

MCP3421
Battery Fuel Gauge Demo Board User's Guide

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MCP3421 BATTERY FUEL GAUGE DEMO BOARD USER'S GUIDE

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MCP3421 BATTERY FUEL GAUGE DEMO BOARD USER'S GUIDE

Preface

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Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP3421 Battery Fuel Gauge Demo Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MCP3421 Battery Fuel Gauge Demo Board as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** - Provides the important information about the MCP3421 Battery Fuel Gauge Demo Board.
- **Chapter 2. "Installation and Operation"** – Covers the installation and operation of the MCP3421 Battery Fuel Gauge Demo Board. It lists the required tools, shows how to set up the board, and demonstrates how to verify the amplifier operation.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and board layouts for the MCP3421 Battery Fuel Gauge Demo Board.
- **Appendix B. "Bill Of Materials (BOM)"** – Lists the parts used to build the MCP3421 Battery Fuel Gauge Demo Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

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RECOMMENDED READING

This user's guide describes how to use MCP3421 Battery Fuel Gauge Demo Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

MPLAB® IDE, Simulator, Editor User's Guide (DS51025)

Consult this document for more information pertaining to the installation and features of the MPLAB Integrated Development (IDE) Software.

MCP3421 Data Sheet, *"18-Bit ADC with I²C Interface and On-Board Reference"* (DS22003)

Data sheet for the 18 bit ADC MCP3421. This data sheet is needed to understand how the MCP3421 is used to meaure the current and battery voltage.

MCP73831/2 Data Sheet, *"Miniature Single-Cell, Fully Integrated Li-Ion, Li-Polymer Charge Management Controllers"* (DS21984)

Data sheet for the Single-Cell Li-Ion, LI-Polymer Charger. This data sheet is helpful to understand how the battery fuel is charged.

PIC18F2455/2550/4455/4550 Data Sheet, (DS39632)

This data sheet is needed if the user wants to modify the firmware used in the demo board.

Note:	In the MCP3421 Battery Fuel Gauge Demo Board Kit, the battery charging function is disabled. Contact Microchip Technology, Inc., if you need this function enabled.

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

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- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: http://support.microchip.com

DOCUMENT REVISION HISTORY

Revision A (October 2007)

- Initial Release of this Document.

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MCP3421 BATTERY FUEL GAUGE DEMO BOARD USER'S GUIDE

Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP3421 Battery Fuel Gauge Demo Board is used to demonstrate the MCP3421 device for battery fuel gauging applications.

The MCP3421 Battery Fuel Gauge Demo Board includes two MCP3421 devices, MCP73831(single cell Li-Ion/Li-Polymer Charger), and PIC18F4550 MCU.

The MCP3421 device is a low-power, single channel 18-bit delta-sigma Analog-to-Digital Converter (ADC) in a SOT-23 package. It has an internal voltage reference (V_{REF} = 2.048V) and programmable gain amplifier (x1,x2, x4, x8). It communicates with a master device with I^2C interface.

The MCP3421 Battery Fuel Gauge Demo Board measures: (a) the battery voltage and (b) the current coming out from the battery in the discharging mode and into the battery in the charging mode using the ADC device (if charging mode is enabled (optional)). It calculates the total fuel used and also remaining fuels. The measurement takes places approximately every one second and updates the measurement data and calculated results on the LCD for about every second.

The MCP3421 Battery Fuel Gauge Demo Board includes 2x16 LCD. The LCD displays: (a) measured battery voltage and current, (b) calculated results of battery fuel used.

The MCP3421 Battery Fuel Gauge Demo Board also includes a buzzer. This buzzer makes a buzzing sound when the battery voltage drops 50% or the battery is not connected.

The PIC18F4550 communicates with the MCP3421 and calculates the fuels. The board also includes a USB connector for a PC graphic user interface (GUI) utility. This GUI is available only for the training class and not included with this demo kit.

Figure 1-1 shows the picture of the MCP3421 Battery Fuel Gauge Demo Board. The board includes device foot prints for the two channel 18-bit ADC (MCP3422). The MCP3421 and MCP3422 are the same device family with the same electrical performance, but the MCP3422 has two channels. Therefore, the two MCP3421 devices on the board can be replaced with one MCP3422 device.

Note: MCP3421 Battery Fuel Gauge Demo Board has a feature to charge the battery in use. This feature is currently disabled in firmware. Please contact Microchip Technology Inc. if you need the battery charging feature.

1.2 FEATURES

The MCP3421 Battery Fuel Gauge Demo Board has the following features:

- Measure the battery voltage and display the result on LCD.
- Measure the current coming out from the battery (discharging current) or coming into the battery (charging current) and displays the value on LCD.

Note: The charging current is only available when the battery charging mode is enabled.

- Calculate the battery fuel that has been used and display the result on LCD.
- Turn on beep sounds if the battery is used more than 50% of its initial value, or the battery is not connected.

