AN1018

Using the C18 Compiler to Interface SPI Serial EEPROMs with PIC18 Devices

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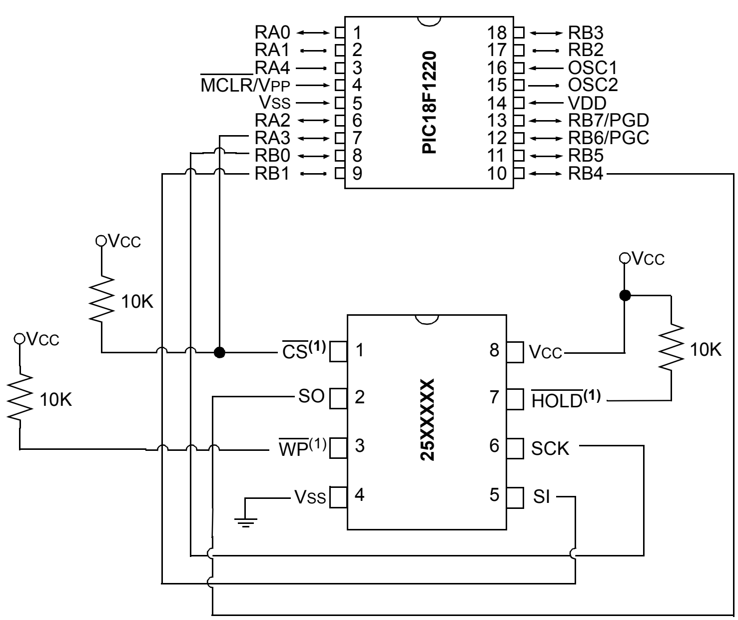
INTRODUCTION

The 25XXX series serial EEPROMs from Microchip Technology are SPI compatible and have maximum clock frequencies ranging from 3 MHz to 20 MHz. Many times when designing an application which utilizes a serial EEPROM device, it may be beneficial to use a microcontroller which does not feature a dedicated protocol-specific serial port. This can be due to several possible reasons, including size restrictions or costs. In these instances, it is required of the designer to write software routines capable of generating the proper signals for communicating with the EEPROM device.

This application note provides assistance and source code to ease the design process of interfacing a Microchip PIC18F1220 PICmicro® microcontroller to a Microchip SPI serial EEPROM, without the use of a hardware serial port.

Figure 1 describes the hardware schematic for the interface between Microchip's 25XXX series devices and the PIC18F1220 PICmicro microcontroller. The schematic shows the connections necessary between the microcontroller and the serial EEPROM as tested, and the software was written assuming these connections. The $\overline{WP}$ and $\overline{HOLD}$ pins are tied to VCC through resistors because the write-protect and hold features are not used in the examples provided.

FIGURE 1: CIRCUIT FOR PIC18F1220 AND 25XXX SERIES DEVICE



Note 1: $\overline{CS}$, $\overline{WP}$ and $\overline{HOLD}$ pins should all have pull-up resistors (~10K ohms).

FIRMWARE DESCRIPTION

The purpose of the program is to show individual features of the SPI protocol and give code samples of the instructions and addressing schemes so that the basic building blocks of a program can be shown. The firmware performs the following operations:

- Low-Density Byte Write
- Low-Density Byte Read
- Low-Density Page Write
- Low-Density Sequential Read
- Write Enable
- WIP Polling

In addition, the following operations are available but not explicitly illustrated:

- High-Density Byte Write
- High-Density Byte Read
- High-Density Page Write
- High-Density Sequential Read
- Write Disable
- Read Status Register
- Write Status Register

The low-density routines are intended for use with the 4K and smaller density devices that use only one byte for addressing. The high-density routines are intended for use with 8K and higher density devices that use two bytes for addressing. This program also exhibits the WIP polling feature for detecting the completion of write cycles after the byte write and page write operations. Read operations are located directly after each write operation, thus allowing for verification that the data was properly written. No method of displaying the input data is provided, but a SEEVAL® 32 evaluation system, an oscilloscope, or a Microchip MPLAB® ICD 2 could be used.

