MCP1630 Low-Cost Li-Ion Battery Charger Reference Design User's Guide

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MCP1630 LOW-COST BATTERY CHARGER USER'S GUIDE

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MCP1630 LOW-COST BATTERY CHARGER USER'S GUIDE

Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

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.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP1630 Low-Cost Li-Ion Battery Charger. 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 MCP1630 Low-Cost Li-Ion Battery Charger as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP1630 Low-Cost Li-Ion Battery Charger.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with this demo board and a description of the demo board.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP1630 Low-Cost Li-Ion Battery Charger.
- **Appendix B. "Bill Of Materials (BOM)"** – Lists the parts used to build the MCP1630 Low-Cost Li-Ion Battery Charger.
- **Appendix C. "Evaluation Board Firmware"** – Provides information about the application firmware and where the source code can be found.

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) { ... }`

RECOMMENDED READING

This user's guide describes how to use the MCP1630 Low-Cost Li-Ion Battery Charger. The following Microchip documents are available and recommended as supplemental reference resources.

MCP1630 Data Sheet, *"High-Speed, Microcontroller-Adaptable, Pulse Width Modulator"*, DS21896

This data sheet provides detailed information regarding the MCP1630 product family.

MCP6291/2/3/4/5 Data Sheet, *"1.0 mA, 10 MHz, Rail-to-Rail Op Amp"*, DS21812

This data sheet provides detailed information regarding the MCP6291/2/3/4/5 product family.

PIC12F683 Data Sheet, *"8-Pin Flash-Based, 8-Bit CMOS Microcontrollers with nanoWatt Technology"*, DS41211

This data sheet provides detailed information regarding the PIC12F683 product family.

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- Technical Support
- Development Systems Information Line

Customers should contact their distributor, representative or field application engineer (FAE) 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 B (November 2005)

- Updated Fast Charge Current to 1.5A.
- Added Constant Voltage Charge Calibration.

Revision A (June 2005)

- Initial Release of this Document.

Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP1630 Low-Cost Li-Ion Battery Charger is used to evaluate Microchip's MCP1630 in a SEPIC power converter application. As provided, the MCP1630 Low-Cost Li-Ion Battery Charger is capable of charging a single-cell, Li-Ion battery pack from an input voltage of 6V to 18V. The MCP1630 Low-Cost Li-Ion Battery Charger provides a constant current, constant voltage charge with preconditioning, cell temperature monitoring and battery pack fault monitoring. Also, the charger provides a status or fault indication. The MCP1630 Low-Cost Li-Ion Battery Charger automatically detects the insertion or removal of a battery pack.

This chapter covers the following topics:

- What is the MCP1630 Low-Cost Li-Ion Battery Charger?
- What the MCP1630 Low-Cost Li-Ion Battery Charger Kit Includes

