AN972

I/O Expansion Using the MCP23X08 and PIC10F202

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INTRODUCTION

This application note discusses using the MCP23008 and MCP23S08 GPIO Expanders with a 6-pin PIC10F202 microcontroller unit (MCU). The discussion is based on the MCP23X08 Evaluation Board, P/N: MCP23008DM.

An I/O expander is used to increase the I/O capability of microcontrollers. The microcontroller performs the master functions for the serial interface (either through the appropriate hardware interface or via a software-implemented interface). The MCP23X08 acts as a slave device.

The MCP23X08 8-bit GPIO family consists of two devices which differ only in the serial interface:

- MCP23008 - I^{2}C™ interface
- MCP23S08 - SPI™ interface

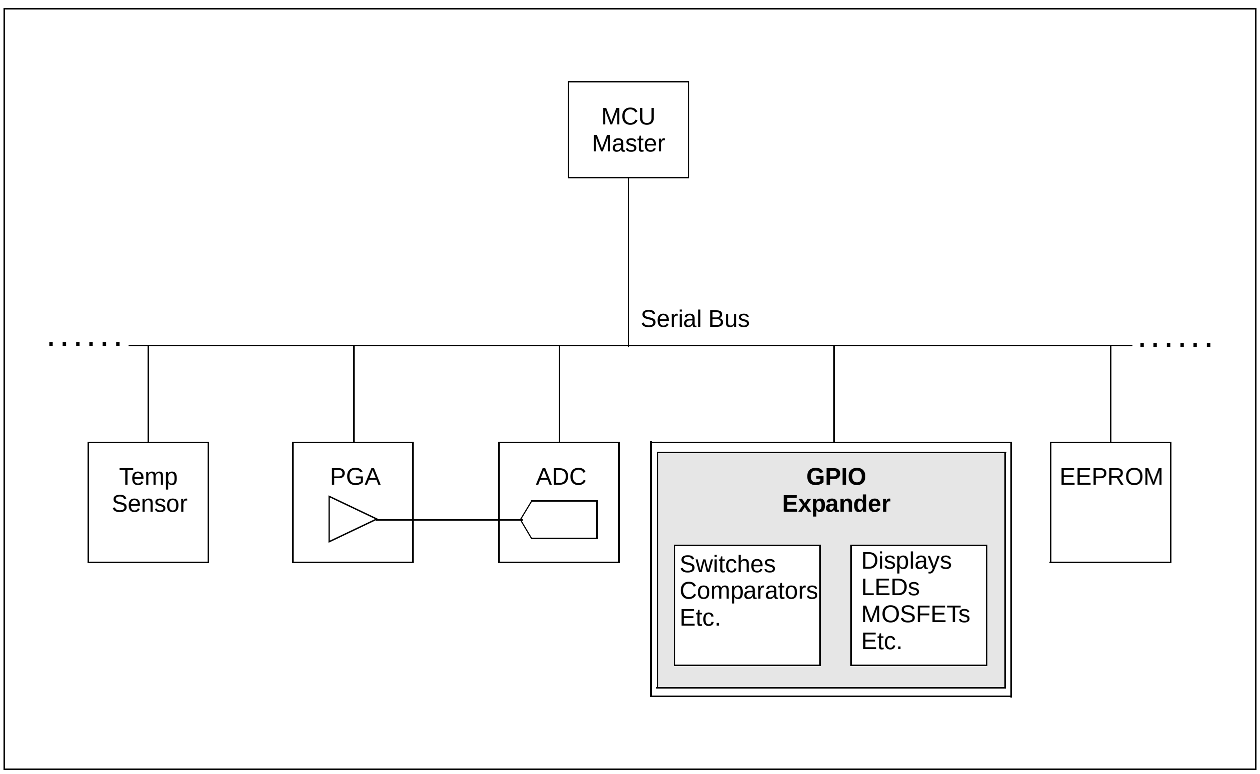
In addition to the serial interface listed, the MCP23X08 implements the following features:

- 8-bit GPIO bidirectional port
- Hardware address pins for allowing multiple MCP23X08 devices on the same bus
- Interrupt output with programmable polarity and function
- Configurable interrupt sources
- Reset input
- Polarity inversion capability for automatically inverting the polarity on the port.

This application note does not detail all of the features of the MCP23X08. Refer to the MCP23008/MCP23S08 Data Sheet, *"8-Bit I/O Expander with Serial Interface"* (DS21919), for more information.

The PIC10F202 communicates with the MCP23008 using the I^{2}C protocol, and with the MCP23S08 using the SPI protocol.

FIGURE 1: GPIO EXPANDER EXAMPLE



INTERFACING TO THE MCP23X08

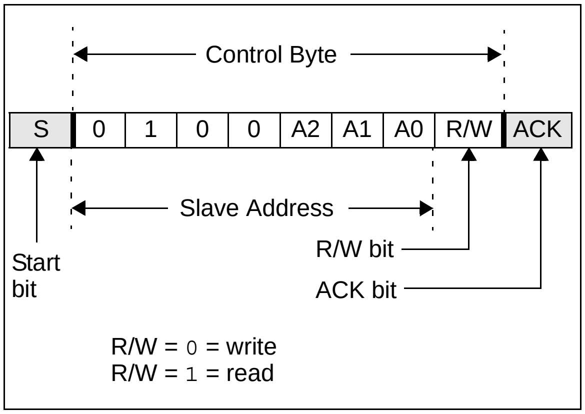
The MCP23008 has an I²C interface. While this application note does not discuss the I²C protocol in detail, an overview as it relates to the MCP23008 is provided.

Interfacing using the I²C™ Protocol

DEVICE ADDRESSING

The I²C specification describes two addressing formats: 10-bit addressing and 7-bit addressing. The MCP23008 is compatible with the 7-bit addressing format. The MCP23008 slave address contains four fixed bits and three user-defined hardware address bits (pins A2, A1 and A0). Figure 2 shows the control byte format for the MCP23008. Refer to the MCP23008/MCP23S08 Data Sheet, *"8-Bit I/O Expander with Serial Interface"* (DS21919), for more information.

