LM5072 5V out 25W IEEE 802.3at Compliant POE+ PD Power Eval_Board

National Semiconductor
RD-180
PowerWise Design Center
November 16, 2009

1.0 Design Specifications

Inputs	Output #1
VinMin=38V	Vout1=5V
VinMax=60V	Iout1=5A

2.0 Design Description

Eval Board Description

This LM5072 based 5V out 25W POE+ PD power supply is fully compliant with IEEE 802.3at standard. This eval board converts 48 Vdc to 5 Vdc. It can deliver up to 25W power as specified by the IEEE 802.3at standard. It has a 2 event detection circuit which can identify the PSE as either Type one or Type two. (See National Semiconductor Application note "Fully Compliant IEEE 802.3at Interface Using the LM5072/ LM5073" for details) The 2 event detection circuit is located on the bottom layer of the PC board. In those applications where this 2 event detection feature is not required, the user only needs to populate top layer components.

The input current limit is 800 mA. The efficiency of this eval board is high enough to keep input current under 800mA at 38Vin full load. The input under voltage lock has 7V hysteresis, with 38V rise and 31V fall. This eval board also has output short circuit protection.

This eval board can also be powered by a 24V AUX power supply. In this configuration, the AUX input port bypasses the LM5072 internal hot swap MOSFET and allows input current to be greater than the 800 mA limit.

LM5072

The LM5072 Powered Device (PD) interface and Pulse-Width-Modulation (PWM) controller provides a complete power solution for the PD connecting into Power over Ethernet (PoE) networks. This controller integrates all functions necessary to implement both a PD powered interface and DC-DC converter with a minimum number of external components. The low RDS(ON) PD interface hot swap MOSFET and programmable DC current limit makes LM5072 suitable for both IEEE 802.3af and IEEE 802.3at compliant PD devices. The 100V maximum voltage rating simplifies selection of the transient voltage suppressor that protects the PD from network transients. The LM5072 includes an easy to use PWM controller. The PWM control scheme is based on peak current mode control, which provides inherent advantages of line feed forward, cycle by cycle current limit and simplifies feedback loop compensation.

IEEE 802.3af and IEEE 802.3at are the PoE specifications this design is compliant with.

3.0 Features

- DC/DC converter efficiency of 85% at 48V in 25W load
- With added two event detection circuit, this design is fully compliant with IEEE 802.3at
- Integrated POE+ RJ45 magetics connector provides Ethernet isolation
- Low ripple voltage <20 mV, tight dynamic load regulation <75 mV
- Inrush current limit, 800 mA input over current protection
- Output short circuit protection, soft start, input under voltage protection
- 24V AUX input port with Oring diode
- Uses standard FA2898-AL transformer from Coilcraft

