ZL8101_30AEV2Z

30A Demonstration Board

AN1781
Rev 0.00
Sep 6, 2012

Description

The ZL8101 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 ZL8101 incorporates current sharing and adaptive efficiency-optimization algorithms to provide a flexible, efficient power IC building block.

The ZL8101_30AEV2Z Demo Board is a 6-layer board demonstrating a 30A 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 demo board to a PC. The PMBus command set is accessed by using the Zilker Labs PowerNavigator™ evaluation software from a PC running Microsoft Windows.

Ordering Information

PART NUMBER	DESCRIPTION
ZL8101_30AEV2Z	30A Single Phase Demo Board

Key Features

- 30A Synchronous Buck Converter
- Optimized for High Current and High Efficiency
- Configurable through SMBus
- Onboard Enable Switch
- Power-Good Indicator

Target Specifications

- V_{IN} = 12V
- V_{OUT} = 1V/30A
- F_{SW} = 533kHz
- Efficiency: >88% at 20A
- Output Ripple: ±1%
- Dynamic Response: ±3% (33%-83%-33% LOAD STEP, di/dt = 5A/µs)
- Operating Temperature: +25°C

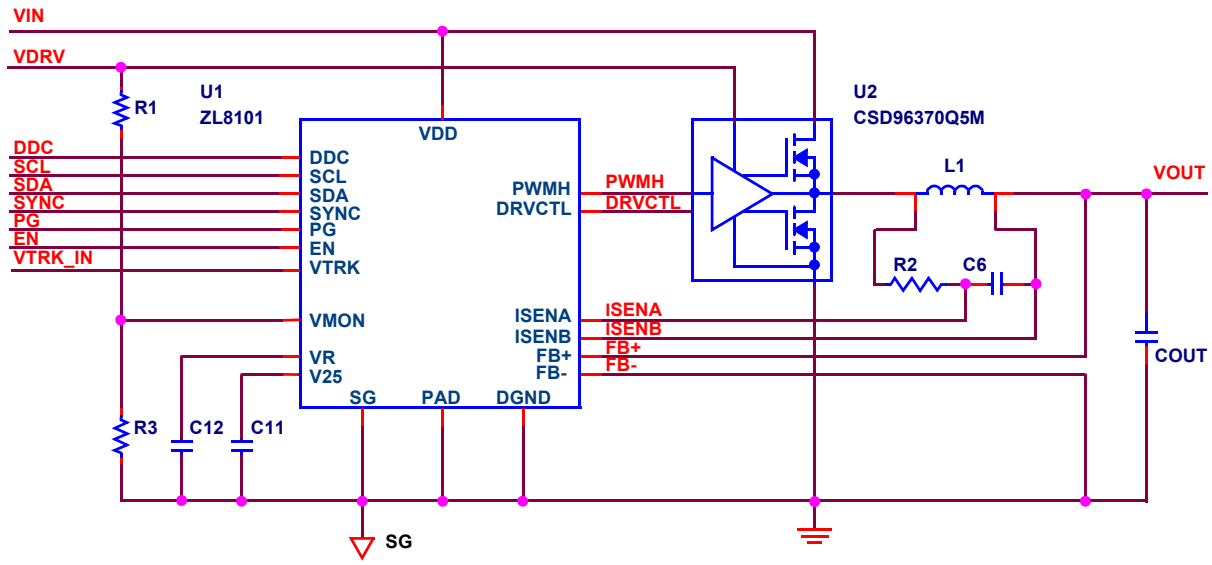

FIGURE 1. ZL8101_30AEV2Z 30A DEMO BOARD SIMPLIFIED SCHEMATIC

Functional Description

The ZL8101_30AEV2Z 30A Demo Board provides all circuitry required to demonstrate the features of the ZL8101. The ZL8101 30A has a functionally optimized ZL8101 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 ZL8101 such as soft-start delay and ramp times, supply sequencing, voltage tracking, and voltage margining are available on this board. For voltage tracking and sequencing evaluation, the board can be connected to any other Zilker Labs evaluation boards that supports the Digital DC (DDC) bus.

Figure1 shows a simplified schematic of the ZL8101_30AEV2Z 30A Demo Board. All power to the board (VIN and I^2C bus) must be removed before changing the jumpers.

The hardware enable function is controlled by a toggle switch on the ZL8101_30AEV2Z 30A board. The power-good (PG) LED indicates the state of PG when external power is applied to the ZL8101_30AEV2Z 30A board. The right angle headers at opposite ends of the board are for connecting a USB to SMBus adapter board or for easy chaining of multiple evaluation boards.

Figure 2 shows the ZL8101_30AEV2Z 30A Demo Board complete circuit. The circuit consists of the ZL8101 IC with its minimal component count to realize a 30A buck converter. The board layout has been optimized for thermal performance. Figure 3 is the board interface circuitry. Figures 5 through 10 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

PMBus Operation

The ZL8101 utilizes the PMBus protocol. The PMBus functionality can be controlled via USB from a PC running the PowerNavigator evaluation software in a Windows XP, Windows 2000/NT, or Windows 7 operating system.

Install the evaluation software using the CD included in the ZL8101_30AEV2Z 30A Demo Board kit.

For board operation, connect the included USB-to-SMBus adapter board to J2 of the ZL8101_30AEV2Z 30A Demo 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 ZL8101 PMBus parameters. The ZL8101 device on the board has been pre-configured as described in the Target Specifications on the front page, but the user may modify the operating parameters through the PowerNavigator 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 AN2033 for PMBus details.

The ENABLE switch can then be moved to “ENABLE” and the ZL8101_30AEV2Z 30A Demo 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 the USB to SMBus adapter board to J2 of the board.
4. Ensure that jumper shorting headers J1, J6, and J7 are installed.
5. Connect supplied USB cable from computer to USB to SMBus adapter board.
6. Connect power supply to VIN+/VIN- (supply turned off).
7. Turn power supply on.
8. Set ENABLE switch to “ENABLE”.
9. Monitor the ZL8101_30AEV2Z 30A demo 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 J2 of ZL8101_30AEV2Z 30A Demo Board.
7. Connect supplied USB cable from computer to USB to SMBus adapter board.
8. Upon first-time connection, the Found New Hardware Wizard will appear.
9. Select ‘No’ at prompt to search the Internet for drivers.
10. Follow the steps on the screen to install the drivers from the CD.
11. Install the PowerNavigator evaluation software by running setup.exe from the PowerNavigator_installer folder on the CD.
12. Using PowerNavigator, set the enable mode to PMBus Enable, press the PMBus Enable button on the PowerNavigator opening screen.
13. Monitor and configure the ZL8101_30AEV2Z 30A Demo Board using PMBus commands in the evaluation software.
14. Test the ZL8101_30AEV2Z 30A Demo Board operation using an oscilloscope and the evaluation software.

Typical room temp efficiency curves are shown in Figure 11. Typical transient and operational waveforms are shown in Figures 12 through 15.

