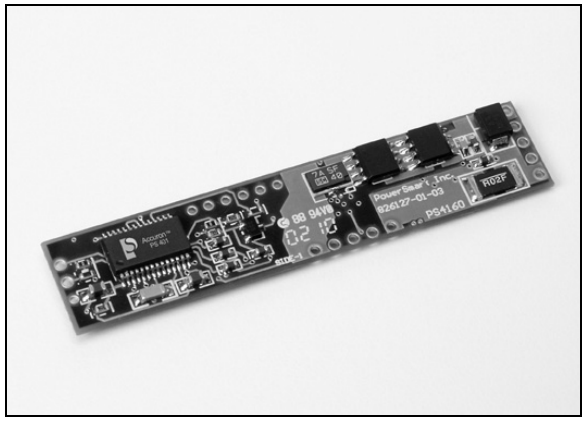
PS4160

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 µA typical
  - Run Mode: < 500 µA typical
  - Sample Mode: < 250 µA 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+.

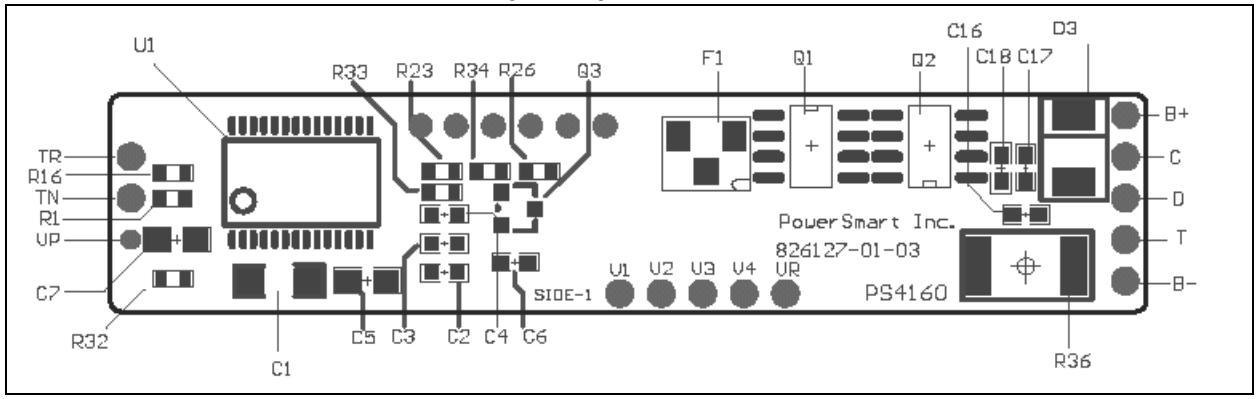
Step 8: The PS4160 is shipped with the secondary safety circuit disabled to avoid damage to the fuse during assembly. To enable the secondary safety circuit, remove R23 and change the value of bit 2 of the FLAGS1 parameter to ‘0’. Setting bit 2 of FLAGS1 disables the GPIOs configured for safety.

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.

