# GPIO Expander Keypad and LCD Demo Board User's Guide

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# GPIO EXPANDER KEYPAD AND LCD DEMO BOARD USER'S GUIDE

# Table of Contents

**NOTES:**

# GPIO EXPANDER KEYPAD AND LCD DEMO BOARD 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 web site (www.microchip.com) to obtain the latest documentation available.**

**Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.**

### INTRODUCTION

This chapter contains general information that will be useful to know before using the GPIO Expander Keypad and LCD 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 GPIO Expander Keypad and LCD Demo Board as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the GPIO Expander Keypad and LCD Demo Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on how to get started with this evaluation board.
- **Appendix A. "Schematics and Board Layouts"** – Shows the schematic and layout diagrams for the GPIO Expander Keypad and LCD Demo Board.
- **Appendix B. "Bill Of Materials (BOM)"** – Lists the parts used to build the GPIO Expander Keypad and LCD Demo Board.

## CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

**DOCUMENTATION CONVENTIONS**

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

## RECOMMENDED READING

For more information regarding the Stand-Alone CAN controller, CAN I/O Expander, and CAN transceiver devices, refer to the appropriate data sheet. Table 1 shows the device and associated Data Sheet literature number. These documents can be found at Microchip's web site at: www.microchip.com.

**TABLE 1: DEVICES AND DATA SHEET LITERATURE NUMBERS**

| Device | Literature # | Device | Literature # |
|---|---|---|---|
| **MCP23X08** | DS21919 | **PIC18F4550** | DS39632 |
| **MCP23X17** | DS21952 | **MCP1702** | DS22008 |

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- Technical Support
- Development Systems Information Line

Customers should contact their distributor, representative or field application engineer 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

## DOCUMENT REVISION HISTORY

### Revision A (October 2006)

- Initial Release of this Document.

**NOTES:**

# Chapter 1.  Product Overview

## 1.1    INTRODUCTION

This chapter provides an overview of the GPIO Expander Keypad and LCD Demo Board and covers the following topics:

• What is the GPIO Expander Keypad and LCD Demo Board?
• What the GPIO Expander Keypad and LCD Demo Board Kit includes

## 1.2    WHAT IS THE GPIO EXPANDER KEYPAD AND LCD DEMO BOARD?

The GPIO Expander Keypad and LCD Demo Board allows the system designer to evaluate the operation of the MCP23X17 and MCP23X08 General Purpose I/O (GPIO) Expanders. The board demonstrates the GPIO Expanders' performance in a keypad and LCD example.

## 1.3    WHAT THE GPIO EXPANDER KEYPAD AND LCD DEMO BOARD KIT INCLUDES

This GPIO Expander Keypad and LCD Demo Board Kit includes:

• One GPIO Expander Keypad and LCD Demo Board (102-00116)
    - MCP23008 GPIO Expander with I$^2$C™ interface (installed)
    - MCP23S08 GPIO Expander with SPI interface (installed)
    - MCP23017 GPIO Expander with I$^2$C™ interface (installed)
    - MCP23S17 GPIO Expander with SPI interface (installed)
• Analog and Interface Products Demonstration Boards CD-ROM (DS21912)
    - GPIO Expander Keypad and LCD Demo Board User's Guide (DS51636)
    - PIC® Microcontroller Firmware
    - PCB Gerber Files

**NOTES:**

# Chapter 2.  Installation and Operation

## 2.1    INTRODUCTION

This chapter discusses the setup and operation of the GPIO Expander Keypad and LCD Demo Board.

The GPIO Expander Keypad and LCD Demo Board is designed to demonstrate using GPIO expanders in a keypad and LCD example. The MCP23X17 interfaces to a 2x16 LCD module and the MCP23X08 interfaces to a 4x4 keyed matrix.

Both the I$^2$C™ and SPI versions are included on the board to demonstrate both serial interfaces.

