

## Description

The ZL2006 is an integrated mixed-signal power conversion and management IC that combines an efficient step-down DC-DC converter with key power and thermal management functions in a single package. The ZL2006 incorporates current sharing and adaptive efficiency-optimization algorithms to provide a flexible, efficient power IC building block.

The ZL2006EV1 platform is a 4-layer board demonstrating a 15A synchronous buck converter. Sequencing, tracking, margining, plus other features can be evaluated using this board.

A USB to SMBus adapter board can be used to connect the eval board to a PC. The PMBus command set is accessed by using the Zilker Labs PowerNavigator™ evaluation software from a PC running Microsoft Windows.

## Features

- 15A synchronous buck converter
- Optimized for small circuit footprint and dynamic response
- Configurable through SMBus
- Onboard enable switch
- Power good indicator

## Target Specifications

- $V_{IN} = 12\text{ V}$
- $V_{OUT} = 1.2\text{ V} / 15\text{ A}$  (20 A max)
- $f_{sw} = 615\text{ kHz}$
- Efficiency: 86% at 10 A
- Output ripple:  $\pm 1\%$
- Dynamic response:  $\pm 2.5\%$   
(50%-100%-50% load step,  $di/dt = 2.5\text{ A}/\mu\text{s}$ )
- Board temperature:  $25^\circ\text{C}$

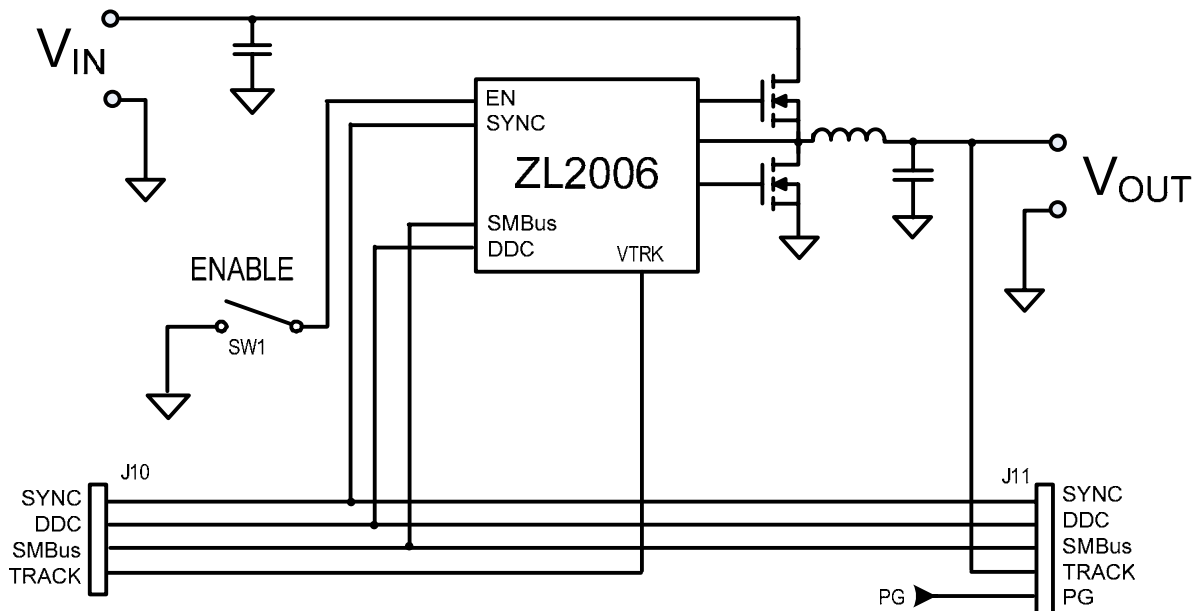


Figure 1. ZL2006EV1 Block Diagram

## Functional Description

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The ZL2006EV1 provides all circuitry required to demonstrate the features of the ZL2006. The ZL2006EV1 has a functionally-optimized ZL2006 circuit layout that allows efficient operation up to the maximum output current. Power and load connections are provided through plug-in sockets.

A majority of the features of the ZL2006 such as soft-start delay and ramp times, supply sequencing, voltage tracking, and voltage margining are available on this evaluation board. For voltage tracking and sequencing evaluation, the board can be connected to any other Zilker Labs evaluation board that supports the Digital DC (DDC) bus.

Figure 1 shows a functional block diagram of the ZL2006EV1 board. The SMBus address is selectable through a jumper on the top side of the board. All power to the board (VIN and I<sup>2</sup>C bus) must be removed before changing the jumpers.

The hardware enable function is controlled by a toggle switch on the ZL2006EV1 board. The power good (PG) LEDs indicate the correct state of PG when external power is applied to the ZL2006EV1 board. The right angle headers at opposite ends of the board are for connecting a USB to SMBus adapter board or for daisy chaining of multiple evaluation boards.

Figure 2 shows the operational circuit. The circuit consists of the ZL2006 IC with its minimal component count to realize a 15 A buck converter. The board layout has been optimized for thermal performance.

Figure 3 is the board interface circuitry. Figure 4 through Figure 8 show the PCB layout for the board including the board fabrication notes.

The bill of materials (BOM) and configuration file are also included for reference.

## Operation

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### PMBus Operation

The ZL2006 utilizes the PMBus protocol. The PMBus functionality can be controlled via USB from a PC running the PowerNavigator evaluation software in a Windows XP or Windows 2000/NT operating system.

Install the evaluation software using the CD included in the ZL2006EV1 kit.

For board operation, connect the included USB-to-SMBus adapter board to J10 of the ZL2006EV1 board. Connect the desired load and an appropriate power supply to the input and connect the included USB cable to the PC running the PowerNavigator evaluation software. Place the ENABLE switch in “DISABLE” and turn on the power.

The evaluation software allows modification of all ZL2006 PMBus parameters. The ZL2006 device on the board has been pre-configured as described in this document, but the user may modify the operating parameters through the eval software or by loading a predefined scenario from a configuration file.

Use the mouse-over pop-ups for PowerNavigator help. Refer to Zilker Labs application note AN33 [2] for PMBus details.

The ENABLE switch can then be moved to “ENABLE” and the ZL2006EV1 board can be tested. Alternately, the PMBus ON-OFF CONFIG and OPERATION commands may be used.

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**Quick Start Guide**

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**Stand Alone Operation**

1. Set ENABLE switch to “DISABLE”
2. Apply load to VOUT+/VOUT-
3. Connect the USB to SMBus adapter board to J10 of ZL2006EV1
4. Connect supplied USB cable from computer to USB to SMBus adapter board
5. Connect power supply to VIN+/VIN- (supply turned off)
6. Turn power supply on
7. Set ENABLE switch to “ENABLE”
8. Monitor ZL2006EV1 board operation using an oscilloscope

**USB (PMBus) Operation**

1. Set ENABLE switch to “DISABLE”
2. Apply load to VOUT+/VOUT-
3. Connect power supply to VIN+/VIN- (supply turned off)
4. Turn power supply on
5. Insert the Zilker Labs Eval Kit CD
6. Connect USB to SMBus adapter board to J10 of ZL2006EV1
7. Connect supplied USB cable from computer to USB to SMBus adapter board
  - a. Upon first-time connection, the Found New Hardware Wizard will appear.
  - b. Windows XP users: Select ‘No’ at prompt to search the Internet for drivers.
  - c. Follow the steps on the screen to install the drivers from the CD.
8. Install the PowerNavigator evaluation software by running setup.exe from the PowerNavigator\_installer folder on the CD.
9. Set ENABLE switch on EVB to “ENABLE”
10. Monitor and configure the ZL2006EV1 board using PMBus commands in the evaluation software
11. Test the ZL2006EV1 operation using an oscilloscope and the evaluation software.

