



# Software Interrupt Techniques

## INTRODUCTION

This application note describes a unique method for implementing interrupts in software on the PIC16C5X series of microcontrollers. The method takes advantage of the PIC16C5X's architecture which allows changing the program counter under software control. Up to eight interrupt lines are possible, but the practical limit for simple code generation is six interrupts, or 64 possible input conditions. The interrupt detection time is under software control and standard I/O pins are used as the interrupt lines.

## THEORY OF OPERATION

### SOFTWARE POLLING OF I/O LINES REPLACES HARDWARE INTERRUPT

The interrupt conditions are determined by detecting changes on the I/O lines that have been selected to be the interrupt lines. These changes are used to create a jump table that allows a different program response to each interrupt condition. The interrupt response time is under software control and can be as short as ten to twenty microseconds, depending on main program and interrupt subroutine program length.

### CREATING THE INTERRUPT SUBROUTINE JUMP TABLE

Each I/O condition may have its own unique subroutine to respond to changes on the interrupt lines. Direct access to these routines is achieved by using the PIC16C5X's ability to change the program counter under software control. Here is an example of how two I/O lines may be polled:

```

MOVF  CONDTN,W  ;LOAD I/O CONDITION INTO W
                ;REGISTER
ANDLW  3        ;MASK OFF TOP 6 BITS
ADDWF  2,1      ;ADD INPUT TO PROGRAM COUNTER
                ;TO CREATE JUMP TABLE
GOTO   MAIN     ;FOR NO CHANGE GO TO MAIN
                ;PROGRAM
GOTO   INT1     ;FOR CHANGE IN BIT 0 GOTO INT1
GOTO   INT2     ;FOR CHANGE IN BIT 1 GOTO INT2
GOTO   INT3     ;FOR BOTH CHANGE GOTO INT3

```

The changes to the I/O lines have been used to create a two bit number that is added to the program counter. The GOTO that is executed depends on the new program counter address.

## CREATING CONSTANT TIME POLLING

In most applications requiring interrupts, it is important to poll the interrupt lines at fixed time intervals, usually only a few microseconds in length. Two techniques may be used on the PIC16C5X to achieve this. They are dividing the main program into multiple sections and implementing an elapsed time counter (see flow chart). Both of these techniques use the same program jump table concept that was described above. First, the main program is divided into several sections based on the desired I/O polling time. When MAIN is called a branch register is added to the program counter. This determines which section of MAIN code should be executed next. At the end of execution the branch register is decremented so the next section of code will be executed after the next polling. If the branch register is zero then the number of sections of main code is added into it to start the main program over again.

An elapsed time counter can be implemented using the RTCC counter. At the beginning of I/O polling the RTCC register is cleared. It then starts counting the instruction cycles. Then after the main program subsection has been executed, the RTCC register is subtracted from the desired polling time. This determines how many instructions need to be executed before the next polling. A jump table is then created to execute these instructions before the next polling. An example is shown below. This example assumes from zero to 15 additional instruction cycles are needed. Actual numbers need to be computed for each individual application.

```

MOVLW  POLL    ;POLL=DESIRED POLL CYCLES - 15
SUBWF  RTCC,W  ;DETERMINE HOW MUCH TIME TO WAIT
ADDWF  2,1     ;ADD WAIT TIME TO PROGRAM COUNTER
NOP                    ;15 ADDITIONAL INSTRUCTION CYCLES
:
:                    ;TOTAL OF 15 NOP'S
NOP                    ;1 ADDITIONAL INSTRUCTION CYCLES
GOTO   START     ;0 ADDITIONAL INSTRUCTION CYCLES

