User's Guide
SLUU306–March 2008

bq24745 EVM (HPA272) for Multi Cell Synchronous Switch-Mode Charger

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1 Introduction

1.1 EVM Features

- Evaluation Module For bq24745
- High Efficiency NMOS-NMOS Synchronous Buck Charger With 300 kHz Frequency
- User-selectable 1-cell, 2-cell, 3-cell, or 4-cell Li-ion Battery Voltage
- Programmable Battery Voltage, Charge Current, and AC Adapter Current via SBS-Like SMBus Interface
- AC Adapter Operating Range 18 V to 22 V
- LED Indication for Control and Status Signals.
- Test Points for Key Signals Available for Testing Purpose. Easy Probe Hook-up.
- Jumpers Available. Easy to Change Connections.

1.2 General Description

The bq24745 evaluation module is a complete charger module for evaluating a multi-cell synchronous notebook charge using the bq24745 devices. It is designed to deliver up to 8 A of charge current to Li-Ion or Li-Pol applications.

The bq24745 has a highly integrated battery charge controller designed to work with external host commands. The charge voltage, charge current, and input current are programmable using an SBS-like SMBus interface.

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 complete specifications and details, see bq24745 data sheet (SLUS761).

1.3 EVM Connection Descriptions

Table 1. bq24745 EVM Connections

Jack		Description
J1–ACPWR		AC adapter, positive output
J1–GND		AC adapter, negative output
J2–CE		CE pin output
J2–SDA		SDA pin output, SMBus data line
J2–SCL		SCL pin output, SMBus clock line
J3–VEXT		External power supply, positive output
J3–GND		External power supply, negative output
J4–ACOK		ACOK pin
J4–ICOUT		ICOUT pin
J4–VICM		VICM pin
J4–VREF		IC reference voltage VREF
J5–1	ACDRV	ACDRV signal
J5–2		LED drive
J6–1	BATDRV	BATDRV signal
J6–2		LED drive
J7–1	DIS CHG	CE pin
J7–2		GND

Table 1. bq24745 EVM Connections (continued)

Jack		Description
J8–HI		Pull-up voltage source
J8–LEDPWR		LED Pull-up power line
J9–VREF		IC reference voltage VREF
J9–VDDSMB		VDDSMB pin
J9–EXT		External voltage supply from J3
J10–GND		Ground
J10–BAT		Connected to battery pack
J10–SYS		Connected to system
J11–1	BYPASS	BYPASS signal
J11–2		LED drive

1.4 Controls and Key Parameters Setting

Table 2. Controls and Key Parameters

Jack	Description	Factory Setting
J5	Conduction of the AC MOSFET indicated when LED lights	Jumper On
J6	Conduction of the battery MOSFET indicated when LED lights	Jumper On
J7	Disable charge process when on	Jumper On
J8	Pull-up power source supplies the LEDs when on LED has no power source when off	Jumper On
J9	VDDSMB voltage source setting 1-2 : Connect VREF to VDDSMB 2-3 : Connect external voltage source to VDDSMB	Jumper on 2-3 (EXT and VDDSMB)
J11	Conduction of the BYPASS MOSFET indicated when LED lights	Jumper On

1.5 Recommended Operating Conditions

Table 3. Recommended Operating Conditions(1)

Parameter		Description	MIN	TYP	MAX	Unit
V_{IN}	Supply voltage	Input voltage from ac adapter input	18	19	22	V
V_{BAT}	Battery voltage	Voltage applied at VBAT terminal of J8	0	3 to 16.8	20	V
I_{AC}	Supply current	Maximum input current from ac adapter input	0		4.5	A
I_{chrg}	Charge current	Battery charge current	2	3 to 4	8	A
T_J	Operating junction temperature range		0		125	°C

(1) For complete specifications and details, see the bq24745 data sheet (SLUS761).

2 Test Summary

This section describes how to configure the bq24745 evaluation board and provides:

- Test Procedure Naming Conventions
- Required Equipment and Software
- Equipment Setup
- Software Installation
- Test Procedures

2.1 Test Procedure Naming Conventions

See the bq24745 schematic for details. On the test procedure these naming conventions are used.

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 the locations for jumpers, test points, and individual components.

2.2 Required Equipment and Software

Table 4. Required Equipment and Software

CATEGORY	NUMBER	DESCRIPTION of REQUIRED ITEM
Power Supplies	PS#1	Can supply 20 V at 5 A
	PS#2	Can supply 5 V at 1 A
	PS#3	Can supply 20 V at 5 A
Loads	Number 1	A 30 V (or greater), 5 A (or greater) electronic load that can operate at constant current mode
	Number 2	An HP 6060B (3 to 60 V) / (0 to 60 A), 300 W system DC electronic load, or equivalent
Meters	Set #1	Seven Fluke 75 multimeters, (equivalent or better)
	Alternative set	Four equivalent voltage meters and three equivalent current meters. Current meters must be capable of measuring 5 A current, or greater.
Computer	One	One USB port, with a USB cable Operating System: Windows 2000 or Windows XP
Communications Kit	One	EV2300 SMBUS Kit that supports SMB four-wire communications
Software	EV2300 USB driver	File: **Driver(USB EV2300) Installer XP2K-Last updated Jan28-04.zip**
	bq24745 SMB evaluation	File: **bq24745bench_v141.zip**

2.3 Software Installation

To install the two software packages necessary to perform the test procedures, use this procedure:

1. Save and unzip the EV2300 USB driver, **Driver(USB EV2300) Installer XP2K-Last updated Jan28-04.zip** filename, to a temporary directory (*c:\temp* or another directory).

2. Double-click on the **setup.exe** installation file.
3. Follow steps displayed by the Installshield wizard that include license agreement, installation directory selection, and completion.
4. Save and unzip the bq24745 SMB evaluation, **bq24745bench_v141.zip** filename, to a temporary directory (*c:\temp* or another directory).
5. Double-click on the **setup.exe** installation file.
6. Follow steps displayed by the Installshield wizard that include license agreement, installation directory selection, and completion.

2.4 Equipment Setup

1. Set power supply #1 to 0 V ± 100 mVDC, 5.0 ± 0.1 A current limit and then turn off the power supply.
2. Connect the output of power supply #1 in series with a current meter (multimeter) to J1 (VIN, GND).
3. Connect a voltage meter across J1 (VIN, GND).
4. Set power supply #2 fto 3.3 V ± 100 mVDC, 1.0 ± 0.1 A current limit and then turn off the power supply.
5. Connect the output of the power supply #2 to J3 (VEXT, GND).
6. Turn off Load #1.
7. Turn off Load #2.
8. Connect a voltage meter across J10 (BAT, GND).
9. Connect a voltage meter across J10 (SYS, GND).
10. Connect J2 (SDA, SCL) and J3 (GND) to the EV2300 kit *SMB* port. Connect the USB port of the EV2300 kit to the USB port of the computer. The connections are shown in Figure 1

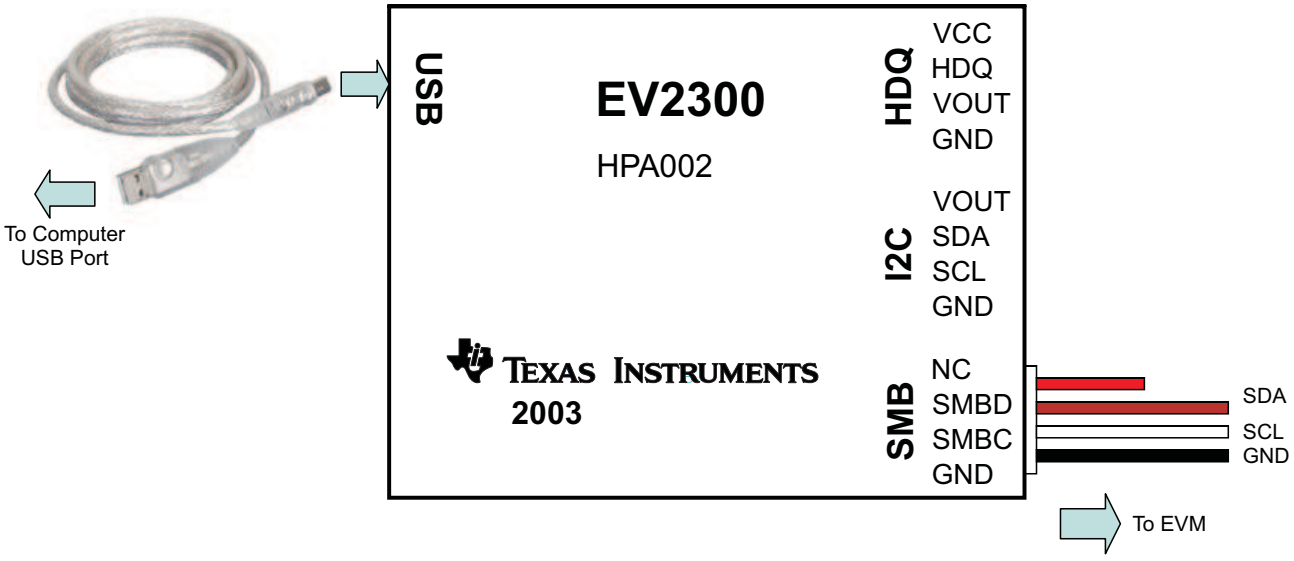

Figure 1. EV2300 Kit Connections

11. Ensure J5: ON, J6: ON, J7: ON, J8: ON, J9 (VDDSMB, EXT): ON, and J11: ON.
    After these previous eleven steps, the test setup for bq24745EVM (HPA272) is shown in Figure 2.

