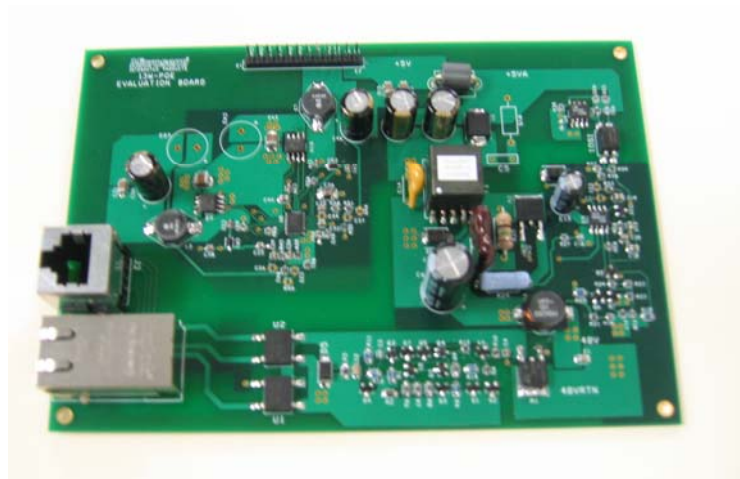


Triple Isolated Power Supply for POE Powered Device Application Using UC3844 and LX1752

Evaluation Board



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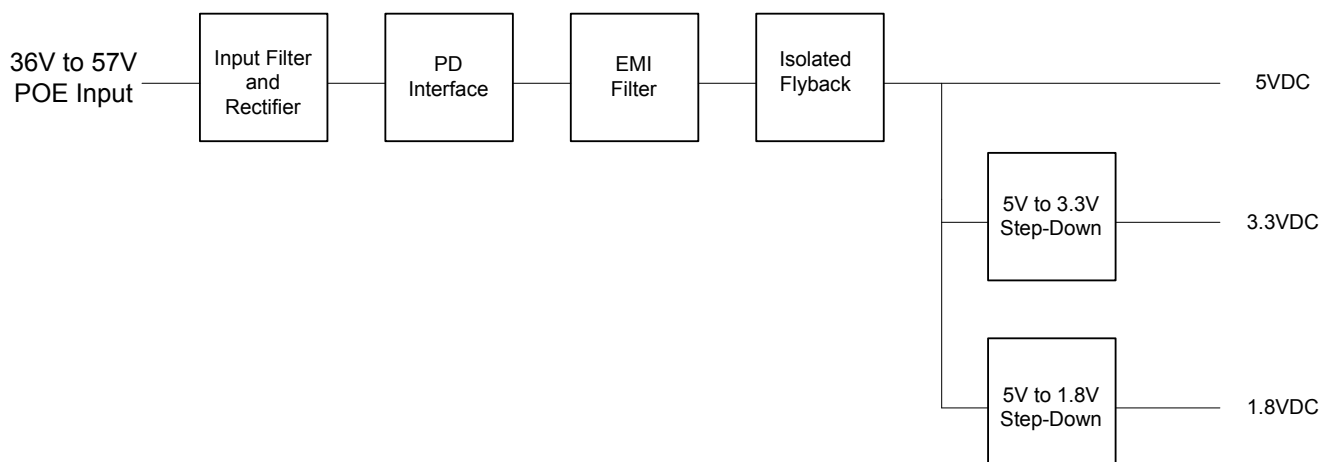
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Introduction to Product

The multi-output power supply evaluation board is a fully assembled and tested printed circuit board (PCB) that provides three step-down regulated output voltages with a 36V to 57V input at 13W. The power supply is designed for Power Over Ethernet (POE) applications, specifically the Powered Device (PD) or the receiver end. Figure 1 shows a block diagram of the PD power supply. The power supply consists of the following sections: Input filter and rectifier, PD interface, EMI filter, 5V output isolated flyback converter, and 5V to 3.3V and 1.8V non-isolated step down converters. The UC3844 is designed as the isolated flyback converter and the LX1752 generates the step down dual outputs. The flyback converter is configured using 13W. The power capability of the design can be increased to 30W by changing the flyback transformer and output rectifier diode to a higher power rating.

Note that the power supply circuitry (minus the PD interface) is not limited to POE applications and can be used in any application requiring a 36V to 57V input and step down output(s) adjusted for the required voltage(s).

Figure 1 – Block Diagram



Key Features:

- 36V to 57V Input Range
- Output Voltages
 - 5V (Isolated Flyback Output)
 - 3.3V (Step-down Switching Regulator)
 - 1.8V (Step-down Switching Regulator)
- 13Watt Input
- Adjustable Output Voltages using External Resistors
- 70% Overall Efficiency
- Power Device Interface

Applications:

- Power Over Ethernet Powered Device / Receiver End Supply
- Multi-output Power Supply

Ordering Information:

- **Part #** LX1752-POE-PD13W

Evaluation Board Operation:

The evaluation board accepts a 36V to 57V input via a CAT-5 cable connected to the Ethernet connector port (J1). The connector J1 integrates an RF transformer for Ethernet data coupling and also an input filter that conducts RF interferences to chassis ground. Connector J2 routes and outputs the Ethernet data from port J1. The diode bridges (U1 and U2), which allow the positive and negative terminals of the input supply to be interchanged, are rated at 1.5A.

The Powered Device (PD) interface consists of a detection, classification, and isolation circuits. The detection block supports two different detection schemes, which comprises of a 25k Ω resistor detection, as required by the IEEE 802.3a standard, and also an input capacitor detection. Classification is optionally performed by the Power Sourcing Equipment (PSE) to determine the level of power consumption by the PD. Isolation circuitry blocks power from the PSE to the flyback during detection and classification. For a detailed explanation of the Power Device interface, refer to Application Note AN-125.

The isolated flyback converter uses the UC3844 current mode controller set to operate at 200kHz. The converter runs in a discontinuous mode. The isolated feedback is provided using an opto-isolator driven by an error amplifier made from a TL431. Additional compensation is provided using the error amplifier contained within the UC3844.

The power transformer T1 has a primary side inductance of 27 μ H +/-15%. Note that upon initial power up, the flyback controller (U3) is kick-started by the energy stored in C13, which is charged up by the input voltage source. After startup, the auxiliary winding will generate the bootstrap voltage to keep U3 enabled. The power transformer also includes a reset winding via an ultra-fast rectifier diode (D8) to ground, to clamp leakage inductance overshoots when M2 turns off and also to provide a path that returns the leakage energy to the input for improving efficiency.

