

# LTC4278: PoE+ (802.3at) Powered Device Controller and Synchronous Flyback

## DESCRIPTION

Demonstration circuit 1561B is a high power supply, featuring the LTC<sup>®</sup>4278. This board is a Type 2 (IEEE 802.3at) compliant, high power Power over Ethernet (PoE), Powered Device (PD). The DC1561B also features a wide auxiliary input voltage range of 9V to 57V. The demonstration board can connect to a Type 2 Power Sourcing Equipment (PSE) device, such as the DC1567.

The LTC4278 provides IEEE 802.3at standard (PoE+) PD interfacing and power supply control. When the PD fully powers, the PD interface passes power from the PSE to the switcher through an internal, low resistance, high power MOSFET. The highly integrated LTC4278 controls a high

power, small power supply that utilizes a highly-efficient isolated flyback topology with synchronous rectification. The DC1561B outputs 5V at 4.5A.

DC1561B also demonstrates the use of an auxiliary wall adapter for nominal 12VDC, 24VAC/24VDC, or 48VDC systems. When present, the auxiliary supply is the dominant supply over PoE to provide power.

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

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## PERFORMANCE SUMMARY (T<sub>A</sub> = 25°C)

PARAMETER	CONDITION	VALUE
PoE Input Voltage (V <sub>PORT</sub> )	At RJ-45 Jack (J1)	37V to 57V
Auxiliary Input Voltage (V <sub>AUX</sub> )	From AUX <sup>+</sup> to AUX <sup>-</sup> Terminals	8V(On)/7V(Off) to 57V
Output Voltage (V <sub>OUT</sub> )	Typical	5V
Output Current (I <sub>OUT</sub> )	Over 9V to 57V Input Voltage	4.5A (Max)
Output Voltage Ripple (Typ)	Over 9V to 57V Input Voltage, I <sub>OUT</sub> = 4.5A	30mV <sub>P-P</sub> (Typ)
Output Regulation	PoE Input Voltage, I <sub>OUT</sub> = 0A to 4.5A Auxiliary Input Voltage, I <sub>OUT</sub> = 0A to 4.5A	±0.4% (Typ) ±1.1% (Typ)
Output Voltage Response to Load Step (Typ)	Load Step = 2.25A to 4.5A, 48V Input Voltage Settling Time (Within 1% of V <sub>OUT</sub> )	±500mV (±10%) (Typ) < 150 $\mu$ s (Typ)
Switching Frequency		250kHz (Typ)
Efficiency	V <sub>AUX</sub> = 24V, I <sub>OUT</sub> = 4.5A (Includes Diode D12)	89% (Typ)

## OPERATING PRINCIPLES

A compatible high power PSE board, such as the DC1567, connects to the DC1561B at the RJ45 connector J1 (see the schematic in Figure 12). As required by IEEE 802.3at, the DC1561B uses a diode bridge across the data pairs and signal pairs. Schottky diodes (D2-D9) are used at the input to improve efficiency over standard diode bridges. The LTC4278 provides the PoE required 25k signature resistance and classification up to class 4 (25.5W). When the PD is powered and voltage reaches above the PoE “On Voltage,” the LTC4278 switches the port voltage over to the power supply controller through its internal MOSFET. This voltage allows the Zener and NPN-based linear regulator (R9/D17/Q3) to power up the bias pin,  $V_{CC}$ , of the power supply controller. The IC begins a controlled soft-start of the output. As the output voltage rises, bias power takes over by the bias supply made up of T1’s bias winding and D11 since it reverse biases the linear regulator’s (Q3) base to emitter junction.

When the soft-start period is over, the output voltage regulates by observing the pulses across the bias winding during the flyback time. The Primary Gate drive (PG) and Synchronous Gate (SG) drive Pulse Width Modulates (PWM) in order to keep the output voltage constant. The synchronous gate drive signal transmits to the secondary via the small signal transformer, T2. The output of T2 drives a discrete gate drive buffer, R22 and Q6/7 to achieve fast gate transition times, hence higher efficiency.

The two-stage input filter, C5, L2, and C6 and output filter, C1/C3, L1, and C9 are the reasons that this PoE flyback supply has exceptionally low differential mode conducted emissions. A common mode filter consisting of a common mode choke (L3) and common mode capacitor (C34) yields low common mode emissions out of the power supply.

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## QUICK START PROCEDURE

Demonstration circuit 1561B is easy to set up to evaluate the performance of the LTC4278 in a PoE+ PD application. Refer to Figure 1 for proper equipment setup and follow the procedure below:

1. Place test equipment (voltmeter, ammeter, and electronic load) across output.
2. Input supplies:
  - a. Connect a PoE+ capable PSE, like the DC1567, with an Ethernet cable to the RJ45 connector, J1. See Figure 1.
  - b. Or, connect a 37V to 57V capable power supply (Power Supply in Figure 1) across VPORT\_P and VPORT\_N.
  - c. Or, if evaluating the auxiliary power supply capability, connect a 9V to 57V at 4A capable power supply across AUX+ to AUX- (Auxiliary Supply in Figure 1).

