



MCP1252 Charge Pump Backlight LED Demo Board User's Guide

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MCP1252 CHARGE PUMP BACKLIGHT LED DEMO BOARD 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.

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 “DSXXXXA”, where “XXXX” 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 MCP1252 Charge Pump Backlight LED Demo 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 MCP1252 Charge Pump Backlight LED Demo Board. The manual layout is as follows:

- **Chapter 1. “Product Overview”** – Important information about the MCP1252 Charge Pump Backlight LED Demo 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 MCP1252 Charge Pump Backlight LED Demo Board.
- **Appendix B. “Bill-Of-Materials (BOM)”** – Lists the parts used to build the MCP1252 Charge Pump Backlight LED Demo Board.
- **Appendix C. “00016R1.asm Source Code”** – Provides information about the application firmware and where the source code can be found.

MCP1252 Charge Pump Backlight LED Demo Board User's Guide

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>File>Save</u>
Bold characters	A dialog button	Click OK
	A tab	Click the Power tab
'bnnnn'	A binary number where <i>n</i> is a digit	'b00100, 'b10
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier font:		
Plain Courier	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
Italic Courier	A variable argument	<i>file.o</i> , where <i>file</i> can be any valid filename
0xnnnnn	A hexadecimal number where <i>n</i> is a hexadecimal digit	0xFFFF, 0x007A
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 MCP1252 Charge Pump Backlight LED Demo Board. The following Microchip documents are available and recommended as supplemental reference resources.

MCP1252/3 Data Sheet, "Low Noise, Positive Regulated Charge Pump", (DS21752)

This data sheet provides detailed information regarding the MCP1252/3 product family.

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site 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

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Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support
- Development Systems Information Line

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>

In addition, there is a Development Systems Information Line which lists the latest versions of Microchip's development systems software products. This line also provides information on how customers can receive currently available upgrade kits.

The Development Systems Information Line numbers are:

1-800-755-2345 – United States and most of Canada

1-480-792-7302 – Other International Locations

DOCUMENT REVISION HISTORY

Revision A (May 2005)

- Initial Release of this Document.

MCP1252 Charge Pump Backlight LED Demo Board User's Guide

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

Today's new color displays require a pure white light for backlighting. White light-emitting diodes have become the component of choice. The MCP1252-ADJ is an excellent choice for biasing the backlighting or driving other LED applications. Light intensity is controlled uniformly through the use of ballast resistors. The peak intensity is set by the feedback (FB) to the MCP1252-ADJ. Dimming is accomplished by pulse-width modulating the shutdown pin of the device.

This chapter covers the following topics:

- What is the MCP1252 Charge Pump Backlight LED Demo Board?
- What the MCP1252 Charge Pump Backlight LED Demo Board Kit Includes

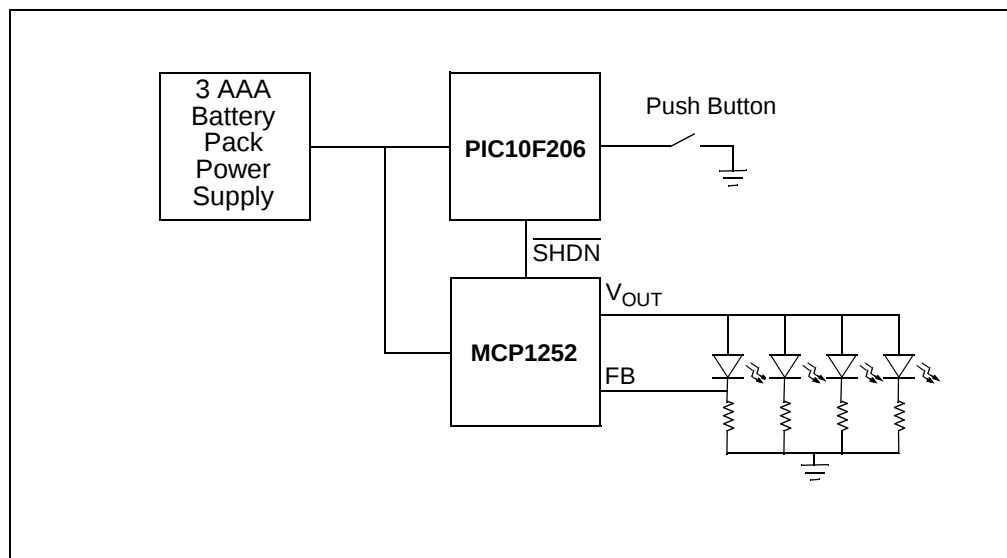


FIGURE 1-1: MCP1252 Charge Pump Backlight LED Demo Board Block Diagram.

1.2 WHAT IS THE MCP1252 CHARGE PUMP BACKLIGHT LED DEMO BOARD?

The MCP1252 Charge Pump Backlight LED Demo Board demonstrates the use of a charge pump device in a LED application. The board also serves as a platform to evaluate the MCP1252 device generally.

The MCP1252-ADJ device used in this application is an inductorless, positive-regulated charge pump DC/DC converter. The device generates an adjustable output voltage. It is specifically designed for applications requiring low noise and high efficiency, and is able to deliver up to 120 mA output current. In addition, a charge pump is a low-cost, compact and simple solution for an application, as it only requires one external capacitor to transfer charge from the input supply to the regulated output.

