ZL2004EV1 Evaluation Board

Description

The ZL2004 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 ZL2004 incorporates current sharing and adaptive efficiency-optimization algorithms to provide a flexible, efficient power IC building block.

The ZL2004EV1 is a 6-layer board that provides a single-phase power rail up to 40A loads using the ZL2004 controller and ZL1505 driver ICs. The design has been optimized for a high step-down ratio with high load currents.

A USB to SMBus adapter is used to connect the ZL2004EV1 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

• Synchronous buck DC/DC converter
• Output current up to 40A
• Configurable through SMBus
• Single-supply operation
• Convenient power connection
• Onboard enable switch
• Power good indicator

Specifications

This board has been designed and optimized for the following conditions:

• V_{IN} = 12V (Board range: 5V to 14V)
• $I_{IN,MAX}$ = 16A
• V_{OUT} = 1.8V
• $I_{OUT, MAX}$ = 40A
• F_{SW} = 400kHz
• V_{OUT} ripple = 1%
• Transient response = 3.5% (15A to 25A step load @ 2.5A/µs)
• Board temperature: +25°C

Functional Description

The ZL2004EV1 provides all circuitry required to evaluate the features of the ZL2004. The ZL2004EV1 has a performance-optimized single-phase ZL2004 circuit layout that allows efficient operation up to the maximum output current of 40A. Power and load connections are provided through plug-in sockets.

Figure 1 shows a functional block diagram of the ZL2004EV1 board. The SMBus address is selectable through a jumper on the top side of the board. All power to the board (VIN and I^{2}C bus) must be removed before changing the jumpers.

The hardware enable function is controlled by a toggle switch on the ZL2004EV1 board. The power good (PG)
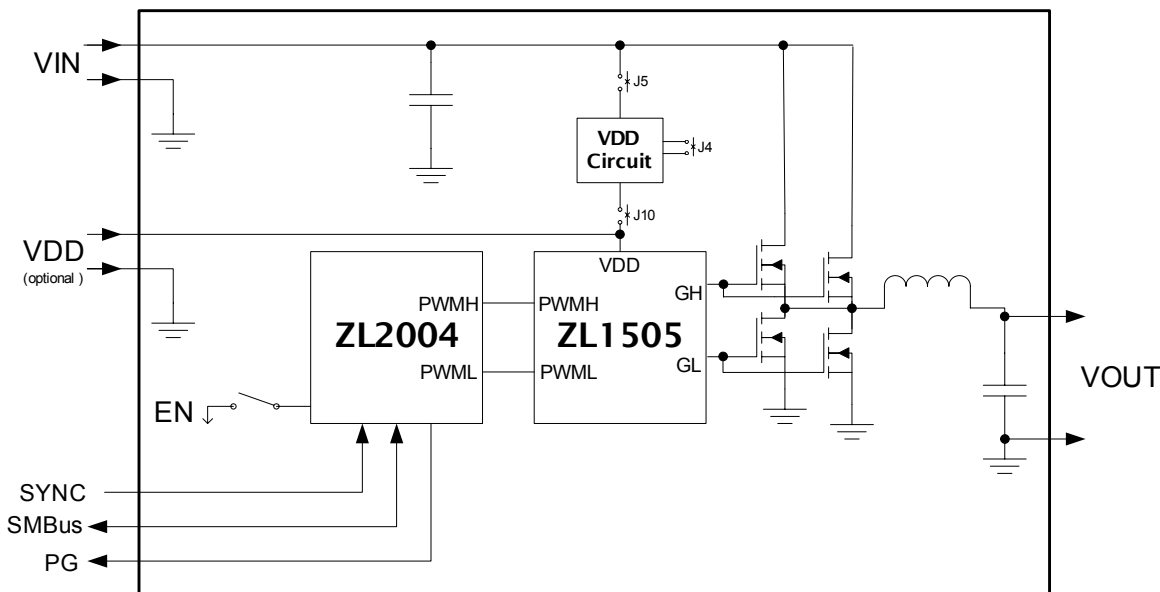

FIGURE 1. ZL2004EV1 BLOCK DIAGRAM

LED indicates the correct state of PG when external power is applied to the ZL2004EV1 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 "ZL2004EV1 Schematic – Main Circuit" shows the operational circuit. The circuit consists of the ZL2004 controller and ZL1505 driver ICs with minimal component count to realize a 40A buck converter. The board layout has been optimized for efficiency and thermal performance.

Figure 3 shows the ZL1505 driver and power train circuit.

The bias for the ZL1505 is supplied by an on-board VDD circuit. Figure 4 shows the on-board VDD circuit for powering the ZL1505's VDD supply. The jumper J5 connects the supply power to the VDD circuit. Jumper J10 connects the VDD circuit to the ZL1505. The J4 jumper enables the on-board VDD circuit. Note that this circuit uses a ZL2105 controller set to SMBus address 0x2F.

Optionally, a 5V to 7.5V bias can be supplied through the P3 connector (labeled VDD+/VDD-). Remove jumpers J5, J10, and J4 when using an external supply for VDD.

Figure 5 "ZL2004EV1 Schematic - Interface Circuit" is the interface and SMBus address selection circuitry for the ZL2004.

Operation

Stand-Alone Operation

The ZL2004 is easy to setup and operate. It is configured, out of the box, to provide an output voltage of 1.8V at 40A from a 12V source. All input and output connections should to be made before turning the input supply on.

When the input power supply is turned on, the ZL2004 will output the configured voltage and the load applied to VOUT+/VOUT- can be varied.

PMBus Operation

The ZL2004 utilizes the PMBus protocol via its SMBus interface. This functionality can be controlled via USB from a PC running the PowerNavigator evaluation software in a Windows XP or Windows 2000/NT operating system.

For PMBus operation, connect the included USB to SMBus adapter board to J6 of the ZL2004EV1 board. Connect the desired load and an appropriate power supply to the input and connect the included USB cable to the PC running the evaluation software. Place the ENABLE switch in "DISABLE" and turn on the power.

The evaluation software allows modification of all ZL2004 PMBus parameters. The ZL2004 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 application note AN2033 [2] for PMBus details.

The ENABLE switch can then be moved to "ENABLE" and the ZL2004EV1 board can be tested. Alternately, the PMBus ON-OFF CONFIG and OPERATION commands may be used.

Quick Start Guide

Stand Alone Operation

1. Set ENABLE switch to "DISABLE"
2. Apply load to VOUT+/VOUT-
3. Connect 12V power supply to VIN+/VIN- (supply turned off)
4. If using an external VDD supply, remove jumpers J5, J10, and J4. Connect an external 5V to 7.5V supply to VDD+/VDD- to bias the ZL1505 driver circuit.
5. Turn 12V power supply on. If using an external supply for driver circuit, turn it on.
6. Set ENABLE switch to "ENABLE"
7. Monitor ZL2004EV1 board operation using an oscilloscope

