



**Bluetooth<sup>®</sup>**  
**White-Color-Mix LED Driver**  
**Reference Design**  
**User's Guide**

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# BLUETOOTH WHITE-COLOR-MIX LED DRIVER REFERENCE DESIGN USER'S GUIDE

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# BLUETOOTH WHITE-COLOR-MIX LED DRIVER REFERENCE DESIGN USER'S GUIDE

## Preface

### NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our website ([www.microchip.com](http://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 Bluetooth White-Color-Mix LED Driver 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 Bluetooth White-Color-Mix LED Driver Reference Design as a development tool to emulate and debug firmware on a target board, as well as how to program devices. The document is organized as follows:

- **Chapter 1. “Product Overview”** – Provides important information about the Bluetooth White-Color-Mix LED Driver Reference Design and shows the hardware details of its components.
- **Chapter 2. “Installation and Operation”** – Includes instructions on how to use, power and test the Bluetooth White-Color-Mix LED Driver Reference Design.
- **Appendix A. “Schematics and Layouts”** – Shows the schematic and layout diagrams for the Bluetooth White-Color-Mix LED Driver Reference Design.
- **Appendix B. “Bill of Materials (BOM)”** – Lists the parts used to build the Bluetooth White-Color-Mix LED Driver Reference Design.
- **Appendix C. “Waveforms”** – Shows sample output waveforms generated by the Bluetooth White-Color-Mix LED Driver Reference Design.

## CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

### DOCUMENTATION CONVENTIONS

Description	Represents	Examples
<b>Arial font:</b>		
Italic characters	Referenced books	<i>MPLAB® IDE User's Guide</i>
	Emphasized text	...is the <i>only</i> 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	<u><i>File&gt;Save</i></u>
Bold characters	A dialog button	Click <b>OK</b>
	A tab	Click the <b>Power</b> 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>
<b>Courier New font:</b>		
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	<i>file.o</i> , where <i>file</i> can be any valid filename
Square brackets [ ]	Optional arguments	mcc18 [options] <i>file</i> [options]
Curly brackets and pipe character: {   }	Choice of mutually exclusive arguments; an OR selection	errorlevel {0 1}
Ellipses...	Replaces repeated text	var_name [, var_name...]
	Represents code supplied by user	void main (void) { ... }

## RECOMMENDED READING

This user's guide describes how to use the Bluetooth White-Color-Mix LED Driver Reference Design. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources:

- **HV9961 Data Sheet – “LED Driver with Average-Current Mode Constant-Current Control” (DS20005588)**
- **PIC16F15313 Data Sheet – “Full-Featured 8/14-Pin Microcontrollers” (DS40001897)**
- **RN4871 Data Sheet – “Bluetooth® Low Energy Module” (DS50002489)**
- **DN2470 Data Sheet – “N-Channel, Depletion-Mode, Vertical DMOS FET” (DS20005410)**

## THE MICROCHIP WEBSITE

Microchip provides online support via our website at [www.microchip.com](http://www.microchip.com). This website is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the website contains the following information:

- **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

## CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- 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 (March 2020)

- Initial release of this document.

NOTES:



## Chapter 1. Product Overview

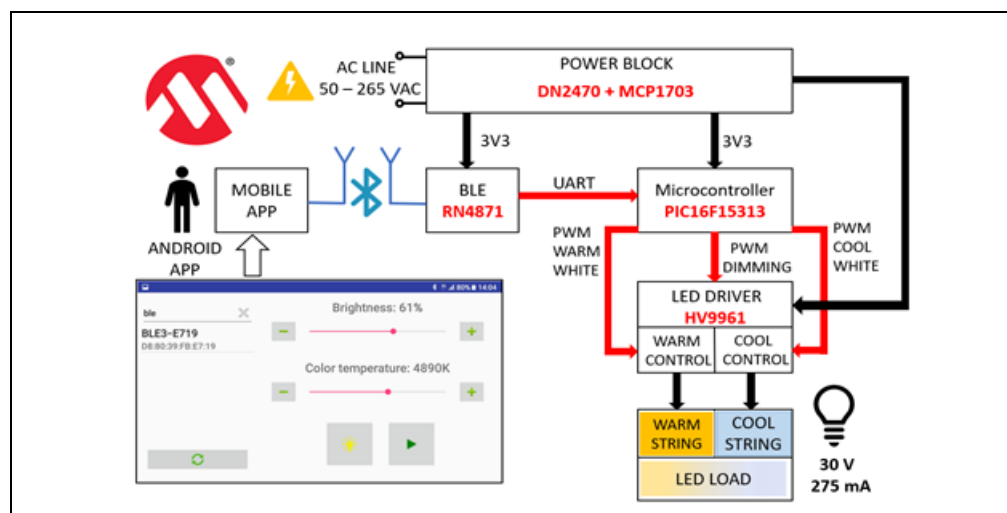
### 1.1 INTRODUCTION

This chapter provides an overview of the Bluetooth White-Color-Mix LED Driver Reference Design and covers the following topics:

- Short Overview
- Key Devices Main Features
- Reference Design Kit Contents

### 1.2 SHORT OVERVIEW

The Bluetooth White-Color-Mix LED Driver Reference Design is a Total System Solution (TSS) that demonstrates how to drive two different temperature color LED strings and how to control the desired color through a Bluetooth communication interface.



**FIGURE 1-1:** Block Diagram.

The important features of the Bluetooth White-Color-Mix LED Driver Reference Design include:

- The reference design combines a basic buck LED driver (HV9961) with an 8-bit PIC16F15313 microcontroller, which communicate through UART with the BLE module RN4871 to create a Microchip Intelligent LED Lighting TSS Solution.
- The microcontroller and the BLE module are supplied directly from the 120 VAC 60 Hz or 230 VAC 50 Hz, by means of a bridge rectifier and a Depletion Field-Effect Transistor (DN2470), followed by a usual 3V3 Low-Dropout (LDO) regulator MCP1703. The Bluetooth White-Color-Mix LED Driver can be supplied from a wide input voltage range, from 50 to 265VAC.
- The Bluetooth White-Color-Mix LED Driver offers an implementation of a passive Power Factor Correction (PFC). It provides a PFC of at least 0.9 at 120 VAC and 0.85 at 230 VAC.
- The PIC16F15313 microcontroller receives the data from the Bluetooth module

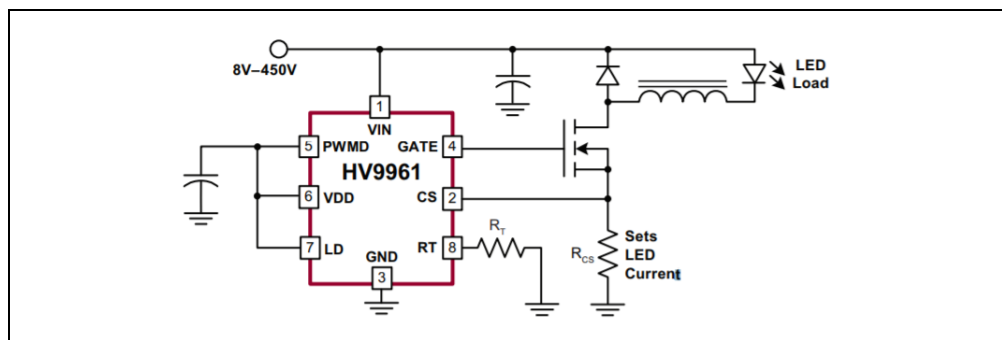
and controls the color Temperature and the intensity of the LED load by means of a 2 PWM output and two auxiliary FETs, according to the values which were set by the user in the mobile Android application.

- At the same time, the microcontroller performs a memory function by retaining the last set values in the flash memory to be used as default values at power on.
- The Bluetooth White-Color-Mix LED Driver uses the RN4871 Bluetooth Low Energy (BLE) module which integrates Bluetooth 4.2 baseband controller, on-board Bluetooth stack, digital and analog I/O, and RF power amplifier into one solution.
- Bluetooth low energy takes a different direction. Instead of increasing the data rates available, it has been optimized for ultra-low power consumption.

## 1.3 KEY DEVICES MAIN FEATURES

### 1.3.1 HV9961 LED Driver - Average Current Mode Control

- Fast Average Current Control
- Programmable Constant Off-Time Switching
- Linear Dimming Input
- PWM Dimming Input
- Operating  $I_Q = 0.5 \mu A$
- LED Current Accuracy  $\pm 3\%$
- Input Supply: 8V - 450V
- Output Short Circuit Protection (SCP) with Skip Mode
- Ambient Operating Temperature:  $-40^{\circ}C$  to  $+125^{\circ}C$
- Package: 8-lead SOIC, 16-lead SOIC



**FIGURE 1-2:** HV9961 Typical Application Circuit.

### 1.3.2 RN4871 - Bluetooth Low Energy Module

- Compact Form Factor, Surface Mount, 12 mm x 22 mm
- Bluetooth 5, FCC Certified
- 2.5x Throughput Improvement vs. Bluetooth 4.1
- Completely Integrated Bluetooth 4.2 Software Stack
- Increased Privacy Features
- Remote Configuration Capability
- 1.9V~3.6V Operating Range
- UART/ I2C/ SPI Interface Supported
- ASCII Command Interface API over UART
- Scripting Engine for Hostless Operation
- ISM Band 2.402 to 2.480 GHz Operation

- Excellent RX Sensitivity: -90 dBm, TX Power: 0 dBm
- Antenna: Ceramic Chip Antenna/External Antenna

