![Texas Instruments logo]

BQ79606A-Q1 Evaluation Module

This user's guide describes the general features, theory of operation, hardware setup, and use of the BQ79606EVM. Throughout this user's guide, the abbreviations *EVM*, *BQ79606EVM*, and the term *evaluation module* are synonymous with the *BQ79606A-Q1 Evaluation Module*, unless otherwise noted. This EVM is an evaluation board of the *BQ79606A-Q1* device for use in large format lithium-ion batteries that provides monitoring, balancing, and communications.

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General Texas Instruments High Voltage Evaluation (TI HV EVM) User Safety Guidelines

WARNING

Warning: To minimize risk of fire hazard, always verify and follow any specific safety instructions and application considerations related to the batteries being used in conjunction with this EVM.

Always follow TI's set-up and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and the safety of those working around you. Contact TI's Product Information Center http://support/ti./com for further information.

Save all warnings and instructions for future reference.

Failure to follow warnings and instructions may result in personal injury, property damage, or death due to electrical shock and/or burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed-circuit-board assembly. It is intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise, and knowledge of electrical safety risks in development and application of high-voltage electrical circuits. Any other use or application are strictly prohibited by Texas Instruments. If you are not suitably qualified, you should immediately stop from further use of the HV EVM.

1. **Work Area Safety:**
   1. Keep work area clean and orderly.
   2. Qualified observer(s) must be present any time circuits are energized.
   3. Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
   4. All interface circuits, power supplies, evaluation modules, instruments, meters, scopes and other related apparatus used in a development environment exceeding 50 V_{RMS} or 75 VDC must be electrically located within a protected Emergency Power Off (EPO) protected power strip.
   5. Use a stable and non-conductive work surface.
   6. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.

2. **Electrical Safety:** As a precautionary measure, it is always a good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.
   1. De-energize the TI HV EVM and all its inputs, outputs, and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
   2. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
   3. Once EVM readiness is complete, energize the EVM as intended.

WARNING: while the EVM is energized, never touch the EVM or its electrical circuits as they could be at high voltages capable of causing electrical shock hazard.

3. **Personal Safety:**

   1. Wear personal protective equipment, for example, latex gloves or safety glasses with side shields or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.

4. **Limitation for Safe Use:**

   1. EVMs are not to be used as all or part of a production unit.

The following warnings and cautions are noted for the safety of anyone using or working close to the BQ76920 EVM. Observe all safety precautions.

	Caution	Do not leave EVM powered when unattended.
	Danger High Voltage	The BQ79606EVM is not rated as a high voltage EVM, has smaller clearances than normally used on high voltage boards and does not have an isolation boundary. If you apply high voltage to this board, all terminals should be considered high voltage. Electric shock is possible when connecting the board to live wire. The board should be handled with care by a professional. For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

CAUTION

The circuit module has signal traces, components, and component leads on the bottom of the board. This may result in exposed voltages, hot surfaces, or sharp edges. Do not reach under the board during operation.

CAUTION

The circuit module may be damaged by overtemperature. To avoid damage, monitor the temperature during evaluation and provide cooling, as needed, for your system environment.

CAUTION

Some power supplies can be damaged by application of external voltages. If using more than 1 power supply, check your equipment requirements and use blocking diodes or other isolation techniques, as needed, to prevent damage to your equipment.

CAUTION

The communication interface is not isolated on the EVM. Be sure no ground potential exists between the computer and the EVM. Also be aware that the computer will be referenced to the Battery- potential of the EVM.

1 General Description

TI's *BQ79606EVM Battery Management System* (BMS) is an evaluation board of the *BQ79606A-Q1* device for use in large format lithium-ion batteries that provide monitoring, balancing, and communications. Each BQ79606EVM can manage up to 6 cells (30-V max) for Li-ion battery applications. Up to 64 BQ79606EVM modules can be stacked, for packs up to 1300 V. The system provides fast cell balancing, diagnostics, and module to controller communication. Independent protection circuitry is also provided. Please see the BQ79606A-Q1 data sheet for more details.

The BQ79606EVM is equipped with precision measurement and synchronous communication to enable a master controller to perform *State of Charge* (SOC) and *State of Health* (SOH) estimation. Highly-accurate cell voltages and a fast sampling time for the entire battery pack allows more efficient operation of battery modules and more accurate SOC and SOH calculations. Communication with stacked BQ79606EVMs is via an isolated daisy-chain differential bus.

Control a single EVM or multiple stacked BQ79606EVMs using a PC-hosted GUI. Communication between the PC and the lowest in a stack of BQ79606EVMs is via an FTDI USB-to-TTL (5 V) serial interface cable. Communication between all other EVMs in the stack is via the isolated, daisy-chain differential communication bus. The PC GUI allows configuration of the BQ79606EVMs to monitor cells and other analog data channels, control balancing, and monitor details of any faults.

1.1 Key Features

This EVM includes the following features:
- Passive cell balancing
- Isolated communications (1 kV)
- Flexible architecture for up to 6 cells
- UART interface
- High-accuracy cell voltage measurement
- Diagnostics
- Resistor ladder to simulate cell voltages

1.2 Key Electrical Parameters

The following table identifies the key electrical parameters:

Maximum battery pack voltage (stacked EVMs)	1300 V
Maximum operating voltage	30 V
Minimum operating voltage	5.5 V
Maximum cell open circuit voltage	5 V
Ambient temperature	–40 ºC to 105 ºC
Nominal operating temperature	–20 ºC to 60 ºC
Cell balancing current	Approximately 100 mA

2 Theory of Operation

Figure 1 shows the system stack diagram.
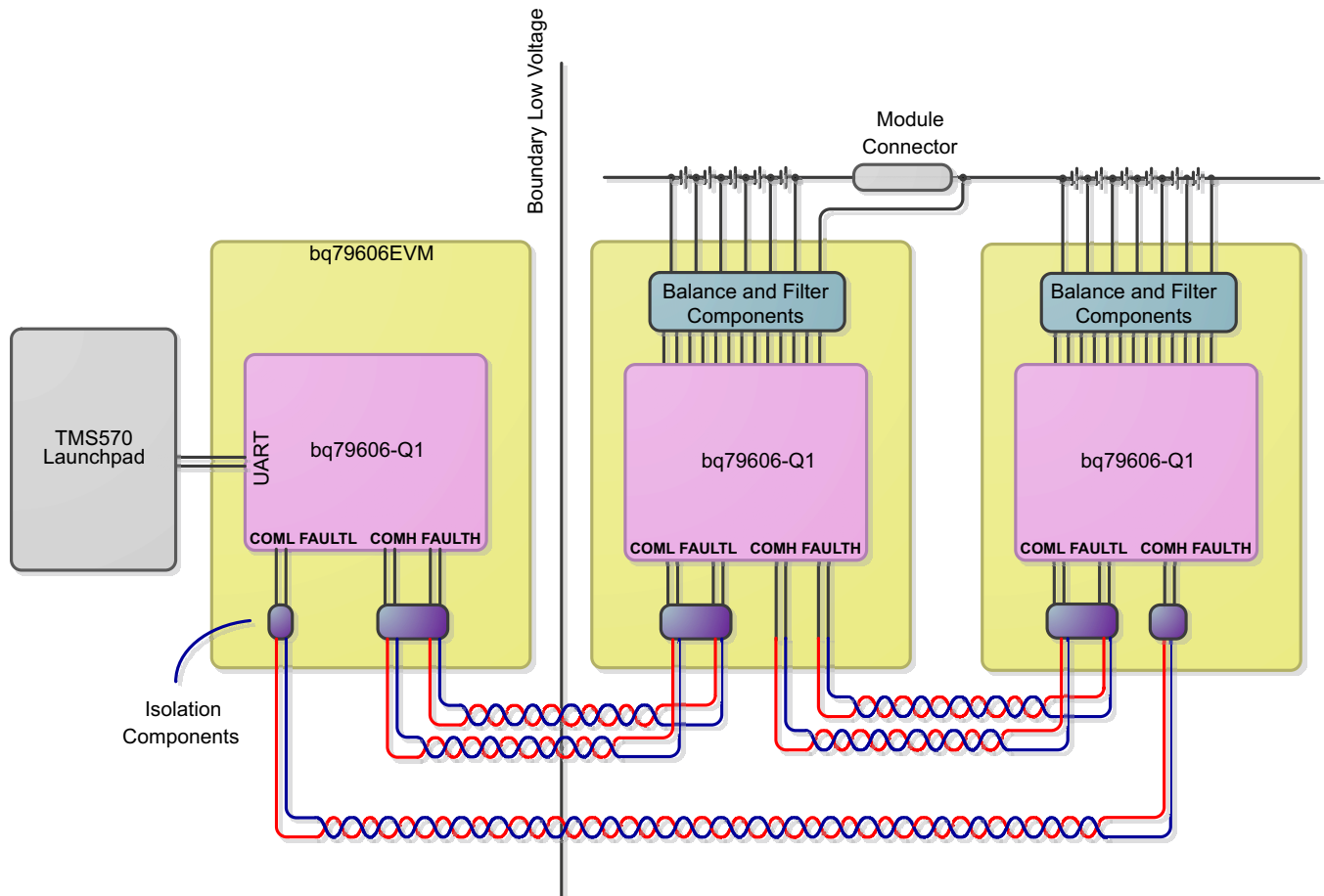
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Figure 1. System Stack Diagram

The BMS system is designed to prolong the useful life of lithium-ion cells in battery packs through passive balancing. The battery pack is broken into a series of modules, each of which contains up to 6 cells. This system will monitor voltages of individual battery cells and transfer charge from the module stack to an under-charged cell or take charge from an over-charged cell and transfer it to the module stack. The BMS allows battery-powered electric machines to use smaller battery packs and use fewer charging cycles to perform the same amount of work. It also improves the overall lifetime of Li-ion battery packs by preventing under- and overvoltage damage from occurring.

The typical BMS system with stacked modules has three main sub-systems, as shown in Figure 1:

- Host controller - in this case a TMS570 LaunchPad™
- A BQ79606A-Q1 configured as an isolated communication bridge device - another BQ79606EVM can support this
- BQ79606EVM based modules attached to cells - these can be stacked up to 64 total (including the bridge device)

All commands and data are communicated with a host via either a UART or daisy-chain communication connection. The BQ79606A will remain idle until a command is received from the host. The BQ79606A can support a host PC or microcontroller (via the UART connection header) or a daisy-chain interface from a BQ79606A-Q1 implemented as a communication bridge.