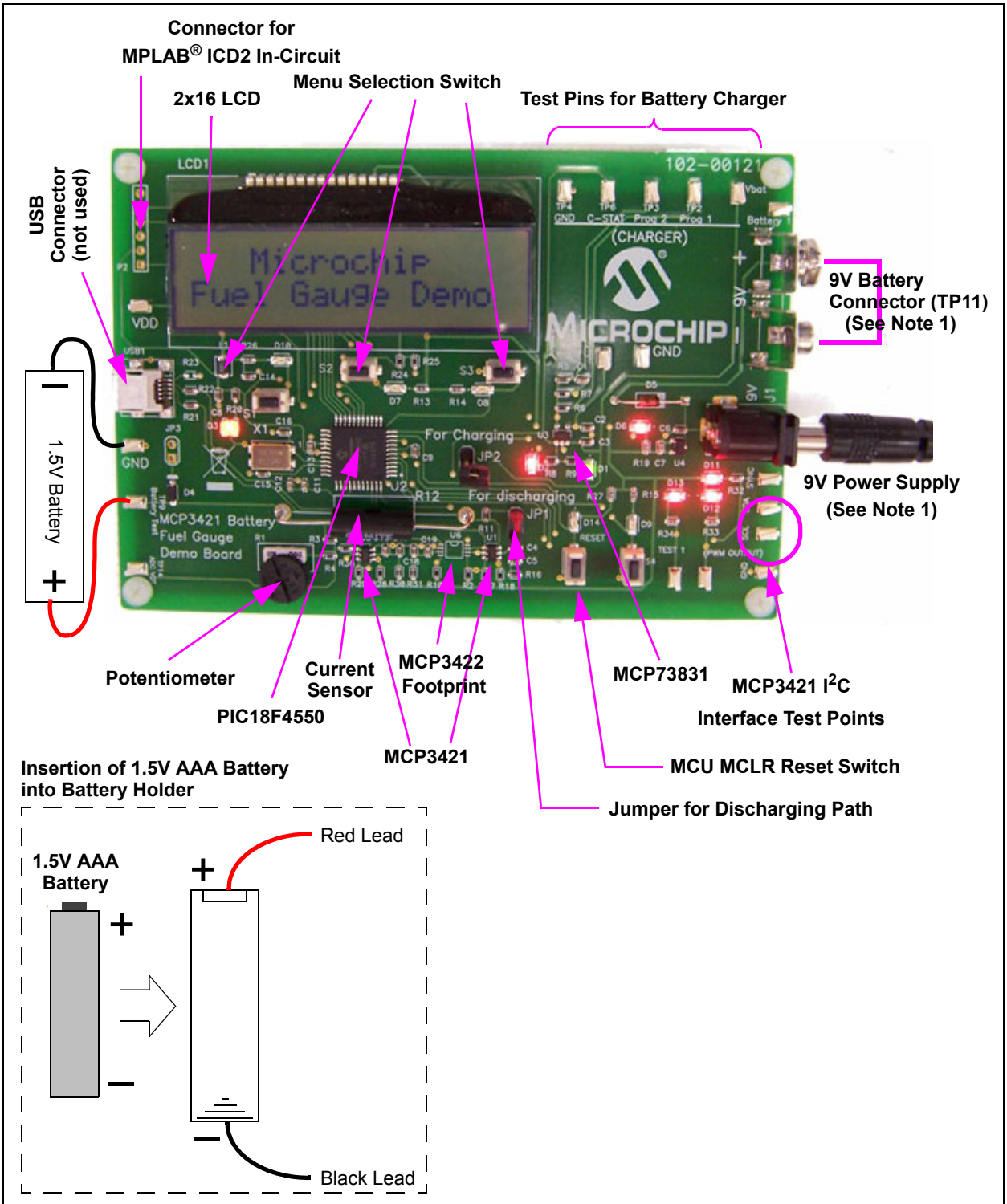
Note: The MCP3421 Battery Fuel Gauge Demo Board can be also configured very easily for other sensor output measurements. Just connect the sensor output at the ADC input terminal. The LCD will display the voltage.

The MCP3421 Battery Fuel Gauge Demo Board includes a 9V and 1.5V AAA batteries. Please make sure the positive lead of the 1.5V battery holder is connected to TP9 and the negative lead (black) is connected to the GND terminal.

WARNING

The U1 and U5 devices may get damaged if the polarity of the battery connection is reversed. If the connection is accidently reversed, replace the U1 and U5 devices in order to obtain accurate measurements.

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NOTICE

Note 1: Use 9V Power Supply or 9V Battery. Do not use both at same time.

2: 1.5V battery connection: connect the positive lead (red) to TP9 and the negative lead (black) to the GND terminal. A reversed connection will damage the U1 and U5 devices.

FIGURE 1-1: *MCP3421 Battery Fuel Gauge Demo Board (Top Side).*

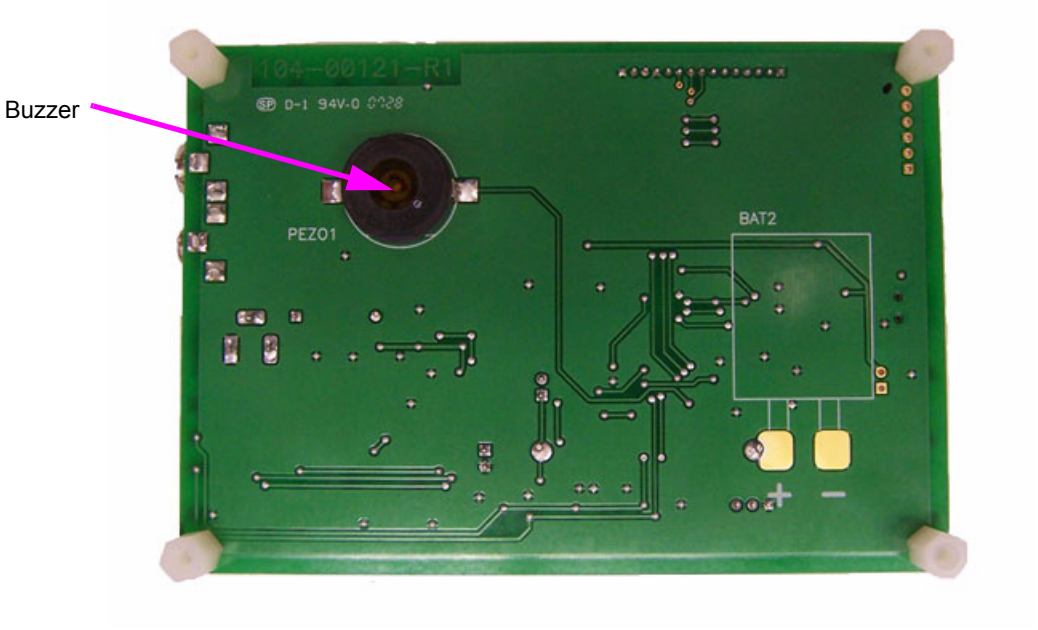


FIGURE 1-2: *MCP3421 Battery Fuel Gauge Demo Board (Bottom Side).*

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Chapter 2. Installation and Operation