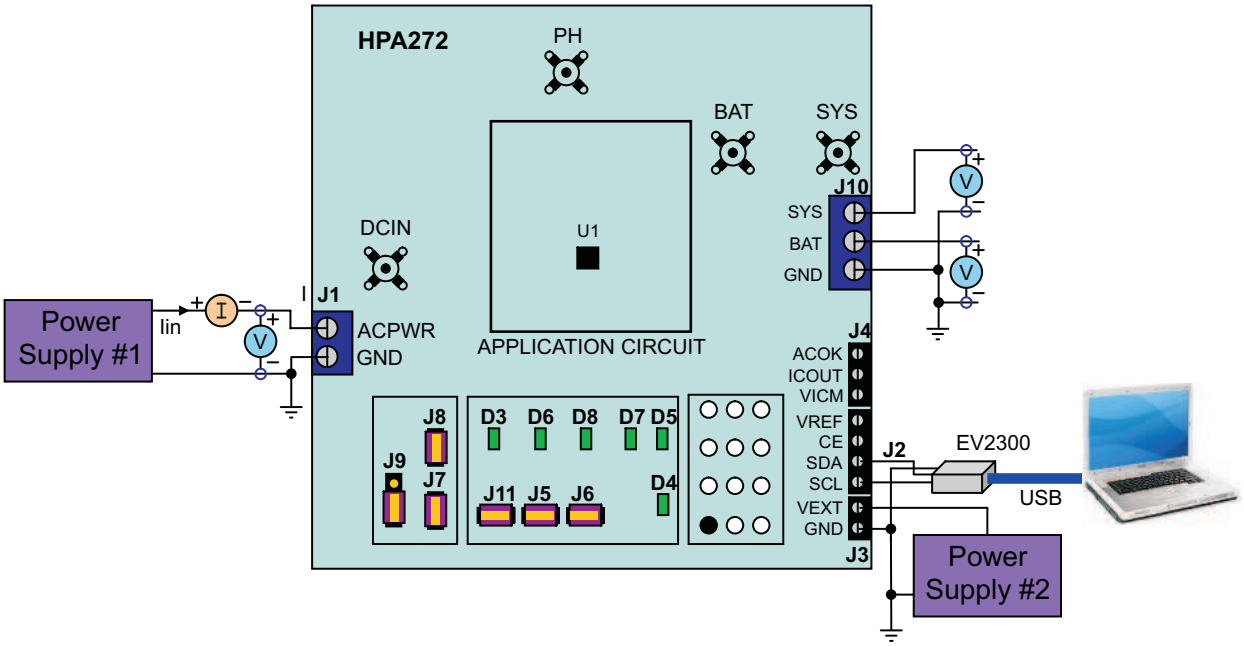

Figure 2. bq24745 EVM Original Test Setup

12. Start the host computer. Start the bq24745 evaluation software by using the cascading menus to select the **start** → **All Programs** → **Texas Instruments** → **bq24745 Evaluation Software** command. The EVM Software displays as shown in Figure 3.

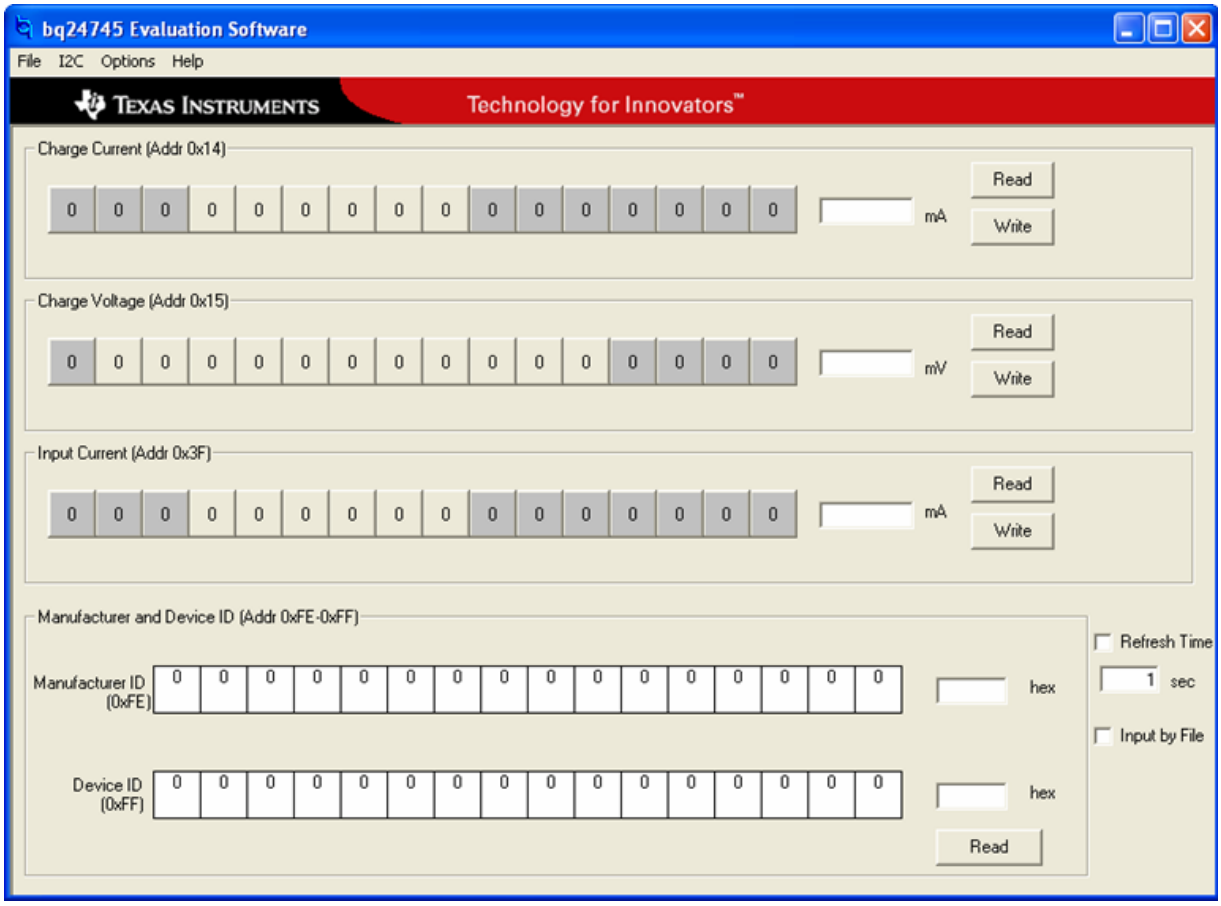

Figure 3. bq24745 SMB Evaluation Software (Main Window)

