User's Manual

ISL91301BII-L-EV1Z, ISL91301BII-H-EV1Z

User's Manual: Evaluation Board

Core Power Solutions

Rev 0.00 Apr 2018

1. Overview

The ISL91301BII-L-EV1Z and ISL91301BII-H-EV1Z platform allows quick evaluation of the high performance features of the ISL91301B multi-output PMIC, which has four controllers capable of configuring its power stages for 1+1+1+1 channel outputs. Each channel can deliver up to 4A per phase continuous output current for a 2.8V ~ 5.5V supply voltage, and 3A per phase current for a wider 2.5V ~ 5.5V supply voltage. The ISL91301B uses R5™ modulator technology to maintain accurate voltage regulation, while providing excellent efficiency and transient response. It also supports the standard I^2C and SPI communication protocols, ideal for systems using a single-cell battery.

1.1 Key Features

- Small, compact design
- Supports both I^2C and SPI bus communication protocols
- Adjustable V_{OUT} and independent DVS control for all four channels
- Real-time fault protection and monitoring (OC, UV, OV, OT)
- Six layer board design optimized for thermal performance and efficiency
- Connectors, test points, and jumpers for easy measurements
- Built-in load transient circuits for each output channel

1.2 Specifications

The board operates at the following conditions:

- ISL91301BII-L-EV1Z (VIN_SEL = GND)
  - Input voltage rating from 2.5V to 5.5V
  - 1+1+1+1 configuration with 3A maximum load current/phase
- ISL91301BII-H-EV1Z (VIN_SEL = AVIN)
  - Input voltage rating from 2.8V to 5.5V
  - 1+1+1+1 configuration with 4A maximum load current/phase
- Programmable output voltage range of 0.3V to 2V
- 4MHz default switching frequency
- DVS slew rate of 2.5mV/µs
- Power-up sequence: Buck1→Buck2→Buck3→Buck4, 1ms delay between each rail
- Power-down sequence: Buck1, 2, 3, and 4 power down at the same time
- Operating temperature range: -40°C to +85°C
- VOUT1, 2, 3, and 4 = 0.9V

1.3 Ordering Information

Part Number	Description
ISL91301BII-L-EV1Z	Evaluation board for ISL91301BII VIN_SEL = GND VIN = 2.5V to 5.5V Max Current = 3A per phase
ISL91301BII-H-EV1Z	Evaluation board for ISL91301BII VIN_SEL = AVIN VIN = 2.8V to 5.5V Max Current = 4A per phase

1.4 Related Literature

For a full list of related documents, visit our website

- ISL91301B product page

1.5 Block Diagrams

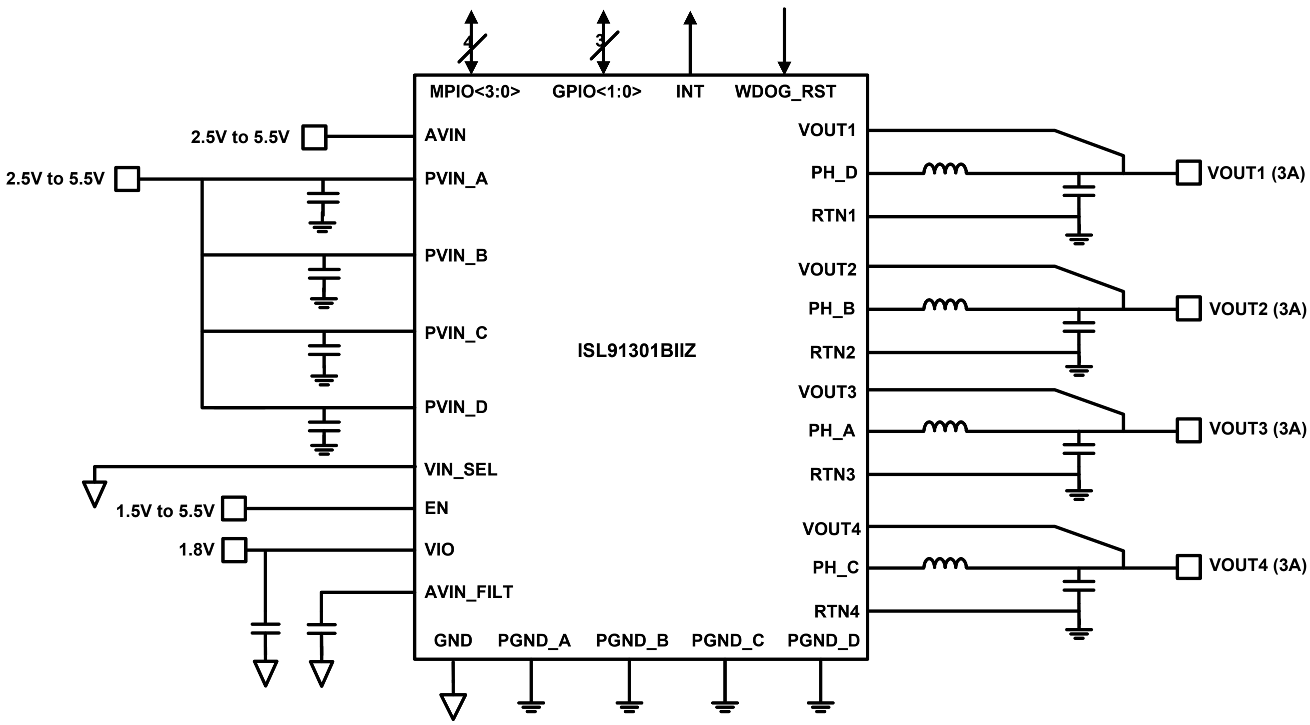


Figure 1. ISL91301B 1+1+1+1 Block Diagram (3A/Phase, VIN_min = 2.5V)

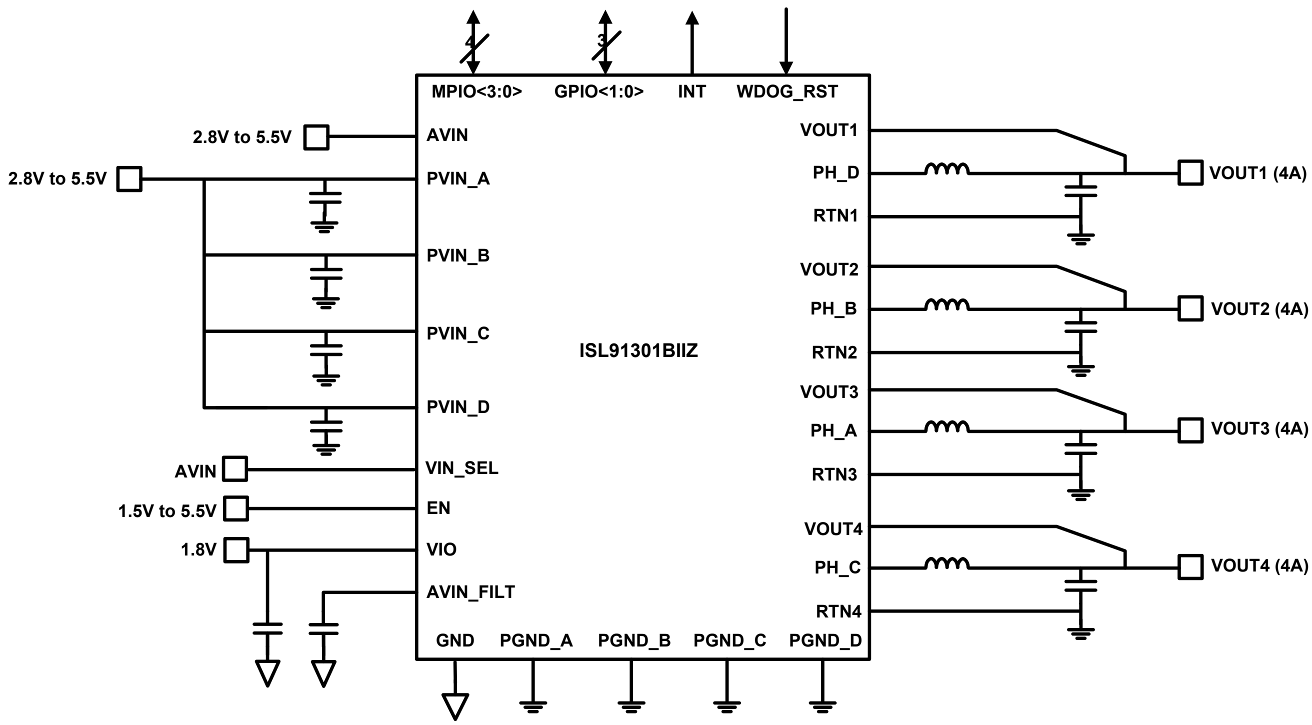


Figure 2. ISL91301B 1+1+1+1 Block Diagram (4A/Phase, VIN_min = 2.8V)

1.6 Contents

The evaluation board contains:

- ISL91301BII-L-EV1Z or ISL91301BII-H-EV1Z evaluation board
- Evaluation software
- Mini USB I^2C dongle with USB cable (ISLUSBMINIEVAL1Z)
- All applicable documentation

1.7 Recommended Equipment

- 0V to 10V power supply with at least 5A current sourcing capability (VIN SUPPLY BIAS)
- 0V to 10V power supply with at least 1A current sourcing capability (VCC_6V SUPPLY BIAS)
- Electronic loads capable of sinking current up to 5A
- Digital multimeter
- 500MHz quad-trace oscilloscope
- Dual edge slew rate controllable signal generator
- Differential probe (for load transient current measurement)

2. Functional Description

The ISL91301BII-L-EV1Z and ISL91301BII-H-EV1Z evaluation boards provide a simple platform to demonstrate the functionalities of the feature-rich ISL91301B PMIC. The board has a 0.9V output (default) on each of its output channels after start-up and each output voltage can be programmed by the I^2C/SPI. The evaluation board is functionally optimized for best performance, working harmoniously with the factory default tuning on the ISL91301B. The input power and load connections are provided through multi-pin connectors for high current operations.