# ZL2006EV1

## Board Schematics

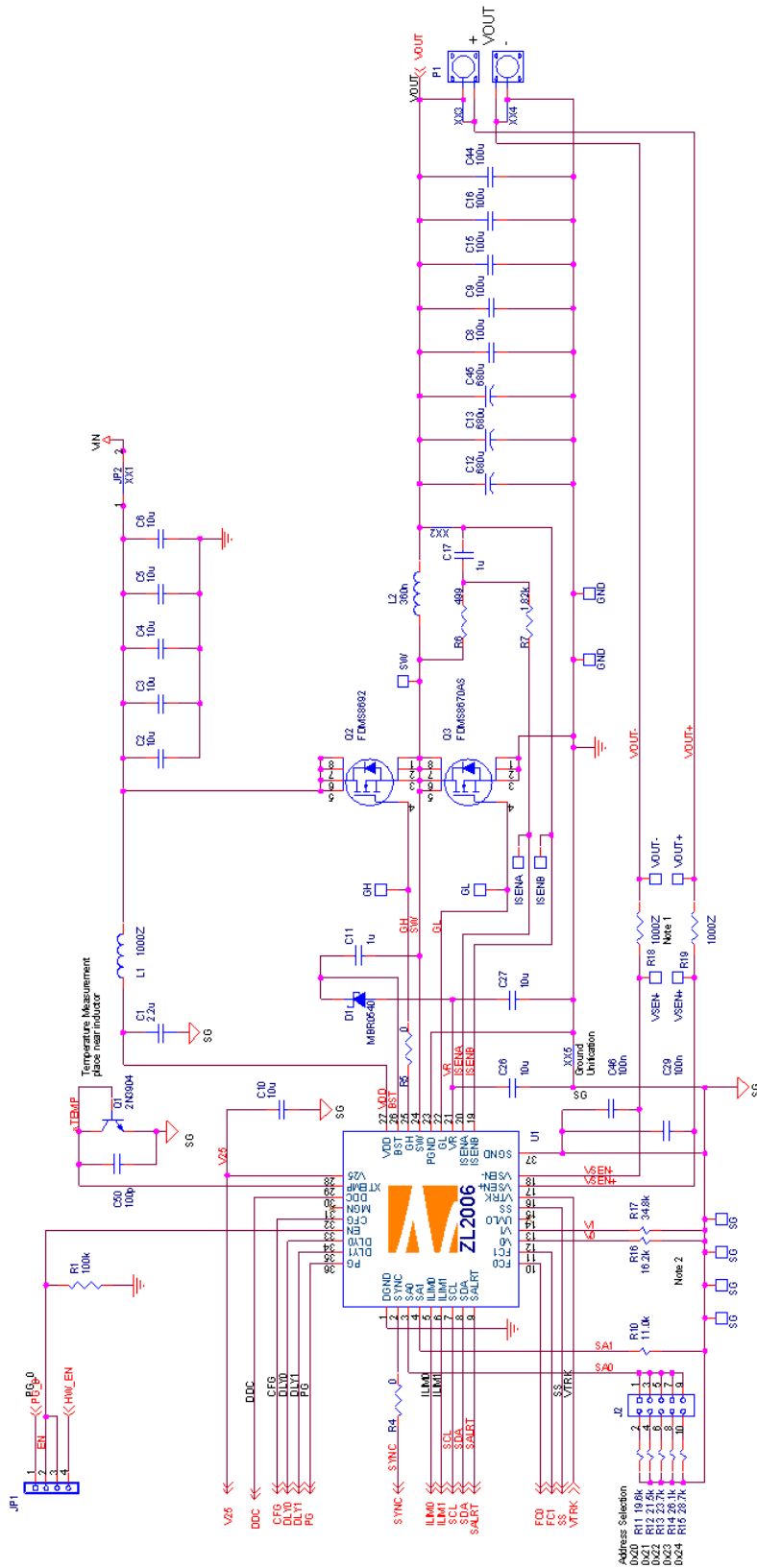


Figure 2. ZL2006EV1 Operational Circuit

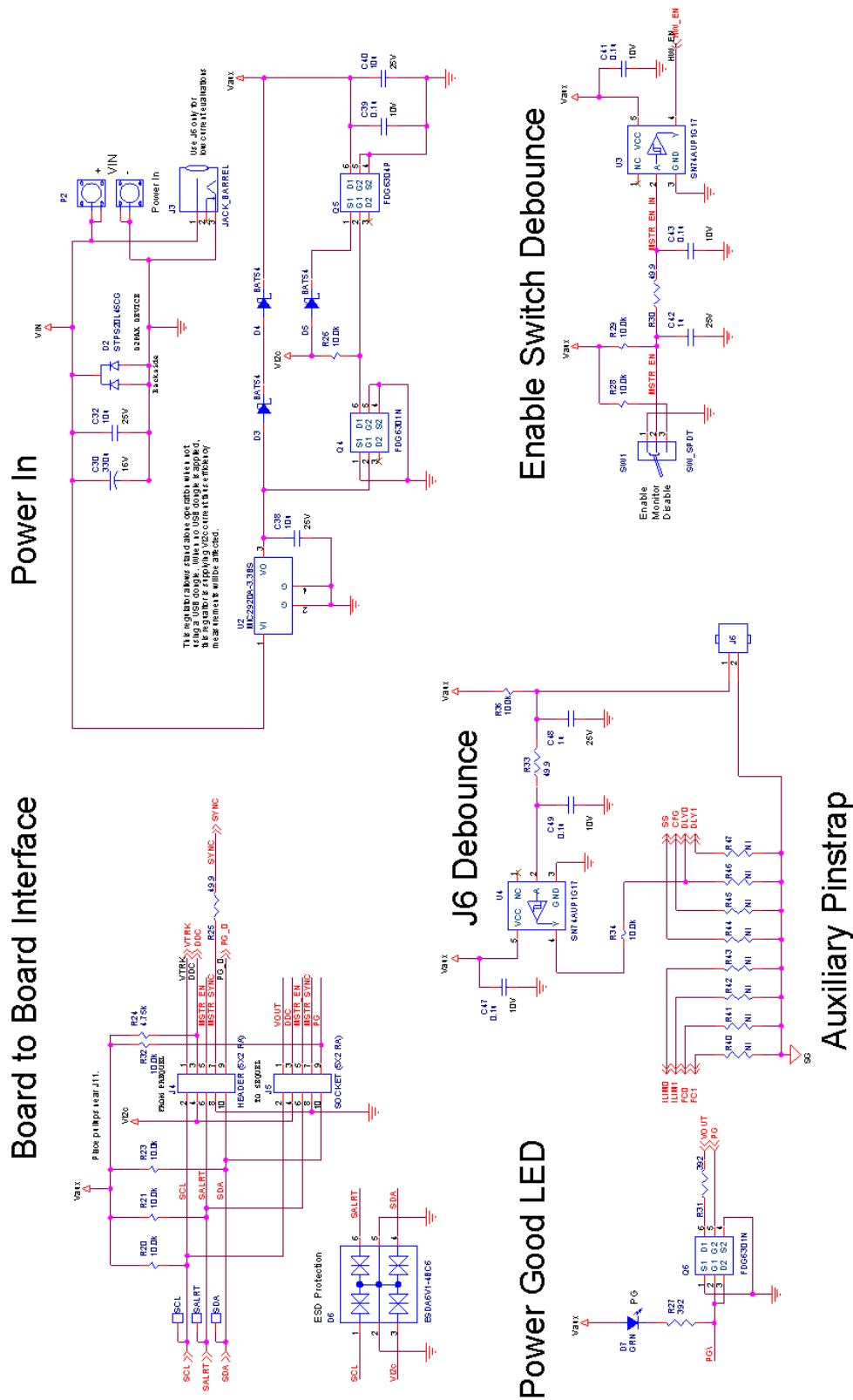