2.5 Test Procedures

AC Adapter Detection Threshold Procedure

1. Ensure that all Equipment Setup steps are completed.
2. Turn on power supply two.
3. Turn on power supply one.
4. Make these voltage measurements:
   - V(J10(SYS)) = 0 V ± 500 mV
   - V(TP(VREF)) = 0 V ± 1000 mV
   - V(TP(VDDP)) = 0 V ± 500 mV
5. Increase the output voltage of power supply one until LED D5 (ACOK) lights without exceeding 20 V output limit.
6. Make these voltage measurements:
   - V(TP(ACIN)) = 2.4 V ± 200 mV
   - V(J1(VIN)) = 17.9 V ± 1 V
   - V(J10(SYS)) = 17.9 V ± 1 V
   - V(TP(VREF)) = 3.3 V ± 200 mV
   - V(TP(VDDP)) = 0 V ± 500 mV
7. Observe that these LED diodes light:
   - D3 (BYPASS)
   - D6 (ACDRV)

Charger Parameters Setting Procedure

1. Increase the voltage of power supply one until you measure V(J1(VIN)) = 19 V ± 0.1 V.
2. Measure the voltage V(J10(BAT, GND)) = 0 V ± 1 V.
3. Go to the **bq24745 Evaluation Software** window and click all four **Read** buttons. Make sure no error information messages display.
4. To set the battery charge current regulation threshold, click in the **Charge Current** text field **mA**, type *512*, and click the **Write** button.
5. Click in the **Charge Voltage** text field **mV**, type *12592*, and click the **Write** button to set the battery voltage regulation threshold.
6. To set the input current regulation threshold, click in the **Input Current** text field **mA**, type *4608*, and click the **Write** button.
7. Uninstall J7 to enable the charging.
8. Observe that the LED D4 (CHG EN) lights.
9. Make these voltage measurements:
   - V(J10(BAT)) = 12.6 V ± 200 mV
   - V(J4(ICOUT)) = 3.3 V ± 300 mV
   - V(TP(VDDP)) = 6 V ± 500 mV

Charge Current and AC Current Regulation (DPM) Procedure

1. Install J7 to disable the charging.
2. Connect the Load Two in series with a current meter (multimeter) to J10 (BAT, GND). Make sure a voltage meter is connected across J10 (BAT, GND).
3. Turn on the Load Two using the constant voltage mode. .
4. Set the output voltage of to 10.5 V for Load Two
5. Connect the output of the Load One in series with a current meter (multimeter) to J10 (SYS, GND). Make sure a voltage meter is connected across J10 (SYS, GND).
6. Turn on the power of Load One.

7. Set the load current to 4.0 A ± 50 mA, but disable the Load One output.
8. Make sure I_{bat} = 0 A ± 10 mA and I_{sys} = 0 A ± 10 mA. Your bq24745 (HPA272) test setup should look like Figure 4.

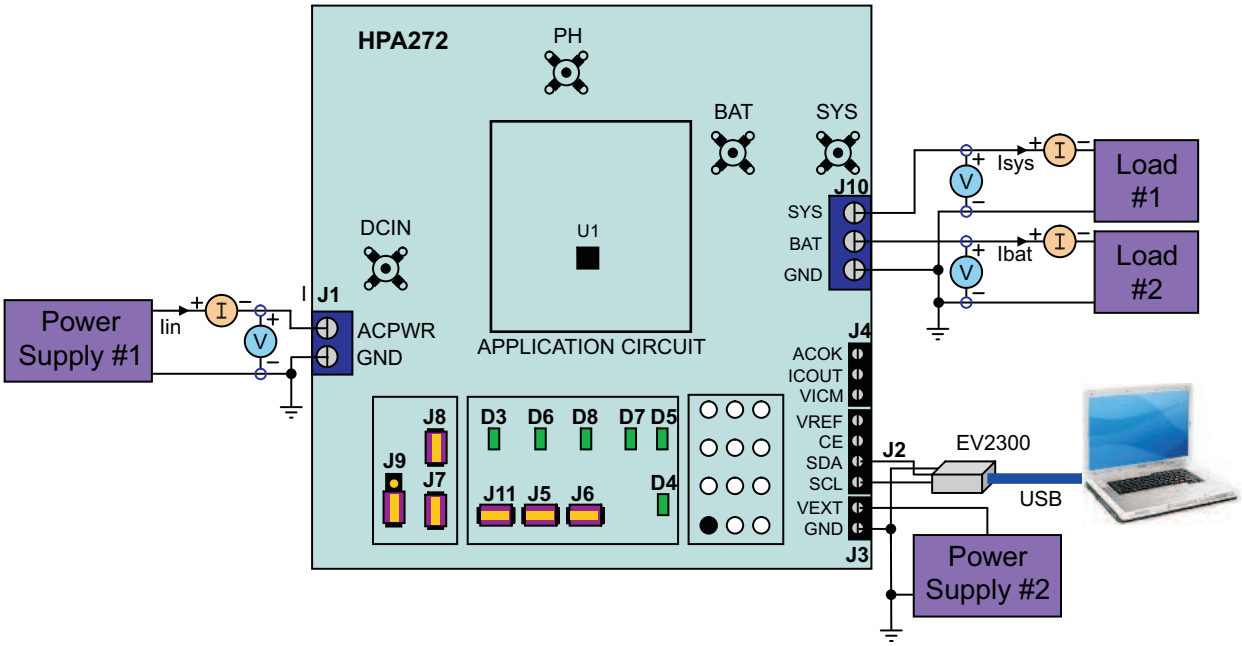

Figure 4. bq24745 EVM (HPA272) Test Setup

9. Uninstall J7 to enable the charging.
10. Observe that LED D4 (CHG EN) lights.
11. Set the battery charge current regulation threshold to 2.944 A by clicking in the **Charge Current** text field **mA**, type *2944*, and click the **Write** button.
12. Make these current and voltage measurements:
    - I_{bat} = 3000 mA ± 300 mA
    - V(TP(VICM)) = 350 mV ± 100 mV
    - V(J4(ICOUT)) = 3.3 V ± 300 mV
13. Observe that LED D7 (LO PWR MODE) lights.
14. Enable the output of Load One.
15. Make these current measurements:
    - I_{sys} = 4000 mA ± 200 mA
    - I_{bat} = 1000 mA ± 500 mA
    - I_{in} = 4600 mA ± 500 mA
16. Make these voltage measurements:
    - V(TP(VICM)) = 920 mV ± 100 mV
    - V(J4(ICOUT)) = 0 V ± 300 mV
17. Observe that LED D7 (LO PWR MODE) turns off.
18. Disable Load One.
19. Make these current measurements:
    - I_{sys} = 0 mA ± 100 mA
    - I_{bat} = 3000 mA ± 300 mA

Power Path Selection Procedure

1. Install J7 to disable the charging.
2. Observe that LED D4 (CHG EN) turns off.
3. Replace Load Two and the current meter with Power Supply Three.
4. Connect a voltage meter across J10 (BAT, GND).
5. Enable the output of the Power Supply Three and ensure the output voltage is 10.5 V ± 500 mV.
6. Measure the voltage V(J10(SYS)) = 19 V ± 1 V (adapter connected to system).
7. Observe these LED states:
   - D3 (BYPASS) lights
   - D6 (ACDRV) lights
   - D8 (BATDRV) turns off
8. Turn off Power Supply One.
9. Measure the voltage V(J10(SYS)) = 10.5 V ± 1 V (battery connected to system).
10. Observe these LED states:
    - D3 (BYPASS) turns off
    - D6 (ACDRV) turns off
    - D8 (BATDRV) lights

3 PCB Layout Guidelines

1. It is critical that the exposed power pad on the backside of the bq24745 package be soldered to the PCB ground. Make sure there are sufficient thermal vias right underneath the IC, connecting to the ground plane on the other layers.
2. The control stage and the power stage *should be* routed **separately**. At each layer, the signal ground and the power ground are connected only at the power pad.
3. AC current sense resistor *must* be connected to CSSP and CSSN with a Kelvin contact. The area of this loop must be minimized. The decoupling capacitors for these pins should be placed as close to the IC as possible.
4. Charge current sense resistor must be connected to CSOP, CSON with a Kelvin contact. The area of this loop must be minimized. The decoupling capacitors for these pins should be placed as close to the IC as possible.
5. Decoupling capacitors for DCIN, VREF, VDDP should be placed underneath the IC (on the bottom layer) and make the interconnections to the IC as short as possible.
6. Decoupling capacitors for BAT, VICM *must* be placed close to the corresponding IC pins and make the interconnections to the IC as short as possible.
7. Decoupling capacitor(s) for the charger input *must* be placed very close to Q4 drain and Q5 source.

