User's Guide

TPS650320-Q1 EVM User's Guide

Table of Contents

Trademarks

1 Introduction

The TPS650320-Q1 device is a highly-integrated PMIC for automotive camera modules. This device combines three step down converters and one low-dropout (LDO) regulator. The BUCK1 step-down converter has an input voltage range up to 18.3 V for connections to power over coax. All converters operate in a forced fixed-frequency PWM mode. The LDO can supply 300 mA and operate with an input voltage range from 2.2 V to 5.5 V. The step-down converters and the LDO have separate voltage inputs that enable maximum design and sequencing flexibility.

2 EVM Configurations

The following sections outline how to configure the TPS650320-Q1 EVM for general experimentation.

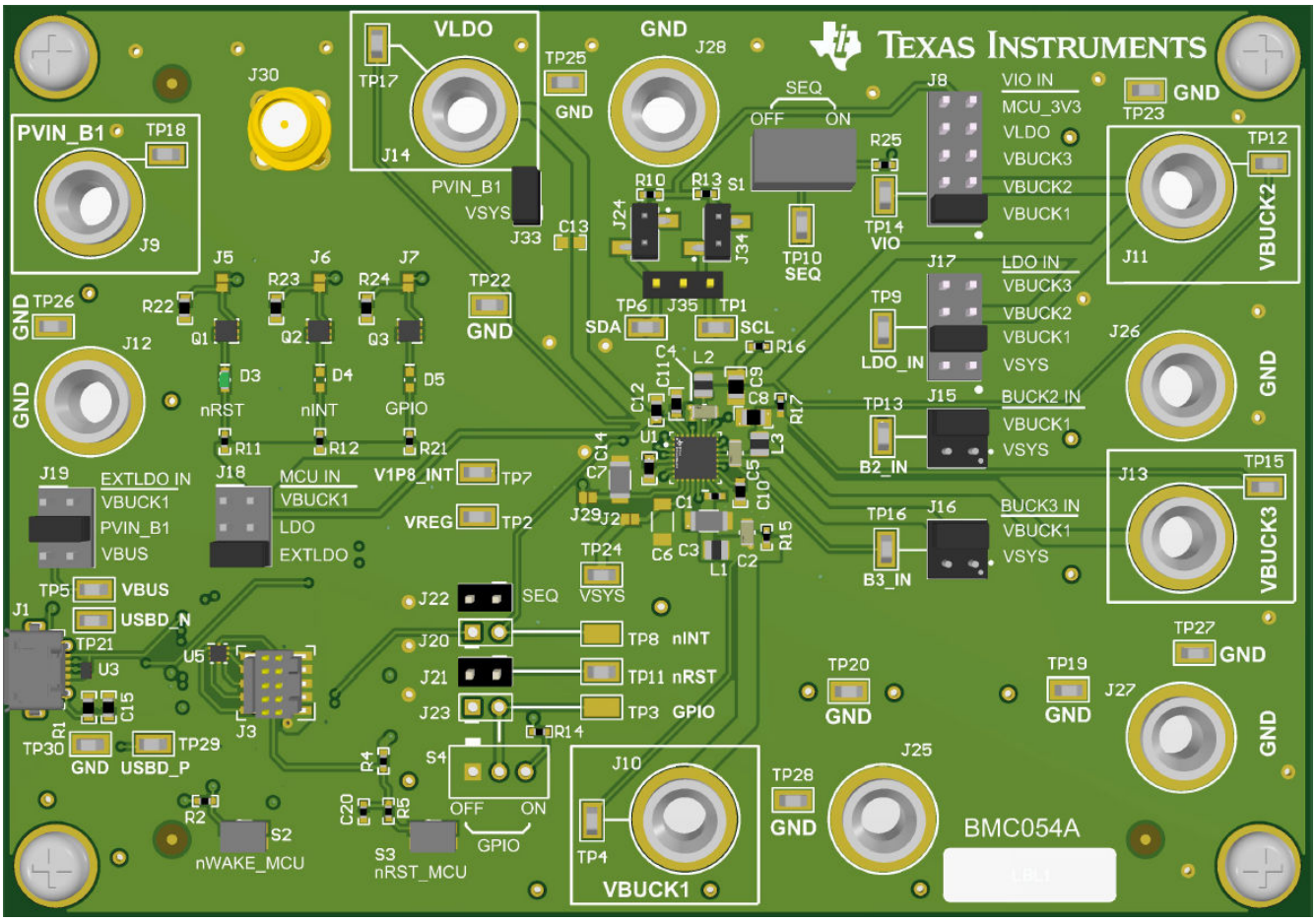


Figure 2-1. TPS650320-Q1 EVM Top View

2.1 Requirements

- Computer with Windows®, macOS®, or Linux® operating system
- Camera PMIC GUI (Link Here)
- Micro-USB Cable
- TPS650320-Q1 EVM
- DC Power Supply (4.5 V to 19 V)
  - Banana Cables for Power and GND

2.2 Operation Instructions

1. Ensure that the USB to I²C Adapter is configured properly using the jumpers mentioned in Configuring the USB to I²C Adapter. This will be the default configurations defined in the tables for most applications.
2. Configure regulator input supply rails for the expected application using the jumpers mentioned in Regulator Input Supplies and Features. Take extra care not to exceed absolute maximum ratings when VSYS supplies BUCK2, BUCK3, or the LDO.
3. Connect Micro-USB to a PC capable of loading the Camera PMIC GUI.
4. Connect VSYS to a power supply capable of supporting the application and enable the supply. Typical supply voltage is 12 V. The PMIC will boot automatically as VSYS is applied.
5. The Buck 1 and Buck 2 regulators will power up automatically once a sufficient VSYS voltage is applied.
6. Set the SEQ switch (S1) to *On* to enable the Buck 3 and LDO regulators.
7. Load the Camera PMIC GUI and ensure the adapter has been recognized by the PC. Refer to TPS650320-Q1 EVM Debugging if the GUI says *Hardware not connected*.
8. The GUI will attempt to read all registers and update the register map once the adapter is connected.

2.3 Configuring the USB to I²C Adapter

An onboard MCU acts as a USB adapter to the PMIC. This adapter allows I²C communication to the host PC as well as GPIO assertion and monitoring. By default, the onboard adapter is powered by the USB cable through an onboard dedicated 3.3 V LDO (U4). Additional configurations are allowed by reconfiguring jumpers J18 and J19, shown in Table 2-1 and Table 2-2. The onboard adapter must have power applied through a valid configuration.

Table 2-1. Adapter Power Source (J18)

Selection Jumper Pin	Adapter Supply Bus
Pin 1 (PMIC Buck 1 Output)	Pin 2 (Adapter Input Supply Rail)
Pin 3 (PMIC LDO Output)	Pin 4 (Adapter Input Supply Rail)
Pin 5 (Dedicated 3.3 V LDO Output - *Default*)	Pin 6 (Adapter Input Supply Rail)

Table 2-2. Dedicated LDO Supply for Adapter (J19)

Selection Jumper Pin	Dedicated 3.3 V LDO Supply Bus
Pin 1 (PMIC Buck 1 Output)	Pin 2 (Dedicated 3.3 V LDO Input Rail)
Pin 3 (PMIC Buck 1 Input)	Pin 4 (Dedicated 3.3 V LDO Input Rail)
Pin 5 (VBUS Rail - *Default*)	Pin 6 (Dedicated 3.3 V LDO Input Rail)

The following Jumpers in Table 2-3 connect the USB adapter to PMIC functional pins. These can be disconnected for flexibility.

Table 2-3. Adapter PMIC Connections

Jumper	PMIC Pin
J20	nINT
J21	nRST
J22	SEQ
J23	GPIO

2.4 Regulator Input Supplies and Features

The four regulators on the TPS650320-Q1 EVM can be supplied with multiple supplies. The following tables show the possible supply configurations in addition to key specifications and programmable features for each regulator.

2.4.1 Buck 1 Input Supply

Table 2-4. Buck 1 Power Source (J33)

Selection Jumper Pin	Buck1 Supply Bus
Pin 1 (VSYS - *Default*)	Pin 2 (Buck 1 Input Supply Rail)

2.4.2 Mid-Vin Buck1 Features

Table 2-5. Mid-Vin (Buck1) Features

Feature	Specification
Input Voltage Range	4 V to 18.3 V
Operating Current	Maximum of 800 mA
Current Limiting	1.5 A to 2.5 A
Status Monitoring	UVLO, UV, HOT, OVP, SCG, and OCP
Over-Voltage Protection (OVP)	VOUT = 109% to 115%
Short-Circuit Threshold (SCG)	VOUT = 250 mV to 350 mV

Table 2-6. Mid-Vin (Buck1) Configurable Settings

Feature	Configurable Range
Output Voltage	2.5 V to 4.0 V
PVIN_B1 UVLO Rising	3.64 V to 9.36 V
PVIN_B1 UVLO Falling	3.5 V to 9 V
Output Discharge	Disabled, 125 Ω, 250 Ω, and 500 Ω
Sequencing	Enable, Dependencies, and Fault RST
Sequence Delay (Off and On)	0 ms to 20 ms

Note: Over-voltage monitor settings are available for the TPS650331-Q1, TPS650332-Q1, and TPS650333-Q1.

2.4.3 Buck 2 Input Supply

Table 2-7. Buck 2 Power Source (J15)

Selection Jumper Pin	Buck2 Supply Bus
Pin 1 (VSYS)	Pin 2 (Buck 2 Input Supply Rail)
Pin 3 (Buck1 Output Rail - *Default*)	Pin 4 (Buck 2 Input Supply Rail)

2.4.4 Buck 3 Input Supply

Table 2-8. Buck 3 Power Source (J16)

Selection Jumper Pin	Buck3 Supply Bus
Pin 1 (VSYS)	Pin 2 (Buck 3 Input Supply Rail)
Pin 3 (Buck1 Output Rail - *Default*)	Pin 4 (Buck 3 Input Supply Rail)

2.4.5 Low-Vin Buck2 and Buck3 Features

Table 2-9. Low-Vin (Buck2 and Buck3) Features

Feature	Specification
Input Voltage Range	2.5 V to 5.5 V
Operating Current	Maximum of 600 mA
Current Limiting	1.2 A to 2.5 A
Status Monitoring	UV, HOT, OVP, SCG, and OCP
Over-Voltage Protection (OVP)	VOUT = 109% to 115%
Short-Circuit Threshold (SCG)	VOUT = 250 mV to 350 mV

Table 2-10. Low-Vin (Buck2 and Buck3) Configurable Settings

Feature	Configurable Range
Output Voltage	0.9 V to 1.9 V
Under-Voltage Flags (UV)	VOUT = 94.5%, 95%, 95.5%, and 96%
Spread Spectrum	Enable or Disable
Sequencing	Enable, Dependencies, and Fault RST

Table 2-10. Low-Vin (Buck2 and Buck3) Configurable Settings (continued)

Feature	Configurable Range
Sequence Delay (Off and On)	0 ms to 20 ms

Note: Over-voltage monitor settings are available for the TPS650331-Q1, TPS650332-Q1, and TPS650333-Q1.

2.4.6 Low Noise LDO Input Supply

Table 2-11. PMIC LDO Power Source (J8)

Selection Jumper Pin	PMIC LDO Supply Bus
Pin 1 (VSYS)	Pin 2 (PMIC LDO Input Supply Rail)
Pin 3 (Buck1 Output Rail - *Default*)	Pin 4 (PMIC LDO Input Supply Rail)
Pin 5 (Buck2 Output Rail)	Pin 6 (PMIC LDO Input Supply Rail)
Pin 7 (Buck3 Output Rail)	Pin 8 (PMIC LDO Input Supply Rail)

2.4.7 Low Noise LDO Features

Table 2-12. Low Noise LDO Features

Feature	Specification
Input Voltage Range	2.5 V to 5.5 V
Operating Current	Maximum of 150 mA or 300 mA
Current Limiting	Minimum of 200 mA or 400 mA
Status Monitoring	UV, HOT, OVP, SCG, and OCP
Over-Voltage Protection (OVP)	VOUT = 109% to 115%
Short-Circuit Threshold (SCG)	VOUT = 250 mV to 350 mV

Table 2-13. Low Noise LDO Configurable Settings

Feature	Configurable Range
Output Voltage	1.8 V, or 2.7 V to 3.3 V
Under-Voltage Flags (UV)	VOUT = 94.5%, 95%, 95.5%, and 96%
Load Switch Mode	Enable or Disable
Current Limit	200 mA, 400 mA
Sequencing	Enable, Dependencies, and Fault RST
Sequence Delay (Off and On)	0 ms to 20 ms

Note: Over-voltage monitor settings are available for the TPS650331-Q1, TPS650332-Q1, and TPS650333-Q1.

2.5 Selecting the Logic Supply Voltage

Table 2-14. VIO Power Source (J8)

Selection Jumper Pin	VIO Supply Bus
Pin 1 (Buck1 Output Rail - *Default*)	Pin 2 (VIO Input Supply Rail)
Pin 3 (Buck2 Output Rail)	Pin 4 (VIO Input Supply Rail)
Pin 5 (Buck3 Output Rail)	Pin 6 (VIO Input Supply Rail)
Pin 7 (PMIC LDO Output Rail)	Pin 8 (VIO Input Supply Rail)
Pin 9 (Dedicated 3.3 V LDO)	Pin 10 (VIO Input Supply Rail)

3 Test Points

3.1 Voltage Test Points

The TPS650320-Q1 EVM contains 30 test points for various measurements. Trace assignments to the test points are shown in Table 3-1. For reference, Figure 3-1 demonstrates the test point locations on the EVM.