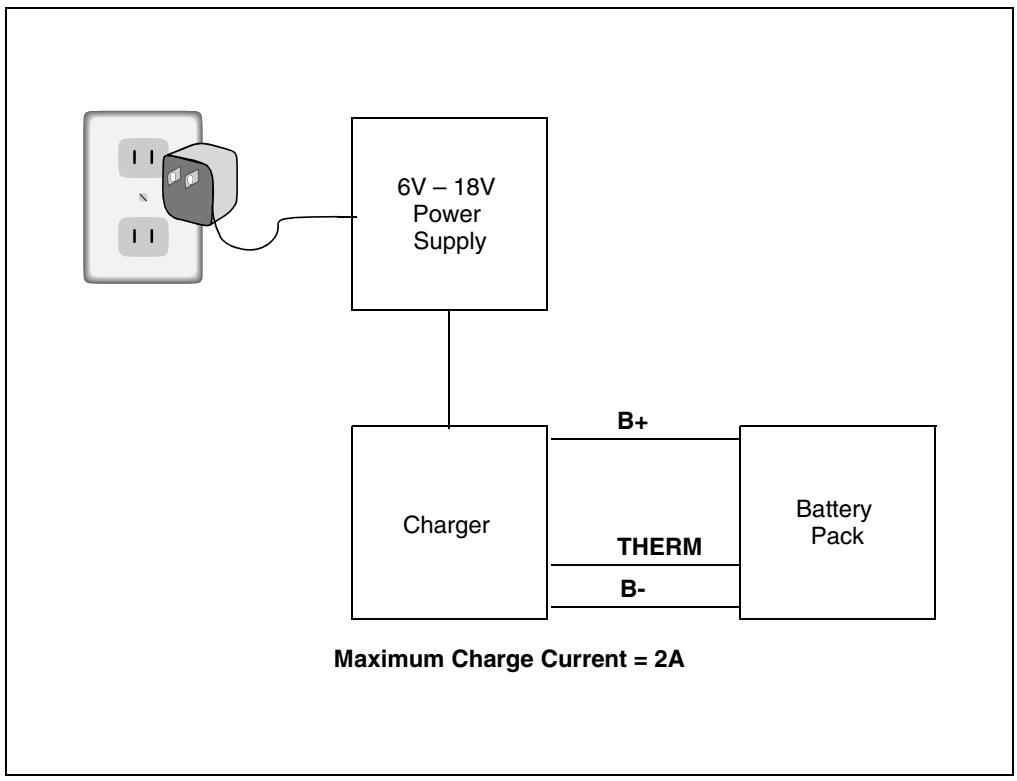


FIGURE 1-1: *MCP1630 Low-Cost Li-Ion Battery Charger System Block Diagram.*

1.2 WHAT IS THE MCP1630 LOW-COST LI-ION BATTERY CHARGER?

The MCP1630 Low-Cost Li-Ion Battery Charger is a complete stand-alone constant current, constant voltage battery charger for single-cell Li-Ion battery packs. Different battery chemistries (i.e. three NiMh or NiCd batteries connected in series) can be charged with minor modifications to the firmware. Multiple series cell Li-Ion battery packs can be charged with minor modifications to the hardware.

This board utilizes Microchip's MCP1630 (high-speed PIC® MCU PWM MSOP8), MCP6292 (dUAL op-amp MSOP8), and PIC12F683 (Flash MCU SOIC8). The input voltage range for the demo board is 6V to 18V. The output is capable of charging at a fast charge rate of 2A constant current.

An input terminal block is provided to apply the input voltage to the charger. An output header is also provided as a means to connect the external battery pack or simulated battery load. A programming header is available for updating the firmware contained in the PIC12F683.

1.3 WHAT THE MCP1630 LOW-COST LI-ION BATTERY CHARGER KIT INCLUDES

This MCP1630 Low-Cost Li-Ion Battery Charger Kit includes:

- The MCP1630 Low-Cost Li-Ion Battery Charger Board,102-00069
- MCP1630 Low-Cost Li-Ion Battery Charger User's Guide, (DS51555).
- MCP1630 Data Sheet, *"High-Speed, Microcontroller-Adaptable, Pulse Width Modulator"*, (DS21896).
- MCP6291/2/3/4/5 Data Sheet, *"1.0 mA, 10 MHz, Rail-to-Rail Op Amp"*, (DS21812).
- PIC12F683 Data Sheet, *"8-Pin Flash-Based, 8-Bit CMOS Microcontrollers with nanoWatt Technology"*, (DS41211).

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MCP1630 Low-Cost Li-Ion Battery Charger demonstrates Microchip's high-speed Pulse Width Modulator (PWM) (the MCP1630) used in a battery charger application. When used in conjunction with a microcontroller, the MCP1630 will control the power system duty cycle to provide output voltage or current regulation. The PIC12F683 microcontroller can be used to regulate output voltage or current, switching frequency and maximum duty cycle. The MCP1630 generates duty cycle and provides fast overcurrent protection based off various external inputs. External signals include the input oscillator, the reference voltage, the feedback voltage and the current sense. The output signal is a square-wave pulse. The power train used for the MCP1630 Low-Cost Li-Ion Battery Charger is a Single-Ended Primary Inductive Converter (SEPIC).

2.2 FEATURES

The MCP1630 Low-Cost Li-Ion Battery Charger has the following features:

- Programmed parameters - modified in firmware
- Factory Settings:
  - Preconditioning Charge Current = 200 mA
  - Preconditioning Threshold = 3 V
  - Constant Current Fast Charge = 1.5 A
  - Constant Voltage Charge = 4.2 V
  - Charge Termination Threshold = 100 mA
- Overvoltage protection (battery removed)
- Overcharge protection to prevent damaging the battery
- Overcurrent protection in the event of a shorted battery
- Battery reversal protection
- Input short circuit protection
- Overtemperature protection to prevent the battery from reaching too high a temperature during charge
- Soft-start capability by holding the reference voltage low during power-up
- The MCP1630 Low-Cost Li-Ion Battery Charger terminates charge by detecting a predefined charge current threshold during constant voltage charge, or a specified elapsed time
- The MCP1630 Low-Cost Li-Ion Battery Charger has the flexibility to optimize the charging algorithm for new battery technology, different battery chemistries or different battery pack configurations
- Proprietary features can be added by modifying the firmware contained in the PIC12F683
- The factory-programmed source code is available
- Ability to adapt to environmental effects, such as ambient temperature

2.3 GETTING STARTED

The MCP1630 Low-Cost Li-Ion Battery Charger is fully assembled and tested for charging single-cell, Li-Ion battery packs with the recommended charge profile for Li-Ion batteries. This board requires the use of an external input voltage source (+6V to +18V) and external load (battery or simulated battery load).

2.3.1 Power Input and Output Connections

2.3.1.1 POWERING THE MCP1630 LOW-COST LI-ION BATTERY CHARGER

1. Apply the input voltage to the input terminal block, J1. The input voltage source should be limited to the 0V to +18V range. For normal operation, the input voltage should be between +6V and +18V. The input voltage must not exceed an absolute maximum of +20V.
2. Connect the positive side of the input source (+) to pin 1 of J1. Connect the negative or return side (–) of the input source to pin 2 of J1. Refer to Figure 2-1.

