# bq24725EVM Evaluation Module

This user's guide describes the features and operation of the bq24725EVM Evaluation Module (EVM). This EVM assists users in evaluation the bq24725 synchronous battery charger. The manual includes the bq24725EVM bill of materials, board layout, and schematic.

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## 1 Introduction

### *1.1 EVM Features*

- Evaluation module for bq24725
- High-efficiency NMOS-NMOS synchronous buck charger with 750-kHz frequency
- High-efficiency and low-cost NMOS power path selector and integrated gate driver
- User-selectable 2-cell, 3-cell, or 4-cell Li-ion battery voltage
- Programmable battery voltage, charge current, and ac adapter current via SMBus interface
- Flexible Chargeoption() register control via SMBus interface
- AC adapter operating range 9 V – 24 V
- Test points for key signals available for testing. Easy probe hook-up

Windows is a trademark of Microsoft Corporation.

- Jumpers available. Easy-to-change connections.

## 1.2 General Description

The bq24725EVM evaluation module (also referred to as HPA-542) is a complete charger module for evaluating a multicell synchronous notebook charge using the bq24725 devices. It is designed to deliver up to 4 A of charge current to Li-ion or Li-polymer applications.

The bq24725 does not include the EV2300 interface board. To evaluate the bq24725, the EV2300 interface board must be ordered separately.

The bq24725 has a highly integrated battery charge controller designed to work with external host commands. The charge voltage, charge current, input current, and flexible charge option are programmable with a SMBus interface.

The bq24725 supports high-efficiency and low-cost NMOS power path selector and has an integrated gate driver for both adapter-side and battery-side power path selector switch.

The dynamic power management (DPM) function modifies the charge current depending on system load conditions, avoiding ac adapter overload.

High-accuracy current sense amplifiers enable accurate measurement of the ac adapter current, allowing monitoring of overall system power.

For details, see bq24725 data sheet (SLUS702).

## 1.3 I/O Description

| Jack | Description |
|---|---|
| J1–DCIN | AC adapter, positive output |
| J1–GND | AC adapter, negative output |
| J2-SYS | Connected to system |
| J2-BAT | Connected to battery pack |
| J2-GND | Ground |
| J3-ACOK | ACOK pin |
| J3-IOUT | IOUT pin |
| J3-3.3V | External voltage supply 3.3 V |
| J4–SCL | SCL pin output, SMBus clock line |
| J4–SDA | SDA pin output, SMBus data line |
| J4– GND | External power supply, negative output |

## 1.4 Controls and Key Parameters Setting

| Jack | Description | Factory Setting |
|---|---|---|
| JMP1 | Connect battery voltage to VCC pin | Jumper installed |

## 1.5 Recommended Operating Conditions

| | | Min | Typ | Max | Unit | Notes |
|---|---|---|---|---|---|---|
| Supply voltage, $V_{IN}$ | Input voltage from ac adapter input | 18 | 19 - 20 | 22 | V | |
| Battery voltage, $V_{BAT}$ | Voltage applied at VBAT terminal | 0 | 6 - 16.8 | 20 | V | |
| Supply current, $I_{AC}$ | Maximum input current from ac adapter input | 0 | | 4.5 | A | |
| Charge current, $I_{chrg}$ | Battery charge current | 1 | 3 | 4 | A | |
| Operating junction temperature range, $T_J$ | | 0 | | 125 | °C | |

# 2 Test Summary

## 2.1 Definitions

This procedure details how to configure the HPA-542 evaluation board. On the test procedure, the following naming conventions are followed. Refer to the HPA542 schematic for details.

| | |
|---|---|
| VXXX : | External voltage supply name (VADP, VBT, VSBT) |
| LOADW: | External load name (LOADR, LOADI) |
| V(TPyyy): | Voltage at internal test point TPyyy. For example, V(TP12) means the voltage at TP12. |
| V(Jxx): | Voltage at jack terminal Jxx. |
| V(TP(XXX)): | Voltage at test point XXX. For example, V(ACDET) means the voltage at the test point which is marked as ACDET. |
| V(XXX, YYY): | Voltage across point XXX and YYY. |
| I(JXX(YYY)): | Current going out from the YYY terminal of jack XX. |
| Jxx(BBB): | Terminal or pin BBB of jack xx |
| Jxx ON: | Internal jumper Jxx terminals are shorted |
| Jxx OFF: | Internal jumper Jxx terminals are open |
| Jxx (-YY-) ON: | Internal jumper Jxx adjacent terminals marked as YY are shorted |
| Measure: → A,B | Check specified parameters A, B. If measured values are not within specified limits, the unit under test has failed. |
| Observe: → A,B | Observe if A, B occur. If they do not occur, the unit under test has failed. |

Assembly drawings have location for jumpers, test points, and individual components.

## 2.2 Equipment

### 2.2.1 Power Supplies

Power Supply #1 (PS#1): a power supply capable of supplying 20 V at 5 A is required.
Power Supply #2 (PS#2): a power supply capable of supplying 5 V at 1 A is required.
Power Supply #3 (PS#3): a power supply capable of supplying 20 V at 1 A is required.

### 2.2.2 Load #1

A 30-V (or above), 5-A (or above) electronic load that can operate at constant current mode

### 2.2.3 Load #2

An HP 6060B 3-V to 60-V/0-A to 60-A, 300-W system dc electronic load or equivalent

### 2.2.4 Meters

Seven Fluke 75 multimeters (equivalent or better)
Or four equivalent voltage meters and three equivalent current meters.
The current meters must be capable of measuring 5-A+ current.

### 2.2.5 Computer

A computer with at least one USB port and a USB cable. The EV2300 USB driver and the bq24725 SMB evaluation software must be properly installed.

