RENESAS

ZL9024MEVAL1Z

User's Manual: Evaluation Board

Industrial Analog and Power

RENESAS

Rev 0.00   Jan 2018

ZL9024MEVAL1Z

Evaluation Board

1. Overview

The ZL9024M is a 33A step-down DC/DC power supply module with an integrated digital PWM controller, single-phase synchronous power switches, inductors, and passives. Only input/output capacitors and minimal passives are needed to finish the design. 33A of continuous output current can be delivered without the need for airflow or a heatsink. The ZL9024M uses ChargeMode™ control (ASCR) architecture, which responds to a transient load within a single switching cycle.

The ZL9024MEVAL1Z evaluation board is a 3in x 4.5in 6-layer FR4 board with 2oz. copper on surface layers and 1oz. copper on buried layers. This evaluation board comes with placeholders for pin-strap resistor population to adjust output voltage, switching frequency, and device PMBus™ address. More configurations, such as sequencing, Digital-DC™ (DDC) bus configuration and fault limits can be easily programmed or changed through the PMBus compliant serial bus interface.

The optional 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. The ZL9024MEVAL1Z can operate in pin-strap mode without needing the ZLUSBEVAL3Z adapter or PMBus communication.

1.1 Key Features

- V_{IN} range of 2.75V to 4V, V_{OUT} adjustable from 0.6V to 1.5V
- Programmable V_{OUT}, margining, input and output UVP/OVP, I_{OUT} limit, OTP/UTP, soft-start/stop, sequencing, and external synchronization
- Monitor: V_{IN}, V_{OUT}, V_{DRV}, 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} = 2.75V to 4V
- V_{OUT} = 1.2V
- I_{MAX} = 33A
- f_{SW} = 533kHz
- ASCR gain = 600, ASCR residual = 80
- On/off delay = 5ms; On/off ramp time = 5ms

1.3 Ordering Information

Part Number	Description
ZL9024MEVAL1Z	ZL9024M evaluation board, ZLUSBEVAL3Z adapter, USB cable

1.4 Related Literature

- For a full list of related documents, visit our website
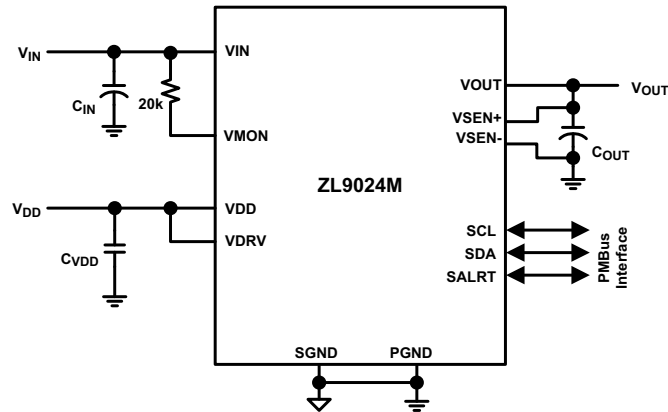   - ZL9024M product page

Figure 1. ZL9024MEVAL1Z Block Diagram

1.5   Recommended Equipment

• DC power supply with two channels or two separate DC power supplies with minimum 6V/20A sourcing capacity and 6V/0.5A sourcing capabilities, respectively

• Electronic load capable of sinking current up to 33A

• Digital Multimeters (DMMs)

• Oscilloscope with higher than 100MHz bandwidth

2.　Functional Description

The ZL9024MEVAL1Z provides all circuitry required to evaluate the features of the ZL9024M. A majority of the features of the ZL9024M, 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 Intersil digital module evaluation board that supports the DDC bus.

Figure 3 on page 8 and Figure 4 on page 9 show the ZL9024MEVAL1Z evaluation board.

2.1　Operating Range

By default, the ZL9024M is configured to operate at V_{OUT} = 1.2V, f_{SW} = 533kHz. V_{IN} ranges can be from 2.75V to 4V. The board can also support a wider operating range to meet the requirements of specific applications. V_{OUT} can be adjusted from 0.6V to 1.5V. The load current range is from 0A to 33A. The f_{SW} and output voltage can also be tuned. However, to ensure sufficient stability margins, switching frequency and output capacitors can be selected using the "ZL9024M Design Guide Matrix and Output Voltage Response" table in the ZL9024M datasheet.

The ZL9024MEVAL1Z is capable of handling a 0A to 33A output current transient, in which the slew rate is less than 2A/μs, such as electronic load. If the slew rate exceeds 2A/μs, 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 for more information.

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　Quick Start Guide

2.2.1　Pin-Strap Option

The ZL9024MEVAL1Z can be configured in pin-strap mode with standard 1% 0603 resistors. The PMBus interface is not required to evaluate the ZL9024MEVAL1Z in pin-strap mode. Output voltage (V_{OUT}), switching frequency (f_{SW}), and the device PMBus address can be changed by populating recommended resistors at placeholders provided in the evaluation board. By default, the evaluation board operates in pin-strap mode and regulates at V_{OUT} = 1.2V, f_{SW} = 533kHz, and PMBus address = 28h. Complete the following steps to evaluate the ZL9024MEVAL1Z in pin-strap mode.

(1)　Set the ENABLE switch to "DISABLE".

(2)　Connect the load to the VOUT lug connectors (J7 and J8).

(3)　Connect the power supply to the VIN connectors (J3 and J4). Make sure the power supply is not enabled when making the connections.

(4)　Connect the VDD voltage supply to the VDD connectors (J9 and J10). Make sure the power supply is not enabled when making the connections.

(5)　Turn on the VIN power supply first, then turn on the VDD power supply.

(6)　Set the ENABLE switch to "ENABLE".

(7)　Measure 1.2V V_{OUT} at the probe point labeled "VOUT" (J16).

(8)　Observe the switching frequency of 533kHz at the probe points labeled "VSWH" (J15).

(9)　To change $V_{OUT,}$ disconnect the board from the setup and populate a 1% standard 0603 resistor at the R6 placeholder location on the bottom layer. Refer to the "Output Voltage Resistor Settings" table in the ZL9024M datasheet for recommended values. By default, VOUT_MAX is set to 110% of V_{OUT} set by the pin-strap resistor.

(10)　To change the switching frequency, disconnect the board from the setup and populate a 1% standard 0603 resistor at the R2 placeholder location on the bottom layer. Refer to the "Switching Frequency Resistor Settings" table in the ZL9024M datasheet for recommended values.