2.1 BOARD DESCRIPTION

The major components of the MCP3421 Battery Fuel Gauge Demo Board are:

1. MCP3421 devices (U1 and U5).
   - U1: Measuring current using the R12 current sensor.
   - U5: Measuring battery voltage.
2. PIC MCU - PCI18F4550 (U2).
3. MPLAB ICD2 Header (P2).
4. USB connector (Not used for this version).
5. Battery discharging path selection Jumper (JP1).
6. Battery charging path selection Jumper (JP2): When battery recharge feature is enabled.
7. 9V Power Supply (BAT 1 and 9V power supply, use only one).
8. 1.5V AAA Battery with battery holder.
9. 2 x 16 LCD (LCD1).
10. MCP73831 device (U3).
11. Switches (SW1, SW2, SW3, SW4, Reset Switch).
12. Potentiometer (R1).

For more detailed circuit information, refer to Appendix A: "Schematics and Layouts" and Appendix B: Bill of Materials".

2.1.1 Power Supply

The MCP3421 Battery Fuel Gauge Demo Board needs a 9V power supply to provide a 5V DC power to all active components including MCU, ADC, battery charger devices, etc. The user can use a 9V power supply or 9V battery. The MCP3421 Battery Fuel Gauge Demo Board has two connectors for both the 9V power supply and 9V battery. Do not use both power sources at same time.

Note: All active electrical components on the board are powered by the 9V power source. The 1.5V AAA battery that is connected to TP9 (positive) and GND (negative) terminals DOES NOT power the board components. During the discharging, the current path of the test battery is from the 1.5V battery to the ground via a 10 mili-ohm current sensor and an 100Ω resistor. During the recharging mode (if recharging mode is enabled), the current path is from the V_{BAT} pin of U3 (MCP73831) to the battery via the current sensor.

2.1.2 Microcontroller (MCU)

The PIC18F4550 (44-pin, TQFT) is used to control ADC devices, charger, buzzer, and LCD. All fuel gauge computations are takes place in the MCU.

2.1.3 LCD Display

The LCD display used is a 2 x 16 character dot matrix type display. The PIC18F4550 device writes characters to the LCD.

2.1.4 Buzzer

This demo board has a buzzer. The buzzer beeps when the board is first powered up and also when the battery fuel is consumed 50% or less, or the battery is disconnected.

2.1.5 USB Connector

This board has a USB connector for the PIC18F4550. The current firmware version for the PIC18F4550 is not including the USB interface feature.

2.1.6 Interface to MPLAB® ICD2 Programmer

The MCP3421 Battery Fuel Gauge Demo Board includes the PIC18F4550. This MCU is used to control the data acquisition devices (ADC) and compute the fuel gauging parameters. The MCU also sends characters to the LCD.

The board has an 8-pin connector for the ICD In-Circuit Serial Programming™ (ICSP™). The MCU source code is written in assembly language. The user can modify the code for their own experiment using the MPLAB ICD2 Programmer. The user needs an ICD-2 ICSP adapter socket (P/N: AC164110) between the MPLAB ICD2 Programmer and the MCP3421 Battery Fuel Gauge Demo Board.

2.1.7 Jumper

The MCP3421 Battery Fuel Gauge Demo Board uses two jumpers, JP1 and JP2. JP1 is used to provide a battery discharge path. Connect JP1 (while JP2 is disconnected) when testing battery discharging. Contact Microchip Technology Inc., if you need the battery charging mode.

Note:	Do not connect both JP1 and JP2 at the same time.

2.1.8 Push Button Switches

The MCP3421 Battery Fuel Gauge Demo Board has 5 push button switches.

- **SW1** is used to enter the battery fuel gauging mode.
- **SW2, SW3, SW4:** are not Used.
- **Reset SW** is the $\overline{\text{MCLR}}$ reset pin switch and is used to reset the MCU.

2.1.9 Potentiometer (R1)

This potentiometer is used to calibrate the input voltage to the ADC and is calibrated before shipping to the customer. If the customer wants to calibrate, then refer to Step 5 of the calibration procedure in **Section 2.2.1 "Battery Fuel Measurement"**.

2.1.10 Signal Outputs

The MCP3421 Battery Fuel Gauge Demo Board has various test points to capture the communication between the MCU and ADC devices. The user can see the I^2C communication data streams at SCL and SDA test pins using an oscilloscope. The SYNC terminal is used as a "trigger" source when the SCL and SDA signals are captured. The board also has the test terminals for the battery charger (U3): Prog 1, Prog 2 and C-STAT terminals.

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2.2 GETTING STARTED

You can simulate battery voltage discharging and charging using the MCP3421 Battery Fuel Gauge Demo Board.

Battery Fuel Measurement Mode: The MCP3421 Battery Fuel Gauge Demo Board measures the currents coming from the battery every second and computes how many fuels are being used. The fuel is calculated from the time when the MCP3421 Battery Fuel Gauge Demo Board is powered and the fuel measurement is initiated. When JP1 jumper is connected, a battery discharging path from the battery to the current sensor to the 100Ω resistor (R11) to ground is created. This simulates how battery fuel is consumed in real applications. The differential input pins of U1 (ADC) are connected across the current sensor and measure the current passing through the current sensor. The ADC can determine whether the measured current is discharging current or charging current by testing the sign of the current value. In the battery discharging path, the direction of current flow is from the battery to the ground through R12 and R11. Therefore, the LCD will display a positive sign (' + ') on the display.

2.2.1 Battery Fuel Measurement

The battery fuel being used is measured by setting up a discharge path. This discharge path is created when connecting Jumper 1 (JP1) while disconnecting Jumper 2 (JP2).

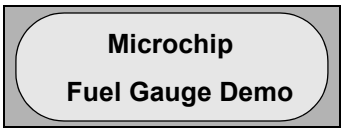
1. Connect JP1.