## 2.2    FEATURES

The GPIO Expander Keypad and LCD Demo Board has the following features:
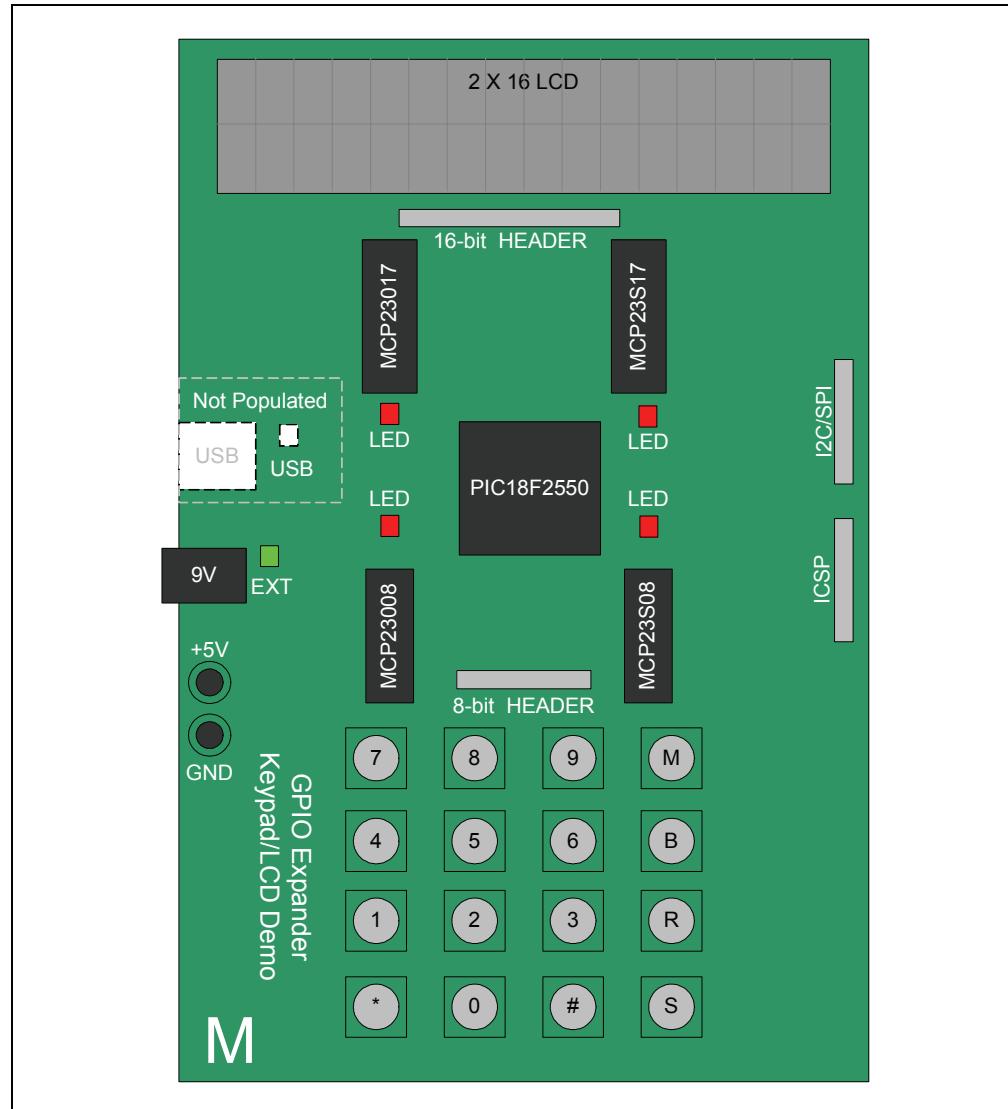
- Two (2) 8-bit GPIO Expanders
    - MCP23008 with I$^2$C™ interface
    - MCP23S08 with SPI interface
- Two (2) 16-bit GPIO Expanders
    - MCP23017 with I$^2$C™ interface
    - MCP23S17 with SPI interface
- 4X4 keypad layout (16 momentary buttons)
    - Numbers 0 - 9
    - Six special function buttons
- A 2X16 LCD module
- Headers for the MCP23X08 and MCP23X17 pins
- Header for programming the PIC18F4550

## 2.3    GETTING STARTED

The GPIO Expander Keypad and LCD Demo Board is a fully functional, assembled and tested board for demonstrating the MCP23008 and MCP23017 ($I^2C$ interface) and MCP23S08 and MCP23S17 (SPI interface) general purpose I/O expanders. The following describes the basic setup and operation (see Figure 2-1):

1. Either connect a 9V power supply into the power jack (J2) or connect a 5 V power supply to the $V_{DD}$ and GND test points.
2. The green power LED will illuminate.
3. The LCD will display the startup splash screen.
4. The appropriate LEDs ($I^2C$ or SPI) will illuminate to indicate the current serial mode.
5. Pressing buttons:
   - **0 - 9, #, *:** will be reflected on the LCD
   - **M:** switches modes ($I^2C$ and SPI) to communicate with the MCP23X17 and MCP23X08; **B:** backspace; **R:** carriage return, and screen clear (2nd press); **S:** space

**FIGURE 2-1:    BOARD LAYOUT**
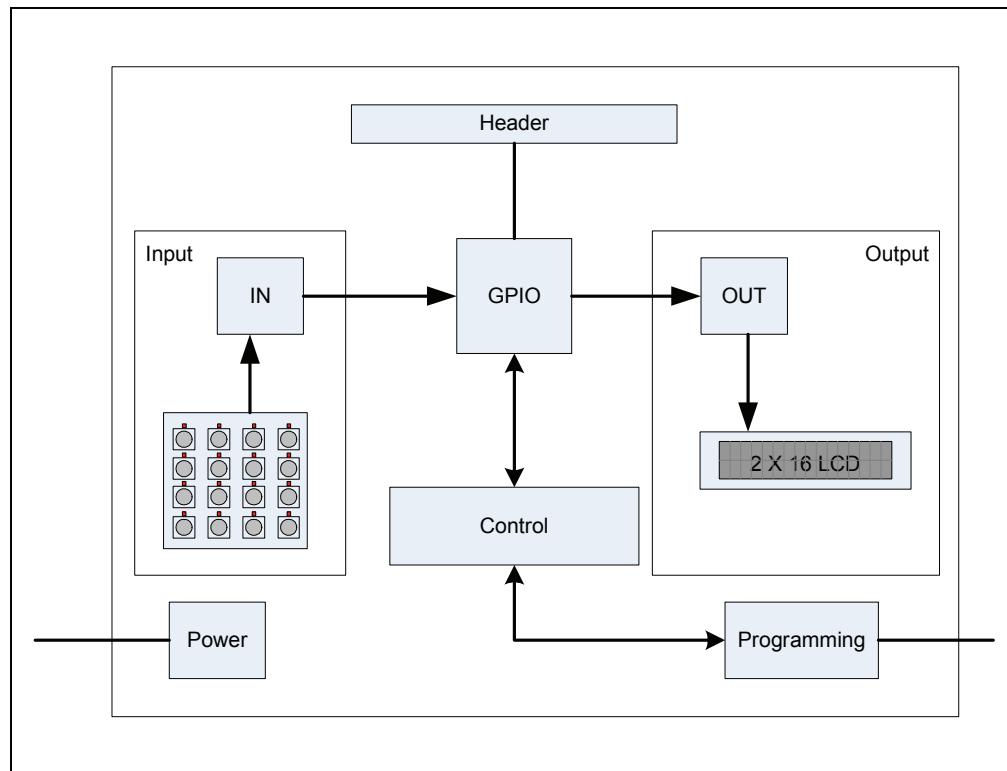
## 2.4    GPIO EXPANDER KEYPAD AND LCD DEMO BOARD DESCRIPTION

