User's Guide

TPS38700Q1EVM Voltage Sequencer

ABSTRACT

This user guide describes the operational use of the TPS38700Q1EVM evaluation module (EVM) as a reference design for engineering demonstration and evaluation of the TPS38700-Q1 Multichannel I2C Programmable Voltage Sequencer. This guide contains the EVM schematic, bill of materials (BOM), assembly drawing, and top and bottom board layouts.

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1 Introduction

The TPS38700Q1EVM is an evaluation module (EVM) for the TPS38700-Q1 Multichannel I2C Programmable Voltage Sequencer. Test points are provided to give the user additional access, if needed, for oscilloscope or multi-meter measurements.

The TPS38700Q1EVM comes pre-populated with TPS38700C03NRGERQ1. This option offers NEM_PD pin which allow the system to issue an emergency power down while also being able to sequence up to ten different devices all with a precise predefined sequence. The device also offers the option of battery backup power, a precise 32.768 kHz clock, and the ability to communicate faults via I2C. ACT and $\overline{\text{SLEEP}}$ pins allow for the device to change state depending on the logic level present on each. The NIRQ pin serves as an interrupt flag to alert the system to possible faults, and the NRST pin asserts logic high under reset condition.

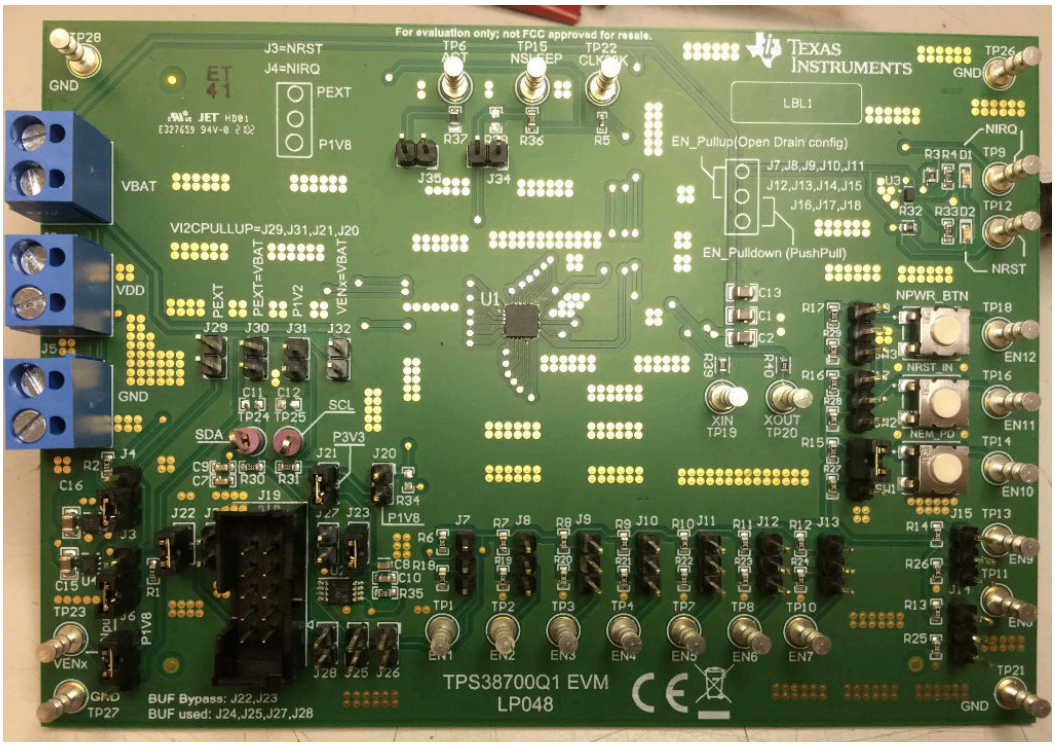

Figure 1-1. TPS38700Q1EVM Board Top

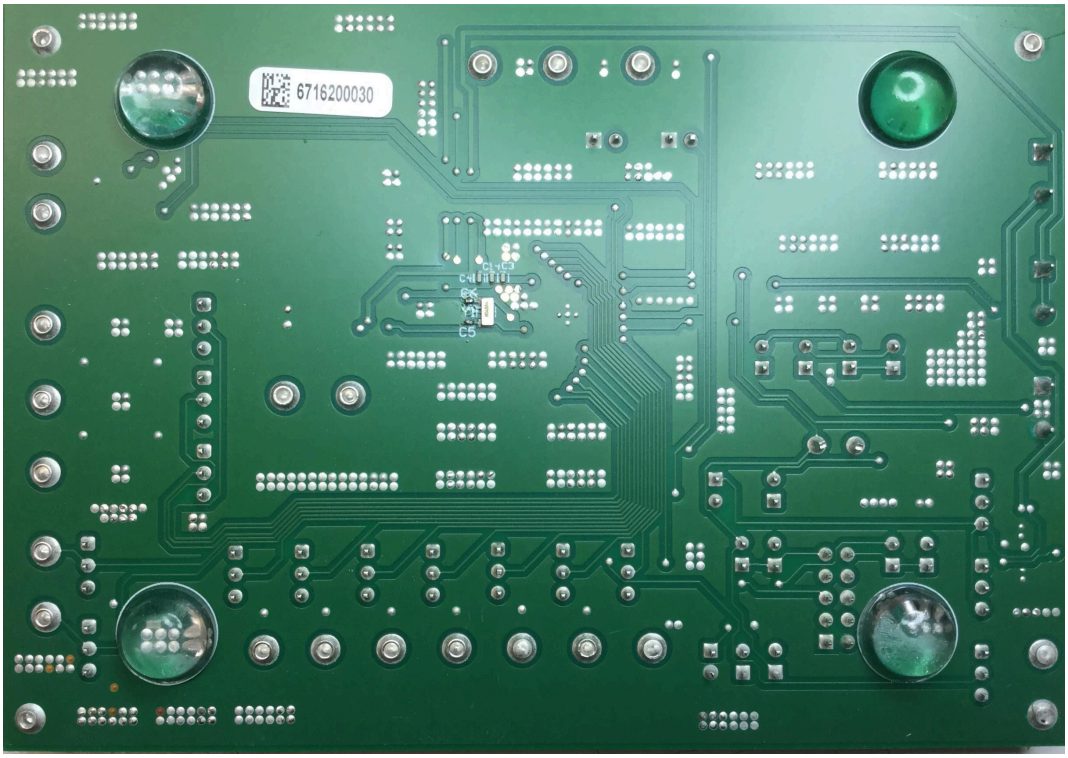

Figure 1-2. TPS38700Q1EVM Board Bottom

1.1 Related Documentation

Datasheet: *TPS38700-Q1 Multichannel I2C Programmable Voltage Sequencer*

1.2 TPS38700-Q1 Applications

- Advanced Driver Assistance System (ADAS)
- Medical robotics
- Industrial robotics

2 Schematic, Bill of Materials, and Layout

This section provides a detailed description of the TPS38700Q1EVM schematic, bill of materials (BOM), and layout.