2.2.2   PMBus Option

The ZL9024MEVAL1Z can be evaluated for all features using the provided ZLUSBEVAL3Z dongle and PowerNavigator evaluation software. PowerNavigator tutorial videos are available at www.intersil.com/powernavigator. Complete the following steps to evaluate the ZL9024MEVAL1Z with the PMBus option.

(1) Install PowerNavigator software from the following website: www.intersil.com/powernavigator.

(2) Set the ENABLE switch to "DISABLE".

(3) Connect the load to the VOUT lug connectors (J7 and J8).

(4) Connect the power supply to the VIN connectors (J3 and J4). Make sure the power supply is not enabled when making the connections.

(5) Connect the VDD voltage supply to the VDD connectors (J9 and J10). Make sure the power supply is not enabled when making the connections.

(6) Connect the ZLUSBEVAL3Z dongle (USB to PMBus adapter) to the ZL9024MEVAL1Z board using the 6-pin male connector labeled "PMBus DONGLE IN".

(7) Turn the power supply on.

(8) Connect the supplied USB cable from the computer USB port to the ZLUSBEVAL3Z dongle.

(9) Start PowerNavigator.

(10) It is optional to load a predefined setup from a configuration file using PowerNavigator. The ZL9024M device on the board operates in pin-strap mode from factory default, 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 7 is provided and can be copied to a plain text editor to make desired changes. The default pin-strap configurations will be overwritten if a user-defined configuration file is loaded.

(11) Set the ENABLE switch to "ENABLE". Alternatively, the PMBus ON_OFF_CONFIG and OPERATION commands may be used from PowerNavigator to allow PMBus Enable.

(12) Monitor and configure the ZL9024MEVAL1Z board using the PMBus commands in the evaluation software. To store the configuration changes, disable the module and use the command STORE_USER_ALL. To restore factory default settings, disable the module and use the command RESTORE_FACTORY and STORE_USER_ALL.

(13) For sequencing with the Digital-DC Bus (DDC) or to evaluate multiple Renesas digital power products using a single ZLUSBEVAL3Z dongle, the ZL9024M can be daisy chained with other digital power evaluation boards. The PMBus address can be changed by placing a 1% standard 0603 resistor at the R_4 placeholder location on the bottom layer. Refer to the "SMBus Address Resistor Selection" table in the ZL9024M datasheet for recommended values.

3.   Evaluation Board Information

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.

3.1   V$_{OUT}$ Transient Response Check

The ZL9024MEVAL1Z board has a built-in transient load test circuit (see the schematic in Figure 2) allowing transient load with a high slew rate. A 100A N-Channel MOSFET (Manufacturer PN: BSC010NE2LSI) is connected across VOUT and PGND next to the remote voltage sensing location. A 10mΩ current-sense resistor R$_{16}$ is used to monitor the drain-to-source current of the MOSFET. For a transient load test, inject the gate drive pulse signal at J12. The load current can be monitored through J13. Because the MOSFET will operate in the saturation region instead of the linear region when the gate turn-on signal is applied, the pulse width and duty cycle of the gate signal must be limited small enough to avoid MOSFET overheating (recommended duty cycle should be less than 2%). The amplitude of the gate driver pulse voltage can be adjusted to obtain a desired transient load current step size.
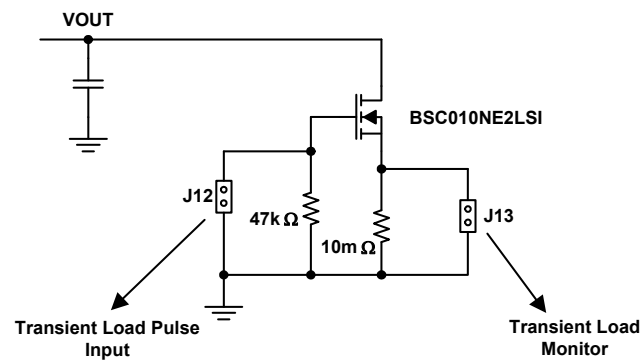
Figure 2. Schematic for Transient Load Measurement

3.2   Thermal Considerations and Current Derating

Board layout is critical to make the module operate safely and deliver maximum allowable power. To work in the 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 ZL9024MEVAL1Z evaluation board is designed to run at 33A at room temperature without additional cooling systems needed. 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 ZL9024M 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.

4. Configuration File

The following is a sample configuration file for the ZL9024M. Copy and paste (from RESTORE_FACTORY TO ### End User Store) to a plain text file and save it as **Confile_file_name.txt**. The # symbol is used for a comment line. The following settings are already loaded to ZL9024M as factory defaults.

```
RESTORE_FACTORY                                            # Resets device to the factory setting
STORE_USER_ALL                                             # Clears user memory space
### Begin User Store
RESTORE_USER_ALL
ON_OFF_CONFIG                     0x17                      # Pin Enable, Immediate Off
VOUT_COMMAND                     0x2666                     # 1.2V
VOUT_CAL_OFFSET                  0x0000                     # 0V
VOUT_MAX                         0x2A3C                     # 1.32V
VOUT_MARGIN_HIGH                 0x2851                     # 1.26V
VOUT_MARGIN_LOW                  0x247A                     # 1.14V
VOUT_TRANSITION_RATE             0xBA00                     # 1V/ms
VOUT_DROOP                       0x0000                     # 0mV/A
INTERLEAVE                       0x0000                     # Configures phase offset between devices
IOUT_CAL_GAIN                    0xB29A                     # 0.65mV/A
IOUT_CAL_OFFSET                  0x0000                     # 0A
VOUT_OV_FAULT_LIMIT              0x2C28                     # 1.38V
VOUT_OV_FAULT_RESPONSE           0x80                       # Disable and no retry
VOUT_OV_WARN_LIMIT               0x2A3C                     # 1.32V
VOUT_UV_FAULT_LIMIT              0x20A3                     # 1.02V
VOUT_UV_FAULT_RESPONSE           0x80                       # Disable and no retry
VOUT_UV_WARN_LIMIT               0x228F                     # 1.08V
IOUT_OC_FAULT_LIMIT              0xE341                     # 52.062A
IOUT_UC_FAULT_LIMIT              0xE58F                     # -39.062A
OT_FAULT_LIMIT                   0xEB98                     # 115 °C
OT_FAULT_RESPONSE                0x80                       # Disable and no retry
OT_WARN_LIMIT                    0xEB48                     # 105 °C
UT_WARN_LIMIT                    0xE580                     # -40 °C
UT_FAULT_LIMIT                   0xE4E0                     # -50 °C
UT_FAULT_RESPONSE                0x80                       # Disable and no retry
POWER_GOOD_ON                    0x228F                     # 1.08V
TON_DELAY                        0xCA80                     # 5ms
TON_RISE                         0xCA80                     # 5ms
TOFF_DELAY                       0xCA80                     # 5ms
TOFF_FALL                        0xCA80                     # 5ms
ISENSE_CONFIG                    0x25                       # 256ns Blanking time, Mid-Range
USER_CONFIG                      0x00                       # Open Drain PG, XTEMP Disabled
DDC_CONFIG                       0x0800                     # Default value determined by PMBus address
POWER_GOOD_DELAY                 0xBA00                     # 1ms
ASCR_CONFIG                      0x01500258                 # ASCR gain = 600, Residual = 80
SEQUENCE                         0x0000                     # 533kHz
DDC_GROUP                        0x00000000                 # All broadcast disabled
MFR_IOUT_OC_FAULT_RESPONSE       0x80                       # Disable and no retry
MFR_IOUT_UC_FAULT_RESPONSE       0x80                       # Disable and no retry
IOUT_AVG_OC_FAULT_LIMIT          0xE280                     # 40A
IOUT_AVG_UC_FAULT_LIMIT          0xDC40                     # -30A
FREQUENCY_SWITCH                 0x0215                     # 533kHz
MFR_ID
MFR_MODEL
MFR_REVISION
MFR_LOCATION
MFR_DATE
MFR_SERIAL
LEGACY_FAULT_GROUP               0x00000000
USER_DATA_00
SYNC_CONFIG                      0x00                       # Use Pin-strap for fSW setting
VIN_OV_FAULT_LIMIT               0xCA40                     # 4.5V
VIN_UV_FAULT_LIMIT               0xC266                     # 2.398V
VIN_OV_FAULT_RESPONSE            0x80                       # Disable and no retry
VIN_UV_FAULT_RESPONSE            0x80                       # Disable and no retry
STORE_USER_ALL                                             # Store all above settings to NVRAM
### End User Store
```