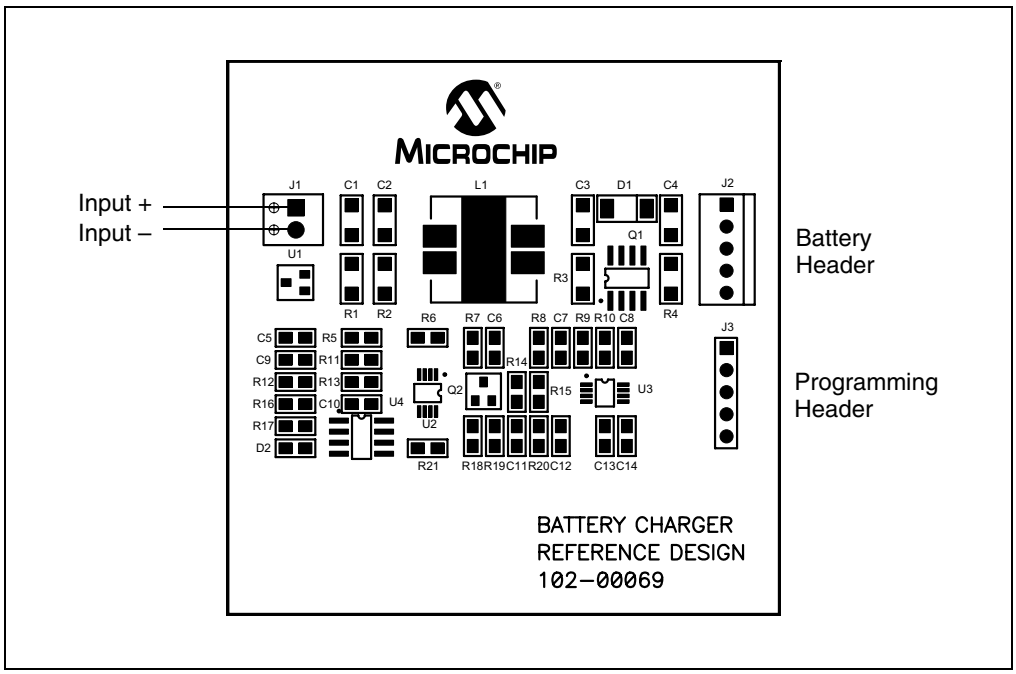


FIGURE 2-1: *Setup Configuration Diagram.*

2.3.1.2 APPLY THE LOAD TO A BATTERY HEADER

1. To apply a load to the MCP1630 Low-Cost Li-Ion Battery Charger, the positive side of the load (B+) should be connected to pin 1 of J2. The negative side of the load (B-) should be connected to pin 5 of J2. Care should be taken when using electronic loads or ground referenced loads.
2. A thermistor referenced to (B-) in the battery pack should be utilized. If a thermistor is not available or not desired, a 10 kΩ resistor should be placed between pins 4 and 5 of the battery header (J2).
3. The installed firmware will prevent the board from entering the Fast Charge mode if the battery terminal voltage is less than 3V. During power-up, the board will always trickle charge first, so using a purely resistive load will not work for trickle and fast-charge current. The best way to evaluate the charger is to use a single-cell Li-Ion battery pack, or the recommended simulated battery load. Refer to Figure 2-2.

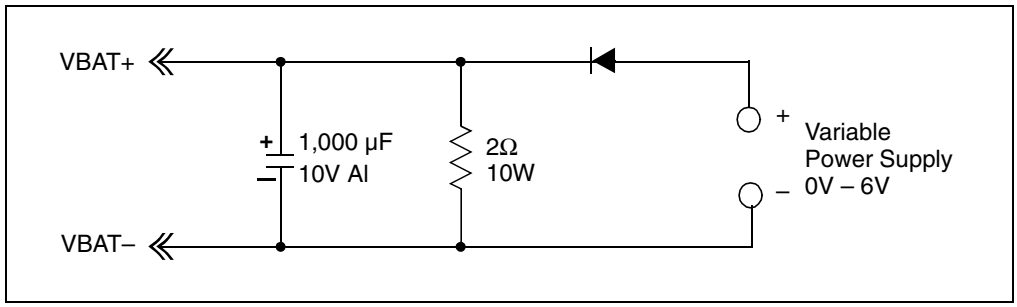


FIGURE 2-2: *Simulated Battery Load.*

2.3.1.3 STATUS LED

1. The MCP1630 Low-Cost Li-Ion Battery Charger has an LED to indicate charge status or fault status. Table 2-1 represents the state of the LED during various states of the charge cycle.

TABLE 2-1: STATUS OUTPUT

CHARGE CYCLE STATE	LED
Qualification	OFF
Preconditioning	ON
Constant Current Fast Charge	ON
Constant Voltage	ON
Charge Complete	OFF
Safety Timer Fault	Flashing (2 Hz, 50% duty cycle)
Cell Temperature Invalid	Flashing (1 Hz, 50% duty cycle)
Battery Disconnected	OFF
Input Power Removed	OFF

2.3.1.4 PROGRAMMING

Header J3 is provided for In-Circuit System Programming™.