Figure 3. ZL2006EV1 Interface Circuitry

# ZL2006EV1

## Board Layout – 4 Layers

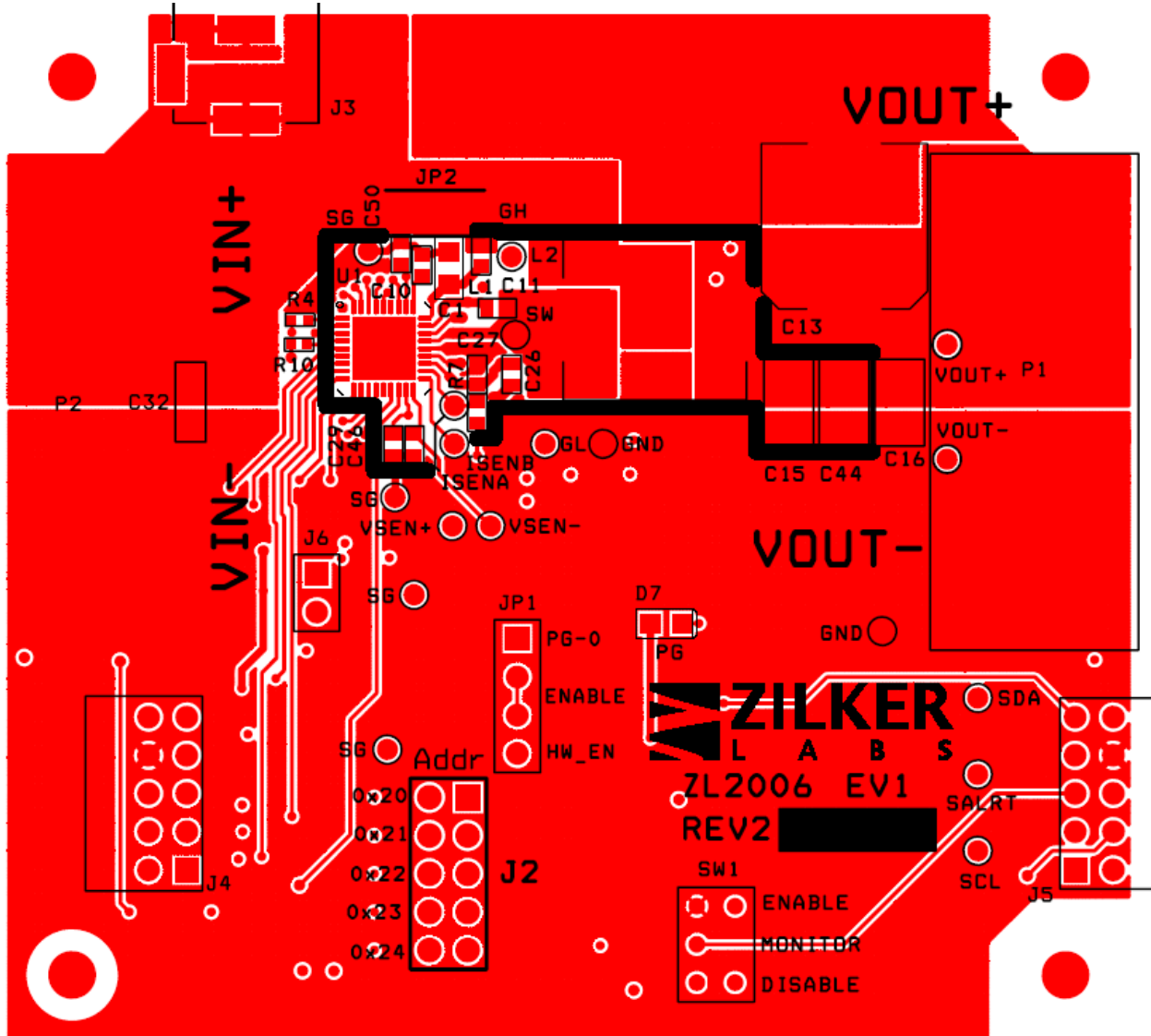


Figure 4. PCB – Top Layer