### 2.4.1    Major Board Components

The functional block diagram is shown in Figure 2-2.

**FIGURE 2-2:        FUNCTIONAL BLOCK DIAGRAM**



1.  The **GPIO BLOCK** contains the MCP23X17 and MCP23X08 GPIO Expanders. Two (2) MCP23X17 devices are connected to the LCD module and two (2) MCP23X08 devices are connected to the keypad matrix.
    A button on the keypad toggles between I$^2$C and SPI mode. When in **I$^2$C mode**, the MCP23017 and MCP23008 are controlled by the PIC MCU. When in **SPI mode**, the MCP23S17 and MCP23S08 are controlled. Only one (1) MCP23X08 and one (1) MCP23X17 is on the bus at a time.
2.  The **CONTROL BLOCK** contains the PIC18F4550 and is the main intelligence in the system.
3.  The **INPUT BLOCK** contains the 4x4 keypad matrix. The MCP23X08 devices are used to scan the keys.
4.  The **OUTPUT BLOCK** contains the 2x16 LCD. The MCP23X17 devices control the display.
5.  The MCP23X17 and MCP23X08 I/O and serial lines are routed to the **HEADER BLOCK** to allow the pins to be probed.
6.  The **PROGRAMMING BLOCK** contains the ICSP™ header for programming/debugging the PIC18F4550.
7.  The **POWER BLOCK** contains the MCP1702 5V voltage regulator. The board can be powered by a 9V supply (connected through the power jack) or by applying 5V directly to the power points.

## 2.5    FIRMWARE DESCRIPTION

See Figure 2-3 for the main firmware flow diagram.

**Main Function:**

1.  The firmware first configures the PIC MCU.
2.  The MCP23X08 and MCP23X17 devices are configured. I$^2$C Devices are selected first by default. The SPI devices I/O are held in reset.
3.  The LCD splash screen is shown.
4.  Wait for an interrupt from the MCP23X08. An interrupt will occur when a button is pressed. Four (4) inputs are configured to interrupt on falling edge. These inputs are for the "columns" of the keypad matrix.
5.  After the interrupt occurs, the firmware calls the **Scan_Buttons** routine.
6.  Then the **Update_LCD** routine.
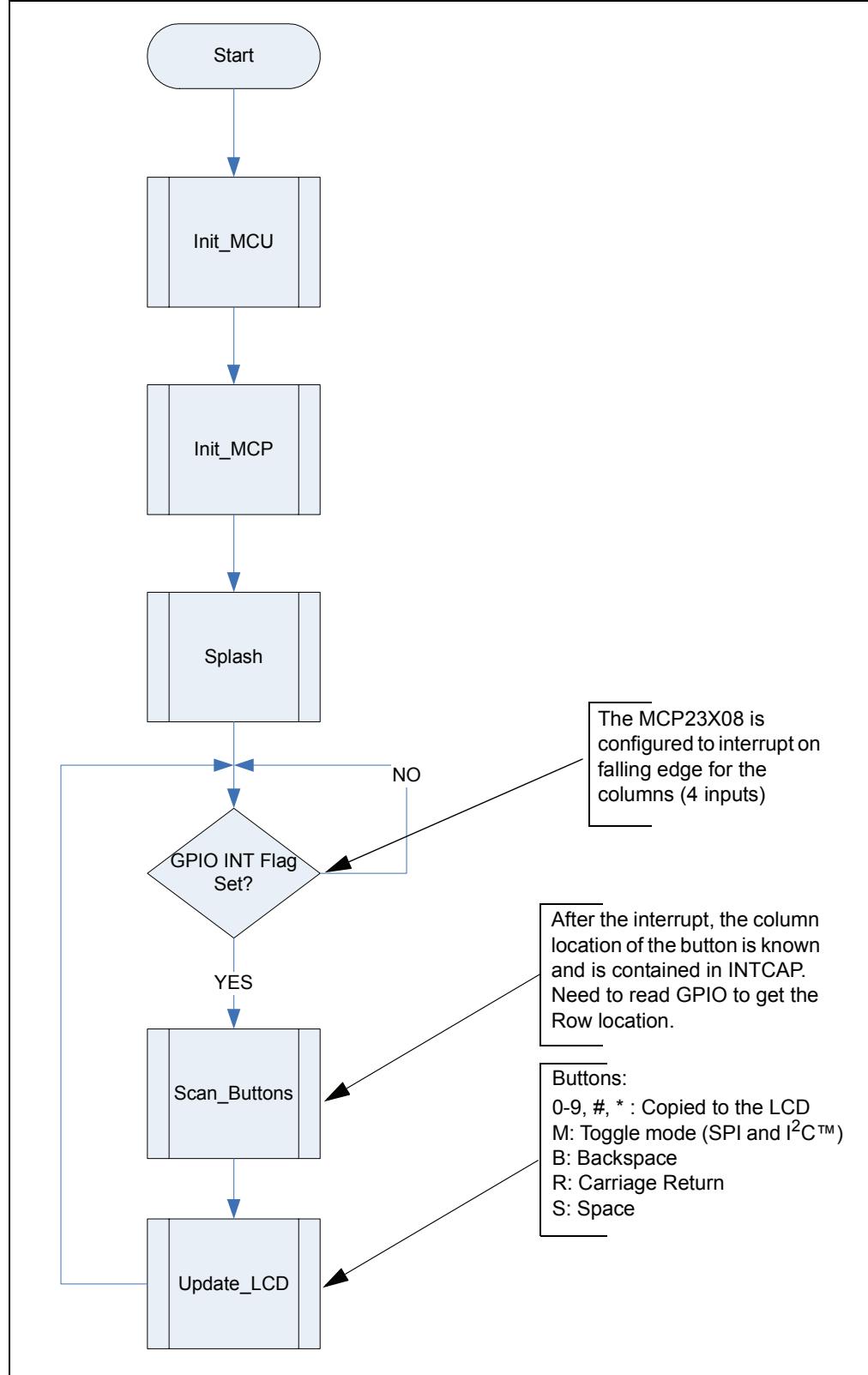
**Scan_Buttons Function:**

