bq24700/bq24701

Notebook PC Battery-Charge Controller and Selector With DPM™ Evaluation Module

User's Guide

January 2002

PMP Battery Management

SLUU097

IMPORTANT NOTICE

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Chapter 1

Introduction

The bq2470x evaluation module (SLUU097) is a complete, designed-and-tested charger for evaluating a multichemistry charge-management solution for notebook PC applications using the bq2470x product family. The charger delivers up to 3 A of continuous charge current for three- or four-cell Li-Ion (or Li-Pol) or five- to ten-cell NiCd/NiMH applications.

The bq2470x is a highly integrated battery charge controller and selector for notebook and subnotebook PC applications. For details, see the bq2470x data sheet (literature number SLUS452A).

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1.1 Features

- Up to 3 A charge current
- Programmable adapter current, charge current, and charge voltage and battery depletion levels
- Support for single-chemistry and multichemistry applications
- Depleted battery detection and indication to protect battery from overdischarge
- Charge-enable and ac-select inputs

1.2 Kit Contents

- bq2470x evaluation module
- Support documentation

Table 1–1. Feature Sets of the bq24700 and bq24701

Condition		Selector Operation
Battery as power source	Battery removal	Automatically selects ac
	Battery re-inserted	Selection based on selector inputs
AC as power source	AC removal	Automatically selects battery
	AC Reapplied	Selection based on selector inputs
Depleted battery	Battery as power source	Sends alarm signal Automatically selects ac (bq24701 only)
	AC as power source	Sends alarm signal

1.3 Performance Specification Summary

This section summarizes the performance specifications of the SLUU097 EVM. Table 1–2 gives the performance specifications of the hubs.

Table 1–2. Performance Specification Summary†

Specification	Test Conditions	Min	Max	Unit
Input adapter voltage, V_{ADP}		V_{BAT}+1.0‡	28	V
Battery charge current, I_{CHG}	Set by host or jumper1	1	3	Amps
System current, I_{SYS}	Set by host or jumper2	1	3	Amps
Battery voltage regulation, V_{BAT}	Set by host or jumper3	9	16.8	V
Battery depletion level, V_{DEP}	Set by jumper4	4.8		V

† Electrical characteristics over recommended operating temperature (–40°C to 85°C)
‡ Minimum voltage due to valley of ripple voltage

Chapter 2

Test Summary

This chapter shows the test setups and the tests performed in designing the SLUU097 EVM.

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2.1 Setup

The bq2470X EVM board requires a dc power source to provide input power, and a load resistor or battery pack to charge.

The test setup connections and jumper setting selections are listed in Table 2–1 and 2–2..

Table 2–1. I/O Connections

Jack	Connect To
J1–Vin	Power source positive output
J1–GND	Power source negative output
J2–SYS	Positive output to system. For setup, do not make a connection until instructed.
J2–GND	Return output to system. For setup, do not make a connection until instructed.
J2–VBAT	Positive output to battery pack. For setup procedure, connect 100-Ω, 5-W resistor, with respect to GND
J2–GND	Negative output to battery pack. For setup procedure, connect 100-Ω, 5-W resistor with respect to VBAT.
J3–ENABLE	0 Vdc: disable; 5Vdc: enable. Use JMPR J4 for local control only.
J3–ACSEL	0 Vdc: disable; 5 Vdc: enable. Use JMPR J5 for local control only.
J7–SRSET	$V_{(srset)} = 25 \times Rs \cdot \times I_{bat}$; $V_{(srset)} < 2.0$ V
J7–ACSET	$V_{(acset)} = 25 \times R \times I_{bat}$; $V_{(acset)} < 2.0$ V
J7–BATSET	5 Vdc < $V_{(batset)}$ < 0.25 Vdc enabled; $V_{(batset)}$ < 0.25 V disabled and uses fixed internal reference.
J7–GND	Signal return
J11–ALARM	TTL HIGH is a battery depletion alarm.
J11–ACPRES	TTL high implies input power good to charge.
J11–IBAT	Relative indication for battery charge current. See data sheet for more detail.
J11–GND	Signal return

Table 2–2. Jumper Selectable Configuration (Factory Set to Bold Selections)

Jumper	Selection
J4	ENABLE, local control, **ON** | OFF†
J5	ACSEL, local control, **ON** | OFF†
J6	VS, set for **ADJ** or OFF
J8	SRSET, set for EXT or **LCL** control.
J9	ACSET, set for EXT or **LCL** control.
J10	BATSET, set for EXT or **LCL** control.