### **1.3.3 PIC16F15313 8-Bit Microcontroller**

- Enhanced Mid-Range Core with 49 Instruction, 16 Stack Levels
- Flash Program Memory with Self-read/write Capability
- eXtreme Low Power (XLP)
- IDLE and DOZE Low Power Modes
- Peripheral Module Disable (PMD)
- Peripheral Pin Select (PPS)
- 4x 10-bit PWMs
- 5-Channel 10-bit ADC with Voltage Reference
- 5-bit Digital to Analog Converter (DAC)
- Temperature Range (°C): -40 to 125
- Operating Voltage Range (V): 1.8 to 5.5
- Package: 8-PIN PDIP, SOIC, MSOP

### **1.3.4 DN2470 - 700V, N-Channel, Depletion Mode, Vertical DMOS FET**

- High D-S Breakdown Voltage
- High Input Impedance
- Low Input Capacitance
- Fast Switching Speeds
- Low On-Resistance
- Free from Secondary Breakdown
- Low Input and Output Leakage
- Package: TO-252 DPAK

## **1.4 REFERENCE DESIGN KIT CONTENTS**

The Bluetooth White-Color-Mix LED Driver Reference Design kit includes:

- LED Driver Board ARD00922
- LED Load Board INT00923
- Important Information Sheet

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## Chapter 2. Installation and Operation

### 2.1 OVERVIEW

The following sections describe how to use the Bluetooth White-Color-Mix LED Driver Board.

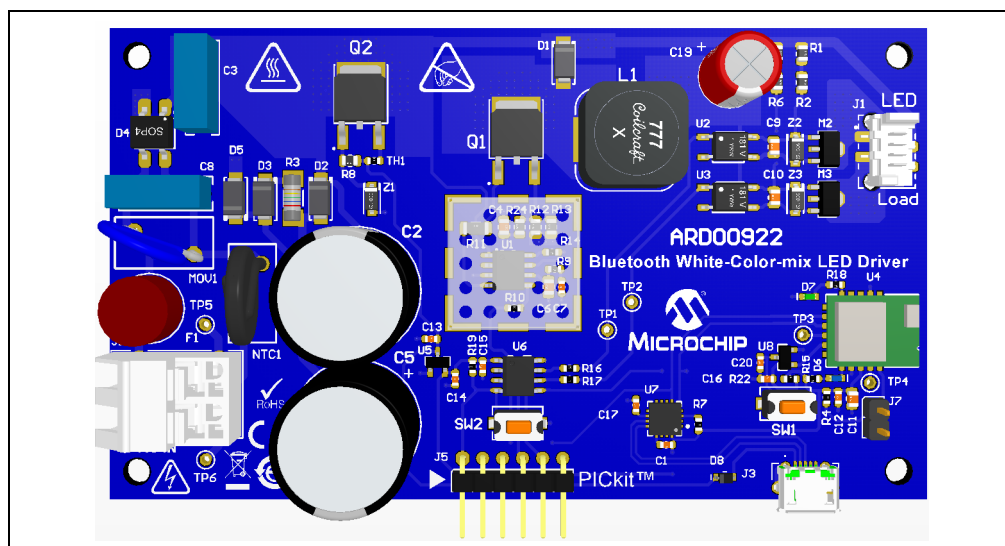
### 2.2 GETTING STARTED

The Bluetooth White-Color-Mix LED Driver Board (ARD00922) is fully assembled and tested to evaluate and demonstrate its functionality connected to the LED Load Board (INT00923), which is provided.

#### 2.2.1 Powering the Bluetooth White-Color-Mix LED Driver Board

The board is connected directly to 230 VAC. A variable AC power supply is needed for testing and evaluation in the laboratory. The power supply requires an output capability of at least 1A and a voltage range of 80 to 265 VAC. This can be obtained from an autotransformer supplied from the mains or an electronic AC/AC power supply (for example, Chroma ATE Inc.'s 61500 series).

The output of the driver can supply a voltage around 30V and an output current of maximum 400 mA.



**FIGURE 2-1:** LED Driver Board - ARD00922.

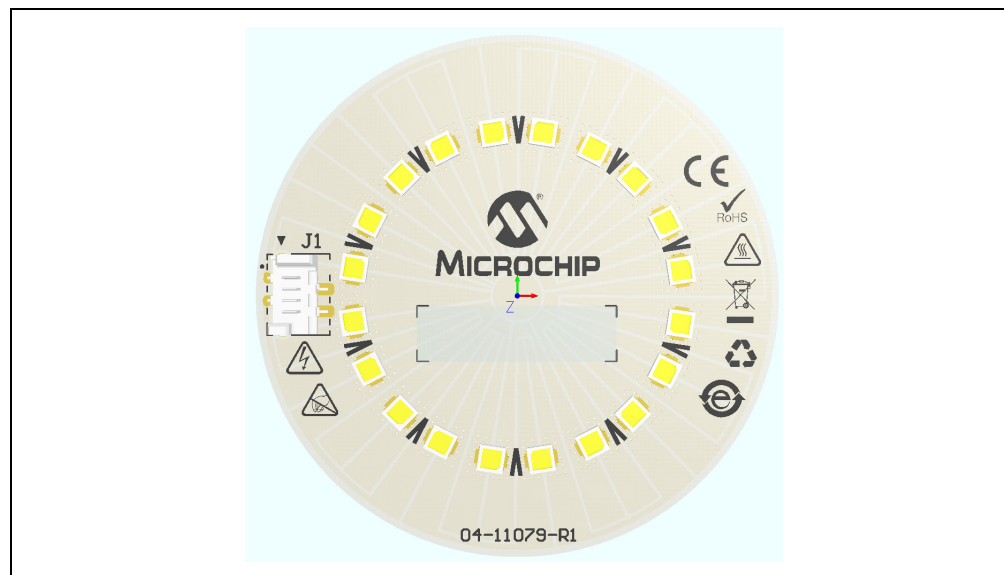
#### 2.2.2 The LED Load (INT00923)

- The LED Load is included in the kit by Microchip Technology. For long-term operation, it is necessary to use a heatsink, which is not provided. As a suggestion, a proper heatsink would be a circular pin-fin heatsink produced by MechaTronix LED Coolers, manufacturer code LPF60A30-5-B.
- The LED Load contains 20 White LEDs distributed into two interlaced strings of 10 LEDs each, in parallel. Every string has a different color temperature, such as 2700K and 6500K.

- The rated voltage/current of the load is 30V/275 mA.
- The connection to the driver is made by a 4-wire flat cable.

The Bluetooth White-Color-Mix LED Driver Board (ARD00922) can vary the output voltage and current of the INT00923 LED load by 2 PWM outputs of the PIC16F15313 microcontroller, which controls the current for the two LED strings of the load. The PIC® controller receives the data from the Bluetooth module and controls the temperature color and the brightness of the LED load according to the values set by the user in the mobile application.

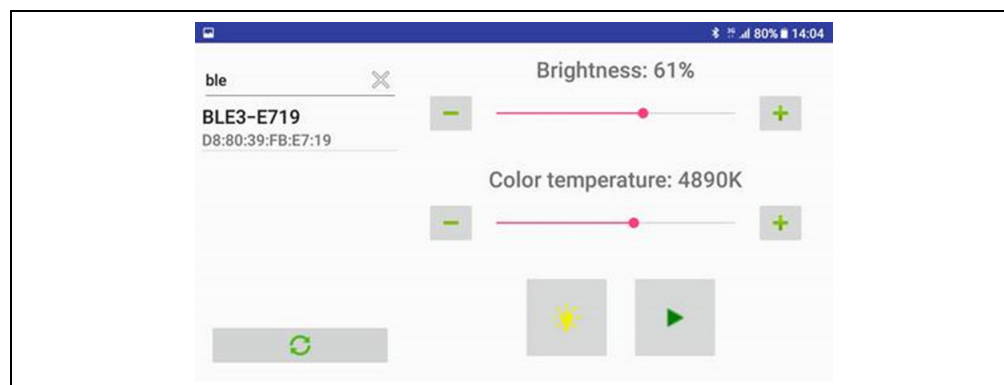
On Power Off, the microcontroller will retain the last set values in flash memory which will be used as default values at Power On.



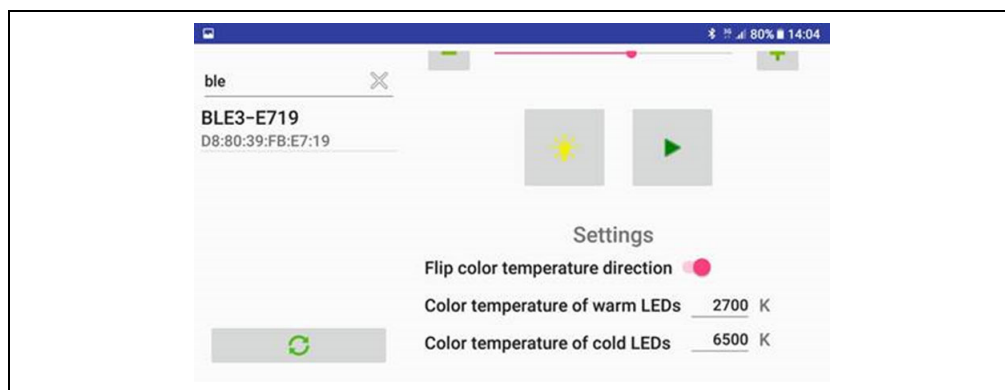
**FIGURE 2-2:** LED Load Board - INT00923.

