



LED Flashlight User's Guide

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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.

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 preface contains general information that will be useful to know before using the LED Flashlight. Topics discussed in this preface include:

- [Document Layout](#)
- [Conventions Used in this Guide](#)
- [Warranty Registration](#)
- [Recommended Reading](#)
- [The Microchip Web Site](#)
- [Development Systems Customer Change Notification Service](#)
- [Customer Support](#)

DOCUMENT LAYOUT

This user's guide provides an overview of the LED Flashlight customer engagement board. The document is organized as follows:

- **Chapter 1. "Introduction to LED Flashlight"** – This chapter introduces the LED Flashlight and provides a brief overview of its features.
- **Chapter 2. "Hardware"** – This chapter describes the board layout and the main components of the LED Flashlight.
- **Chapter 3. "Demonstration Application on LED Flashlight"** – This chapter describes the demonstration software that is preloaded on the device that accompanies the LED Flashlight.
- **Appendix A. "InvenSense (ICM-20648) Information"** – This appendix provides a brief introduction about ICM-20648 and a link to access more information about the product.
- **Appendix B. "Board Schematics and Bill of Materials"** – This appendix provides a schematic of the board and a table which details the bill of materials.

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CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	<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>Save</i></u>
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	<i>file.o</i> , where <i>file</i> can be any valid filename
Square brackets []	Optional arguments	mcc18 [options] <i>file</i> [options]
Curly braces 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

PIC32MM0064GPL028 data sheet

To obtain the document, visit the Microchip web site at www.microchip.com.

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- **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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The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers and other language tools. These include the MPLAB[®] XC compiler; MPASM[™] and MPLAB 16-bit assemblers; MPLINK[™] and MPLAB 16-bit object linkers; and MPLIB[™] and MPLAB 16-bit object librarians.
- **Emulators** – The latest information on the Microchip MPLAB REAL ICE[™] in-circuit emulator.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debugger, MPLAB ICD 3.
- **MPLAB X IDE** – The latest information on Microchip MPLAB X IDE, the Windows[®] Integrated Development Environment for development systems tools. This list is focused on the MPLAB X IDE, MPLAB SIM simulator, MPLAB X IDE project manager, and general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include the MPLAB PM3 device programmer and the PICkit[™] 3 development programmer.

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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 web site at: <http://support.microchip.com>.

Chapter 1. Introduction to LED Flashlight

1.1 OVERVIEW

The LED Flashlight is a customer engagement board, intended to demonstrate the on-chip peripheral features of PIC32 MM GPL Family of eXtreme Low Power (XLP), Low Cost, 32-bit microcontrollers.

The LED Flashlight demo intends to showcase Analog, MCCP/SCCP, CLC, SPI and XLP features of PIC32MM0064GPL028 microcontrollers.

For more information refer to:

<http://www.microchip.com/wwwproducts/en/PIC32MM0064GPL028#documents>

1.2 FEATURES

1.2.1 Analog

- Analog to Digital Converter with 12-bit, 200K samples/second conversion rate (single Sample-and-Hold)

1.2.2 Digital

- 4-Wire SPI modules (up to 25 MHz) with I²S
- Timer1: Dedicated 16-bit timer/counter
- Multiple Output (MCCP) module
- Single Output (SCCP) modules
- Configurable Logic Cells (CLC) with internal connections to select peripherals and PPS

1.3 APPLICATION DEMO MODES

User can navigate to the following application demo modes either using Switch (SW1) or by InvenSense motion detection:

Mode 0: LED ON (Full Brightness)

Mode 1: LED Dimming (30% Brightness)