† Do not use jumper if using external control.

2.2 Setup and Test Procedure for Li-Ion/Li-Pol Applications

The bq2470XEVM is configured from the factory as shown in Table 2–3.

Table 2–3. Battery Pack: Four 4.2-V Cells (16.8-V Pack)

Potentiometer Adjustment	**Threshold Setting**
R9 – ACDET ADJ. (power present threshold)	17.8 V
R31 – BATSET ADJ. (fixed/adjustable reference)	If $V_{BATSET} \le 0.25$ V, then $V_{REF} = 1.25$ V; If $V_{BATSET} > 0.25$ V, then $V_{REF} = V_{BATSET}$
R29 – ACSET ADJ. (input current limit)	3A
R27 – SRSET ADJ. (battery charge current limit)	2 A
R24 – BATP ADJ. (battery regulation voltage)	16.8 V
R22 – BATDEP ADJ. (depletion alarm threshold)	12 V
R18 – VS ADJ. (break before make system power threshold)	16.8 V

This procedure configures the evaluation board and evaluates the IC using the EVM as a stand-alone unit. The board was originally configured according to Table 2–3. To configure the board differently, make sure the EVM is set up as shown in the I/O and jumper tables above. An external power source (20 V, 3 A) and a 100 Ω, 5-W resistor are needed to set up the EVM. To evaluate the EVM, use an electronic load, a battery pack, and a current meter. The inputs (SRSET, ACSET, BATSET, ENABLE, and ACSEL) can be controlled externally via the connectors and by proper placement of the jumpers.

1) Adjust the BATSET potentiometer R31 fully counter clockwise.
2) Set the power source for the minimum input voltage to be used to fully charge the battery pack. $V_{in(min)} = V_{(reg)} + 1$ Vdc. For setup procedure, do not let the input exceed 19 Vdc. If BATP and BATSET potentiometers are both adjusted for maximum values, then the regulation voltage is set over 19 V, which exceeds the maximum voltage on the SR sense pins. Once the regulation is set, the input (after this procedure) can be set within the operating range of the EVM.
3) Adjust R9 (AC DET) until TP2 measures 1.235 V.
4) Adjust the ACSET potentiometer R29 fully clockwise.
5) Adjust the SRSET potentiometer R27 fully clockwise.
6) Set the battery regulation voltage by first replacing the battery pack with a load resistor (100 Ω, 5 W). The regulation voltage can be set by either of two methods:
   a) Using the internal reference (BATSET adjusted fully counter clockwise, $V_{(batset)} = 0$ Vdc), adjust the BATP potentiometer R24 for the desired regulation voltage. This method is preferred for a single fixed regulation.
   b) Using the external reference (Adjust R24 (BATP) fully clockwise), adjust BATSET potentiometer, R31, until the desired regulation voltage is reached.

Note:

Until $V_{(batset)}$ is greater than 0.25V, the BATSET pin is not in control. The regulation voltage drops significantly once this threshold is exceeded. Continue adjustment until the desired regulation voltage is achieved. This method is preferred for multiple regulation settings, usually controlled externally by a microcontroller.

7) Adjust the BAT DEP potentiometer R22, until TP14 measures the calculated voltage.

   $V_{(batdep)}$ ($V_{(tp14)}$) = 1.22 × $V_{(reg)}$/$V_{(dep)}$

   Example for 3 Li Ion cells:

   $V_{(batdep)}$ = 1×22.(3×4.2)/(3×3.0) = 1.22×4.2V/3.0 V = 1.71 V

Note:

The VBAT output has to be at the regulation voltage during this adjustment to get the correct scaling for BAT DEP.

8) Adjust the VS potentiometer, R18, until $V_{(vs)}$ (TP6) measures the calculated value.

   V(vs) = 1.22 × $V_{(sys)}$/$V_{(reg)}$. Example for $V_{(sys)}$ = 18 V, $V_{(reg)}$ = 12.6 V:

   $V_{(vs)}$ = 1.22 × 18 V/12.6 V = 1.74 V. Note that $V_{(sys)}$ is the input voltage minus the drops and should be measured at J2–SYS.