Note:	Make sure JP2 is **not** connected.

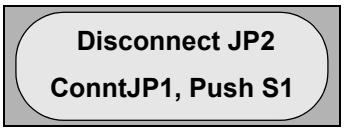
2. Connect a 9V power supply to J1, or connect a 9V battery to TP11.

There are two 9V connections. You can use either 9V battery or 9V power supply. Only one power source is used.

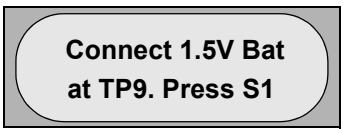
3. The LED D3 will turn on, and the LCD will display the following message:



4. A few seconds later, the LCD will display the following message:

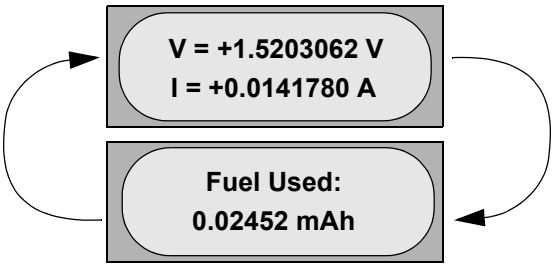


5. Press S1. The LCD will display the following message:



If the 1.5V battery is disconnected, connect the positive lead (red) of the 1.5V battery holder to the TP9 terminal and the negative lead (black) to the GND terminal. Make sure the 1.5V AAA battery is correctly inserted into the battery holder. Press the S1 push button.

6. The LCD will display the following message continuously:



WARNING

If the 1.5V AAA battery is reverse connected to the TP9 and GND, it will cause permanent damage to the U1 and U5 devices. The reading on the LCD is not reliable anymore.

If this happens, one of the symptoms is that the LCD will display a higher reading or a lesser reading (negative) sign in the current "I" reading. Please replace the U1 and U5 devices, if this incident occurred or contact Microchip Technology Inc.

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ADC Input Voltage Calibration:

The potentiometer (R1) is used to calibrate the ADC input voltage. If the displayed battery voltage on the LCD is suspicious, the customer can calibrate the ADC input voltage using the following method:

1. Connect a digital voltmeter between the TP9 (Battery) and Ground (TP4).
2. Read the volts value on the LCD while adjusting the potentiometer. Adjust the potentiometer until the reading on the LCD is the same as the reading on the Digital Volt Meter (DVM). This completes the ADC input calibration.

Note: The MCP3421 (U5) is used to measure the battery voltage. The internal reference voltage of the MCP3421 is 2.048V. The MCP3421 (U5) will give a saturated output if the input is greater than its reference voltage (2.048V). To avoid the saturation, the MCP3421 Battery Fuel Gauge Demo Board uses a voltage divider formed by R3, R4 and R1. The potentiometer (R1) is used to calibrate the voltage divider, and provide 50% of the voltage applied at TP9 to the input pin of the MCP3421 (U5).
The microcontroller (U2) firmware takes into account this voltage divider value automaticaly. The firmware multiplies a factor of 2 on the U5 result and displays the result on the LCD.

