User's Manual

ISL8278MEVAL1Z

User's Manual: Evaluation Board

Industrial Analog and Power

Rev 0.00 Jul 2017

1. Overview

The ISL8278M is a 33A step-down, DC/DC power supply module with an integrated digital PWM controller, synchronous power switches, an inductor, and passives. Only bulk input and output capacitors are needed to finish the design. The 33A of continuous output current can be delivered without the need for airflow or a heatsink. The ISL8278M uses ChargeMode™ control architecture, which responds to a transient load within a single switching cycle.

The ISL8278MEVAL1Z evaluation board is a 3in x 4.5in 4-layer FR4 board with 2 oz. in all layers. This evaluation board comes with a placeholder for pin-strap resistors to adjust output voltage, switching frequency, input undervoltage (UVLO) protection threshold, and the device PMBus address. More configurations, such as soft-start and fault limits, can be easily programmed or changed using a PMBus compliant serial bus interface.

ZLUSBEVAL3Z (USB to PMBus adapter) is provided with this evaluation board, which connects the evaluation board to a PC to activate the PMBus communication interface. The PMBus command set is accessed by using the PowerNavigator™ evaluation software from a PC running Microsoft Windows.

1.1 Key Features

- V_{IN} range of 4.5V to 14V, V_{OUT} adjustable from 0.6V to 5V
- Programmable V_{OUT}, margining, UV/OV, I_{OUT} limit, soft-start/stop, sequencing, and external synchronization
- Monitor: V_{IN}, V_{OUT}, I_{OUT}, temperature, duty cycle, switching frequency, and faults
- ChargeMode control tunable with PMBus
- Mechanical switch for enable and power-good LED indicator

1.2 Specifications

This board has been configured for the following operating conditions by default:

- V_{IN} = 5V to 12V
- V_{OUT} = 1.2V
- I_{MAX} = 33A
- f_{SW} = 533kHz
- Peak efficiency: >91% at 50% load
- ASCR gain = 250, ASCR residual = 90
- On/off delay = 5ms, On/off ramp time = 5ms

1.3 Ordering Information

Part Number	Description
ISL8278MEVAL1Z	ISL8278M board (EVB, ZLUSBEVAL3Z Adapter, USB Cable)

1.4 Related Literature

- For a full list of related documents, visit our website
  - ISL8278M product page

1.5 Recommended Equipment

- DC power supply with minimum 15V/25A sourcing capacity
- Electronic load capable of sinking current up to 33A
- Digital multimeters (DMMs)
- Oscilloscope with higher than 100MHz bandwidth

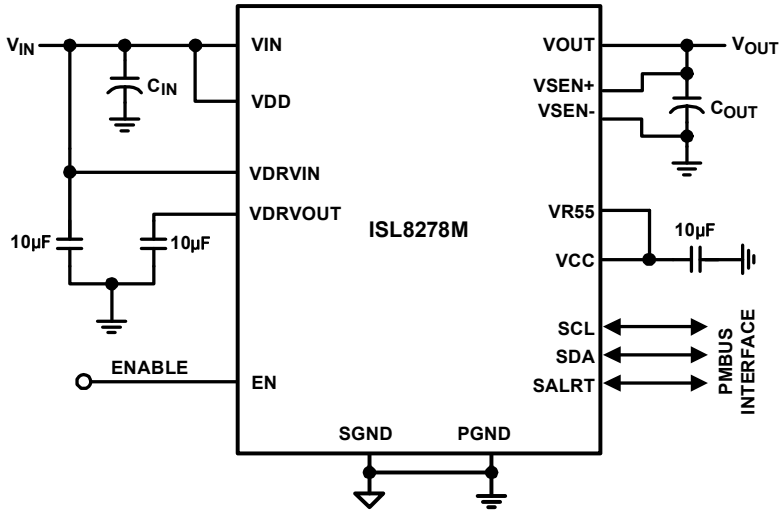

Figure 1. ISL8278MEVAL1Z Block Diagram

2. Functional Description

The ISL8278MEVAL1Z provides all circuitry required to evaluate the features of the ISL8278M. A majority of the features of the ISL8278M, such as compensation-free ChargeMode control, soft-start delay and ramp times, supply sequencing, and voltage margining are available on this evaluation board. For sequencing evaluation, the board can be connected to any Renesas digital module evaluation board that supports the Digital-DC™ (DDC) bus.

Figure 2 shows an image of the ISL8278MEVAL1Z evaluation board.

2.1 Operating Range

By default, the ISL8278MEVAL1Z is configured to operate at V_{OUT} = 1.2V, f_{SW} = 533kHz. V_{IN} ranges from 4.5V to 12V. The board can also support a wider operating range to meet the requirements of specific applications. The V_{OUT} can be adjusted from 0.6V to 5V. Load current range is from 0A to 33A. Note that, for continuous operation at 33A, airflow across the board may be needed. The f_{SW} and output voltage can also be tuned. However, to ensure sufficient stability margins, switching frequency and output capacitors should be selected using "ISL8278M Design Guide Matrix and Output Voltage Response" table in the ISL8278M datasheet.

If the input voltage is less than 5.3V, tie the VCC test point directly to VIN or to a separate 5V power supply for normal operation and best efficiency.

The ISL8278MEVAL1Z is capable of handling a 0A to 33A output current transient, in which the slew rate is less than 2A/µs, such as an electronic load. If the slew rate exceeds the 2A/us, then it may be necessary to increase the output capacitance or change VOUT_OV_FAULT_LIMIT and VOUT_UV_FAULT_LIMIT values for proper operation (refer to "PMBus Option" on page 5).

If external synchronization is used, connect the SYNC test point to the external clock. Note that the external clock signal should be active before the module is enabled.

2.2 PMBus Operation

The ISL8278M utilizes the PMBus protocol. The PMBus functionality can be controlled via ZLUSBEVAL3Z dongle from a PC running the PowerNavigator evaluation software in a Windows XP or Windows 7 operating systems.

Install the evaluation software from the following Renesas website: powernavigator.