The ISL91301BII-L-EV1Z and ISL91301BII-H-EV1Z evaluation boards are shown in Figures 9 and 10. Table 1 lists the evaluation board's key test points and jumpers. The ISL91301B's internal registers can be accessed by the I^2C/SPI through the on-board header J24 (SPI) and J42B (I^2C).

Table 1. Description of Important Test Points and Jumpers

Test Point(s)	Description
J6(+), J7(-)	Header for connecting VIN supply
J35(+), J65(-)	Buck1 header for connecting external load
J37(+), J58(-)	Buck2 header for connecting external load
J57(+), J36(-)	Buck3 header for connecting external load
J64(+), J38(-)	Buck4 header for connecting external load
J3	V_{IN} Kelvin connection for efficiency measurements
J15	Buck1 V_{OUT} Kelvin connection for efficiency measurements
J18	Buck2 V_{OUT} Kelvin connection for efficiency measurements
J56	Buck3 V_{OUT} Kelvin connection for efficiency measurements
J63	Buck4 V_{OUT} Kelvin connection for efficiency measurements
TP1	VCC_6V supply for VIO LDO and load transient circuits
J60	Buck1 driver input for load transient circuit
J61	Buck2 driver input for load transient circuit
J62	Buck3 driver input for load transient circuit
J66	Buck4 driver input for load transient circuit
J52	Load transient current sense, 1A/10mV
J55	Load transient current sense, 1A/10mV
J59	Load transient current sense, 1A/10mV
J67	Load transient current sense, 1A/10mV
J24	Header for connecting to SPI interface
J42B	Header for connecting to I^2C interface
SW1	Enable/disable IC

The evaluation software Graphical User Interface (GUI) window for the ISL91301B is shown in Figure 8 on page 10. The schematics of the ISL91301BII-L-EV1Z and ISL91301BII-H-EV1Z evaluation boards are shown in Figures 13, 16, and 17. The PCB layout images for all layers are shown in Figures 18 through 25. The ISL91301BII-L-EV1Z and ISL91301BII-H-EV1Z evaluation board bill of materials is shown in "Bill of Materials" on page 21.

2.1 Operating Range

The ISL91301BII-L-EV1Z's V_{IN} range is 2.5V to 5.5V with 3A per phase I_{OUT} range. The ISL91301BII-H-EV1Z's V_{IN} range is 2.8V to 5.5V with 4A per phase I_{OUT} range. The adjustable V_{OUT} range for both versions is 0.3V to 2.0V. The operating ambient temperature range is -40°C to +85°C.

2.2 Quick Start Guide

The default output voltage for the ISL91301BII-L-EV1Z and ISL91301BII-H-EV1Z evaluation boards is set at 0.9V for all four outputs. No jumper configurations are needed to power up the part into its default state. All the settings and features are instead loaded through the one-time programmable memory inside the IC when minimum bias conditions are met. Refer to the "Setup Guide" for information about powering up the board for proper operation.

2.2.1 Setup Guide

(1) Place scope probes on the V_{OUT} test point and other test points of interest.

(2) Connect a power supply to J6 (V_{IN} supply) and J7 (GND), with the voltage set between 2.5V and 5.5V. This will bias the PVIN and AVIN pins of the IC, but no startup sequence has initiated and the quiescent current should be less than 1mA.

(3) Connect a second power supply to TP1 (VCC_6V), with the voltage set to 6V. This will bias the VIO and Chip Enable pin as well as the on-board load transient circuits. The ISL91301B will boot up its internal reference, load the default register settings, and initiate a power-on sequence by toggling SW1 to the "ENABLE" position. All four outputs should turn on in Pulse Skipping mode if there are no external loads present, and V_{OUT} should default to 0.9V.

(4) During the startup sequence, all four outputs should turn on sequentially, from Buck1 to Buck2 to Buck3 and then Buck4. Buck1 will turn on with a 1.4ms delay from the Chip Enable pin going high, while the other buck regulators will turn on 1ms apart.

(5) To initiate a shutdown sequence, toggle SW1 to the "DISABLE" position, and the ISL91301B will turn off all the buck regulators at the same time.

2.2.2 I²C/SPI Communication

The ISL91301B supports I²C communication by default. A USB to I²C communication dongle (ISLUSBMINIEVAL1Z) is included with each ISL91301BII-L-EV1Z or ISL91301BII-H-EV1Z purchase, and the GUI will support this tool across all operating systems.

(1) To communicate with the ISL91301B through I²C, connect the USB to I²C dongle to J42B. Make sure R_{93} is present on the board, as it provides the pull-up from SPI_SS to 1.8V VIO supply.

Note: For the SPI communication option using the GUI, contact your local sales office.

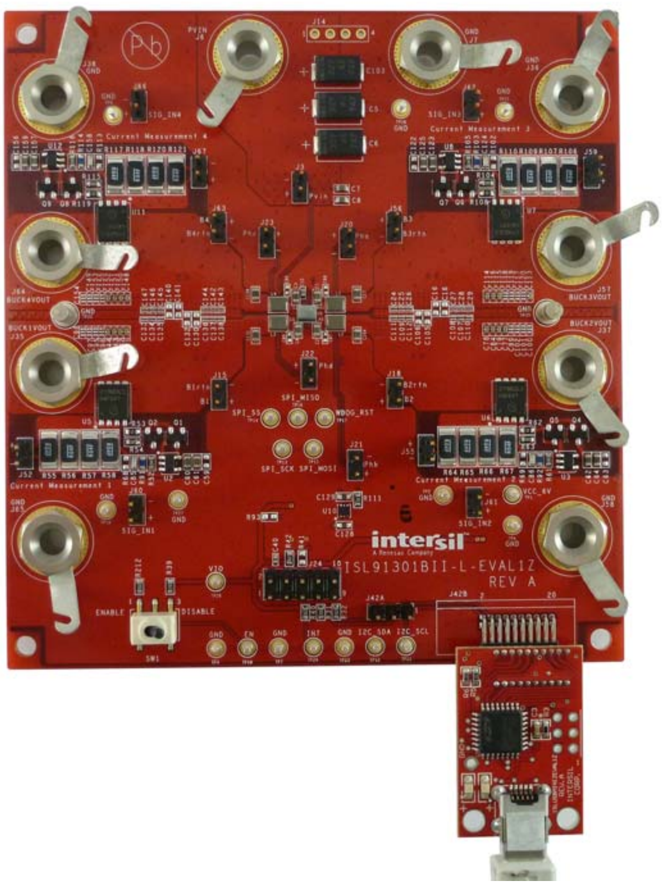


Figure 3. Communication Dongle Connection

2.2.3 Efficiency Measurement

(1) Connect a power supply at J6 (V_{IN} supply), with the voltage set between 2.5V and 5.5V (ISL91301BII-L-EV1Z) or a voltage between 2.8V and 5.5V (ISL91301BII-H-EV1Z). The current limit should be set high enough to support the maximum load current with additional head room. If the power supply supports remote sense lines, use a Kelvin connection on J3. Otherwise, connect a multimeter at J3.

(2) Apply 6V to TP1 (VCC_6V) to initiate the startup sequence and all four outputs will turn on. To get an accurate single channel measurement, disable the other three outputs using the GUI.

(3) Turn on the electronic load at VOUTx. The connection should be made at J35 (VOUT1), J37 (VOUT2), J57 (VOUT3), or J64 (VOUT4). Make sure the load current does not exceed 3A per phase (ISL91301BII-L-EV1Z) or 5A per phase (ISL91301BII-H-EV1Z), and the correct wire size is used when attaching the electronic load.

(4) Measure the output voltage with a multimeter. The voltage should regulate within datasheet specification limits.

(5) To determine efficiency, measure input and output voltages at the Kelvin sense test points (S+ and S-), which are located at the J3 (V_{IN} SENSE) and J15 (BUCK1 SENSE), J18 (BUCK2 SENSE), J56 (BUCK3 SENSE), or J63 (BUCK4 SENSE) headers. Measure the input and output currents from the VIN power supply and the electronic load. Calculate efficiency based on these measurements. For detailed setup information, refer to Figure 11 on page 13.

2.2.4 Load Transient Measurement

(1) Complete the setup procedure. The ISL91301BII-L-EV1Z should already be powered up with 2.5V to 5.5V at J6 (V_{IN} supply) and 6V at TP1 (VCC_6V). The ISL91301BII-H-EV1Z should already be powered up with 2.8V to 5.5V at J6 (V_{IN} supply) and 6V at TP1 (VCC_6V).

(2) Connect a slew rate controllable signal generator to transient load circuit input, J60 (TRANSIENT 1 PULSE GEN), J61 (TRANSIENT 2 PULSE GEN), J62 (TRANSIENT 3 PULSE GEN), or J63 (TRANSIENT 4 PULSE GEN).

(3) Program the signal generator to pulse mode. Set the frequency to 100Hz, the ON duration to 200µs, and the signal amplitude from 0V to 2V. The load transient circuit starts to turn on when the input is ~2.6V. When in doubt, always connect the signal generator output to an oscilloscope set to a 1MΩ termination. The slew rate of the pulse, both rising and falling, should be conservatively slow, for example, 1µs.

(4) Connect a differential probe to monitor load current across the sense resistors J52 (ISENSE1), J55 (ISENSE2), J59 (ISENSE3), or J67 (ISENSE4). The load current can be accurately converted to a voltage at 1A/10mV. Ensure the vertical scale of the oscilloscope is set properly to display the full amplitude of the load profile.

(5) Connect a second differential probe at the VOUT sense points connected to the VOUT decoupling capacitors, J15 (BUCK1 SENSE), J18 (BUCK2 SENSE), J56 (BUCK3 SENSE), or J63 (BUCK4 SENSE).