If the factory installed firmware is modified or if the PIC12F683 is reprogrammed, the board needs to be calibrated. To perform calibration, a 4.2V source should be applied to the battery header. Then, when input power is applied for the first time, the board will perform a self calibration. The LED will flash when the calibration has been completed. The 4.2V source should be removed and input power cycled for normal operation.

NOTES:

Appendix A. Schematic and Layouts

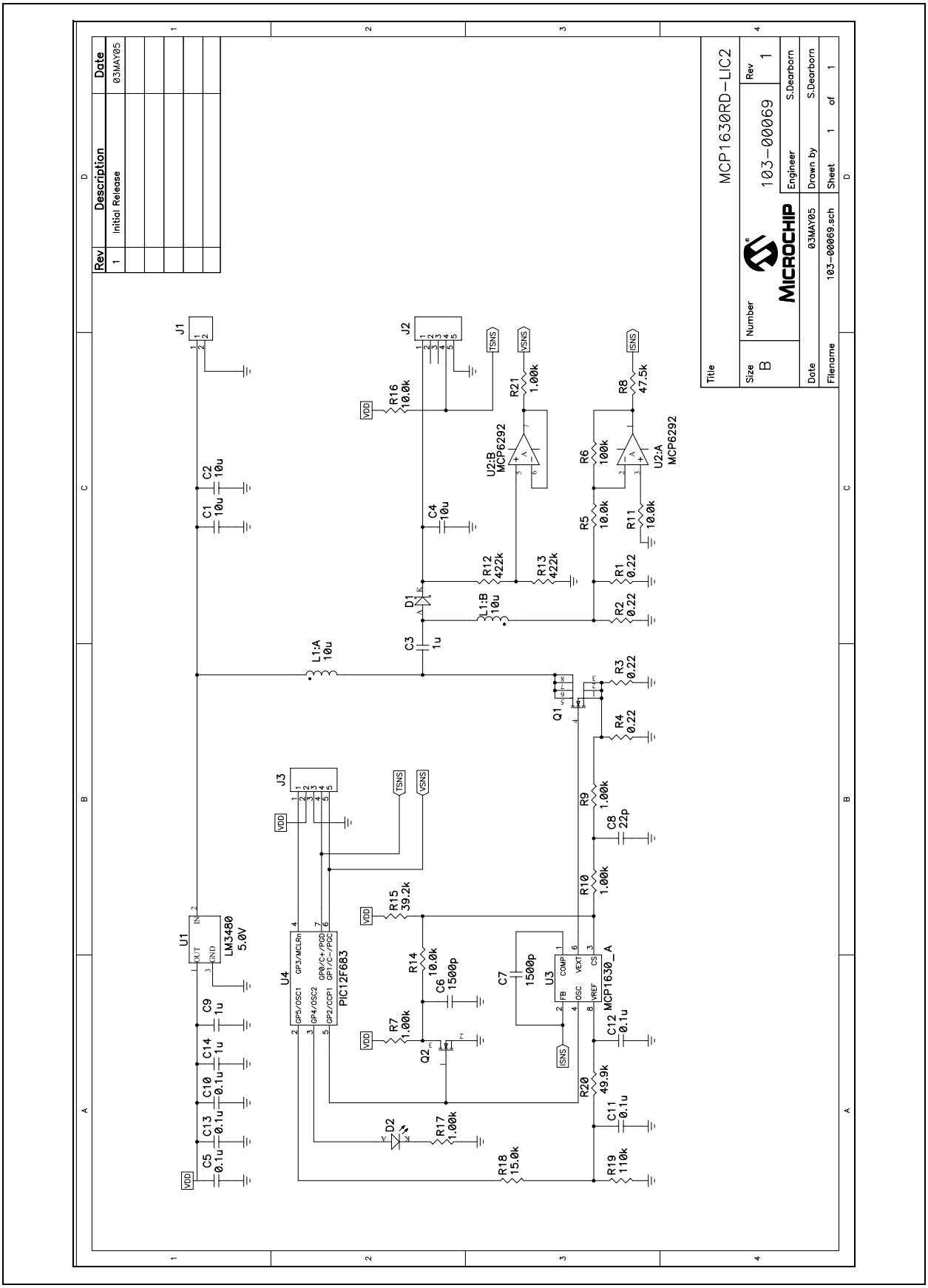
A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the MCP1630 Low-Cost Li-Ion Battery Charger.