```

# Software Interrupt Techniques

For example, if the desired instruction time is 50 cycles and the subsection we just executed has consumed a total of 40 instruction cycles (including all overhead cycles) the value of

$$RTCC(40) - POLL(50-15(35)) = 5$$

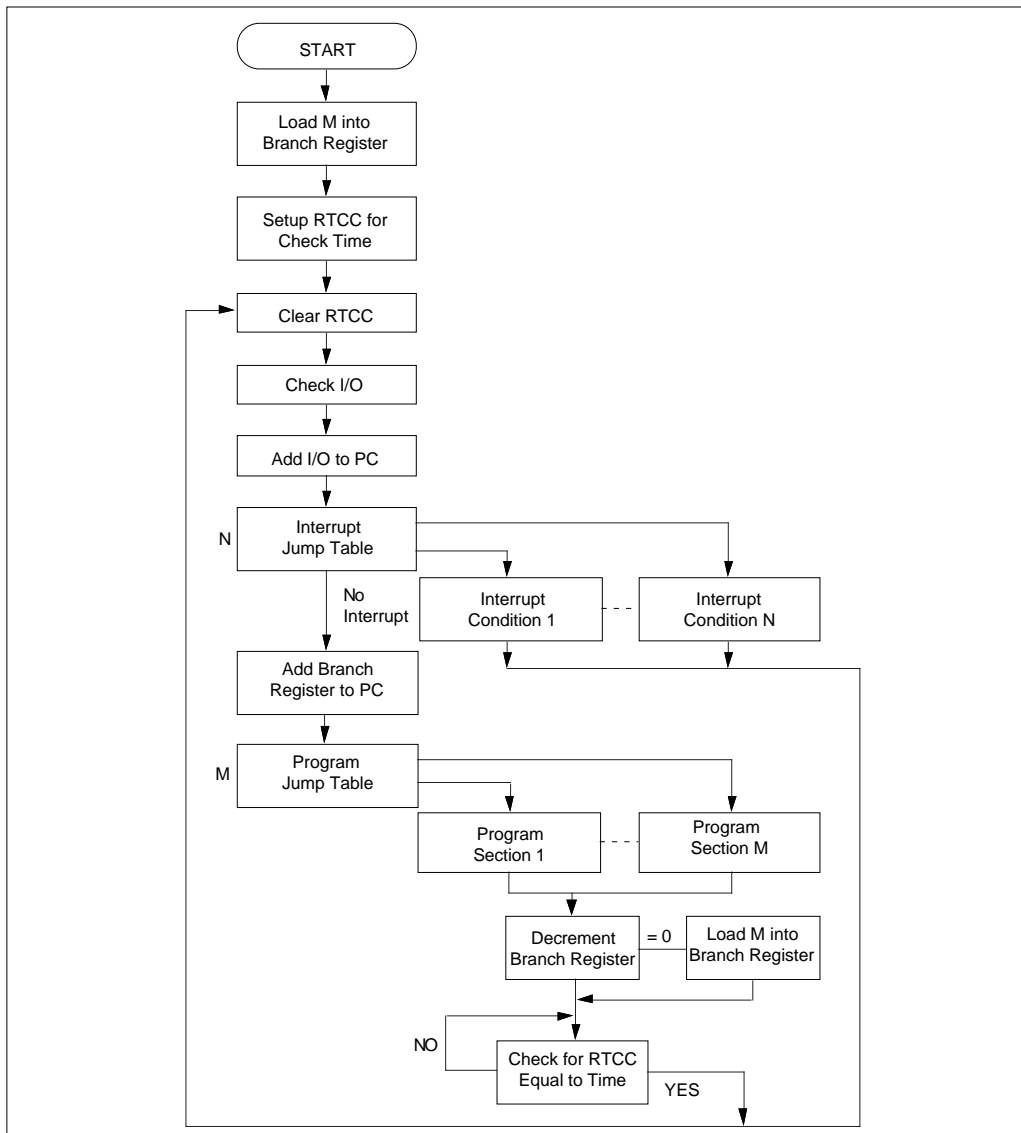
will be added to the program counter. The program will then jump to the sixth NOP. That NOP plus the 9 following it will be executed for a total of ten more instruction cycles. Note that the final GOTO has two

instruction cycles and these must be included in the program overhead.

## Example

The following example (see flow chart and code) is the core program for the software interrupt technique described above. This program assumes four interrupt conditions, four main program sections and an eight additional elapsed time instructions.

