EVM User's Guide: LP87694Q1EVM

LP8769x-Q1 Evaluation Module

Description

The LP87694Q1EVM board can be used to test, demo, debug and configure one or more LP8769x-Q1 power management ICs for automotive and industrial applications. The device on board is LP876940C0RQKRQ1 which has 1+1+1+1-phase configuration for 4 different output voltage rails. The EVM boards can be stacked for multi-PMIC operation testing

Get Started

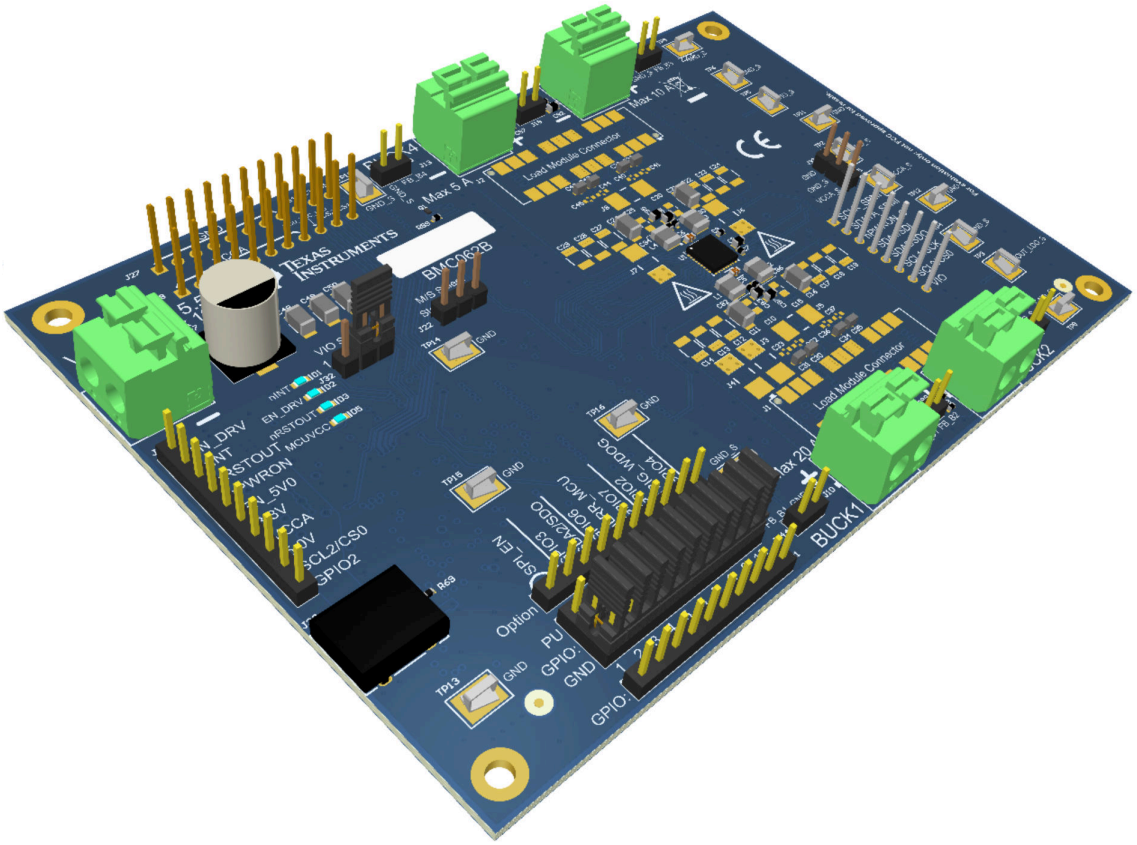
1. Order the EVM here.
2. Download the GUI here for configuration and evaluation.
3. Download the supporting documents here.
4. Get additional material in functional safety and design secure resources here.

Features

- Input voltage range from 2.8V to 5.5V
- Evaluation module can be powered with a bench power supply or USB-C®
- On-board MSP432 to communicate with PMIC using the GUI via USB-C cable
- Board can be reworked to support other LP8769-Q1 phase configurations
- Boards can be stacked to support multi-PMIC operation testing

Applications

- Advanced driver assistance systems (ADAS)
- Front camera
- Surround view system ECU
- Long range radar
- Sensor fusion
- Domain controller



1 Evaluation Module Overview

1.1 Introduction

The LP8769x-Q1 power management integrated circuit (PMIC) family is extremely flexible and scalable, providing configurability at the device and system level. At the device level, a single PMIC can provide up to four separate step down converters (buck regulators). These buck regulators can be used in multiphase mode to provide a single 20A source. At the system level, several PMICs can be configured to work in a controller-target topology with one controller and up to five target PMICs. The LP8769x-Q1 evaluation module (EVM) is both an evaluation and development tool. With the EVM both device level and system level configurability are available through an easy to use graphical user interface (GUI) tool.

The LP8769x-Q1 evaluation module (EVM) highlights the performance and flexibility of the LP8769x-Q1 power management integrated circuit (PMIC). The modular design allows the EVMs to be stacked to provide a multi-PMIC design with a single PMIC acting as the controller and up to five PMICs as target. This document can be used in conjunction with the Scalable PMIC's GUI User's Guide and the LP8769-Q1 High Frequency Quad Step-Down DC-DC.

CAUTION

Hot surface. Contact can cause burns. Do not touch.

High current connectors are marked with maximum current text next to the corresponding connector.

1.2 Kit Contents

The following items are included in the EVM box:

1. EVM
2. USB-A male to USB-C® male cable
3. Literature and EVM disclaimer document

1.3 Specification

The default voltages and current output capabilities of the LP876940C0RQKRQ1 are shown in Table 1-1 . These output voltages are enabled when a proper supply is given to the device. For all jumper options, refer to Section 2.2.3.

Table 1-1. LP876940C0RQKRQ1 Rails

Rail	Voltage	Current Capability
VCCA	3.3V	-
BUCK1	0.75V	5A
BUCK2	0.8V	5A
BUCK3	1.2V	5A
BUCK4	1.8V	5A

1.4 Device Information

Table 1-2 shows the available controller and target EVM, the silicon associated with the EVM, the initial non-volatile memory (NVM) configuration, and the hardware components associated with the configuration. Because of the configurable nature of both the part and the EVM, any EVM can be configured as a controller or target device.

Table 1-2. EVM Description

EVM Part Number	PMIC Device Part Number	NVM Phase Configuration	f_{SW}	Populated phase components	
				R1-R7	J3-J8
LP87694Q1EVM	LP876940C0RQKRQ1	1+1+1+1-phase, 4-output: BUCK1, BUCK2, BUCK3, BUCK4	2.2MHz	R1, R3, R4 and R7	-

2 Hardware

2.1 Getting Started

Only a power supply and the EVM board are required to evaluate and test the LP8769x-Q1 default configuration under load conditions. This section contains the controller and controller+target configurations and how to run these two default configurations.

2.1.1 Getting Started: Single EVM

1. Connect power to the EVM.
2. Connect the EVM to the Host PC through the USB. If the power is provided by the USB cable, apply the appropriate jumper connection to connect EN_5V0 with 3.3V and VCCA with 5.0V, see Table 2-5.
3. Launch the GUI and evaluate.

Terminal J9, labeled VCCA in Figure 2-1, can accept wire gauges up to 14 AWG. The voltage supplied must be within the input range of the device, 2.8V to 5.5V. The power supply providing the input to VCCA is required to supply 135 % of the output power. Once power has been supplied to VCCA, the GPIO4 / ENABLE jumper can be used to power on the output rails (in LP87694Q1EVM GPIO2 can be used to control BUCK4 after GPIO4 has been set high). The default ON Request for the controller device is the ENABLE pin which is a level sensitive input. Please refer to LP8769-Q1 High Frequency Quad Step-Down DC-DC for more details.

Figure 2-1 shows the LP8769x-Q1 EVM (controller).