2.1 TPS38700Q1EVM Schematic

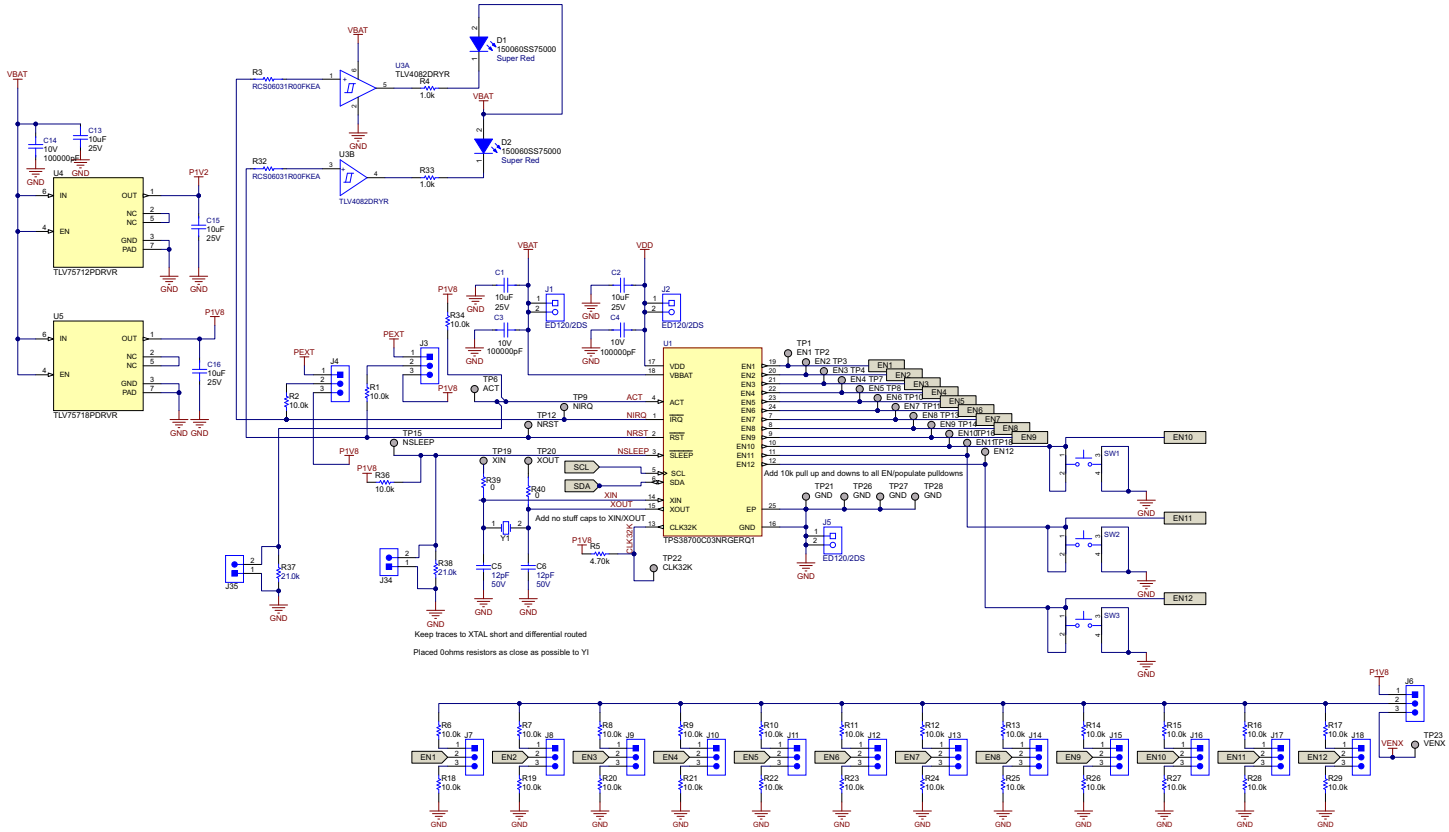

Figure 2-1. TPS38700Q1EVM Schematic 1 of 2

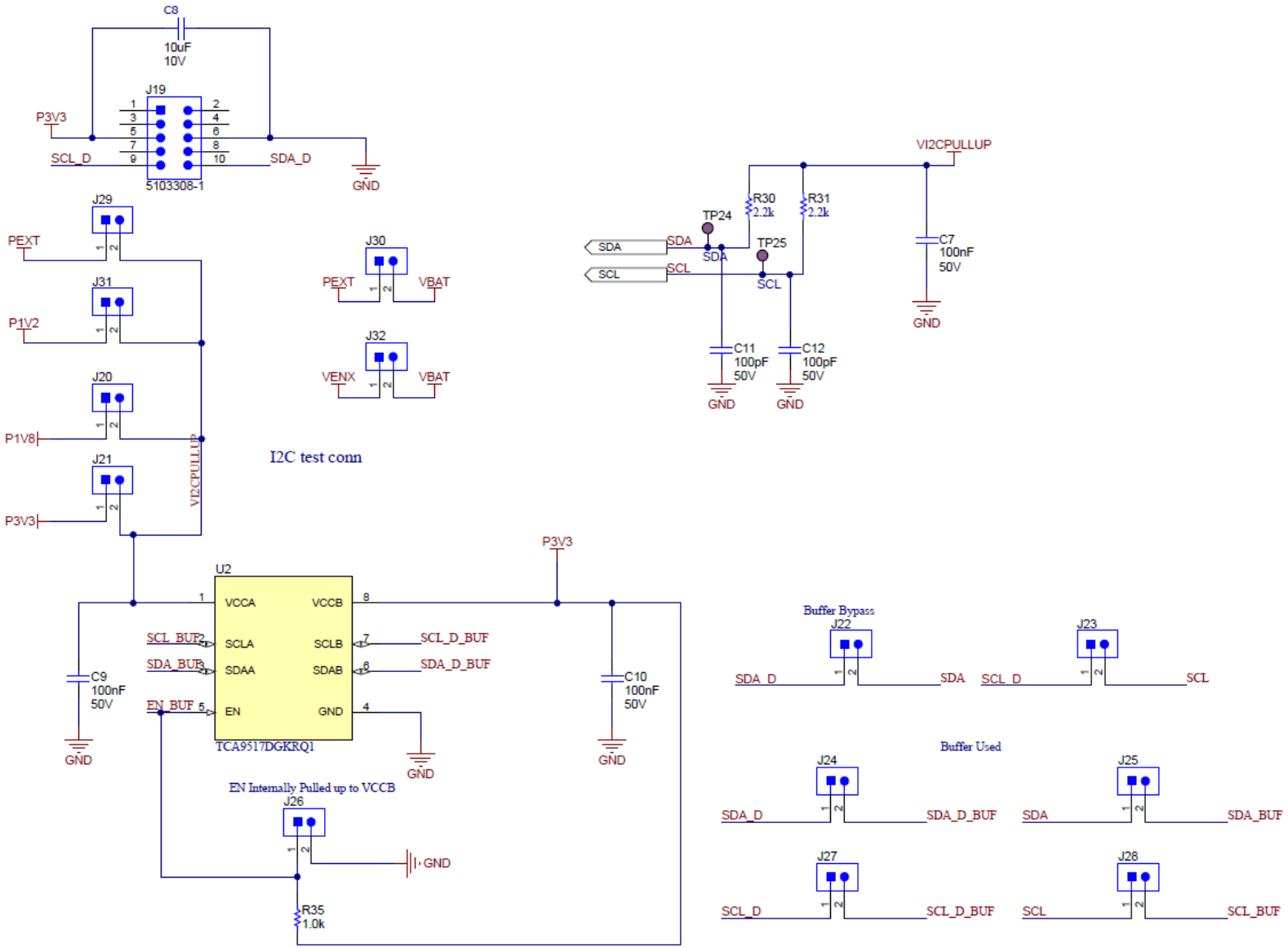

Figure 2-2. TPS38700Q1EVM Schematic 2 of 2

2.2 TPS38700Q1EVM Bill of Materials

Table 2-1. BOM

DESIGNATOR	QTY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
PCB	1		Printed Circuit Board		LP048	Any
C1, C2, C13, C15, C16	5	10 µF	10 µF ±10% 25 V Ceramic Capacitor X7S 0805 (2012 Metric)	0805	C2012X7S1E106K125AC	TDK
C3, C4, C14	3	0.1 µF	0.1 µF ±10% 10 V Ceramic Capacitor X7R 0402 (1005 Metric)	0402	885012205018	Wurth Electronics
C5, C6	2	12 pF	CAP, CERM, 12 pF, 50 V, +/- 5%, C0G/NP0, 0201	0201	GRM0335C1H120JA01D	MuRata
C7, C9, C10	3	0.1 µF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0603	0603	06035C104KAT2A	AVX
C8	1	10 µF	10 µF ±10% 10 V Ceramic Capacitor X5R 0603 (1608 Metric)	0603	C1608X5R1A106K080AC	TDK
C11, C12	2	100 pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	06035A101JAT2A	AVX
D1, D2	2	Red	LED, Super Red, SMD	SMD	150060SS75000	Wurth Elektronik
FID1, FID2, FID3	3		Fiducial mark. There is nothing to buy or mount.		N/A	N/A
H1, H2, H3, H4	4		Bumpon, Hemisphere, 0.44 X 0.20, Clear		SJ-5303 (CLEAR)	3M
J1, J2, J5	3		Terminal Block, 5.08 mm, 2x1, Brass, TH	2x1 TH	ED120/2DS	On-Shore Technology
J3, J4, J6, J7, J8, J9, J10, J11, J12, J13, J14, J15, J16, J17, J18	15		Header, 100mil, 3x1, Gold, TH	3x1 TH	TSW-103-07-G-S	Samtec
J19	1		Header (shrouded), 100mil, 5x2, Gold, TH	5x2 TH	5103308-1	TE Connectivity
J20, J21, J22, J23, J24, J25, J26, J27, J28, J29, J30, J31, J32, J34, J35	15		Header, 100mil, 2x1, Gold, TH	2x1 TH	TSW-102-07-G-S	Samtec
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll		THT-14-423-10	Brady
R1, R2, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29	26	10.0 kΩ	RES, 10.0 kΩ, 1%, 0.1 W, 0603	0603	RC0603FR-0710KL	Yageo
R3, R32	2	1 Ω	1 Ω ±1% 0.25 W, ¼ W Chip Resistor 0603 (1608 Metric) Automotive AEC-Q200, Pulse Withstanding Thick Film	0603	RCS06031R00FKEA	Vishay
R4, R33	2	1.0 kΩ	RES, 1.0 kΩ, 5%, 0.1 W, 0603	0603	RC0603JR-071KL	Yageo
R5	1	4.7 kΩ	RES, 4.70 kΩ, 1%, 0.063 W, 0402	0402	CRG0402F4K7	TE Connectivity
R30, R31	2	2.2 kΩ	RES, 2.2 kΩ, 5%, 0.1 W, 0603	0603	RC0603JR-072K2L	Yageo
R34, R36	2	10.0 kΩ	RES, 10.0 kΩ, 1%, 0.1 W, 0603	0603	RCG060310K0FKEA	Vishay Draloric

Table 2-1. BOM (continued)

DESIGNATOR	QTY	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
R35	1	1.0 kΩ	RES, 1.0 kΩ, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031K00JNEA	Vishay-Dale
R37, R38	2	21.0 kΩ	RES, 21.0 kΩ, 1%, 0.1 W, 0603	0603	RC0603FR-0721KL	Yageo
R39, R40	2	0 Ω	0 Ω Jumper 0.1 W, 1/10 W Chip Resistor 0603 (1608 Metric) Automotive AEC-Q200 Thick Film	0603	ERJ-3GEY0R00V	Panasonic
SW1, SW2, SW3	3		Switch Tactile N.O. SPST Round Button J-Bend 32VAC 32 VDC 1VA 100000Cycles 3N SMD Tube/T/R	SMD	KT11P3JM34LFS	C&K Components
TP1, TP2, TP3, TP4, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP18, TP19, TP20, TP21, TP22, TP23, TP26, TP27, TP28	24		Terminal, Turret, TH, Triple	TH	1598-2	Keystone
TP24, TP25	2		Test Point, Multipurpose, Purple, TH	TH	5129	Keystone
U2	1		Automotive, Level-Shifting I2C Bus Repeater, DGK0008A (VSSOP-8)	VSSOP-8	TCA9517DGKRQ1	Texas Instruments
U3	1		Dual-Channel, Low-Power Comparator with Integrated Reference (USON)	USON	TLV4082DRYR	Texas Instruments
U4	1		1 A Low-Quiescent-Current Low-Dropout (LDO) Regulator, DRV0006A (WSON-6)	WSON-6	TLV75712PDRVR	Texas Instruments
U5	1		1 A Low-Quiescent-Current Low-Dropout (LDO) Regulator, DRV0006A (WSON-6)	WSON-6	TLV75718PDRVR	Texas Instruments
U1	1		ASIL-B Multichannel I2C Programmable Voltage Sequencer (VQFN)	VQFN	TPS38700C03NRGERQ1	Texas Instruments
Y1	1		Crystal, 32.768 kHz, 12.5 pF, SMD	SMD	NX3215SA-32.768K-STD-MUA-8	NDK

2.3 Layout and Component Placement

Figure 2-3 and Figure 2-4 show the top and bottom assemblies of the printed circuit board (PCB) to show the component placement on the EVM.

Figure 2-5 and Figure 2-6 show the top and bottom layouts, Figure 2-7 and Figure 2-8 show the top and bottom layers, and Figure 2-9 shows the top solder mask of the EVM.