For board operation, connect the included ZLUSBEVAL3Z dongle to the 6 pin male connector labeled as "PMBus DONGLE IN". 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. Set the ENABLE switch to "DISABLE" before turning on the power.

The evaluation software allows modification of all ISL8278M PMBus parameters. The ISL8278M device on the board has been preconfigured as described in this document, but the user can modify the operating parameters through the evaluation software or by loading a predefined set-up from a configuration file. A sample "Configuration File" on page 13 is provided and can be copied to a text editor to make desired changes.

The ENABLE switch can then be moved to "ENABLE" and the ISL8278MEVAL1Z board can be tested. Alternately, the PMBus ON_OFF_CONFIG and OPERATION commands can be used from the PowerNavigator GUI.

2.3 Quick Start Guide

2.3.1 Pin-Strap Option

ISL8278MEVAL1Z can be configured in Pin-Strap mode with standard 1% 0603 resistors. The PMBus interface is not required to evaluate ISL8278M in Pin-Strap mode. Output voltage (V_{OUT}), switching frequency (f_{SW}), input undervoltage protection (UVLO) threshold, and the device PMBus address can be changed by populating the recommended resistors at placeholders provided in the evaluation board. By default, the evaluation board is programmed to regulate at V_{OUT} = 1.2V, f_{SW} = 533kHz, UVLO = 4.5V, and PMBus address = 28h. Follow these steps to evaluate ISL8278M in Pin-Strap mode:

(1) Set the ENABLE switch to “DISABLE”.
(2) Connect a load to the VOUT lug connectors (J8 and J9).
(3) Connect a power supply to the VIN connectors (J1 and J2). Make sure the power supply is not enabled when the making connection.
(4) Turn the power supply on.
(5) Set the ENABLE switch to “ENABLE”.
(6) Measure 1.2V VOUT at probe points TP9 and TP13.
(7) Observe switching frequency of 533kHz at the probe point labeled VSWH (TP8).
(8) To change V_{OUT}, disconnect the board from the setup and populate with a 1% standard 0603 resistor at the R_6 placeholder location on the bottom layer. Refer to the “Output Voltage Resistor Settings” table in the ISL8278M datasheet for recommended values. By default, VOUT_MAX is set to 110% of V_{OUT} set by the pin-strap resistor.
(9) To change the switching frequency, disconnect the board from the setup and populate with a 1% standard 0603 resistor at the R_2 placeholder location on the bottom layer. Refer to the “Switching Frequency Resistor Settings” table in the ISL8278M datasheet for recommended values.
(10) To change UVLO, disconnect the board from the setup and populate with a 1% standard 0603 resistor at the R_7 placeholder location on the bottom layer. Refer to the “UVLO Resistor Settings” table in the ISL8278M datasheet for the recommended values.

2.3.2 PMBus Option

ISL8278MEVAL1Z can be evaluated for all features using the provided ZLUSBEVAL3Z dongle and PowerNavigator evaluation software. Follow these steps to evaluate ISL8278M with the PMBus option.

(1) Install the PowerNavigator software.
(2) Set the ENABLE switch to “DISABLE”.
(3) Connect the load to a VOUT lug connectors (J8 and J9).
(4) Connect the power supply to the VIN connectors (J1 and J2). Make sure the power supply is not enabled when making the connection.
(5) Turn the power supply on.
(6) Connect the ZLUSBEVAL3Z dongle (USB to PMBus adapter) to ISL8278MEVAL1Z board to the 6 pin male connector labeled as “PMBus DONGLE IN”.
(7) Connect the supplied USB cable from the computer through the USB to ZLUSBEVAL3Z dongle.
(8) Launch the PowerNavigator software.
(9) Set the ENABLE switch to “ENABLE”.
(10) Monitor and configure the ISL8278MEVAL1Z board using PMBus commands in the evaluation software.

PowerNavigator tutorial videos are available at the Renesas powernavigator website.

For sequencing using the Digital-DC Bus (DDC), or to evaluate multiple Renesas digital power products using a single ZLUSBEVAL3Z dongle, the ISL8278M can be daisy chained with other digital power evaluation boards. PMBus address can be changed by placing a 1% standard 0603 resistor at the R5 placeholder location on the bottom layer. Refer to the “SMBus Address Resistor Selection” table in the ISL8278M datasheet for recommended values.

3. PCB Layout Guidelines

To achieve stable operation, low losses, and good thermal performance, some layout considerations are necessary.

The key features of the ISL8278MEVAL1Z layout are:

- Establish separate SGND and PGND planes, then connect the SGND plane to the PGND plane in the middle layer. For making connections between SGND/PGND on the top layer and other layers, use multiple vias for each pin to connect to the inner SGND/PGND layers. Do not connect SGND directly to PGND on a top layer. Connecting SGND directly to PGND without establishing the SGND plane will bypass the decoupling capacitor at the internal reference supplies, making the controller susceptible to noise.
- Place enough ceramic capacitors between VIN and PGND, VOUT and PGND, and bypass capacitors between VDD and the ground plane, as close to the module as possible to minimize high frequency noise.
- Use large copper areas for a power path (VIN, PGND, and VOUT) to minimize conduction loss and thermal stress. Also, use multiple vias to connect the power planes in different layers. Extra ceramic capacitors at VIN and VOUT can be placed on the bottom layer under the VIN and VOUT pads when multiple vias are used for connecting copper pads on the top and bottom layers.
- Connect differential remote sensing traces to the regulation point to achieve a tight output voltage regulation. Route a trace from VSEN+ and VSEN- to the point-of-load where the tight output voltage is desired. Avoid routing any sensitive signal traces, such as the VSENSE signal near VSWH pads.
- For noise sensitive applications, it is recommended to connect VSWH pads only on the top layer; however, thermal performance will be sacrificed. External airflow might be required to keep module heat at desired levels. For applications where switching noise is less critical, excellent thermal performance can be achieved in this power module by increasing the copper mass attached to the VSWH pad. To increase copper mass on the VSWH node, create copper islands in the middle and bottom layers under the VSWH pad and connect them to the top layer with multiple vias. Make sure to shield those copper islands with a PGND layer to avoid any interference to noise sensitive signals.