3. Check for the proper output voltage of 5V.
4. Once the proper output voltage is confirmed, adjust the output’s load current within the operating range and observe the output voltage regulation, output ripple voltage, efficiency, and other parameters.

**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 (or input) voltage ripple by touching the probe tip and probe ground directly across the +VOUT and -VOUT (or VPORT\_P and VPORT\_N) terminals. See Figure 2 for proper scope probe technique.

# QUICK START PROCEDURE

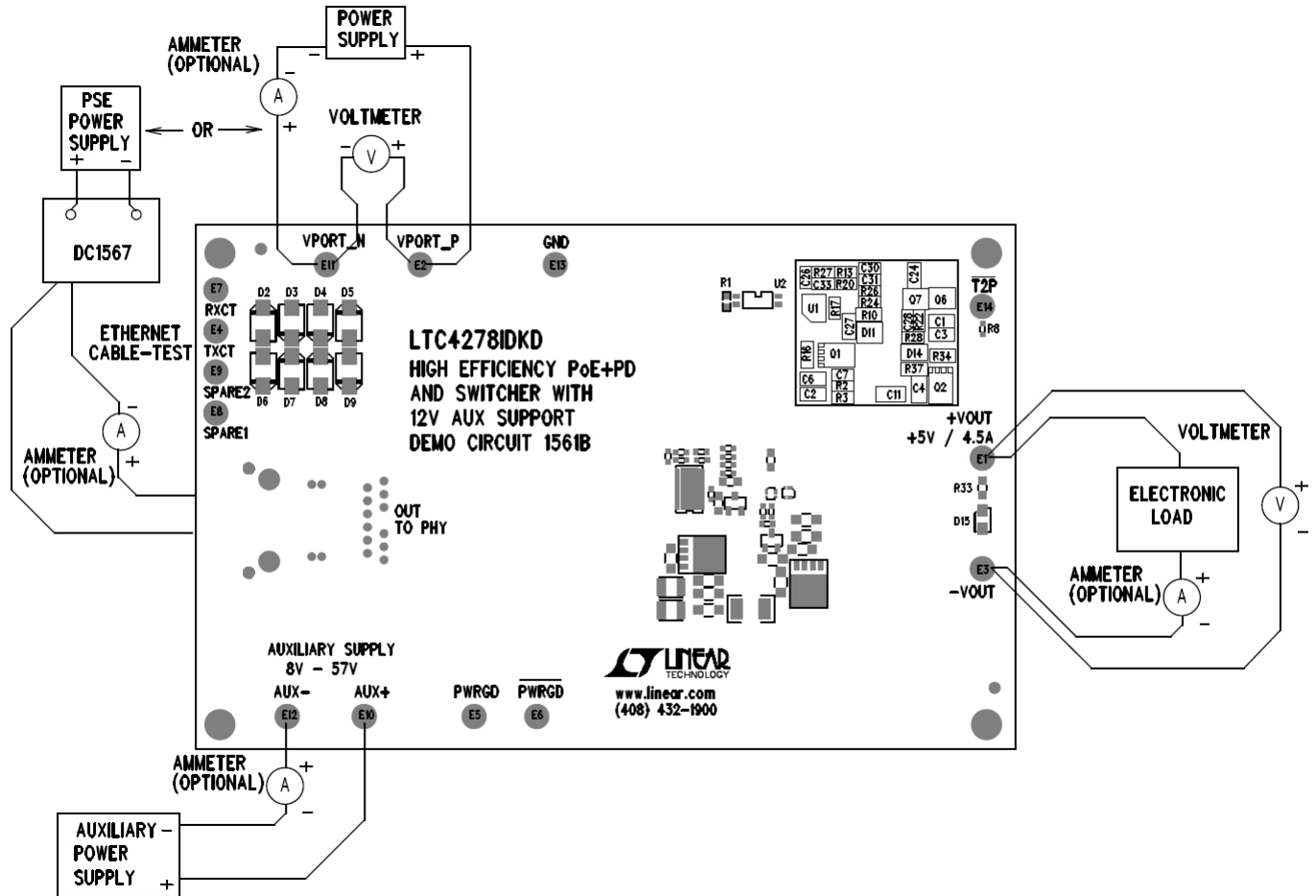


Figure 1. Proper Measurement Equipment Setup

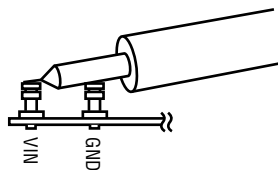


Figure 2. Measuring Input and Output Ripple

## MEASURED DATA

Figures 3 through 11 are measured data for a typical DC1561B. Figure 12 is the schematic and Figure 13 is the bill of materials.