### 2.2.6 EV2300 SMBUS Communication Kit

An EV2300 SMBUS communication kit

### 2.2.7 Software

1. "Driver(USB EV2300) Installer XP2K-Last updated Jan28-04.zip": This is the EV2300 USB driver. Save and unzip to c:\temp (or other directory). Double-click on the "setup.exe" file. Follow the installation steps.
2. "bq24725EVMSetup.zip" (SLUC202): This is the bq24725 SMB evaluation software. Save and unzip to c:\temp (or other directory). Double-click on the "SETUP.EXE" file. Follow the installation steps. This software needs to be installed after the EV2300 USB driver.
3. Note: When the EV2300 is first inserted into the USB port of the personal computer, the user must follow the instructions of the "Found New Hardware Wizard."
4. Allow Windows™ to connect to Windows Update to search for software. Then click Next.
5. Select "Install software automatically (Recommended)." Then click Next.
6. If a window pops up informing the user that the TI USB Firmware Updater has not passed WIndows Logo testing, click "Continue Anyway."
7. If a target file already exists and is newer, do not overwrite the newer file.
8. Click Finish.

## 2.3 Equipment Setup

1. Set the power supply #1 for 0 V ±100 mVdc, with the current limit set to >5 A, and then turn off supply.
2. Connect the output of power supply #1 in series with a current meter (multimeter) to J1 (DCIN, GND).
3. Connect a voltage meter across J1 (DCIN, GND).
4. Set the power supply #2 for 3.3 V ±100 mVdc, 0.2-A ±0.1-A current limit, and then turn off supply.
5. Connect the output of the power supply #2 to J3 (3.3 V) and J4 (GND).
6. Connect a voltage meter across J2 (BAT, GND).
7. Connect a voltage meter across J2 (SYS, GND).
8. Connect J4 (SDA, SCL) and J4 (GND) to the EV2300 kit SMB port. See Table 1 for connection references. Connect the USB port of the EV2300 kit to the USB port of the computer. The connections are shown in Figure 1.