4.0 Schematic

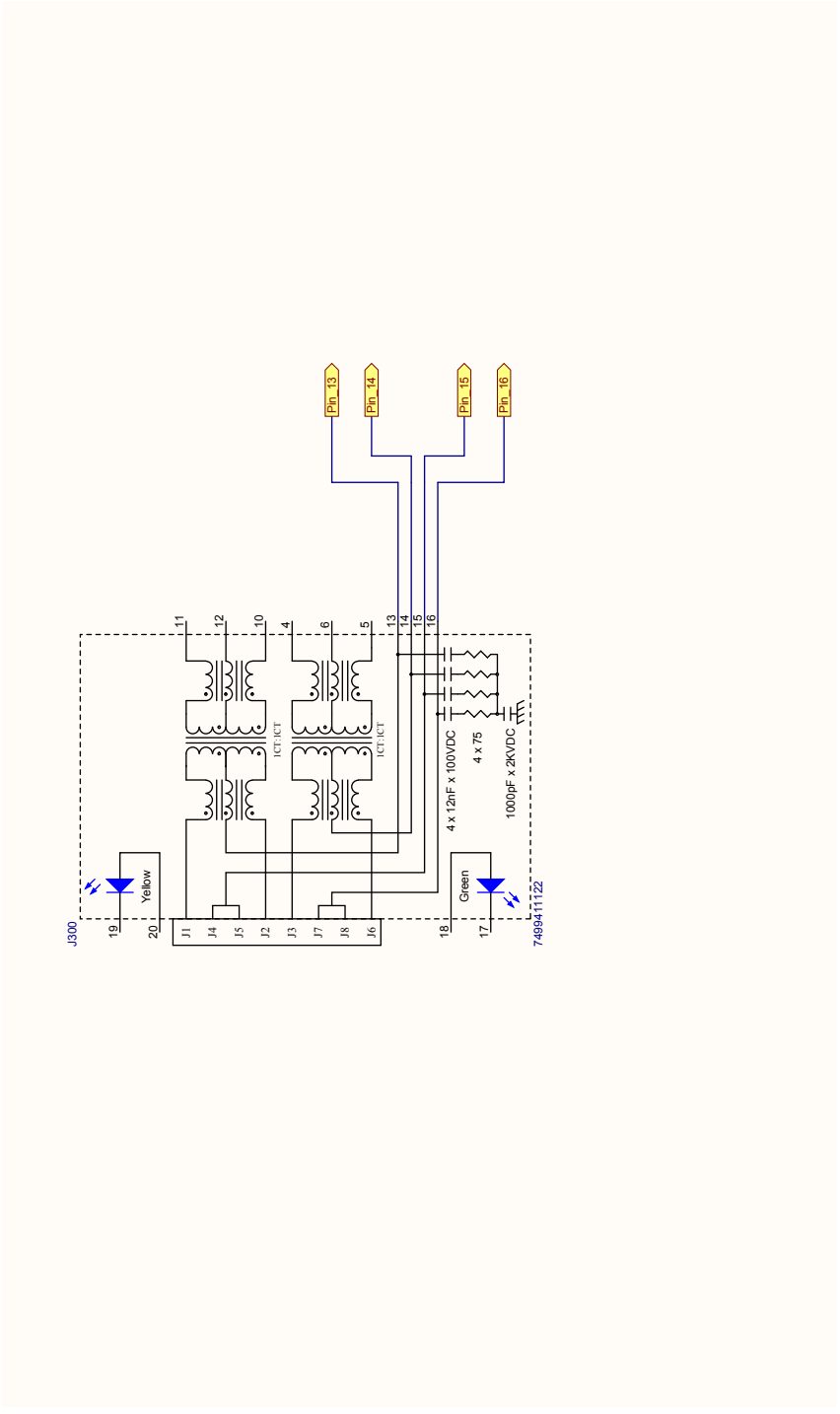


FIGURE 1. Schematic_sheet1

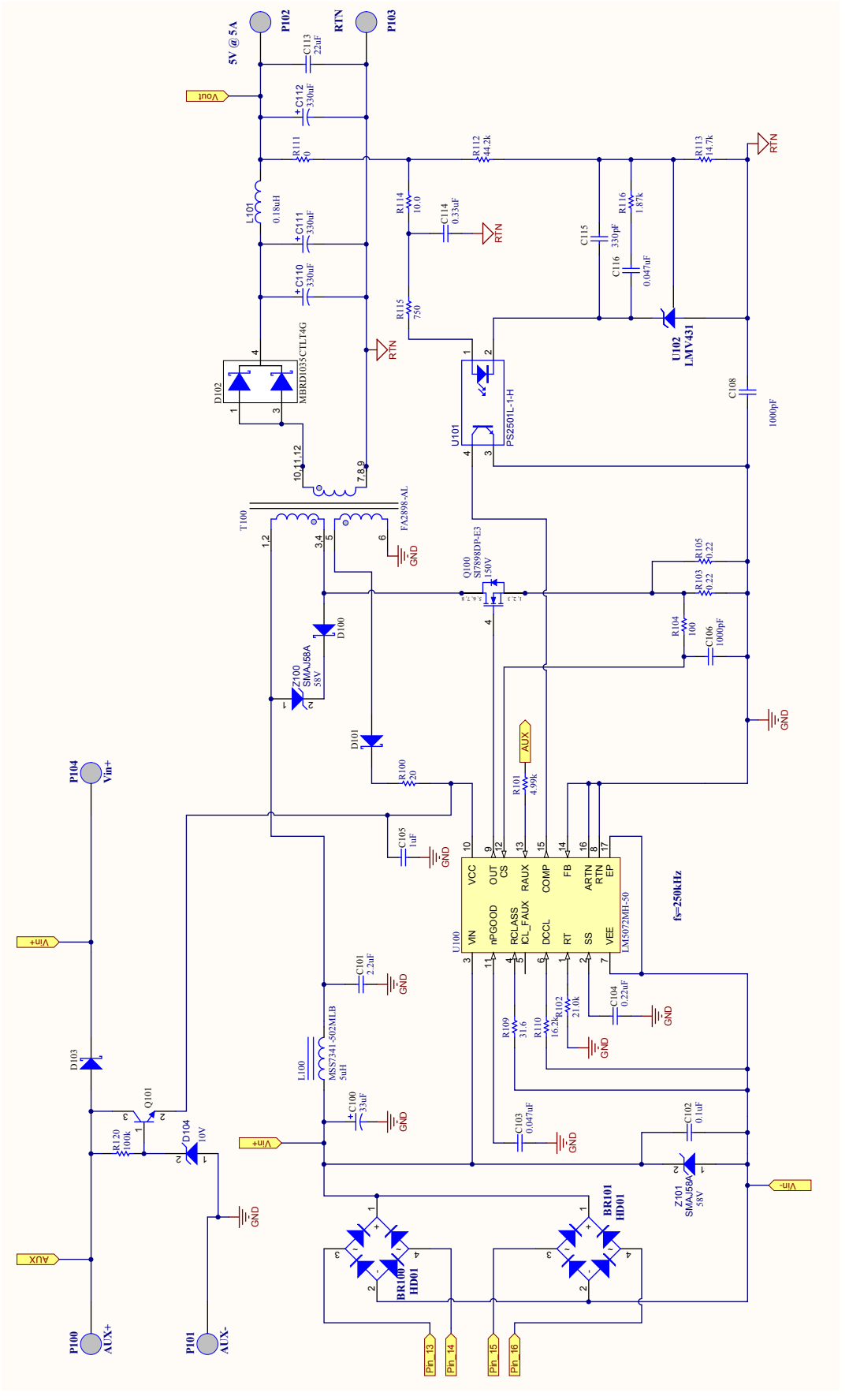


FIGURE 2. Schematic_sheet2

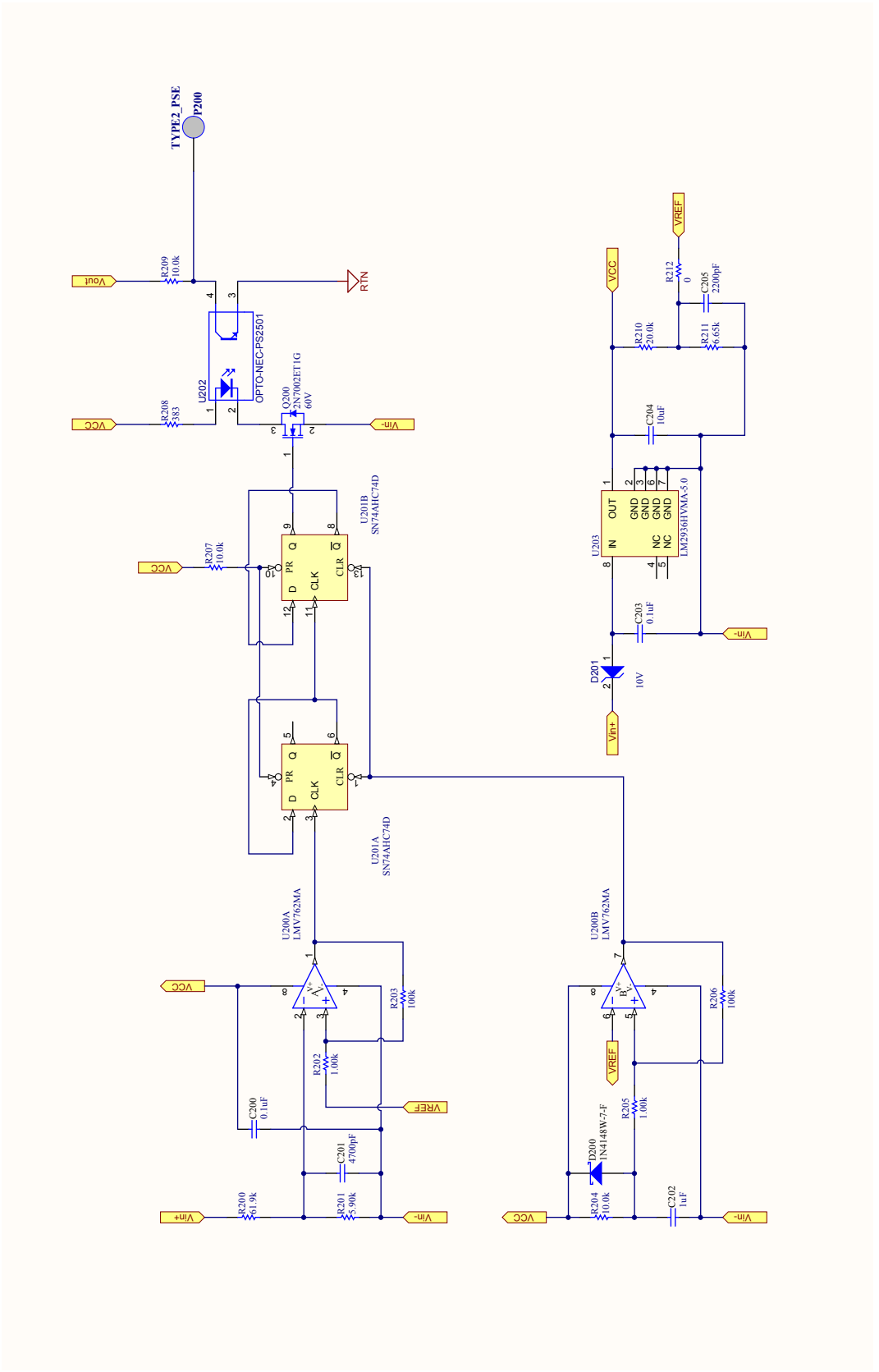


FIGURE 3. Schematic_sheet3

5.0 Bill of Materials

bom6

Designator	CompType	Value	Package	Description	Manufacturer	PartNumber
BR100	Diode	100V	MiniDip	Diode Bridge 100V, 0.8A	Diodes Inc.	HD01
BR101	Diode	100V	MiniDip	Diode Bridge 100V, 0.8A	Diodes Inc.	HD01
C100	Capacitor	33uF	SMD	AL, 100V, 20%	Nippon Chemi-Con	EMVE101ADA330MJA0G
C101	Capacitor	2.2uF	1210	Ceramic, X7R, 100V, 10%	MuRata	GRM32ER72A225KA35L
C102	Capacitor	0.1uF	0805	Ceramic, X7R, 100V, 10%	TDK	C2012X7R2A104K
C103	Capacitor	0.047uF	0805	Ceramic, X7R, 25V, 10%	MuRata	GRM218R71E473KA01D
C104	Capacitor	0.22uF	0805	Ceramic, X7R, 16V, 10%	TDK	C2012X7R1C224K
C105	Capacitor	1uF	0805	Ceramic, X7R, 16V, 10%	TDK	C2012X7R1C105K
C106	Capacitor	1000pF	0805	Ceramic, C0G/NP0, 50V, 5%	TDK	C2012C0G1H102J
C108	Capacitor	1000pF	1210	Ceramic, X7R, 1000V, 10%	Vishay-Vitramon	VJ1210Y102KXGAT5Z
C110	Capacitor	330uF	SMD	Polarized Capacitor 6.3V 330uF	United Chemi-con	APXE6R3ARA331MF80G
C111	Capacitor	330uF	SMD	Polarized Capacitor 6.3V 330uF	United Chemi-con	APXE6R3ARA331MF80G
C112	Capacitor	330uF	SMD	Polarized Capacitor 6.3V 330uF	United Chemi-con	APXE6R3ARA331MF80G
C113	Capacitor	22uF	0805	Ceramic, X5R, 6.3V, 20%	TDK	C2012X5R0J226M
C114	Capacitor	0.33uF	0805	Ceramic, X7R, 16V, 10%	TDK	C2012X7R1C334K
C115	Capacitor	330pF	0805	Ceramic, C0G/NP0, 50V, 5%	MuRata	GRM2165C1H331JA01D
C116	Capacitor	0.047uF	0805	Ceramic, X7R, 25V, 10%	MuRata	GRM218R71E473KA01D
C200	Capacitor	0.1uF	0805	Ceramic, X7R, 50V, 10%	TDK	C2012X7R1H104K
C201	Capacitor	4700pF	0805	Ceramic, C0G/NP0, 25V, 5%	TDK	C2012C0G1E472J
C202	Capacitor	1uF	0805	Ceramic, X5R, 25V, 10%	TDK	C2012X5R1E105K