9) Adjust the SRSET potentiometer, R27, until $V_{(srset)}$ (TP16) measures the calculated value.

   $V_{(srset)}$ = 25$R_{(s)}$.×$_{(bat)}$. Example for 2 amp charge:
   $V_{(srset)}$ = 25 × 025×2 = 1.25 V. Note, an electronic load can replace the 100-Ω resistor to load the output and set/verify the current.

10) Adjust the ACSET potentiometer, R29, until V_{acset} (TP17) measures the calculated value.

   $V_{(acset)}$ = 25×$R_{(s2)}$×$I_{(adpt)}$

   Example for 3-A maximum adapter current:

   $V_{(acset)}$ = 25×0.025×3 = 1.875 V

Note:

An electronic load placed on the SYS output can set the adapter current, while monitoring the input current.

The adapter input current is a function of both the battery current and the system current.

2.3 Test Procedure for NiCd/NiMH Applications

This procedure configures the evaluation board and evaluates the IC, using the EVM as a stand-alone unit. The board was originally configured as in Table 2–3. To configure the board differently, make sure the EVM has been set up as shown in the I/O and jumper tables. An external power source (20 V, 3 A) and a 100-Ω, 5-W resistor are needed to set up the EVM. To evaluate the EVM, an electronic load, a battery pack, and a current meter are required. The inputs (SRSET, ACSET, BATSET, ENABLE, and ACSEL) can be controlled externally, by the connectors, and by proper placement of the jumpers.

1) Adjust the BATSET potentiometer R31 fully CCW, $V_{(batset)}$ = 0 Vdc.

2) Set the power source for the minimum input voltage required to fully charge the battery pack. $V_{I(min)} = V_{(reg)}$ + 1 Vdc. For setup procedure, do not let the input exceed 19 Vdc. If BATP and BATSET potentiometers are both adjusted for maximum values, then the float voltage is set over 19 V, which exceeds the maximum voltage on the SR sense pins. Once the float voltage is set, the input (after this procedure) can be set within the operating range of the EVM.

3) Adjust R9 (AC DET) until TP2 measures 1.235 Vdc.

4) Adjust the ACSET potentiometer R29 fully CW.

5) Adjust the SRSET potentiometer R27 fully CW.

6) Set the battery float voltage by first replacing the battery pack with a load resistor (100 Ω, 5 W). The regulation voltage can be set by either of two methods:

   a) Using the internal reference (BATSET adjusted fully CCW, $V_{(batset)}$ = 0 Vdc). Adjust the BATP potentiometer, R24, for the desired float voltage. This method is preferred for a single fixed regulation.

   b) Using the external reference (Adjust R24 (BATP) fully CW). Adjust BATSET potentiometer, R31, until the desired float voltage is reached. Note that until $V_{(batset)}$ is greater than 0.25 V, the BATSET pin is not in control. The float voltage drops significantly once this threshold is exceeded. Continue adjustment until the desired regulation voltage is achieved. This method is preferred for multiple regulation settings, usually controlled externally by a microcontroller.

7) Adjust BAT DEP, R22, until TP14 measures the calculated voltage.

   $V_{(batdep)}\ (V_{(tp14)}) = 1.22 \times V_{(float)}/V_{(dep)}$

   Example for 8 NiCd cells:
   $V_{(batdep)} = 1.22 \times (8 \times 1.8)/(8 \times 1.0) = 1.22 \times 1.8\ V/1\ V = 2.20\ V$

Note:

The VBAT output has to be at the float voltage during this adjustment to get the correct scaling for BAT DEP.

8) Adjust the VS potentiometer, R18, until Vvs (TP6) measures the calculated value.

   $V_{(vs)} = 1.22 \times V_{sys}/V_{(float)}$

   Example for V_{sys} = 18 V, 8 NiCd cells:
   $V_{(float)}$ = 1.8 V/cell × # of cell = 1.8 V/cell×8cells= 14.4 V,
   V_{VS} = 1.22 × 18 V/14.4 V = 1.53 V

Note:

V_{sys} is the input voltage minus the drops and should be measured at J2–SYS.

9) Adjust the SRSET potentiometer, R27, until Vsrset (TP16) measures the calculated value. Vsrset = $25 \times R_S \times I_{bat}$.