**Table 1. bq24275EVM and EV2300 Connections**

| bq24725EVM | EV2300 |
|---|---|
| GND (J4) | GND (1) |
| SCL (J4) | SMBC (2) |
| SDA (J4) | SMBD (3) |

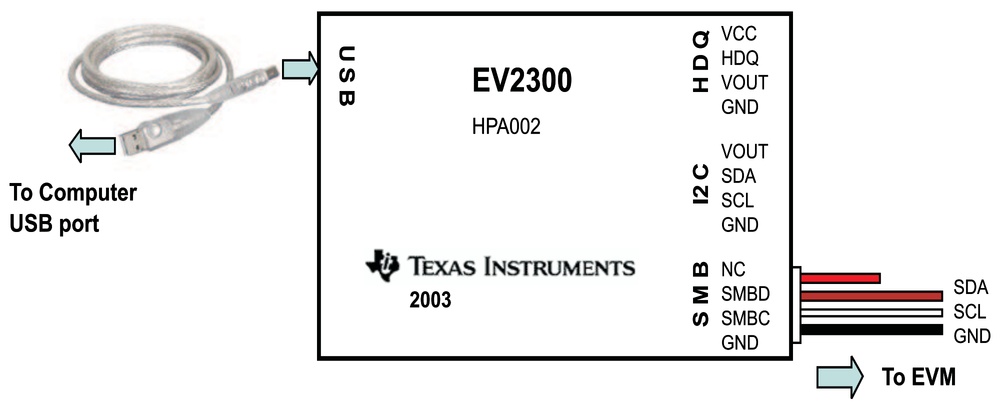



**Figure 1. Connections of the EV2300 Kit**

9. If JMP1 is not installed, install the jumper.
10. The test setup for HPA542 is shown in Figure 2.

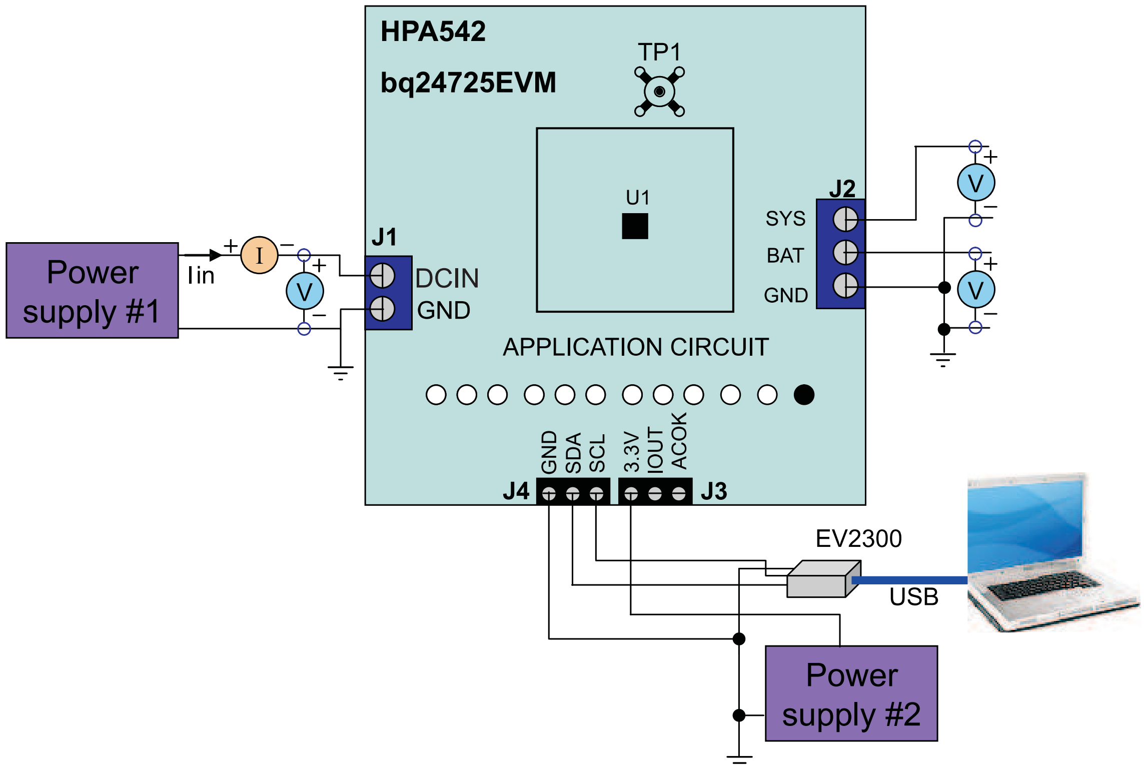



**Figure 2. Original Test Setup for HPA-542 (bq24725 EVM)**

11. Turn on the computer. Open the bq24725 evaluation software. The main window of the software is shown in Figure 3.

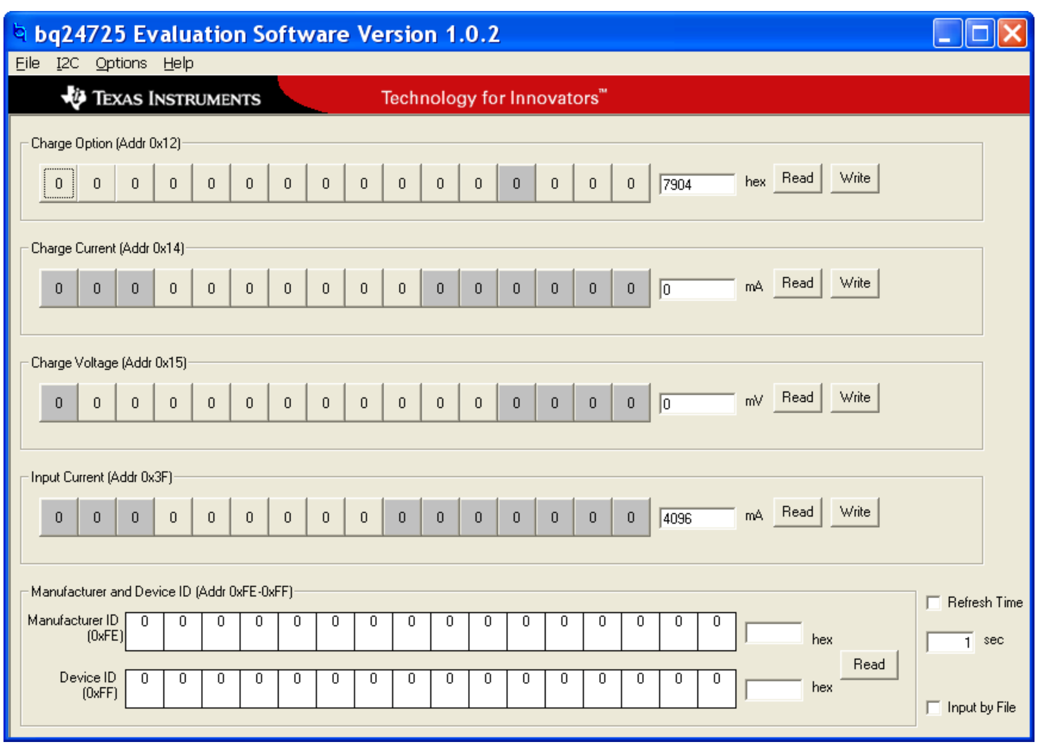



**Figure 3. Main Window of the bq24725 Evaluation Software**

## 2.4 Procedure

### 2.4.1 AC Adapter Detection Threshold

1. Be sure to follow EQUIPMENT SETUP steps. Turn on PS#2.
2. Turn on PS#1.
3. Increase the output voltage of PS#1 to 19.5 V.

   *Measure* → V(TP(ACDET)) = 2.6 V ±0.1 V
   *Measure* → V(TP(ACOK)) = 3.3 V ±0.1 V
   *Measure* → V(J2(SYS)) = 19.5 V ±0.5 V
   *Measure* → V(TP(REGN)) = 6 V ±0.5 V
   *Measure* → V(TP(ACDRV, CMSRC)) = 6 V ±0.5 V
   *Measure* → V(J2(BAT, GND)) = 1 V ±1 V

### 2.4.2 Charger Parameters Settings

1. In the software main window, click all the Read buttons. Make sure no error information is generated.
2. If an error information window pops up that reads "USB Error. Ensure USB cable is connected and Driver is working," perform the following steps.
   - Click OK. Close main window (shown in Figure 3), and disconnect the USB cable.
   - Check the 3.3-V power supply (PS#2) and power supply #1 (PS#1) voltage on the EVM board.
   - Disconnect any uncertain SMBus connections. Plug in the USB cable into the original EVM2300 installation USB port.
   - Open the bq24725 evaluation software. The main window of the software is shown in Figure 3.
3. Type in "512" (mA) in the Charge Current DAC, and click the Write button. This sets the battery charge current regulation threshold.
4. Type in "12592" (mV) in the Charge Voltage DAC, and click the Write button. This sets the battery voltage regulation threshold.

   *Measure* → V(J2(BAT)) = 12.6 V ±200 mV

### 2.4.3 Charge Current and AC Current Regulation (DPM)

1. Type in "7905" in the Charge Option, and click the Write button. This disables charging.
2. Connect the Load #2 in series with a current meter (multimeter) to J2 (BAT, GND). Ensure that a voltage meter is connected across J2 (BAT, GND). Turn on the Load #2. Use the constant voltage mode. Set the output voltage to 10.5 V.
3. Turn on the power of the Load #1. Set the load current to 3 A ±50 mA but disable the output. The setup is now like Figure 4 for HPA542. Ensure that Ibat = 0 A ±10 mA and Isys = 0 A ±10 mA.