2.4 Layout

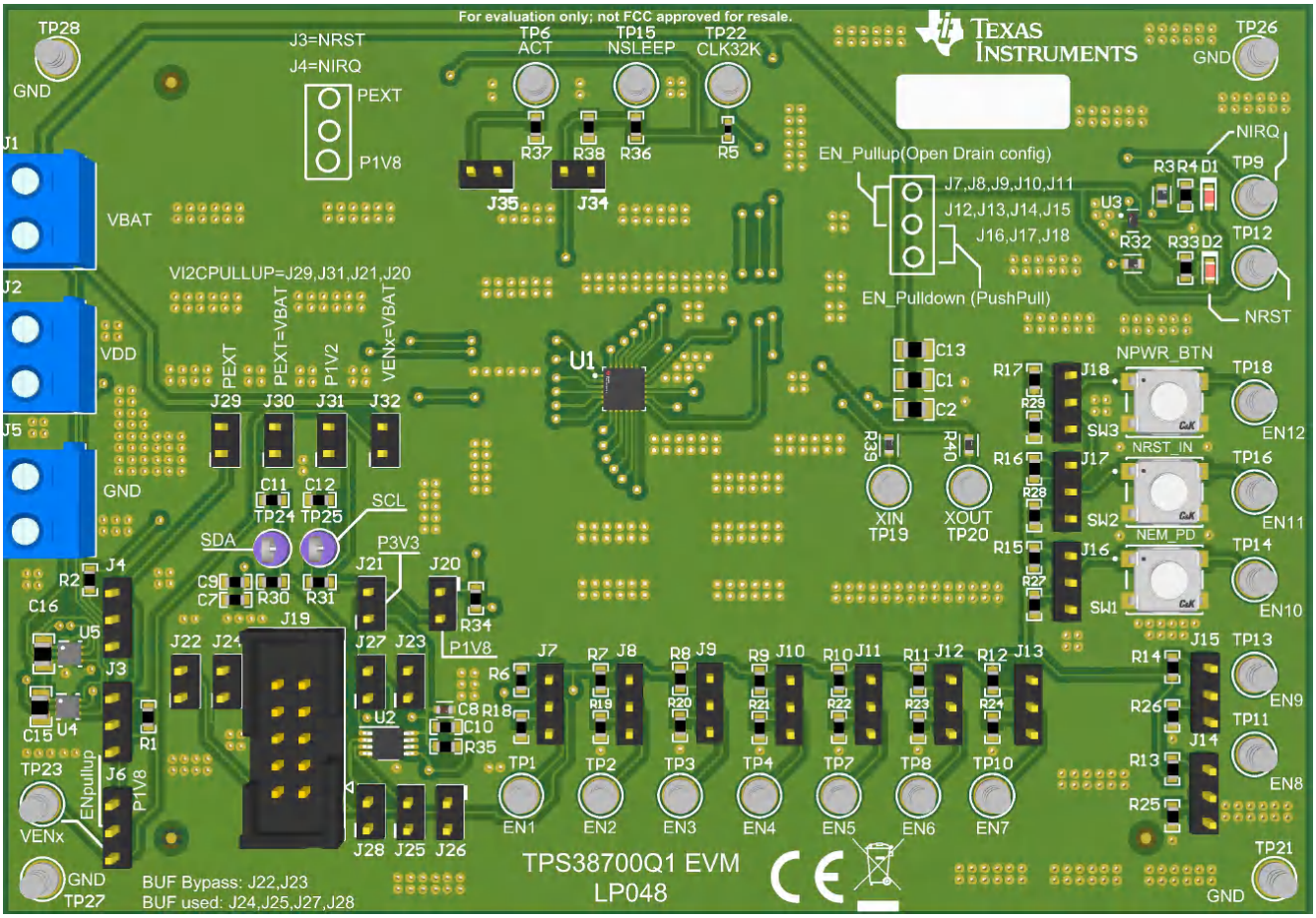

Figure 2-3. Component Placement—Top Assembly

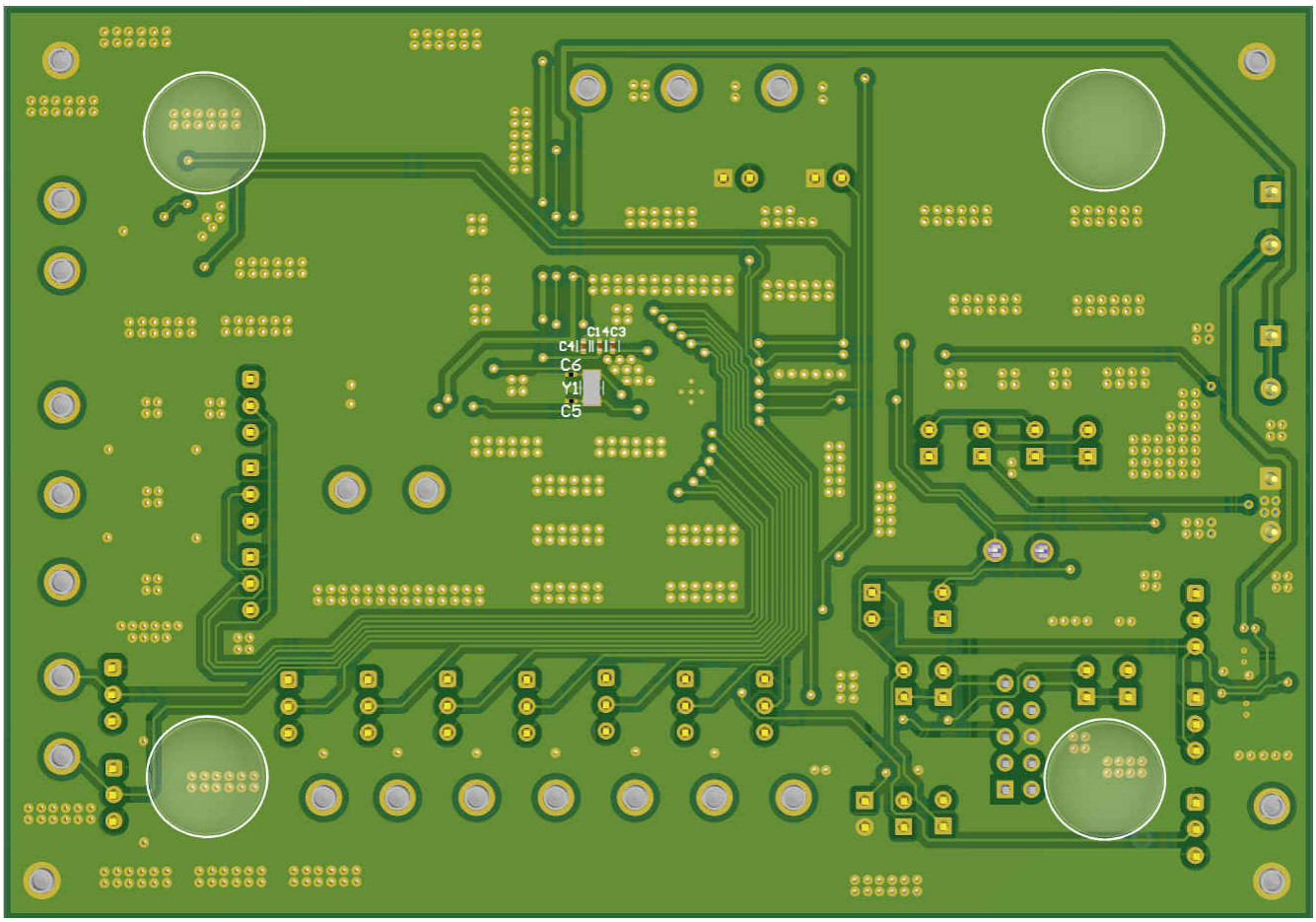

Figure 2-4. Component Placement—Bottom Assembly

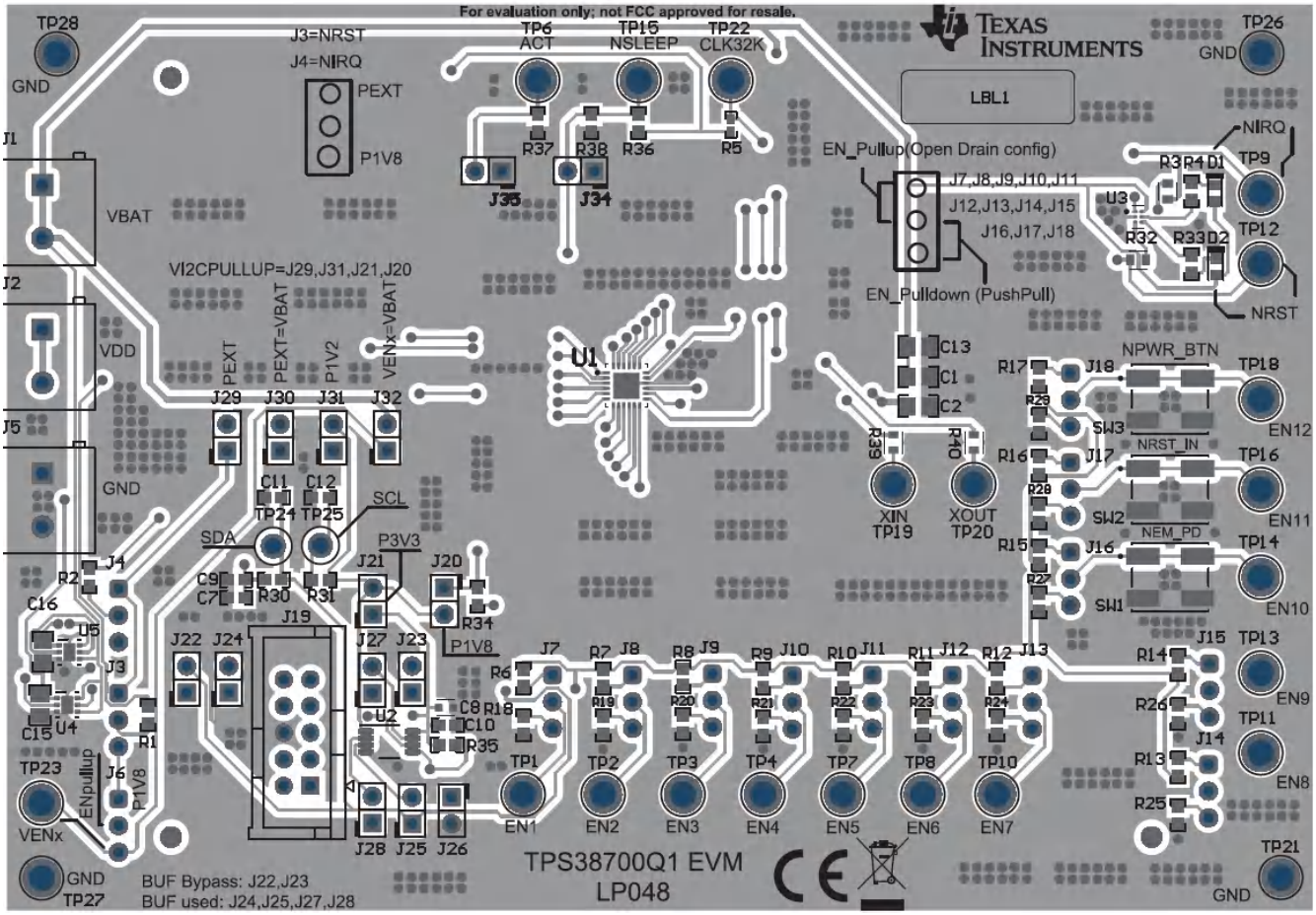

Figure 2-5. Layout—Top

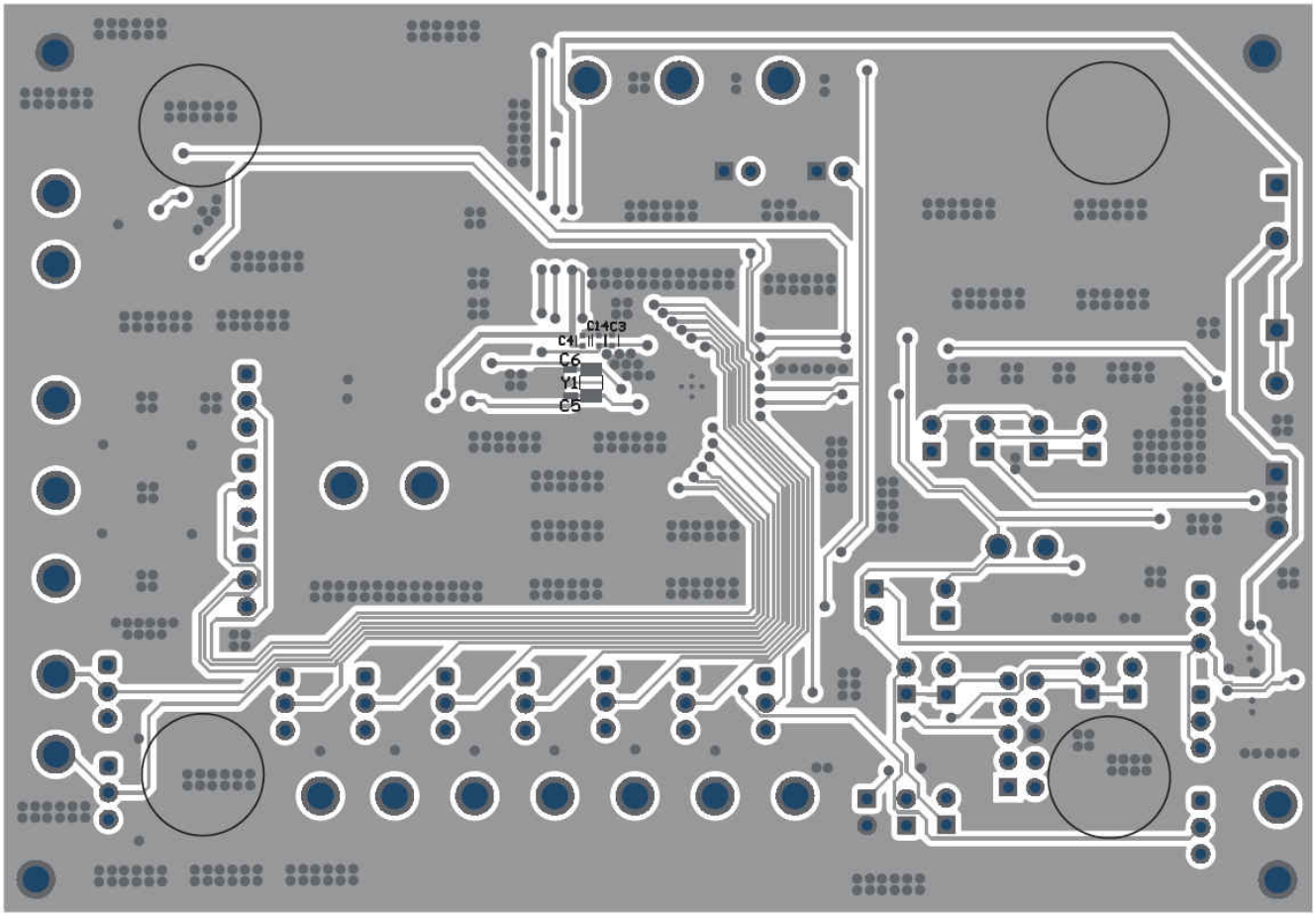

Figure 2-6. Layout—Bottom

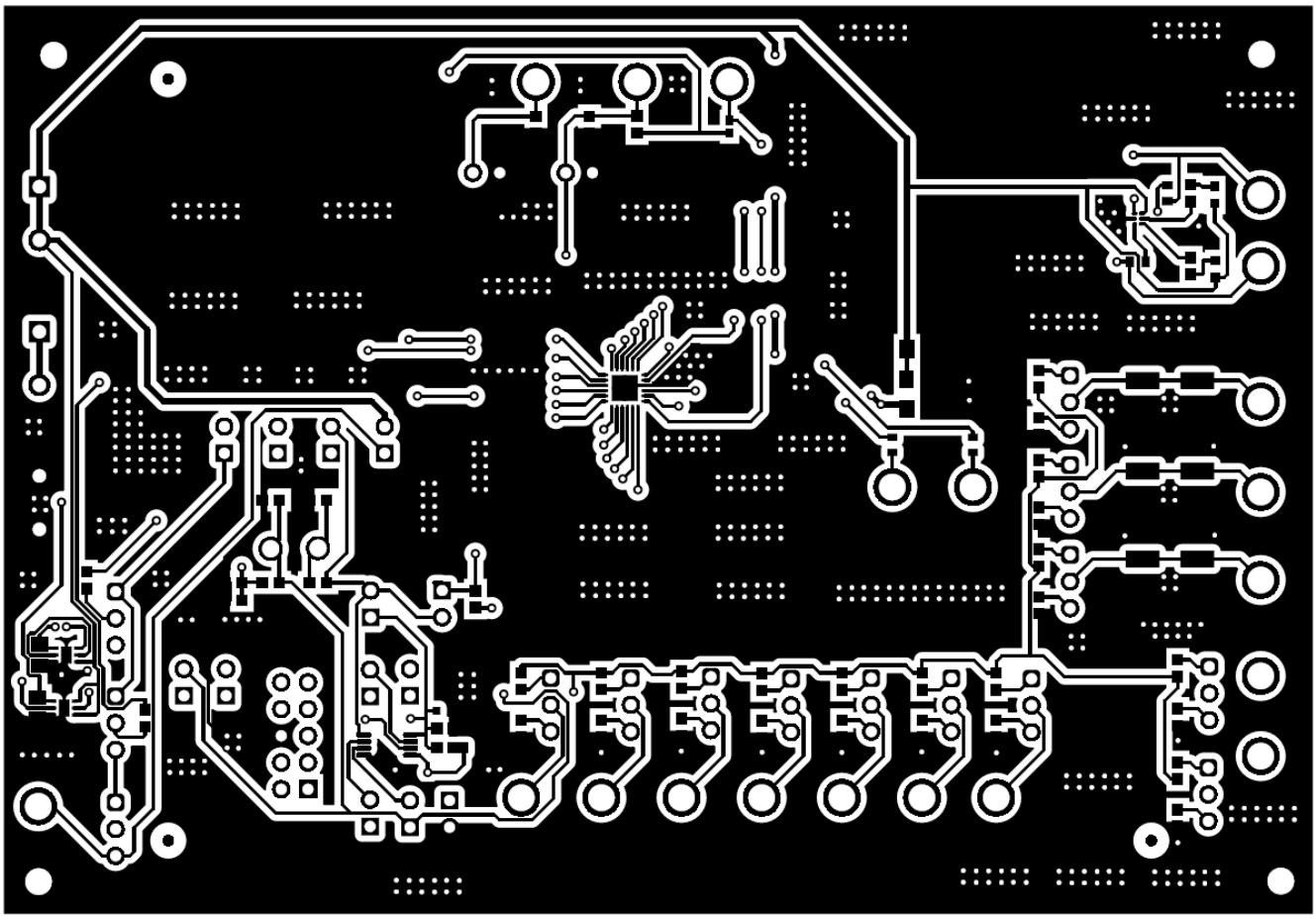

Figure 2-7. Top Layer

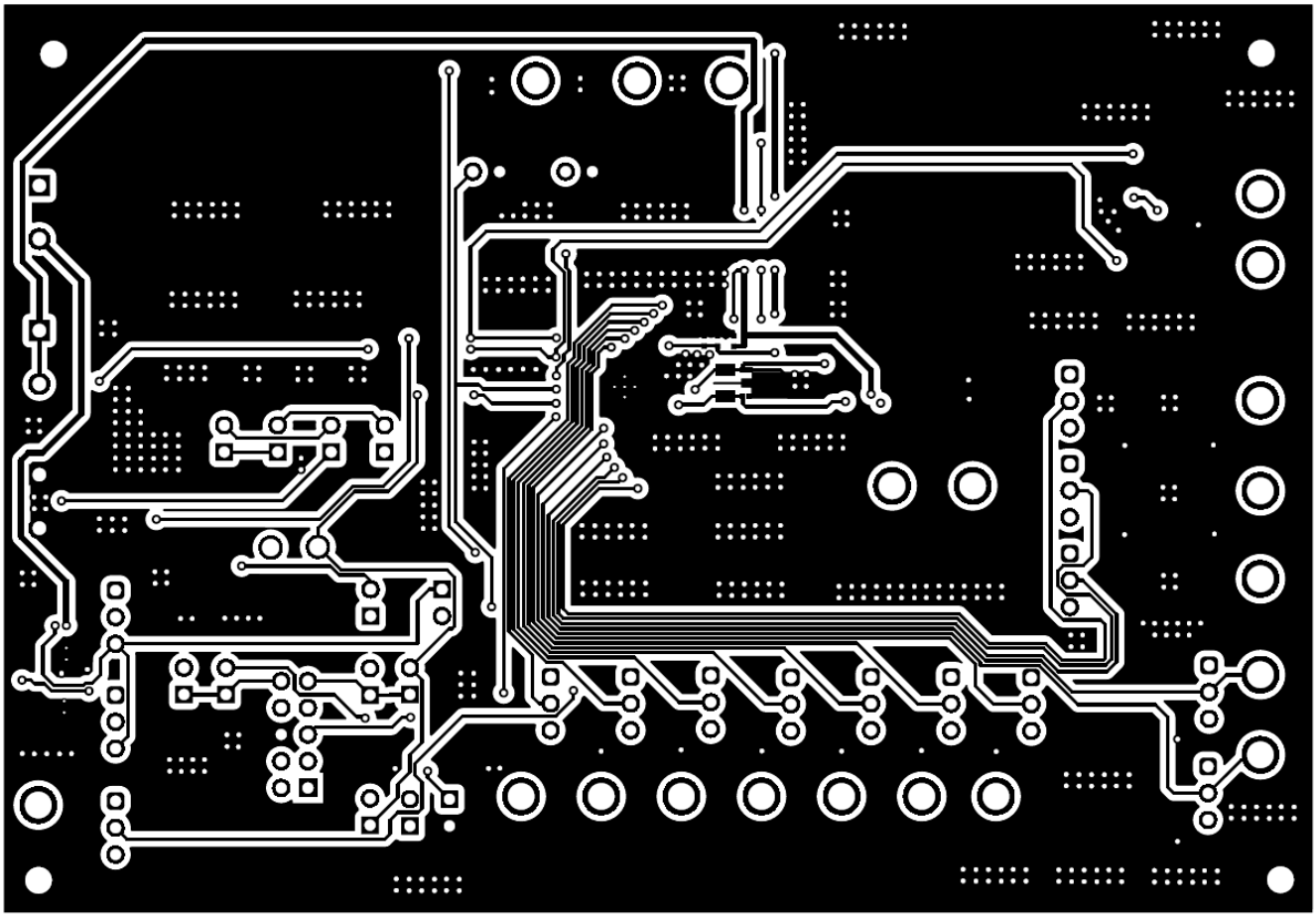

Figure 2-8. Bottom Layer

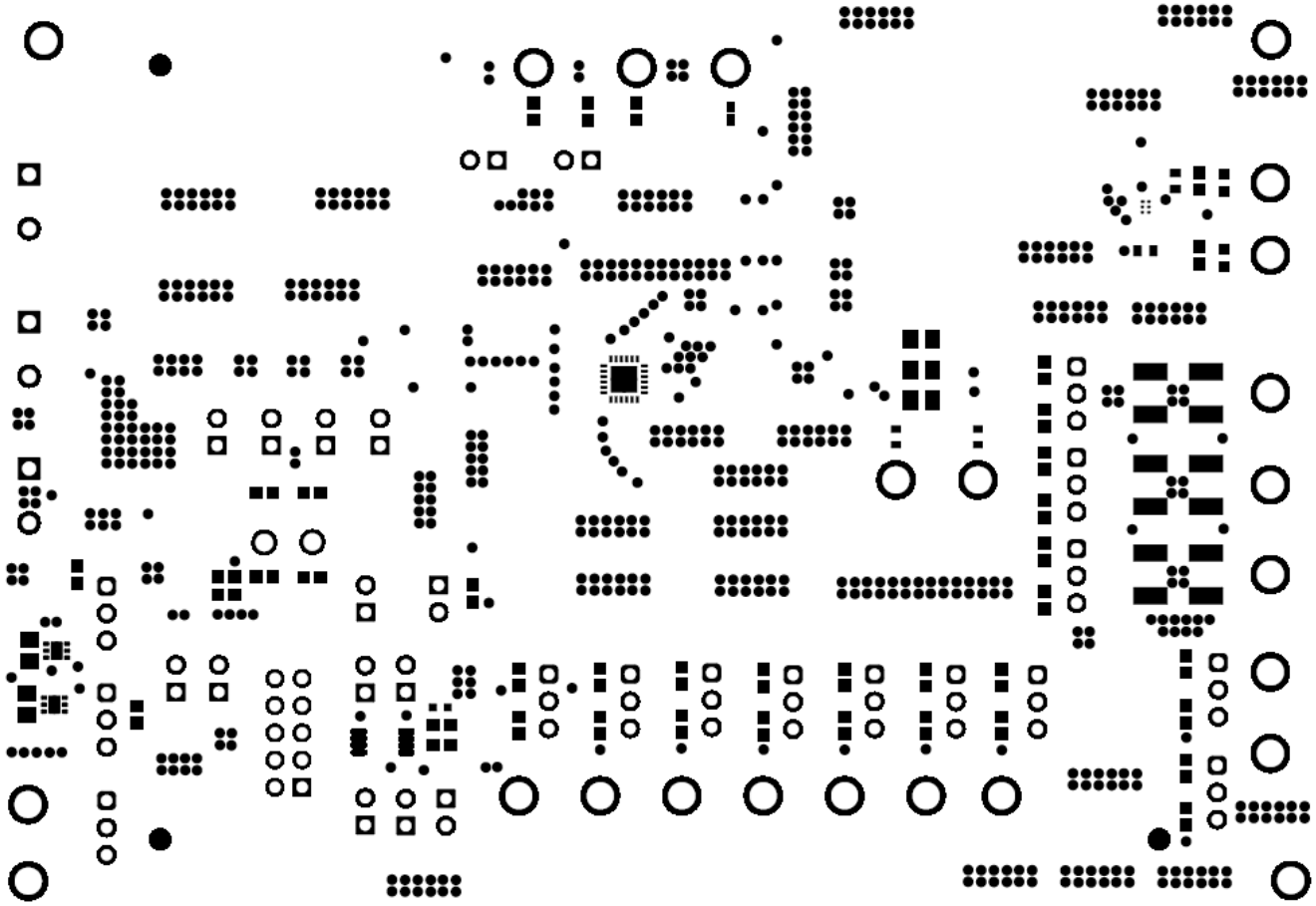

Figure 2-9. Top Solder Mask

3 EVM Connectors

This section describes the connectors, jumpers, and test points on the EVM as well as how to connect, set up, and properly use the EVM. Each device has an independent supply connection, but all grounds are connected on the board.

3.1 EVM Test Points

Table 3-1 lists the EVM test points as well as their functional descriptions. All TPS38700-Q1 pins have a corresponding test point on the EVM. These test points are located close to the pins for more accurate measurements. In addition to the test points listed below, the EVM also has four additional GND test points.

Table 3-1. Test Points

TEST POINT NUMBER	TEST POINT SILKSCREEN LABEL	FUNCTION	DESCRIPTION
TP1	EN1	Connection to EN1 pin	Allows the user to monitor the SENSE1 pin
TP2	EN2	Connection to EN2 pin	Allows the user to monitor the EN2 pin
TP3	EN3	Connection to EN3 pin	Allows the user to monitor the EN3 pin
TP4	EN4	Connection to EN4 pin	Allows the user to monitor the EN4 pin
TP6	ACT	Connection to ACT pin	Allows the user to set ACT input
TP7	EN5	Connection to EN5 pin	Allows the user to monitor the EN5 output
TP8	EN6	Connection to EN6 pin	Allows the user to monitor the EN6 output
TP9	NIRQ	Connection to NIRQ pin	Allows the user to monitor the NIRQ output
TP10	EN7	Connection to EN7 pin	Allows the user to monitor the EN7 output
TP11	EN8	Connection to EN8 pin	Allows the user to monitor the EN8 output
TP12	NRST	Connection to NRST pin	Allows the user to monitor the NRST output
TP13	EN9	Connection to EN9 pin	Allows the user to monitor the EN9 output
TP14	EN10/NEM_PD	Connection to EN10 pin and Emergency Shutdown pin	Allows the user to monitor the EN10 output
TP15	$\overline{\text{SLEEP}}$	Connection to $\overline{\text{SLEEP}}$ pin	Allows the user to set $\overline{\text{SLEEP}}$ input