Board Schematics

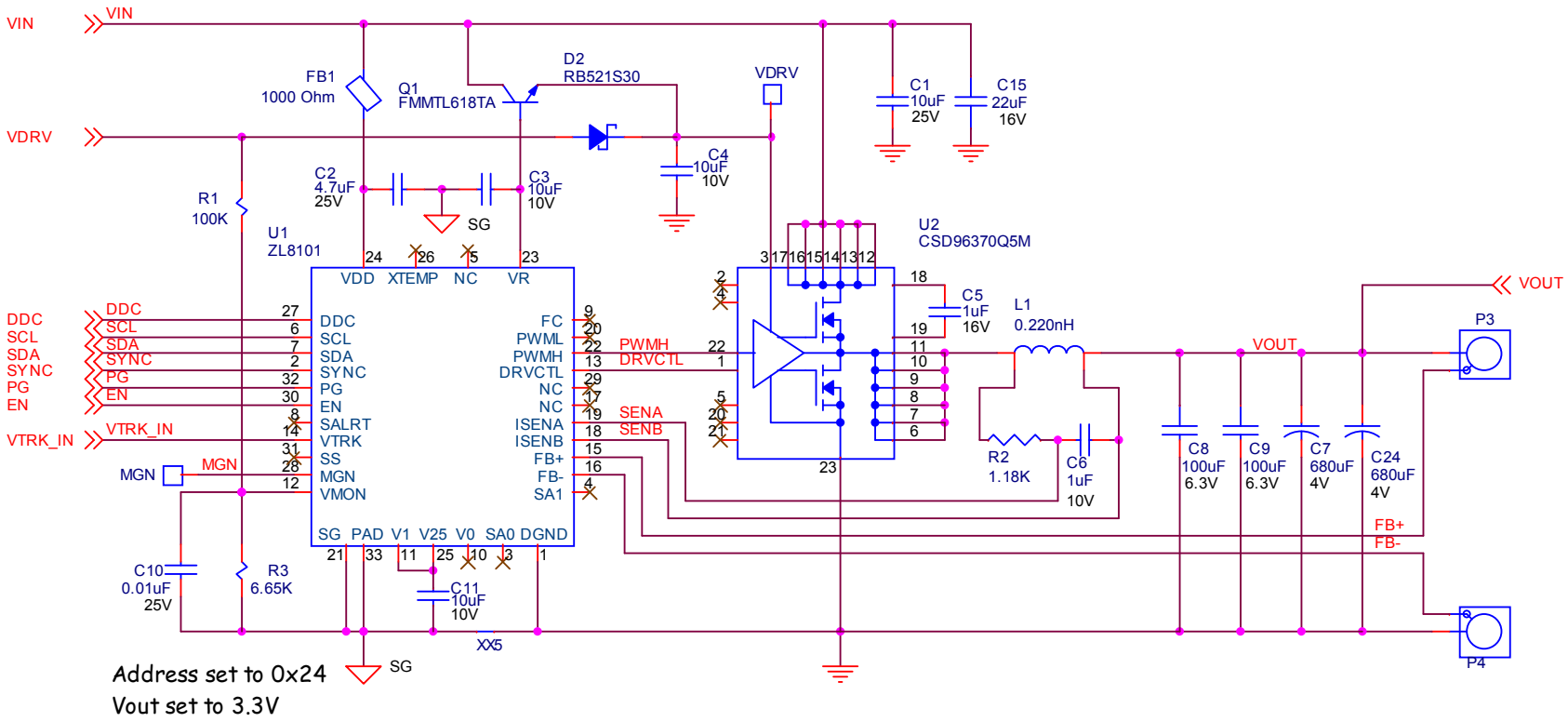

FIGURE 2. ZL8101_30AEV2Z 30A DEMO BOARD COMPLETE CIRCUIT

Board Schematics (Continued)