C203	Capacitor	0.1uF	0805	Ceramic, X7R, 100V, 10%	TDK	C2012X7R2A104K
C204	Capacitor	10uF	1206	Ceramic, X5R, 6.3V, 20%	TDK	C3216X5R0J106M
C205	Capacitor	2200pF	0805	Ceramic, C0G/NP0, 100V, 5%	TDK	C2012C0G2A222J
D100	Diode	0.79V	SMA	Vr = 100V, Io = 1A, Vf = 0.79V	Diodes Inc.	B1100-13-F
D101	Diode	1.25V	SOD-123	Vr = 100V, Io = 0.15A, Vf = 1.25V	Diodes Inc.	1N4148W-7-F
D102	Diode	0.56V	DPAK	Vr = 35V, Io = 10A, Vf = 0.56V	ON Semiconductor	MBRD1035CTLT4G
D103	Diode	0.79V	SMC	Vr = 100V, Io = 3A, Vf = 0.79V	Diodes Inc.	B3100-13-F
D104	Zener	10V	SOD-123	SMT Zener Diode	Diodes Inc.	MMSZ5240B-7-F
D200	Diode	100V	SOD-123	Vr = 100V, Io = 0.15A, Vf = 1.25V	Diodes Inc.	1N4148W-7-F
D201	Zener	10V	SOD-123	SMT Zener Diode	Diodes Inc.	MMSZ5240B-7-F
J300	Connector			Integrated PoE+ 10/100 Base-T RJ45	Midcom Wurth	7499411122
L100	Inductor	5uH	MSS7341	Shielded Drum Core, 3.16A, 0.024 Ohm	Coilcraft Inc.	MSS7341-502MLB
L101	Inductor	0.18uH	DO1813	Inductor	Coilcraft	DO1813H-181ML
Q100	MOSFET	150V	PowerPAK SO-8	3A, 17nC, rDS(on) @ 4.5V =0.076	Vishay-Siliconix	SI7898DP-E3
Q101	BJT	40V	SOT-23	NPN, 0.2A, 40V	Central Semiconductor	CMPT3904 LEAD FREE
Q200	MOSFET	60V	SOT-23	0.26A, 0.81nC, rDS(on) @ 4.5V =3	ON Semiconductor	2N7002ET1G
R100	Resistor	20	0805	5%, 0.125W	Vishay-Dale	CRCW080520R0JNEA
R101	Resistor	4.99k	0805	1%, 0.125W	Vishay-Dale	CRCW08054k99FKEA
R102	Resistor	21.0k	0805	1%, 0.125W	Vishay-Dale	CRCW080521k0FKEA
R103	Resistor	0.22	1206	1%, 0.25W	Panasonic	ERJ-8RQFR22V
R104	Resistor	100	0805	1%, 0.125W	Vishay-Dale	CRCW0805100RFKEA
R105	Resistor	0.22	1206	1%, 0.25W	Panasonic	ERJ-8RQFR22V
R109	Resistor	31.6		Resistor	Vishay-Dale	CRCW080531R6FKEA
R110	Resistor	16.2k	0805	1%, 0.125W	Vishay-Dale	CRCW080516k2FKEA
R111	Resistor	0	0805	5%, 0.125W	Vishay-Dale	CRCW0805000Z0EA
R112	Resistor	44.2k	0805	1%, 0.125W	Vishay-Dale	CRCW080544k2FKEA
R113	Resistor	14.7k	0805	1%, 0.125W	Vishay-Dale	CRCW080514k7FKEA