**FIGURE 1 - SOFTWARE INTERRUPT FLOW CHART**



## APPENDIX A:

MPASM B0.54

PAGE 1

```

                                LIST    P=16C54

                                ;SOFTWARE INTERRUPT APPLICATIONS
                                ;BRANCH IS MAIN PROGRAM REGISTER

0008          BRANCH EQU      8
0009          CNDTN EQU      9
000A          IO    EQU      0A
000B          TEMP  EQU      0B

0000 0069          SETUP  CLRF  CNDTN
0001 0C04          MOV LW  4
0002 0028          MOV WF  BRANCH ;FOUR MAIN PROGRAM SECTIONS
0003 0C08          MOV LW  8
0004 0002          OPTION  ;SET RTCC TO ONE COUNT PER INSTRUCTION CYCLE

0005 0061          START  CLRF  1      ;CLEAR RTCC REGISTER
0006 0206          MOV F  6,W      ;READ I/O
0007 002A          MOV WF  IO
0008 0109          IOR WF  CNDTN,W  ;THIS SECTION OF CODE CALCULATES THE
0009 002B          MOV WF  TEMP     ;JUMP TABLE. ANY INPUT THAT CHANGES FROM
000A 0209          MOV F  CNDTN,W  ;A ZERO TO A ONE IS CONSIDERED AN INTERRUPT.
000B 00AB          SUB WF  TEMP,1   ;THE EQUATION IS:
000C 020A          MOV F  IO,W     ; (IO + CNDTN) - CNDTN = INTERRUPT
000D 0029          MOV WF  CNDTN   ;WHERE IO IS CURRENT INPUT AND
000E 020B          MOV F  TEMP,W   ;CNDTN IS PREVIOUS INPUT.
000F 0E03          AND LW  3      ;MASK OFF TOP 6 BITS
0010 01E2          ADD WF  2,1     ;ADD INPUT TO PC TO CREATE JUMP TABLE
0011 0A1B          GOTO   MAIN     ;FOR INPUT=00
0012 0A15          GOTO   INT1    ;FOR INPUT=01
0013 0A17          GOTO   INT2    ;FOR INPUT=10
0014 0A19          GOTO   INT3    ;FOR INPUT=11

0015 0000          INT1   NOP      ;INTERRUPT LINE 1 CODE
0016 0A05          GOTO   START
0017 0000          INT2   NOP      ;INTERRUPT LINE 2 CODE
0018 0A05          GOTO   START
0019 0000          INT3   NOP      ;INTERRUPT LINES 1 AND 2 CODE
001A 0A05          GOTO   START

001B 0208          MAIN  MOV F  BRANCH,W
001C 01E2          ADD WF  2,1     ;ADD BRANCH TO PC TO CREATE JUMP TABLE
001D 0000          NOP
001E 0A28          GOTO   MAIN4    ;JUMP TABLE, LAST FIRST ON DECREMENT TABLE
001F 0A26          GOTO   MAIN3
0020 0A24          GOTO   MAIN2
0021 0A22          GOTO   MAIN1

0022 0000          MAIN1 NOP      ;MAIN PROGRAM CODE BANK ONE
0023 0A2A          GOTO   BRNCHK
0024 0000          MAIN2 NOP      ;MAIN PROGRAM CODE SECTION TWO
0025 0A2A          GOTO   BRNCHK
0026 0000          MAIN3 NOP      ;MAIN PROGRAM CODE SECTION THREE
0027 0A2A          GOTO   BRNCHK
0028 0000          MAIN4 NOP      ;MAIN PROGRAM CODE SECTION FOUR
0029 0A2A          GOTO   BRNCHK

002A 02E8          BRNCHK DECFSZ BRANCH,1 ;DECREMENT BRANCH REGISTER AND CHECK FOR ZERO
002B 0A2E          GOTO   TIMCHK
002C 0C04          MOV LW  4
002D 0028          MOV WF  BRANCH ;RELOAD BRANCH WITH 4 AT END OF MAIN

002E 0C29          TIMCHK MOV LW  D'41' ;CHECK TO SEE IF RTCC HAS REACHED 50(50-7)

```



# Software Interrupt Techniques

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```
002F 0081          SUBWF  1,W      ;DETERMINE WAIT TIME
0030 01E2          ADDWF  2,1     ;ADD WAIT TIME TO PC
0031 0000          NOP
0032 0000          NOP
0033 0000          NOP
0034 0000          NOP
0035 0000          NOP
0036 0000          NOP
0037 0000          NOP
0038 0A05          GOTO   START
                   END
```

```
Errors   :    0
Warnings :    0
```

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9/22/95

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