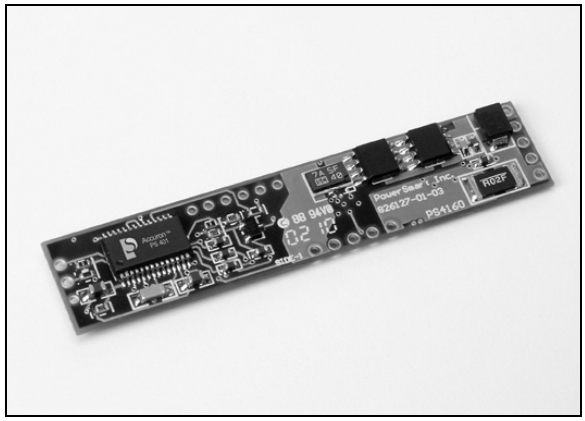
PS4160

PS401 Battery Manager Module with LED SOC Display

Features

- PS401 tested, fully populated modules for evaluation and production
- Designed to work with 3 cell and 4 cell series Li Ion configurations
- Performs all major Li Ion battery management functions including
  - Accurate capacity monitoring
  - Direct control of external charge circuitry
- Direct control of secondary safety functions
- SOC display with four LEDs and a switch can be removed to use GPIOs for other operations
- Fully compliant with industry standard Smart Battery Data Specification v1.1a
  - SMBus v1.1 with PEC/CRC-8 communication with system host
- High accuracy measurement of charge/discharge current, voltage, and temperature with on-chip 15-bit integrating A/D
- Precise capacity reporting using Microchip patented algorithms and 3D battery cell models
- 3D models and “learned” parameters stored in integrated EPROM and EEPROM
- Extremely low power operation:
  - SLEEP Mode: < 25 A typical
  - Run Mode: < 500 A typical
  - Sample Mode: < 250 A typical
- Complete hardware and software development tools available
- Overall mechanical dimensions:
  - 0.525 W x 2.500 L (inches)
  - 13.34 W x 63.50 L (millimeters)

Board Photo



Ordering Information

Part No.	Description Function
PS4160-3	Li Ion - 3 series cells
PS4160-4	Li Ion - 4 series cells

1.0 GENERAL DESCRIPTION

The PS4160 module is a complete smart battery controller subsystem with safety based on the Microchip PS401 battery manager with patented Accuron™ technology. The module is designed to operate in a battery pack consisting of three (3) or four (4) series connected Lithium cells. The module consists of three circuit sections – the Microchip PS401 battery manager IC, Mitsumi MM1414 based primary safety circuit and a secondary safety circuit controlled by the PS401 to provide backup to the MM1414.

1.1 Quick Start – Pack Assembly

Follow these directions to assemble a pack with the PS4160 module.

- Use standard precautions when handling static sensitive devices.
- Modules should be connected to battery cells in the order indicated below to insure proper start-up and operation. Wires should be attached to the modules first and then connected to the battery cells as instructed.
- The connection sequence is critical to successful use of the PS401 family of CMOS ASICs. Pack positive should always be connected first, followed by the intermediate cell voltages from highest to lowest, and finishing with the negative end of the pack.

Step 1: Configure the module for the number of series cells according to the following chart:

	Li Ion 3-cell	Li Ion 4-cell
R27	Removed	Installed
R28	Installed	Removed
R30	Installed	Removed

Step 2: Configure the module for the following options.

Use Optional External Thermistor

The PS401 IC has an integrated temperature sensor. If you would like to add an optional external thermistor, remove R16.

Charge FET Control

The PS4160 is shipped with the Mitsumi 1414 IC controlling both the charge and discharge FETs. If you would like to enable PS401 control of the charge FET, remove R25 and change the value of bit 2 of the FLAGS1 parameter to ‘0’. Setting bit 2 of FLAGS1 disables the GPIOs.