(6) Set the oscilloscope to measure the rise and fall times and maximum level of the load current. Slowly increase the signal generator amplitude and slew rate until the desired load profile is achieved. For detailed setup information, refer to Figure 12 on page 13.

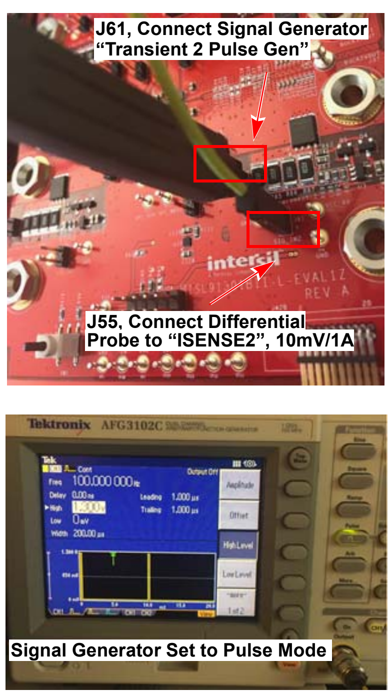


Figure 4. BUCK1 Transient Load Connection Example

2.3 Evaluation Software Installation and Use

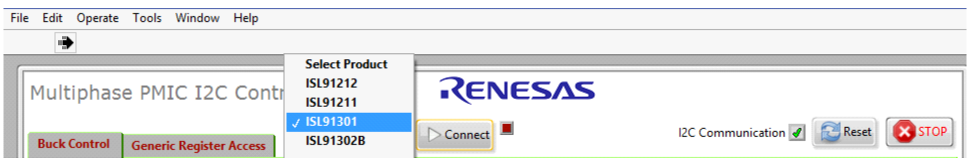
(1) Extract the package and double-click **AutoRun.exe**. Follow the instructions that appear to install the Multiphase PMIC I^2C Control Tool Software.

(2) Attach the USB - I^2C interface (ISLUSBMINIEVAL1Z) dongle to the computer using the supplied USB cable.

(3) Attach the USB - I^2C interface dongle to J42B of the ISL91301BII-x-EV1Z. Following the instructions in "Setup Guide" on page 6, connect the power supplies, DC load, and other test equipment to the ISL91301BII-x-EV1Z evaluation board, then apply power.

(4) Start the Multiphase PMIC Control Tool software. Select Start > Programs > Renesas > Multiphase PMIC I2C Control Tool.

(5) Select ISL91301B from the "Select Product" drop down menu. Click "Connect" button on the GUI to establish connection between GUI and the dongle . The LED light on the dongle will lit. If a connection is not detected, the software shows a red X next to I2C Communication. Press Reset to reconnect the dongle.



(6) After the evaluation software establishes a connection to the USB-I^2C interface dongle, the software loads a blank startup script by default and reads all the pertinent register values to show on screen.

(7) Buck1, Buck2, Buck3, and Buck4 are all enabled, and the default DVS0 values should be 0.9V. If no fault conditions occurred during the board power-up during Step 3, all the fault indicators (UV, OV, OC) should be clear instead of red.

(8) To change the output voltage, enter the desired value in voltages in the DVS0 control. Four default DVS values are also loaded as part of the ISL91301B one time programmable memory space. Navigate to any of them and activate a DVS command by clicking the DVS Pointer.

Figure 5. DVS Pointer Selection

(9) Changing the 'Max Voltage' controls will change the internal feedback divider between ratios of 1x, 0.8x, and 0.6x. This will change the maximum output voltage the ISL91301B can support with the maximum being 2V. Keep in mind the smallest DVS resolution the IC and the software can support will be no less than the maximum voltage divided by 1024.

(10) After the evaluation software runs without hiccup, it polls all the registers at 2s intervals by default. This feature can be disabled by deselecting the 'Continuous Read' function. Alternatively, click the 'Read All Once' control to perform a one-time read of all the registers.

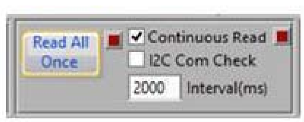


Figure 6. Continuous Read and Manual Read all Options

(11) The fault indicators will self clear after the software performs a read of the register either through the Continuous Read or the 'Read All Once' function. Three additional replica fault indicators (UV, OV, and OC)

latch the faults so they will clear only after the user clicks the ‘Push To Clear’ control in the event of a spurious fault condition.

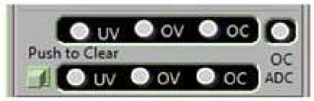


Figure 7. Fault Indicators

Note: The default switching frequency of the ISL91301B is set to 4MHz and the slew rates for both DVS and power-up/down are set to 2.5mV/µs. These settings, along with many other features, are programmable only through an OTP request or a startup script, and are not supported by the evaluation software. For more information, please contact your local sales representative.

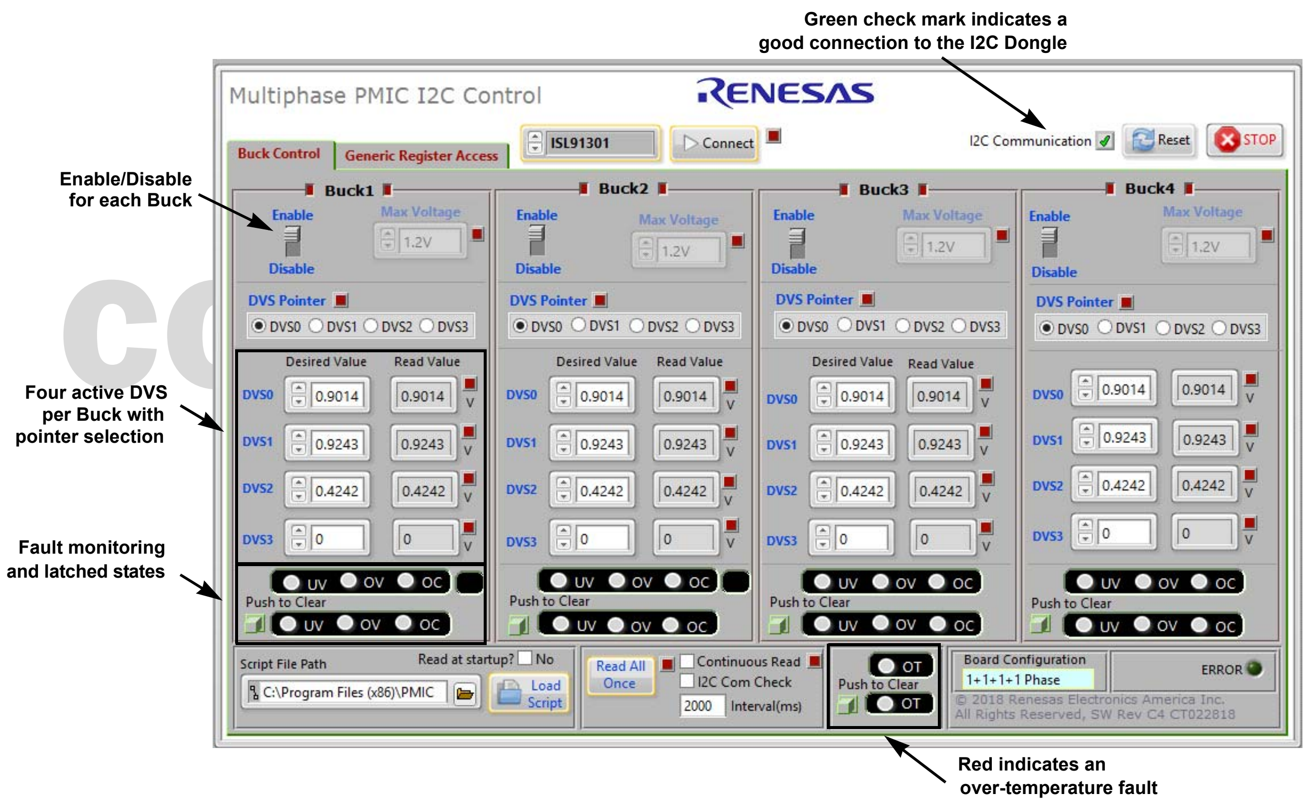


Figure 8. ISL91301B Evaluation Software Window

3. PCB Layout Guidelines

The ISL91301BII-L-EV1Z and ISL91301BII-H-EV1Z are 6-layer FR4 boards. The main components are the ISL91301B and its passive filter components, test points, and connectors. A 220nH inductor is located close to each phase node of the ISL91301B, and 3x22µF plus 4x4.3µF capacitors are populated at the output of each inductor. PVIN is distributed using a power plane on an inner layer with a 10µF capacitor placed in close proximity to the PVIN and PGND balls of the power stage. In addition, a 10µF AVIN filter capacitor is placed next to the ISL91301B referenced to a quiet ground plane.

Proper PCB layout is a critical design step when ensuring that the designed converter works under optimum conditions. The ISL91301B's power loop is composed of the inductor, output capacitors, phase node, and PGND pins. Keep this loop as short as possible and the connecting traces among them direct, short, and wide. The phase nodes of the ISL91301B are very noisy, so keep remote sense signals away from traces coming out of the phase nodes, and do not route them under the inductor in an adjacent layer. The input capacitor should be placed as close as possible to the PVIN and PGND pins, and a large unbroken ground plane should connect all the decoupling capacitors together.

The heat of the ISL91301B is mainly dissipated through the GND and PHASE plane vias under the IC. To maximize thermal performance, use as much copper area as possible connecting to these vias. In addition, a solid ground plane is helpful for better EMI performance.

3.1 Summary of Key Layout Strategies

- Place input capacitors as close as possible to their respective PVIN and PGND pins to minimize parasitic loop inductance.
- Route phase nodes with short, wide traces and avoid any sensitive nodes.
- Route the remote sense lines directly to the load using small, low inductance capacitors at the load for bypassing.
- Output capacitors should be close to the inductors and have a low impedance path to the PGND pins.
- Keep digital and phase nodes from intersecting the AVIN_FILT, VOUT, and RTN lines.
- Create a PGND plane on the second layer of the PCB below the power components and bumps carrying high switching currents.