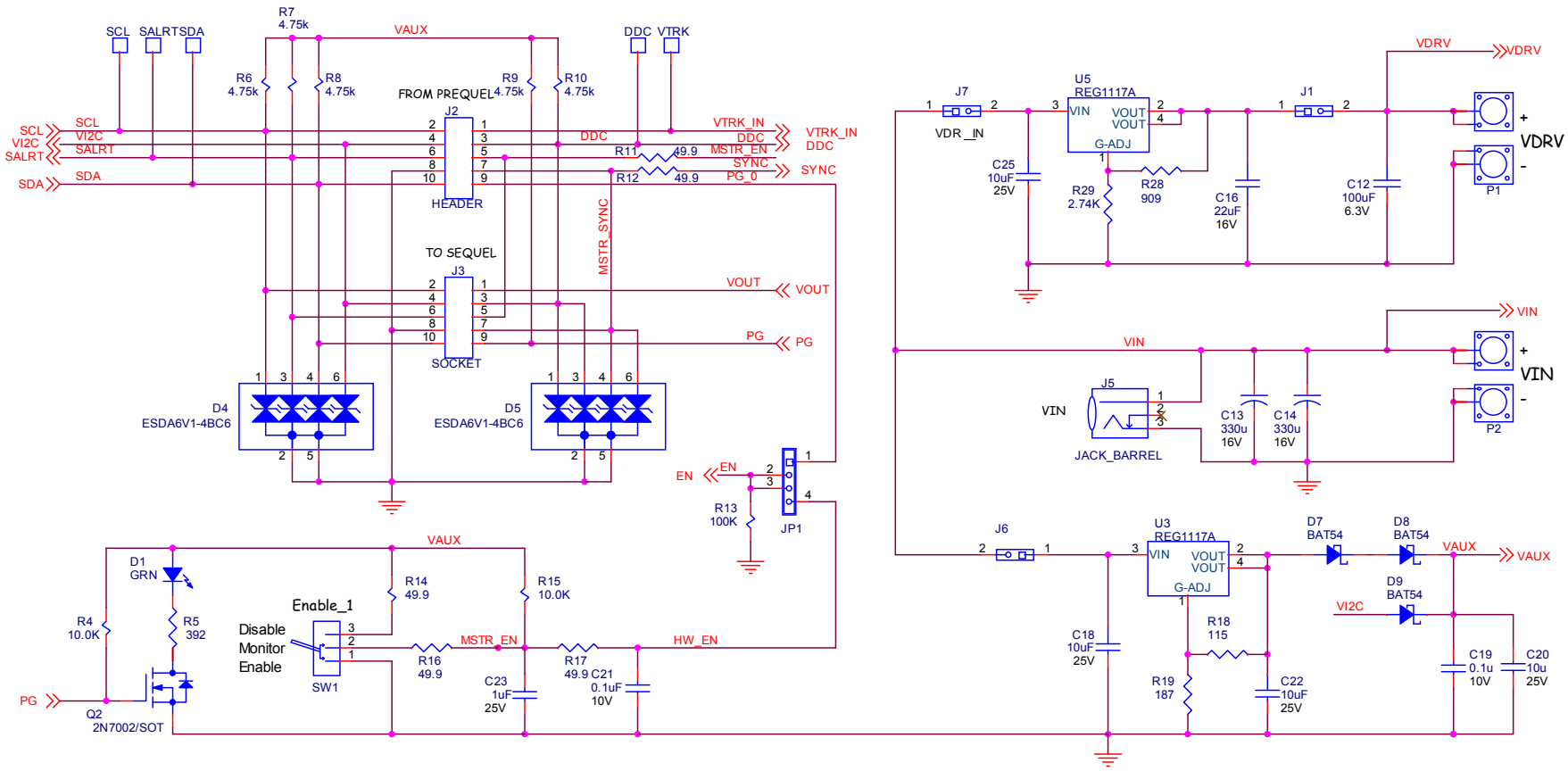

FIGURE 3. ZL8101_30AEV2Z 30A DEMO BOARD – INTERFACE CIRCUITRY

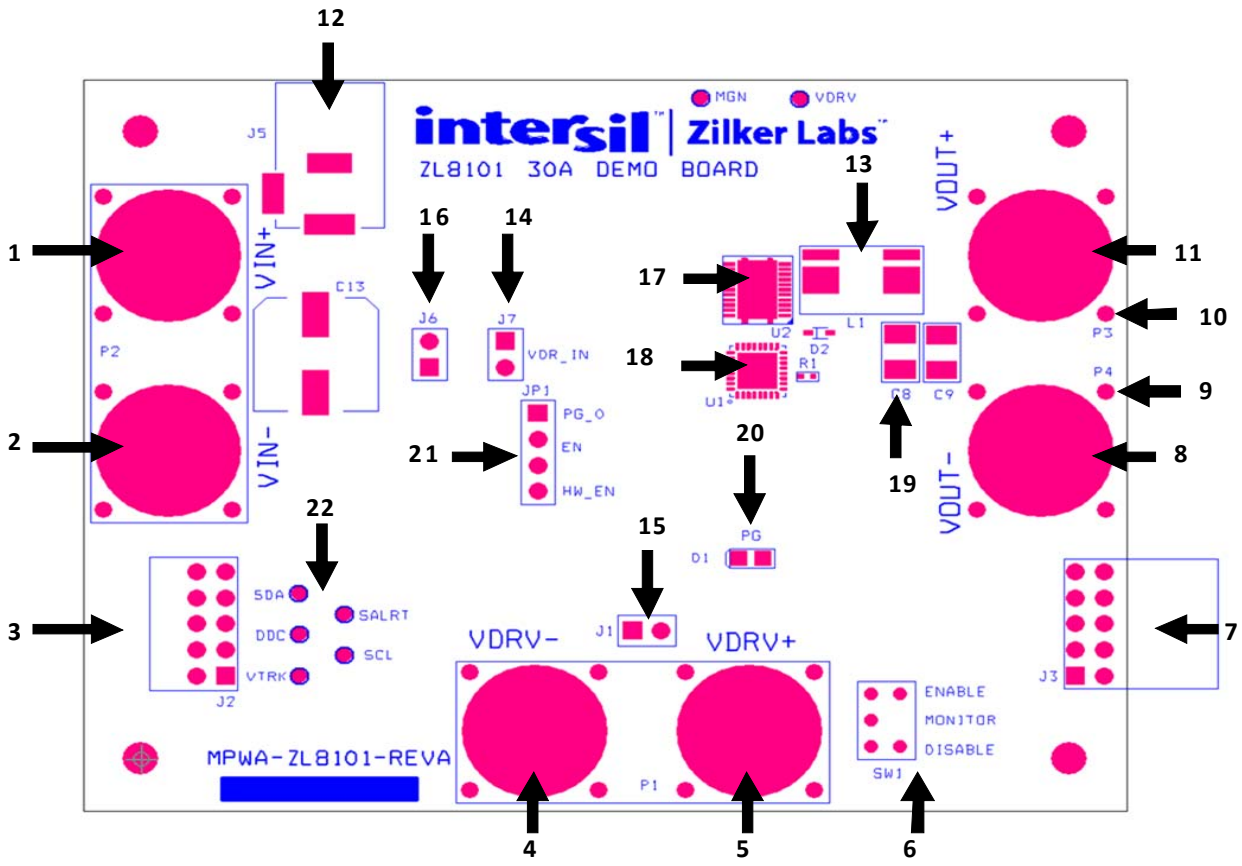

FIGURE 4. ZL8101_30AEV2Z 30A DEMO BOARD GUIDE

The top view of the ZL8101_30AEV2Z 30A Demo Board is shown in Figure 4, and the most important parts of the board are covered in Table 1

TABLE 1. COMMENTS ABOUT DIFFERENT PARTS IN THE ZL8101_30AEV2Z 30A DEMO BOARD

ITEM	QUANTITY	REFERENCE	VALUE	TOLERANCE	RATING	TYPE	MANUFACTURER	PART NUMBER	DISTRIBUTOR	DIST. PN
1	1	C1	10µF	±10%	25V	X7R	Taiyo Yuden	TMK316B7106KL-TD	Digikey	587-2399-2-ND
2	1	C2	4.7µF	±10%	25V	X7R	AVX	0805YC475KAT2A	Digikey	478-5722-1-ND
3	3	C3, C4, C11	10µF	±10%	10V	X7R	Murata	GRM21BR71A106KE51L	Digikey	490-3905-2-ND
4	1	C5	1µF	±10%	16V	X7R	Kemet	C0603C105K4RACTU	Digikey	C0603C105K4RACTU-ND
5	1	C6	1µF	10%	10V	X7R	Taiyo Yuden	LMK107B7105KA-T	Digikey	587-1242-2-ND
6	2	C7, C24	680µF	20%	4V	AL POLY	Kemet	T530Y687M004ATE005	Digikey	399-4750-1-ND
7	3	C8, C9, C12	100µF		6.3V	X5R	Taiyo Yuden	JMK325BJ107MY-T	Digikey	587-1388-2-ND
8	1	C10	0.01µF	±10%	25V	X7R	Kemet	C0402C103K3RACTU	Digikey	399-1278-2-ND
9	2	C13, C14	330µ	20%	16V	AL POLY	United Chemi-Con	APXA160ARA331MJC0G	Digikey	565-3081-2-ND
10	2	C15, C16	22µF	20%	16V	X5R	Murata	GRM31CR61C226ME15L	Digikey	490-4739-2-ND
11	3	C18, C22, C25	10µF	10%	25V	X5R	Panasonic - ECG	ECJ-3YB1E106K	Digikey	PCC2414TR-ND
12	1	C19	0.1µ	10%	10V	X7R	Kemet	C0603C104K8RACTU	Digikey	399-1095-2-ND
13	1	C20	10µ	10%	25V	X5R	Panasonic - ECG	ECJ-3YB1E106K	Digikey	PCC2414TR-ND
14	1	C21	0.1µF	10%	10V	X7R	Kemet	C0603C104K8RACTU	Digikey	399-1095-2-ND
15	1	C23	1µF	10%	25V	X5R	Taiyo Yuden	TMK107BJ105KA-T	Digikey	587-1248-2-ND
16	1	D1	GRN		2V		Chicago Minature	CMD17-21VGC	Mouser	606-CMD17-21VGC
17	1	D2	RB521S30		30V	Schottky	ON SEMI	RB521S30	Digikey	RB521S30CT-ND
18	2	D4, D5	ESDA6V1-4BC6		6.1V, 80W		ST Micro	ESDA6V1-4BC6	Digikey	497-4643-2-ND
19	3	D7, D8, D9	BAT54		30V	Schottky	On Semi	BAT54XV2T1OS	Digikey	BAT54XV2T1OSTR-ND
20	1	FB1	1000 Ω		150mA	Ferrite	Taiyo Yuden	BK1005HM102-T	Digikey	587-1835-2-ND
21	1	JP1	4 PIN				Tyco	3-644456-4	Digikey	A31114-ND
22	3	J1, J6, J7	2 POS			VERT	Samtec	TSW-102-07-L-S	Digikey	SAM1031-02-ND
23	1	J2	HEADER			RA	Samtec	TSW-105-08-T-D-RA	Digikey	SAM1049-05-ND
24	1	J3	SOCKET			RA	Samtec	SSQ-105-02-T-D-RA	Digikey	SAM1224-05-ND
25	1	J5	JACK_BARREL		1.5A @ 18VDC	RA	Kobiconn	163-5004-E	Mouser	163-5004-E
26	1	L1	0.220nH		70	Inductor	ITG	SL3732_R22KHF	ITG	SL3732_R22KHF
27	2	P1, P2	JACK_DUAL_BANANA		15A		Emerson	108-0740-001	Digikey	J147-ND
28	2	P3, P4	JACK_BANANA_1						Digikey	J147-ND
29	1	Q1	FMMTL618TA		20V	NPN	Diodes Inc	FMMTL618TA	Digikey	FMMTL618CT-ND
30	1	Q2	2N7002/SOT		60V 115mA	N-CH	ON SEMI	2N7002LT1	Digikey	2N7002LT1OSTR-ND
31	1	R1	100k	1%		1/16W	Vishay/Dale	CRCW0402100KFKED	Digikey	541-100KLTR-ND
32	1	R2	1.18k	1%		Resistor	Panasonic - ECG	ERJ-3EKF1181V	Digikey	P1.18KHTR-ND
33	1	R3	6.65k	1%		1/16W	Panasonic - ECG	ERJ-2RKF6651X	Digikey	P6.65KLTR-ND
34	1	R4	10.0k	1%		1/16W	Yageo	RC0402FR-0710KL	Digikey	311-10.0KLRTR-ND
35	1	R5	392	1%		THK FILM	Panasonic - ECG	ERJ-3EKF3920V	Digikey	P392HTR-ND
36	5	R6, R7, R8, R9, R10	4.75k	1%		1/16W	Panasonic - ECG	ERJ-2RKF4751X	Digikey	P4.75KLTR-ND
37	4	R11, R12, R16, R17	49.9	1%	100mW	THK FILM	Panasonic - ECG	ERJ-3EKF49R9V	Digikey	P49.9HTR-ND
38	1	R13	100k	1%	63mW	THK FILM	Panasonic - ECG	ERJ-2RKF1003X	Digikey	P100KLTR-ND
39	1	R14	49.9	1%	63mW	THK FILM	Vishay/Dale	CRCW040249R9FKED	Digikey	541-49.9LTR-ND
40	1	R15	10.0k	1%	63mW	THK FILM	Panasonic - ECG	ERJ-2RKF1002X	Digikey	P10.0KLTR-ND
41	1	R18	115	1%	100mW	THK FILM	Panasonic - ECG	ERJ-3EKF1150V	Digikey	P115HTR-ND