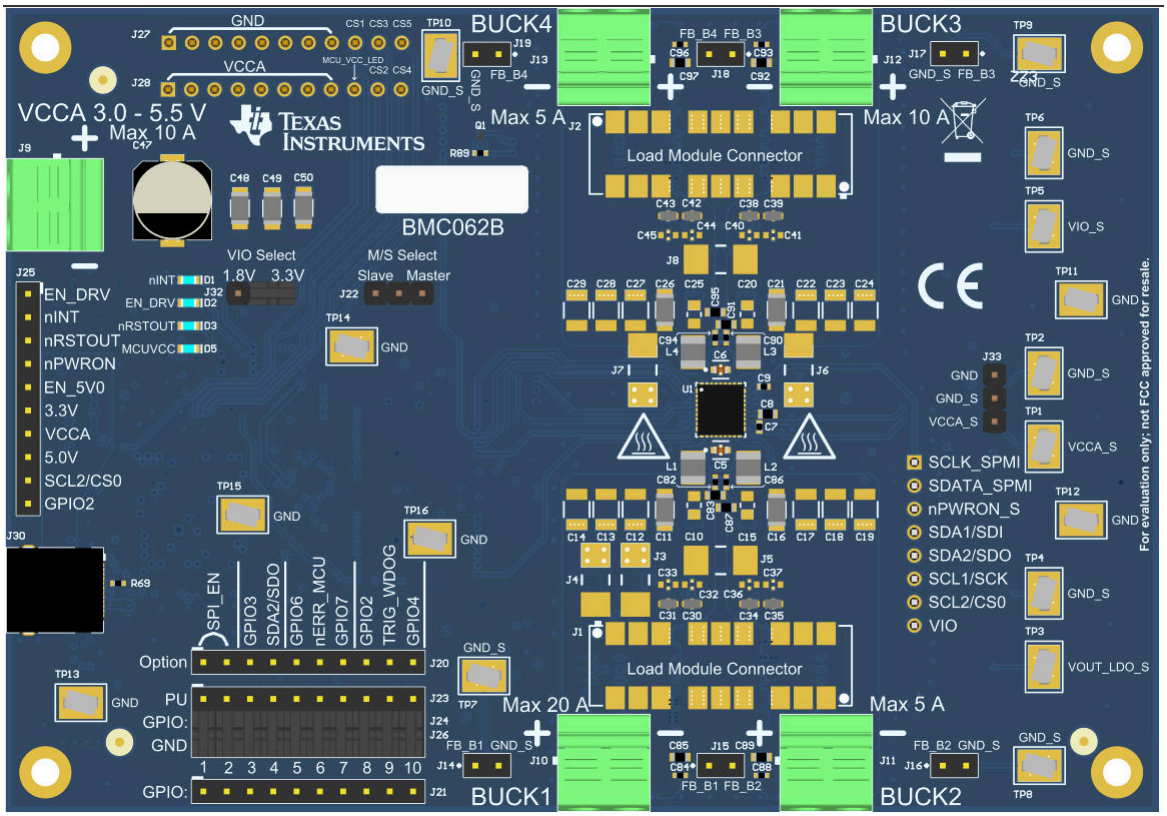


Figure 2-1. EVM (Top View)

2.1.2 Getting Started: Multiple EVM Evaluation

1. Connect power to one EVM and remove the jumpers on all EVMs shorting 5.0V with VCCA and EN_5V0 with 3.3V (J25). All VCCA and GND power pins are shared between the stacked EVMs. Remove the VIO jumper (J32) from the target EVM.
2. Connect controller EVM to the Host PC through the USB. In the event that the power is provided by the USB cable, apply the appropriate jumper connection to connect VCCA with 5.0V and 3.3V with EN_5V0 as shown Table 2-5.
3. Stack controller EVM and target EVMs. For convenience, TI recommends to place the controller on the top of the stack.
4. Launch the GUI and evaluate.

The EVM can be powered solely from the 5V USB connection, provided that the total power taken from the USB port is less than 2 W. This removes the requirement for a separate supply when evaluating a number of the digital features of the PMIC with the EVM.

The distinguishing characteristics of the target EVM are the PMIC and the jumper position on J22. With the jumper on J22 placed in the target position, SPMI connection between controller and target EVMs is enabled. When EVM is defined as target the EVM I2C pull-ups are disabled to avoid too strong pull-up on I2C bus. Once the controller and target devices are stacked, supplying power on J9 is the only requirement for getting started. VCCA is distributed across all stacked boards through J28. The power supply can be applied to any of the available J9 terminals in the stack.

2.2 EVM Details

The following sections describe the various interfaces for measuring and controlling the configuration. Note: the configurations are in coordination with the settings of the PMIC. Note the importance to understand that both the EVM configuration and the settings of the PMIC must match. For example, if the GUI is used to change the PMIC interface to SPI from I^2C, then the appropriate SPI related jumpers must be in place on J20 and J25. Please refer to the GUI User's Guide SLVUBT8 on how to update the PMIC communication protocol.

2.2.1 Terminal Blocks

The terminal blocks are simple push and release terminals which can accommodate wire sizes up to 14 AWG. Table 2-1 lists the terminal blocks found around the perimeter of the EVM. J9, VCCA, is the input voltage for the regulators. The rest of the terminal blocks are for the BUCK outputs.

Table 2-1. Terminal Blocks

Terminal	Designator	Description
VCCA	J9	All regulator input, 2.8V to 5.5V range
BUCK1	J10	Buck 1 output, 5A capable
BUCK2	J11	Buck 2 output, 5A capable
BUCK3	J12	Buck 3 output, 5A capable
BUCK4	J13	Buck 4 output, 5A capable

2.2.2 Test Point Descriptions

Numerous test points are provided to access voltages and signals. Test points marked with _S are designed for sensing voltages only and are not designed to carry large DC currents.

Table 2-2. Test Point Descriptions

Test Point	Device Pin	Description
TP1	VCCA_S	VCCA voltage sense point. Routed from close to the VCCA pin of the LP8769-Q1.
TP2, TP4, TP6, TP7, TP8, TP9, TP10	GND_S	Ground sense points routed from various locations.
TP3	VOUT_LDO_S	Voltage sense point for the internal LDO output voltage.
TP5	VIO_S	VIO voltage sense routed from the VIO pin of the LP8769-Q1.
TP11, TP12, TP13, TP14, TP15, TP16	GND	Solid ground points. Are able to carry larger DC currents.
J14, J16, J17, J19	FB_B1, FB_B2, FB_B3, FB_B4	Buck output voltage sense points. Secondary buck unused FBs are possible to use as voltage monitor as well.

2.2.3 Configuration Headers

There are four headers available to configure the EVM functions. Header J22 configures controller and target mode of operation. Header J20, as shown in the silk screen picture in Figure 2-2, is used to configure the EVM to match the feature setting written to the LP8769x-Q1 configuration registers. J32 is used to select the PMIC IO voltage, either 1.8V or 3.3V. The fifth header is J25 which allows VCCA to be powered from the USB connection and the configuration of GPIO2, I2C2 or SPI.

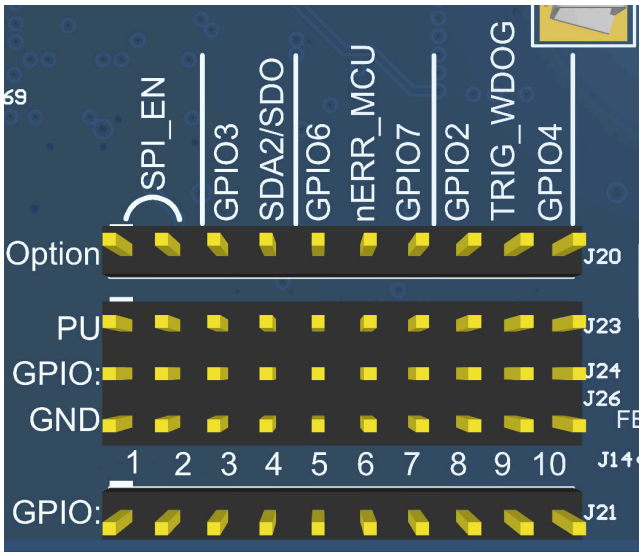


Figure 2-2. EVM Header J20

Table 2-3. Header J20 Description

Option Pins	Configuration	Description	
SPI_EN	Open (Default)	I²C Mode. The signal path for I²C communication between the MCU and the PMIC is enabled.	
	Closed	SPI mode. The signal path for SPI communication between the MCU and the PMIC is enabled.	
GPIO3, SDA2/SDO	Open (Default)	GPIO mode. GPIO2 from PMIC is connected to PM7 of the MCU through a level translator.	
	GPIO3,SDA2/SDO: Closed	I²C Mode (J20 VIO, I2C/SPI: Open)	Q&A Watchdog mode. GPIO3 of the PMIC must be in the Alternative function to support the Q&A Watchdog and the I²C mode is selected. This setting must also be done on connector J25 by closing GPIO2 to SCL2/CS if I2C2 is wanted to be used.
		SPI mode (J20 VIO, I2C/SPI: Closed)	SPI mode, Chip Select. GPIO2 and GPIO3 of the PMIC must be in the Alternative function to support SPI communication. This setting must also be done on connector J25 by closing GPIO2 to SCL2/CS if I2C2 is wanted to be used.
GPIO6, nERR_MCU, GPIO7	Open (Default)	GPIO mode. GPIO6 of the PMIC is connected to PP5 of the through a level translator.	
	GPIO6, nERR_MCU Closed	System error count down input signal from the MCU. VIO select must be 3.3V. GPIO6 or GPIO7 of the PMIC must be in the Alternative function to support the system error count down from the MCU.	
	nERR_MCU, GPIO7 Closed		
GPIO2, TRIG_WDG, GPIO4	Open (Default)	GPIO mode. GPIO7 of the PMIC is connected to PH0 of the through a level translator.	
	GPIO2, TRIG_WDG Closed	Trigger signal for trigger mode watchdog. VIO Select must be 3.3V. GPIO7 or GPIO6 of the PMIC must be in the Alternative function to support the trigger mode watchdog signal.	
	TRIG_WDG, GPIO4 Closed		