The MCP1252 allows the input voltage to be lower or higher than the the output voltage by automatically switching between buck and boost operation. This makes it especially suited for battery applications, allowing the system voltage to be maintained even after the batteries have discharged below the system voltage level, further extending the overall charge life of the battery.

1.3 WHAT THE MCP1252 CHARGE PUMP BACKLIGHT LED DEMO BOARD KIT INCLUDES

This MCP1252 Charge Pump Backlight LED Demo Board kit includes:

- MCP1252 Charge Pump Backlight LED Demo Board (102-00016)
- MCP1252 Charge Pump Backlight LED Demo Board User's Guide (DS51551)



MCP1252 CHARGE PUMP BACKLIGHT LED DEMO BOARD USER'S GUIDE

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MCP1252 Charge Pump Backlight LED Demo Board uses the MCP1252-ADJ to power four white LEDs. A PIC10F206 microcontroller in a SOT23 package is used to provide an enable signal to the MCP1252. It also accepts a push button input that allows the user to adjust the white LEDs to five different light intensities, in addition to placing the system in a standby mode that consumes less than 1 μA of current (typ.).

The PIC10F206 microcontroller is programmable, allowing the user to modify or develop their own firmware routines to further evaluate the MCP1252 in this application.

2.2 FEATURES

The MCP1252 Charge Pump Backlight LED Demo Board has the following features:

- Programmed MCP1252 charge pump control (via the PIC10F206)
- Four white LEDs
- PIC10F206 microcontroller
 - Enables the MCP1252 charge pump
 - Controls light intensity
 - Places system into Sleep mode ($< 1 \mu\text{A}$)
- Push button interface for multiple control options
- Baseline Flash Microcontroller Programmer (BFMP) Header for reprogramming the PIC10F206
- 3 AAA battery pack (batteries not included)

2.3 GETTING STARTED

The MCP1252 Charge Pump Backlight LED Demo Board comes fully assembled and tested. The board requires 3 AAA batteries as a power source for the application.

2.3.1 Powering the MCP1252 Charge Pump Backlight LED Demo Board

Insert three AAA batteries into the battery pack on the bottom of the board. As soon as the system powers up, the internal program of the PIC10F206 will initialize and remain in a low-power sleep mode ($<1\ \mu\text{A}$) until the S1 button is pressed by the user.

The MCP1252 Charge Pump Backlight LED Demo Board does not need a power switch or power jumper because of the “standby” or “sleep” mode of the PIC10F206 microcontroller. Upon entering Sleep mode, the system requires less than $1\ \mu\text{A}$ (typ) of current. So, with three AAA batteries used in the application (at 1250 mAh per battery), the system's power requirements in Sleep mode are minimal (the “shelf life” of an alkaline battery is 5-7 years, whereas the system current load in Sleep mode would discharge the battery pack in about 400 years!).

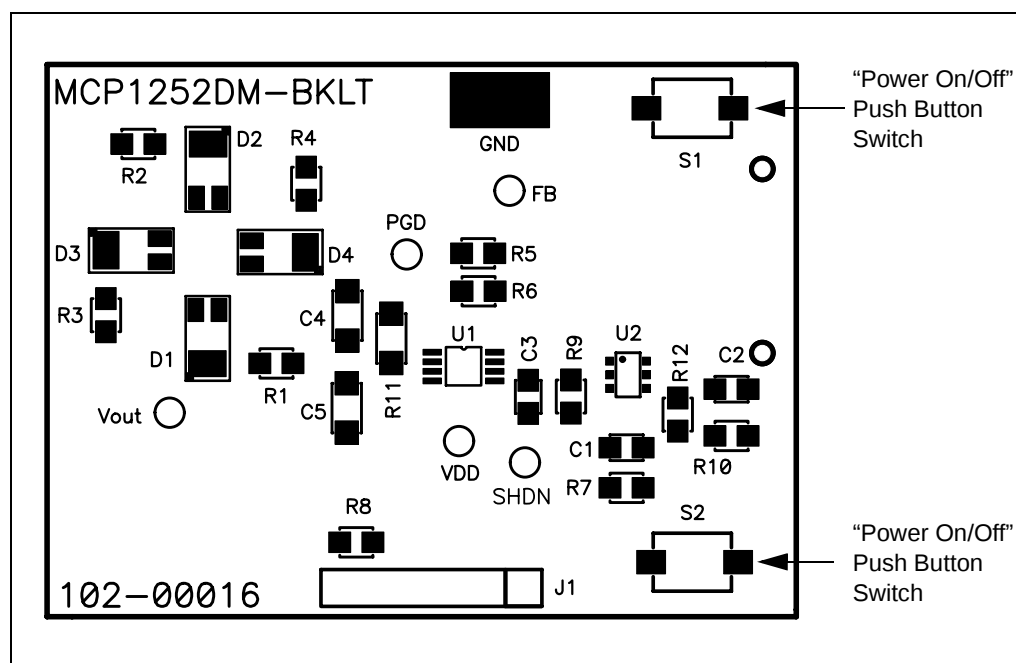


FIGURE 2-1: Setup Configuration Diagram.

Activating Application and Changing the LED intensity

1. To activate the LEDs, simply press the S1 push button. The LEDs will turn on at a low intensity level when the push button is pressed, gaining intensity when the push button is pressed again. There are 5 levels of LED intensity (plus the “off” state).