5.   PCB Layout Guidelines

5.1   ZL9024MEVAL1Z Evaluation Board

Interconnects DDC and SYNC Between Boards

Connect to ZLUSBEVAL3Z Dongle for PMBus option. For Multiple Board Evaluation, Connect to PMBus DONGLE OUT Connection of Other Board

PGOOD LED

ENABLE Switch

Interconnects DDC and SYNC Between Boards

To Daisy Chain PMBus Connection

VOUT Regulation Monitor
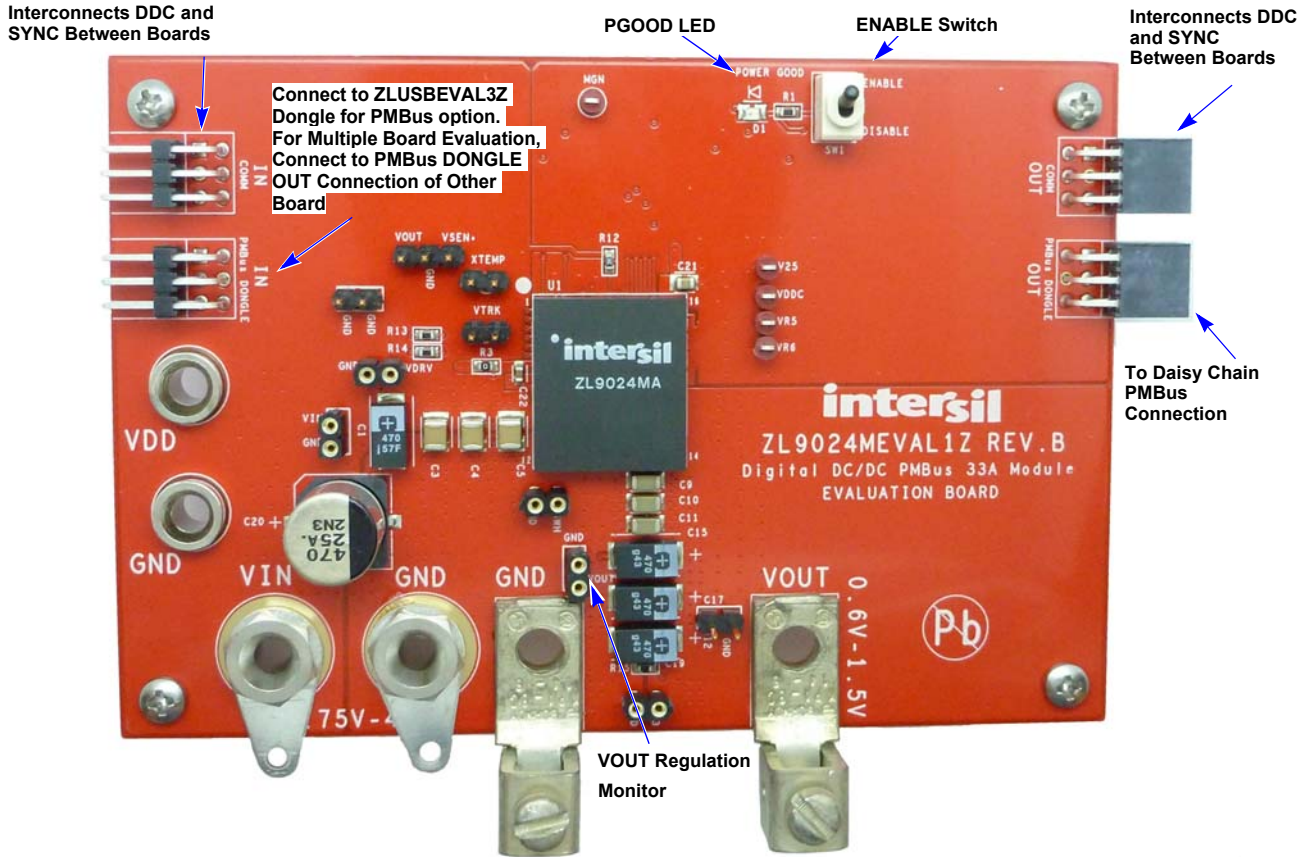
Figure 3. ZL9024MEVAL1Z Evaluation Board Top Side

