MCP16411 Boost Converter with Dynamic UVLO Reference Design User's Guide

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ISBN: 978-1-5224-8575-9

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MCP16411 BOOST CONVERTER WITH DYNAMIC UVLO REFERENCE DESIGN USER'S GUIDE

Table of Contents

NOTES:

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 website (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 "DSXXXXXXXXA", where "XXXXXXXX" 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 online help. Select the Help menu, and then Topics to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP16411 Boost Converter with Dynamic UVLO Reference Design. Items discussed in this chapter include:

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

DOCUMENT LAYOUT

This document describes how to use the MCP16411 Boost Converter with Dynamic UVLO Reference Design as a development tool. The document is organized as follows:

- **Chapter 1. "Product Overview"** – provides important information about the MCP16411 and the MCP73830.
- **Chapter 2. "Installation and Operation"** – includes instructions on how to get started with the MCP16411 Boost Converter with Dynamic UVLO Reference Design and a description of each function.
- **Appendix A. "Schematics and Layouts"** – shows the schematic and PCB layout for the MCP16411 Boost Converter with Dynamic UVLO Reference Design.
- **Appendix B. "Bill of Materials (BOM)"** – lists the parts used to build the MCP16411 Boost Converter with Dynamic UVLO Reference Design.

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	`xctapcog"]."` `xctapcog000_`

	Represents code supplied by user	`xqkf"ockp"*xqkf+`
		`}"000`
		`¡`

RECOMMENDED READING

This user's guide describes how to use the MCP16411 Boost Converter with Dynamic UVLO Reference Design. Another useful document is listed below. The following Microchip documents are available and recommended as a supplemental reference resource:

- **MCP1641X Data Sheet – *"Low IQ Boost Converter with Programmable Low Battery, UVLO and Automatic Input-to-Output Bypass Operation"* (DS20006394).**
- **MCP73830/L Data Sheet** – ***"Single-Cell Li-Ion/Li-Polymer Battery Charge Management Controllers in 2x2 TDFN"* (DS20005049).**

THE MICROCHIP WEBSITE

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- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **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 (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 website at:
http://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (July 2021)

- Initial release of this document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP16411 Boost Converter with Dynamic UVLO Reference Design and covers the following topics:

- MCP16411 and MCP73830 Short Overview
- Functional Description
- What is the MCP16411 Boost Converter with Dynamic UVLO Reference Design?
- Contents of the MCP16411 Boost Converter with Dynamic UVLO Reference Design Kit

1.2 MCP16411 AND MCP73830 SHORT OVERVIEW

The MCP16411 Boost Converter with Dynamic UVLO Reference Design consists of the following main devices:

- MCP16411 - Low I_Q Boost Converter with Automatic Bypass
- MCP73830 - Single-Cell Lithium-Ion/Lithium-Polymer Charge Management Controller

Figure 1-1 represents the block diagram of the MCP16411 Boost Converter with Dynamic UVLO Reference Design.

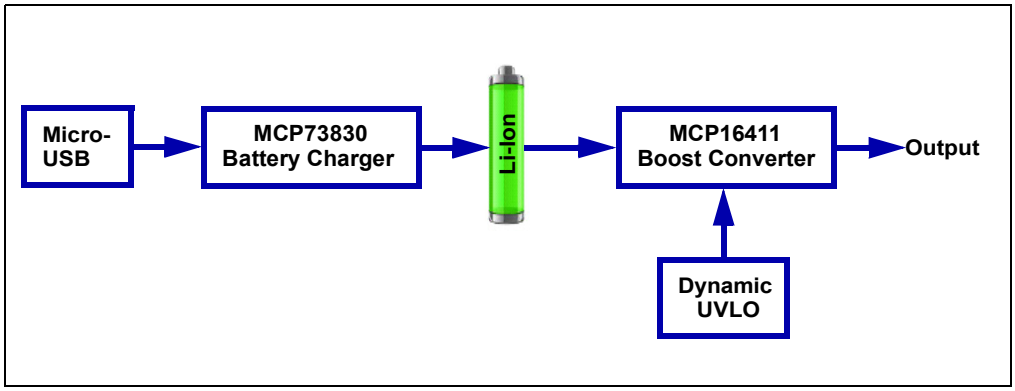


FIGURE 1-1: *MCP16411 Boost Converter with Dynamic UVLO Reference Design Block Diagram.*

1.2.1 MCP16411 Device Overview

The MCP16411 is a compact, fixed frequency, synchronous step-up DC-DC converter which features integrated internal compensation, low-noise anti-ringing control, inrush current limit and soft start.

The MCP1641X family of devices provides a battery monitoring feature, which delivers high efficiency over a wide range of inputs: single-cell, two-cell, alkaline/NiMH batteries or single-cell Li-Ion/Li-Polymer batteries can be used. These low-voltage boost converters feature low-quiescent current, a programmable start-up voltage (Undervoltage Lockout – UVLO), Low Battery Output (LBO), adjustable output voltage and dual mode of operation: Automatic PFM/PWM and PWM only.

The boost converter starts in normal operation at 0.85V ($UVLO_{START}$) by default. The start-up voltage is easily programmed by a resistive divider connected to the UVLO pin but cannot be lower than 0.85V. The $UVLO_{STOP}$ prevents faulty operation below 0.8V. Additionally, a low battery indication circuit is implemented with an LBO warning pin if the voltage of the battery decreases below the UVLO's trip point.

The MCP1641X family provides an Automatic Input-to-Output Bypass operation which helps to optimize the battery utilization. The Automatic Input-to-Output Bypass mode is active when the V_{IN} is close to the targeted V_{OUT} or higher; the device will resume Boost mode if V_{OUT} falls to approximately 90% of the set regulation voltage.