1.  Read INTCAP register. This register contains a snapshot of the port condition when the interrupt occurred.
2.  Swap inputs and outputs so the rows can be read.
3.  Read GPIO register and merge with variable containing INTCAP value.
4.  The pressed key is determined by looking up the result in a lookup table.
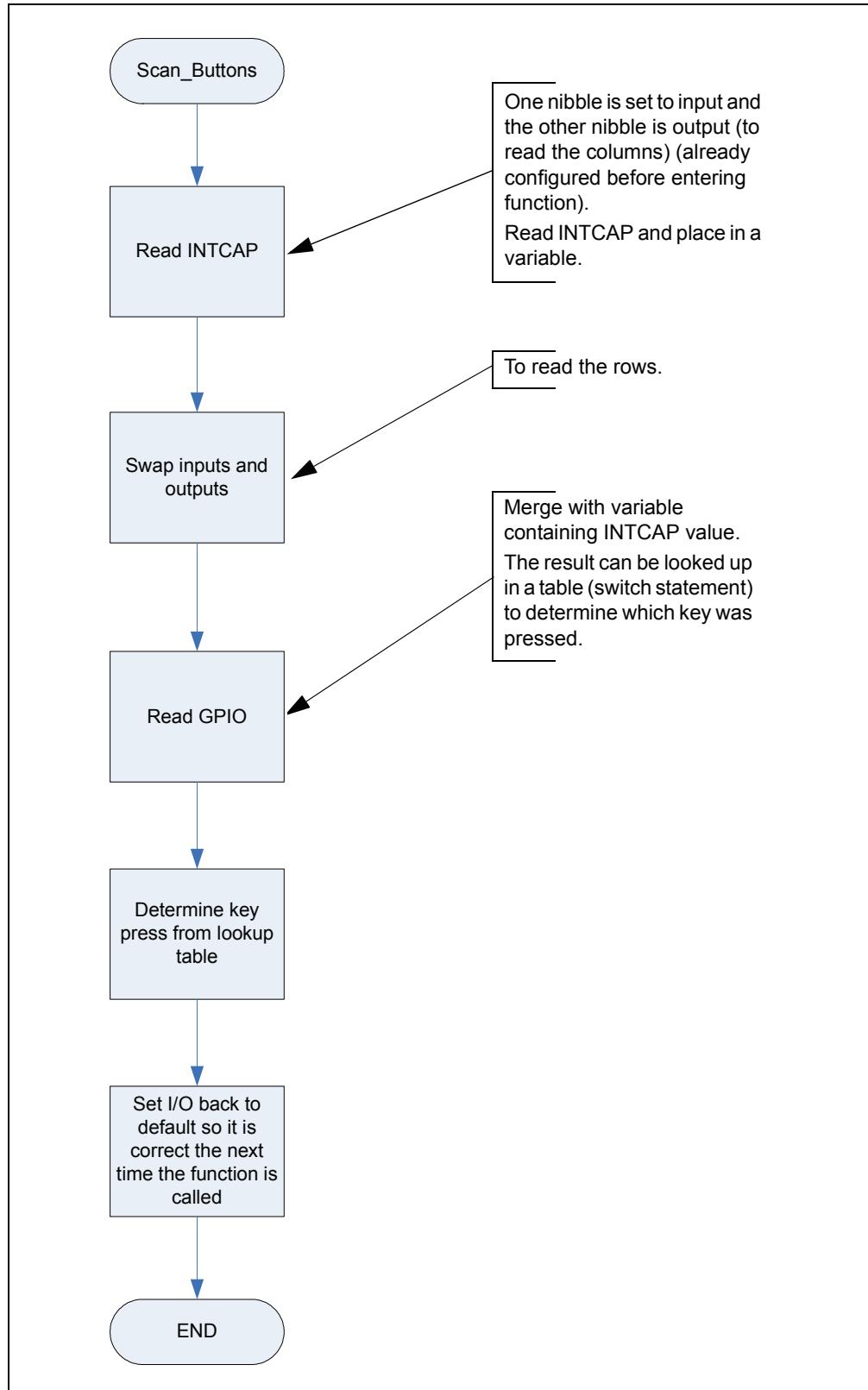
**Update_LCD Function:**