Table 2-4. Header J32 VIO Voltage Select

Configuration	Description
Open	Not allowed for single or controller EVM, 1.8V or 3.3V must be selected. Leave open on target EVM.
VIO Select, 3.3V: Closed (Default)	VIO is 3.3V
VIO Select, 1.8V: Closed	VIO is 1.8V

Table 2-5. Header J25, VCCA, GPIO2/I2C/SPI

Configuration	Description	
3.3V, VCCA: Closed (Default)	3.3V from TLV733P-Q1 (U11) is connected to VCCA. The input for U11 is the 5V from the USB connection (VBUS). VBUS is not intended to support heavy load conditions. 2 W must be the maximum power drawn from the USB.	
EN_5V0, 3.3V, VCCA, 5.0V Open	On board 5V regulator is disabled and VCCA isolated from other on board supplies. VCCA must be powered from J9.	
EN_5V0, 3.3V: Closed	5V on board regulator (powered from USB) is enabled. 5V regulated supply can be used to power VCCA.	
VCCA, 5.0V: Closed	5V on board regulator (powered from USB) is connected to the LP8769-Q1 VCCA. 5V on board regulator is not intended for heavy load condition.	
SCL2/CS, GPIO2: Open	GPIO mode. GPIO2 of the PMIC is connected to IO2 of the MCU.	
SCL2/CS, GPIO2: Closed (Default)	I^2C mode (J22 SPI_EN: Open)	Q&A Watchdog mode. GPIO2 and GPIO3 of the PMIC must be in the Alternative function to support the Q&A Watchdog and the I^2C mode selected. This setting must also be done on connector J20 by closing GPIO3 to SDA2/SDO if I2C2 is wanted to be used.
	SPI mode (J22 SPI_EN: Closed)	SPI mode, Chip Select. GPIO2 and GPIO3 of the PMIC must be in the Alternative function to support SPI communication. This setting must also be done on connector J20 by closing GPIO3 to SDA2/SDO.

Note

The PMIC device can be configured for a power good level of 3.3V or 5V for the VCCA pin. If VCCA_VMON feature is enabled, then check that the input voltage is correct and use sense connection to compensate IR voltage drop with heavy load currents. Align the VCCA/3.3V/5.0V jumper with the PMIC configuration. The default PMIC configuration supports the whole recommended VCCA voltage range.

2.2.4 Stack-up Headers

As shown in Figure 2-3, multiple boards can be configured into a controller-target relationship (1 controller and up to 5 targets) and physically stacked upon each other. Stacked boards can be either LP87694Q1EVM, LP87644Q1EVM, TPS65941111EVM or TPS65941212EVM evaluation modules. VCCA and GND are shared between boards on headers J27 and J28. Communication between the boards is shared on header J29. This header, J29, is marked on the bottom silkscreen, as shown in Figure 2-4.

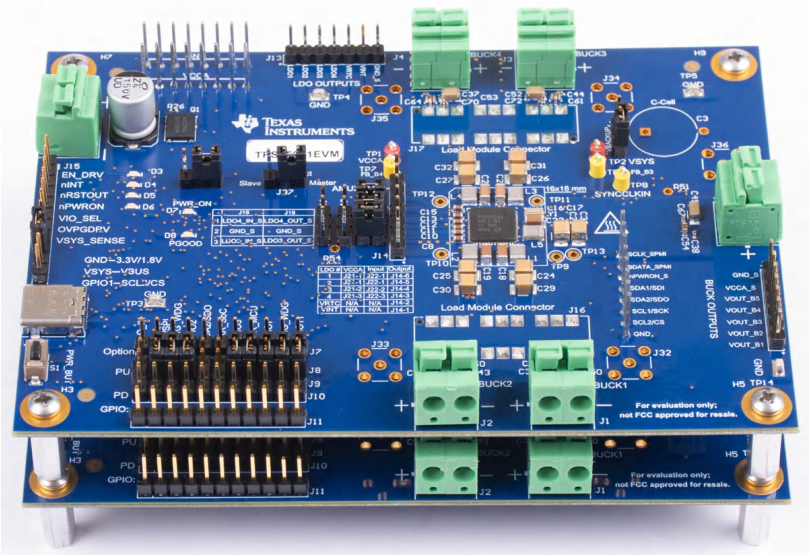


Figure 2-3. EVM Controller-Target Configuration

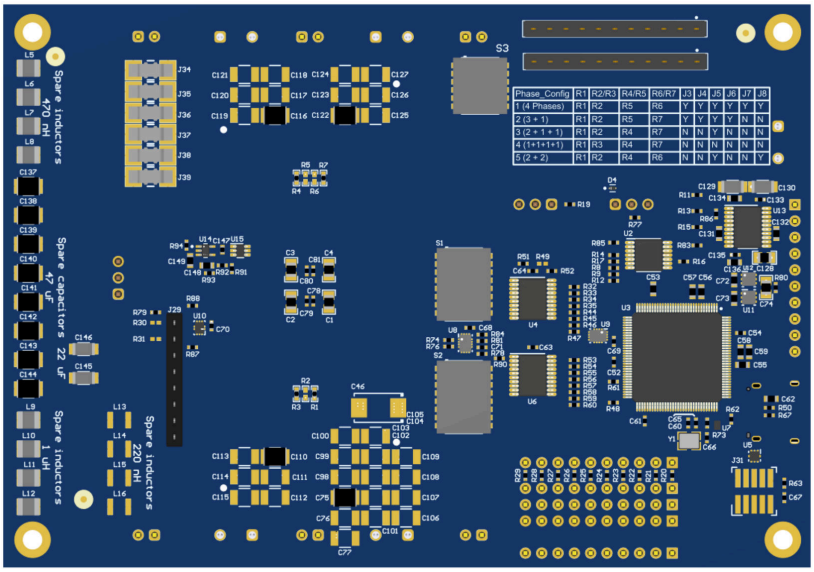


Figure 2-4. EVM (Bottom View)

Setting J22 to controller position connects nPWRON signal from controller to target through nPWRON_S pin on connector J29. This signal allows a SPMI connection between controller and target PMICs. Jumper J22 needs to be set to target position on target EVMs to disable pull-up resistors. By using this stackup configuration, the power up sequences of one or more target EVMs always follow the controller.

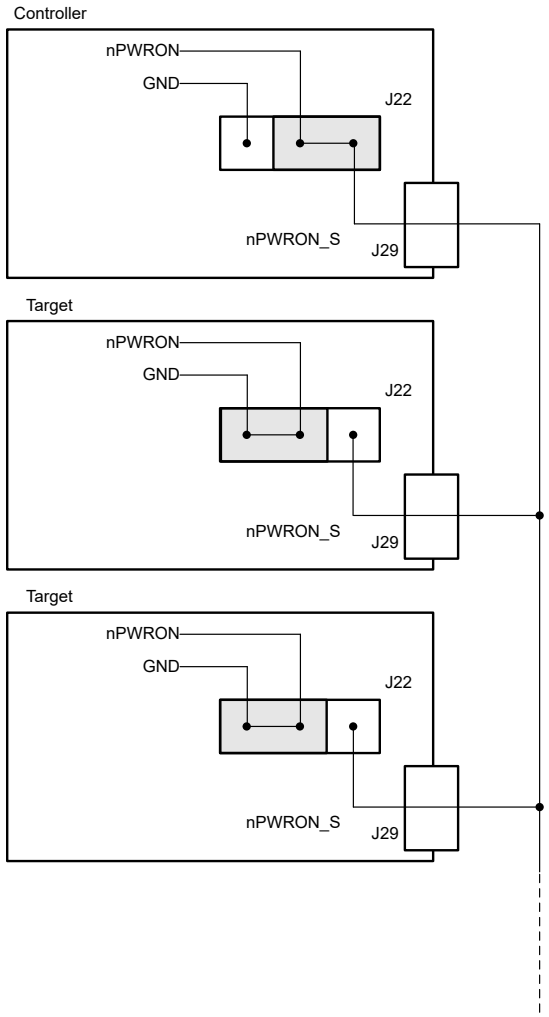


Figure 2-5. Header J22, Recommended Power Sequence (Enable) for Controller and One or More Targets

Table 2-6. Header J22 Controller/Target Select

Configuration	Description
Open	When used as a single PMIC (no stacking). The controller EVM can use GPIO8 and GPIO9 to be connected to a MCU on EVM. I2C pull-up resistors are enabled.
Target, M/S select: closed	Target mode: the target EVM can use GPIO8 and GPIO9 for SPMI communication between PMICs. I2C pull-up resistors are disabled on target EVMs.
M/S select, controller: closed	Controller mode: the controller EVM can use GPIO8 and GPIO9 for SPMI communication between PMICs. I2C pull-up resistors are enabled on controller EVM.

2.2.5 Connectors

Two load module connector footprints are provided, J1 and J2. These load module connectors are intended to be used with PMICLOADBOARDEVM which is sold separately. The connector components are not populated and the required connectors are shipped with PMICLOADBOARDEVM.