To further prevent premature startup of the flyback converter, the circuitry consisting of Q6, Q7, and Q8 is a comparator used to hold off the UC3844 by providing a low impedance path from the COMP output through Q8 to ground until M1 is completely turned on. When M1 is turned off, the base voltage of Q6 will be less than the base voltage of Q7, driving the gate of Q8 high. When M1 is turned on and the input voltage rises to its nominal value, the base voltage of Q6 will be higher than the base voltage of Q7, pulling the gate of Q8 low to turn it off, allowing the COMP pin to rise to start the flyback circuit.

A soft-start is implemented by adding D11, C18, and R30 to the COMP pin of the UC3844 since the COMP pin voltage directly controls the maximum current through the switch. Finally, note that since the flyback converter has a pulsed input current, an EMI filter is included to prevent the 200kHz current chop from becoming conducted emissions. The EMI filter consists of L4, C6, and C7.

The final stage of the POE PD power supply consists of the LX1752 buck regulator configured to operate at a switching frequency of 800kHz, with output voltages set at 1.8V and 3.3V. The buck inputs, the input supply VIN to the LX1752, and VCCL of the LX1752 are powered by the 5V output of the flyback and are all tied to the same node. Feedback compensation of the LX1752 is provided externally using type 2. The current limit for both outputs is set at approximately 5A and can be externally adjusted. For more information regarding the LX1752, please refer to the device datasheet.

Performance:

Performance of the POE PD Power Supply is observed for 13W at the input under the following conditions:

Nominal Output Voltage	Output Current
1.8V	1A
3.3V	1A
5V	0.75A

Overall Efficiency at Full Load Conditions

The overall efficiency is the total output power of the 3 regulated outputs with respect to the input power applied at the Ethernet port connector.

Overall Efficiency (includes the diode bridges, PD interface, filters, Flyback, and Buck) 5V @ 0.75A 1.8V @ 1A 3.3V @ 1A	VIN=36V	70.5%
	VIN=48V	70%
	VIN=57V	69.7%

LX1752 Buck Efficiency

1.8V @ 1A 3.3V @ 1A	VIN=5V	92.6%
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Output Ripple

Output Voltage	No Load	Full Load
5V Flyback Output, VIN = 48V	10mVpp	16mVpp
1.8V Step-Down Output, VIN = 48V	15mVpp	17mVpp
3.3V Step-Down Output, VIN=48V	20mVpp	22mVpp

Line Regulation

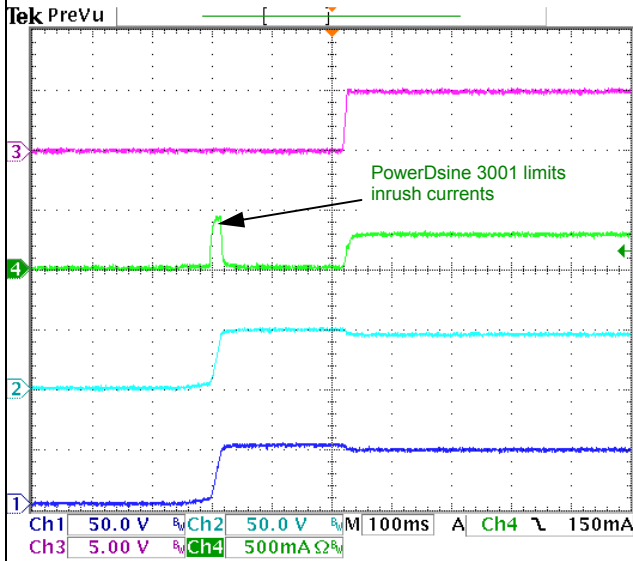
5V @0.75A, VIN=36V, 57V	<0.1%
1.8V @1A, VIN=36V, 57V	<0.1%
3.3V @1A, VIN=36V, 57V	<0.1%

Load Regulation

5V @ no load and 0.75A, VIN=48V	<0.1%
1.8V @ no load and 1A, VIN=48V	<0.1%
3.3V @ no load and 1A, VIN=48V	<0.1%

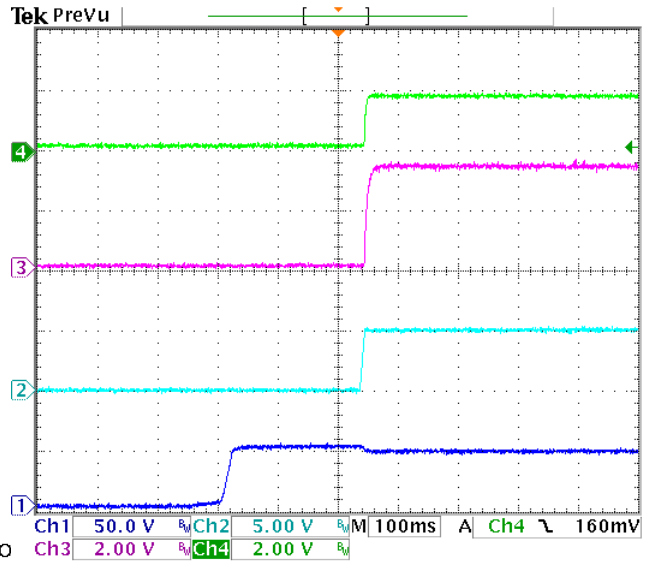
TYPICAL CHARACTERISTICS @ 25°C (REFER TO FIGURE 2)

Hot Insertion Startup Under Full Load Conditions



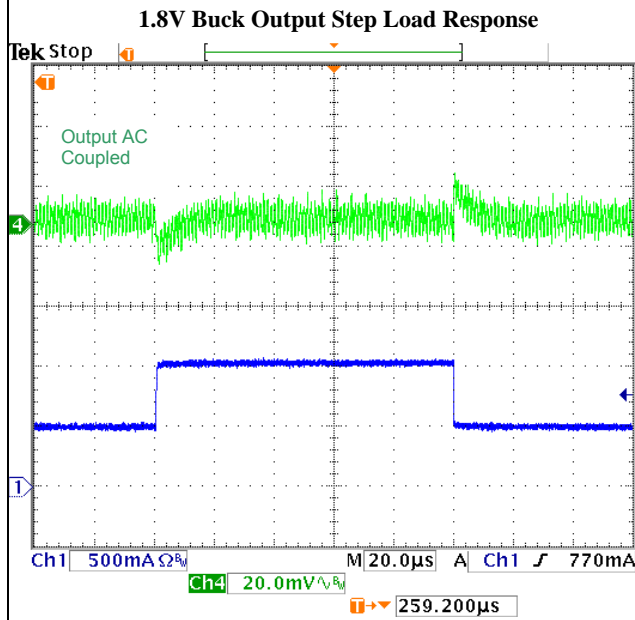
CH1 – POE Input Source
 CH4 – POE Input Current
 CH2 – Flyback Input Voltage
 CH3 – 5V Flyback Output Loaded at 750mA