An additional safety feature is represented by the combined Power Good and Die Overtemperature Output which flags a warning signal when the output voltage drops with 10% or the die temperature exceeds +75°C. Both functions are implemented in the MCP16411/2/3/4 devices (on the same PGT pin) while the MCP16415/6/7/8 devices have the Power Good only option.

The MCP1641X can be enabled/disabled using the EN pin. The selectable shutdown state options are Output Discharge for MCP16411/2/5/6 and Input-to-Output Bypass for MCP16413/4/7/8.

The MCP1641X is offered in small MSOP-10 and 3 mm x 3 mm TDFN packages.

The goal of the MCP16411 Boost Converter with Dynamic UVLO Reference Design is to demonstrate the features and capabilities of the MCP16411 device into a real application.

1.2.1.1 MCP16411 DEVICE FEATURES

- Up to 96% Efficiency
- Input Voltage Range: 0.8V to 5.25V (after start-up)
- Output Voltage Range: 1.8V to 5.25V
- Inductor Peak Current Limit: 1A (typical)
- Output Current Capability: minimum 600 mA, at V_{IN} = 3.6V and V_{OUT} = 5V
- Automatic Input-to-Output Bypass during operation when $V_{IN} \geq V_{OUT}$
- Programmable UVLO Start-up Threshold
- Programmable Low Battery Output (LBO)
- Automatic Pulse Frequency Modulation (PFM)/Pulse Width Modulation (PWM) Operation
- Switching Frequency: 500 kHz, PWM Mode Operation
- Low Device Shutdown Current: 2.3 µA (typical)
- Low Device Quiescent Current: 5.0 µA (typical, Non-switching, PFM Mode)
- Internal Compensation
- Inrush Current Limiting
- Internal Soft Start
- Low-Noise, Anti-Ringing Control
- Power Good and Die Overtemperature Output (PGT)
- Thermal Shutdown: +140°C, with +10°C Hysteresis
- Output Discharge option in Shutdown Mode
- Available Packages: 10-lead MSOP and 10-lead TDFN (3 mm x 3 mm)

1.2.2 MCP73830 Device Overview

The MCP73830 is a highly integrated, linear battery charge management controller that provides specific charge algorithms for single-cell Li-Ion or Li-Polymer batteries. This device was designed to achieve the optimal capacity of the battery as well as to ensure safety in the shortest charging time possible.

The MCP73830 provides constant-current charging followed by constant-voltage charging with automatic charge termination.

The constant-current value for the Fast Charge is set with one external resistor from 100 mA to 1000 mA. Note that the MCP73830/L devices allow a charge current range from 20 mA to 200 mA for applications that do not require faster constant-current charging.

The MCP73830/L devices have an internal 4 Hour Fixed Elapsed Timer. If this timer expires before the voltage threshold of the Fast Charge mode is reached, a Timer Fault is indicated and the charge cycle is terminated. The MCP73830/L devices remain in this condition until the battery is removed, the input power is cycled, or CE is toggled. If the battery is removed, the MCP73830/L devices enter Standby mode and remain in this condition until a battery is reinserted.

The MCP73830/L devices provide a thermal foldback function that limits the charge current based on the die's temperature during high-power or high-ambient conditions. This thermal regulation optimizes the charge cycle time while maintaining the device's reliability.

The MCP73830/L devices are fully specified over the ambient temperature range of -40°C to +85°C.

The MCP73830/L is available in a 6-lead TDFN (2 mm x 2 mm) package.

1.2.2.1 MCP73830 DEVICE FEATURES

- Linear Charge Management Controller
- Constant-Current/Constant-Voltage Operation
- High-Accuracy Preset Voltage Regulation: +0.75%
- Programmable Charge Current: 100 mA to 1000 mA
- Programmable Safety Charge Timers
- Fixed Elapsed Timer: 4 Hours
- Automatic End-of-Charge (EOC) Control Termination
- Preconditioning of Deeply Depleted Cells
- Automatic Power-Down when Input Power Removed
- Undervoltage Lockout (UVLO)
- Chip/Charge Enable (CE) Pin
- Inrush Current Limiting and Soft Start
- Temperature Range: -40°C to +85°C
- Available Package: TDFN-6 (2 mm x 2 mm)

1.3 FUNCTIONAL DESCRIPTION

The MCP16411 Boost Converter with Dynamic UVLO Reference Design is a fully analogic Total System Solution that can be powered by a single-cell Li-Ion battery. This proposed circuit was developed to provide a solution for several applications such as portable instruments, personal and health care products, as well as wearable technologies.

Figure 1-2 displays a simplified schematic of the MCP16411 Boost Converter with Dynamic UVLO Reference Design.