3.2 ISL91301BII-L/H-EV1Z Evaluation Board

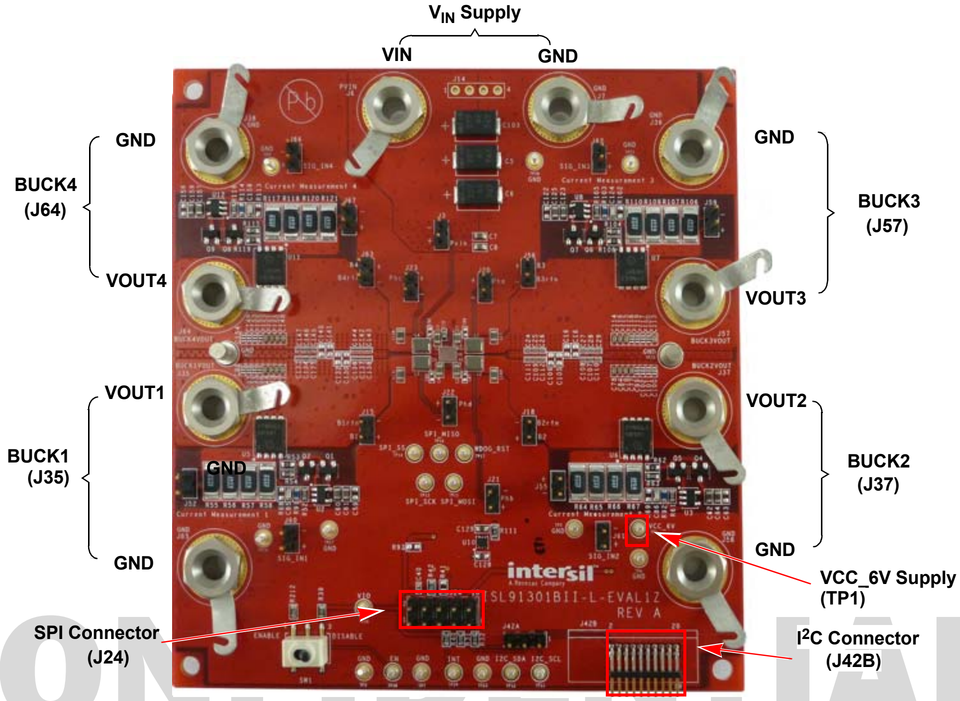


Figure 9. ISL91301BII-L/H-EV1Z Top View

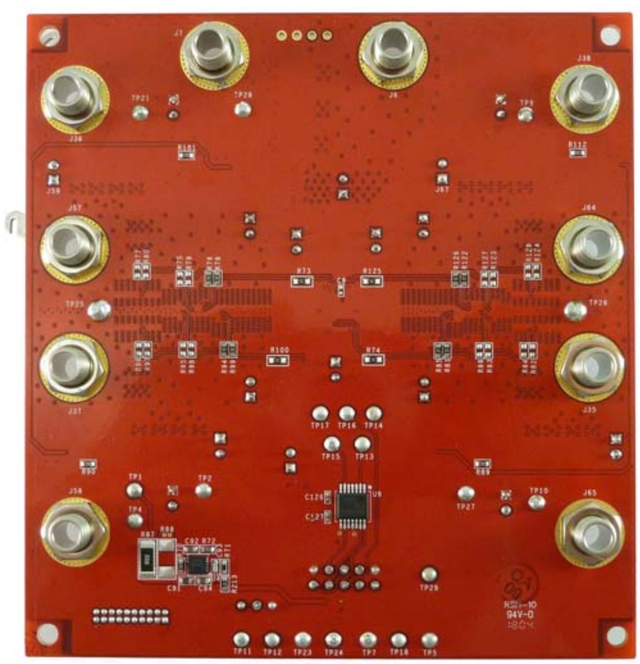


Figure 10. ISL91301BII-L/H-EV1Z Bottom View

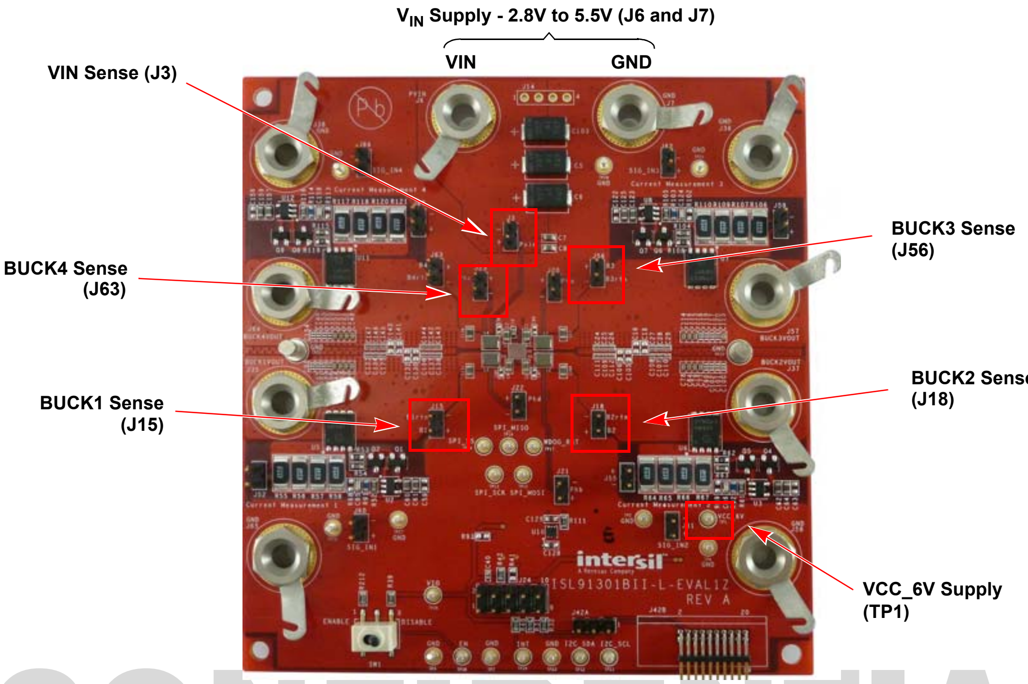


Figure 11. ISL91301BII-L/H-EV1Z Efficiency Measurement Connections

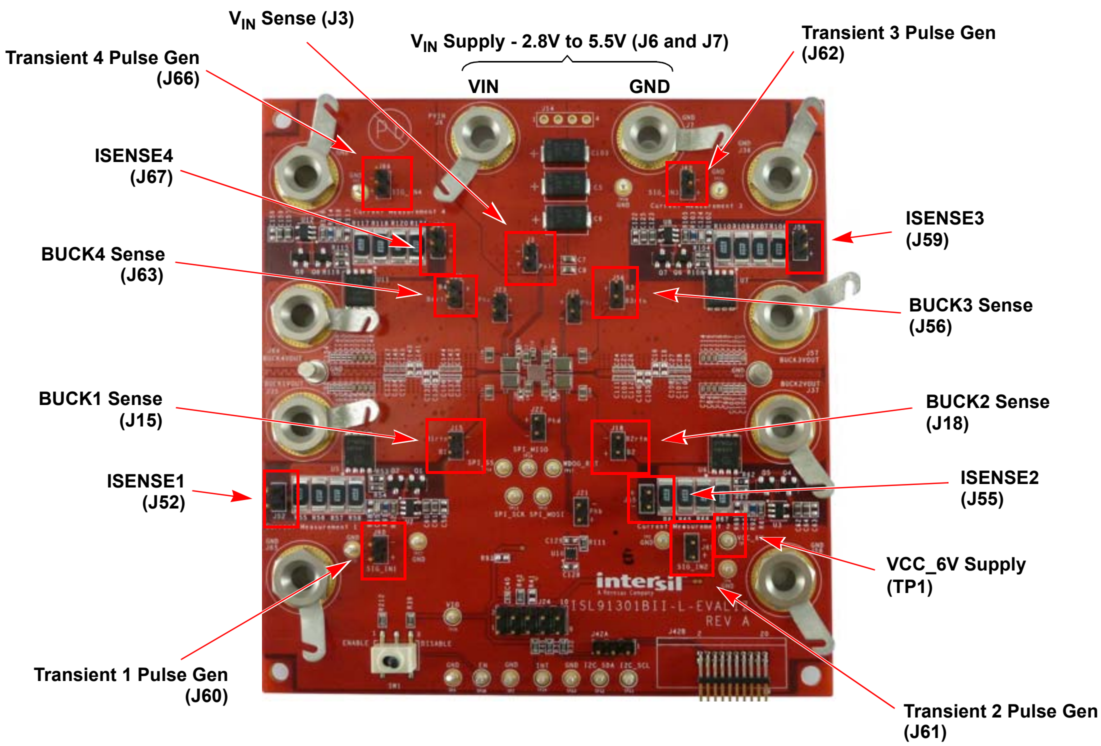