Mode 2: LED Blinking

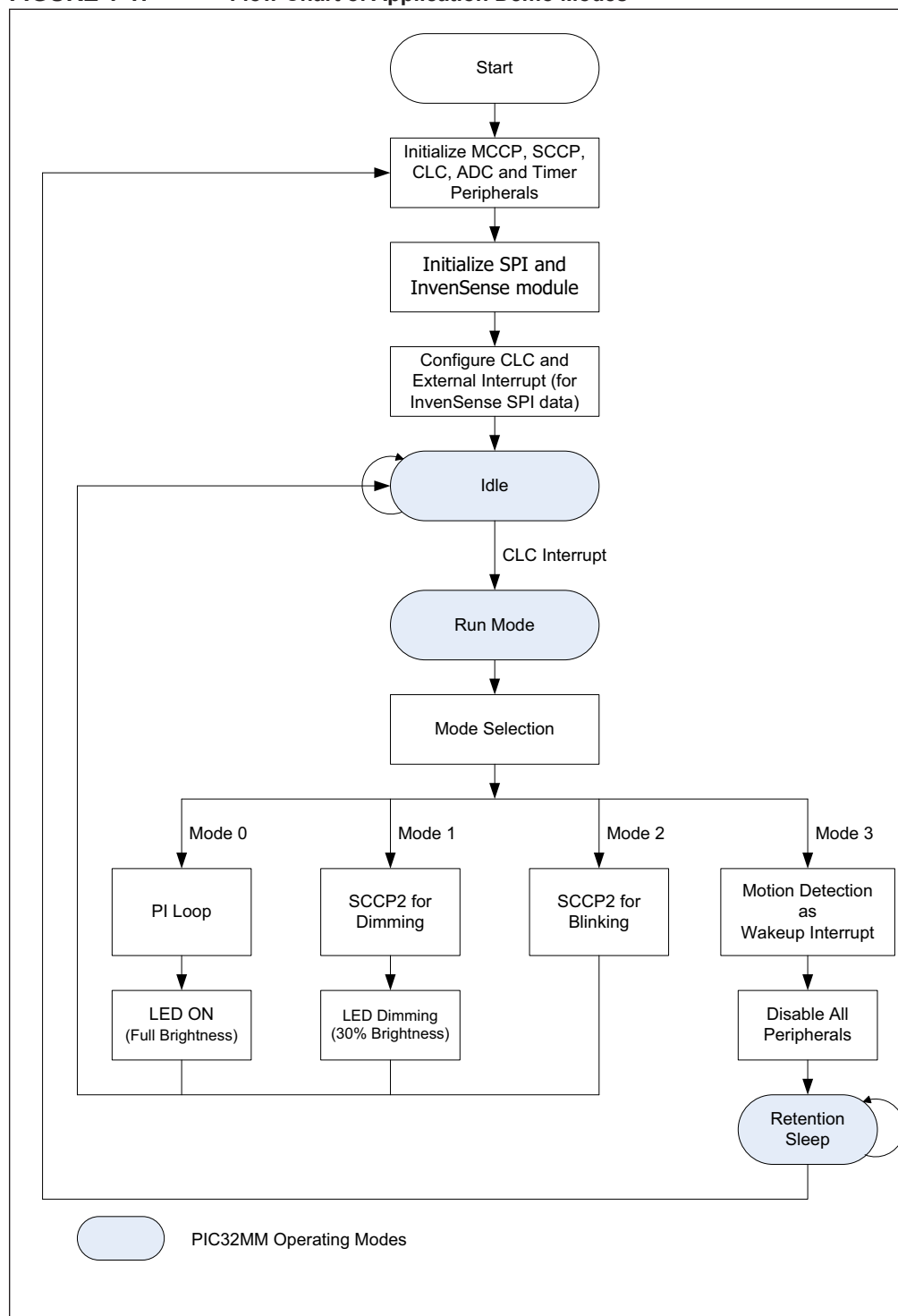
Mode 3: Retention Sleep

Demo supports a couple of PIC32MM power saving modes (Idle and Retention Sleep):

- Idle mode:
 - CPU is OFF
 - All peripherals are ON
 - LEDs are ON
- Retention Sleep mode:
 - CPU and peripherals are OFF
 - LEDs are OFF
- Run mode:
 - CPU and peripherals are ON
 - LEDs are ON

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FIGURE 1-1: Flow Chart of Application Demo Modes



Chapter 2. Hardware

Figure 2-1 and Figure 2-2 identify the major components of the hardware.