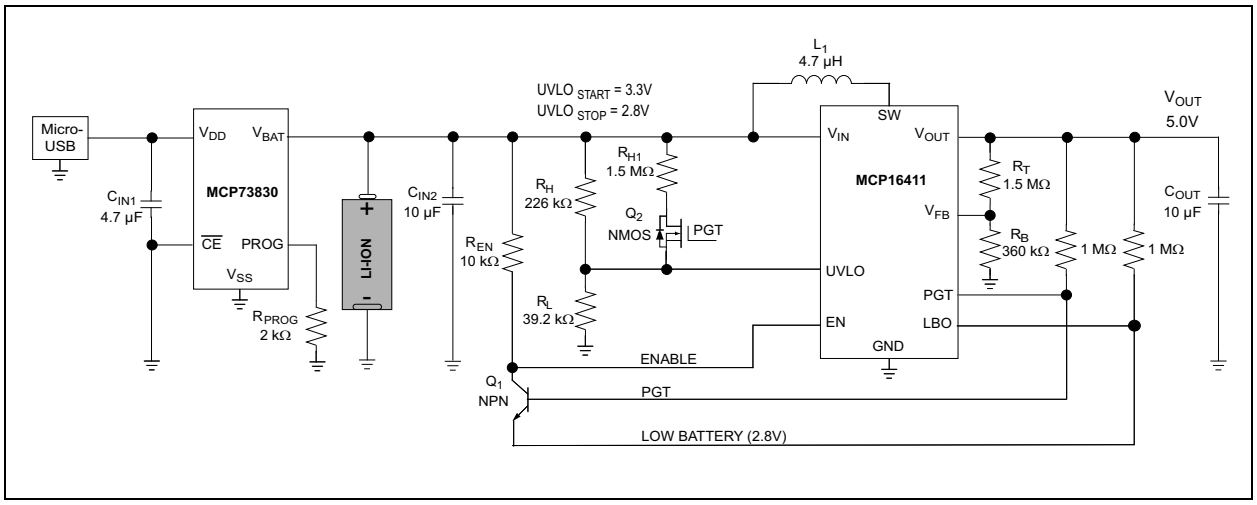


FIGURE 1-2: *MCP16411 Boost Converter with Dynamic UVLO Reference Design Simplified Schematic.*

1.3.1 MCP16411 - Boost Converter Operation

The MCP16411 was chosen out of the MCP1641X family of synchronous boost switching regulators due to the Automatic PFM/PWM Operation. This operation maintains the efficiency high even at light loads and ensures a lower quiescent current compared to the PWM only versions. Another reason for choosing this device is the combined Power Good and Die Overtemperature features available on the same pin (PGT pin). These safety features provide an error signal if the output voltage drops below 10% of its nominal value or the temperature of the IC's die exceeds +75°C.

The MCP16411 boost converter used in this design has the Output Discharge option in Shutdown Mode. When the device is disabled, this feature keeps the output voltage close to 0V and the quiescent current consumed is only 2.3 µA, typically.

In this proposed application, the MCP16411 is used to provide an output voltage of 5.0V from a single-cell Li-Ion battery. The output voltage of the MCP16411 is adjustable and its value can be calculated using the Equation 1-1.

EQUATION 1-1:

$$R_T = R_B\left(\frac{V_{OUT}}{V_{FB}} - 1\right)$$

Where:
V_{FB} = feedback voltage and has a typical value of 0.97V

The MCP16411 features an Undervoltage Lockout (UVLO) internal block, which allows the boost converter to start normal operation at 0.85V ($UVLO_{START}$) by default and prevents faulty operation below 0.8V ($UVLO_{STOP}$). The start-up voltage can be easily programmed through an external resistive divider connected to the UVLO pin (see Equation 1-2). This new feature is used to increase the $UVLO_{START}$ threshold, but it cannot be lower than 0.85V; in this application, the $UVLO_{START}$ threshold is set to 3.3V.

On the other hand, an open-drain Low Battery Output (LBO) pin will warn the user to replace the battery if the input voltage ramps down below the programmed $UVLO_{START}$ value.

EQUATION 1-2:

$$R_H = R_L\left(\frac{UVLO_{START}}{V_{REF\_UVLO}} - 1\right)$$

1.3.2 MCP16411 - Dynamic Changing Method for UVLO's Thresholds

For this proposed solution which was designed to be powered from a single-cell Li-Ion battery, it is important to know the battery behavior to ensure a safe application and the best battery lifetime. The voltage fluctuation of the battery must be considered for the input voltage range, which for Li-Ion battery type is from 4.2V (when fully charged) down to 2.8V (when fully discharged).

If the battery is discharged below the recommended Function End Point (FEP) or Cut-Off Voltage, its performance can be affected. The FEP for 18650 Li-Ion batteries is around 2.8V or 2.7V. Under this threshold, the cell does not have a fair amount of energy available and deep discharging can be translated into a shorter cycle life in which the battery may die prematurely.

The proposed application was designed to turn off the output of the converter if the input voltage decreases below 2.8V to prevent deep discharging. The dynamic UVLO/LBO thresholds prevent the battery to overdischarge which could lead to battery leakage and damage.

The dynamic changing threshold for the UVLO can be calculated using Equation 1-3, where V_{REF_UVLO} is 485 mV and LBO_{HYST} is a hysteresis of 20 mV, typically.

EQUATION 1-3:

$$UVLO_{DYNAMIC} = \left(\frac{R_H \parallel R_{H1}}{R_L} + 1\right)(V_{REF\_UVLO} - LBO_{HYST})$$

The MCP16411 starts the output regulation at 5.0V when the battery voltage is 3.3V or higher than 3.3V. After start-up, the PGT signal will turn on the N-MOS switch (Figure 1-2) and will connect R_H in parallel with R_{H1}. Therefore, the UVLO threshold will be dynamically changed from 3.3V to 2.8V. The LBO signal will warn the user to recharge or to replace the battery when the battery voltage drops below 2.8V.

While the LBO pin is asserted to low, the emitter of the NPN transistor is asserted to low as well, turning it on and pulling to low the EN input, which will shut down the MCP16411.

As shown in Figure 1-2, the MCP73830 device is used to charge the Li-Ion battery from a Micro-USB port. The user can program the charging current by means of an on-board resistor, using Equation 1-4:

EQUATION 1-4:

$$I_{REG} = \frac{1000}{R_{PROG}}$$

Where:
R_{PROG} = current programming resistor

1.4 WHAT IS THE MCP16411 BOOST CONVERTER WITH DYNAMIC UVLO REFERENCE DESIGN?

The MCP16411 Boost Converter with Dynamic UVLO Reference Design is used to evaluate and demonstrate Microchip's MCP16411 and MCP73830 products.

The MCP16411 Boost Converter with Dynamic UVLO Reference Design has been developed to highlight the MCP16411 step-up switching regulator's capabilities in an application that needs to be powered from a single-cell Li-Ion battery.

It also provides a solution for improving the battery life as it will not be discharged below the cut-off voltage. The battery can be charged from a USB port or wall adapter by adding a battery charger (MCP73830) into the circuit.