The typical flow is for the host to go through the following simplified sequence:

1. Wakeup the BQ79606EVM board by sending a WAKEUP pulse when using the UART interface, or sending a WAKE tone when using the BQ79606EVM in a stack of other BQ79606EVM boards for a large battery pack or a BQ79606-Q1 configured as a bridge. Initialize the BQ79606A-Q1 to be ready for use.

2. Send a sample command to the BQ79606A-Q1 to read the cell measurement results.

3. The host will use the cell measurement data to calculate an average and determine the highest or lowest cells and determine the cells that should be balanced.

4. If no stop command is sent, the BQ79606A-Q1 has a built-in timeout (set by the user), after which time the discharge will be stopped automatically.

5. The host can then decide to repeat the process (back to step 2) or send commands to shutdown the BQ79606EVM and return later.

2.1 Single Board

As a single board the BMS can passively balance up to 6 cells, up to 30 V of total voltage. Communication to the BQ79606EVM is handled by the daisy-chain communications bus from another BQ79606A-Q1 or the UART host interface.

2.2 Stacked Systems

The BMS boards may be stacked up to 1300 V. Communication to the BQ79606EVM is handled by the daisy-chain communications bus from another BQ79606A-Q1.

3 Connectors

3.1 Primary Input and Output Connectors

3.1.1 Battery Connector

The battery cell connections are made from connector J1. Cell voltage measurements and balancing currents use these connections. Short unused channels to the top cell connection in the wiring harness to support fewer than 6 cells.

Figure 2. Molex 39502-1009 (Reference Image Only)

Table 1. Connector Information

Designator	Manufacturer	Part Number	Mating Connector
J1	Molex	Manufacturer: 39502-1009 Digi-Key: WM7777-ND	Manufacturer: 39500-0009 Digi-Key: WM7739-ND

Table 2. Pin Description

Pin	Name	Comments
1	PWR	Positive terminal of BAT6, connect LDOIN and BAT6 by placing J2
2	CELL6	Positive terminal of BAT6
3	CELL5	Positive terminal of BAT5, negative terminal of BAT6
4	CELL4	Positive terminal of BAT4, negative terminal of BAT5
5	CELL3	Positive terminal of BAT3, negative terminal of BAT4
6	CELL2	Positive terminal of BAT2, negative terminal of BAT3
7	CELL1	Positive terminal of BAT1, negative terminal of BAT2
8	CELL0	Negative terminal of BAT1, local ground for module
9	GND	EVM GND, connect BAT0 and GND by placing J3

3.1.2 Host Interface

The 6-pin J8 - Serial connector is used to connect the BQ79606EVM to a PC running the GUI or to a host controller. Signals at the J8 - Serial connector are 5-V TTL signals. Texas Instruments recommends using FTDI's USB-to-TTL serial converter cable to allow connection with the USB port of a PC. The recommended cable is available from FTDI (http://www.ftdichip.com), and the appropriate part number for the 1.8-meter cable is TTL-232R-5V.

Figure 3. Molex 22-12-4062 (Reference Image Only)

Table 3. Connector Information

Designator	Manufacturer	Part Number	Mating Connector
J8	Molex	Manufacturer: 22-12-4062	Manufacturer: 22-01-2061 Digi-Key: WM1579-ND Contacts: Manufacturer: 08-55-0101 (22-30 AWG) Digi-Key: WM2312CT-ND

Table 4. Pin Description

Pin	Name	Mating Cable Color
1	Ground	Black
2	$\overline{FAULT}$ signal from BQ79606A-Q1	Black
3	5-V input from PC	Red
4	TX from PC (BQ79606A-Q1 RX)	Orange

Table 4. Pin Description (continued)

5	TX from BQ79606A-Q1 (PC RX)	Yellow
6	$\overline{WAKE}$ signal from PC	Green

3.1.3 GPIO or Thermistor Inputs

There are 6 GPIO pins (with a parallel set of 6 connected to the same signal) which can also be used as thermistor connections. The first two columns of pins (J15 and the left column of J16) are tied together by row with the GPIO in ascending order (top row is GPIO1, second row is GPIO2, etc). The third column of pins (the right column of J16) are all GND. The board provides a 10-kΩ pullup to TSREF.

Figure 4. Sullins Connector Solutions PEC06DAAN (Reference Image Only)

Table 5. Connector Information

Designator	Manufacturer	Part Number	Mating Connector
J16	Tyco Electronic	Manufacturer: 43045-1601	Manufacturer: 43025-1600 Digi-Key: WM2490-ND Contacts: Manufacturer: 43030-0012 (22-30 AWG) Digi-Key: WM2779CT-ND

Table 6. Pin Description - J16

Pin	Name	Comments
1	GPIO1	Thermistor 1 connection (on-board 10-kΩ pullup to TSREF)
2	GND	Ground
3	GPIO2	Thermistor 2 connection (on-board 10-kΩ pullup to TSREF)
4	GND	Ground
5	GPIO3	Thermistor 3 connection (on-board 10-kΩ pullup to TSREF)
6	GND	Ground
7	GPIO4	Thermistor 4 connection (on-board 10-kΩ pullup to TSREF)
8	GND	Ground
9	GPIO5	Thermistor 5 connection (on-board 10-kΩ pullup to TSREF)
10	GND	Ground
11	GPIO6	Thermistor 6 connection (on-board 10-kΩ pullup to TSREF)
12	GND	Ground

Table 7. Pin Description - J15

Pin	Name	Comments
1	GPIO1	Tied to J16 Pin 1
2	GPIO2	Tied to J16 Pin 3
3	GPIO3	Tied to J16 Pin 5
4	GPIO4	Tied to J16 Pin 7
5	GPIO5	Tied to J16 Pin 9
6	GPIO6	Tied to J16 Pin 11

3.1.4 High-Side and Low-Side Communications

There are two sets of 4-position molex connectors available on each board. These provide high-side (J6) and low-side (J5) communications between stacked EVM devices.

Table 8. Connector Information

Designator	Manufacturer	Part Number	Mating Connector
J5/J6	Molex	Manufacturer: 0705510038 Digi-Key: WM14059-ND	Manufacturer: 0050579404 Digi-Key: WM2902-ND

Table 9. Pin Description - J5

Pin	Name	Comments
1	COML_N	COM lowside negative
2	COML_P	COM lowside positive
3	FAULTL_N	FAULT lowside negative
4	FAULTL_P	FAULT lowside positive

Table 10. Pin Description - J6

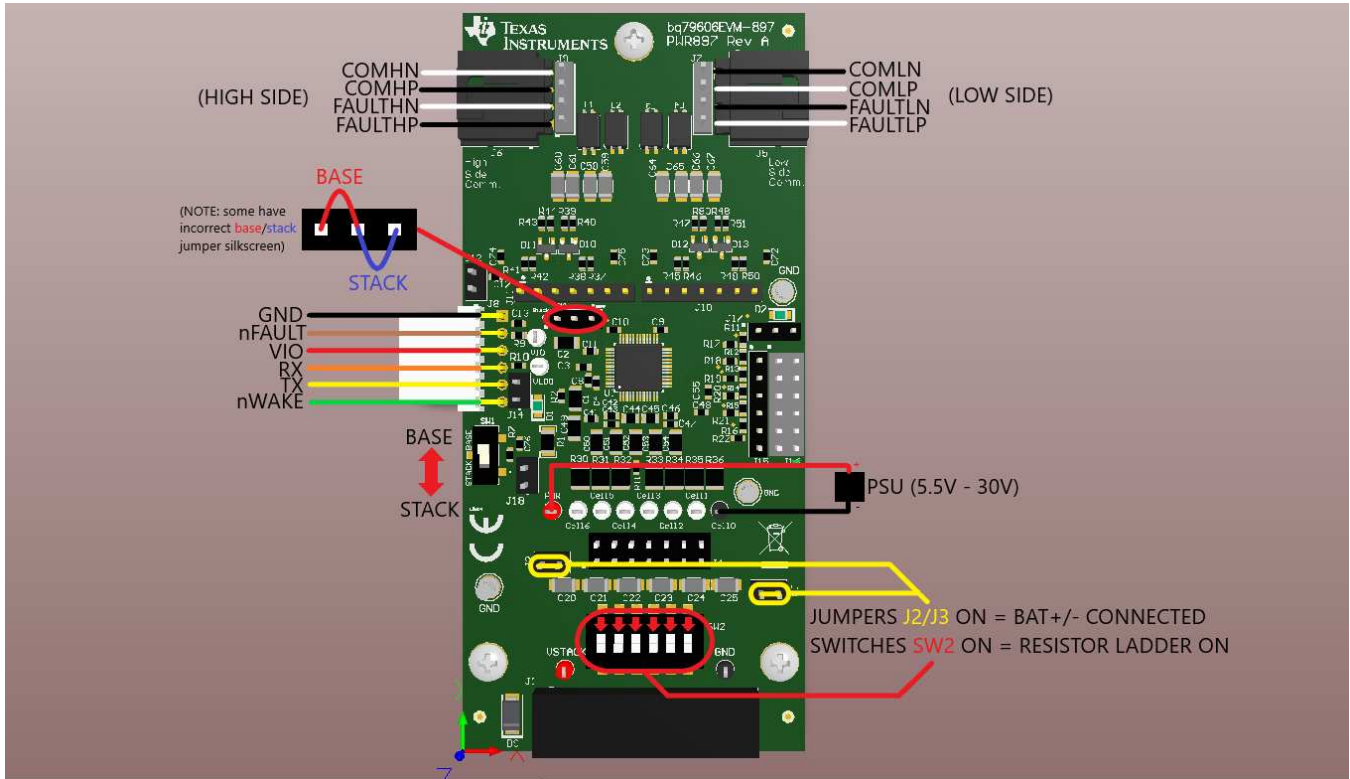| Pin	Name	Comments
1	FAULTH_P	FAULT highside positive
2	FAULTH_N	FAULT highside negative
3	COMH_P	COM highside positive
4	COMH_N	COM highside negative