Table 3-1. TPS650320-Q1 EVM Test Points

Test Point Number	Associated Trace
TP1	SCL
TP2	VREG
TP4	Buck 1 Output
TP5	VBUS
TP6	SDA
TP7	V1P8_INT
TP9	PMIC LDO Input
TP10	SEQ
TP11	nRSTOUT
TP12	Buck 2 Output
TP13	Buck 2 Input
TP14	VIO
TP15	Buck 3 Output
TP16	Buck 3 Input
TP17	PMIC LDO Output
TP18	Buck 1 Input
TP19	GND
TP20	GND
TP21	USBD_N
TP22	GND
TP23	GND
TP24	VSYS
TP25	GND
TP26	GND
TP27	GND
TP28	GND
TP29	USBD_P
TP30	GND

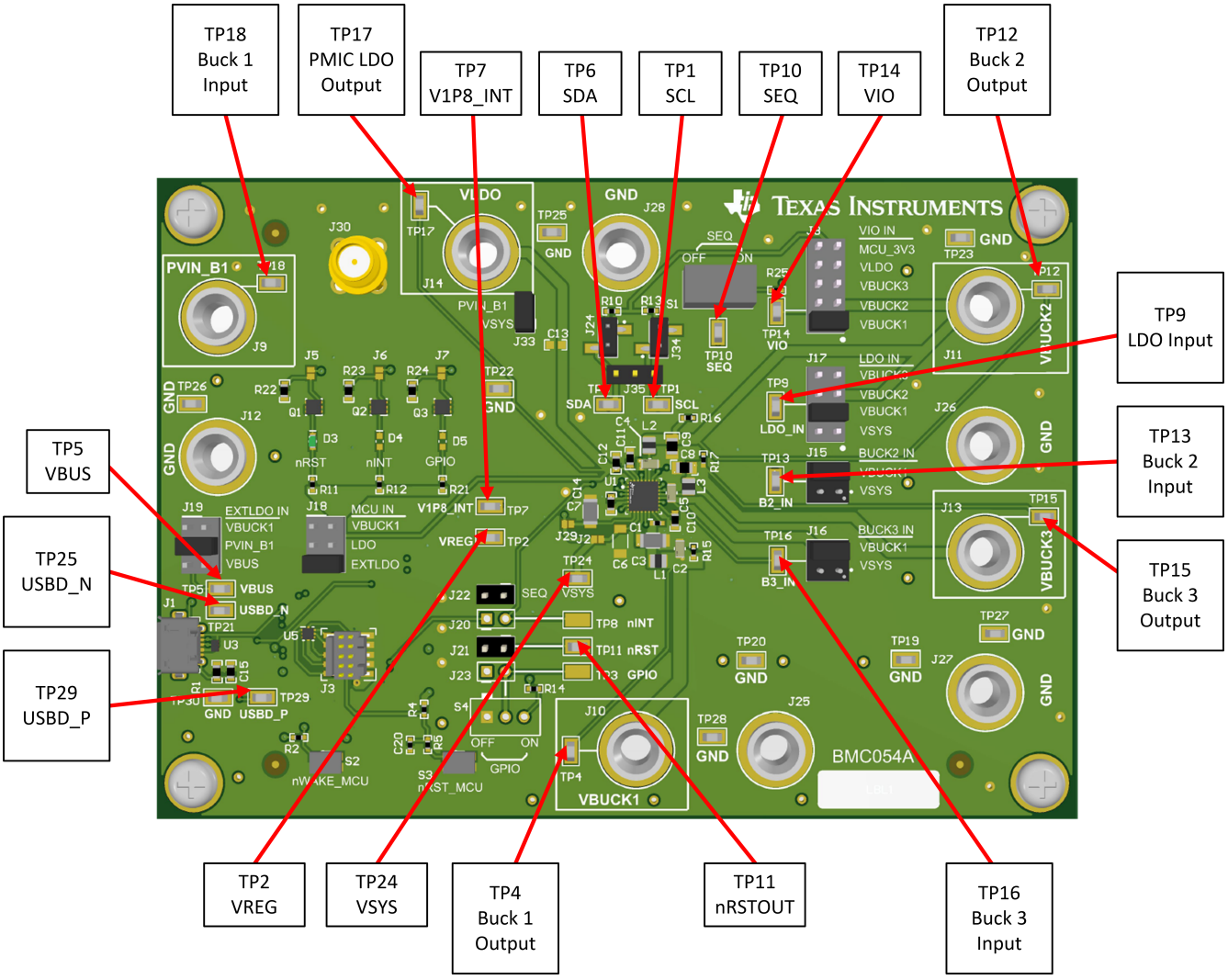


Figure 3-1. TPS650320-Q1 EVM Test Point Locations

4 Graphical User Interface

The Graphical User Interface (GUI) for the EVM can be found in the Gallery at TI DevTools. The GUI can be operated through Google Chrome® or Mozilla Firefox® web browsers. To run the GUI in the browser, click the thumbnail and follow the prompted instructions for first time installation. The GUI requires both a browser plugin and the TI Cloud Agent software for access to the local USB ports. The GUI can also be downloaded for offline operation by hovering over the downward arrow in the GUI thumbnail and selecting the desired platform – Windows®, Mac®, or Linux®

4.1 TPS650320-Q1 EVM Debugging

Refer to to debug potential issues while using the TPS650320-Q1 EVM.

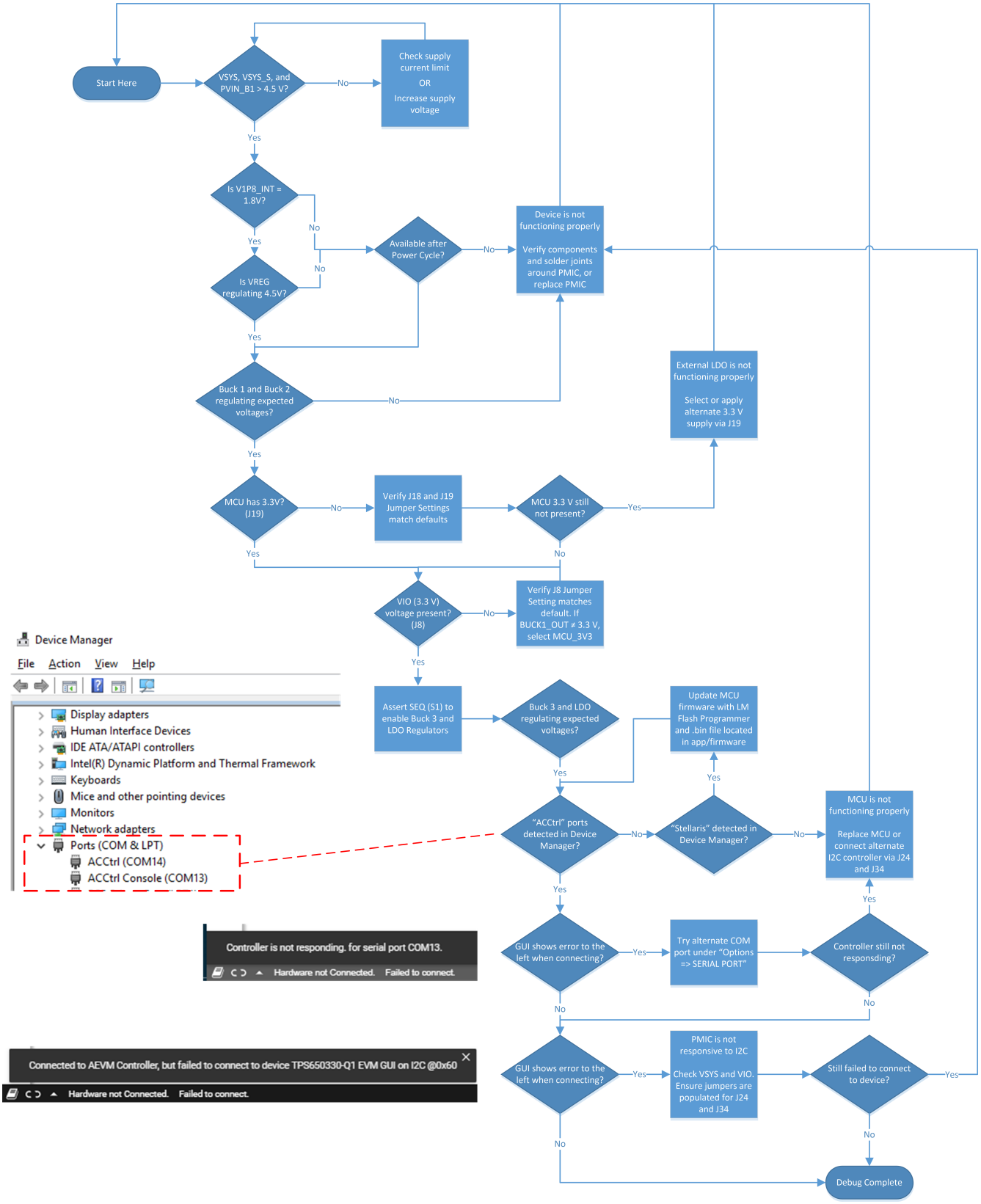


Figure 4-1. TPS650320-Q1 EVM Debugging Flow Chart

4.1.1 I²C Communication Port and Adapter Debugging

By default, the GUI will recognize two serial ports from the EVM adapter, but may not select the I²C bridge automatically. Once the EVM is powered and the USB cable is connected to the computer, click the connect icon at the bottom left of the GUI. If the bottom notification updates to *Hardware Not Selected*:

1. Click the Options menu at the top of the GUI, select *Serial Port*.

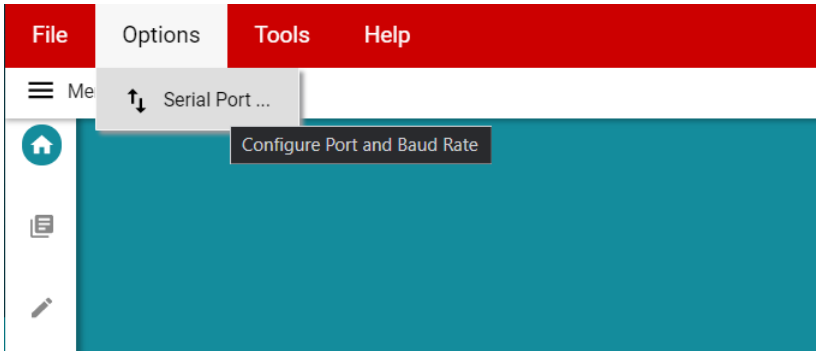


Figure 4-2. Opening Serial Port Options

2. Use the Ports dropdown to select the alternative interface.

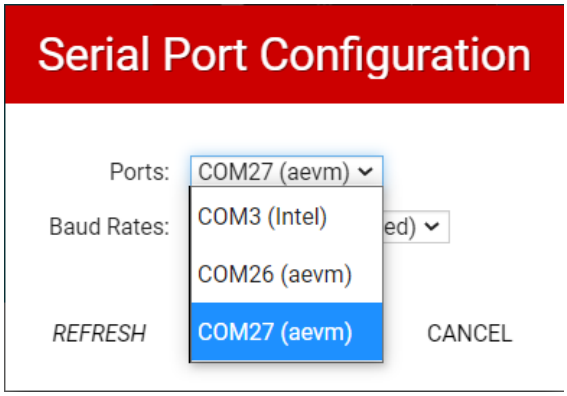


Figure 4-3. Selecting an Alternate Port

After clicking OK, the GUI should connect to the device properly. If communication to the EVM is lost, most issues can be resolved by pressing the nRST_MCU button (S3) on the EVM. Afterwards, further issues can be diagnosed by confirming that MCU_IN (J18) is still present, and that the I²C pull-up domain is still active.

4.1.2 Updating MCU Firmware

If the EVM on-board MCU is showing up under the Device Manager with a *Stellaris...* title, the MCU firmware needs to be updated to communicate with the GUI. One way to do this is with TI's free LM Flash Programmer tool. Once the firmware is updated, the MCU should show up as *ACCtrl...* COM ports in the Device Manager.

1. Download the GUI source files from the Gallery. The EVM firmware is the .bin file located in the install_image_TPS6503xx-Q1_GUI/TPS6503xx-Q1_GUI/app/firmware folder.
2. Open LM Flash Programmer with the EVM connected through USB.
3. Select *USB DFU* in the *Configuration* tab. The Stellaris device should show in the device list box after refreshing.
4. Select the *Program* tab.
5. Browse to the .bin file downloaded from the GUI.
6. Leave all other settings as default.
7. Click *Program*.

4.2 Navigating the GUI

The GUI contains the following five sections, selectable on the left side of the GUI or by clicking the Menu tab in the top left corner.

- Home
- Block Diagram
- Registers
- Device Configuration
- Re-Program PMIC

4.2.1 Home

The Home section is the landing page of the GUI. Here the GUI presents an overview of the EVM and Programming BoosterPack (BOOSTXL-TPS65033), and emphasize navigation to the remaining four sections through the tiles on the bottom of the page.

