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MCP1664 LED Driver Evaluation Board User's Guide

ISBN: 978-1-63277-376-0

Object of Declaration: MCP1664 LED Driver Evaluation Board

EU Declaration of Conformity

Manufacturer: Microchip Technology Inc.
2355 W. Chandler Blvd.
Chandler, Arizona, 85224-6199
USA

This declaration of conformity is issued by the manufacturer.

The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8^{th} February 2010).

This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.

This development/evaluation tool, when incorporating wireless and radio-telecom functionality, is in compliance with the essential requirement and other relevant provisions of the R&TTE Directive 1999/5/EC and the FCC rules as stated in the declaration of conformity provided in the module datasheet and the module product page available at www.microchip.com.

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Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA

Derek Carlson
VP Development Tools

12-Sep-14
Date

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 "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 MCP1664 LED Driver Evaluation 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 MCP1664 LED Driver Evaluation Board as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP1664 LED Driver Evaluation Board.
- **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 MCP1664 LED Driver Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP1664 LED Driver Evaluation Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

<table>
<tr><th>Description</th><th>Represents</th><th>Examples</th></tr>
<tr><td colspan="3">Arial font:</td></tr>
<tr><td rowspan="2">Italic characters</td><td>Referenced books</td><td>MPLAB® IDE User's Guide</td></tr>
<tr><td>Emphasized text</td><td>...is the only compiler...</td></tr>
<tr><td rowspan="3">Initial caps</td><td>A window</td><td>the Output window</td></tr>
<tr><td>A dialog</td><td>the Settings dialog</td></tr>
<tr><td>A menu selection</td><td>select Enable Programmer</td></tr>
<tr><td>Quotes</td><td>A field name in a window or dialog</td><td>"Save project before build"</td></tr>
<tr><td>Underlined, italic text with right angle bracket</td><td>A menu path</td><td><u>File>Save</u></td></tr>
<tr><td rowspan="2">Bold characters</td><td>A dialog button</td><td>Click OK</td></tr>
<tr><td>A tab</td><td>Click the Power tab</td></tr>
<tr><td>N'Rnnnn</td><td>A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.</td><td>4'b0010, 2'hF1</td></tr>
<tr><td>Text in angle brackets < ></td><td>A key on the keyboard</td><td>Press <Enter>, <F1></td></tr>
<tr><td colspan="3">Courier New font:</td></tr>
<tr><td rowspan="7">Plain Courier New</td><td>Sample source code</td><td>#define START</td></tr>
<tr><td>Filenames</td><td>autoexec.bat</td></tr>
<tr><td>File paths</td><td>c:\mcc18\h</td></tr>
<tr><td>Keywords</td><td>_asm, _endasm, static</td></tr>
<tr><td>Command-line options</td><td>-Opa+, -Opa-</td></tr>
<tr><td>Bit values</td><td>0, 1</td></tr>
<tr><td>Constants</td><td>0xFF, 'A'</td></tr>
<tr><td>Italic Courier New</td><td>A variable argument</td><td>file.o, where file can be any valid filename</td></tr>
<tr><td>Square brackets [ ]</td><td>Optional arguments</td><td>mcc18 [options] file [options]</td></tr>
<tr><td>Curly brackets and pipe character: { | }</td><td>Choice of mutually exclusive arguments; an OR selection</td><td>errorlevel {0|1}</td></tr>
<tr><td rowspan="2">Ellipses...</td><td>Replaces repeated text</td><td>var_name [, var_name...]</td></tr>
<tr><td>Represents code supplied by user</td><td>void main (void)
{ ...
}</td></tr>
</table>

RECOMMENDED READING

This user's guide describes how to use the MCP1664 LED Driver Evaluation Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

- **MCP1664 Data Sheet – *"High-Voltage Step-Up LED Driver with UVLO and Open Load Protection"* (DS20005408)**

This data sheet provides detailed information regarding the MCP1664 LED Driver device.

- **MCP1663 Data Sheet – *"High-Voltage Integrated Switch PWM Boost Regulator with UVLO"* (DS20006506)**

This data sheet provides detailed information about the MCP1663 High-Voltage Integrated Switch PWM Boost Regulator with UVLO device.

THE MICROCHIP WEB SITE

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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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- Field Application Engineer (FAE)
- Technical Support

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

DOCUMENT REVISION HISTORY

Revision A (May 2015)

- Initial Release of this Document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP1664 LED Driver Evaluation Board and covers the following topics:

- MCP1664 Short Overview
- What is the MCP1664 LED Driver Evaluation Board?
- Contents of the MCP1664 LED Driver Evaluation Board

1.2 MCP1664 SHORT OVERVIEW

The MCP1664 is a compact, battery-operated, fixed-frequency, step-up DC-DC converter optimized as LED constant current generator. This product provides an easy-to-use power supply solution with a minimum number of external components for applications powered by two-cell or three-cell alkaline, NiCd or NiMH batteries, one-cell Li-Ion or Li-Polymer batteries.

The MCP1664 is a PWM-only device that operates at a fixed 500 kHz switching frequency. The device has an operating input voltage range from 2.4V to 5.5V (with an undervoltage of 2.3V to start and 1.85V to stop). The reference voltage is only 300 mV in order to minimize the losses on the sense resistor and to increase the overall efficiency of the application.

The LED can be turned on and off with a variable duty cycle applied to the EN pin for applications that require current dimming. Compared to its counterpart, the MCP1663 which is designed to be a voltage source, the start-up time for the MCP1664 has been decreased in order to obtain better performance in dimming applications.

The MCP1664 can supply up to 200 mA of current for a string of four LEDs (considering a LED Forward Voltage of 3V) from a 3V or higher input voltage source. More detailed information regarding the current capabilities of the MCP1664 are available in the data sheet.

In order to provide a compact solution, the device is available in a small 5-Lead SOT-23 and an 8-Lead 2x3 TDFN package.