3.1 Thermal Considerations and Current Derating

Board layout is very critical to make the module operate safely and deliver maximum allowable power. To work in high temperature environments and carry large currents, the board layout needs to be carefully designed to maximize thermal performance. To achieve this, select enough trace width, copper weight, and the proper connectors.

The ISL8278MEVAL1Z evaluation board is designed for running 33A at room temperature without additional cooling systems. However, if the output voltage is increased or the board is operated at elevated temperatures, then the available current is derated. Refer to the derated current curves in the ISL8278M datasheet to determine the maximum output current the evaluation board can supply. θ_{JA} is measured by inserting a thermocouple inside the module to measure peak junction temperature.

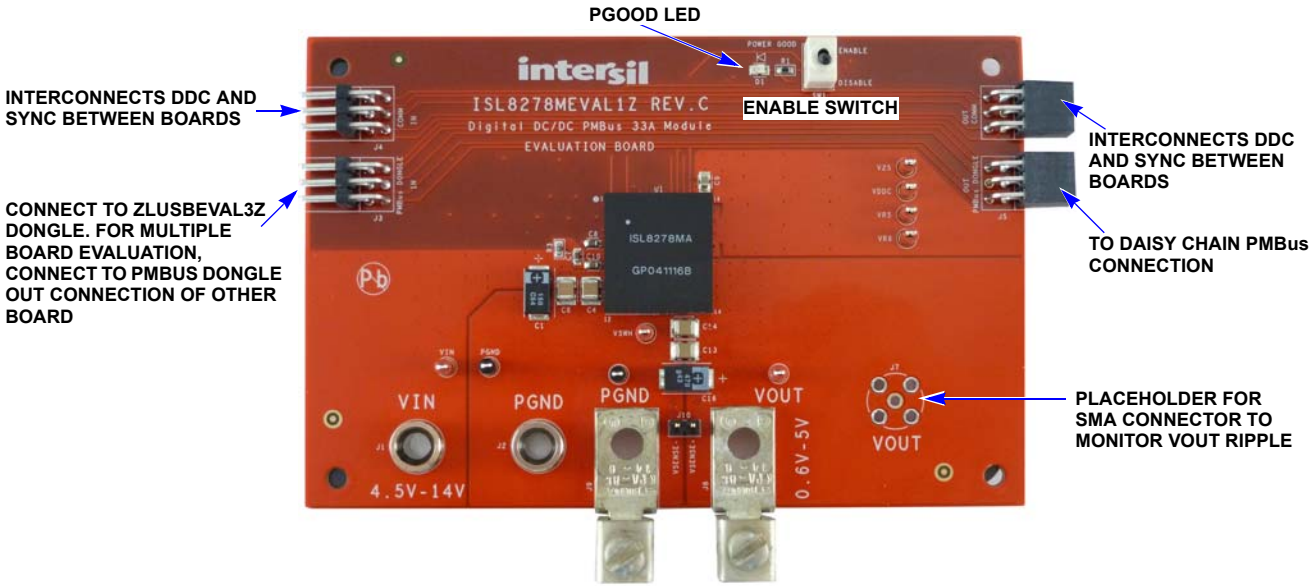

Figure 2. ISL8278MEVAL1Z Evaluation Board (Top Side)

Figure 3. ISL8278MEVAL1Z Evaluation Board (Bottom Side)