Hot Insertion Startup Under Full Load Conditions

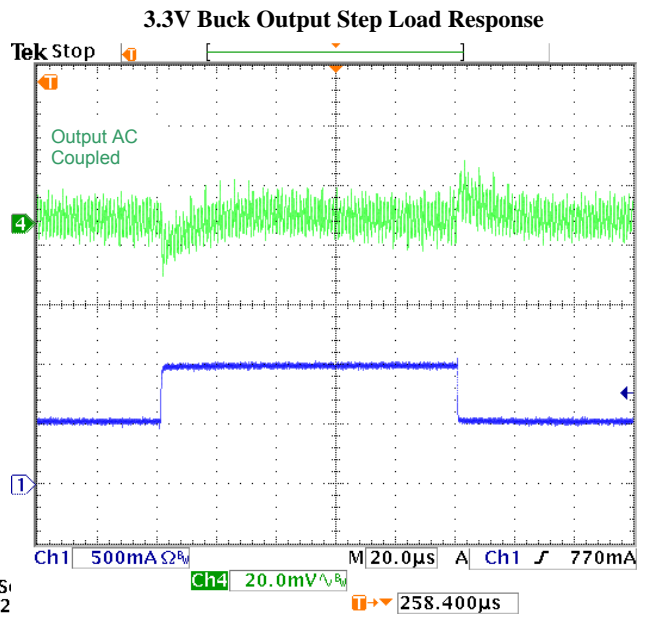


CH1 – POE Input Source
 CH2 – 5V Flyback Output at 750mA
 CH3 – 3.3V Buck Output at 1A
 CH4 – 1.8V Buck Output at 1A

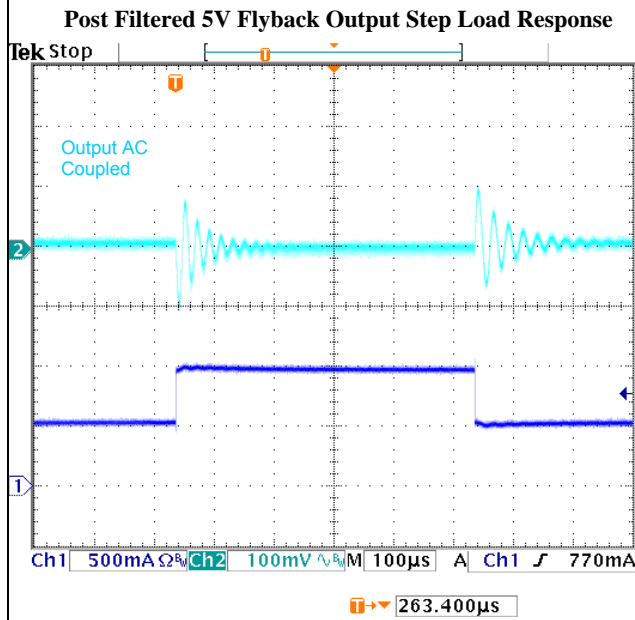
TYPICAL CHARACTERISTICS @ 25°C (REFER TO FIGURE 2)



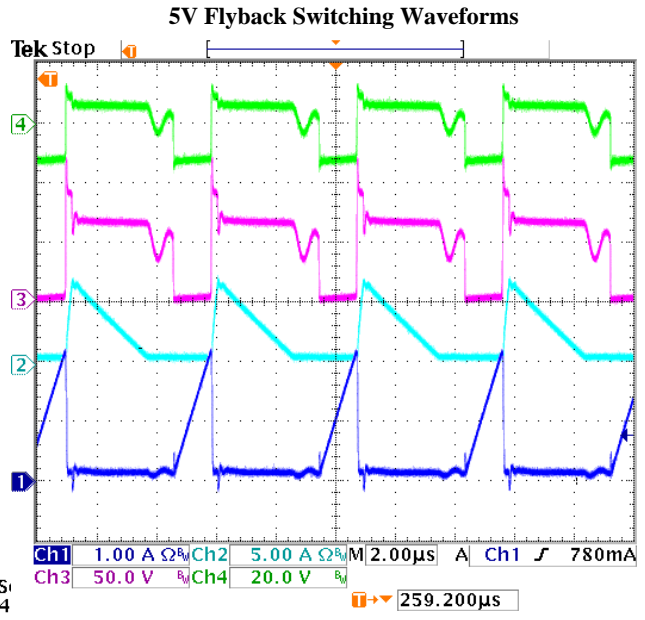
30 Se
13:2



30 Se
13:16



25 Se
12:4

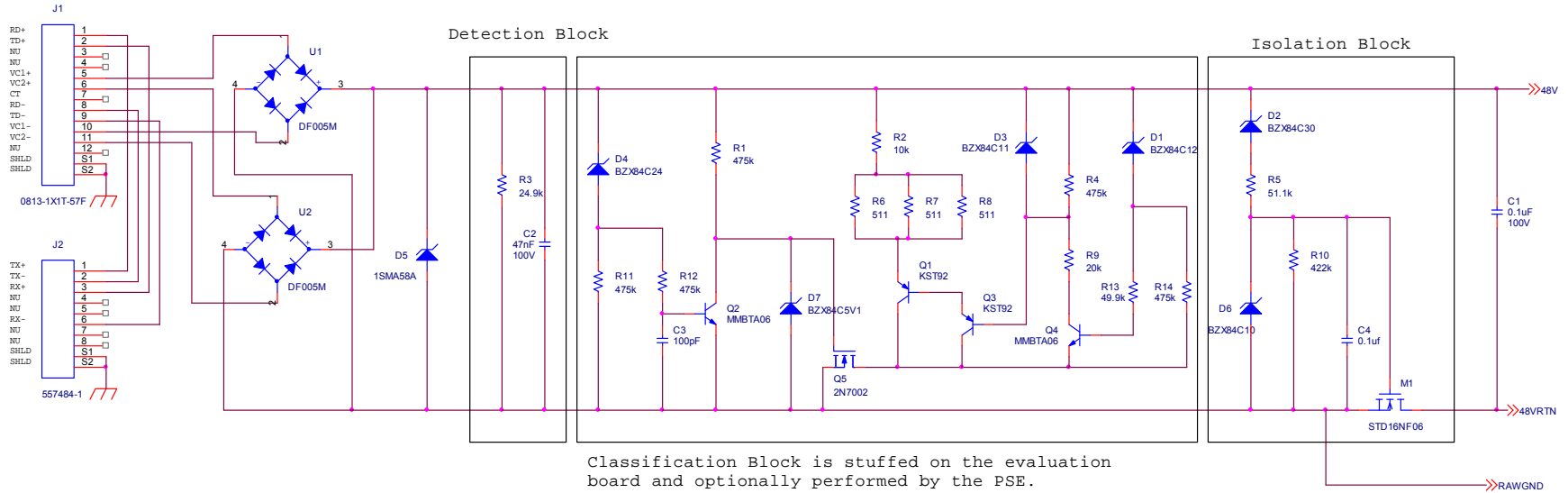


30 Se
14:03

Note: Output ringing during step load due to LC filter (L1, C11, C12) resonance. LC filter attenuates flyback output ripple voltage.