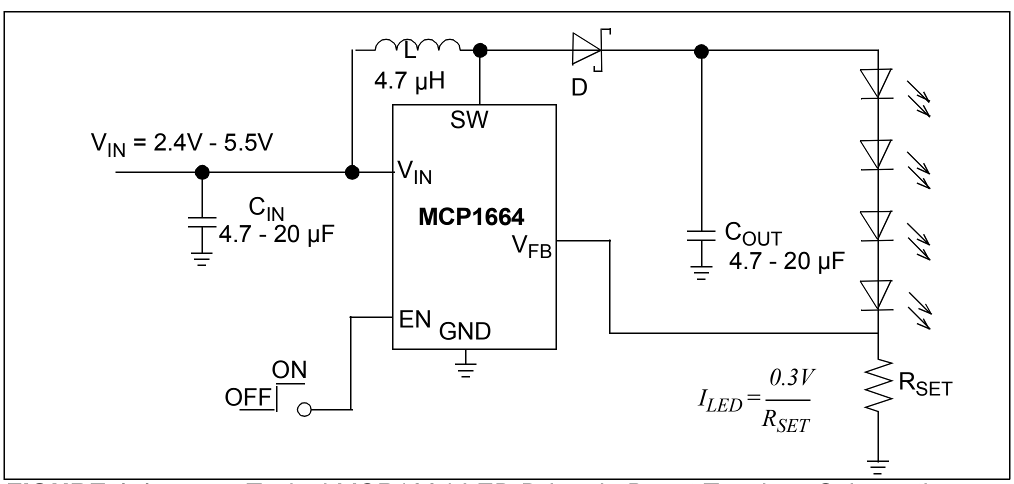


FIGURE 1-1: *Typical MCP1664 LED Driver in Boost Topology Schematic*

1.3 WHAT IS THE MCP1664 LED DRIVER EVALUATION BOARD?

The MCP1664 LED Driver Evaluation Board is used to evaluate and demonstrate Microchip Technology's MCP1664 product. This board demonstrates the MCP1664 in a boost-converter application supplied from an external voltage source, which drives a string of LEDs with three selectable currents. The MCP1664 LED Driver Evaluation Board was developed to help engineers reduce the product design cycle time.

LEDs can be dimmed in two ways:

- Analog dimming: changes LED light output by simply adjusting the value of the sense resistor and, by doing so, modifying the DC current in the LED string.
- Pulse-width modulation (PWM) dimming: achieves the same effect as analog dimming by varying the duty cycle of a constant current in the string to effectively change the average current in the string.

For analog dimming, three output currents can be selected: 90 mA,180 mA and 270 mA. The output current can be changed with a dual switch that changes the external LED current sense equivalent resistance.

For PWM dimming, a small triangular wave generator was added to the board along with a variable resistor that sets the duty cycle for the EN pin.

1.4 CONTENTS OF THE MCP1664 LED DRIVER EVALUATION BOARD

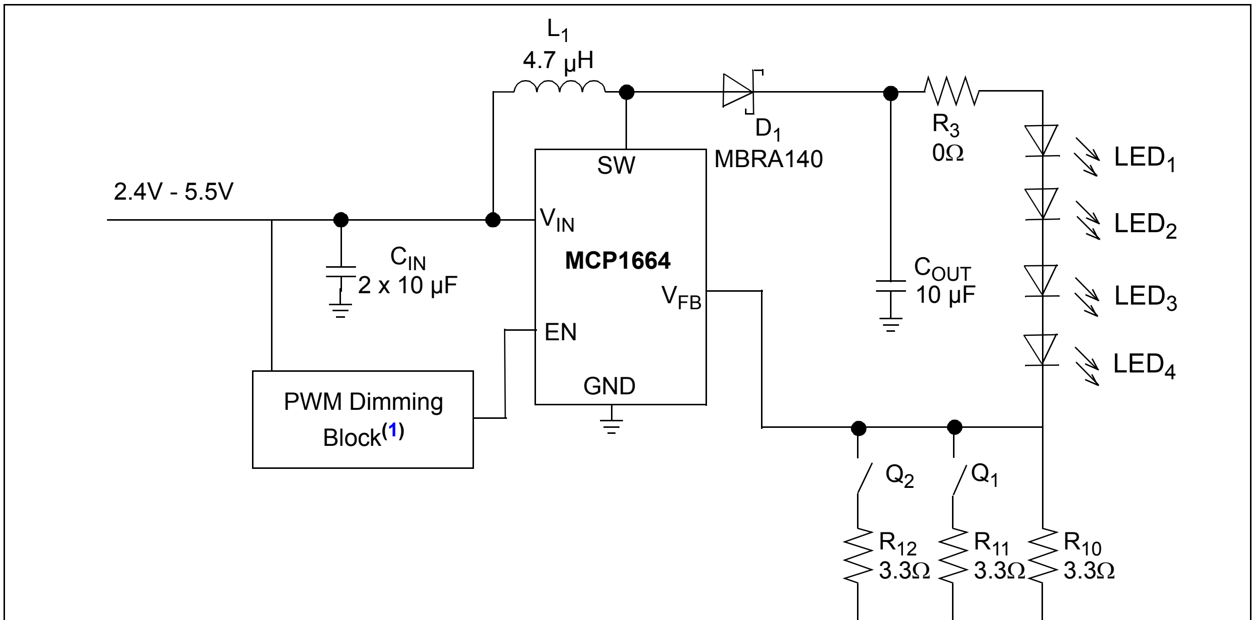
This MCP1664 LED Driver Evaluation Board kit includes:

- One MCP1664 LED Driver Evaluation Board unit (ADM00641)
- Important Information Sheet

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MCP1664 has been developed for applications that require driving a string of LEDs from a low-voltage source. The MCP1664 is a non-synchronous step-up regulator that can operate over a wide output range up to 32V. Its maximum output current is based on the switch peak current limit (set to 1.8A) and on the maximum duty cycle of 90%. An important feature is that the device integrates the compensation and protection circuitry so that the final solution will require a minimum number of additional components.