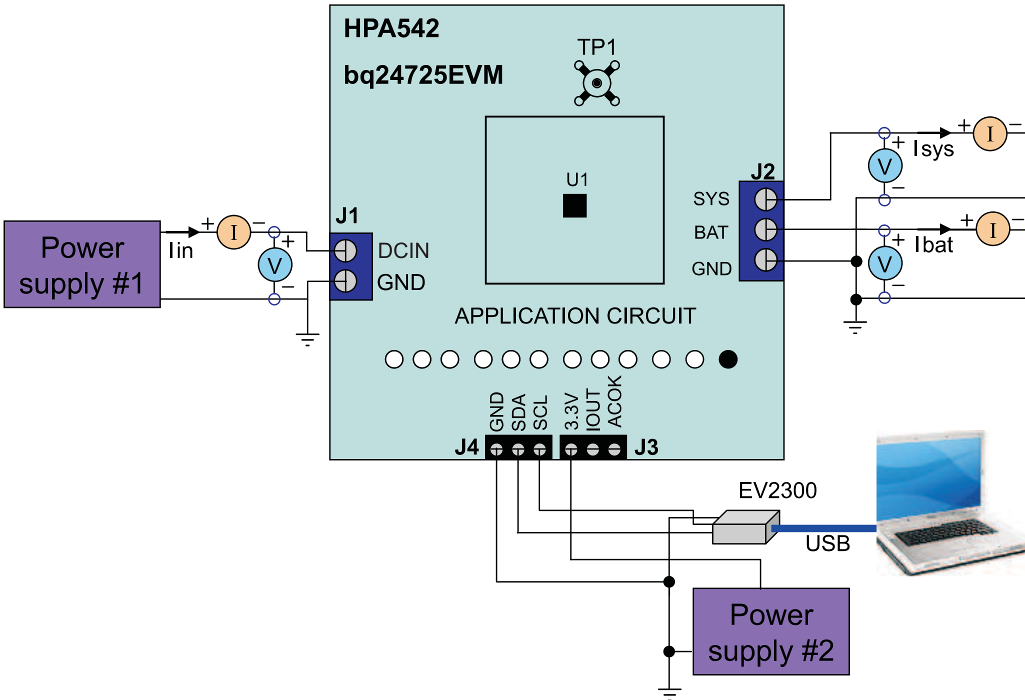



**Figure 4. Test Setup for HPA-542**

4. Type in "7905" in the Charge Option, and click the Write button. This enables charging.
   Measure → Ibat = 500 mA ±100 mA
5. Type in "2944" (mA) in the Charge Current DAC, and click the Write button. This sets the battery charge current regulation threshold to 2.944 A.
   Measure → Ibat = 3000 mA ±300 mA
   Measure → V(TP(IOUT)) = 340 mV ±40 mV
6. Enable the output of the Load #1.
   Measure → Isys = 3000 mA ±300 mA, Ibat = 1600 mA ±200 mA, Iin = 4100 mA ±400 mA
   Measure → V(TP(IOUT)) = 820 mV ±100 mV
7. Turn off the Load #1.
   Measure → Isys = 0 A ±100 mA, Ibat = 3000 mA ±300 mA.
8.

### 2.4.4 Power Path Selection

1. Type in "7905" in the Charge Option, and click the Write button. This disables charging.
2. Replace Load #2 and current meter with PS#3. Make sure a voltage meter is connected across J2 (BAT, GND). Enable the output of the PS #3. Ensure that the output voltage is 10 V ±500 mV.
   Measure → Measure ±V(J2(SYS)) = 19.5 V ±1 V (adapter connected to system)
3. Turn off PS#1.
   Measure → V(J2(SYS)) = 10 V ±1 V (battery connected to system)
   Measure → V(J2(BAT)) = 10 V ±1 V (battery connected to system)

## 3 PCB Layout Guideline

The switching node rise and fall times must be minimized for minimum switching loss. Proper layout of the components to minimize high-frequency current path loop is important to prevent electrical and magnetic field radiation and high-frequency resonant problems. The following is a printed-circuit board (PCB) layout priority list for proper layout. Laying out a PCB according to this specific order is essential.

1. Place input capacitor as close as possible to switching MOSFET's supply and ground connections, and use shortest copper trace connection. These parts must be placed on the same layer of the PCB instead of on different layers and vias used to make this connection.
2. The integrated circuit (IC) must be placed close to the switching MOSFET's gate terminals and the gate drive signal traces kept short for a clean MOSFET drive. The IC can be placed on the other side of the PCB of switching MOSFETs.
3. Place inductor input terminal to switching MOSFET's output terminal as close as possible. Minimize the copper area of this trace to lower electrical and magnetic field radiation but make the trace wide enough to carry the charging current. Do not use multiple layers in parallel for this connection. Minimize parasitic capacitance from this area to any other trace or plane.
4. The charging current sensing resistor mut be placed right next to the inductor output. Route the sense leads connected across the sensing resistor back to the IC in the same layer, close to each other (minimize loop area), and do not route the sense leads through a high-current path. Place decoupling capacitor on these traces next to the IC.
5. Place output capacitor next to the sensing resistor output and ground.
6. Output capacitor ground connections need to be tied to the same copper that connects to the input capacitor ground before connecting to system ground.
7. Use single ground connection to tie charger power ground to charger analog ground. Just beneath the IC, use analog ground copper pour but avoid power pins to reduce inductive and capacitive noise coupling.
8. Route analog ground separately from power ground. Connect analog ground and power ground separately. Connect analog ground and power ground together using power pad as the single ground connection point. Or use a 0-Ω resistor to tie analog ground to power ground (power pad must tie to analog ground in this case if possible).
9. Decoupling capacitors must be placed next to the IC pins, and make trace connection as short as possible.
10. It is critical that the exposed power pad on the backside of the IC package be soldered to the PCB ground. Ensure that sufficient thermal vias are directly under the IC, connecting to the ground plane on the other layers.