Placeholders for Pin-Strap Resistors
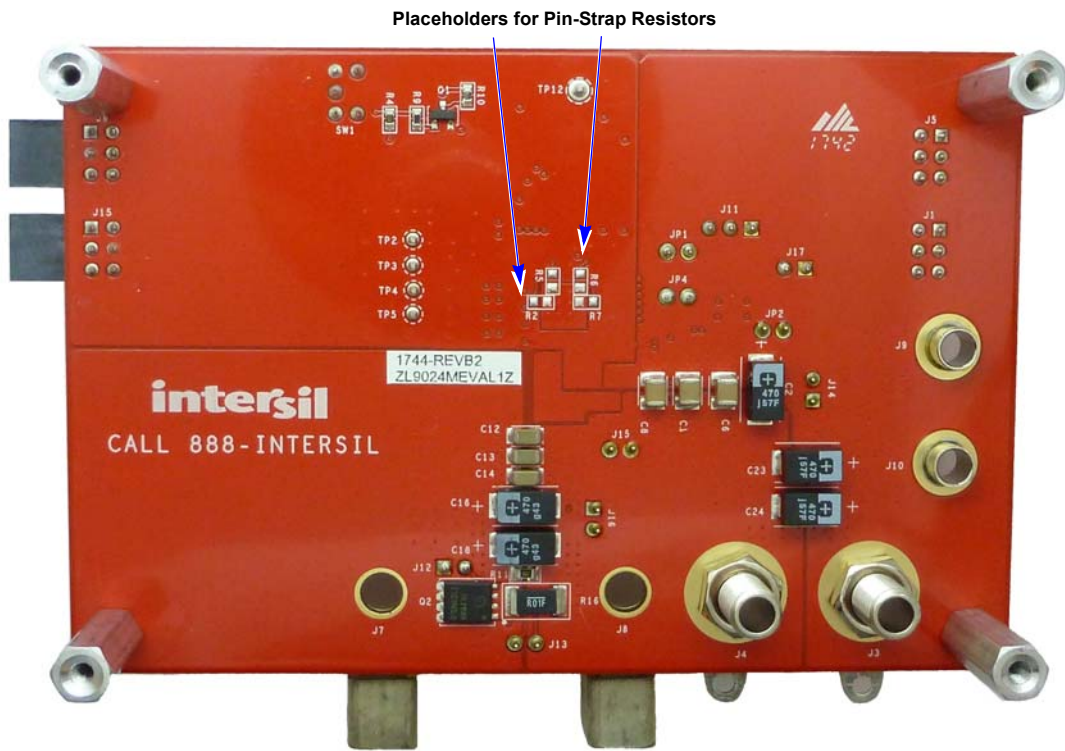
Figure 4. ZL9024MEVAL1Z Evaluation Board Bottom Side