2.2.6 Dip Switches

There are three DIP switches S1, S2, and S3 on the back side of the PCB. S1 and S2 switches allow the user to disconnect the level shifter from the PMIC GPIOs or serial interfaces. The level shifter has pull-ups on the MCU side that can cause unwanted high state on the GPIO signals if configured in high impedance state. S3 switch is used for configuring chip select for target device in multi PMIC/stacked use case. See the Table 2-7 for the descriptions of the switches.

Table 2-7. Dip Switches

Switch	Pin	Signal Line
S1	1-16	SDA_I2C1/SDI_SPI
	2-15	SCL_I2C1/SCK_SPI
	3-14	SDA_I2C2/SDO_SPI
	4-13	SCL_I2C2/CS_SPI
	5-12	GPIO1
	6-11	GPIO2
	7-10	GPIO3
	8-9	GPIO4
S2	1-16	GPIO5
	2-15	GPIO6
	3-14	GPIO7
	4-13	GPIO8
	5-12	GPIO9
	6-11	GPIO10
	7-10	Not connected
	8-9	nINT
S3	1-12	CS5
	2-11	CS4
	3-10	CS3
	4-9	CS2
	5-8	CS1
	6-7	GPIO2

2.2.7 EVM Control and GPIO

The EVM has a built-in USB interface based on the MSP432E401Y (U3) to allow the GUI, from the host computer, to communicate with the PMIC. The supply voltage required by the MSP432E401Y is generated automatically by the TLV73333PQDRVRQ1 (U11) and TLV73318PQDRVRQ1 (U12) LDOs which provides 3.3V and 1.8V from USB power, +VBUS. These voltages are available for supplying VIO for the PMIC (selectable from J32). Two SN74GTL2003 level shifters (U4, U6) are used in order to support the use case of the PMIC VIO of 1.8V (the MCU IO is always be 3.3V). In addition to the level shifters, the TS3A5018RSVR (U8) switch is used to apply the pullup voltages to the I^2C lines only when the EVM is configured as controller (J22). Additional TS3A5018RSVR (U9) switch for SPI enable/disable. The application of the pullup resistors is for I^2C mode only and is only intended for one board in a stack-up application. The EVM has four LEDs to indicate board power, on or off, and some predefined PMIC GPOs status. The signals are listed in Table 2-8.

Note

In the stack-up configuration, only controller board can have a valid +VBUS voltage on the board. This means that the controller board can have a connected USB cable supplying +VBUS and that controller board VCCA can be connected to +5.0V through J25, see Table 2-5.

Table 2-8. EVM LED Indicators

LED Designator	Indication
D1	LED is on when nINT is low.
D2	LED is on when EN_DRV is high.
D3	LED is on when nRSTOUT is low.
D5	EVM power indicator.

2.3 Customization

The EVM, in conjunction with GUI tool, provides various degrees of customization. A couple of examples are provided here which can be generalized to a number of functions. There are spare components assembled on the EVM to help with the customization, namely inductors L5...L12, capacitors C137...C146, and jumper bridges J34...J39.

2.3.1 Changing the Communication Interface

The default settings for communication with the PMIC is I^2C. Changing to SPI requires a minor change to the jumper settings and those settings changes in the case of multiple EVMs in a stackup configuration. These jumper settings are highlighted in red in Figure 2-6. The first jumper to place is on the SPI_EN option on connector J20. Placing this jumper connects the micro controller to the SPI bus, which is connected to all available PMICs through the EVM stack connection through J29. In a multiple EVM stackup, this jumper can only be placed on the controller EVM with the USB connection to the host computer. The SPI does not have a device ID and, therefore, the chip select is used to determine which PMIC receives and responds to commands on the SPI bus. The signals SCL2/CS and GPIO2 on J25 can only be jumpered on the controller EVM, which connects to the USB. Stacked target EVMs must have the CS selected with the S3 dip switch on the bottom of the board. For example, with first target board GPIO2 switch and SPI_CS1 switches can be closed, other switches open. And, on second target board GPIO2 and SPI_CS2 switches must be closed and so on. See Table 2-7 for details on S3 switch settings.

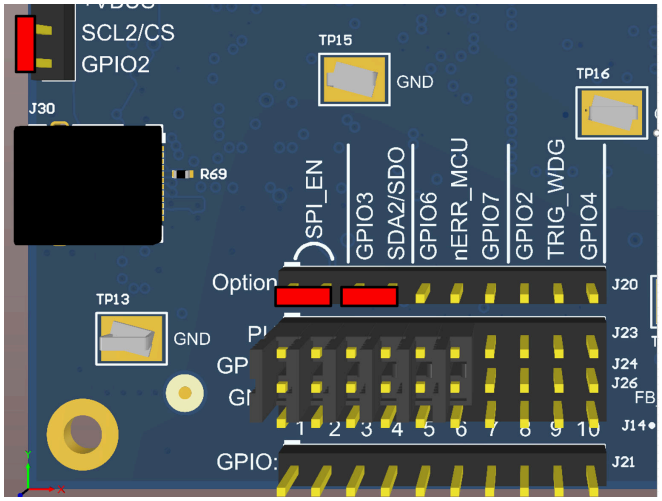


Figure 2-6. Interface Settings for SPI Communication

2.3.2 Changing the Phase Configuration

There are five possible phase configurations as shown in Table 2-9. Note the importance that the phase configuration of the EVM matches the phase configuration of the PMIC. Jumpers J3-J8 are located on the top side of the PCB whereas the resistors R1-R7 are on the bottom side of the PCB.

Table 2-9. Phase Configurations

Phase Configuration	R1	R2/R3	R4/R5	R6/R7	J3	J4	J5	J6	J7	J8
1 (4-phase)	R1	R2	R5	R6	Y	Y	Y	Y	Y	Y
2 (3+1)	R1	R2	R5	R7	Y	Y	Y	Y	N	N
3 (2+1+1)	R1	R2	R4	R7	N	N	Y	N	N	N
4 (1+1+1+1)	R1	R3	R4	R7	N	N	N	N	N	N
5 (2+2)	R1	R2	R4	R6	N	N	Y	N	N	Y

This table is also printed on the EVM on the bottom side of the PCB. All the feedback voltages can be measured from J14-J19 where J15 and J18 are differential feedbacks.

Note

Users can use unused the feedbacks for the secondary buck for voltage monitoring. 0ohm resistor connecting the FB pin to GND must be opened in this case (for example, R5/R6).

3 Software

3.1 GUI Tool

Texas Instruments provides a GUI tool to enable, configure, and evaluate the various features of the LP8769x-Q1 with the EVM. Please refer to the GUI User's Guide for a more detailed description of this tool.

The GUI runs on most PC platforms and requires an available USB port. The EVM USB connector is a USB Type-C® and a Type-A to Type-C cable is provided with the EVM to connect to the host computer. The EVM enumerates as two COM ports and one additional port for the device firmware updates. The GUI must be using ACCtrl COM port, which can be found from the device manager of the operating system. The COM port can be changed from the GUI from Options - Serial port menu.

A tool for estimating the efficiency of LP8769x-Q1 device is also available called PMIC Efficiency Estimator Tool. The tool can be accessed here.