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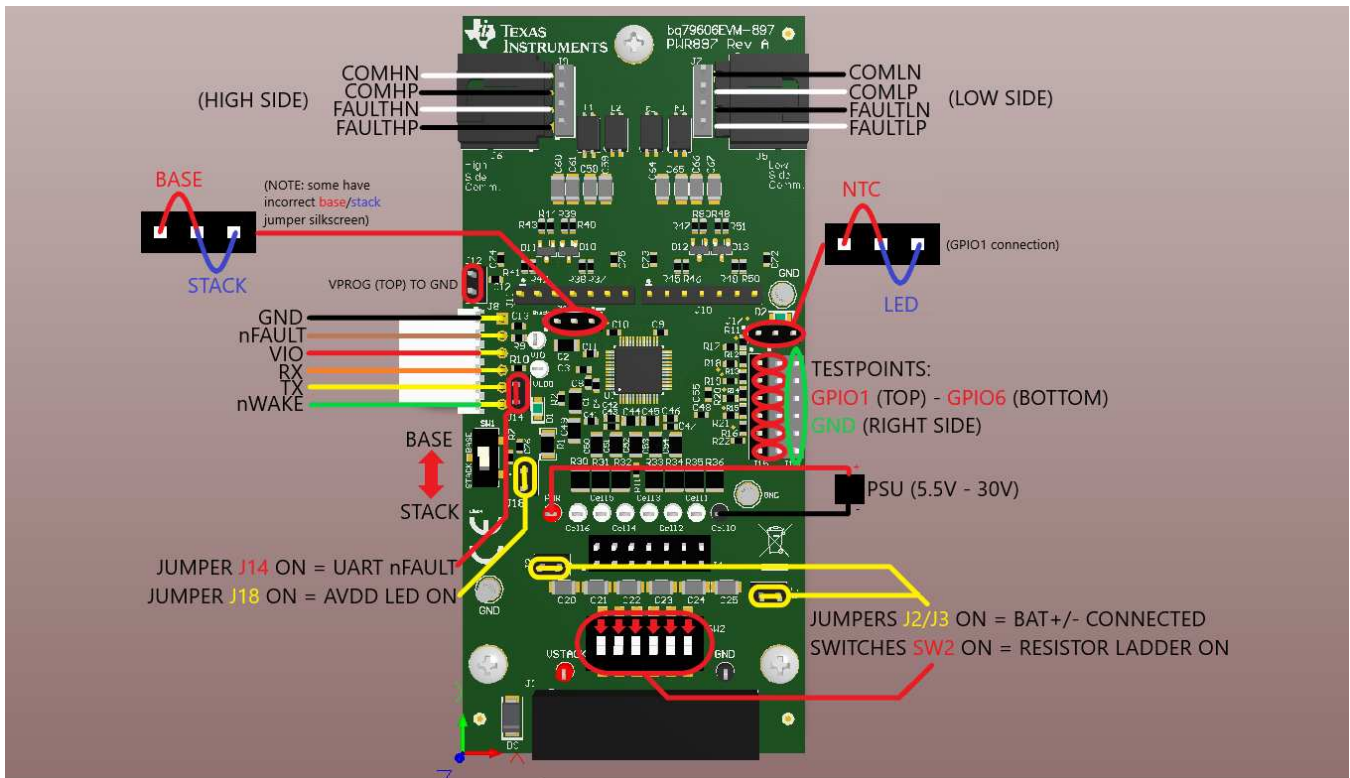

Figure 5. Basic EVM Setup

Figure 6. Advanced EVM Setup

This section includes hardware setup instructions, connection procedures, and software and GUI instructions.

4.1 Required Devices

The system is implemented using the TMS570LS04 LaunchPad™ board (TMS570LS0432 MCU) and the BQ79606EVM.

The part numbers of the evaluation modules are LAUNCHXL-TMS57004 and BQ79606EVM. These boards are available from the TI eStore (https://estore.ti.com/) or from your local TI sales representative. For more details and information related to the LaunchPad modules, see the specific module user's guide.

4.1.1 LaunchPad Required Modification

To allow use of the SCI1 UART pin on the LaunchPad with the BQ79606EVM, remove resistor R8.

4.2 Power Connections

If powering the BQ79606EVM using the included resistor ladder as cells, simply ensure that the power supply positive terminal is connected to the "VSTACK" or "PWR" testpoints provided on the board, and the power supply negative terminal is connected to the "GND" or "Cell0" testpoints provided on the board, or any "GND" standoff provided.

If not using the resistor ladder, the power supply positive terminal must be connected to the "PWR" testpoint, and the power supply negative terminal must be connected to the "Cell0" testpoint.

Also ensure that headers J2 and J3 are both jumpered, to allow for power and ground to be supplied from the "battery stack" (resistor ladder).

4.2.1 On-Board Resistor Ladder - Power Supply

The BQ79606EVM utilizes an on-board resistor ladder to simplify the evaluation process. Each of the six resistors is nominally 1 kΩ, resulting in roughly one-sixth of the module voltage at each cell connection. By default, all actuators of SW2 are positioned closest to the IC, which is the "off" or "open" state. In this state, none of the resistors are connected to the BQ79606A sense and balance connections.

To simulate connected cells to the sense and balance connections (using a power supply), all switch actuators on SW2 must be moved towards the module connector J1. Moving the actuators in this manner connects the BQ79606A to the resistor ladder, and allows for simulated cell measurements.

4.2.2 On-Board Resistor Ladder - Using Actual Battery Cells

When using actual battery cells, disconnect the resistor ladder by moving all switch actuators on SW2 to the "OFF" position (away from J1).

4.3 Connecting the BQ79606EVM to TMS570 LaunchPad

The EVMs are connected using a standard wire jumper; Table 11 shows the connections between the two EVMs. By default, the TMS570 LaunchPad is powered by the USB port on the host computer. VIO on the BQ79606EVM can be powered by 3.3 V or 5 V supplies from the TMS570 (3.3 V used in this example).

Table 11. Connections Between BQ79606EVM and TMS570 LaunchPad

Connection Name	BQ79606EVM	TMS570 LaunchPad
TX	J8 pin 5	J1 pin 3 (SCI1_RX)
RX	J8 pin 4	J1 pin 4 (SCI1_TX)
nWAKE	J8 pin 6	J2 pin 3 (GIOA0)
nFAULT	J8 pin 2	J2 pin 4 (GIOA1)
VIO	J8 pin 3	J1 pin 1 (+3V3)
GND	J8 pin 1	J2 pin 1 (DGND)

4.4 Stacking BQ79606EVMs

The EVMs are connected using 4-position Molex connectors. There is a high side (J6) and low side (J5) communication connector available on each device. A jumper and a switch must be configured for proper stack operation (see Section 4.4.1 and Section 4.4.2).

Table 12. Connections Between High-Side/Low-Side BQ79606EVMs

Connection Name	BQ79606EVM High Side	BQ79606EVM Low Side
COMH_N/COML_N	J6 pin 4	J5 pin 1
COMH_P/COML_P	J6 pin 3	J5 pin 2
FAULTH_N/FAULTL_N	J6 pin 2	J5 pin 3
FAULTH_P/FAULTL_P	J6 pin 1	J5 pin 4

4.4.1 Base/Stack Jumper Setup - J13

NOTE: Silkscreen for this jumper may be **INCORRECT** on some EVMs. Please place the jumper as defined below.

For base devices, ensure that the jumper is placed on the left side of J13. For stack devices, ensure that the jumper is placed on the right side of J13.

4.4.2 Base/Stack Switch Setup - SW1

For base devices, ensure that the switch is placed in the "BASE" position (up). For stack devices, ensure that the switch is placed in the "STACK" position (down).

4.5 Software

The software provides a command API and drivers that are capable of implementing the examples provided in *BQ79606A-Q1 Software Design Reference*.

The example code only provides a control interface to the BQ79606A-Q1 and does not provide any other communications interface to the outside world. The customer is expected to develop their own communication implementation. Examples of communications interfaces available to the TMS570 are SPI, CAN, or UART. For the TMS570 example code, UART is the communication protocol used between the microcontroller and BQ79606A-Q1 device.

This firmware provided with this application note provides source code examples of the command sequences described in the *BQ79606A-Q1 Software Design Reference*.

Importing a project into *Code Composer Studio* ™:

1. Launch the provided file: *BQ79606A-Q1 Example Code 0.1 Installer.exe* and extract files to the default path provided (C:\ti\BQ79606A-Q1 Example Code 0.1).

2. Launch *Code Composer Studio* (CCS):
   Start → Programs → Texas Instruments → Code Composer Studio v8 → Code Composer Studio v8

3. When it launches, CCS requests a workspace is selected, choose "C:\myWorkspace". Once CCS loads, go to:
   Project → Import CSS Projects... → Select search-directory

4. In Select search-directory, browse to the folder:
   C:\ti\BQ79606A-Q1 Example Code 0.1

5. In *Discovered projects:*, check BQ79606A-Q1 example code

4.6 GUI

For initial evaluation, it may be more beneficial to use the graphical user's interface (GUI), which provides a "point and click" interface to become familiar with the BQ79606A. During the initial sampling phase, please contact your local TI FAE to get the latest BQStudio file supporting the BQ79606A (the BQStudio file will be publicly available after GUI validation and release).

To get started with the GUI, please refer to the *Getting Started with the BQ79606A GUI* document.

4.6.1 GUI UART Connection

Physical setup for the GUI is the same as for the microcontroller, but will instead use an FTDI cable for the UART connections on J8. This FTDI cable must have the metal contacts facing upwards when connecting the 6 pin side of the cable to the EVM, with the other side of the cable connected via USB to the host PC.

5   Physical Dimensions

5.1   Board Dimensions

Board dimensions: 4.304 in × 2 in

Board height:
- Top - Tallest component (GPIO, Shunts) is 0.35 in (8.8 mm) above PCB.
- Bottom - Tallest component (Transformers) is 0.41 in (10.5 mm) above PCB.