3.2 ISL8278MEVAL1Z Board Schematic

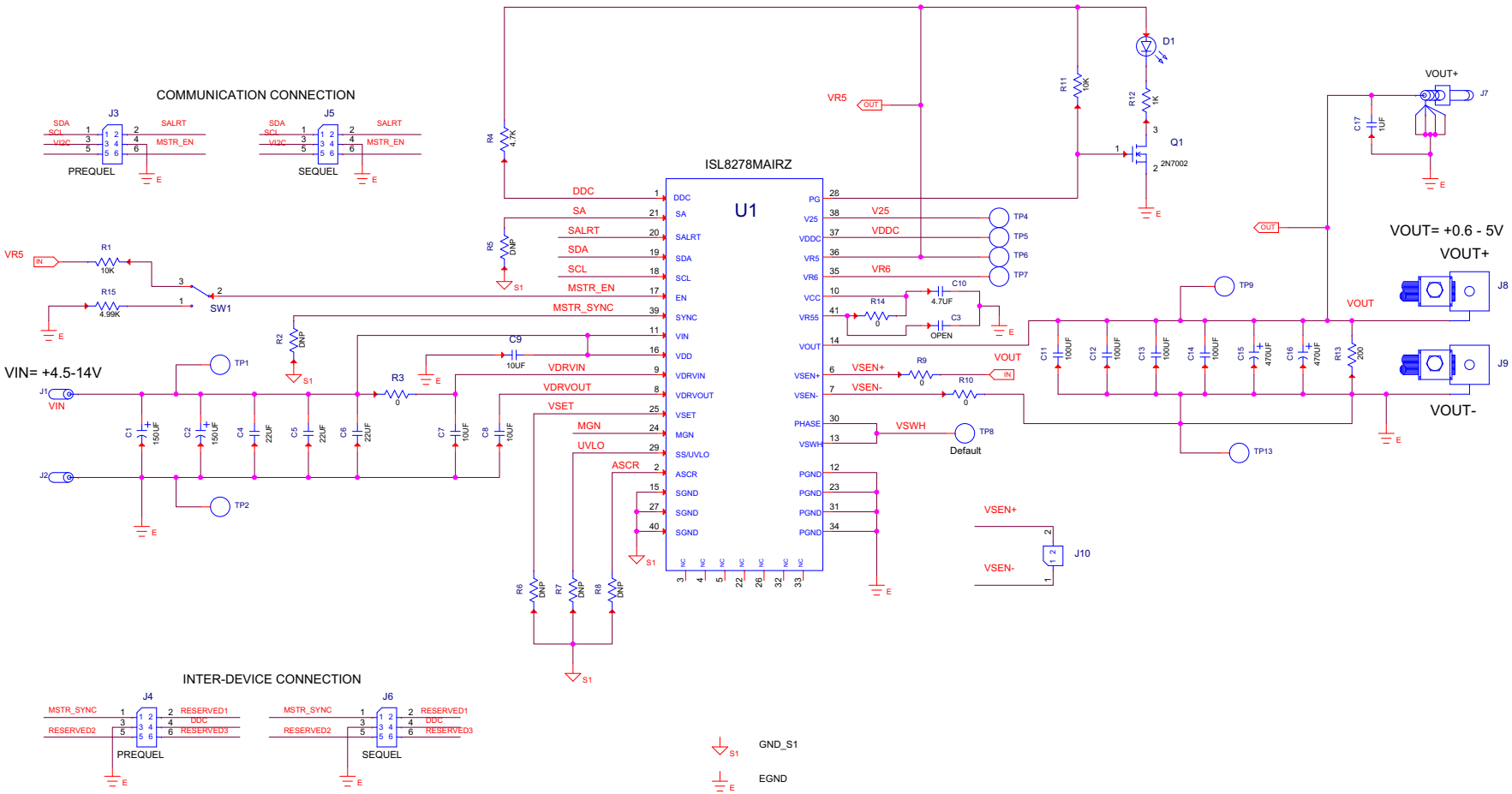

Figure 4. Schematic

3.3 Bill of Materials

Qty	Referencae Designator	Description	Manufacturer	Manufacturer Part
1		PWB-PCB, ISL8278MEVAL1Z, REVC, ROHS	SHENZHEN MULTILAYER PCB TECHNOLOGY CO., LTD	ISL8278MEVAL1ZREVCPCB
3	C4, C5, C6	CAP, SMD, 1210, 22µF, 25V, 10%, X7R, ROHS	MURATA	GRM32ER71E226KE15L
1	C17	CAP, SMD, 0402, 1µF, 6.3V, 10%, X5R, ROHS	PANASONIC	ECJ-0EB0J105K
2	C7, C8	CAP, SMD, 0603, 10µF, 16V, 10%, X5R, ROHS	MURATA	GRM188R61C106KAALD
1	C10	CAP, SMD, 0603, 4.7µF, 16V, 10%, X5R, ROHS	VENKEL	C0603X5R160-475KNE
0	C3	CAP, SMD, 0603, DNP-PLACE HOLDER, ROHS		
1	C9	CAP, SMD, 0805, 10µF, 25V, 10%, X5R, ROHS	TDK	C2012X5R1E106K
4	C11, C12, C13, C14	CAP, SMD, 1210, 100µF, 6.3V, 10%, X5R, ROHS	AVX	12106D107KAT2A
2	C1, C2	CAP-POSCAP, SMD, 7.3x4.3, 150µF, 16V, 20%, 50mΩ, ROHS	SANYO/ PANASONIC	16TQC150MYF
2	C15, C16	CAP-POSCAP, SMD, 7.3x4.3, 470µF, 4V, 20%, 12mΩ, ROHS	PANASONIC/ SANYO	4TPE470MCL
7	TP1, TP4-TP9	CONN-MINI TEST PT, VERTICAL, RED, ROHS	KEYSTONE	5000
2	TP2, TP13	CONN-MINI TEST PT, VERTICAL, BLK, ROHS	KEYSTONE	5001
2	J1, J2	CONN-JACK, MINI BANANA, 0.175 PLUG, NICKEL/BRASS, ROHS	KEYSTONE	575-4
1	J10	CONN-HEADER, 1x2, BRKAWY 1x36, 2.54mm, ROHS	BERG/FCI	68000-236HLF
2	J5, J6	CONN-SOCKET STRIP, TH, 2x3, 2.54mm, TIN, R/A, ROHS	SAMTEC	SSQ-103-02-T-D-RA
2	J3, J4	CONN-HEADER, 2x3, BRKAWY, 2.54mm, TIN, R/A, ROHS	SAMTEC	TSW-103-08-T-D-RA
1	D1	LED, SMD, 0805, GREEN, CLEAR, 10mcd, 2.1V, 20mA, 570nm, ROHS	CHICAGO MINIATURE	CMD17-21VGC/TR8
1	U1	IC-33A DC/DC, PWR MODULE, 40P, HDA, 17X19, ROHS	Renesas	ISL8278MAIRZ
1	Q1	TRANSISTOR, N-CHANNEL, 3LD, SOT-23, 60V, 115mA, ROHS	DIODES, INC.	2N7002-7-F
0	R2, R5, R6, R7, R8	RESISTOR, SMD, 0603, 0.1%, MF, DNP-PLACE HOLDER		
4	R3, R9, R10, R14	RES, SMD, 0603, 0Ω, 1/10W, TF, ROHS	VENKEL	CR0603-10W-000T
1	R12	RES, SMD, 0603, 1k, 1/10W, 1%, TF, ROHS	PANASONIC	ERJ-3EKF1001V
2	R1, R11	RES, SMD, 0603, 10k, 1/10W, 1%, TF, ROHS	VENKEL	CR0603-10W-1002FT
1	R4	RES, SMD, 0603, 4.7k, 1/10W, 1%, TF, ROHS	YAGEO	9C06031A4701FKHFT
1	R15	RES, SMD, 0603, 4.99k, 1/10W, 1%, TF, ROHS	PANASONIC	ERJ-3EKF4991V
1	R13	RES, SMD, 1206, 200Ω, 1/4W, 1%, TF, ROHS	PANASONIC	ERJ-8ENF2000V
1	SW1	SWITCH-TOGGLE, THRU-HOLE, SPDT, 5P, ROHS	ITT CANNON	GT11MCBE
2	J8, J9	HDWARE, MTG, CABLE TERMINAL, 6-14AWG, LUG&SCREW, ROHS	BERG/FCI	KPA8CTP
4	Bottom four corners	BUMPONS, 0.44inW x 0.20inH, DOMETOP, , BLACK	3M	SJ-5003SPBL
1	Place assy in bag	BAG, STATIC, 5X8, ZIPLOC, ROHS	Renesas	212403-013
0	J7	DO NOT POPULATE OR PURCHASE		