   Example for 2 amp charge:
   $V_{(srset)} = 25 \times 0.025 \times 2 = 1.25$ V.

Note:

An electronic load can be used, in place of the 100-Ω resistor to load the output and set/verify the current.

10) Adjust the ACSET potentiometer, R29, until $V_{(acset)}$ (TP17) measures the calculated value.

   $V_{(acset)} = 25 \times Rs2 \times I_{(adpt)}$.

   Example for 3-A maximum adapter current:
   $V_{(acset)} = 25 \times 0.025 \times 3 = 1.875$ V.

Note:

An electronic load can be placed on the SYS output to set the adapter current while monitoring the input current.

Note:

The adapter input current is a function of both the battery current and the system current.

Chapter 3

Board Layouts, Bill of Materials, and Schematic

This chapter contains the physical layouts, the bill of materials, and the schematic for the EVM.

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3.1 Board Layout

Figure 3–1 shows the top layer of the EVM. Figure 3–2 shows the bottom layer. Figure 3–3 shows the top assembly view.

Figure 3–1. Board Layout (Top Layer)

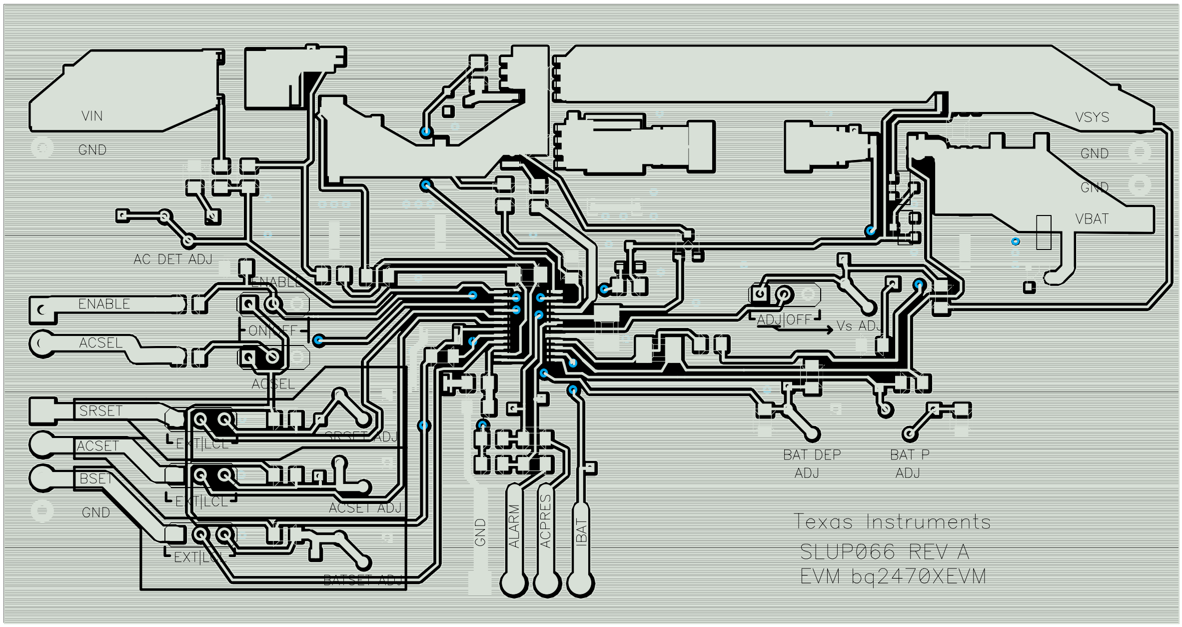


Figure 3–2. Board Layout (Bottom Layer)

