC10J8R2TRF
42	1	R6	RES, CHIP, 3.3k 5% 0603	NIC NRC06J332TRF
43	1	R7	RES, CHIP, 1Ω 5% 0805	NIC NRC10I R0TRF
44	3	R12, R28, R34	RES, CHIP, 0Ω SHUNT 0603	NIC NRC06Z0TRF
45	1	R13	RES, CHIP, 100Ω 5% 0603	VISHAY CRCW0603100RJNEA
46	1	R14	RES, CHIP, 15mΩ 1% 2010	VISHAY WSL2010R0150FEA
47	1	R15	RES, CHIP, 15Ω 5% 0603	NIC NRC06J150TRF
48	1	R33	RES, CHIP, 0Ω SHUNT 0805	NIC NRC06Z0TRF
49	1	R17	RES, CHIP, 2.00k 1% 0603	NIC NRC06F2001TRF
50	2	R18, R26	RES, CHIP, 10k 5% 0603	NIC NRC06J103TRF
51	1	R21	RES, CHIP, 158k 1% 0603	NIC NRC06F1583TRF
52	1	R22	RES, CHIP, 107k 1% 0603	NIC NRC06F1071TRF
53	2	R27, R31	RES, CHIP, 10Ω 5% 0402	NIC NRC04J100TRF
54	1	R29	RES, CHIP, 931k 1% 0603	NIC NRC06F9313TRF
55	0	R32	RES, CHIP, OPT 1% 1812	OPT
56	1	ISO1	OPTO, TRANSISTOR OUTPUT OPTOCOUPLER, S04	TOSHIBA TLP291 (GR-TPSE)
57	1	T3	XFMR, SMD GATE DRIVE, EPA4271GE	PCA EPA4271GE
58	0	T3 (ALTERNATE)	XFMR, SMD GATE DRIVE, PE-68386NL	PULSE PE-68386NL
59	0	T4	XFMR, SMD GATE DRIVE, OPT	OPT
60	1	U1	IC, PD AND SWITCHER CONTROLLER, LT4276BIUFD QFN28	LINEAR TECH LT4276BIUFD
61	1	U3	IC, PoE IDEAL DIODE BRIDGE CONTROLLER, LT4321IUF QFN16	LINEAR TECH LT4321IUF
62	1	U4	IC, IDEAL DIODE BRIDGE CONTROLLER, LT4320IDD DFN8	LINEAR TECH LT4320IDD
63	4	MH1-MH4	STAND-OFF, NYLON 0.50" TALL (SNAP ON)	KEystone 8833
64	1		STENCIL	STENCIL DC2047A

DC2047A-A

1	2	C2,C3	CAP, CER, X5R 10μF 16V 10% 1206	MURATA GRM31CR61C106KA88
2	1	C4	CAP, ELEC, 22μF 16V 20% 5.0x5.9	PANASONIC 16SVP22M
3	1	C8	CAP, CER, U2J 220pF 630V 5% 1206	MURATA GRM31A7U2J221JW31D
4	1	C9	CAP, CER, U2J 220pF 630V 5% 1206	MURATA GRM31A7U2J221JW31D
5	1	C16	CAP, CER, X7R 1μF 25V 10% 0805	MURATA GRM21BR71E105KA99L
6	1	C22	CAP, CER, X7R 3.3nF 25V 10% 0603	AVX 06033C332KAT2A
7	1	C24	CAP, CER, X7R 0.1μF 25V 10% 0603	MURATA GRM188R71E104KA01D
8	1	C25	CAP, CER, X7R 100pF 25V 10% 0603	AVX 06033C101KAT2A
9	0	D18	DIODE, SCHOTTKY, OPT SOD323	OPT
10	1	L1	IND, 180nH	COILCRAFT DO1813P-181HC
11	1	Q2	MOSFET, N-CH, TPH5200FNH 250V SOP ADVANCE	TOSHIBA TPH5200FNH
12	1	R2	RES, CHIP, 1.5k 5% 0805	NIC NRC06J152TRF
13	1	R3	RES, CHIP, 62Ω 5% 1206	PANASONIC ERJ-8GEYJ620V