The intensity of the LEDs are controlled via the $\overline{\text{SHDN}}$ input pin of the MCP1252. A Pulse-Width Modulated (PWM) signal is generated by the PIC10F206 and routed to the SHDN input pin of the MCP1252. The MCP1252 is actually pulsed, and the duty cycle of the PWM waveform is varied, such that narrow pulses create a low-intensity condition, while wider pulses create a high-intensity condition.

2. The LEDs will be turned off, and the system will enter Sleep mode, when the LEDs are in the high-intensity state and the push button is pressed. Subsequent push button presses will cycle the LEDs as described in Step 1.

Evaluating the Application

The best way to evaluate the MCP1252 Charge Pump Backlight LED Demo Board is to dig into the circuit. Measure voltages and currents with a DVM and probe the board with an oscilloscope. Test points have been provided to simplify this task. The test points correspond to the pins of the MCP1252: PGD (= PGOOD), Vout, V_{DD} (= V_{IN}), GND, SHDN and FB.

The firmware program in the PIC10F206 can also be edited to modify the operation of the application. For example, the output signal that is routed from GP0 of the PIC10F206 to SHDN of the MCP1252 can be changed to implement different light intensities, slowly blinking the LEDs on/off or provide some other pattern. There is also an optional push button (S2) that can be used to provide additional control options to the system

Firmware

The PIC10F206 comes preprogrammed with firmware to operate the system as described above. The program file can be found on the CD that comes with the kit. The file listing and firmware flow diagram are shown in **Appendix C. “00016R1.asm Source Code”**.

The program is fairly simple and straightforward. There is an initialization routine at the beginning of the program. The constants allow for five LED intensity levels to be adjusted to the appropriate light intensity (`LED_HI_ON`, `LED_MEDHI_ON`, etc.), set the PWM period (`PERIOD`) and maximum time (`MAX_TIME`) before the unit switches back to Sleep mode. The variables track what mode the unit is in (`MODE`), implement counters (`COUNTER`, `TIMERH`, `TIMERL`), etc.

Upon resetting the processor, the ports are initialized and registers are configured in the `INIT_PORTS` routine. If the device has come out of Sleep mode, the `MODE` variable is set so the LEDs will be at low intensity. The `OPTION` register is configured to wake-up on Port pin change. The GPIO port is configured to set GP0 (PWM to the MCP1252) as an output and GP1, GP2 and GP3 (push button) as inputs. The processor will reset on power-up or due to a wake-up from Sleep mode. Therefore, the `STATUS` register needs to be tested to determine the source of the reset. If the reset occurred due to powering up the system for the first time, the program proceeds to the `INIT_VARS` subroutine, where the program variables are initialized. If the reset occurred due to a wake-up from Sleep mode, the program proceeds to the `WAKE` subroutine.

The WAKE routine tests the GPIO push button input to determine if the button has been pressed. If it has, the program goes to the INC_MODE subroutine to set the new LED intensity mode. The INC_MODE and MODE_SELECT routines determine the appropriate light intensity when the device is reset, comes out of Sleep mode, or button S1 is pressed to increment the light intensity. The LED_FULL, LED_HIGH, LED_MEDHI, LED_MED, LED_LOW, and LED_OFF routines set one of six LED settings (five light intensity settings and "off").

Programming

Header JP1 is provided for in-system circuit programming. This is an optional feature since the demo board comes pre-programmed with F/W to operate the system. The PIC10F206 can be reprogrammed with the Baseline Flash Microcontroller Programmer (BFMP).

The BFMP is a simple and easy-to-use in-circuit serial programmer intended to be used with any of Microchip's new baseline Flash PIC[®] microcontrollers, specifically, the PIC10F200/202/204/206, PIC12F508/509, PIC16F505 and PIC16F54/57/59. The BFMP provides a 6-pin linear In-Circuit Serial Programming[™] (ICSP[™]) header for standard ICSP support, as well as stand-alone programming support for the PIC10F family when paired with the PIC10F2XX programmer adapter, providing the least expensive method of programming. The BFMP utilizes USB and does not require an external power supply. The included Graphical User Interface (GUI) allows you to read, write and verify the microcontroller to be programmed.

Please refer to Microchip's web site (www.microchip.com) for additional information on the BFMP.