5.2   Board Mounting
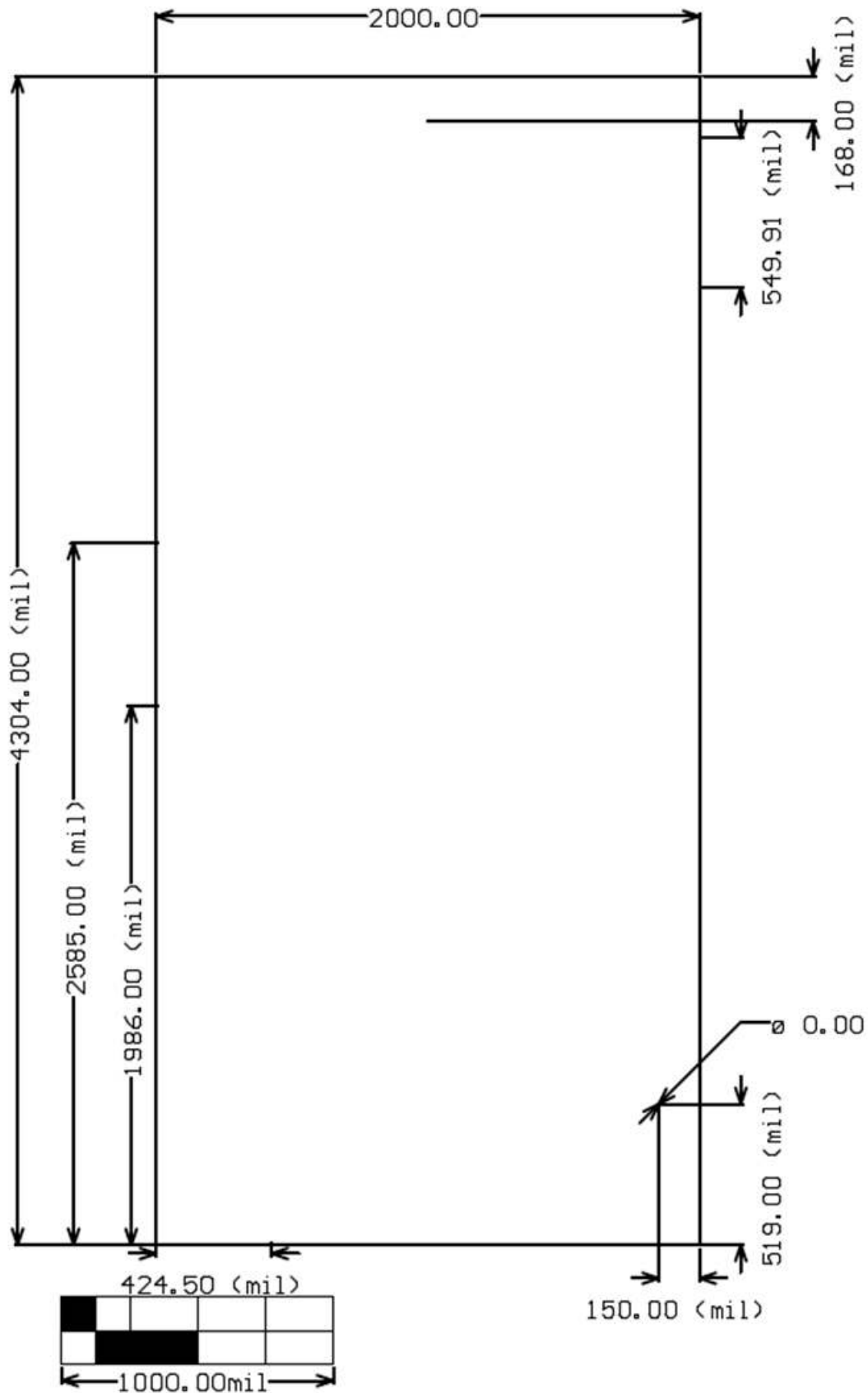
Figure 7 illustrates the EVM dimension drawing.

Figure 7. Board Dimensions

6 Schematic, Assembly, Layout, and BOM

Provided are the BQ79606EVM schematic, assembly, layout and BOM in their respective sections.

6.1 Schematic
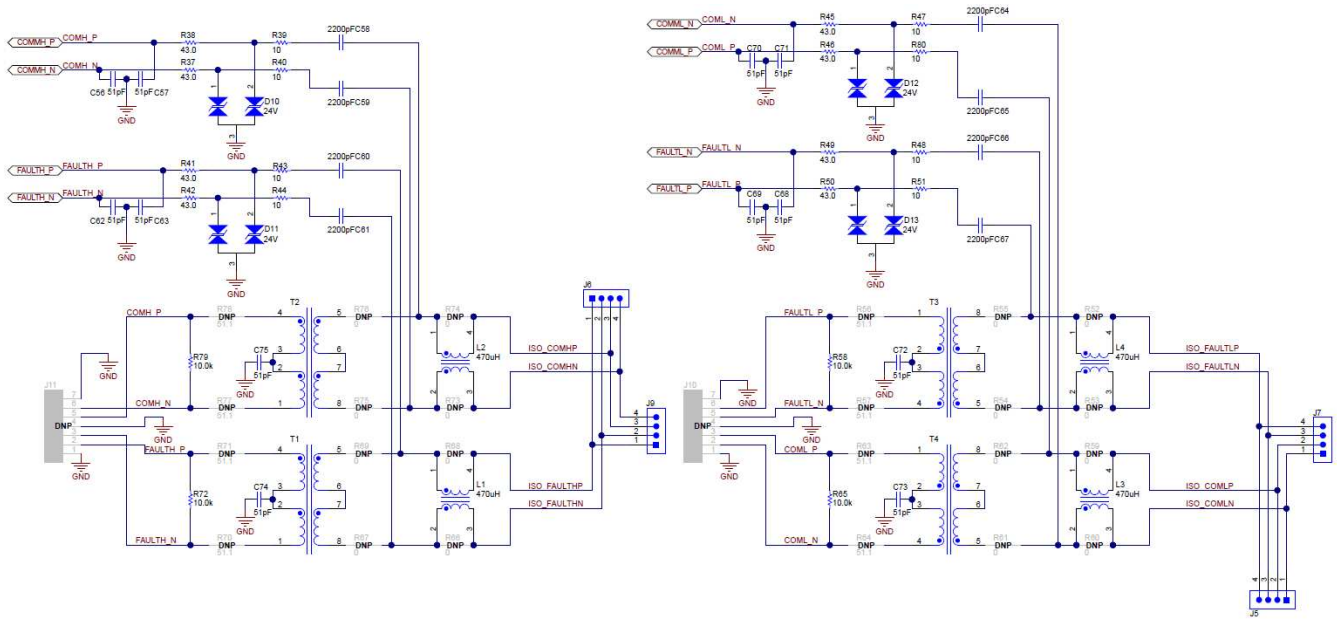
Figure 8. BQ79606EVM Schematic Part 1
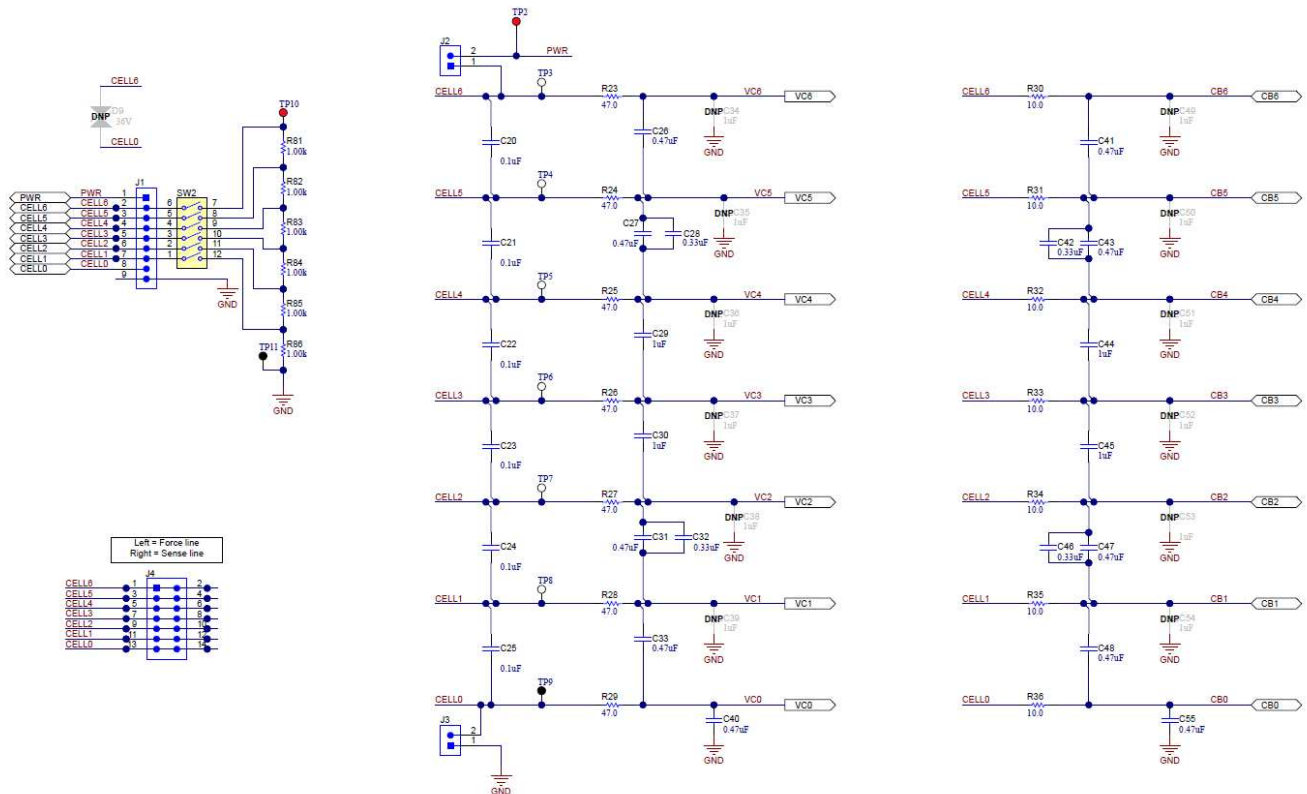
Figure 9. BQ79606EVM Schematic Part 2