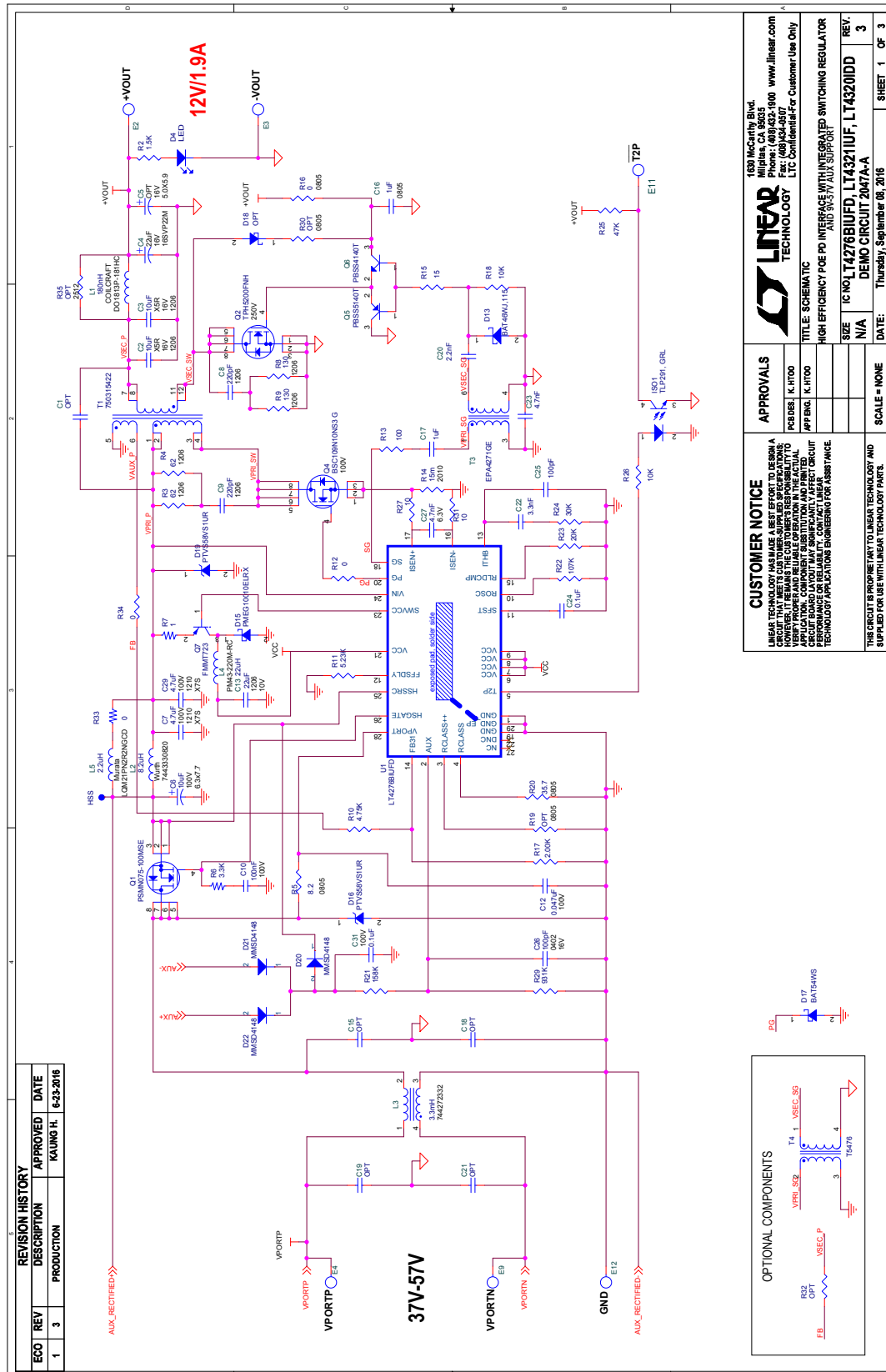
DEMO MANUAL

DC2047A-A

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
14	1	R4	RES, CHIP, 62 Ω 5% 1206	PANASONIC ERJ-8GEYJ620V
15	1	R8	RES, CHIP, 130 Ω 5% 1206	NIC NRC12J131TRF
16	1	R9	RES, CHIP, 130 Ω 5% 1206	NIC NRC12J131TRF
17	1	R10	RES, CHIP, 4.75k 1% 0603	NIC NRC06F4751TRF
18	1	R11	RES, CHIP, 5.23k 1% 0603	VISHAY, CRCW06035K23FKEA
19	1	R16	RES, CHIP, 0 Ω SHUNT 0805	VISHAY CRCW08050000Z0EA
20	0	R19	RES, CHIP, OPT 1% 0805	OPT
21	1	R20	RES, CHIP, 35.7 Ω 1% 0805	VISHAY CRCW080535R7FKEA
22	1	R23	RES, CHIP, 20k 5% 0603	VISHAY CRCW060320K0JNEA
23	1	R24	RES, CHIP, 30k 5% 0603	VISHAY CRCW060330K0JNEA
24	1	R25	RES, CHIP, 47k 5% 0603	NIC NRC06J473TRF
25	0	R30	RES, CHIP, OPT 5% 0805	OPT
26	0	R35	RES, CHIP, OPT 5% 2512	OPT
27	1	T1	XFMR, PWR TRAN, 750315422	WURTH 750315422
28	0	T1 (ALTERNATE)	XFMR, PWR TRAN, EPC3601	PCA ELECTRONICS EPC3601G-LF
29	1		FAB, PRINTED CIRCUIT BOARD	DEMO CIRCUIT 2047A

