**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 (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

SPI™ is a trademark of Motorola Inc.
On power-up and the rising edge of Chip Select (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 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 CS pin is raised to execute the command. The user must always ensure that multiples of 16 clock cycles are always provided (while 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.

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:

<table>
<thead>
<tr>
<th>Memory Type</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Memory</td>
<td>48 bytes</td>
</tr>
<tr>
<td>Data Memory</td>
<td>0 bytes</td>
</tr>
<tr>
<td>EEPROM Memory</td>
<td>0 bytes</td>
</tr>
</tbody>
</table>

REFERENCES


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

#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’
MOVFTRISA ;SET PORTA AS AN OUTPUT
MOVFTRISC ;SET PORTC AS AN OUTPUT
BCF STATUS, RP0 ;SPECIFY BANK 0

CLR PCLATH ;ENSURE PCLATH BIT 3 IS CLEARED
CLR INTCON ;ENSURE ALL INTERRUPTS ARE DISABLED
MOVLM 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 COUNTER

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
;--------------------------------------------------------------------------
;----------------------------------  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

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