FIGURE 2: MCP23008 CONTROL BYTE



START AND STOP CONDITIONS

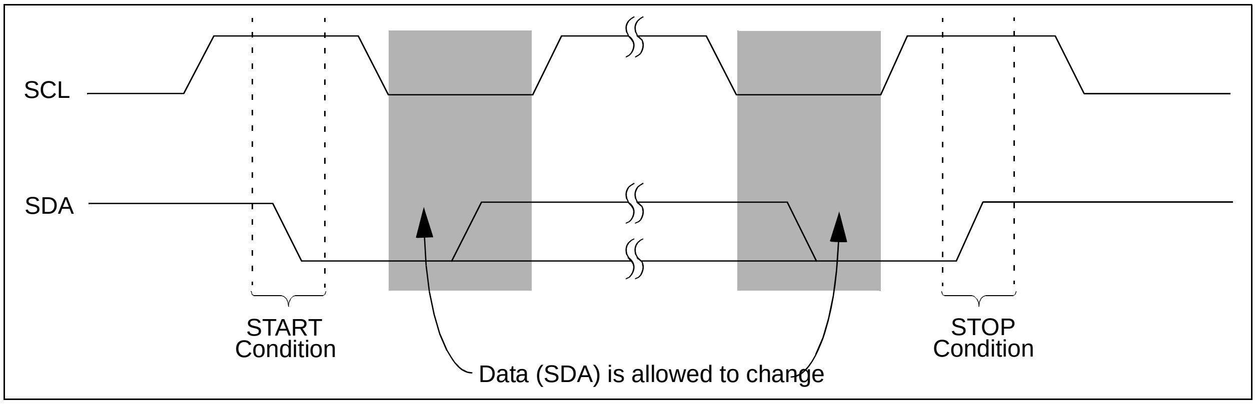
START Condition:

Data transfers are initiated by the master issuing a START condition during a bus idle period. To generate a START condition, both the clock (SCL) and data (SDA) start out high. SDA is then brought low, generating the START condition. See Figure 3.

STOP Condition:

Data transfers are terminated (and the bus released) by the master issuing a STOP condition. To generate a STOP condition, SCL starts out high and SDA starts out low. SDA is then brought high, generating a STOP condition. See Figure 3.

FIGURE 3: I²C™ BUS START/STOP BITS TIMING



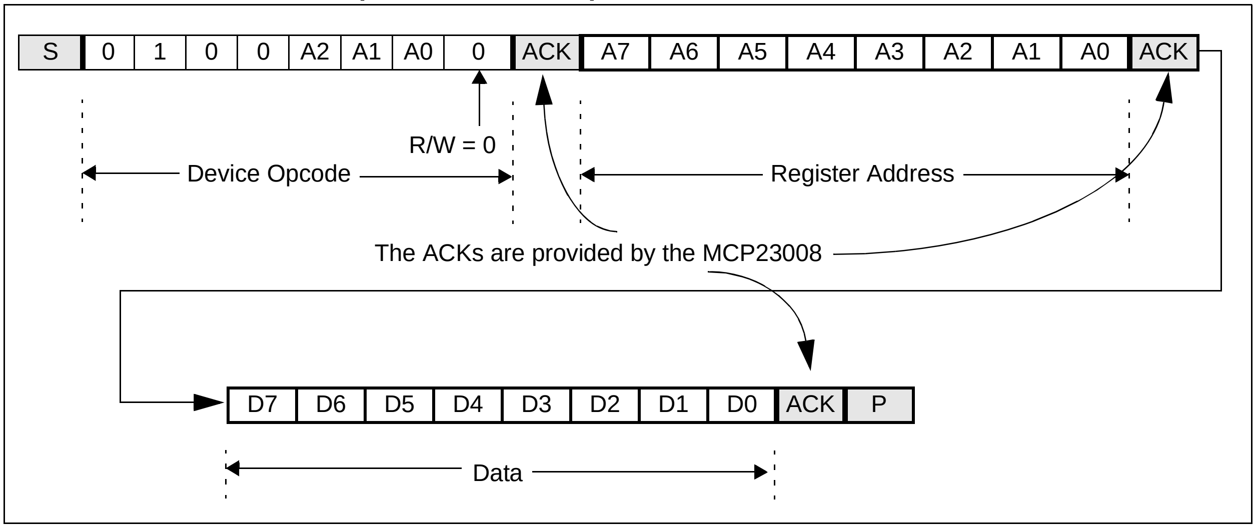
WRITING TO THE MCP23008

The Write operation (Figure 4) proceeds as follows:

- Master issues a start condition
- Master sends device opcode (slave address + R/W bit) with the R/W bit **cleared**
- MCP23008 sends an ACK
- Master sends the register address of the MCP23008
- MCP23008 sends an ACK
- Master sends the data (8 bits)
- MCP23008 sends an ACK
- Master issues a STOP condition

Note:	While the MCP23008 is capable of sequential writes and reads, this application note only implements byte writes and reads. Refer to the MCP23008/MCP23S08 Data Sheet, *"8-Bit I/O Expander with Serial Interface"* (DS21919), for more information about sequential operations.

FIGURE 4: MCP23008 (I^2C™ INTERFACE) BYTE WRITE OPERATION

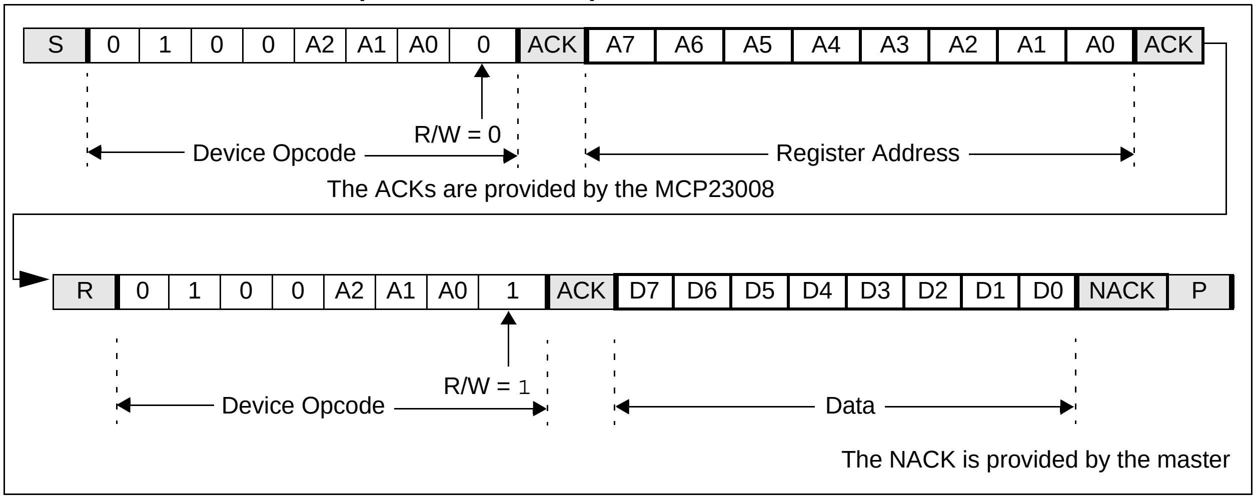


READING FROM THE MCP23008

Read operations (Figure 5) start with the write command, as shown in the upper-half of Figure 4. The remaining sequence follows:

- Master issues a re-start condition (which is basically the same as a START condition)
- Master sends device opcode (slave address + R/W bit) with the R/W bit **set**
- MCP23008 sends an ACK
- Master clocks data out of the MCP23008
- Master sends a No-ACK (NACK). Note, if another byte is to be read, the master would send an ACK instead
- Master sends a STOP condition

FIGURE 5: MCP23008 (I^2C™ INTERFACE) BYTE READ OPERATION

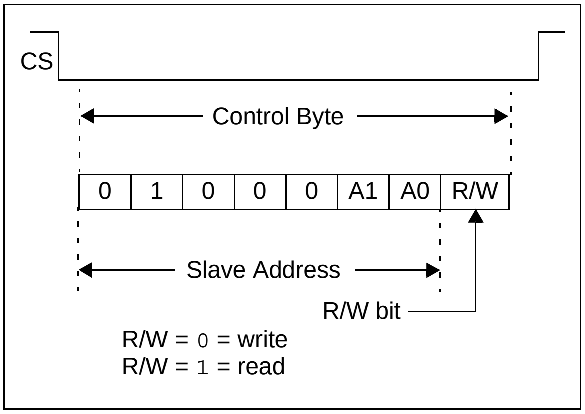


Interfacing using the SPI™ Protocol

DEVICE ADDRESSING

The MCP23S08 slave address contains five fixed bits and two user-defined hardware address bits (pins A1 and A0). Figure 6 shows the control byte format for the MCP23008. Refer to the MCP23008/MCP23S08 Data Sheet, *"8-Bit I/O Expander with Serial Interface"* (DS21919), for more information.

FIGURE 6: MCP23S08 CONTROL BYTE



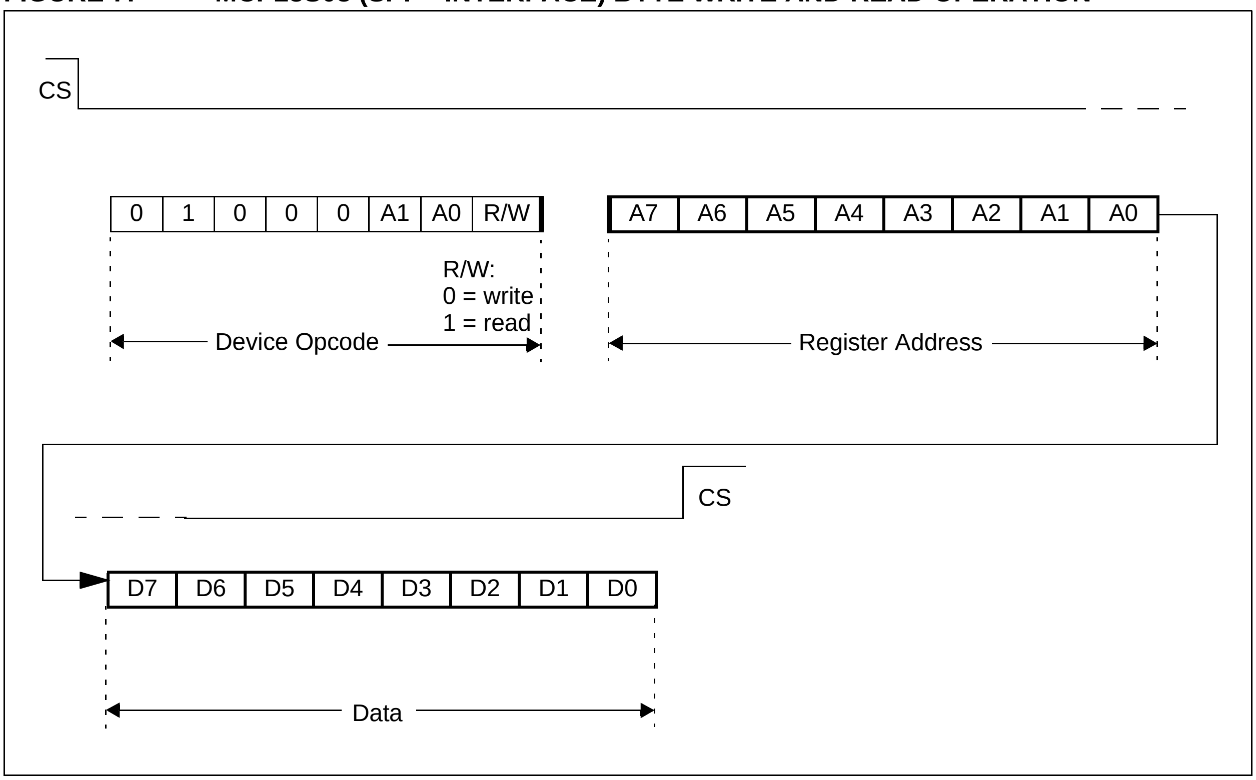
WRITING TO THE MCP23S08

The Write operation (Figure 7) is begun by lowering $\overline{CS}$. The Write command (slave address with R/W bit **cleared**) is then clocked into the device. The opcode is then followed by an address and at least one data byte.

READING FROM THE MCP23S08

Like the write operation, the read operation (Figure 7) is started by lowering $\overline{CS}$. The read command (slave address with R/W bit **set**) is then clocked into the device. The opcode is followed by an address and at least one data byte is clocked out of the device.

FIGURE 7: MCP23S08 (SPI™ INTERFACE) BYTE WRITE AND READ OPERATION



FIRMWARE DISCUSSION

For this application note, the I^{2}C and SPI drivers are implemented in firmware.

The firmware code is written in Microchip MPASM™ Assembler and MPLAB® IDE version 6.62 and is available free-of-charge on the Microchip web site (www.microchip.com).

Table 1 shows the files used.

TABLE 1: MPASM™ ASSEMBLER SOURCE CODE FILES

File Name	Description
`00010R1.ASM`	Main source code
`00010R1.LKR`	Linker script

Subroutines Used

The linker (`00010R1.LKR`) reserves the entire lower half (except for the reset code which reserves two locations) of the program space (1/2 page) for the subroutines. This can be seen in the linker file:

SECTION NAME=SUBROUTINES ROM=page0

CODEPAGE NAME=page0 START=0x02 END=0x0FF

TABLE 2: SUBROUTINES

Name	Description
I2CByteWrite	Writes a byte to the MCP23008 (I^{2}C™)
I2CByteRead	Reads a byte from the MCP23008 (I^{2}C)
I2CClockByte	Clocks 8-bits in the I^{2}C format. The data to be clocked is placed in “DataByte” variable
I2CStart	Applies a start condition (I^{2}C)
I2CStop	Applies a stop condition (I^{2}C)
I2CACK	The PIC10F202 sends an ACK on the I^{2}C bus.
NoACK	The PIC10F202 sends a No ACK (NACK) on the I^{2}C bus
IsACK?	Detects if the MCP23008 generated an ACK
SPIByteWrite	Writes a byte to the MCP23S08 (SPI™)
SPIByteRead	Reads a byte from the MCP23S08 (SPI)
SPIClockByte	Clocks 8-bits in the SPI format. The data to be clocked is placed in “DataByte” variable
ClockMode00	Sets the SPI clock in idle high. This is called at the beginning and end of the SPIByteWrite and SPIByteRead routines.