TABLE 1. COMMENTS ABOUT DIFFERENT PARTS IN THE ZL8101_30AEV2Z 30A DEMO BOARD (Continued)

ITEM	QUANTITY	REFERENCE	VALUE	TOLERANCE	RATING	TYPE	MANUFACTURER	PART NUMBER	DISTRIBUTOR	DIST. PN
42	1	R19	187	1%	100mW	THK FILM	Panasonic - ECG	ERJ-3EKF1870V	Digikey	P187HTR-ND
43	1	R28	909	1%	100mW	THK FILM	Panasonic - ECG	ERJ-3EKF9090V	Digikey	P909HTR-ND
44	1	R29	2.74k	1%	100mW	THK FILM	Panasonic - ECG	ERJ-3EKF2741V	Digikey	P3.32KHTR-ND
45	1	SW1	SW_SPDT			PCB VERT	NKK	G13AP-RO	Mouser	633-G13AP-RO
53	1	U1	ZL8101				Intersil	ZL8101	Intersil	ZL8101
54	1	U2	CSD96370Q5M		25V		Texas Instruments	CSD96370Q5M	Digikey	296-28235-2-ND
55	2	U3, U5	REG1117A				Texas Instruments	REG1117A	Digikey	REG1117A-ND

Board Layout – 6 Layers

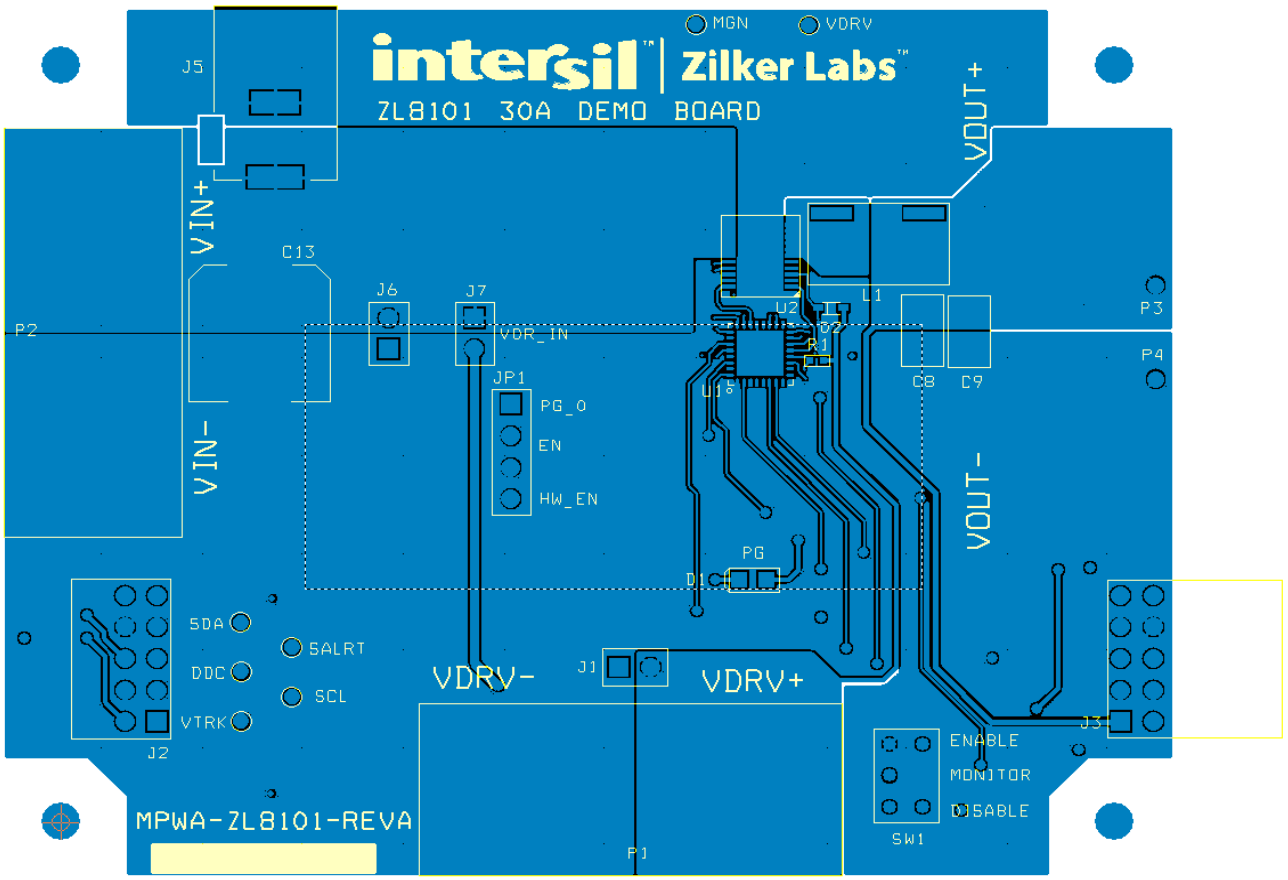

FIGURE 5. PCB - TOP LAYER

Board Layout – 6 Layers (Continued)