GPIO<3:0> Operation:

The PS4160 is shipped with four LEDs for a SOC display. These LEDs are connected to GPIO<3:0> pins on the PS401 IC. The GPIO<3:0> pins can be used for operation other than the LED SOC display by removing the LED and monitoring the adjacent test point.

Step 3: Connect wires to module. Use large diameter wire (18AWG-20 AWG) for current carrying lines from VR and V1. All others are signal only lines (24 to 22 AWG).

Step 4: Connect V1 to the most positive point on the battery cell stack.

Step 5: Connect cell voltage pickups:
4 series cells – negative end of topmost cell in stack to V2, negative end of next cell to V3, and negative end of third cell to V4.
3 series cells – negative end of topmost cell in stack to V2, negative end of next cell to V3, no connection at V4.

Step 6: Connect VR to the most negative point on the battery cell stack.

Step 7: Connect external connector to B-Neg, T, C, D and B+.

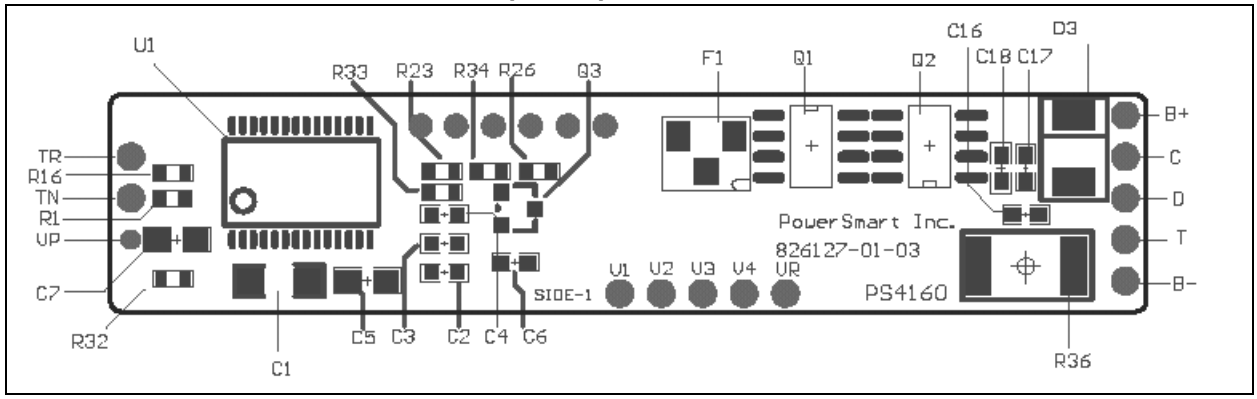
Step 8: The PS4160 is shipped with the secondary safety circuit disabled to avoid damage to the fuse during assembly. To enable the secondary safety circuit, remove R23 and change the value of bit 2 of the FLAGS1 parameter to ‘0’. Setting bit 2 of FLAGS1 disables the GPIOs configured for safety.

Step 9: Program the assembled pack using Microchip's PowerTool™ software and PowerCal™ board or PowerInfo™ board hardware.

The EEPROM parameters can be changed at will using the utilities on the P4 EE page in the PowerTool software. The OTP EPROM parameters can be changed a limited number of times using utilities on the P4 OTP page. To write to the OTP EPROM, an additional voltage (V_{PP}) must be applied to the PS401. This programming voltage can be obtained from the PowerInfo board and applied to the PS4160 at connection VP (small thru-hole) located on the small edge of the board opposite the connector edge.