Figure 10. BQ79606EVM Schematic Part 3

Figure 11. BQ79606EVM Schematic Part 4

6.2 Assembly

Figure 12. BQ79606EVM Assembly Top
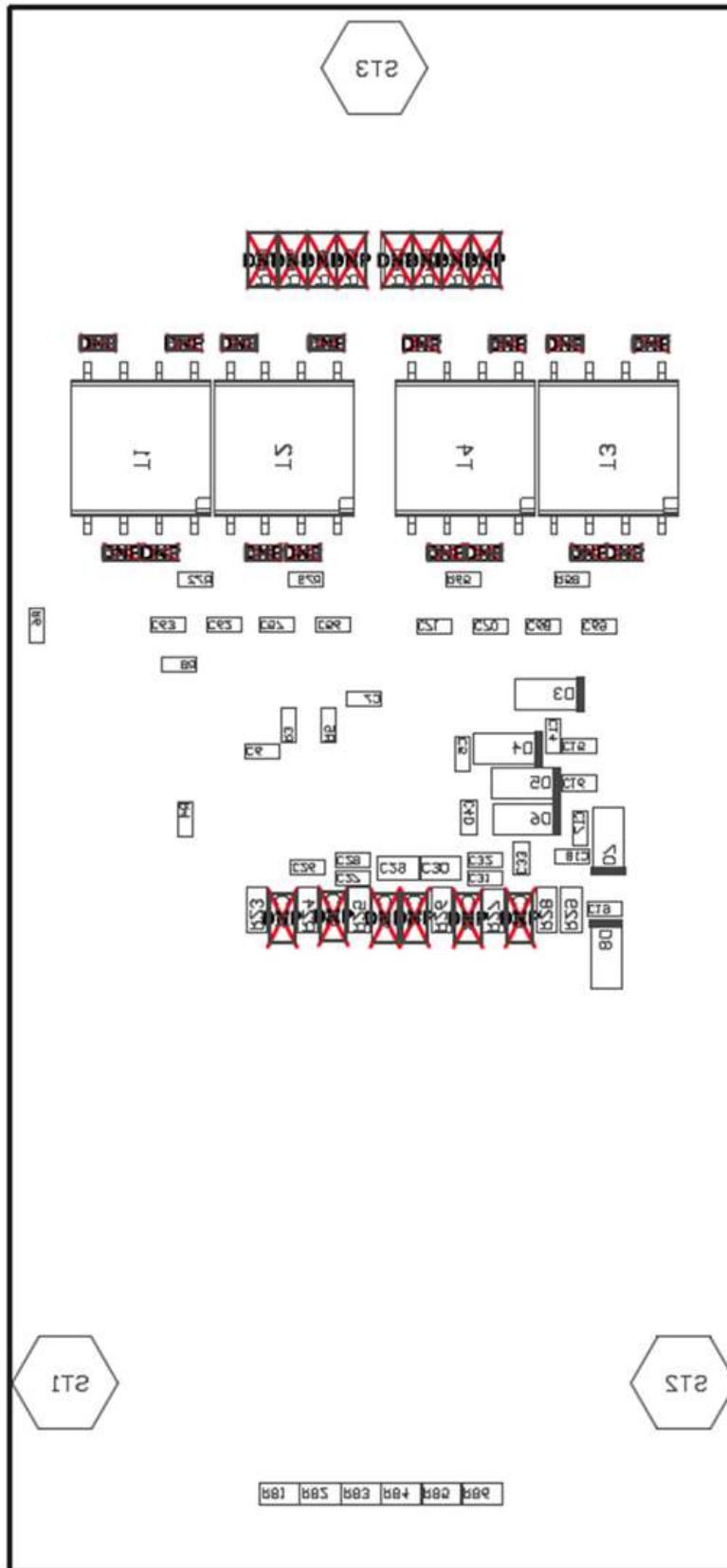
Figure 13. BQ79606EVM Assembly Bottom