# 4 Bill of Materials, Board Layouts and Schematics

## *4.1 Bill of Materials*

**Table 2. Bill of Materials**

| Count | RefDes | Value | Description | Size | Part Number | MFR |
|---|---|---|---|---|---|---|
| 1 | C1 | 2.2 μF | Capacitor, Ceramic, 25V, X7R, 10% | 1210 | Std | Std |
| 6 | C2, C3, C4, C5, C6, C7 | 10 μF | Capacitor, Ceramic, 25V, X7R, 10% | 1206 | Std | Std |
| 6 | C8, C14, C15, C16, C17, C19 | 0.1 μF | Capacitor, Ceramic, 25V, X7R, 10% | 603 | Std | Std |
| 4 | C9, C10, C20, C25 | 1 μF | Capacitor, Ceramic, 25V, X7R, 10% | 603 | Std | Std |
| 2 | C11, C12 | 0.01 μF | Capacitor, Ceramic, 25V, X7R, 10% | 603 | Std | Std |
| 0 | C13, C18, C24, C26 | OPEN | Capacitor, Ceramic, 25V, X7R, 10% | 603 | Std | Std |
| 1 | C21 | 0.047 μF | Capacitor, Ceramic, 25V, X7R, 10% | 603 | Std | Std |
| 1 | C22 | 100 pF | Capacitor, Ceramic, 25V, X7R, 10% | 603 | Std | Std |
| 1 | C23 | 2200 pF | Capacitor, Ceramic, 25V, X7R, 10% | 603 | Std | Std |
| 1 | D1 | BAT54-V-G | Diode, Schottky, 200-mA, 30-V | SOT23 | BAT54-V-G | Vishay-Liteon |
| 1 | D2 | BAT54C-V-G | Diode, Dual Schottky, 200-mA, 30-V | SOT23 | BAT54C-V-G | Vishay-Liteon |
| 1 | J1 | ED120/2DS | Terminal Block, 2-pin, 15-A, 5.1mm | 0.40 x 0.35 inch | ED120/2DS | OST |
| 1 | J2 | ED120/3DS | Terminal Block, 3-pin, 15-A, 5.1mm | 0.60 x 0.35 inch | ED120/3DS | OST |
| 2 | J3, J4 | ED555/3DS | Terminal Block, 3-pin, 6-A, 3.5mm | 0.41 x 0.25 inch | ED555/3DS | OST |
| 1 | JP1 | PEC02SAAN | Header, Male 2-pin, 100mil spacing, | 0.100 inch x 2 | PEC02SAAN | Sullins |

### Table 2. Bill of Materials (continued)

| Count | RefDes | Value | Description | Size | Part Number | MFR |
|---|---|---|---|---|---|---|
| 1 | JP1 | 929950-00 | Shorting jumpers, 2-pin, 100mil spacing, | | 929950-00 | 3M/ESD |
| 1 | L1 | 4.7 µH | Inductor, SMT | 0.255 x 0.270 inch | IHLP2525CZER4R7M0 1 | Vishay |
| 3 | Q1, Q2, Q3 | FDS6680A | MOSFET, NChan, 30V, 12.5A, 9.5millohm | PWRPAK S0-8 | FDS6680A | Fairchild |
| 2 | Q4, Q5 | Sis412DN-T1 | MOSFET, NChan, 30V, 12A, 30millohm | PWRPAK 1212 | Sis412DN-T1 | Vishay |
| 1 | Q6 | BSS138W-7-F | MOSFET, Nch, 50V, 200mA, | SOT-323 | BSS138W-7-F | Diodes |
| 2 | R1, R2 | 0.01 | Resistor, Chip, 1/2W, 1% 150PPM<br>Resistor, Chip, 1W, 1% 75 PPM | 1206 | PMR18EZPFU10L0<br>WSLP1206R0100FEA | Rohm<br>Vishay/Dale |
| 2 | R3, R5 | 0 | Resistor, Chip, 1/16W, 5% | 603 | Std | Std |
| 1 | R4 | 7.5 | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 2 | R6, R7 | 3.9 | Resistor, Chip, 0.5W, 5% | 1210 | Std | Std |
| 3 | R8, R9, R13 | 4.02k | Resistor, Chip, 1/10W, 1% | 603 | Std | Std |
| 0 | R10, R11 | OPEN | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 1 | R12 | 1.00M | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 1 | R14 | 66.5k | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 1 | R15 | 430k | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 1 | R16 | 10 | Resistor, Chip, 1/4W, 1% | 1206 | Std | Std |
| 3 | R17, R18, R19 | 10.0k | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 1 | R20 | 100k | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 1 | R21 | 12.1k | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 1 | R22 | 316k | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 1 | R23 | 3.01M | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 1 | R24 | 10 | Resistor, Chip, 1/16W, 1% | 603 | Std | Std |
| 1 | TP1 | 131-4244-00 | Adaptor, 3.5-mm probe clip ( or 131-5031-00) | 0.200 inch | 131-4244-00 | Tektronix |
| 11 | TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12 | | Test Point, White, Thru Hole Color Keyed | 0.100 x 0.100 inch | 5002 | Keystone |
| 1 | TP13 | GND | Test Point, Black, Thru Hole Color Keyed | 0.100 x 0.100 inch | 5001 | Keystone |
| 0 | TP14, 15, 16, 17, 18 | | | | | |
| 4 | | | 6-32 NYL nuts | | NY HN 632 | Building Fasteners |
| 4 | ST1, ST2, ST3, ST4 | 4816 | STANDOFF M/F HEX 6-32 NYL 0.500" | sf_thvt_325_rnd | 4816 | Keystone |
| 1 | U1 | bq24725RGR | IC, SMBus charge controller with NMOS selector | | bq24725RGR | TI |
| 1 | – | | Label | 1.25 x 0.25 inch | THT-13-457-10 | Brady |
| 1 | – | HPA542 | 2.5x2.5inch 4 layer 2oz. PCB | 2.5x2.5inch | PCB | Any |