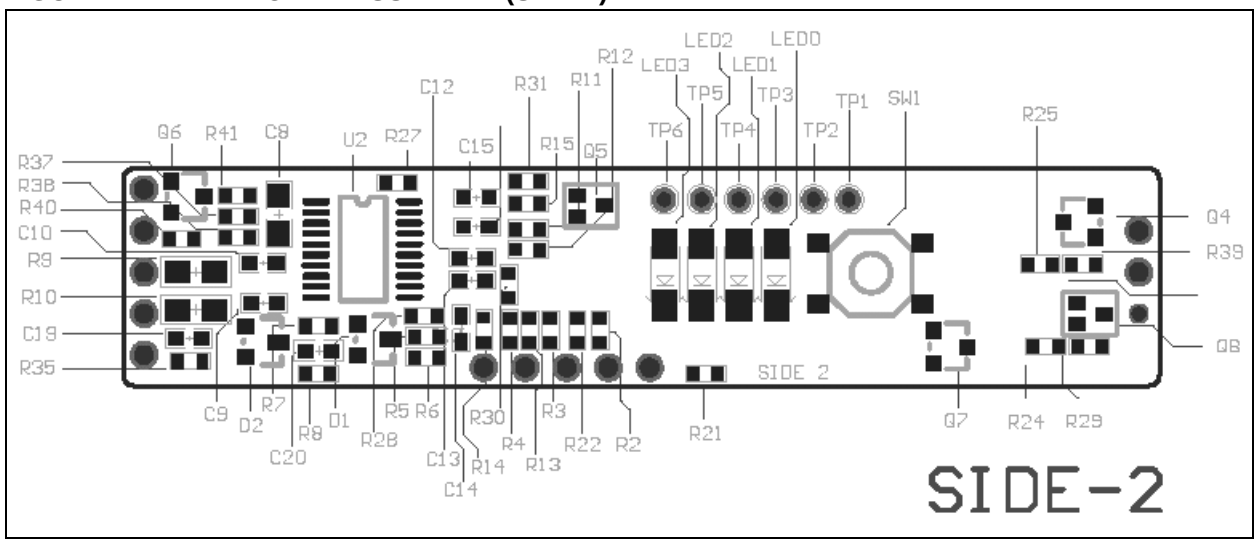
Step 10: Calibrate the pack using the PowerTool software and PowerCal board hardware. The pack is now ready for use.