1.  The LCD is updated based on which button was pressed.

**FIGURE 2-3:** **MAIN FIRMWARE FLOW**



Start

Init_MCU

Init_MCP

Splash

GPIO INT Flag Set?

NO

The MCP23X08 is configured to interrupt on falling edge for the columns (4 inputs)

YES

Scan_Buttons

After the interrupt, the column location of the button is known and is contained in INTCAP. Need to read GPIO to get the Row location.

Update_LCD

Buttons:
0-9, #, * : Copied to the LCD
M: Toggle mode (SPI and I$^2$C™)
B: Backspace
R: Carriage Return
S: Space

# GPIO Expander Keypad and LCD Demo Board User's Guide

**FIGURE 2-4:**      **KEYPAD SCAN**

Scan_Buttons

Read INTCAP

One nibble is set to input and the other nibble is output (to read the columns) (already configured before entering function).

Read INTCAP and place in a variable.

Swap inputs and outputs

To read the rows.

Merge with variable containing INTCAP value.

The result can be looked up in a table (switch statement) to determine which key was pressed.

Read GPIO

Determine key press from lookup table

Set I/O back to default so it is correct the next time the function is called

END

**FIGURE 2-5:       LCD UPDATE**

**NOTES:**

# Appendix A. Schematics and Board Layouts

## A.1 INTRODUCTION

This appendix contains the schematic and PCB layout for the GPIO Expander Keypad and LCD Demo Board. Diagrams included:

- Board Schematics - Pages 1 - 3.
- Board - Top Layer (with silk screen)
- Board - Bottom Layer
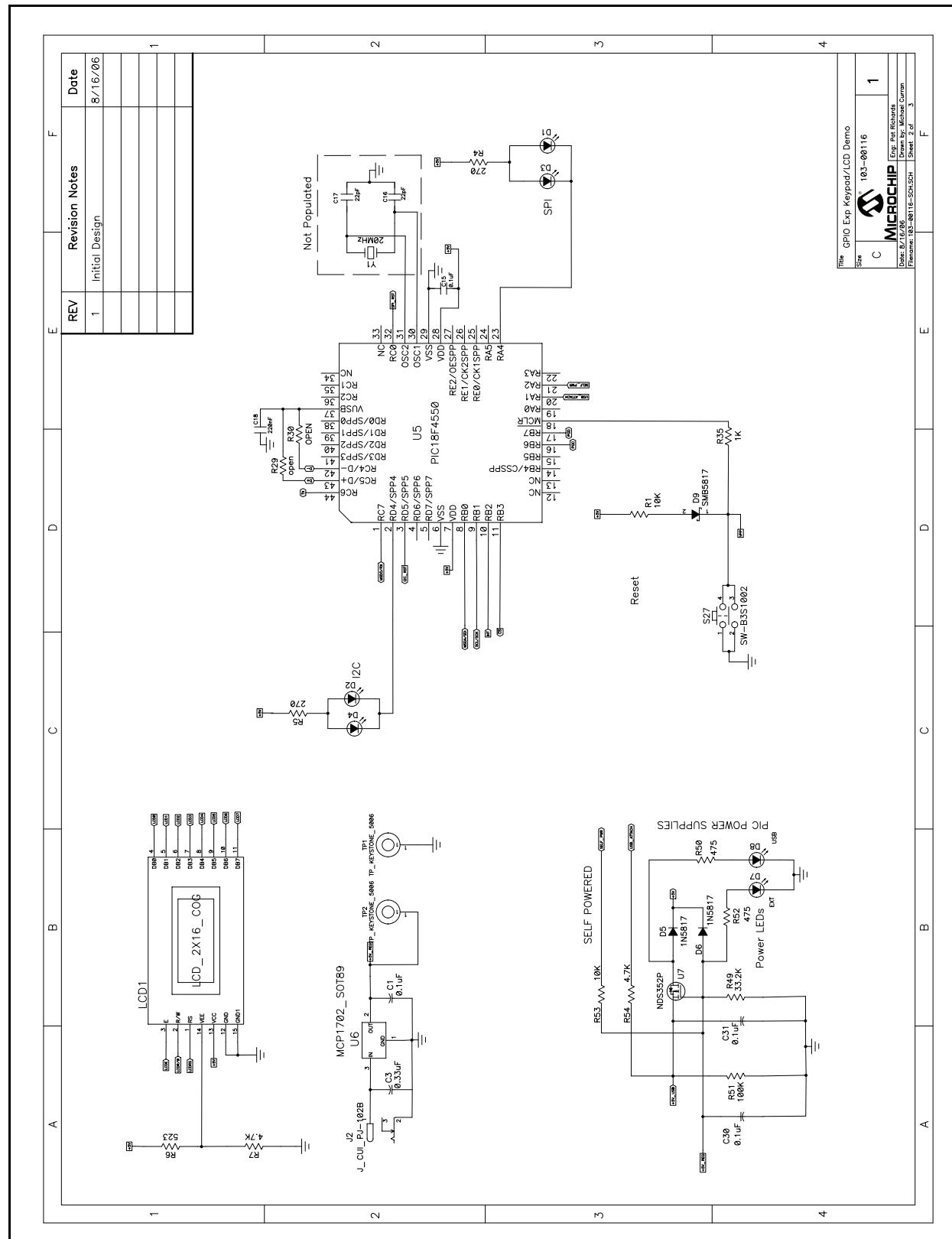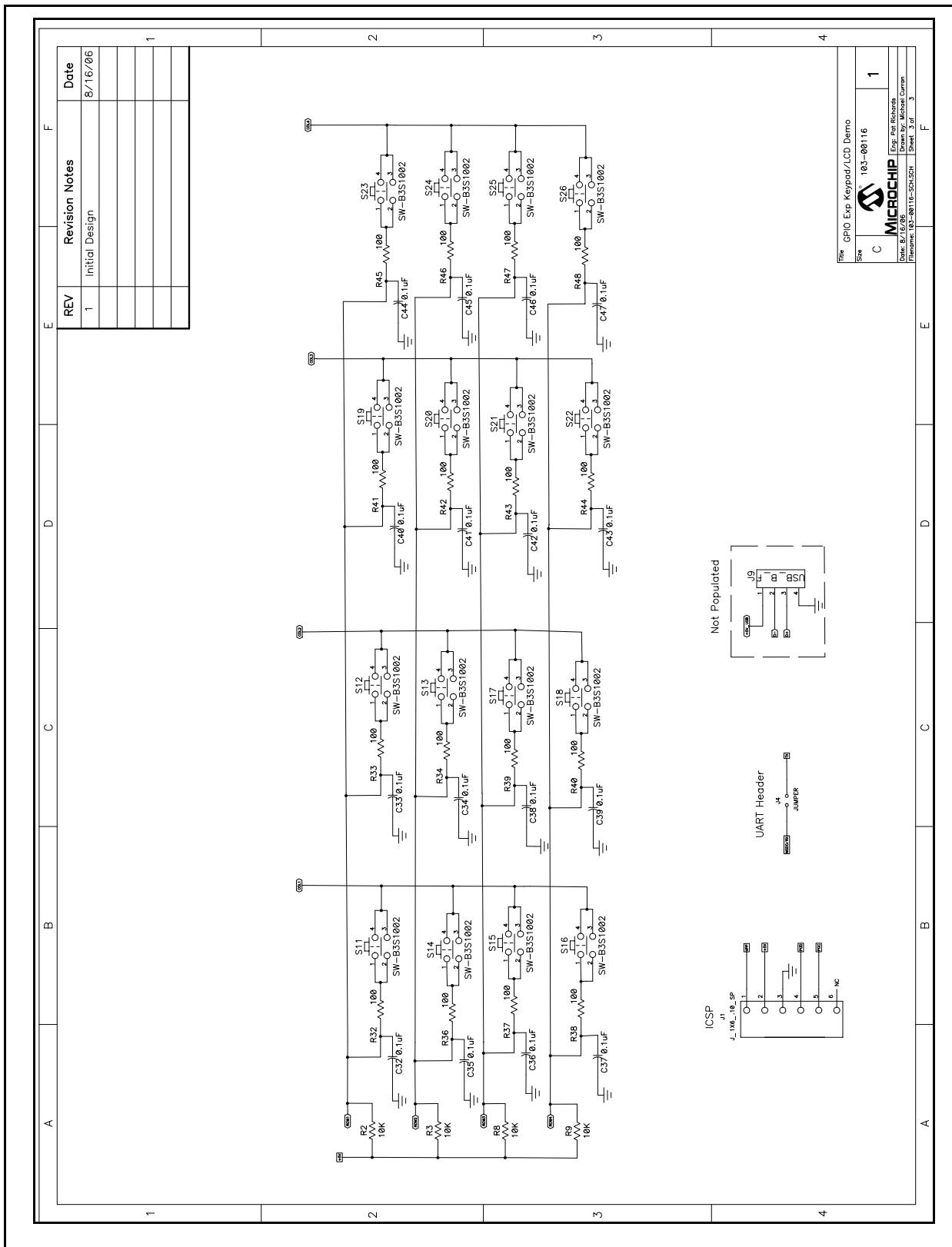
## A.2    BOARD SCHEMATIC - PAGE 1
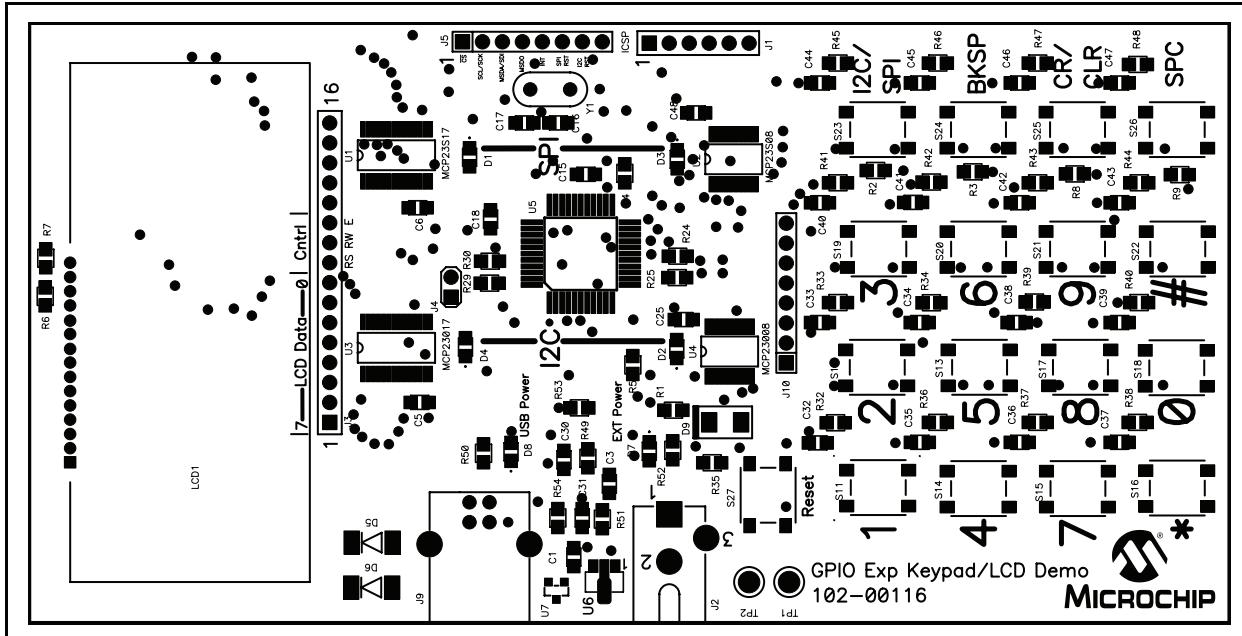
## A.3    BOARD SCHEMATIC - PAGE 2