5.2 ZL9024MEVAL1Z Circuit Schematic
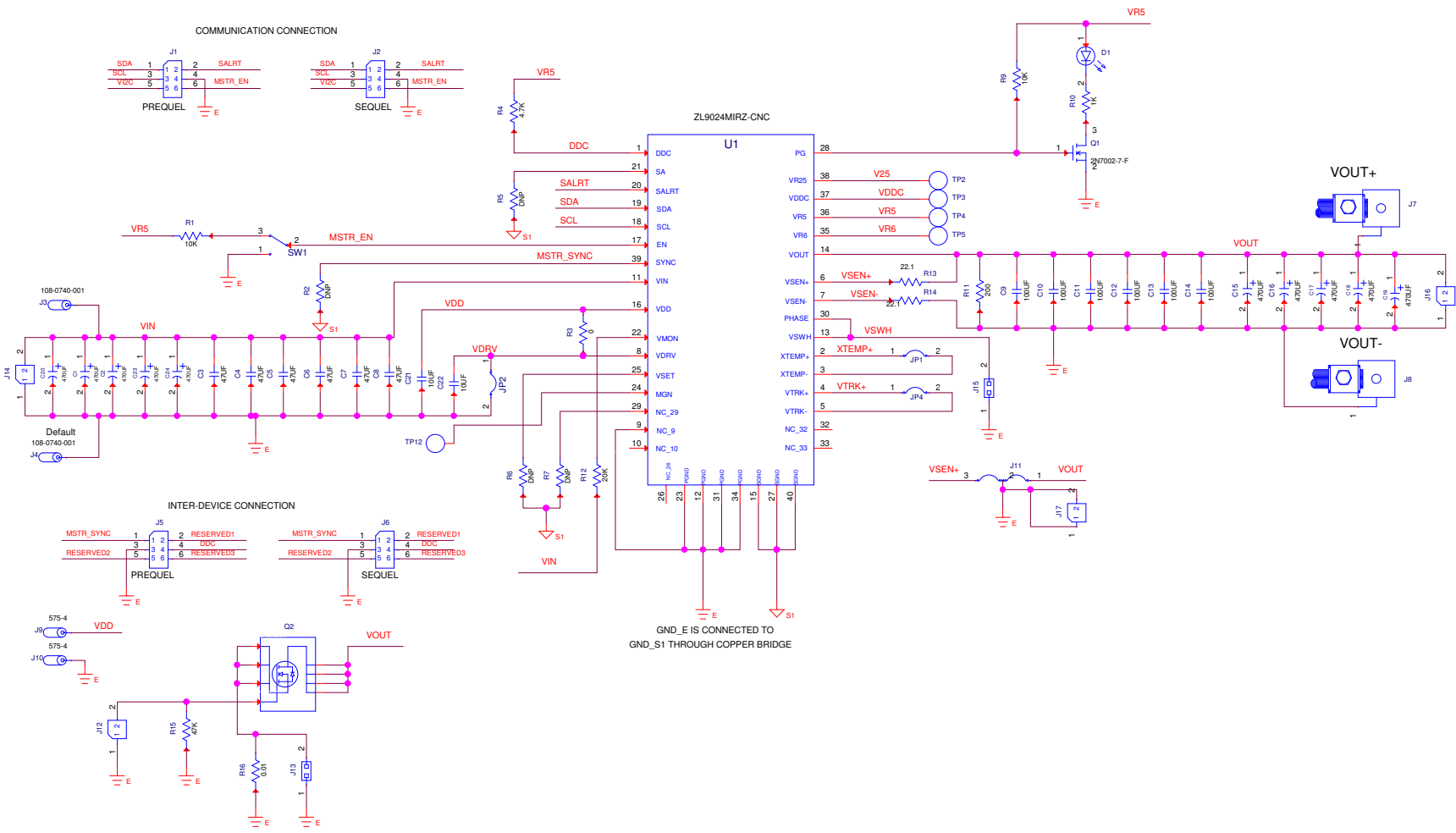
Figure 5. Schematic

5.3   Bill of Materials

Qty	Reference Designators	Description	Mfr	Manufacturer Part Number
4	C1, C2, C3, C4	CAP TANT POLY 470µF 6.3V 2917	Panasonic	6TPF470MAH
5	C15 - C19	CAP TANT POLY 470µF 4V 2917	Panasonic	4TPE470MCL
1	C20	CAP ALUM 470µF 20% 25V SMD	Panasonic	EEE-1EA471P
1	C21	CAP CER 10µF 25V X5R 0805	Murata	GRM21BR61E106KA73L
1	C22	CAP CER 10µF 10V X5R 0603	Taiyo Yuden	LMK107BJ106MALTD
6	C9 - C14	CAP CER 100µF 6.3V X5R 1206	Murata	GRM31CR60J107ME39L
6	C3 - C8	CAP CER 47µF 16V X5R 1210	Murata	GRM32ER61C476KE15L
1	R3	RES SMD 0Ω JUMPER 1/10W 0603	Yageo	RC0603JR-070RL
1	R10	RES SMD 1KΩ 1% 1/10W 0603	Yageo	RC0603FR-071KL
2	R1, R9	RES SMD 10KΩ 1% 1/10W 0603	Yageo	RC0603FR-0710KL
1	R12	RES SMD 20KΩ 1% 1/10W 0603	Yageo	RC0603FR-0720KL
2	R13, R14	RES SMD 22.1Ω 1% 1/10W 0603	Yageo	RC0603FR-0722R1L
1	R4	RES SMD 4.7KΩ 1% 1/10W 0603	Panasonic	ERJ-3EKF4701V
1	R15	RES SMD 47KΩ 1% 1/10W 0603	Yageo	RC0603FR-0747KL
1	R16	RES SMD 10 MΩ 1% 2W 2512	Vishay	WSL2512R0100FEA18
1	R11	RES SMD 200Ω 1% 1/8W 0805	Yageo	RC0805FR-07200RL
2	J3, J4	THREADED MOUNTING Standard Type Banana Jack	Clinch Connectivity	108-0740-001
1	J11	3 Positions Header, Unshrouded Connector 0.100" (2.54mm) Through Hole Gold	Amphenol	68000-103HLF
5	J13 - J16, JP2	2 Positions Receptacle Socket, Unshrouded Connector 0.100" (2.54mm) Through Hole Gold	Mil-Max	310-93-164-41-001000
2	J7, J8	HDWARE,MTG,CABLE TERMINAL,6-14AWG, LUG&SCREW, ROHS	Burndy	KPA8CTP
2	J2, J6	6 Pin Female Right Angle Header 2.54mm x 2.54mm (.100)	Samtec	SSQ-103-02-T-D-RA
5	TP2 - TP5, TP12	Miniature Red Test Point .100 Pad .040 Thole	Keystone	5000
2	J9, J10	SOLDER MOUNT BANANA PLUG	Keystone	575-4
2	J1,J5	6 Pin Male Right Angle Header 2.54mm x 2.54mm (.100)	Samtec	TSW-103-08-T-D-RA
4	J12, J17, JP1, JP4	CONN HEADER 2POS VERT T/H	Amphenol FCI	77311-118-02LF
1	Q1	MOSFET N-CH 60V 115MA SOT23-3	Diodes	2N7002-7-F
1	Q2	MOSFET N-CH 25V 38A TDSON-8	Infineon	BSC010NE2LSI
1	D1	LED GREEN CLEAR 0805 SMD	Visual Communication	CMD17-21VGC/TR8
1	U1	Digital DC/DC PMBus 33A MODULE	Renesas	ZL9024MAIRZ
1	SW1	SWITCH TOGGLE SPDT 0.4VA 20V	C&K	GT11MCBE