Note 1: For PWM Dimming Block refer to Figure 2-4.

FIGURE 2-1: *MCP1664 LED Driver Boost Converter 90,180,270 mA Constant Current Application.*

2.2 FEATURES

The MCP1664 LED Driver Evaluation Board has the following features:

- Input voltage range, V_{IN}: 2.4V to 5.5V, with $V_{IN} < V_{OUT}$
- Undervoltage lockout: 2.3V to start; 1.85V to stop
- Adjustable output current: 90 mA, 180 mA or 270 mA, selected using a mini dip switch on board
- PWM Switching frequency = 500 kHz
- Variable resistor and triangular wave generator on the board that can be used for PWM dimming
- 1.8A peak current limit
- Overtemperature protection (if the die temperature exceeds +150°C, 25°C hysteresis)
- Open load protection: if the LED string fails or is disconnected, the converter will shut down to prevent failure.

2.3 GETTING STARTED

The MCP1664 LED Driver Evaluation Board is fully assembled and tested to evaluate and demonstrate the MCP1664 product. This board requires the use of external lab supplies.

2.3.1 Power Input and Output Connection

2.3.1.1 POWERING THE MCP1664 LED DRIVER EVALUATION BOARD

Soldered test points are available for input voltage connections. The maximum input voltage should not exceed 5.5V.
The MCP1664 LED Driver Evaluation Board was designed to help the engineer in the process of validating the device. The package selected for the MCP1664 LED Driver Evaluation Board is the 5-Lead SOT-23.

2.3.1.2 BOARD POWER-UP PROCEDURE:

1. Connect input supply as shown in Figure 2-2.
2. Using the variable resistor, the duty cycle applied on the EN pin is modified and PWM dimming is obtained. When turning the variable resistor from one side to the other, a change in the brightness of the LED can be observed.
3. Change the value of the output current using the Current Select Switch. There are three available currents: 90 mA,180 mA and 270 mA. When modifying the value of the sense resistor, a change in the brightness of the LED can be noticed.

Additional test points are available for visualizing different signals: SW node, output current (by removing the R_3 resistor and using an ampermeter or a current probe between the CS and VOUT test points), FB node, the triangular signal or the PWM signal applied on the EN pin.

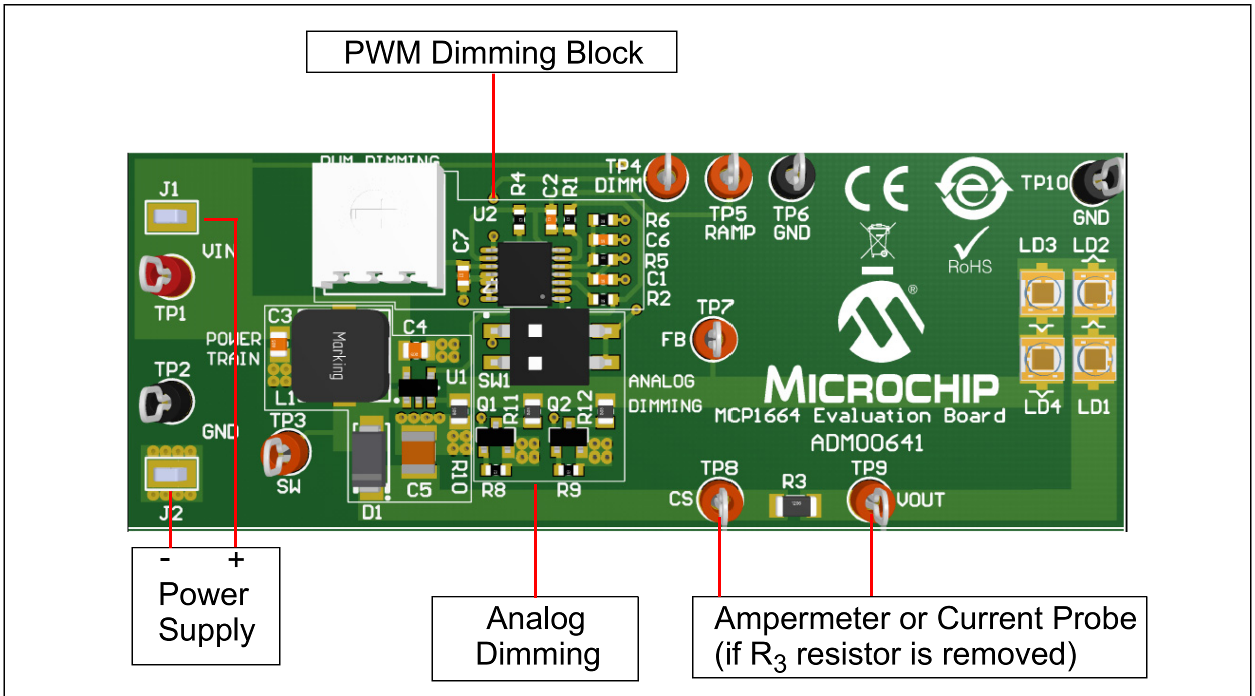


FIGURE 2-2: MCP1664 LED Driver Evaluation Board Setup.

2.3.1.3 ADJUSTING LED CURRENT BY RECALCULATING THE SENSE RESISTOR (ANALOG DIMMING)

The sense resistor is used to modify the value of the output current. The value for the resistor can be calculated using the following equation:

EQUATION 2-1: SENSE RESISTOR CALCULATION

$$R_{SENSE} = \frac{V_{FB}}{I_{LED}}$$

Where:

V_{FB} = 0.300V

I_{LED} = output LED current

Note: If the sense resistor is recalculated, the switch used for current selecting will not be used, as it will add a resistor in parallel with the calculated component and the value of the current will be different than the one specified in the User Guide.