## A.4    BOARD SCHEMATIC - PAGE 3
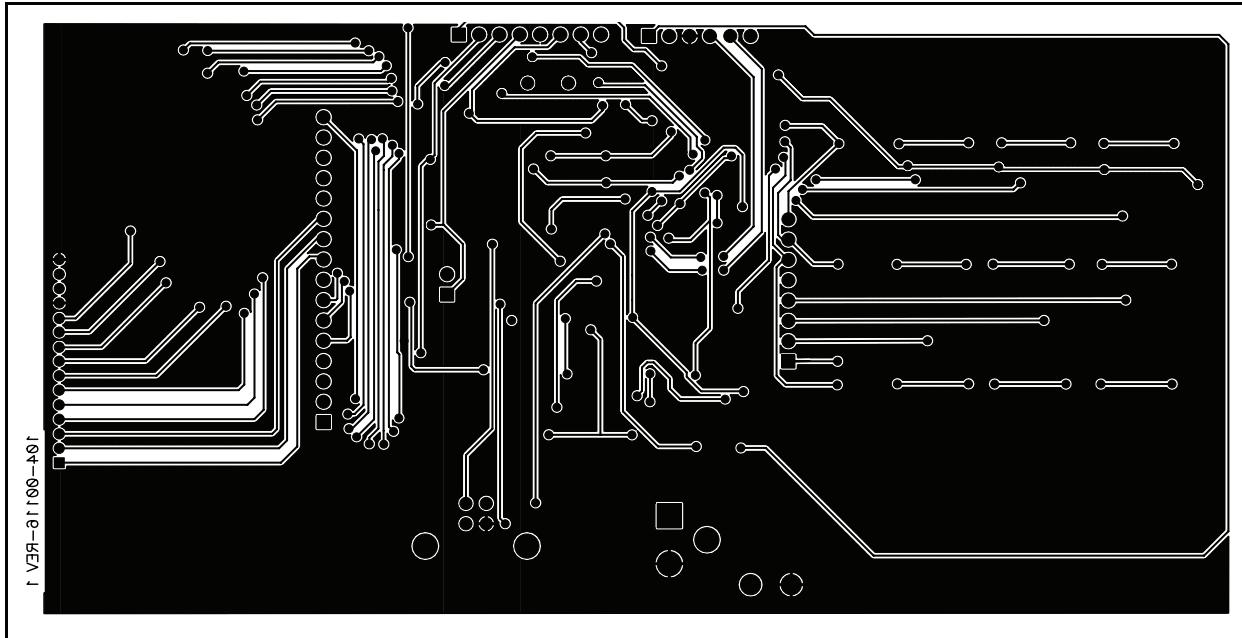
## A.5    BOARD - TOP LAYER (WITH SILK SCREEN)