3.4 ISL8278MEVAL1Z Board Layout

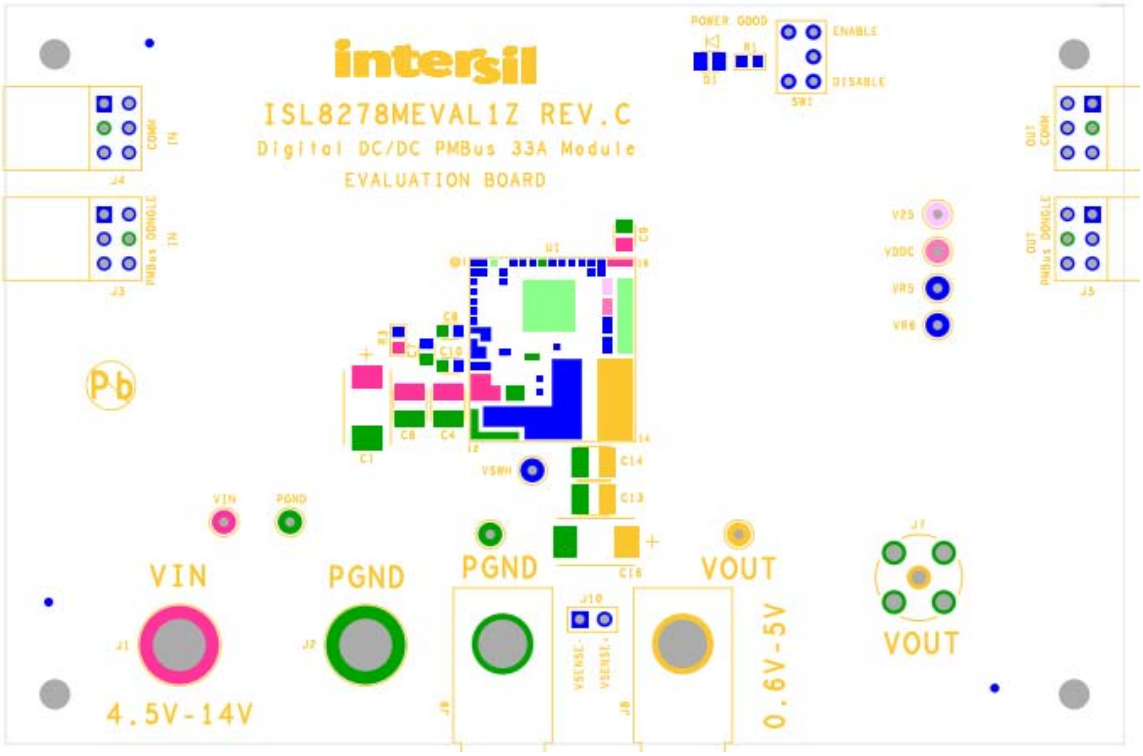

Figure 5. PCB - Top Silk Screen

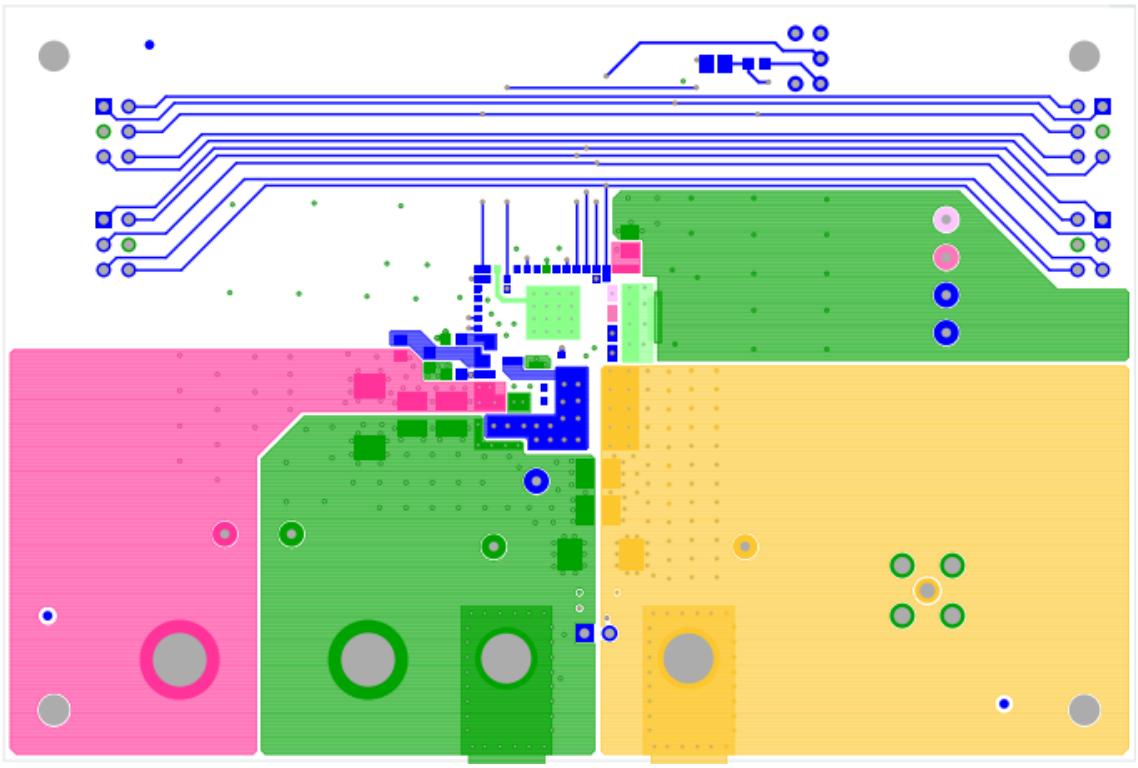

Figure 6. PCB - Top Layer