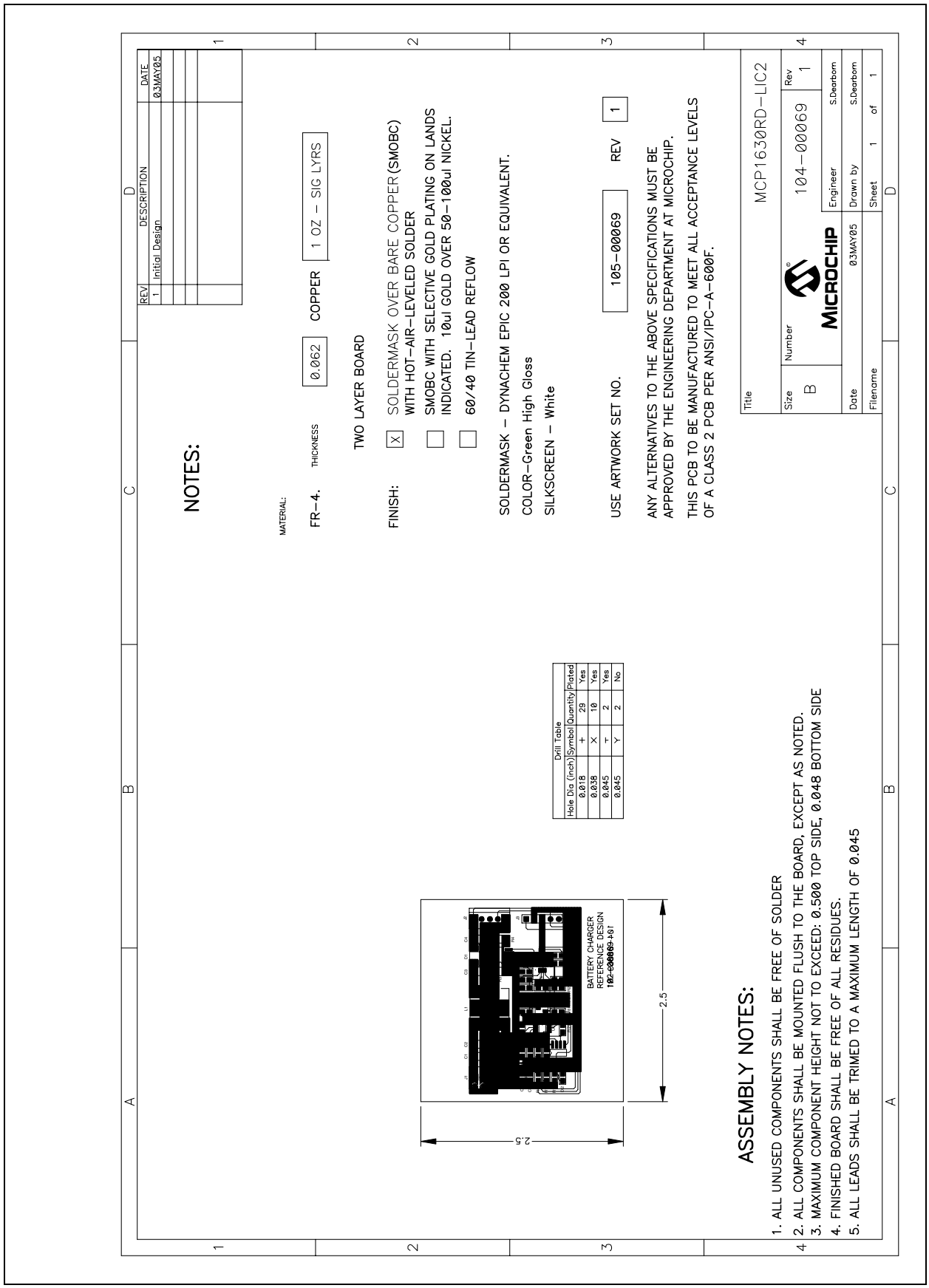
Diagrams included in this appendix:

- Board Schematic
- Board – Assembly Drawing
- Board – Top Overlay
- Board – Top Layer
- Board – Bottom Layer

