

ZL9024MEVAL1Z

User's Manual: Evaluation Board

Industrial Analog and Power

ZL9024MEVAL1Z

Evaluation Board

UG155
Rev.0.00
Jan 29, 2018

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

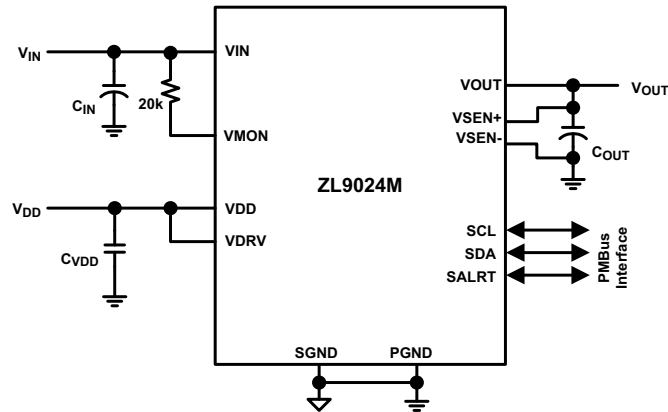


Figure 1. ZL9024MEVAL1Z Block Diagram

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 $2A/\mu s$, such as electronic load. If the slew rate exceeds $2A/\mu s$, then it may be necessary to increase the output capacitance or change $V_{OUT_OV_FAULT_LIMIT}$ and $V_{OUT_UV_FAULT_LIMIT}$ 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, V_{OUT_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 R₄ 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 V_{OUT} and PGND next to the remote voltage sensing location. A $10\text{m}\Omega$ 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.