- CH1 – Current into M2 External NFET
- CH2 – Current into Rectifier D9
- CH3 – External NFET Drain Voltage
- CH4 – Transformer Secondary Output Voltage

Schematic



Classification Block is stuffed on the evaluation board and optionally performed by the PSE.

Note: For different levels of classification, R2 must be adjusted to the proper value. See AN-125 for details.

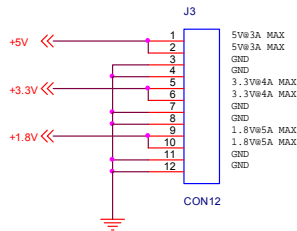


Figure 2 – Ethernet Connectors, Diode Bridges, PD Interface Schematic

Schematic

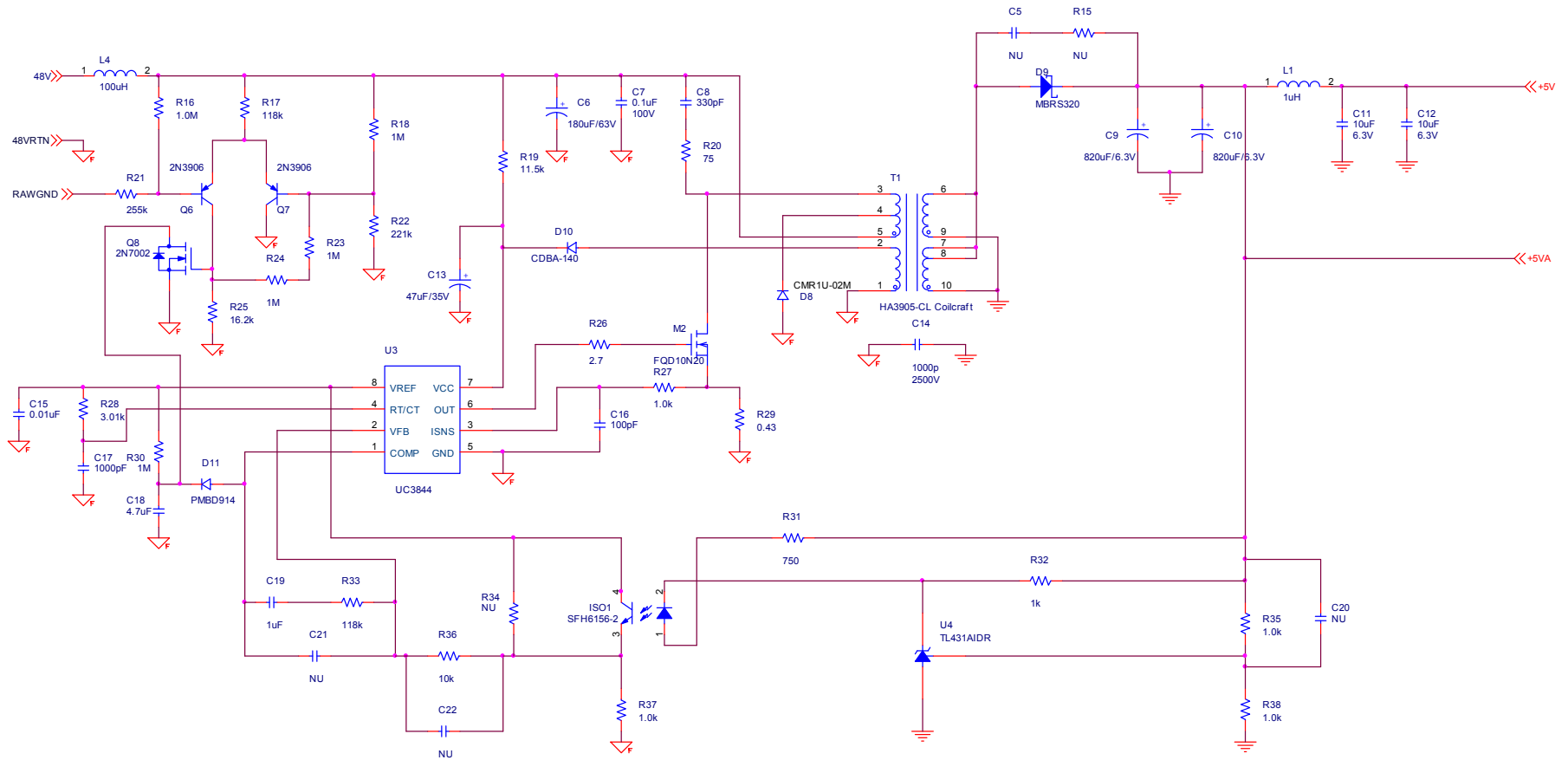


Figure 3 – 48V to 5V Isolated Flyback Schematic

Schematic

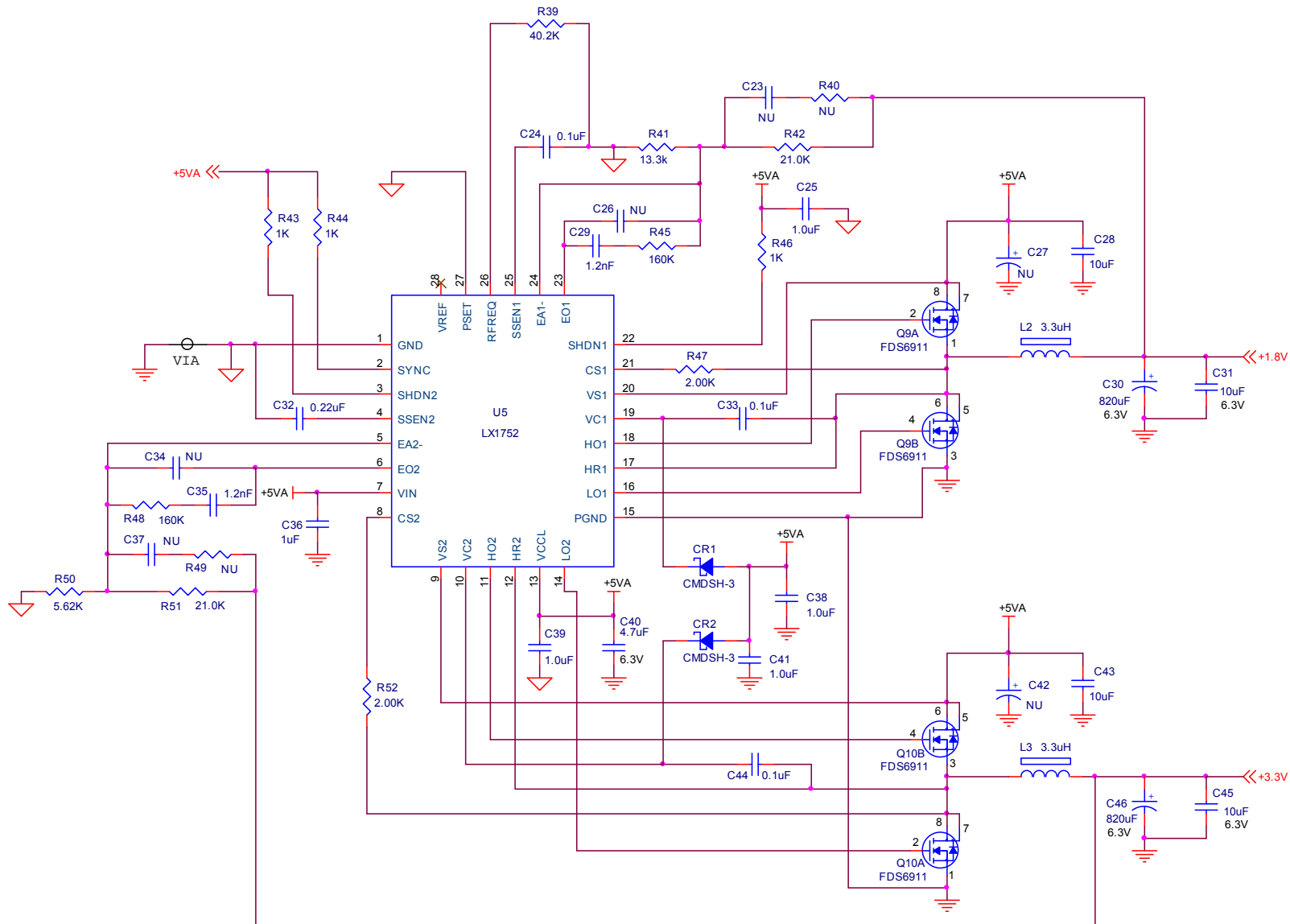


Figure 3 – 5V to 1.8V and 3.3V Dual Output Step-Down Converter Schematic

Evaluation Board Build Of Materials

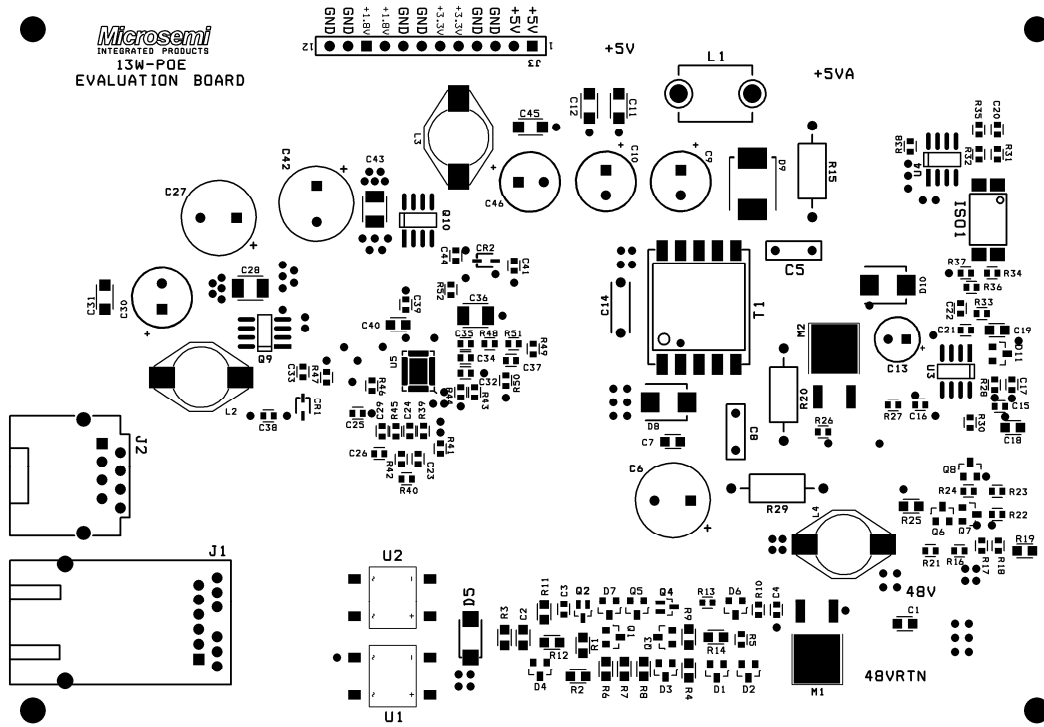
13W POE PD Evaluation Board BOM					
Qty	Reference Designators	Part Number	Value	Vendor	Package Type
2	C1, 7	GCM21BR72A104	0.1uF, 100V	Murata	805
1	C2	GRM21BR72A473	47nF, 100V	Murata	805
2	C3,16	ECJ-1VC1H101K	100pF, 50V	Panasonic	603