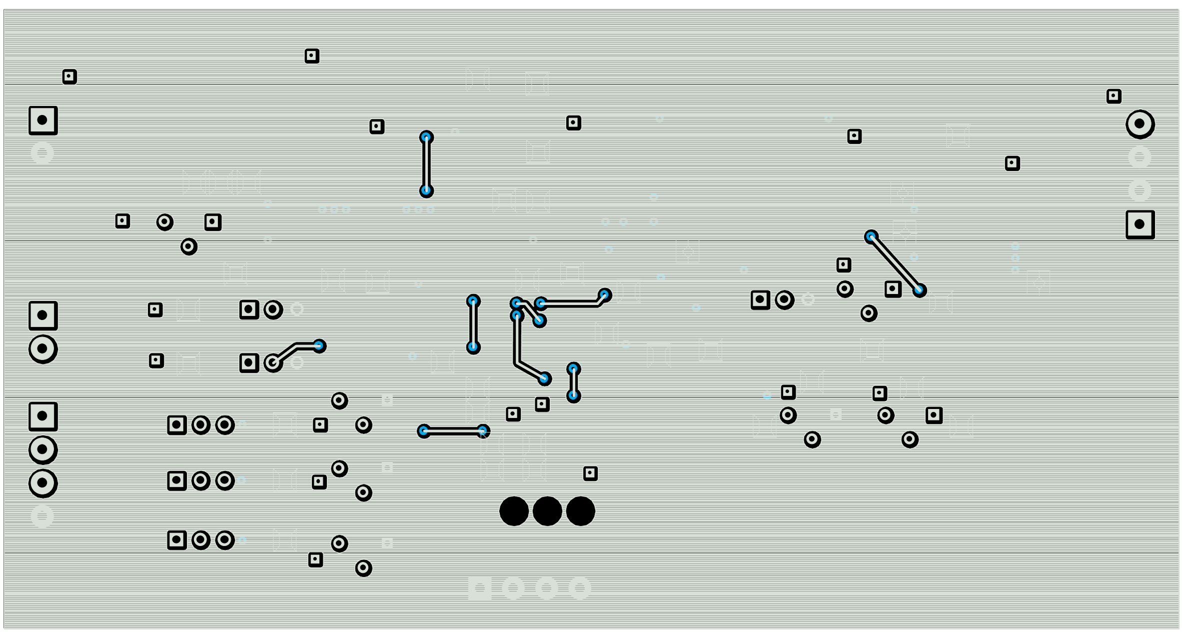
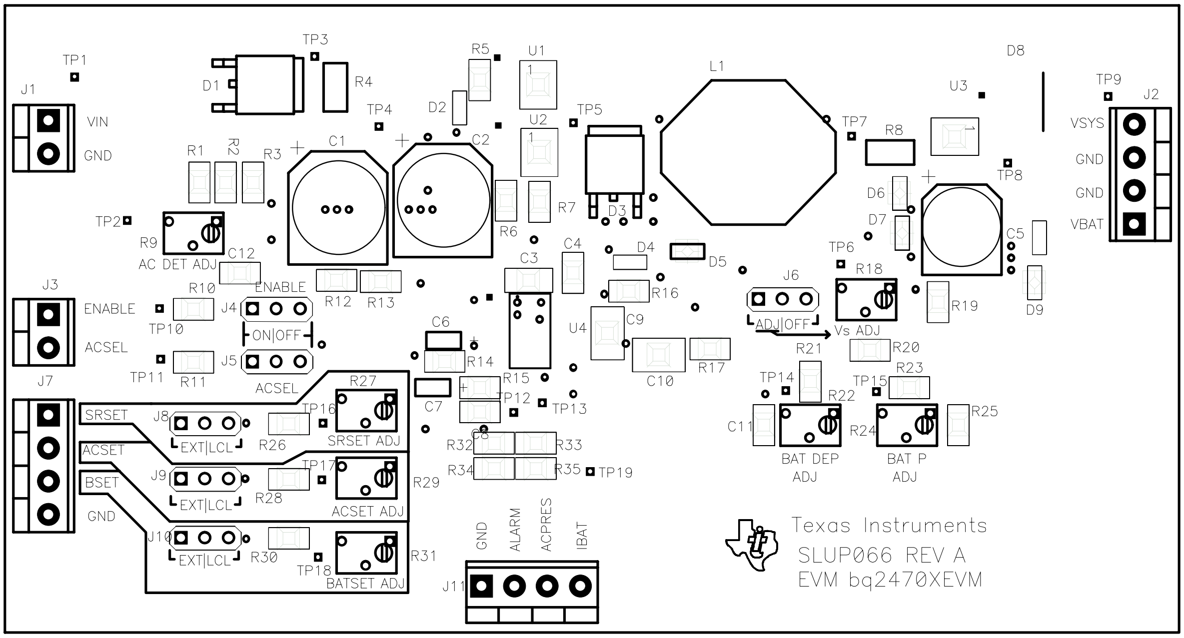


Figure 3–3. Top Assembly View



3.2 Bill of Materials

Table 3–1 lists materials required for the SLUU097 EVM.