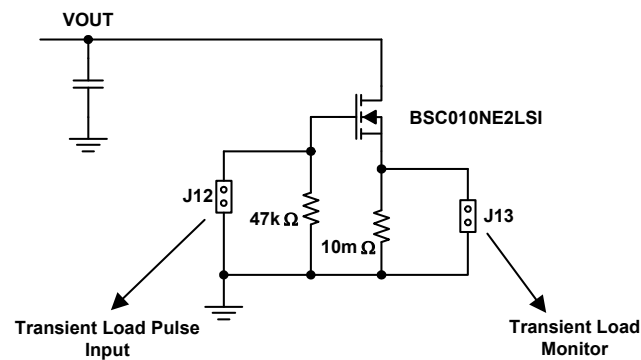


Figure 2. Schematic for Transient Load Measurement

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

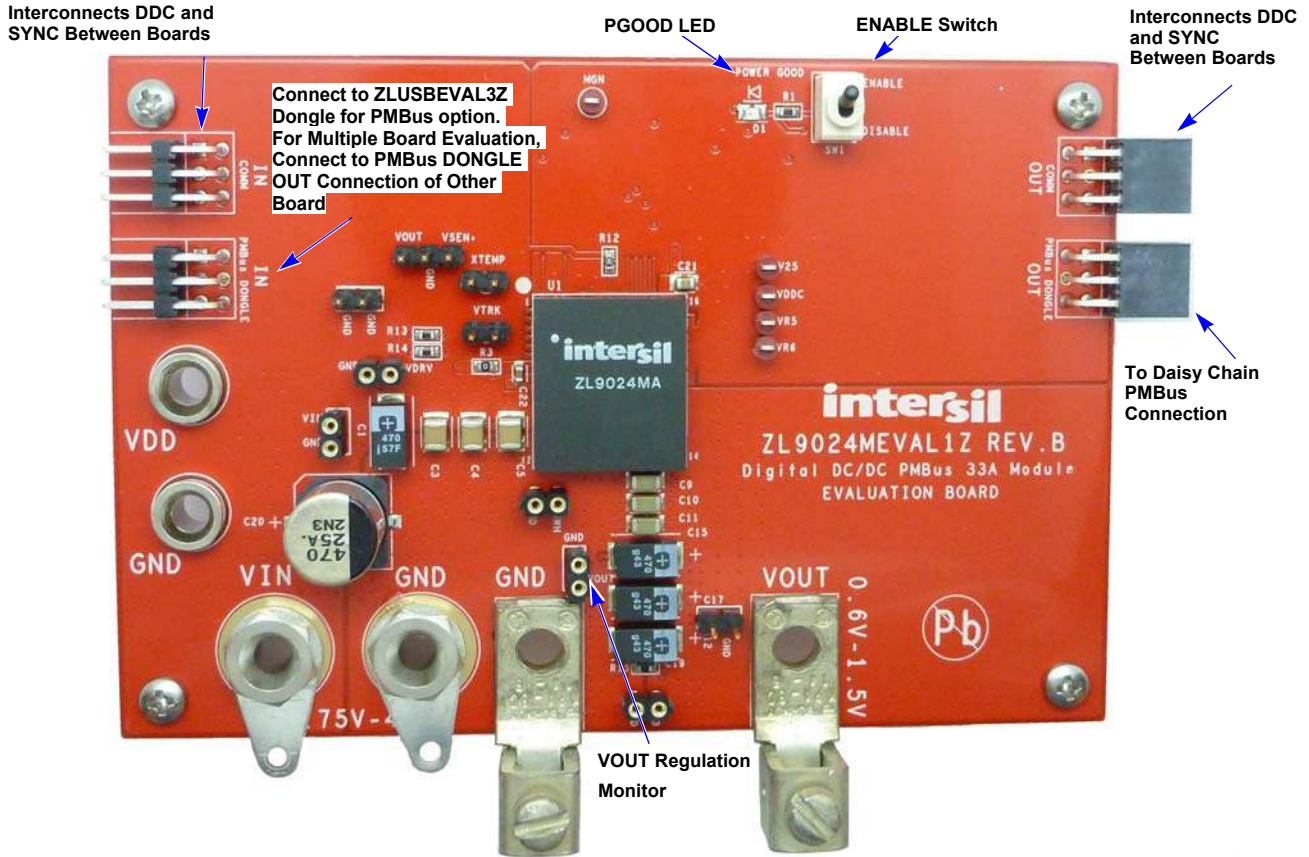


Figure 3. ZL9024MEVAL1Z Evaluation Board Top Side

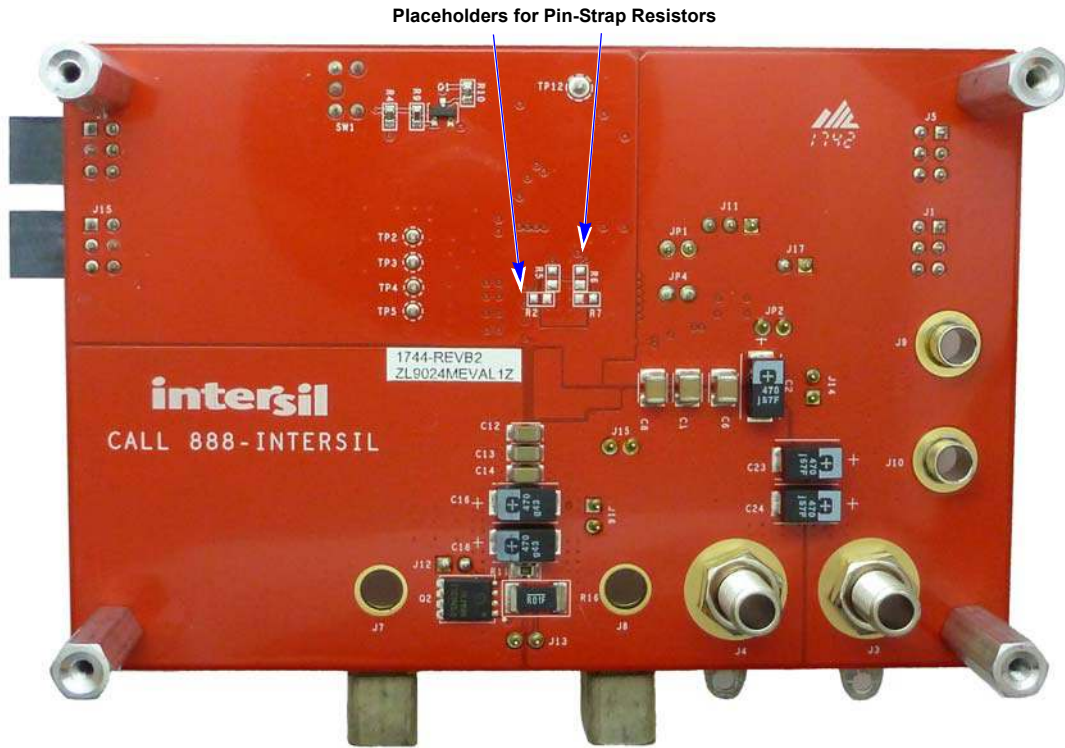


