MCP1630
Low-Cost NiMH Battery Charger Reference Design

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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.

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 MCP1630 Low-Cost NiMH Battery Charger Reference Design. 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 NiMH Battery Charger Reference Design as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP1630 Low-Cost NiMH Battery Charger Reference Design.
- **Chapter 2. "Installation and Opation"** – Includes instructions on how to get started with this user's guide and a description of how to use the MCP1630 Low-Cost NiMH Battery Charger Reference Design.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP1630 Low-Cost NiMH Battery Charger Reference Design.
- **Appendix B. "Bill Of Materials (BOM)"** – Lists the parts used to build the MCP1630 Low-Cost NiMH Battery Charger Reference Design.
- **Appendix C. "Demo Board Firmware"** – Provides information about the application firmware and source code.

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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 MCP1630 Low-Cost NiMH Battery Charger Reference Design. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

MCP1630/MCP1630V Data Sheet, *"High-Speed, Microcontroller-Adaptable, Pulse Width Modulator"* (DS21896)

This data sheet provides detailed information regarding the MCP1630/MCP1630V product family.

PIC12F683 Data Sheet, *"8-Pin Flash-Based, 8-Bit CMOS Microcontrollers with Nano Watt Technology"* (DS41211)

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

AN960 Application Note, *"New Components and Design Methods Bring Intelligence to Battery Charger Applications"* (DS00960)

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
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- Technical Support

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

DOCUMENT REVISION HISTORY

Revision A (February 2007)

- Initial Release of this Document.

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Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP1630 Low-Cost NiMH Battery Charger Reference Design is used to charge three series cell NiMH or NiCd batteries. The board uses the MCP1630 high-speed analog PWM and PIC12F683 to generate the charge algorithm for NiMH or NiCd batteries.

The MCP1630 Low-Cost NiMH Battery Charger Reference Design is used to evaluate Microchip's MCP1630 in a SEPIC power converter application. As provided, the MCP1630 Low-Cost NiMH Battery Charger Reference Design is capable of charging a three series cell NiMH battery pack from an input voltage of 6V to 14V. The MCP1630 Low-Cost NiMH Battery Charger Reference Design provides a constant current charge with preconditioning, cell temperature monitoring and battery pack fault monitoring. Also, the charger provides a status or fault indication. The MCP1630 Low-Cost NiMH Battery Charger Reference Design automatically detects the insertion or removal of a battery pack.

This chapter covers the following topics.

- What is the MCP1630 Low Cost NiMH Battery Charger Reference Design?
- What the MCP1630 Low Cost NiMH Battery Charger Reference Design Kit includes.

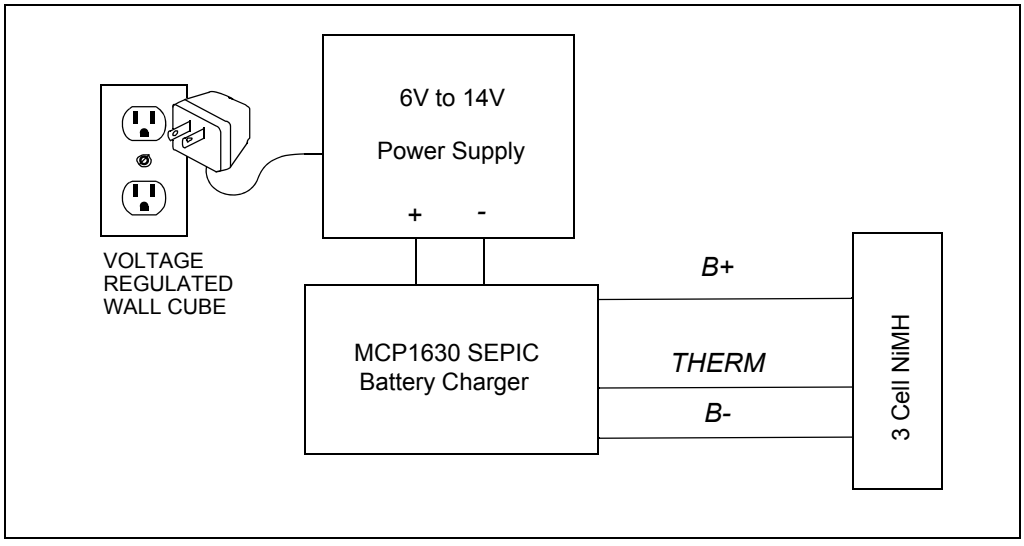

FIGURE 1-1: *MCP1630 Low Cost NiMH Battery Charger Reference Design Block Diagram.*

1.2 WHAT IS THE MCP1630 LOW COST NIMH BATTERY CHARGER REFERENCE DESIGN?

The MCP1630 Low-Cost NiMH Battery Charger Reference Design is a complete stand-alone constant current battery charger for a three series cell NiMH or NiCd battery pack. Different battery chemistries (i.e. Li-Ion batteries connected in series) can be charged with minor modifications to the firmware or with the MCP1630 Low-Cost NiMH Battery Charger Reference Design. 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 14V. The output is capable of charging at a fast charge rate of 1.3A 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 and external 10K thermistor. A programming header is available for updating the firmware contained in the PIC12F683.