Figure 12. ISL91301BII-L/H-EV1Z Load Transient Measurement Connections

3.3 ISL91301BII-L/H-EV1Z PCB Schematic

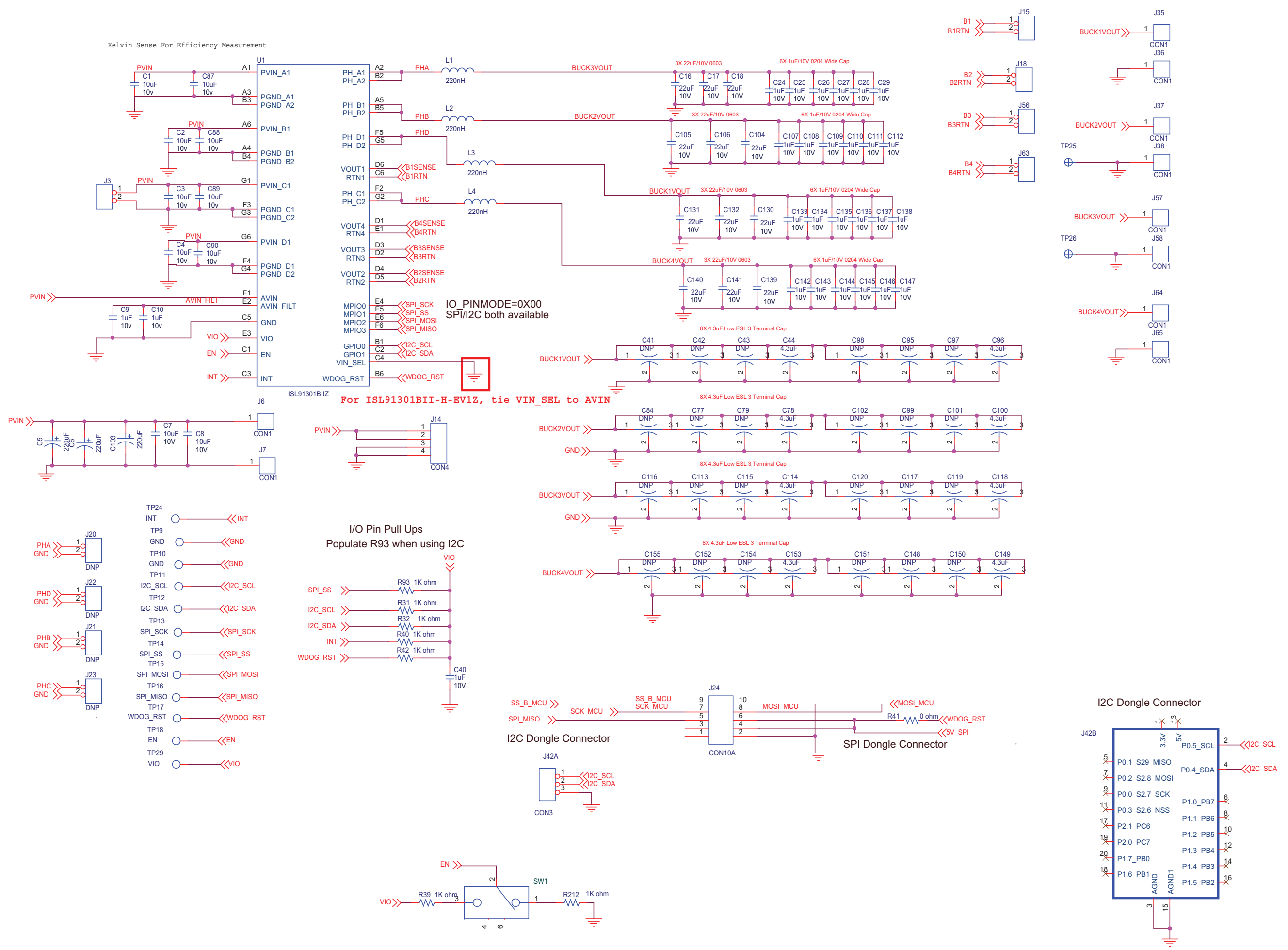


Figure 13. ISL91301BII-L/H-EV1Z Schematic - Page 1

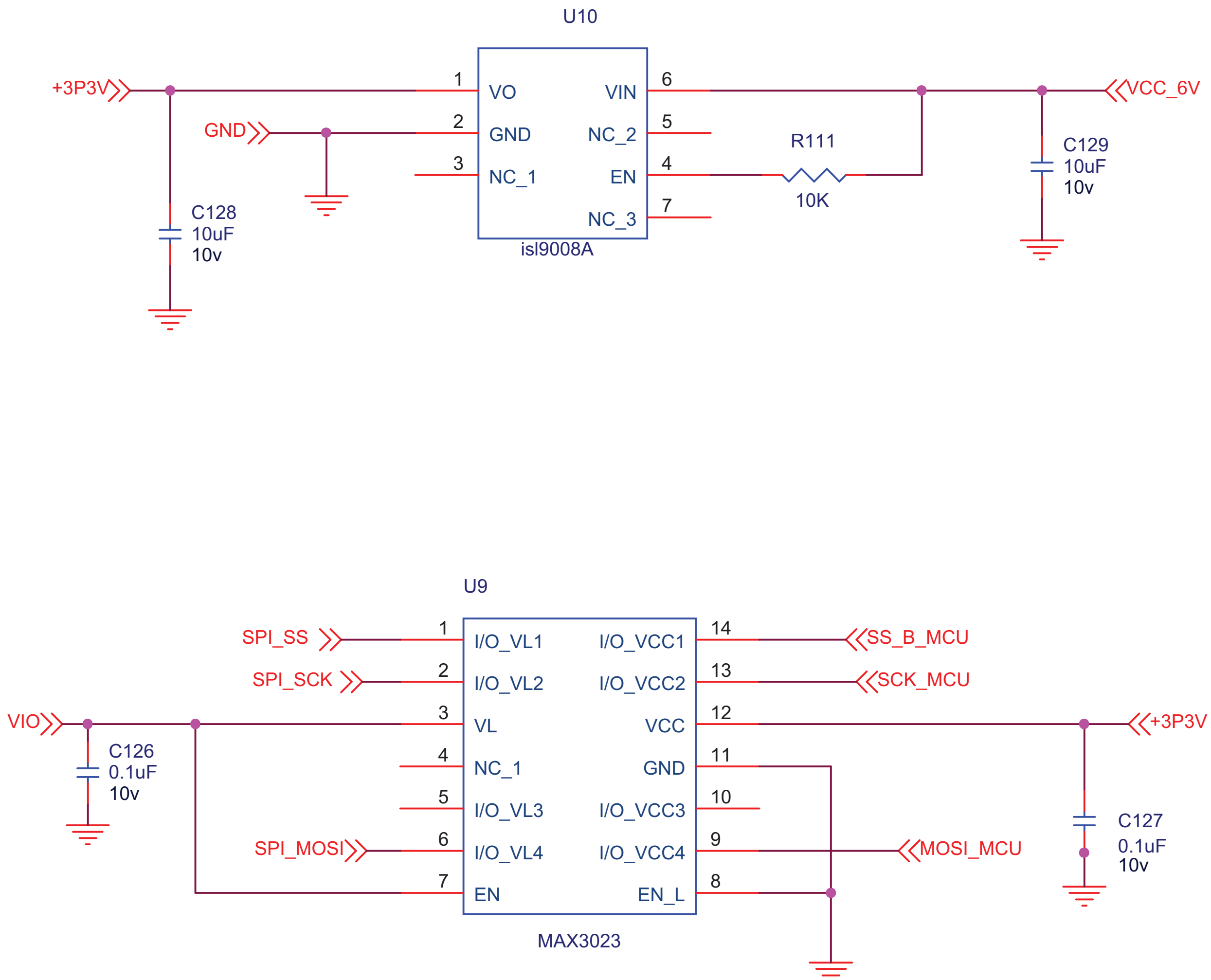


Figure 14. ISL91301BII-L/H-EV1Z Schematic - Page 2

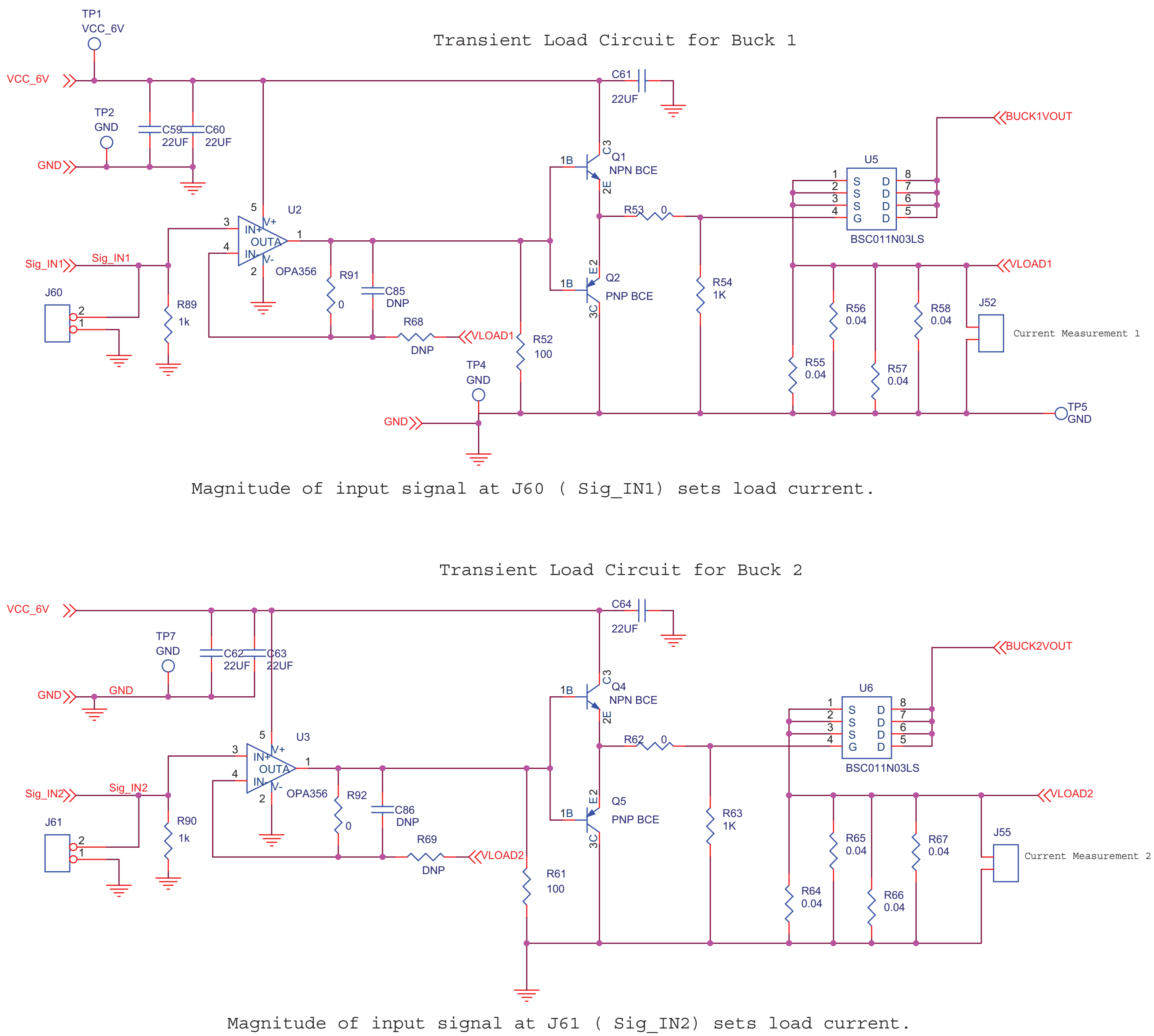


Figure 15. ISL91301BII-L/H-EV1Z Schematic - Page 3