Figure 4. ZL9024MEVAL1Z Evaluation Board Bottom Side

5.2 ZL9024MEVAL1Z Circuit Schematic

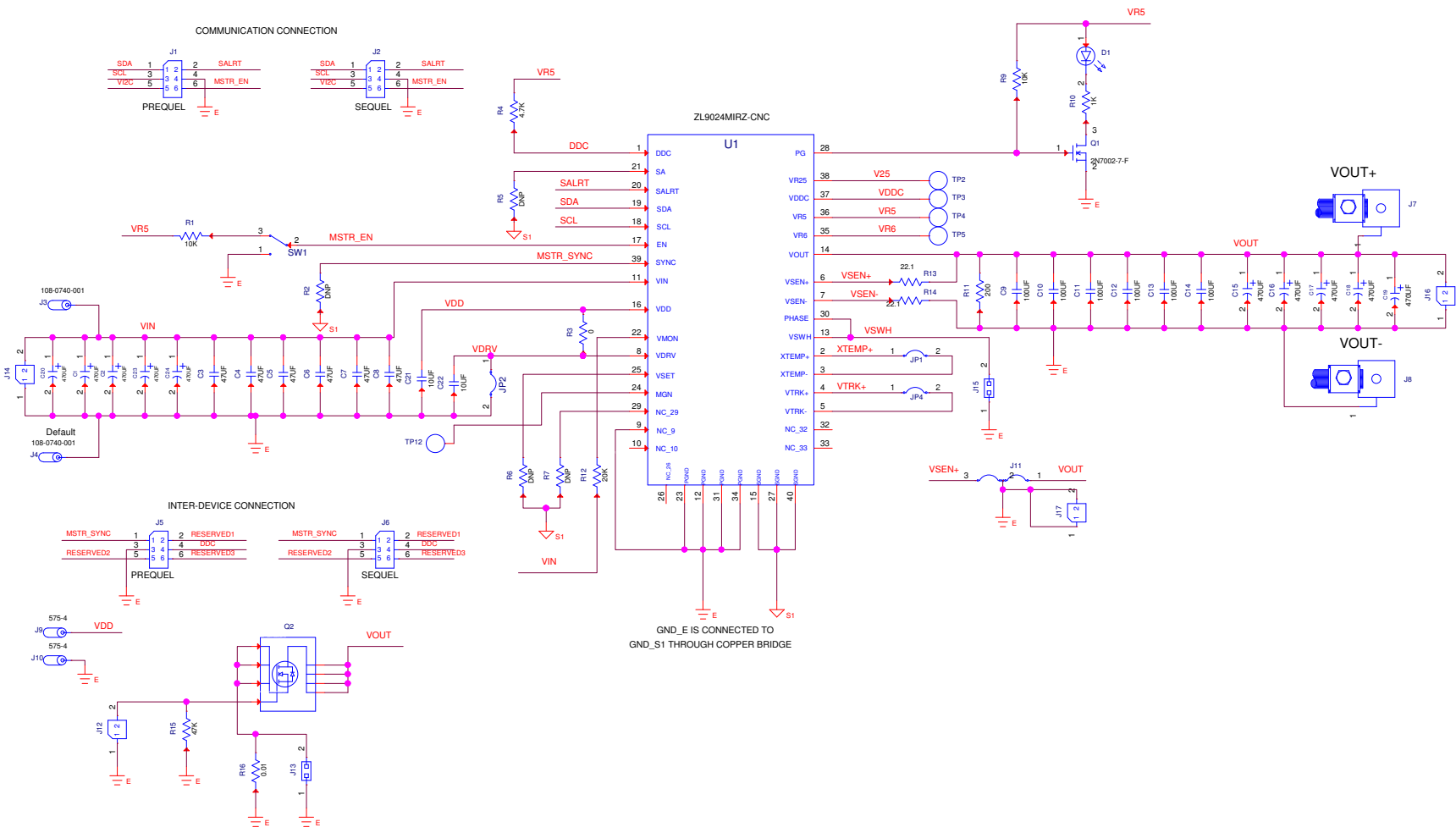


Figure 5. Schematic

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 TDSO8 | 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

