# MCP73871 Demo Board with Voltage Proportional Current Control User's Guide

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# MCP73871 DEMO BOARD WITH VOLTAGE PROPORTIONAL CURRENT CONTROL USER'S GUIDE

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**NOTES:**


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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 MCP73871 Demo Board with Voltage Proportional Current Control. 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 MCP73871 Demo Board with Voltage Proportional Current Control as a linear Li-Ion battery charge controller that can share a load. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP73871 Demo Board with Voltage Proportional Current Control.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with this user's guide and a description of the user's guide.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP73871 Demo Board with Voltage Proportional Current Control.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP73871 Demo Board with Voltage Proportional Current Control.

## 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 MCP73871 Demo Board with Voltage Proportional Current Control. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

- **MCP73871 Data Sheet - *"Stand-Alone System Load Sharing and Li-Ion / Li-Polymer Battery Charge Management Controller"*, DS22090**

This data sheet provides detailed information regarding the MCP73871 product family.

## THE MICROCHIP WEB SITE

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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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- Field Application Engineer (FAE)
- Technical Support

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

## DOCUMENT REVISION HISTORY

### Revision B (November 2009)

Initial Release of this Document.

- Updated **Section 2.2 "Features"** with information on the Voltage Proportional Current Control Input Voltage.
- Added footnote to Table 2-1.
- Updated **Section 2.3.3 "Voltage Proportional Charge Control (VPCC) Function"**.
- Added **Section 2.3.3.1 "Example"**.

### Revision A (April 2009)

- Initial Release of this Document.


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# Chapter 1. Product Overview

## 1.1 INTRODUCTION

The MCP73871 Demo Board with Voltage Proportional Current Control is designed to demonstrate Microchip's stand-alone linear Li-Ion battery charger with system power path and load sharing management control solution. The MCP73871 integrates the required elements to meet design challenges when developing new Li-Ion / Li-Polymer batteries powered products.

The MCP73871 requires minimum external components to power the system load and charge single cell Li-Ion batteries independently. When input power is absent or insufficient, the Li-Ion battery becomes the primary power source and supports the required system load current. The MCP73871 Demo Board with Voltage Proportional Current Control feature added is developed to assist engineers in reducing product design cycle and time by utilizing Microchip's favorite stand-alone Li-Ion battery charger and system load sharing management controller.

This chapter provides an overview of the MCP73871 Demo Board with Voltage Proportional Current Control and covers the following topics:

- What is the MCP73871 Demo Board with Voltage Proportional Current Control?
- What the MCP73871 Demo Board with Voltage Proportional Current Control Kit includes?

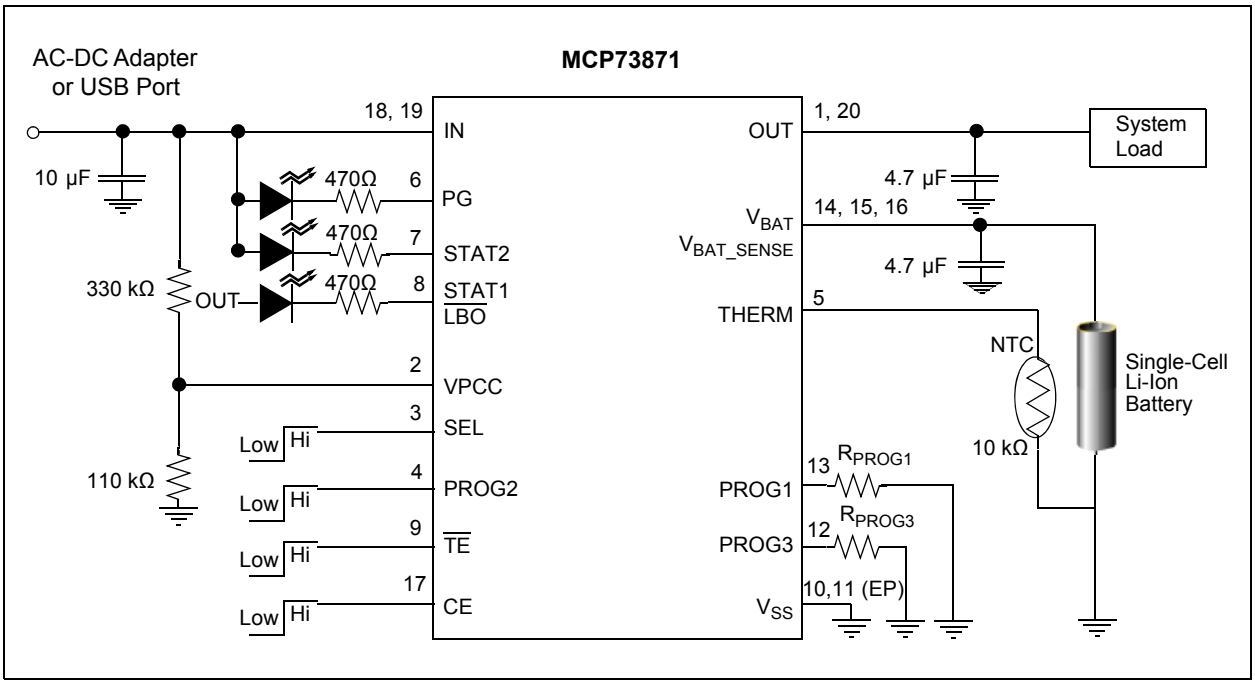


***FIGURE 1-1:*** *MCP73871 With System Power Path and Voltage Proportional Current Control (VPCC) Management Typical Application.*