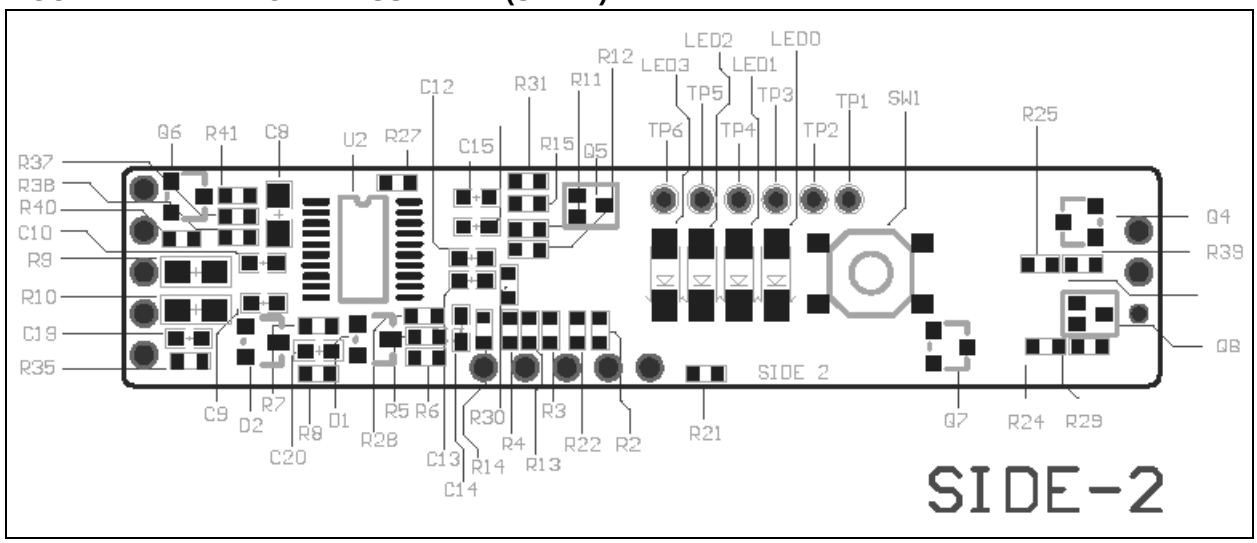
Step 10: Calibrate the pack using the PowerTool software and PowerCal board hardware. The pack is now ready for use.

FIGURE 1-1: BOARD ASSEMBLY (SIDE 1)



- Connection points for cells and connector are located here.
- To add an external thermistor, remove R16 (left side of drawing above).
- To enable the secondary safety circuit, remove R23 (to the right of PS401, label at top).

FIGURE 1-2: BOARD ASSEMBLY (SIDE 2)



- Follow chart in step one to configure module for 3 or 4 series cells. The configuration resistors are located on side 2. Follow the label line to locate the resistors. Approximate label locations follow.
  - R27 - top of drawing, above protection IC, U2.
  - R28 - bottom of drawing, below protection IC, U2.
  - R30 - bottom of drawing, right of R28, left of R22.
- To enable PS401 control of the charge FET, remove R25 (right side of drawing, label at top).
- LEDs and the test points for the GPIOs are located here.

2.0 FUNCTIONAL DESCRIPTION

2.1 PS401 Fuel Gauge

The module fuel gauge provides State-of-Charge (SOC) and battery status data in accordance with the SMBus standards version 1.1. The PS401 monitors the cell voltages, battery temperature, and current to determine SOC and battery status. The State-of-Charge calculations are compensated for cell self discharge. The remaining time calculation is compensated for temperature and discharge rate. The parameters for determining battery status flags and alarm thresholds are all programmable as is the battery design capacity and the battery performance model data. Please refer to the PS401 Single Chip Battery Manager Data Sheet (DS40238) for details on configuring the PS401.

2.2 Primary Safety

The primary safety circuit provides cell protection from conditions of overcharge, overdischarge and overcurrent. Analog IC MM1414DV from Mitsumi measures individual cell voltages and voltage across the discharge FET. These values are compared against internal reference values and the gates of two P-channel power MOSFETs are controlled based on the comparison results.