1.3 WHAT THE MCP1630 LOW COST NIMH BATTERY CHARGER REFERENCE DESIGN KIT INCLUDES

This MCP1630 Low Cost NiMH Battery Charger Reference Design kit includes:

- The MCP1630 Low-Cost NiMH Battery Charger Reference Design Board, (102-00127)
- Analog and Interface Products Demonstration Boards CD-ROM (DS21912)
  - MCP1630 Low-Cost NiMH Battery Charger Reference Design User's Guide, (DS51648)

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Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MCP1630 Low-Cost NiMH Battery Charger Reference Design 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 NiMH Battery Charger Reference Design is a Single-Ended Primary Inductive Converter (SEPIC).The PIC12F683 microcontroller is programmable, allowing the user to modify or develop their own firmware routines to further evaluate the MCP1630 Low-Cost NiMH Battery Charger Reference Design in this application.

2.2 FEATURES

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

- Programmed parameters - modified in firmware
- Factory Settings:
  - Preconditioning Charge Current =170 mA
  - Preconditioning Threshold = 3V
  - Constant Current Fast Charge = 1.35A
  - Charge Termination based on delta - V_{BATT} / delta time
  - Charge Termination based on delta + T_{BATT} / delta time, with external thermistor installed
- Top Off Charge Current = 130 mA for 1 Hour
- 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 NiMH 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

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2.3 GETTING STARTED

The MCP1630 Low-Cost NiMH Battery Charger is fully assembled and tested for charging three series cell NiMH batteries. The charge termination is based on a negative slope in battery voltage or a positive slope in battery pack temperature, (when external thermistor is installed). This board requires the use of an external voltage source to charge the series connected batteries with a range of +6V to +14V input. An external load and thermistor is also required to evaluate the charger reference design.

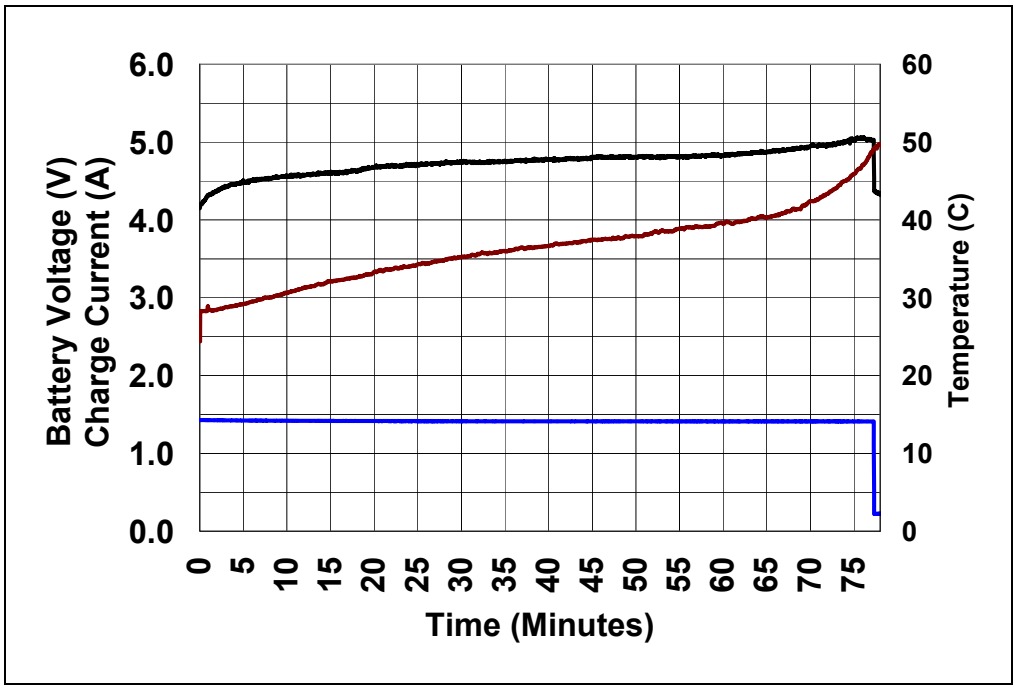

FIGURE 2-1: *MCP1630 Low-Cost NiMH Battery Charger Reference Design Charge Profile.*

2.3.1 Power Input and Output Connection

2.3.1.1 POWERING THE MCP1630 LOW-COST NIMH BATTERY CHARGER

1. Apply the input voltage to the input terminal block, J1. The input voltage source should be limited to the 0V to +14V range. For nominal operation the input voltage should be between +6V and +14V.
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 2-2.