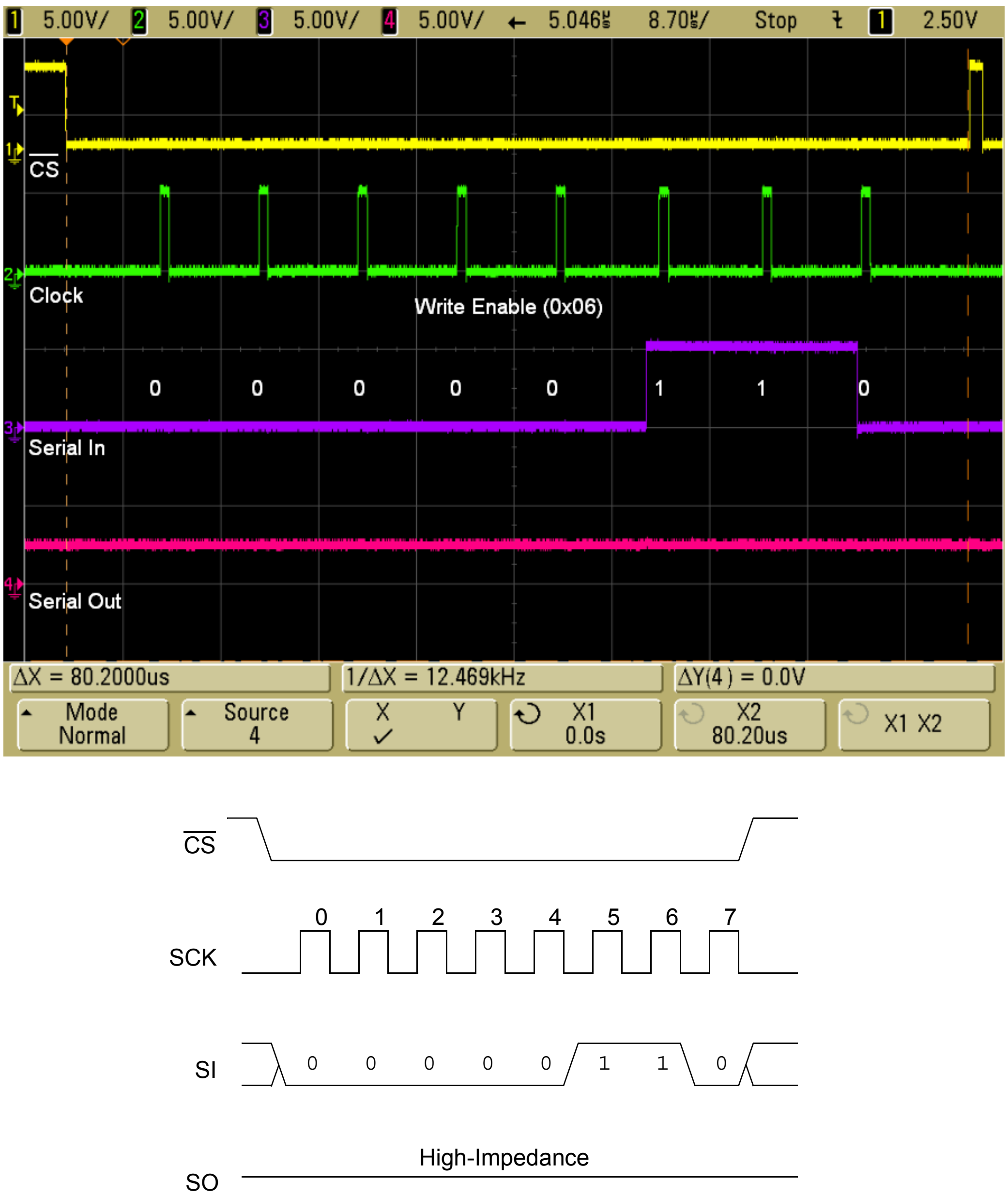
The low-density code was tested using the 25LC040 serial EEPROM. This device features 512 x 8 (4 Kbit) of memory and 16-byte pages. The high-density code was tested using the 25LC256 serial EEPROM. This device features 32K x 8 (256 Kbit) of memory and 64-byte pages. Only the low-density operations are illustrated in this application note.