TP16	EN11/NRST_IN	Connection to EN11 pin and Reset In	Allows the user to monitor the EN11 output
TP18	EN12/NPWR_BTN	Connection to EN12 pin and Power Button	Allows the user to monitor the EN12 output
TP21	GND	GND for EVM	GND for EVM
TP22	CLK32K	Connection to CLK32K pin	Allows the user to monitor the CLK32K output
TP23	VENx	Connection to External Voltage	Allows the user to connect to an external voltage for pulling up enable pins
TP26	GND	GND for EVM	GND for EVM
TP27	GND	GND for EVM	GND for EVM
TP28	GND	GND for EVM	GND for EVM

3.2 EVM Jumpers

Table 3-2 lists the jumpers on the TPS38700Q1EVM. As ordered, the EVM will have sixteen (16) jumpers installed. Figure 3-1 is provided as visual aid.

Table 3-2. List of On-board Jumpers

JUMPER	DEFAULT JUMPER CONFIGUATION	DESCRIPTION
J1	VBAT	For connecting VBAT power to the EVM
J2	VDD	For connecting VDD power to the EVM
J3 & J4	Shunt to bottom position	For connecting NRST and NIRQ to P1V8 or PEXT (Any external power)
J5	GND	For connecting GND to the EVM
J6	P1V8	For pulling- up ENABLE pins to P1V8 or VENX (Any external voltage)
J7 - J18	No connect	For pulling-up or down ENABLE pins (Only for open-drain configuration)/No connection for push-pull confiugration
J16	Shunt to top position	For pulling-up EN10 pin to P1V8.
J19	Connect	For connecting the EVM to TI's USB Interface Adapter
J20, J29, & J31	No connect	For connecting the on-board buffer to either P1V8, PEXT or P1V2. Only shunt one of these jumpers when using the buffer. Please revmove the shunt of J21 when using one of these jumpers.
J21	Shunt	For connecting the on-board bufffer IC to P3V3
J22 & J23	Shunt	For I2C lines to bypass buffer.
J24, J25, J27 & J28	No connect	For I2C lines to use the on-board buffer.
J30	No connect	For connecting VBAT to PEXT
J32	No connect	For connecting VENX to VBAT
J34 & J35	No connect	For manually pulling down NSLEEP and ACT pins

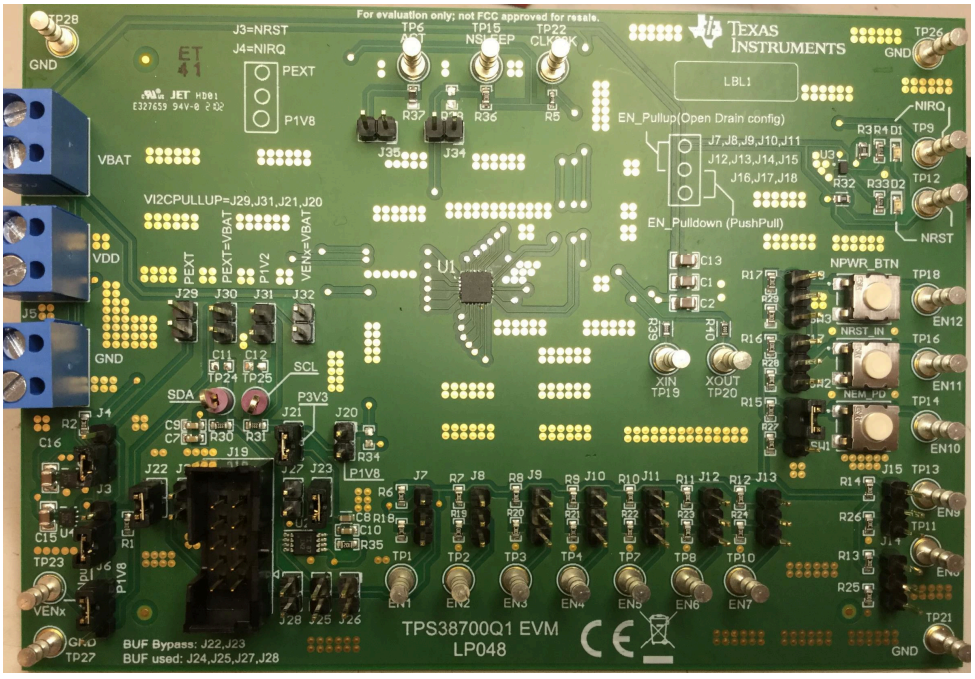

Figure 3-1. Jumper Settings

4 EVM Setup and Operation

This section describes the functionality and operation of the TPS38700Q1EVM. Refer to the TPS38700-Q1 Multichannel I2C Programmable Voltage Sequencer data sheet for details on the electrical characteristics of the device.