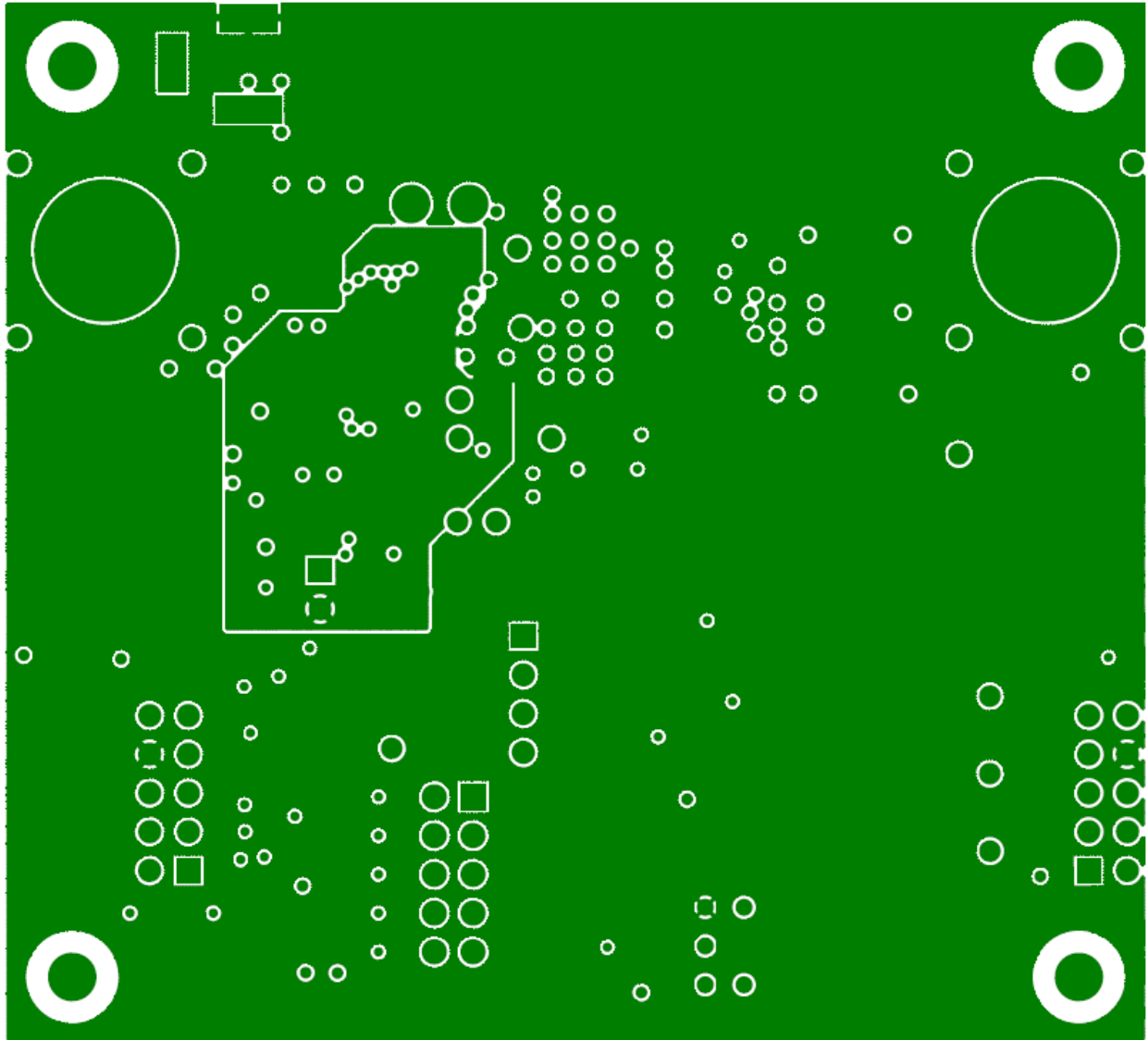


Figure 5. PCB – Inner Layer 1 (Viewed from Top)

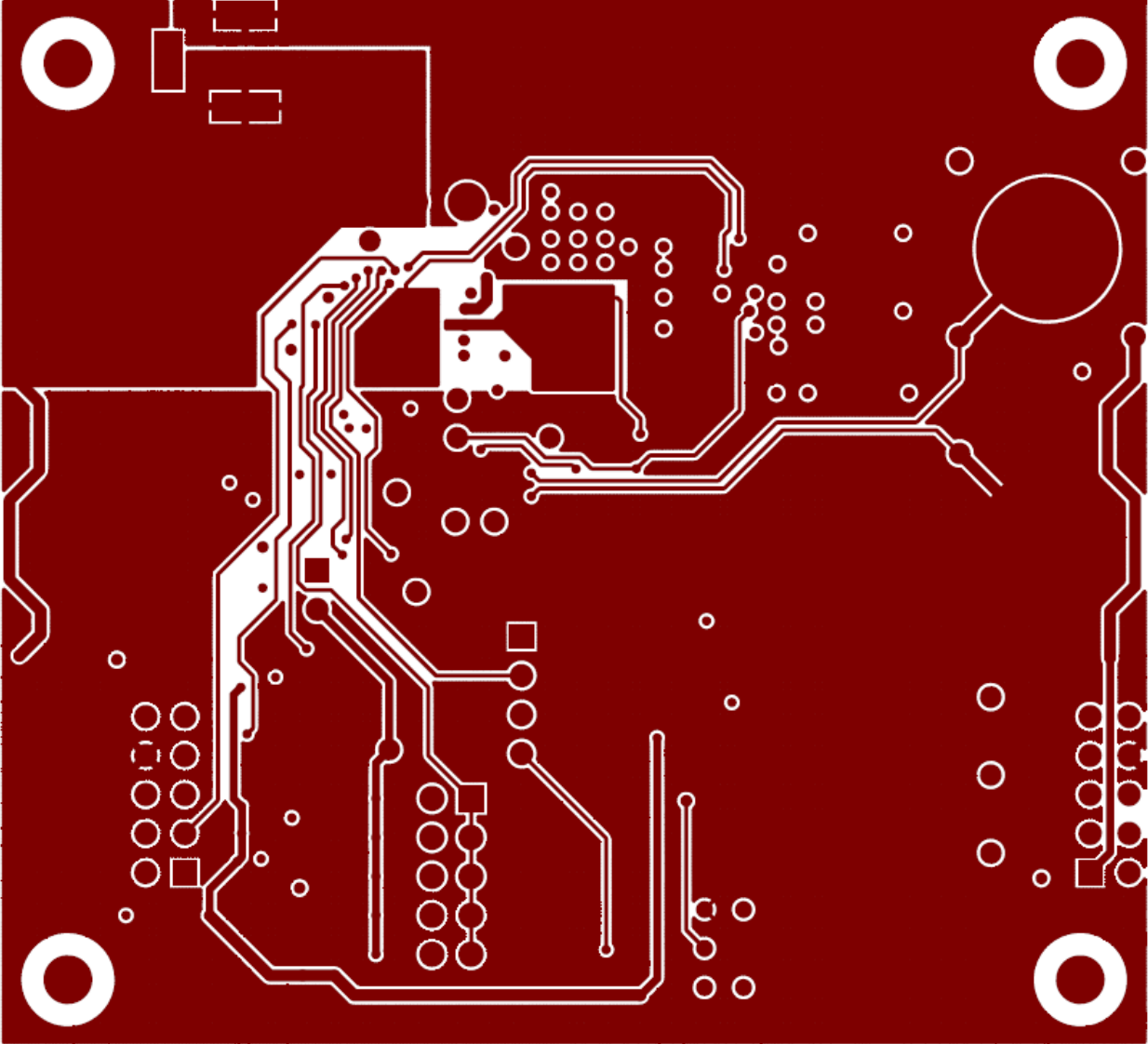


Figure 6. PCB – Inner Layer 2 (Viewed from Top)