## 4.2 Board Layouts

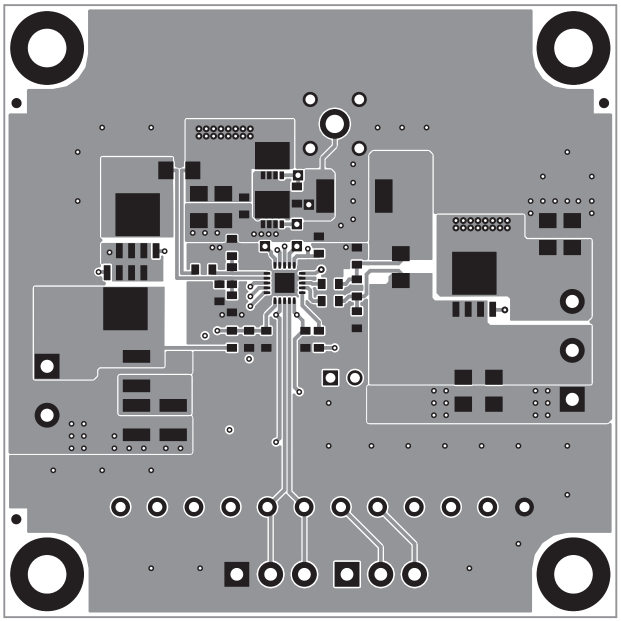


**Figure 5. Top Layer**

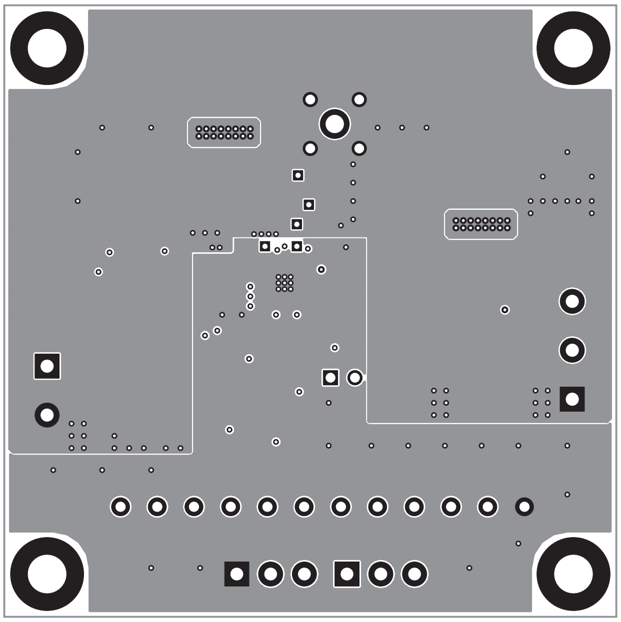


**Figure 6. Second Layer**

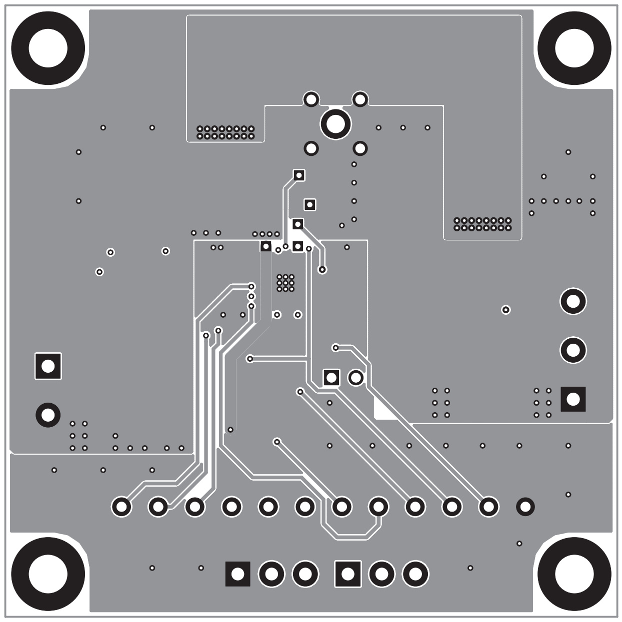


**Figure 7. Third Layer**

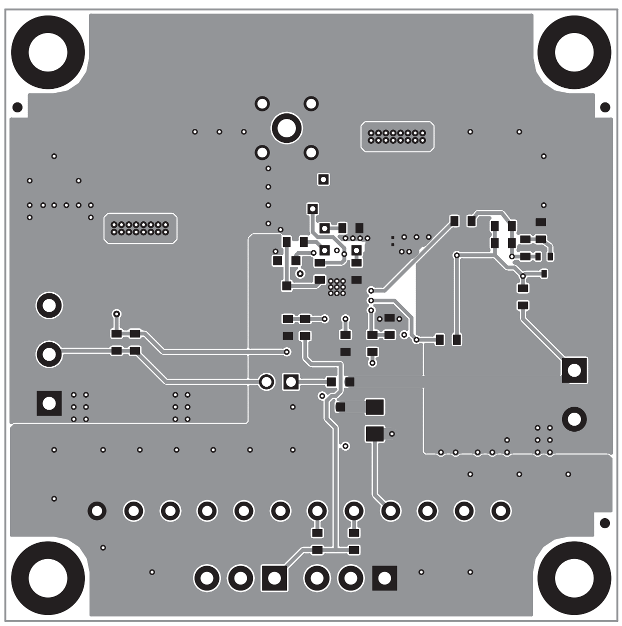


**Figure 8. Bottom Layer**

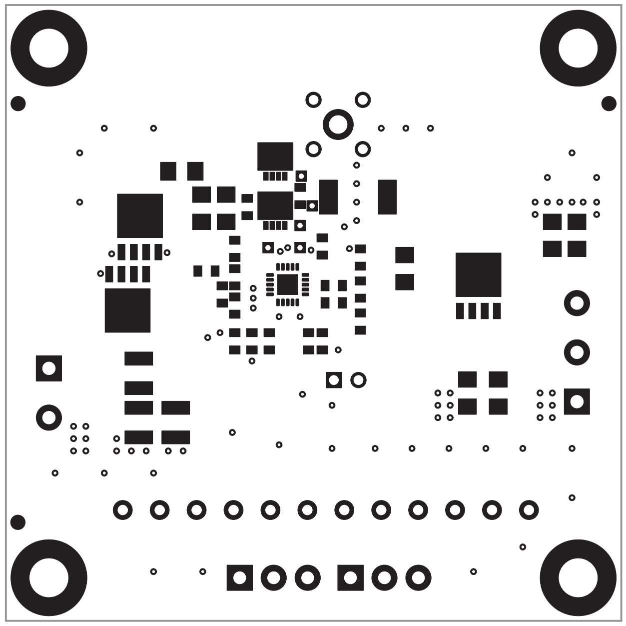


**Figure 9. Top Mask**

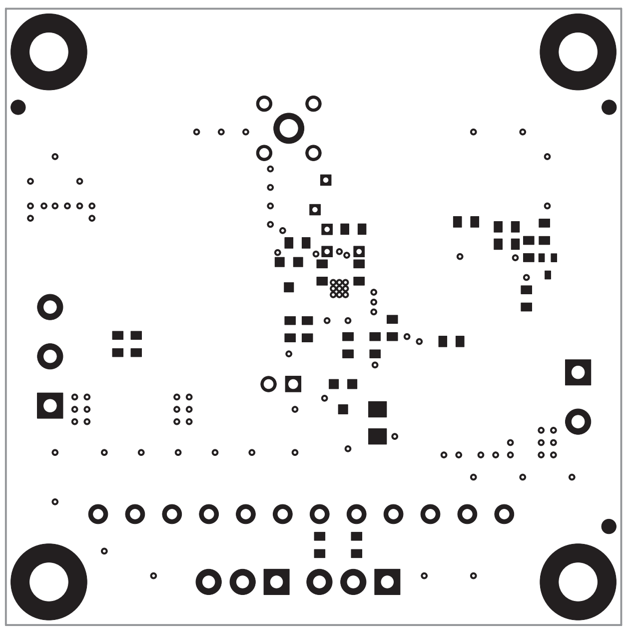


**Figure 10. Bottom Mask**

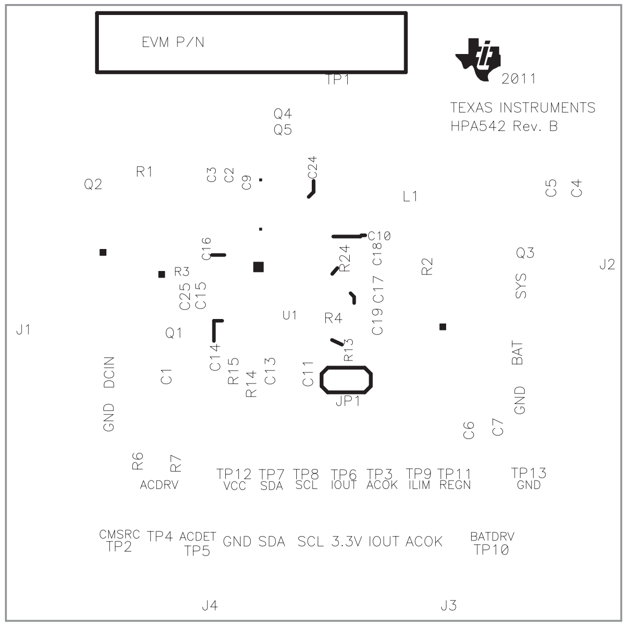