Oscilloscope screen shots are labeled for ease in reading. The data sheet version of the waveforms are shown below the oscilloscope screen shots. All timings are designed to meet the data sheet specs, and a 10 MHz crystal oscillator is used to clock the PIC18F1220. If a different clock is used, the code may need to be modified to avoid violating timing specs. All values represented in this application note are decimal values unless otherwise noted.

WRITE ENABLE

Figure 2 shows an example of the Write Enable command. Chip Select is brought low (active) and the opcode (0x06) is shifted out. The Write Enable command must be given in order to set the WEL bit before a write is attempted to either the array or the STATUS register. The WEL bit can be cleared by issuing a Write Disable command (WRDI) and is also automatically reset if the device is powered down or if a write cycle is completed.

FIGURE 2: WRITE ENABLE (WREN)

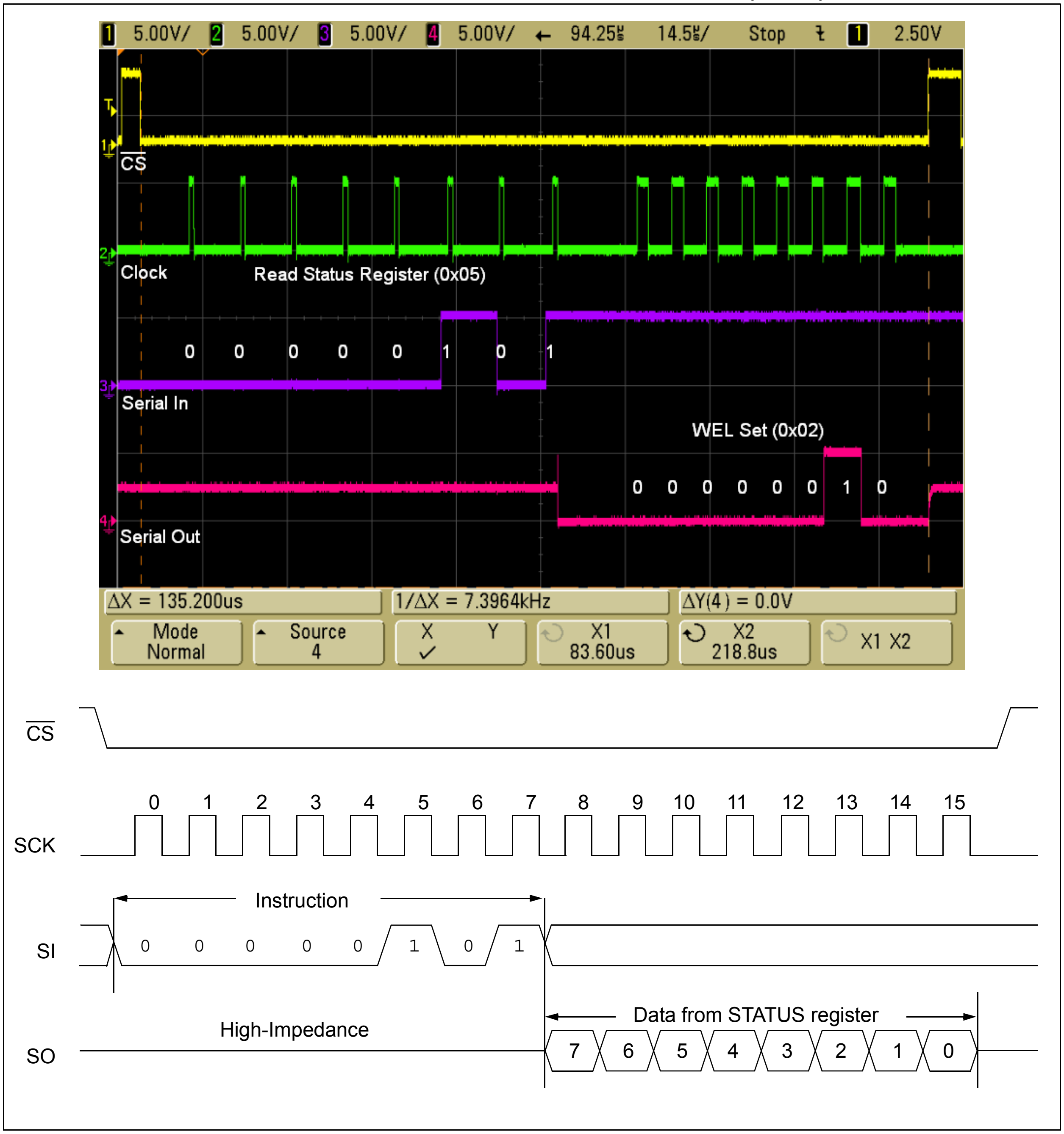


READ STATUS REGISTER TO CHECK FOR WEL BIT

Figure 3 shows an example of the Read Status Register command to check for the WEL bit. This bit must be set before a write is attempted to either the STATUS register or the array. It is good programming practice to check for the bit to be set before attempting the write. Once again the device is selected and the opcode (0x05) is sent.

The STATUS register is shifted out on the Serial Out pin. A value of 0x02 shows that the WEL bit in the STATUS register has been set. The device is now ready to do a write to either the STATUS register or the array.

FIGURE 3: READ STATUS REGISTER TO CHECK FOR WEL BIT (RDSR)



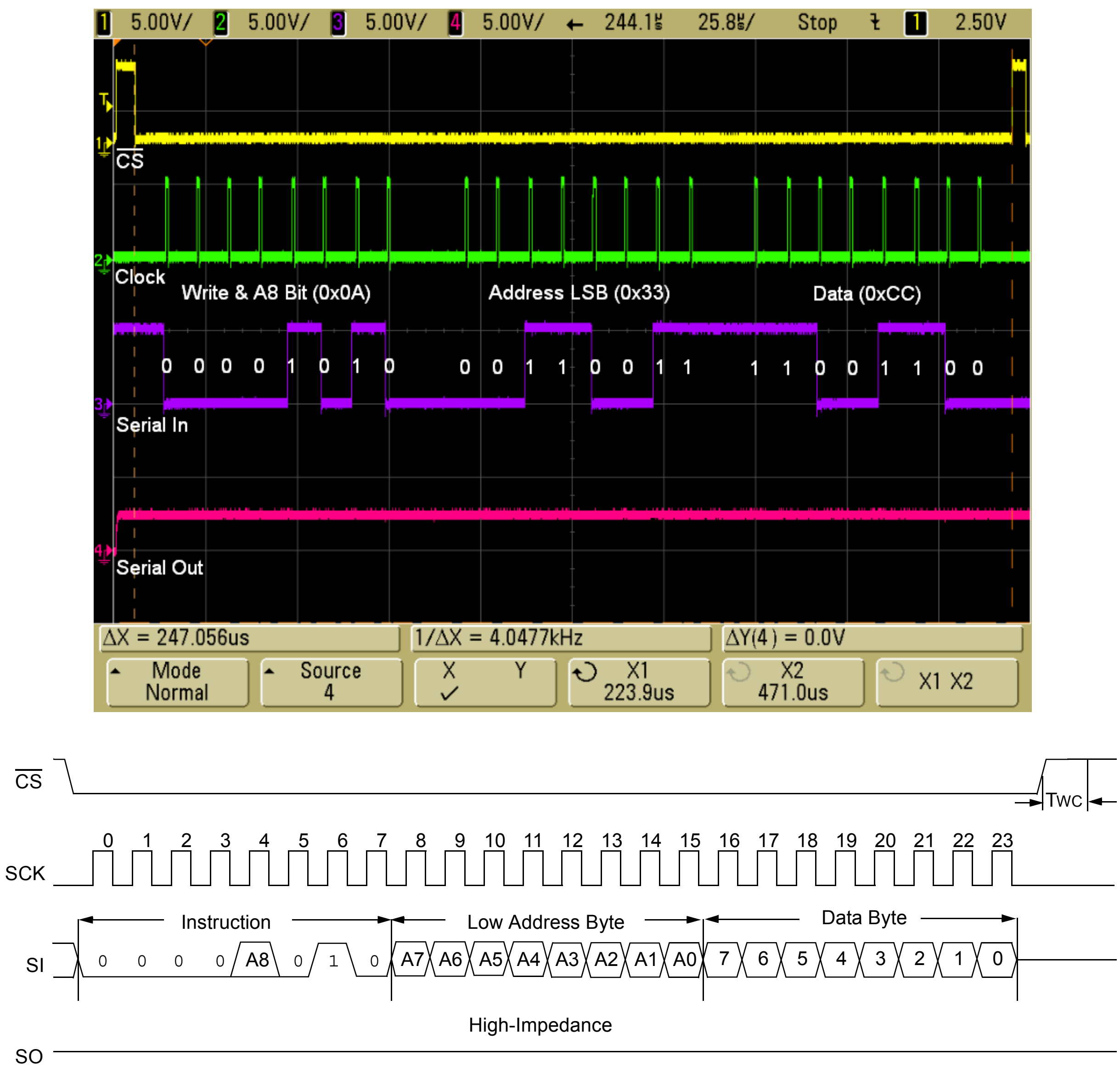
BYTE WRITE COMMAND (OPCODE, ADDRESS AND DATA)