4 Bill of Materials, Board Layout, and Schematic

4.1 Bill of Materials

Table 5. bq24745EVM Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
1	C1	2.2µF	Capacitor, Ceramic, 25V, X5R, 10%	1210	Std	Std
0	C2, C10	Open	Capacitor, Ceramic, 25V, X5R, 10%	1210	Std	Std
0	C3	Open	Capacitor, Ceramic, 35V, X5R, 10%	805	Std	Std
2	C4, C11	10nF	Capacitor, Ceramic, 50V, X7R, 10%	603	Std	Std
1	C5	2000 pF	Capacitor, Ceramic, 50V, C0G, 5%	603	Std	Std
1	C6	51 pF	Capacitor, Ceramic, 50V, C0G, 5%	603	Std	Std
7	C7, C12, C13, C17, C20, C22, C28	0.1µF	Capacitor, Ceramic, 50V, X7R, 10%	805	Std	Std
1	C8	130pF	Capacitor, Ceramic, 50-V, C0G, 5%	603	Std	Std
1	C9	1µF	Capacitor, Ceramic, 25V, X5R, 10%	603	Std	Std
1	C14	100pF	Capacitor, Ceramic, 50V, C0G, 5%	603	Std	Std
3	C15, C19, C21	1µF	Capacitor, Ceramic, 25V, X5R, 10%	805	Std	Std
4	C16, C18, C23, C26	10µF	Capacitor, Ceramic, 25V, X5R, 10%	1210	Std	Std
2	C24, C30	10µF	Capacitor, Ceramic, 25V, X5R, 10%	1206	Std	Std
0	C25	Open	Capacitor, Ceramic, 50V, X7R, 10%	603	Std	Std
2	C27, C29	0.1µF	Capacitor, Ceramic, 50V, X7R, 10%	603	Std	Std
1	D1	BAT54	Diode, Schottky, 200-mA, 30-V	SOT23	BAT54	Vishay-Liteon
1	D2	BAT54C	Diode, Schottky, 200-mA, 30-V	SOT23	BAT54C	Vishay-Liteon
6	D3, D4, D5, D6, D7, D8	Green	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	LED603	LTST-C190GKT	Lite On
1	J1	D120/2DS	Terminal Block, 2-pin, 15-A, 5,1mm	0.40 x 0.35 inch	D120/2DS	OST
1	J2	ED555/3DS	Terminal Block, 3-pin, 6-A, 3.5mm	0.41 x 0.25 inch	ED555/3DS	OST
1	J3	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25 inch	ED555/2DS	OST
1	J4	ED555/4DS	Terminal Block, 4-pin, 6-A, 3.5mm	0.55 x 0.25 inch	ED555/4DS	OST
5	J5, J6, J7, J8, J11	PTC36SAAN	Header, 2-pin, 100mil spacing, (36-pin strip)	0.100 inch x 2	PTC36SAAN	Sullins
1	J9	PTC36SAAN	Header, 3-pin, 100mil spacing, (36-pin strip)	0.100 inch x 3	PTC36SAAN	Sullins
1	J10	D120/3DS	Terminal Block, 3-pin, 15-A, 5.1mm	0.60 x 0.35 inch	D120/3DS	OST
6		929950-00	Shorting jumpers, 2-pin, 100mil spacing		929950-00	3M/ESD
4			6-32 NYL nuts			
4		4816	STANDOFF M/F HEX 6-32 NYL 0.500"	sf_thvt_325_rnd	4816	Keystone
1	L1	5.6µH	Inductor, SMT, 16A, 24.8mΩ	0.51 x 0.51 inch	IHLP5050CE5R6M01	Vishay
3	Q1, Q2, Q8	Si4435DY	MOSFET, P-ch, 30-V, 8.0-A, 20-mΩ	SO8	Si4435DY	Siliconix
9	Q3, Q6, Q10, Q11, Q13, Q14, Q15, Q17, Q18	2N7002DICT	MOSFET, N-ch, 60-V, 115-mA, 1.2-Ω	SOT23	2N7002DICT	Vishay-Siliconix
2	Q4, Q5	FDS6680A	Transistor, MOSFET, NChan, 30V, 12.5A, Rds 9.5 mΩ	SO8	FDS6680A	Fairchild
1	Q7	NDS0605	MOSFET,P-ch, –60 V, 180-mA, 5 Ω	SOT-23	NDS0605	Vishay
3	Q9, Q12, Q16	TP0610K	MOSFET, P-Ch, 60V, Rds 6 Ω, Id 185 mA	SOT-23	TP0610K	Vishay-Siliconix
2	R1,R40	4.02	Resistor, Chip, 1/2W, 1%	1210	Std	Std
1	R2	430K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R3	66.5K	Resistor, Chip, 1/16W, 1%	603	Std	Std

Table 5. bq24745EVM Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
11	R4, R5, R8, R10, R11, R14, R16, R19, R20, R23, R24	10K	Resistor, Chip, 1/16W, 5%	402	Std	Std
1	R6	200K	Resistor, Chip, 1/16W, 1%	402	Std	Std
1	R7	49.9K	Resistor, Chip, 1/16W, 1%	402	Std	Std
1	R9	200K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R12	7.5K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R13	4.7K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R15	1.40M	Resistor, Chip, 1/10W, 1%	805	Std	Std
2	R17, R21	0	Resistor, Chip, 1/16W, 5%	402	Std	Std
2	R18, R26	0.01	Resistor, Chip, 1/2W, 1%	2010	Std	Std
1	R22	1Meg	Resistor, Chip, 1/16W, 5%	402	Std	Std
8	R25, R27, R28, R29, R32, R33, R37, R38	100K	Resistor, Chip, 1/16W, 5%	402	Std	Std
6	R30, R31, R34, R35, R36, R39	2.2K	Resistor, Chip, 1/16W, 5%	603	Std	Std
2	TP1, TP23	5001	Test Point, Black, Thru Hole Color Keyed	0.100 x 0.100 inch	5001	Keystone
4	TP2, TP18, TP19, TP20	131-4244-00	Adaptor, 3.5-mm probe clip (or 131-5031-00)	0.200 inch	131-4244-00	Tektronix
11	TP21, TP22, TP24, TP25, TP26, TP27, TP28, TP29, TP30, TP31, TP32	5002	Test Point, White, Thru Hole Color Keyed	0.100 x 0.100 inch	5002	Keystone
1	U1	bq24745RHD	IC, SMBus-Controlled Level 2 Multi-Chem Battery Charger Controller		bq24745RHD	TI
1	–	HPA272	4x4.25 inch 4 layer 2oz. PCB	4x4.25 inch	PCB	Any