USB (PMBus) Operation

1. Follow step 1 - 5 above
2. Insert the Zilker Labs Eval Kit CD
3. Connect USB to SMBus adapter board to J6 of ZL2004EV1
4. 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.
5. Install the PowerNavigator evaluation software by running setup.exe from the PowerNavigator_installer folder on the CD.
6. Set ENABLE switch on EVB to "ENABLE"
7. Monitor and configure the ZL2004EV1 board using PMBus commands in the evaluation software
8. Test the ZL2004EV1 operation using an oscilloscope and the evaluation software.
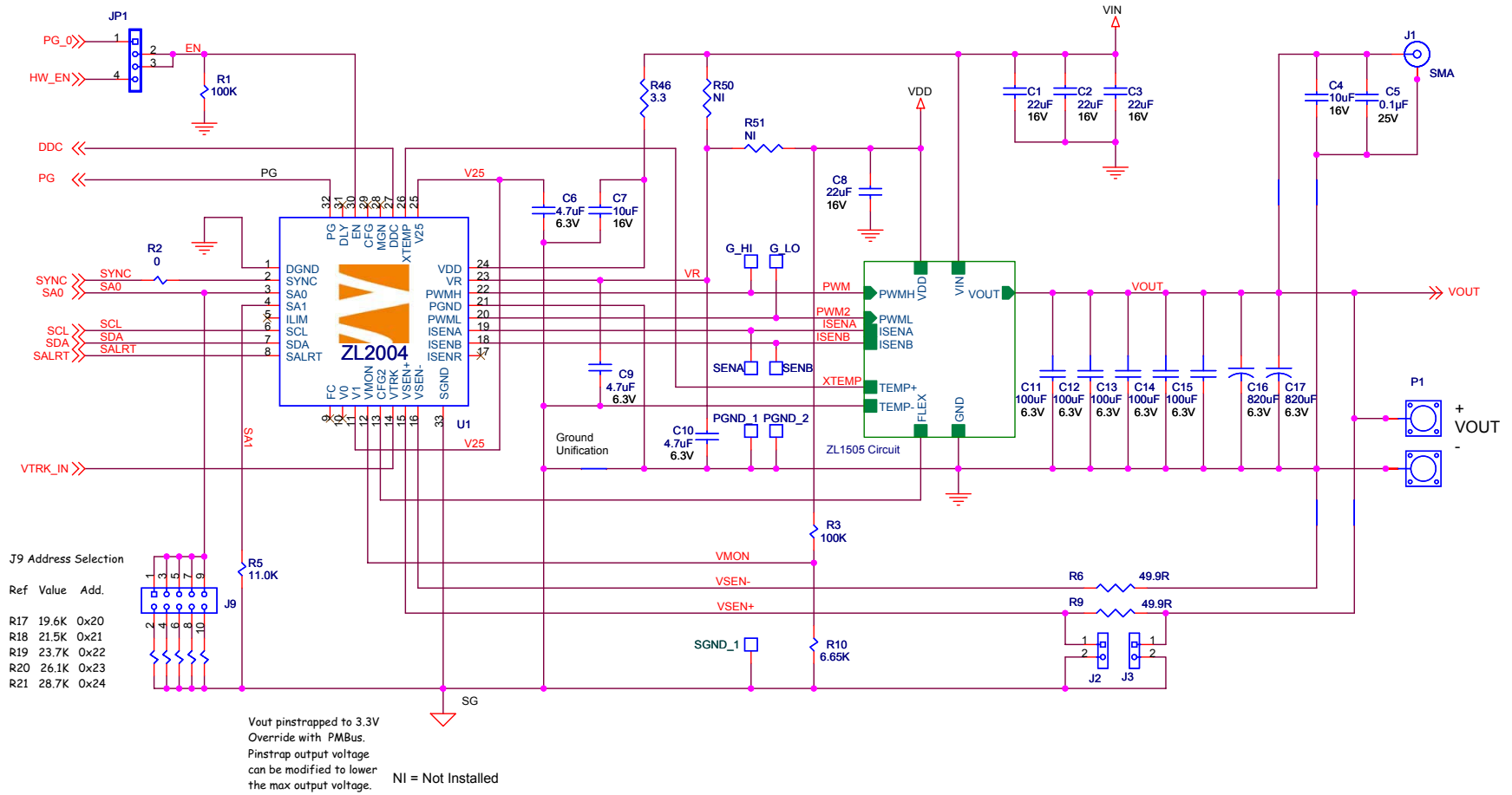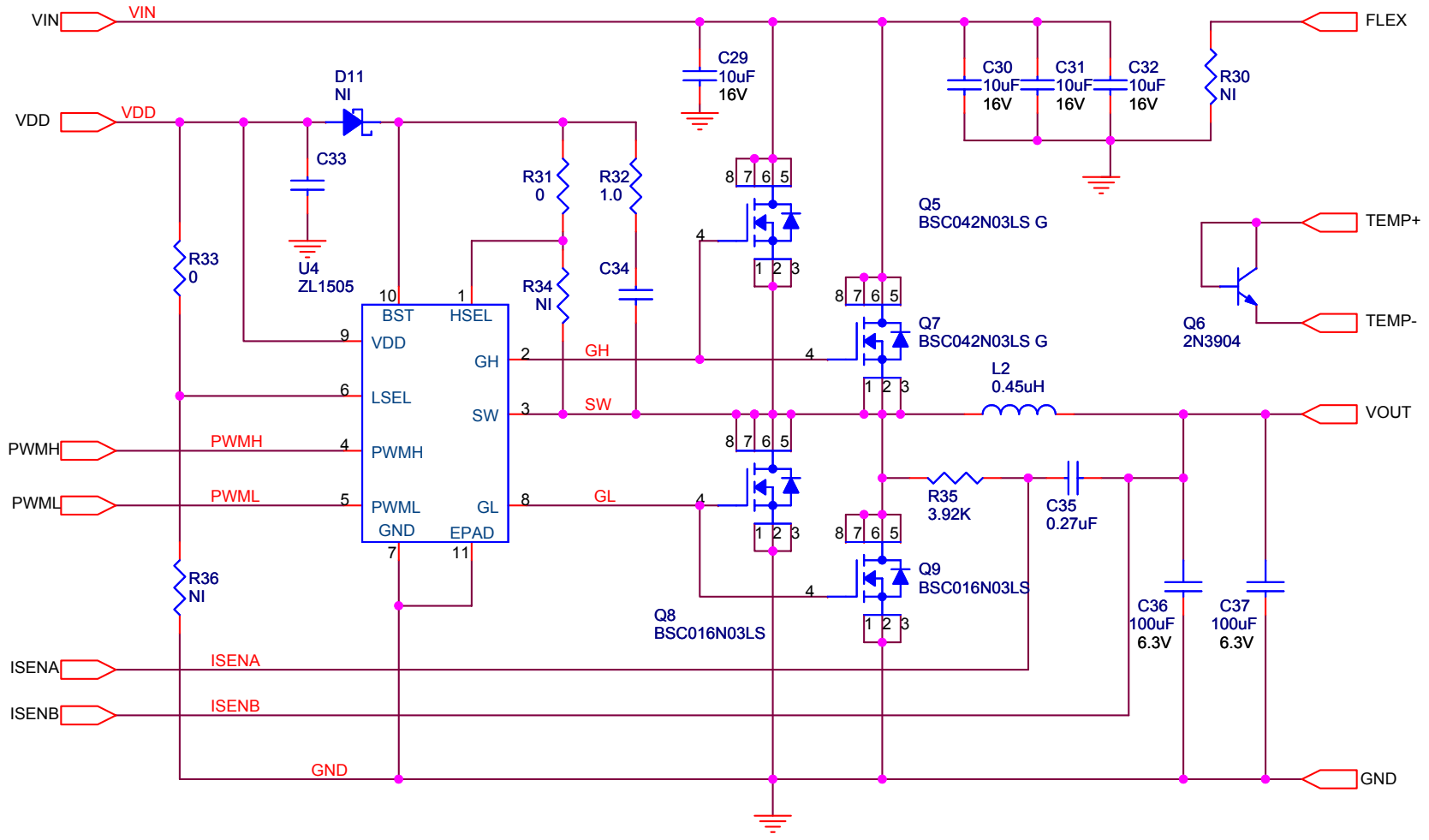
Schematics