2.3 Secondary Safety

A secondary level of safety protection is provided on the PS4160. GPIO<6> (pin 4) of the PS401, with R25 removed and bit 2 of FLAGS1 = 0, is programmed to provide backup overcharge protection and is activated in the case of pack over voltage, over temperature or charge over current. In the situation where the parameter being monitored is the same as that of the MM1414 the limits are set beyond those of the MM1414. This means that the secondary protection is triggered only in the event the primary protection fails to activate.

2.4 Ultimate Safety

The third level of safety protection is activated by GPIO<7> (pin 5) of the PS401 when R23 is removed and bit 2 of FLAGS1 = 0. This pin is activated whenever any individual cell voltage is measured above a programmable limit that is beyond both the primary and secondary safety limits. An N-channel MOSFET is turned on and allows current to pass through the resistive heater section of a fuse. This heating opens the fuse, permanently disabling the pack from further charge or discharge.

2.5 OTP EPROM Programming

To write to the OTP EPROM, an additional voltage (V_{PP}) must be applied to the PS401. This programming voltage can be obtained from the PowerInfo board and applied to the PS4160 at connection VP (small thru-hole) located on the small edge of the board opposite the connector edge. Then use the utilities located on the PS OTP page of the PowerTool software to write new values to the PS401 OTP EPROM.

2.6 Programmable I/Os

The PS4160 features four additional pins, GPIO<3:0> (pins 24-27), which are used to drive the LED SOC display. GPIO<5> (pin 3), is connected to the switch which activates the LED display. Alternately, these GPIOs may be used for other purposes by removing the unused LEDs, programming the pins appropriately, and using the adjacent test points to monitor the pins.

3.0 BOARD DESCRIPTION

PCB schematics and bill of materials are included here for completeness. To download full size schematic and BOM, please visit the Microchip web site (www.microchip.com).