4 Hardware Design Files

4.1 Schematics

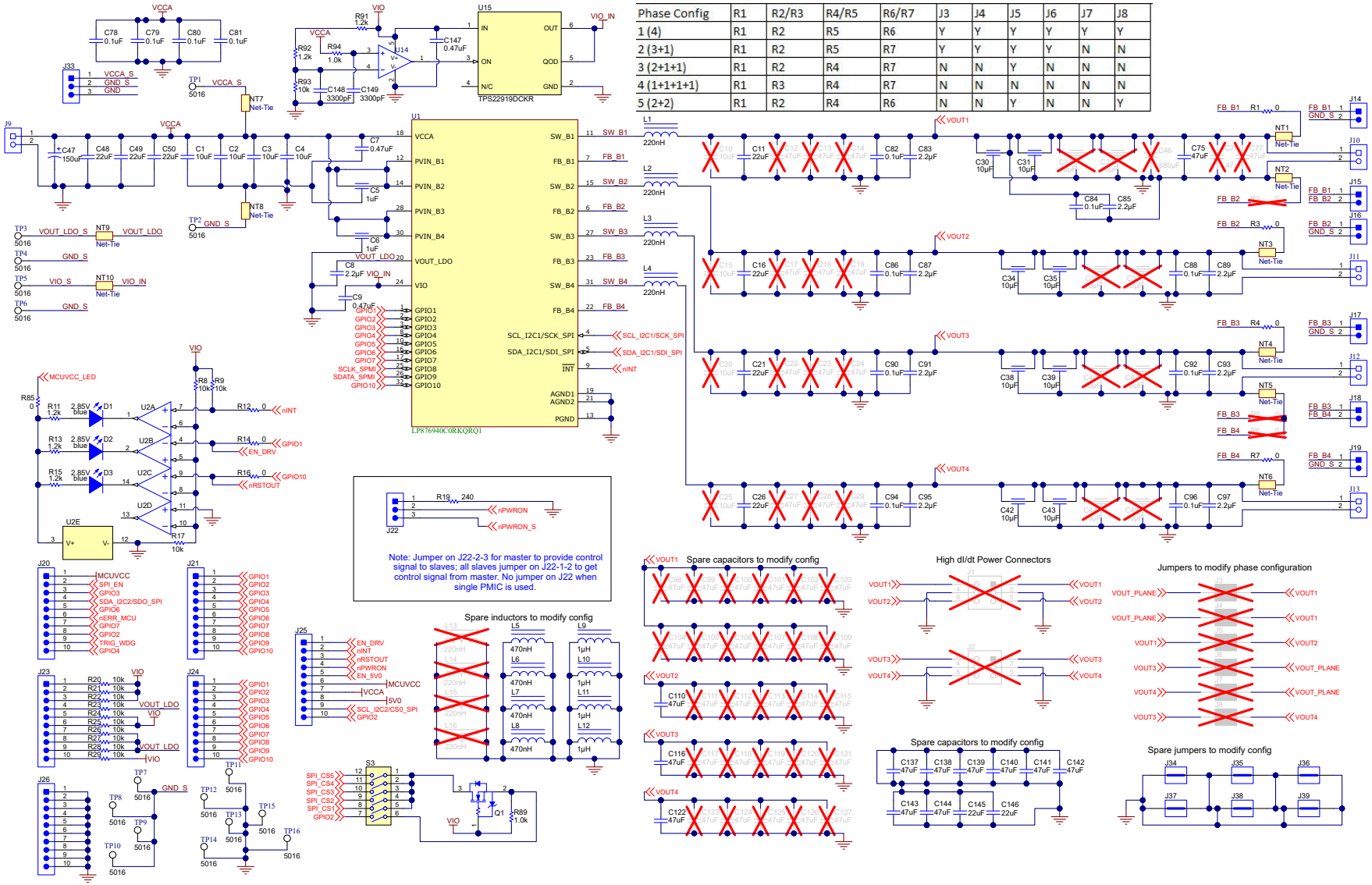


Figure 4-1. Schematic Page 1

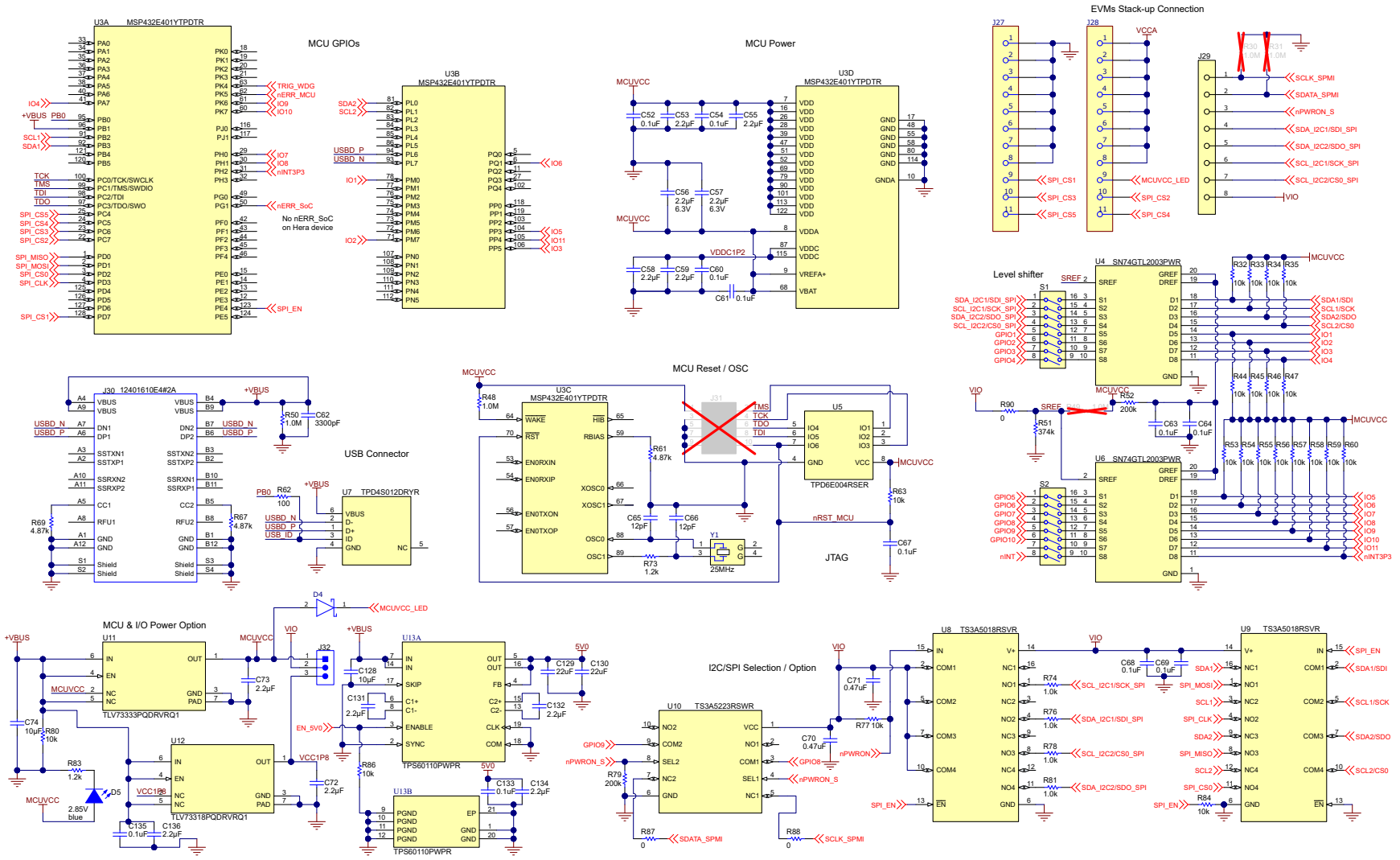


Figure 4-2. Schematic Page 2

4.2 PCB Layouts

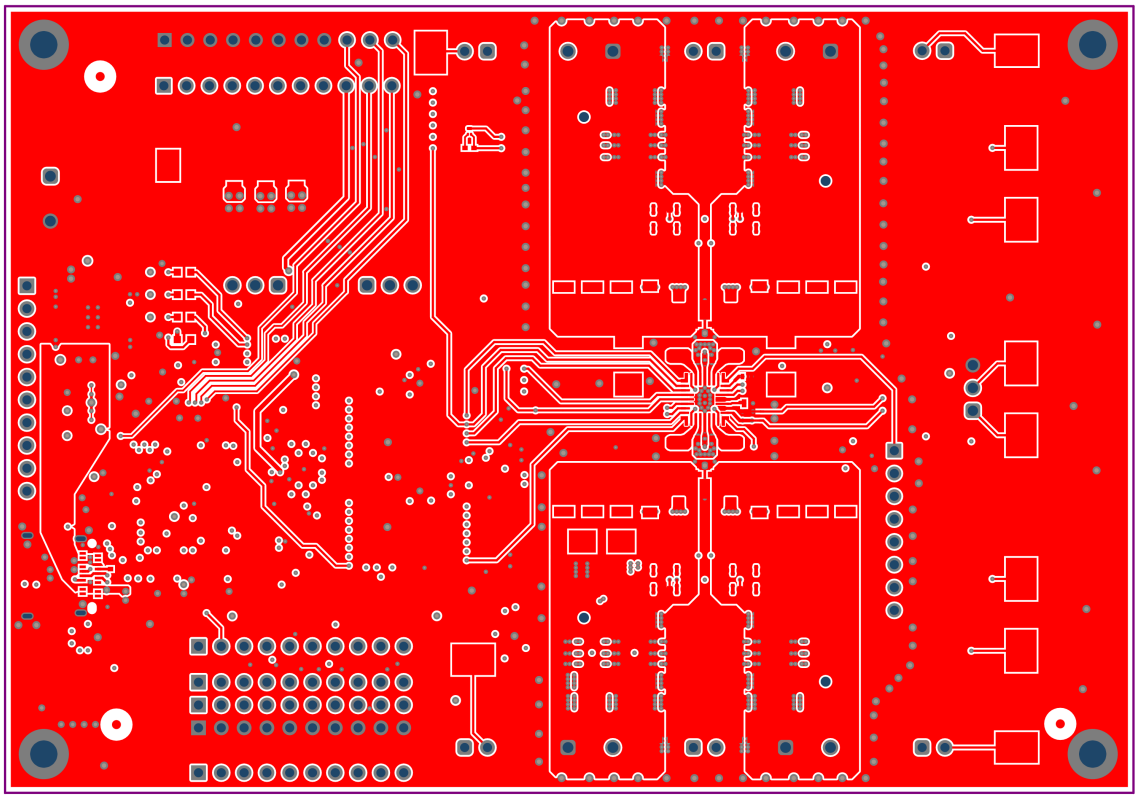


Figure 4-3. Layout Top, Layer 1

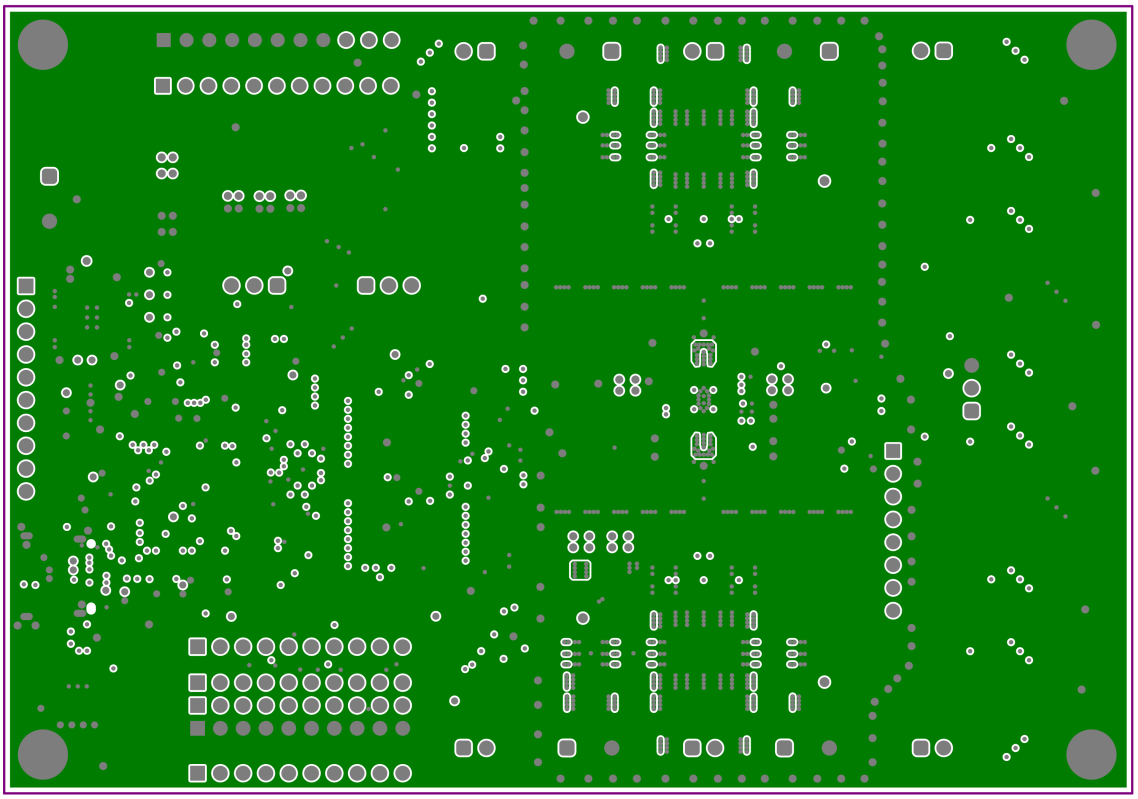


Figure 4-4. Layout Ground, Layer 2

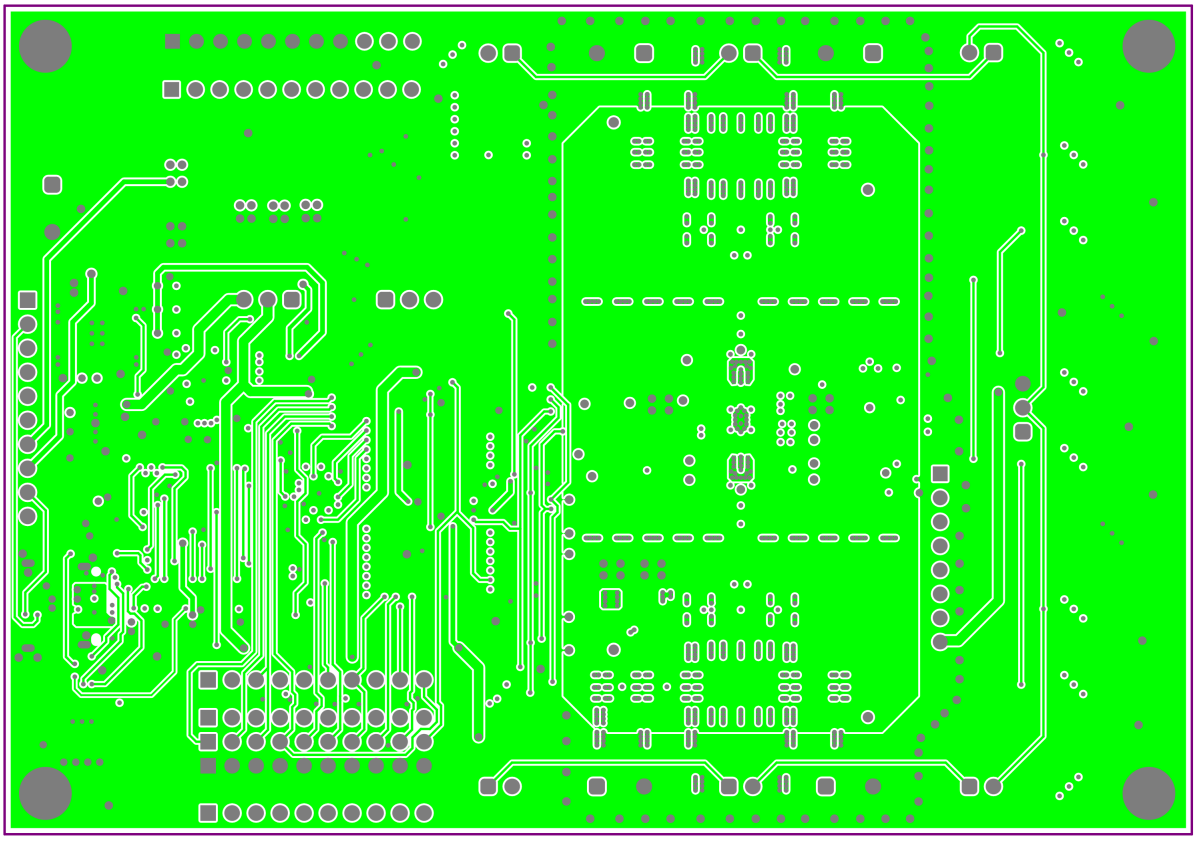


Figure 4-5. Layout Signal, Layer 3

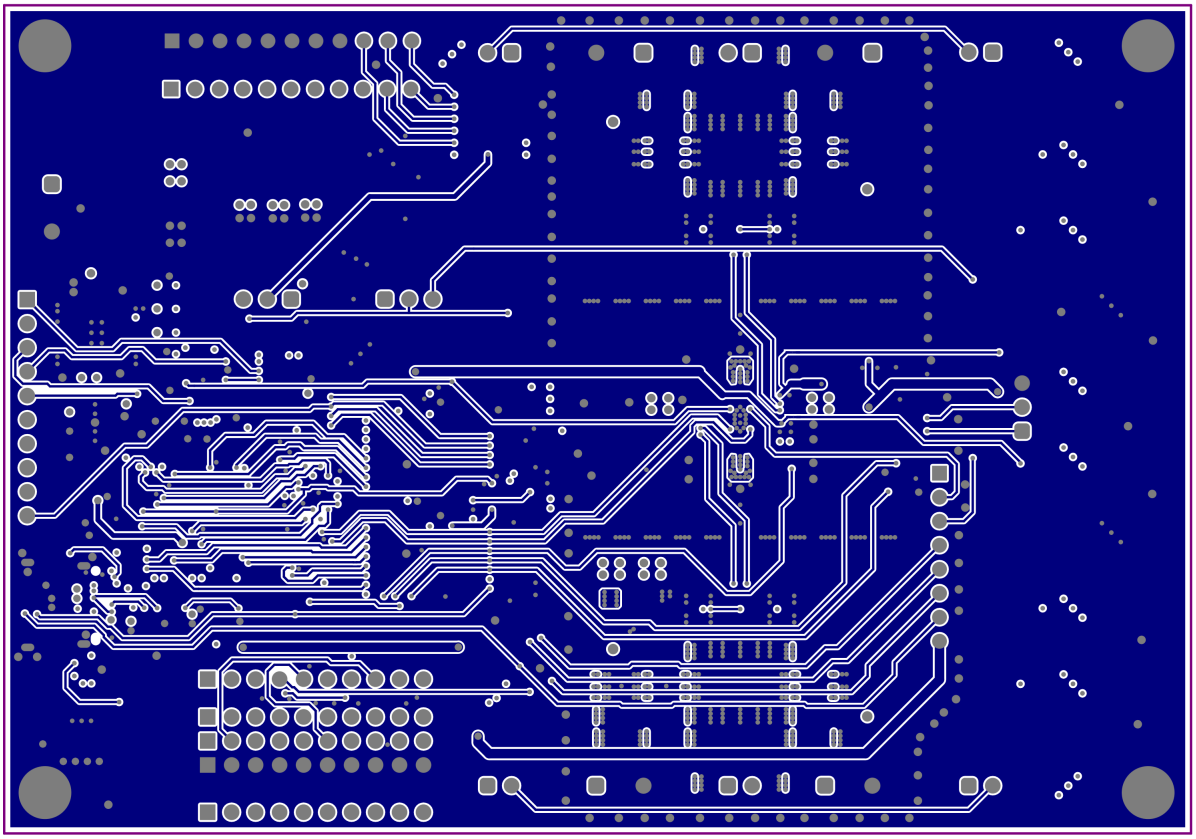


Figure 4-6. Layout Signal, Layer 4

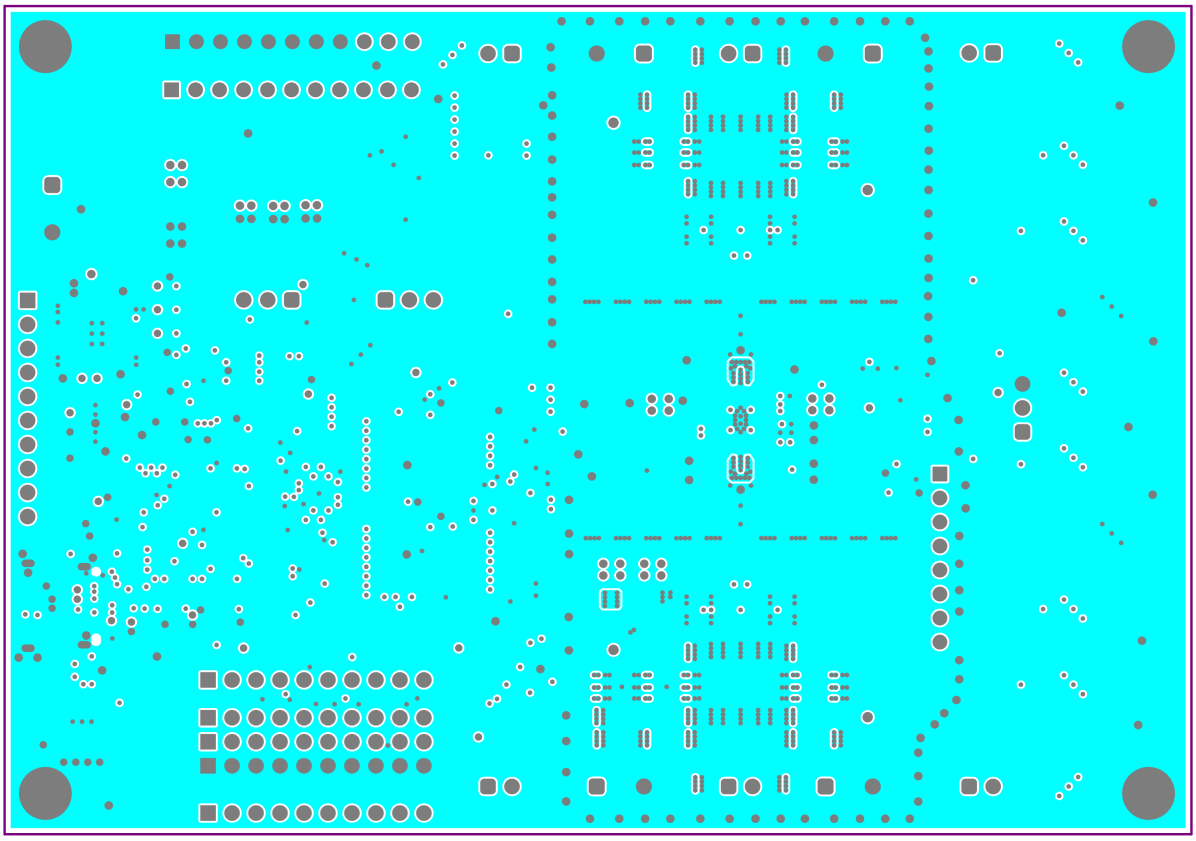


Figure 4-7. Layout Ground, Layer 5

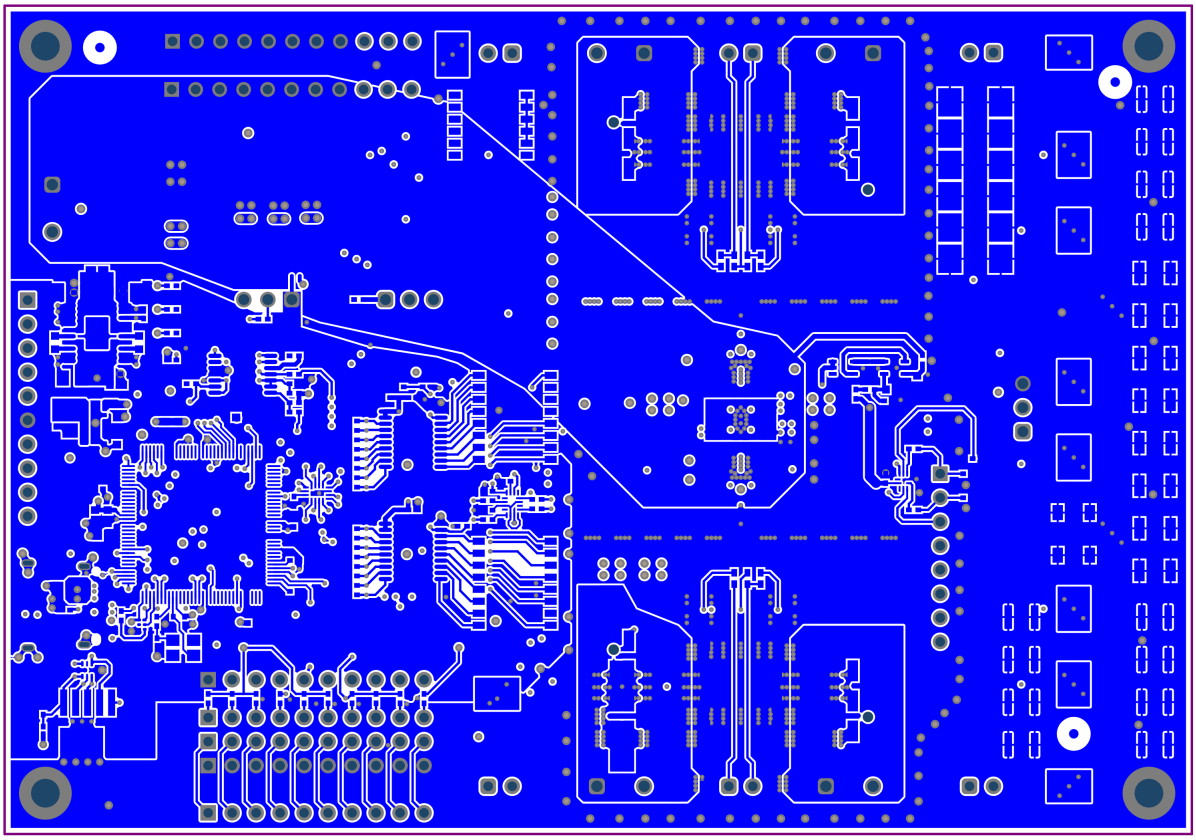


Figure 4-8. Layout Bottom

4.3 Bill of Materials (BOM)

Table 4-1. Bill of Materials

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