The TPS38700Q1EVM comes pre-populated with the TPS38700C03NRGERQ1. The EVM is capable of many different configurations in order to fully evaluate the functionality of all the TPS38700-Q1 device variants. The default configuration of the EVM Jumpers is mentioned in the Table 3-2. The TPS38700Q1EVM comes populated with I2C bus repeater, comparators, LDO, 32.768 kHz crystal and TPS38700C03NRGERQ1 programmable voltage sequencer.

The TPS38700Q1EVM also provides an option to apply a separate pull-up voltage to any of the ENABLE pins by changing the position of jumper J6 to VENx and connecting the pull-up voltage to test points TP23.

Equipment Needed

- TPS38700Q1EVM
- TI's USB Interface Adapter (with ribbon cable)
- Power Supply (3.3 V)
- Function Generator (provide pulse input for evaluation)
- Multi-channel Oscilloscope (review evaluation waveforms)
- Jumper Cables (additional evaluation)

4.1 Setup and GUI Installations

Follow the steps below for EVM connections and GUI installation:

1. Connect VBAT (J1) and VDD (J2) to 3.3 V from the power supply.
2. Connect GND (J5) to ground from the power supply.
3. Make sure the jumpers are connected as per the guidelines in the Table 3-2.
4. Power on the power supply briefly to check if the voltage is at 3.3 V and the quiescent current is at 10 mA. Once reviewed, power down the power supply.
5. Connect the Oscilloscope's channel 1 to TP1, channel 2 to TP2, and channel 3 to TP6.
6. Connect the function generator to TP6.
7. Connect the TI's USB Interface Adapter to J19 using a ribbon cable.
8. Connect the TI's USB Interface Adapter to the computer using the USB.
9. Final connections should look similar to . Figure 4-1.

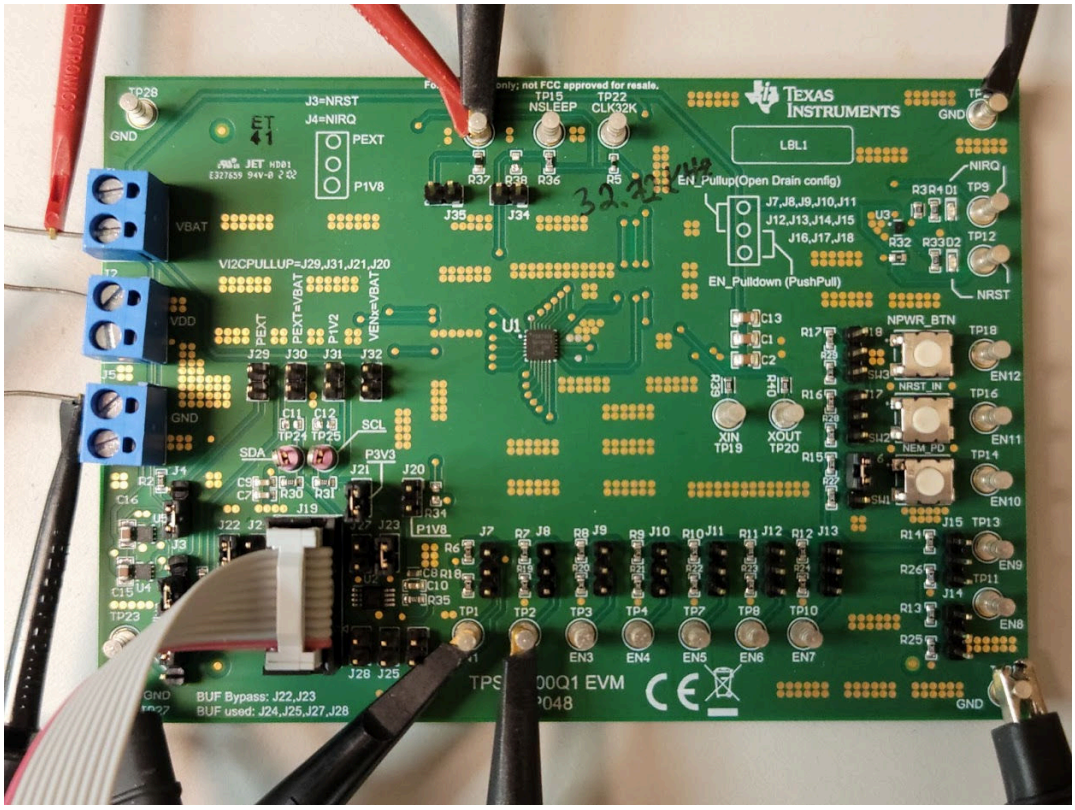

Figure 4-1. EVM Connections for Testing EN1 and EN2

10. Install the GUI.
    a. Download the Fusion Digital Power Designer Platform GUI for TPS38700Q1EVM
    b. Open the downloaded file.
    c. In the Welcome Wizard window, click Next.

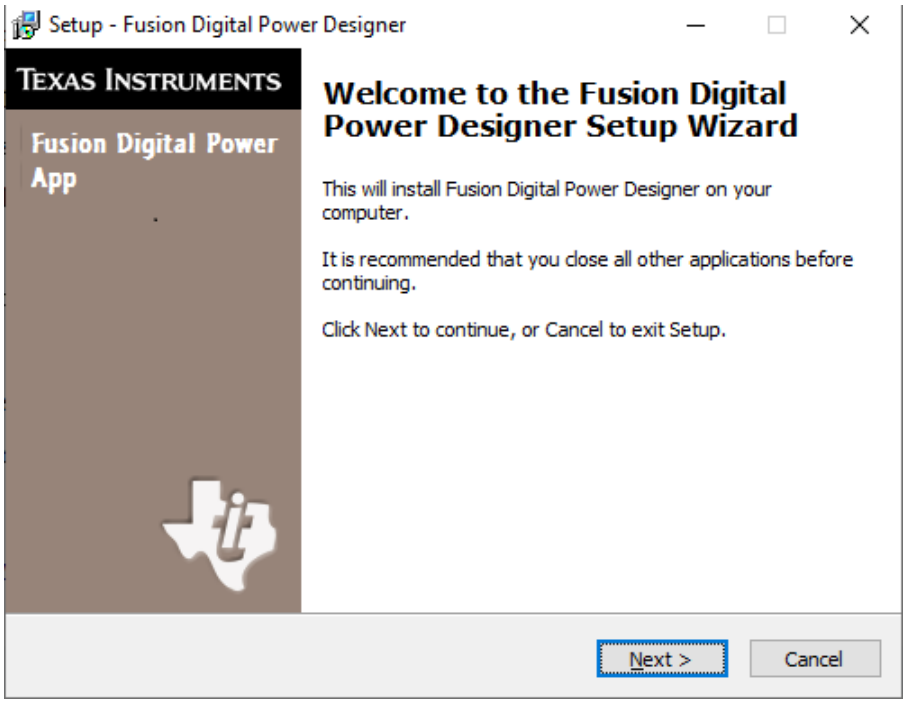

Figure 4-2. Welcome Setup Window

    d. Accept the license agreement and then click Next.

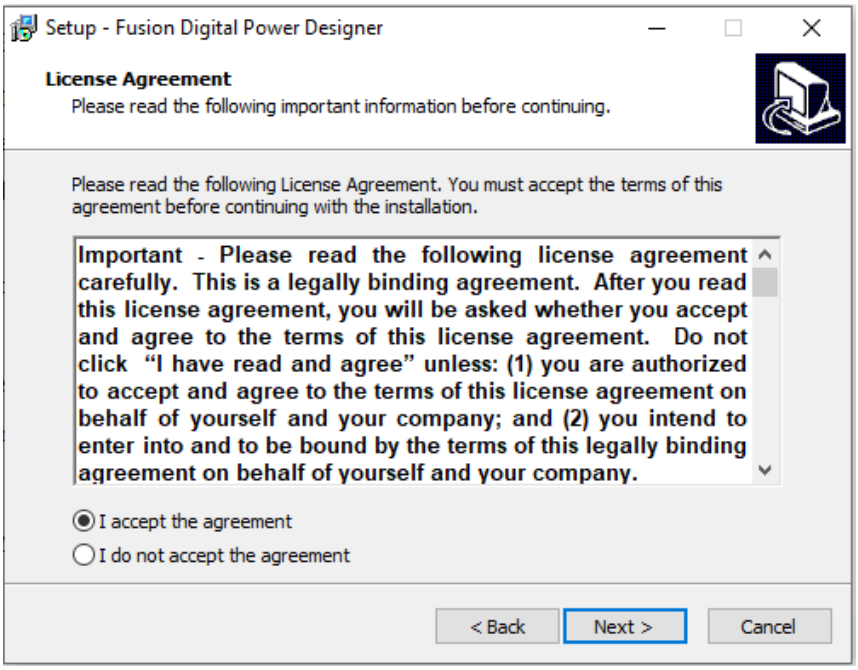

Figure 4-3. Setup License Agreement Window

e. The default destination folder works best. Click Next.

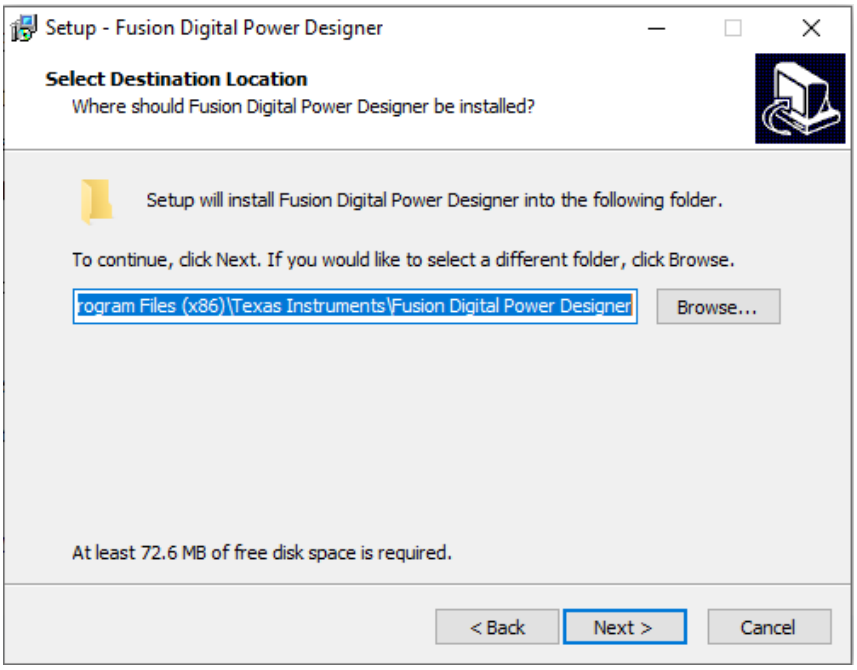

Figure 4-4. Setup Destination Window

f. Click Next for the Select Start Menu Folder option.

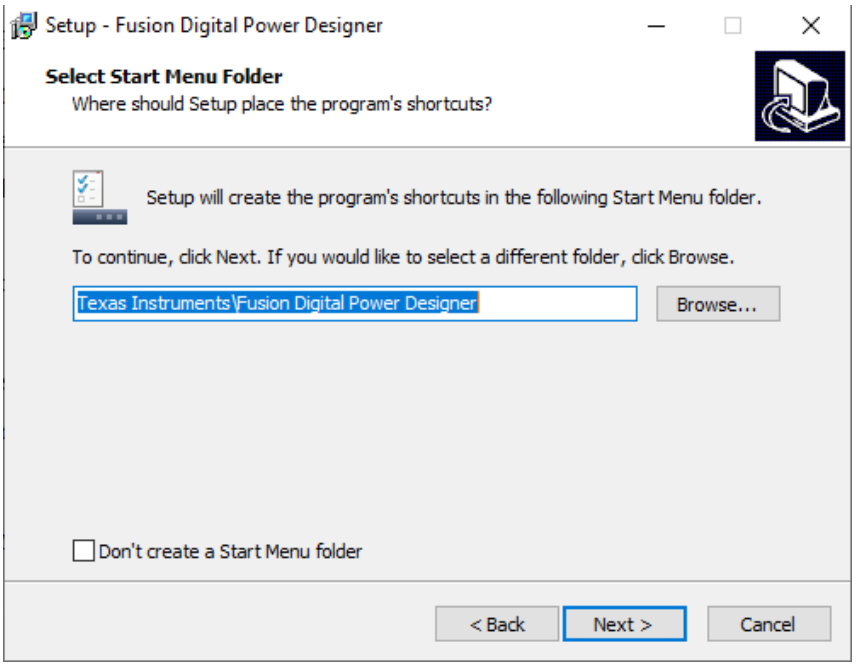

Figure 4-5. Setup Window - Start Menu Selection

g. There is no need to install additional options for this EVM. Click Next.

