

# <u>AN597</u>

# **Implementing Ultrasonic Ranging**

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## INTRODUCTION

Object ranging is essential in many types of systems. One of the most popular ranging techniques is ultrasonic ranging. Ultrasonic ranging is used in a wide variety of applications including:

- · Auto focus cameras
- Motion detection
- Robotics guidance
- · Proximity sensing
- · Object ranging

This application note describes a method of interfacing PIC16CXX microcontrollers to the Polaroid 6500 Ranging Module. This implementation uses a minimum of microcontroller resources, a CCP module and two I/O pins. The two major components of the system are:

- Microcontroller
- Polaroid 6500 Ranging Module

The microcontroller performs the intelligence and arithmetic functions for ultrasonic ranging, while the Polaroid 6500 Ranging Module performs the ultrasonic signal transmissions and echo detection.

#### FIGURE 1: RANGING MODULE INTERFACE

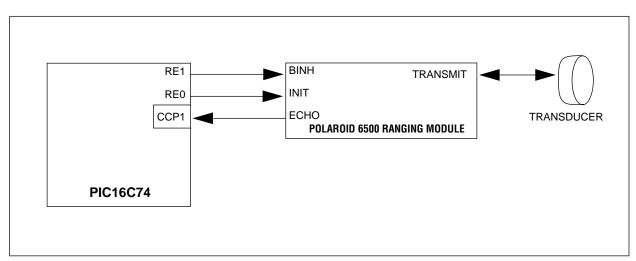
## THEORY OF OPERATION

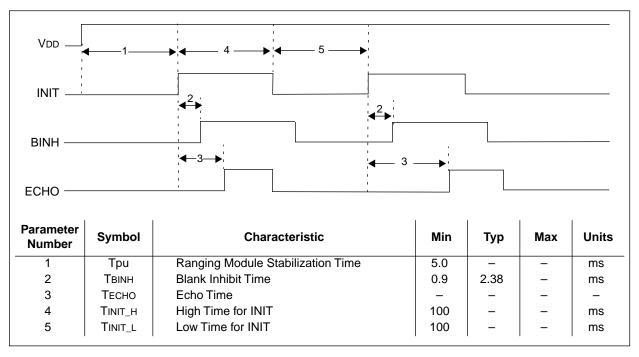
Ultrasonic ranging entails transmitting a sound wave and measuring the time that it takes for the sound wave to reflect off of an object and back to the origin. The reflection time is proportional to the distance that the object is from the source. In this implementation, the sound wave is transmitted and received from the same transducer. Therefore, a blanking interval is required between signal transmission and reception to eliminate false echoes (i.e., a transmitted signal being detected as its own echo).

# **CIRCUIT CONFIGURATION**

In this implementation, a PIC16C74 is connected to the ranging module as shown in Figure 1. The RE0 and RE1 I/O pins are configured as digital outputs and are tied to INIT and BINH, respectively. The CCP1 pin is configured as a digital input and is tied to ECHO through a pull-up resistor. The pull-up resistor is needed since the ECHO signal is an open-collector output. The CCP1 pin is configured for capture mode (CCP1CON). Figure 2 shows the timing relationship for VDD and the three signal lines (INIT, BINH, and ECHO).

**Note:** The ranging module requires 5.0 milliseconds to stabilize during power-up.





#### FIGURE 2: TIMING DIAGRAM OF RANGING MODULE CONTROL LINES

The PIC16C74 is configured to use one of its internal timers, Timer1, in capture mode to measure the time between signal transmission and echo detection. The resolution of the timer is determined by the microcontroller clock frequency. For this application, a 4 MHz external oscillator was used, giving a resolution of 1 ms per bit. The PIC16C74 initiates a ranging cycle by first clearing Timer1. Timer1 is then enabled and INIT is immediately asserted on the ranging module. When INIT is asserted, the ranging module transmits a series of 16 pulses on the transducer at 49.4 kHz. The transmitted pulses reflect off the object and are received back at the transducer.

The transducer is used for both transmitting and receiving sound waves. A blanking interval is needed to ensure that the transmitted signal has decayed on the transducer, in order not to receive false echoes. In normal operation, the ranging module has a blanking interval of 2.38 milliseconds, which corresponds to a minimum detection distance of approximately 17 inches. However, the BINH (blank inhibit) signal can be manipulated to reduce the blanking time on the transducer to allow for object ranging as close as 6 inches.