6.3 Layout
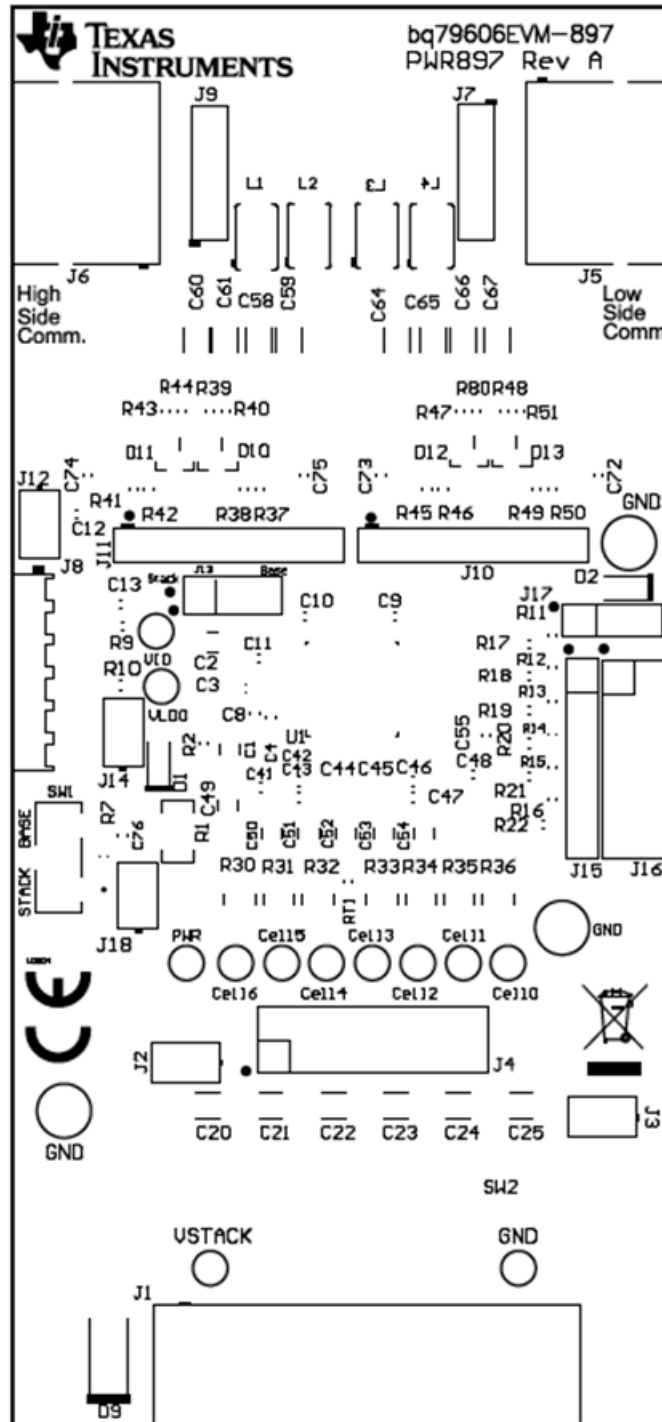
Figure 14. BQ79606EVM Top Overlay
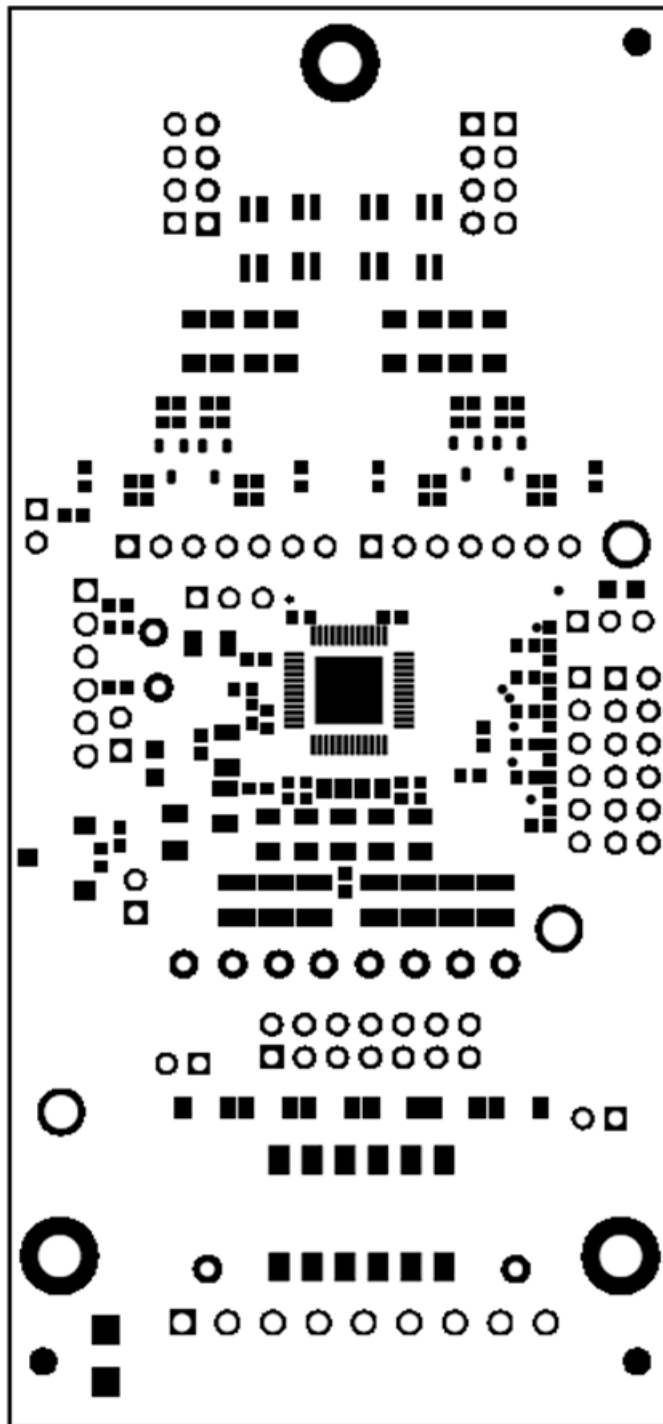
Figure 15. BQ79606EVM Top Solder
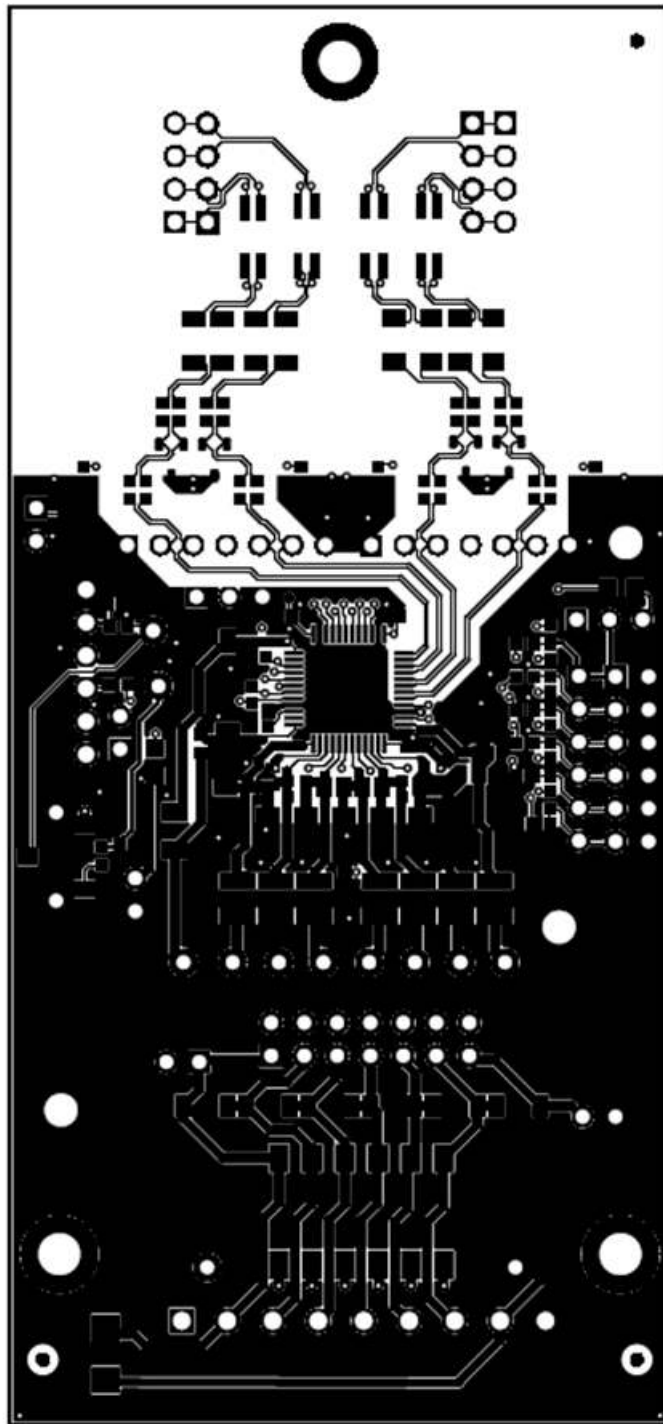
Figure 16. BQ79606EVM Top Layer
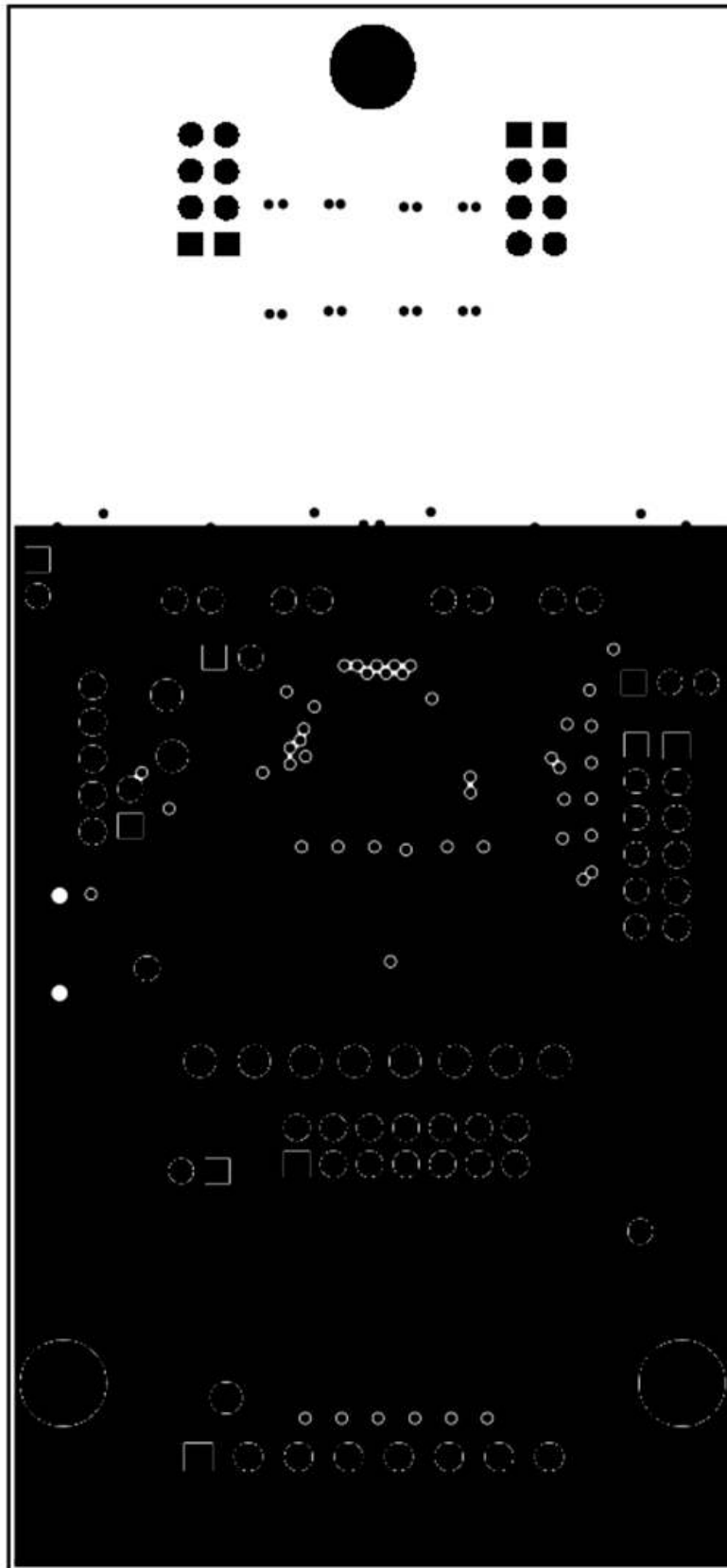
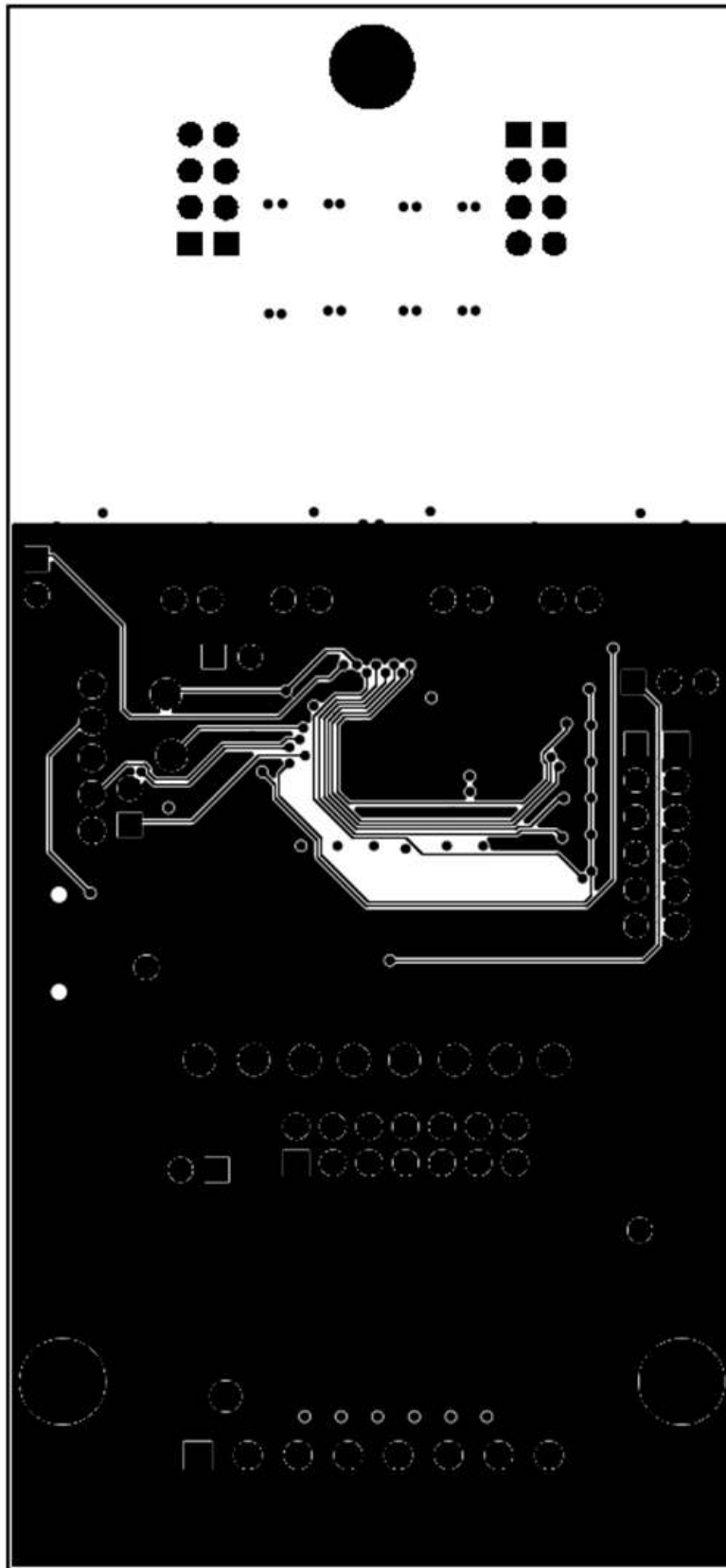**Figure 17. BQ79606EVM Internal Signal Layer 1 - GND Plane**