FIGURE 3-1: BOARD SCHEMATIC

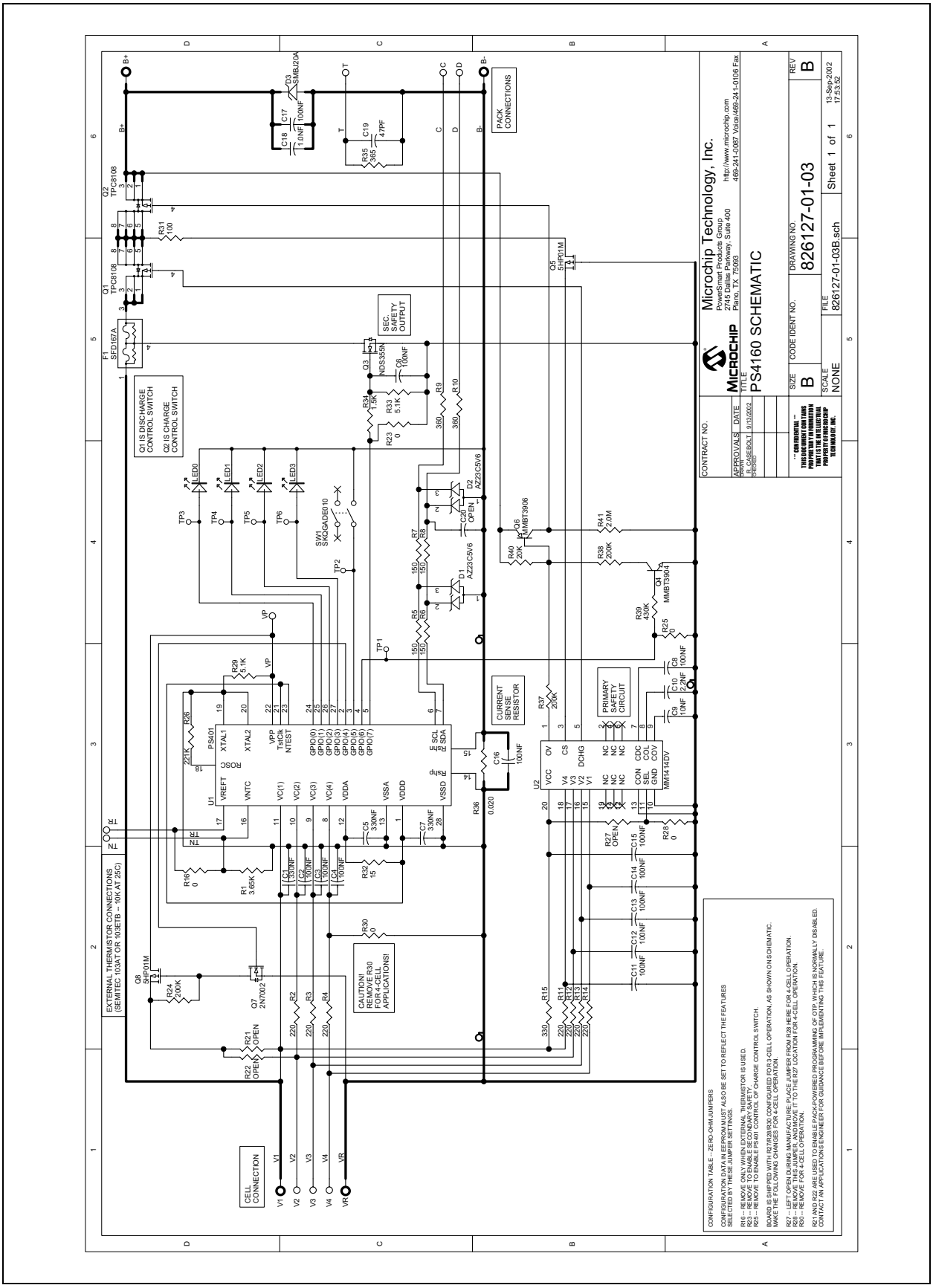


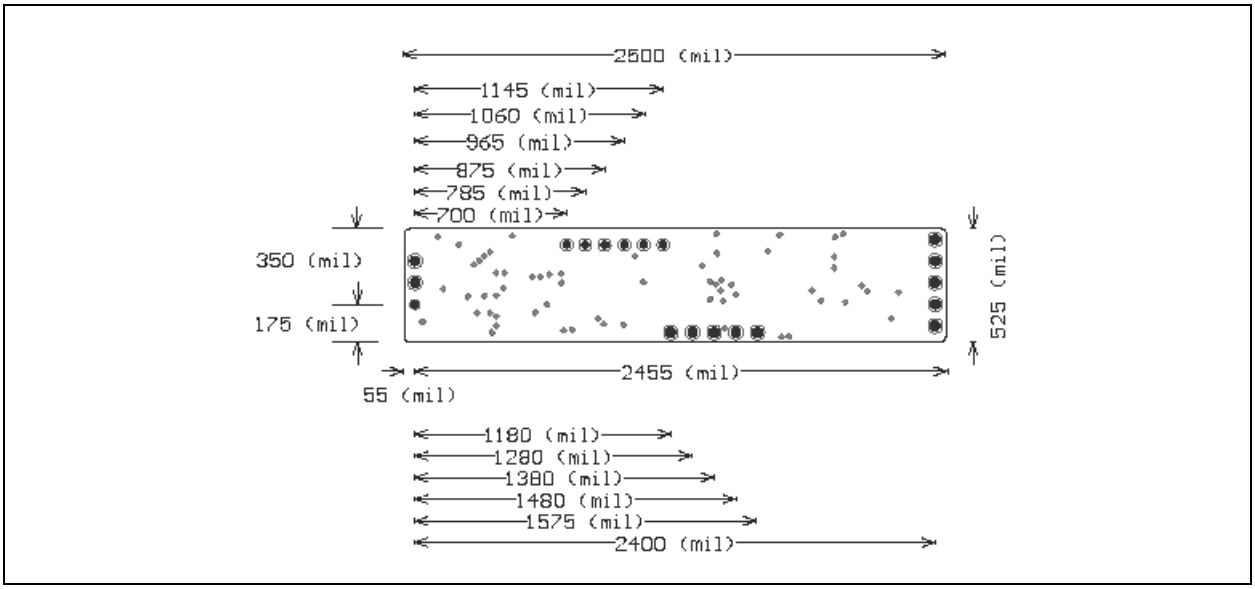
TABLE 3-1: BILL OF MATERIALS

Symbols	Description	Manufacturer	Manufacturer Part Number	Qty
C9	Capacitor, Ceramic, 10 nF, 25V, +/- 10%, X7R dielectric, 0603	Panasonic	ECJ-1VB1E103K	1
C18, C20	Capacitor, Ceramic, 1.0 nF, 50V, +/-10%, X7R dielectric, 0603	Panasonic	ECJ-1VB1H102K	2
C10	Capacitor, Ceramic, 2.2 nF, 50V, +/-10%, X7R dielectric, 0603	Panasonic	ECJ-1VB1H222K	1
C19	Capacitor, Ceramic, 47 pF, 50V, +/-5%, C0G dielectric, 0603	Panasonic	ECJ-1VC1H470J	1
C2-C4, C6 C11-C17	Capacitor, Ceramic, 100 nF, 25V, +80%/-20%, Y5V dielectric, 0603	Panasonic	ECJ-1VF1E104Z	11
C8	Capacitor, Ceramic, 100 nF, 25V, +/-10%, X7R dielectric, 0805	Panasonic	ECJ-2VB1E104K	1
C5, C7	Capacitor, Ceramic, 330 nF, 25V, +80%/-20%, Y5V dielectric, 0805	Panasonic	ECJ-2YF1E334Z	2
C1	Capacitor, Ceramic, 330 nF, 25V, +/-10%, X7R dielectric, 1206	Panasonic	ECJ-3VB1E334K	1
LED0-LED3	LED, clear green, 1206 package	Lumex	SML-LX1206GC-TR	4
D3	TVS, 20V, 600W, unipolar, SMB package	Diodes, Inc. Crydom	SMBJ20A-13 SMBJ20A	1
D1, D2	Dual Zener Diode, 5.6V +/- 5%, 300 mW, common-anode, SOT-23	Diodes Inc. General Semiconductor	AZ23C5V6-7 AZ23-C5V6	2
F1	Fuse, battery-pack protector, 7A, 36 VDC, 50A breaking capacity, 5 +/- 1.5 mOhm resistance, 31.6 +/- 3.2 ohms heater resistance, 11.1-25.0V heater operating voltage range, UL248-14, 3-terminal surface-mount package	Sony Chemicals	SFD-167A	1
	Raw PCB, PS4160	Microchip Technology Inc.	PCB-826127-01-03	1
Q4	Transistor, NPN, 40V, 350 mW SOT-23	Diodes Inc.	MMBT3904-7	1
Q6	Transistor, PNP, -40V, 350 mW SOT-23	Diodes Inc.	MMBT3906-7	1
Q5, Q8	MOSFET, P-channel enhancement-mode, -50V, 250 mW, surface-mount package	Sanyo	5HP01M	2