R114	Resistor	10.0	0805	1%, 0.125W	Vishay-Dale	CRCW080510R0FKEA
R115	Resistor	750	0805	1%, 0.125W	Vishay-Dale	CRCW0805750RFKEA
R116	Resistor	1.87k	0805	1%, 0.125W	Vishay-Dale	CRCW08051k87FKEA
R120	Resistor	100k	0805	1%, 0.125W	Vishay-Dale	CRCW0805100kFKEA
R200	Resistor	61.9k	0805	1%, 0.125W	Vishay-Dale	CRCW080561k9FKEA
R201	Resistor	5.90k	0805	1%, 0.125W	Vishay-Dale	CRCW08055k90FKEA
R202	Resistor	1.00k	0805	1%, 0.125W	Vishay-Dale	CRCW08051k00FKEA
R203	Resistor	100k	0805	1%, 0.125W	Vishay-Dale	CRCW0805100kFKEA
R204	Resistor	10.0k	0805	1%, 0.125W	Vishay-Dale	CRCW080510k0FKEA
R205	Resistor	1.00k	0805	1%, 0.125W	Vishay-Dale	CRCW08051k00FKEA
R206	Resistor	100k	0805	1%, 0.125W	Vishay-Dale	CRCW0805100kFKEA
R207	Resistor	10.0k	0805	1%, 0.125W	Vishay-Dale	CRCW080510k0FKEA
R208	Resistor	383	0805	1%, 0.125W	Vishay-Dale	CRCW0805383RFKEA
R209	Resistor	10.0k	0805	1%, 0.125W	Vishay-Dale	CRCW080510k0FKEA
R210	Resistor	20.0k	0805	1%, 0.125W	Vishay-Dale	CRCW080520k0FKEA
R211	Resistor	6.65k	0805	1%, 0.125W	Vishay-Dale	CRCW08056k65FKEA
R212	Resistor	0	0805	5%, 0.125W	Vishay-Dale	CRCW0805000Z0EA
T100	Transformer		EFD20		Coilcraft	FA2898-AL
U100	MiscPower		MXA16A	Integrated 100V POE Controller	National Semiconductor	LM5072MH-80
U101	OPTOCOUPLER		PS2501L-1		NEC	PS2501L-1-H
U102	Shunt Regulator		SOT23-5	LOW VOLTAGE ADJ SHUNT	National Semiconductor	LMV431AIM5
U200	Comparator IC		M08A_L	Low Voltage, Precision Comparator with Push-Pull	National Semiconductor	LMV762MA
U201	Flip Flop IC		D014	Dual Positive-Edge-Triggered D-Type Flip-Flop	Texas Instruments	SN74AHC74D
U202	OPTOCOUPLER		PS2501L-1		NEC	PS2501L-1-H
U203	LDO IC		M08A	Ultra-Low Quiescent Current LDO Voltage Regulator	National Semiconductor	LM2936HVMA-5.0
Z100	TVS	58V	SMA	SMT Zener Diode	Diodes Inc	SMAJ58A
Z101	TVS	58V	SMA	SMT Zener Diode	Diodes Inc	SMAJ58A