1.5 CONTENTS OF THE MCP16411 BOOST CONVERTER WITH DYNAMIC UVLO REFERENCE DESIGN KIT

The MCP16411 Boost Converter with Dynamic UVLO Reference Design kit includes:

- MCP16411 Boost Converter with Dynamic UVLO Reference Design
- Important Information Sheet

Chapter 2. Installation and Operation

2.1 OVERVIEW

The following sections describe how to use the MCP16411 Boost Converter with Dynamic UVLO Reference Design.

The MCP16411 Boost Converter with Dynamic UVLO Reference Design was developed as a Total System Solution for applications that can be powered from one-cell 18650 Cylindrical Li-Ion battery and can deliver a 5.0V (USB 2.0) output voltage and output current up to 900 mA, depending on the battery voltage. Refer to Figure 2-3 for the maximum output current that can be delivered.

Figure 2-1 and Figure 2-2 represent the board for the MCP16411 Boost Converter with Dynamic UVLO, top and bottom view, respectively.

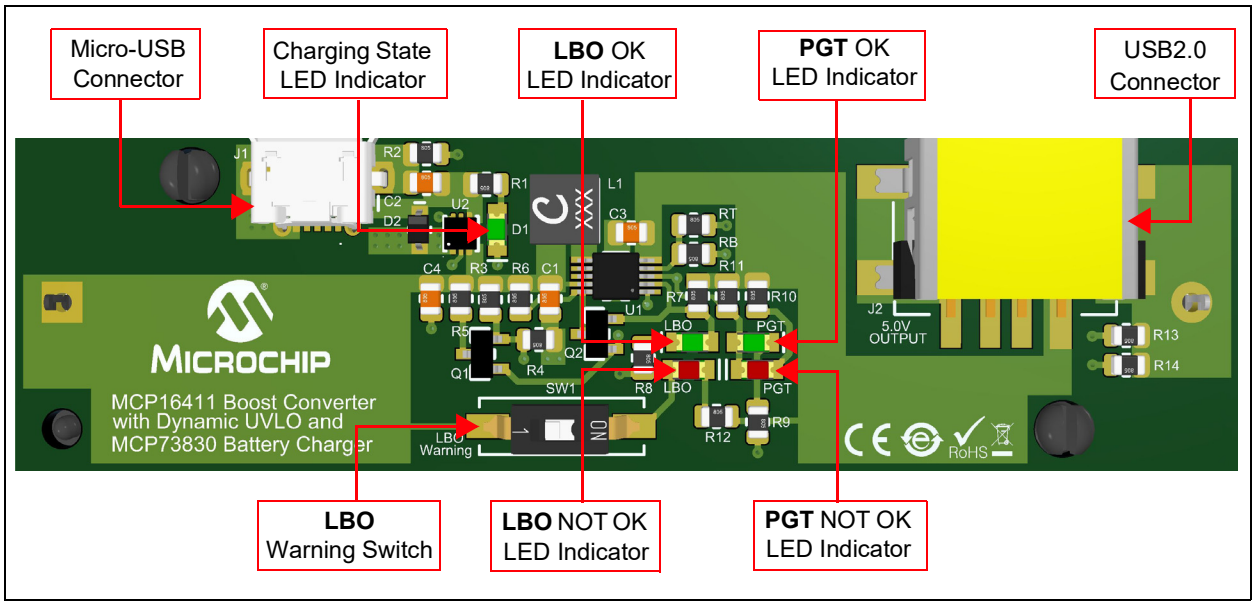


FIGURE 2-1: *MCP16411 Boost Converter with Dynamic UVLO Reference Design Board – Top View.*

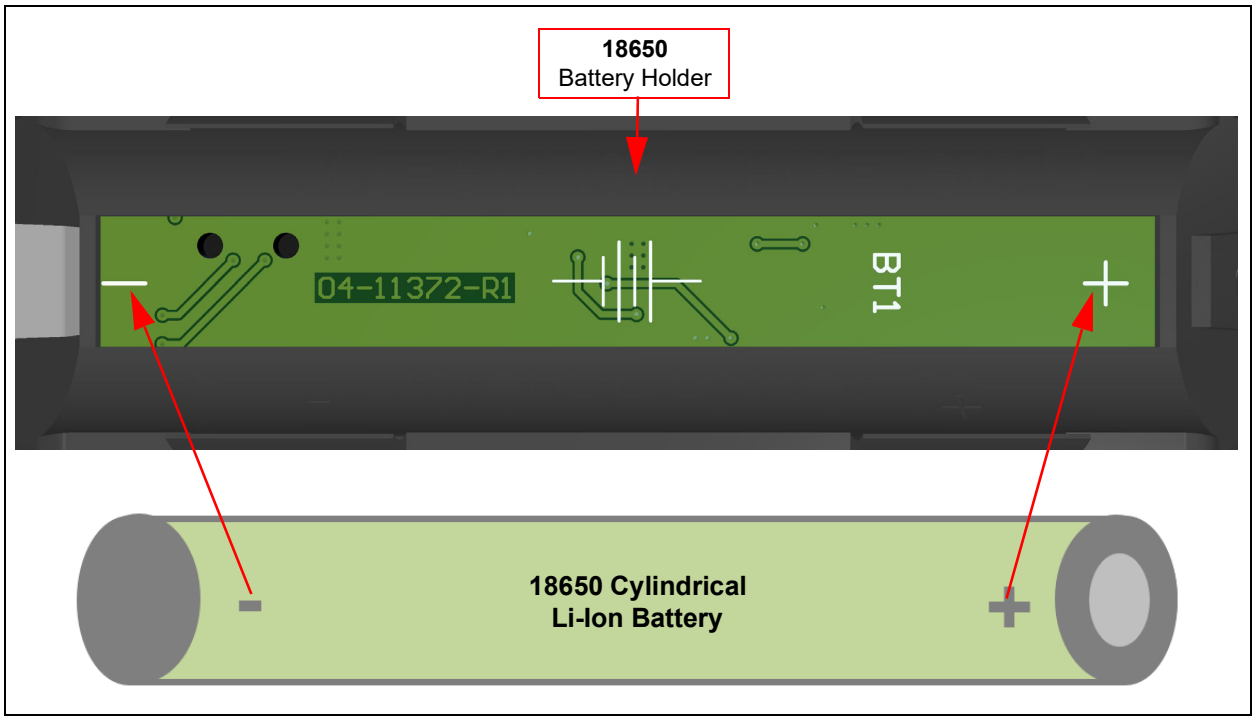


FIGURE 2-2: *MCP16411 Boost Converter with Dynamic UVLO Reference Design Board – Bottom View.*