Figure 2-1: LED Flashlight Hardware - Front View

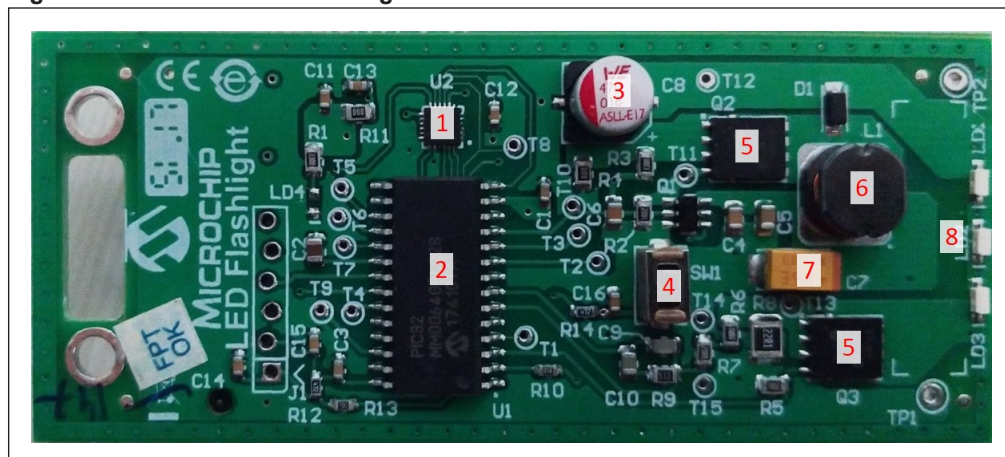


Figure 2-2: LED Flashlight Hardware - Back View

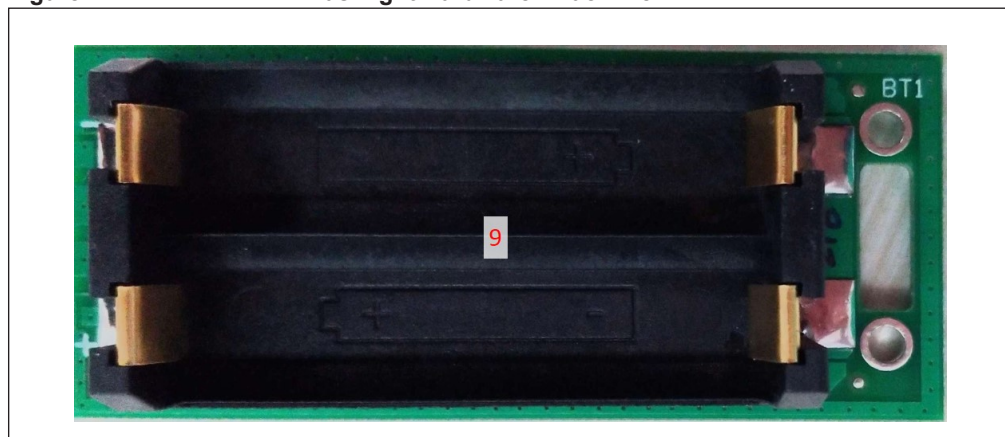


TABLE 2-1: LED FLASHLIGHT HARDWARE COMPONENTS

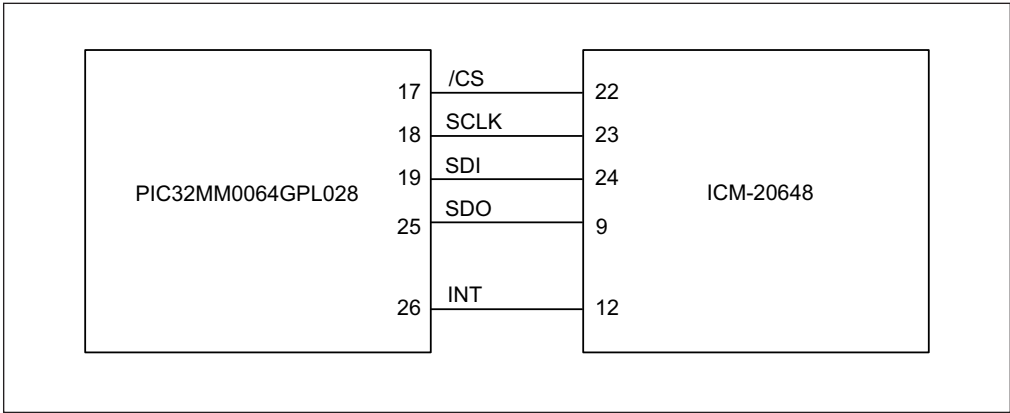
Number	Description
1	InvenSense ICM-20648 Motion Sensor
2	Microchip PIC32MM0064GPL028 MCU
3	Aluminum Electrolytic Capacitor
4	Tactile Switch SPST
5	Microchip MCP87130T-U/MFCT-ND N-Channel MOSFET
6	Inductor
7	Tantalum Capacitor
8	White LED
9	AA Battery Holder

2.1 InvenSense ICM-20648 MOTION-TRACKING SENSOR

The PIC32MM0064GPL028 microcontroller is interfaced with an InvenSense ICM-20648 motion-tracking sensor. The sensor contains an accelerometer along with other sensors. The microcontroller communicates with the sensor over an SPI. The interrupt pin of the sensor is connected to an external interrupt pin on the microcontroller.