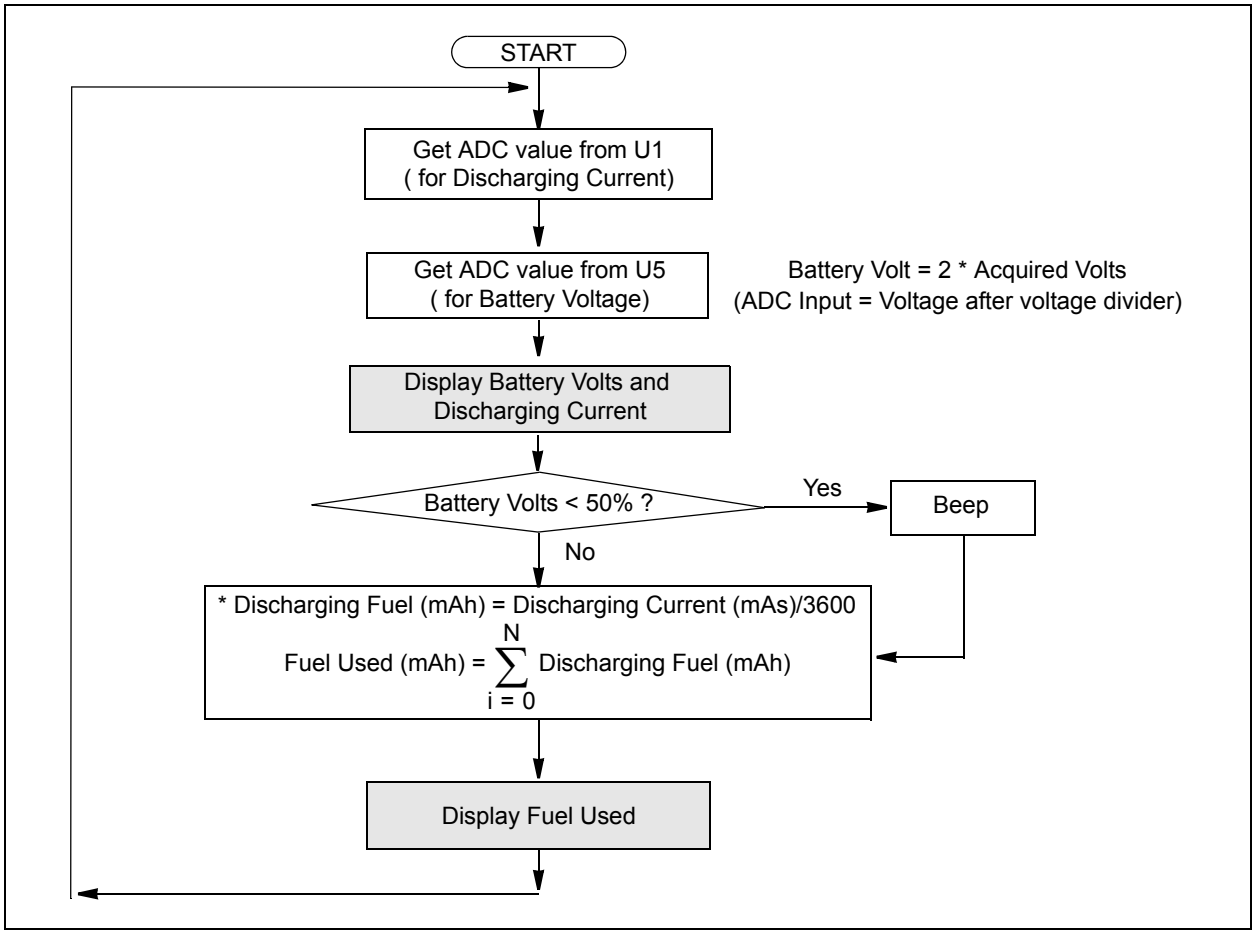


FIGURE 2-1: *MCP3421 Battery Fuel Gauge Computation Algorithm.*

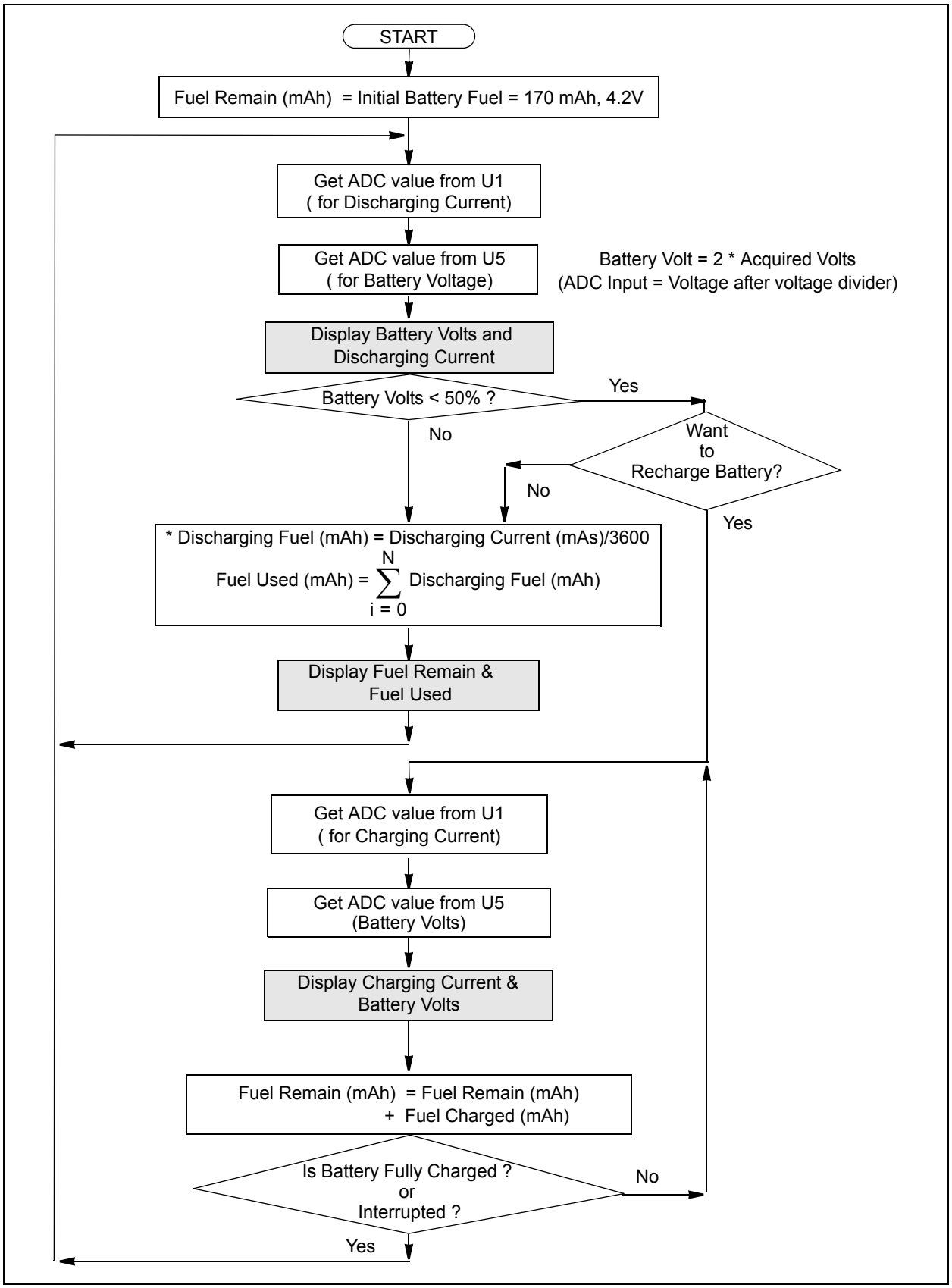


FIGURE 2-2: *MCP3421 Battery Fuel Gauge Computation Algorithm with Battery Recharge Feature Enabled. (Contact Microchip Technology Inc., if you need this feature enabled).*

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Appendix A. Schematic and Layouts