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

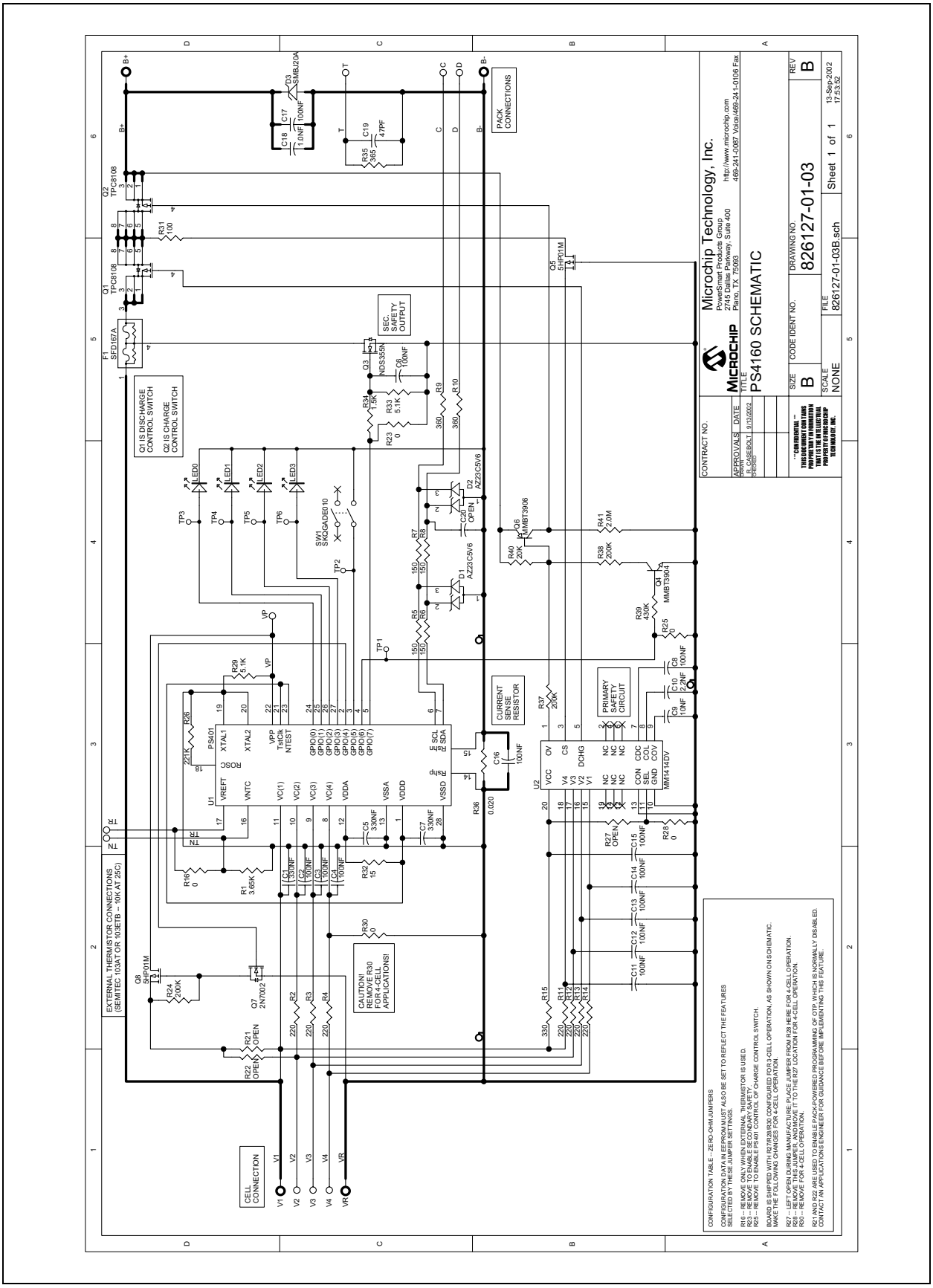


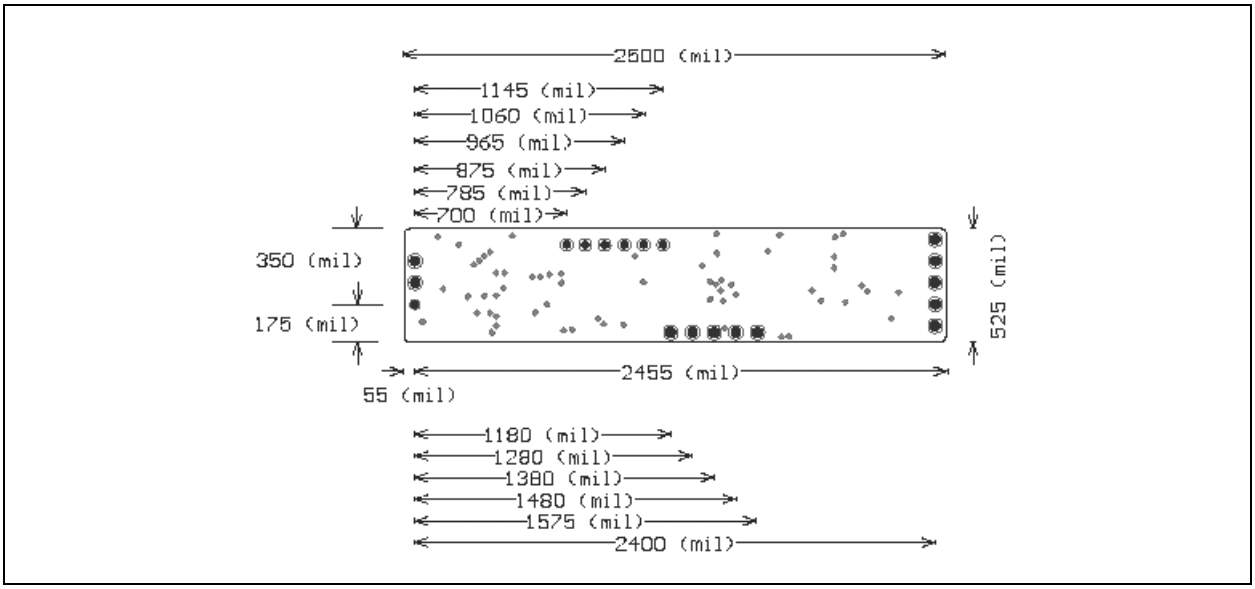
TABLE 3-1: BILL OF MATERIALS

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

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200 Fax: 480-792-7277
Technical Support: 480-792-7627
Web Address: http://www.microchip.com

Atlanta
3780 Mansell Road, Suite 130
Alpharetta, GA 30022
Tel: 770-640-0034 Fax: 770-640-0307

Boston
2 Lan Drive, Suite 120
Westford, MA 01886
Tel: 978-692-3848 Fax: 978-692-3821

Chicago
333 Pierce Road, Suite 180
Itasca, IL 60143
Tel: 630-285-0071 Fax: 630-285-0075