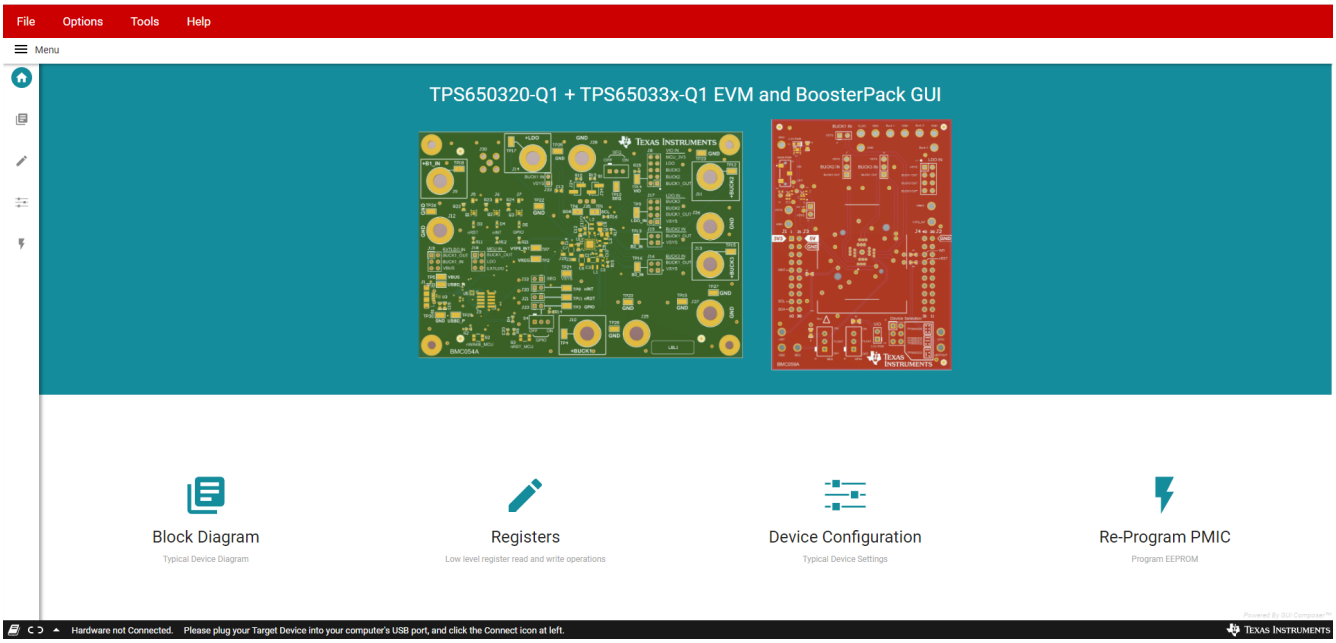


Figure 4-4. TPS6503xx-Q1 GUI Home Screen

4.2.2 Block Diagram

The Block Diagram section displays the typical components and functional blocks of the PMIC. A block diagram for the Programming BoosterPack is also shown.

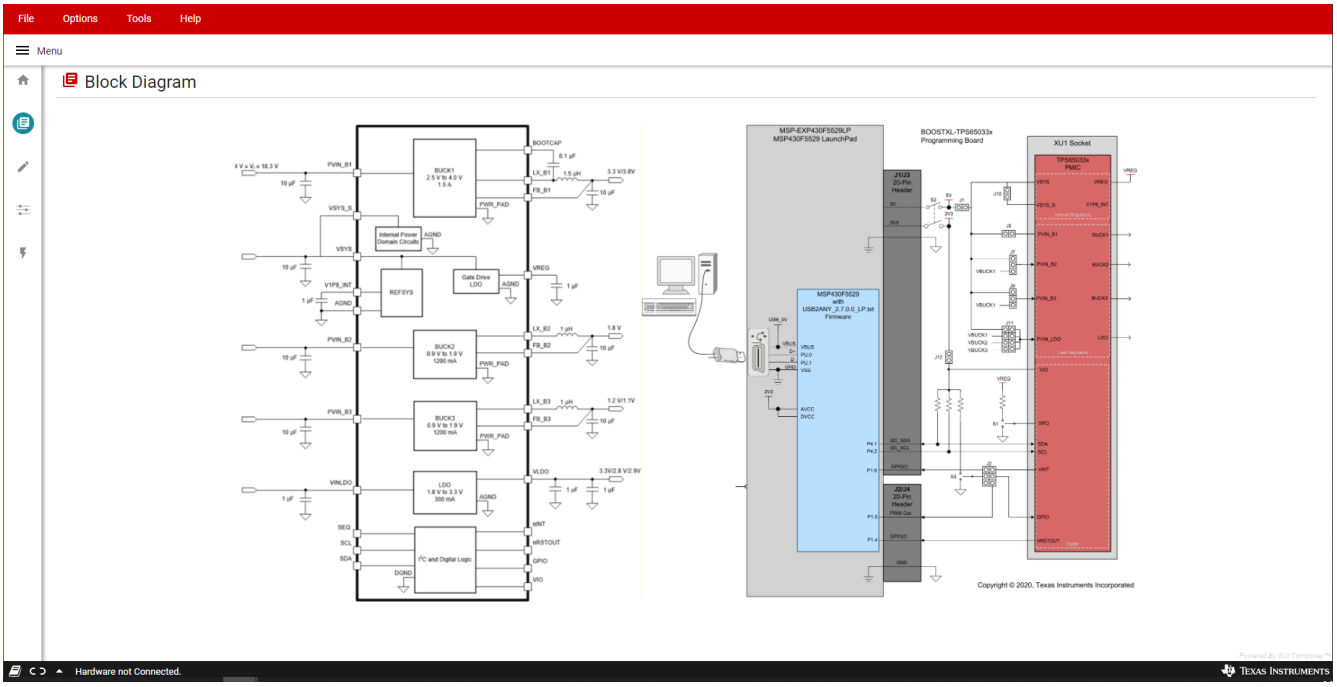


Figure 4-5. TPS6503xx-Q1 GUI Block Diagram Page

4.2.3 Registers

The Registers section provides an overview of the internal register map, and includes basic interfaces for each PMIC register. Figure 4-6 illustrates the register page and the primary interactive regions.

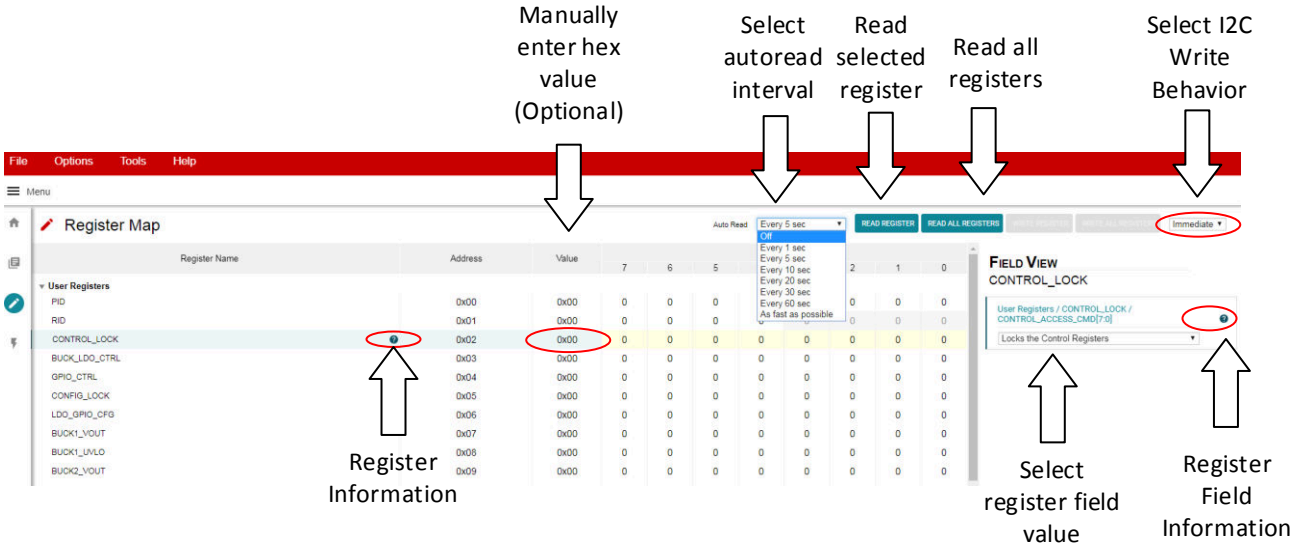


Figure 4-6. Register Page Interfaces

The register table displays each register name, address, last known value from the PMIC, and corresponding bit values. Selecting a title or bit fields in the table will update the Field View column on the right side of the GUI. The Field View displays the individual fields contained within the associated register address. Within the register page, clicking a blue icon containing a question mark (?) will expand additional descriptions if available. The expanded description views can then be closed by clicking the red (x) icon.

This register page can poll the device periodically using the *Auto Read* feature in the top right corner, or allow manual read instructions using the *Read Register* and *Read All Registers* buttons.

A dropdown selection at the top right of the register map indicates how the registers are written as the user interacts with the register page. With *Immediate* selected, any update to the register page is automatically sent to the PMIC, whereas *Deferred* will wait for the *Write Register* or *Write All Registers* instructions before communicating with the device. After each write, the register page will automatically read the affected register address to confirm the latest value in the device.

4.2.4 Device Configuration

The Device Configuration section is organized into selectable tabs at the top of the page, where only the contents of the blue tab is actively displayed. Each tab contains categorized visual instruments relating to individual bit fields within the register map. Each instrument is linked to the latest bit values in the register map table, and can be used to alter settings within the PMIC through the dropdown menus or check box features. If the *Auto Read* function in the register map is inactive, the *Read All Registers* button in the top right area of the Device Configuration page can be used to manually refresh the register page, which will then update the instruments with the latest device values.

The PMIC incorporates *Control Lock* and *Configuration Lock* features that can prevent I^2C writes to various registers within the device. The status of these locks will always be displayed in the top right hand corner of the Device Configurations page, and can be toggled by clicking their associated checkbox. When the GUI is properly connected to the EVM and write instructions appear to be ignored by the PMIC, confirm the status of these indicators to verify the device is able to accept new write instructions.

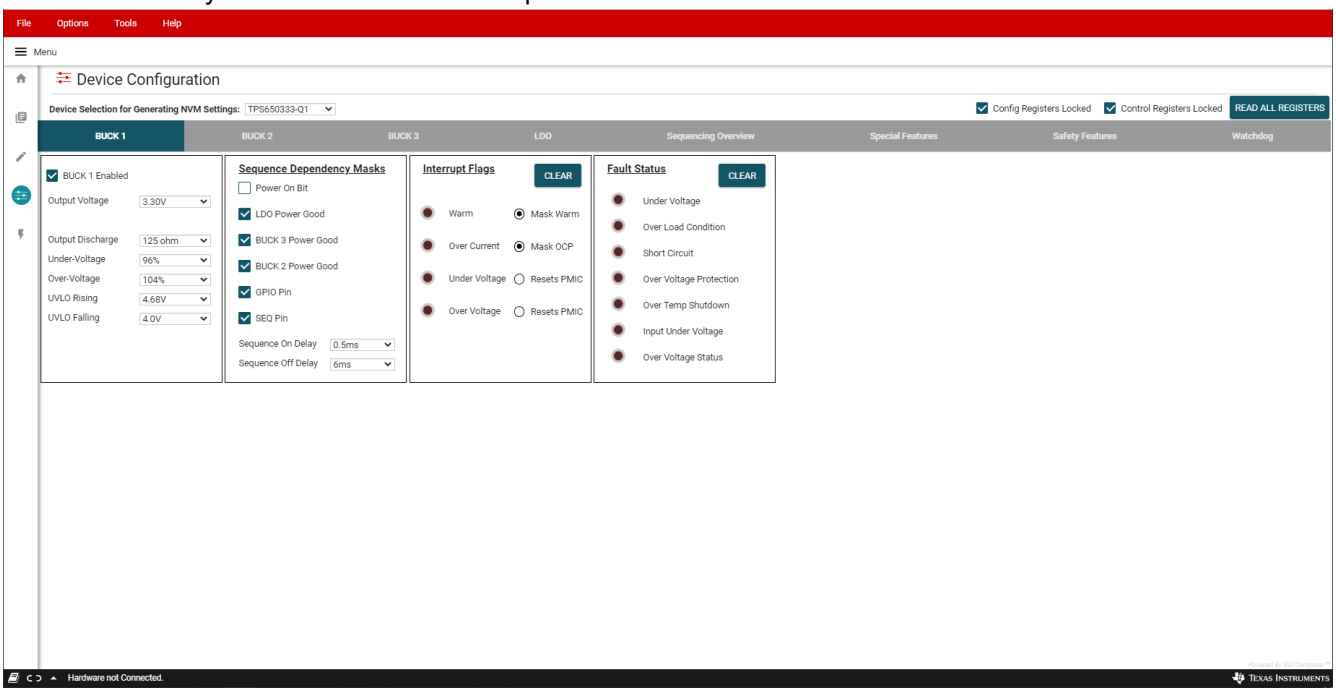


Figure 4-7. TPS6503xx-Q1 GUI Device Configuration Page

4.2.4.1 Using Device Configuration to Define Spin Settings

In some circumstances, TI may provide customized, pre-programmed devices for the camera application. Contact a local TI sales representative for more information.

The Device Configuration tabs in the GUI can be used to define custom settings for TI to pre-program into the device Non-Volatile Memory (NVM). Before beginning the spin definition, see the Camera PMIC Spin Selection Guide to determine if there is an exisiting spin that is already compatible with the target application and the image sensor or both.

Since the visual instruments in the Device Configuration page link directly to the corresponding bits and registers in the Register Map page, the Device Configuration page can be used to quickly define desired OTP register settings.

1. Select the desired camera PMIC from the drop-down menu above the tab indicators to start. The GUI will automatically show, hide, or disable features corresponding to the selected PMIC. This drop down box will not be adjustable if a device is connected to the GUI.