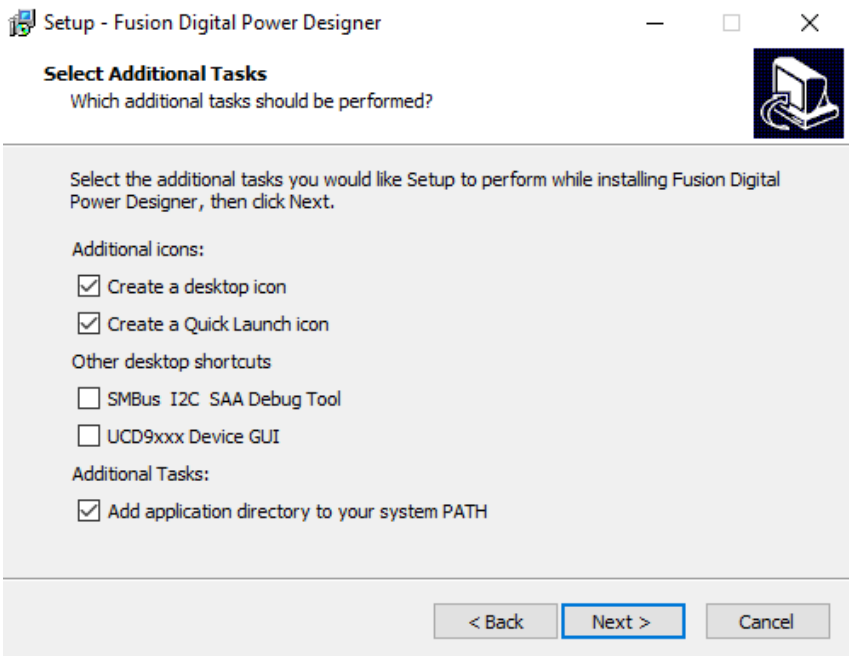

Figure 4-6. Setup Window - Additional Tasks

h. Finally click Install to install the Fusion software.

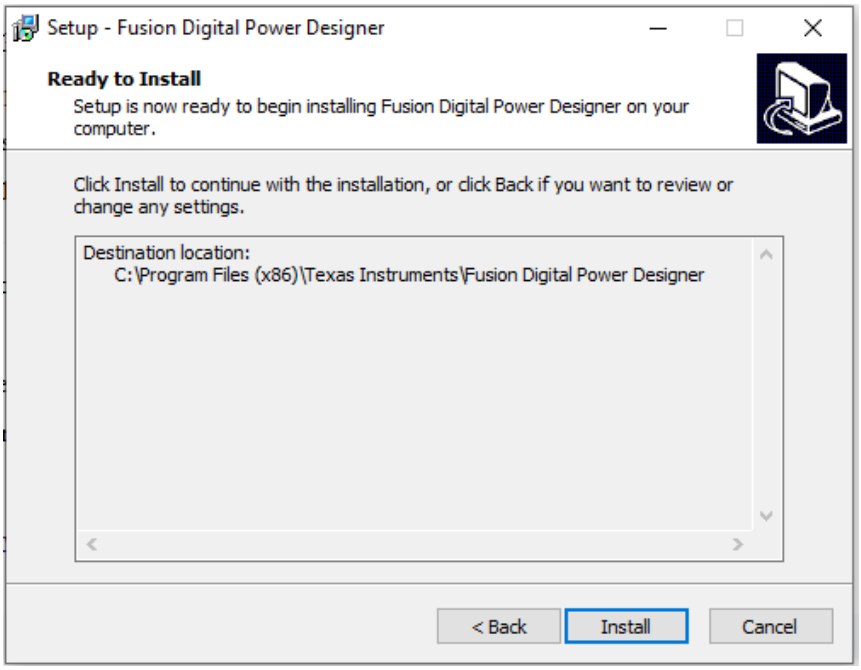

Figure 4-7. Setup Installation Window

i. Click on Finish to complete the installation setup and launch the software.

Figure 4-8. Installation Complete Window

4.2 GUI

This section shows the graphical user interface (GUI) the user will use to interact with the EVM. Refer to the TPS38700-Q1 Multichannel I2C Programmable Voltage Sequencer datasheet for details on the register description of the device.

