The PIC16C74 is one of the latest mid-range microcontrollers from Microchip Technology Inc. In this article we will be addressing a few of the new features and peripherals of this new part. The main focus will be on the A/D (Analog-to-Digital) Converter, the SCI (Serial Communication Interface), and the PWM (Pulse Width Modulator). Our intention is to give you a small program that initializes these peripherals as well as exercises them. A schematic is provided. The PICDEM™ 2 board from Microchip will run this program. The second trimpot does not exist on the PICDEM 2 board, so the second A/D value may float around. The second trimpot is only used to show a method of changing A/D input pins. If you are using the PICDEM 2 board, then the LED and a current limiting resistor must be connected to the PWM output. When the program is run, the RS-232 terminal will display two A/D values. The brightness of an LED is adjusted using pulse width modulation. The duty cycle is determined by the trimpot setting.

Assumptions

Although dangerous, sometimes we need to make assumptions. For this discussion on the PIC16C74, let us agree that RA0 and RA1 will be connected through a series resistor to the wipers on two potentiometers, with the other ends connecting across VDD and ground (see schematic). The oscillator clock will be 4 MHz. First, we’ll read an A/D input, send its result out the serial port (to be displayed on a PC terminal program), and then switch to the next channel. We will adjust the PWM output pulse width to match the first potentiometer. Each time we are ready to begin a new sequence, we will first send a pair of sync bytes to signal the receiving processor. To simplify our discussion, we will forgo using interrupts and we will do this in a polled fashion. The Watchdog Timer is disabled for this program.

To ensure there are no surprises, it is a good idea to initialize every Special Function Register (SFR) and data register to some known value prior to use.

A/D Converter Mysteries

The A/D converter and its eight input channels will be our first topic. Setting up the A/D converter involves two special function registers:

- ADCON0
- ADCON1

In the program included with this article, is a code segment initad that sets up the A/D. ADCON0 is the work horse register for this peripheral. This register is used to select the conversion clock frequency and channel. This register is also where we signal the start of a conversion and detect the completion of a conversion. ADCON1 has only one purpose in life for this part, and that is A/D port configuration. When ADCON1 is used, it does not override the TRISA register controls. The TRISA register must be set up. Once these registers are set up, all the program has to do is select the desired pin and set the GO/DONE bit in ADCON0. The program then waits for the conversion complete bit, GO/DONE, to be cleared by hardware. Then the ADRES (A/D conversion result register) register is read. The value from the first pot’s conversion is then used to adjust the PWM pulse width, thereby adjusting the LED brightness.
Pulse Width Modulation (PWM)

The PORTC<1> pin is used as the PWM output. The registers that need to be set up for this PWM operation are:

- TRISC
- T2CON
- CCP2L
- PR2
- CCP2CON.

The code init_pwm is an example of what might be done to initialize the PWM module. TRISC was cleared earlier, thus setting PORTC as output. By writing a "4" to the T2CON register, we will set the prescaler equal to 0 and select TIMER2 operation. Writing a 0Fh to the CCP2CON register selects PWM mode and standard resolution. The 0Fh written to the CCPR2L register sets the high period to a low value initially. Setting the PR2 register to FFh allows the CCPR2L value (from the A/D converter result) to approach a 100% duty cycle. Now we can control the brightness of the LED attached to this pin by adjusting the pot on pin RA0 and writing the A/D result to the CCPR2L register, as already described earlier.

SCI

The Serial Communications Interface Module is our RS-232 communications channel. We will configure the SCI as an asynchronous full duplex serial port. This is done with the routine at init_sci in the program provided. There are a few fine points to remember relative to this peripheral. The baud rate is determined by a dedicated eight-bit baud rate generator and can be used to derive standard baud rate frequencies from the oscillator. Since we are not using interrupts, there are only five registers to deal with:

- RCSTA - receiver status
- TXSTA - transmitter status
- TXREG - transmit buffer
- RCREG - receive buffer
- SPBRG - to set the baud rate generator

FIGURE 2: SERIAL COMMUNICATIONS INTERFACE MODULE

First global interrupts are disabled. The init_sci code does the serial port setup and the sendat code handles the actual sending of the data.