Figure 2-3 shows the maximum output current for four LEDs:

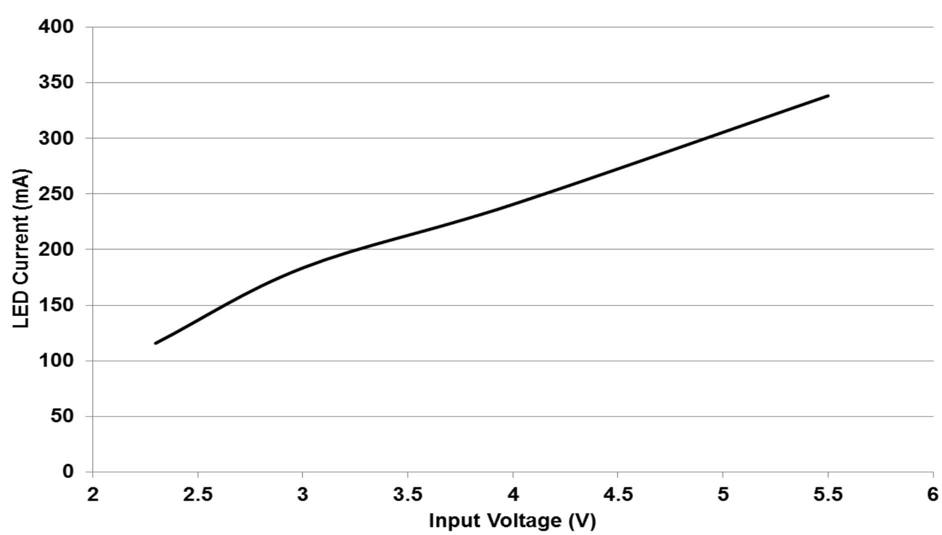


FIGURE 2-3: *Maximum Output Current vs. Input Voltage.*

For the MCP1664 LED Driver Evaluation Board, if the current select switch is set to 90 mA, the input voltage range varies from 2.4V to 5.5V; when the current select switch is set to 180 mA, the input voltage range is from 3V to 5.5V; when the current select switch is set to 270 mA, the input voltage range runs from 4.5V to 5.5V

2.3.1.4 PWM DIMMING BLOCK

The MCP1664 allows PWM dimming by turning on and off the LED with a PWM signal applied to the EN pin. The maximum frequency for dimming is limited by the start-up and the load. By varying the duty cycle of the PWM signal applied on the EN pin, the LED current changes linearly.

In order to test this feature, a small variable PWM generator, created using three operational amplifiers from a single quad-op-amp chip, was included on the board.

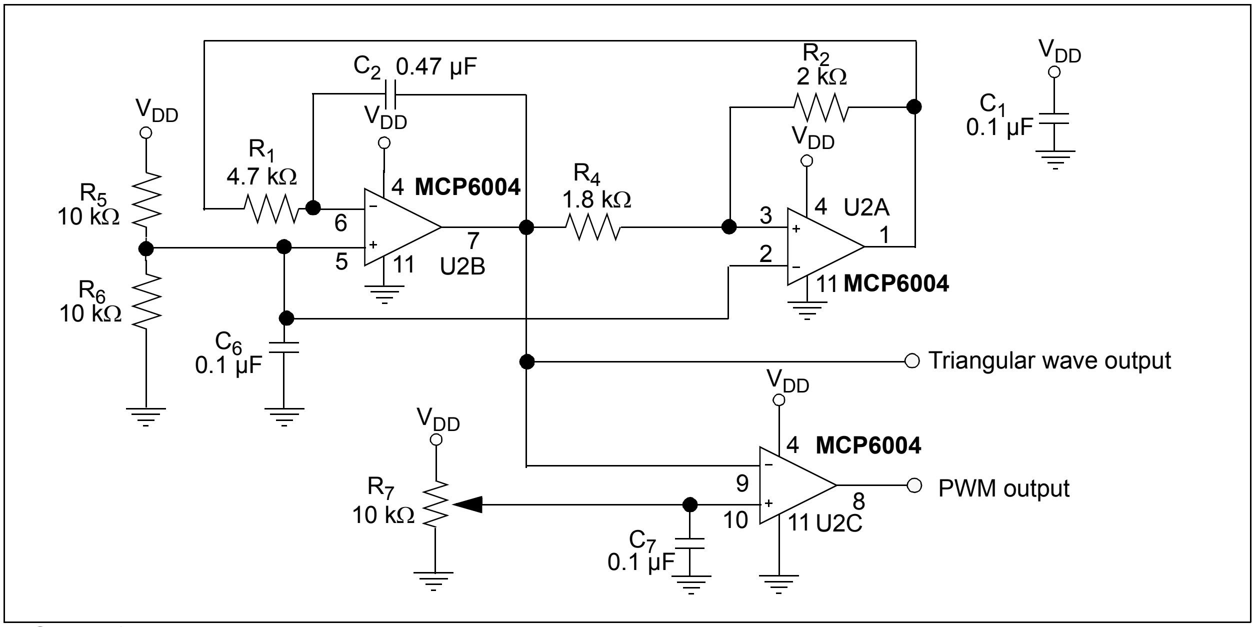


FIGURE 2-4: *PWM Dimming Block.*

The circuit consists of a triangular wave generator which is made up of U2B (functioning as an integrator), U2A (acting as a comparator with hysteresis) and a comparator (U2C). U2B non-inverting input is biased at $V_{DD}/2$.

A virtual connection between the inverting and non-inverting inputs allows a constant current through R_1 equal to $I = V_{DD}/(2R_1)$ which charges the capacitor C_2. This way, the U2B integrator output increases linearly with time. When it reaches 95% V_{DD}, the comparator output changes to its maximum output voltage V_{DD}.