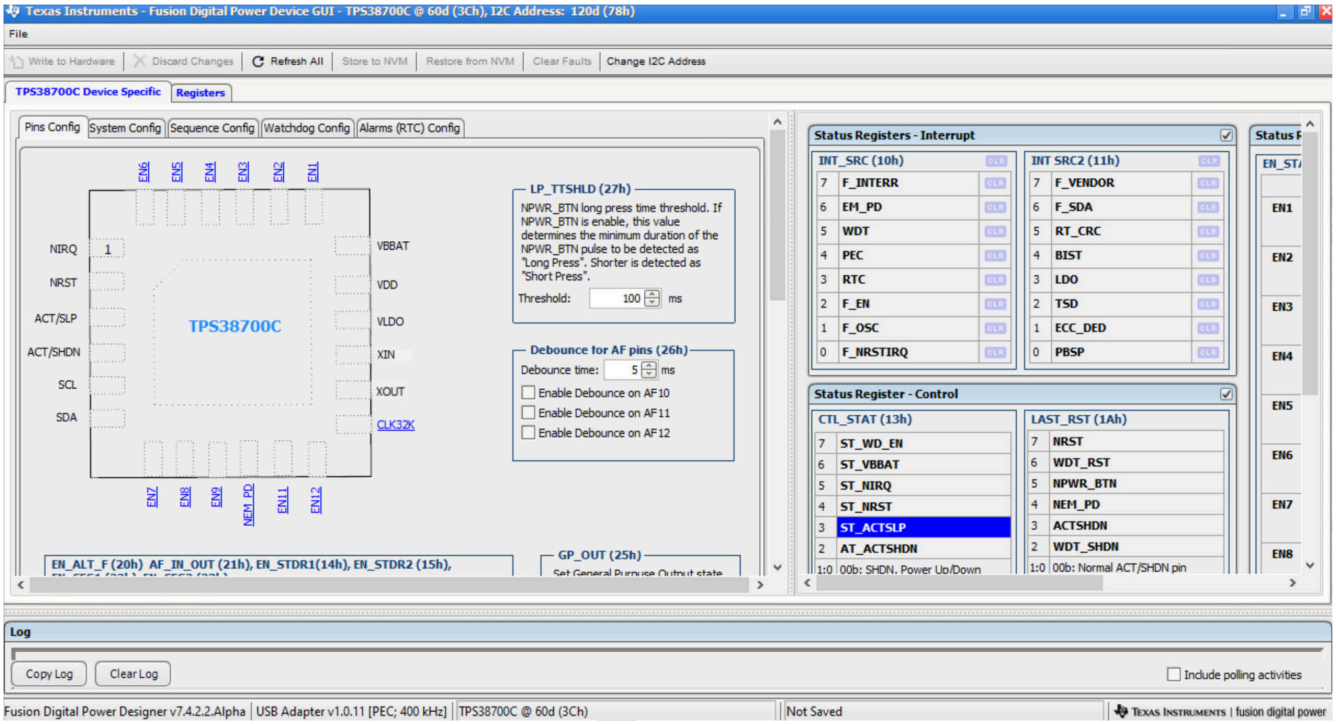

Figure 4-9. Main GUI Screen

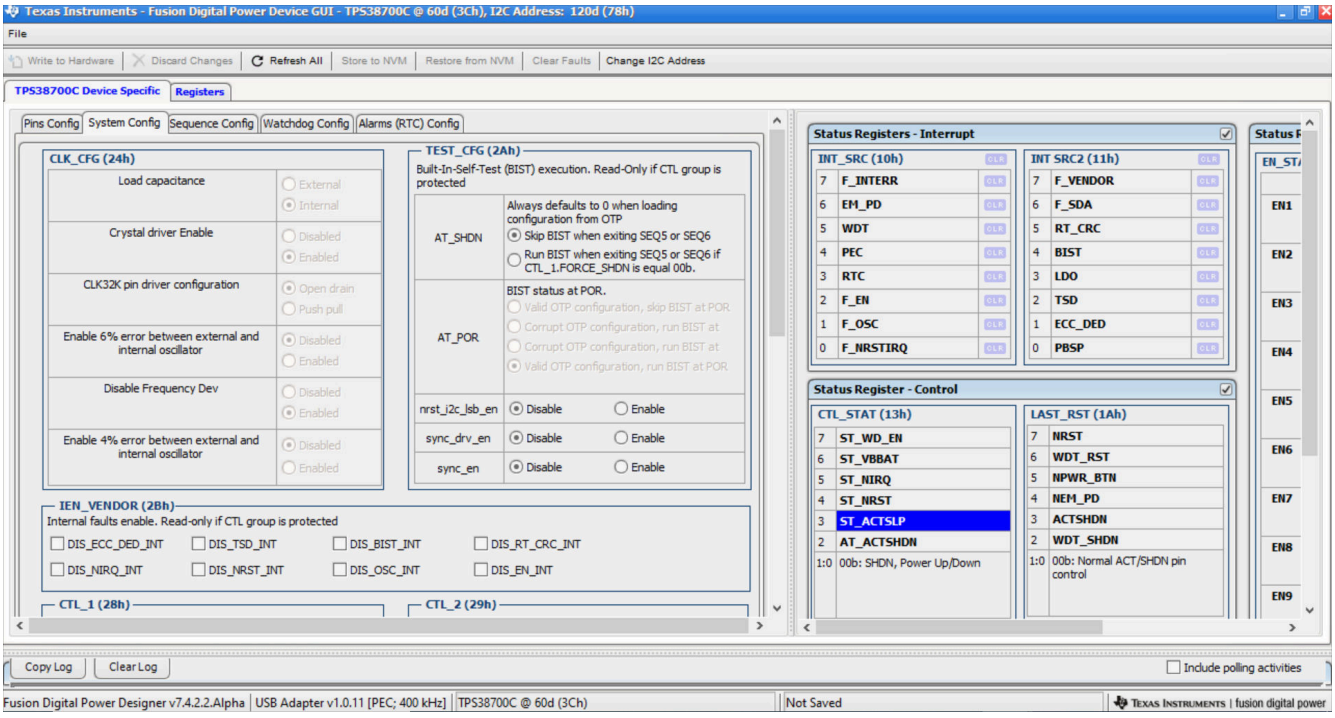

Figure 4-10. System Config

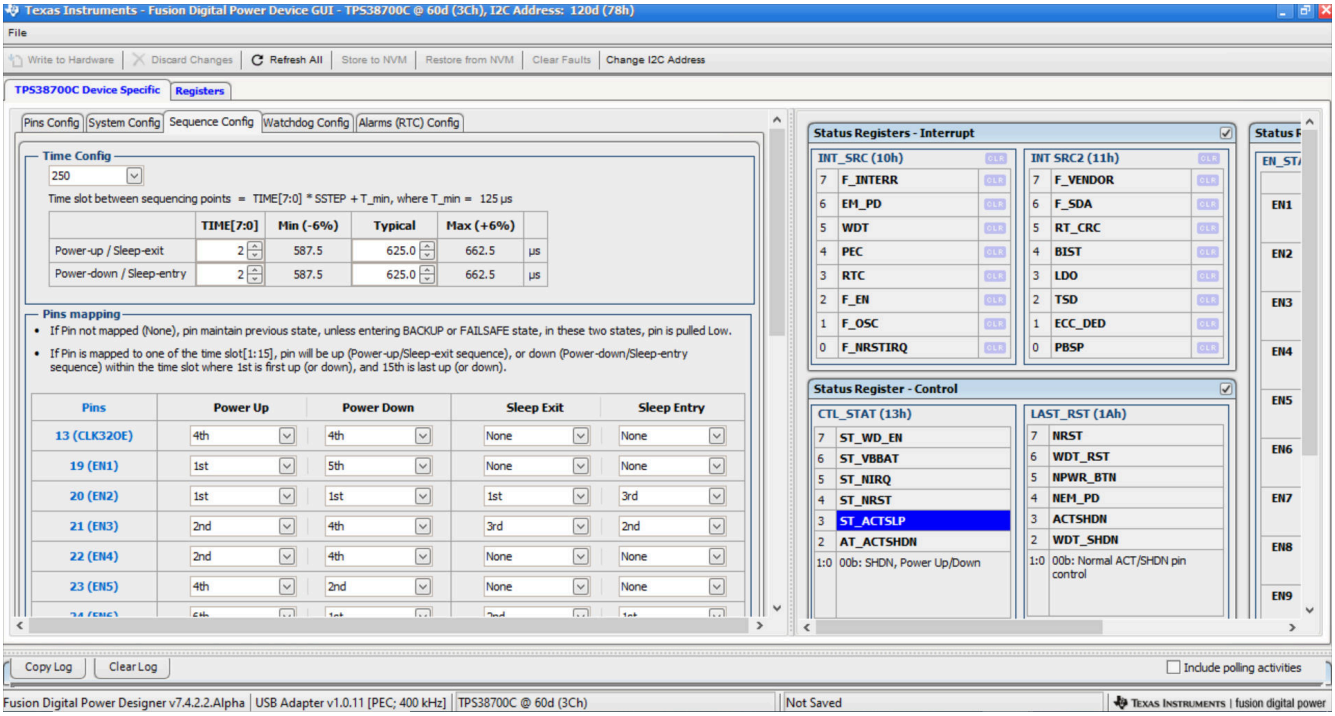

Figure 4-11. Sequence Config

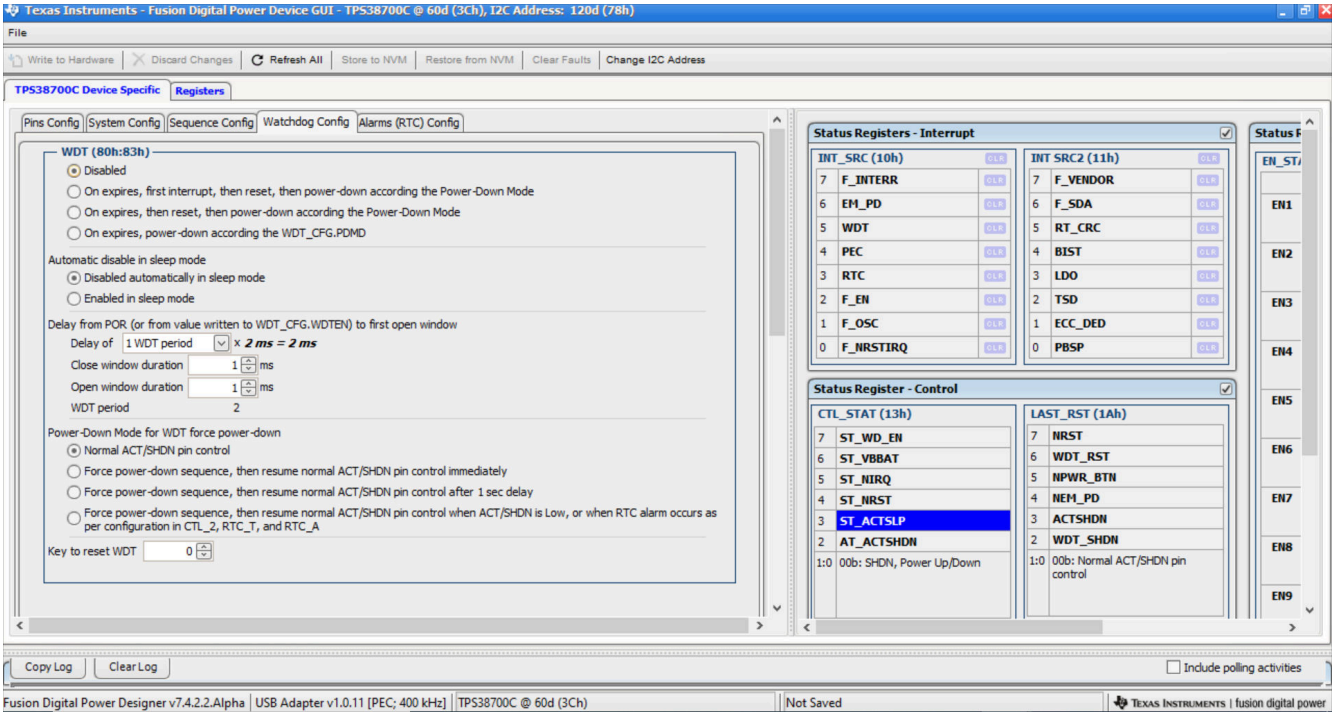

Figure 4-12. Watchdog Config

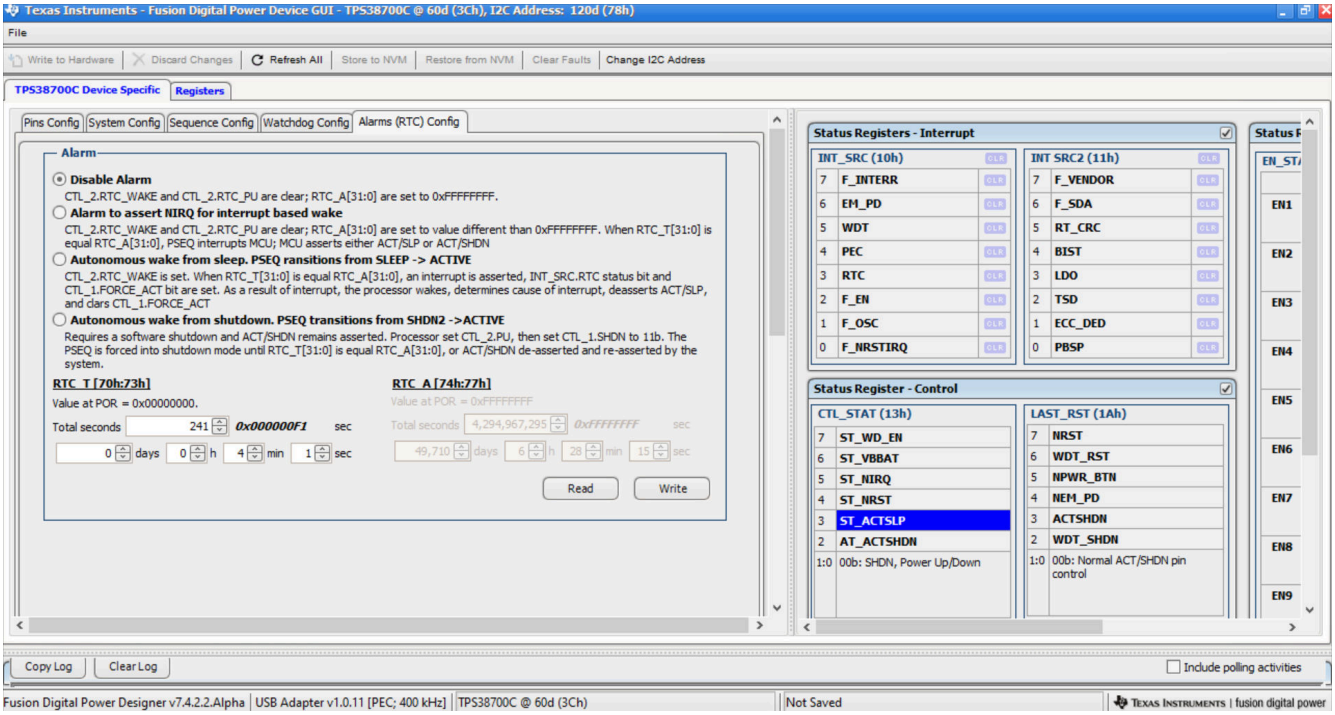

Figure 4-13. Alarms Config

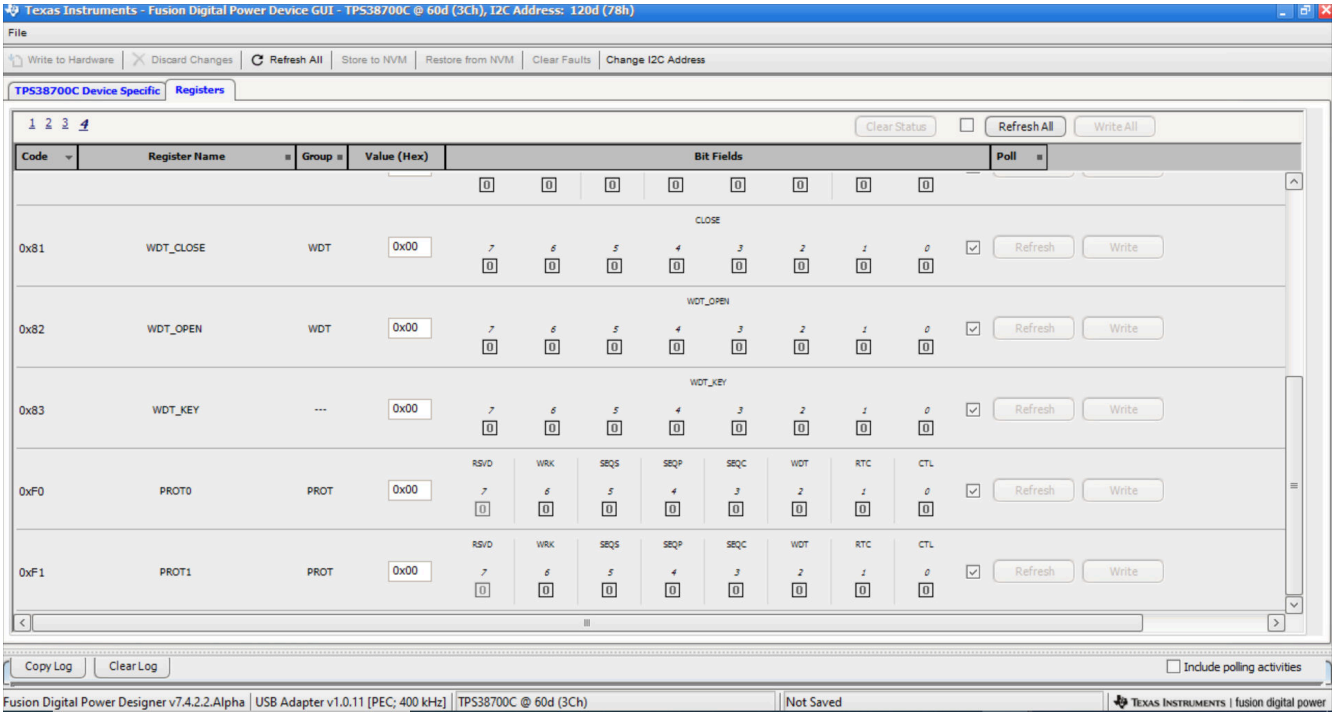

Figure 4-14. Registers

4.3 Quick Start

Follow the steps below precisely to quickly evaluate the TPS38700-Q1. In this quick start, we will be looking at Enable 1 and Enable 2 signals after the ACT pin is triggered.

1. Make the connections described in Section 4.1. Skip the GUI installation if the TPS38700Q1EVM GUI is already installed.
2. Power the EVM by turning on the power supply. Note that the voltage and current at the supply are 3.3 V and 10 mA.
3. Once the TI's USB Interface Adapter is connected to EVM and the laptop, launch the evaluation software Fusion Digital Power Designer.
4. Click on I2C GUI in the bottom right.

