Communicating with Daisy Chained MCP42XXX Digital Potentiometers

Authors: Craig L. King & Ezana Haile
Microchip Technology Inc.

OVERVIEW

The MCP41XXX and MCP42XXX family of digital potentiometers allow for daisy chaining of multiple devices on a single SPI™ bus. It is possible to communicate to multiple devices using one 3-wire data bus ($\overline{CS}$, CLK and DATA), by connecting the SO pin on one device to the SI pin of the next device in the chain. This application note details one example of source code that is used to communicate with eight daisy chained devices.

COMMUNICATION

Daisy chaining allows multiple devices to share the same clock and chip select line, freeing I/O pins on the microcontroller. Figure 1 shows connections for three devices. Note that the SO pin is connected to the SI pin of the next device in the chain. It is not recommended to use the single-channel MCP41XXX at the beginning or middle of a daisy chain, because this device does not have an SO pin. However, the MCP41XXX device can be connected at the end of the chain as shown in Figure 1. The waveforms in Figure 2 illustrates that data will be clocked out of the SO pin on the falling edge of the clock.

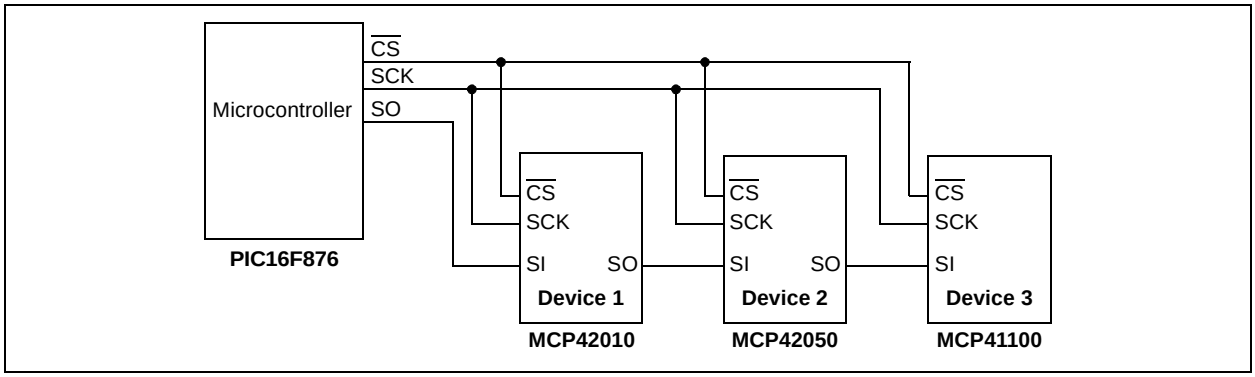

FIGURE 1: *Connections For Daisy Chained Devices*

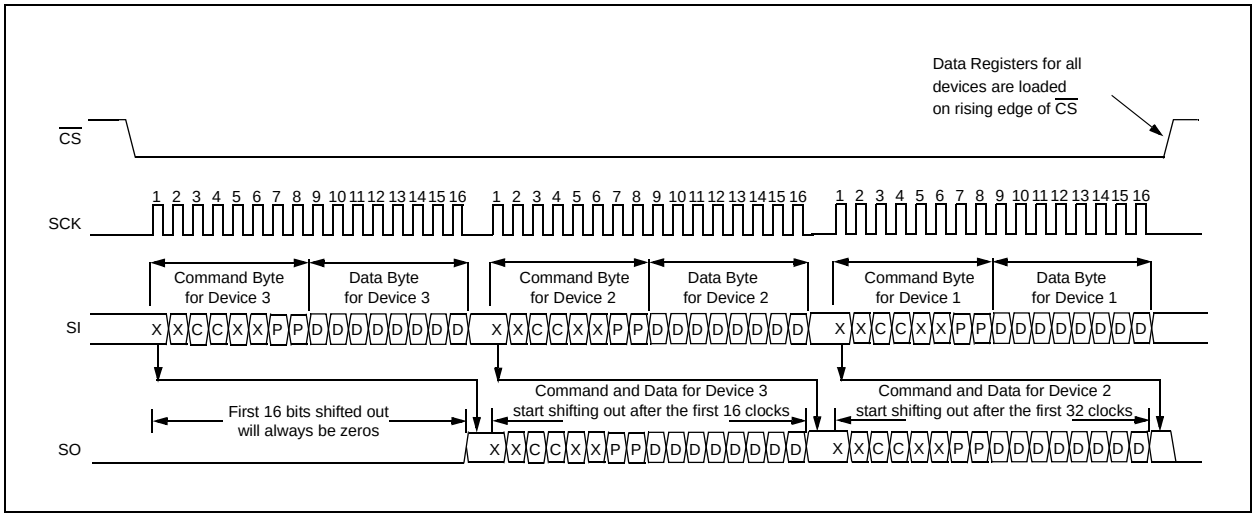

FIGURE 2: *Protocol For Daisy Chained Devices*

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On power-up and the rising edge of Chip Select ($\overline{CS}$), the shift register of each device is automatically loaded with zeros. Because of this, the first 16 bits that come out of the SO pin after the $\overline{CS}$ line goes low will always be zeros. Consequently, the first command that is loaded into a device in the daisy chain will invoke a NOP command into the next device in the chain. This feature makes it necessary only to send command and data bytes to the device farthest down the chain that needs a new command. For example, if there are three devices in a daisy chain and the device in the middle (second device) requires an update, four bytes need to be transmitted from the controller. The first two bytes are the command and data bytes for the second device and the last two bytes are the command and data bytes for the first device. The first device does not need to be updated, therefore, the command byte for this device should be `'XX00XXXX'`. The last device in the chain will have a NOP loaded from the previous device so no registers will be affected when the $\overline{CS}$ pin is raised to execute the command. The user must always ensure that multiples of 16 clock cycles are always provided (while $\overline{CS}$ is low), otherwise, commands will be ignored.