The SCI is setup for 2400 baud, 8 data bits and 1 STOP bit with no parity. A terminal program, such as TERMINAL in Windows®, set to the same settings can be used to see our output. If you use the Windows TERMINAL program, then set the communications parameters to 2400 baud, 8 data bits, 1 STOP bit, no parity and hardware handshake.

Tying The Pieces Together

The main loop for getting the process running and restarting it again is mloop. The adcnvrt routine handles port pin selection and actual conversion control. The dopwm routine handles updating the PWM duty cycle register CCPR2L. The routine sendat checks transmit ready status and loads the transmit buffer when the status reports ready. You will notice there is no error recovery routine. It is up to the user to determine.

Here is what the program will do:

Once all peripherals have been initialized, two sync bytes "< >" are sent to the terminal. The A/D conversion results are then sent and the LED brightness is adjusted to match the RA0 trimpot setting. To simplify displaying A/D values, only the highest nibble is used, and thirty is added to put it into an ASCII range.
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APPENDIX A: CARE AND FEEDING OF PIC16C74 SOURCE CODE

LIST P=16C74
INCLUDE P16CXX.INC ;new include file that comes with MPASM (on BBS)
Adcnt equ 20h ;a/d converter pin count register
Adcntw equ 21h ;a/d converter pin work register
Temp equ 22h ;temporary data holding register seems we always need one
org 0
goto init ;go to where our code really begins
org 5h ;begin program above interrupt service vector address
init bcf INTCON,7 ;make sure we don't get interrupted
clr PORTA ;don't rely on anything, set port latches where you want them
clr PORTB
clr PORTC
clr PORTD
clr PORTE
clr Adcnt ;clear RAM registers we will be using
clr Adcntw
clr Temp
bsf STATUS ,RP0 ;switch to page 1 to access trisX registers
clr TRISB ;set all ports outputs
clr TRISC ;just for this program to minimize current
clr TRISD ; and prevent pins from floating
clr TRISX
movlw 0Bh
movwf TRISA ;set analog inputs as inputs, the rest as outputs
bcf STATUS,RP0 ;
initad movlw 0C1h ;Internal RC A/D clock, input channel 0 , A/D on
movwf ADCON0 ;(user must wait for specified period before sampling)
bsf STATUS,RP0 ;select page 1 of the SFRs
movlw 4
movwf ADCON1 ;setup a/d inputs on RA0, RA1 and RA3 with Vref = Vdd
;we are still in page 1 of the SFRs
initsci movlw 19h ;setup 2400 baud
movwf SPBRG
movlw 20h ;setup for async operations
movlw 00h
movwf TXSTA
bcf STATUS,RP0 ;back to page 0 for a moment
movlw 08h ;enable serial port operations and the associated pins
movwf RCSTA
clr TXREG ;clear our serial port buffers for start up
clr RCREG
initpwm movlw 4h ;setup T2CON with prescaler = 0 and timer2 on
movwf T2CON
movlw 00h ;setup capture/compare to PWM mode standard resolution
movwf CCP2CON
movlw 00h ;set compare register to half for now
movwf CCP2R2L
bsf STATUS,RP0 ;select page 1 for the PR2 register
movlw 0ffh
movwf PR2
bcf STATUS,RP0
mloop movlw 0dh ;send a carriage return character
call sendat
movlw 3ch ;begin main loop for data gathering and serial transmission
call sendat ;these are our sync bytes to tell receiving micro a new
movlw 3eh ;sequence is beginning
call sendat
clr Adcnt ;our first time through select AN0 pin
adloop call adcnvrt ;go do a conversion and send the result
movf Adcnt,0 ;get Adcnt into the W register
xorlw 2 ;(# determines number of AD inputs to scan)
btfss STATUS,2 ;have we sampled all of the pins yet?
goto dopwm ;go adjust the PWM output
goto mloop ;all done go do it again
adcnvrt movf Adcnt,0 ;get a/d count value
movwf Adcntw ;put in work register
bcf STATUS,0 ;clear the carry flag for the upcoming rotate operations
rlf Adcntw,1 ;rotate left and leave the number in adcntw
rlf Adcntw,1 ;need to do it three times to put the count in the right
rlf Adcntw,1
movlw 0C1h ;load the initial ADCON0 value excepting channel select
iorwf Adcntw,0 ;set the pin select bits we want
movwf ADCON0 ;set the new ADCON0 with new channels selected
call wait ;wait about twenty micro seconds
bsf ADCON0,2 ;start conversion
incf Adcnt ;increment pin counter register
adwait btfs ADCON0,2 ;wait for conversion done
goto adwait ;not done yet
swapf ADRES,0 ;conversion done, swap result nibbles into W register
andlw 0Fh ;mask off the upper nibble to limit number to an ascii range
addlw 30h ;convert to ascii character to make it visible on terminal
sendat bsf STATUS,RP0 ;select page one
btfss TXSTA,1 ;check transmit status ready to send
goto sendat ;if not ready go try again
bcf STATUS,RP0 ;back to page 0
movwf TXREG ;transmit buffer empty send new data
return
dopwm movf ADRES,0 ;get the a/d conversion value
movwf CCPR2L ;put the value into the PWM duty cycle register
goto adloop
wait movlw 08h ;do a wait loop of before using a/d converter
movwf Temp
wl decfsz Temp
goto wl
return
end ;end of program
FIGURE A-1: PIC16C74 DEMO SCHEMATIC
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**San Jose**
Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