4.2 Board Layout

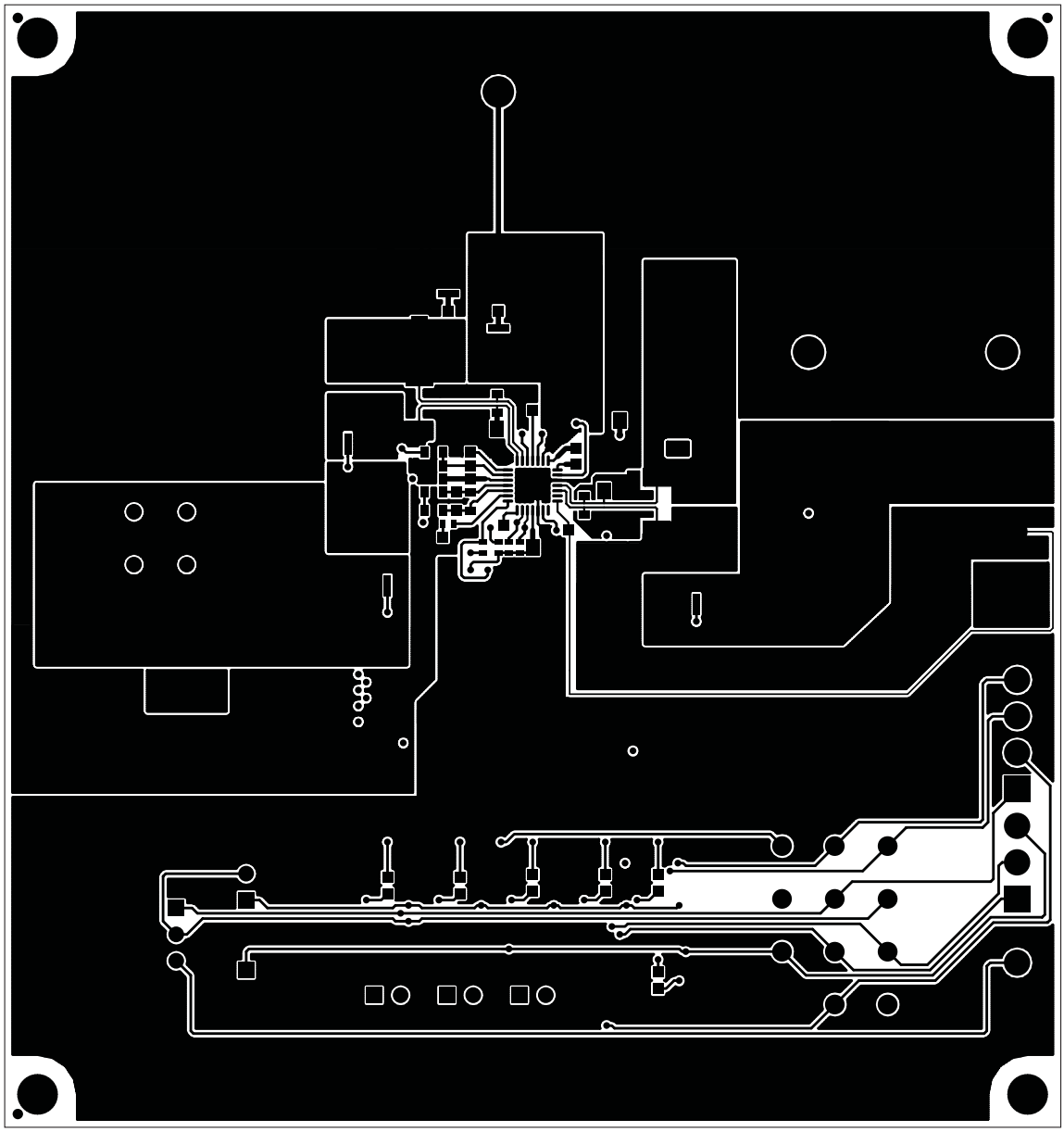

Figure 5. Top Routing Layer

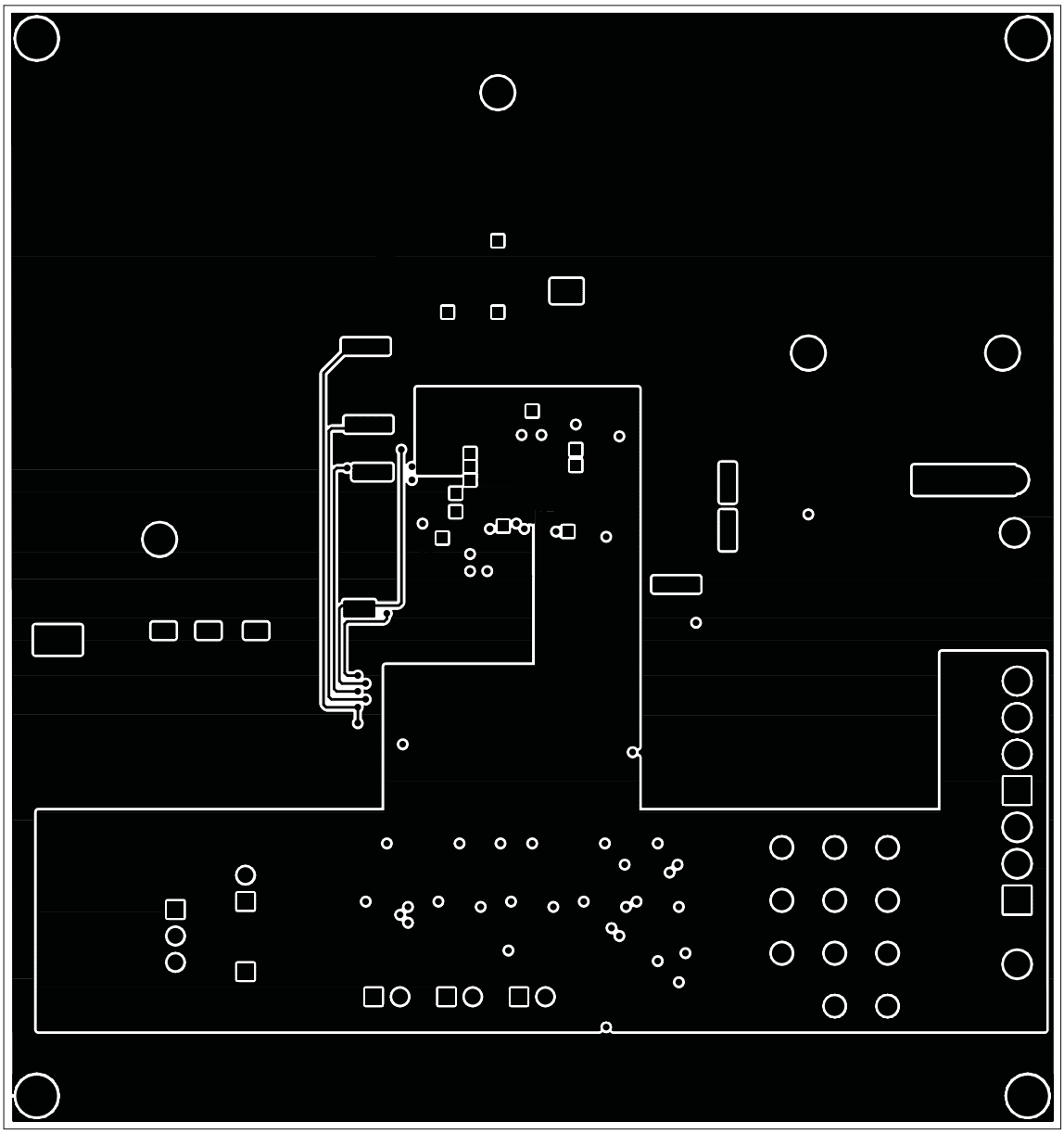

Figure 6. Second Routing Layer

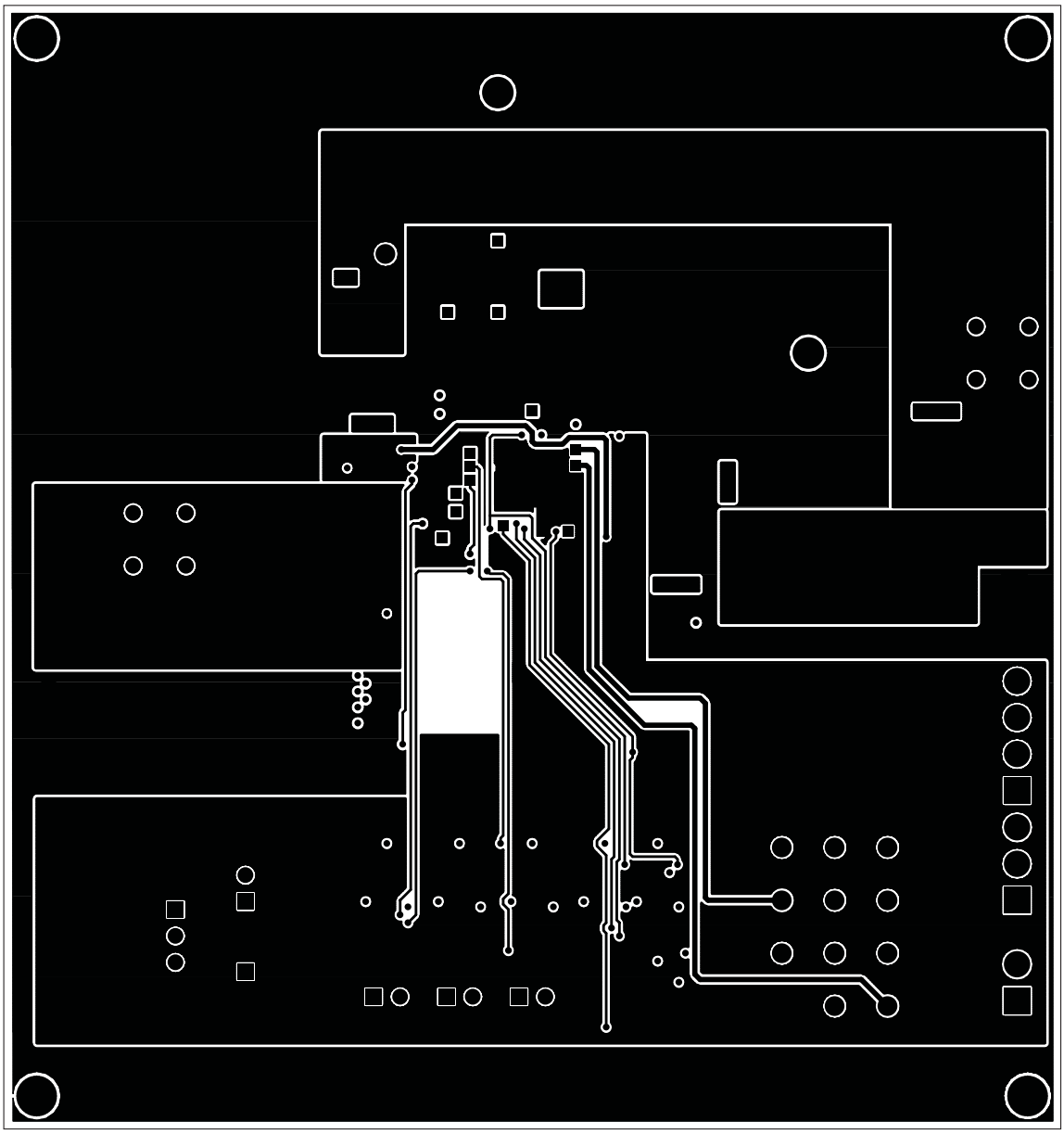

Figure 7. Third Routing Layer

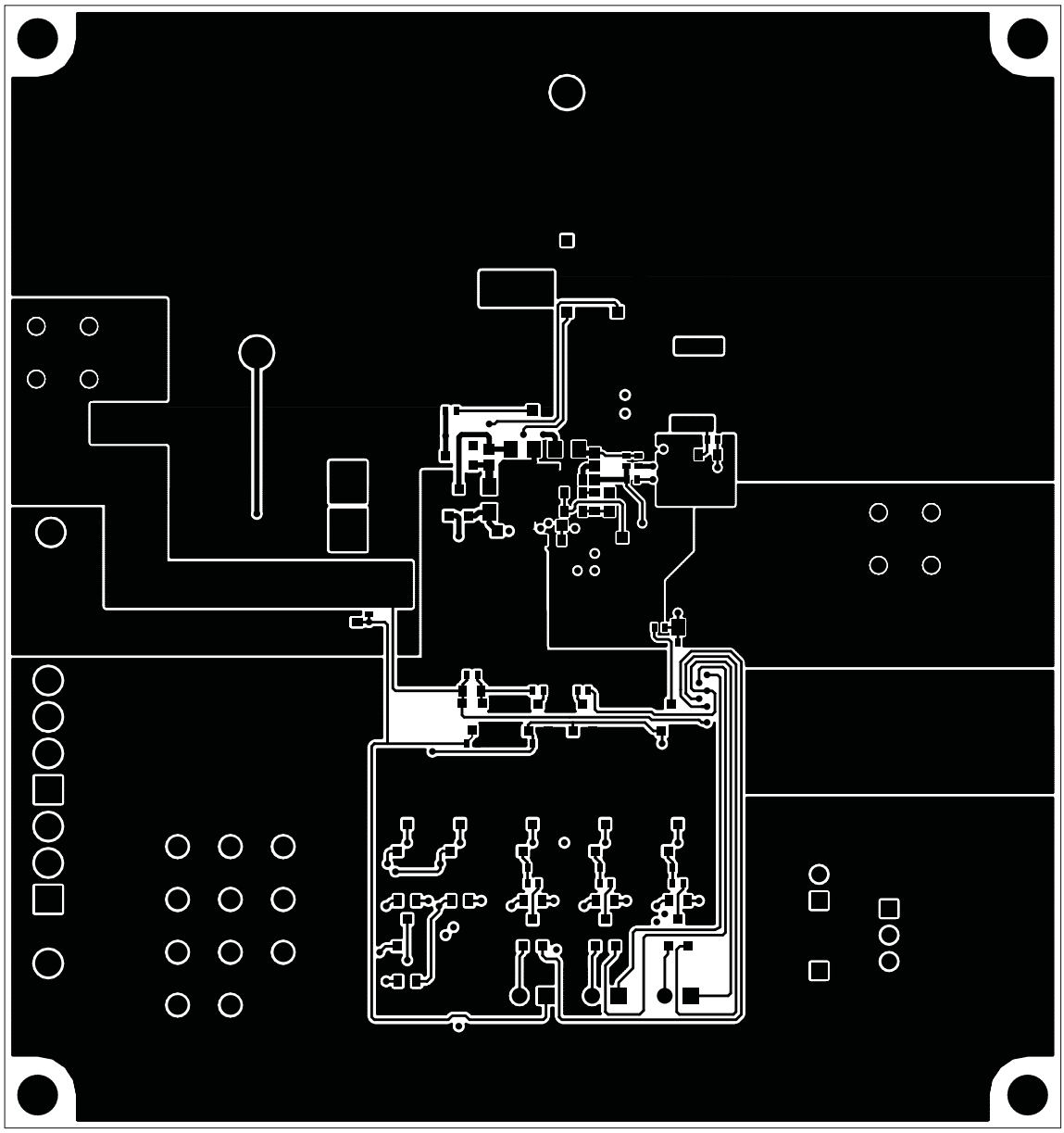