FIGURE 2. ZL2004EV1 SCHEMATIC — MAIN CIRCUIT

Application Note 1463

NI = Not Installed

FIGURE 3. ZL2004EV1 SCHEMATIC — ZL1505 CIRCUIT
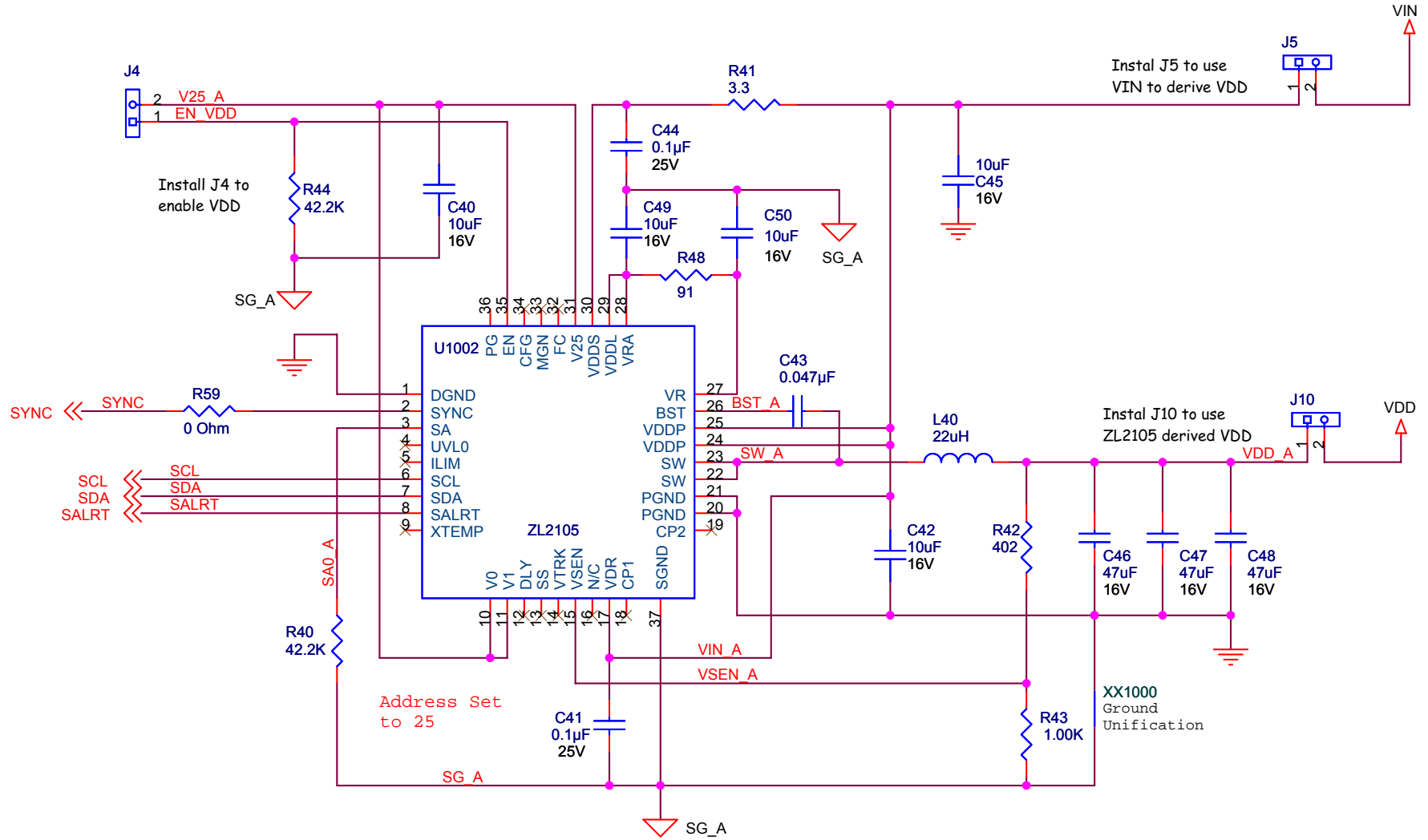
FIGURE 4. ZL2004EV1 SCHEMATIC — VDD CIRCUIT FOR ZL1505

Board to Board Interface

Vaux

Place pullups near the last load on the bus.

R11 10.0K
R12 10.0K
R13 10.0K
+Vi2c
R14 10.0K

FROM PREQUEL
J6

SCL
SALRT
SDA

VTRK_IN DDC
R55 49.9R MSTR_EN
MSTR SYNC SYNC
PG_0 R15 49.9R

VTRK_IN DDC
SYNC
PG_0

HEADER

TO SEQUEL
J8

VOUT

VOUT

PG

PG

SOCKET

D4
ESDA6V1-4BC6

Vaux

Enable Switch Debounce

SW_SPDT

R22 10.0K
R23 10.0K
R25 49.9R

U3
SN74AUP1G17

VCC

Disable
Monitor
Enable

MSTR_EN

A
NC
GND

Y

HW_EN

HW_EN

SW1

C27 2.2uF 16V

C28 0.1uF

C26 0.1µF

25V

25V

25V

VIN

VDD

D1
STPS20L45CG

P2

+
VIN

C18 22uF 16V

P3

+
VDD

−

J7

JACK_BARREL

Power In

C19 180uF 16V
C20 180uF 16V
C21 180uF 16V
C22 180uF 16V
C23 22uF 16V

This regulator allows stand alone operation when not using a USB interface dongle. When no Vi2c is applied (i.e USB dongle), this regualtor supplies VAUX current from VIN thus efficiency measurements will be affected.

U2
MIC2920A-3.3BS

VI
G G
VO

D2 BAT54
D3 BAT54

+Vi2c

VAUX

D6 GRN
Power Good LED

R24 10.0K

R16
21.5K

D5 BAT54

R26 392

R27 10.0K VOUT

S1 D1
G1 G2
D2 S2

S1 D1
G1 G2
D2 S2

PG\

S1 D1
G1 G2
D2 S2

PG

C24 22uF 16V

Q1
FDG6303N

Q2
FDG6304P

C25 22uF 16V

Q4
FDG6303N

FIGURE 5. ZL2004EV1 SCHEMATIC - INTERFACE CIRCUIT
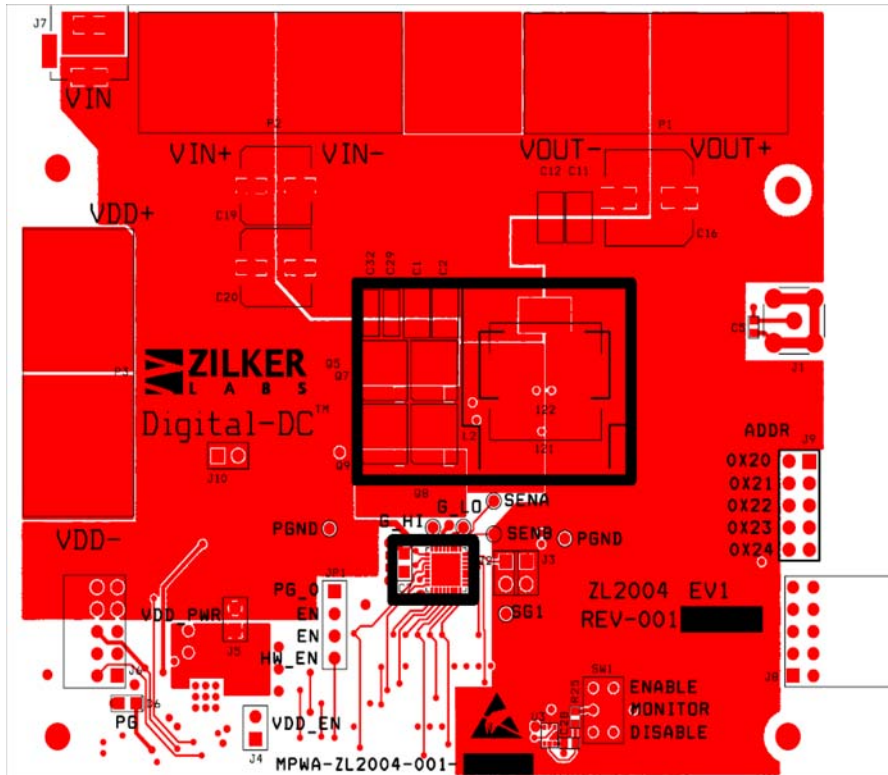
Board Layout – Silkscreen

FIGURE 6. PCB – TOP LAYER

FIGURE 7. PCB – INNER LAYER 1 (VIEWED FROM TOP)

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Board Layout – Silkscreen (Continued)