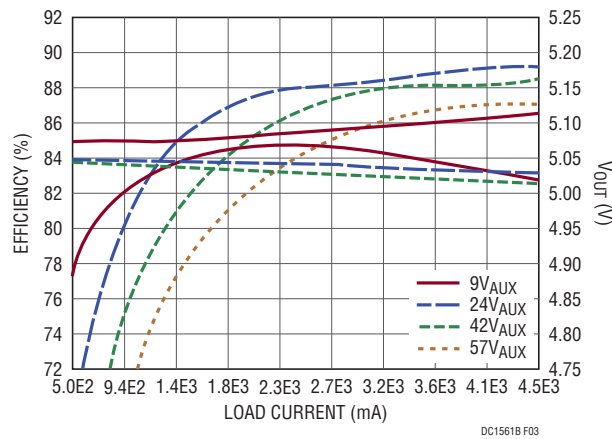


Figure 3. Efficiency and Regulation (Including OR'ing Diode, D12)

MEASURED DATA

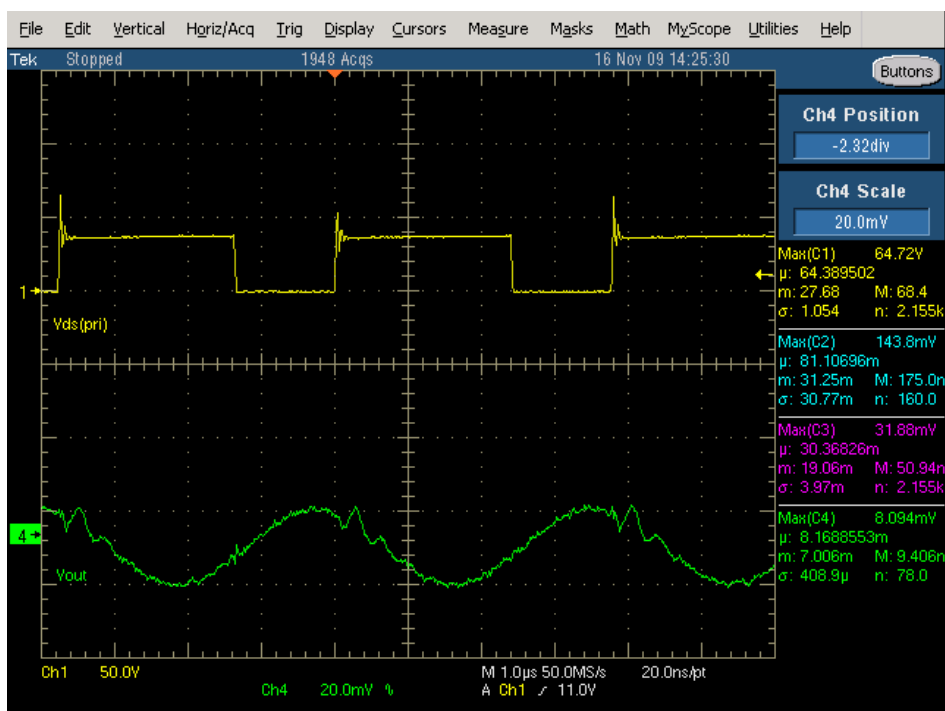


Figure 4. Output Ripple (24V<sub>AUX</sub>, 4.5A)

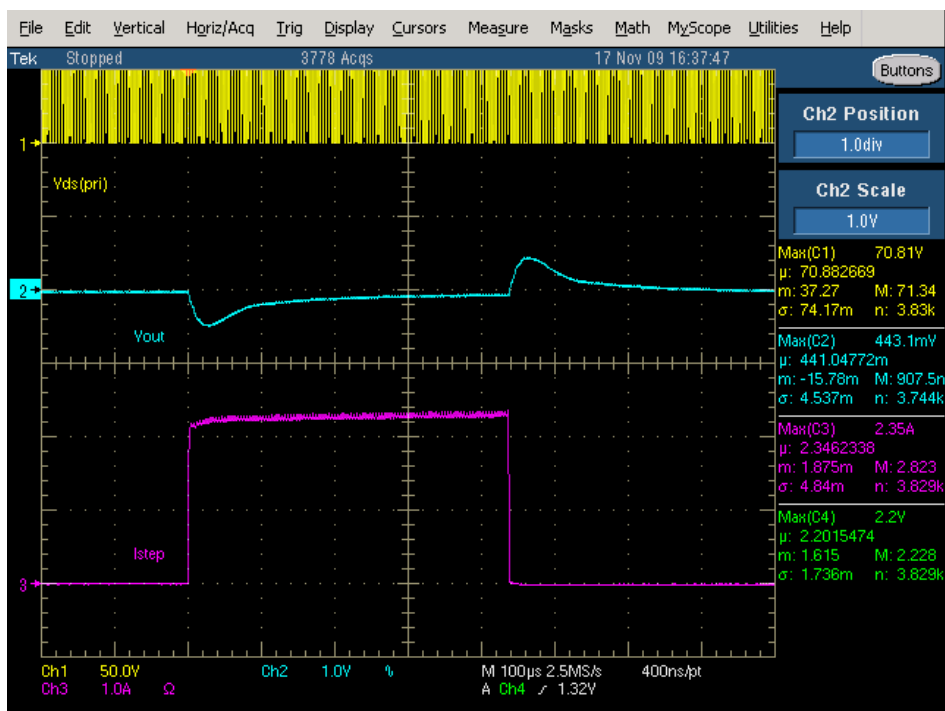


Figure 5. Load Transient Response (57V<sub>PORT</sub>, 2.25A to 4.5A to 2.25A)

## MEASURED DATA



Figure 6. Temperature Data (9V<sub>AUX</sub>, 4.5A, Top)