4	C4, 24, 33, 44	ECJ-1VB1E104K	0.1uF, 25V	Panasonic	603
1	C6	UHE1J181MPD	180uF, 63V	Nichicon	10x20
1	C8	ECJ-2VB2D331K	330pF, 200V	Panasonic	805
4	C9, 10, 30, 46	6.3MCZ820M8X11.5	820uF, 6.3V	Rubycon	8.0 x 11.5
6	C11, 12, 28, 31, 43, 45	JMK212BJ106M	10uF, 6.3V	Taiyo Yuden	805
1	C13	ECA-1VHG470	47uF, 35V	Panasonic	5.0 x 11
1	C14	62O102MQECS	1000pF, 2500V	AVX	Through hole
1	C15	ECJ-1VB1C103	0.01uF, 16V	Panasonic	603
1	C17	ECJ-1VB1H102	1000pF, 50V	Panasonic	603
2	C18, 40	JMK212BJ475M	4.7uF, 6.3V	Taiyo Yuden	805
8	C19, 25, 36, 38, 39, 41, 43, 45	JMK212BJ105M	1uF, 16V	Taiyo Yuden	805
3	C5, 27, 42	Not Used			Through hole
7	C20, 21, 22, 23, 26, 34, 37	Not Used			603
2	C29, 35	ECJ-1VB1H122	1200pF, 50V	Panasonic	603
1	C32	ECJ-1VB1E224K	0.22uF, 25V	Panasonic	603
2	CR1, 2	CMDSH-3	30V, 100mA	Central Semi	SOD-323
1	D1	BZX84C12	Zener, 12V, 5%	Philips	SOT-23
1	D2	BZX84C30	Zener, 30V, 5%	Philips	SOT-23
1	D3	BZX84C11	Zener, 11V, 5%	Philips	SOT-23
1	D4	BZX84C24	Zener, 24V, 5%	Philips	SOT-23
1	D5	1SMA58A	58V, 400W, TVS	On Semi	SMA
1	D6	BZX84C10	Zener, 10V, 5%	Philips	SOT-23