IMPLEMENTATION

This application uses a PIC16F876 to communicate with eight MCP42XXX devices on a single daisy chain. The MXDEV™ Analog/Mixed Signal Evaluation System hardware was used to test the code. The driver board was connected to the MCP42XXX digital potentiometer evaluation board and the additional seven digital potentiometers were interfaced by hardwiring to a breadboard.

Appendix A shows absolute assembly code communicating to the daisy chained devices. The communication is accomplished using the hardware SPI module. The command and data bytes required by the digital potentiometers are stored orderly in the program memory using a lookup table. The table order is formed so that the device at the end of the chain (device 8) has its command and data bytes at the top of the lookup table as shown in Figure 3.

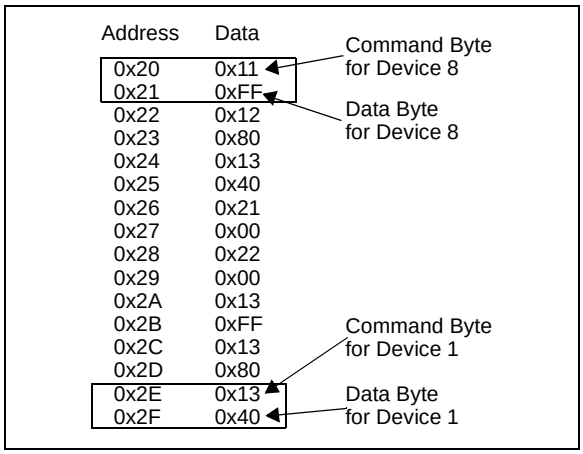

FIGURE 3: *Potentiometer Data Structure In RAM*

The source code initializes the Synchronous Serial Port (SSP) module on the PIC16F876 device to communicate in the SPI mode. A counter is used as a pointer to the program memory table. Initially, the counter is cleared and communication is initiated by pulling chip select low. Then the contents of the counter is transferred to the Working Register (W) and a call to the `TABLE` is executed to fetch the first command byte which is targeted to the 8th device. This command byte is transferred to the W register upon return from the call.

A call to the `TRANSMIT` routine transmits the content of the W register to the digital potentiometer through SPI. Then counter is incremented and the data byte fetching and transmission routine repeats. After the completion of the data byte transmission, the counter is incremented and checked for end-of-table.

The loop repeats for the next device (the seventh device). Once the first device in the chain is programmed with the corresponding byte, transmission is terminated by pulling Chip Select High. It is important to note that Chip Select is not pulled high until the command and data bytes for all eight devices on the chain have been transmitted.