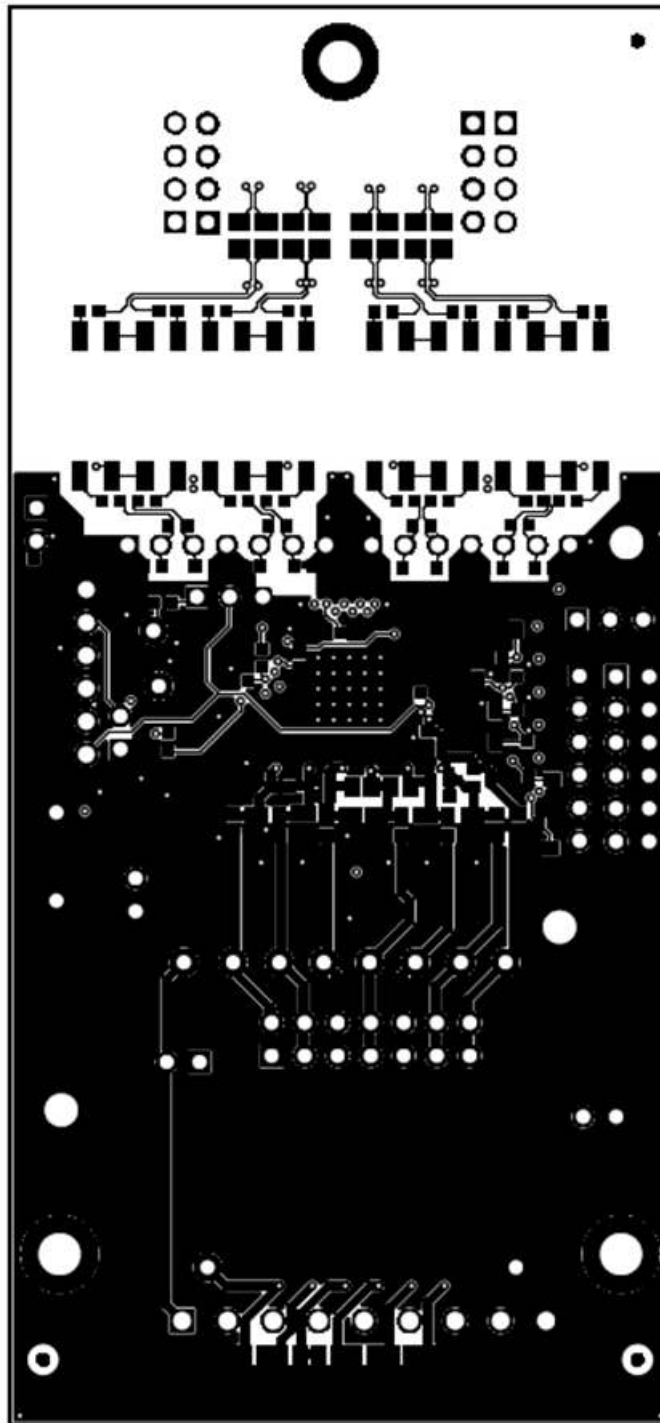
Figure 18. BQ79606EVM Internal Signal Layer 2
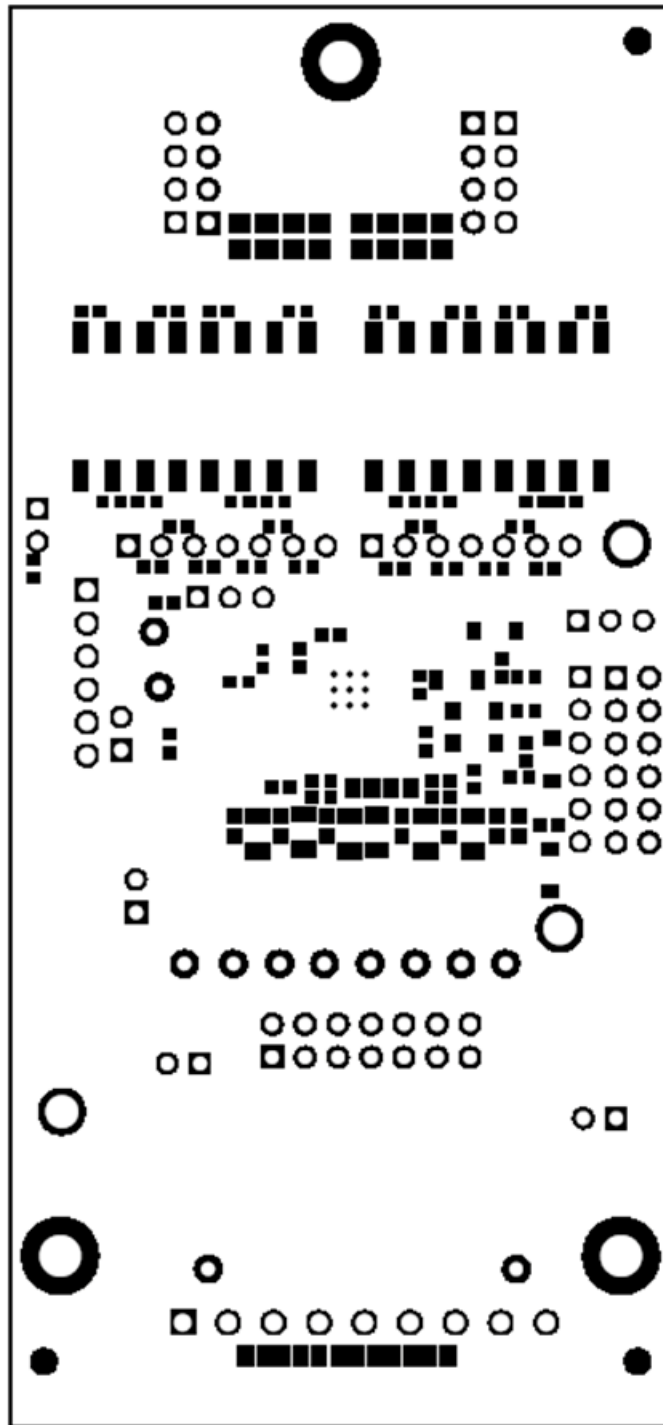
Figure 19. BQ79606EVM Bottom Layer
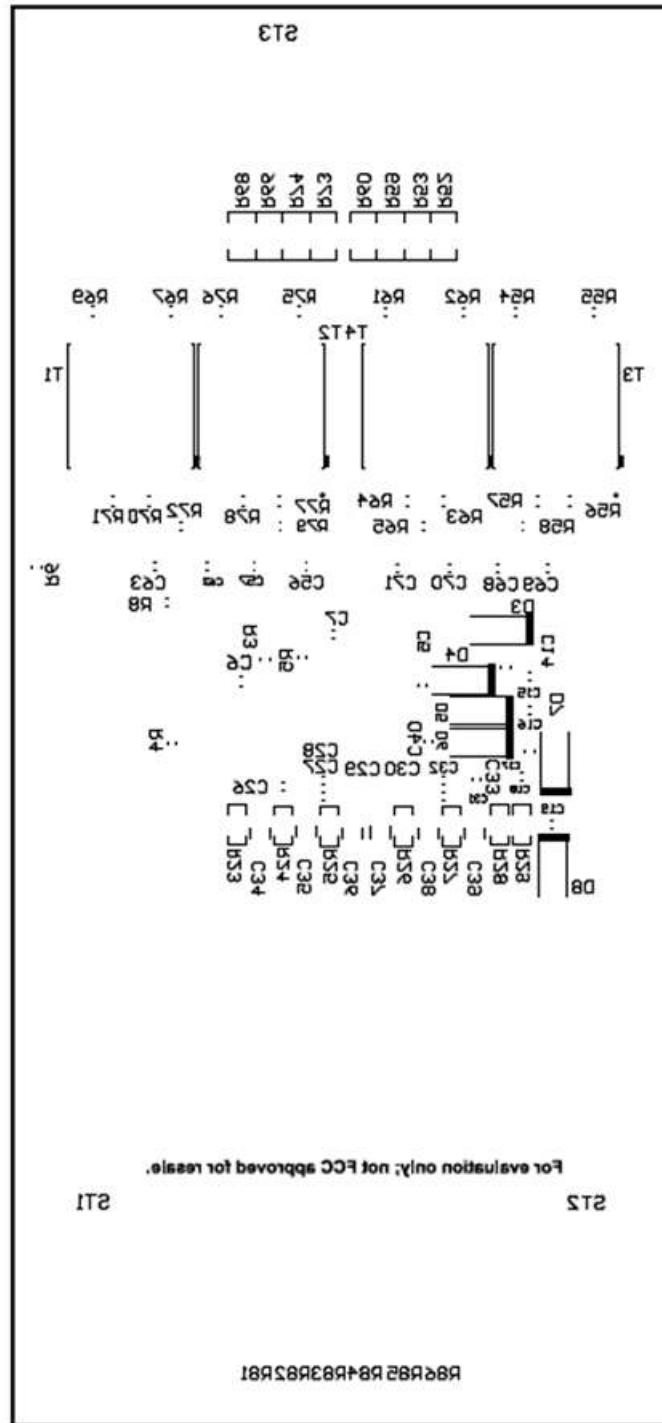
Figure 20. BQ79606EVM Bottom Solder
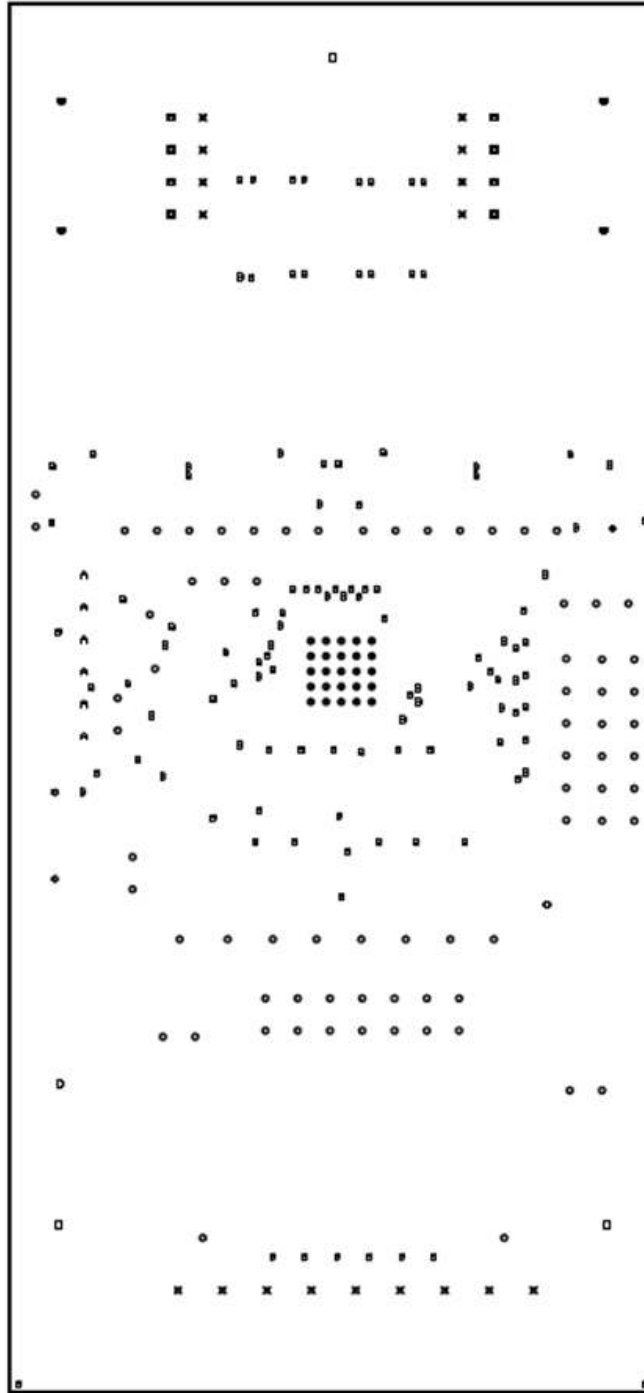
Figure 21. BQ79606EVM Bottom Overlay