## 1.2 WHAT IS THE MCP73871 DEMO BOARD WITH VOLTAGE PROPORTIONAL CURRENT CONTROL?

The MCP73871 Demo Board with Voltage Proportional Current Control demonstrates the features of Microchip's MCP73871 "Stand-Alone System Load Sharing and Li-Ion / Li-Poly Battery Charge Management Controller".The MCP73871 Demo Board with Voltage Proportional Current Control is designed to deliver minimum 1.5A total current to system load and to a single cell Li-Ion battery at 4.2V preset voltage regulation (4.1V, 4.35V and 4.4V options are also available for MCP73871). The MCP73871 Demo Board with Voltage Proportional Current Control has one dip switch (S1) with four poles to control input current limits, enable charge timer and enable charging. The first switch decides the input power source between AC-DC wall adapter and USB port (AC/USB). The second switch of S1 determines the 500 mA high-power USB port or the 100 mA low-power USB port (High/Low), if the first switch of S1 is enabled (ON). The input current limit is governed by the USB specification when selecting USB on S1 switch.

The maximum fast current when AC is selected on S1 is programmed by the resistor $R_{PROG1}$ at 1A, and the termination current is set at 100 mA by $R_{PROG3}$ (see Figure 1-1).

The MCP73871 Demo Board with Voltage Proportional Current Control offers three status LED (for charge status outputs and a power-good indicator).

**Note:** Refer to Table 2-1 for charge status outputs and Figure 2-1 for charge current setups.

The MCP73871 Demo Board with Voltage Proportional Current Control comes with a factory preset low-battery indicator (LBO) when input is absent. The preset value is 3.2V and STAT1 LED (Green) will turn ON if the battery voltage is below the threshold voltage.

The MCP73871 Demo Board with Voltage Proportional Current Control is designed to cover all the features of the MCP73871 device. A thermistor can be added at test points TP6 and TP7, but resistor R6 must be removed (see the **A.2 "Board – Schematic"**). The board layout easily permit to change the two programmable resistors: $R_{PROG1}$ and $R_{PROG3}$.

## 1.3 WHAT THE MCP73871 DEMO BOARD WITH VOLTAGE PROPORTIONAL CURRENT CONTROL KIT INCLUDES?

This MCP73871 Demo Board with Voltage Proportional Current Control kit includes:

- One MCP73871 Demo Board with Voltage Proportional Current Control, 102-00244
- Important Information "Read First"


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# Chapter 2. Installation and Operation

## 2.1 INTRODUCTION

The MCP73871 Demo Board with Voltage Proportional Current Control demonstrates Microchip's standalone linear Li-Ion battery charger with system power path and load sharing management control solution. The system load is also powered by the Li-Ion battery when the input power is disconnected. A number of device options allow the MCP73871 to be utilized in a variety of applications. Please refer to the MCP73871 Data Sheet (DS22090) and/or contact local Microchip supports for additional device options.

Typical applications for the reference design are in Smart Phones, PDA, Portable Media Players, MP3 Players, Digital Cameras, Handheld Medical devices, Bluetooth headsets, Ultra-Mobile PC and Portable Communicators.

## 2.2 FEATURES

The MCP73871 Demo Board with Voltage Proportional Current Control has the following features:

- Integrated System Load Sharing
- Voltage Proportional Current Control (VPCC) Input voltage: 5.5V with ±0.5V tolerance (additional information available in the MCP73871 Data Sheet)
- Input Current Limit Control hardware selected (typical 1650 mA, USB-High maximum 500 mA, and USB-Low maximum 100 mA)
- Three LEDs to indicate charge status, low battery and power good signal
- Preset Li-Ion battery charge voltage: 4.2V ± 0.5%
- Temperature monitoring is disabled by default, but can be enabled to use with a NTC thermister (tied at TP6 and TP7 and removing R6)
- Factory preset 0.1C preconditioning current of deeply depleted cells
- Factory preset Safety Timer with Timer Enable feature (by S1 switch)
- Constant Current/Constant Voltage (CC/CV) charge algorithm
- Resistor programmed maximum charge current ($R_{PROG1}$): 1A
- Resistor programmed termination set point ($R_{PROG3}$): 100 mA
- Automatic Charge Termination
- Automatic Recharge
- Internal Thermal Regulation
- Exposed Pad with extra via underneath for better heat dissipations

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## 2.3 GETTING STARTED

The MCP73871 Demo Board with Voltage Proportional Current Control is fully assembled and tested for charging a single-cell Li-Ion or Li-Polymer battery with or without system load.

### 2.3.1 Power Input and Output Connection

2.3.1.1 POWERING THE MCP73871 DEMO BOARD WITH VOLTAGE PROPORTIONAL CURRENT CONTROL

1. Connect the positive battery terminal to $V_{BAT}$+ (TP4) and negative battery terminal to GND (TP1 or TP5).
2. Connect the 5V – 6V DC power supply Negative Terminal to GND (TP1 or TP5).
3. Connect the 5V – 6V DC power supply Positive Terminal to $V_{DD}$ (TP2).
4. Connect positive of load to OUT (TP3) on the board and negative of load to GND (TP1 or TP5). The system load can be a power resistor or E-Load.
5. The maximum current that system load requires should not violate the specification of Li-Ion battery manufacturer (typical at 1C or less) or 1A for safety and performance concerns.
6. You should initiate the battery charging cycle when turning CE switch of S1 OFF. Turning the CE switch ON disables the Li-Ion battery charger function.
7. The S1 switch #1 in OFF position (SEL - "AC-DC") allows maximum input current of 1.8A to support both system load and Li-Ion battery charger at 1000 mA fast charge current rate.
8. The S1 switch #1 in ON position (SEL - "USB") limits the input current to meet USB specifications.
9. If switch SEL is in ON position (PROG2), the user has two options for switch #2:
   - OFF - limits the total input current to 500 mA
   - ON - for maximum input current at 100 mA.