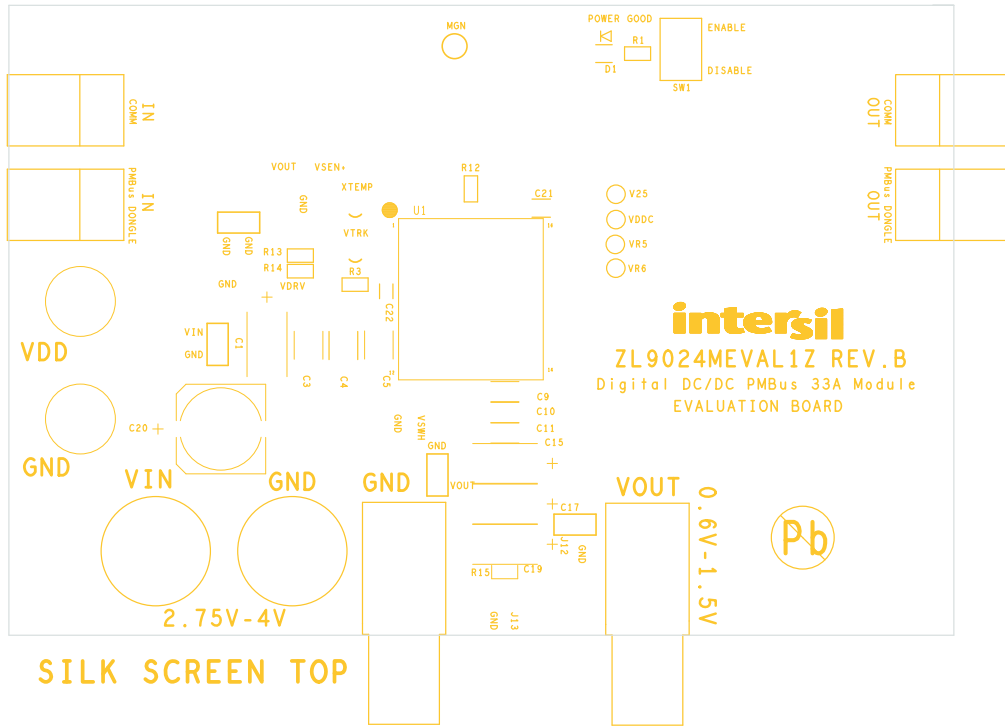


Figure 6. Silkscreen Top

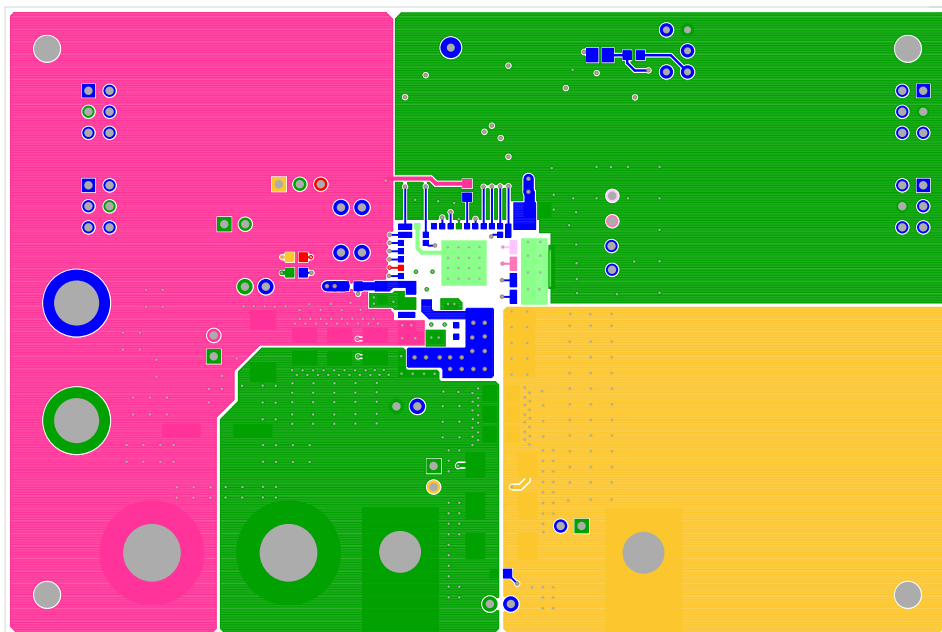


Figure 7. Top Layer

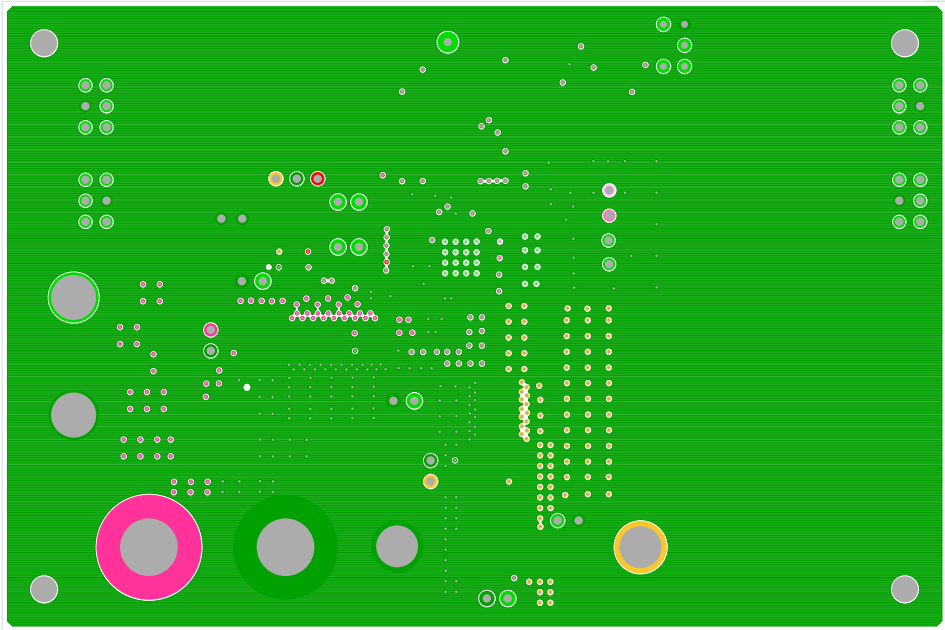