Q1, Q2	MOSFET, P-channel enhancement-mode, -30V, -11A, 9.5 mOhm, 1.9W, SO-8	Toshiba	TPC8108	2
Q7	MOSFET, N-channel enhancement-mode, 60V, 115 mA, 7.5 Ohm, 200 mW, SOT-23	Fairchild Semiconductor	2N7002	1
Q3	MOSFET, N-channel enhancement-mode, 30V, 1.6A, 0.125 Ohm, 500 mW, SOT-23	Fairchild Semiconductor	NDS355N	1
R26	Resistor, film, 0603, 1%, 221 kOhms	Panasonic	ERJ-3EKF2213V	1
R1	Resistor, film, 0603, 1%, 3.65 kOhms	Panasonic	ERJ-3EKF3651V	1
R35	Resistor, film, 0603, 1%, 365 ohms	Panasonic	ERJ-3EKF3650V	1
R16, R21, R23, R25, R28, R30	Resistor, zero-ohm, 0603	Panasonic	ERJ-3GEY0R00V	6
R34	Resistor, film, 0603, 5%, 1.5 kOhms	Panasonic	ERJ-3GEYJ152V	1
R31	Resistor, film, 0603, 5%, 100 ohms	Panasonic	ERJ-3GEYJ101V	1
R5-R8	Resistor, film, 0603, 5%, 150 ohms	Panasonic	ERJ-3GEYJ151V	4
R32	Resistor, film, 0603, 5%, 15 ohms	Panasonic	ERJ-3GEYJ150V	1
R41	Resistor, film, 0603, 5%, 2.0 Megohms	Panasonic	ERJ-3GEYJ205V	1
R24, R37-R38	Resistor, film, 0603, 5%, 200 kOhms	Panasonic	ERJ-3GEYJ204V	3
R40	Resistor, film, 0603, 5%, 20 kOhms	Panasonic	ERJ-3GEYJ203V	1
R2-R4, R11-R14	Resistor, film, 0603, 5%, 220 ohms	Panasonic	ERJ-3GEYJ221V	7
R15	Resistor, film, 0603, 5%, 330 ohms	Panasonic	ERJ-3GEYJ331V	1
R39	Resistor, film, 0603, 5%, 430 kOhms	Panasonic	ERJ-3GEYJ434V	1
R29, R33	Resistor, film, 0603, 5%, 5.1 kOhms	Panasonic	ERJ-3GEYJ512V	2
R9-R10	Resistor, film, 0805, 5%, 360 ohms	Panasonic	ERJ-6GEYJ361V	2
R36	Resistor, metal strip, 2512, 1%, 0.020 ohms	Vishay	WSL2512-0.020-1%-R86	1
SW1	Switch, SPST-momentary, push button, surface-mount	ALPS	SKQGADE010	1
U1	IC, Single-chip Battery Manager, programmable, -25°C to 85°C, SSOP-28	Microchip Technology Inc.	PS401	1
U2	IC, Battery Protection Circuit, Li-Ion, 3- or 4-cell, -20°C to 70°C, TSOP-20	Mitsumi	MM1414DV	1