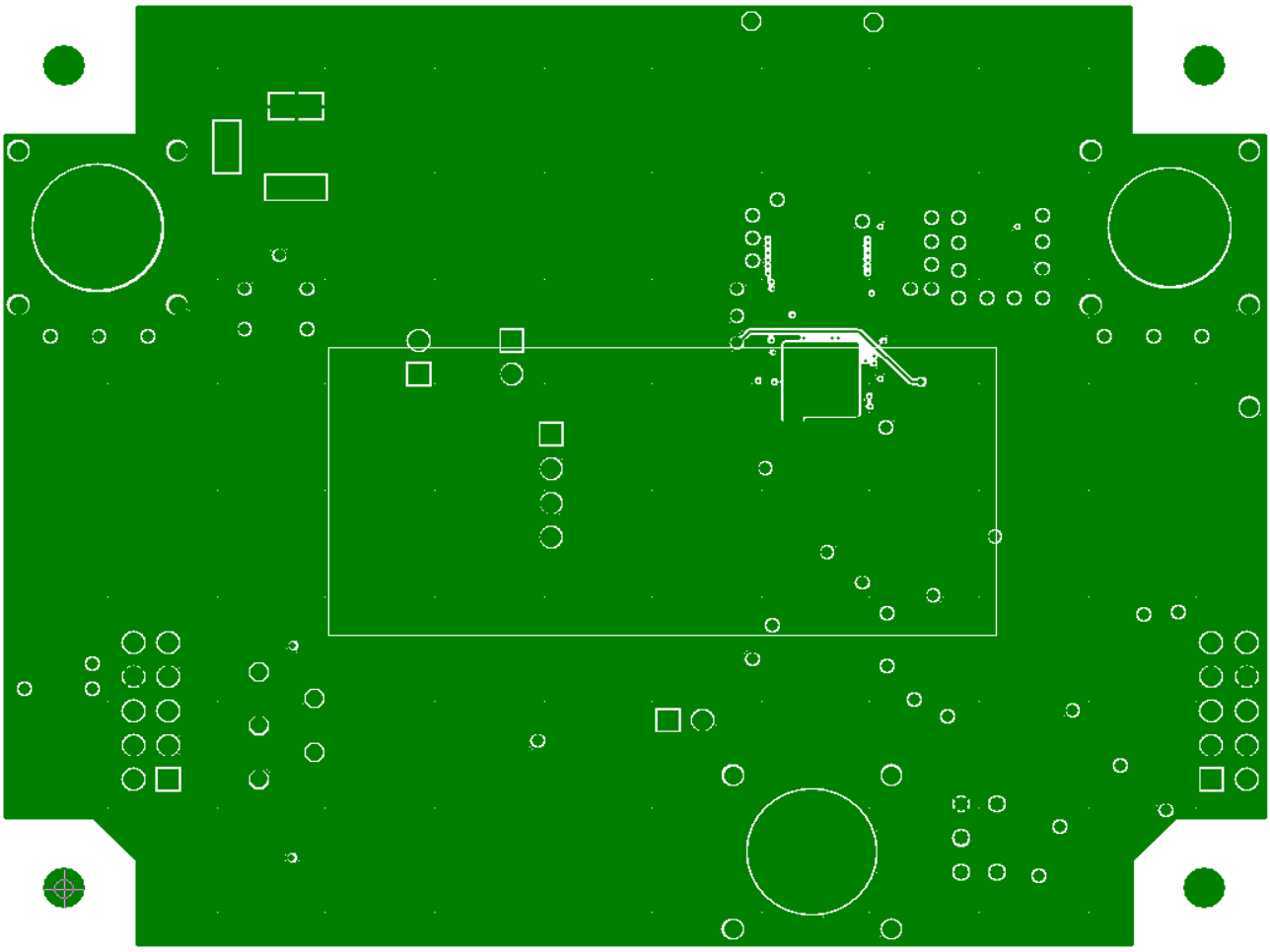

FIGURE 6. PCB - INNER LAYER 1 (VIEWED FROM TOP)

Board Layout – 6 Layers (Continued)

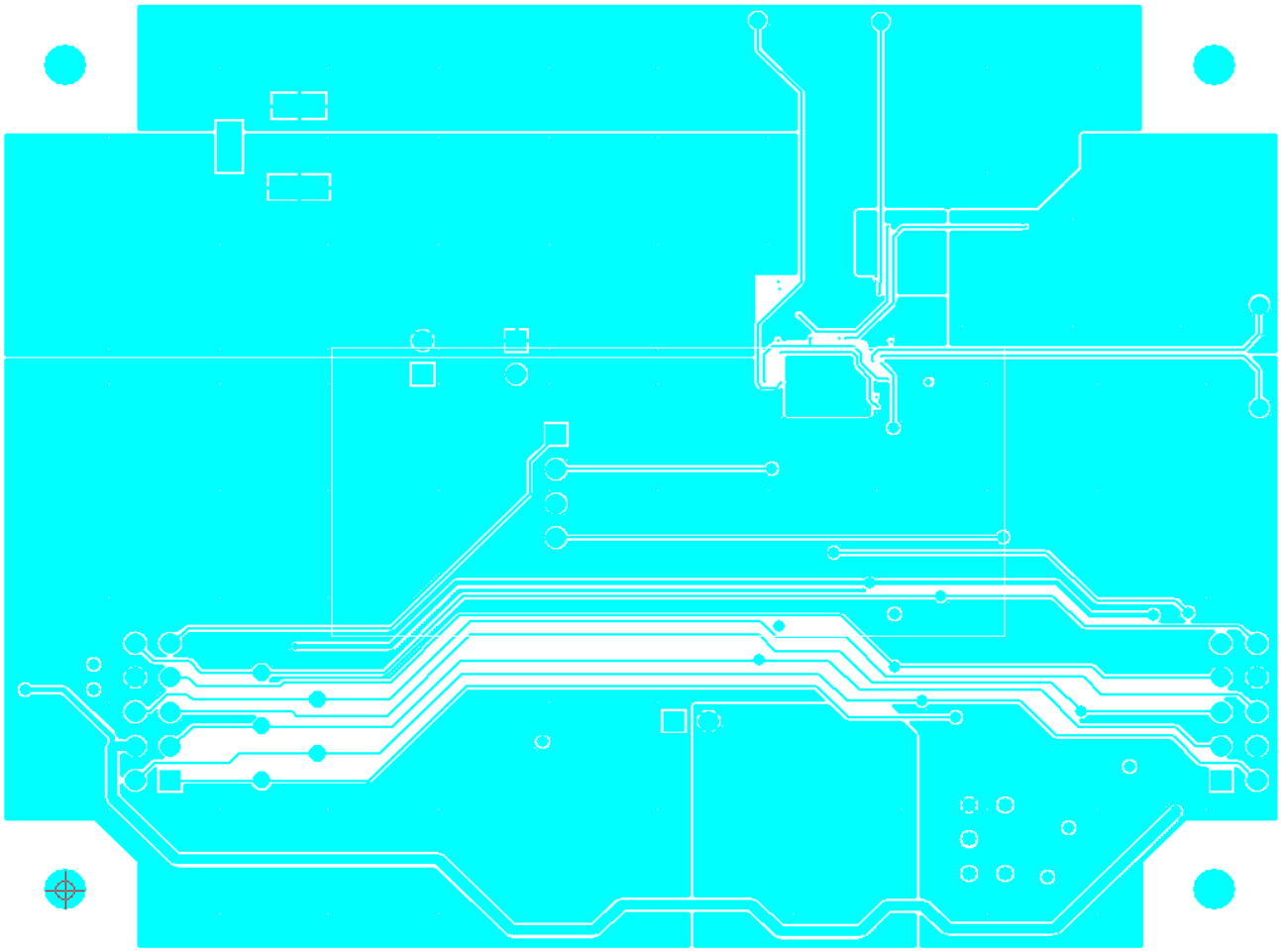

FIGURE 7. PCB - INNER LAYER 2 (VIEWED FROM TOP)

Board Layout – 6 Layers (Continued)