Figure 4 shows an example of the Write command. First, the device is selected by bringing Chip Select low (active). In this example, the Most Significant bit of the address is a '1'. This bit is embedded in the opcode (0x02 for a Write command), and so the value, 0x0A, is sent. The Low Address byte (0x33) is sent next. Finally, the data is clocked in last, in this case, 0xCC. Once Chip Select is toggled at the end of this command, the internal write cycle is initiated. After the write cycle has begun, the WIP bit in the STATUS register can be polled to check when the write finishes. If polling is not used, a delay (~5ms) needs to be added to ensure the write has finished. This code uses WIP polling.

A page write can be accomplished by continuing to send data bytes to the device without toggling $\overline{CS}$. Up to 16 bytes can be written to the 25LC040 before a write cycle is needed. Once $\overline{CS}$ is brought high after the data bytes have been transmitted, then the write cycle timer will begin and normal polling can be initiated.

The Page Write function provided in the firmware is used to program 16 bytes of data, starting at address 0x150. Because page writes cannot cross page boundaries, care must be taken to avoid having data wrap around to the beginning of the page and overwrite existing data.

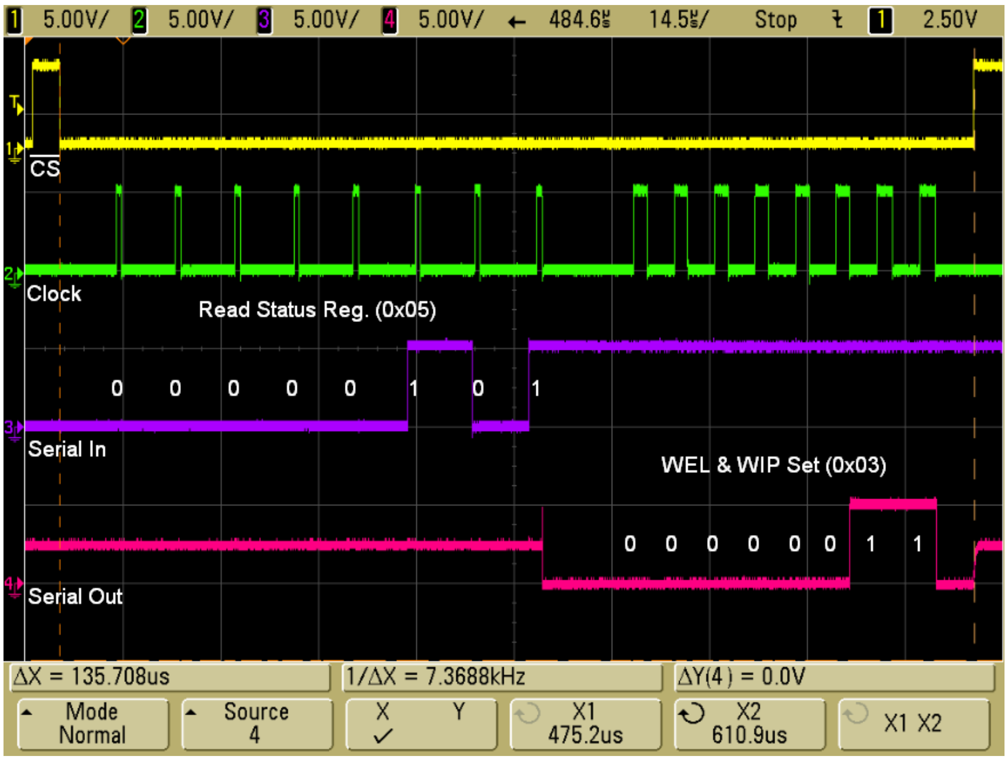
FIGURE 4: BYTE WRITE COMMAND, ADDRESS AND DATA