Figure 8. Layer 2

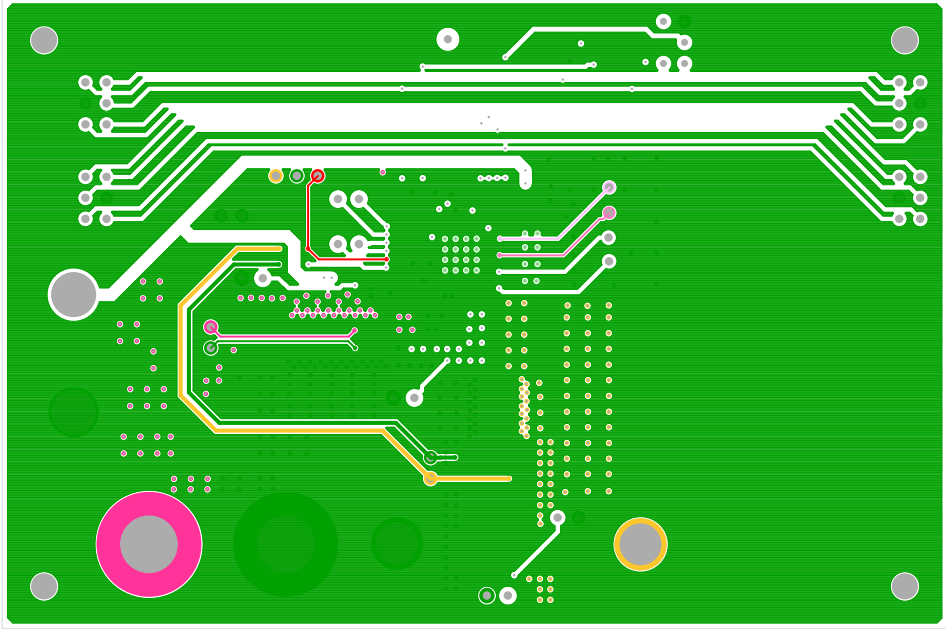


Figure 9. Layer 3

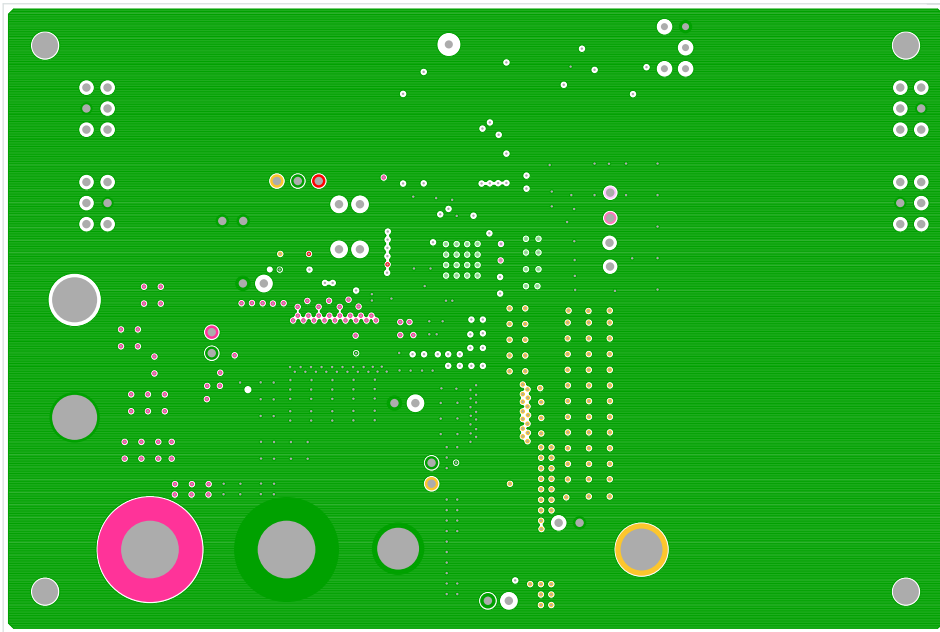


Figure 10. Layer 4

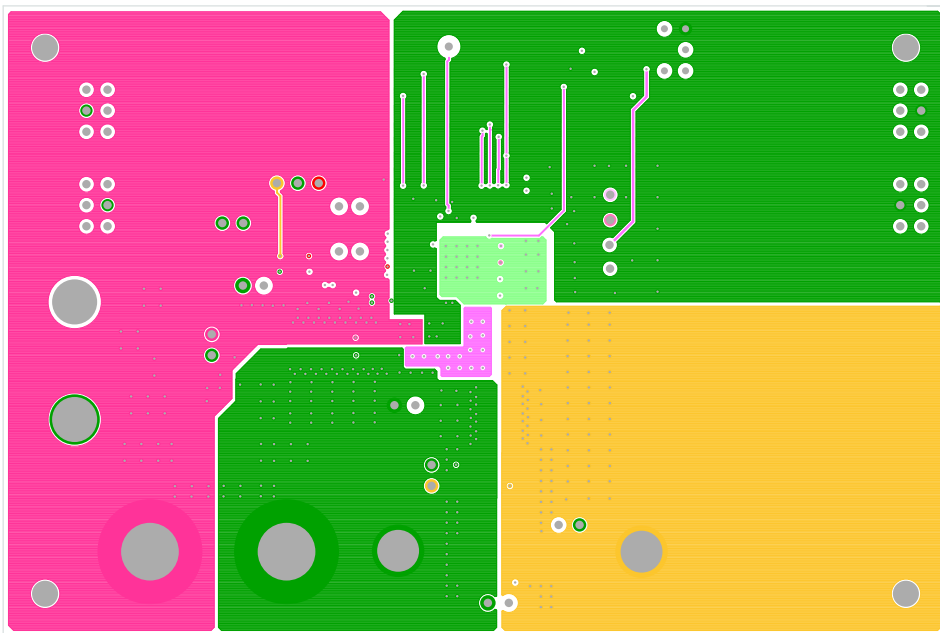