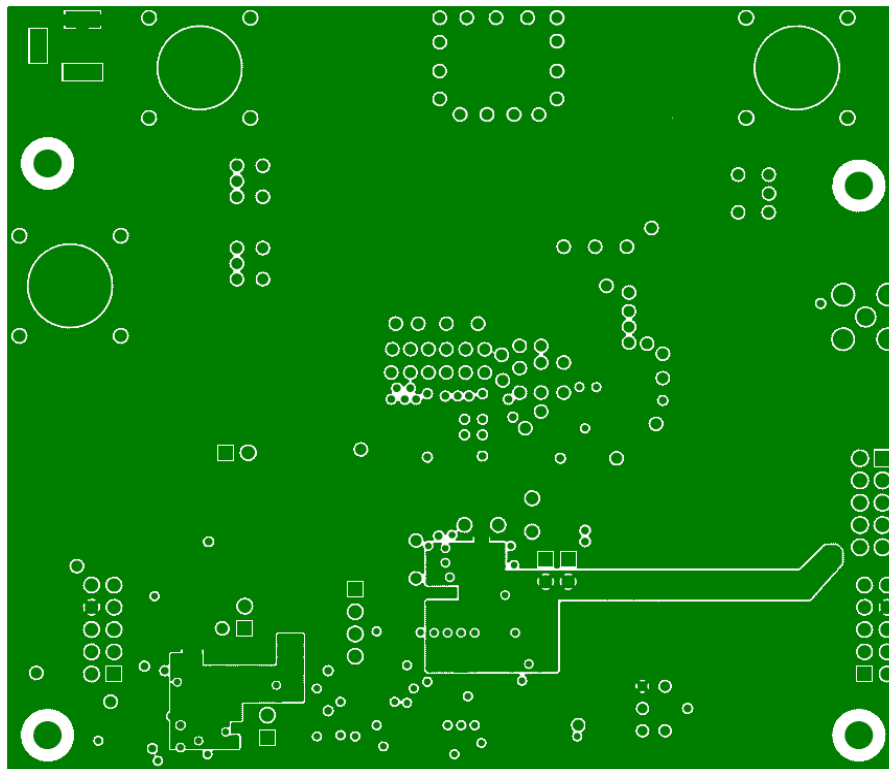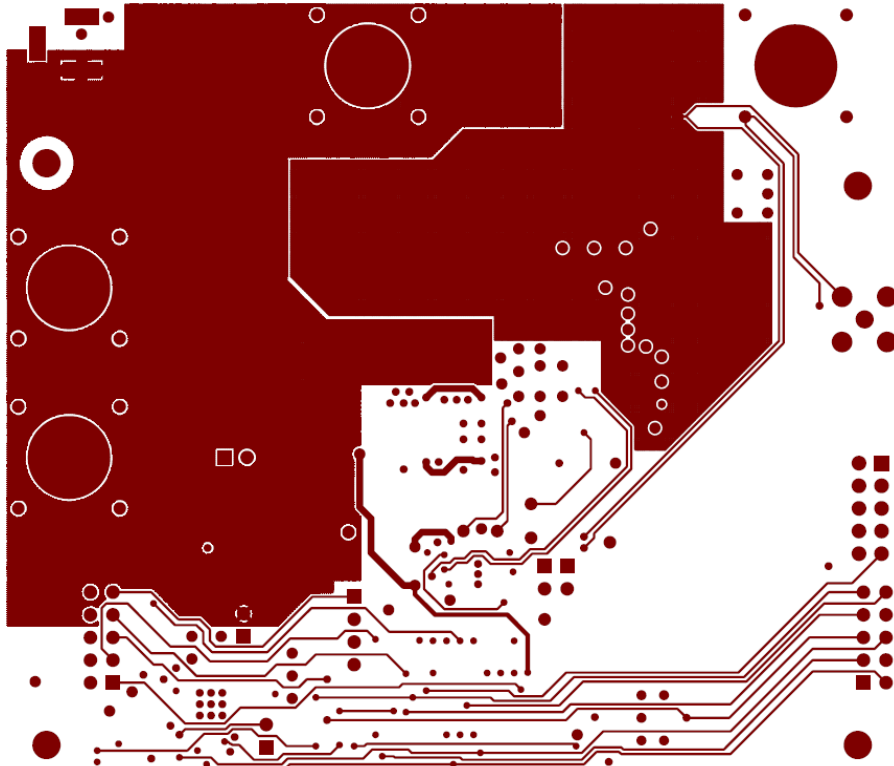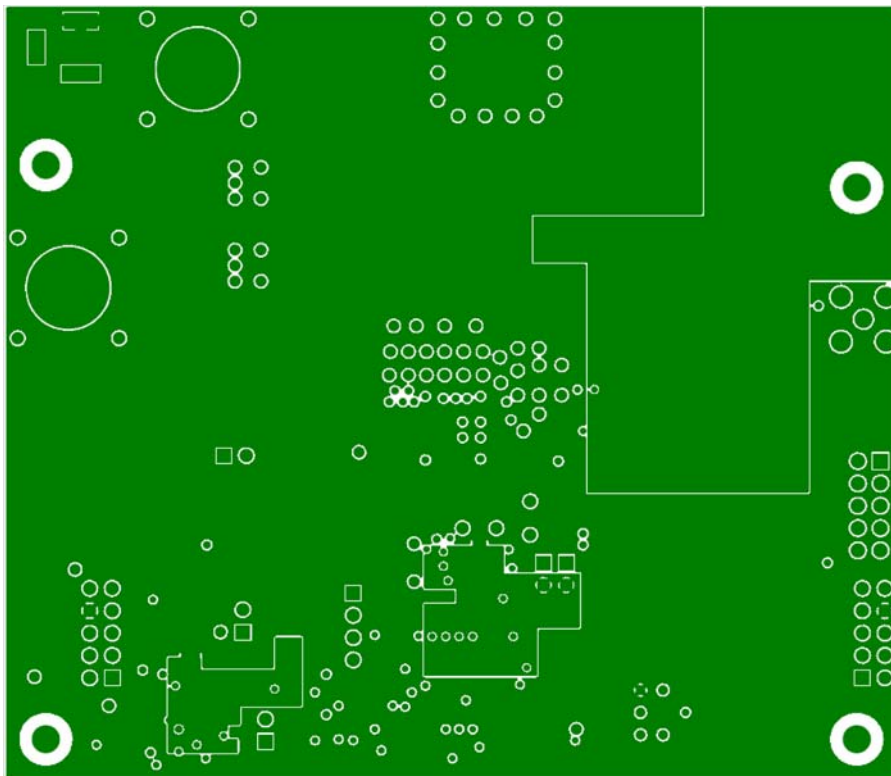FIGURE 8. PCB – INNER LAYER 2 (VIEWED FROM TOP)

FIGURE 9. PCB – INNER LAYER 3 (VIEWED FROM TOP)