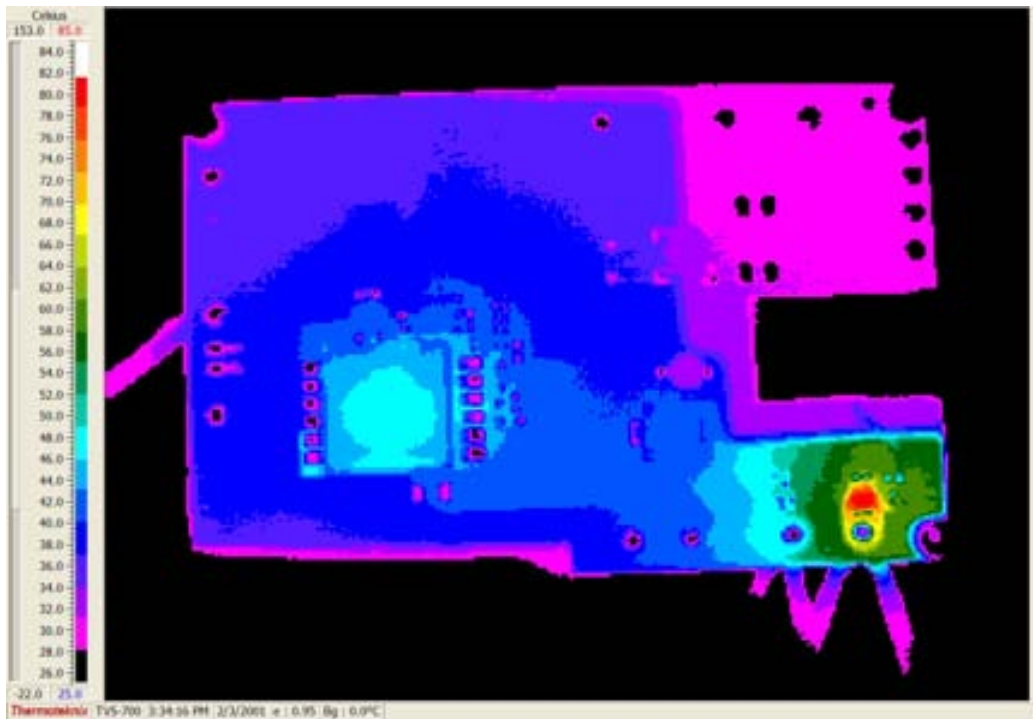


Figure 7. Temperature Data (9V<sub>AUX</sub>, 4.5A, Bottom)

MEASURED DATA

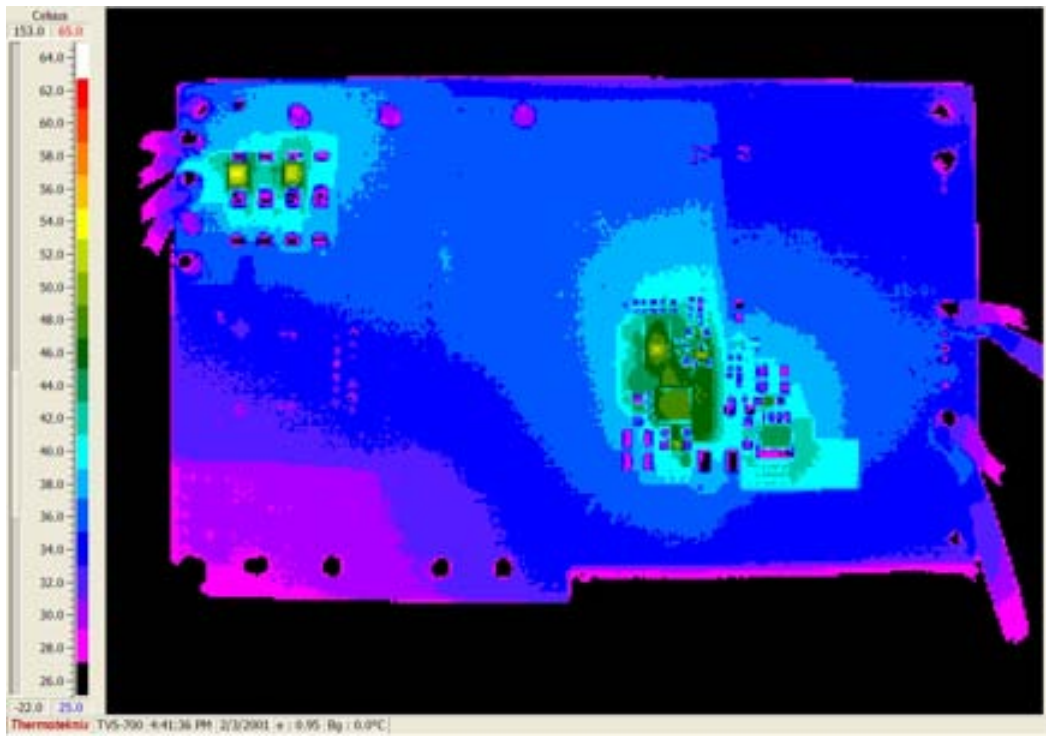


Figure 8. Temperature Data (37V<sub>PORT</sub>, 4.5A, Top)