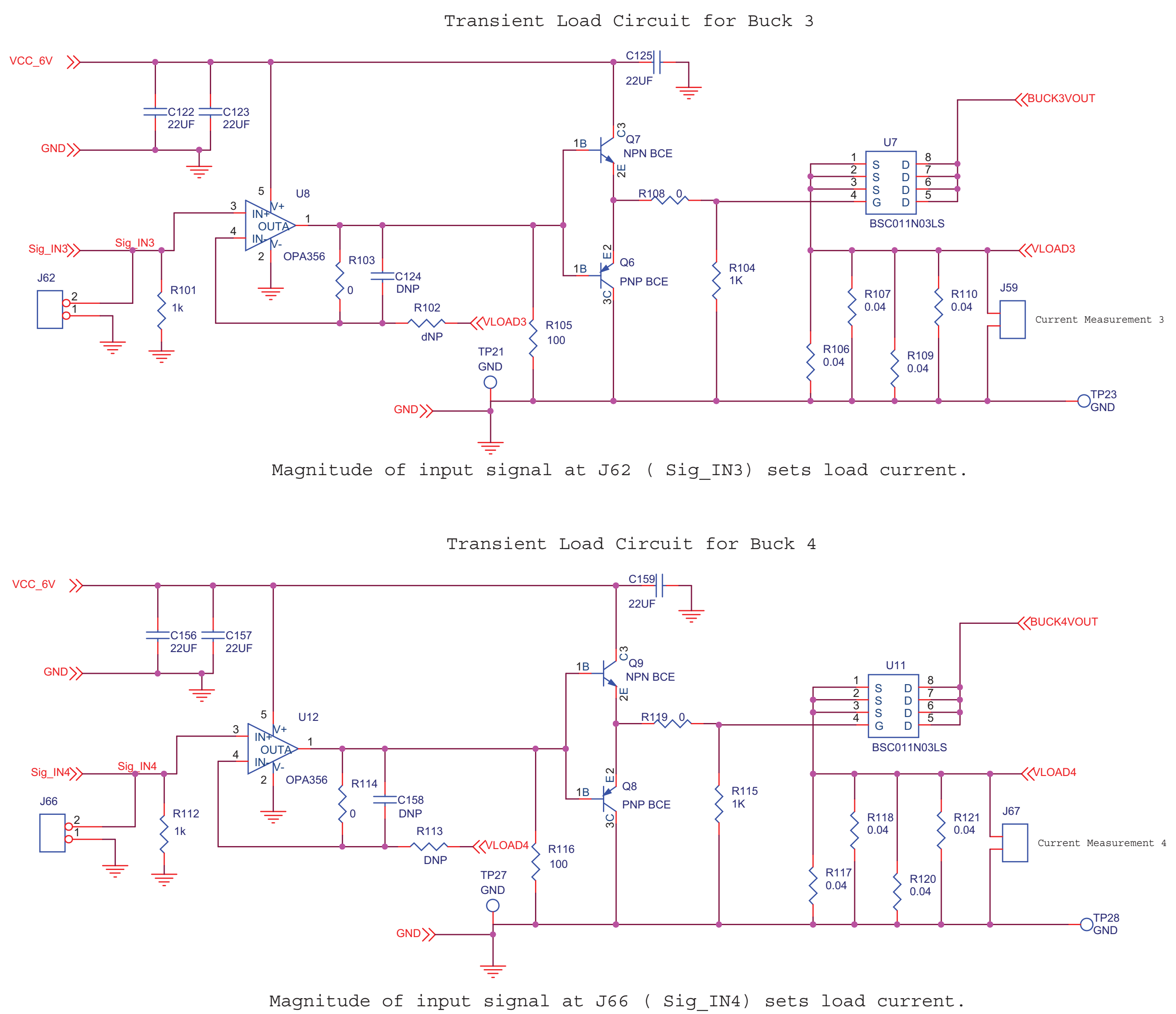


Figure 16. ISL91301BII-L/H-EV1Z Schematic - Page 4

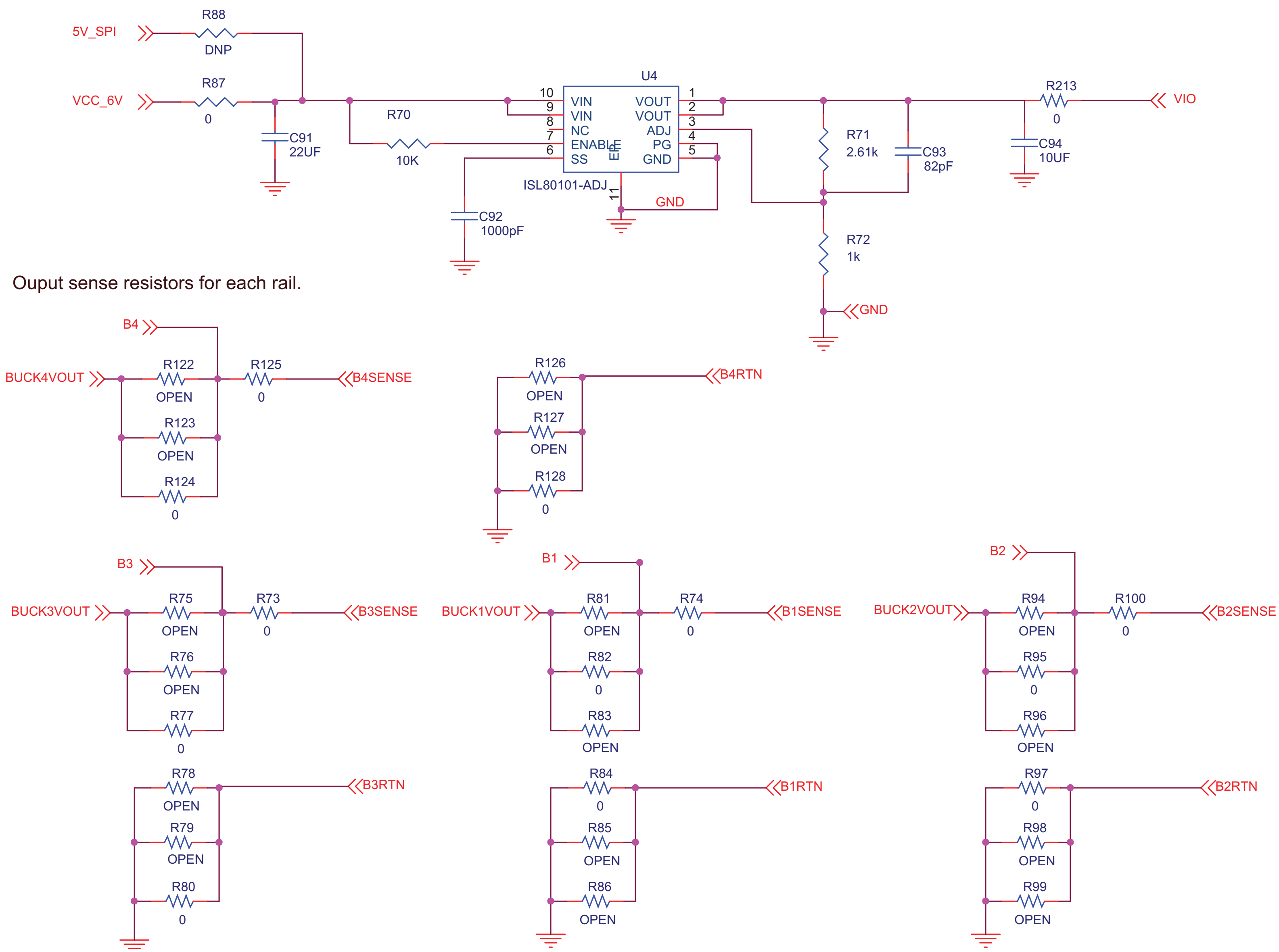


Figure 17. ISL91301BII-L/H-EV1Z Schematic - Page 5

3.4 ISL91301BII-L/H-EV1Z PCB Layout

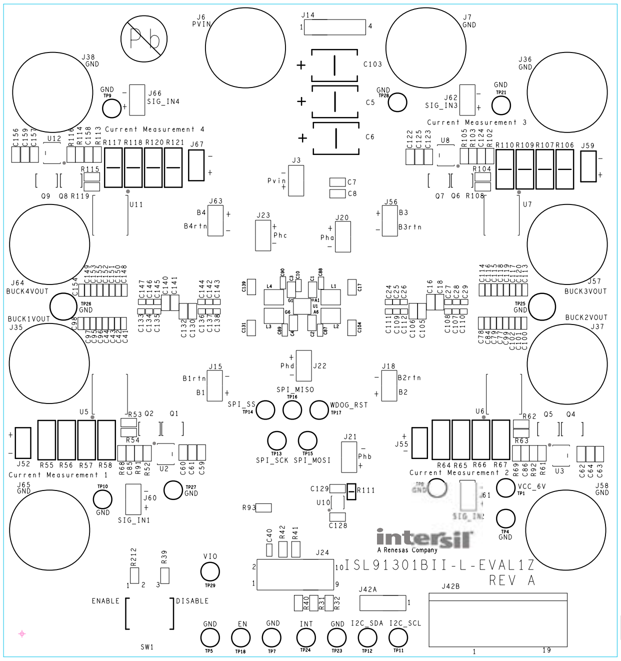


Figure 18. Top Silkscreen Layer

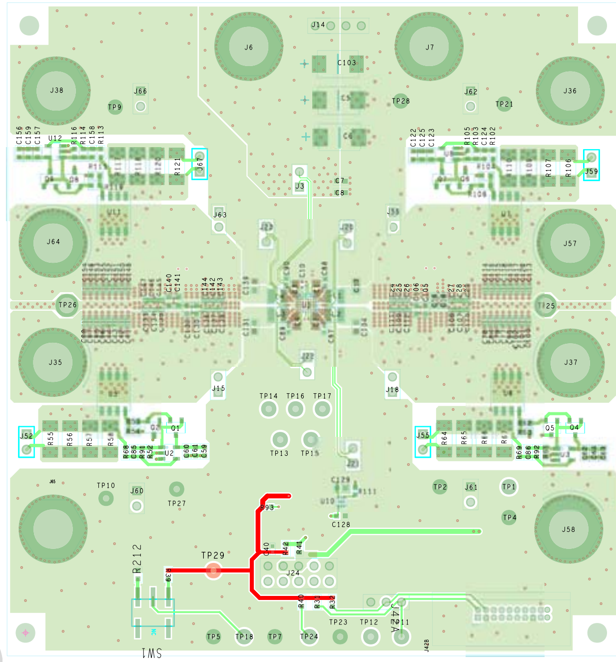


Figure 19. Top Layer