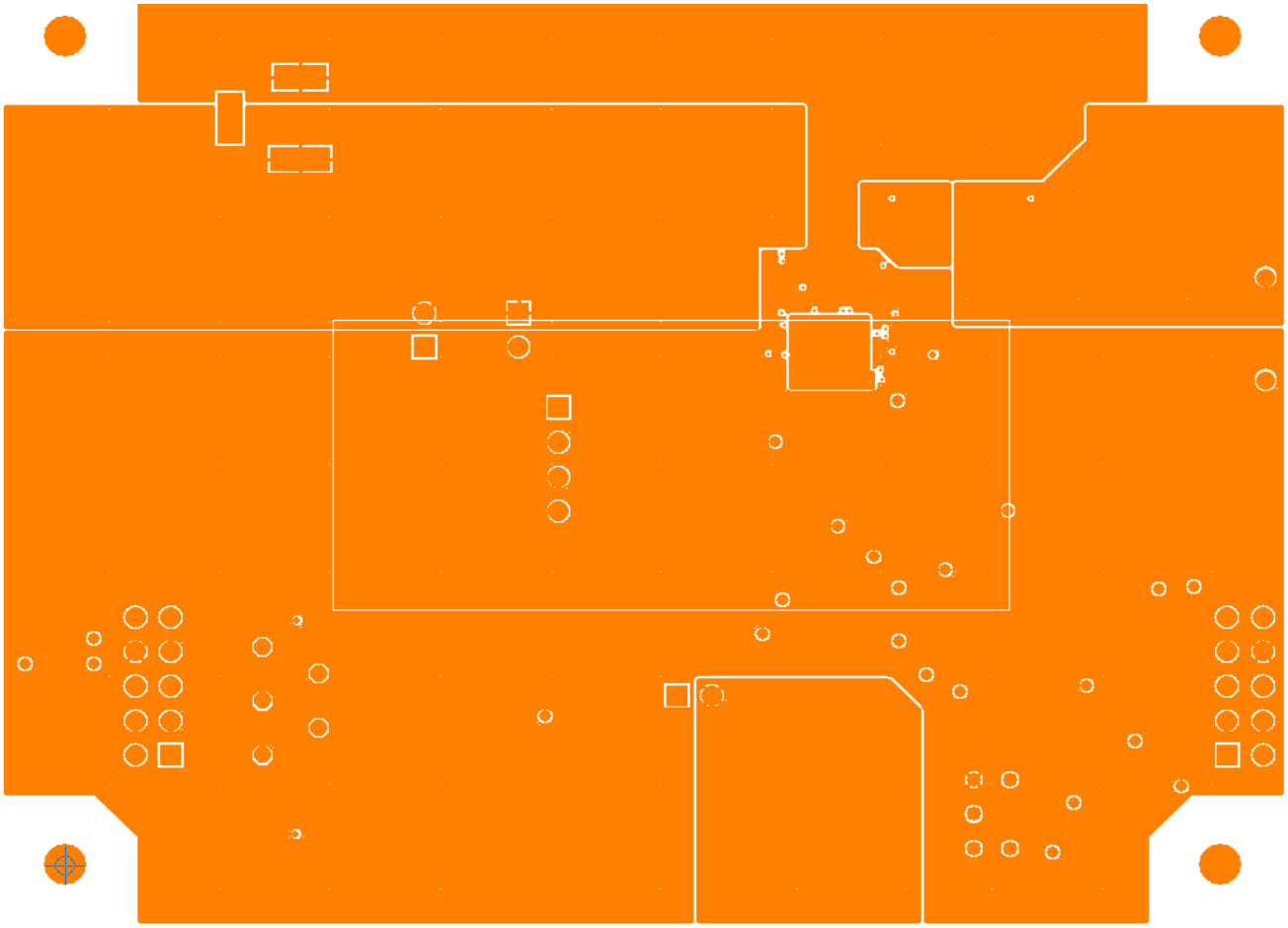

FIGURE 8. PCB - INNER LAYER 3 (VIEWED FROM TOP)

Board Layout – 6 Layers (Continued)

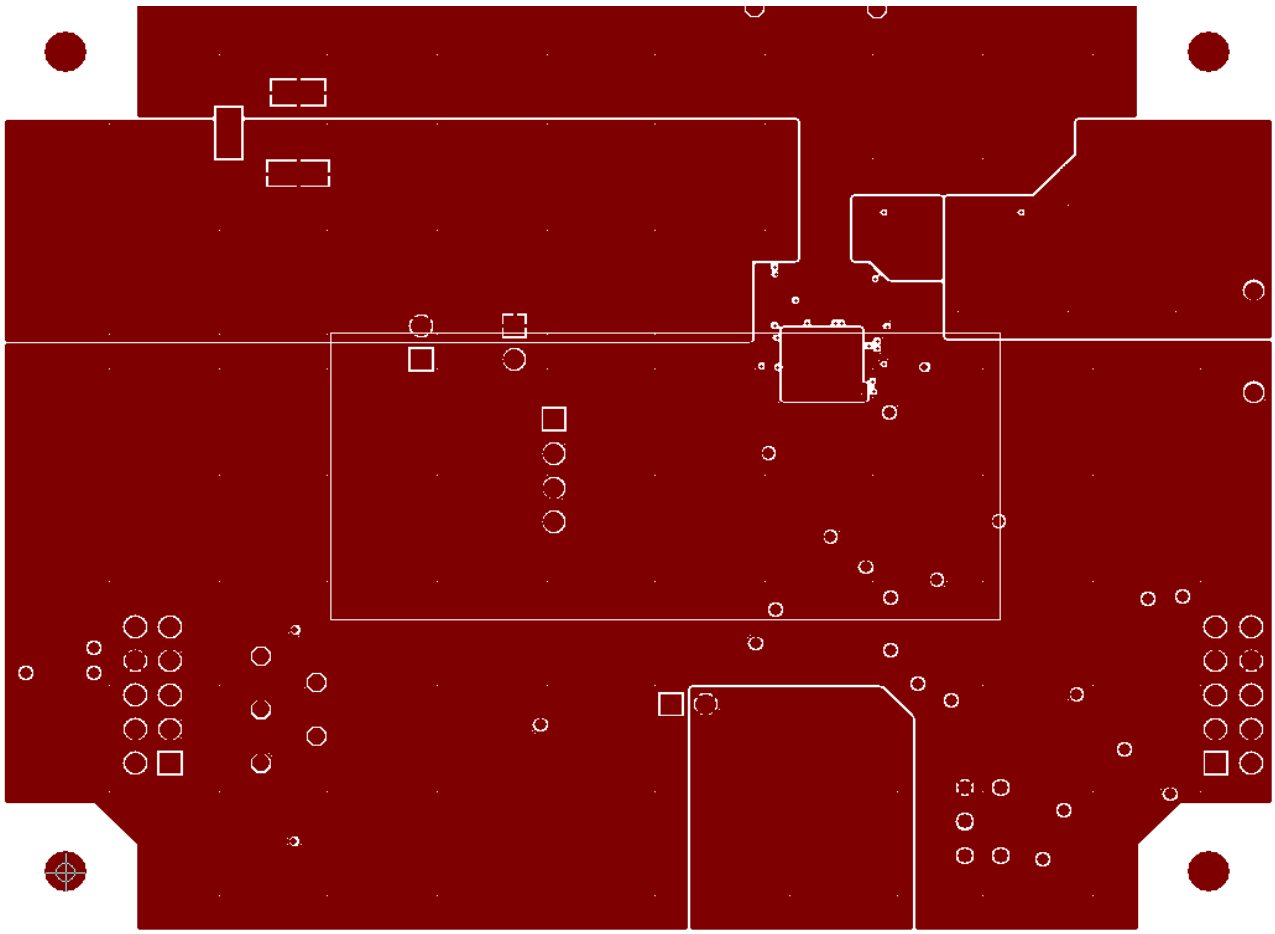

FIGURE 9. PCB - INNER LAYER 4 (VIEWED FROM TOP)

Board Layout – 6 Layers (Continued)