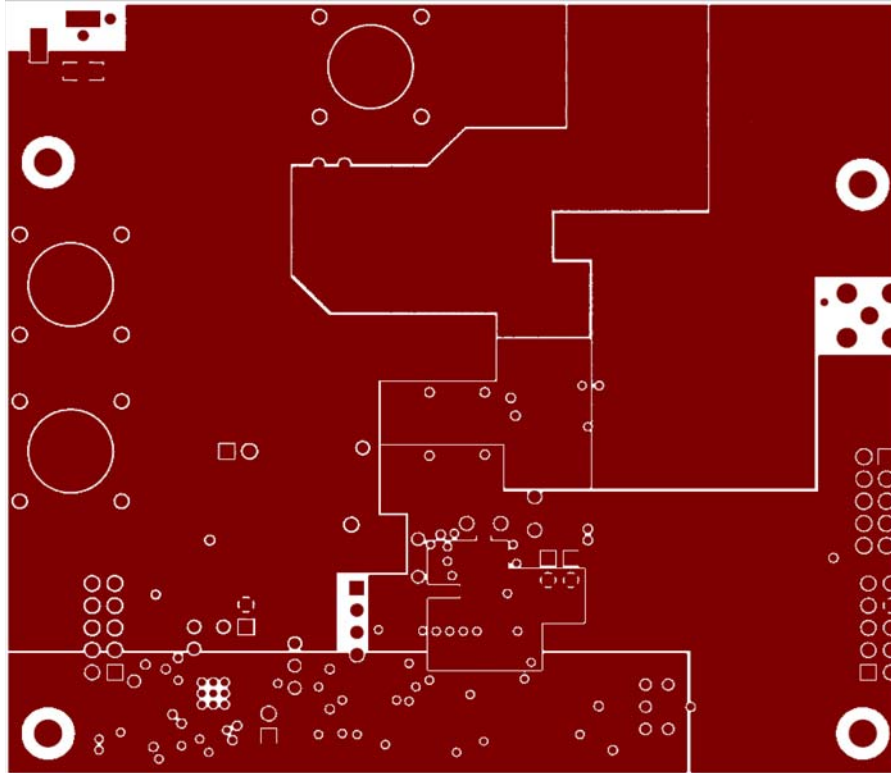# Board Layout – Silkscreen (Continued)
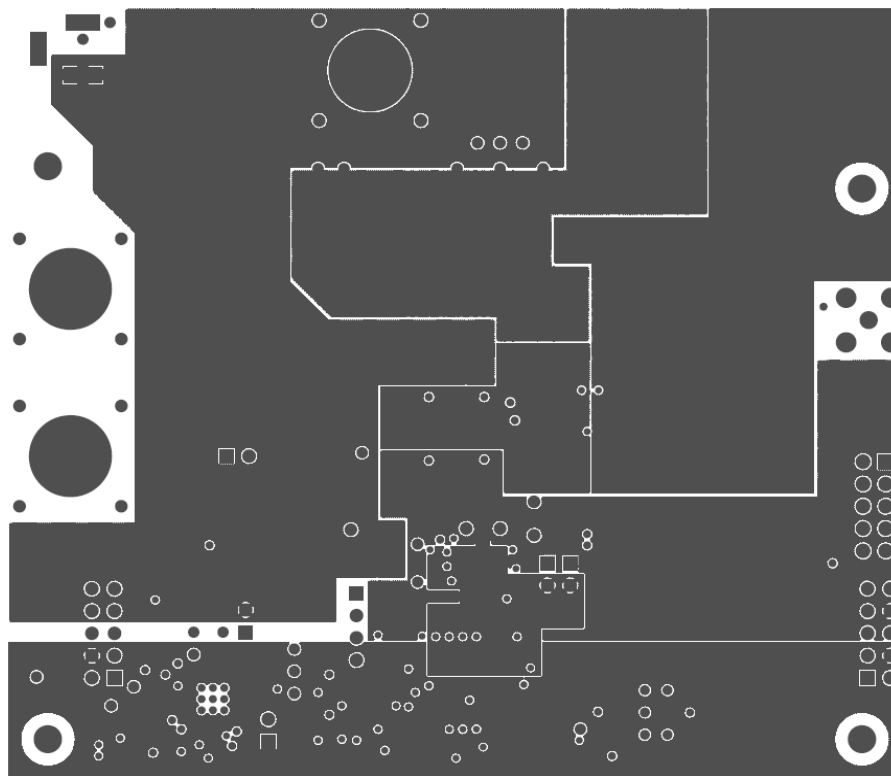

FIGURE 10. PCB – INNER LAYER 4 (VIEWED FROM TOP)

FIGURE 11. PCB – INNER LAYER 5 (VIEWED FROM TOP)
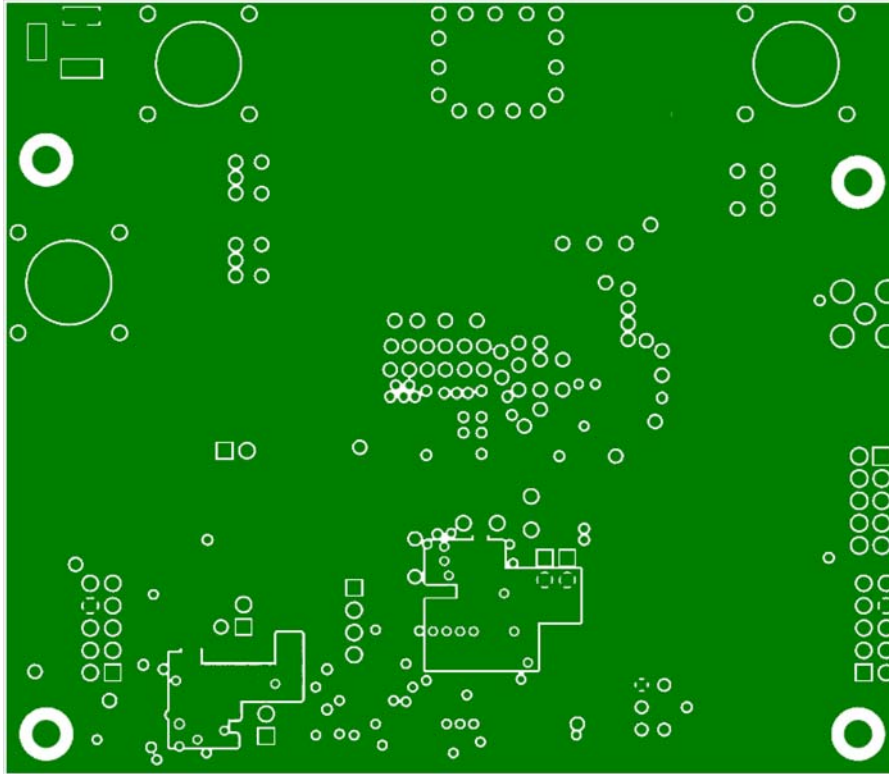
Board Layout – Silkscreen (Continued)

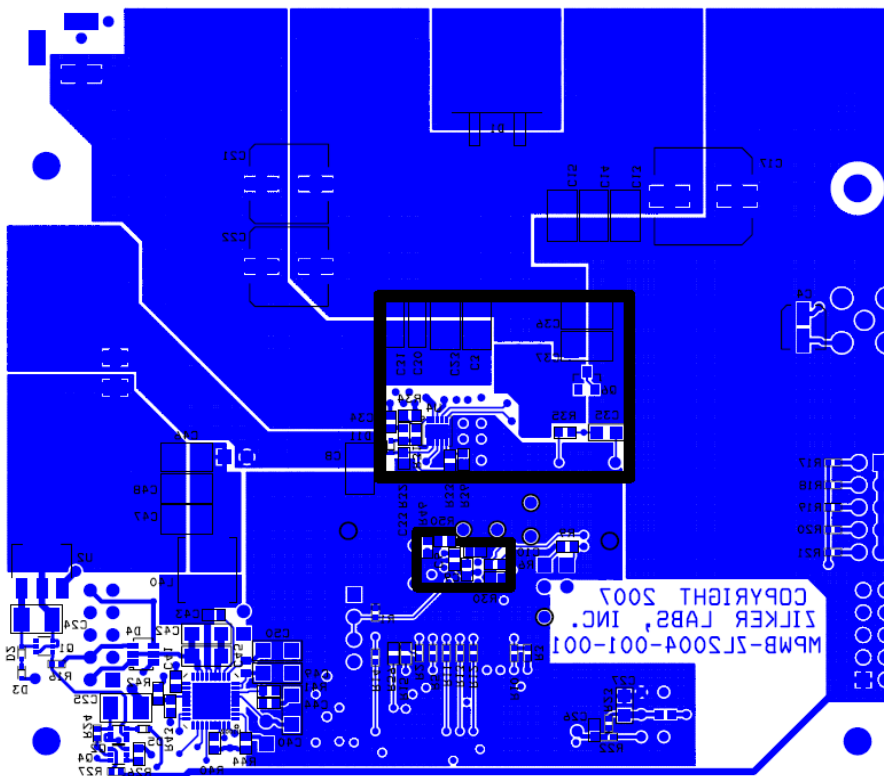**FIGURE 12. PCB – INNER LAYER 6 (VIEWED FROM TOP)**