Table 3–1. Bill of Materials

–0 Qty.	–1 Qty.	RefDes	Description	Size	MFR	Part Number
2	2	C1, C2	Capacitor, aluminum, SM, 330 µF, 3.5 V, 150 mΩ, FC series	10x12mm	Panasonic	EEV–FC1V331P
1	1	C3	Capacitor, ceramic, 1 µF, 16 V, XR7, 10%	1206	{std}	{std}
4	4	C4, C8, C11, C12	Capacitor, ceramic, 0.1 µF, 50 V, XR7, 10%	805	{std}	{std}
1	1	C5	Capacitor, aluminum, 22 µF, 35 V, 20%, FC Series	0.335 x 0.374	Panasonic	EEVFC1V220P
2	2	C6, C7	Capacitor, tantalum, 4.7 µF, 25 V, 20%		Panasonic	ECS–T1EX475R
2	2	C9, C10	Capacitor, tantalum, 10 µF, 16 V, 20%	1210	Panasonic	ECS–T1CX106R
2	2	D1, D3	Diode, dual Schottky, 6 A, 40 V	DPAK	On Semi	MBRD640CTT4
2	2	D2, D4	Diode, switching, 10 mA, 85 V, 350 mW	SOT23	Vishay–Liteon	BAS16
3	3	D5, D6, D7	Diode, Zener, 18 V, 19 mA, 350 mW	SOT23	General Semiconductor	MMBZ5248
2	2	J1, J3	Terminal block, 2 pin, 6 A, 3.5 mm	75525	OST	ED1514
3	3	J2, J7, J11	Terminal block, 4 pin, 6 A, 3.5 mm	148400	OST	ED1516
6	6	J4, J5, J6, J8, J9, J10	Header, 3 pin, 100mil spacing	34100	Sullins	PTC36SAAN
1	1	L1	Inductor, SMT, 33 µH, 3 A, 50 mΩ	0.472 sq	Sumida	CDRH127–330
1	1	R1	Resistor, Chip, 54.9 kΩ, 0.1 W, 5%	805	Std	Std
3	3	R10, R11, R16	Resistor, chip, 100 kΩ, 0.1 W, 5%	805	Std	Std
3	3	R12, R13, R15	Resistor, chip, 100 Ω, 0.1 W, 5%	805	Std	Std
1	1	R14	Resistor, chip, 4 kΩ, 0.1 W, 5%	805	Std	Std
1	1	R17	Resistor, chip, 10 Ω, 0.1 W, 5%	805	Std	Std
2	2	R19, R23	Resistor, chip, 604 Ω, 0.1 W, 5%	805	Std	Std