### 2.2.3 Mobile Application

- The mobile application is used to connect to the Bluetooth White-Color-mix LED Driver Board (ARD00922) through the Bluetooth protocol.
- It offers two slide bars used to vary the **Brightness** and **Color Temperature** of the LED Load.
- At the same time, the application offers two buttons used to switch the light ON/OFF and one button to trigger a demonstrative function.
- The button **Flip Color** is used to accommodate the proper sequence of the LEDs as populated on the LED Load.

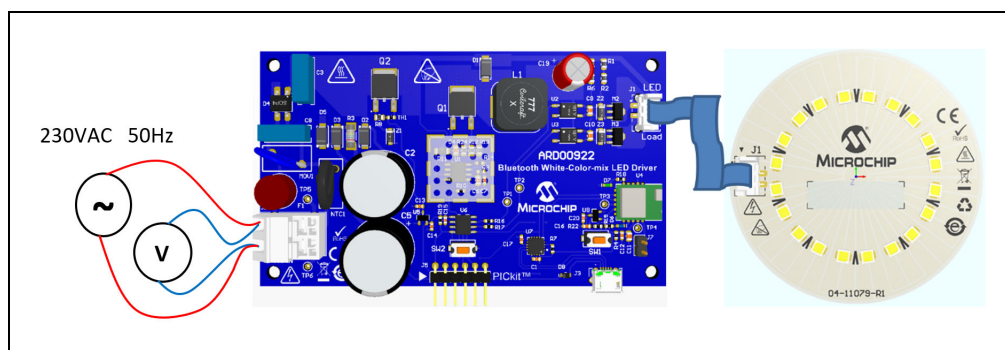


**FIGURE 2-3:** First Window of the Android Application.



**FIGURE 2-4:** Second Window of the Android Application.

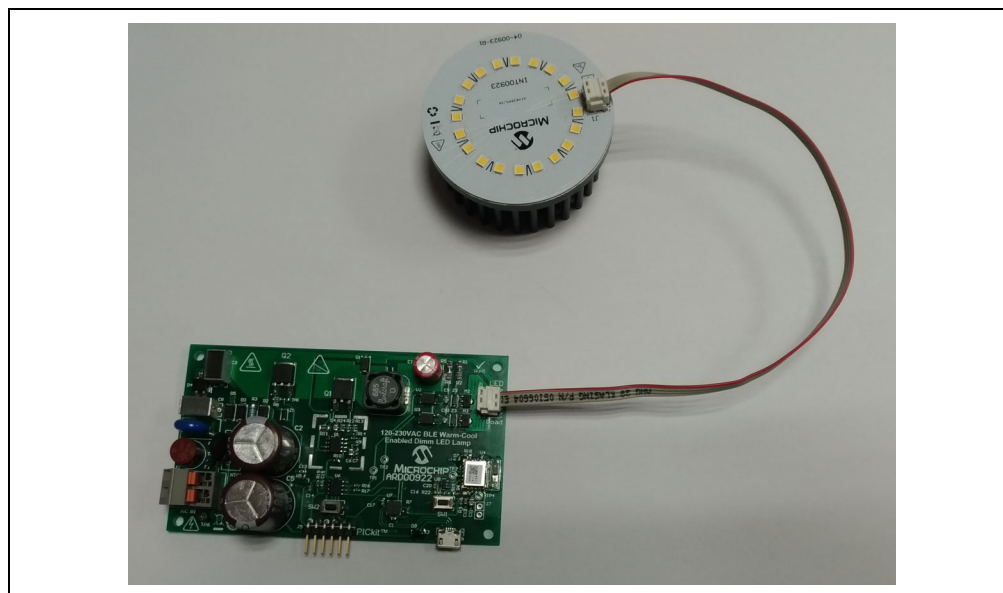
## 2.3 SETUP/CONFIGURATION



**FIGURE 2-5:** Test Configuration Set-Up.

### 2.3.1 Procedure for Testing the LED Driver - LED Load Assembly

1. Connect the supply (230 VAC) as shown in Test Configuration Set-Up, at the input of the driver board J2 (the frequency of the power supply can be 50 Hz or 60 Hz). The maximum accepted line voltage is 265 VAC.
2. With the power supply OFF, connect the J1 connector from the driver board (ARD00922) with the J1 connector from the LED Load, INT00923, by means of the 4-wire ribbon cable. Make sure to connect the ribbon cable in the right position regarding its one-way connection key.
3. Use a light filter (color plexiglass) to dim the light and protect your eyes before checking that all the LEDs are working (lit).
4. Turn on the power supply for a few seconds (maximum 1 minute, as no heatsink is installed on the LED Load). For longer term operation, you should attach the LED Load on a proper heatsink.
5. On an Android device, install the Bluetooth application downloaded from the Microchip site. Enable "installation by unknown sources" on your device. After installation, launch the application and enable the Bluetooth and the location for the device.
6. Search for the device named "BLE" and select it. If the connection was successful, the LED D6 will blink twice periodically.
7. Check if the intensity of the light can be changed by moving the cursor of the **Brightness** bar or the Color Temperature by changing the **Color Temperature** bar in the Android application, at the first window (Figure 2-3).



**FIGURE 2-6:** LED Driver and LED Load - Physical Assembly.



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## **Appendix A. Schematics and Layouts**

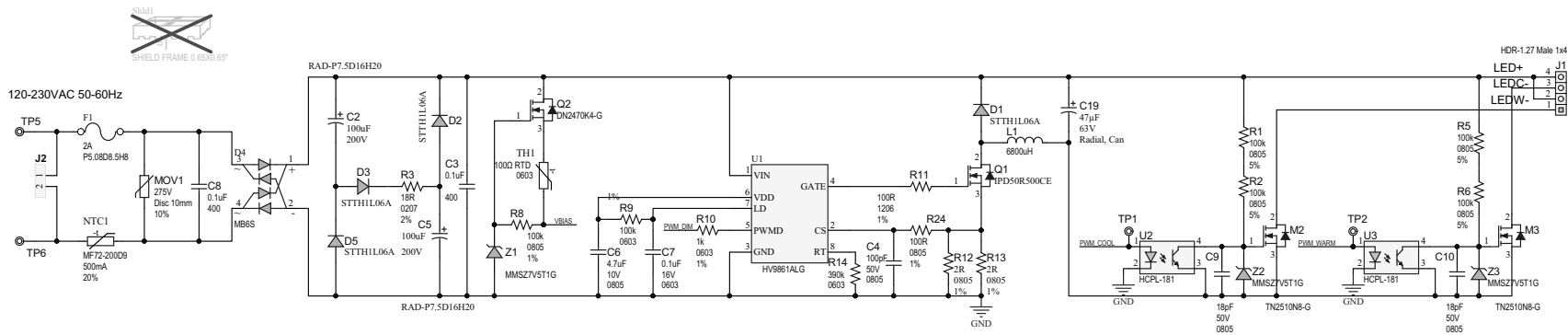
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### **A.1 INTRODUCTION**

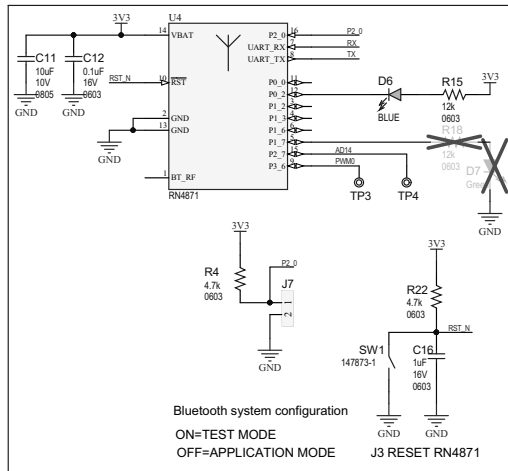
This appendix contains the following schematics and layouts for the LED Driver Board (ARM00922) and INT00923 Board (INT00923):

- [LED Driver Board – Schematic](#)
- [INT00923 Board – Schematic](#)
- [LED Driver Board – Top Silk](#)
- [LED Driver Board – Top Copper and Silk](#)
- [LED Driver Board – Top Copper](#)
- [LED Driver Board – Bottom Copper](#)
- [LED Driver Board – Bottom Copper and Silk](#)
- [LED Driver Board – Bottom Silk](#)
- [INT00923 Board – Top Silk](#)
- [INT00923 Board – Top Copper and Silk](#)
- [INT00923 Board – Top Copper](#)
- [INT00923 Board – Bottom Copper](#)
- [INT00923 Board – Bottom Copper and Silk](#)
- [INT00923 Board – Bottom Silk](#)

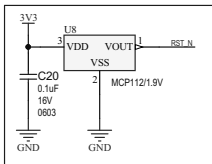
## A.2 LED DRIVER BOARD – SCHEMATIC



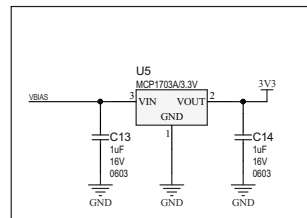
RN4871 BLUETOOTH MODULE AND CONFIGURATION CIRCUITS



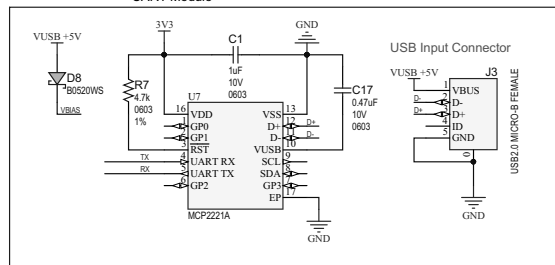
Bluetooth Module Reset Circuit



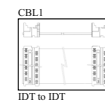
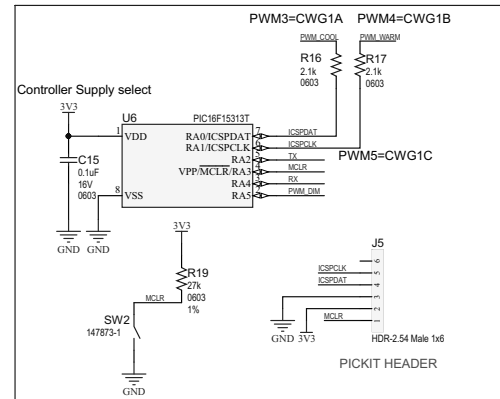
3V3 LDO