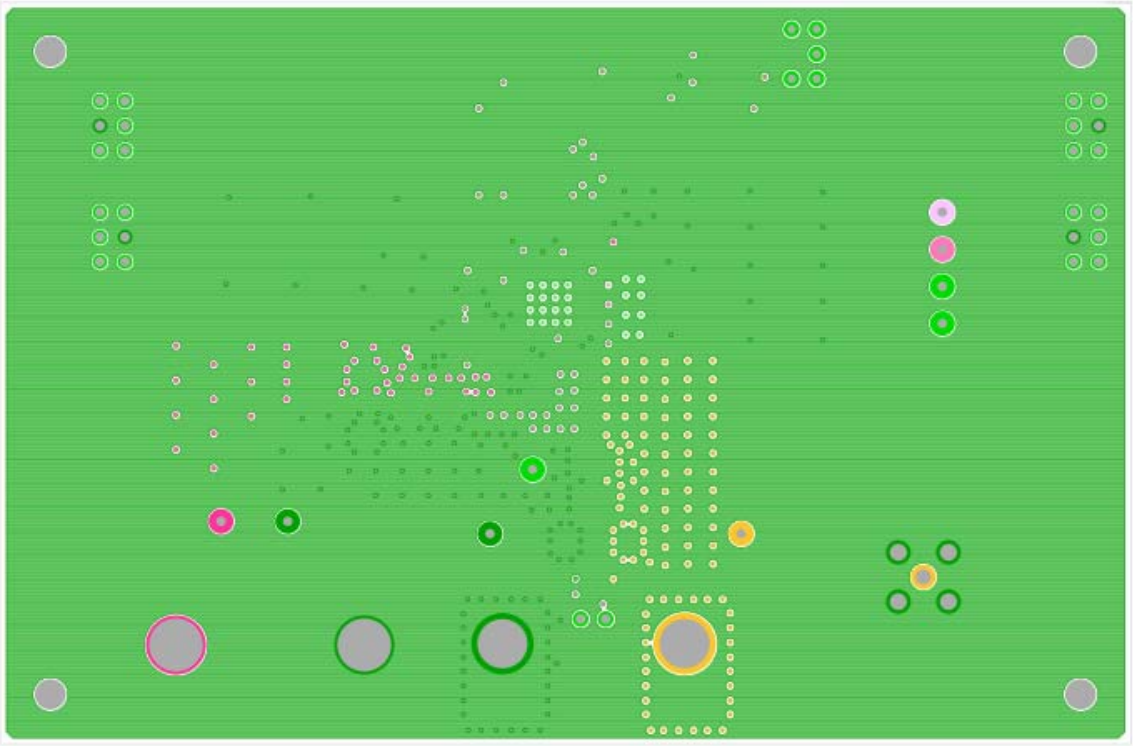

Figure 7. PCB - Inner Layer - Layer 2 (Top View)

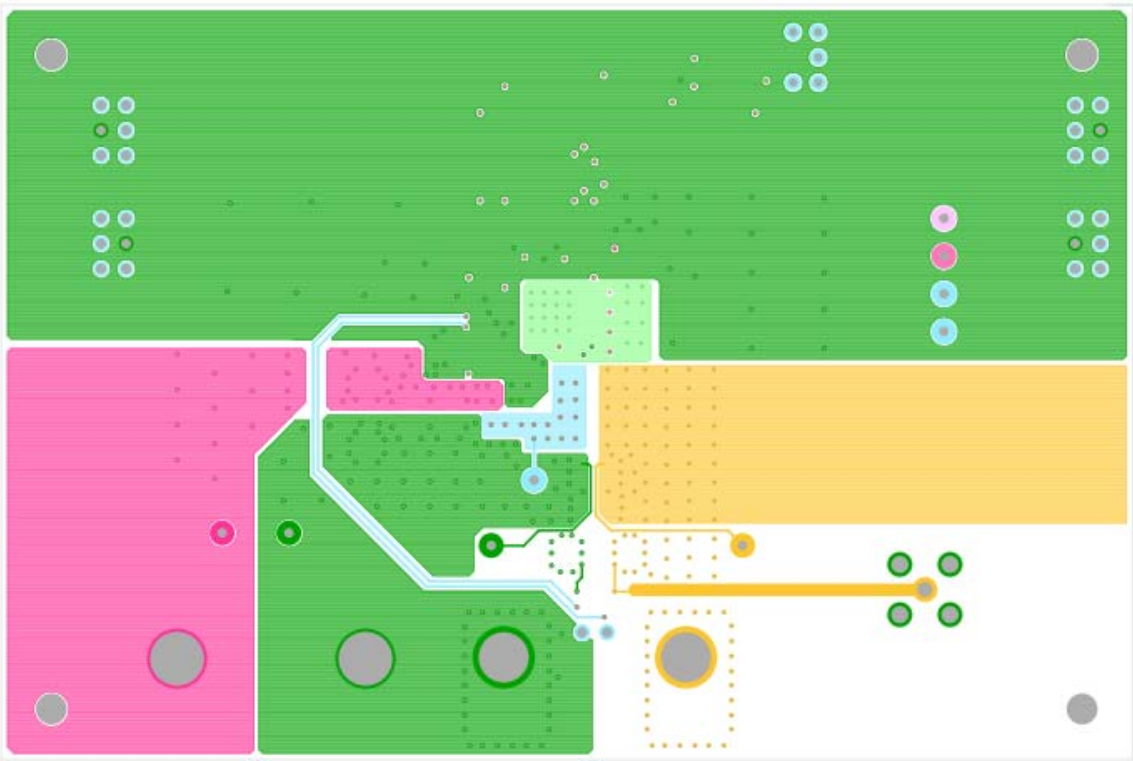

Figure 8. PCB - Inner Layer - Layer 3 (Top View)