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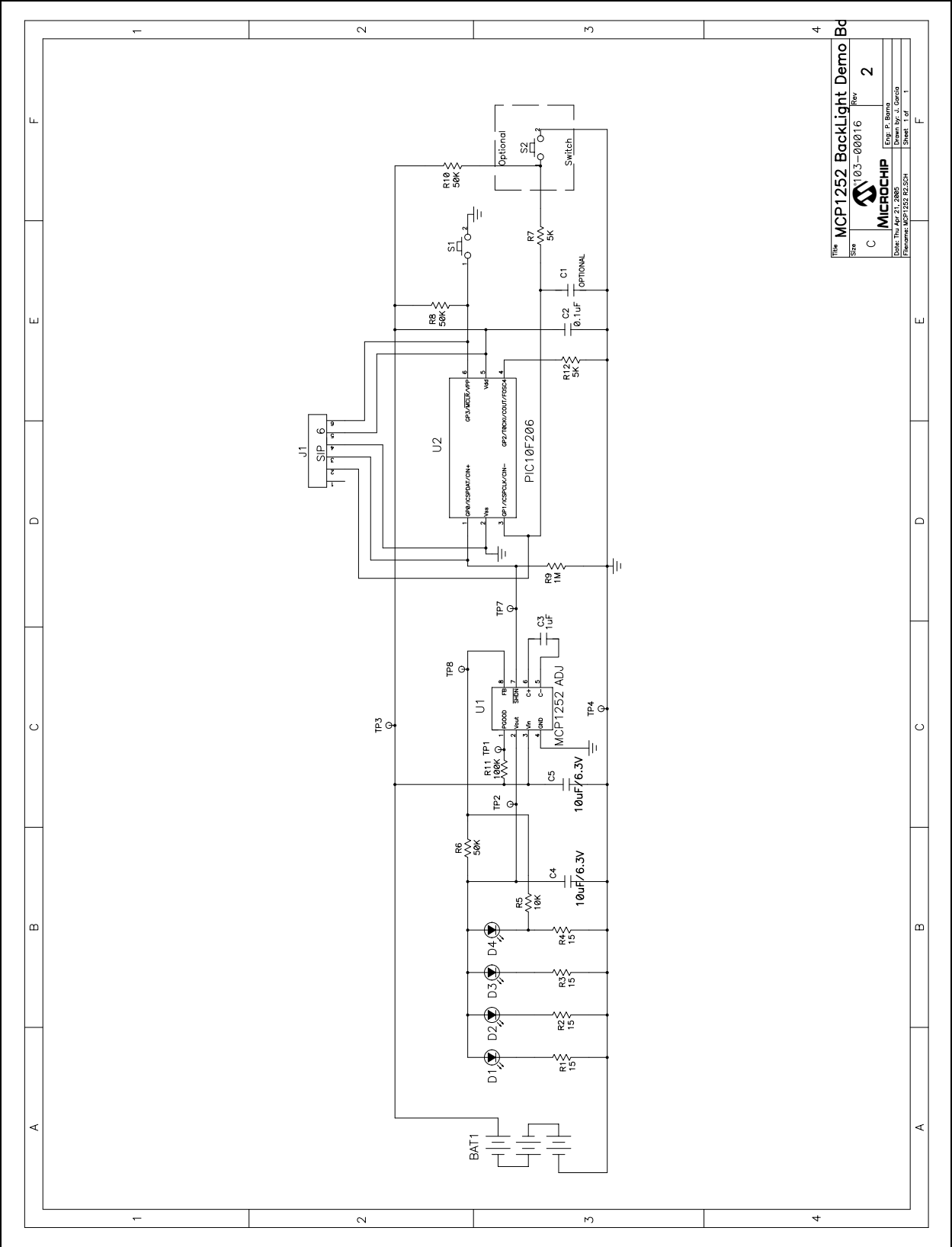
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the MCP1252 Charge Pump Backlight LED Demo Board:

- Board – Schematic
- Board – Top Assembly Drawing
- Board – Top Layer + Silk-Screen
- Board – Bottom Layer

A.2 BOARD – SCHEMATIC



A.3 BOARD – TOP ASSEMBLY DRAWING

A	B	C	D
---	---	---	---

REV

REV	DESCRIPTION	DATE
A	Initial Design	

NOTES:

MATERIAL:

FR-4, THICKNESS 0.062 COPPER 1 OZ – SIG LYRS

TWO LAYER BOARD

FINISH:

☒ SOLDERMASK OVER BARE COPPER(SMOBC) WITH HOT-AIR-LEVELED SOLDER
☐ SMOBC WITH SELECTIVE GOLD PLATING ON LANDS INDICATED. 10µi GOLD OVER 50–100µi NICKEL.
☐ 60/40 TIN-LEAD REFLOW

SOLDERMASK – DYNACHEM EPIC 200 LPI OR EQUIVALENT.

COLOR—Green High Gloss

SILKSCREEN – White

USE ARTWORK SET NO. 105–00016 **REV** 2

ANY ALTERNATIVES TO THE ABOVE SPECIFICATIONS MUST BE APPROVED BY THE ENGINEERING DEPARTMENT AT MICROCHIP.

THIS PCB TO BE MANUFACTURED TO MEET ALL ACCEPTANCE LEVELS OF A CLASS 2 PCB PER ANSI/IPC-A-600F.

ASSEMBLY NOTES:

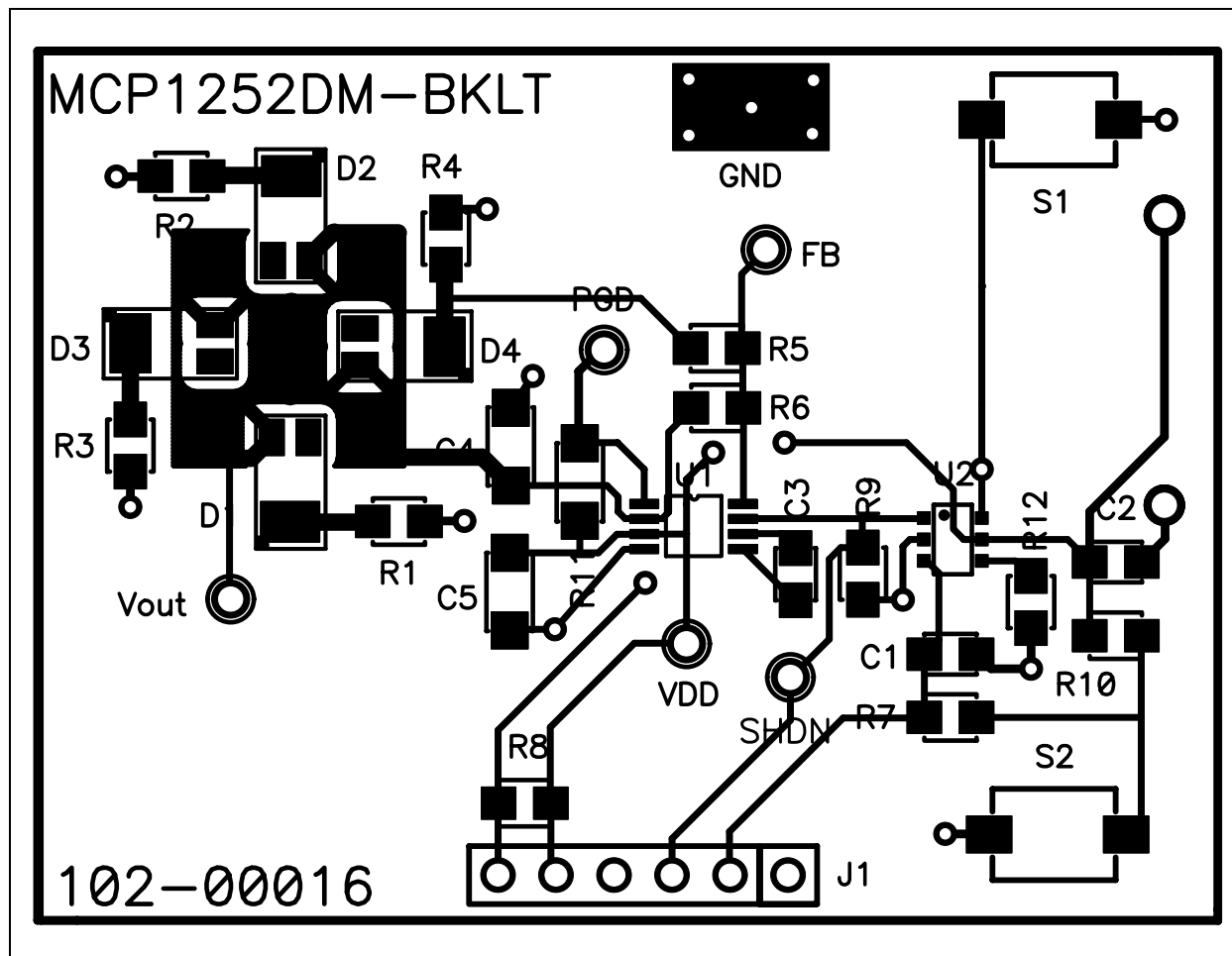
1. ALL UNUSED COMPONENTS SHALL BE FREE OF SOLDER
2. ALL COMPONENTS SHALL BE MOUNTED FLUSH TO THE BOARD, EXCEPT AS NOTED.
3. MAXIMUM COMPONENT HEIGHT NOT TO EXCEED: 0.148 TOP SIDE, 0.048 BOTTOM SIDE
4. FINISHED BOARD SHALL BE FREE OF ALL RESIDUES.
5. THESE COMPONENTS REQUIRE SOCKETS :
6. ALL LEADS SHALL BE TRIMMED TO A MAXIMUM HEIGHT OF 0.045

Hole Dia (inch)	Symbol	Quantity	Plated
0.016	+	19	Yes
0.035	X	6	Yes
0.042	Y	7	Yes