Flow Diagrams

FIGURE 8: MAIN PROGRAM FLOW

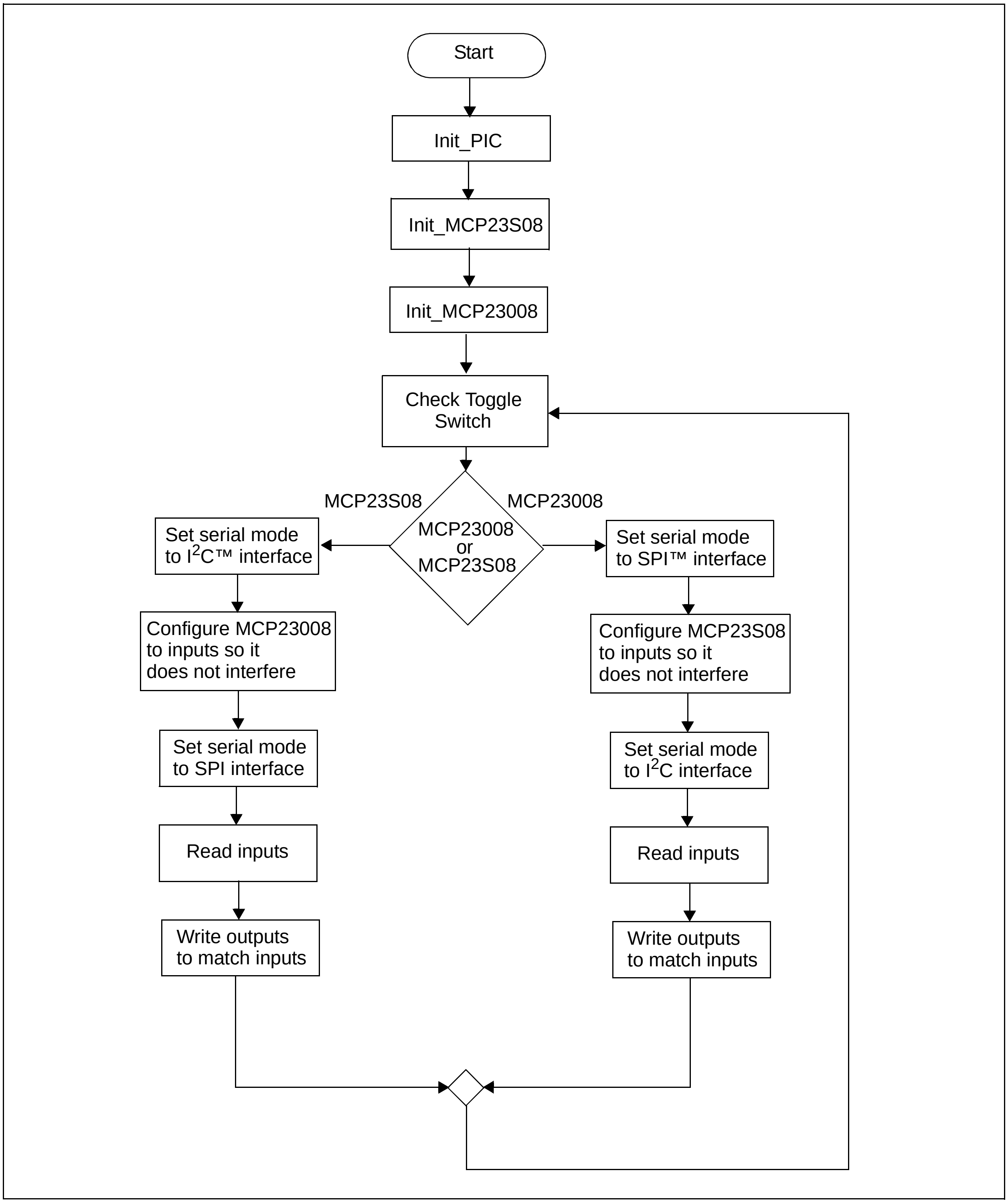


FIGURE 9: I²C™ BYTE WRITE

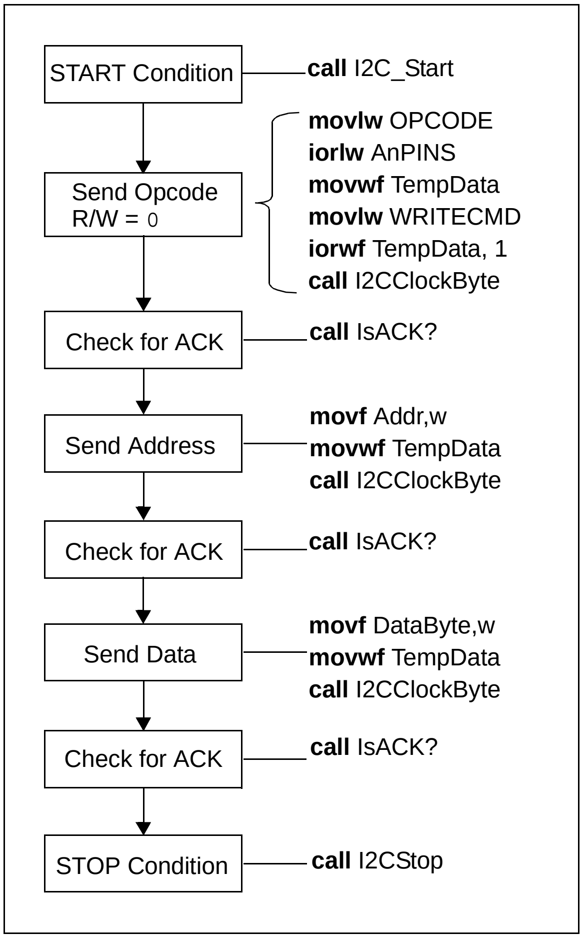


FIGURE 10: I²C™ BYTE READ

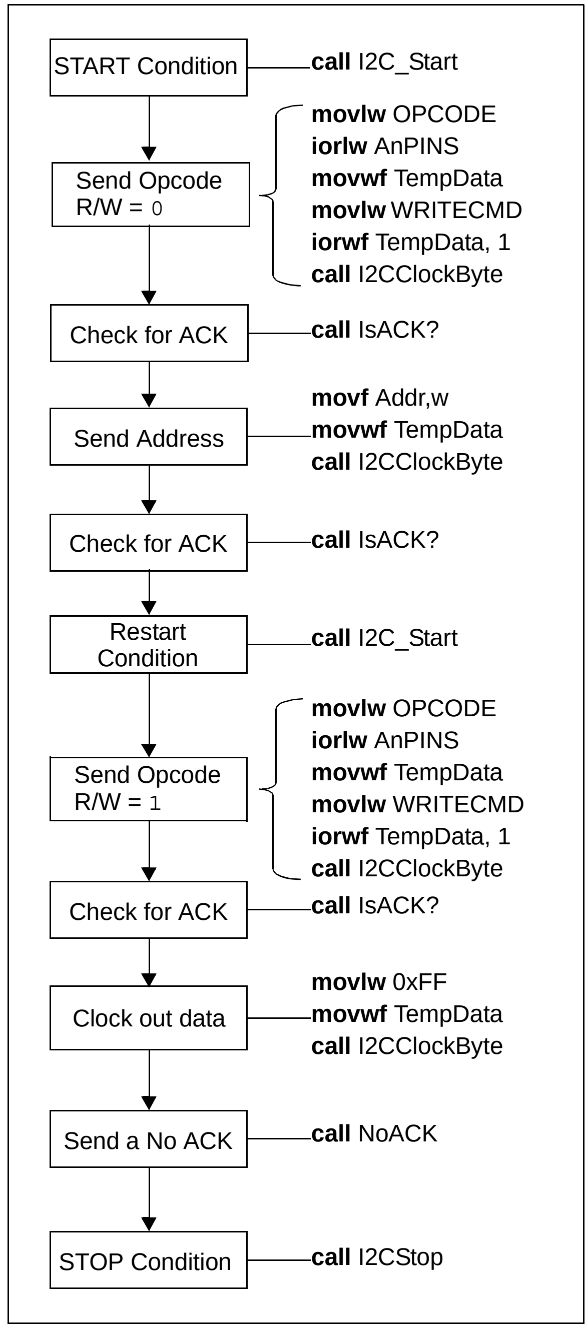


FIGURE 11: SPI™ BYTE WRITE

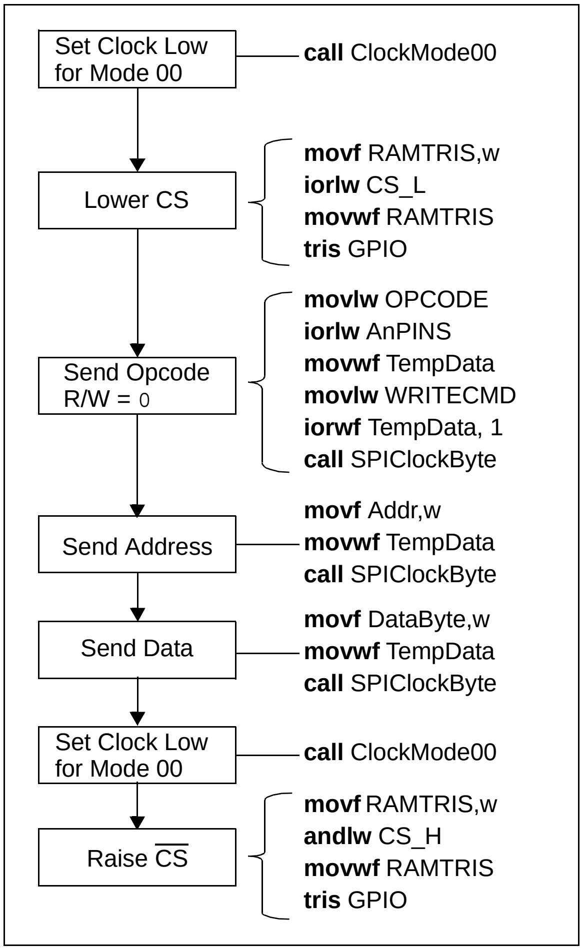
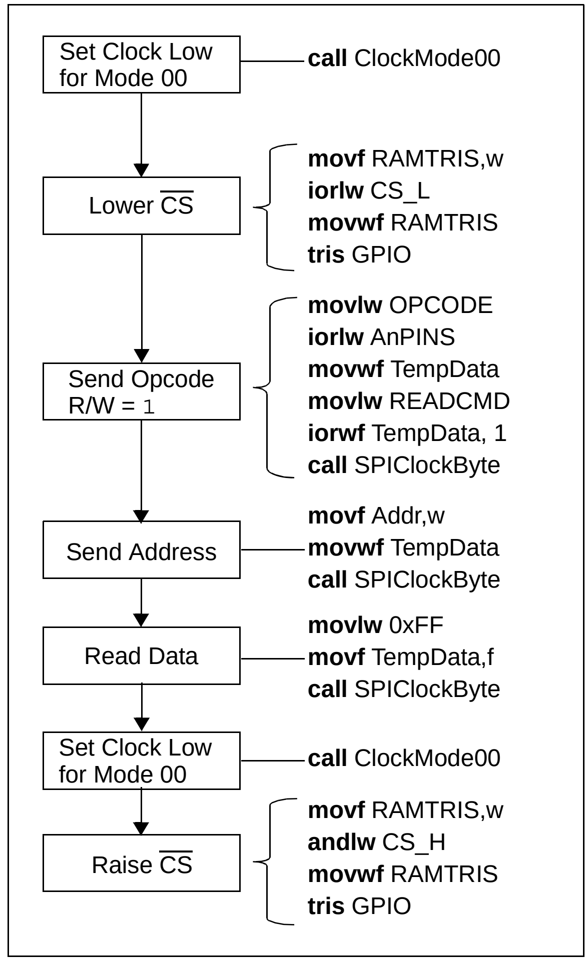


FIGURE 12: SPI™ BYTE READ



APPLICATION BOARD

Evaluation Board Overview

The MCP23008/MCP23S08 Evaluation Board is a simple demonstration of some of the MCP23X08 capabilities. The board consists of a 6-pin PIC10F202 and two MCP23X08 devices (1 – MCP23008 with an I^{2}C interface and 1 – MCP23S08 with a SPI interface). Additionally, there is a 4-bit DIP switch, four output LEDs, three headers and several unpopulated jumpers. Refer to Figure 13 for more information regarding the following topics.

PICmicro® MCU, MCP23X08 AND SELECTOR SWITCH

The PIC10F202 communicates with either device, depending on a selector switch setting. When the switch (SW1) is placed in the left position, the MCP23008 is selected for communication. When placed in the right position, the MCP23S08 is selected.