The Motion Tracking Sensor is configured to generate a pulse when it is shaken. This pulse generates an interrupt in the microcontroller, it can be used by the application to determine when the board is shaken.

FIGURE 2-3: HARDWARE CONNECTIONS BETWEEN MCU AND SENSOR



Chapter 3. Demonstration Application on LED Flashlight

This chapter provides an overview of the LED Flashlight and describes the preprogrammed demo application. The topics covered are:

- Startup
- Sections of the Demo

3.1 STARTUP

On power-up, the device enters Mode 0 and the LEDs are turned “ON” with full brightness.

3.2 SECTIONS OF THE DEMO

The demo application is divided into several user interface sections, each section demonstrates a unique function/feature of the microcontroller peripherals. Different application modes can be accessed by using the “motion sense” feature of the InvenSense module (ICM-20648). When the board is quickly shaken up and down twice, it is considered as one “motion”.

The available modes are as follows:

Mode 0: LED ON (Full Brightness)

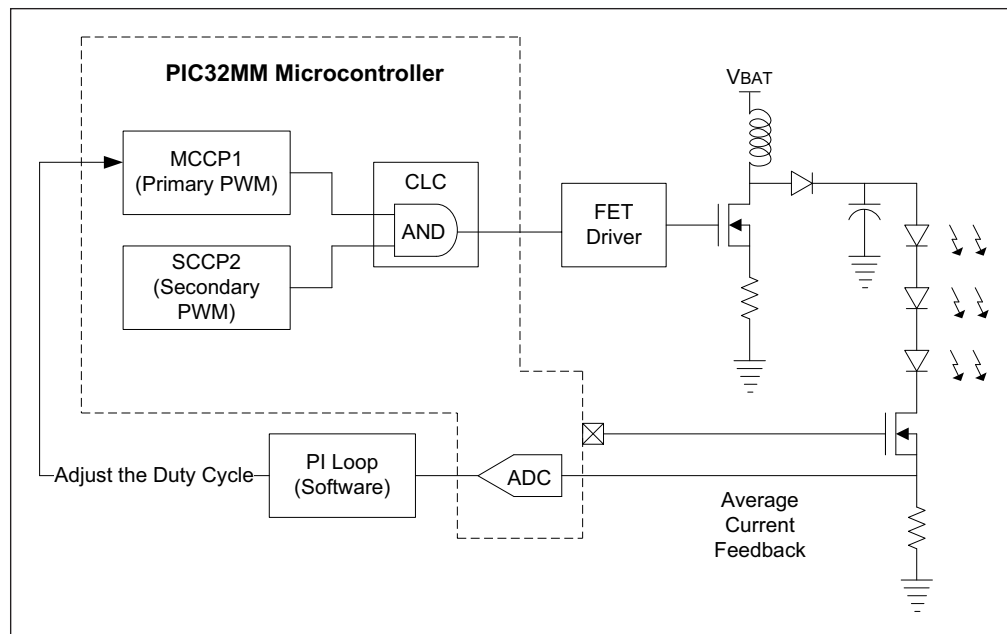
Mode 1: LED Dimming (30% Brightness)

Mode 2: LED Blinking

Mode 3: Retention Sleep

Figure 3-1 shows the LED control block diagram.