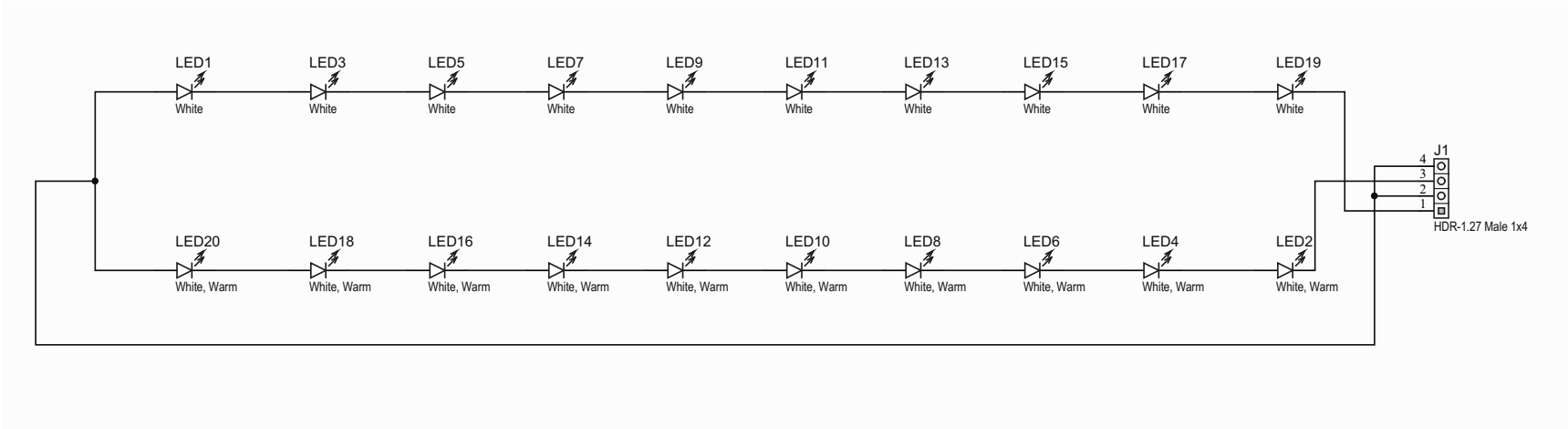
UART Module

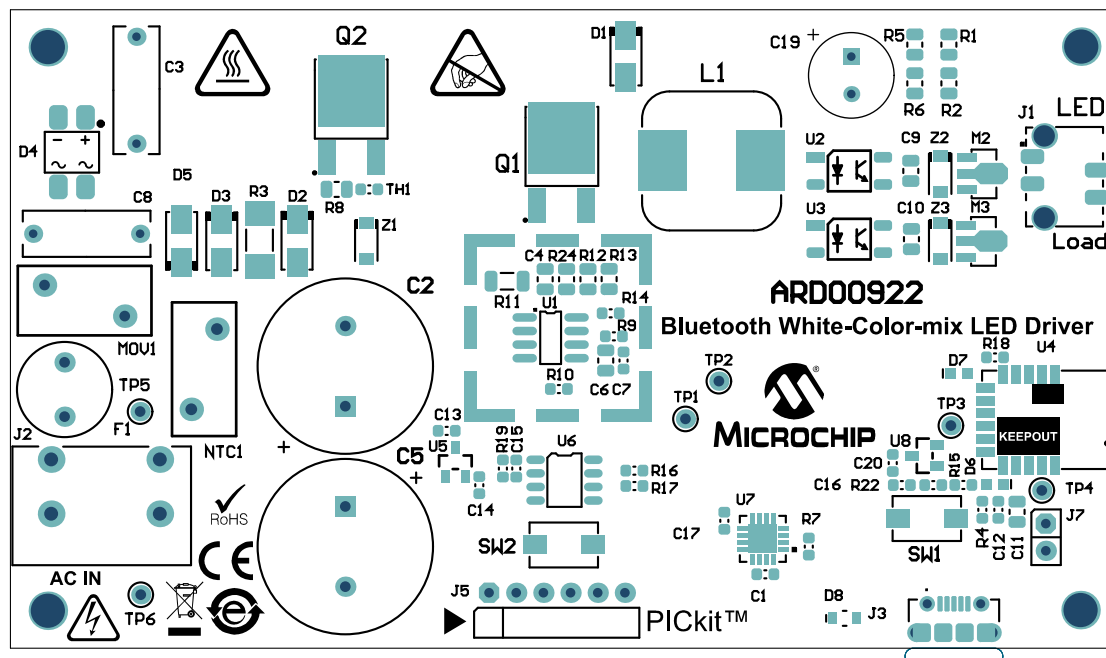


MICROCONTROLLER CIRCUIT

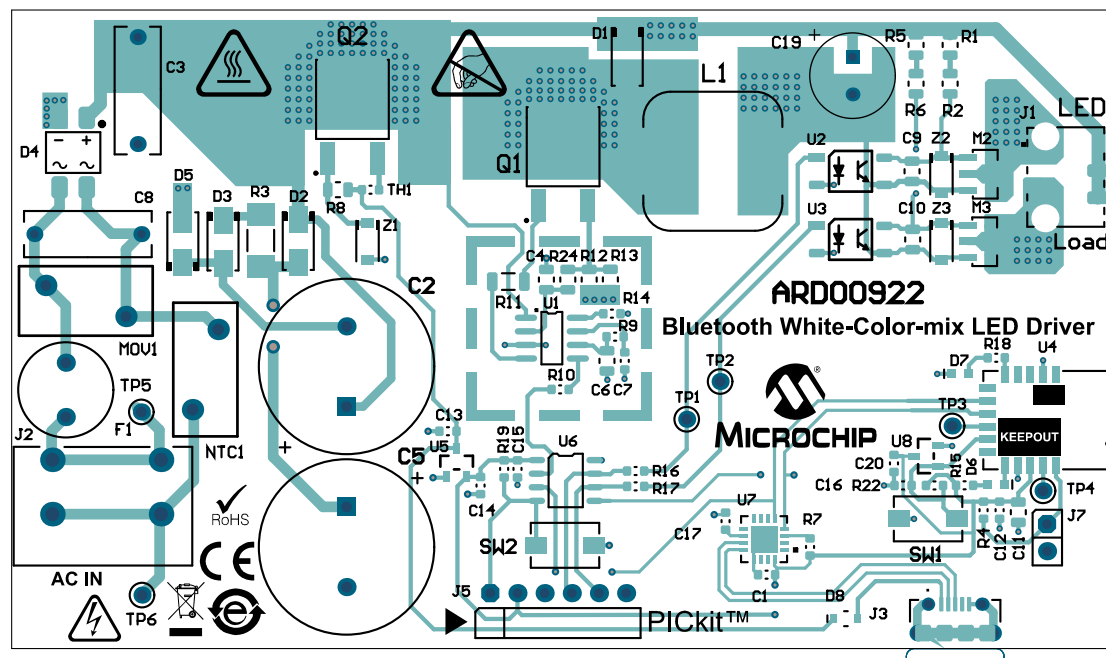


A.3 INT00923 BOARD – SCHEMATIC