1	!PCB1	1		BMC062	Any	Printed Circuit Board	
2	C1, C2, C3, C4, C74, C128	6	10uF	GCM21BR71A106KE22L	MuRata	CAP, CERM, 10uF, 10V, +/- 10%, X7R, 0805	805
3	C5, C6	2		NFM18HC105C1C3D	Murata	3 Terminals Low ESL Chip Multilayer Ceramic Capacitors for Automotive	603
4	C7, C9, C70, C71, C147	5	0.47uF	GCM155C71A474KE36D	MuRata	CAP, CERM, 0.47uF, 10V,+/- 10%, X7S, 0402	402
5	C8, C53, C55, C56, C57, C58, C59, C72, C73, C83, C85, C87, C89, C91, C93, C95, C97, C131, C132, C134, C136	21	2.2uF	GCM188R70J225KE22D	MuRata	CAP, CERM, 2.2uF, 6.3V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	603
6	C11, C16, C21, C26, C48, C49, C50, C129, C130, C145, C146	11	22uF	GCM31CR71A226KE02L	MuRata	CAP, CERM, 22uF, 10V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206
7	C30, C31, C34, C35, C38, C39, C42, C43	8	10uF	NFM18HC106D0G3	MuRata	CAP, CERM, 10µF, 4V,+/- 20%, 1.6x0.8mm	1.6x0.8mm
8	C47	1	150uF	UUD1V151MNL1GS	Nichicon	CAP, AL, 150uF, 35V, +/- 20%, 0.17 ohm, SMD	8x10
9	C52, C54, C60, C61, C63, C64, C67, C68, C69, C78, C79, C80, C81, C82, C84, C86, C88, C90, C92, C94, C96, C133, C135	23	0.1uF	GCM155R71C104KA55D	MuRata	CAP, CERM, 0.1uF, 16V, +/- 10%, X7R, 0402	402
10	C62, C148, C149	3	3300pF	C0603C332K5RACTU	Kemet	CAP, CERM, 3300pF, 50V, +/- 10%, X7R, 0603	603
11	C65, C66	2	12pF	GCM1555C1H120JA16J	MuRata	CAP, CERM, 12pF, 50V,+/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	402
12	C75, C110, C116, C122, C137, C138, C139, C140, C141, C142, C143, C144	12	47uF	GCM32ER70J476ME19L	MuRata	CAP, CERM, 47uF, 6.3V, +/- 20%, X7R, 1210	1210
13	D1, D2, D3, D5	4	Blue	LB Q39G-L2N2-35-1	OSRAM	LED, Blue, SMD	BLUE 0603 LED