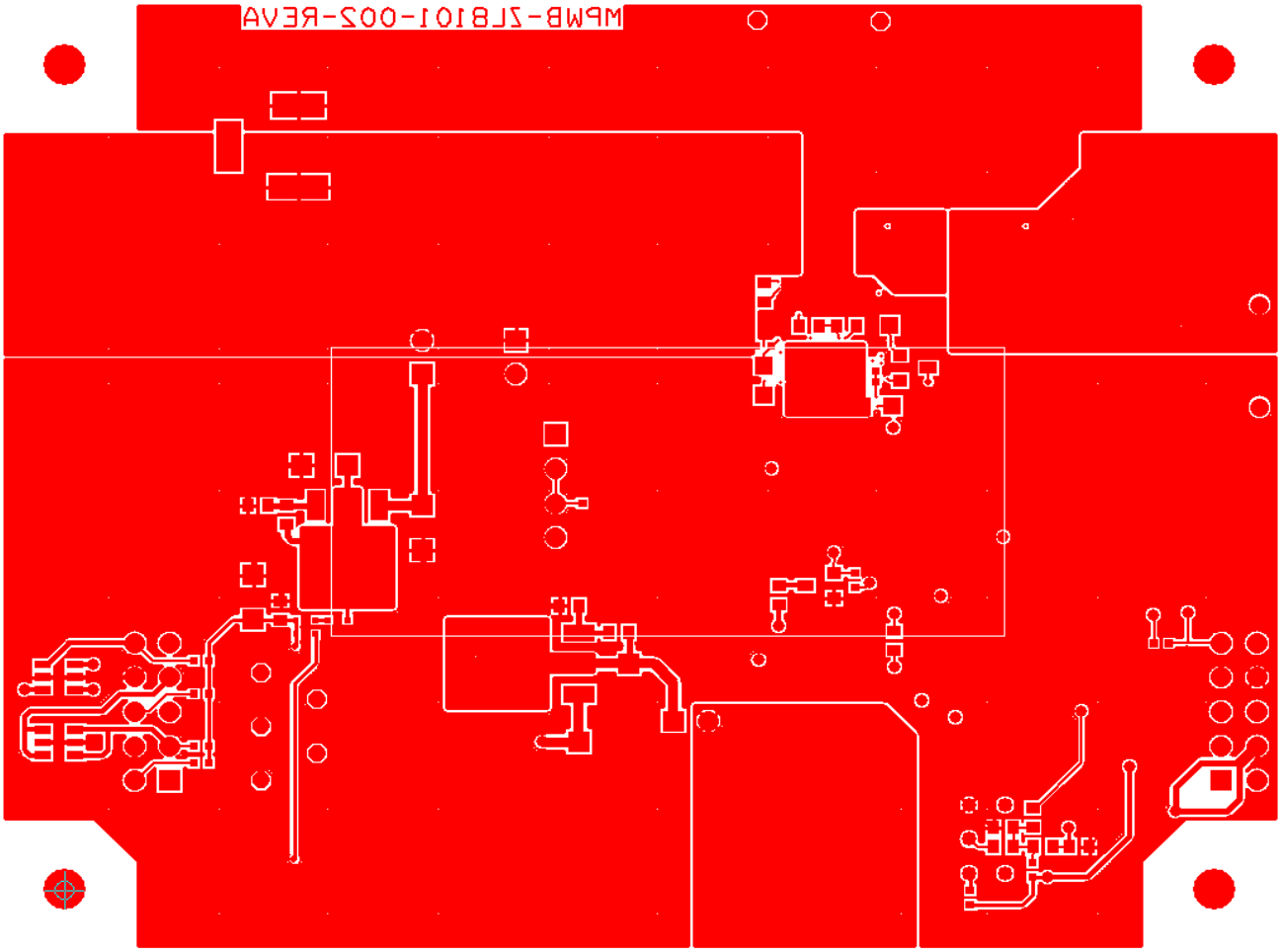

FIGURE 10. PCB - BOTTOM LAYER (VIEWED FROM TOP)

Default Configuration Text

The following text is loaded into the ZL8101 device on the board as default settings. Each PMBus command is loaded via the PowerNavigator software. The # symbol is used for a comment line.

```
# Zilker Labs 8101 6/7/2012
# ZL Configuration File Revision A
# Schematic revision level
# BOM revision level
# Change log:
RESTORE_FACTORY
STORE_USER_ALL
STORE_DEFAULT_ALL
MFR_ID                          Zilker_Labs
MFR_MODEL                       30A
MFR_REVISION                    REV_A
MFR_LOCATION                    Austin
MFR_DATE                        8/2012
MFR_SERIAL                      1p0V_35A
VOUT_COMMAND                    1.0
FREQUENCY_SWITCH                533
POWER_GOOD_DELAY                5
IOUT_SCALE                      0.30
IOUT_CAL_OFFSET                 -2.0
TON_DELAY                       5
TON_RISE                        5
TOFF_DELAY                      5
TOFF_FALL                       5
VOUT_OV_FAULT_RESPONSE          0x80
VOUT_UV_FAULT_RESPONSE          0x80
OVUV_CONFIG                     0x80
IOUT_OC_FAULT_LIMIT             50
IOUT_AVG_OC_FAULT_LIMIT         45
IOUT_UC_FAULT_LIMIT             -40
IOUT_AVG_UC_FAULT_LIMIT         -40
MFR_IOUT_OC_FAULT_RESPONSE      0x80
MFR_IOUT_UC_FAULT_RESPONSE      0x80
MFR_VMON_OV_FAULT_LIMIT         7.0
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               4.2
VIN_UV_FAULT_LIMIT              4.0
VIN_UV_FAULT_RESPONSE           0x80
OT_WARN_LIMIT                   110.0
OT_FAULT_LIMIT                  125
OT_FAULT_RESPONSE               0x80
UT_WARN_LIMIT                   -20
UT_FAULT_LIMIT                  -40
```

UT_FAULT_RESPONSE	0x00
DEADTIME	0x0C0C
DEADTIME_CONFIG	0x8686
DEADTIME_MAX	0x0C0C
MAX_DUTY	94
TRACK_CONFIG	0x00
INTERLEAVE	0x0000
#SEQUENCE	0x0000
MFR_CONFIG	0x6A10
NLR_CONFIG	0x00000000
TEMPCO_CONFIG	0x28
MISC_CONFIG	0x2000
ISHARE_CONFIG	0x0000
AUTO_COMP_CONFIG	0x79
PID_TAPS	A=6504.62, B=-11568.50, C=5078.00
USER_CONFIG	0x0011
DDC_GROUP	0x00000000
#DDC_CONFIG	0x0000
INDUCTOR	0.22
ON_OFF_CONFIG	0x1A
STORE_DEFAULT_ALL	
RESTORE_DEFAULT_ALL	

Measured Data The following data was acquired using a ZL8101_30AEV2Z 30A Demo Board.