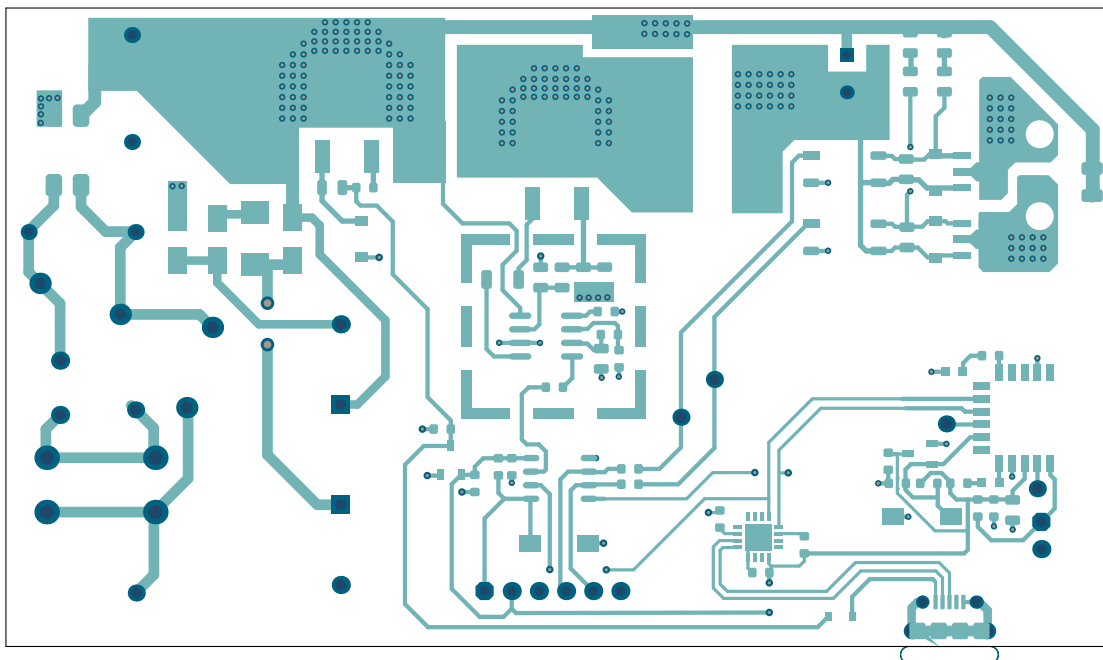




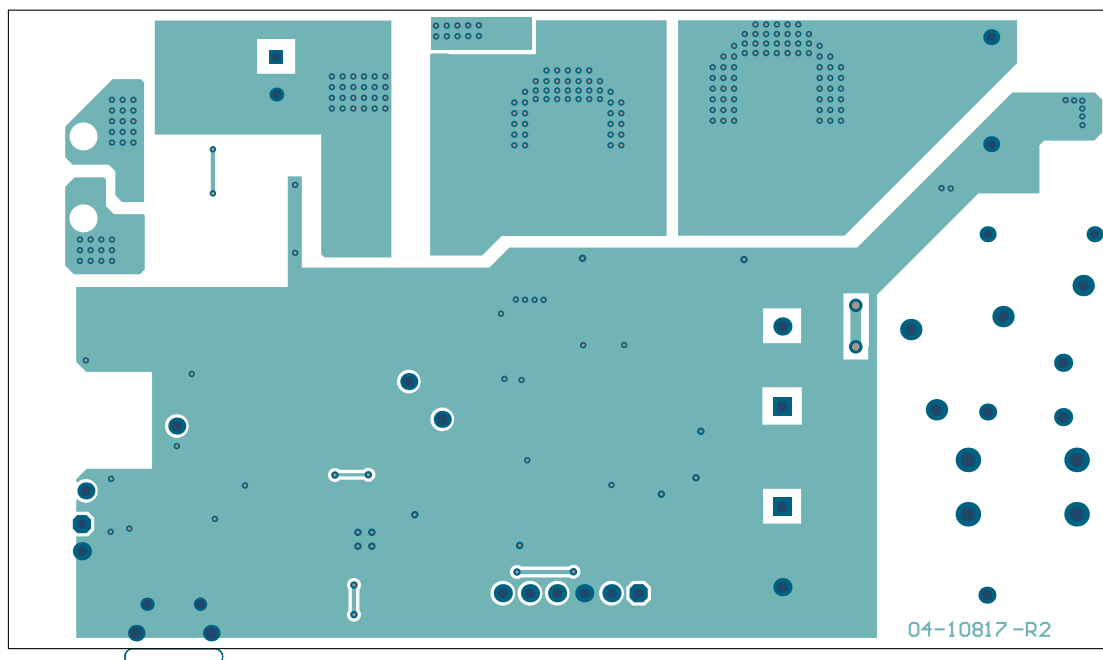
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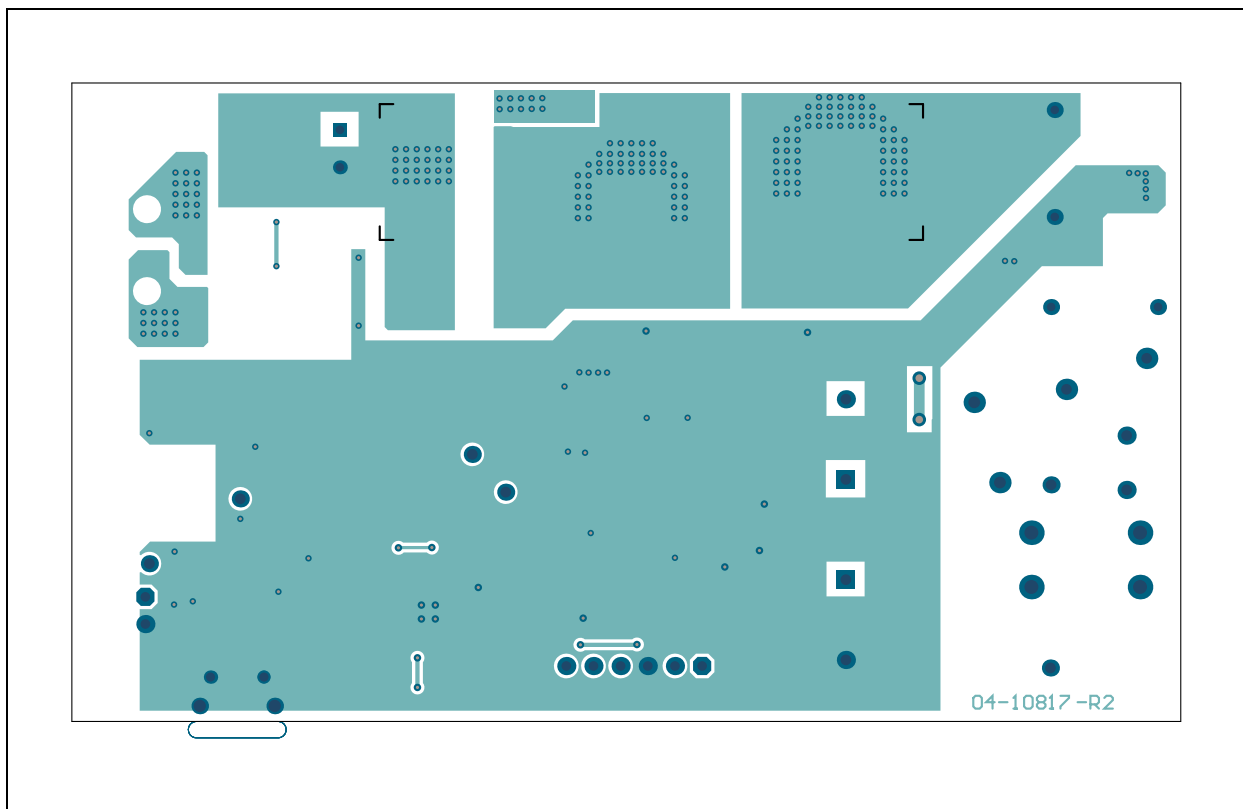
## A.6 LED DRIVER BOARD – TOP COPPER