5.4   Board Layout
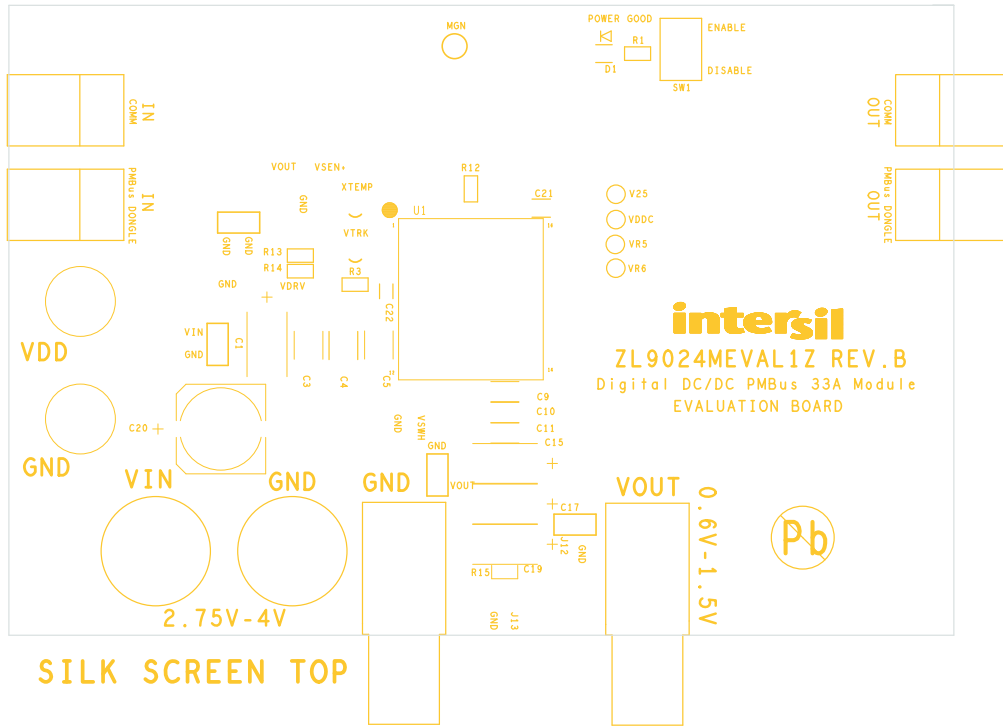
Figure 6. Silkscreen Top
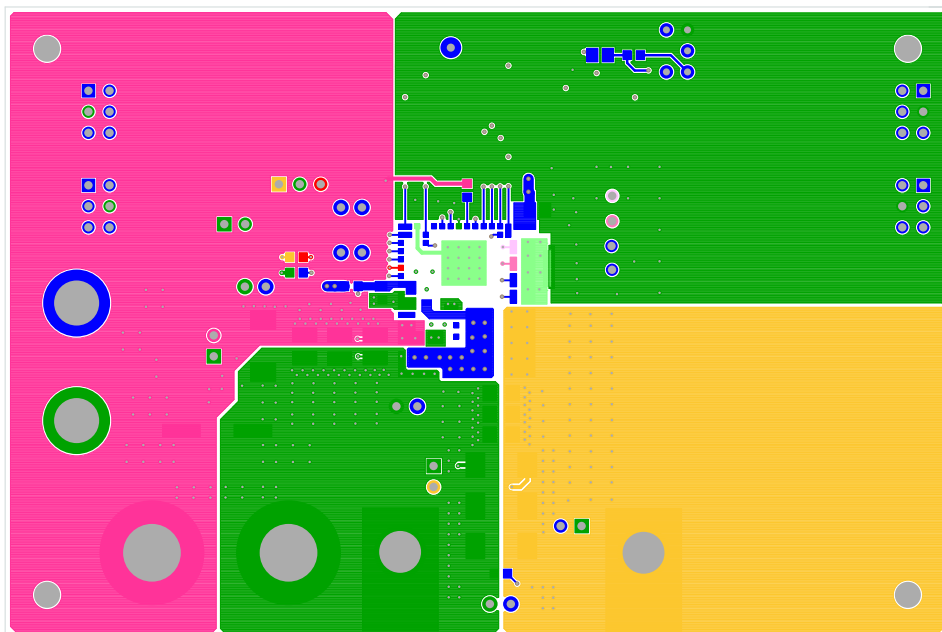
Figure 7. Top Layer
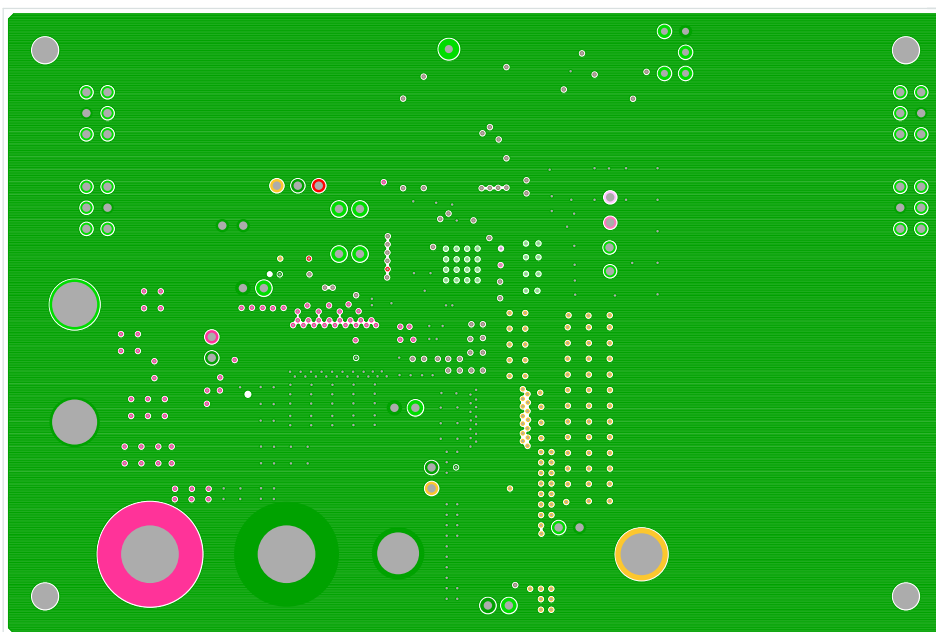
Figure 8. Layer 2