FIGURE 13. PCB – BOTTOM LAYER

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Bill of Materials

ITEM	QTY.	REFERENCE	VALUE	TOL.	RATING	TYPE	PCB FOOTPRINT	MANUFACTURER	PART NUMBER
1	8	C1, C2, C3, C8, C18, C23, C24, C25	22µF	10%	16V	X5R	SM1210	Murata	GRM32ER61C226KE20L
2	2	C4, C7	10µF	±10%	16V	X7R	SM1210	Murata	GRM32DR71C106KA01L
3	5	C5, C26, C28, C41, C44	0.1µF	10%	25V	X7R	SM0603	Kemet	C0603C104K3RACTU
4	5	C6, C9, C10, C33, C34	4.7µF		6.3V	X5R	SM0603	Panasonic-ECG	ECJ-1VB0J475M
5	10	C11, C12, C13, C14, C15, C36, C37, C46, C47, C48	47µF	±20%	16V	X5R	SM1210	Kemet	C1210C476M9PACTU
6	2	C16, C17	820µF		6.3V	ELECT POLY	SM_CAP_10.5X10.5_PXA	UnitedChemi-Con	APXA6R3ARA821MJC0G
7	4	C19, C20, C21, C22	180µF		16V	ELECT POLY	SM_CAP_8.3X8.3_PXA	UnitedChemi-Con	APXA160ARA181MHC0G
8	1	C27	2.2µF	0.1	16V	X5R	SM0805	Murata	GRM21BR61C225KA88L
9	4	C29, C30, C31, C32	10µF			Capacitor	SM1206	Kemet	C1206C106K4RACTU
10	1	C35	0.27µF		16V	X7R	SM0805	Panasonic-ECG	ECJ-2YB1C274K
11	5	C40, C42, C45, C49, C50	10µF	20%	16V	X5R	SM1206	TDK Corporation	C3216X5R1C106M
12	1	C43	0.047µF	±10%	25V	X7R	SM0603	Panasonic-ECG	ECJ-1VB1E473K
13	1	D1	STPS20L45CG		45V-20A	SCHOTT-2CC	D-2PAK	ST Micro	STPS20L45CG
14	3	D2, D3, D5	BAT54		30V	Schottky	SOD523	ON Semiconductor	BAT54XV2T1OS
15	1	D4	ESDA6V1-4BC6		6.1V, 80W		SOT23_6L	ST Micro	ESDA6V1-4BC6
16	1	D6	GRN		2V		SM0805	Chicago Minature	CMD17-21VGC
17	1	JP1	4 PIN				SIP4/100	Tyco	3-644456-4
18	5	J2, J3, J4, J5, J10	2 PIN				SIP2/100	Tyco	3-644456-2
19	1	J6	HEADER				HDR10DUAL100X100	Samtec	TSW-105-08-T-D-RA
20	1	J7	JACK_BARREL		1.5A		JACK_RA.079PIN	Kobiconn	163-5004-E
21	1	J8	SOCKET				HDRF5DUALRA100X100	Samtec	SSQ-105-02-T-D-RA
22	1	J9	HEADER 5x2 PIN				HDR10DUAL100X100	Samtec	TSW-105-07-T-D
23	1	L2	0.45µH		70	Inductor		Pulse	PA1294.450
24	1	L40	22µH	20%	1.62A	SH DRUM	IHLP_2525BD	COILTRONICS	DR73-220-R
25	3	P1, P2, P3	JACK_BANANA		15A		JACK	EMERSON	108-0740-001
26	2	Q1, Q4	FDG6303N		25V	Dual N-Chan	SC70_6	Fairchild	FDG6303N
27	1	Q2	FDG6304P		25V	Dual P-Chan	SC70_6	Fairchild	FDG6304P
28	2	Q5, Q7	BSC042N03LS G		30V		FLMP/SO8FL_ALLP	Infineon	
29	1	Q6	2N3904		40V	NPN	SOT-23	ON Semiconductor	MMBT3904LT3

Bill of Materials (Continued)

ITEM	QTY.	REFERENCE	VALUE	TOL.	RATING	TYPE	PCB FOOTPRINT	MANUFACTURER	PART NUMBER
30	2	Q8, Q9	BSC016N03LS		30V		FLMP/SO8FL_ALLP	Infineon	
31	2	R1, R3	100k	1%		1/16W	SM0402	Vishay/Dale	CRCW0402100KFKED
32	1	R2	0				SM0402	ROHM	MCR01MZPJ000
33	1	R5	11.0k	1%		1/16W	SM0402	Vishay/Dale	CRCW040211K0FKED
34	5	R6, R9, R15, R25, R55	49.9R	0.01	100mW	THK FILM	SM0603	ROHM	MCR03EZPFX49R9
35	1	R10	6.65k	1%		1/16W	SM0402	Panasonic-ECG	ERJ-2RKF6651X
36	8	R11, R12, R13, R14, R22, R23, R24, R27	10.0k	1%		1/16W	SM0402	Yageo	RC0402FR-0710KL
37	2	R16, R18	21.5k	1%		1/16W	SM0402	Vishay/Dale	CRCW040221K5FKED
38	1	R17	19.6k	1%		1/16W	SM0402	Vishay/Dale	CRCW040219K6FKED
39	1	R19	23.7k	1%		1/16W	SM0402	Vishay/Dale	CRCW040223K7FKED
40	1	R20	26.1k	1%		1/16W	SM0402	Vishay/Dale	CRCW040226K1FKED
41	1	R21	28.7k	1%		1/16W	SM0402	Vishay/Dale	CRCW040228K7FKED
42	1	R26	392	1%		THK FILM	SM0603	Panasonic-ECG	ERJ-3EKF3920V
43	2	R31, R33	0				SM0603	ROHM	ERJ-3GEY0R00V
44	1	R32	1	1%			SM0603	Susumu Co Ltd	RP1608S-1R0-F
45	1	R35	3.92k	1%		Resistor	SM0603	Panasonic-ECG	ERJ-3EKF3921V
46	2	R40, R44	42.2k	1%			SM0603	Panasonic-ECG	ERJ-3EKF1622V
47	2	R41, R50	3.3	1%			SM0603	Susumu Co Ltd	RP1608S-3R3-F
48	1	R42	402	±1%			SM0603	Panasonic-ECG	ERJ-3EKF4020V
49	1	R43	1.00k	±1%			SM0603	Panasonic-ECG	ERJ-3EKF1001V
50	2	R46, R59	0Ω				SM0603	ROHM	ERJ-3GEY0R00V
51	1	R48	91	1%	100mW		SM0603	ROHM	MCR03EZPFX91R0
52	1	SW1	SW_SPDT				SW_TOG_SPDT	NKK	G13AP-RO
53	1	U1	ZL2004				MLF36	Zilker Labs	
54	1	U2	MIC2920A-3.3BS				SOT223_1234_FLD	Micrel	MIC2920A-3.3WS
55	1	U3	SN74AUP1G17				SC70_5	Texas Instruments	SN74AUP1G17DCKR
56	1	U4	ZL1505				MLF10		
57	1	U1002	ZL2105				MLF36_6X6BX	ZILKER LABS INC	ZL2105ALNFT

Default Configuration Text

The following text is loaded into the ZL2004EV1 as default settings. Each PMBus command is loaded via the ZL2004EV1 interface software. The # symbol is used for a comment line.