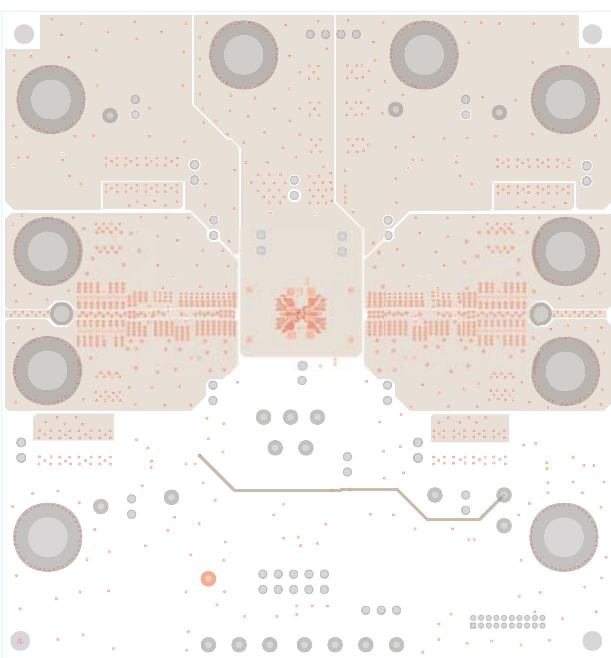


Figure 20. Layer 2 (PVIN Plane)

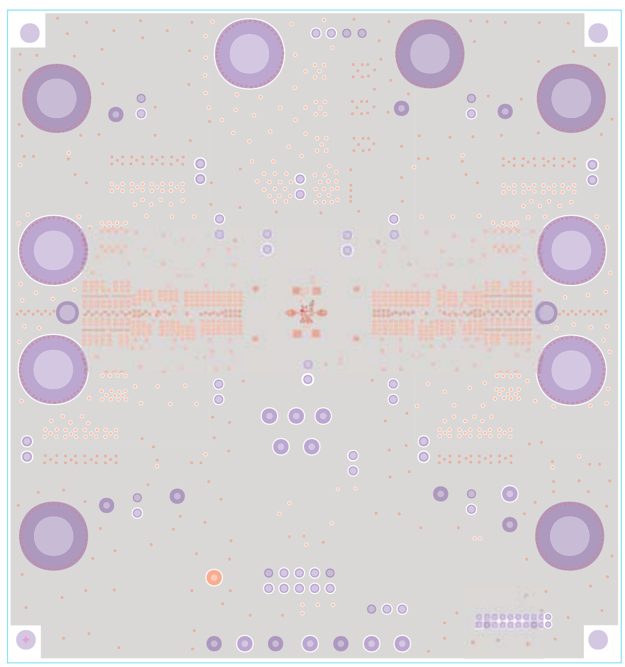


Figure 21. Layer 3 (GND Plane)

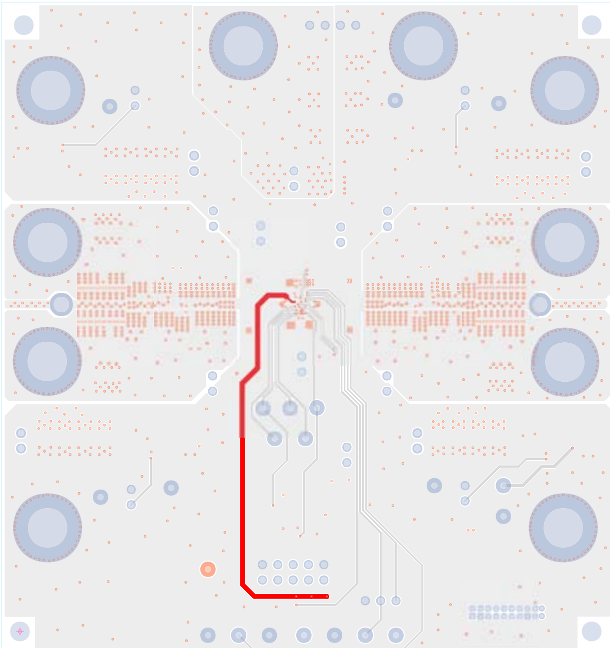


Figure 22. Layer 4 (IO Communications)

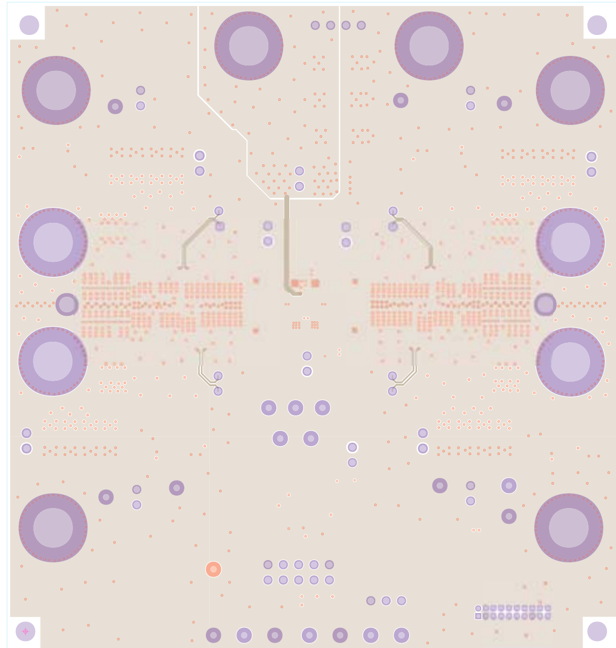


Figure 23. Layer 5 (GND Plane)

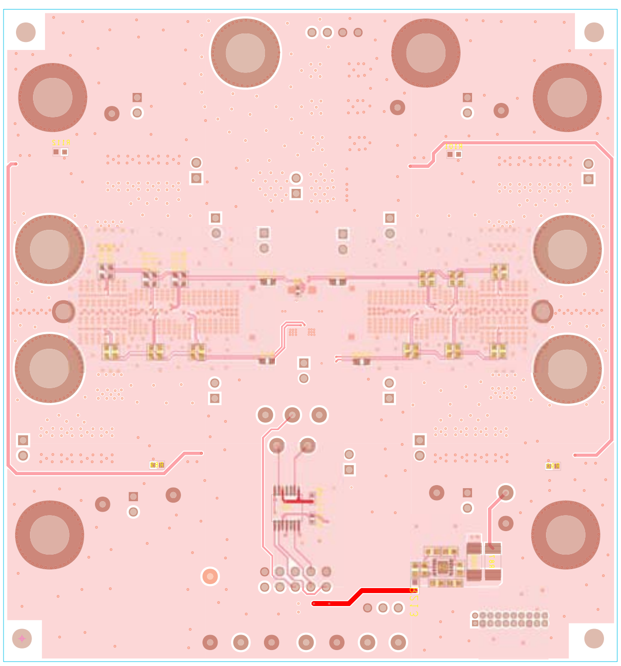


Figure 24. Bottom Layer (Remote Sense Lines)