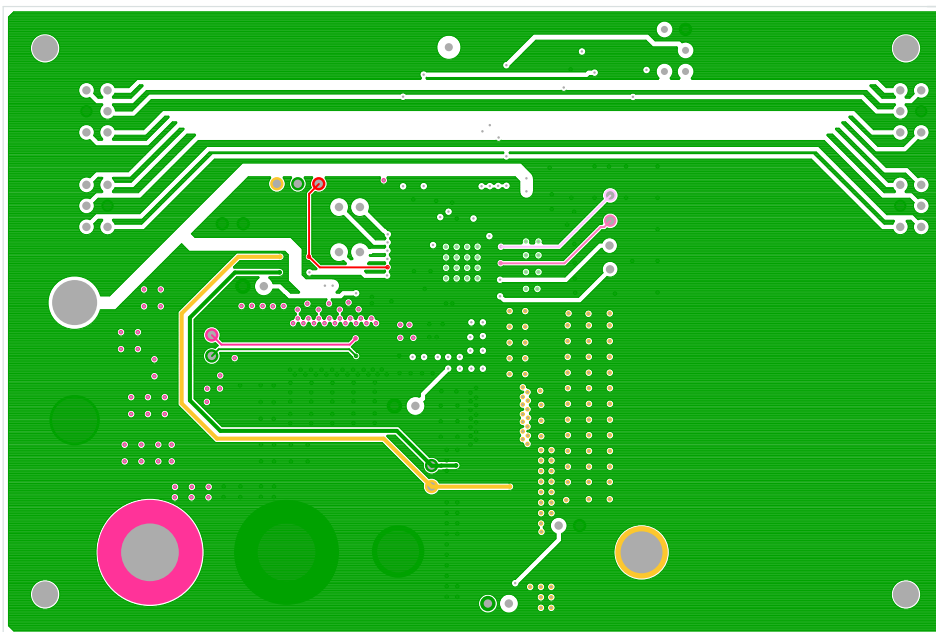
Figure 9. Layer 3
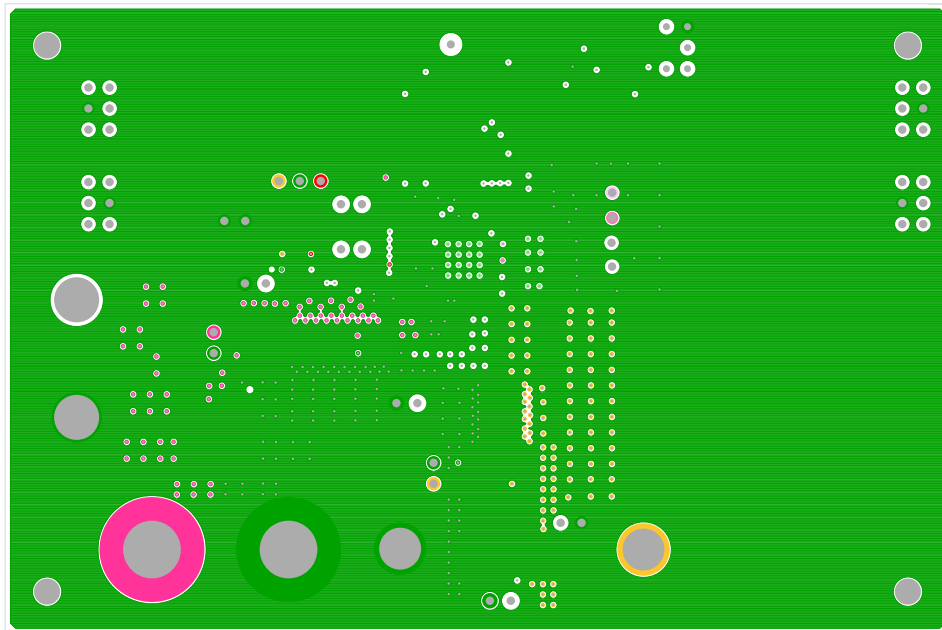
Figure 10. Layer 4
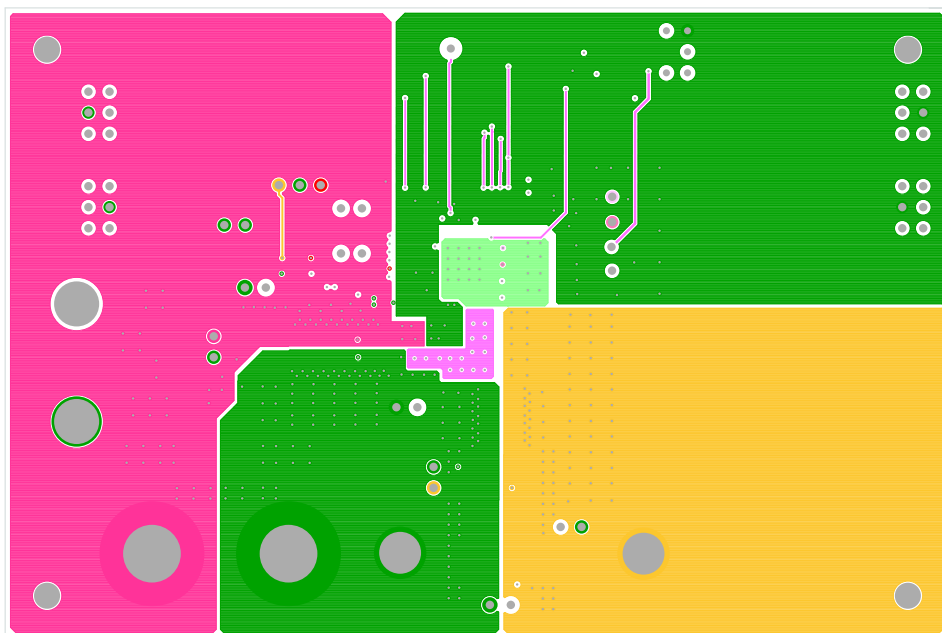
Figure 11. Layer 5
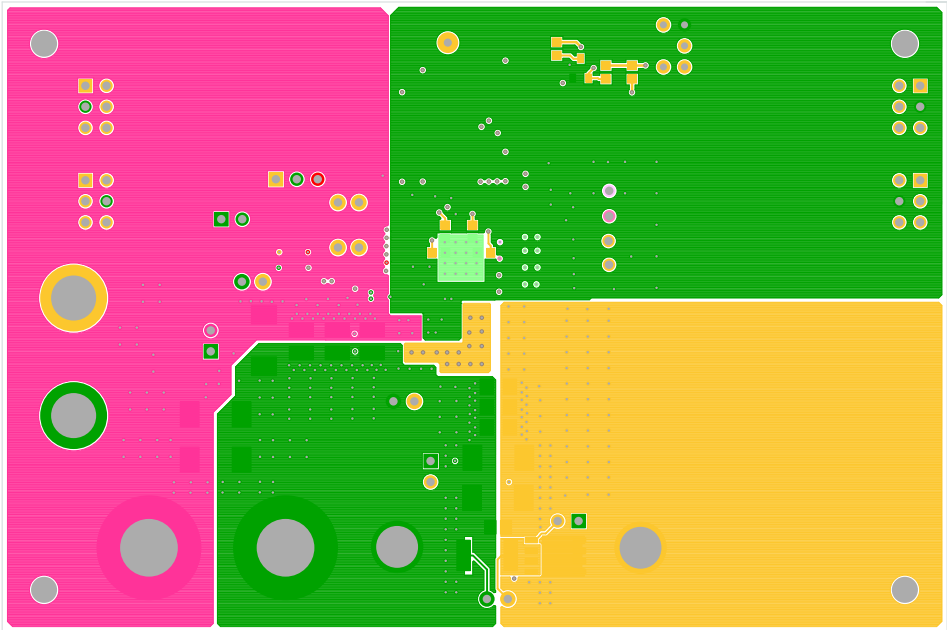
Figure 12. Bottom Layer