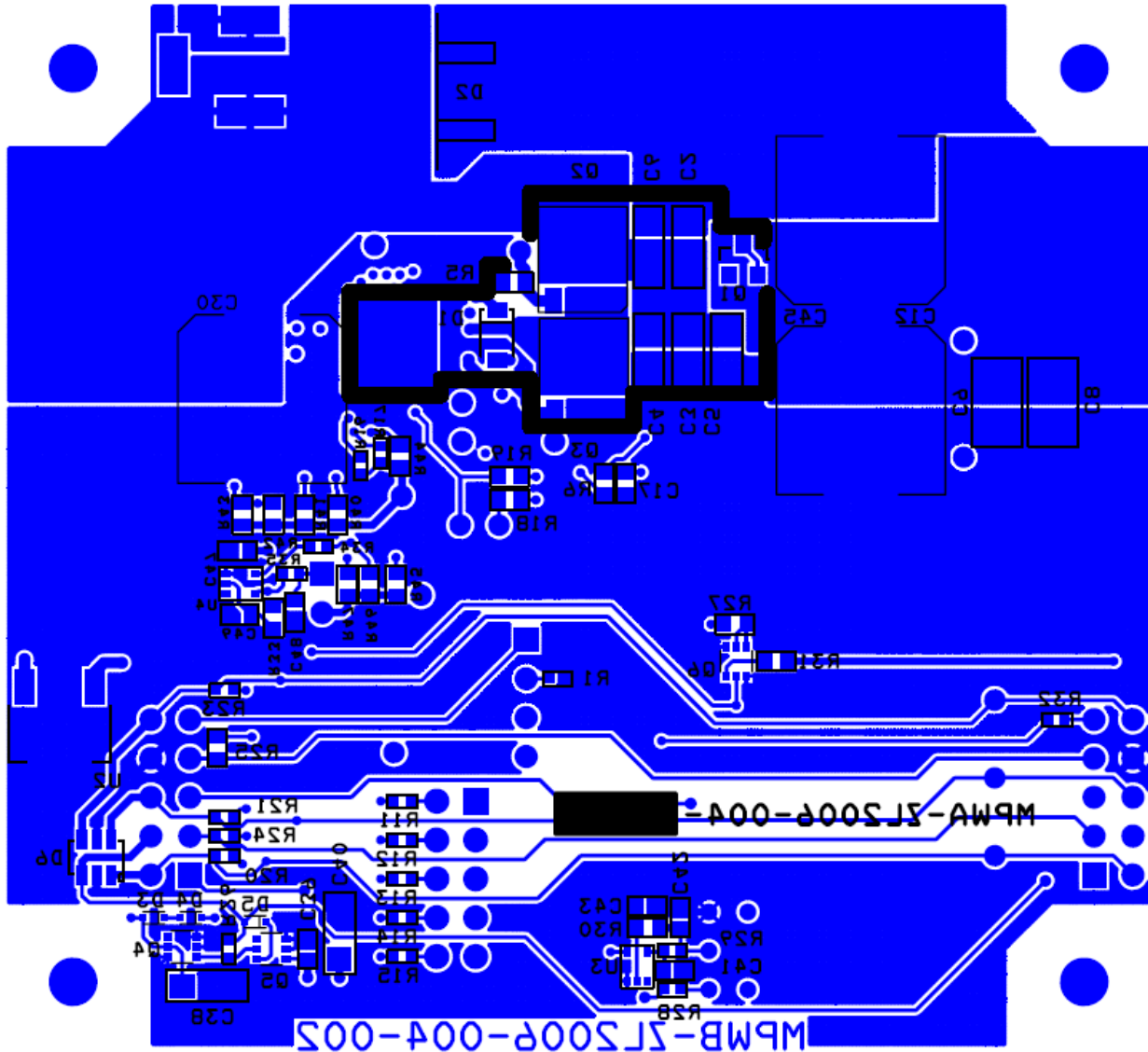


Figure 7. PCB – Bottom Layer (Viewed from Top)

NOTES UNLESS OTHERWISE SPECIFIED:

1. FABRICATE USING ARTWORK AND DRILL FILES PER TABLE BELOW.
2. FINISHED BOARDS MUST CONFORM TO ZILKER LABS QUALITY PROCEDURE SQAS-002-PCBREQ.
3. MATERIAL: NEMA GRADE FR-4; MINIMUM UL FLAMMABILITY RATING 94 V-0  
BOARD LAYER SPACING  
SPACING BETWEEN 1-2 = .013 TO .017  
SPACING BETWEEN 3-4 = .013 TO .017  
TOTAL BOARD THICKNESS = .062
4. COPPER THICKNESS SHALL BE 1 OZ. INNER LAYERS, 1 OZ. PLATED TO 2 OZ. OUTER LAYERS.
5. REFERENCE POINT 0,0 FOR DRILL FILE LISTING.
6. ALL HOLES PLATED THROUGH (UNLESS OTHERWISE NOTED). PLATING IN HOLES PER ZILKER LABS QUALITY PROCEDURE SQAS-002-PCBREQ.
7. BOARD COATING SHALL BE SOLDERMASK OVER BARE COPPER, HOT AIR SOLDER LEVELING.
8. SOLDERMASK PER ZILKER LABS QUALITY PROCEDURE SQAS-002-PCBREQ.
9. VENDOR IDENTIFICATION, UL COMPLIANCE AND DATE CODE TO BE PERMANENTLY AFFIXED AND LOCATED AS SHOWN, ON BOTTOM TRACE LAYER.
10. ELECTRICAL TEST MARK, ON BOTTOM TRACE LAYER, PER ZILKER LABS QUALITY PROCEDURE SQAS-002-PCBREQ.
11. FIDUCIALS TOP AND BOTTOM THESE LOCATIONS.
12. WARNING: THE MANUFACTURING PROCESSES AND THE MATERIALS ASSOCIATED WITH THIS PART MAY REQUIRE SPECIAL SAFETY PRECAUTIONS.