2.1.1 Board Features

The MCP16411 Boost Converter with Dynamic UVLO Reference Design Board has the following features:

- Input Voltage: one-cell 18650 Cylindrical Li-Ion battery
- Output Voltage: 5.0V
  - Output port: USB2.0
- Output Current: minimum 600 mA at 3.6V V_{IN}
- Automatic PFM/PWM Operation: 500 kHz, PWM Switching Frequency
- High Efficiency: up to 96%
- Programmable UVLO Thresholds:
  - $UVLO_{START}$: 3.3V
  - $UVLO_{STOP}$: 2.8V
- Programmable LBO Threshold:
  - LBO warning: 2.8V
- Output Discharge Option in Shutdown Mode
- Battery Charging Port: Micro-USB
- Battery Charging and Operating Mode LED Indicators

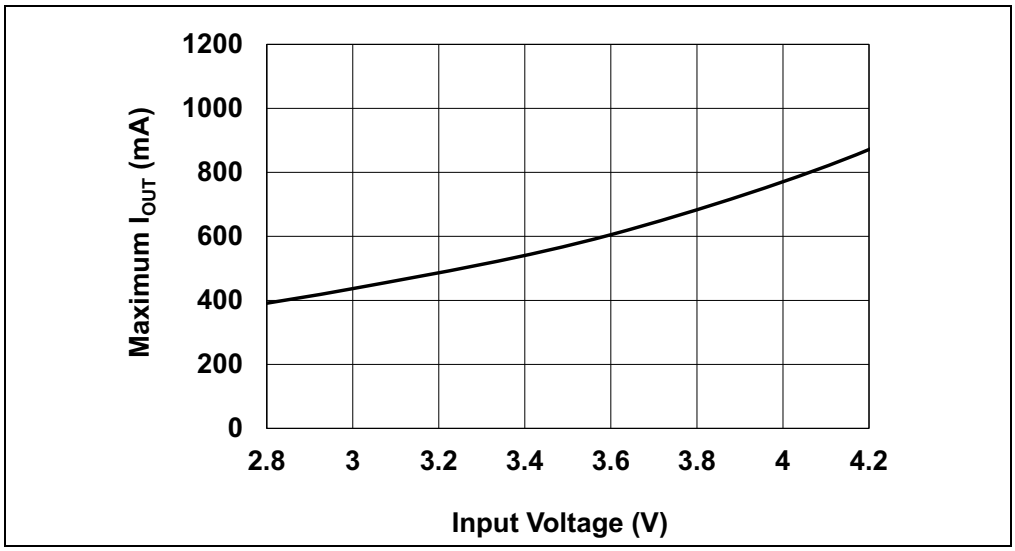


FIGURE 2-3: *MCP16411 Boost Converter 5.0V V_{OUT} Maximum I_{OUT} vs. V_{IN}.*

2.2 GETTING STARTED

The MCP16411 Boost Converter with Dynamic UVLO Reference Design is fully assembled and tested to evaluate and demonstrate the Microchip products used in this document. For the evaluation of this application, the battery is not provided with the board, but it is required to have a single-cell 18650 Cylindrical Li-Ion battery.

2.2.1 Power Input and Output Connections

2.2.1.1 POWERING THE MCP16411 BOOST CONVERTER WITH DYNAMIC UVLO REFERENCE DESIGN

The MCP16411 Boost Converter with Dynamic UVLO Reference Design is powered from a single-cell 18650 Cylindrical Li-Ion battery. The battery holder is available on the bottom side of the board.

For the onboard connectors, please refer to Figure 2-1 and Figure 2-2.

2.2.1.2 BOARD POWER-UP PROCEDURE

To power-up the board, please follow the next steps:

1. Insert the 18650 Li-Ion Battery into the holder, as shown in Figure 2-2. Make sure that the battery terminals follow the correct polarity indicated by the silkscreen markings.
2. Make sure that the **SW1 LBO Warning** switch is into the **ON** position.
3. Once powered-up, the LED indicators will light as follows, depending on the battery's voltage:
   - When the **LBO OK** (Green LED) and the **PGT OK** (Green LED) are lighting, the battery voltage is within the 3.3V-4.2V range and the voltage at the output of the converter (USB2.0 connector) is 5.0V.
   - When the **LBO OK** (Green LED) and the **PGT NOT OK** (Red LED) are lighting, the battery voltage is within the 3.3V-4.2V range, but the output voltage of the MCP16411 is less than 90% of the nominal V_{OUT} or the MCP16411's temperature is higher than +75°C.

- When the **LBO NOT OK** (Red LED) is lighting, the battery voltage is below 2.8V and the output of the converter is 0V. This means that the battery is discharged and should be recharged or replaced.

4. To recharge the battery, connect the wall charger/USB cable to the Micro-USB connector. The D1 (Green LED) indicates that the charging process of the battery is in progress.

Note: To disable the **LBO NOT OK** warning, slide **SW1** switch into the **OFF** position.