1	D7	BZX84C5V1	Zener, 5.1V, 5%	Philips	SOT-23
1	D8	CMR1U-02M	200V, 1A	Central Semi	SMA
1	D9	MBRS320	20V, 3A	On Semi	SMC
1	D10	CDBA140-G	40V, 1A	Comchip	SMA
1	D11	PMBD914	75V, 215mA	Philips	SOT-23
1	ISO1	SFH6156-2	Opto, CTR 100%	Vishay	SMD-4
1	J1	0813-1X1T-57F	RJ-45 POE	Bel	Non std
1	J2	557484-1	RJ-45	Tyco	Non std
1	J3	p/o PBC36SFCN	12 p x 0.1"ctr	Sullins	16 pin header
1	L1	2643000801	1uH	Fair-rite	Ferrite bead
2	L2, 3	SPC-10049P-3R3	3.3uH 6A	TMP	10x10
1	L4	SMI-0805-0101	100uH, 1.2A	TMP	13.3 x 9.4
1	M1	STD16NF06L	Nch, 60V, 24A	ST Micro	DPAK
1	M2	FQD10N20	Nch, 200V, 7.8A	Fairchild	DPAK
2	Q1, 3	KST92	PNP,300V, 0.5A	Fairchild	SOT-23
2	Q2, 4	MMBTA06	NPN,80V, 300mA	On Semi	SC-70
2	Q6, Q7	SMBT3906	Dual PNP, 40V	Infineon	SOT-363
2	Q5, 8	2N7002	Nch, 60V, 385mA	Philips	SOT-23
2	Q9, 10	FDS6911	Dual Nch 20V 7.5A	Fairchild	SOIC8
5	R1, 4, 11, 12, 14	ERJ-6ENF4753V	475k, 1/8W	Panasonic	805
1	R2	ERJ-6ENF1002V	10.0k, 1/8W	Panasonic	805
1	R3	ERJ-6ENF2492V	24.9k, 1/8W	Panasonic	805
1	R5	ERJ-3EKF2492V	51.1, 1/10W	Panasonic	603
3	R6, 7, 8	ERJ-6ENF5110V	511, 1/8W	Panasonic	805
1	R9	ERJ-6ENF2002V	20k, 1/8W	Panasonic	805
1	R10	ERJ-6EKF4223V	422k, 1/10W	Panasonic	603
1	R13	ERJ-3EKF4992V	49.9k, 1/10W	Panasonic	603
5	R16, 18, 23, 24, 30	ERJ-3EKF105V	1.0M, 1/10W	Panasonic	603

2	R17, R33	ERJ-3EKF1183V	118k, 1/10W	Panasonic	603
1	R25	ERJ-6ENF1622V	16.2k, 1/8W	Panasonic	805
1	R19	ERJ-6ENF1152V	11.5k, 1/8W	Panasonic	805
1	R20	RMC1/875R01%G	75 1/4W	SEI	1206
1	R21	ERJ-3EKF2553V	255k, 1/10W	Panasonic	603
1	R22	ERJ-3EKF2213V	221k, 1/10W	Panasonic	603
1	R26	ERJ-3GEYJ2R7V	2.7, 1/10W	Panasonic	603
8	R27, 32, 35, 37, 38, 43, 44, 46	ERJ-3EKF1001V	1.00k, 1/10W	Panasonic	603
1	R28	ERJ-3EKF3011V	3.01k, 1/10W	Panasonic	603
1	R29	73L6R47J	0.47, 3/4W	CTS	2010
1	R31	ERJ-3EKF7500V	750, 1/10W	Panasonic	603
1	R36	ERJ-3EKF1002V	10k, 1/10W	Panasonic	603
1	R39	ERJ-3EKF4022V	40.2k, 1/10W	Panasonic	603
3	R34, 40, 49	Not Used			603
1	R15	Not Used			1206
1	R41	ERJ-3EKF1332V	13.3k, 1/10W	Panasonic	603
2	R42, 51	ERJ-3EKF2102V	21.0k, 1/10W	Panasonic	603
2	R45, 48	ERJ-3EKF1603V	160k, 1/10W	Panasonic	603
2	R47, 52	ERJ-3EKF2001V	2.0k, 1/10W	Panasonic	603
1	R50	ERJ-3EKF5621V	5.62k, 1/10W	Panasonic	603
1	T1	HA3905-CL	Flyback Tfmr	Coilcraft	
2	U1,2	DF005S	Bridge Rect	Fairchild	SDIP
1	U3	UC3844ADM	CMPS Controller	Microsemi	SOIC8
1	U4	TL431AIDR	Shunt Regulator	TI	SOIC8
1	U5	LX1752CLQ	Dual PWM	Microsemi	MLPQ28