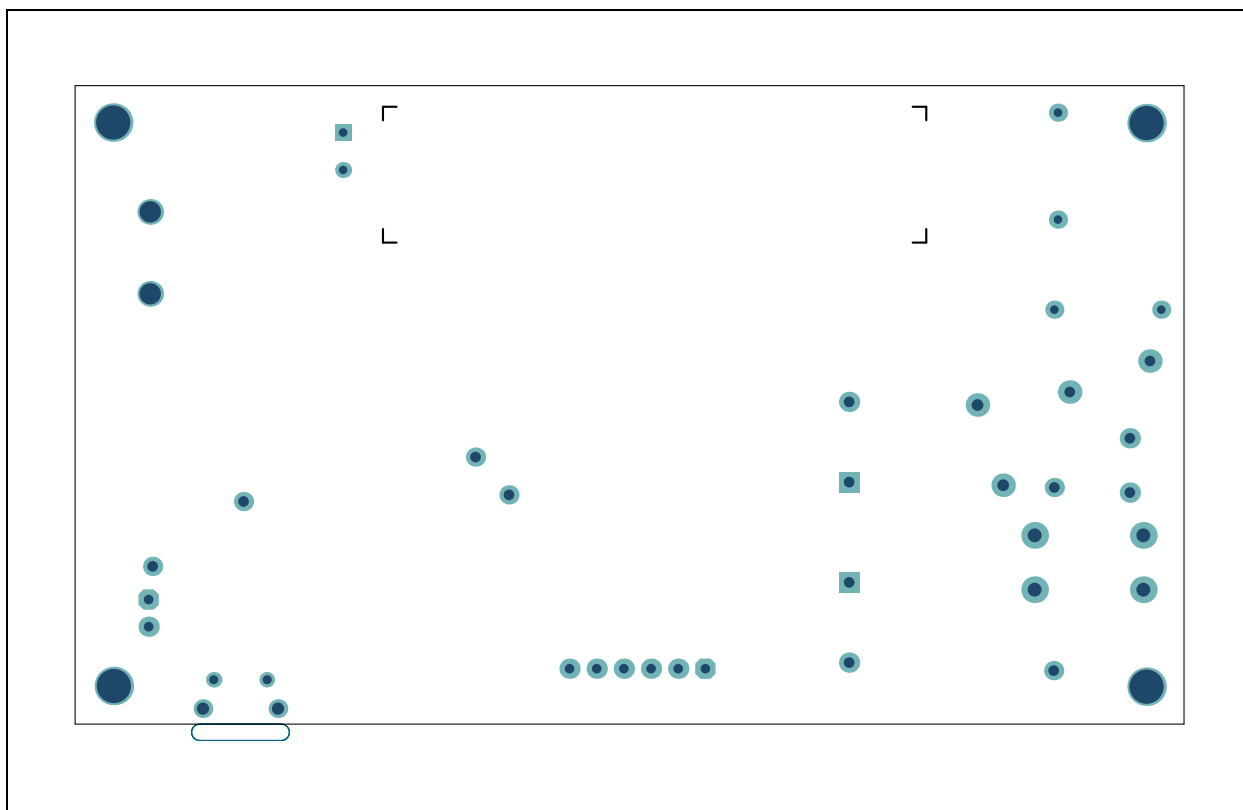
## A.7 LED DRIVER BOARD – BOTTOM COPPER



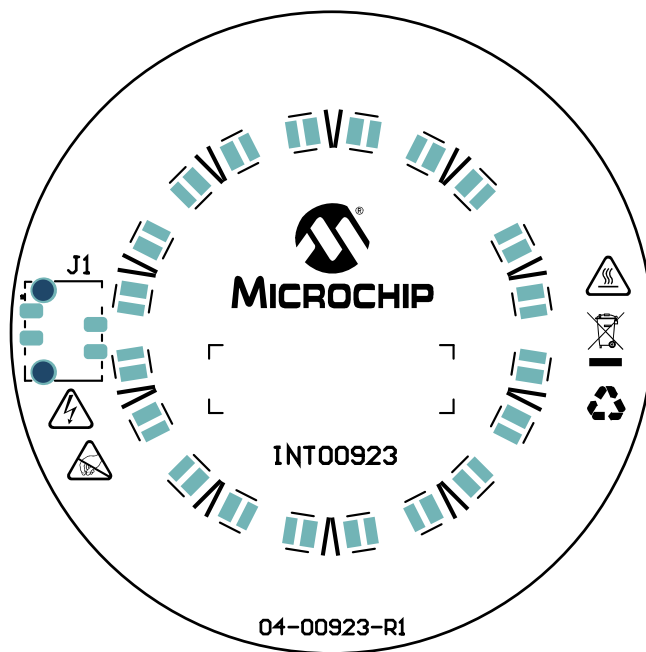
## A.8 LED DRIVER BOARD – BOTTOM COPPER AND SILK



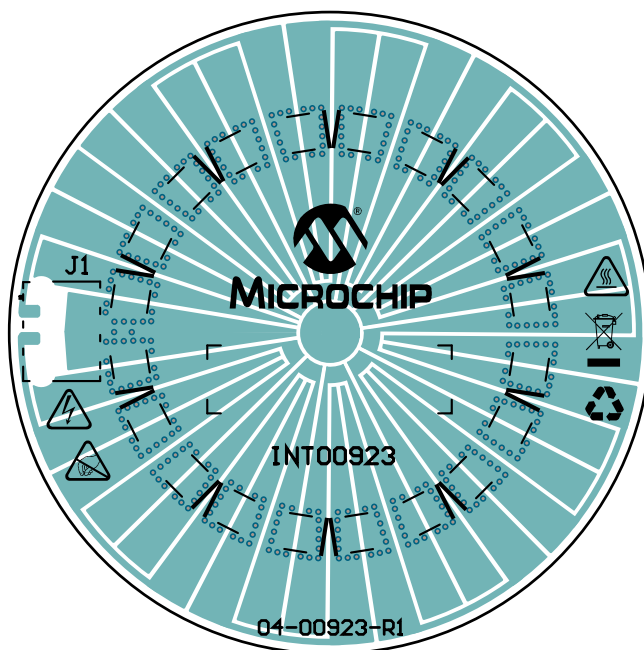
## A.9 LED DRIVER BOARD – BOTTOM SILK



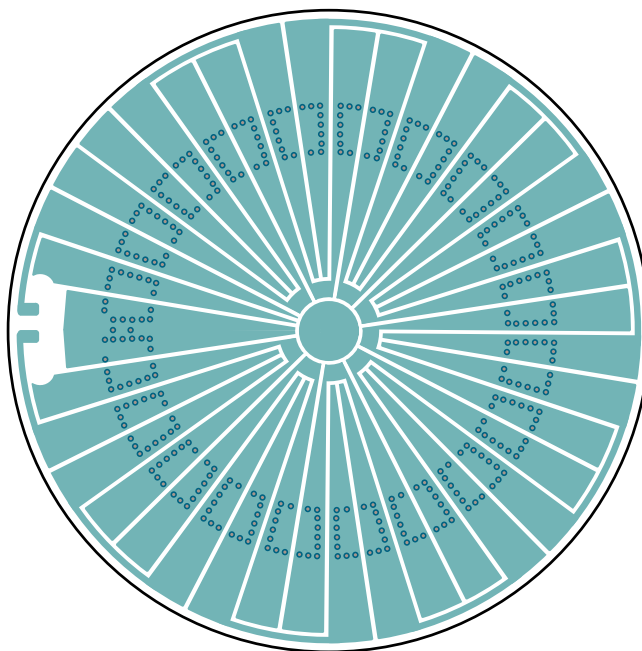
## A.10 INT00923 BOARD – TOP SILK



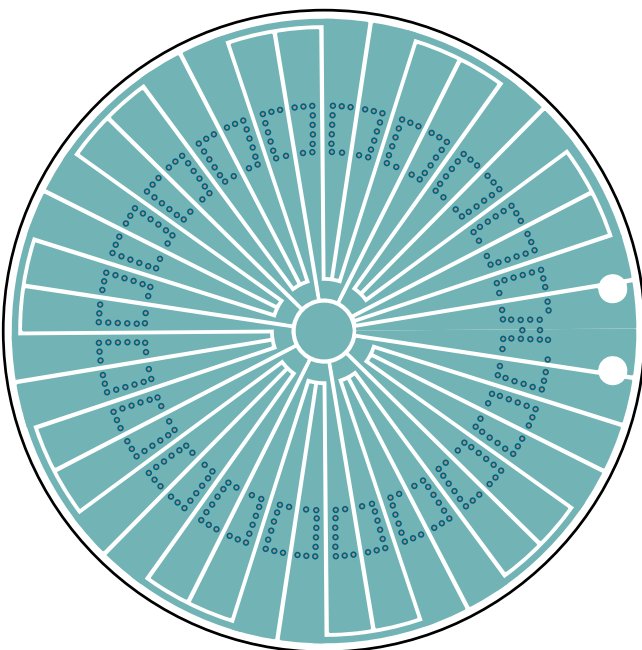
## A.11 INT00923 BOARD – TOP COPPER AND SILK