Figure 11. Layer 5

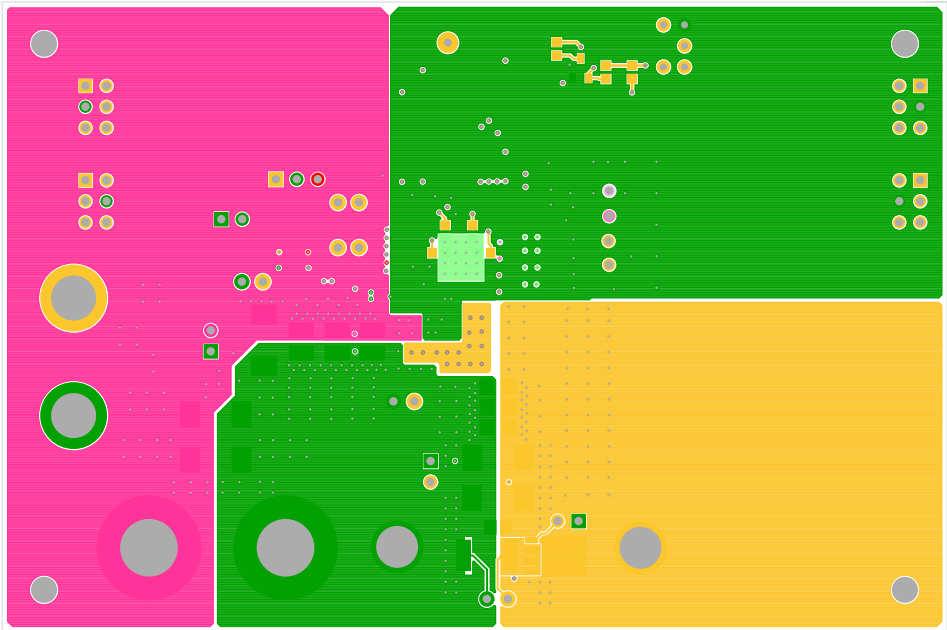


Figure 12. Bottom Layer

6. Typical Performance Curves

The following data was acquired using a ZL9024MEVAL1Z evaluation board.