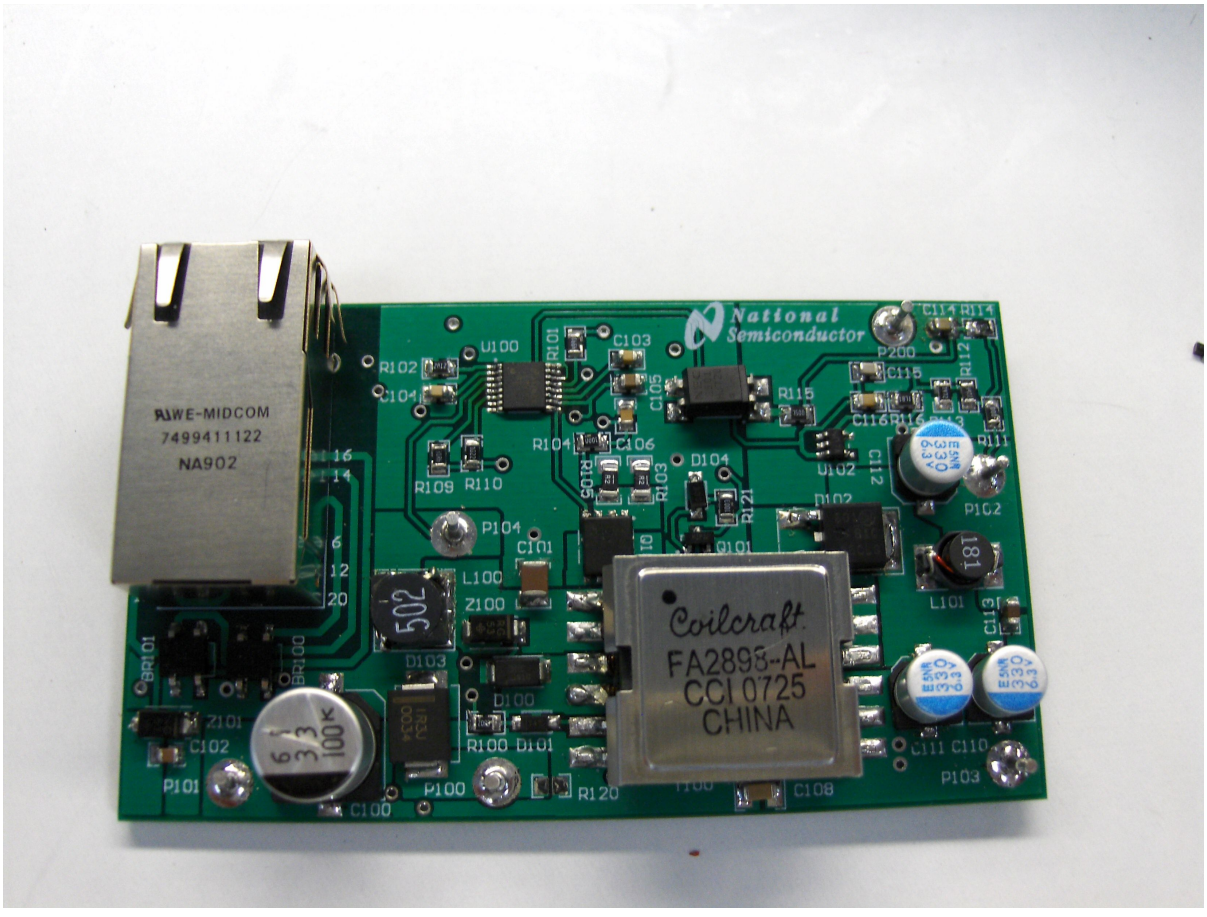
FIGURE 4. BOM

6.0 Other Operating Values

Operating Values

Description	Parameter	Value	Unit
Modulation Frequency	Frequency	250	KHz
Total output power	Pout	25	W
Steady State Efficiency	Efficiency	85	%
Control scheme	Control scheme	Current Mode	
Peak-to-peak ripple voltage	Vout p-p	20	mV
Static load regulation	Static load	50	mV
Dynamic load regulation	Dynamic load	75	mV

7.0 Board Photos



boardphoto1

FIGURE 5. Board Photo

8.0 Quick Start

Recommended Equipment:

- IEEE 802.3at compliant PSE or a regular DC Lab Power Supply
- Electronic Load
- Multimeter
- Oscilloscope
- Ethernet Cable

Test Procedure:

If PSE is used

1. Connect output of PSE to J300 of the eval board via ethernet cable.
2. Connect test point P102 on the eval board to the positive terminal of the electronic load. Connect test point P103 on the

eval board to the negative terminal of the electronic load. Set electronic load current to 5A.

3. Turn on the PSE.

If lab power supply is used

1. Cut and strip one end of the Ethernet cable. Connect wires #4 and #5 to the positive output of the DC power supply. Connect wires #7 and #8 to the negative output of the DC power supply.

2. Plug Ethernet cable to J300 on the eval board.

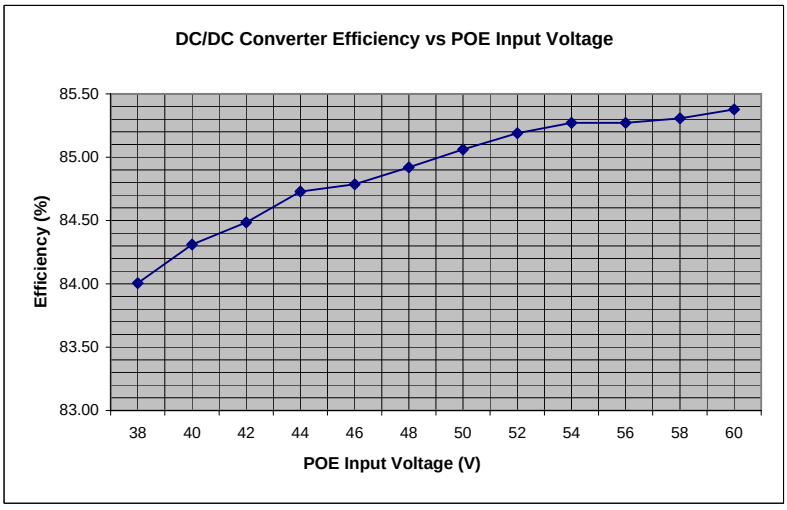
3. Connect test point P102 on the eval board to the positive terminal of the electronic load. Connect test point P103 on the eval board to the negative terminal of the electronic load. Set electronic load current to 5A.