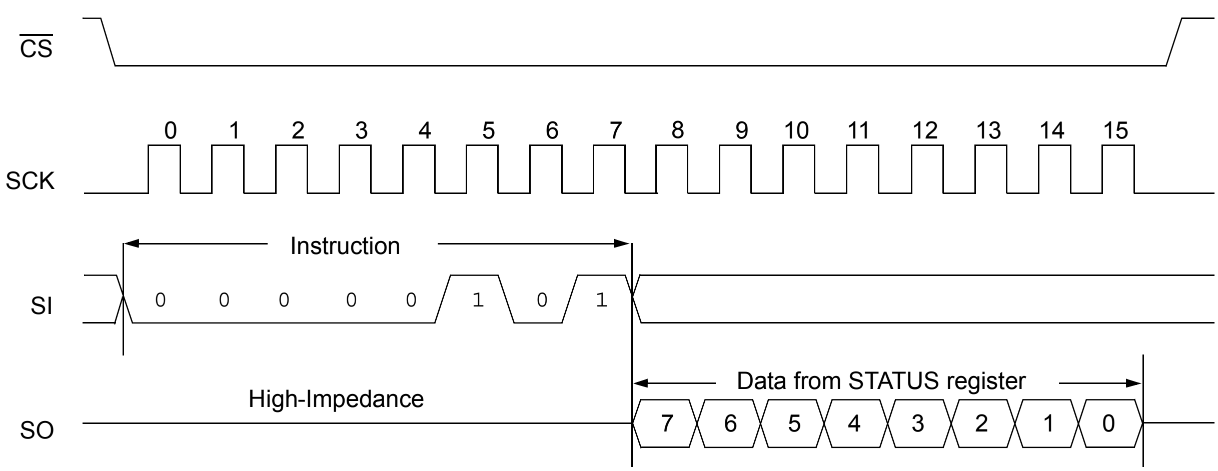


DATA POLLING (RDSR – CHECK FOR WIP SET)

After a valid Write command is given, the STATUS register can be read to check if the internal write cycle has been initiated, and it can continuously be monitored to look for the end of the write cycle. In this case, the device is selected and the RDSR opcode (0x05) is sent. The STATUS register is then shifted out on the Serial Out (SO) pin resulting in a value of 0x03. Figure 5 shows that both the WEL bit (bit 1) and the WIP bit (bit 0) are set, meaning that the write cycle is in progress.

FIGURE 5: DATA POLLING (READ STATUS REGISTER TO CHECK WIP BIT)