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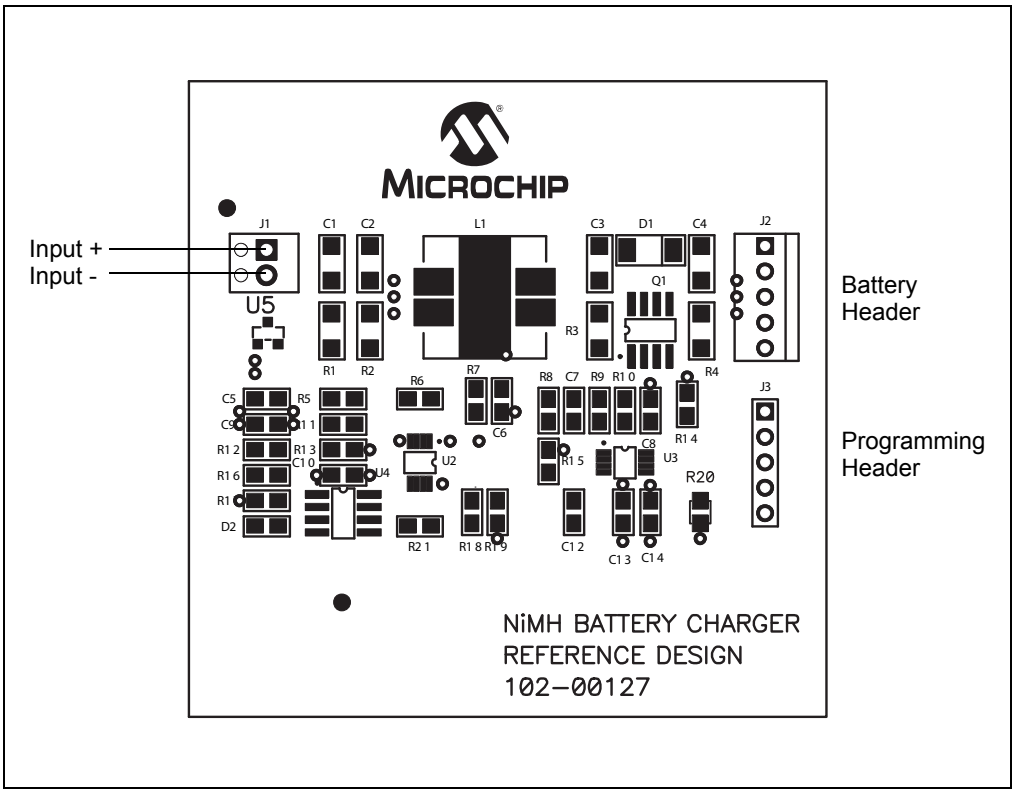

FIGURE 2-2: *Setup Configuration Diagram.*

2.3.1.2 APPLYING A LOAD TO THE MCP1630 LOW-COST NIMH BATTERY CHARGER REFERENCE DESIGN

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, recommended EPCOS Inc. PN B57509m103A5. 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 1.3A Fast Charge mode, if the battery terminal voltage is less than 2V. 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 three series cell NiMH 2,200 mA/hour batteries, or the recommended simulated battery load. Refer to Figure 2-3 before applying a load to the MCP1630 Low-Cost NiMH Battery Charger Reference Design.

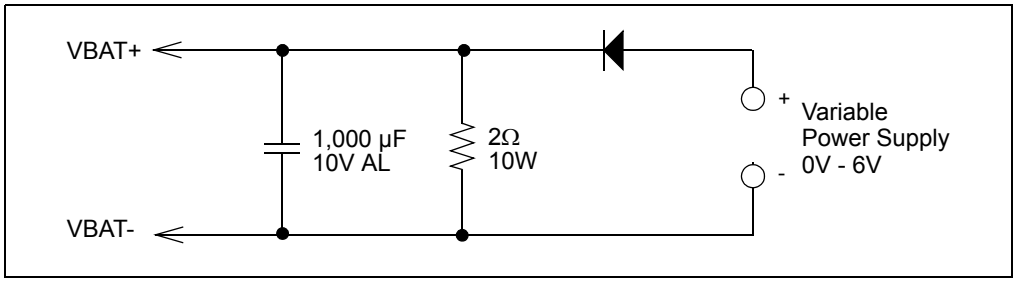

FIGURE 2-3: *Simulated Battery Load.*

2.3.1.3 STATUS LED

1. The MCP1630 Low-Cost NiMH 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
Top Off Charge	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-system circuit programming.