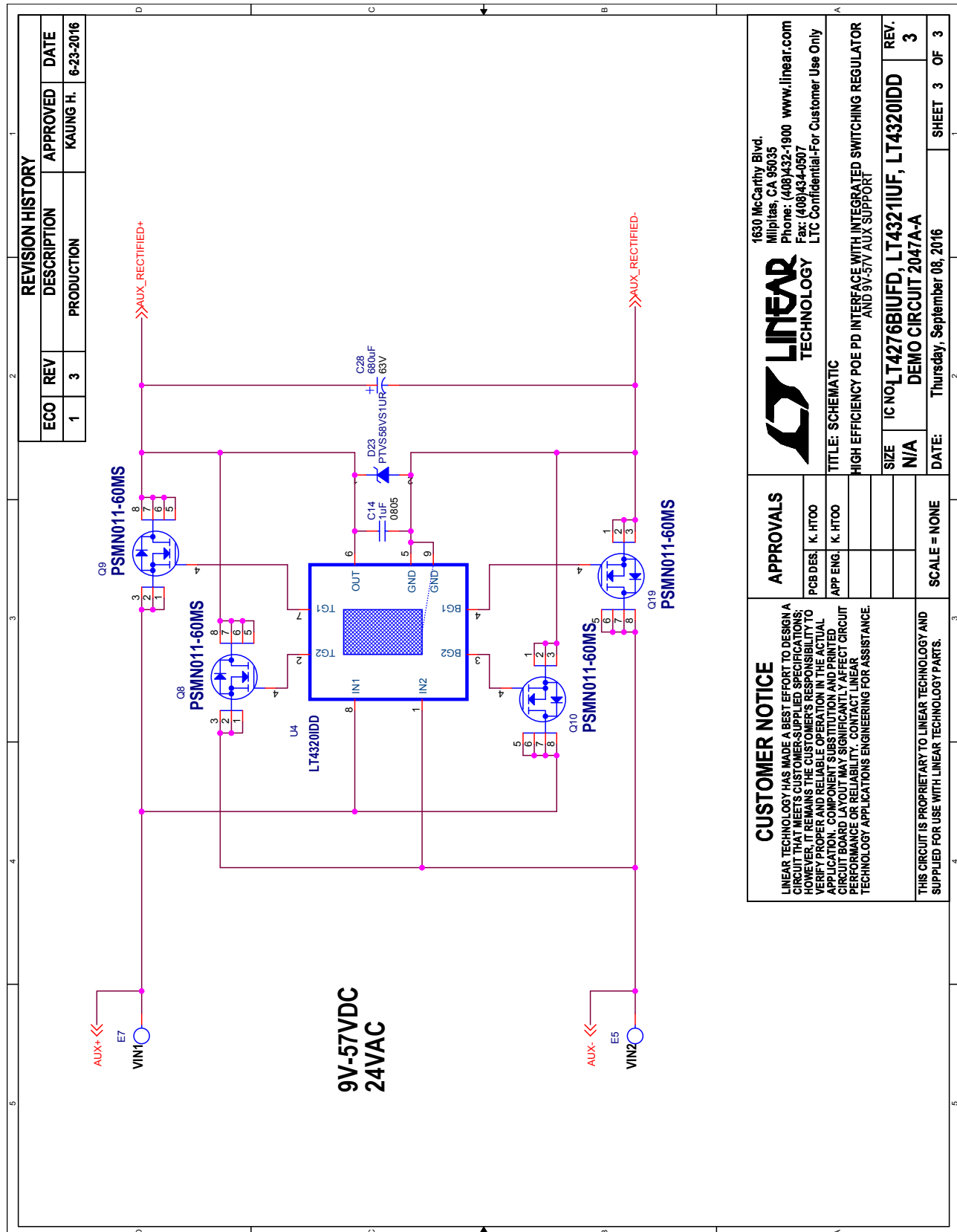
SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



SCHEMATIC DIAGRAM



DEMO MANUAL

DC2047A-A

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