INPUT SWITCHES AND OUTPUT LEDS

The board is populated with a 4-bit DIP switch and four LEDs. The switches are connected to four GPIO pins configured as inputs, while the LEDs are connected to four GPIO pins configured as outputs.

When an input switch is toggled, the corresponding LED is toggled. This is explained more in the following sections.

HEADERS AND JUMPERS

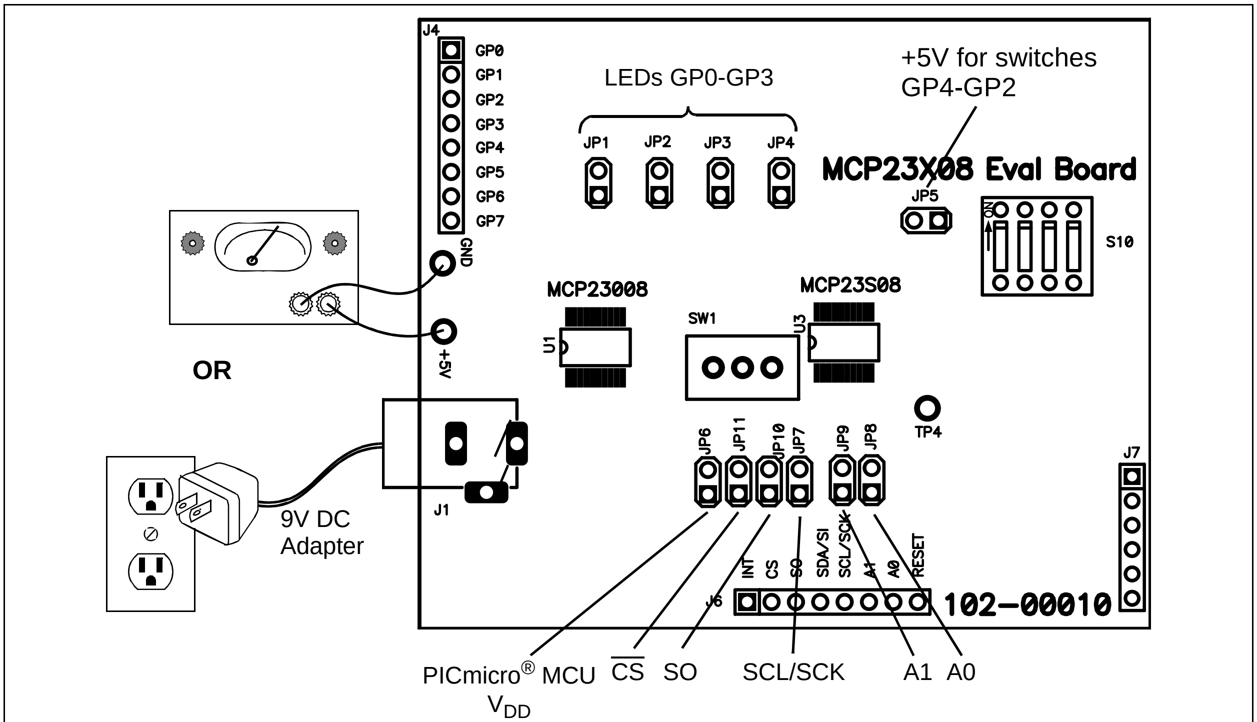
There are two headers that are associated with the MCP23X08 and one header for the Baseline Flash Microcontroller Programmer (BFMP) board, which is used to program the PIC10F202.

Note:	MPLAB® ICD 2 can also be used with this header if the standard ICD 2 cable is modified to a flat connector.

There are several jumpers (not populated) on the board. The purpose of the jumpers is to isolate the MCP23X08 pins from the PIC10F202, LEDs and switches so that another MCU can be used to evaluate the MCP23X08.

Note:	All of the jumper locations (except for JP10) are shorted on the bottom of the board by default. The trace on the bottom of the board must be cut, and the location populated, if the jumper is to have a function.

FIGURE 13: BLOCK DIAGRAM OF MCP23X08 EVALUATION BOARD



Note:	All jumpers (except JP10) are shorted by default with a trace on the bottom of the board.

APPENDIX A: SCHEMATICS

FIGURE A-1: BOARD SCHEMATIC - (SHEET 1 OF 4)