MEMORY USAGE

In the MCP41XXX/42XXX Digital Potentiometer, the following memory was used:

Program Memory:	48 bytes
Data Memory:	0 bytes
EEPROM Memory:	0 bytes

REFERENCES

MCP41XXX/42XXX Single/Dual Digital Potentiometer with SPI Interface, Microchip Technology Inc., DS11195, 2000.

KEYWORDS

1	Potentiometer
2	Digital Potentiometers
3	MCP4XXXX
4	MCP41XXX
5	MCP42XXX
6	SPI
7	Daisy chain

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APPENDIX A: SOURCE CODE FOR COMMUNICATING WITH DAISY CHAINED DEVICES

```
;*************************************************************************************************
;                                                                                                *
;         COMMUNICATING WITH EIGHT DAISY CHAINED MCP42XXX DIGITAL POTENTIOMETERS                 *
;                                                                                                *
;                  - THIS PROGRAM IS ABSOLUTE ASSEMBLY USING THE HARDWARE                        *
;                  SPI MODULE TO PROGRAM THE DIGITAL POTENTIOMETERS                              *
;                                                                                                *
;*************************************************************************************************
;                                                                                                *
;                                                                                                *
;         Filename:          MCP42_Dzy.ASM                                                       *
;         Date:              01.30.2001                                                          *
;         File Version:      1.00                                                                *
;                                                                                                *
;         Assembler:         MPASM     VERSION 2.50                                              *
;                                                                                                *
;         PROGRAMER:         PRO MATE DEVICE PROGRAMMER, VERSION 5.30.00                         *
;                                                                                                *
;         File Required:     PIC16F876.inc                                                       *
;                                                                                                *
;         Author:            Ezana Haile/Craig L. King                                           *
;         Company:           Microchip Technology Incorporated                                   *
;                                                                                                *
;                                                                                                *
;*************************************************************************************************
;                                                                                                *
;                                                                                                *
;         This code demonstrates how to communicate to daisy-chained MCP42xxx digital            *
;         potentiometers. The potentiometers require a serial communication to program           *
;         the command byte and the data byte. This MCU (PIC16F876) has a built-in                *
;         Serial Peripheral Interface (SPI) which can be used to program the Pot                 *
;         effectively. There are eight daisy-chained digital Pots. This code programs            *
;         all at once and terminates. User would have to change the command and data             *
;         bytes from the table below and reprogarm the MCU.                                      *
;                                                                                                *
;                                                                                                *
;*************************************************************************************************


                  #include <p16f876.inc>
                  ERRORLEVEL -302
                  __CONFIG  _BODEN_OFF & _PWRTE_OFF & _CP_OFF & _WDT_OFF & _XT_OSC
```

```
;*****************************************************************************************
;********************  EQUATES  ******************************************************
;*****************************************************************************************

CS                EQU       H'00'     ;CHIP SELECT PIN

COUNTER           RES       1         ;COUNTER

;*****************************************************************************************
;********************  PROGRAM ORIGIN  ***********************************************
;*****************************************************************************************

                  ORG       0X00

;-----------------------------------------------------------------------------------------
;--------------------  PORTB AND SPI SETTING  --------------------------------------------
;-----------------------------------------------------------------------------------------

                  BSF       STATUS, RP0       ;SPECIFY BANK 1
                  MOVLW     H'00'
                  MOVWF     TRISA             ;SET PORTA AS AN OUTPUT
                  MOVWF     TRISC             ;SET PORTC AS AN OUTPUT
                  BCF       STATUS, RP0       ;SPECIFY BANK 0

                  CLRF      PCLATH            ;ENSURE PCLATH BIT 3 IS CLEARED
                  CLRF      INTCON            ;ENSURE ALL INTERRUPTS ARE DISABLED
                  MOVLW     0x30              ;
                  MOVWF     SSPCON            ;SET SYNC SERIAL PORT CONTROL REGISTER

;-----------------------------------------------------------------------------------------
;----------------------  PROGRAM ALL POTs USING LOOKUP TABLE -----------------------------
;-----------------------------------------------------------------------------------------

                  CLRF      COUNTER           ;SET THE COUNTER

                  BCF       PORTA, CS         ;INITIATE COMMUNICATION

LOOP              MOVF      COUNTER,W
                  CALL      TABLE             ;FETCH BYTE FROM THE LOOKUP TABLE
                  CALL      TRANSMIT          ;TRANSMIT THE COMMAND BYTE

                  INCF      COUNTER,F         ;INCREMENT COUTNER

                  MOVF      COUNTER,W
                  CALL      TABLE
                  CALL      TRANSMIT          ;TRANSMIT THE RESISTANCE VALUE

                  INCF      COUNTER,F
                  BTFSS     COUNTER,4         ;TEST FOR COMPLETION (END-OF-TABLE)
                  GOTO      LOOP

                  BSF       PORTA, CS         ;TERMINATE COMMUNICATION
                  GOTO      FINISH            ;FINISH
```