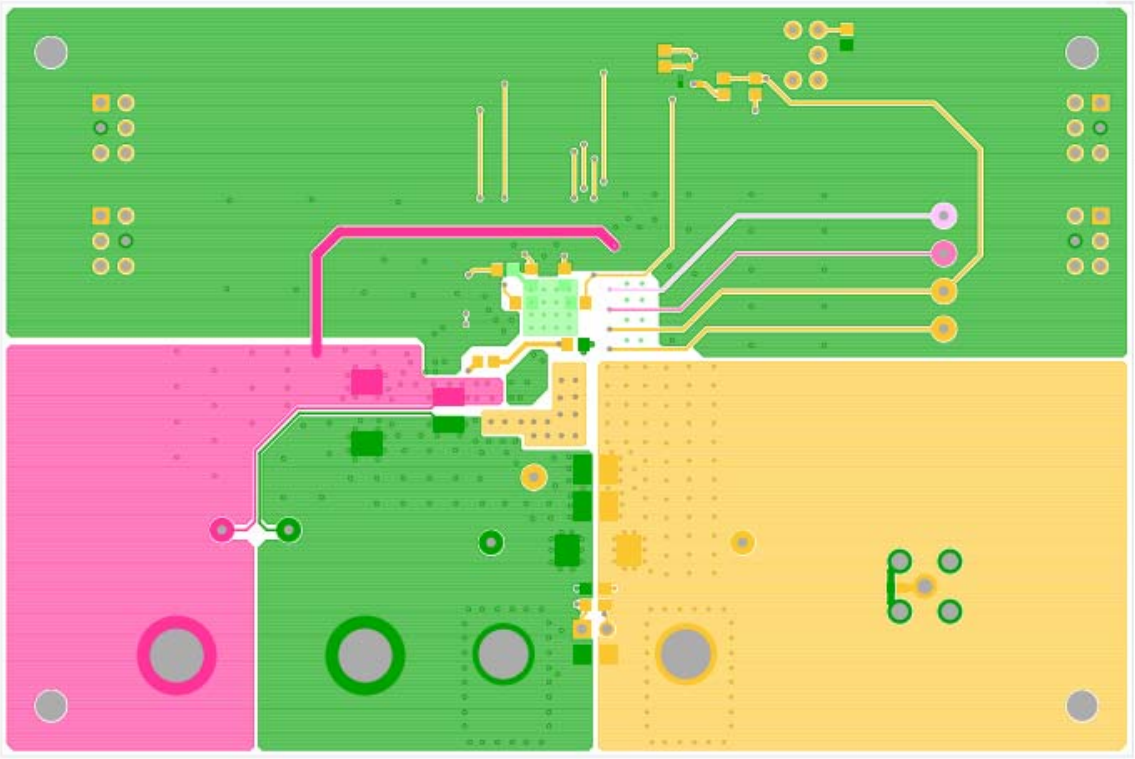

Figure 9. PCB - Bottom Layer (Bottom View)

4. Configuration File

Sample Configuration File for the ISL8278M module. Copy and paste (from RESTORE_FACTORY TO ### End User Store) to a text editor and save it as Confile_file_name.txt. The # symbol is used for a comment line. The following settings are already loaded to ISL8278M module as factory defaults.

```
RESTORE_FACTORY
STORE_USER_ALL
### Begin User Store
RESTORE_USER_ALL
ON_OFF_CONFIG                   0x1A
VOUT_COMMAND                    0x2666      # 1.2 V
VOUT_CAL_OFFSET                 0x0000      # 0 V
VOUT_MAX                        0x2A3C      # 1.32 V
VOUT_MARGIN_HIGH                0x2851      # 1.26 V
VOUT_MARGIN_LOW                 0x247A      # 1.14 V
VOUT_TRANSITION_RATE            0xBA00      # 1 mV/us
VOUT_DROOP                      0x0000      # 0 mV/A
INTERLEAVE                      0x0000
IOUT_CAL_GAIN                   0xB2AE      # 0.67 mV/A
IOUT_CAL_OFFSET                 0x0000      # 0 A
VOUT_OV_FAULT_LIMIT             0x2C28      # 1.38 V
VOUT_OV_FAULT_RESPONSE          0x80
VOUT_OV_WARN_LIMIT              0x2A3C      # 1.32 V
VOUT_UV_FAULT_LIMIT             0x20A3      # 1.02 V
VOUT_UV_FAULT_RESPONSE          0x80
VOUT_UV_WARN_LIMIT              0x228F      # 1.08 V
IOUT_OC_FAULT_LIMIT             0xE280      # 40 A
IOUT_UC_FAULT_LIMIT             0xE57F      # -40.062 A
OT_FAULT_LIMIT                  0xEBE8      # 125 °C
OT_FAULT_RESPONSE               0x80
OT_WARN_LIMIT                   0xEB70      # 110 °C
UT_WARN_LIMIT                   0xDC40      # -30 °C
UT_FAULT_LIMIT                  0xE530      # -45 °C
UT_FAULT_RESPONSE               0x80
POWER_GOOD_ON                   0x228F      # 1.08 V
TON_DELAY                       0xCA80      # 5 ms
TON_RISE                        0xCA80      # 5 ms
TOFF_DELAY                      0xCA80      # 5 ms
TOFF_FALL                       0xCA80      # 5 ms
ISENSE_CONFIG                   0x05
USER_CONFIG                     0x00
DDC_CONFIG                      0x08        # 8 null
POWER_GOOD_DELAY                0xCA00      # 4 ms
ASCR_CONFIG                     0x015A00FA  # ASCR Gain=250, Residual=90
SEQUENCE                        0x0000
TRACK_CONFIG                    0x00
DDC_GROUP                       0x00000000
LEGACY_FAULT_GROUP              0x00000000  # 0 null
MFR_IOUT_OC_FAULT_RESPONSE      0x80
MFR_IOUT_UC_FAULT_RESPONSE      0x80
MFR_VMON_OV_FAULT_LIMIT         0xCB00      # 6 V
MFR_VMON_UV_FAULT_LIMIT         0xCA00      # 4 V
FREQUENCY_SWITCH                0x0215      # 533 kHz
VIN_OV_FAULT_LIMIT              0xD3A0      # 14.5 V
VIN_OV_FAULT_RESPONSE           0x80
VIN_OV_WARN_LIMIT               0xD343      # 13.047 V
VIN_UV_WARN_LIMIT               0xCA79      # 4.945 V
VIN_UV_FAULT_LIMIT              0xCA40      # 4.5 V
VIN_UV_FAULT_RESPONSE           0x80
MFR_ID
MFR_MODEL
MFR_REVISION
MFR_LOCATION
MFR_DATE
MFR_SERIAL
USER_DATA_00
DDC_ENG                         0x0A5A
SYNC_CONFIG                     0x00
STORE_USER_ALL
### End User Store
```

5. Measured Data

The following data was acquired using an ISL8278MEVAL1Z evaluation board.