Dallas
4570 Westgrove Drive, Suite 160
Addison, TX 75001
Tel: 972-818-7423 Fax: 972-818-2924

Detroit
Tri-Atria Office Building
32255 Northwestern Highway, Suite 190
Farmington Hills, MI 48334
Tel: 248-538-2250 Fax: 248-538-2260

Kokomo
2767 S. Albright Road
Kokomo, Indiana 46902
Tel: 765-864-8360 Fax: 765-864-8387

Los Angeles
18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1888 Fax: 949-263-1338

Phoenix
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7966 Fax: 480-792-4338

San Jose
Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

Toronto
6285 Northam Drive, Suite 108
Mississauga, Ontario L4V 1X5, Canada
Tel: 905-673-0699 Fax: 905-673-6509

ASIA/PACIFIC

Australia
Microchip Technology Australia Pty Ltd
Marketing Support Division
Suite 22, 41 Rawson Street
Epping 2121, NSW
Australia
Tel: 61-2-9868-6733 Fax: 61-2-9868-6755

China - Beijing
Microchip Technology Consulting (Shanghai) Co., Ltd., Beijing Liaison Office
Unit 915
Bei Hai Wan Tai Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Chengdu
Microchip Technology Consulting (Shanghai) Co., Ltd., Chengdu Liaison Office
Rm. 2401-2402, 24th Floor,
Ming Xing Financial Tower
No. 88 TIDU Street
Chengdu 610016, China
Tel: 86-28-86766200 Fax: 86-28-86766599

China - Fuzhou
Microchip Technology Consulting (Shanghai) Co., Ltd., Fuzhou Liaison Office
Unit 28F, World Trade Plaza
No. 71 Wusi Road
Fuzhou 350001, China
Tel: 86-591-7503506 Fax: 86-591-7503521

China - Hong Kong SAR
Microchip Technology Hongkong Ltd.
Unit 901-6, Tower 2, Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

China - Shanghai
Microchip Technology Consulting (Shanghai) Co., Ltd.
Room 701, Bldg. B
Far East International Plaza
No. 317 Xian Xia Road
Shanghai, 200051
Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

China - Shenzhen
Microchip Technology Consulting (Shanghai) Co., Ltd., Shenzhen Liaison Office
Rm. 1812, 18/F, Building A, United Plaza
No. 5022 Binhe Road, Futian District
Shenzhen 518033, China
Tel: 86-755-82901380 Fax: 86-755-82966626

China - Qingdao
Rm. B505A, Fullhope Plaza,
No. 12 Hong Kong Central Rd.
Qingdao 266071, China
Tel: 86-532-5027355 Fax: 86-532-5027205

India
Microchip Technology Inc.
India Liaison Office
Marketing Support Division
Divyasree Chambers
1 Floor, Wing A (A3/A4)
No. 11, O'Shaugnessey Road
Bangalore, 560 025, India
Tel: 91-80-2290061 Fax: 91-80-2290062

Japan
Microchip Technology Japan K.K.
Benex S-1 6F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa, 222-0033, Japan
Tel: 81-45-471- 6166 Fax: 81-45-471-6122

Korea
Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea 135-882
Tel: 82-2-554-7200 Fax: 82-2-558-5934

Singapore
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 188980
Tel: 65-6334-8870 Fax: 65-6334-8850

Taiwan
Microchip Technology (Barbados) Inc., Taiwan Branch
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Austria
Microchip Technology Austria GmbH
Durisolstrasse 2
A-4600 Wels
Austria
Tel: 43-7242-2244-399
Fax: 43-7242-2244-393

Denmark
Microchip Technology Nordic ApS
Regus Business Centre
Lautrup hoj 1-3
Ballerup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

France
Microchip Technology SARL
Parc d'Activite du Moulin de Massy
43 Rue du Saule Trapu
Batiment A - ler Etage
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany
Microchip Technology GmbH
Steinheilstrasse 10
D-85737 Ismaning, Germany
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy
Microchip Technology SRL
Via Quasimodo, 12
20025 Legnano (MI)
Milan, Italy
Tel: 39-0331-742611 Fax: 39-0331-466781

United Kingdom
Microchip Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5869 Fax: 44-118 921-5820

03/25/03