**Note 1:** For setup/configuration follow the information in Table 2-2.

**2:** Fast Charge Current and Termination Current can be easily programmed with various resistors based on Figure 2-1.

**3:** The Li-Ion battery pack can be replaced with test circuit or electronic load that can sink current with DC power supply. Refer to Figure 2-2 for details.

10. If DC power is removed, the load should be supported by the Li-Ion battery.

### 2.3.2 Programming Resistors

The resistors that connected at $R_{PROG1}$ and $R_{PROG3}$ pins select the maximum charge current in constant current mode from ac-dc adapter and termination current, respectively. The relationship between fast charge current and value of $R_{PROG1}$ resistor is illustrated in Figure 2-1. The correspondence of $R_{PROG1}$ on MCP73871 Demo Board with Voltage Proportional Current Control is $R_1$. The default value is 1 kΩ, which sets the maximum charge current at 1A.

For $R_{PROG3}$, the correspondent resistor is $R_2$. A 10 kΩ resistor sets the charge termination current at 100 mA and a 100 kΩ value results a 10 mA termination point. Read carefully the additional information on the schematic in **A.2 "Board – Schematic"**. The boards comes with $R_2$ =10 kΩ.


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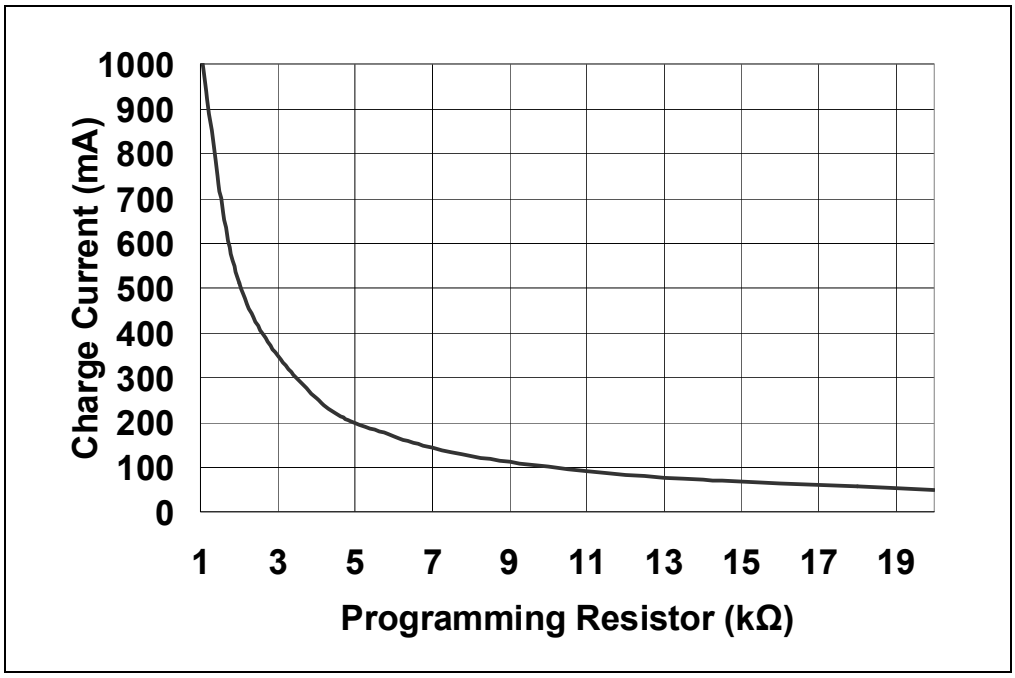