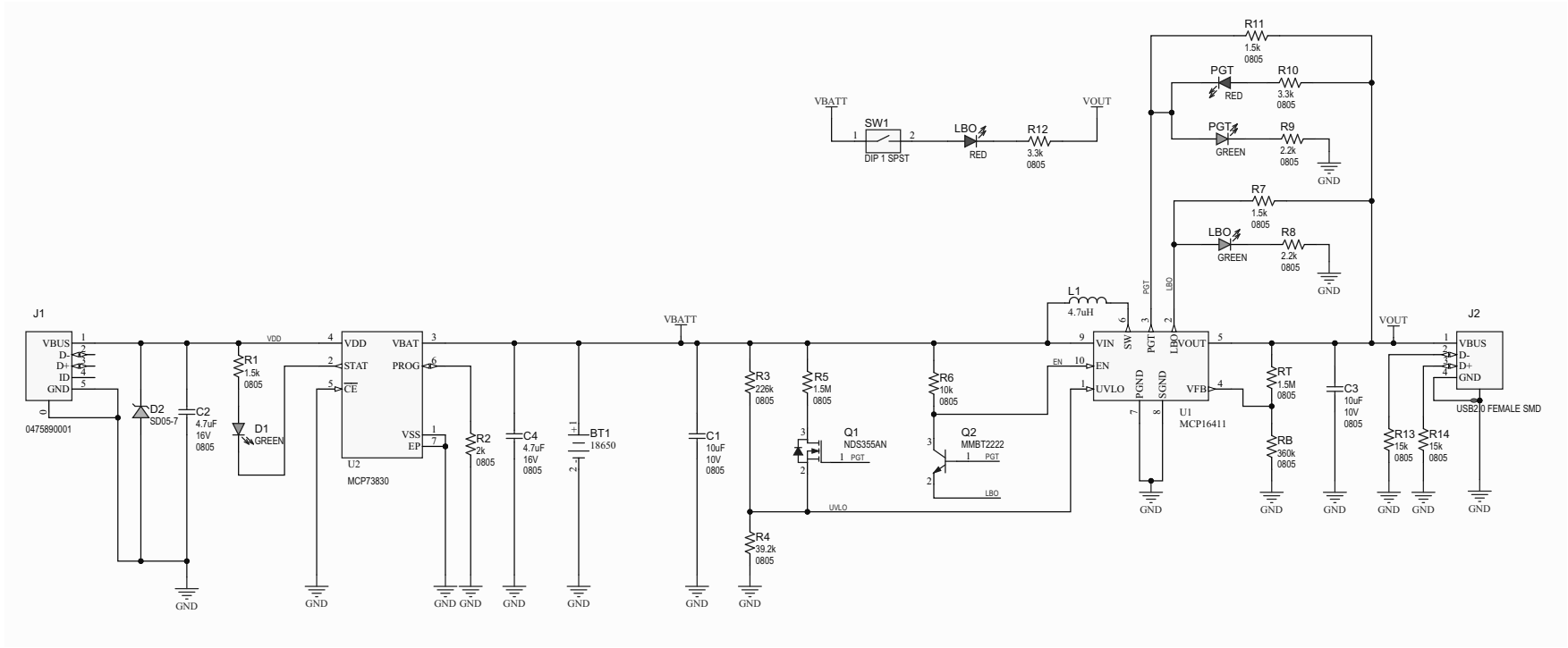
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

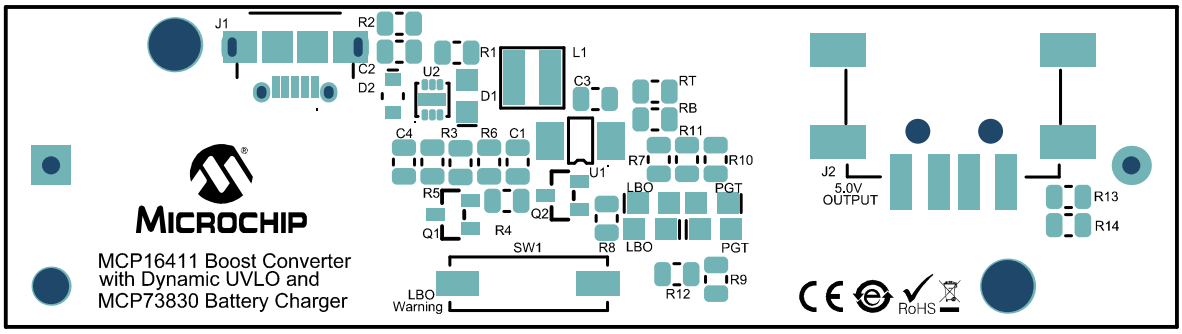
This appendix contains the following schematics and layouts for the MCP16411 Boost Converter with Dynamic UVLO Reference Design:

- Board – Schematic
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper
- Board – Top Copper and Silk
- Board – Bottom Silk