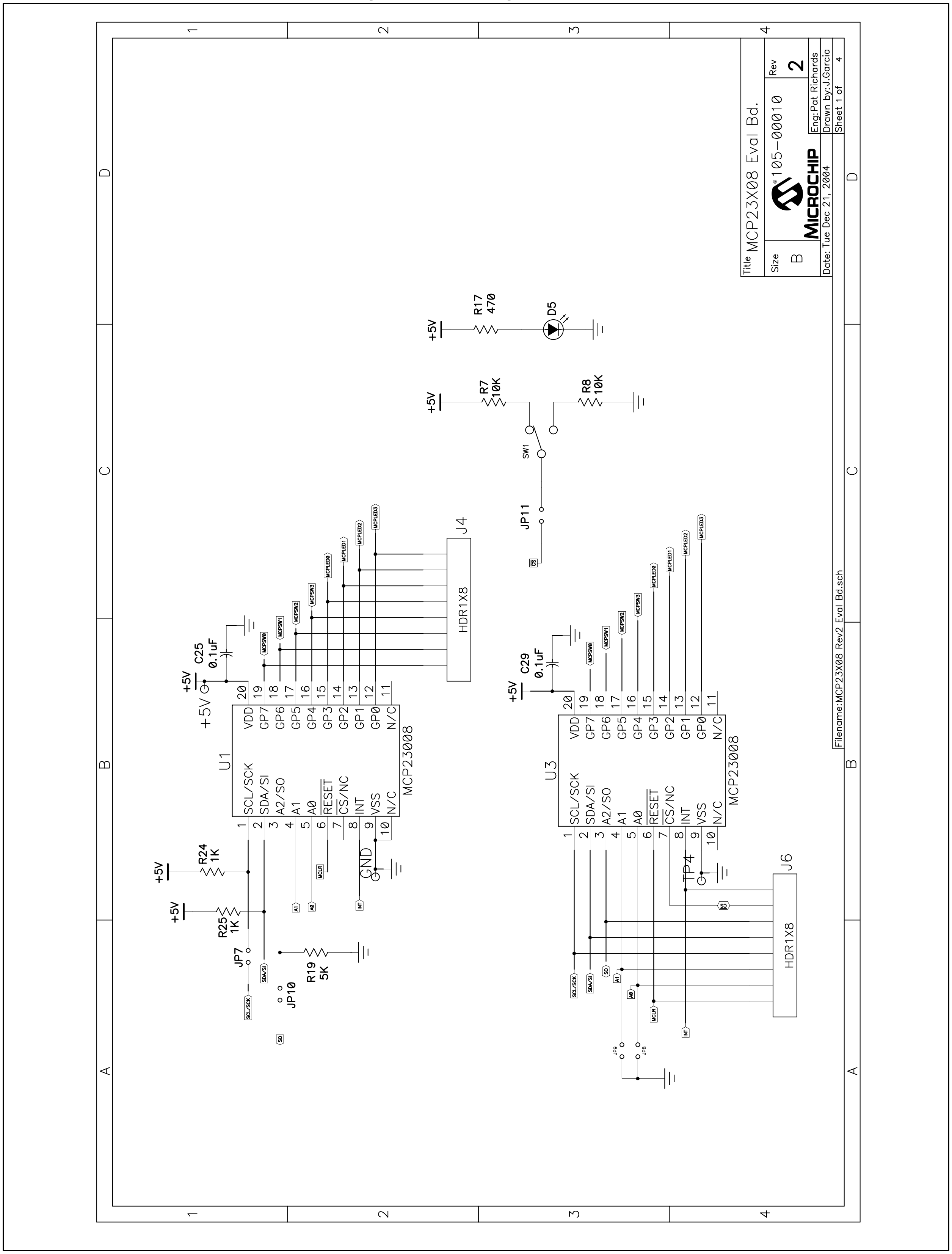


FIGURE A-2: BOARD SCHEMATIC - (SHEET 2 OF 4)

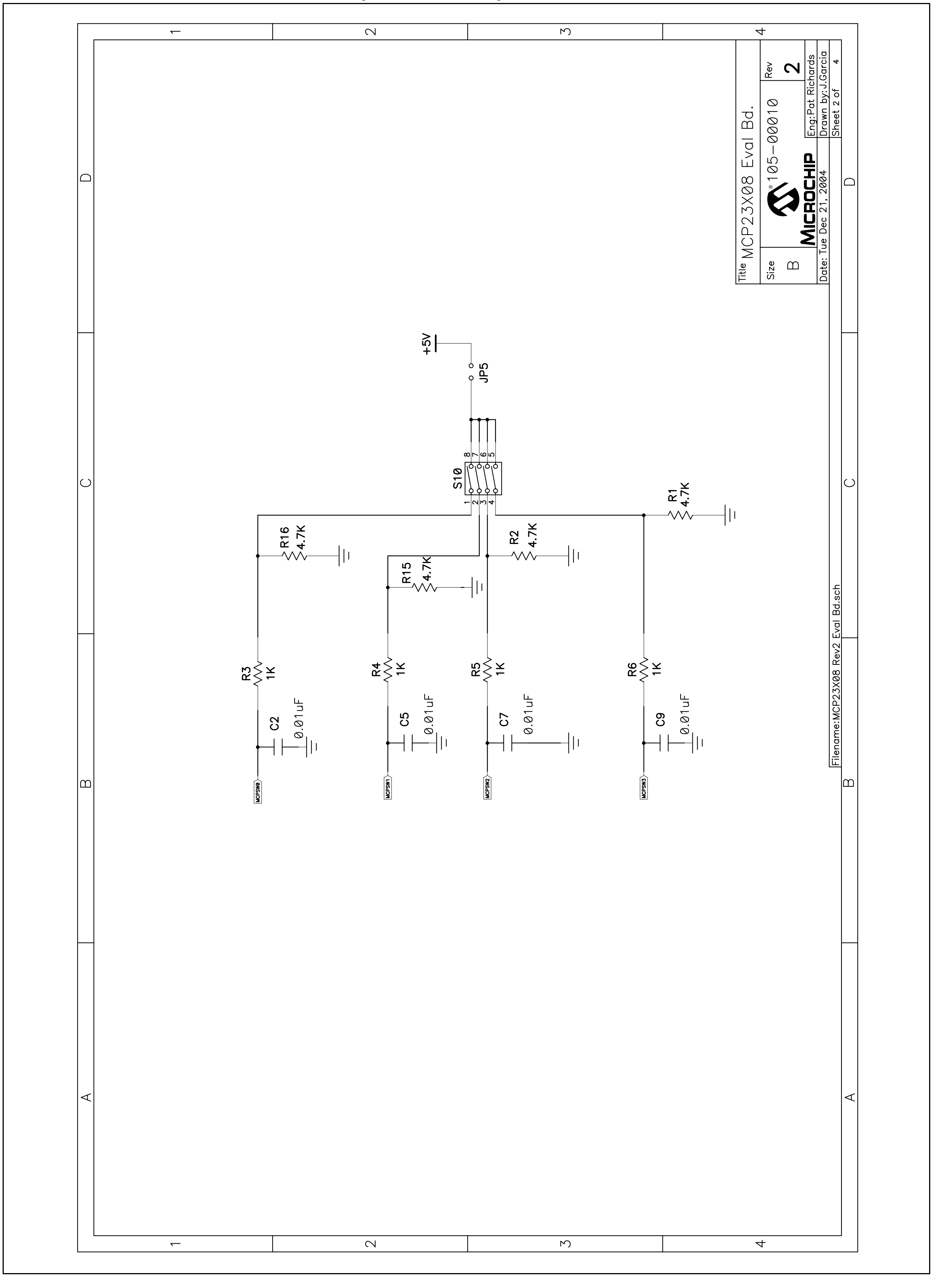


FIGURE A-3: BOARD SCHEMATIC - (SHEET 3 OF 4)