3.1 Mechanical Dimensions

Overall Dimensions: 2500 mils x 525 mils

FIGURE 3-2: PS401 BATTERY MANAGER MODULE WITH LED SOC DISPLAY



4.0 DEVELOPMENT TOOL SUMMARY

Microchip provides all the necessary hardware and software to enable easy tailoring of battery control algorithm parameters and cell performance models to meet specific application requirements and attain the highest accuracy available anywhere. Table 4-1 summarizes the development tool offering from Microchip to support the PS4160. Please refer to the Microchip web site for ordering information and design documentation (including schematics) at www.microchip.com.

4.1 Reference Documents

This data sheet provides an overview of the PS4160 Battery Manager Module. For further information on the PS401 and development tool operations, please refer to the documents listed in Table 4-2 available for download at www.microchip.com.

TABLE 4-1: MICROCHIP DEVELOPMENT TOOL SUMMARY

Development Tool	Use
PowerInfo™ hardware with PowerTool™ software (PS041)	Read and write Smart Battery data values, EEPROM programming, OTP EPROM programming
PowerCal™ hardware with PowerTool software (PS042)	Read and write Smart Battery data values, EEPROM programming, OTP EPROM programming, pack calibration, pack test

TABLE 4-2: MICROCHIP REFERENCE DOCUMENTS

Document Number	Documents Available
DS40238A	PS401 Single Chip Battery Manager Data Sheet (IC Products)
DS40234A	PS041 PowerInfo Configuration Interface Product Brief
DS40237A	PS042 PowerCal Calibration Platform Data Sheet

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