Configuration file for ZL2004 on ZL2004EV1

RESTORE_FACTORY

STORE_DEFAULT_ALL

STORE_USER_ALL

RESTORE_DEFAULT_ALL

MFR_ID	Zilker_Labs
MFR_MODEL	ZL2004EV1 Vout
MFR_REVISION	Rev 2
MFR_LOCATION	Austin_TX

ON_OFF_CONFIG	0x16

VOUT_COMMAND	1.80
VOUT_MAX	2.16
VOUT_MARGIN_HIGH	1.89
VOUT_MARGIN_LOW	1.71
VOUT_DROOP	0.0

IOUT_SCALE	0.65
IOUT_CAL_OFFSET	1

TON_DELAY	5
TON_RISE	5
TOFF_DELAY	5
TOFF_FALL	5

FREQUENCY_SWITCH	400

VOUT_OV_FAULT_LIMIT	2.07
VOUT_OV_FAULT_RESPONSE	0x80
VOUT_UV_FAULT_LIMIT	1.53
VOUT_UV_FAULT_RESPONSE	0x80
OVUV_CONFIG	0x80

Default Configuration Text (Continued)

IOUT_OC_FAULT_LIMIT	62.5
IOUT_AVG_OC_FAULT_LIMIT	75
IOUT_UC_FAULT_LIMIT	-25
IOUT_AVG_UC_FAULT_LIMIT	-20
MFR_IOUT_OC_FAULT_RESPONSE	0x80
MFR_IOUT_UC_FAULT_RESPONSE	0x80
MFR_VMON_OV_FAULT_LIMIT	7.8
VMON_OV_FAULT_RESPONSE	0X80
MFR_VMON_UV_FAULT_LIMIT	4.5
VMON_UV_FAULT_RESPONSE	0X80
VIN_OV_WARN_LIMIT	14.3
VIN_OV_FAULT_LIMIT	14.5
VIN_OV_FAULT_RESPONSE	0x80
VIN_UV_WARN_LIMIT	4.4
VIN_UV_FAULT_LIMIT	4.0
VIN_UV_FAULT_RESPONSE	0x80
OT_WARN_LIMIT	110.0
OT_FAULT_LIMIT	120
OT_FAULT_RESPONSE	0x80
UT_WARN_LIMIT	-20
UT_FAULT_LIMIT	-30
UT_FAULT_RESPONSE	0x80
PID_TAPS	A=9829.50, B=-16416.50, C=6637.12
POWER_GOOD_ON	1.62
POWER_GOOD_DELAY	5
DEADTIME	0x3838
DEADTIME_CONFIG	0x0808
MAX_DUTY	94

Default Configuration Text (Continued)

TRACK_CONFIG   0x06

MFR_CONFIG   0x7AD4

NLR_CONFIG   0XD2218363

USER_CONFIG   0x6010

TEMPCO_CONFIG   0xA8

MISC_CONFIG   0x0480

ISHARE_CONFIG   0x0000

INTERLEAVE   0x0000

SEQUENCE   0x0000

DDC_GROUP   0x00000000

DDC_CONFIG   0x0000

INDUCTOR   0.47

STORE_DEFAULT_ALL

RESTORE_DEFAULT_ALL

Measured Data The following graphs show measured data from the ZL2004EV1 board.

Efficiency

Adaptive diode emulation and adaptive frequency modes are disabled for this efficiency measurement.
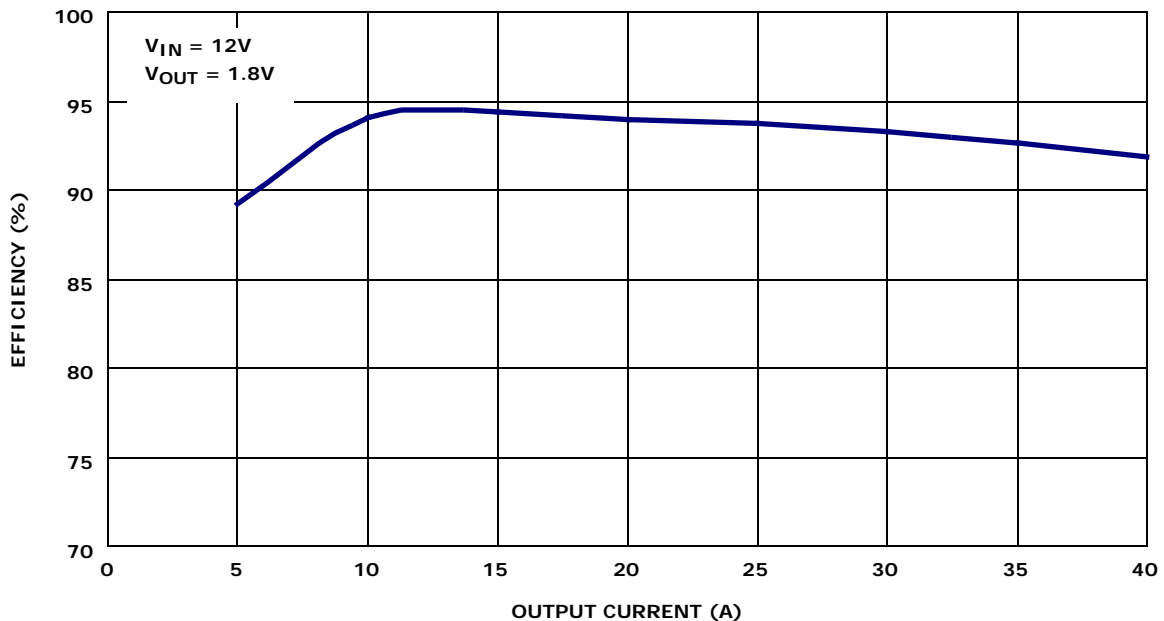
FIGURE 14. EFFICIENCY, V_{IN} = 12V, V_{OUT} = 1.8V, EXTERNAL V_{DD} = 7.5V

Measured Data The following graphs show measured data from the ZL2004EV1 board. **(Continued)**
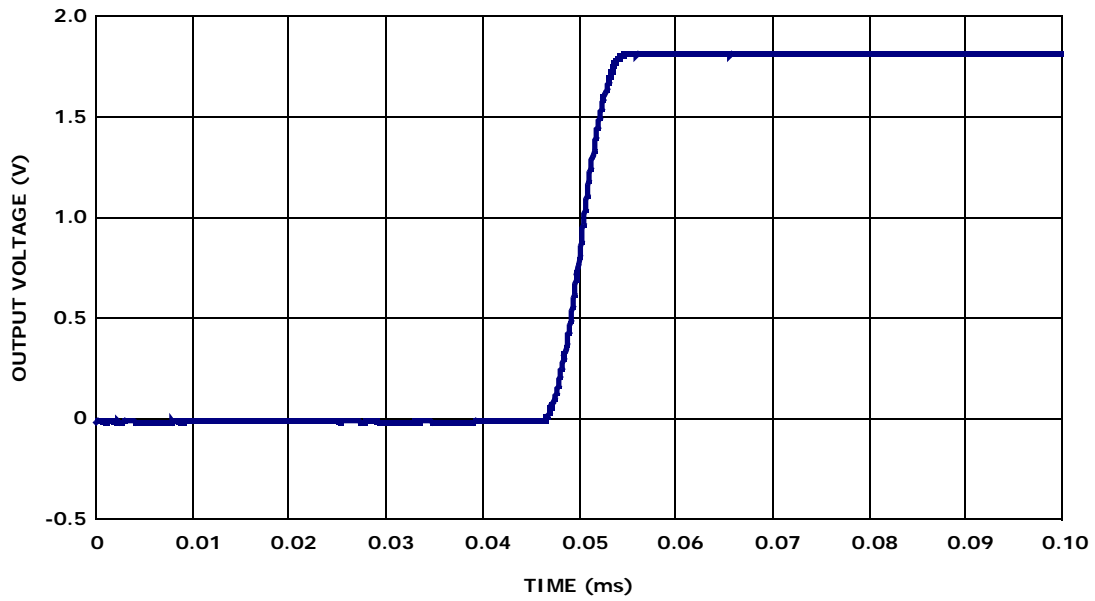
Ramp-up/Ramp-down Characteristics
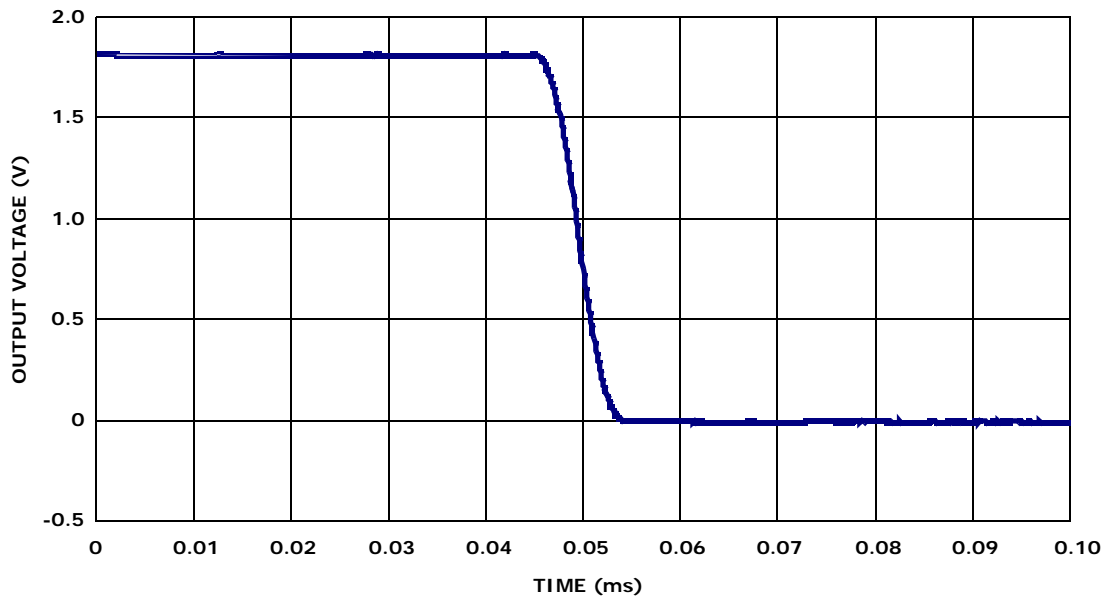