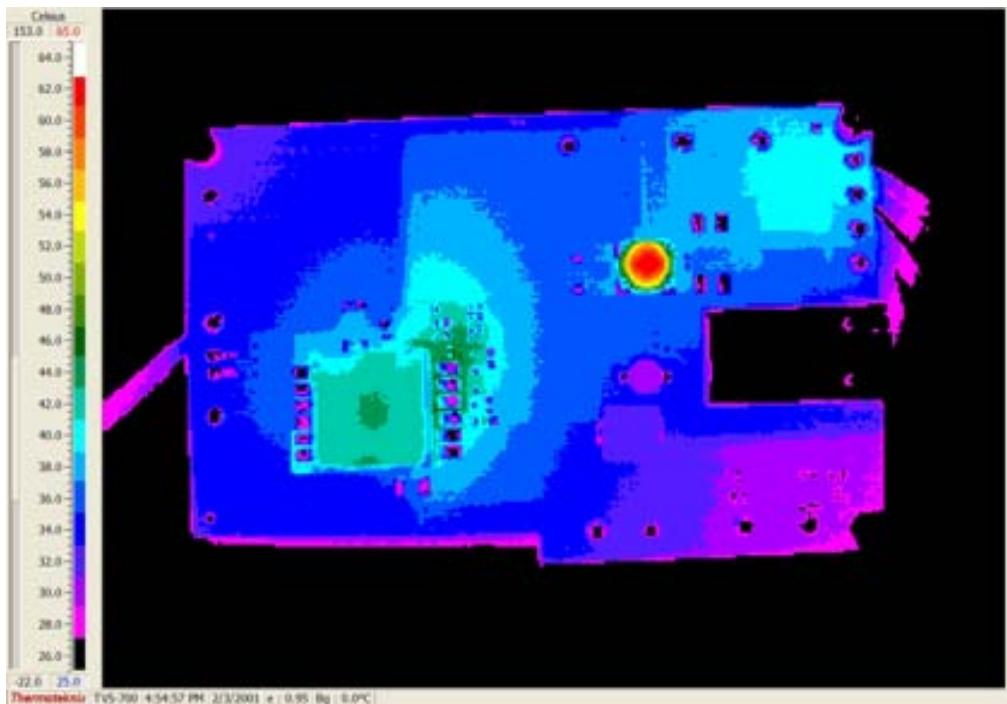


Figure 9. Temperature Data (37V<sub>PORT</sub>, 4.5A, Bottom)



## MEASURED DATA

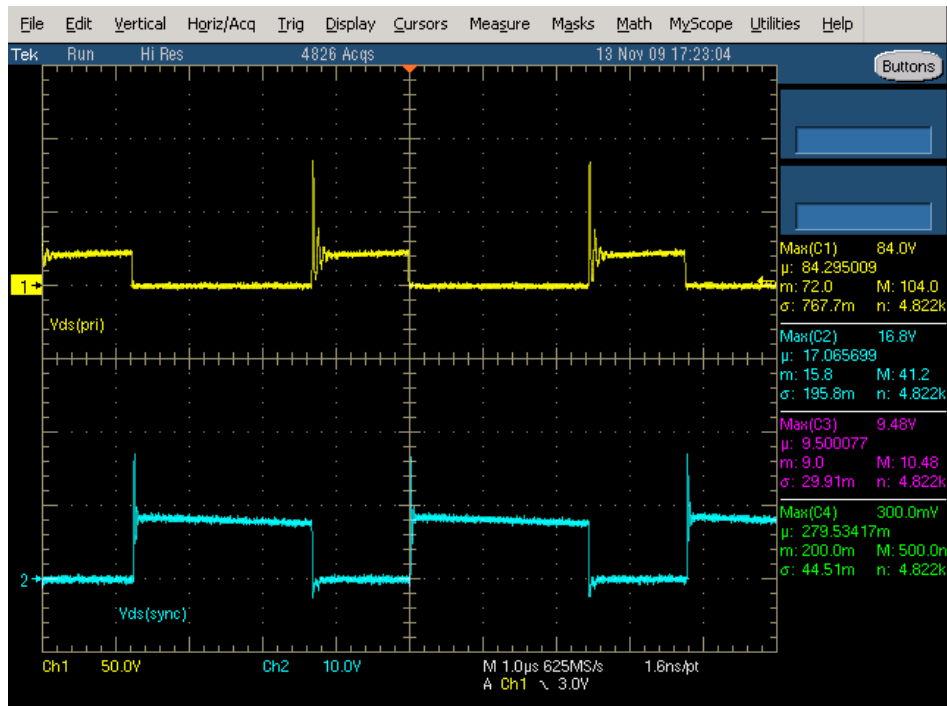


Figure 10. Stresses (9V<sub>AUX</sub>, 4.5A)