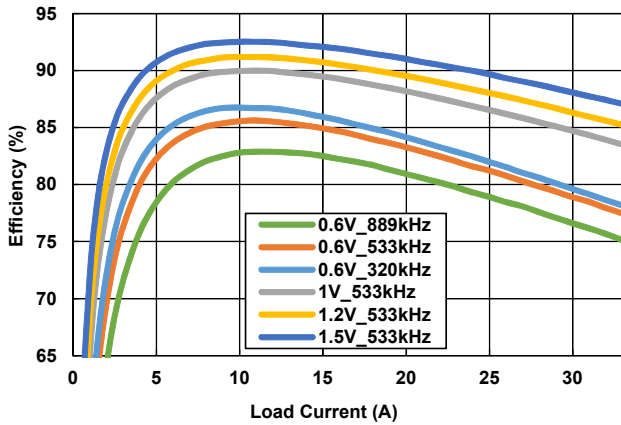


Figure 13. Efficiency vs Output Current at $V_{IN} = 3.3V$ for Various Output Voltages and Switching Frequencies

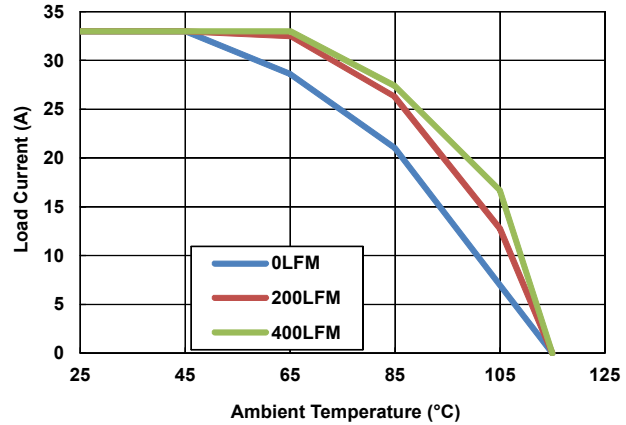


Figure 14. Derating Curve, $V_{IN} = 3.3V$, $V_{OUT} = 1.2V$, $f_{SW} = 533kHz$

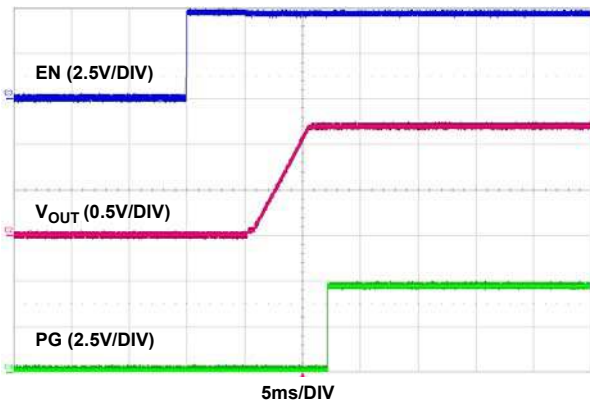


Figure 15. Soft-Start at $V_{IN} = 3.3V$, $V_{OUT} = 1.2V$, $T_{ON_DELAY} = 5ms$, $T_{ON_RISE} = 5ms$, $POWER_GOOD_DELAY = 2ms$

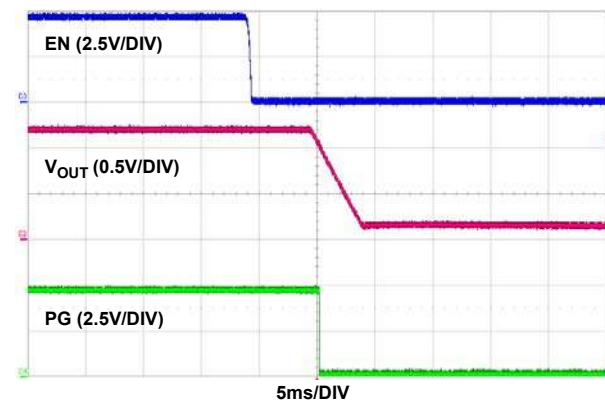


Figure 16. Soft-Start at $V_{IN} = 3.3V$, $V_{OUT} = 1.2V$, $T_{OFF_DELAY} = 5ms$, $T_{OFF_FALL} = 5ms$