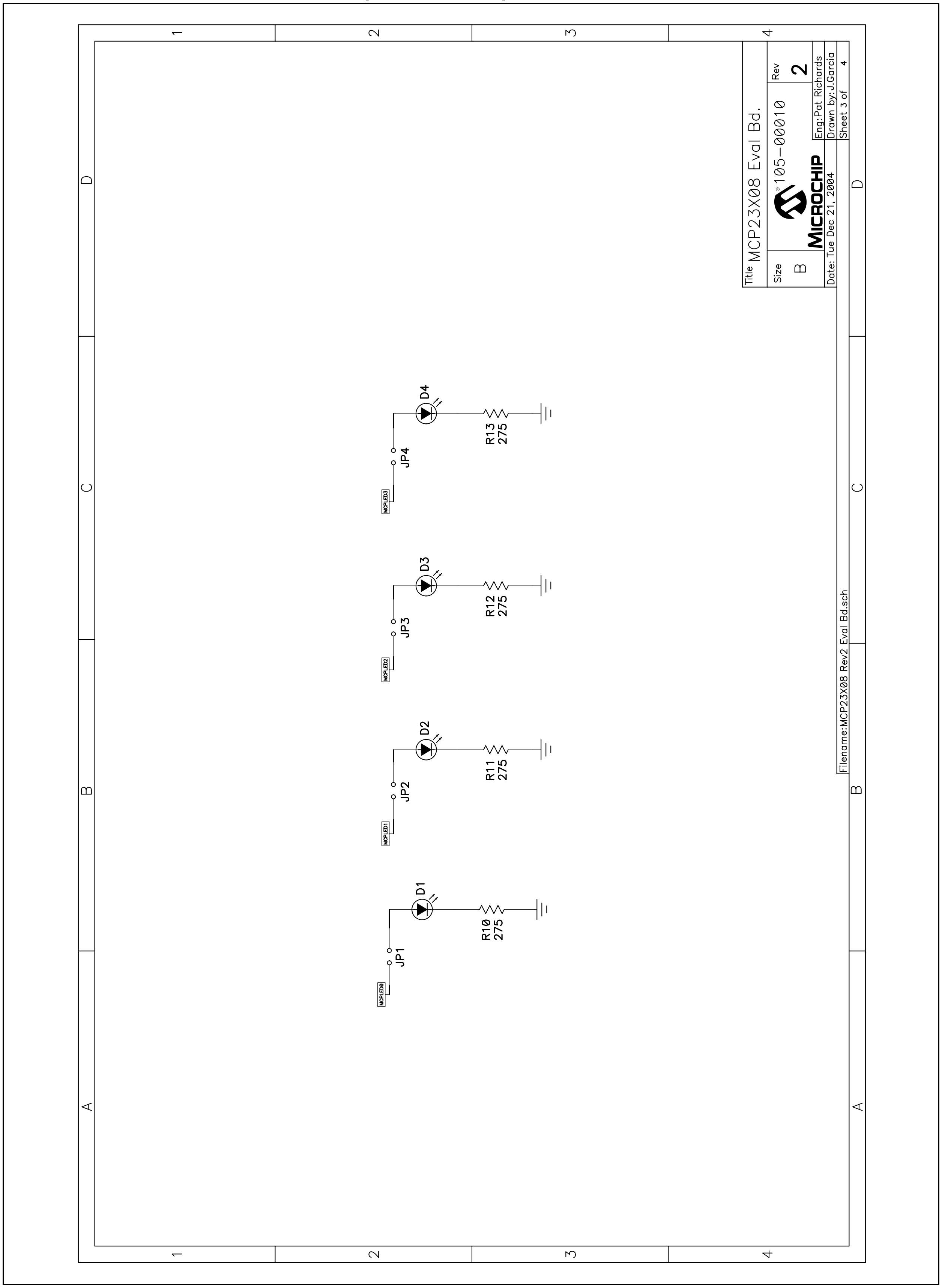
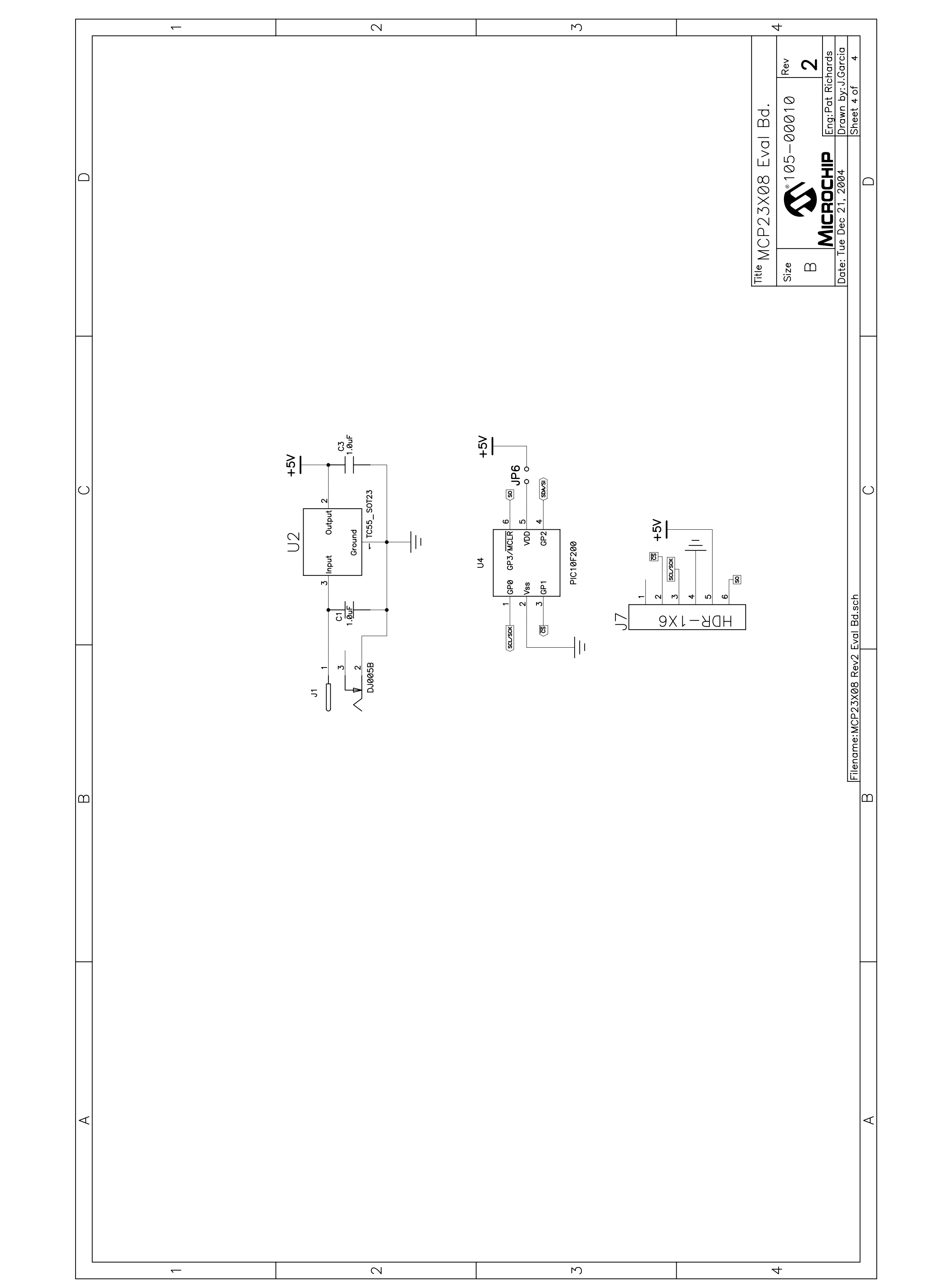


FIGURE A-4: BOARD SCHEMATIC - (SHEET 4 OF 4)



APPENDIX B: EVALUATION BOARD FIRMWARE

For the latest version of the MCP23X08 Evaluation Board firmware, visit the Microchip web site at www.microchip.com.

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