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Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the MCP1630 Low-Cost NiMH Battery Charger Reference Design:

- Board Schematic
- Board – Top Silk Layer
- Board – Top Metal Layer
- Board – Bottom Silk Layer
- Board – Bottom Metal Layer

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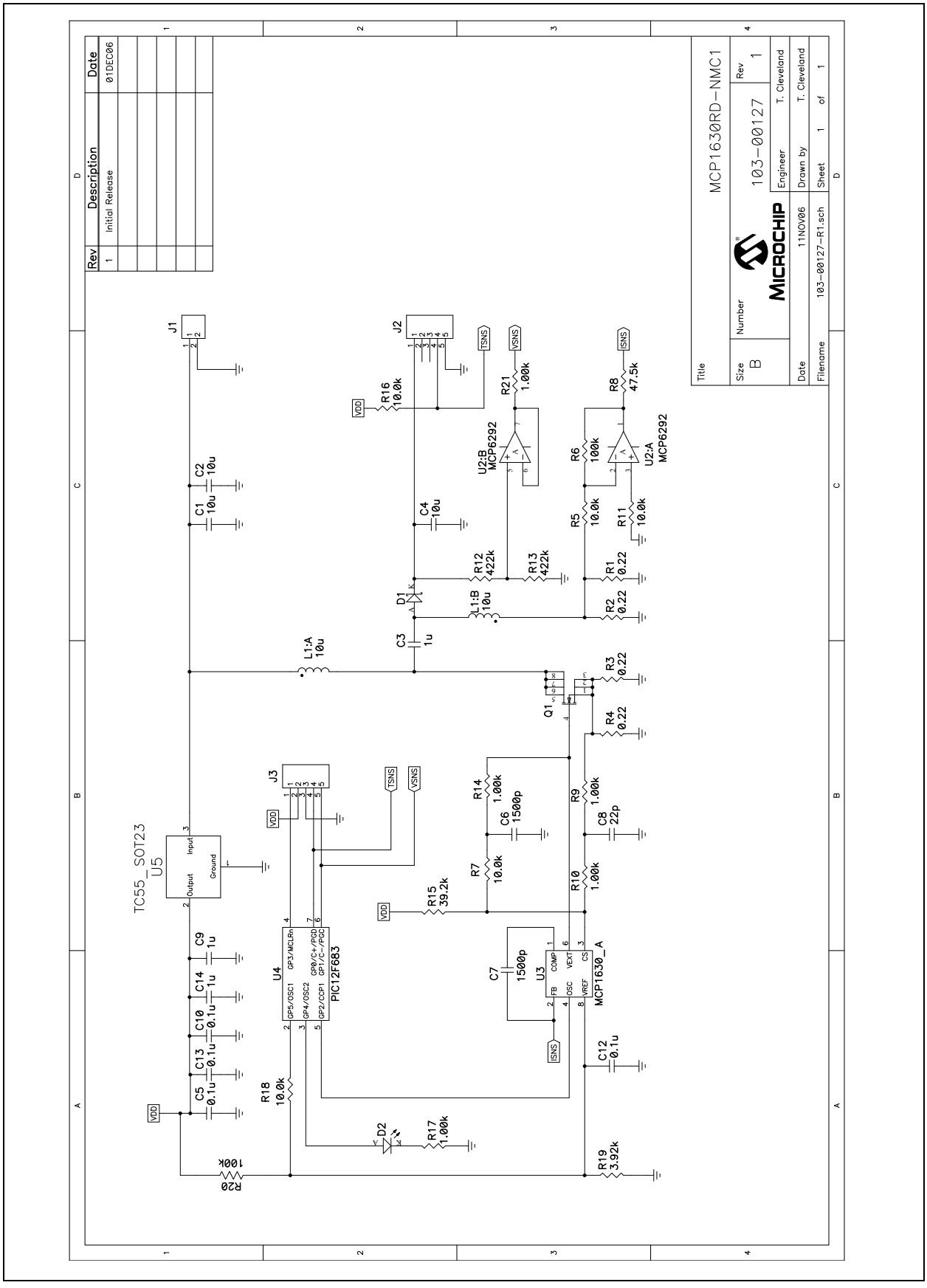
A.2 BOARD – SCHEMATIC