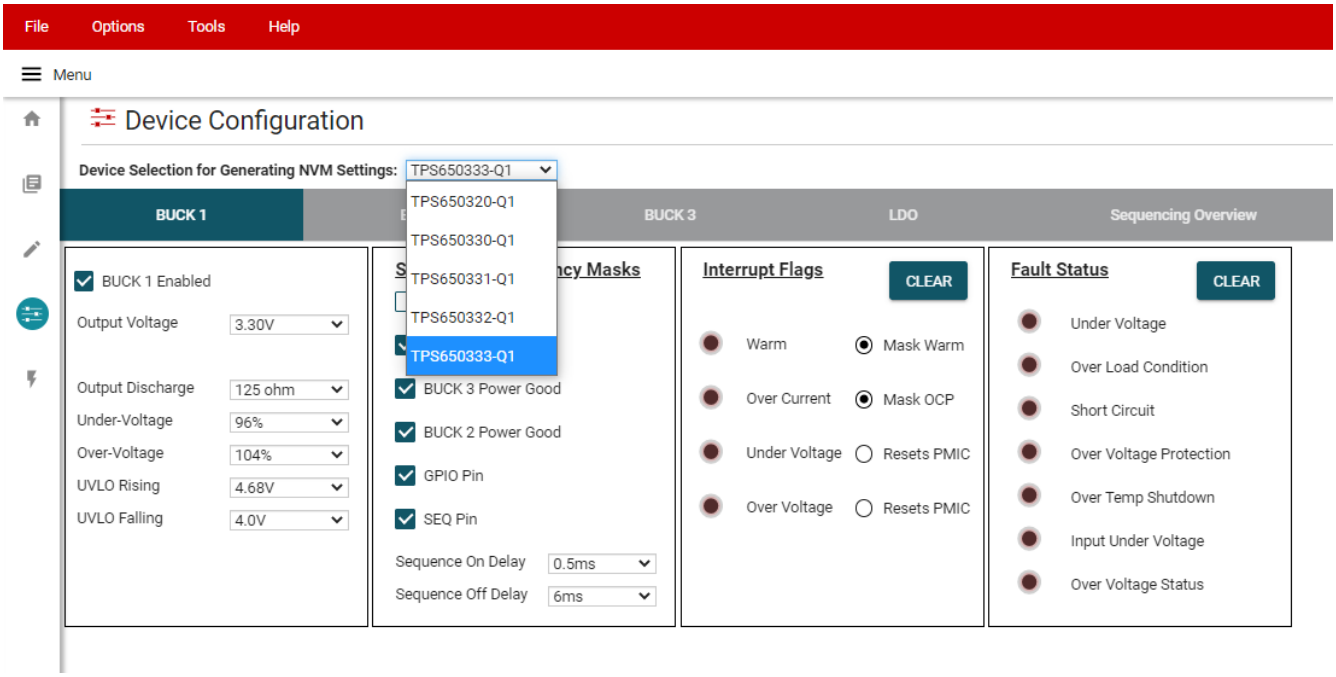


Figure 4-8. Device Selection for Generating NVM Settings

2. Select the desired regulator, sequencing, and additional feature settings in each of the tabs. These changes will be reflected in the Register Map page. For determining the power sequence settings, see Section 4.2.4.2.
3. Click File > Save Settings in the top left corner of the GUI. This exports the register settings in a JSON file that is provided to generate the NVM spin.

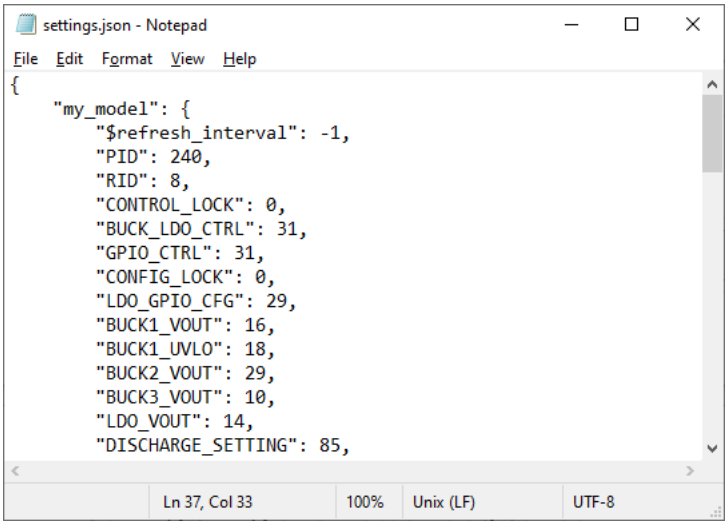


Figure 4-9. Example Settings Output

4.2.4.2 Configuring the Power Sequence

The *Sequencing Overview* tab includes instruments to customize the power sequence of the PMIC. Note that the check boxes are power sequence *masks*. If a particular logic signal needs to be included as part of the regulator or logic power up sequence, leave the box next to the logic signal unchecked. TI recommends to set *Power On Bit* unmasked for each rail that is required in the application.

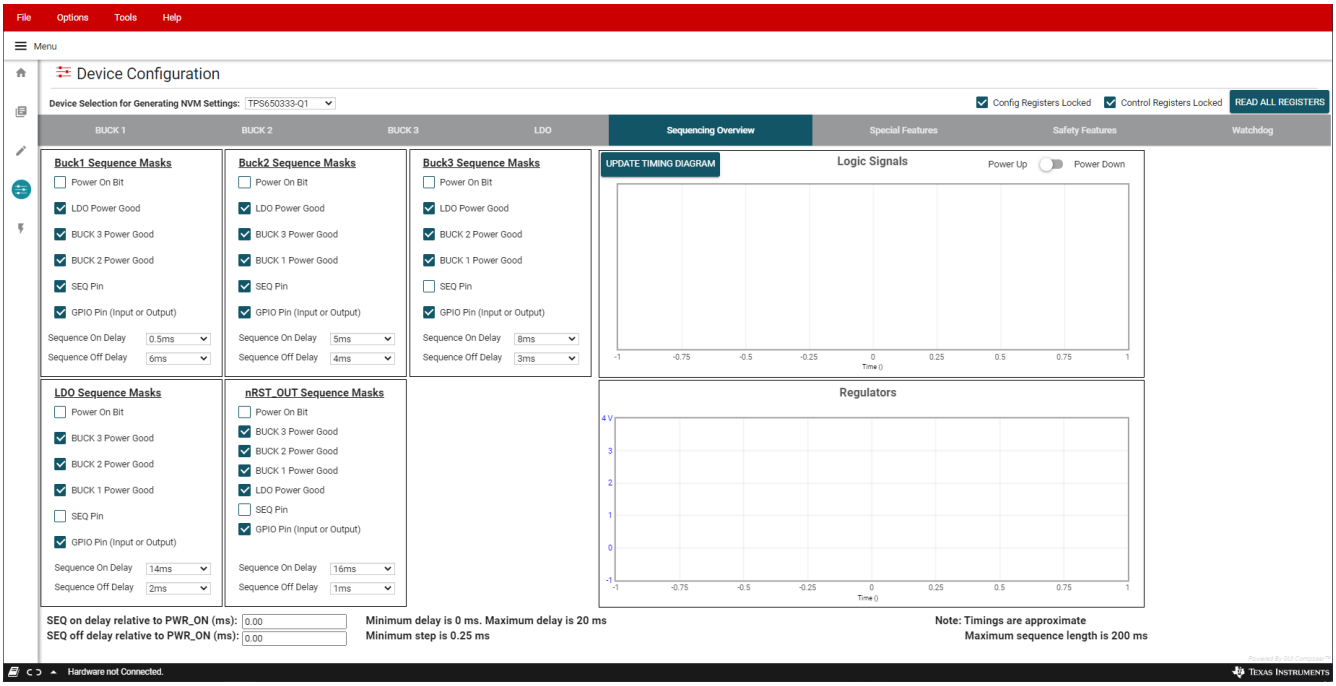


Figure 4-10. Sequencing Overview Tab

For reference, the GUI can generate example power-up and power-down timing diagrams based on the sequence settings present when the *UPDATING TIMING DIAGRAM* button is clicked. As noted, rise and fall times are approximate, and the maximum sequence length is 200 ms. Changes to regulator enable and output discharge settings are reflected in the timing diagram. If the sequence settings are not valid, the GUI will provide a notifying message and the timing diagram will not be updated. For example, if a regulator is enabled but fails to power-up within 200 ms, the sequence settings are not valid.

Figure 4-11. GUI Generated Timing Diagram

4.3 Re-Program PMIC

The Re-Program PMIC section contains a button for sending the EEPROM Program Command to the device. After the EEPROM Program Command is sent, the device will store the existing register configurations permanently and the PMIC will automatically restart with the latest settings. The device can be re-programmed multiple times to evaluate various configurations.

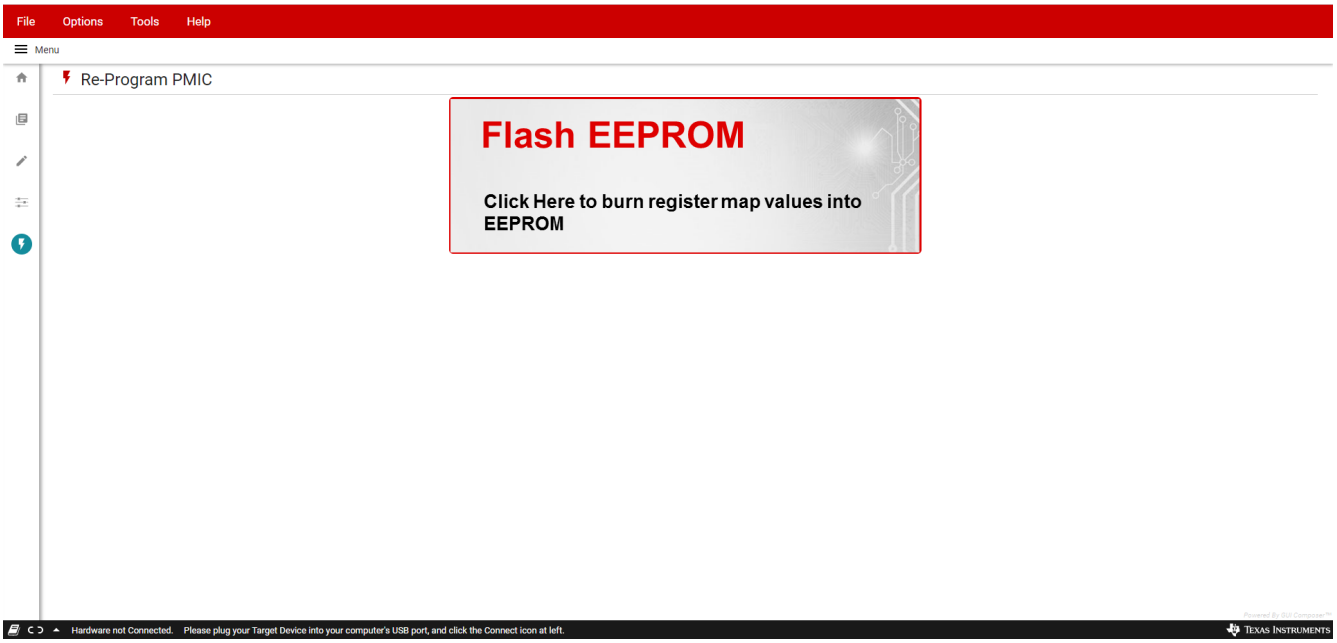


Figure 4-12. TPS6503xx-Q1 GUI Re-Program PMIC Page

4.4 In-Circuit Programming

The TPS650320-Q1 EVM demonstrates the in-circuit programming capabilities of the TPS650320-Q1 PMIC in a typical application. This section provides an example in-circuit programming procedure with application considerations.

1. Verify the desired power and sequence settings using the GUI's Sequencing Overview tools. See Section 4.2.4.2.
2. Validate the settings with the BOOSTXL-TPS65033. This socketed board provides a quicker way to evaluate device settings.
3. Configure the TPS650320-Q1 EVM for a typical camera application once the follwoing settings are verified and validated:
   a. Ensure the I2C pull-up jumpers (J24 and J34) are populated.
   b. Supply the PMIC VIO with either the Buck 1 or Buck 2 output. See Selecting the Logic Supply Voltage.
   c. Tie the PMIC Buck 1 input to VSYS. See Section 2.4.1.
   d. Supply the PMIC Buck 2, Buck 3, and LDO with the Buck 1 output. See Section 2.4.
4. Apply a Buck 1 input voltage (typical is 12 V) to power up the device. By default, the Buck 1 and Buck 2 regulators are enabled, allowing the 3.3 V and 1.8 V rails to power up.
   a. In a typical camera application, this may be sufficient to power up the serializer and enable PMIC programming over the Serializer-Deserializer (SerDes) back-channel.
   b. If additional rails are required, assert SEQ (S1) to enable the Buck 3 and LDO regulators.
5. Unlock the configuration and control registers.
6. Re-program the PMIC settings. If changing a regulator output voltage, TI recommends disabling the regulator first. If doing this in an application setting shuts down a critical component, change the output voltage in small steps to prevent triggering under or over-voltage fault handling.
7. If the device configuration Cyclic Redundancy Check (CRC) is enabled, calculate and write the new configuration CRC by running the GUI's built-in script. For more information on the GUI's capabilities for programming automation, see the BOOSTXL-TPS65033 User's Guide.