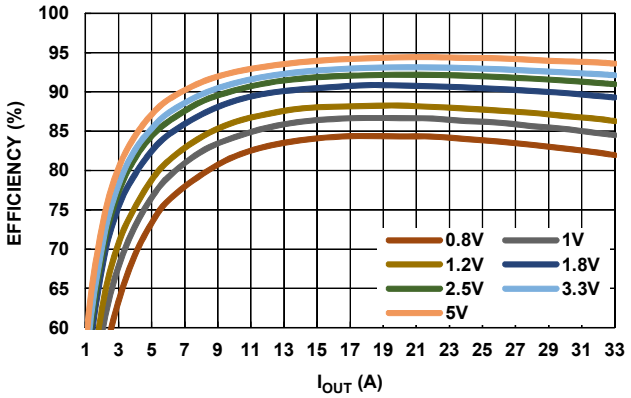

Figure 10. Efficiency vs output Current at V_{IN} = 12V and f_{SW} = 533kHz for Various Output Voltages

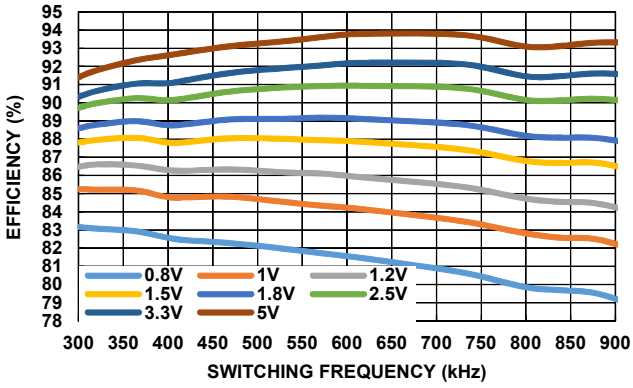

Figure 11. Efficiency vs Switching Frequency at V_{IN} = 12V and I_{OUT} = 33A for Various Output Voltages

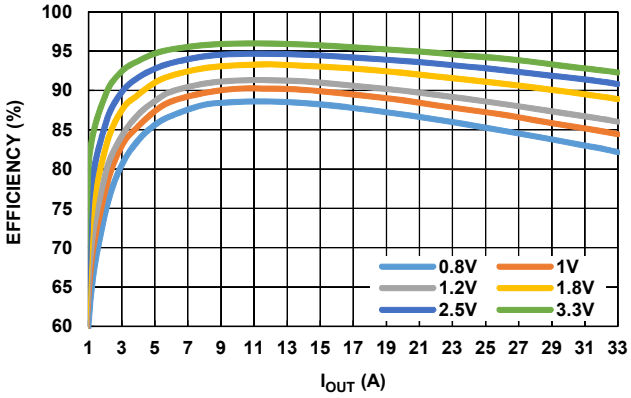

Figure 12. Efficiency vs Output Current at V_{IN} = 5V and f_{SW} = 533kHz for Various Output Voltages

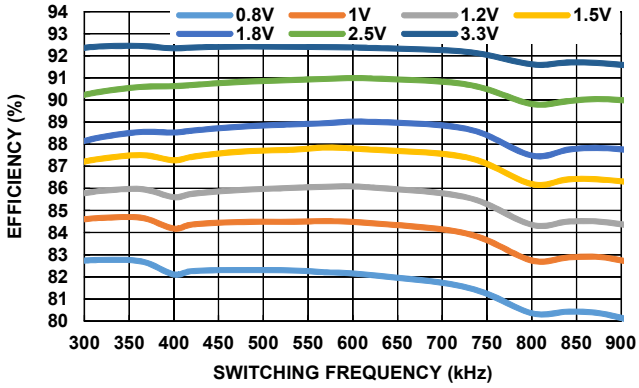

Figure 13. Efficiency vs Switching Frequency at V_{IN} = 5V and I_{OUT} = 33A for Various Output Voltages

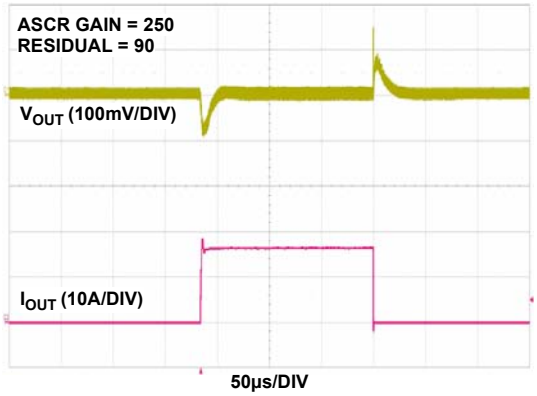

Figure 14. 12V_{IN} to 1.2V_{OUT} Transient Response, f_{SW} = 533kHz, C_{OUT} = 4x100µF Ceramic + 2x470µF POSCAP

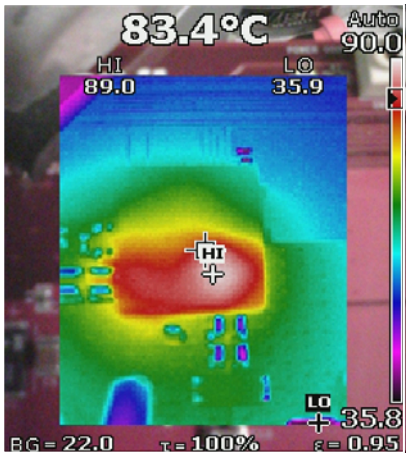

Figure 15. Thermal Image, 12V_{IN} to 1V_{OUT}, I_{OUT} = 33A, T_A = +25°C, f_{SW} = 550kHz, No Air Flow

6. ISL8278MEVAL1Z Revision History

Rev.	Date	Description
0.00	Jul 31, 2017	Initial release

Notice

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(Rev.4.0-1 November 2017)

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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

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