4. Turn on the DC power supply. Slowly increase the input voltage. The eval board will turn on at around 38V.

9.0 Waveforms

DC/DC Converter Efficiency vs POE input voltage (Not including the diode bridges)

Vin (V)	Iin (A)	Pin (W)	Vout (V)	Iout (A)	Pout (W)	Ploss (W)	Efficiency (%)
38	0.77	29.26	4.916	5	24.58	4.68	84.01
40	0.729	29.16	4.917	5	24.585	4.575	84.31
42	0.693	29.106	4.918	5	24.59	4.516	84.48
44	0.66	29.04	4.921	5	24.605	4.435	84.73
46	0.631	29.026	4.922	5	24.61	4.416	84.79
48	0.604	28.992	4.924	5	24.62	4.372	84.92
50	0.579	28.95	4.925	5	24.625	4.325	85.06
52	0.556	28.912	4.926	5	24.63	4.282	85.19
54	0.535	28.89	4.927	5	24.635	4.255	85.27
56	0.516	28.896	4.928	5	24.64	4.256	85.27
58	0.498	28.884	4.928	5	24.64	4.244	85.31
60	0.481	28.86	4.928	5	24.64	4.22	85.38

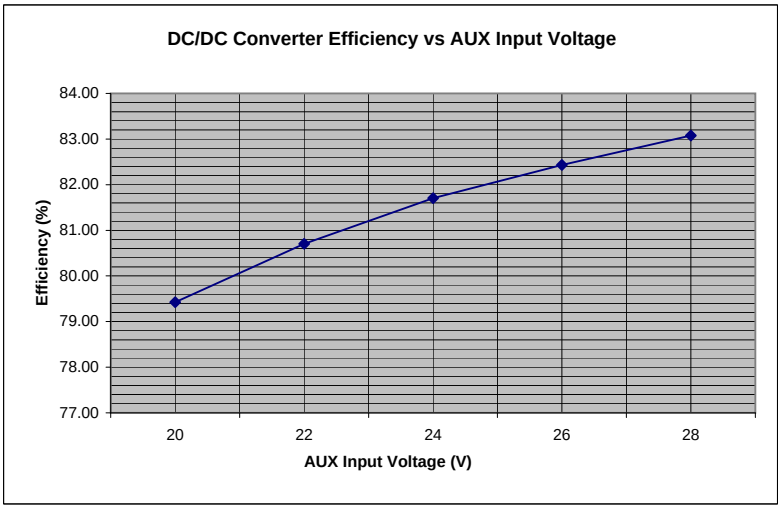


waveform1

FIGURE 6. Efficiency at POE Input

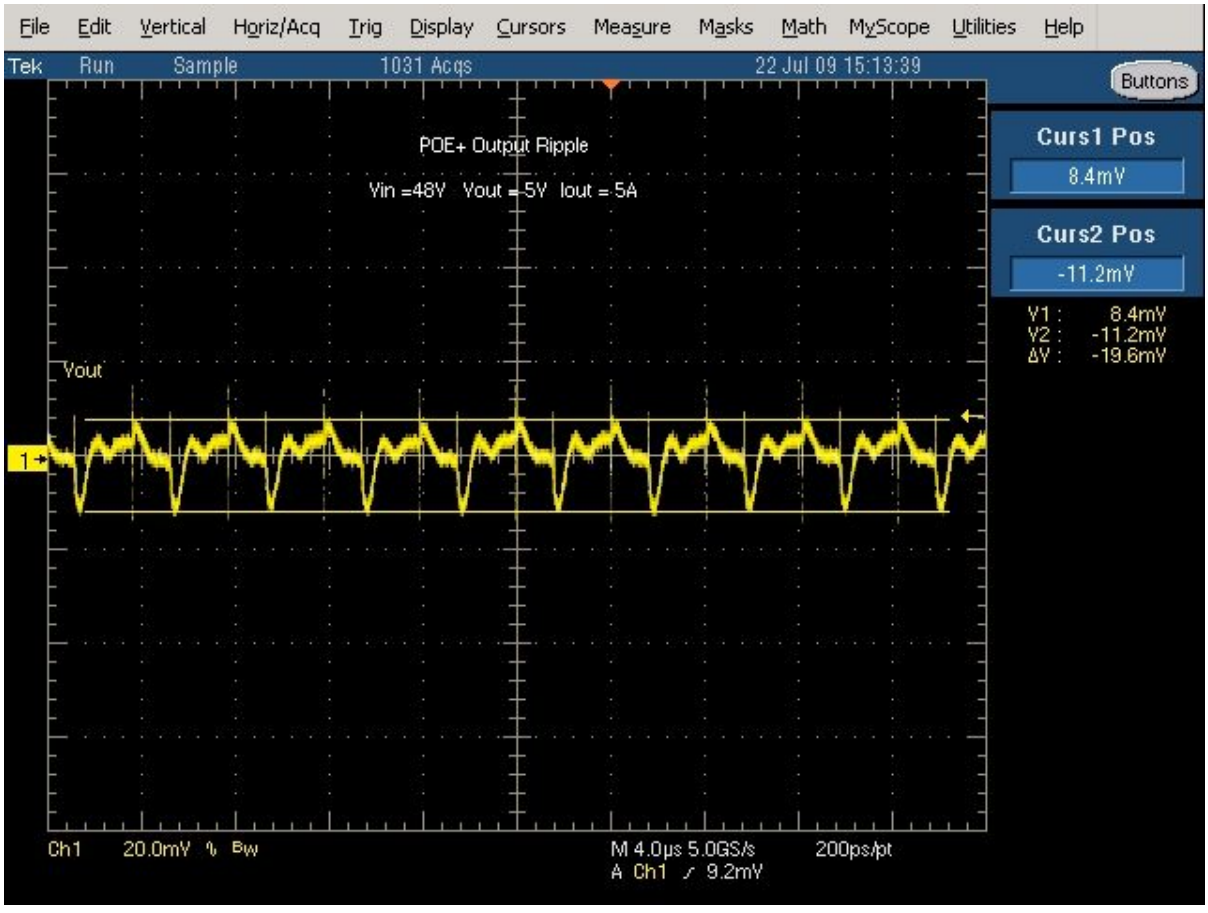
DC/DC Converter Efficiency vs AUX port input voltage (Including Oring diode)