EFFICIENCY

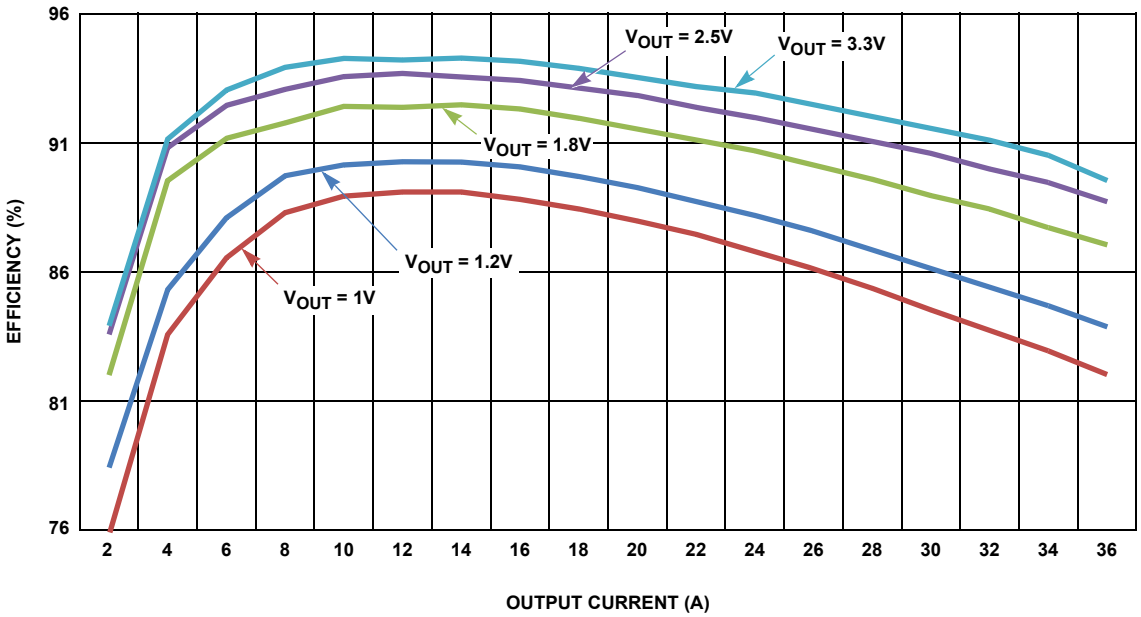

FIGURE 11. EFFICIENCY FOR DIFFERENT OUTPUT VOLTAGES, V_{IN} = 12V, F_{SW} = 533kHz

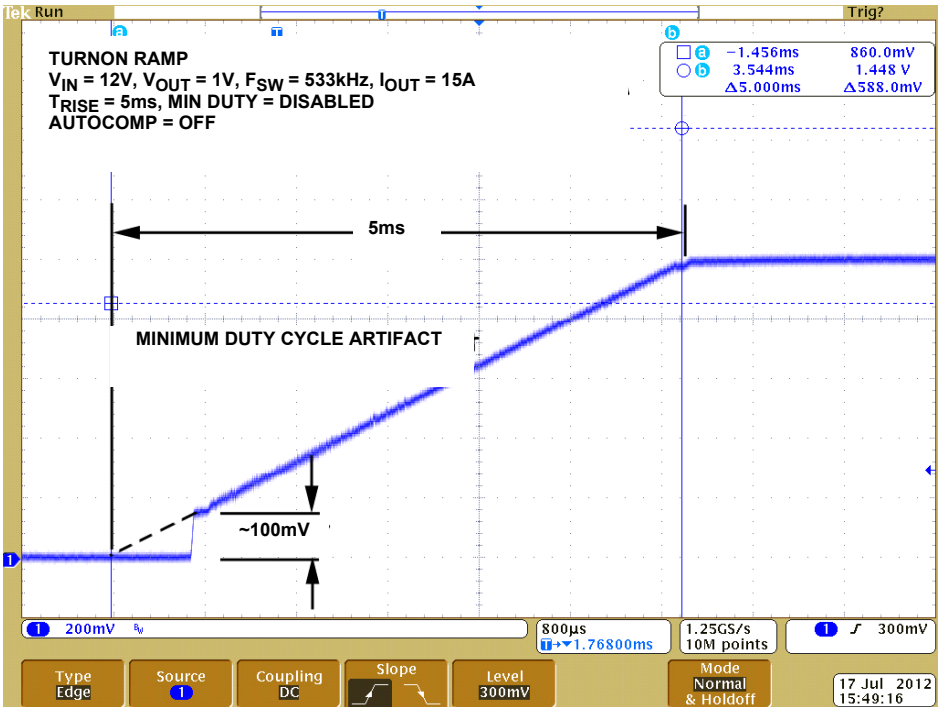

FIGURE 12. RAMP UP

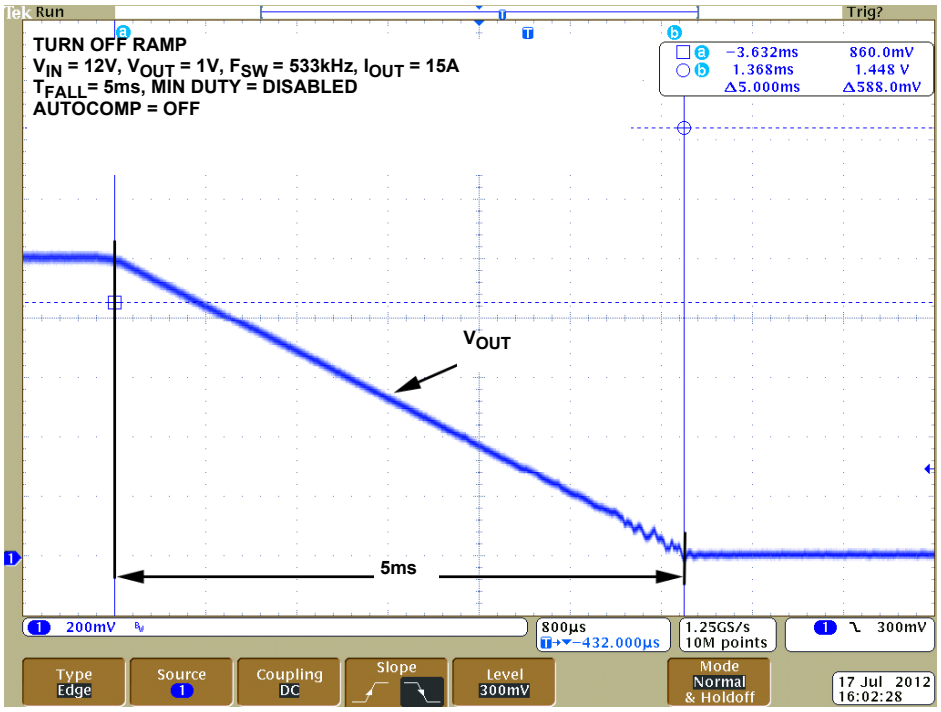

FIGURE 13. RAMP DOWN

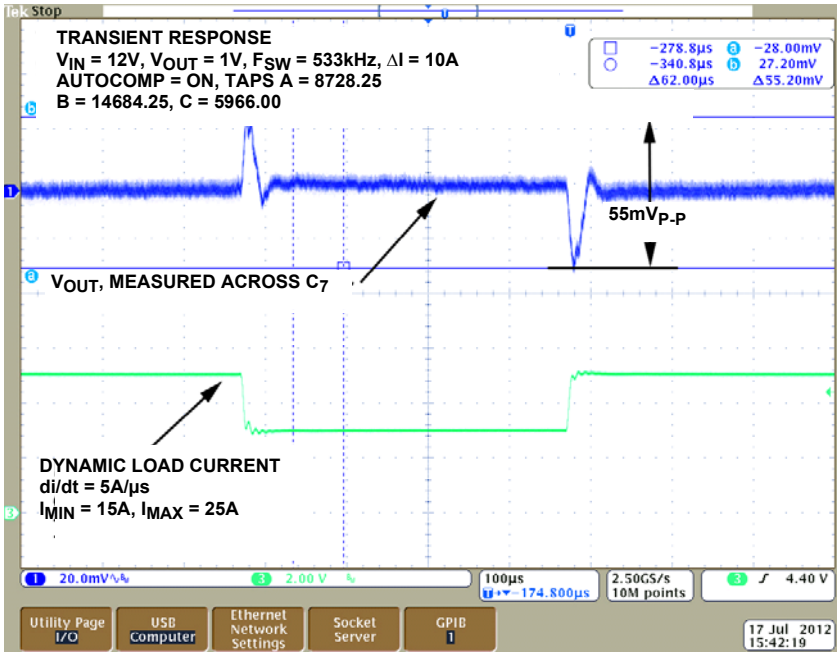

FIGURE 14. DYNAMIC RESPONSE, 10A TO 25A (AND VICE VERSA) LOAD STEP

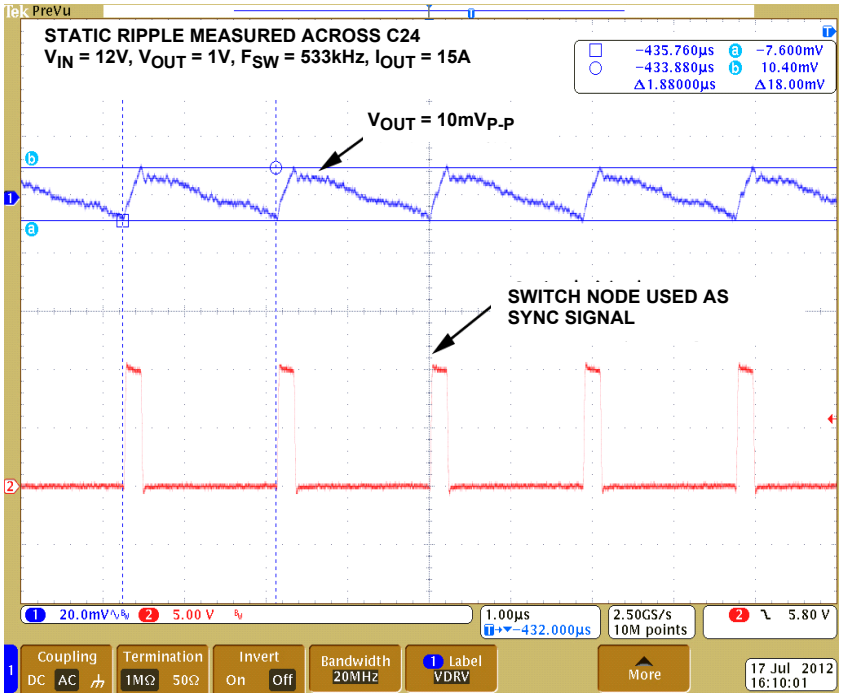

FIGURE 15. OUTPUT VOLTAGE RIPPLE WHEN VO = 1V, IO = 25A, V_{IN} = 12V, F_{SW}= 800kHZ

References

[1] ZL8101 Data Sheet, Zilker Labs, Inc., 2012.

[2] AN2033 – PMBus™ Command Set, Zilker Labs, Inc., 2009.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below.

   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.
6. When using Renesas Electronics products, refer to the latest product information (data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note 1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note 2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)

RENESAS

SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

Refer to "http://www.renesas.com/" for the latest and detailed information.

Renesas Electronics America Inc.
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338

Colophon 7.0