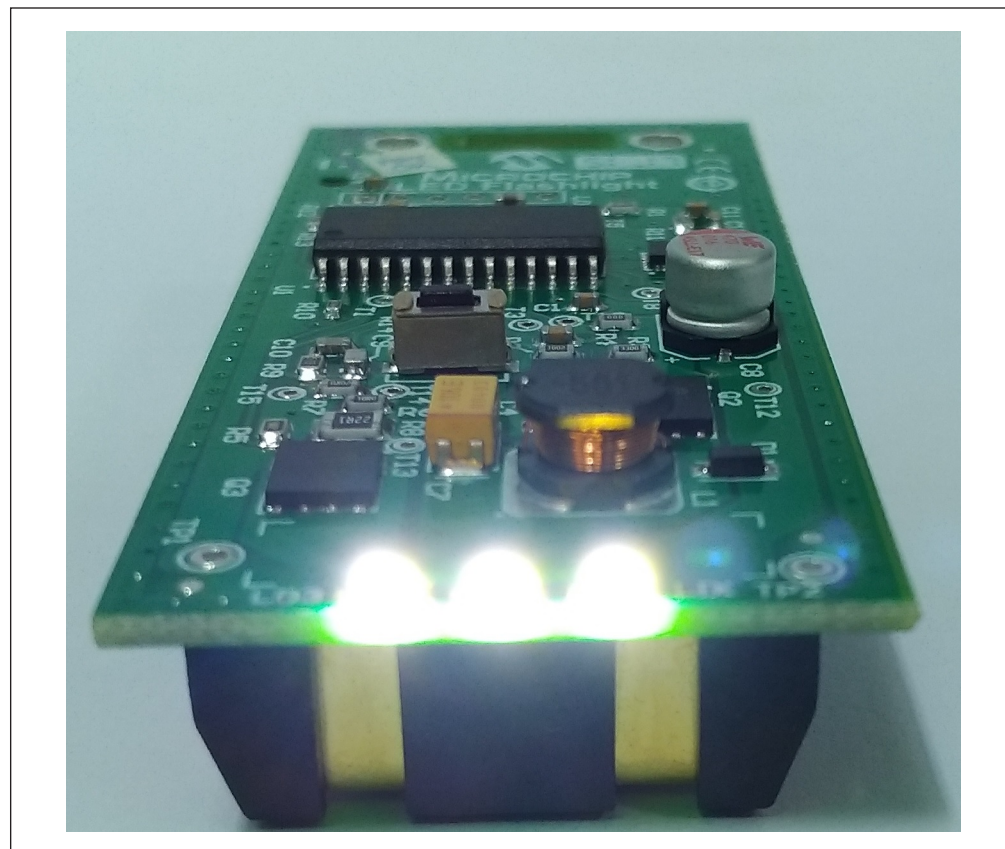
FIGURE 3-1: LED CONTROL BLOCK DIAGRAM



3.2.1 Mode 0 - LED Full Brightness

In Mode 0, LEDs are ON with full brightness. M CCP1 module is used as a Primary PWM. Software PI loop uses the “Average current feedback” to maintain the constant load current. This is done by adjusting the duty cycle of the primary PWM (refer to [Figure 3-1](#)).