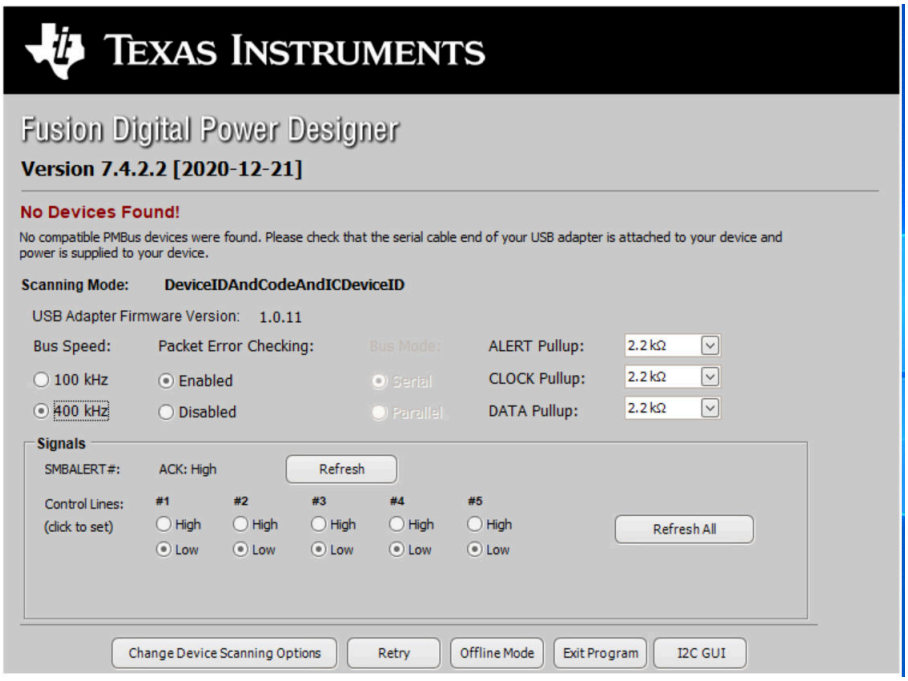

Figure 4-15. Fusion Welcome Window

5. Click on Change Scan Mode to select TPS38700x and then click OK.

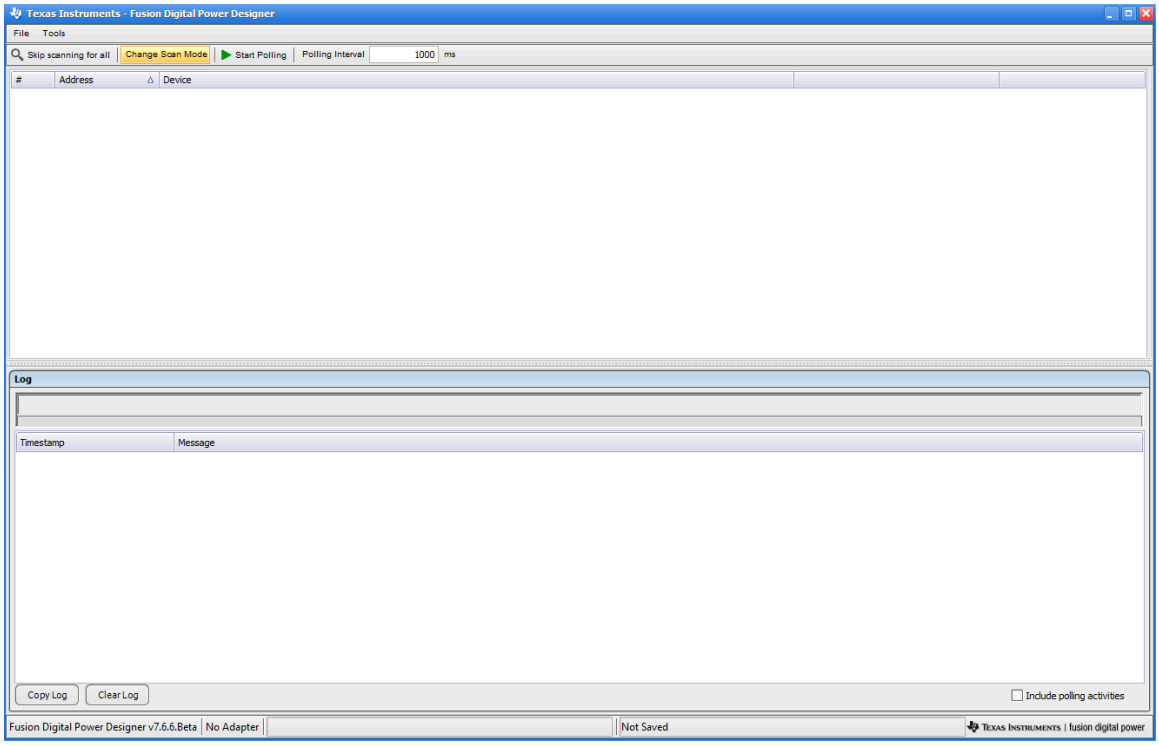

Figure 4-16. Fusion Scan Window

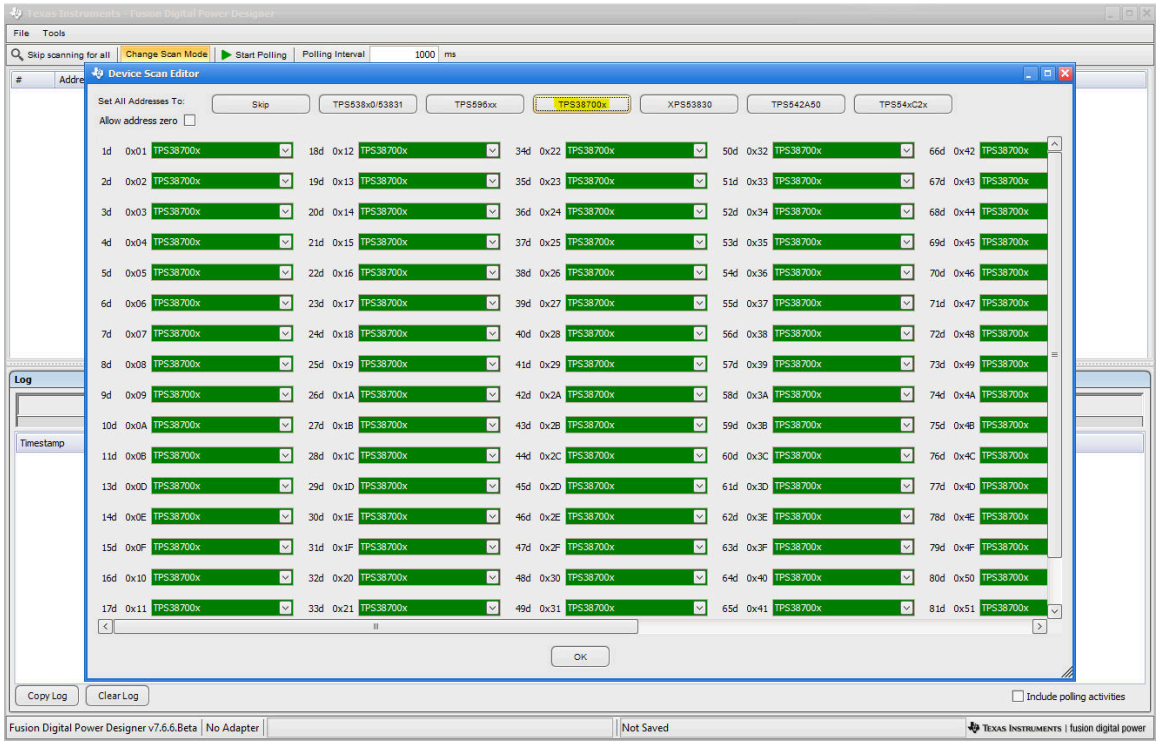

Figure 4-17. Fusion Scan Selection Window

6. Scan for the TPS38700Q1EVM by clicking on "*Scan for TPS38700x*" on top left of the window.

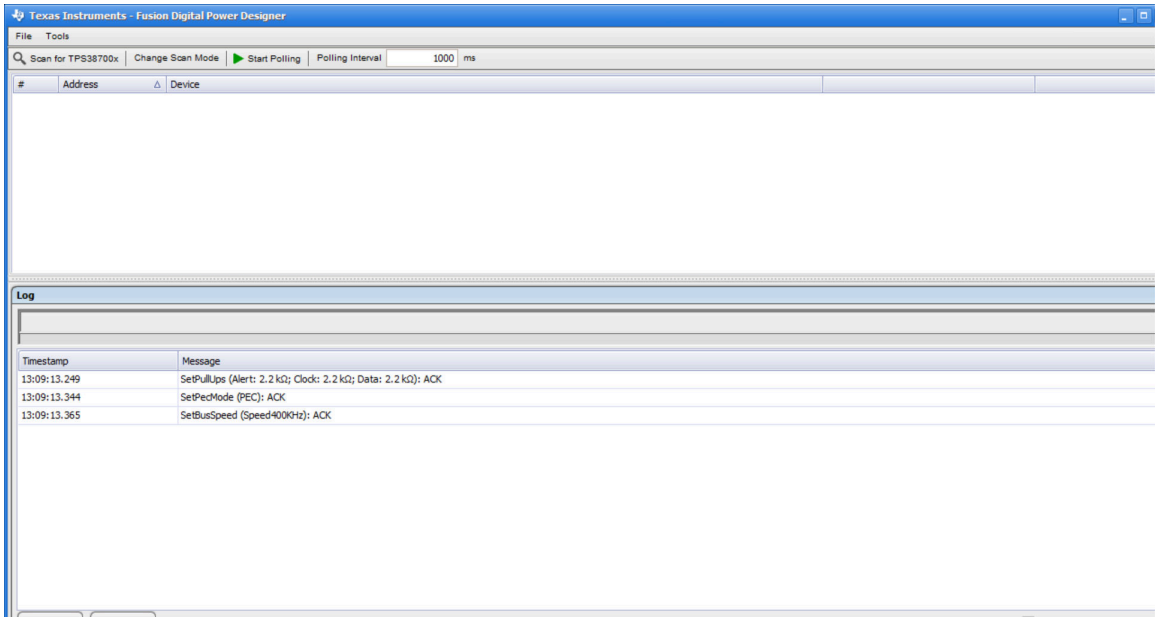

Figure 4-18. Fusion Scan Window - Scanning for TPS38700Q1EVM

7. Once the EVM is discovered, select Click to Configure (text in blue).

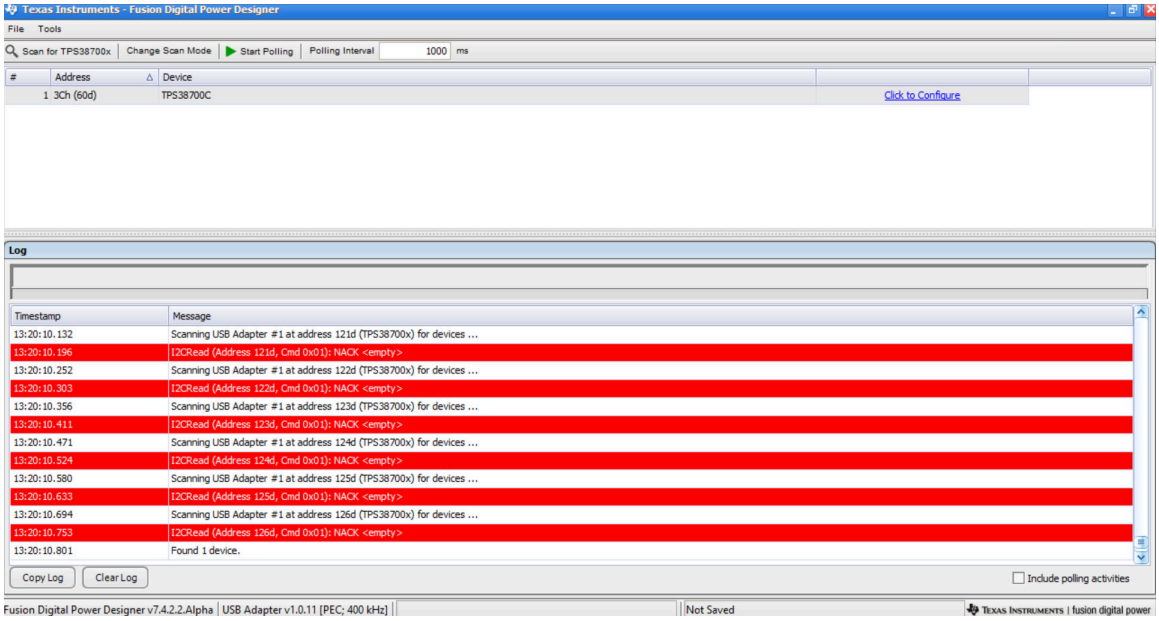

Figure 4-19. Fusion Scan Window - Scan for TPS38700Q1EVM Completed

8. Go to the Sequence Config tab. In the Pins mapping section, change the pin 19's (EN1) Power Up sequence from 1st to 4th sequence. Now, the Enable 1 signal is part of the 4th power-up sequence. Hence, delaying the signal by about 2 ms from Enable 2 signal (which is still part of the first power-up sequence).

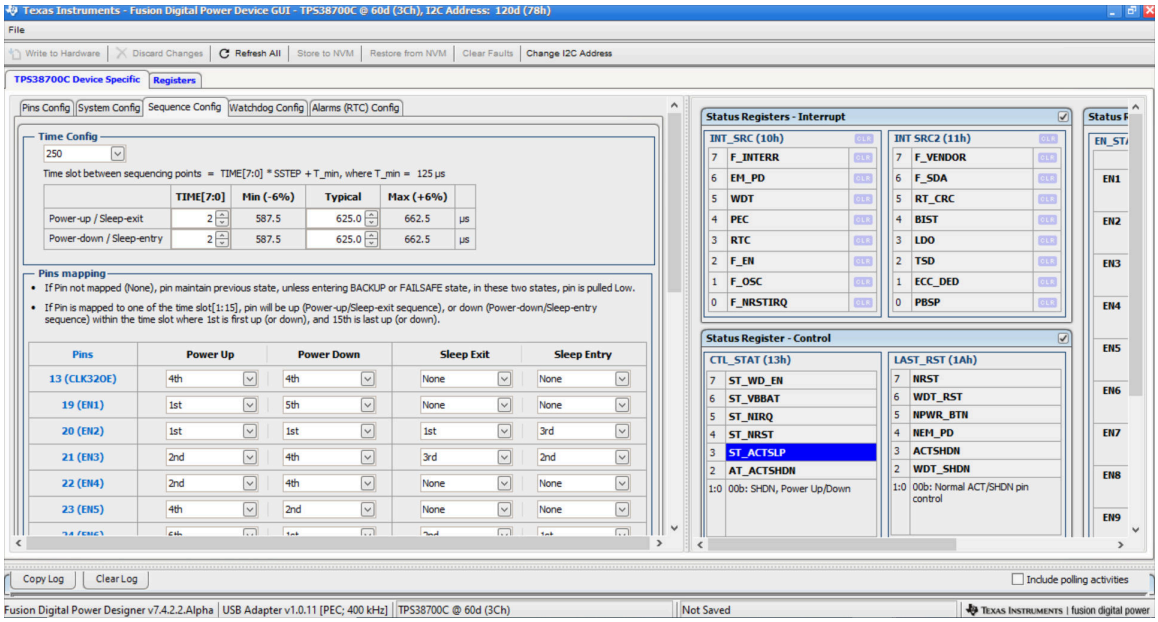

Figure 4-20. TPS38700 GUI Window - Sequence Config Tab

9. Change the trigger in the oscilloscope from channel 1 to channel 3 to get the trigger from ACT pin.
10. Set the Function Generator to create a 3.3 V pulse waveform. Turn-on the output from the Function Generator connected to the ACT pin to trigger the power-up sequence.
11. The output at the oscilloscope should look like the Figure 4-21 where green waveform is the pulse to the ACT pin (TP6), red waveform is Enable 2 signal and blue waveform is the Enable 1 Signal.

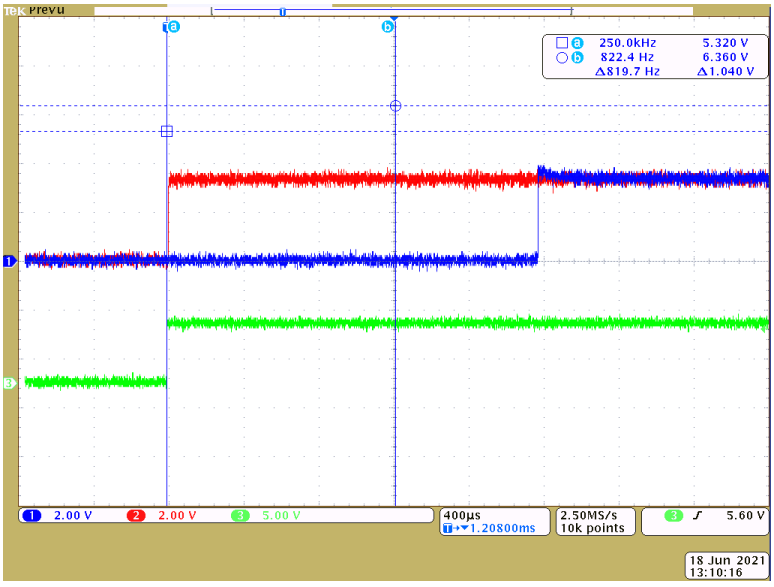

Figure 4-21. Expected Output Signal

5 Revision History

Changes from Revision A (April 2022) to Revision B (July 2023)	Page
• Update to sequencer part number throughout document	3

Changes from Revision * (July 2021) to Revision A (April 2022)	Page
• Edited the TPS38700Q1EVM Schematic to reflect the new TPS38700-Q1 package pinout	6
• First public release	19
• Edited the Main GUI Screen image to reflect the new TPS38700-Q1 package pinout	25

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NOTE:

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

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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

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- *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.*

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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.

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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

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

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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.

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