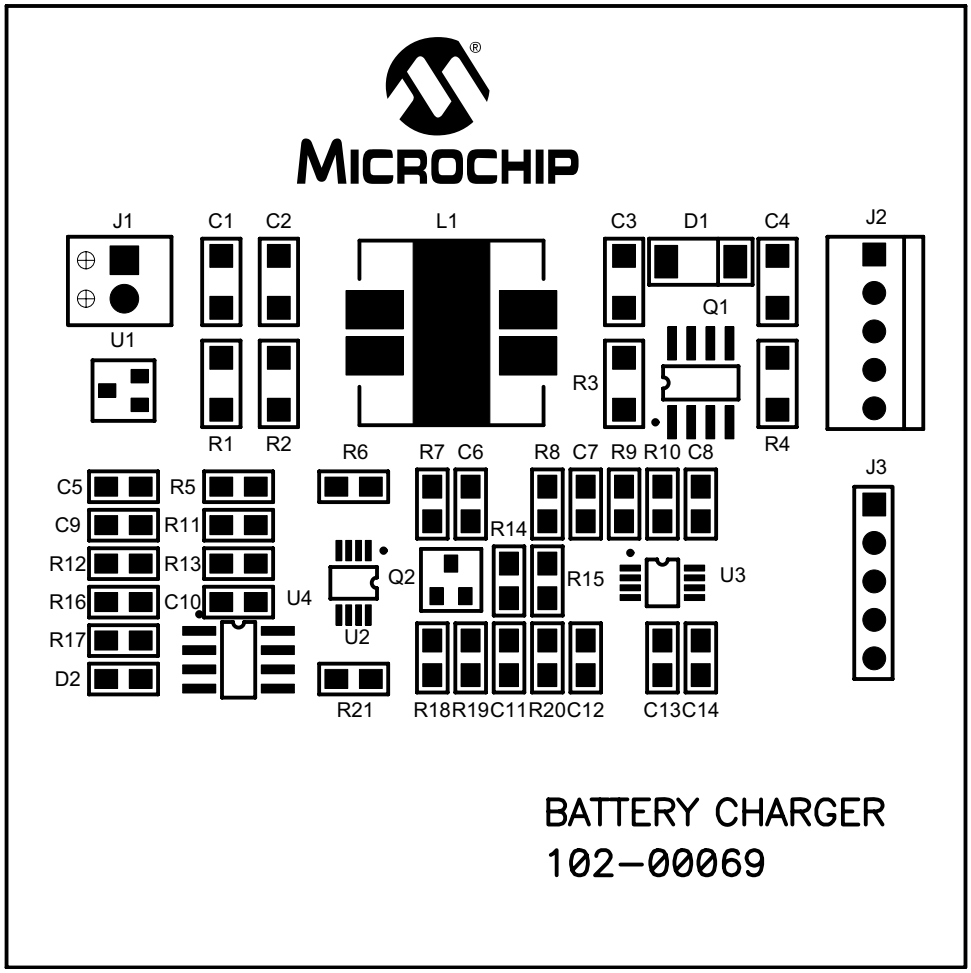
A.2 BOARD SCHEMATIC



A.3 BOARD – ASSEMBLY DRAWING

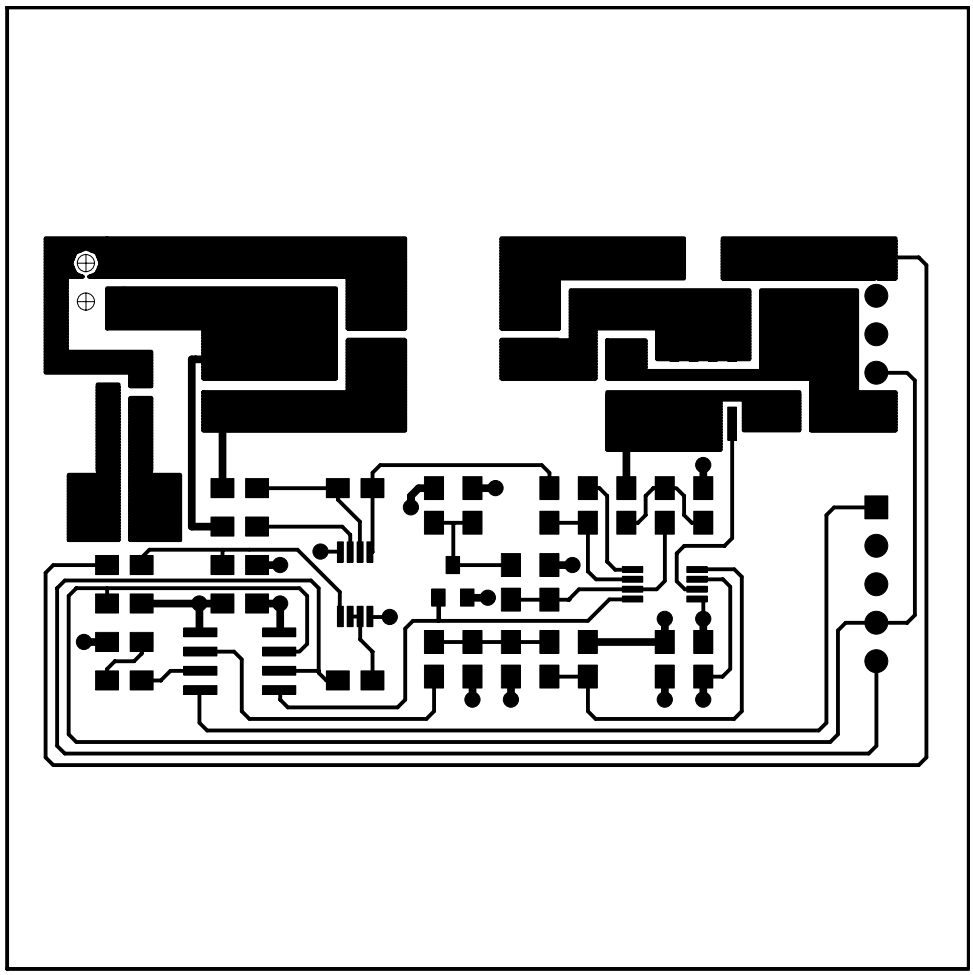


A.4 BOARD – TOP OVERLAY



Scale = 2:1

A.5 BOARD – TOP LAYER



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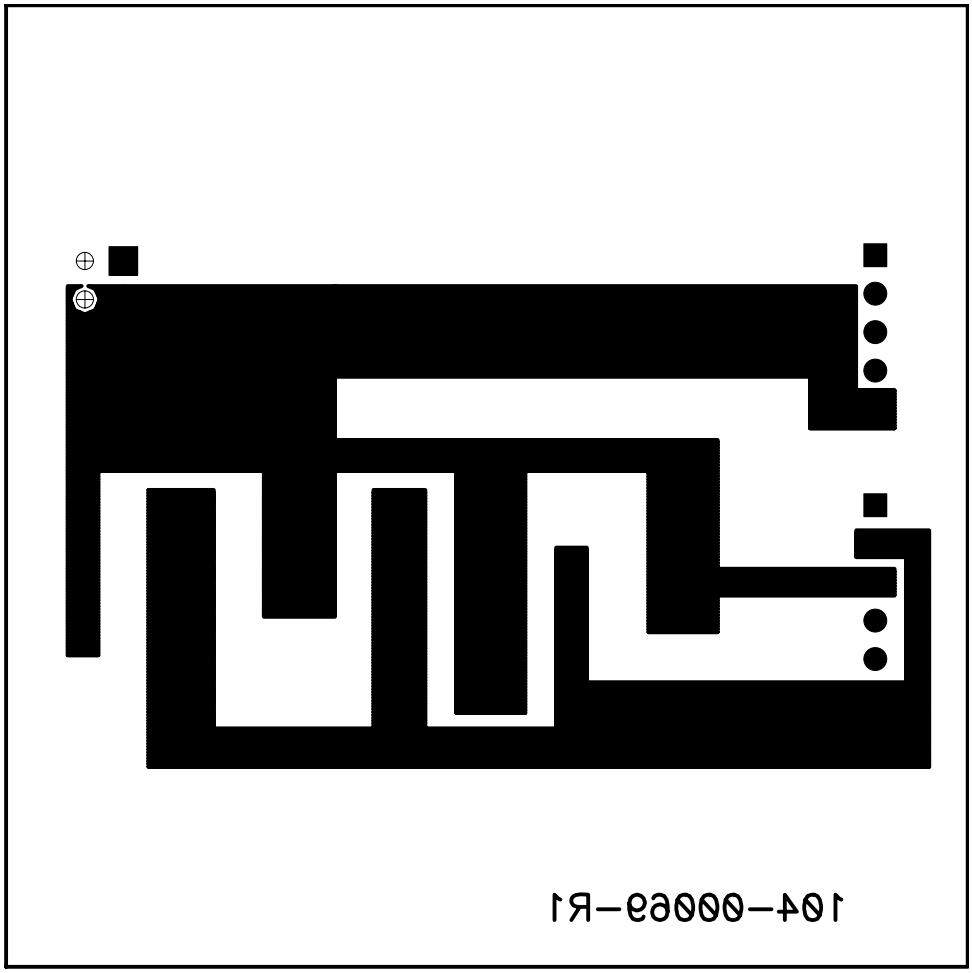
A.6 BOARD – BOTTOM LAYER



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Appendix B. Bill Of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Mfgr.	Part Number
5	C5,C10,C11,C12,C13	0.1 µF, X7R Ceramic, 16V, 0805	Panasonic®-ECG	ECJ-2VB1C104K
2	C9,C14	1 µF, X5R Ceramic, 16V, 0805	Panasonic-ECG	ECJ-2FB1C105K
1	C8	22 pF, NPO Ceramic, 50V, 0805	Panasonic-ECG	ECJ-2VC1H220J
1	C7	1500 pF, X7R Ceramic, 100V, 0805	Panasonic-ECG	ECJ-2VB2A152K
1	C3	1 µF, X7R Ceramic, 25V, 1206	Panasonic-ECG	ECJ-3YB1E105K
3	C1,C2,C4	10 µF, X5R Ceramic, 25V, 1206	Panasonic-ECG	ECJ-3YB1E106M
1	L1	10 µH, Coupled Inductor, DRQ127	Coiltronics®	DRQ127-100
1	J3	Header, 5 Pos., 2.54 mm, HDR1X5	Molex®	22-03-2051
1	J2	Header, 5 Pos., 2.54 mm, Friction Lock, HDR1X5-FL	Molex®	22-23-2051
1	D2	Green LED, 0805	Lumex® Opto/Components	SML-LXT0805GW-TR
1	U1	5.0V, Voltage Regulator, SOT23	National Semicondutor	LM3480IM3-5.0