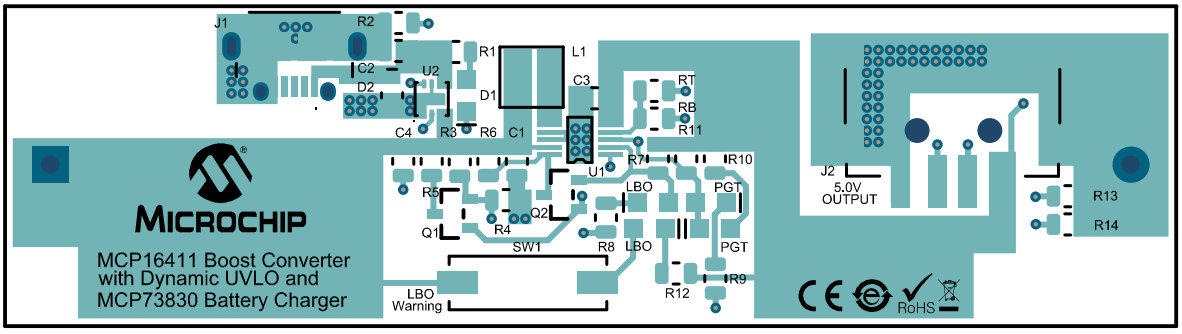
A.2 BOARD – SCHEMATIC



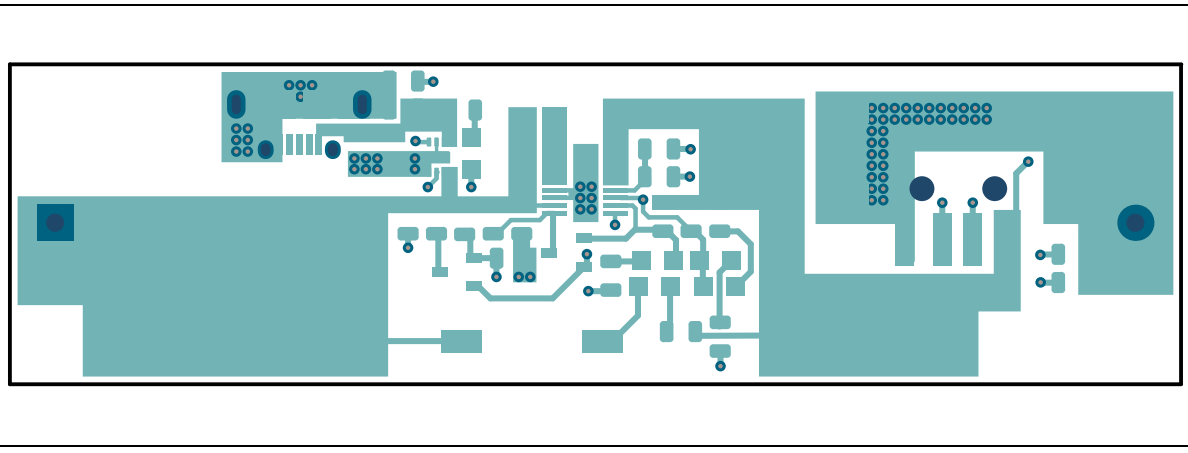
A.3 BOARD – TOP SILK



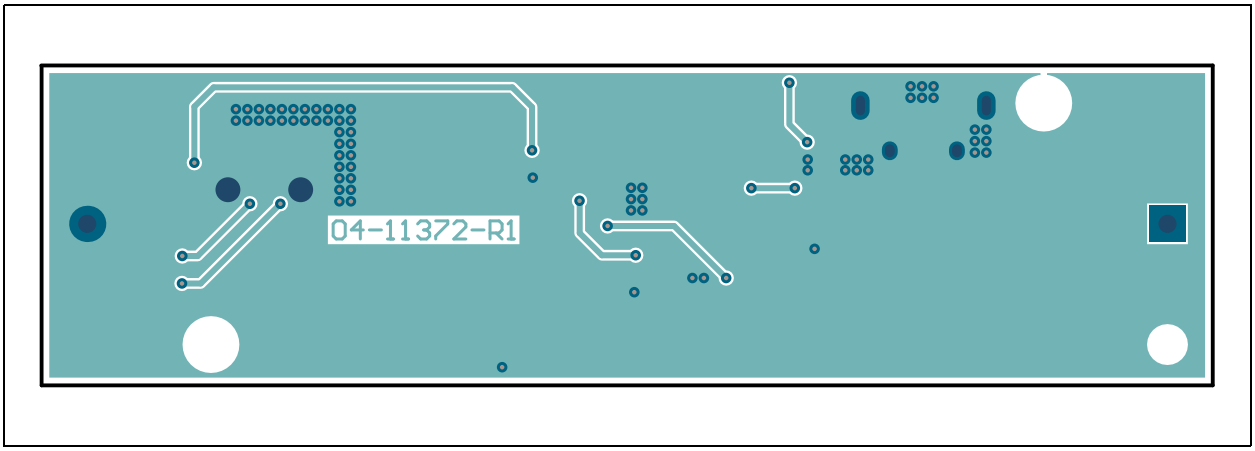
A.4 BOARD – TOP COPPER AND SILK



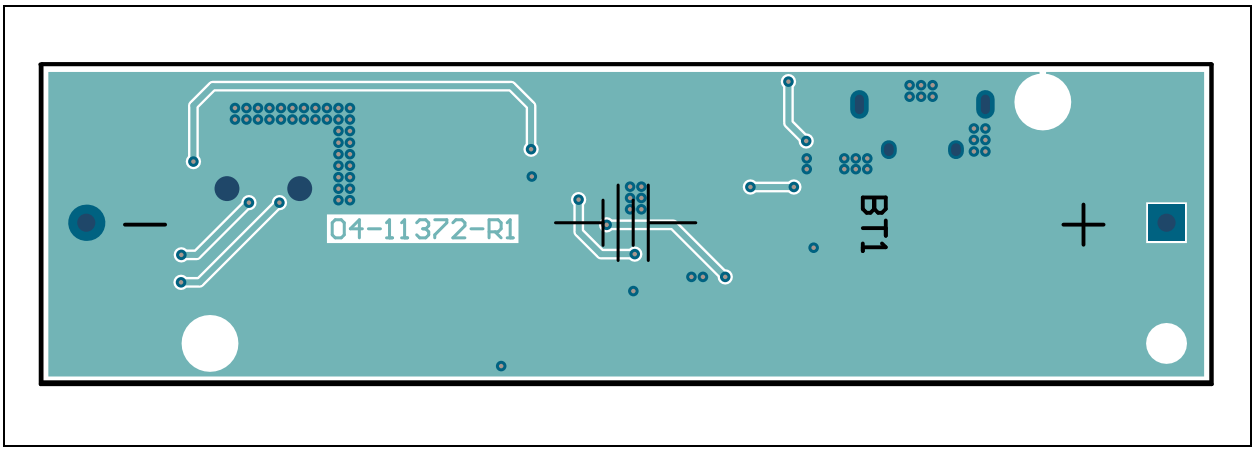
A.5 BOARD – TOP COPPER



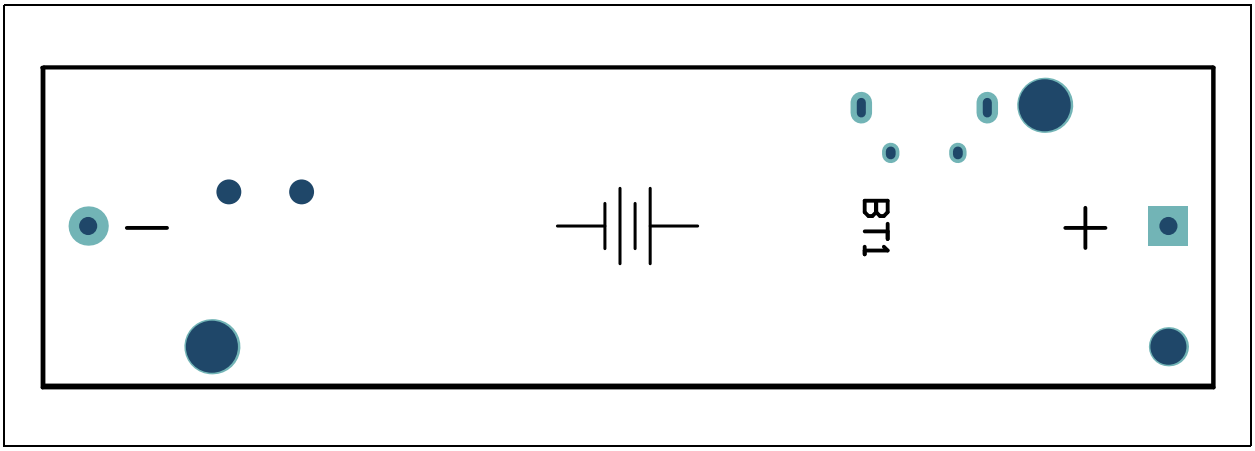
A.6 BOARD – BOTTOM COPPER



A.7 BOARD – BOTTOM COPPER AND SILK



A.8 BOARD – BOTTOM SILK



Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
1	BT1	Battery Holder, 1 TH, 18650	Keystone Electronics Corp.	1043
2	C1, C3	Capacitor, Ceramic, 10 µF, 10V, 10%, X7R, SMD, 0805	TDK Corporation	C2012X7R1A106K125AC
2	C2, C4	Capacitor, Ceramic, 4.7 µF, 16V, 20%, Y5V, SMD, 0805	Panasonic Electronic Components	ECJ2FF1C475Z
3	D1, LBO, PGT	Diode, LED, Green, 2.1V, 30 mA, Clear, SMD, 0805	Kingbright Electronic Co., Ltd.	APT2012CGCK
1	D2	Diode, TVS, SD05-7, 5V, 350W, SOD-323	Diodes Incorporated®	SD05-7
1	J1	Connector, USB2.0, MICRO-AB, Female, SMD, R/A	Molex®	0475890001
1	J2	Connector, USB2.0, Female, SMD, RA	Wurth Elektronik	629104190121
1	L1	Inductor, 4.7 µH, 2A, 20%, SMD, XFL4020	Coilcraft	XFL4020-472MEB
2	LBO, PGT	Diode, LED, Red, 1.7V, 20 mA, 11.7 mcd, Diffuse, SMD, 0805	Kingbright Electronic Co., Ltd.	APT2012EC
1	PCB1	Printed Circuit Board	Microchip Technology Inc.	**04-11372-R1**
1	Q1	Transistor, FET N-CH, NDS355AN, 30V, 1.7A, 500 mW, SOT-23-3	ON Semiconductor®/ Fairchild	NDS355AN