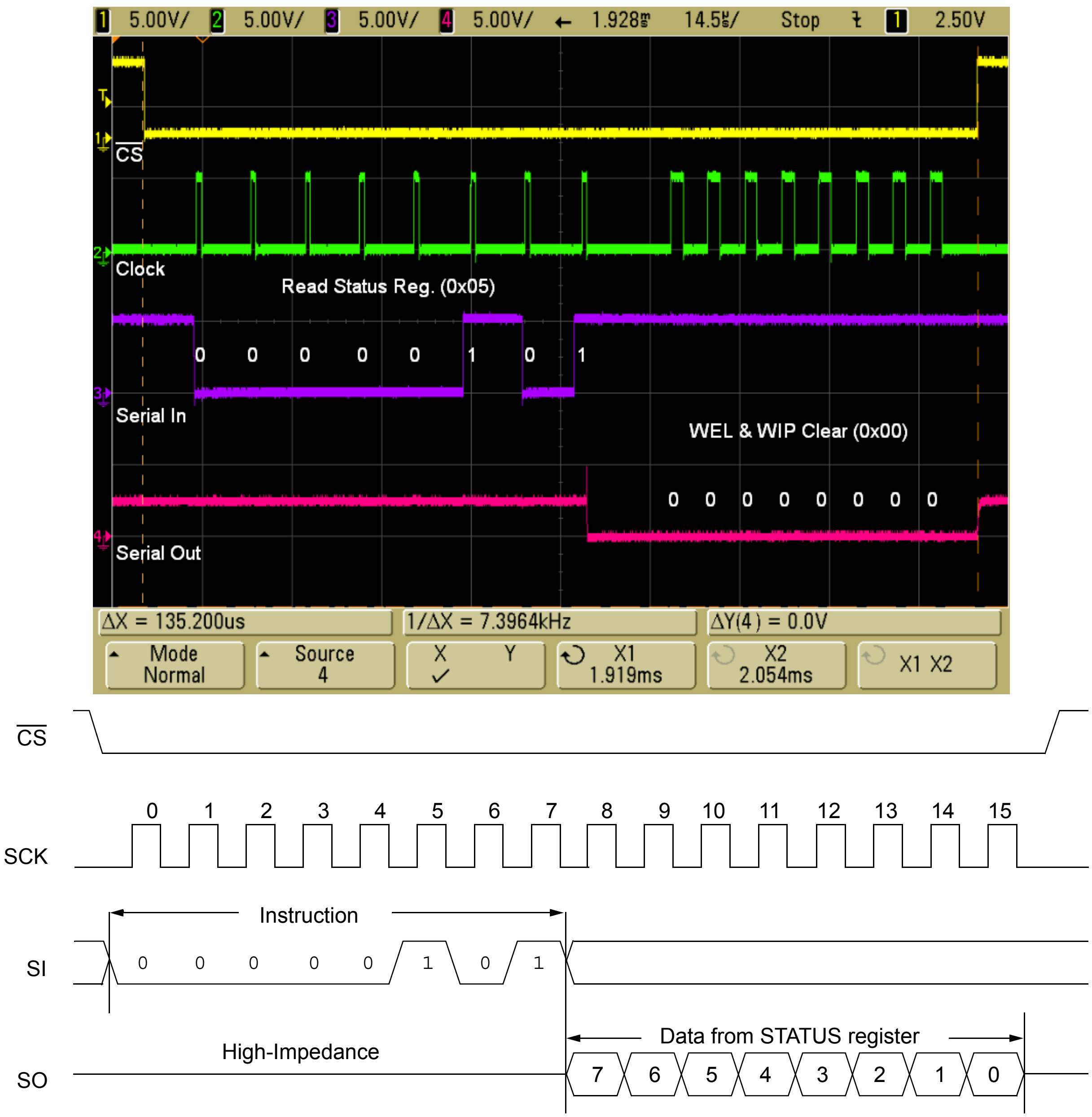




DATA POLLING FINISHED (RDSR – WIP BIT CLEARED)

The firmware remains in a continuous loop and the WIP status is evaluated until the bit is cleared. Figure 6 shows the Read Status Register command followed by a value of 0x00 being shifted out on the Serial Out (SO) pin. This indicates that the write cycle has finished and the device is now ready for additional commands. The WEL bit is also cleared at the end of a write cycle, which serves as additional protection against unwanted writes.