At that point, the output voltage of the integrator decreases linearly. When it reaches 5% V_{DD}, the comparator output voltage switches to zero and the cycle repeats. Thus, the integrator output is a triangular wave that swings between the levels of 5% and 95% V_{DD}.

U2C compares the triangular wave against the DC level given by the R_7 variable resistor. Its output is a square wave, with a duty cycle that varies from 0% to 100%. The frequency of the PWM signal is determined by R_1, C_2, R_2 and R_4:

EQUATION 2-2: PWM DIMMING FREQUENCY

$$f = \frac{R_2}{4R_1R_4C_2}$$

The R_1 and R_2 resistors affect not only the operating frequency but also the amplitude of the triangular wave. Considering the maximum voltage of the triangular waves (V_{TH}) and the minimum voltage of the triangular waves (V_{TL}), the amplitude swing and the threshold voltages can be calculated by means of the following equation:

EQUATION 2-3: TRIANGULAR WAVE AMPLITUDE SWING

$$V_{TH} - V_{TL} = \frac{R_4}{R_2} V_{DD}$$

Where: $R_4 < R_2$

For the MCP1664 LED Driver Evaluation Board, the components were chosen so that they feature a PWM Dimming frequency of 125 Hz and an amplitude swing from 5% V_{DD} to 95% V_{DD}.