1	U3	PWM Building Block, MSOP8	Microchip Technology Inc.	MCP1630-E/MS
1	U2	Dual Operational Amplifier 10 MHz, MSOP8	Microchip Technology Inc.	MCP6292-E/MS
1	Q1	N-Channel MOSFET, SOIC8	International Rectifier	IRF7807V
1	Q2	N-Channel MOSFET, SOT23	Fairchild®	NDS7002A
1	U4	8-Bit FLASH MCU, SOIC8	Microchip Technology Inc.	PIC12F683-I/SN
5	R7,R9,R10,R17,R21	1.00 kΩ, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF1001V
4	R5,R11,R14,R16	10.0 kΩ, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF1002V
1	R18	15.0 kΩ, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF1502V
1	R8	47.5 kΩ, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF4752V
1	R20	49.9 kΩ, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF4992V
1	R6	100 kΩ, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF1003V
1	R19	110k, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF1103V
2	R12,R13	422 kΩ, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF4223V
4	R1,R2,R3,R4	0.22Ω, 1/4W, Chip Resistor, 1206	Panasonic-ECG	ERJ-8RQFR22V
1	D1	3.0A, 30V Schottky Diode, SMA	Toshiba®	CMS01 (TE12L)
1	J1	Terminal Block, 2 Pos., 2.54 mm, TB254-2	Phoenix Contact	1725656