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```
;*****************************************************************************************
;--------------------------------  LOOKUP TABLE  ---------------------------------------
;*****************************************************************************************


TABLE
                  ADDWF    PCL,1             ; Add the offset on the program counter
                  retlw    0x11              ; Command Byte for Device 8 - Write P0
                  retlw    0XFF              ; Data Byte for Device 8
                  retlw    0x12              ; Command Byte for Device 7 - Write P1
                  retlw    0x80              ; Data Byte for Device 7
                  retlw    0x13              ; Command Byte for Device 6 - Write P0 and P1
                  retlw    0x40              ; Data Byte for Device 6
                  retlw    0x21              ; Command Byte for Device 5 - Shutdown P0
                  retlw    0x00              ; Data Byte for Device 5
                  retlw    0x22              ; Command Byte for Device 4 - Shutdown P1
                  retlw    0x00              ; Data Byte for Device 4
                  retlw    0x13              ; Command Byte for Device 3 - Write P0 and P1
                  retlw    0xFF              ; Data Byte for Device 3
                  retlw    0x13              ; Command Byte for Device 2 - Write P0 and P1
                  retlw    0x80              ; Data Byte for Device 2
                  retlw    0x13              ; Command Byte for Device 1 - Write P0 and P1
                  retlw    0x40              ; Data Byte for Device 1


;*****************************************************************************************
;----------------------------  TRANSMISSION SUBROUTINE  ----------------------------------
;*****************************************************************************************


TRANSMIT          BCF      STATUS, RP0       ;SPECIFY BANK 0
                  MOVWF    SSPBUF            ;PLACE DATA IN BUFFER TO SEND

                  BSF      STATUS, RP0       ;SPECIFY BANK 1
WAIT              BTFSS    SSPSTAT, BF       ;CHECK IF TRANSMISSION IS COMPLETE
                  GOTO     WAIT              ;
                  BCF      STATUS, RP0       ;SPECIFY BANK 0

                  RETURN                     ;RETURN FROM SUBROUTINE


;*****************************************************************************************


FINISH            GOTO     FINISH

                  END


;********************  END OF PROGRAM  ***************************************************
```

NOTES:

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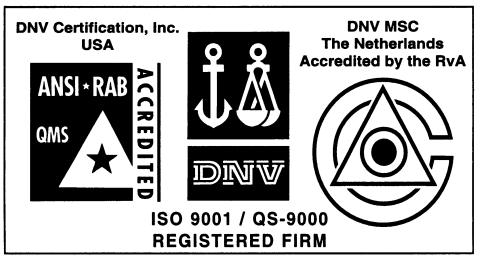

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San Jose
Microchip Technology Inc.
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San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

Toronto
6285 Northam Drive, Suite 108
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Tel: 905-673-0699 Fax: 905-673-6509

ASIA/PACIFIC

Australia
Microchip Technology Australia Pty Ltd
Suite 22, 41 Rawson Street
Epping 2121, NSW
Australia
Tel: 61-2-9868-6733 Fax: 61-2-9868-6755

China - Beijing
Microchip Technology Beijing Office
Unit 915
New China Hong Kong Manhattan Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Shanghai
Microchip Technology Shanghai Office
Room 701, Bldg. B
Far East International Plaza
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Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

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RM 2101, Tower 2, Metroplaza
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Microchip Technology Inc.
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1 Floor, Wing A (A3/A4)
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United Kingdom
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505 Eskdale Road
Winnersh Triangle
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