## A.6    BOARD - BOTTOM LAYER

**NOTES:**

# GPIO EXPANDER KEYPAD AND LCD DEMO BOARD USER'S GUIDE

## Appendix B. Bill Of Materials (BOM)

**TABLE B-1: BILL OF MATERIALS**

| Qty | Reference Designator | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 23 | C1, C5, C6 C15, C25, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41, C42, C43, C44, C45, C46, C47, C48 | CAP 1UF 16V CERAMIC Y5V 0805 | Panasonic® - ECG | ECJ-2VF1C105Z |
| 1 | C3 | CAP CER .33UF 16V Y5V 0805 | Murata Electronics® North America | GRM219F51C334ZA01D |
| 2 | C16, C17 | CAP 22PF 50V CERM CHIP 0805 SMD *Do Not Populate* | Panasonic - ECG | ECJ-2VC1H220J |
| 1 | C18 | CAP .22UF 16V CERAMIC X7R 0805 | Panasonic - ECG | ECJ-2VB1C224K |
| 4 | D1, D2, D3, D4 | LED 636NM SUPER RED 0805 SMD | LITE-ON INC | SML-LX0805SIC-TR |
| 2 | D5, D6 | DIODE SCHOTTKY 20V 0.5A SOD123 | ON Semiconductor® | MBR0520LT1G |
| 2 | D7, D8 | LED THIN 565NM GRN DIFF 0805 SMD | Optoelectronics | SML-LXT0805GW-TR |
| 1 | D9 | RECT SCHOTTKY 1A 20V DO-214AA | Micro Commercial Co. | SMB5817-TP |
| 4 | EA Corner | BUMPON X-TALL TAPER SQ .81X.30BK | 3M/ESM | SJ-5523 (BLACK) |
| 1 | J1 | *Do Not Populate* | — | — |
| 1 | J2 | CONN POWER JACK 2.5MM PCB CIRC | CUI Inc | PJ-102B |
| 1 | J3 | *Do Not Populate* | — | — |
| 1 | J4 | *Do Not Populate* | — | — |
| 2 | J5, J10 | *Do Not Populate* | — | — |
| 1 | J9 | CONN USB RTANG FEMALE TYPE B PCB *Do Not Populate* | Assmann Electronics Inc | AU-Y1007-R |
| 1 | LCD1 | LCD_2x16 | Fema | CG1626-SGR1 |
| 6 | R1, R2, R3, R8, R9, R53 | RES 10.0K OHM 1/10W 1% 0805 SMD | Panasonic - ECG | ERJ-6ENF1002V |
| 2 | R4, R5 | RES 270 OHM 1/8W 5% 0805 SMD | Panasonic - ECG | ERJ-6GEYJ271V |
| 1 | R6 | RES 523 OHM 1/8W 1% 0805 SMD | Yageo® Corporation | RC0805FR-07523RL |
| 2 | R7, R54 | RES 4.70K OHM 1/8W 1% 0805 SMD | Yageo Corporation | RC0805FR-074K7L |
| 3 | R24, R25, R35 | RES 1.00K OHM 1/10W 1% 0805 SMD | Panasonic - ECG | ERJ-6ENF1001V |
| 2 | R29, R30 | RES 0.0 OHM 1/8W 5% 0805 SMD | Panasonic - ECG | ERJ-6GEY0R00V |

**Note 1:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

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

| Qty | Reference Designator | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 16 | R32, R33, R34, R36, R37, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R48 | RES 100 OHM 1/10W 3900PPM 5%0805 | Panasonic - ECG | ERA-S39J101V |
| 1 | R49 | RES 33.2K OHM 1/8W 1% 0805 SMD | Yageo® Corporation | RC0805FR-0733K2L |
| 2 | R50, R52 | RES 475 OHM 1/10W 1% 0603 SMD | Panasonic - ECG | ERJ-3EKF4750V |
| 1 | R51 | RES 100K OHM 1/8W 5% 0805 SMD | Panasonic - ECG | ERJ-6GEYJ104V |
| 17 | S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25, S26, S27 | SWITCH TACT 6MM SMD MOM 160GF | Omron Electronics Inc | B3S-1000 |
| 1 | TP1 | TEST POINT PC MULTI PURPOSE BLK | Keystone Electronics® | 5011 |
| 1 | TP2 | TEST POINT PC MULTI PURPOSE RED | Keystone Electronics | 5010 |
| 1 | U1 | 16 Bit I/O Expander with Serial Interface | Microchip Technology Inc | MCP23S17-E/SS |
| 1 | U2 | 8-Bit I/O Expander with SPI Interface | Microchip Technology Inc | MCP23S08-E/SS |
| 1 | U3 | 16 Bit I/O Expander with Serial Interface | Microchip Technology Inc | MCP23017-E/SS |
| 1 | U4 | 8-Bit I/O Expander with I$^2$C Interface | Microchip Technology Inc | MCP23008-E/SS |
| 1 | U5 | 44-Pin, High-Performance, Enhanced Flash, USB Microcontroller | Microchip Technology Inc | PIC18F4550 |
| 1 | U6 | 2 µA Low Dropout Positive Voltage Regulator | Microchip Technology Inc | MCP1702T-5002I/CB |
| 1 | U7 | MOSFET P-CH 20V 850MA SSOT3 | Fairchild Semiconductor® | NDS352P |
| 1 | Y1 | CRYSTAL 20.0000 MHZ SERIES RES *Do Not Populate* | CTS-Frequency Controls | ATS200 |

**Note  1:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

**NOTES:**

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