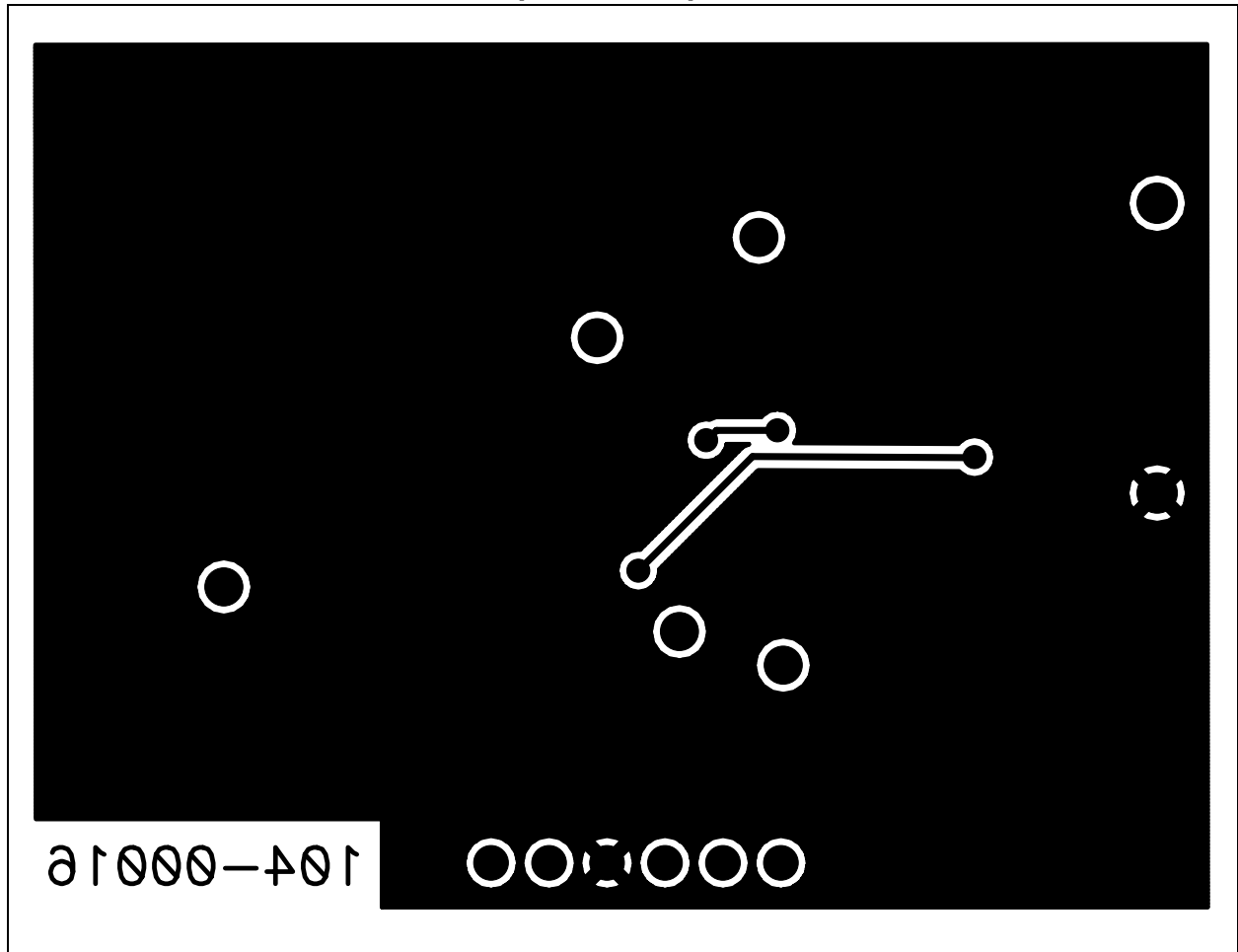
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A.4 BOARD – TOP LAYER + SILK-SCREEN



A.5 BOARD – BOTTOM LAYER (FROM TOP)



NOTES:



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Appendix B. Bill-Of-Materials (BOM)

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

QTY	Reference	Description	Manufacture	MFG PART #
1	C2	CAP .1UF 25V CERAMIC X7R 0805	Panasonic® – ECG	ECJ-2VB1E104K
1	C3	CAP 1.0UF 10V CERAMIC X7R 0805	Kemet®	C0805C105K8RACTU
2	C4,C5	CAP 10UF 6.3V CERAMIC X5R 1206	Kemet	C1206C106K9PACTU
4	R1,R2,R3,R4	RES 15.0 OHM 1/10W 1% 0805 SMD	Panasonic – ECG	ERJ-6ENF15R0V
1	R5	RES 10.0K OHM 1/10W 1% 0805 SMD	Panasonic – ECG	ERJ-6ENF1002V
2	R7,R12	RES 4.99K OHM 1/10W 1% 0805 SMD	Panasonic – ECG	ERJ-6ENF4991V
3	R6,R8,R10	RES 49.9K OHM 1/10W 1% 0805 SMD	Panasonic – ECG	ERJ-6ENF4992V
1	R11	RES 100K OHM 1/10W 1% 0805 SMD	Panasonic – ECG	ERJ-6ENF1003V
1	R9	RES 1.00M OHM 1/10W 1% 0805 SMD	Panasonic – ECG	ERJ-6ENF1004V
4	D1,D2,D3,D4	LED WHITE DIFFUSED 2-PLCC SMD	Osram Opto Semiconductors Inc	LW T67C-T2U2-3C5D
2	S1,S2	SWITCH LT TOUCH 6X3.5 100GF SMD	Panasonic – ECG	EVQ-PJS04K
1	BAT 1	HOLDER BATTERY 3CELL AAA PC MNT	Keystone Electronics®	2479
1	J1	SIP_6 Pin "Do Not Populate"	—	—
1	JP1	CONN HEADER 2POS .100 VERT TIN	Molex®/Waldom® Electronics Corp	22-28-4021
1	U1	MCP1252	Microchip Technology Inc.	MCP1252-ADJI/MS
1	U2	PIC10F206-E/OTG	Microchip Technology Inc.	PIC10F206-E/OTG

NOTES:

Appendix C. 00016R1.asm Source Code

C.1 DEVICE FIRMWARE

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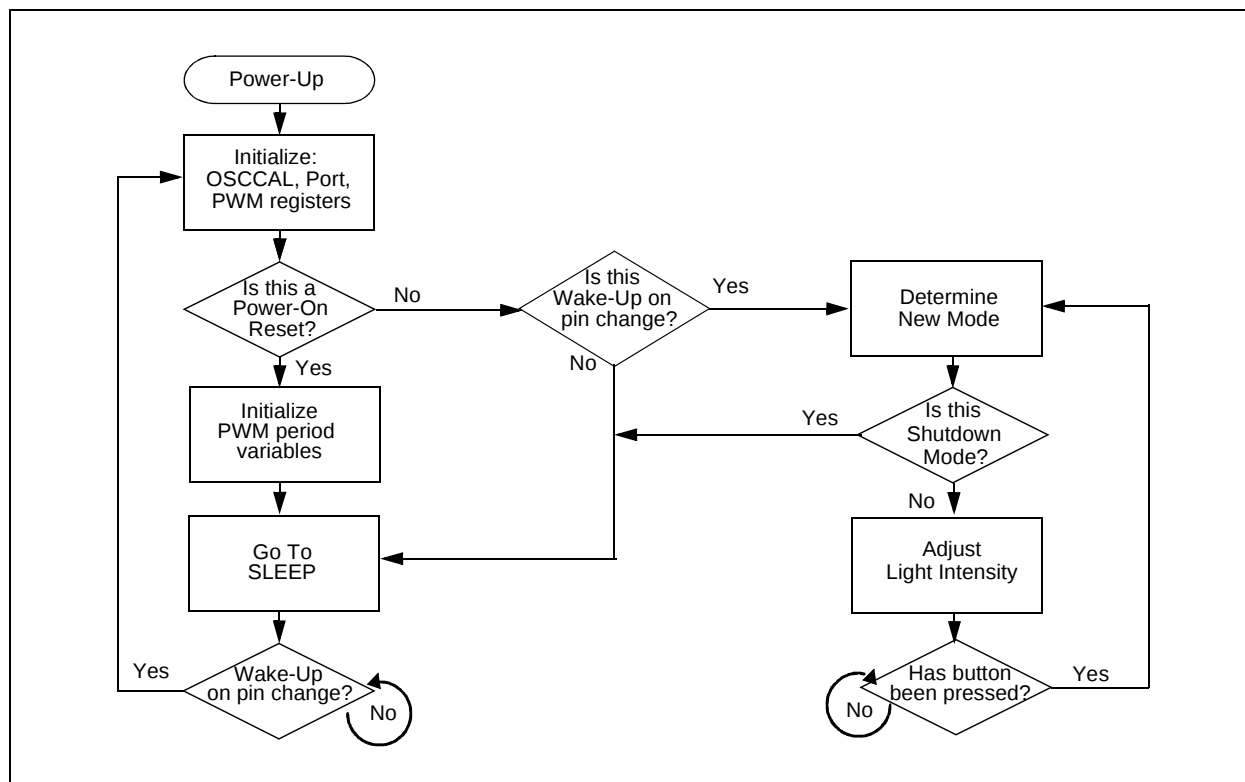


FIGURE C-1: Firmware Flowchart – Page 1.

TABLE C-1: 00016R1.ASM

```

;*****
;
;      Filename:      00016R1.asm
;      Date:          31aug04
;      File Version:  pp1
;
;      Author:   M Waldron
;      Company:  MCHP
;      10f204/ 10f206 PWM to control LED driver
;
;*****
;
;      Files required:
;
;
;
;*****
;
;      Notes: Changed file name, added led_medhi routine,
;             adjusted intensity of various modes.  PB 3/29/05
;
;
;
;*****

list p=10f206          ; list directive to define processor
#include <p10f206.inc>   ; processor specific variable definitions

__CONFIG _CP_OFF & _WDT_OFF & _MCLRE_OFF & _IntRC_OSC

; '_CONFIG' directive is used to embed configuration data within .asm file.
; The labels following the directive are located in the respective .inc file.
; See respective data sheet for additional information on configuration word.

;constants
;increase led_xxx_on to increase intensity ( value must be less than period value)
;increase period to reduce PWM frequency and increase PWM resolution
led_hi_on      = 0x16    ;on loops for high brightness mode
led_hi_off     = 0x11    ;off loops for high brightness mode, value will be calculated
by the program (10)
led_medhi_on   = 0x08    ;on loops for medium_high brightness mode
led_medhi_off  = 0x11    ;off loops for high brightness mode (11)
led_med_on     = 0x06    ;on loops for medium brightness mode
led_med_off    = 0x11    ;off loops for high brightness mode (11)
led_low_on     = 0x05    ;on loops for low brightness mode
led_low_off    = 0x12    ;off loops for high brightness mode (12)
period         = 0x0E    ;total loops per PWM period
max_time       = 0xff    ;on time before unit swithces back to sleep

;variables
mode           = 0x13    ;current mode ( high, med, lo )
counter        = 0x14    ;hi and low time counter
debounce       = 0x15    ;debounce counter
flag           = 0x16    ;debounce control flags

```

TABLE C-1: 00016R1.ASM (CONTINUED)

```

timerh      = 0x17      ;on timer high byte
timerl      = 0x18      ;on timer low byte

;bits used in the flag variable
new_mode    = 7          ;when set a debounced user keypress has been detected
timer_ena   = 6          ;when clear the debounce timer will not increment
;GPIO pins
button      = 3          ;mode select button
pwm         = 0          ;pwm output

;other
TO          EQU          H'0004'
PD          EQU          H'0003'
GPWU        EQU          H'0007'
GPPU        EQU          H'0006'
COUTEN      EQU          H'0006'
CMPTOCS     EQU          H'0004'
CWU         EQU          H'0000'

    org 0x00

                goto reset

    org 0x10

reset         nop
                nop
                bcf OSCCAL, FOSC4      ; GP2/T0CKI/COUT applied to GP2 pin
init_ports   movlw 0x01      ;italize mode, upon wake up led will be at low intensity
                movwf mode
                ;
                movlw b'00001111'      ;configure for wake on port change
OPTION
                ;
                movlw b'01010011'      ;disable the comparator
                movwf 0x07              ;write to CMCON0
                ;
                clrf GPIO
                movlw 0x0E
                tris GPIO              ;configure port
                ;
                bcf STATUS, GPWUF
                btfsc STATUS, CWUF      ;test for wake up or reset
                goto wake
                btfsc STATUS, GPWUF
                goto wake
                btfss STATUS, TO
                goto wake
                btfss STATUS, PD
                goto wake
                goto init_vars          ;initialize vars

init_vars    movlw 0xFF
                movwf timerh
                movwf timerl
                ;
                movlw led_hi_on          ;calculate off times based on time remaining in
PWM period