Figure 4-13. GUI Configuration CRC Script

8. Burn the final PMIC register settings to EEPROM.
9. Validate the settings on subsequent startups.

5 Typical Performance Plots

5.1 Power Sequence Plots

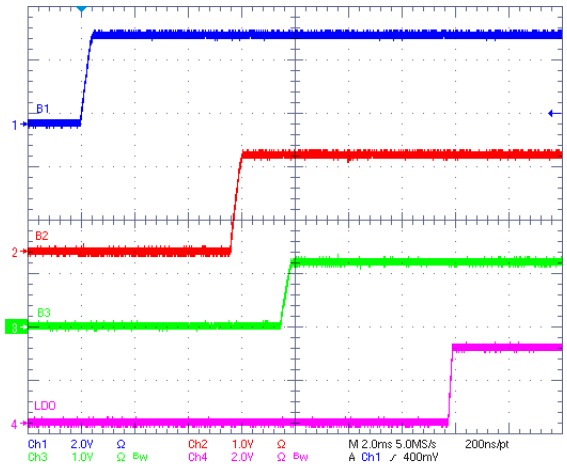


Figure 5-1. TPS650320-Q1 Default Power Up Sequence

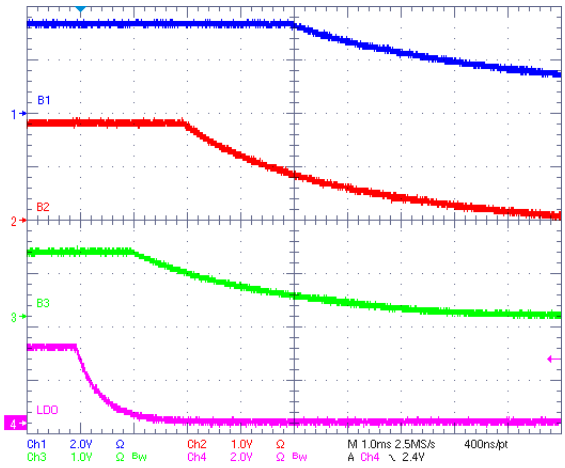
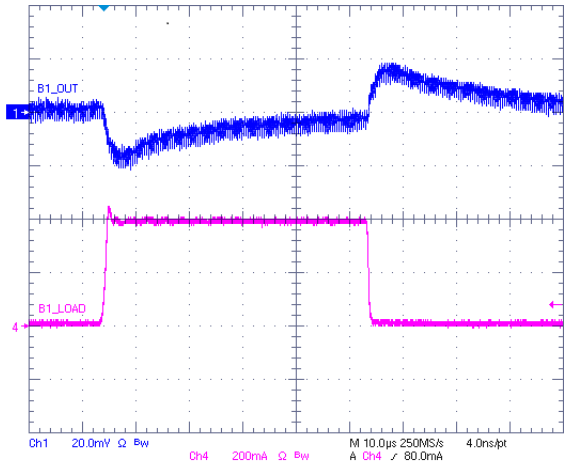


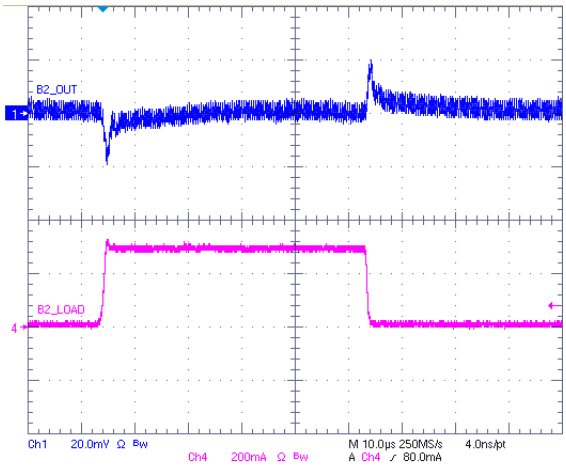
Figure 5-2. TPS650320-Q1 Default Power Down Sequence

5.2 Load Transient Plots



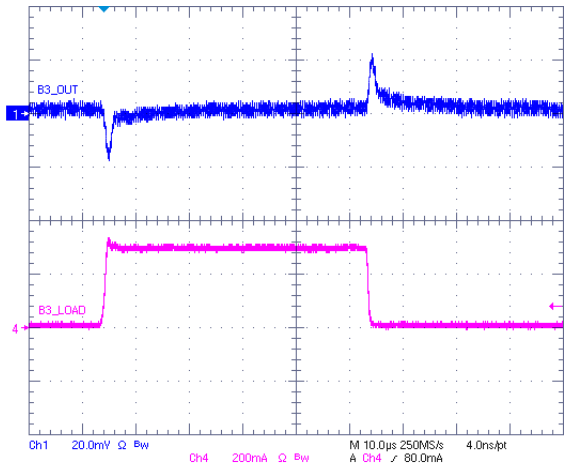
VIN = 12 V VOUT = 3.3 V IOUT = 1 mA to 400 mA in 1 µs

Figure 5-3. Buck 1 Load Transient



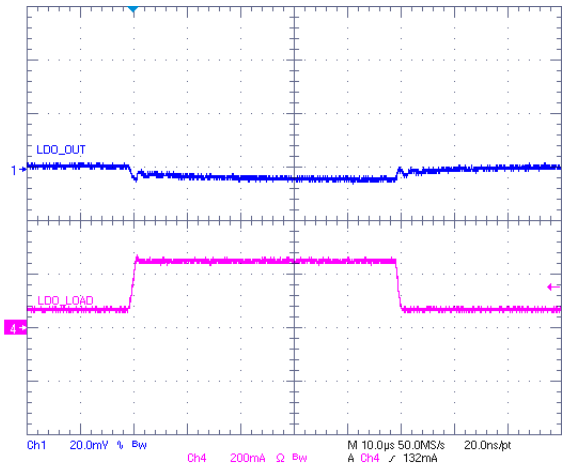
VIN = 3.3 V VOUT = 1.8 V IOUT = 1 mA to 300 mA in 1 µs

Figure 5-4. Buck 2 Load Transient



VIN = 3.3 V VOUT = 1.2 V IOUT = 1 mA to 300 mA in 1 µs

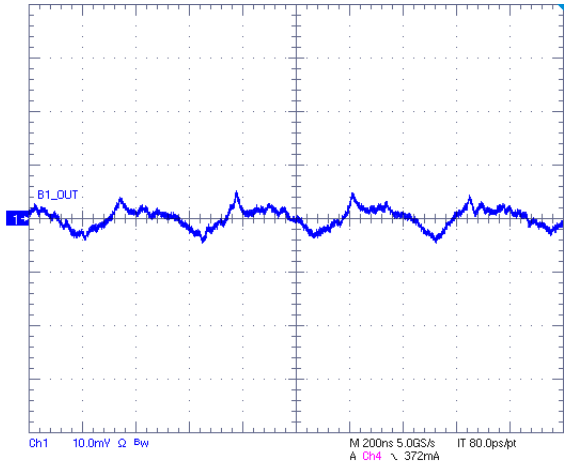
Figure 5-5. Buck 3 Load Transient



VIN = 3.3 V VOUT = 2.8 V IOUT = 60 mA to 240 mA in 1 µs

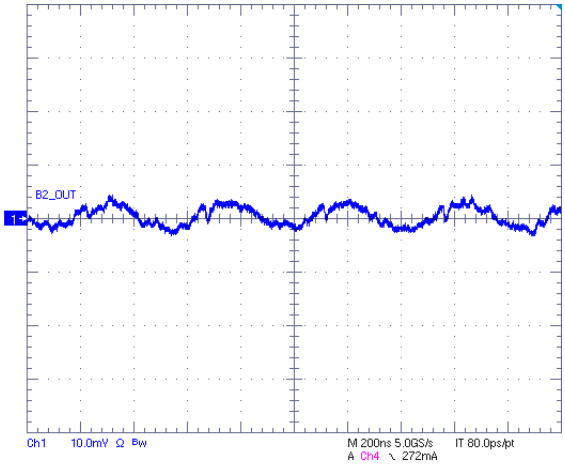
Figure 5-6. LDO Load Transient

5.3 Output Voltage Ripple Plots



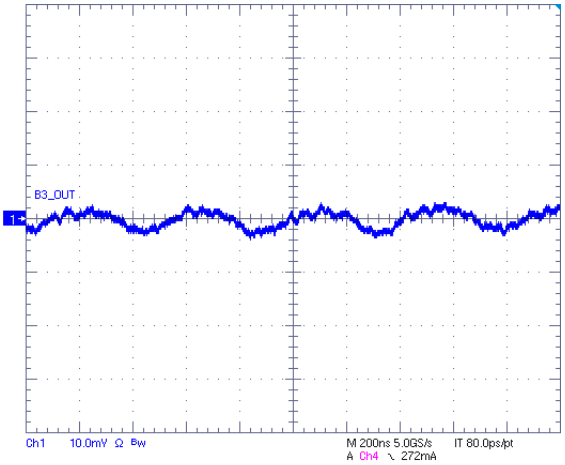
VIN = 12 V VOUT = 3.3 V IOUT = 400 mA

Figure 5-7. Buck 1 Output Voltage Ripple



VIN =3.3 V VOUT = 1.8 V IOUT = 300 mA

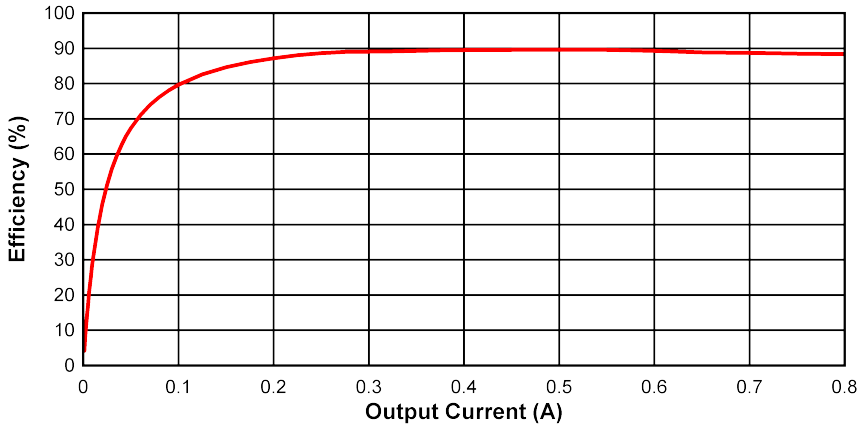
Figure 5-8. Buck 2 Output Voltage Ripple



VIN = 3.3 V VOUT = 1.2 V IOUT = 300 mA

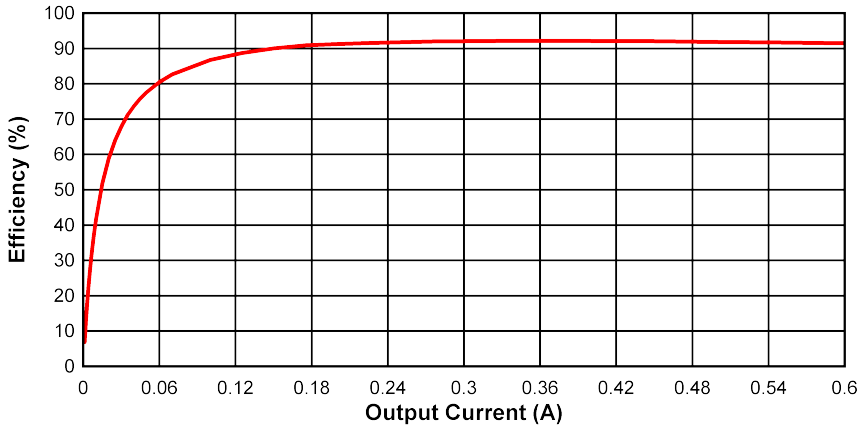
Figure 5-9. Buck 3 Output Voltage Ripple