**Toronto**
6285 Northam Drive, Suite 108
Mississauga, Ontario L4V 1X5, Canada
Tel: 905-673-0699 Fax: 905-673-6509

## Asia/Pacific

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

**China - Beijing**
Microchip Technology Consulting (Shanghai) Co., Ltd., Beijing Liaison Office
Unit 915
Bei Hai Wan Tai Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

**China - Chengdu**
Microchip Technology Consulting (Shanghai) Co., Ltd., Chengdu Liaison Office
Rm. 2401, 24th Floor,
Ming Xing Financial Tower
No. 88 TIDU Street
Chengdu 610016, China
Tel: 86-28-6766200 Fax: 86-28-6766599

**China - Fuzhou**
Microchip Technology Consulting (Shanghai) Co., Ltd., Fuzhou Liaison Office
Unit 71 Wus Road
Fuzhou 350001, China
Tel: 86-591-7503050 Fax: 86-591-7503521

**China - Shanghai**
Microchip Technology Consulting (Shanghai) Co., Ltd., Shanghai Liaison Office
Rm. 1301, World Trade Plaza
No. 71 Wus Road
Shanghai, 2000051
Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

**China - Shenzhen**
Microchip Technology Consulting (Shanghai) Co., Ltd., Shenzhen Liaison Office
Rm. 1315, 13/F, Shenzhen Kerry Centre,
Renminnan Lu
Shenzhen 518001, China
Tel: 86-755-2350361 Fax: 86-755-2366086

**Hong Kong**
Microchip Technology Hong Kong Ltd.
Unit 901-6, Tower 2, Metroplaza
223 Hing Fong Road
Kai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

**India**
Microchip Technology India.
India Liaison Office
Divyasee Chambers
1 Floor, Wing A (A3/A4) No. 11, O’Shaughnessy Road
Bangalore, 560 025, India
Tel: 91-80-2290061 Fax: 91-80-2290062

**Japan**
Microchip Technology Japan K.K.
Benex S-1 6F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa, 222-0033, Japan
Tel: 81-45-471-6166 Fax: 81-45-471-6122

**Korea**
Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea 135-882
Tel: 82-2-554-7200 Fax: 82-2-558-5934

**Singapore**
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore, 189980
Tel: 65-6334-8870 Fax: 65-6334-8850

**Taiwan**
Microchip Technology Taiwan
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

## Europe

**Denmark**
Microchip Technology Nordic ApS
Regus Business Centre
Lautrup høj 1-3
Ballrup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

**France**
Microchip Technology SARL
Parc d’Activite du Moulin de Massy
43 Rue du Saule Trapu
Batiment A - ier Etage
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

**Germany**
Microchip Technology GmbH
Gustav-Heinemann Ring 125
D-81739 Munich, Germany
Tel: 49-89-6275-5060 Fax: 49-89-6275-5060

**Italy**
Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-039-65791-1 Fax: 39-039-6899883

**United Kingdom**
Microchip Technology Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5869 Fax: 44-118 921-5820

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