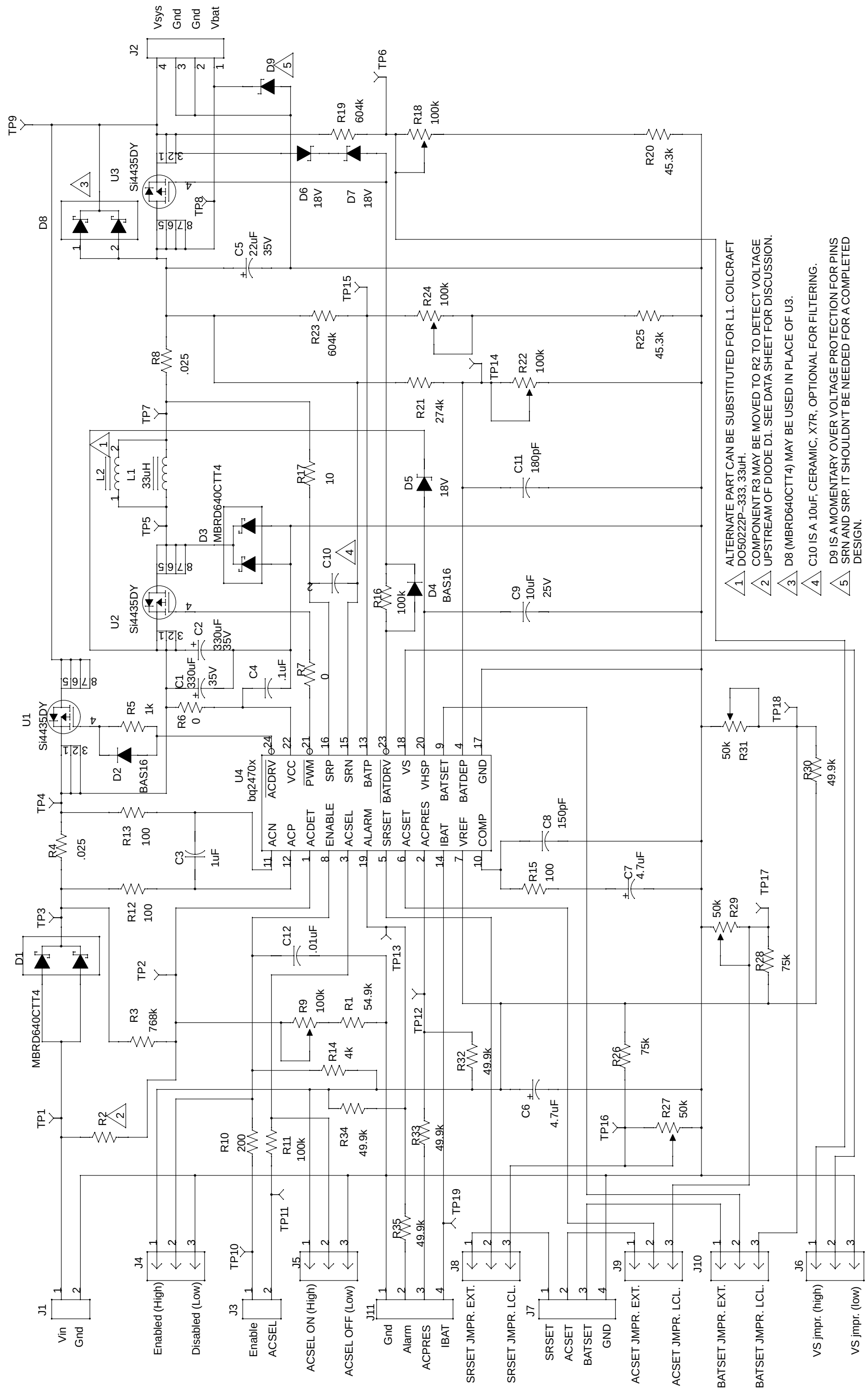
Table 3–1. Bill of Materials (Continued)

–0 Qty.	–1 Qty.	RefDes	Description	Size	MFR	Part Number
2	2	R20, R25	Resistor, chip, 45.3 kΩ, 1/10 W, 5%	805	Std	Std
1	1	R21	Resistor, chip, 274 kΩ, 1/10 W, 5%	805	Std	Std
2	2	R26, R28	Resistor, chip, 75 kΩ, 1/10 W, 1%	805	Std	Std
3	3	R27, R29, R31	Potentiometer, 50 k, 1/4 Cermet	Top-Adjust	Bourns	3266W–503
1	1	R3	Resistor, chip, 768 kΩ, 1/10 W, 5%	805	Std	Std
5	5	R30, R32, R33, R34, R35	Resistor, chip, 49.9 kΩ, 1/10 W, 5%	805	Std	Std
2	2	R4, R8	Resistor, chip, 0.25 Ω, 1/2 W, 1%	2010	Vishay – Dale	WSL2010.025±1%
1	1	R5	Resistor, chip, 1 kΩ, 0.1 W, 5%	805	Std	Std
2	2	R6, R7	Resistor, chip, 0.00 Ω, 0.1 W	805	Std	Std
4	4	R9, R18, R22, R24	Potentiometer, 100 kΩ, 1/4 Cermet	Top-Adjust	Bourns	3266W–104
3	3	U1, U2, U3	MOSFET, P–ch, 30 V, 8.0 A, 20 mΩ	SO8	Siliconix	Si4435DY
1	0	U3	IC, battery charge controller/selector w/DPM	TSSOP23	TI	bq24700PW
0	1	U4	IC, battery charge controller/selector w/DPM	TSSOP24	TI	bq24701PW

3.3 Schematic

This section contains the schematic diagram for the EVM

Figure 3–4. EVM Schematic Diagram



3.4 Reference

1. bq2470x data sheet (literature number SLUS452A)