FIGURE 3-2: LEDS TURNED “ON” WITH FULL BRIGHTNESS



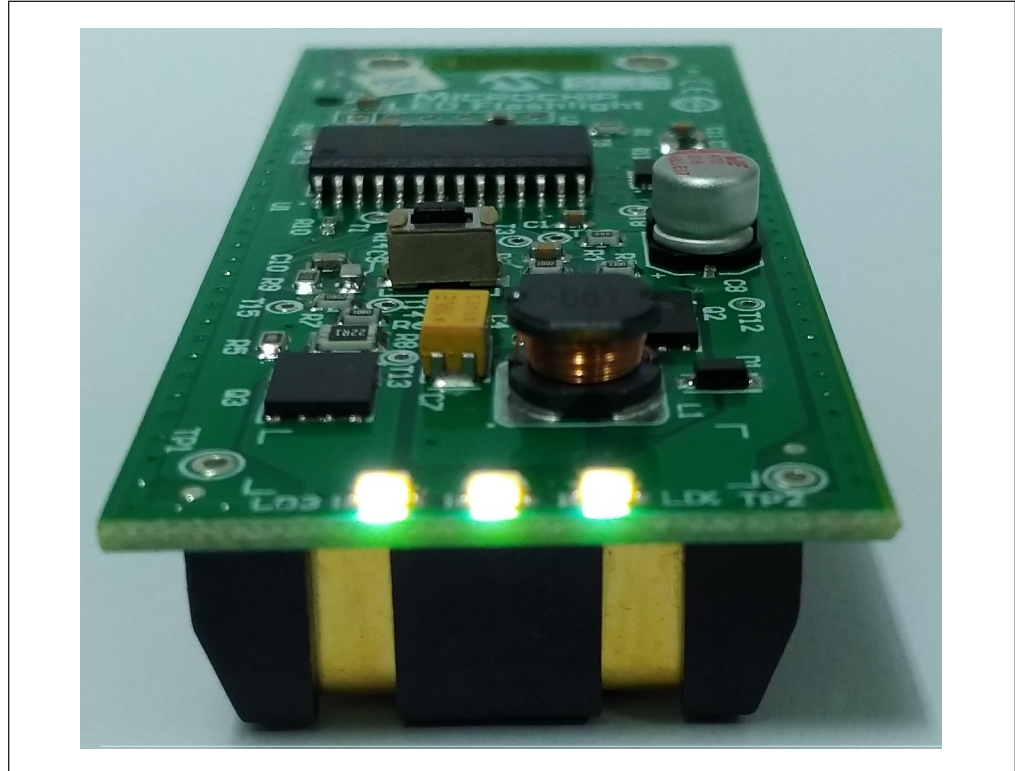
3.2.2 Mode 1 - LED Dimming

In Mode 1 the brightness of the LEDs is reduced to 30%. S CCP2 module which acts as a Secondary PWM or override enable, generates the dimming frequency. Primary PWM and dimming PWM are “AND”ed by the CLC module (refer to [Figure 3-1](#)).

Advantages of LED Digital Dimming are:

- Switches LED current ON and OFF for a short period of time
- Provides constant current while maintaining the brightness
- Reduces heat
- Increases LED life
- Facilitates core-independent operation

FIGURE 3-3: LEDS DIMMED TO 30% BRIGHTNESS



3.2.3 Mode 2 - LED Blinking

In Mode 2, LEDs blink at the rate of 1 Hz. The SCCP2 module acts as a secondary PWM and generates the 1 Hz signal. Primary PWM and secondary/dimming PWM are “AND”ed by the CLC module (refer to [Figure 3-1](#)).

3.2.4 Mode 3 - Retention Sleep

Mode 3 is the lowest power consumption/power saving mode of the PIC32MM device in which the device switches to Retention Sleep mode. On detecting a “motion” the device wakes up and enters Mode 0 (refer to [Figure 1-1](#)).

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Chapter 4. Memory Usage

Memory usage of the device is shown in [Table 4-1](#).

TABLE 4-1: MEMORY USAGE

Memory	Size (Bytes)	Used (%)
Program Memory	65536	22
Data Memory	8192	6

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Appendix A. InvenSense (ICM-20648) Information

ICM-20648 is a 6-axis motion-tracking device that is ideally suited for Smartphones, Tablets, Wearable Sensors, and general IoT applications. ICM-20648 supports I²C and high speed SPI interfaces. In the demo, an SPI interface is being used. For more information about the ICM module, refer to:

<https://www.invensense.com/products/motion-tracking/6-axis/icm-20648/>

Figure A-1: ICM-20648



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Appendix B. Board Schematics and Bill of Materials

This chapter provides Board Schematics (refer to [Figure B-1](#)) and Bill of Materials (refer to [Table B-1](#)) of the hardware.