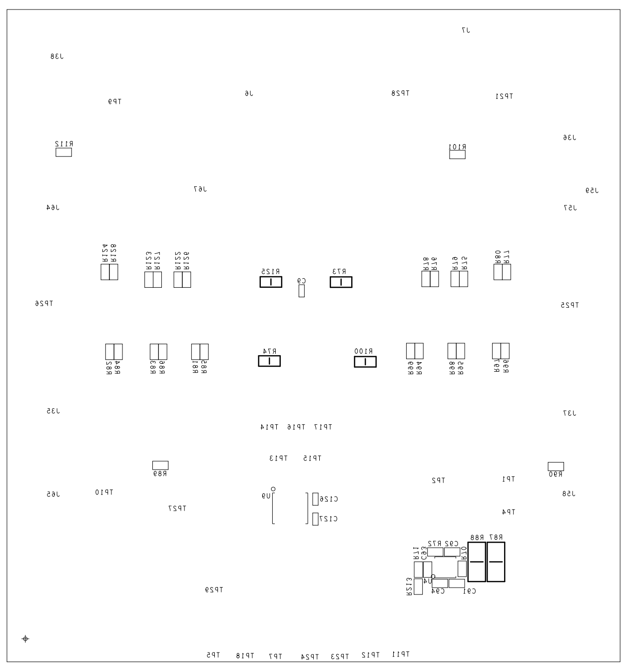


Figure 25. Bottom Silk Screen Layer

3.5 Bill of Materials

Qty	Top Components	Bottom Components	Description	Manufacturer	Part Number
5	C85, C86, C124, C158	C93	82pF, NP0, 0603	Taiyo Yuden	QVS107CG820JCHT
1		C92	1000pF, 100V, X7R, 0603	Taiyo Yuden	HMK107B7102KA-T
2		C126, C127	0.1µF, 10V, X5R, 0402	Taiyo Yuden	LMK105BJ104KV-F
1	C40		1µF, 10V, X5R, 0402	Taiyo Yuden	LMK105BJ105KV-F
2	C128, C129		1µF, 10V, X5R, 0603	Taiyo Yuden	LMK107BJ105KA-T
16	C41, C42, C43, C44, C77, C78, C79, C84, C113, C114, C115, C116, C148, C150, C151, C152		4.3µF Multi-Terminal, 4V, X5R, 0402	Murata	LLD154R60G435ME01
7	C1, C2, C3, C4, C7, C8	C94	10µF, 10V, X5R, 0603	Taiyo Yuden	LMK107BBJ106MAHT
1	C10		10µF, 10V, X5R, 0402	Samsung Electronics	CL05A106MP5NUNC
13	C17, C60, C61, C62, C64, C104, C123, C125, C131, C139, C157, C159	C91	22µF, 10V, X5R, 0603	TDK	C1608X5R1A226M080AC
3	C5, C6, C103		220µF, 6.3V, Polymer Tant, D Case	KEMET	T520D227M006ATE040
21	R53, R62, R108, R119, R91, R92, R103, R114	R73, R74, R78, R76, R85, R81, R99, R94, R100, R125, R122, R126, R213	0Ω, 1/10W, 0603	Panasonic	ERJ-3GEY0R00V
1		R87	RES SMD 0.0Ω Jumper 3/4W 2010	Stackpole	RMCF2010ZT0R00
16	R55, R56, R57, R58, R64, R65, R66, R67, R106, R107, R109, R110, R117, R118, R120, R121		0.04Ω, 1%, 1W, 2010	Vishay	WSL2010R0400FEA18
4	R52, R61, R105, R116		100Ω, 1%, 1/10W, 0603	Panasonic	ERJ-3EKF1000V
15	R31, R32, R39, R40, R42, R212, R54, R63, R104, R115	R72, R89, R90, R101, R112	1.0kΩ, 1%, 1/10W, 0603	Panasonic	ERJ-3EKF1001V
1		R71	2.61kΩ, 1%, 1/10W, 0603	Panasonic	ERJ-3EKF2611V
1		R70	10kΩ, 1%, 1/10W, 0603	Panasonic	ERJ-3EKF1002V
1	R111		10kΩ, 1%, 1/10W, 0603	Panasonic	ERJ-3EKF1002V
4	L1, L2, L3, L4		0.22µH, 12mΩ, 6.6Asat, 2520 Inductor	Cyntec	HMQR25201T-R22MSR
4	Q1, Q4, Q7, Q9		TRANS NPN 40V 0.2A SOT-23	Fairchild	MMBT3904
4	Q2, Q5, Q6, Q8		TRANS PNP 40V 0.2A SOT-23	Fairchild	MMBT3906
9	J6, J7, J35, J36, J37, J38, J57, J58, J64, J65		Conn Banana Jack Threaded 12AWG	Cinch Connectivity	108-0740-102
21	TP1, TP2, TP4, TP5, TP7, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP21, TP23, TP24, TP27, TP28, TP29		Conn-Gen, Compact Test Point, Vertical, White	Keystone	5007

Qty	Top Components	Bottom Components	Description	Manufacturer	Part Number
17	J3, J15, J18, J20, J21, J22, J23, J52, J55, J56, J59, J60, J61, J62, J63, J66, J67		2 Pin Header, 100 mil spacing	FCI	77311-118-02LF
1	J42		3 Pin Header, 100 mil spacing	Harwin	M22-2510305
1	J24		2x5 Pin Header, 100 mil spacing	Harwin	M20-9980545
1	J42B		Right Angle Connector	Harwin	M50-3901042
1	SW1		Switch-Toggle, SMD, 6PIN, SPDT, 2POS, ON-NONE-ON, ROHS	ITT INDUSTRIES/ C&K DIVISION	GT11MSCBE
2	TP25, TP26		Turret Binding Post	Keystone	1514-2
1	U1		ISL91301IILZ, 0.4mm Pitch WLCSP	Renesas	ISL91301IILZ
4	U2, U3, U8, U12		IC OPAMP VFB 200MHZ RRO SOT23-5	Texas Instruments	OPA356AIDBVR
1		U4	IC REG LDO ADJ 1A 10DFN	Renesas	ISL80101IRAJZ
4	U5, U6, U7, U11		MOSFET N-CH 30V 100A 8TDSON	Infineon	BSC011N03LSCT-ND
1		U9	IC Translator LVL 100MBPS 14TSSO	Maxim	MAX3023EUD+-ND
1	U10		Linear Regulator IC Fixed Output 3.3V 150mA 6-UTDFN (1.6x1.6)	Renesas	ISL9008AIENZ-T

4. Typical Performance Curves

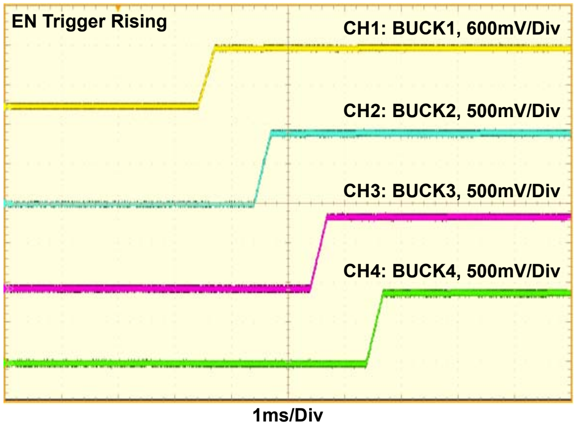


Figure 26. Startup by EN, VOUT1, 2, 3, 4 = 0.9V

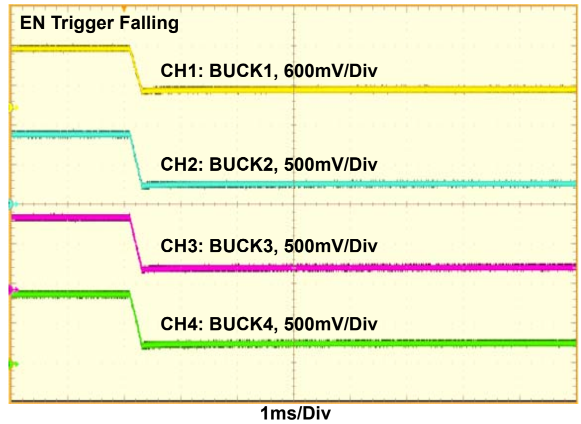


Figure 27. Shutdown by EN, VOUT1, 2, 3, 4 = 0.9V

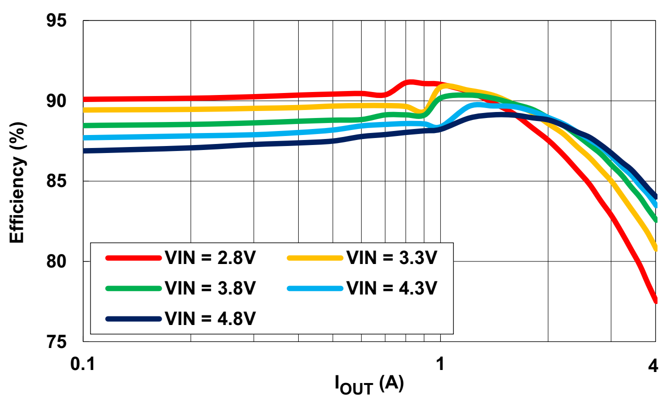
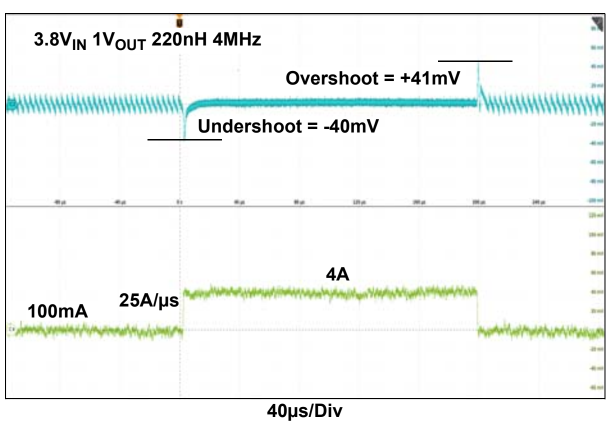


Figure 28. Single-Phase Efficiency (V_{OUT} = 1V), Continuous Load Sweep (0.1A to 4A), Switching Frequency = 4MHz



Load Step Slew Rate: 25A/µs, 0.1A to 4A
220nH Inductor (Cyntec PIFE25201T-R22MS)
2x22µF Capacitor (0603 6.3V Murata)
2x4.3µF Capacitor (0402 Low ESL Murata)

Figure 29. Single-Phase Load Transient (4A/160ns)

5. Revision History

Rev.	Date	Description
0.00	Apr 4, 2018	Initial release

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

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