## A.12 INT00923 BOARD – TOP COPPER

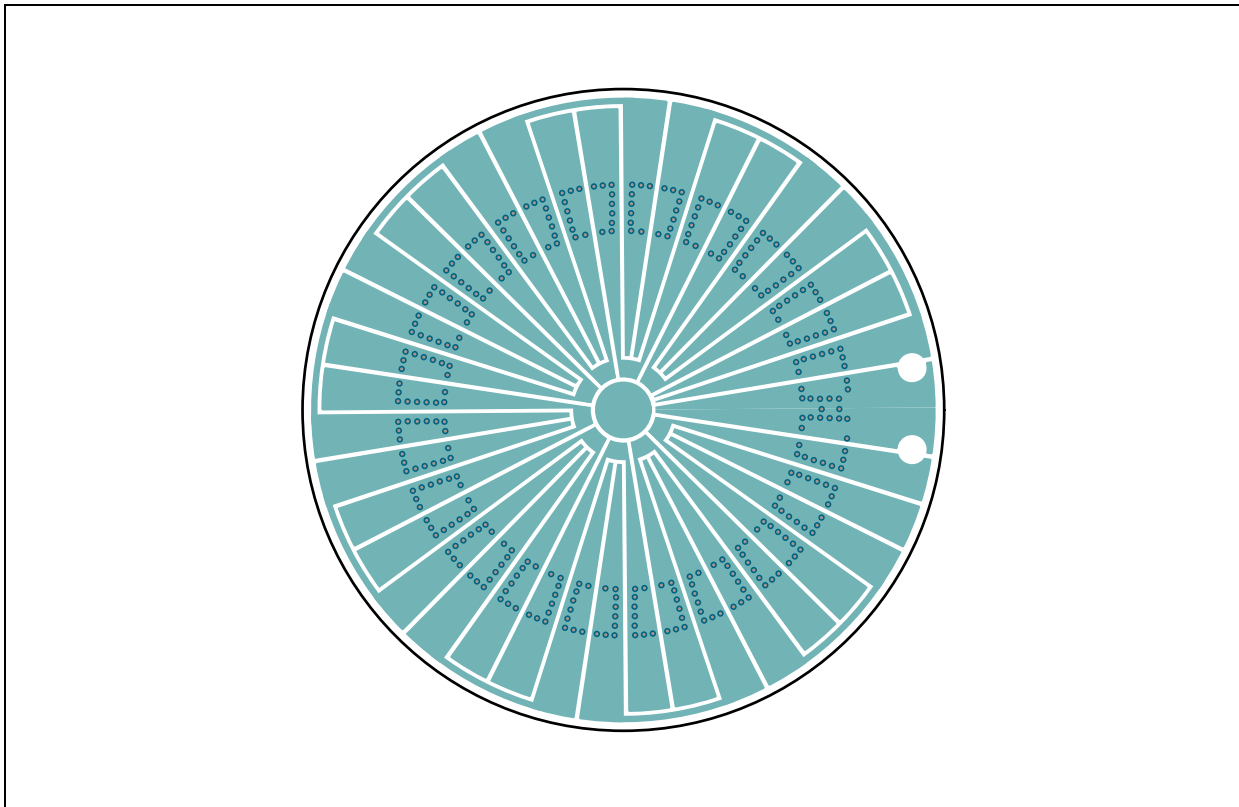


## A.13 INT00923 BOARD – BOTTOM COPPER

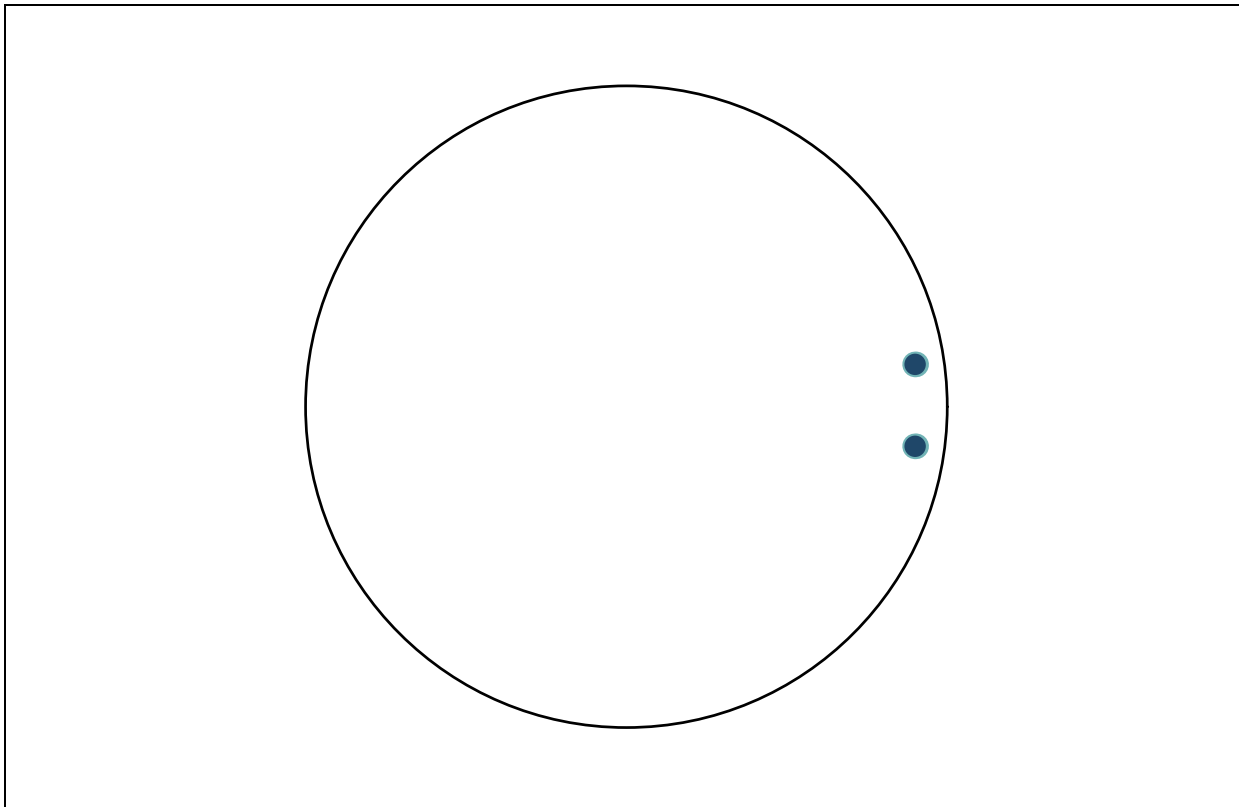




#### A.14 INT00923 BOARD – BOTTOM COPPER AND SILK



#### A.15 INT00923 BOARD – BOTTOM SILK



NOTES:

## Appendix B. Bill of Materials (BOM)

**TABLE B-1: BILL OF MATERIALS (BOM)**

Qty.	Reference	Description	Manufacturer	Part Number
1	C1	Capacitor, ceramic, 1 $\mu$ F, 10V, 10%, X7R, SMD, 0603	Taiyo Yuden Co., Ltd.	CELMK107B7105KA-T
2	C2, C5	Capacitor, aluminum, 100 $\mu$ F, 200V, 20%, RAD, P7.5D16H20	United Chemi-Con	EKXG201ELL101ML20S
2	C3, C8	Capacitor, film, 0.1 $\mu$ F, 400V, 10%, RAD, P10L11.5W4H6.9	TDK Electronics (previously EPCOS)	B32561J6104K
1	C4	Capacitor, ceramic, 100 pF, 50V, 5%, C0G, SMD, 0805	Würth Elektronik	885012007057
1	C6	Capacitor, ceramic, 4.7 $\mu$ F, 10V, 20%, X7R, SMD, 0805	TDK Corporation	C2012X7R1A475M125AC
4	C7, C12, C15, C20	Capacitor, ceramic, 0.1 $\mu$ F, 16V, 10%, X7R, SMD, 0603	Samsung	CL10B104KO8NNNC
2	C9, C10	Capacitor, ceramic, 18 pF, 50V, 5%, NP0, SMD, 0805	Yageo Corporation	CC0805JRNPO9BN180
1	C11	Capacitor, ceramic, 10 $\mu$ F, 10V, 10%, X5R, SMD, 0805	Taiyo Yuden Co., Ltd.	LMK212BJ106KG-T
3	C13, C14, C16	Capacitor, ceramic, 1 $\mu$ F, 16V, 20%, Y5V, SMD, 0603	Yageo Corporation	CC0603ZRY5V7BB105
1	C17	Capacitor, ceramic, 0.47 $\mu$ F, 10V, 10%, X5R, SMD, 0603	KEMET	C0603C474K8PACTU
1	C19	Capacitor, aluminum, 47 $\mu$ F, 20%, 63V, Through Hole	Würth Elektronik	860080774008
1	CBL1	Mechanical, hardware, cable, Picoflex, IDT to IDT, 4-Cond., 250 mm	Molex®	92315-0425
4	D1, D2, D3, D5	Diode, rectifier, STTH1L06A, 1.3V, 1A, 600V, SMD, SMA	STMicroelectronics	STTH1L06A
1	D4	Diode, rectifier, BRG, MB6S, 1V, 0.5A, 600V, SMD, SOIC-4	Sensitron Semiconductor	MB6S
1	D6	Diode, LED, Blue, 2.8V, 20 mA, 15 mcd, clear, SMD, 0603	Vishay Lite-On	LTST-C193TBKT-5A
0	D7	Diode, LED, green, 2.05V, 10 mA, clear, SMD, 0603 - DO NOT POPULATE	Panasonic SSG	LNJ326W83RA
1	D8	Diode, Schottky, B0520WS, 430 mV, 500 mA, 20V, SOD-323	Diodes Incorporated®	B0520WS-7-F
1	F1	Resistor, fuse, 2A, 300 VAC slow radial, Through Hole, P5.08D8.5H8	Littelfuse Wickmann	38312000000
1	J1	Connector, header-1.27, male, 1x4, tin, SMD, vertical	Molex®	90814-0804
1	J2	Connector, terminal, 5.08mm, 1x2, female, 16-22AWG, 12A, Through Hole, R/A	On-Shore Technology, Inc.	OSTHD020080

**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.

**TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)**

Qty.	Reference	Description	Manufacturer	Part Number
1	J3	Connector, USB2.0, Micro-B, female, Through Hole/SMD, R/A	Amphenol Corporation	10118194-0001LF
1	J5	Connector, header-2.54, male, 1x6, gold, 5.84MH, Through Hole, R/A	Würth Elektronik	61300611021
1	J7	Connector, header-2.54, male, 1x2, gold, 5.84MH, Through Hole, vertical	Multicomp Inc.	SPC20481
1	L1	Inductor, 6800 µH, 380 mA, 10%, SMD, L12.3W12.3H10, AEC-Q200	Coilcraft	MSS1210-685KEB
2	M2, M3	Transistor, FET, N-Channel, TN2510N8-G, 100V, 730 mA, 1.6W, SOT-89	Microchip Technology Inc.	<b>TN2510N8-G</b>
1	MOV1	Resistor, varistor, MO, 275V, 43J, disc, 10 mm	TDK Electronics (previously EPCOS)	B72210S0271K151
1	NTC1	Resistor, thermistor, NTC, 200R, 0.5A, 20%, RAD, P7.5L11W5.5	Canadian Thermostats & Control Devices Ltd.	MF72-200D9
1	PCB1	Printed Circuit Board	Microchip Technology Inc.	<b>04-10817-R2.2</b>
1	Q1	Transistor, FET, N-Chan., IPD50R500CEAU-MA1, 550V, 7.6A, 57W TO-252-3	Infineon Technologies AG	IPD50R500CEAUMA1
1	Q2	Transistor, FET, N-Chan., DN2470K4-G, 700V, 0.17A, 2.5W, TO-252-3	Microchip Technology Inc.	<b>DN2470K4-G</b>
4	R1, R2, R5, R6	Resistor, TKF, 15k, 1%, 1/8W, SMD, 0805	Yageo Corporation	RC0805FR-0715KL
1	R3	Resistor, CF, 18R, 2%, 1W, SMD, 0207	Vishay Beyschlag	CMB02070X1809GB200
2	R4, R22	Resistor, TKF, 4.7k, 5%, 1/10W, SMD, 0603	Panasonic	ERJ-3GEYJ472V
1	R7	Resistor, TKF, 4.7k, 1%, 1/16W, SMD, 0603	Multicomp Inc.	MC0063W060314K7
1	R8	Resistor, TKF, 100k, 1%, 1/8W, SMD 0805	Vishay Dale	CRCW0805100KFKEC
1	R9	Resistor, TKF, 100k, 1%, 1/10W, SMD, 0603	TE Connectivity	1622827-1
1	R10	Resistor, TKF, 1k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-071KL
1	R11	Resistor, TKF, 100R, 1%, 1/4W, SMD, 1206	Yageo Corporation	RC1206FR-07100RL
2	R12, R13	Resistor, TKF, 2R, 1%, 1/8W, SMD, 0805	Yageo Corporation	RC0805FR-072RL
1	R14	Resistor, TKF, 390k, 1%, 1/10W, SMD, 0603	Panasonic	ERJ-3EKF3903V
1	R15	Resistor, TKF, 12k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0712KL
2	R16, R17	Resistor, TKF, 2.1k, 1%, 1/10W, SMD, 0603	Panasonic	ERJ-3EKF2101V
0	R18	Resistor, TKF, 12k, 1%, 1/10W, SMD, 0603 - DO NOT POPULATE	Yageo Corporation	RC0603FR-0712KL
1	R19	Resistor, TKF, 27k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0727KL
1	R24	Resistor, TKF, 100R, 1%, 1/8W, SMD, 0805	Panasonic	ERJ-6ENF1000V
0	Shld1	Mechanical, hardware, board shield 0.65X0.65X0.142" AL Frame 2118707-4 - DO NOT POPULATE	TE Connectivity	2118707-4
2	SW1, SW2	Switch, Tact. Spst., 24V, 50 mA, 147873-1, SMD	TE Connectivity Alcoswitch	147873-1
1	TH1	Temp. sensor, RTD, 100 OHM, 0603	Vishay Beyschlag	PTS060301B100RP100
1	U1	Microchip Analog LED Driver, HV9961LG-G, SOIC-8	Microchip Technology Inc.	<b>HV9961LG-G</b>