Figure 8. Bottom Routing Layer

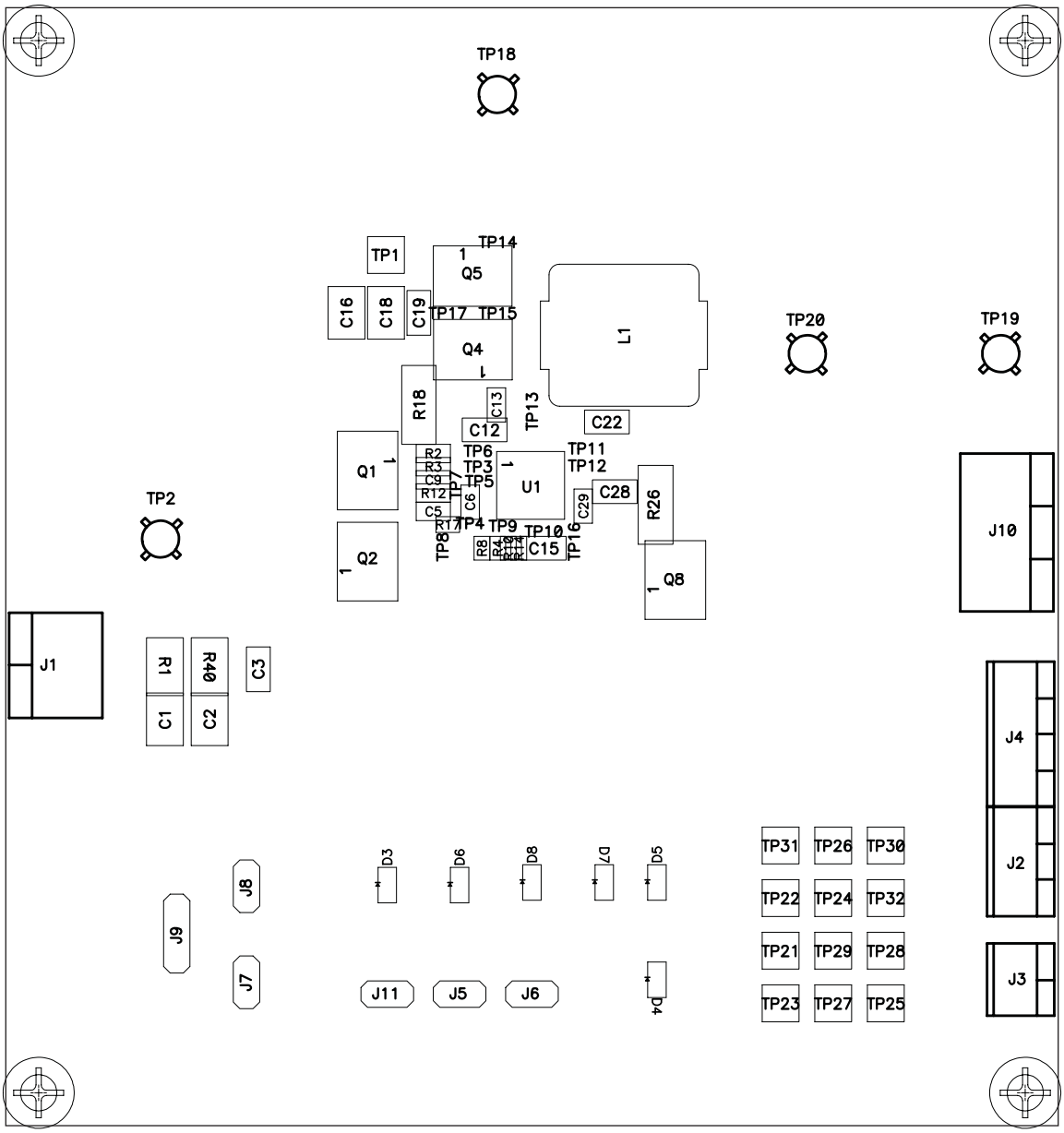

Figure 9. Top Assembly

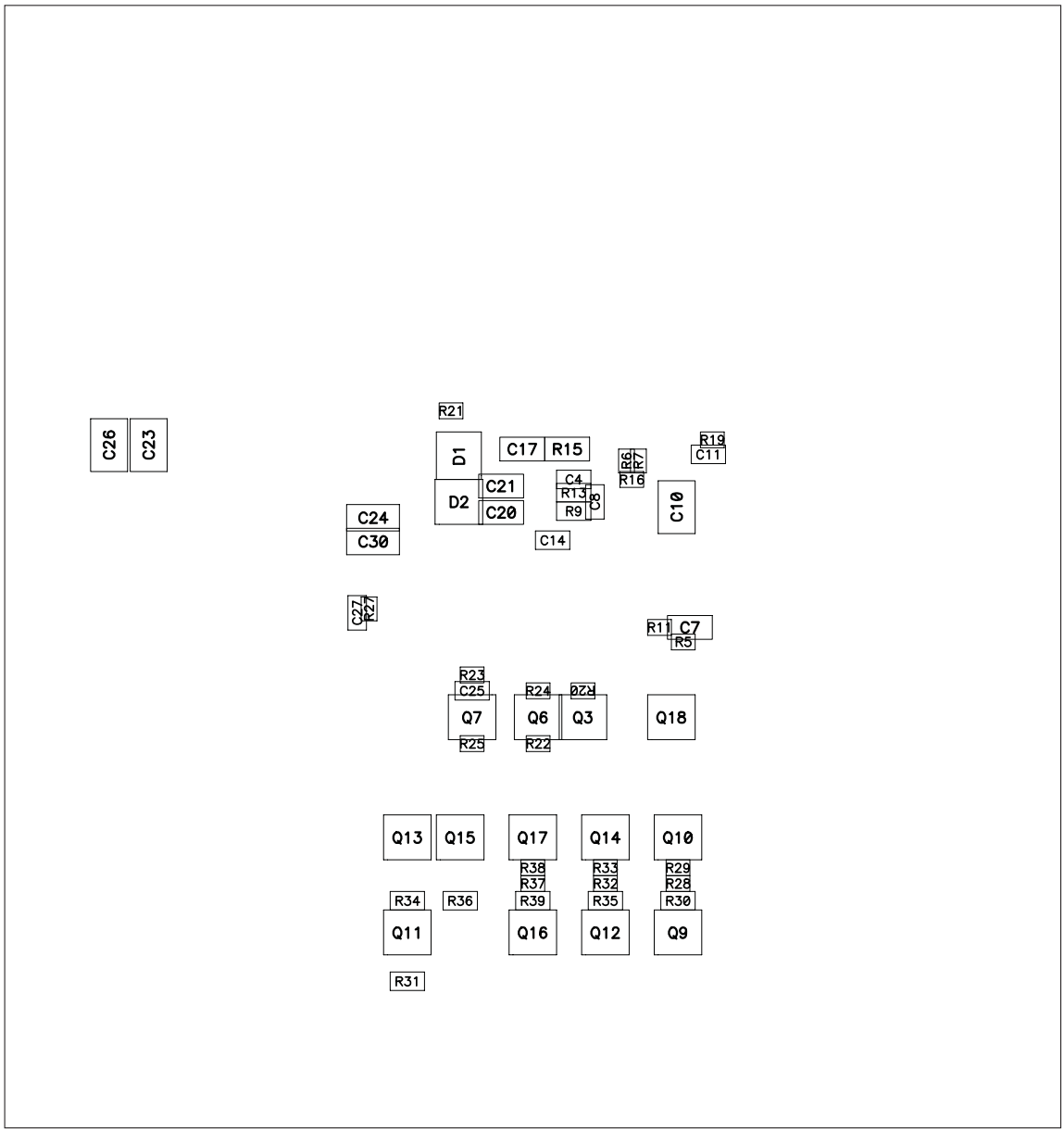

Figure 10. Bottom Assembly

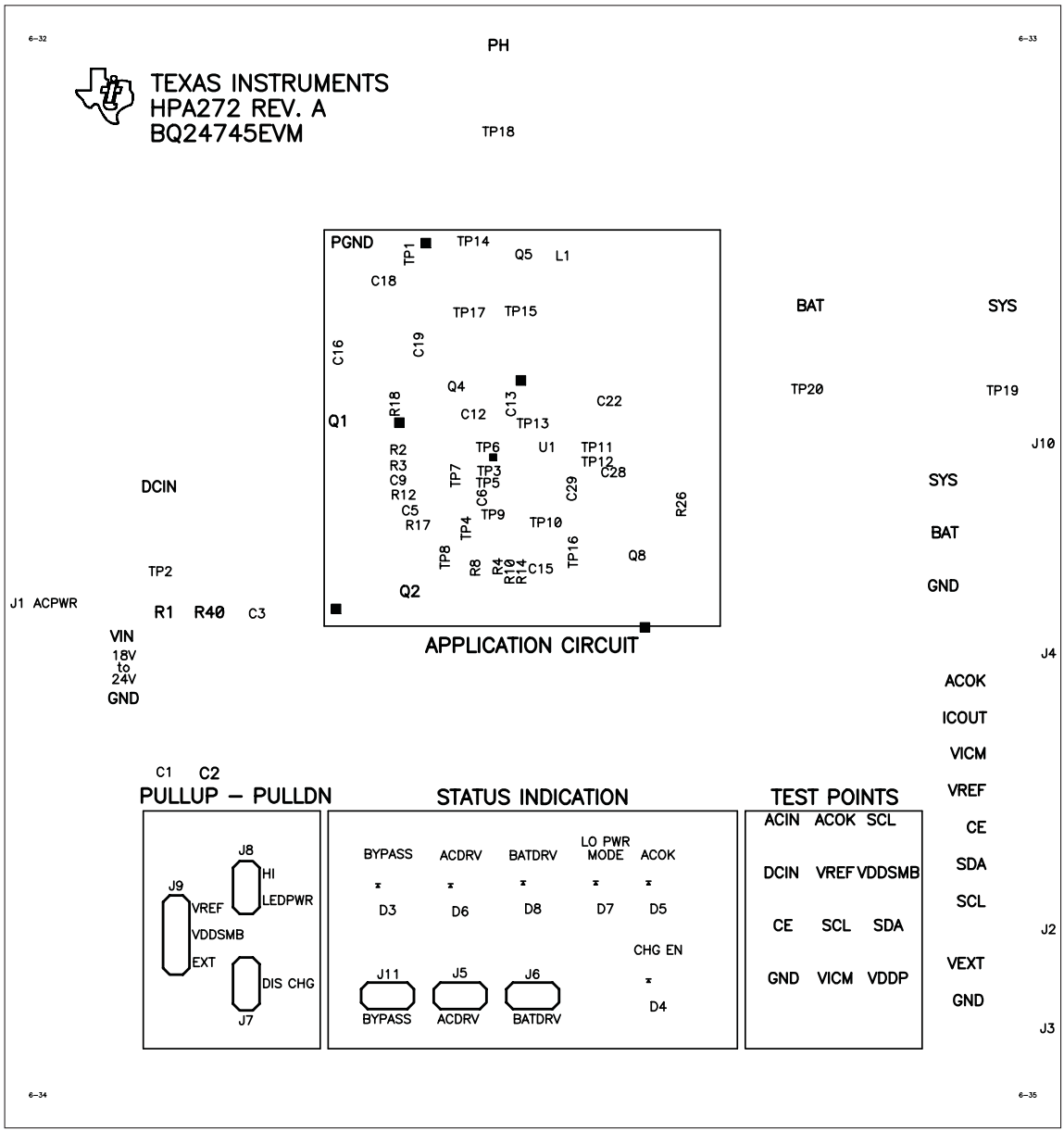

Figure 11. Top Silkscreen

4.3 Schematic