Figure 22. BQ79606EVM Drill Drawing

6.4 Bill of Materials (BOM)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
PCB	1		Printed Circuit Board		PWR897	Any

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C1, C2	2	0.33 uF	CAP, CERM, 0.33 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	GCM31MR71H334KA37L	MuRata
C3, C4, C7, C8, C9, C10, C11	7	2.2 uF	CAP, CERM, 2.2 uF, 16 V, +/- 20%, X7S, AEC-Q200 Grade 1, 0603	0603	CGA3E1X7S1C225M080AC	TDK
C5, C13	2	1000 pF	CAP, CERM, 1000 pF, 25 V, +/- 10%, C0G/NP0, 0603	0603	C0603C102K3GACTU	Kemet
C6, C56, C57, C62, C63, C68, C69, C70, C71, C72, C73, C74, C75	13	51 pF	CAP, CERM, 51 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C1H510JA01D	MuRata
C12, C14, C15, C16, C17, C18, C19, C76	8	1 uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	GCM188R71C105KA64D	MuRata
C20, C21, C22, C23, C24, C25	6	0.1 uF	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L2X7R2A104K160AA	TDK
C26, C27, C31, C33, C40, C41, C43, C47, C48, C55	10	0.47 uF	CAP, CERM, 0.47 uF, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	GCM188R71C474KA55D	MuRata
C28, C32, C42, C46	4	0.33 uF	CAP, CERM, 0.33 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7R1H334K080AB	TDK
C29, C30, C44, C45	4	1 uF	CAP, CERM, 1 uF, 16 V, +/- 20%, X8R, AEC-Q200 Grade 0, 0805	0805	CGA4J3X8R1C105K125AB	TDK
C58, C59, C60, C61, C64, C65, C66, C67	8	2200 pF	CAP, CERM, 2200 pF, 2000 V,+/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	1206J2K00222KXR	Knowles Capacitors
D1, D2	2	Green	LED, Green, SMD	LED_0805	LTST-C170KGKT	Lite-On
D3, D4, D5, D6, D7, D8	6	6.2 V	Diode, Zener, 6.2 V, 500 mW, AEC-Q101, SOD-123	SOD-123	DDZ6V2B-7	Diodes Inc.
D10, D11, D12, D13	4	24 V	Diode, TVS, Bi, 24 V, 70 Vc, AEC-Q101, SOT-23	SOT-23	PESD1CAN,215	NXP Semiconductor
H1	1		Terminal Block, 9 Pos, 3.5 mm		39500-0009	Molex

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
H2, H3	2		Rectangular Housing Connector, 4 Pos, 2.54 mm		50-57-9404	Molex
H4	1		USB to TTL Serial 5 V Cable 5.90' (1.80 m) Kitted Item		TTL-232R-5V	Future Technology Devices International Ltd
H5, H6, H7	3		MACHINE SCREW PAN PHILLIPS 4-40	Machine Screw, 4-40, 1/4 inch	PMSSS 440 0025 PH	B&F Fastener Supply
J1	1		Header(Shrouded), 3.5 mm, 9 x 1, R/A, TH	Header(Shrouded), 3.5 mm, 9 x 1, R/A, TH	39502-1009	Molex
J2, J3, J12, J14, J18	5		Header, 2.54 mm, 1 x 2, Tin, Black, TH	Header, 2.54 mm, 2 x 1, TH	PEC01DAAN	Sullins Connector Solutions
J4	1		Header, 100 mil, 7 x 2, Tin, TH	Header, 7 x 2, 100 mil, Tin	PEC07DAAN	Sullins Connector Solutions
J5, J6	2		Header(shrouded), 2.54 mm, 4 x 1, R/A, Gold, TH	Header(shrouded), 2.54 mm, 4 x 1, R/A, TH	70551-0038	Molex
J7, J9	2		Header, 100 mil, 4 x 1, Tin, TH	Header, 4 x 1, 100 mil, TH	PEC04SAAN	Sullins Connector Solutions
J8	1		Header, 0.5 mm, 6 x 1, R/A, Gold, TH	Header, 0.5 mm, 6 x 1, R/A, TH	22/12/4062	Molex
J13, J17	2		Header, 100 mil, 3 x 1, Tin, TH	Header, 3 PIN, 100 mil, Tin	PEC03SAAN	Sullins Connector Solutions
J15	1		Header, 100 mil, 6 x 1, Tin, TH	TH, 6-Leads, Body 608 x 100 mil, Pitch 100 mil	PEC06SAAN	Sullins Connector Solutions
J16	1		Header, 100 mil, 6 x 2, Tin, TH	Header, 6 x 2, 100 mil, Tin	PEC06DAAN	Sullins Connector Solutions
L1, L2, L3, L4	4	470 uH	Coupled inductor, 470 uH, 0.4 A, 0.35 ohm, SMD	5 x 3.3 mm	744242471	Wurth Elektronik
R1	1	47	RES, 47, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW120647R0JNEA	Vishay-Dale
R2, R7, R10	3	100	RES, 100, 5%, 0.25 W, AEC-Q200 Grade 0, 0603	0603	ESR03EZPJ101	Rohm
R3, R9, R11, R12, R13, R14, R15, R16, R58, R65, R72, R79	12	10.0 k	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R4, R17, R18, R19, R20, R21, R22	7	1.0 k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031K00JNEA	Vishay-Dale
R5	1	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
R6, R8	2	100 k	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603100KJNEA	Vishay-Dale
R23, R24, R25, R26, R27, R28, R29	7	47.0	RES, 47.0, 1%, 0.1 W, 0603	0603	RC0603FR-0747RL	Yageo America
R30, R31, R32, R33, R34, R35, R36	7	10.0	RES, 10.0, 1%, 0.5 W, AEC-Q200 Grade 0, 1210	1210	ERJ-14NF10R0U	Panasonic
R37, R38, R41, R42, R45, R46, R49, R50	8	43.0	RES, 43.0, 1%, 0.1 W, 0603	0603	RC0603FR-0743RL	Yageo America
R39, R40, R43, R44, R47, R48, R51, R80	8	10	RES, 10, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310R0JNEA	Vishay-Dale
R81, R82, R83, R84, R85, R86	6	1.00 k	RES, 1.00 k, 0.1%, 0.25 W, 0805	0805	RP73PF2A1K0BTDF	TE Connectivity
RT1	1	10 k	Thermistor NTC, 10 k ohm, 2%, 0603	0603	ERT-J1VG103GA	Panasonic
SH1, SH2, SH3, SH4, SH5	5		Shunt, 100 mil, Gold plated, Black	Shunt 2 pos. 100 mil	881545-2	TE Connectivity
ST1, ST2, ST3	3		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
SW1	1		Switch, Slide, SPDT, 0.2 A, GULL, 12 V, SMD	SMD, 3-Leads, Body 8.5 x 3.5 mm, Pitch 2.5 mm	CL-SB-12B-01T	Copal Electronics
SW2	1		Switch, SPST 6Pos, SMT	10.4 x 3.9 x 9.3 mm	SDA06H1SBD	C&K Components
T1, T2, T3, T4	4		Transformer, 618 uH, SMT	9.7 x 9.5 mm	CEP99	Sumida
TP1, TP3, TP4, TP5, TP6, TP7, TP8, TP12	8		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
TP2, TP10	2		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP9, TP11	2		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
TP14, TP15, TP16	3		Terminal, Turret, TH, Triple	Keystone1598-2	1598-2	Keystone

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
U1	1		SafeTI Precision Monitor With Integrated Hardware Protector for Multi-Cell Lithium-Ion and Lithium Phosphate Battery Pack Automotive Applications SYSTEMS SPECIFICATION, PHP0048G (HTQFP-48)	PHP0048G	BQ79606APHPQ1	Texas Instruments
ZZ4	1		Screws H5, H6 and H7 are for the standoffs ST1, ST2 and ST3			
C34, C35, C36, C37, C38, C39, C49, C50, C51, C52, C53, C54	0	1 uF	CAP, CERM, 1 uF, 50 V, +/-10%, X7R, AEC-Q200 Grade 1, 1206	1206	GCM31MR71H105KA55L	MuRata
D9	0	36 V	Diode, TVS, Bi, 36 V, SMA	SMA	SMAJ36CA	Littelfuse
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J10, J11	0		Header, 2.54 mm, 7 x 1, Gold, TH	Header, 2.54 mm, 7 x 1, TH	PBC07SAAN	Sullins Connector Solutions
R52, R53, R59, R60, R66, R68, R73, R74	0	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW08050000Z0EA	Vishay-Dale
R54, R55, R61, R62, R67, R69, R75, R76	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R56, R57, R63, R64, R70, R71, R77, R78	0	51.1	RES, 51.1, 1%, 0.1 W, 0603	0603	RC0603FR-0751R1L	Yageo America

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from D Revision (December 2018) to E Revision	Page

- Changed instances of BQ79606/BQ79606-Q1 to BQ79606A/BQ79606A-Q1. 1