***FIGURE 2-1:*** *MCP73871 Charge Current ($I_{OUT}$) vs. Programming Resistor ($R_{PROG1}$).*

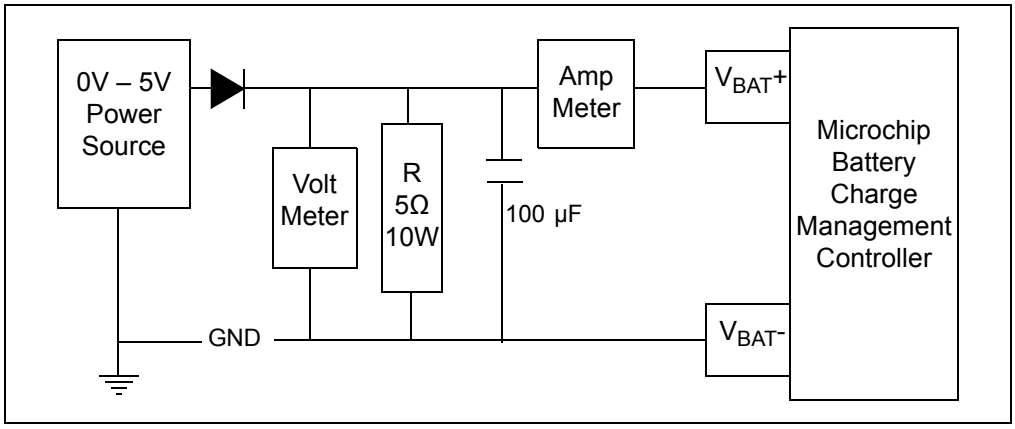


***FIGURE 2-2:*** *Simulated Battery Load.*

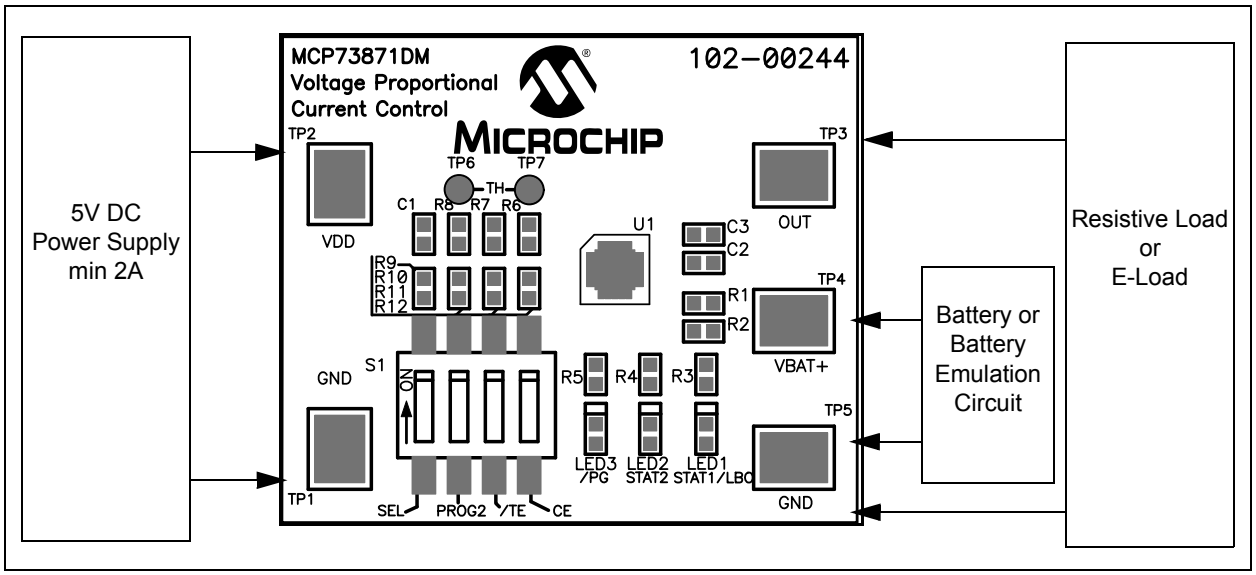


***FIGURE 2-3:*** *MCP73871 Top Board and Application Circuit.*

**TABLE 2-1: MCP73871 CHARGE STATUS OUTPUTS**

| Charge Cycle State | STAT1 (Green) | STAT2 (Red) | $\overline{PG}$ (Blue) |
|---|---|---|---|
| Shutdown | OFF | OFF | OFF |
| Standby | OFF | OFF | ON |
| Charge in Progress | ON | OFF | ON |
| Charge Complete (EOC) | OFF | ON | ON |
| Temperature Fault | ON | ON | ON |
| Timer Fault | ON | ON | ON |
| Low Battery Indicator (LBO) | ON | OFF | OFF |
| No Battery Present | OFF | OFF | ON |
| No Input Power | OFF | OFF | OFF |

**Note:** LED Status Outputs are given for the battery connected at $V_{BAT}$ and GND.

**TABLE 2-2: MCP73871 DEMO BOARD DIP SWITCH CONFIGURATION**

| Switch # / Name | State / Function | | Observations |
|---|---|---|---|
| | OFF | ON | |
| 1 / SEL | AC-DC Adapter | Power from USB | — |
| 2 / PROG2 | USB maximum 500 mA | USB max 100 mA | Only if SEL is ON |
| 3 / $\overline{TE}$ | Timer Enable OFF | Timer Enable activated | Factory preset at 4h, 6h and 8h |
| 4 / CE | Charge is enabled | Charge function OFF | CE = Chip Enable |


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### 2.3.3 Voltage Proportional Charge Control (VPCC) Function

If the input voltage drops to a preset value, determined by the threshold established at the VPCC input (1.23V at pin #2), due to a limited amount of input current or input source impedance, the battery charging current is reduced. The VPCC control tries to reach a steady state condition where the system load has priority and the battery is charged with the remaining current. Therefore, if the system demands more current that the input can provide, the MCP73871 changes its status and the battery is able to supplement the input current to the system load.

The VPCC function sustains the system load as its highest priority. It does this by reducing the noncritical charge current while maintaining the maximum power output of the adapter. Further demand from the system is supported by the battery, if possible. The VPCC feature functions are identical for USB port or AC-DC adapter inputs. This feature can be disabled by removing resistor $R_7$ and replacing $R_8$ with a zero ohms 0603 resistor.

The demo board is designed to operate with 5.5V with +/-0.5V tolerance input voltage, by setting accordingly the voltage on VPCC pin by R7 and R8 resistors (see **A.2 "Board – Schematic"**). Additional information on the configuration of the VPCC function is available in the MCP73871 Data Sheet.

#### 2.3.3.1 EXAMPLE

A system is designed with a 5.0V rated DC power supply with ±0.5V tolerance. The worst condition of 4.5V is selected, which is used to calculate the VPCC supply voltage with divider. The voltage divider equation is shown below:

$$VPCC = \frac{R7}{R7 + R8} \times V_{DDmin}$$

$$1.23V = \frac{110k}{110k + R8} \times 4.5V$$

$$R8 = 292.43k\Omega$$

The calculated $R_8$ equals to 292.43 kΩ when 110 kΩ is selected for $R_7$. The 294 kΩ resistor is selected for $R_8$ to build the voltage divider for VPCC pin.

Figure 2-4 illustrates the influence of various input voltages.