**Figure 8. Board Fabrication Notes**

Bill of Materials

ITEM	QTY	REFDES	VALUE	TOL	RATING	TYPE	PCB FOOTPRINT	MFR	MFR PN
1	1	C1	2.2u	10%	16V	X5R	SM0805	MURATA	GRM21BR61C225KA88L
2	3	C2,C3,C4	10u	10%	25V	X5R	SM1206	PANASONIC-ECG	ECJ-3YB1E106K
		C8,C9,C15,							
4	5	C16,C44	100u	20%	6.3V	X5R	SM1210	TAIYO YUDEN	JMK325BJ107MY-T
5	3	C10,C26,C27	10u	20%	6.3V	X5R	SM0603	PANASONIC-ECG	ECJ-1V80J106M
6	3	C11,C17,C42	1u	10%	25V	X5R	SM0603	TAIYO YUDEN	TMK107BJ105KA-T
7	2	C12,C13	680u	20%	6.3V	AL POLY	SM10P5X10P5	UNITED CHEMI-CON	APXA6R3ARA681MJC0G
8	2	C29,C46	100n	10%	25V	X7R	SM0603	PANASONIC ECG	ECJ-1V81E104K
9	1	C30	330u	20%	16V	AL POLY	10.3X10.3_PXA	UNITED CHEMI-CON	APXA160ARA331MJC0G
10	3	C32,C38,C40	10u	10%	25V	X7R	SM1206	PANASONIC-ECG	ECJ-13YB1E106K
11	3	C39,C41,C43	0.1u	10%	10V	X7R	SM0603	KEMET	C0603C104K8RACTU
15	1	C50	100p	5%	100V	NPO	SM0603	PANASONIC ECG	ECJ1VC2A101J
16	1	D1	MBR0540		40V	SCHOTTKY	SOD123	ON SEMI	MBR0540T1
17	1	D2	STPS20L45CG		45V-20A	SCHOTTKY	D-2PAK	ST MICRO	STPS20L45CG
18	3	D3,D4,D5	BAT54		30V	SCHOTTKY	SOD523	ON SEMI	BAT54XV2T10S
19	1	D6	ESDA6V1-4BC6		6.1V,80W		SOT23_6L	ST MICRO	ESDA6V1-4BC6
20	1	D7	GRN		2V	VERT	SM0805	CHICAGO MINIATURE	CMD17-21VGC
21	1	JP1	4 PIN				SIP4/100	TYCO/AMP	3-644456-4
23	1	J2	HEADER 5x2 PIN			VERT	100X100	SAMTEC	TSW-105-07-T-D
24	1	J3	JACK_BARREL		1.5A@18VDC	RA	RA.079PIN	KOBICONN	163-5004-E
25	1	J4	HEADER (5X2 RA)			RA	100X100	SAMTEC	TSW-105-08-T-D-RA
26	1	J5	SOCKET (5X2 RA)			RA	100X100	SAMTEC	SSQ-105-02-T-D-RA
28	3	L1,R18,R19	1000Z		50mA	FERRITE	SM0603	MURATA	BLM18HD102SN1D
29	1	L2	360n	20%	35A	POWDER	IHLP_4040DZ_05	VISHAY	IHLP4040DZERR36M61
30	2	P1,P2	JACK_BANANA		15A		.175PLUG/TSTPTS	EMERSON	108-0740-001
31	1	Q1	2N3904		40V	NPN	SOT-23	ON SEMI	MMBT3904L3G
32	1	Q2	FDMS8692		30V	N-CH	SO8FL_ALLP	FAIRCHILD	FDMS8692
33	1	Q3	FDMS8670AS		30V	N-CH	SO8FL_ALLP	FAIRCHILD	FDMS8670AS
34	2	Q4,Q6	FDG6301N		25V	DUAL N-CH	SC70_6	FAIRCHILD	FDG6301N
35	1	Q5	FDG6304P		25V	DUAL P-CH	SC70_6	FAIRCHILD	FDG6304P
36	1	R1	100k	1%	63mW	THK FILM	SM0402	VISHAY	CRCW0402100KFKED
37	1	R4	0	5%	63mW	THK FILM	SM0402	ROHM	MCR01MZPJ000
38	1	R5	0	5%	100mW	THK FILM	SM0603	YAGEO	RC0603JR-070RL
39	1	R6	499	1%	100mW	THK FILM	SM0603	PANASONIC-ECG	ERJ-3EKF4990V
40	1	R7	1.82k	1%	100mW	THK FILM	SM0603	PANASONIC-ECG	ERJ-3EKF1821V
41	1	R10	11.0k	1%	63mW	THK FILM	SM0402	VISHAY	CRCW040211K0FKED
42	1	R11	19.6k	1%	63mW	THK FILM	SM0402	VISHAY	CRCW040219K6FKED
43	1	R12	21.5k	1%	63mW	THK FILM	SM0402	VISHAY	CRCW040221K5FKED
44	1	R13	23.7k	1%	63mW	THK FILM	SM0402	VISHAY	CRCW040223K7FKED
45	1	R14	26.1k	1%	63mW	THK FILM	SM0402	VISHAY	CRCW040226K1FKED
46	1	R15	28.7k	1%	63mW	THK FILM	SM0402	VISHAY	CRCW040228K7FKED
47	1	R16	16.2k	1%	63mW	THK FILM	SM0402	PANASONIC-ECG	ERJ-2RKF1622X
48	1	R17	34.8k	1%	63mW	THK FILM	SM0402	PANASONIC-ECG	ERJ-2RKF3482X
		R20,R21,R23,							
49	7	R26,R28,R29	10.0k	1%	63mW	THK FILM	SM0402	YAGEO	RC0402FR-0710KL
		R32							
50	1	R24	4.75k	1%	63mW	THK FILM	SM0402	PANASONIC-ECG	ERJ-2RKF4751X
51	2	R25,R30	49.9	1%	100mW	THK FILM	SM0603	ROHM	MCR03EZPF49R9
52	2	R27,R31	392	1%	100mW	THK FILM	SM0603	PANASONIC-ECG	ERJ-3EKF3920V
58	1	SW1	SW_SPDT			PCB VERT	ULTRAMIN	NKK	G13AP-RO
73	1	U1	ZL2006				MLF36_6X6BX	ZILKER LABS, INC.	ZL2006ALNFT
74	1	U2	MIC2920A-3.3BS				SOT223	MICREL	MIC2920A-3.3WS
75	1	U3	SN74AUP1G17			TTL	SC70_5	TI	SN74AUP1G17DCKR
78	2	XX6,XX9	SHUNT_HDR				SHUNT_HDR	TYCO	881545-2
		XX7,XX10,XX12,							
79	4	XX14	STANDOFF				4-40		
		XX8,XX11,XX13,							
80	4	XX15	SCREW			PHL	4-40	BUILDING FASTENER	PM5 440 0025 PH
		XX16,XX17,XX18							
81	4		CAP_MOLDED				0.25ID	CAPPLUGS	VC-234-8
82	1	XX20	PCB			FR-4	2.75HX2.188L	ZILKER LABS INC	MPWB-ZL2006-004
NOT INSTALLED:									
3	2	C5,C6	10u	10%	25V	X5R	SM1206	PANASONIC-ECG	ECJ-3YB1E106K
12	1	C45	680u	20%	6.3V	AL POLY	SM10P5X10P5	UNITED CHEMI-CON	APXA6R3ARA681MJC0G
13	2	C47,C49	0.1u	10%	10V	X7R	SM0603	KEMET	C0603C104K8RACTU
14	1	C48	1u	10%	25V	X5R	SM0603	TAIYO YUDEN	TMK107BJ105KA-T
22	1	JP2	JUMPER				18AWGX.150LS		
27	1	J6	2 POS			VERT	SIP2/100	SAMTEC	TSW-102-07-L-S
53	1	R33	49.9	1%	100mW	THK FILM	SM0603	ROHM	MCR03EZPF49R9
54	2	R34,R35	10.0k	1%	63mW	THK FILM	SM0402	YAGEO	RC0402FR-0710KL
55	1	R40	NI	1%	100mW	THK FILM	SM0603	PANASONIC-ECG	
		R41,R43,R44,							
56	6	R45,R46,R47	NI	1%	100mW	THK FILM	SM0603	PANASONIC-ECG	
57	1	R42	NI	1%	100mW	THK FILM	SM0603	PANASONIC-ECG	
76	1	U4	SN74AUP1G17			TTL	SC70_5	TI	SN74AUP1G17DCKR
		XX1,XX2,XX3,							
77	5	XX4,XX5	TIEPT/10WIDE				TIEPT/10WIDE		

## Default Configuration Text

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The following text is loaded into the ZL2006 device on the EV1 as default settings. Each PMBus command is loaded via the PowerNavigator software. The # symbol is used for a comment line.

```
#NOTE: This file is intended for the Rev. 2 ZL2006-EV1
#with L=360nH, Co=5x(100uF/2.0mohm)+(2x680uF/10mohm)

#Erase user store & default store
RESTORE_FACTORY
STORE_USER_ALL
STORE_DEFAULT_ALL

#Prepare device for all commands to be added to the DEFAULT store
RESTORE_DEFAULT_ALL

#Manufacturer information fields in ASCII:
MFR_ID           Zilker Labs
MFR_MODEL        ZL2006EV1
MFR_LOCATION     Austin
MFR_REVISION     Rev 4.2

#Output Voltage commands
VOUT_COMMAND     1.200000    #V
OVUV_CONFIG      0x01        #2 counts

#Output current
IOUT_CAL_GAIN    0.920000    #mohms
IOUT_CAL_OFFSET  1.4          #A
IOUT_OC_FAULT_LIMIT  30.000000    #A
IOUT_AVG_OC_FAULT_LIMIT  24.000000    #A
IOUT_UC_FAULT_LIMIT  -15.000000    #A
IOUT_AVG_UC_FAULT_LIMIT  -10.000000    #A

#Input Voltage
VIN_OV_FAULT_LIMIT  13.4        #V
VIN_OV_WARN_LIMIT  13.0        #V
VIN_UV_WARN_LIMIT   4.7        #V
VIN_UV_FAULT_LIMIT  4.5        #V

#Other Faults
OT_FAULT_LIMIT     120.000000    #deg C
OT_WARN_LIMIT      110.000000    #deg C
UT_WARN_LIMIT      -20.000000    #deg C
UT_FAULT_LIMIT     -30.000000    #deg C

#General converter commands
TON_DELAY         5.000000    #ms
TON_RISE          5.000000    #ms
TOFF_DELAY        5.000000    #ms
TOFF_FALL         5.000000    #ms
FREQUENCY_SWITCH  615.000000    #kHz
PID_TAPS          A=15141.91, B=-29677.9, C=14599.08
MAX_DUTY          90.000000    %
DEADTIME          0x3838      #56ns max
DEADTIME_CONFIG   0x0404      #8ns min, dynamic
INDUCTOR          0.36        #uH
```

```
#Advanced commands
MFR_CONFIG      0x6A10      #416ns; 5 count; XTEMP dis; fault on internal
USER_CONFIG     0x0000
NLR_CONFIG      0xCA010200 #On;1%load;1.5%unload;1toLoad;2toUnload;NoOuter;NoBlank
MISC_CONFIG     0x0480      #Precise dis; Adaptive dis;
INTERLEAVE      0x0000
SEQUENCE        0x0000
TEMPCO_CONFIG   0x28        #4000PPM/°C internal

STORE_DEFAULT_ALL
RESTORE_DEFAULT_ALL
```