Table 4-1. Bill of Materials (continued)

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
14	D4	1		NSR05T40P2T5G	onsemi	Diode Schottky 40V 500mA (DC) Surface Mount SOD-923	SOD-923
15	H1, H2, H3, H4	4		FC2058-440-A	Fascomp		SPACER
16	H5, H6, H7, H8	4		9900	Keystone	MACHINE SCREW PAN PHILLIPS 4-40	
17	J9, J10, J11, J12, J13	5		1792863	Phoenix Contact	Terminal Block, 5mm, 2x1, R/A, TH	Terminal Block, 5mm, 2x1, R/A, TH
18	J14, J15, J16, J17, J18, J19	6		TSW-102-07-G-S	Samtec	Header, 100mil, 2x1, Gold, TH	2x1 Header
19	J20, J21, J23, J24, J25, J26	6		TSW-110-07-G-S	Samtec	Header, 100mil, 10x1, Gold, TH	10x1 Header
20	J22, J32, J33	3		6.13E+10	Wurth Elektronik	Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH
21	J27, J28	2		ESQ-111-14-T-S	Samtec	Conn Elevated Socket SKT 11 POS 2.54mm Solder ST Thru-Hole Tube	HDR11
22	J29	1		ESQ-108-14-T-S	Samtec	Board-To-Board Connector, Vertical, ESQ Series, 8 Contacts, Receptacle, 2.54mm, Through Hole	HDR8
23	J30	1		12401610E4#2A	Amphenol Canada	Receptacle, 0.5mm, USB TYPE C, R/A, SMT	Receptacle, 0.5mm, USB TYPE C, R/A, SMT
24	J34, J35, J36, J37, J38, J39	6		S1911-46R	Harwin	JUMPER TIN SMD	6.85x0.97x2.51 mm
25	J40, J41, J42, J43, J44, J45, J46, J47, J48, J49, J50	11		NPC02SXON-RC	Sullins Connector Solutions		CONN_JUMPER
26	L1, L2, L3, L4	4	220nH	TFM322512ALMAR22MTAA	TDK	Inductor, Thin Film, 220nH, 7.6A, 0.01 ohm, AEC-Q200 Grade 0, SMD	TDK Inductor
27	L5, L6, L7, L8	4	470nH	TFM322512ALMAR47MTAA	TDK	Inductor, Thin Film, 470nH, 5.3A, 0.021 ohm, AEC-Q200 Grade 0, SMD	TDK Inductor
28	L9, L10, L11, L12	4	1uH	TFM322512ALMA1R0MTAA	TDK	Inductor, Thin Film, 1µH, 4A, 0.037 ohm, AEC-Q200 Grade 0, SMD	TDK Inductor
29	LBL1	1		THT-14-423-10	Brady	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch
30	Q1	1	12V	CSD13381F4	Texas Instruments	MOSFET, N-CH, 12V, 2.1A, YJC0003A (PICOSTAR-3)	YJC0003A
31	R1, R3, R4, R7, R12, R14, R16, R85, R87, R88, R90	11	0	CRCW04020000Z0ED	Vishay-Dale	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402

Table 4-1. Bill of Materials (continued)

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
32	R8, R9, R17, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29, R32, R33, R34, R35, R44, R45, R46, R47, R53, R54, R55, R56, R57, R58, R59, R60, R63, R77, R80, R84, R86, R93	35	10k	CRCW040210K0JNED	Vishay-Dale	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402
33	R11, R13, R15, R73, R83, R91, R92	7	1.2k	CRCW04021K20JNED	Vishay-Dale	RES, 1.2 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402
34	R19	1	240	CRCW0402240RJNED	Vishay-Dale	RES, 240, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402
35	R48, R50	2	1.0Meg	CRCW04021M00JNED	Vishay-Dale	RES, 1.0M, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402
36	R51	1	374k	CRCW0402374KFKED	Vishay-Dale	RES, 374 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402
37	R52, R79	2	200k	CRCW0402200KJNED	Vishay-Dale	RES, 200 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402
38	R61, R67, R69	3	4.87k	CRCW04024K87FKED	Vishay-Dale	RES, 4.87 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402
39	R62	1	100	CRCW0402100RJNED	Vishay-Dale	RES, 100, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402
40	R74, R76, R78, R81, R89, R94	6	1.0k	CRCW04021K00JNED	Vishay-Dale	RES, 1.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	402
41	S1, S2	2		218-8LPST	CTS Electrocomponents	Switch, SPST, 8 Pos, 25mA, 24VDC, SMD	11.33x5.8mm
42	S3	1		218-6LPST	CTS Electrocomponents	Switch, SPST, Slide, Off-On, 6 Pos, 0.025A, 24V, SMD	5.8x8.79mm
43	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16	16		5016	Keystone	Test Point, Compact, SMT	Testpoint_Keystone_Compact
44	U1	1		LP876940C0RKQRQ1	Texas Instruments	High Frequency Quad Step-Down DC-DC	VQFN-HR32
45	U2	1		LM2901AVQPWRQ1	Texas Instruments	AEC-Q100 Quad Comparator, PW0014A (TSSOP-14)	PW0014A

Table 4-1. Bill of Materials (continued)

Item #	Designator	Quantity	Value	Part Number	Manufacturer	Description	Package Reference
46	U3	1		MSP432E401YTPDTR	Texas Instruments	MSP432E401YTPDT, PDT0128A (TQFP-128)	PDT0128A
47	U4, U6	2		SN74GTL2003PWR	Texas Instruments	8-BIT BIDIRECTIONAL LOW-VOLTAGE TRANSLATOR, PW0020A (TSSOP-20)	PW0020A
48	U5	1		TPD6E004RSER	Texas Instruments	Low-Capacitance 6-Channel +/-15 kV ESD Protection Array for High-Speed Data Interfaces, RSE0008A (UQFN-8)	RSE0008A
49	U7	1		TPD4S012DRYR	Texas Instruments	4-Channel USB ESD Solution with Power Clamp, DRY0006A (USON-6)	DRY0006A
50	U8, U9	2		TS3A5018RSVR	Texas Instruments	10-Ohm Quad SPDT Analog Switch, RSV0016A (UQFN-16)	RSV0016A
51	U10	1		TS3A5223RSWR	Texas Instruments	0.5Ω Dual SPDT Bidirectional Analog Switch, RSW0010A (UQFN-10)	RSW0010A
52	U11	1		TLV73333PQDRVRQ1	Texas Instruments	Capacitor-Free, 300mA, Low-Dropout Regulator for Automotive, DRV0006A (WSON-6)	DRV0006A
53	U12	1		TLV73318PQDRVRQ1	Texas Instruments	Capacitor-Free, 300mA, Low-Dropout Regulator for Automotive, DRV0006A (WSON-6)	DRV0006A
54	U13	1		TPS60110PWPR	Texas Instruments	5V, Boost Charge Pump, 300mA, 2.7V to 5.4V Input with Synchonrization pin, -40℃ to 85℃, 20-pin SOP (PWP20), Green (RoHS & no Sb/Br)	PWP0020C
55	U14	1		TLV9031QDCKRQ1	Texas Instruments	Automotive single low-voltage comparator with push-pull output 5-SC70 -40 to 125	SC70-5
56	U15	1		TPS22919DCKR	Texas Instruments	5.5V, 1.5A, 100-mohm Load Switch with Output Discharge, DCK0006A (SOT-SC70-6)	DCK0006A
57	Y1	1		NX3225SA-25.000M-STD-CRS-2	NDK	CRYSTAL 25.0000MHZ 8PF SMD	SMT_XTAL_3MM2_2MM5

5 Additional Information

5.1 Additional Resources

- Scalable PMIC's GUI User’s Guide
- LP8769-Q1 High Frequency Quad Step-Down DC-DC

5.2 Trademarks

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All trademarks are the property of their respective owners.

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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2. 実験局の免許を取得後ご使用いただく。
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なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

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