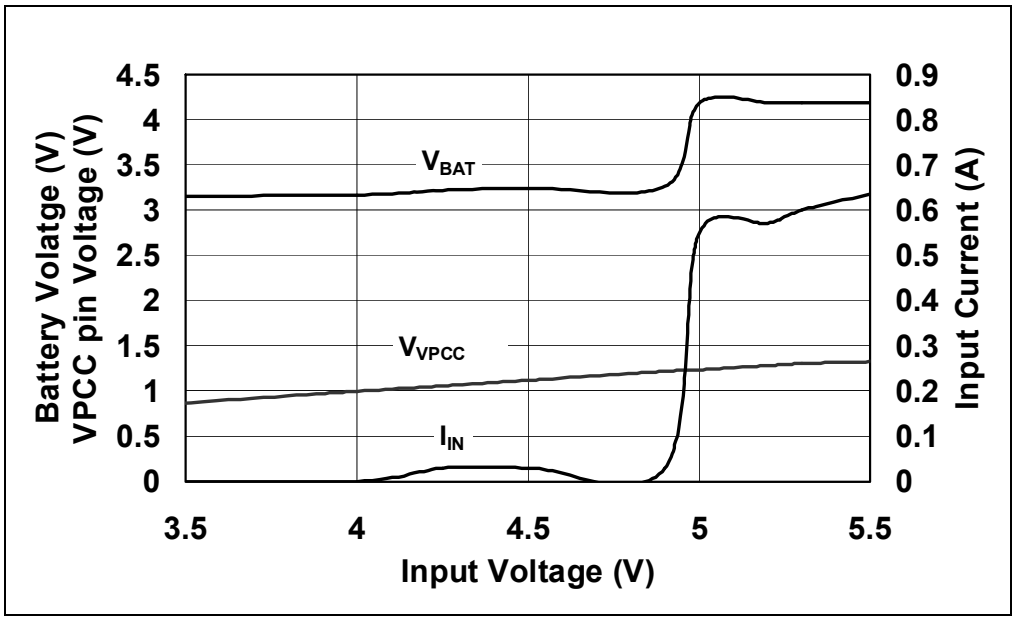


***FIGURE 2-4:*** *Input and Output Parameters when Input Voltage is Variable, from 2.5V to 5.5V. See the Influence of VPCC Pin.*

### 2.3.4 Temperature Monitoring Option

The MCP73871 device monitors continuously the battery temperature during a charge cycle by measuring the voltage between the THERM and $V_{SS}$ pins. An internal current source provides the bias for most common 10 kΩ negative-temperature coefficient thermistors (NTC). The MCP73871 device compares the voltage at the THERM pin to factory set thresholds of 1.24V and 0.25V, typically. Once a voltage outside the thresholds is detected during a charge cycle, the MCP73871 device immediately suspends the charge cycle, by turning off the charge and holding the timer value. The charge cycle resumes when the voltage at the THERM pin returns to the normal range.

To activate this feature, remove R6 resistor and connect a 10 kΩ NTC thermistor to TP6 and TP7 test points.