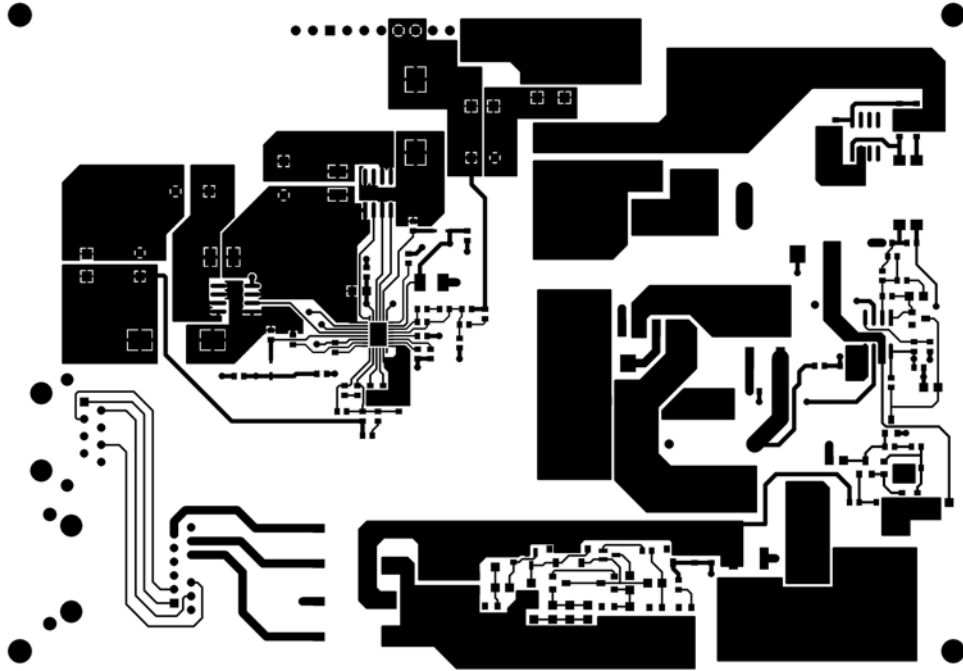
Evaluation Board PCB Layout

Top Silkscreen and Solder Mask

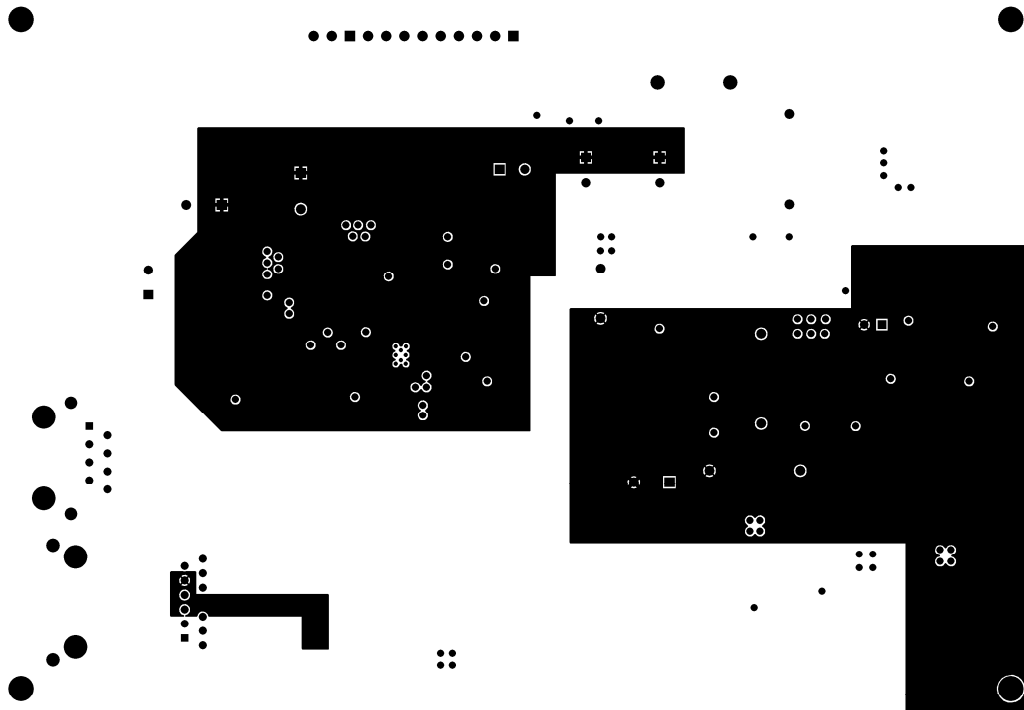


TOP SILKSCREEN
TOP SOLDERMASK

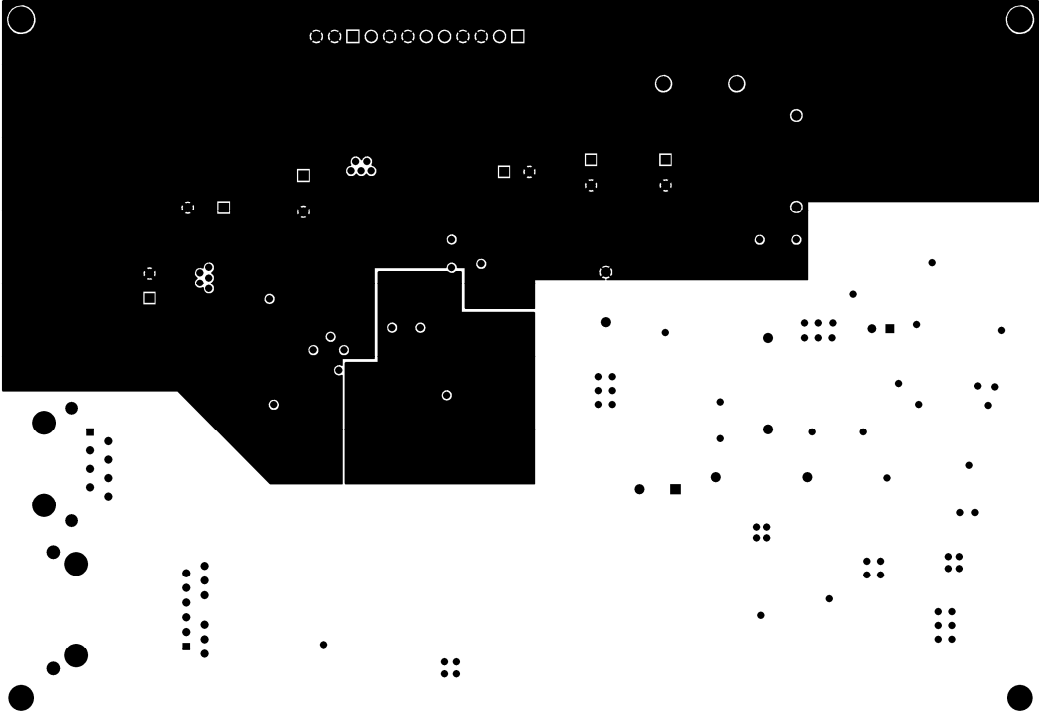
Top Layer



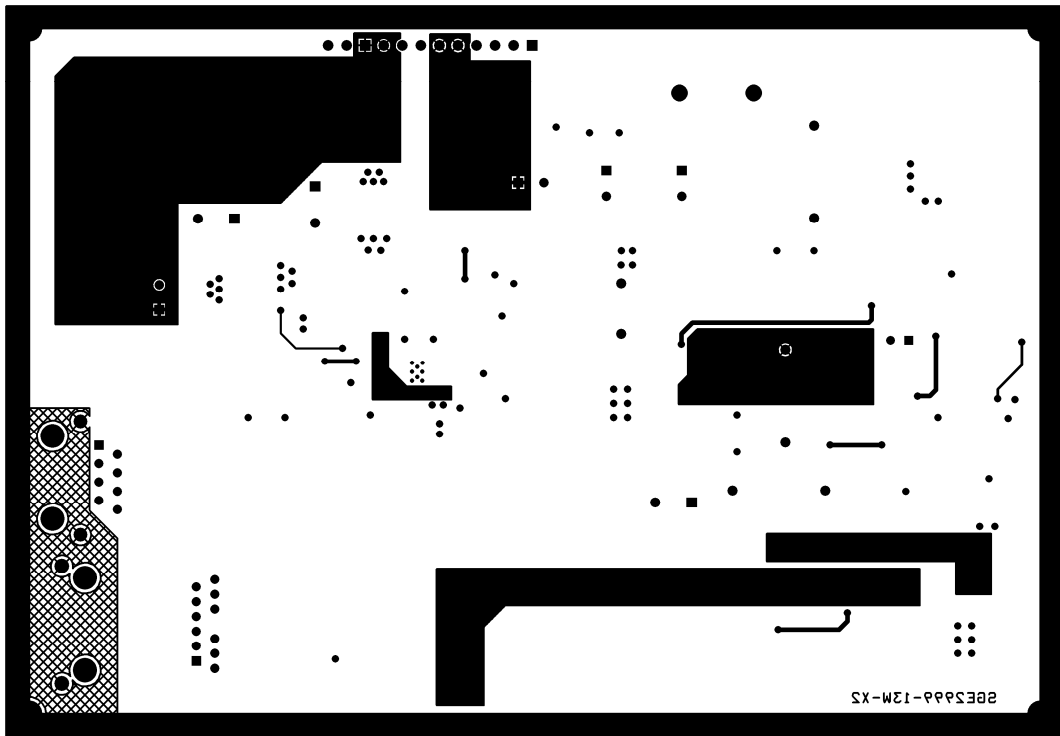
Inner Layer 2

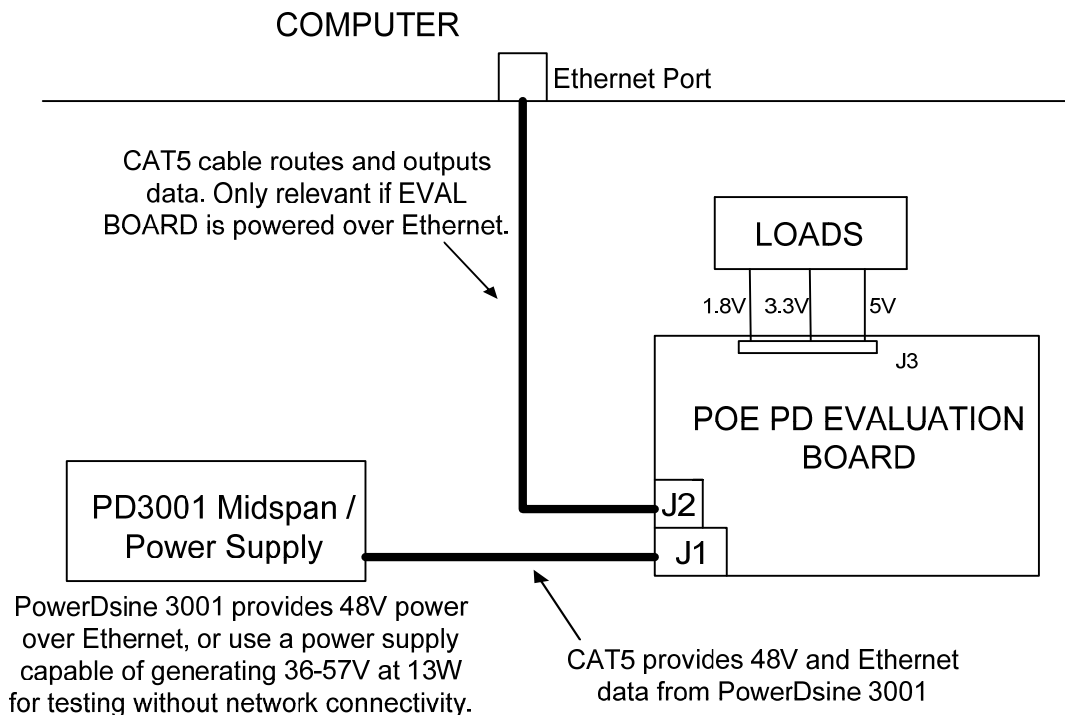


Inner Layer 3



Bottom Layer



Test Setup:**Test Procedure:**

The following is a demonstration scenario that can be used to evaluate the POE PD power supply:

- 1) The evaluation board can be powered over Ethernet via 48V, or by a regular external power supply for testing without network connectivity.
- 2) To verify the circuit operation over the full input range, use a bench top DC power supply capable of generating a voltage range of 36V to 57V and a current output of 1A for sourcing power via either node VC1+/VC1- or VC2+/VC2-. Set the power supply current limit to 500mA. Insure that the supply is shut off before connecting.
- 3) For power over Ethernet interface, use a POE source such as the PowerDsine 3001 Midspan from Microsemi and connect the Data & Power Out Port to the evaluation board port J1 via a CAT-5 cable. The evaluation board should now be powered by 48V.
- 4) If using an external power supply, set the supply voltage to 57V. Turn on the power supply. Without any output load currents, verify that the input current from the supply is below 30mA.
- 5) Using an oscilloscope, monitor the 5V output of the flyback at connector J3. Also monitor the step-down outputs of 1.8V and 3.3V at connector J3.
- 6) Using DMM (Digital Multi Meter), verify the nominal output DC voltages are stable at connector J3: +5VDC nominal +/-3%, +1.8VDC nominal +/-3%, +3.3VDC nominal +/-3%
- 7) Test load regulation. Using resistive load or electronic load, apply a 1A load at each of the 1.8V and 3.3V output, and a 750mA load at the 5V output. Monitor with DVM that the output voltages remain within 3% of the nominal. Note that the input current from the external power supply will be approximately 228mA at 57V or 270mA at 48V.
- 8) Test line regulation at full load conditions: Reduce the power supply voltage from 57V to 36V and verify that the output voltages remain within +/-3% of the nominal output voltages. Line regulation test is only applicable using external power supply to adjust the input voltage.
- 9) With power over Ethernet, connect another CAT-5 cable from port J2 to a computer for network connectivity. Actual setup using PowerDsine 3001 Midspan is shown below and can be used to verify actual network connectivity.

Power Over Ethernet Using PowerDsine 3001 Midspan for Network Connectivity