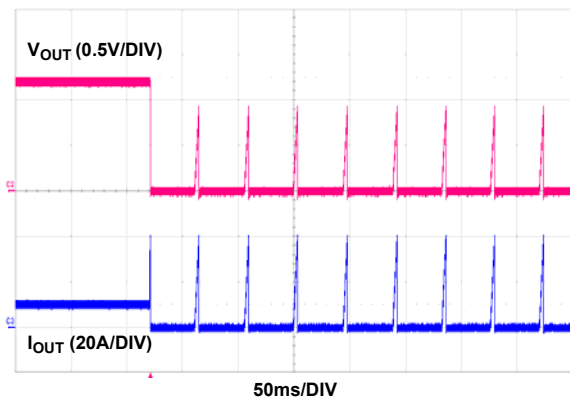


Figure 17. Output Short-Circuit Protection with Continuous Retry Enabled (Hiccup Mode) with 35ms Waiting Time, $V_{IN} = 3.3V$, $V_{OUT} = 1.2V$, $I_{OUT_OC_FAULT_LIMIT} = 40A$

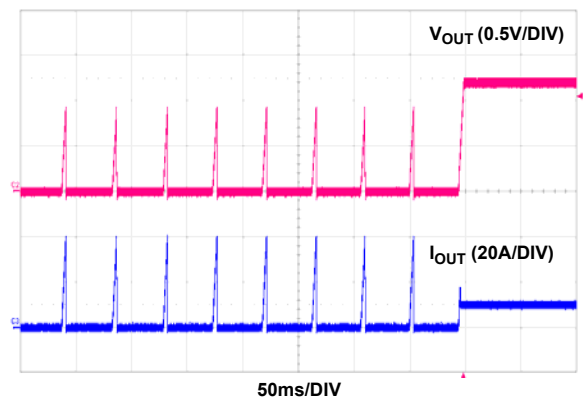


Figure 18. Output Short-Circuit Recovery with Continuous Retry Enabled (Hiccup Mode) with 35ms Waiting Time, $V_{IN} = 3.3V$, $V_{OUT} = 1.2V$, $I_{OUT_OC_FAULT_LIMIT} = 40$

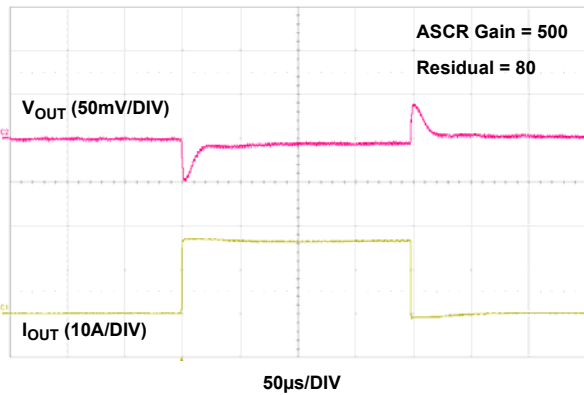


Figure 19. Load Transient Response at $V_{IN} = 3.3V$, $V_{OUT} = 1.2V$, $I_{OUT} = 0A$ to $16.5A$ ($>15A/\mu s$), $f_{SW} = 533kHz$, $C_{OUT} = 6 \times 100\mu F$ ceramic + $4 \times 470\mu F$ POSCAP

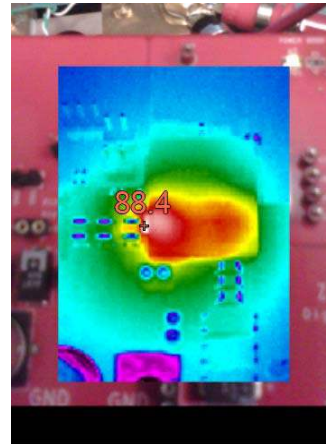


Figure 20. Thermal Image, $3.3V_{IN}$ to $1.5V_{OUT}$, $I_{OUT} = 33A$, $T_A = 25^\circ C$, $f_{SW} = 533kHz$, No Airflow

7. Revision History

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

Notice

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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.
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