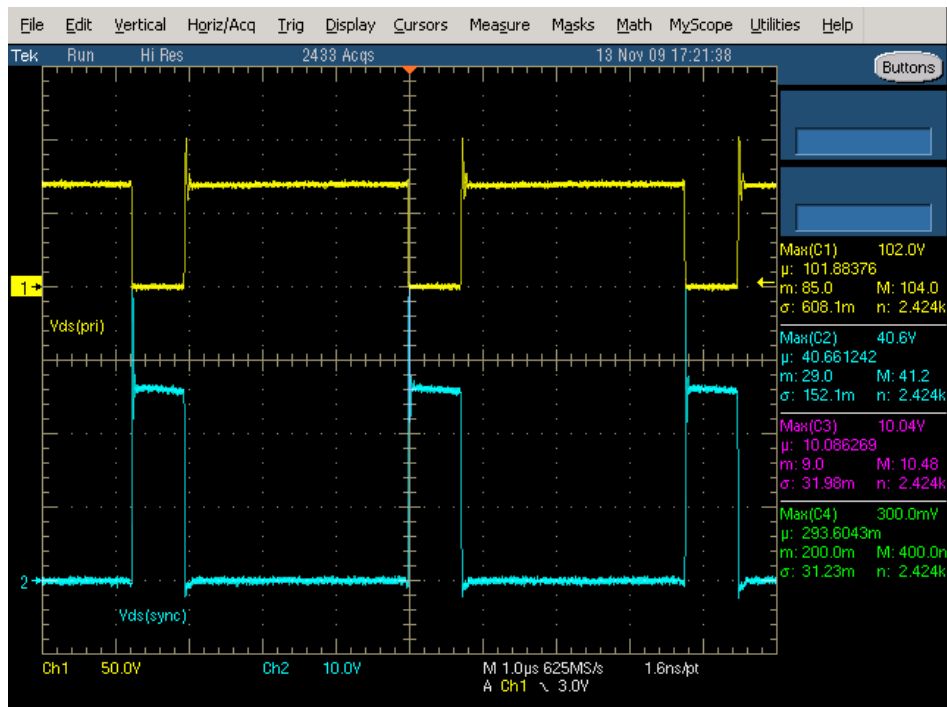


Figure 11. Stresses (57V<sub>AUX</sub>, 4.5A)



## PARTS LIST

QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components (Note 1)</b>			
2	C1, C3	CAP, X5R, 22 $\mu$ F, 6.3V, 1206	MURATA, GRM31CR60J226KE19L
2	C6, C2	CAP, X7S, 3.3 $\mu$ F, 100V, 1210	TDK, C3225X7S2A335M
1	C4	CAP, X7R, 1000pF, 50V, 1206	AVX, 12065C102KAT
1	C5	CAP, ELEC., 10 $\mu$ F, 100V	NIC COMP, NACEW100M100V6.3X8TR13F
1	C7	CAP, NPO, 220pF, 200V, 1206	AVX, 12062A221KAT2A
1	C8	CAP, X7R, 0.1 $\mu$ F, 100V, 0805	AVX, 08051C104JAT2A
1	C9	CAP, X5R, 100 $\mu$ F, 6.3V, 1210	TDK, C3225X5R0J107M
3	C19, C24, C27	CAP, X7R, 1 $\mu$ F, 16V, 0805	MURATA, GRM21BR71C105KA01L
1	C25	CAP, X7R, 1000pF, 50V, 0603	AVX, 06035C102KAT2A
1	C26	CAP, X7R, 33nF, 50V, 0603	AVX, 06035C333KAT2A
1	C28	CAP, X7R, 2200pF, 50V, 0603	AVX, 06035C222KAT2A
1	C30	CAP, NPO, 33pF, 50V, 0603	AVX, 06035A330KAT2A
1	C32	CAP, X7R, 0.1 $\mu$ F, 50V, 0603	AVX, 06035C104KAT2A
1	C33	CAP, X7R, 3300pF, 50V, 0603	AVX, 06035C332KAT2A
1	C34	CAP, X7R, 4700pF, 2KV, 1812	MURATA, GR443DR73D472KW01L
1	D1	DIODE, 58V 600W TVS, SMB-DIODE	DIODES/ZETEX, SMBJ58A-13-F
1	D16	DIODE, SCHOTTKY, 1A, SMA-DIODE	DIODES/ZETEX, B1100-13-F
1	D11	DIODE, FAST SWITCHING, SOT23	DIODES/ZETEX, BAS21-7-F
1	D12	DIODE, SCHOTTKY, 5A	DIODES/ZETEX, PDS5100H-13
1	D13	DIODE, 1A SM RECTIFIER	DIODES/ZETEX, S1B-13-F
1	D14	DIODE, SCHOTTKY, SOT23	DIODES/ZETEX, BAT54-7-F
1	D17	DIODE, SMT ZENER 7.5V, 500mW	CENTRAL SEMI., CMHZ4693 TR
1	L1	INDUCTOR, 180 $\mu$ H, DO1813H-181MLD	COILCRAFT, DO1813H-181MLD
1	L2	INDUCTOR, 8.2 $\mu$ H, WE-HCC	WÜRTH, 7443330820
1	Q1	MOSFET, N-CHANNEL, 100V, Power 56	FAIRCHILD, FDMS86101
1	Q2	MOSFET, N-CHANNEL, 40V, LFPK	RENESAS, HAT2169H
1	Q3	TRANSISTOR, NPN, SOT23	DIODES/ZETEX, FMMT624TA
1	Q5	TRANSISTOR, PNP, SOT23	ON SEMI., BSS63LT1G
1	Q6	TRANSISTOR, PNP, SOT23	CENTRAL SEMI., CMLT7820G TR
1	Q7	TRANSISTOR, NPN, SOT23	CENTRAL SEMI., CMLT3820G TR
1	R28	RES., CHIP, 10k, 1/10W, 1%, 0603	VISHAY, CRCW060310K0FKEA
1	R2	RES., CHIP, 47 $\Omega$ , 1/4W, 5%, 1206	VISHAY, CRCW120647R0JNEA
1	R9	RES., CHIP, 20k, 1/4W, 5%, 1206	VISHAY, CRCW120620K0JNEA
1	R10	RES., CHIP, 20 $\Omega$ , 1/8W, 5%, 0805	VISHAY, CRCW080520R0JNEA
1	R12	RES., CHIP, 294k, 1/10W, 1%, 0603	VISHAY, CRCW0603294KFKEA
1	R13	RES., CHIP, 21.5k, 1/10W, 1%, 0603	VISHAY, CRCW060321K5FKEA
1	R14	RES., CHIP, 2.49k, 1/10W, 1%, 0603	VISHAY, CRCW06032K49FKEA
1	R15	RES., CHIP, 10 $\Omega$ , 1/10W, 1%, 0603	VISHAY, CRCW060310RFKEA
1	R16	RES., CHIP, 0.012 $\Omega$ , 1/4W, 1%, 1206	VISHAY, WSL1206R0120FEA
1	R17	RES., CHIP, 100 $\Omega$ , 1/10W, 1%, 0603	VISHAY, CRCW0603100RFKEA