NOTICE TO CUSTOMERS

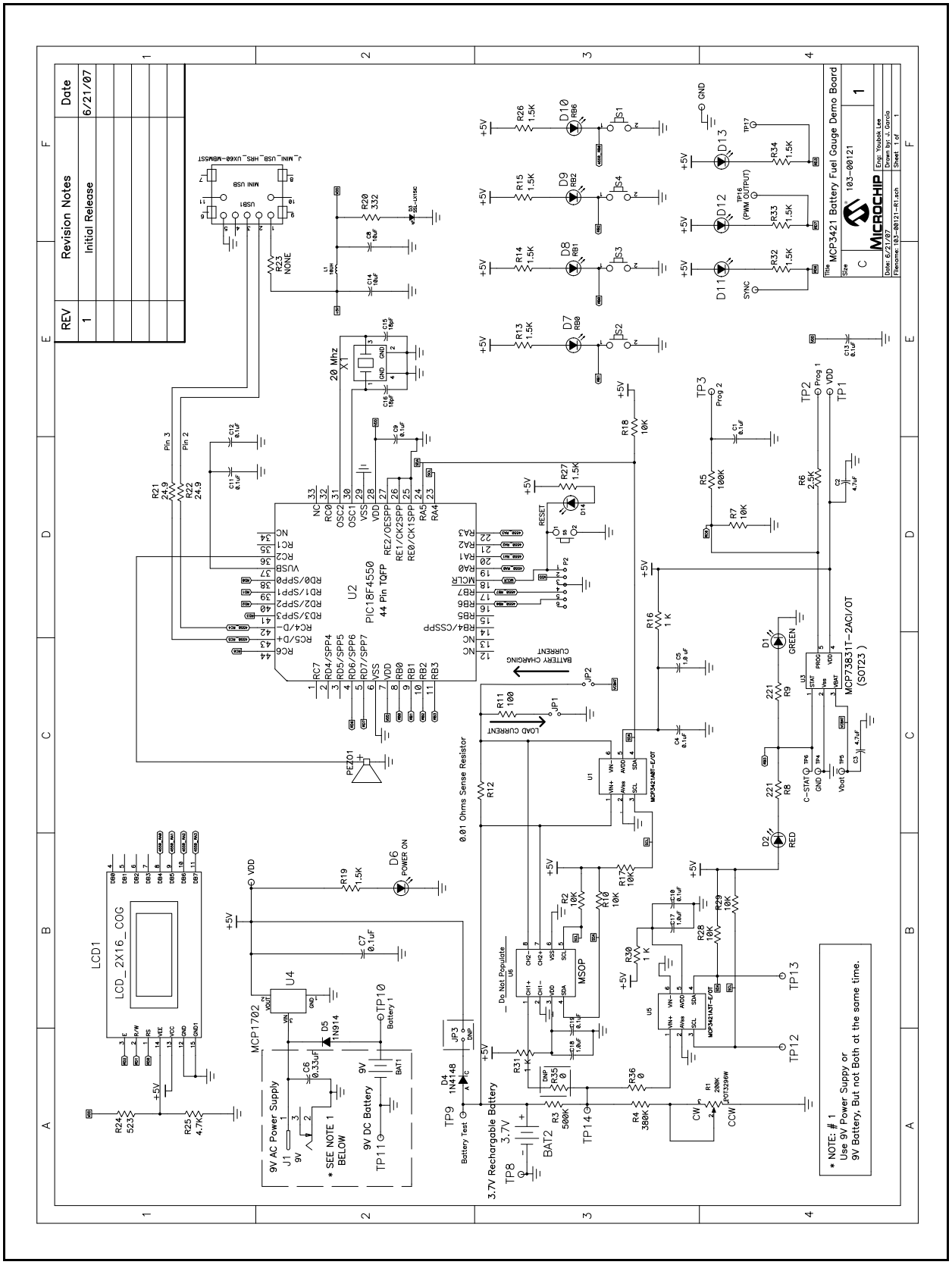
All documentation becomes dated, and this user's guide is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some schematics and board layouts may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

A.1 INTRODUCTION

This appendix contains the schematics and PCB layouts for the MCP3421 Battery Fuel Gauge Demo Board. This Appendix includes:

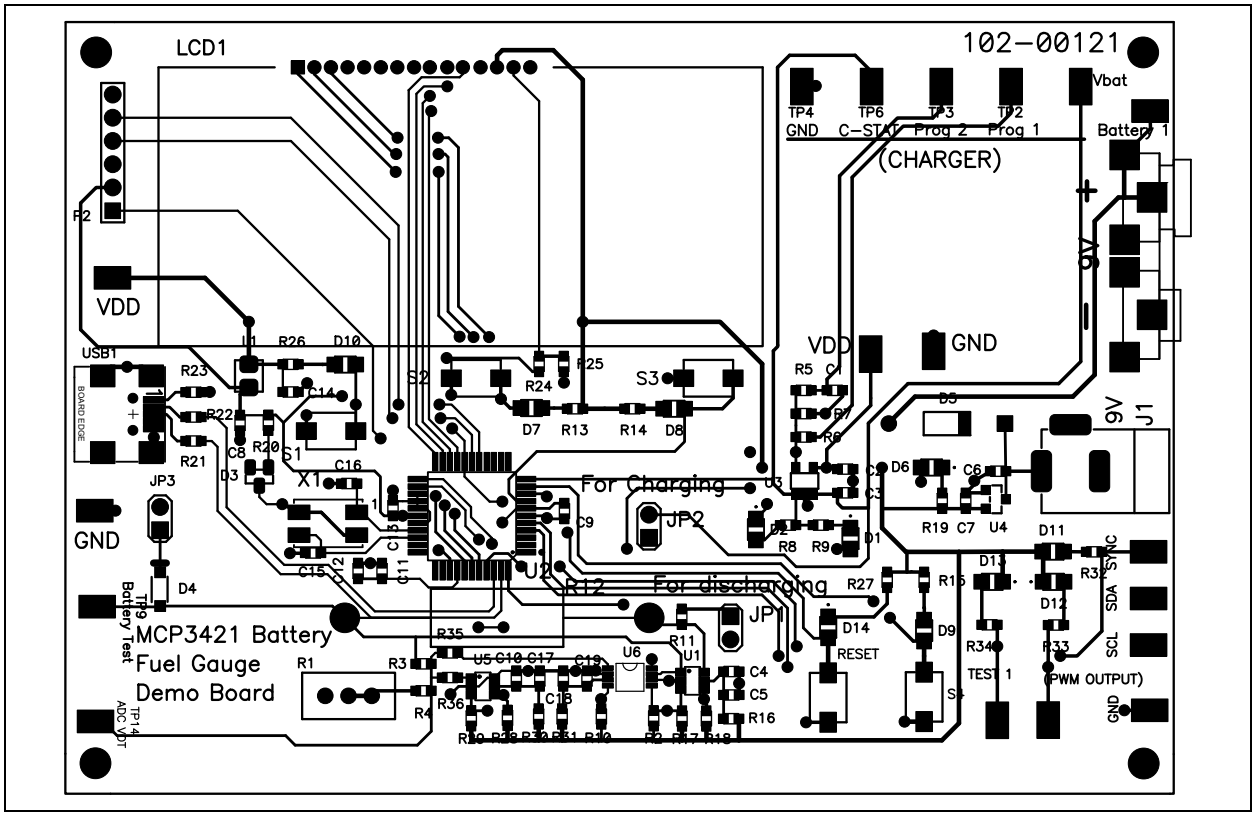
- Schematic
- Top Layer (with silk screen)
- Bottom Layer