5.4 Efficiency Plots



VIN = 9 V VOUT = 3.3 V Ta = 25°C

Figure 5-10. Buck 1 Efficiency Curve



VIN = 3.3 V VOUT = 1.8 V Ta = 25°C

Figure 5-11. Buck 2 Efficiency Curve

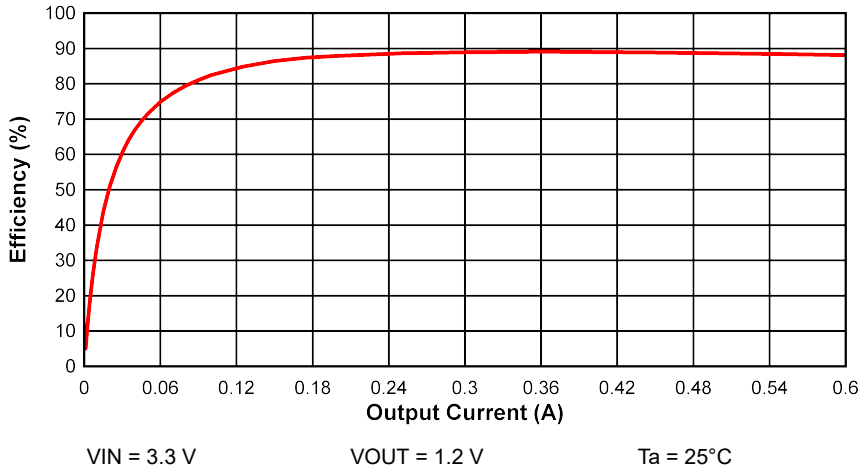


Figure 5-12. Buck 3 Efficiency Curve

5.5 LDO Output Noise

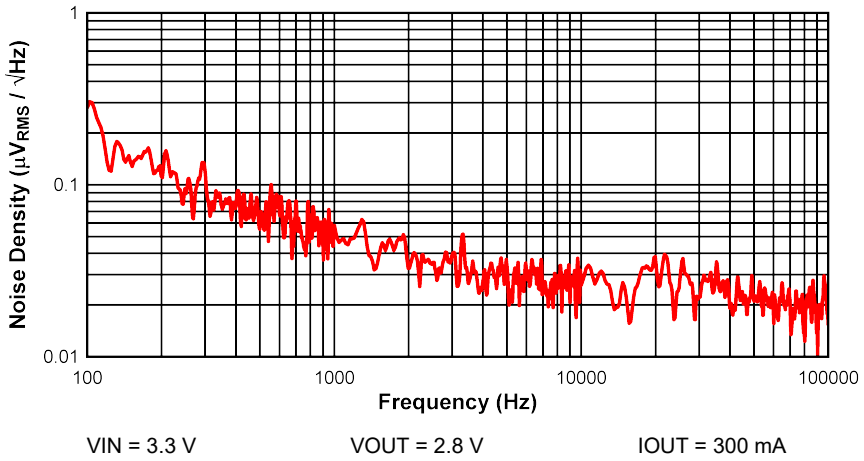


Figure 5-13. LDO Output Noise Density

6 TPS650320-Q1 EVM Schematic

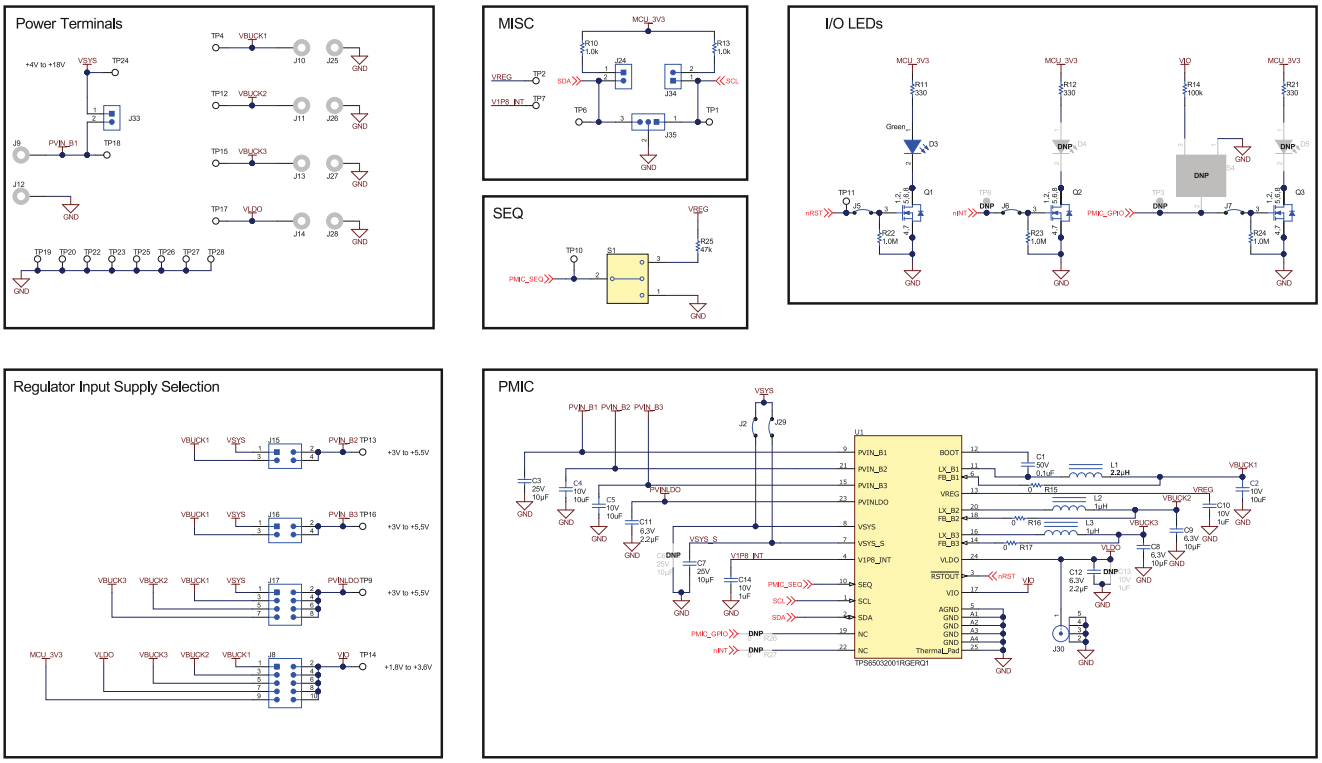


Figure 6-1. TPS650320-Q1 Schematic

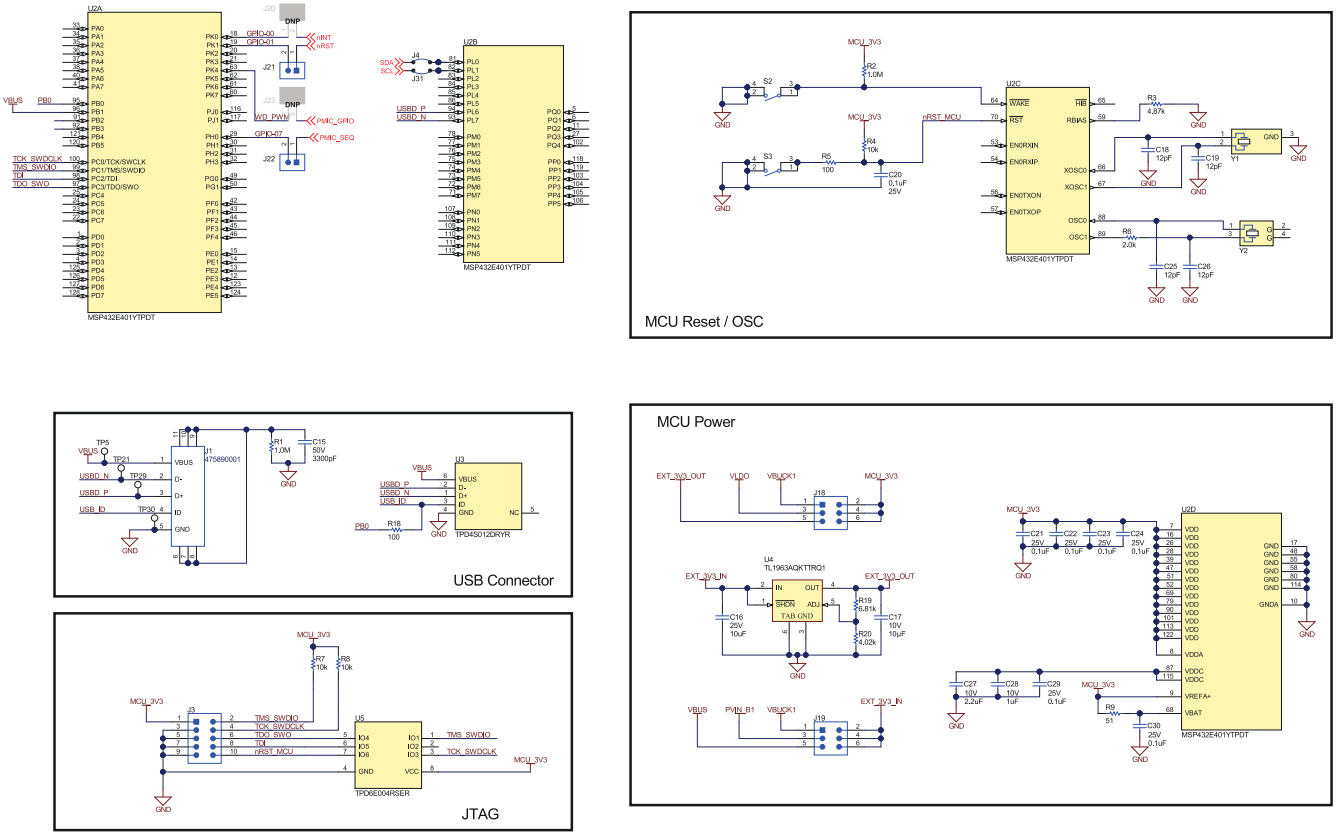


Figure 6-2. MSP432E401Y Schematic

7 TPS650320-Q1 EVM PCB Layers

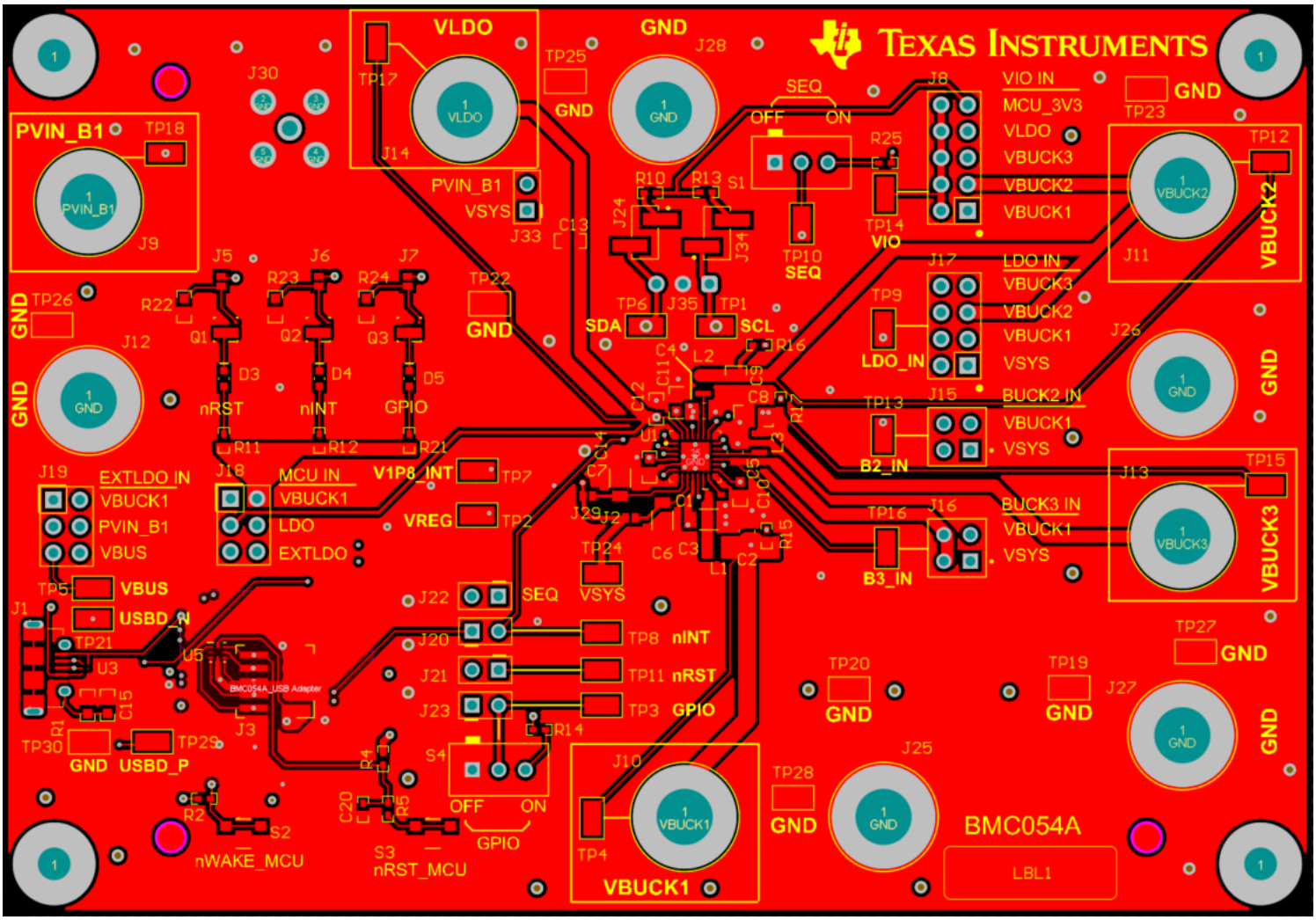


Figure 7-1. Top Layer

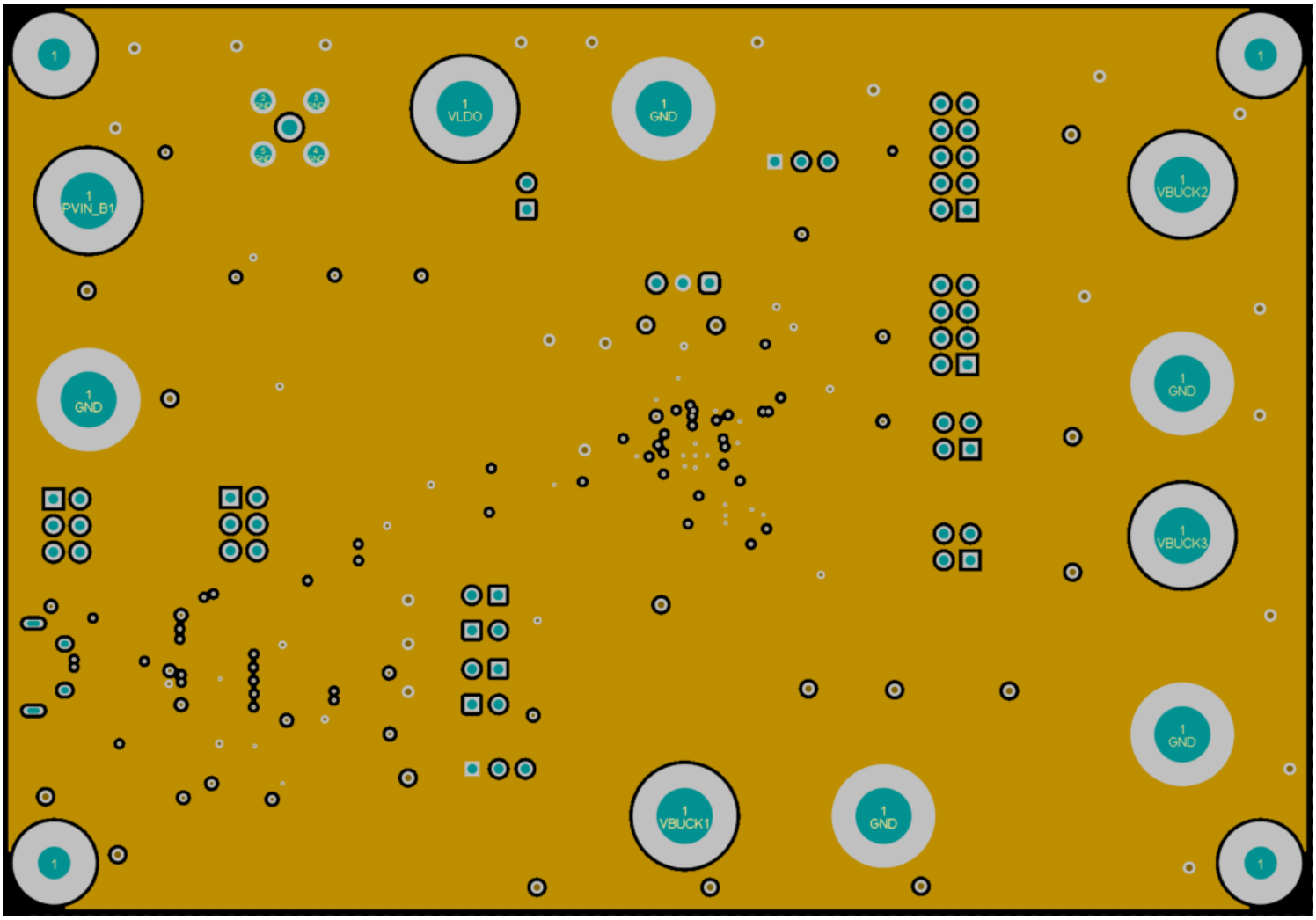


Figure 7-2. Mid-Layer 1

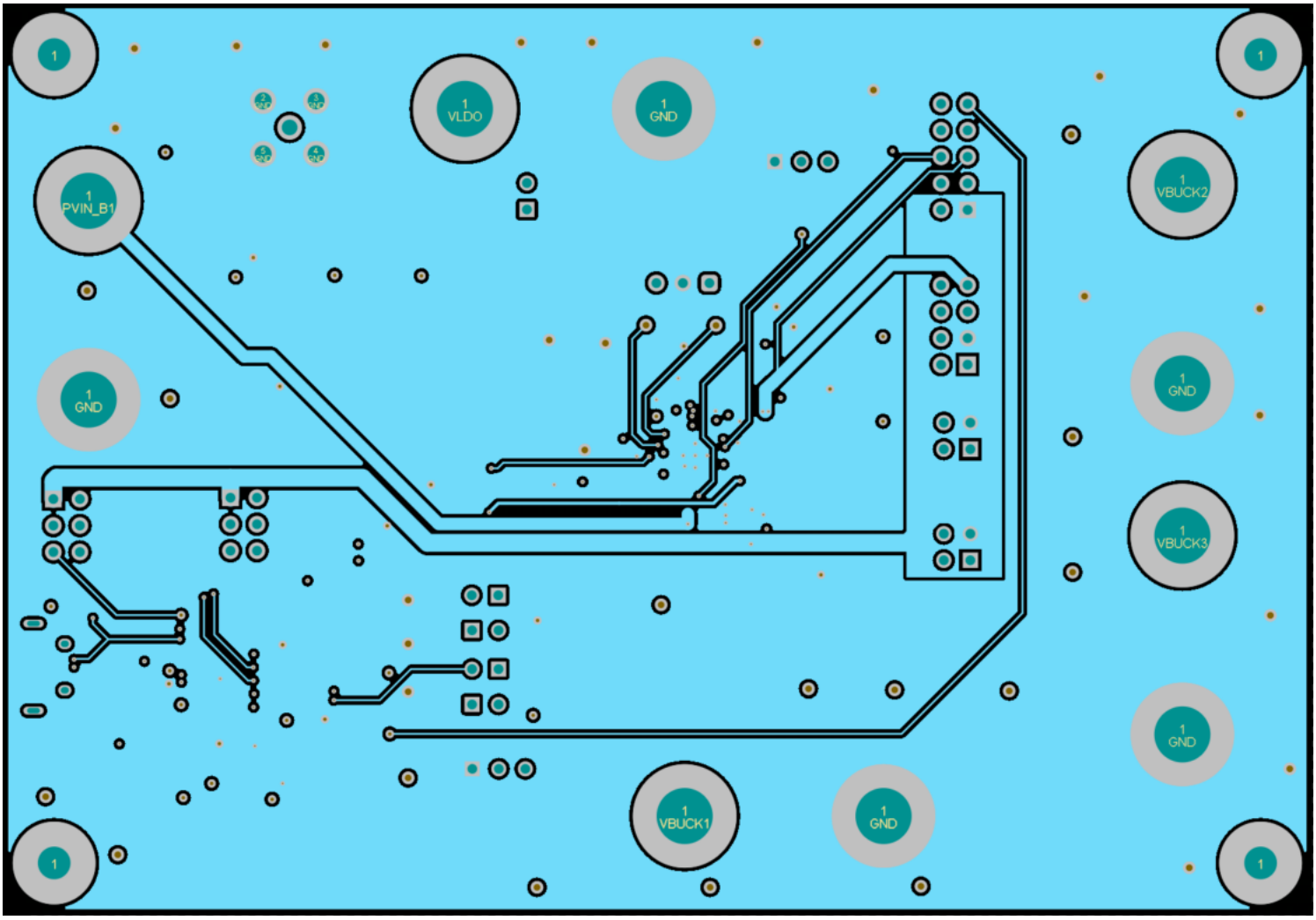


Figure 7-3. Mid-Layer 2

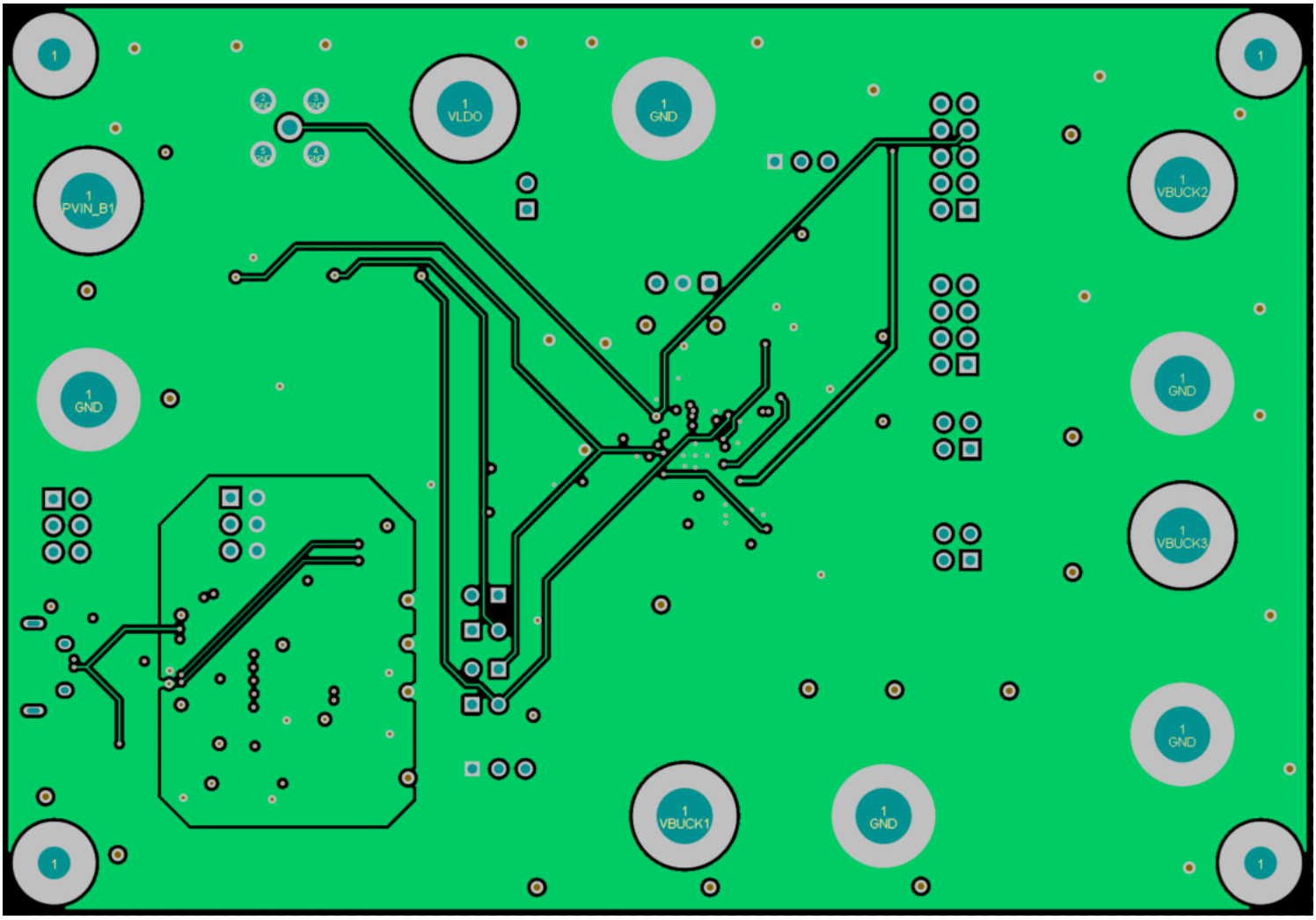


Figure 7-4. Mid-Layer 3

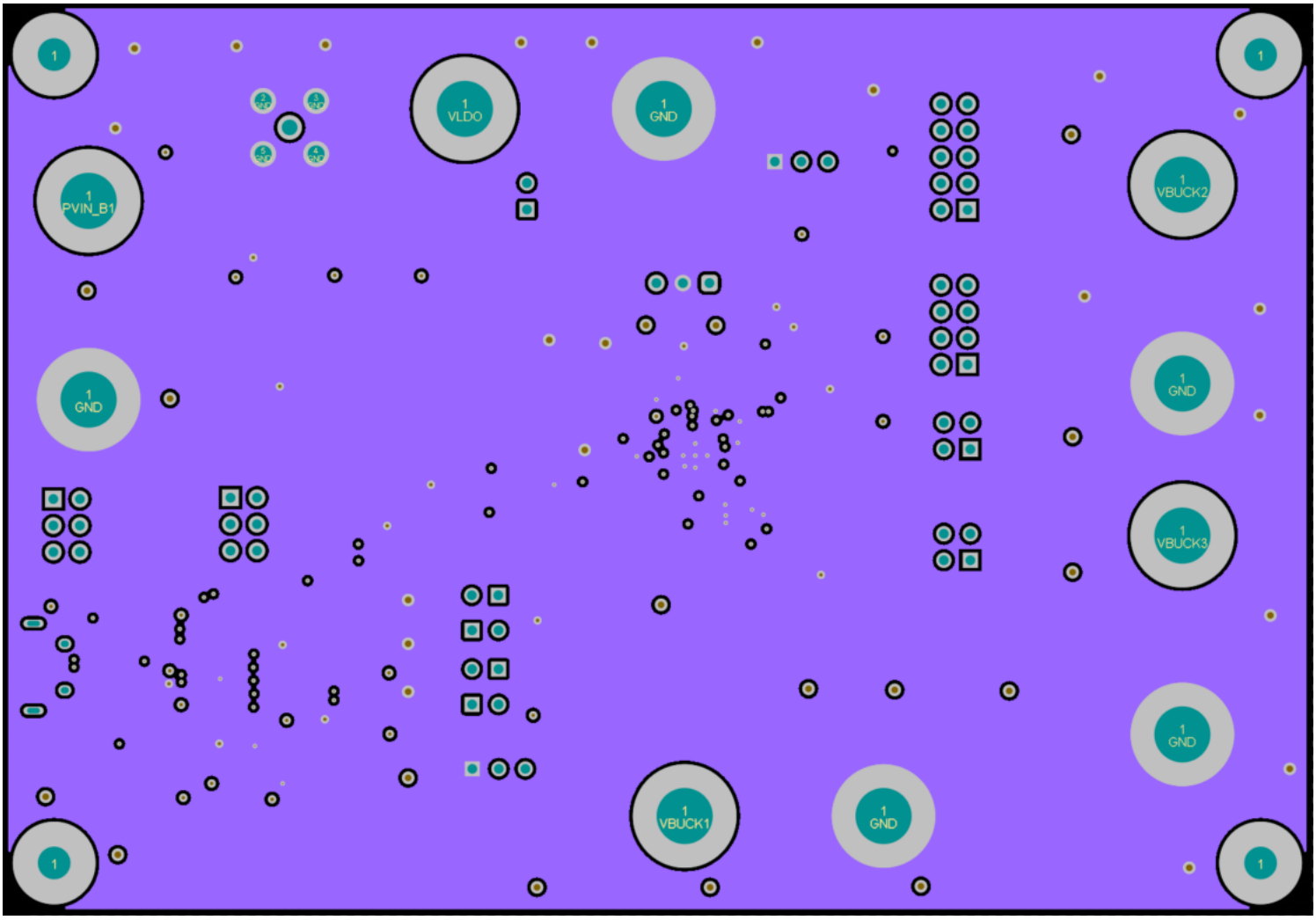


Figure 7-5. Mid-Layer 4

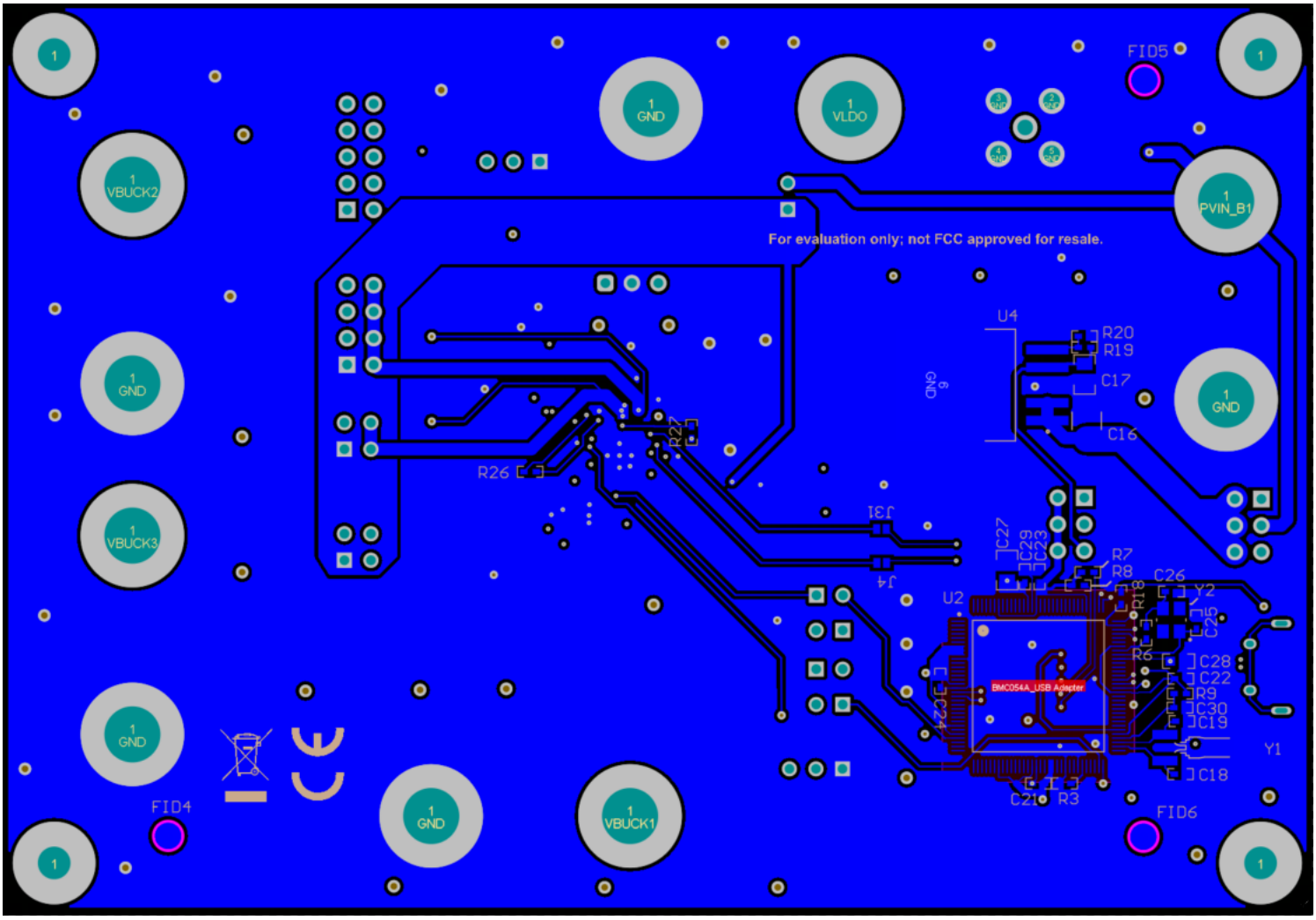


Figure 7-6. Bottom Layer (Mirrored)

8 TPS650320-Q1 EVM Bill of Materials

Table 8-1. TPS650320-Q1 EVM Bill of Materials

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		BMC054	Any
C1	1	0.1 µF	CAP, CERM, 0.1 µF, 50 V, ± 20%, X7R, AEC-Q200 Grade 1, 0402	0402	CGA2B3X7R1H104M050BB	TDK
C2, C4, C5	3		10µF ±10% 10V Ceramic Capacitor X7S 0805 (2012 Metric)	0805	CGA4J3X7S1A106K125AE	TDK
C3, C7	2	10 µF	CAP, CERM, 10 µF, 25 V,± 5%, X7R, AEC-Q200 Grade 1, 1206	1206	C1206C106J3RACAUTO	Kemet
C8, C9	2	10 µF	CAP, CERM, 10 µF, 6.3 V,± 10%, X7R, AEC-Q200 Grade 1, 0805	0805	JMJ212CB7106KGHT	Taiyo Yuden
C10, C14, C28	3	1 µF	CAP, CERM, 1 µF, 10 V, ± 10%, X7R, AEC-Q200 Grade 1, 0603	0603	LMK107B7105KAHT	Taiyo Yuden
C11, C12	2	2.2 µF	CAP, CERM, 2.2 µF, 6.3 V, ± 10%, X7R, AEC-Q200 Grade 1, 0603	0603	GCM188R70J225KE22D	MuRata
C15	1	3300 pF	CAP, CERM, 3300 pF, 50 V, ± 10%, X7R, 0603	0603	C0603C332K5RACTU	Kemet
C16	1	10 µF	CAP, CERM, 10 µF, 25 V, ± 20%, X7R, AEC-Q200 Grade 1, 1210	1210	CGA6P1X7R1E106M250AC	TDK
C17	1	10 µF	CAP, CERM, 10 µF, 10 V,± 5%, X7R, AEC-Q200 Grade 1, 0805	0805	C0805C106J8RACAUTO	Kemet
C18, C19, C25, C26	4	12 pF	CAP, CERM, 12 pF, 50 V,± 5%, C0G/NP0, AEC-Q200 Grade 1, 0402	0402	GCM1555C1H120JA16J	MuRata
C20, C21, C22, C23, C24, C29, C30	7	0.1 µF	CAP, CERM, 0.1 µF, 25 V, ± 10%, X7R, 0402	0402	GRM155R71E104KE14D	MuRata
C27	1	2.2 µF	CAP, CERM, 2.2 µF, 10 V, ± 10%, X7R, 0805	0805	C0805C225K8RACTU	Kemet
D3	1	Green	LED, Green, SMD	1.7x0.65x0.8 mm	LG L29K-G2J1-24-Z	OSRAM
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5 in L #4-40 Nylon	Standoff	1902C	Keystone

Table 8-1. TPS650320-Q1 EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
J1	1		Connector, Receptacle, Micro-USB Type AB, R/A, Bottom Mount SMT	5.6x2.5x8.2 mm	475890001	Molex