FIGURE B-1: BOARD SCHEMATICS

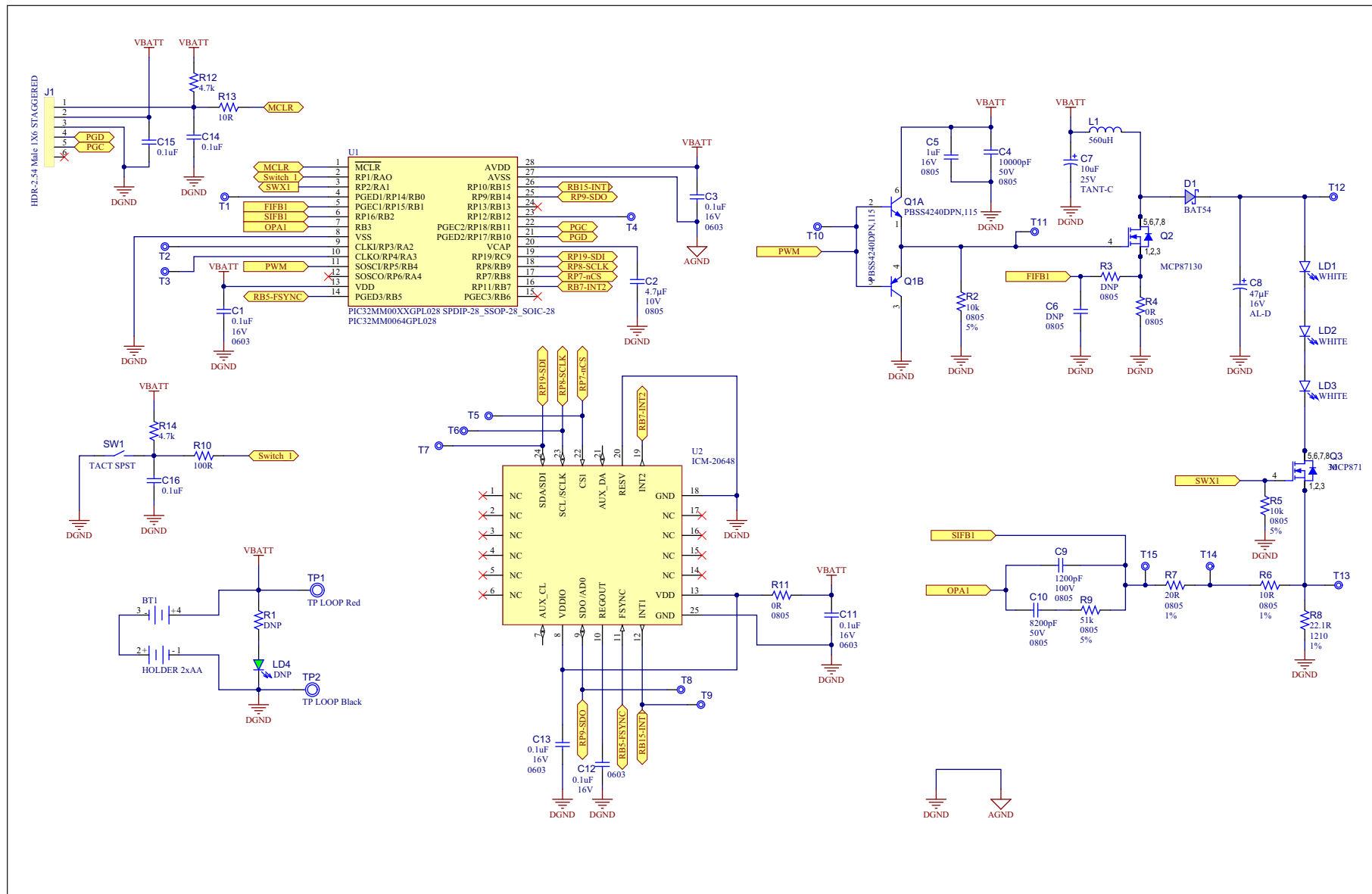


TABLE B-1: BILL OF MATERIALS

Qty.	Designator	Description_	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1
1	BT1	BATT Holder 2 SMD AA	Keystone Electronics	1012	Digi-Key	1012K-ND
1	D1	DIO SCTKY BAT54 900 mV 300 mA 40V SOD-123	STMicroelectronics	BAT54ZFILM	Digi-Key	497-5562-1-ND
1	J1	CON HDR-2.54 Male 1x6 Stag- gered DNP	Sullins Connector Solu- tions	PBC06SAAN	Digi-Key	S1011E-06-ND
1	LABEL1	Label, ASSY W/REV Level (Small Modules) PER MTS-0002			Dev Tools	
1	U2	SENOR ACCEL/GYRO/TEMP ICM-20648 SMD QFN	TDK InvenSense	ICM-20648	Digi-Key	1428-1061-1-ND
1	U1	MCHP MCU 32-BIT 25 MHz 64 kB 8 kB PIC32MM0064GPL028-I/SO SOIC-28	Microchip Technology Inc	PIC32MM0064GPL028-I/ SO	Microchip Technology Inc	PIC32MM0064GPL028-I/SO
8	C1, C3, C11, C12, C13, C14, C15, C16	CAP CER 0.1 μ F 16V 10% X7R SMD 0603	Wurth Electronics Inc.	885012206046	Digi-Key	732-7965-1-ND
1	C10	CAP CER 8200 pF 50V 10% X7R SMD 0805	Murata Electronics North America	GRM216R71H822KA01D	Digi-Key	490-11579-1-ND
1	C2	CAP CER 4.7 μ F 10V 10% X7R SMD 0805	Wurth Electronics Inc.	885012207025	Digi-Key	732-7657-1-ND
1	C4	CAP CER 10000 pF 50V 10% X7R 0805	Wurth Electronics Inc.	885012207092	Digi-Key	732-8074-1-ND
1	C5	CAP CER 1uF 16V 10% X7R SMD 0805	Wurth Electronics Inc.	885012207051	Digi-Key	732-7664-1-ND
1	C6	CAP CER 330 pF 16V 10% X7R SMD 0805	Wurth Electronics Inc.	885012207030	Digi-Key	732-8030-1-ND
1	C7	CAP TANT 10 μ F 25V 10% 1.5 Ohm SMD C	KEMET	T491C106K025AT	Digi-Key	399-3734-1-ND
1	C8	CAP ALU 47 μ F 16V 20% SMD D	Wurth Electronics Inc.	865060343004	Digi-Key	732-8521-1-ND
1	C9	CAP CER 1200 pF 100V 5% NP0 SMD 0805	Murata Electronics North America	GRM2195C2A122JA01D	Digi-Key	490-3313-1-ND
1	L1	Inductor 560 μ H 410 mA 10% SMD L7.8W7H5.5	Wurth Electronics Inc.	768775256	Digi-Key	732-3952-2-ND