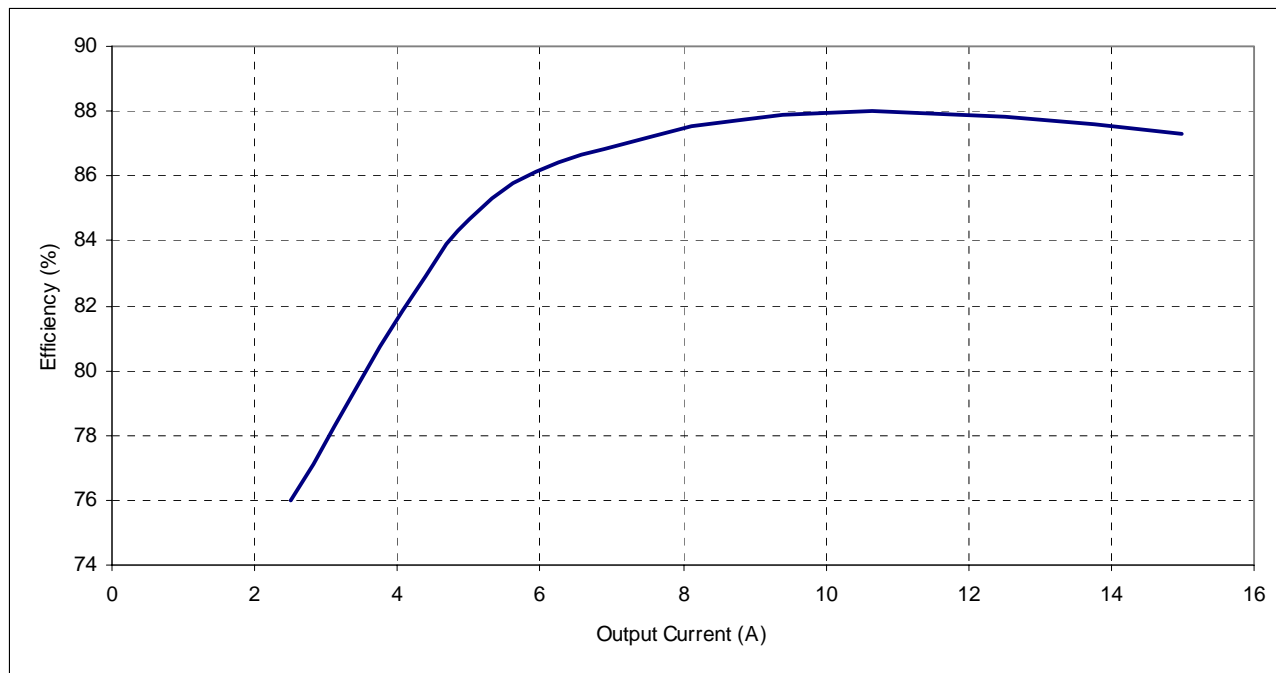
## Measured Data

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The following data was acquired using a ZL2006EV1 rev 2 evaluation board.

### Efficiency

Adaptive diode emulation and adaptive frequency modes are disabled for these efficiency measurements.