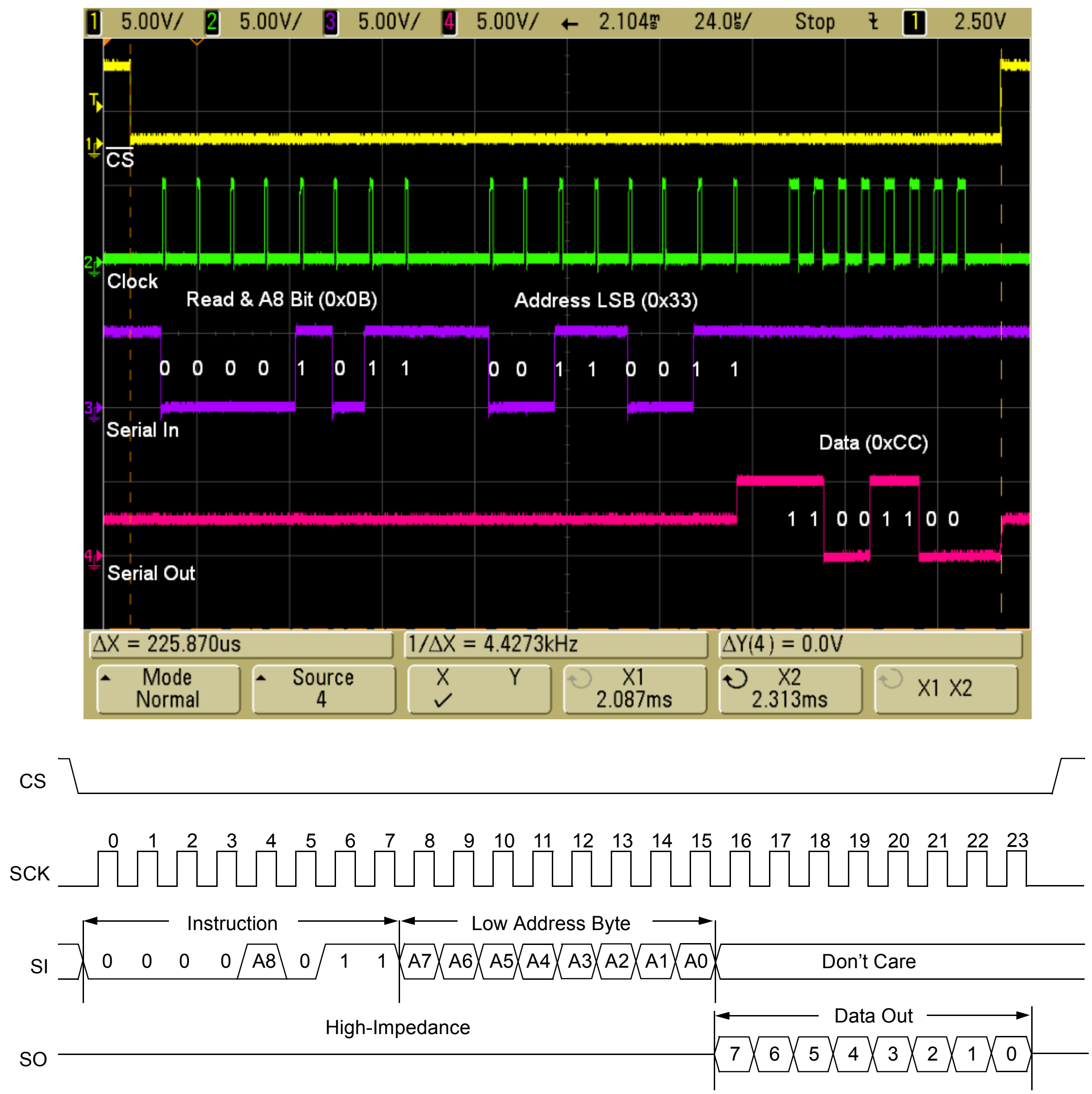
FIGURE 6: DATA POLLING FINISHED (RDSR – WIP AND WEL BITS CLEARED)



READ COMMAND (OPCODE, ADDRESS AND DATA)

Figure 7 shows an example of the Read command. For this, the device is selected. As with the Write command, the Most Significant bit of the address is a '1'. Therefore, when combined with the Read opcode (0x03), the value 0x0B is sent. The Low Address byte, 0x33, is then sent. Finally the data, 0xCC in this case, is clocked out on the Serial Out (SO) pin. In order to perform a sequential read, more clocks need to be generated. It is possible to read the entire chip by continuing to clock the device. Once the end of the array is reached, the data will wrap to the beginning of the array (address 0x000) and keep reading out until $\overline{CS}$ is deselected or the device is no longer being clocked.

FIGURE 7: READ COMMAND, ADDRESS AND DATA



CONCLUSION

These are some of the basic features of SPI communications on one of Microchip's PIC18 devices without the use of a hardware serial port. The code is highly portable and can be used on many PICmicro® microcontrollers with very minor modifications. Using the code provided, designers can begin to build their own SPI libraries to be as simple or as complex as needed. The code was tested on Microchip's PICDEM™ 2 Plus Demonstration Board with the connections shown in Figure 1.

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