J2, J4, J5, J6, J7, J29, J31	7		Jumper, SMT	shorting jumper, SMT	JMP-36-30X40SMT	Any
J3	1		Header (Shrouded), 1.27mm, 5x2, Gold, SMT	Header(Shrouded), 1.27 mm, 5x2, SMT	FTSH-105-01-F-DV-K	Samtec
J8	1		Header, 100mil, 5x2, Tin, TH	Header, 5x2, 100 mil, Tin	PEC05DAAN	Sullins Connector Solutions
J9, J10, J11, J12, J13, J14, J25, J26, J27, J28	10		Standard Banana Jack, Uninsulated, 8.9mm	Keystone575-8	575-8	Keystone
J15, J16	2		Header, 100mil, 2x2, Tin, TH	Header, 2x2, 2.54 mm, TH	PEC02DAAN	Sullins Connector Solutions
J17	1		Header, 100mil, 4x2, Tin, TH	Header, 4x2, 100 mil, Tin	PEC04DAAN	Sullins Connector Solutions
J18, J19	2		Header, 100mil, 3x2, Tin, TH	3x2 Header	PEC03DAAN	Sullins Connector Solutions
J21, J22, J33	3		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100 mil, Tin	PEC02SAAN	Sullins Connector Solutions
J24, J34	2		Header, 100mil, 2x1, Tin, SMD	SMD, 2-Leads, Body 200x100 mil	TSM-102-01-T-SV-P-TR	Samtec
J30	1		Connector, SMA, TH	SMA	142-0701-201	Cinch Connectivity
J35	1		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec
L1	1	2.2 µH	Inductor, Shielded, Metal Composite, 2.2 µH, 1.9 A, 0.152 ohm, AEC-Q200 Grade 0, SMD	0806	TFM201610ALMA2R2MTAA	TDK
L2, L3	2	1 µH	Inductor, Shielded, Metal Composite, 1 µH, 3.1 A, 0.06 ohm, AEC-Q200 Grade 0, SMD	0806	TFM201610ALMA1R0MTAA	TDK
LBL1	1		Thermal Transfer Printable Labels, 0.650 in W x 0.200 in H - 10,000 per roll	PCB Label 0.650 x 0.200 in	THT-14-423-10	Brady
Q1, Q2, Q3	3	25 V	MOSFET, N-CH, 25 V, 5 A, DQK0006C (WSON-6)	DQK0006C	CSD16301Q2	Texas Instruments
R1, R22, R23, R24	4	1.0 Meg	RES, 1.0 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M00JNEA	Vishay-Dale
R2	1	1.0 Meg	RES, 1.0 M, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021M00JNED	Vishay-Dale

Table 8-1. TPS650320-Q1 EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R3	1	4.87 k	RES, 4.87 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04024K87FKED	Vishay-Dale
R4, R7, R8	3	10 k	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0JNED	Vishay-Dale
R5, R18	2	100	RES, 100, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402100RJNED	Vishay-Dale
R6	1	2.0 k	RES, 2.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K00JNED	Vishay-Dale
R9	1	51	RES, 51, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040251R0JNED	Vishay-Dale
R10, R13	2	1.0 k	RES, 1.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021K00JNED	Vishay-Dale
R11, R12, R21	3	330	RES, 330, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402330RJNED	Vishay-Dale
R14	1	100 k	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GEJ104X	Panasonic
R15, R16, R17	3	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04020000Z0ED	Vishay-Dale
R19	1	6.81 k	RES, 6.81 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04026K81FKED	Vishay-Dale