FIGURE 15. RAMP UP WAVEFORM

FIGURE 16. RAMP DOWN WAVEFORM

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Measured Data The following graphs show measured data from the ZL2004EV1 board. **(Continued)**
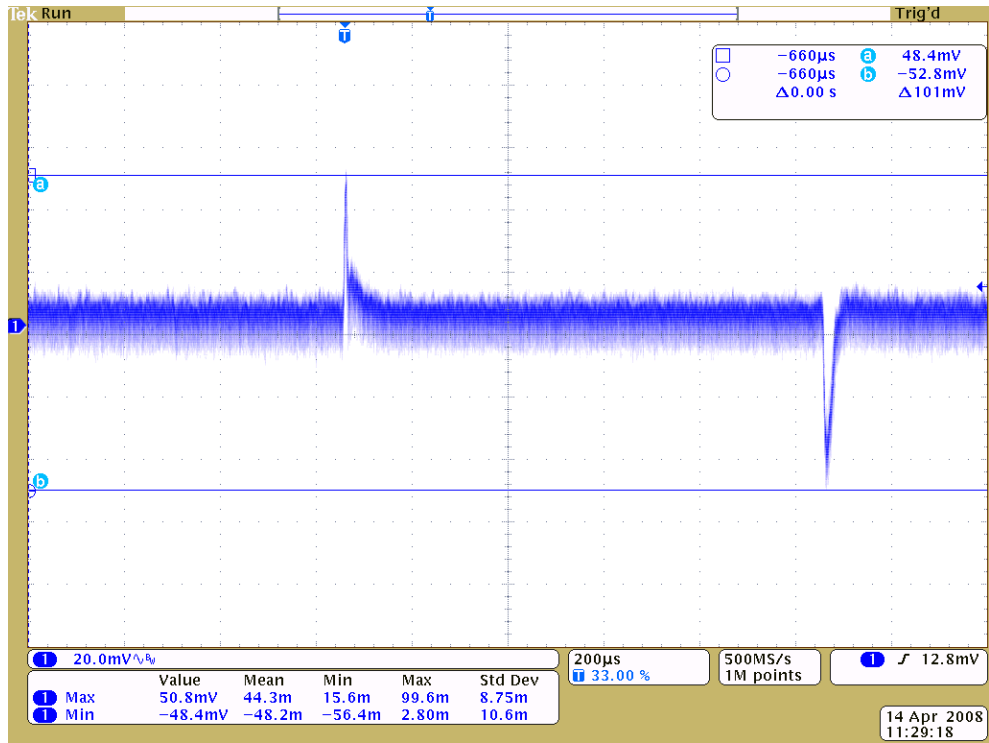
Dynamic Load Response

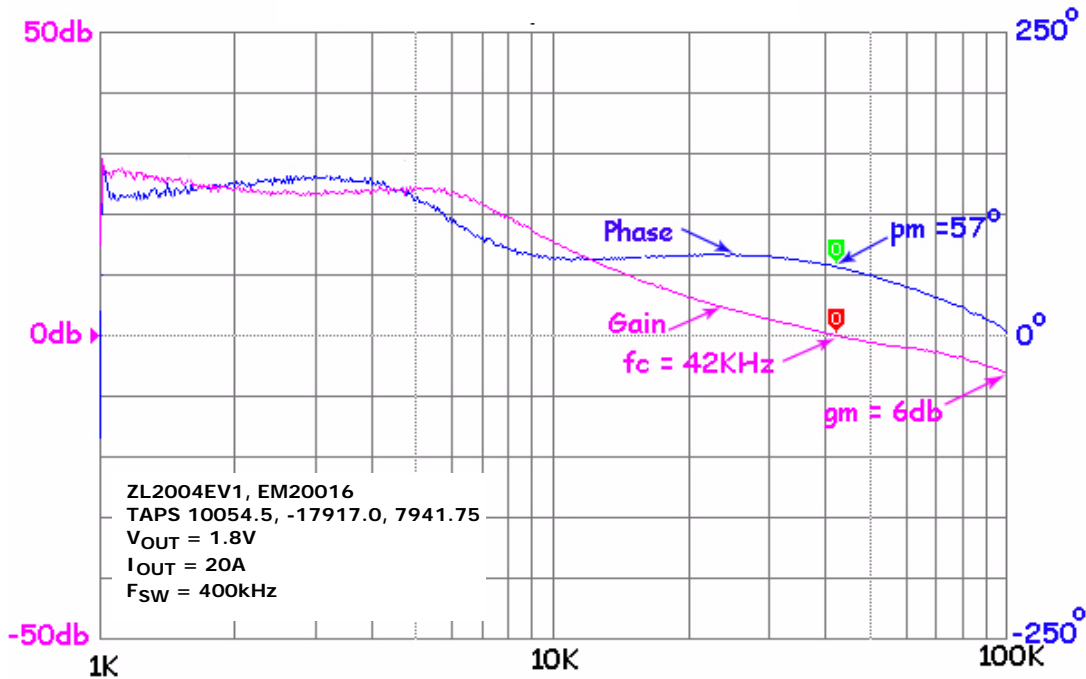**FIGURE 17. DYNAMIC LOAD RESPONSE, 15A TO 25A LOAD STEP**

Phase/Gain Plot

FIGURE 18. ZL2004EV1 PHASE/GAIN PLOT

References

[1]   *ZL2004 Data Sheet*, Zilker Labs, Inc., 2008.

[2]   *AN2033 – PMBus™ Command Set*, Zilker Labs, Inc., 2008.

Ordering Information

PART NUMBER	DESCRIPTION
ZL2004EVK1	ZL2004 Evaluation Kit, one channel

Revision History

DATE	REV. #	CHANGE
August 2009	AN1463.0	Converted to Intersil format and assigned file number AN1463. This is the first release with this file number.
April 2008	1.0	Initial Release
July 2008	1.1	Updated output capacitor values from 47µF to 100µF
August 2008	1.2	Updated schematic and BOM. Changed R40, R44 from 16.2k to 42.2k ZL2105 device address changed from 0x25 to 0x2F
September 2008	1.3	Updated Default Configuration text
October 2008	1.4	Changed dynamic response limit from 3% to 3.5%

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