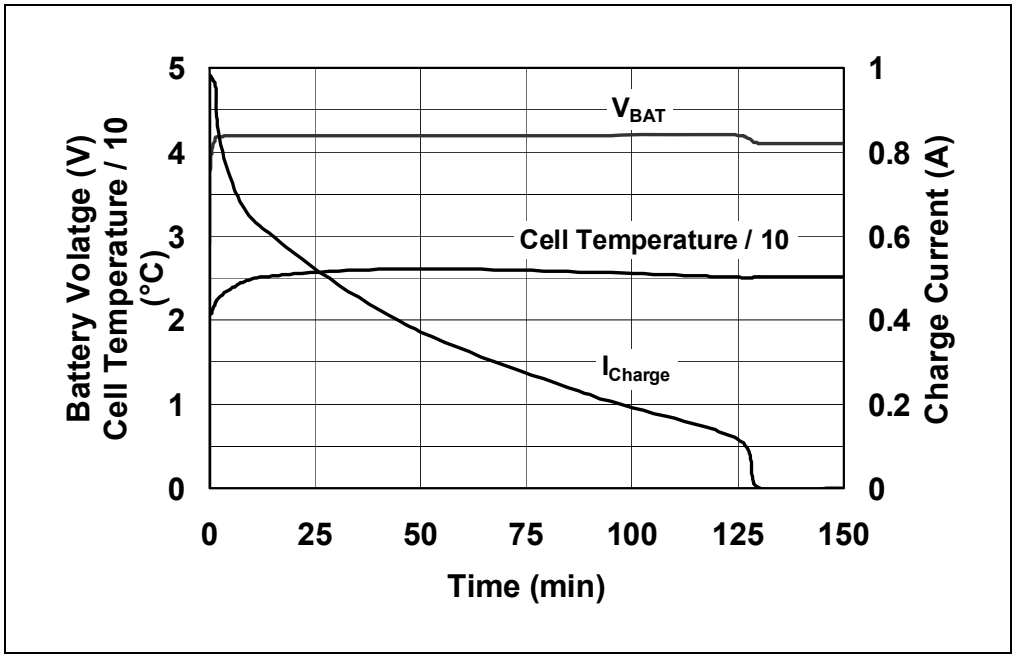


***FIGURE 2-5:*** *MCP73871 Charge Profile in Constant Voltage Mode for a 900 mAh Li-Ion Cell.*


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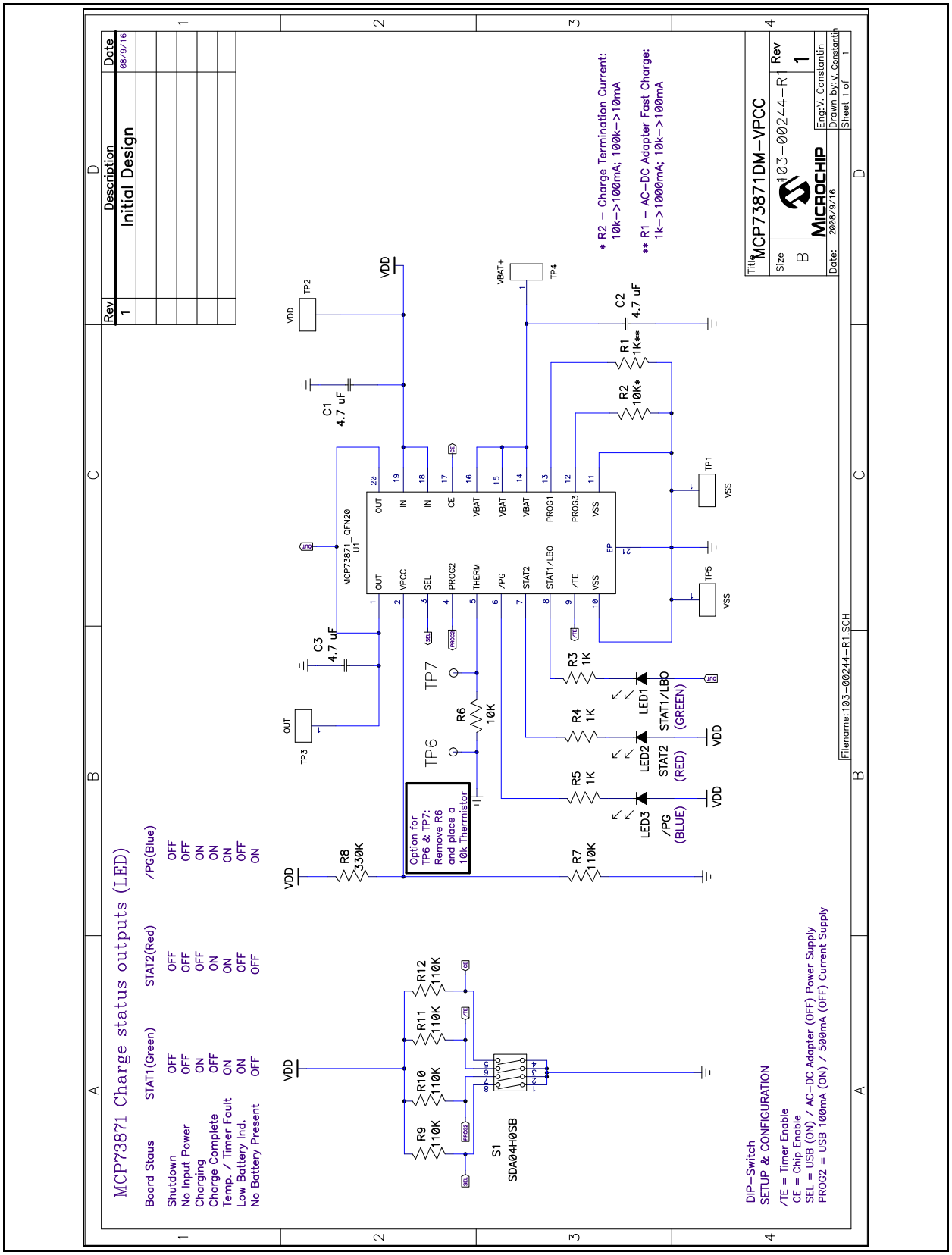
# Appendix A. Schematic and Layouts

## A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the MCP73871 Demo Board with Voltage Proportional Current Control:

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

## A.2 BOARD – SCHEMATIC





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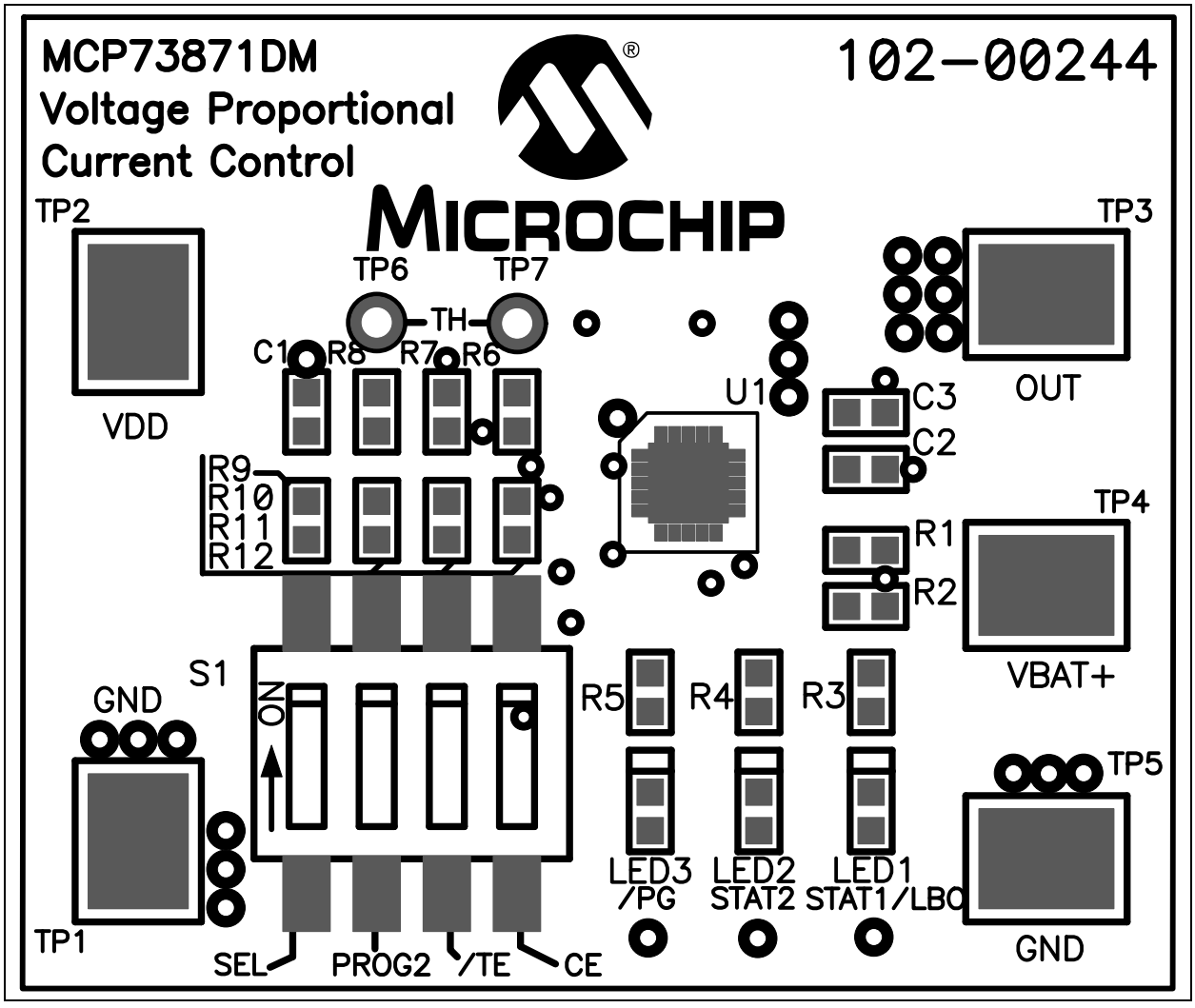
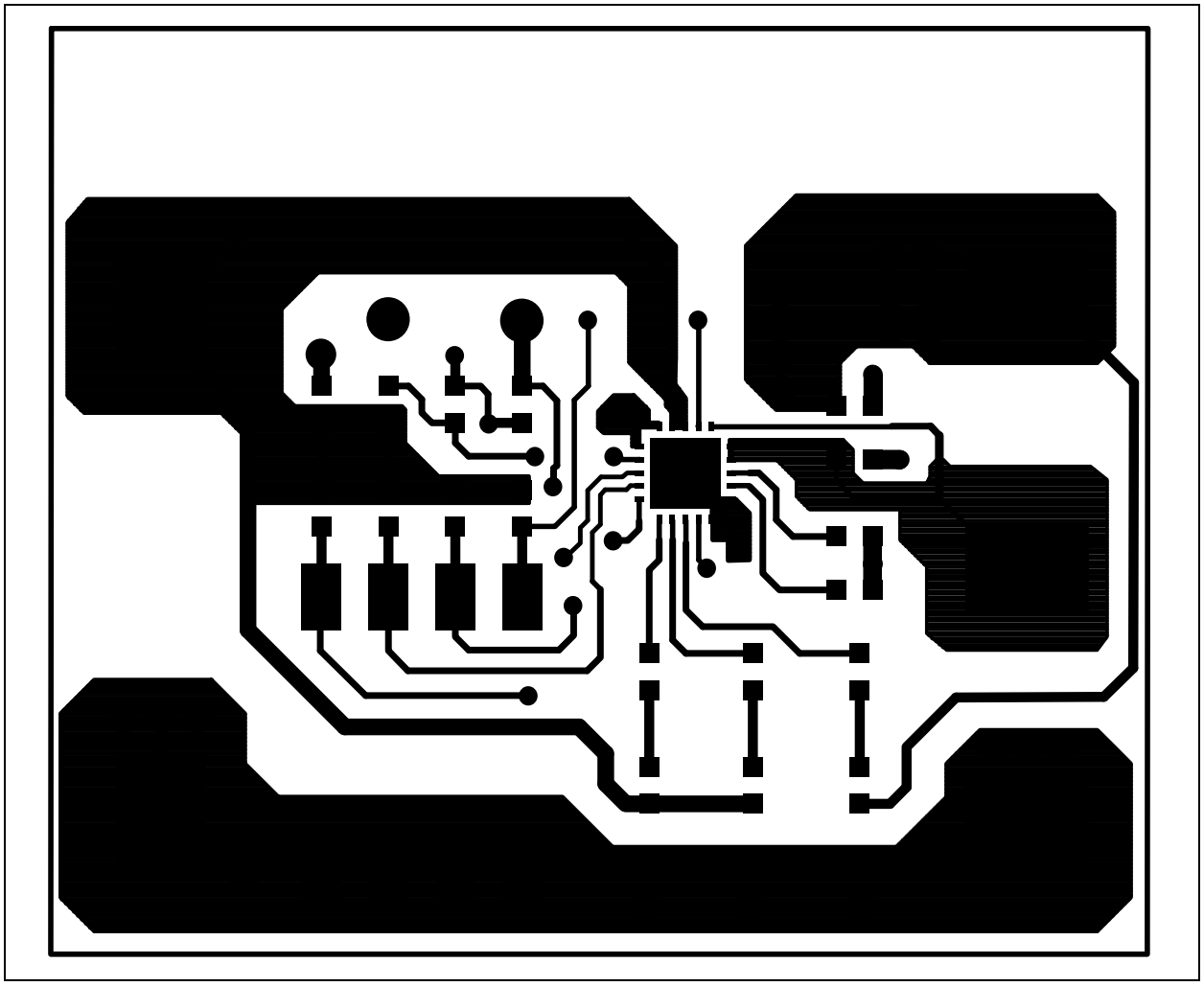
### A.3 BOARD – TOP SILK AND PADS