R20	1	4.02 k	RES, 4.02 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04024K02FKED	Vishay-Dale
R25	1	47 k	RES, 47 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040247K0JNED	Vishay-Dale
S1	1		Switch, Slide, SPDT, On-Off-On, 3 Pos, 0.05A, 48 V, TH	9.5x5 mm	AS1E-2M-10-Z	Copal Electronics
S2, S3	2		Switch, SPST, Off-Mom, 0.05 A, 12 VDC, SMD	3.5x2.9 mm	434153017835	Wurth Elektronik
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9	9	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100 mil Shunt	SPC02SYAN	Sullins Connector Solutions

Table 8-1. TPS650320-Q1 EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
TP1, TP2, TP4, TP5, TP6, TP7, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP23, TP24, TP25, TP26, TP27, TP28, TP29, TP30	28		Test Point, Miniature, SMT	Testpoint_Keystone_Miniature	5015	Keystone
U1	1		Automotive Camera PMIC	VQFN24	TPS65032001RGERQ1	Texas Instruments
U2	1		MSP432E401YTPDT, PDT0128A (TQFP-128)	PDT0128A	MSP432E401YTPDT	Texas Instruments
U3	1		USB ESD Solution with Power Clamp, 4 Channels, -40 to +85 °C, 6-pin SON (DRY), Green (RoHS & no Sb/Br)	DRY0006A	TPD4S012DRYR	Texas Instruments
U4	1		Single Output Fast Transient Response LDO, 1.5 A, Adjustable 1.21 to 20 V Output, 2.1 to 20 V Input, 5-pin DDPAK (KTT), -40 to 125 °C, Green (RoHS & no Sb/Br)	KTT0005A	TL1963AQKTTRQ1	Texas Instruments
U5	1		Low-Capacitance 6-Channel ±15 kV ESD Protection Array for High-Speed Data Interfaces, RSE0008A (UQFN-8)	RSE0008A	TPD6E004RSER	Texas Instruments
Y1	1		Crystal, 32.768 kHz, SMD	D1.9xL6 mm	CMR200T-32.768KDZY-UT	Citizen FineDevice
Y2	1		Crystal, 25 MHz, 8pF, SMD	3.2x0.75x2.5 mm	NX3225GA-25.000M-STD-CRG-2	NDK
C6	0	10 µF	CAP, CERM, 10 µF, 25 V,± 5%, X7R, AEC-Q200 Grade 1, 1206	1206	C1206C106J3RACAUTO	Kemet
C13	0	1 µF	CAP, CERM, 1 µF, 10 V, ± 10%, X7R, AEC-Q200 Grade 1, 0603	0603	LMK107B7105KAHT	Taiyo Yuden
D4, D5	0	Green	LED, Green, SMD	1.7x0.65x0.8 mm	LG L29K-G2J1-24-Z	OSRAM
J20, J23	0		Header, 100mil, 2x1, Tin, TH	Header, 2 PIN, 100 mil, Tin	PEC02SAAN	Sullins Connector Solutions

Table 8-1. TPS650320-Q1 EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R26, R27	0	0	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04020000Z 0ED	Vishay-Dale
S4	0		Switch, Slide, SPDT, On-Off-On, 3 Pos, 0.05A, 48 V, TH	9.5x5 mm	AS1E-2M-10-Z	Copal Electronics
TP3, TP8	0		Test Point, Miniature, SMT	Testpoint_Keyston e_Miniature	5015	Keystone

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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

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。
上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale (https:www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265