**Figure 11. Top Silkscreen**

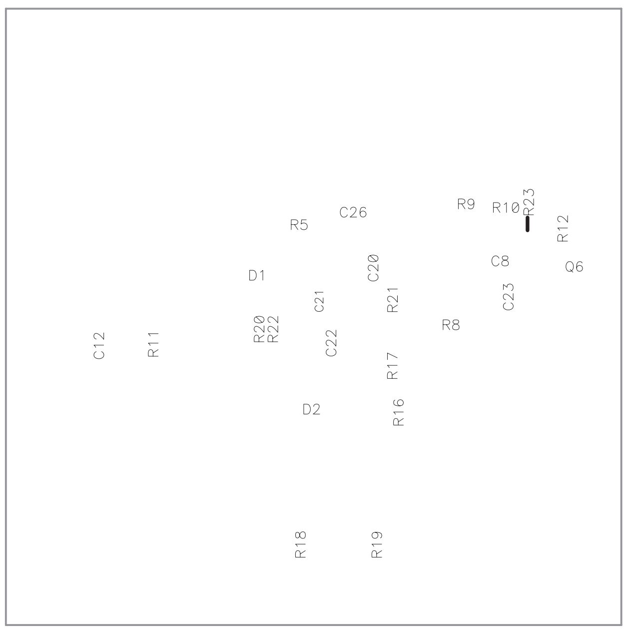



**Figure 12. Bottom Silkscreen**

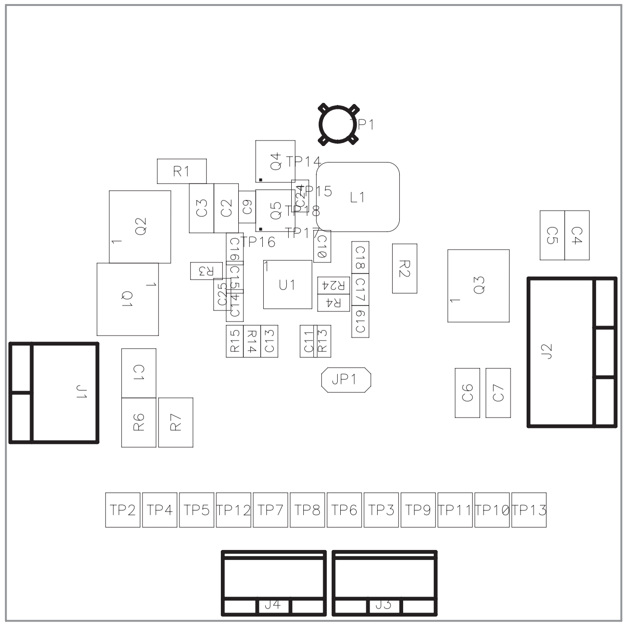



**Figure 13. Top Assembly**

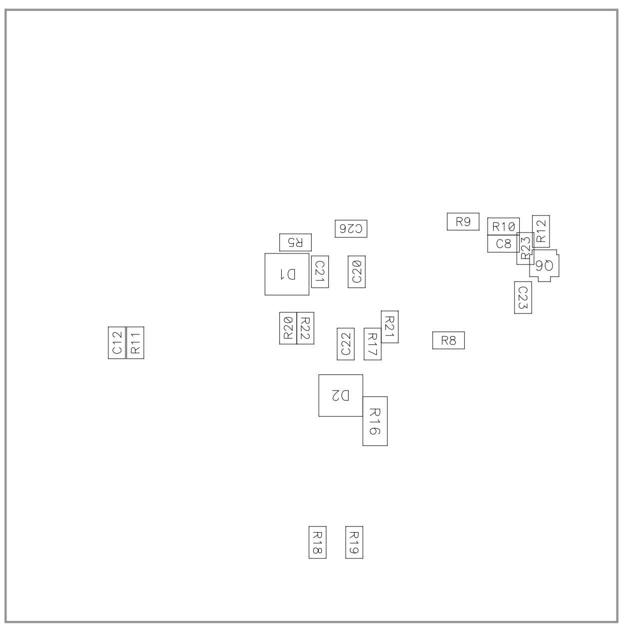
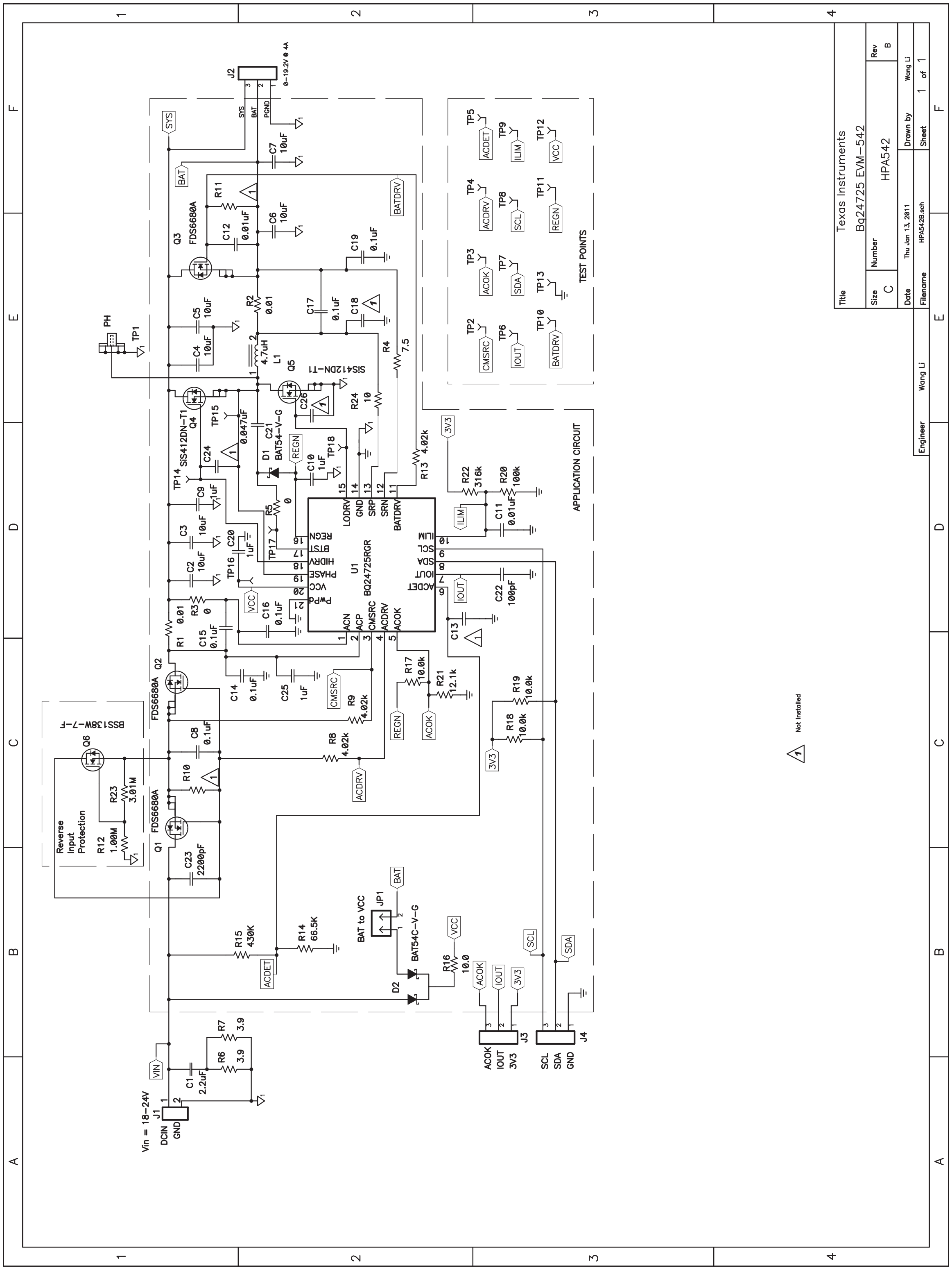



**Figure 14. Bottom Assembly**

## 4.3 Schematics

The schematic is shown on the following page.


Texas Instruments
Bq24725 EVM-542
HPA542
APPLICATION CIRCUIT
TEST POINTS
Reverse Input Protection
BQ24725RGR
Not Installed

## Evaluation Board/Kit Important Notice

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

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## EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 18 V to 22 V and the output voltage range of 6 V to 20 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60° C. The EVM is designed to operate properly with certain components above 60° C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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