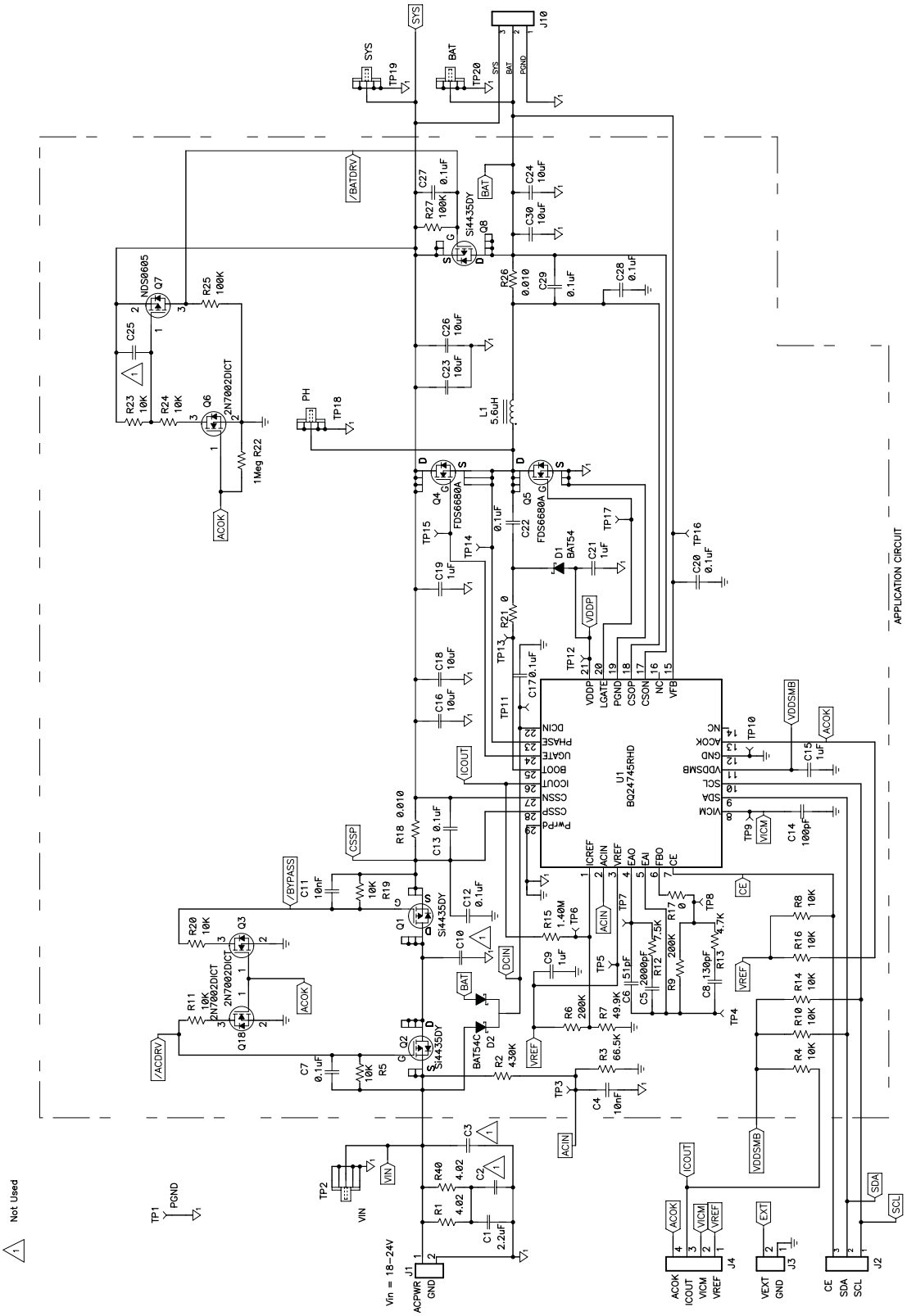

Figure 12. bq24745 EVM Schematic (Sheet 1 of 2)

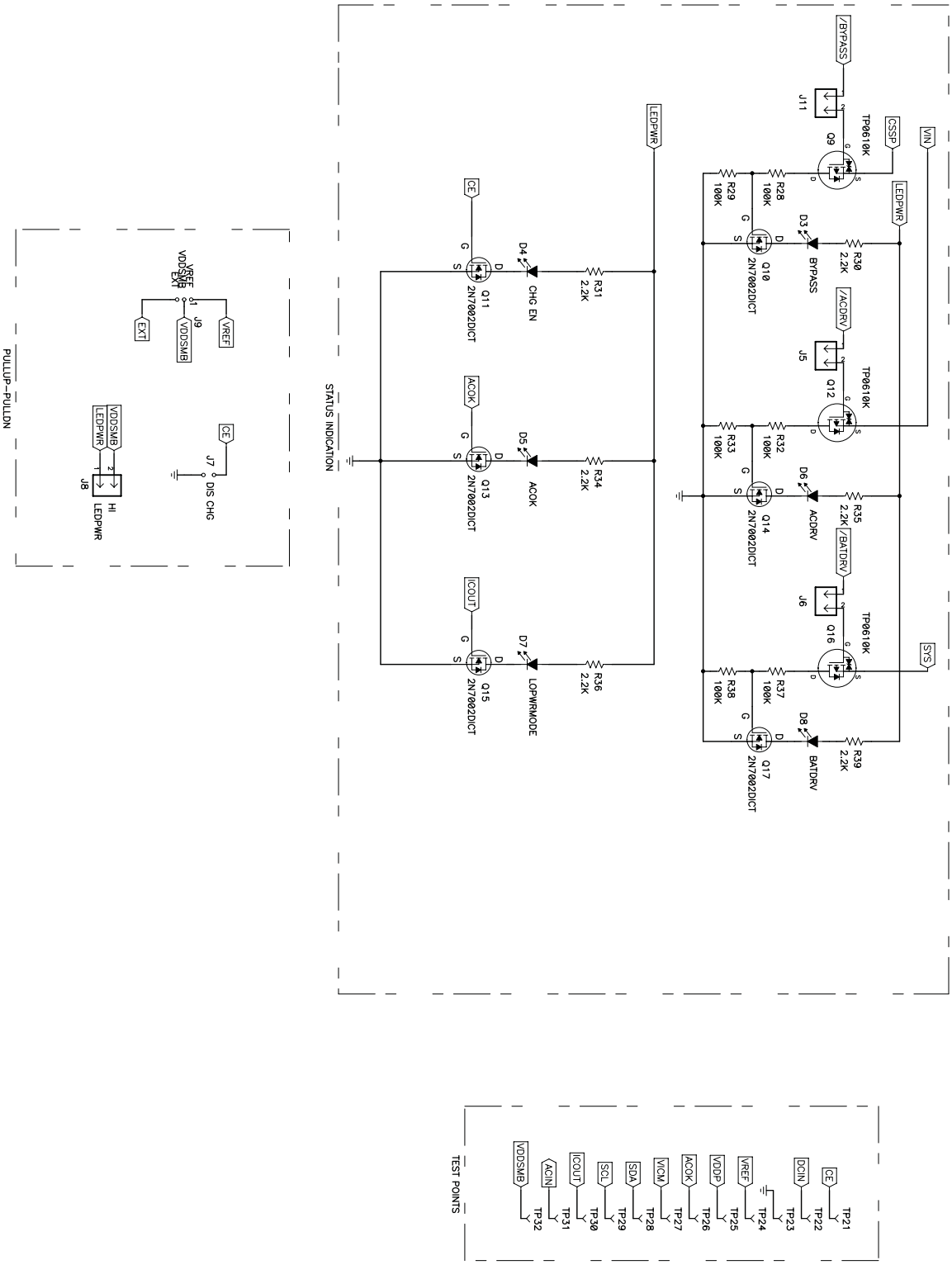

Figure 13. bq24745 EVM Schematic (Sheet 2 of 2)

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It is important to operate this EVM within the input voltage range of 0 V to 22 V and the output voltage range of 0 V to 20 V.

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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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