# DEMO MANUAL DC1561B

## PARTS LIST

QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
1	R18	RES., CHIP, 20k, 1/10W, 1%, 0603	VISHAY, CRCW060320K0FKEA
1	R19	RES., CHIP, 54.9k, 1/10W, 1%, 0603	VISHAY, CRCW060354K9FKEA
1	R20	RES., CHIP, 3.01k, 1/10W, 1%, 0603	VISHAY, CRCW06033K01FKEA
1	R21	RES., CHIP, 24k, 1/10W, 5%, 0603	VISHAY, CRCW060324K0JNEA
1	R22	RES., CHIP, 15 $\Omega$ , 1/10W, 5%, 0603	VISHAY, CRCW060315R0JNEA
1	R23	RES., CHIP, 12k, 1/10W, 5%, 0603	VISHAY, CRCW060312K0JKEA
1	R24	RES., CHIP, 100k, 1/10W, 1%, 0603	VISHAY, CRCW0603100KFKEA
1	R25	RES., CHIP, 1.82k, 1/10W, 1%, 0603	VISHAY, CRCW06031K82FKEA
1	R26	RES., CHIP, 38.3k, 1/10W, 1%, 0603	VISHAY, CRCW060338K3FKEA
1	R27	RES., CHIP, 3.3k, 1/10W, 1%, 0603	VISHAY, CRCW06033K30FKEA
1	R34	RES., CHIP, 5.1 $\Omega$ , 1/4W, 5%, 1206	VISHAY, CRCW12065R10JNEA
1	R36	RES., CHIP, 30.9 $\Omega$ , 1/10W, 1%, 0603	VISHAY, CRCW060330R9FKEA
1	T1	Flyback Transformer EPC3472G-LF	PCA Electronics Inc., EPC3472G-LF
1	T2	XFMR, GATE DRIVE, EPA4271GE	PCA, EPA4271GE-LF
0	T2 (ALTERNATE)	XFMR, GATE DRIVE	PULSE, PE-68386NL
0	T2 (ALTERNATE)	XFMR, GATE DRIVE	EPCOS, T5476
1	U1	IC, LTC4278IDKD, DFN32	LINEAR TECH., LTC4278IDKD