## A.4 BOARD – TOP METAL LAYER

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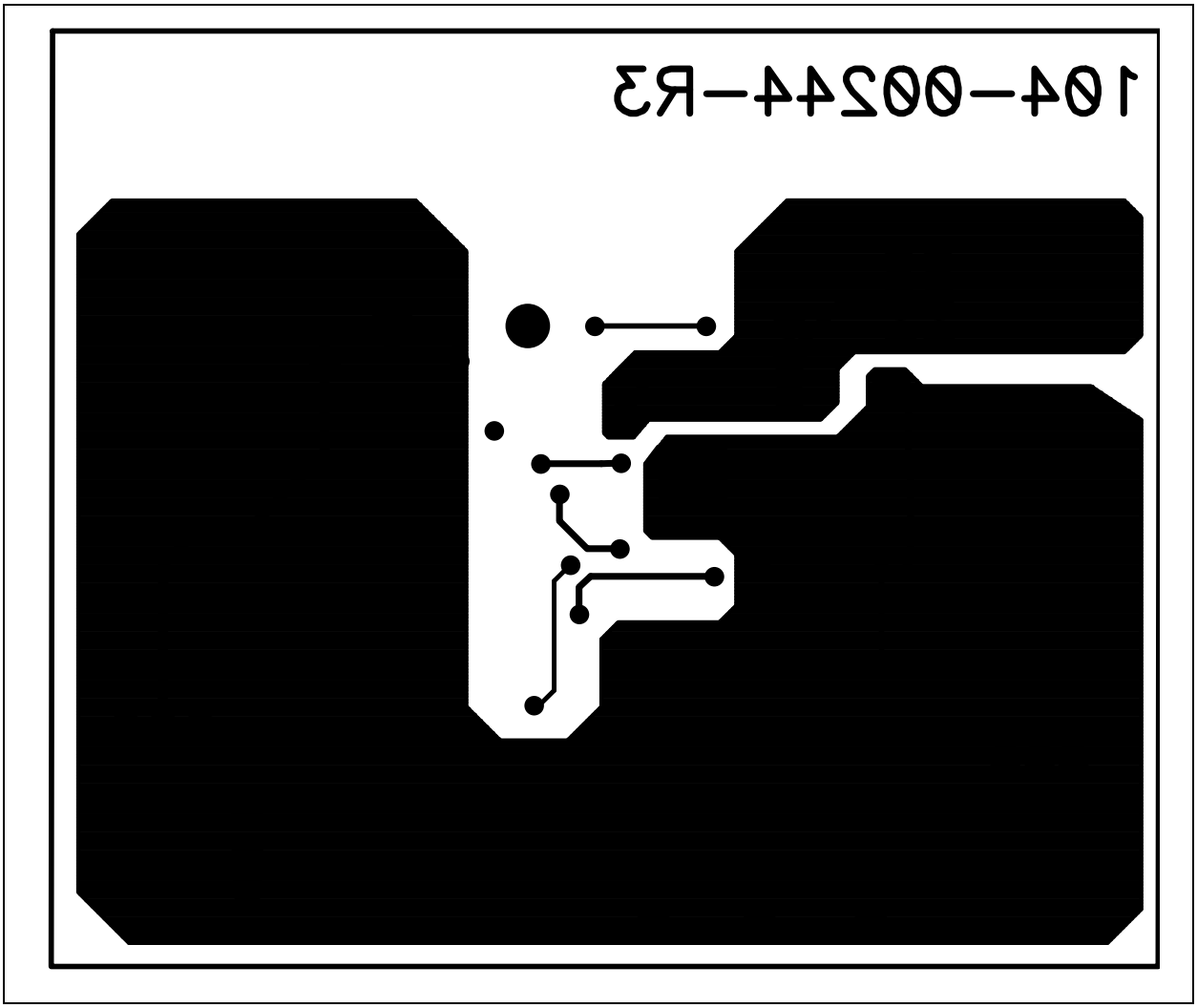
## A.5 BOARD – BOTTOM LAYER



**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, C3 | CAP CERAMIC 4.7 uF 10 X5R 0603 | Taiyo Yuden® | LMK107BJ475KA-T |
| 1 | LED1 | True Green Water Clear 0603 SMD LED | Para Light USA | L-C191LGCT-U1 |
| 1 | LED2 | Super Red Water Clear 0603 SMD LED | Para Light USA | L-C191KRCT-U1 |
| 1 | LED3 | Blue Water Clear 0603 SMD LED | Para Light USA | L-C191LBCT-U1 |
| 1 | PCB | RoHS Compliant Bare PCB, MCP73871 Demo Board w/ Voltage Proportional Current Control | Advanced Circuits | 104-00244 |
| 4 | R1, R3, R4, R5 | RES 1K OHM 1/10W 1% 0603 SMD | Panasonic® - ECG | ERJ-3EKF1001V |
| 2 | R2, R6 | RES 10K OHM 1/10W 1% 0603 SMD | Panasonic - ECG | ERJ-3EKF1002V |
| 5 | R7, R9, R10, R11, R12 | RES 110K OHM 1/10W 1% 0603 SMD | Panasonic - ECG | ERJ-3EKF1103V |
| 1 | R8 | RES 330K OHM 1/10W 5% 0603 SMD | Panasonic - ECG | ERJ-3GEYJ334V |
| 1 | S1 | SWITCH DIP TAPE SEALED 4POS SMD | C&K Components | SDA04H0SB |
| 5 | TP1, TP2, TP3, TP4, TP5 | PC Test Point Compact SMT | Keystone Electronics® | 5016 |
| 1 | U1 | Stand-Alone System Load Sharing and Li-Ion / Li-Polymer Battery Charge Management Controller | Microchip Technology Inc. | MCP73871-2CCI/ML |
| 4 | Bump | BUMPON HEMISPHERE .44X.20 WHITE | 3M | SJ5003-9-ND |

**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.

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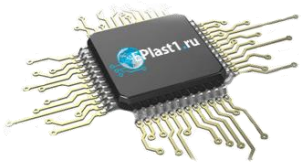


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