Vin (V)	Iin (A)	Pin (W)	Vout (V)	Iout (A)	Pout (W)	Ploss (W)	Efficiency (%)
20	1.549	30.98	4.921	5	24.605	6.375	79.42
22	1.385	30.47	4.918	5	24.59	5.88	80.70
24	1.254	30.096	4.918	5	24.59	5.506	81.71
26	1.148	29.848	4.921	5	24.605	5.243	82.43
28	1.058	29.624	4.922	5	24.61	5.014	83.07



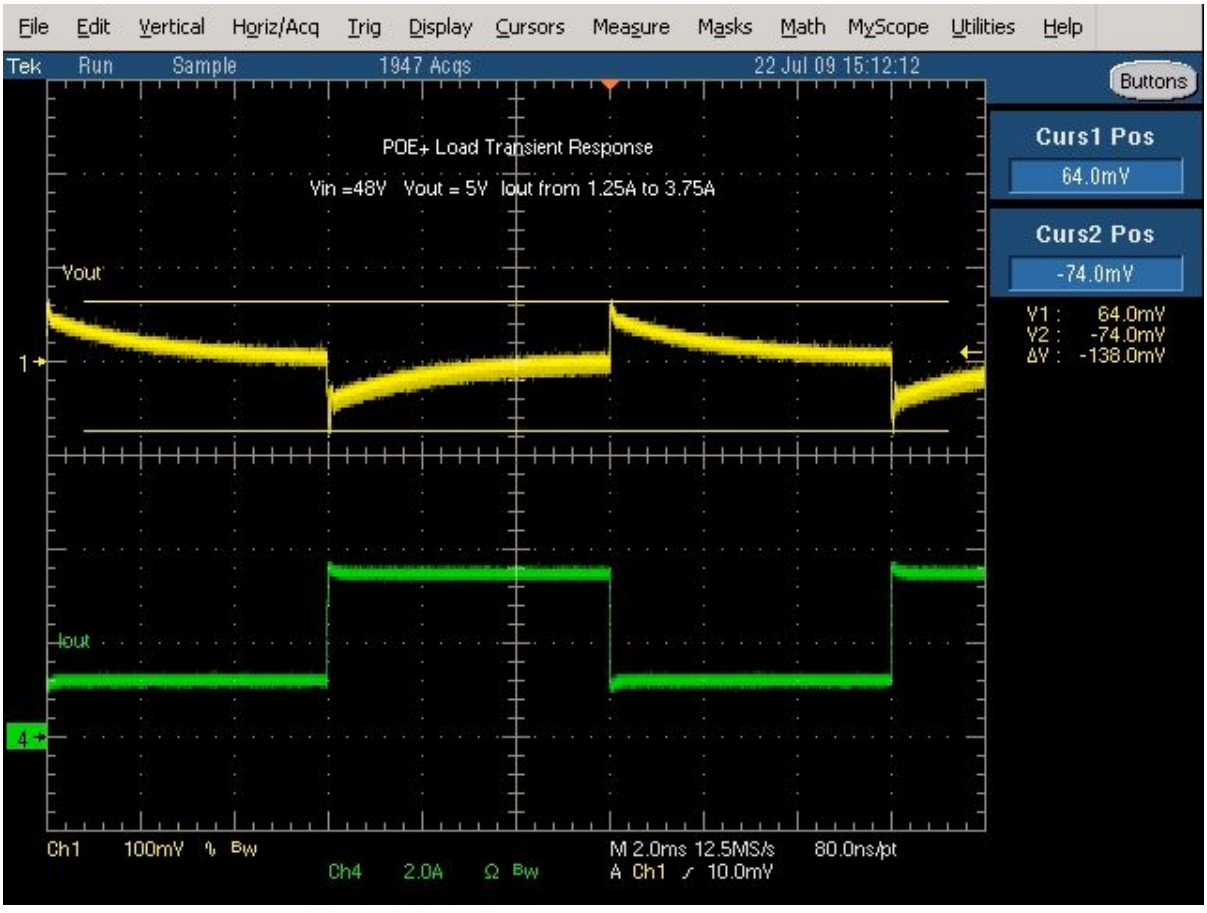
waveform3