**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.

**TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)**

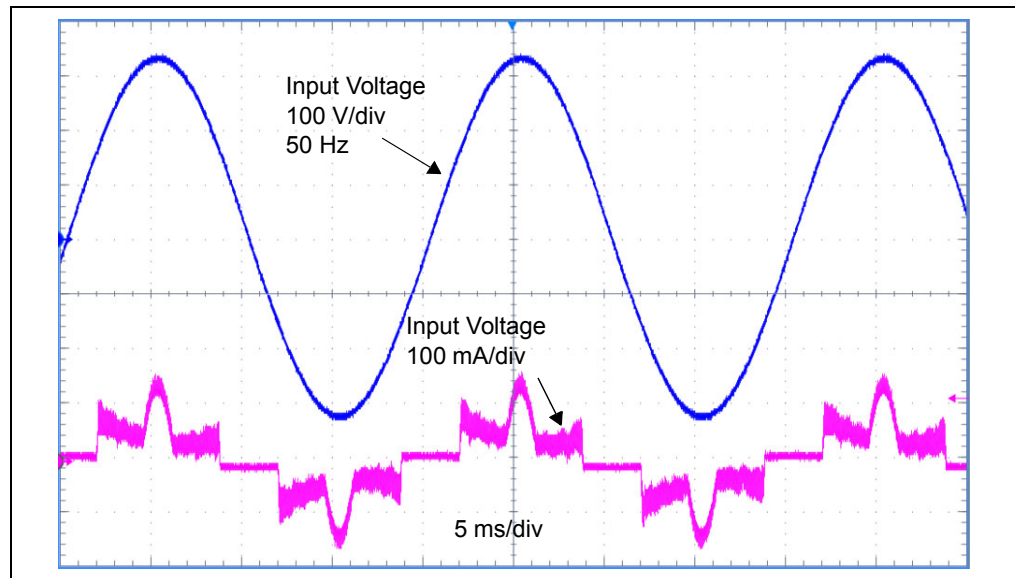
Qty.	Reference	Description	Manufacturer	Part Number
2	U2, U3	IC Photo, HCPL-181, 4-SMD	Broadcom®	HCPL-181-00CE
1	U4	Microchip RF Bluetooth, RN4871-V/RM118, Module -16	Microchip Technology Inc.	<b>RN4871-V/RM118</b>
1	U5	Microchip Analog LDO, 3.3V, MCP1703AT-5002E/CB, SOT-23A-3	Microchip Technology Inc.	<b>MCP1703AT-3302E/CB</b>
1	U6	Microchip MCU, 8-bit, 32 MHz, 3.5 kB, PIC16F15313T-I/SN, SOIC-8	Microchip Technology Inc.	<b>PIC16F15313T-I/SN</b>
1	U7	Microchip Interface, USB, I2C/UART, MCP2221A-I/ML, QFN-16	Microchip Technology Inc.	<b>MCP2221A-I/ML</b>
1	U8	Microchip Analog Voltage Detector, 1.9V, MCP112T-195I/TT, SOT-23-3	Microchip Technology Inc.	<b>MCP112T-195I/TT</b>
3	Z1, Z2, Z3	Diode Zener, MMSZ7V5T1G, 7.5V, 500 mW, SMD, SOD-123	Rochester Electronics, LLC	MMSZ7V5T1G

**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.

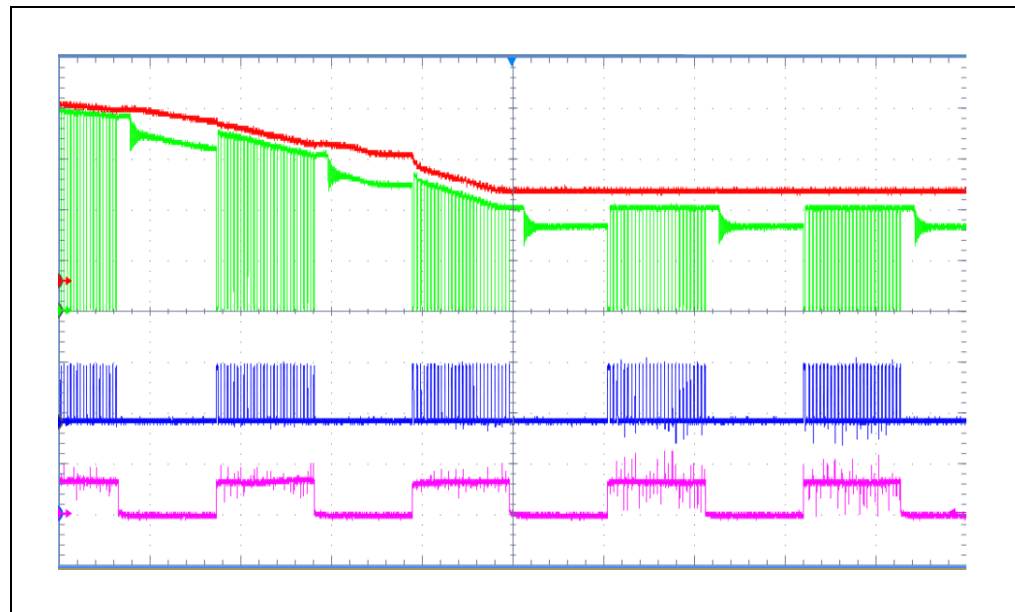
**NOTES:**

## Appendix C. Waveforms

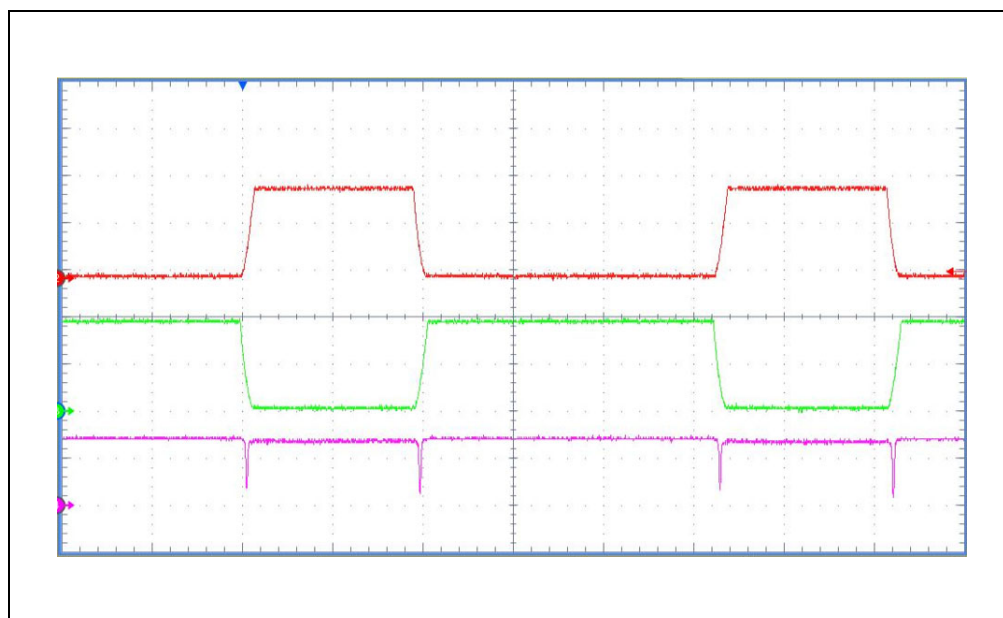
### C.1 BLUETOOTH WHITE-COLOR-MIX LED DRIVER BOARD TEST WAVEFORM EXAMPLES



**FIGURE C-1:** *Input Voltage and Input Current.*



**FIGURE C-2:** *LED Driver's Switching Node Waveforms with PWM Dimming to 50%.*



**FIGURE C-3:** LED Driver Output Current with 40-60% Switching Ratio Between Warm-Cool Color.



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