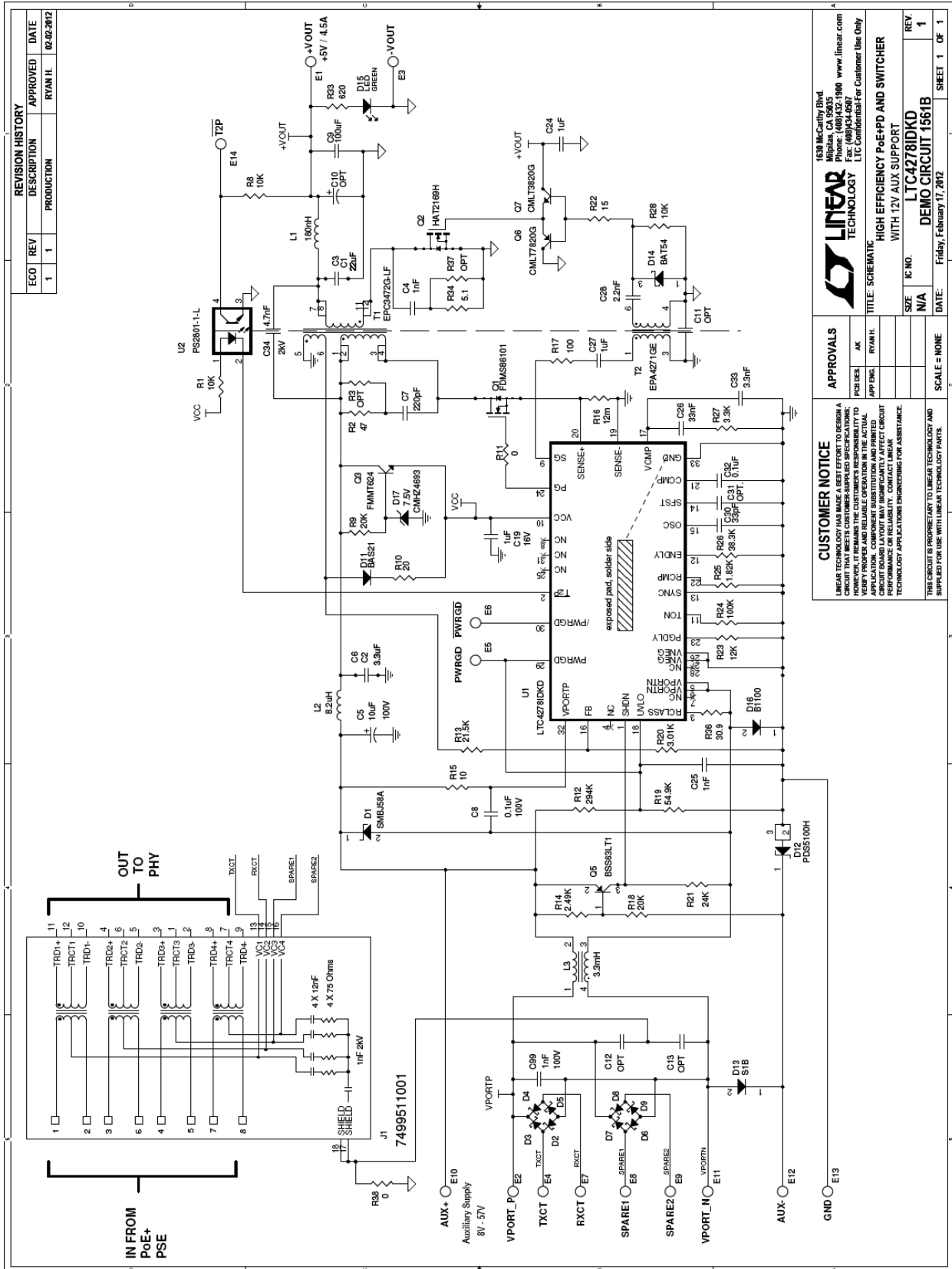
### Additional Demo Board Circuit Components (Note 2)

0	C10 OPT	CAP, TANT, 100 $\mu$ F, 6.3V, 3528	NEO CAPACITOR, PSLB20J107M(25)
0	C11, C12, C13 (OPT)	CAP, 1812, OPT	
0	C31 (OPT)	CAP, 0603	
1	C99	CAP, X7R, 1000pF, 50V, 0603	AVX, 06035C102KAT2A
8	D2-D9	DIODE, SCHOTTKY, 1A, SMA-DIODE	DIODES/ZETEX, B1100-13-F
1	D15	LED, SMT GREEN	PANASONIC, LN1351C-(TR)
14	E1-E14	TP, TURRET, 0.094"	MILL-MAX, 2501-2-00-80-00-00-07-0
1	J1	CONN., Integrated Jack	WÜRTH, 7499511001
1	L3	INDUCTOR, 3.3mH, 744272332	WÜRTH, 744272332
2	R1, R8	RES., CHIP, 10k, 1/10W, 1%, 0603	VISHAY, CRCW060310K0FKEA
2	R11, R38	RES., CHIP, 0 $\Omega$ , JUMPER, 0603	VISHAY, CRCW06030000Z0EA
0	R3, R37 (OPT)	RES., 1206	
1	R33	RES., CHIP, 620, 1/10W, 1%, 0603	VISHAY, CRCW0603620RFKEA
1	U2	I.C., OPTOCOUPERS PS2801-1-L	NEC, PS2801-1-F3-A

**Note 1:** Required Circuit Components are those parts that are required to implement the core circuit function.

**Note 2:** Additional Demo Board Circuit Components are those parts that provide added functionality for the demo board but are or may not be required in the actual circuit. Some of these parts, like the Ethernet transformer (T3), can be substituted with other vendor's parts.

SCHEMATIC DIAGRAM



REVISION HISTORY		
ECO	REV	DESCRIPTION
1	1	PRODUCTION

APPROVED		DATE
RYAN H.		02-02-2012

APPROVALS		
PCB DES.	AK	
APP ENGR.	RYAN H.	

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**LINEAR TECHNOLOGY**  
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TITLE: SCHEMATIC  
HIGH EFFICIENCY PoE-PD AND SWITCHER  
WITH 12V AUX SUPPORT

SIZE	IC NO.	REV.
N/A	LTC4278DKD	1

DATE: Friday, February 17, 2012 SHEET 1 OF 1

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# DEMO MANUAL DC1561B

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