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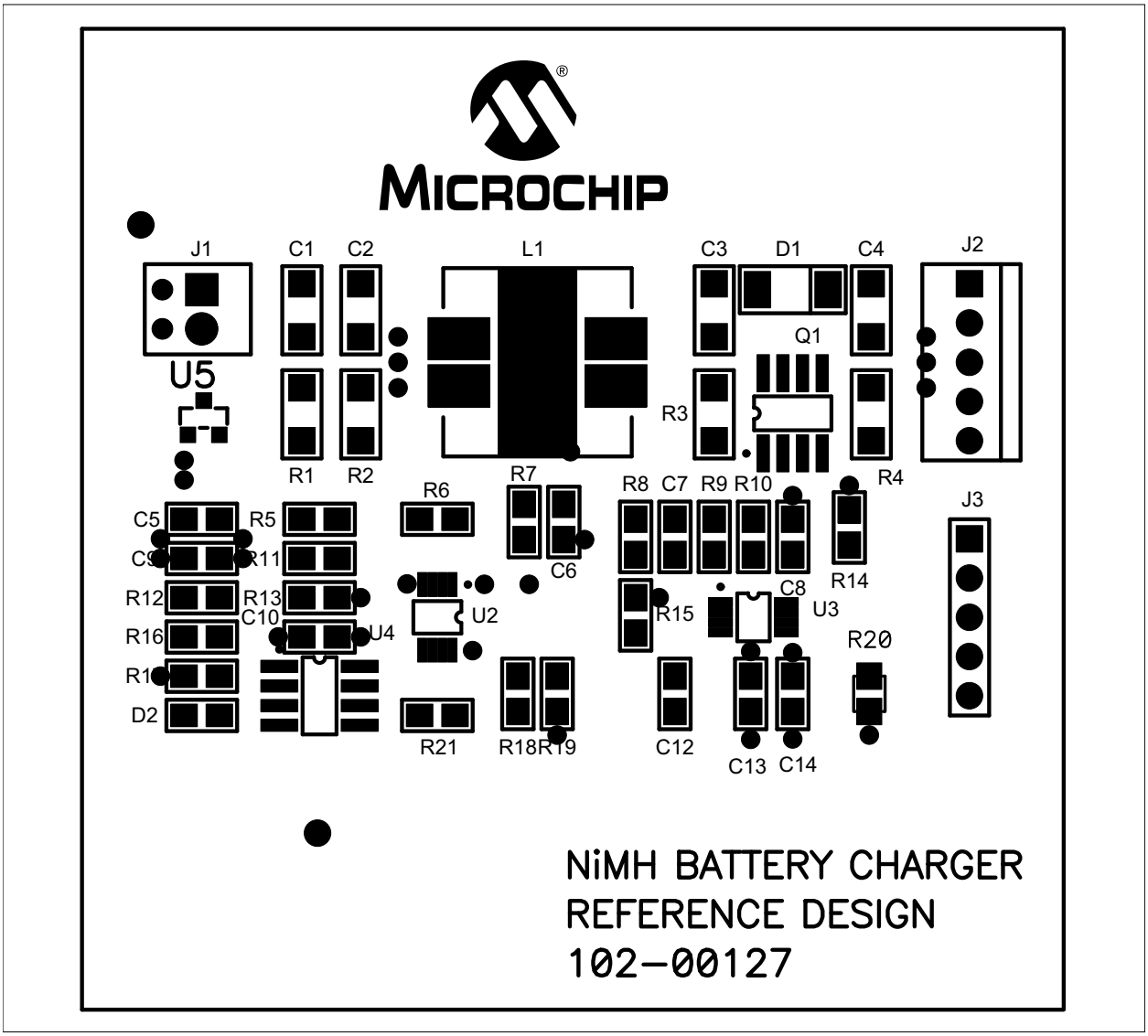
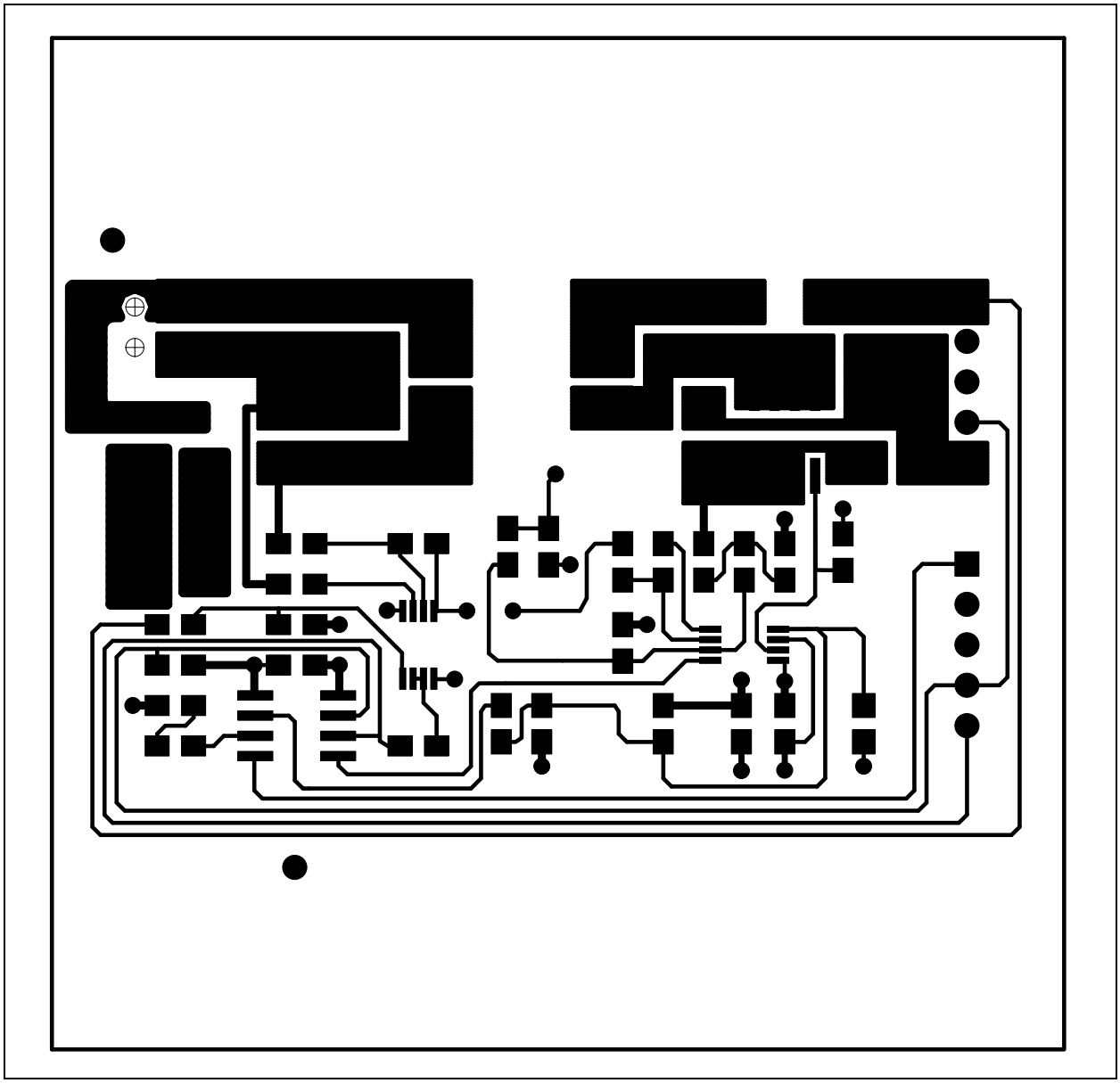
A.3 BOARD – TOP SILK LAYER