**Figure 9. Efficiency, Vin=12V, Vout=1.2V**

Ramp-up / Ramp-down Characteristics

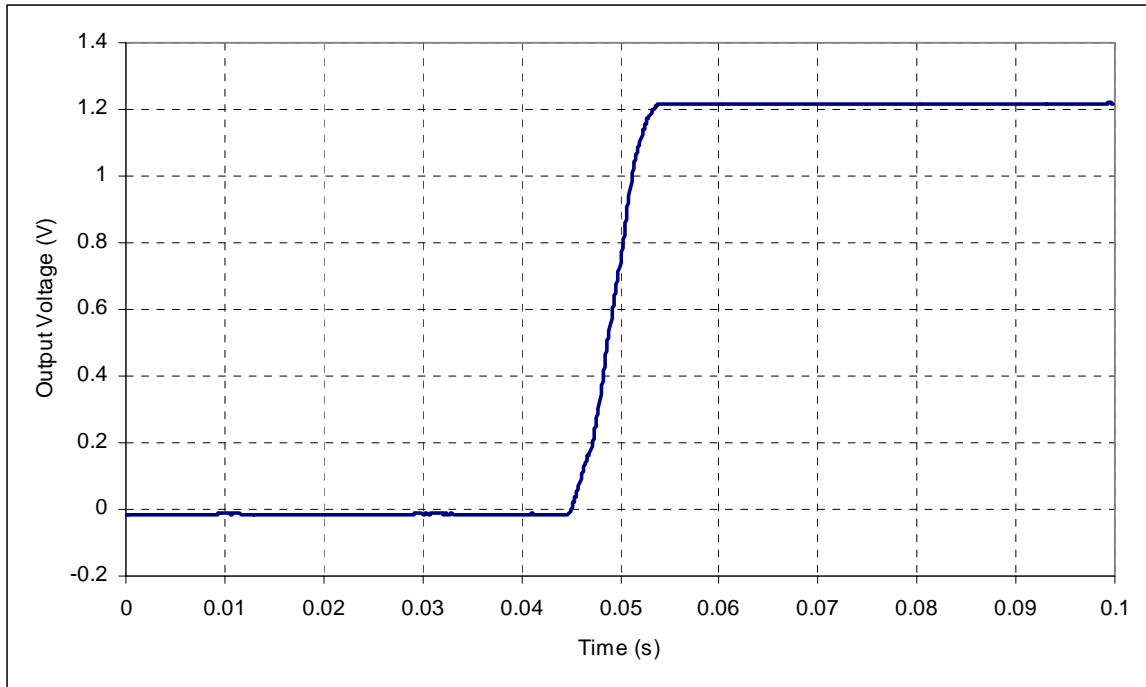


Figure 10. Ramp Up

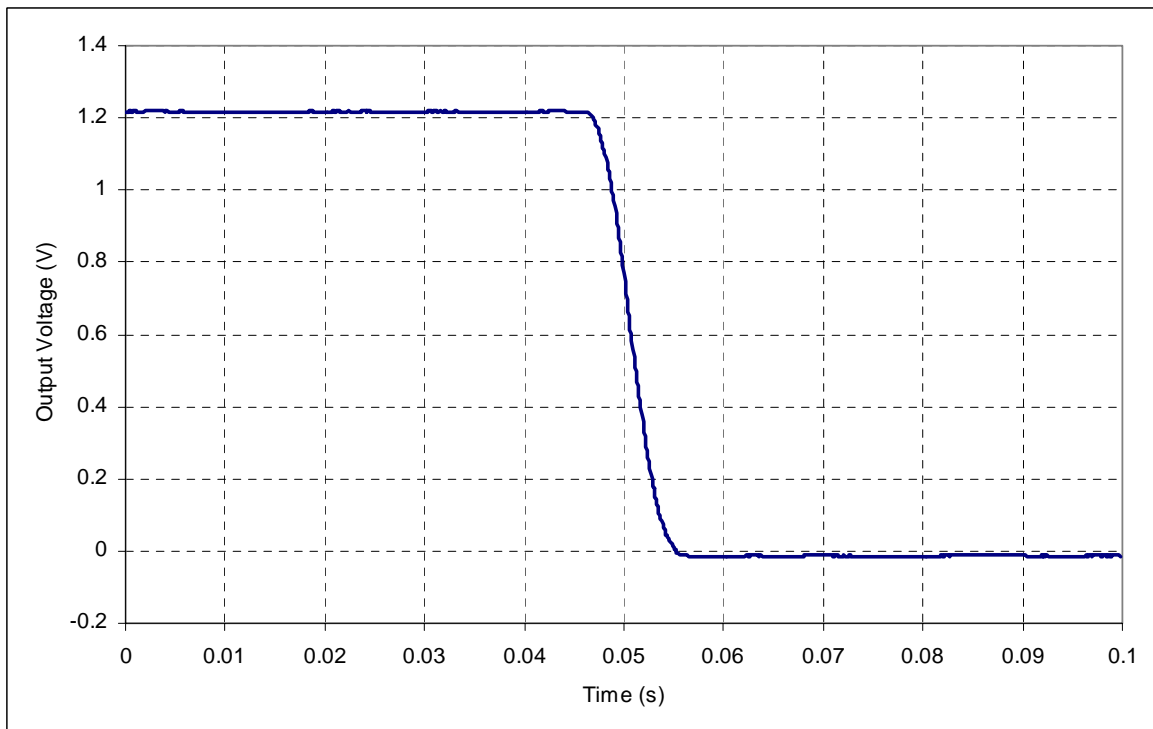


Figure 11. Ramp Down

## Dynamic Load Response

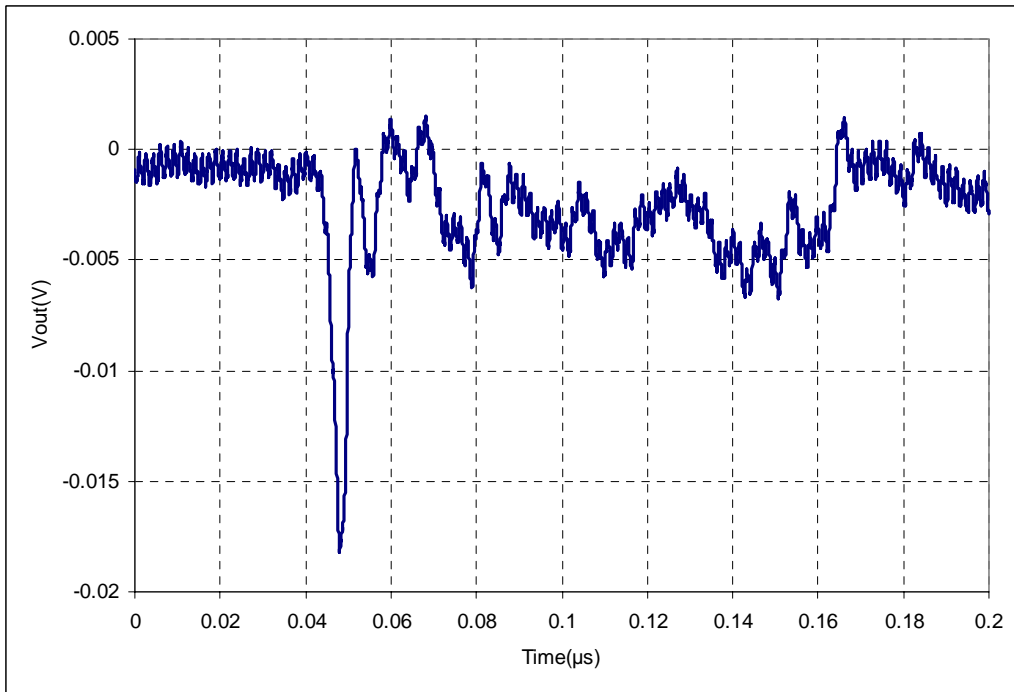


Figure 12. Dynamic Response, 7A to 15A Load Step

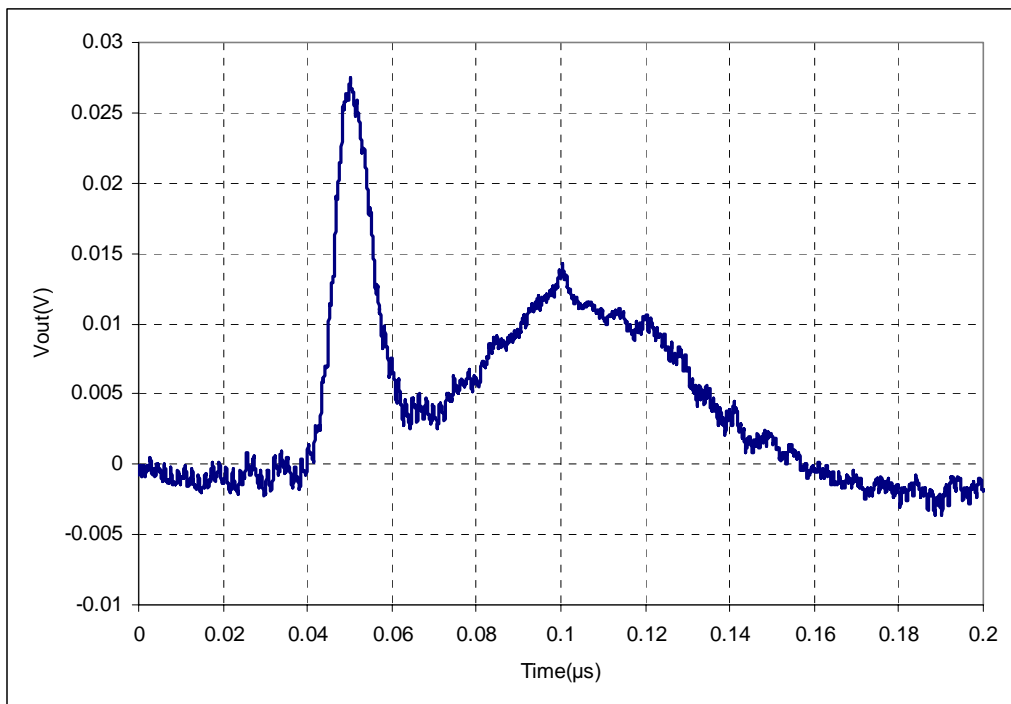


Figure 13. Dynamic Response, 15A to 7A Load Step



## References

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- [1] *ZL2006 Data Sheet*, Zilker Labs, Inc., 2008.
- [2] *AN33 – PMBus™ Command Set*, Zilker Labs, Inc., 2008.

## Ordering Information

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<b>Orderable Part Number</b>	<b>Description</b>
ZL2006EVK1	ZL2006 Evaluation Kit (EVB, USB Adapter, Cable, Software)
ZL2006EV1	ZL2006 Evaluation board only

## Revision History

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<b>Date</b>	<b>Rev. #</b>	<b>Description</b>
February 2009	2.0	Initial release with board rev 2



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