```

TABLE C-1: 00016R1.ASM (CONTINUED)

		movwf led_hi_off ;add the complement of on time to the window time
		comf led_hi_off, f
		movlw period
		addwf led_hi_off, f
		;
PWM period		movlw led_medhi_on ;calculate off times based on time remaining in
time		movwf led_medhi_off ;add the complement of on time to the window
		comf led_medhi_off, f
		movlw period
		addwf led_medhi_off, f
		;
PWM period		movlw led_med_on ;calculate off times based on time remaining in
		movwf led_med_off ;add the complement of on time to the window time
		comf led_med_off, f
		movlw period
		addwf led_med_off, f
		;
PWM period		movlw led_low_on ;calculate off times based on time remaining in
		movwf led_low_off ;add the complement of on time to the window time
		comf led_low_off, f
		movlw period
		addwf led_low_off, f
		;
		movf GPIO, w ;read port before entering sleep mode
wake	sleep	
	btfss	GPIO, button ;only allow a low to bring PIC out of sleep
	goto	inc_mode
	movlw	0x20
	call	delay
	movf	GPIO, w
	sleep	
	;	
inc_mode	incf	mode, f ;it was a pin change, determine new mode
		;determine current mode
mode_select	bcf	flag, new_mode ;clear new mode flag
	;	
	movlw	0x01
	subwf	mode, w
	btfsc	STATUS, Z
	goto	led_off
	;	
	movlw	0x02
	subwf	mode, w
	btfsc	STATUS, Z
	goto	led_low
	;	
	movlw	0x03
	subwf	mode, w
	btfsc	STATUS, Z
	goto	led_med
	;	

TABLE C-1: 00016R1.ASM (CONTINUED)

```

        movlw 0x04
        subwf mode, w
        btfsc STATUS, Z
        goto led_medhi
        ;
        movlw 0x05
        subwf mode, w
        btfsc STATUS, Z
        goto led_high
        ;
        movlw 0x06
        subwf mode, w
        btfsc STATUS, Z
        goto led_full
        ;
        movlw 0x01          ;on mode rollover reset to low brightness mode
        movwf mode
        goto mode_select

        ;full on
led_full  bsf GPIO, pwm
        movlw 0x0F
        call delay          ;used as debounce
        call bounce
        btfss flag, new_mode
        goto led_full
        goto mode_select

        ;high brightness routine
led_high  bsf GPIO, pwm          ;turn on LED(s) for a set time
        movlw led_hi_on
        call delay
        bcf GPIO, pwm          ;turn off LED(s) fo a set time
        movf led_hi_off, w
        call delay
        call bounce
        btfss flag, new_mode
        goto led_high
        goto mode_select
        ;medium-high brightness routine
led_medhi bsf GPIO, pwm          ;turn on LED(s) for a set time
        movlw led_medhi_on
        call delay
        bcf GPIO, pwm          ;turn off LED(s) fo a set time
        movf led_medhi_off, w
        call delay
        call bounce
        btfss flag, new_mode
        goto led_medhi
        goto mode_select
        ;medium brightness routine

```

TABLE C-1: 00016R1.ASM (CONTINUED)

```

led_med    bsf GPIO, pwm          ;turn on LED(s) for a set time
            movlw led_med_on
            call delay
            bcf GPIO, pwm          ;turn off LED(s) fo a set time
            movf led_med_off, w
            call delay
            call bounce
            btfss flag, new_mode
            goto led_med
            goto mode_select

            ;low brightness routine
led_low    bsf GPIO, pwm          ;turn on LED(s) for a set time
            movlw led_low_on
            call delay
            bcf GPIO, pwm          ;turn off LED(s) for a set time
            movf led_low_off, w
            call delay
            call bounce
            btfss flag, new_mode
            goto led_low
            goto mode_select

            ;led off
led_off    movlw 0x20
            call delay
            bcf GPIO, pwm          ;turn off LED(s)
            movf GPIO, w           ;read port before entering sleep mode
            sleep

            ;delay loop for on and off time
delay      movwf counter          ; Delay = (3 + (3 * counter) + 2) Tcy
loop       decfsz counter, f
            goto loop
            retlw 0x00

            ;check for button press
bounce     btfss GPIO, button      ; Is Button Depressed?
            goto bounce1           ; Yes, go to "bounce1"
            bsf flag, timer_ena     ; No, allow timer to start
            clrf debounce          ; no user entry, reset debounce timer
            retlw 0x00             ;
bounce1     btfss flag, timer_ena
            retlw 0x00             ;do not increment as we have not seen the debounce
released yet
            incfsz debounce, f      ;inc debounce timer
            retlw 0x00             ;not yet
            bsf flag, new_mode
            incf mode, f            ;a valid press has been detected
            bcf flag, timer_ena     ;prevent timer from incrementing to prevent
cycling though modes by holding debounce
bounce00    retlw 0x00

end

```

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