A.4 BOARD – TOP METAL LAYER



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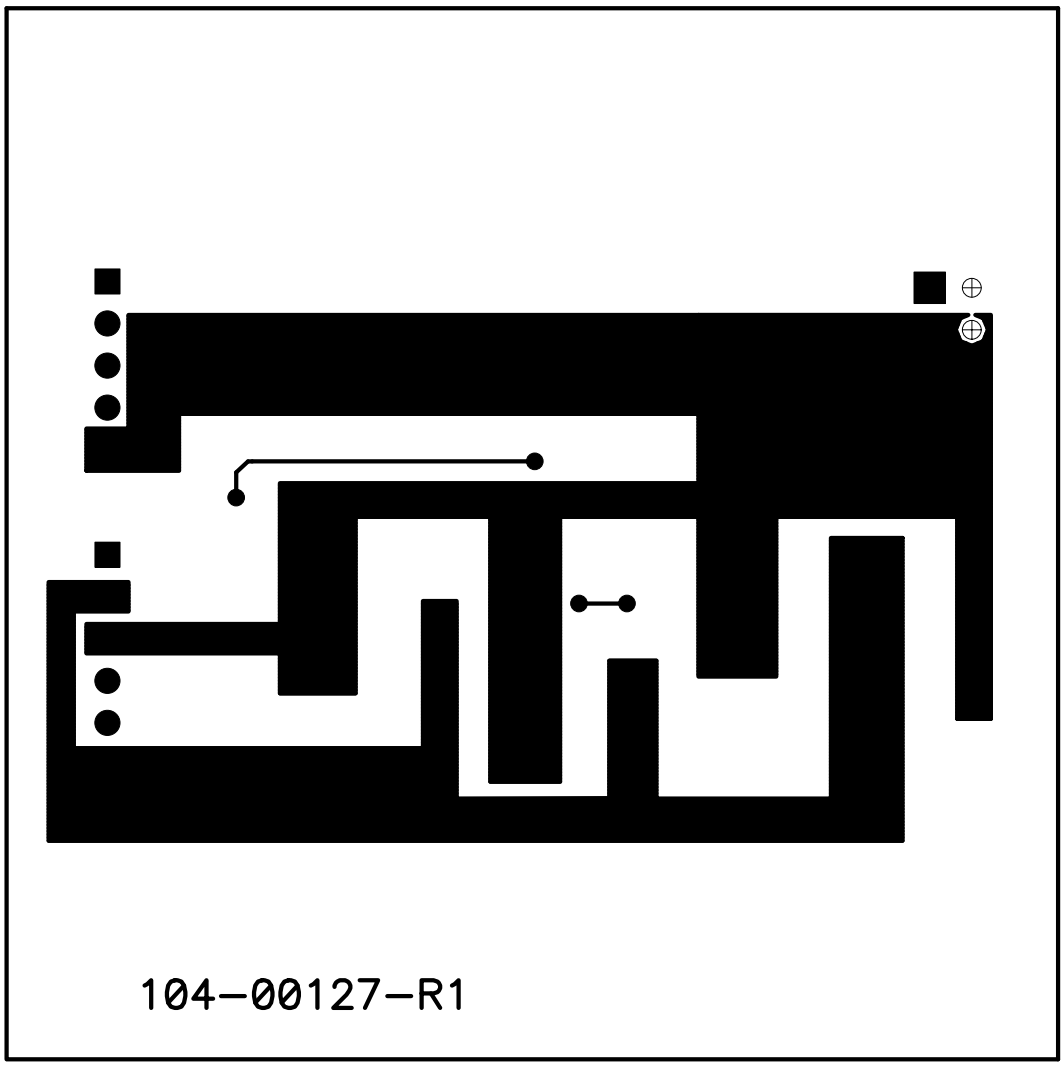
A.5 BOARD – BOTTOM METAL LAYER