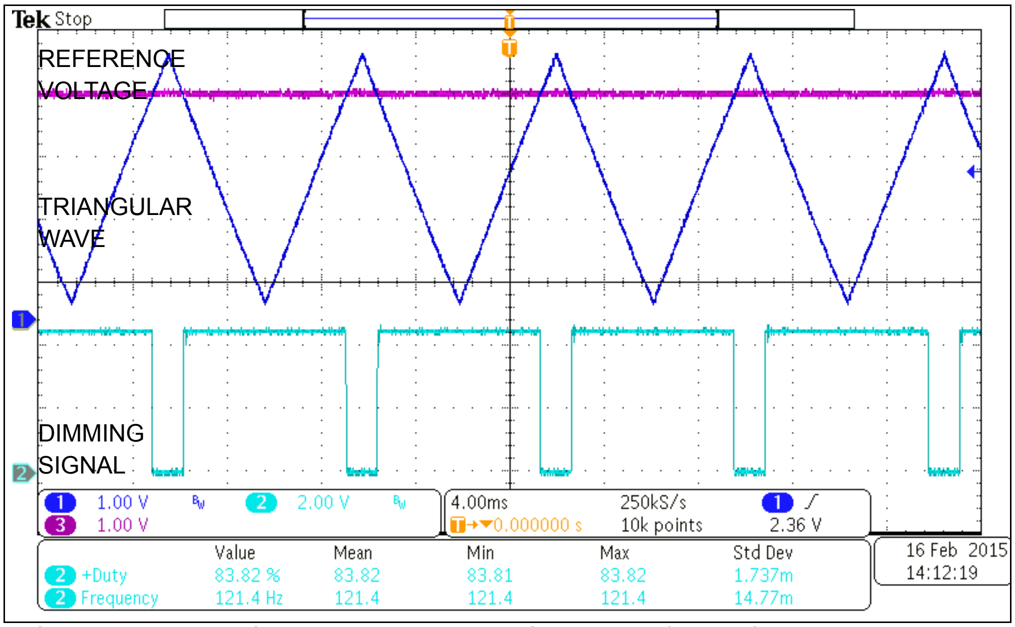


FIGURE 2-5: *Obtaining the Dimming Signal - 84% Duty Cycle.*

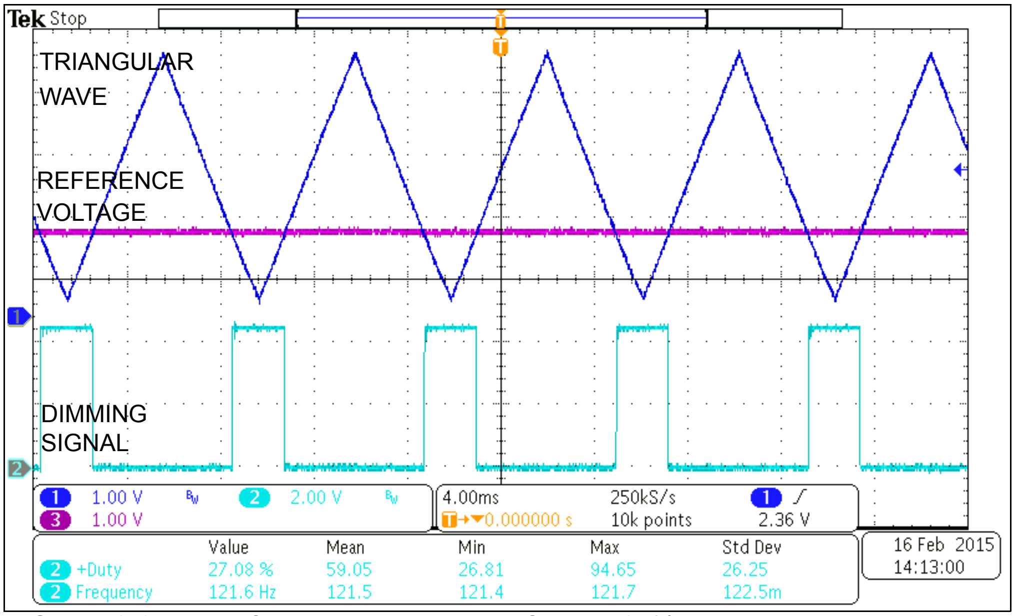


FIGURE 2-6: *Obtaining the Dimming Signal - 27%.*

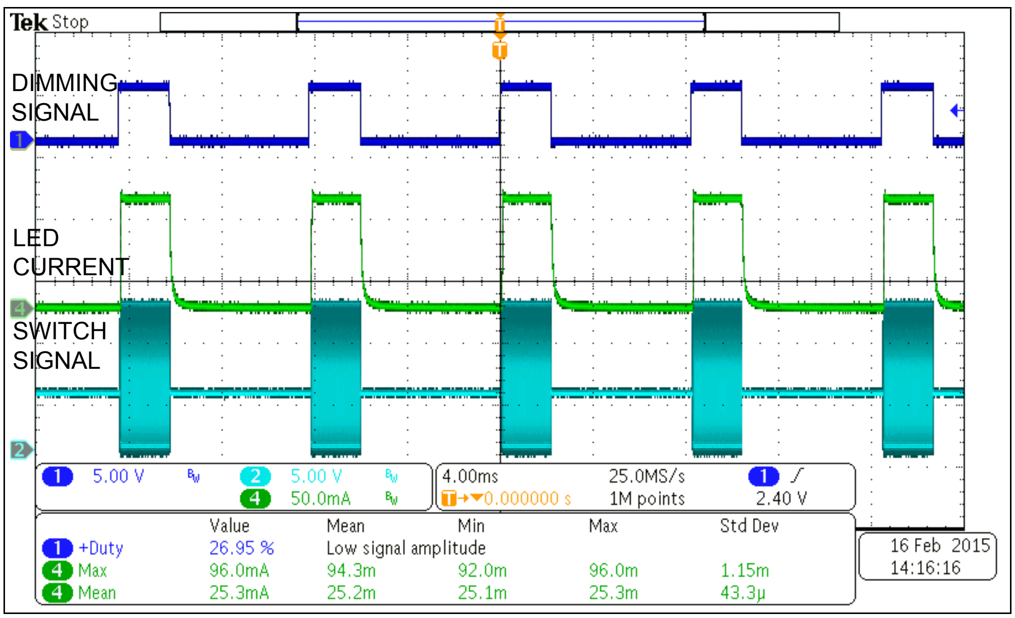


FIGURE 2-7: *Dimming Results - V_{IN} = 4.5V, I_{LED_SET} = 90 mA, DUTY = 27%.*

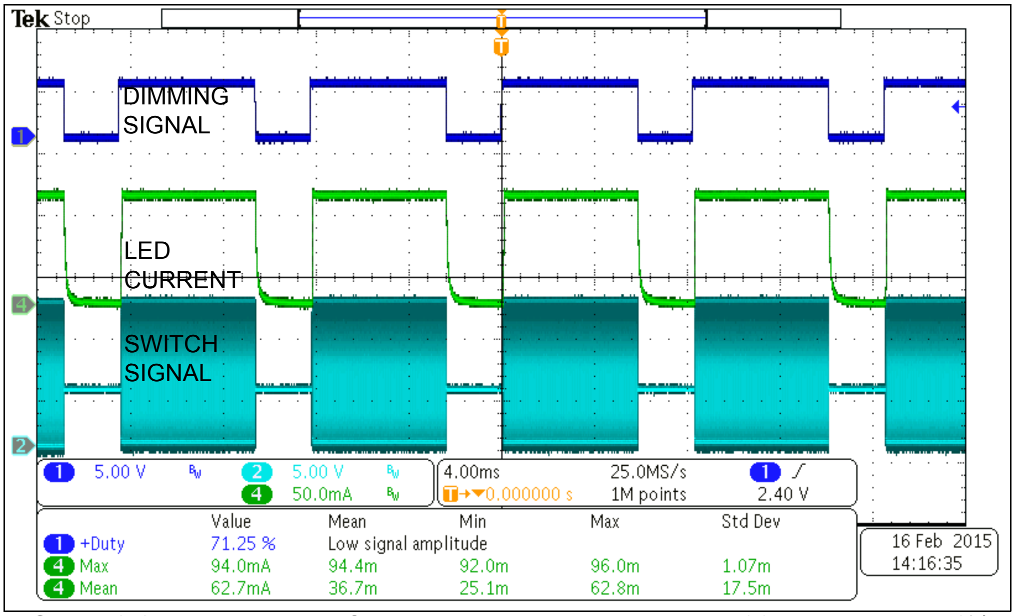


FIGURE 2-8: *DIMMING results - V_{IN} = 4.5V, I_{LED_SET} = 90 mA, DUTY = 71%*

NOTES:

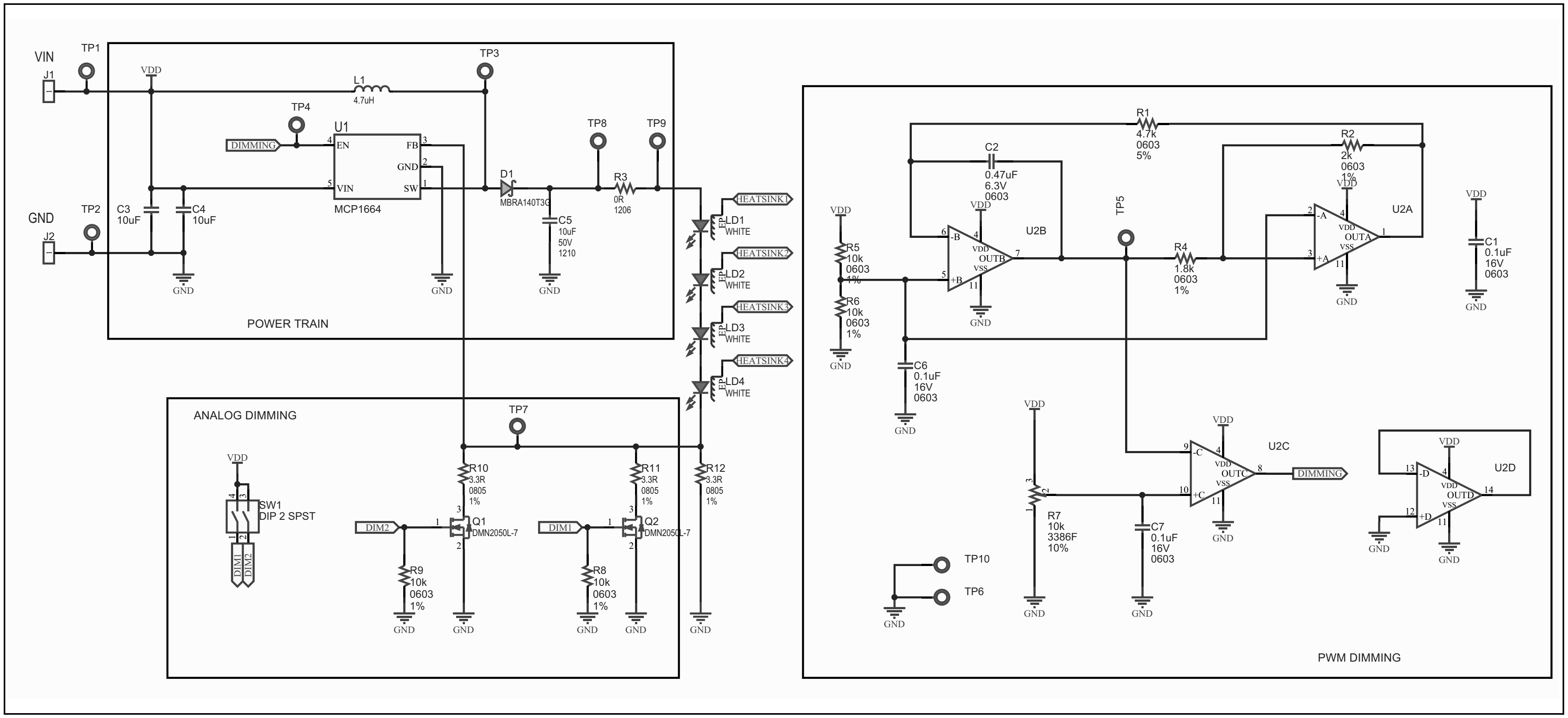
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

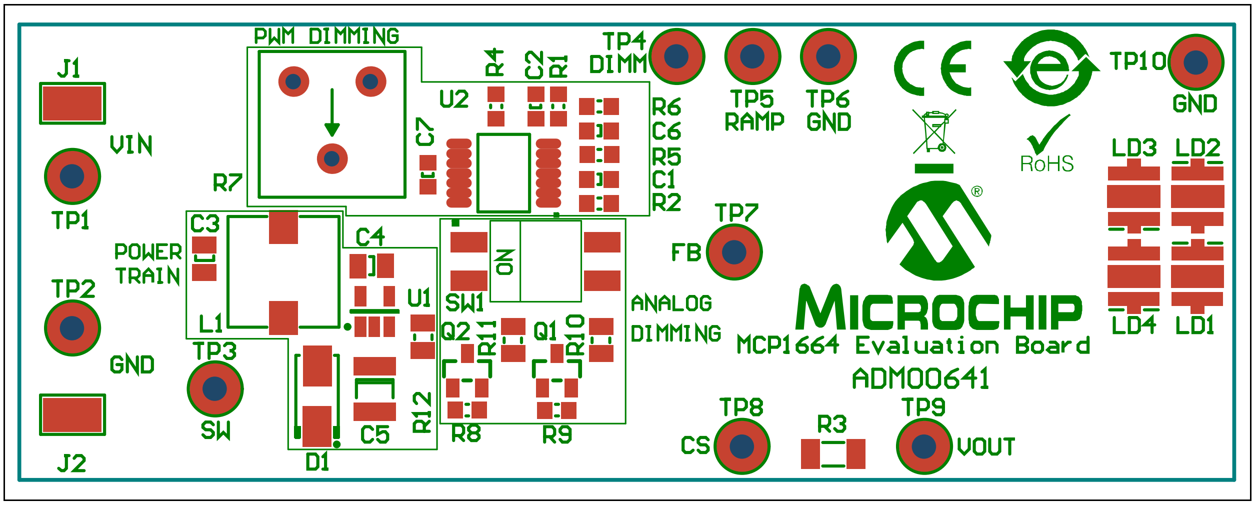
This appendix contains the following schematics and layouts for the MCP1664 LED Driver Evaluation Board:

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

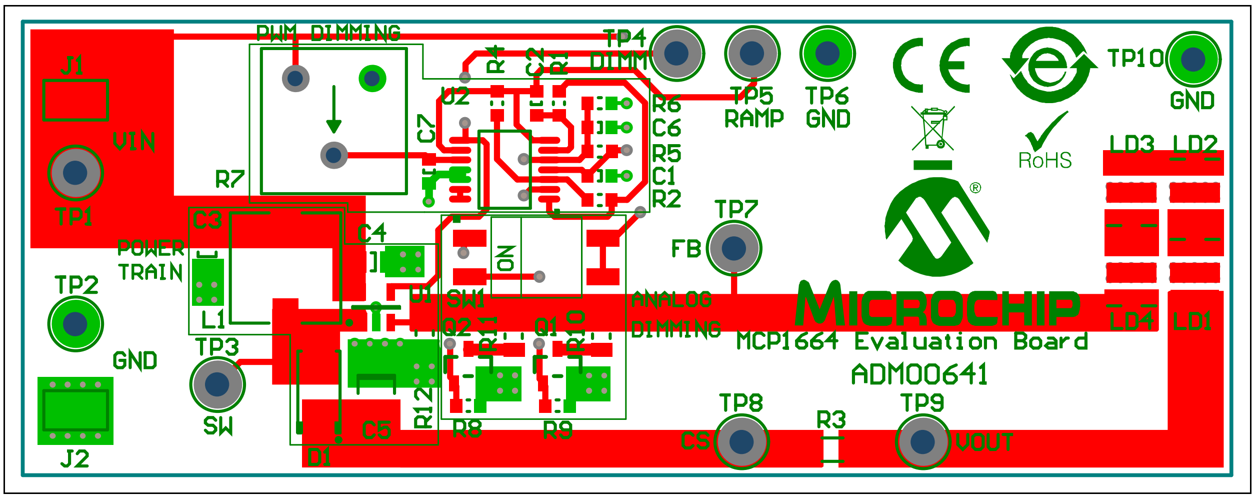
A.2 BOARD – SCHEMATIC



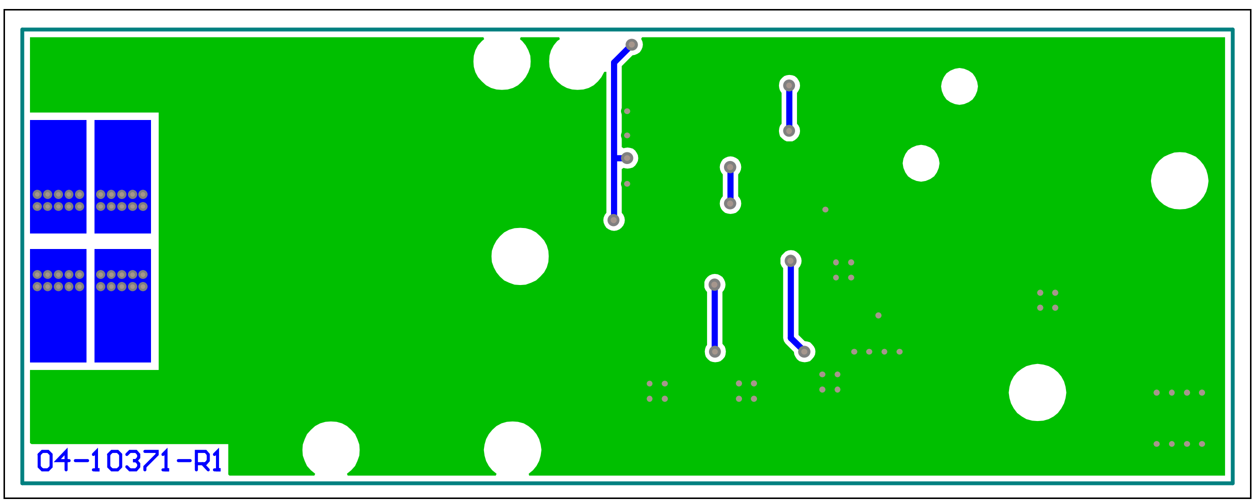
A.3 BOARD – TOP SILK



A.4 BOARD – TOP COPPER AND SILK



A.5 BOARD – BOTTOM COPPER AND SILK



NOTES:

Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
3	C1, C6, C7	Cap. ceramic 0.1 µF 16V 10% X7R SMD 0603	AVX Corporation	0603YC104KAT2A
1	C2	Cap. ceramic 0.47 µF 6.3V 10% X5R SMD 0603	Murata Electronics®	GRM188R60J474KA01D
2	C3, C4	Cap. ceramic 10 µF 10V 10% X7R SMD 0805	Murata Electronics	GRM21BR71A106KE51L
1	C5	Cap. ceramic 10 µF 50V 20% X7R SMD 1210	Taiyo Yuden Co., Ltd.	UMK325AB7106MM-T
1	D1	Diode Schottky MBRA140T3G 505 mV 1A 40V DO-214AC_SMA	ON Semiconductor®	MBRA140T3G
2	J1, J2	Conn. TP Loop Tin SMD	Harwin Inc.	S1751-46R
1	L1	Inductor 4.7 µH 3.16A 20% SMD L7.3W7.3H4.5	Würth Elektronik	7447779004
4	LD1, LD2, LD3, LD4	Diode LED White 3.2V 700 mA 95lm 2700K SMD L3.45W3.45H2.2	Würth Elektronik	158353027
2	Q1, Q2	Trans. FET N-CH DMN2050L-7 20V 5.9A 1.4W SOT-23-3	Diodes® Incorporated	DMN2050L-7
1	PCB	Printed Circuit Board – MCP1664 LED Driver Evaluation Board	—	04-10371
1	R1	Res. TKF 4.7k 5% 1/10W SMD 0603	Panasonic® - ECG	ERJ-3GEYJ472V
1	R2	Res. TKF 2k 1% 1/10W SMD 0603	Panasonic - ECG	ERJ-3EKF2001V
1	R3	Res. TKF 0R SMD 1206	KOA Speer Electronics, Inc.	RK73Z2BTTD
1	R4	Res. TKF 1.8k 1% 1/10W SMD 0603	Panasonic - ECG	ERJ-3EKF1801V
4	R5, R6, R8, R9	Res. TF 10k 1% 1/16W SMD 0603	TE Connectivity, Ltd.	5-1879337-9
1	R7	Res. Trimmer Cermet 10k 10% 500 mW TH 3386F	Bourns®, Inc.	3386F-1-103T
3	R10, R11, R12	Res. TKF 3.3R 1% 1/8W SMD 0805	Vishay/Dale	CRCW08053R30FKEA
1	SW1	Switch DIP 2 SPST 24V 25 mA 418121270802 SMD	Würth Elektronik	418121270802
1	TP1	Conn. TP Loop Red TH	Keystone Electronics Corp.	5010
3	TP2, TP6, TP10	Conn. TP Loop Black TH	Keystone Electronics Corp.	5011
6	TP3, TP4, TP5, TP7, TP8, TP9	Conn. TP Loop Orange TH	Keystone Electronics Corp.	5013

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