NOTES:

Appendix C. Evaluation Board Firmware

C.1 DEVICE FIRMWARE

For the latest copy of the MCP1630 Low-Cost Battery Charger User's Guide firmware, visit our web site at www.microchip.com.

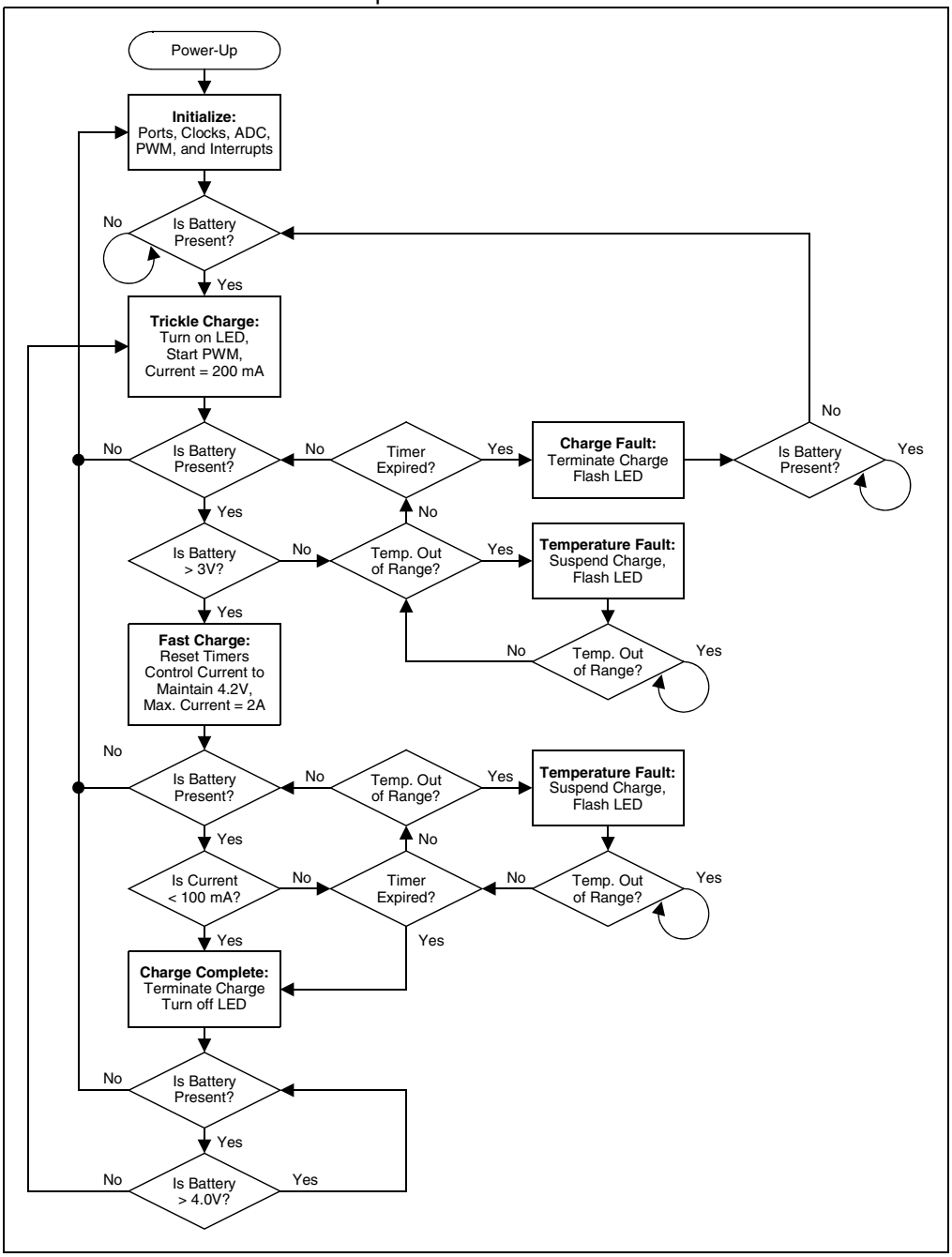

FIGURE C-1: *Firmware Flowchart.*

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