NOTES:

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Appendix B. Bill Of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty	Reference	Description	Manufacturer	Part Number
3	C1, C2, C4	10uF, X5R Ceramic, 25V, 1206	Panasonic®-ECG	ECJ-3YB1E106M
1	C3	1uF, X7R Ceramic, 25V, 1206	Panasonic-ECG	ECJ-3YB1E105K
5	C5, C10, C12, C13	0.1uF, X7R Ceramic, 16V, 0805	Panasonic-ECG	ECJ-2VB1C104K
2	C6, C7	1500pF, X7R Ceramic, 100V, 0805	Panasonic-ECG	ECJ-2VB2A152K
1	C8	22pF, NPO Ceramic, 50V, 0805	Panasonic-ECG	ECJ-2VC1H220J
2	C9, C14	1uF, X5R Ceramic, 16V, 0805	Panasonic-ECG	ECJ-2FB1C105K
1	D1	3.0A, 30V Schottky Diode, SMA	Toshiba	CMS01 (TE12L)
1	D2	Green LED, 0805	Lumex® Opto	SML-LXT0805GW-TR
1	J1	Connector Terminal Block, 2 Pos., 2.54mm, TB254-2	Phoenix Contact	1725656
1	J2	Connector Header, 5 Pos., 2.54mm, Friction Lock, HDR1X5-FL	Molex	22-23-2051
1	J3	Connector Header, 5 Pos., 2.54mm, HDR1X5	Molex	22-03-2051
1	L1	10uH, Coupled Inductor, DRQ127	Coiltronics	DRQ127-100
1	PCB	RoHS Compliant Bare PCB, MCP1630 Low-Cost NiMH Battery Charger Reference Design	—	104-000127
1	Q1	N-Channel MOSFET, SOIC8	International Rectifier	IRF7807V
4	R1, R2, R3, R4	0.22, 1/4W, Chip Resistor, 1206	Panasonic-ECG	ERJ-8RQFR22V
4	R5, R7, R11, R16, R18	10.0k, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF1002V
1	R6, R20	100k, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF1003V
1	R8	47.5k, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF4752V
5	R9, R10, R14, R17, R21	1.00k, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF1001V
2	R12, R13	422k, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF4223V
1	R15 ,R19	39.2k, 1/10W, Chip Resistor, 0805	Panasonic-ECG	ERJ-6ENF3922V
1	U2	Dual Operational Amplifier 10MHz, MSOP8	Microchip Technology Inc	MCP6292-E/MS
1	U3	PWM Building Block, MSOP8	Microchip Technology Inc	MCP1630-E/MS
1	U4	Enhanced FLASH Microcontroller, SOIC8	Microchip Technology Inc	PIC12F683-I/SN
1	U5	5.0V, 250mA, Voltage Regulator, SOT23	Microchip Technology Inc	MCP17025002E/CB

Note 1: 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.

NOTES:

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Appendix C. Demo Board Firmware

C.1 DEVICE FIRMWARE FLOWCHART - PAGE 1

For the latest copy of the MCP1630 Low-Cost NiMH Battery Charger Reference Design firmware, visit our website at www.microchip.com.