A.2 SCHEMATIC

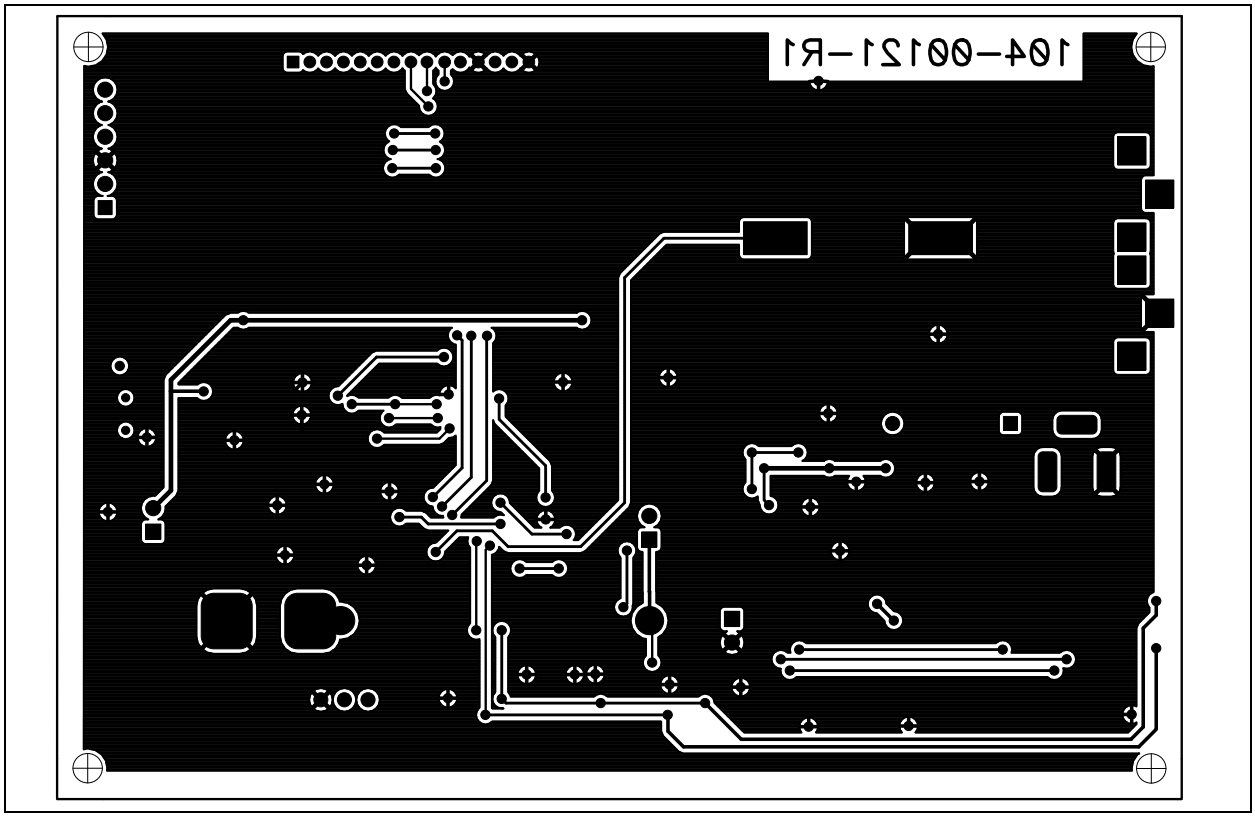


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A.3 TOP LAYER AND SILK SCREEN



A.4 BOTTOM LAYER



NOTES:

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Appendix B. Bill Of Materials (BOM)

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TABLE B-1: BILL OF MATERIALS (BOM)

Qty	Reference	Description	Manufacturer	Part Number
1	BAT1	BATTERY ALKALINE 9V	Gold Peak	29A
1	BAT1 + lug	CONN BATT 9V MALE OFF-BRD SNAP	Keystone Electronics®	635
1	BAT1 - lug	CONN BATT 9V FEMALE OFF-BRD SNAP	Keystone Electronics	636
0	BAT2	DO NOT POPULATE Polymer Li-Ion Battery: One Mini size (25x20x5 mm) 3.7V, 170mAh for Micro RC Car or Device	—	PL-052025
1	BAT3	IC Test Clips Red	Kobiconn	13IC307
1	BAT3	IC Test Clips Black	Kobiconn	13IC308
1	BAT3	HOLDER BATTERY 1CELL AAA 6"LEAD	Keystone Electronics	2467
1	BT3	Alkaline Batteries AAA SIZE ALKA-CELL	Gold Peak	GP24AU-OS2
1	BUZZER PIEZO	BUZZER PIEZO 4KHZ 17.5MM SMT	Mallory Sonalert Products Inc	AST100Q
9	C1, C4, C7, C9, C10, C11, C12, C13, C19	CAP .1UF 16V CERAMIC X7R 0603	Panasonic® - ECG	ECJ-1VB1C104K
2	C2, C3	CAP CERAMIC 4.7UF 6.3V X5R 0603	Panasonic - ECG	ECJ-1VB0J475K
3	C5, C17, C18	CAP 1.0UF 16V CERAMIC X5R 0603	Panasonic - ECG	ECJ-1VB1C105K
1	C6	CAP CER .33UF 16V X7R 0603	Murata Electronics North America	GRM188R71C334KA01D
2	C8,C14	CAP CER 10UF 6.3V X5R 0603	Murata Electronics North America	GRM188R60J106ME47D
2	C15, C16,	CAP CERAMIC 18PF 50V 0603 SMD	Panasonic - ECG	ECJ-1VC1H180J
1	D1	LED THIN 565NM GRN DIFF 0805 SMD	Lumex® Inc.	SML-LXT0805GW-TR