6. Typical Performance Curves

The following data was acquired using a ZL9024MEVAL1Z evaluation board.
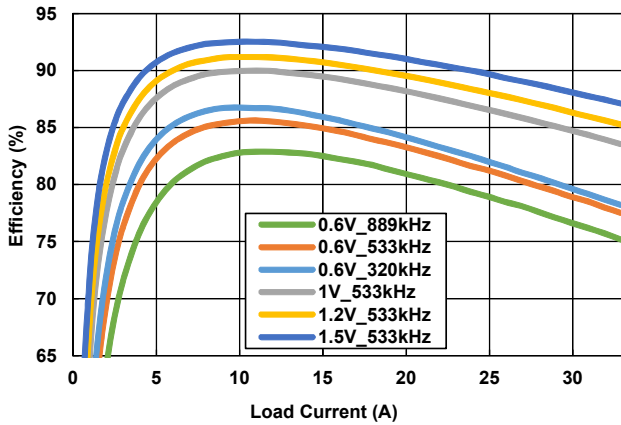
Figure 13. Efficiency vs Output Current at V_{IN} = 3.3V for Various Output Voltages and Switching Frequencies
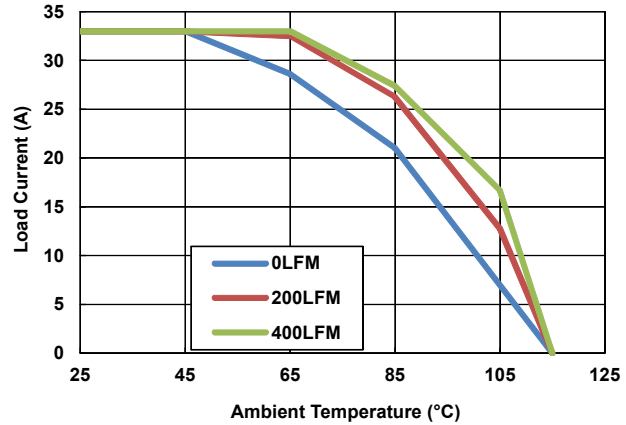
Figure 14. Derating Curve, V_{IN} = 3.3V, V_{OUT} = 1.2V, f_{SW} = 533kHz
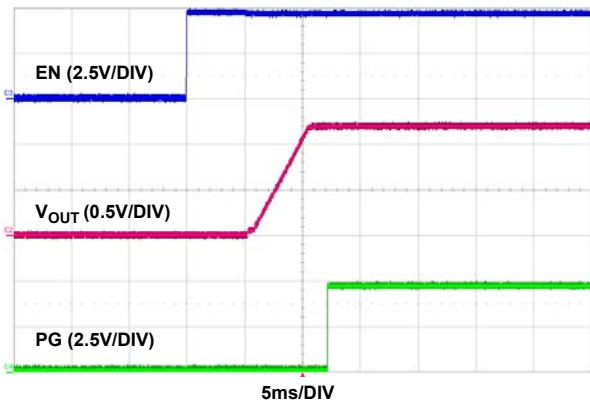
Figure 15. Soft-Start at V_{IN} = 3.3V, V_{OUT} = 1.2V, TON_DELAY = 5ms, TON_RISE = 5ms, POWER_GOOD_DELAY = 2ms
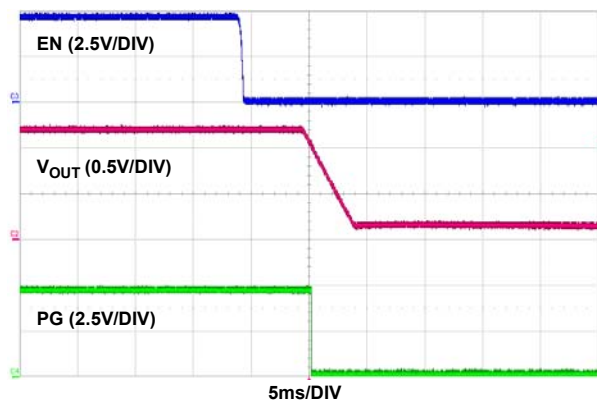
Figure 16. Soft-Start at V_{IN} = 3.3V, V_{OUT} = 1.2V, TOFF_DELAY = 5ms, TOFF_FALL = 5ms
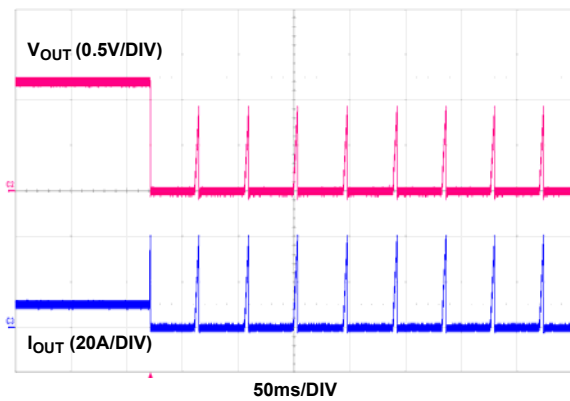
Figure 17. Output Short-Circuit Protection with Continuous Retry Enabled (Hiccup Mode) with 35ms Waiting Time, V_{IN} = 3.3V, V_{OUT} = 1.2V, IOUT_OC_FAULT_LIMIT = 40A
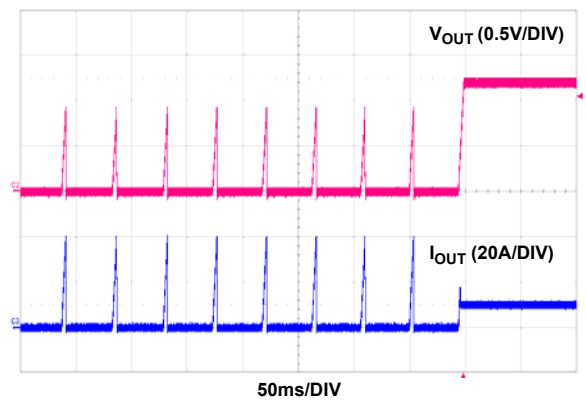
Figure 18. Output Short-Circuit Recovery with Continuous Retry Enabled (Hiccup Mode) with 35ms Waiting Time, V_{IN} = 3.3V, V_{OUT} = 1.2V, IOUT_OC_FAULT_LIMIT = 40
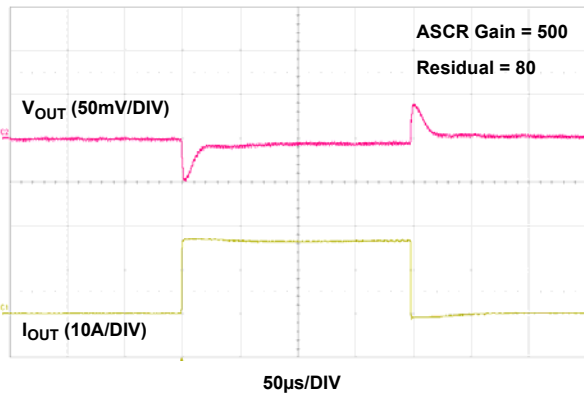
Figure 19. Load Transient Response at V_{IN} = 3.3V, V_{OUT} = 1.2V, I_{OUT} = 0A to 16.5A (>15A/μs), f_{SW} = 533kHz, C_{OUT} = 6 x 100μF ceramic + 4 x 470μF POSCAP
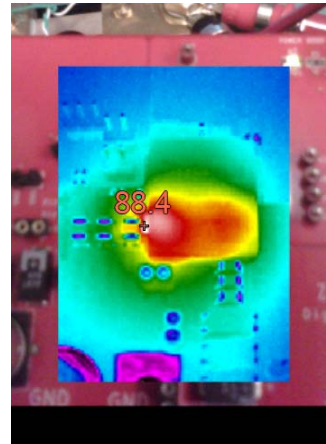
Figure 20. Thermal Image, 3.3V_{IN} to 1.5V_{OUT}, I_{OUT} = 33A, T_A = 25 °C, f_{SW} = 533kHz, No Airflow

7. Revision History

Rev.	Date	Description
1.00	Jan 29, 2018	Updated Figure 5.
0.00	Jan 26, 2018	Initial release

RENESAS

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

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