TABLE B-1: BILL OF MATERIALS

Qty.	Designator	Description_	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1
3	LD1, LD2, LD3	DIO LED White 3.2V 20 mA 315 mcd Clear SMD L3W1.2H1.20	OSRAM Opto Semicon- ductors Inc.	LW Y87C-S1T2-3K8L-Z	Digi-Key	475-1173-1-ND
1	LD4	DIO LED Green 3.2V 20 mA 430 mcd Clear SMD 0603	Würth Electronics Inc.	150060GS75000	Digi-Key	732-4971-1-ND
2	R1, R3	RES TKF 330R 1% 1/8W SMD 0805	ROHM	MCR10EZHF3300	Digi-Key	RHM330CCT-ND
1	R10	RES TKF 100R 5% 1/10W SMD 0603	Vishay	CRCW0603100RJNEA	Digi-Key	541-100GCT-ND
2	R12, R14	RES TKF 4.7k 5% 1/10W SMD 0603	Panasonic	ERJ-3GEYJ472V	Digi-Key	P4.7KGCT-ND
1	R13	RES TKF 10R 5% 1/10W SMD 0603	Panasonic	ERJ-3GEYJ100V	Digi-Key	P10GCT-ND
2	R2, R5	RES TKF 10k 5% 1/8W SMD 0805	Panasonic	ERJ-6GEYJ103V	Digi-Key	P10KACT-ND
2	R4, R11	RES TKF 0R 1/8W SMD 0805	Panasonic	ERJ-6GEY0R00V	Digi-Key	P0.0ACT-ND
1	R6	RES TKF 10R 1% 1/8W SMD 0805	ROHM	MCR10EZHF10R0	Digi-Key	RHM10.0CCT-ND
1	R7	RES TKF 20R 1% 1/8W SMD 0805	ROHM	MCR10EZHF20R0	Digi-Key	RHM20.0CCT-ND
1	R8	RES SMD 22.1 Ohm 1% 1/2W 1210	Stackpole Electronics Inc.	RMCF1210FT22R1	Digi-Key	RMCF1210FT22R1CT-ND
1	R9	RES TKF 51k 5% 1/8W SMD 0805	Panasonic	ERJ-6GEYJ513V	Digi-Key	P51KACT-ND
1	SW1	Switch TACT SPST 24V 50 mA KSR231GLFS SMD 6X3.5 mm	TE Connectivity Alcoswitch Switches	147873-2	Digi-Key	450-2049-1-ND
1	TP1	Misc, Test Point Multipurpose Mini Red	Keystone	5000	Digi-Key	36-5000-ND
1	TP2	Misc, Test Point Multipurpose Mini Black	Keystone	5001	Digi-Key	36-5001-ND
1	Q1	Trans BJT Dual PNP/NPN PBSS4240DPN,115 40V 1.1A 1.1W SOT-23-6	NXP Semiconductors	PBSS4240DPN,115	Digi-Key	568-4349-1-ND
2	Q2, Q3	MCHP Analog MOSFET N-CH 25V 43A MCP87130T-U/MF PDFN-8	Microchip Technology	MCP87130T-U/MF	Digi-Key	MCP87130T-U/MFCT-ND

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Japan - Osaka
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Japan - Tokyo
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Taiwan - Hsin Chu
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