Note: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)

Qty	Reference	Description	Manufacturer	Part Number
10	D2, D6, D7, D8, D9, D10, D11, D12, D13, D14	LED THIN 635NM RED DIFF 0805 SMD	Lumex Inc.	SML-LXT0805IW-TR
1	D3	Lumex Opto/Components Inc	Lumex Inc.	SML-LX15IC-TR
1	D4	DIODE SWITCH 100V 150MA SOD123	Micro Commercial Co.	1N4148W-TP
1	D5	DIODE SWITCHING 100V DO35	Micro Commercial Co.	1N914B-TP
4	Ea. Corner	SCREW MACH PHIL 4-40X1/4 NYLON	Building Fasteners	NY PMS 440 0025 PH
4	Ea. Corner	STANDOFF HEX .375/4-40THR NYLON	Keystone Electronics	1902B
1	J1	CONN POWER JACK 2.5MM PCB CIRC	CUI Inc	PJ-102B
2	JP1, JP2	CONN HEADER VERT 2POS .100 TIN	Tyco® Electronics/Amp	3-644695-2
0	JP3	Do Not Populate	—	—
2	SHNTS JP1 & JP2	SHUNT LP W/HANDLE 2 POS 30AU	Tyco Electronics/Amp	881545-2
1	L1	INDUCTOR FIXED SMD 10UH 10%	Panasonic - ECG	ELJ-FC100KF
1	LCD1	16 X 2 LCD Character Display	Fema	CG1626-SGR1
0	P2	Do Not Populate	Tyco Electronics/Amp	3-644456-6
1	PCB	RoHS Compliant Bare PCB, MCP3421 Battery Fuel Gauge Demo Board	—	104-00121
1	R1	POT 200K OHM THUMBWHEEL CERM ST	Bourns Inc.	3352T-1-204LF
7	R2, R7, R10, R17, R18, R28, R29	RES 10.0K OHM 1/10W 1% 0603 SMD	Vishay/Dale	CRCW060310K0FKEA
1	R3	RES 510K OHM 1/10W 5% 0603 SMD	Rohm	MCR03EZPJ514
1	R4	RES 390K OHM 1/10W 5% 0603 SMD	Rohm	MCR03EZPJ394
1	R5	RES 100K OHM 1/10W 1% 0603 SMD	Vishay/Dale	CRCW0603100KFKEA
1	R6	RES 2.49K OHM 1/10W 1% 0603 SMD	Vishay/Dale	CRCW06032K49FKEA
2	R8, R9	RES 221 OHM 1/10W 1% 0603 SMD	Vishay/Dale	CRCW0603221RFKEA
1	R11	RES 100 OHM 1/8W 1% 0805 SMD	Panasonic - ECG	ERJ-6ENF1000V
1	R12	RES CURRENT SENSE .010 OHM 3W	Ohmite	13FR010E
9	R13, R14, R15, R19, R26, R27, R32, R33, R34	RES 1.5K OHM 1/16W .5% 0603 SMD	Susumu Co Ltd	RR0816P-152-D
2	R16, R30, R31	RES 1.0K OHM 1/10W .5% 0603 SMD	Yageo® Corporation	RT0603DRD071KL

Note: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)

Qty	Reference	Description	Manufacturer	Part Number
1	R20	RES 332 OHM 1/10W 1% 0603 SMD	Vishay/Dale	CRCW0603332RFKEA
2	R21, R22	RES 24.9 OHM 1/10W 1% 0603 SMD	Vishay/Dale	CRCW060324R9FKEA
0	R23	Do Not Populate	—	—
1	R24	RES 523 OHM 1/10W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF5230V
1	R25	RES 4.7K OHM 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ472V
2	R35, R36	RES 0.0 OHM 1/10W 5% 0603 SMD	Yageo Corporation	RC0603JR-070RL
5	S1, S2, S3, S4, S5	SWITCH LT TOUCH 6X3.5 100GF SMD	Panasonic - ECG	EVQ-PJS04K
12	TP1<>TP18	PC TEST POINT COMPACT SM	Keystone Electronics	5016
1	U1	18-Bit Analog-to-Digital Converter with I2C Interface and On-Board Reference	Microchip Technology Inc.	MCP3421A0T-E/OT
1	U2	High-Performance, Enhanced Flash, USB Microcontroller, 44-Pin, QFP	Microchip Technology Inc.	PIC18F4550-I/PT
1	U3	Minature Single Cell, Fully integrated Li-Ion, Li-Polymer Charge Management Controller	Microchip Technology Inc.	MCP73831-2ACI/OT Alternate Part# MCP73831-2ACI/OT
1	U4	MCP1702 mA Low Quiescent Current LDO Regulator	Microchip Technology Inc.	MCP1702T-5002I/CB
1	U5	18-Bit Analog-to-Digital Converter with I2C Interface and On-Board Reference	Microchip Technology Inc.	MCP3421A3T-E/OT
0	U6	Do Not Populate	—	—
1	USB1	CONN RECEPT MINI USB2.0 5POS	Hirose Electronic Co. Ltd	UX60-MB-5ST
1	X1	CRYSTAL 20.000MHZ 18PF FUND SMD	Connor-Winfield	XM-1-20.0000

Note: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

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