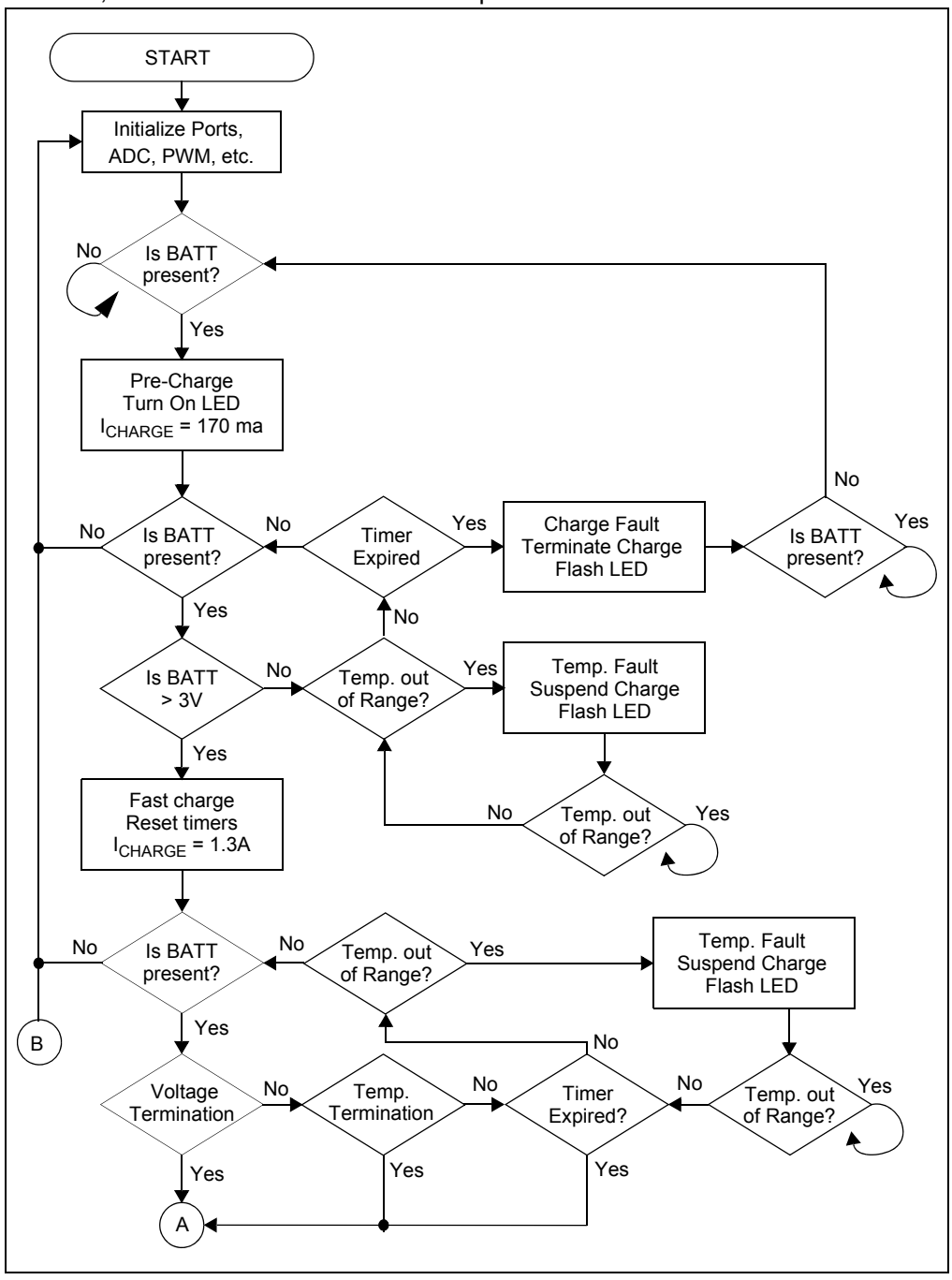

FIGURE C-1: *Firmware Flowchart, page 1.*

C.2 DEVICE FIRMWARE FLOWCHART - PAGE 2

For the latest copy of the MCP1630 Low-Cost NiMH Battery Charger Reference Design firmware, visit our website at www.microchip.com.

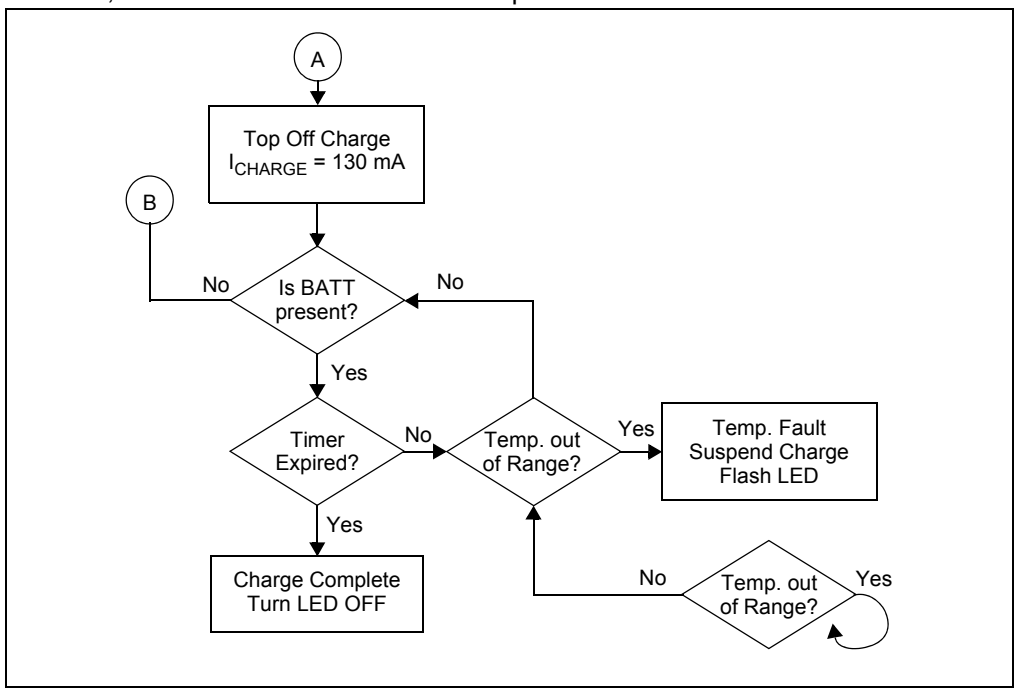

FIGURE C-2: *Firmware Flowchart, page 2.*

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