1	Q2	Transistor, BJT, NPN, MMBT2222, 30V, 600 mA, 350 mW, SOT-23-3	Fairchild Semiconductor®	MMBT2222
3	R1, R7, R11	Resistor, TKF, 1.5k, 1%, 1/8W, SMD, 0805	Panasonic Electronic Components	ERJ-6ENF1501V
2	R10, R12	Resistor, TKF, 3.3k, 1%, 1/8W, SMD, 0805	Stackpole Electronics Inc.	RMCF-1/10-3.3K-1%
2	R13, R14	Resistor, TKF, 15k, 1%, 1/8W, SMD, 0805	Yageo Corporation	RC0805FR-0715KL
1	R2	Resistor, TF, 2k, 0.1%, 1/10W, SMD, 0805	Stackpole Electronics, Inc.	RNCS0805BKE2K00
1	R3	Resistor, TKF, 226k, 1%, 1/8W, SMD, 0805, AEC-Q200	Panasonic Electronic Components	ERJ-6ENF2263V
1	R4	Resistor, TKF, 39.2k, 1%, 1/8W, SMD, 0805		ERJ-6ENF3922V
2	R5, RT	Resistor, TKF, 1.5M, 1%, 1/8W, SMD, 0805		ERJ-6ENF1504V
1	R6	Resistor, TKF, 10k, 5%, 1/2W, SMD, 0805		ERJ-P06J103V
2	R8, R9	Resistor, TKF, 2.2k, 1%, 1/8W, SMD, 0805	Yageo Corporation	RC0805FR-072K2L
1	RB	Resistor, TKF, 360k, 1%, 1/8W, SMD, 0805	Panasonic Electronic Components	ERJ-6ENF3603V
1	SW1	Switch, DIP, 1 SPST, 24V, 25 mA, 418121160801, SMD	Wurth Elektronik	418121160801
1	U1	Microchip Analog Switcher Boost, ADJ, 0.6A, MCP16411T, MSOP-10	Microchip Technology Inc.	**MCP16411T-I/UN**
1	U2	Microchip Analog Battery Charger, MCP73830T-2AAI/MYY, TDFN-6	Microchip Technology Inc.	**MCP73830T-2AAI/MYY**

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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