FIGURE 7. Efficiency at AUX Input



waveform

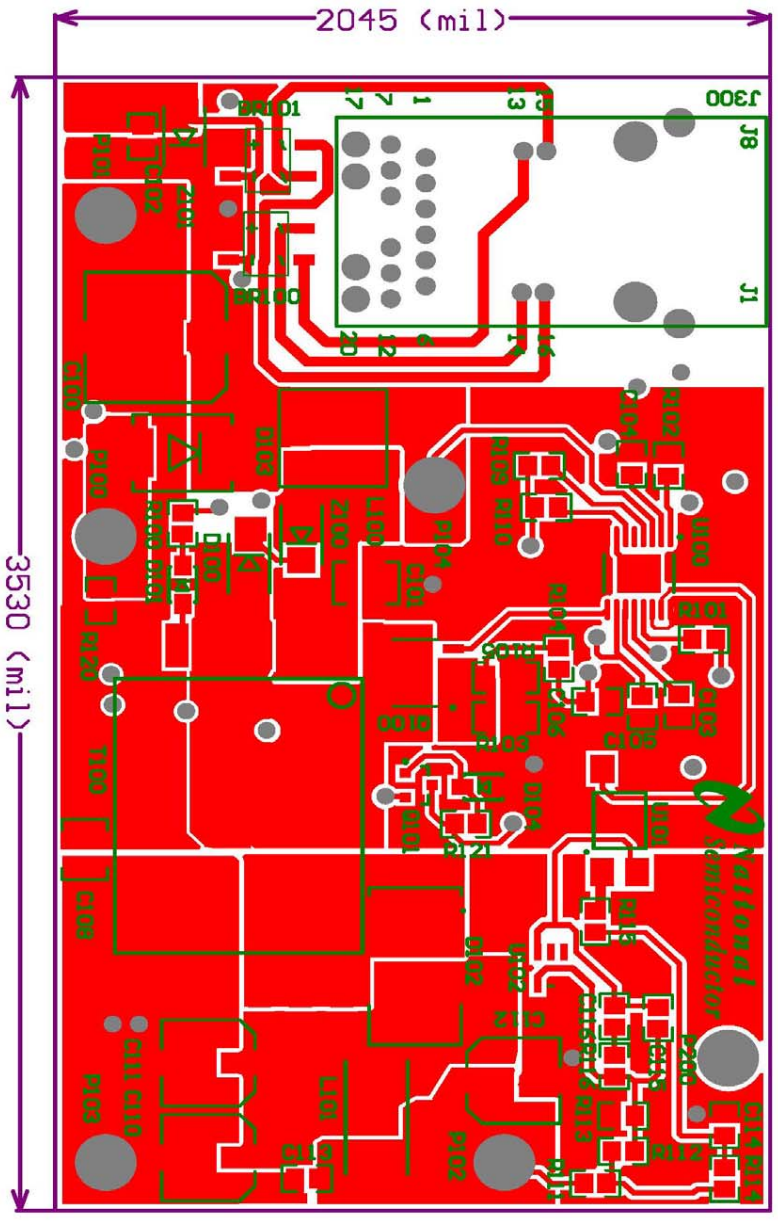
FIGURE 8. Output Ripple and Noise



waveform1

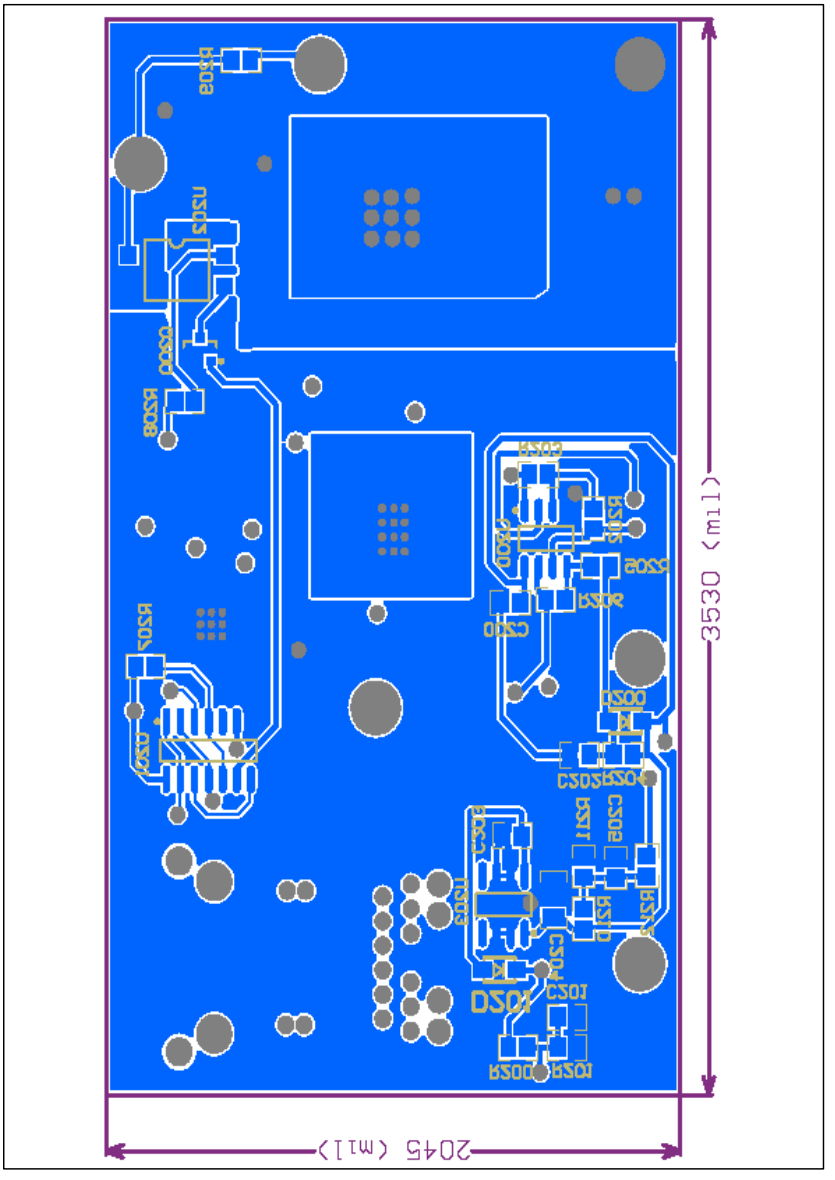
FIGURE 9. Load Transient Response

10.0 Layouts



layout6

FIGURE 10. PCB TOP



layout7

FIGURE 11. PCB BOTTOM

Notes

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