In this implementation, the PIC16C74 asserts the BINH signal approximately 0.9 milliseconds after signal transmission. This enables the transducer to receive reflections off objects at a distance of 6 inches. The ranging module asserts the ECHO signal when a valid reflection has been detected. The PIC16C74 uses the ECHO signal to trigger a capture of the Timer1 value. The capture register contains the 16-bit value

representing the elapsed time between signal transmission and echo detection. The PIC16C74 then calculates object distance based on the Timer1 value, microcontroller clock speed, and the velocity of sound in the atmosphere. The basic equation for calculating distance is given below:

Distance (inches) = TECHO time / 147.9 microseconds

Note:	The minimum high and low time for INIT is
	100 milliseconds, as seen in Figure 2.

### **DESIGN CONSIDERATIONS**

There are several design considerations which must be taken into account and are listed below.

The absolute measuring distance supported by the ranging module is 6 inches to 35 feet with an accuracy of +/-1%.

The distance output from the ranging module can be averaged over time to filter distance calculations.

In some applications, the gain of the receiver amplifier may be too low or too high and may need to be adjusted. For example, if the transducer is mounted in a cylinder, the gain may need to be lowered to reduce false echoes within the cylinder. In this case, R1 (refer to the Polariod Ultrasonic Ranging System manual) may be replaced with a 20 k $\Omega$  potentiometer to tweak the gain of the receiver amplifier to reduce false echoes.

In order for the Polaroid 6500 ranging module to operate properly, the power supply must be capable of handling high current transients (2.5 A) during the

transmit pulse. The instantaneous drain on the power supply can be mitigated by installing a storage capacitor across the power lines at the ranging module. A value of 500 microfarads is recommended.

A 200 millisecond interval is recommended between ranging cycles (Figure 2) to allow the transducer to clear.

The ECHO line requires a pull-up resistor (4.7 k $\Omega$  was used in this application).

There must be a common ground between the PIC16C74 circuitry and the ranging module.

Some applications may not need the resources of the higher end PIC16CXX devices. It is still possible to do this application using a device that does not contain a CCP module (for ECHO timing). The capture function can be implemented in firmware. The effect of a firmware implementation is that the resolution of the ECHO time would be 3 Tcy cycles versus 1 Tcy cycle for the CCP module. Also, the firmware implementation would not allow other tasks to be performed while the capture function was occurring.

Refer to Appendix A for general ranging module specifications.

# APPENDIX A: POLAROID MODULE SPECIFICATIONS

Note: This appendix contains general specifications from the Polaroid Ultrasonic Ranging System Manual. Please refer to the current Polaroid Ultrasonic Ranging System Manual for current information regarding ranging module design considerations.

## DESIGN CONSIDERATIONS IN ULTRASONICS

**Range:** (with user custom designed processing electronics)

#### Farther

- a) Use an acoustic horn to "focus" the sound (narrowing the beamwidth).
- b) Use two transducers 1 receiver and 1 transmitter facing each other.
- c) Lower the transmitting frequency (which will decrease the attenuation in air).

#### <u>Closer</u>

- a) Use a shorter transmit signal (such as four cycles).
- a) Use two transducers one to transmit, one to receive (eliminates waiting for damping time).

#### <u>Resolution</u>

- a) Above all, know the target and range well, and design a system with them in mind.
- b) Use a higher transmit frequency.
- c) Look at phase differences of a given cycle of the transmitted signal and received echo (as opposed to using and integration technique).
- d) Increase the clock frequency of the timer.
- Accuracy: (again, you must have a well defined target)

#### Temperature Compensate

- a) Use a second small target, as a reference, at a known distance in the ranging path (such as a 1/4" rod several feet away), process both echoes, then normalize the second distance with respect to the first, since t1/d1 = t2/d2.
- b) Incorporate a temperature sensing integrated circuit to drive a VCO to do the distance interval clocking.
- c) To increase sensitivity of detection circuit change the value of C4 from 3300 pF to 1000 pF on the 6500 Series Ranging Module.

#### Beam Width:

#### <u>Increase</u>

- a) Use an acoustic lens (to disperse the signal).
- b) Decrease the transmitting frequency.
- c) Use several transducers to span an area.

#### Decrease

- a) Use an acoustic horn (to focus the sound).
- b) Increase the transmitting frequency.

#### TABLE 1: RECOMMENDED OPERATING CONDITIONS

		Min.	Max.	Unit
Supply Voltage, Vcc		4.5	6.8	V
High-level input voltage, VIH	BINH, INIT	2.1		V
Low-level input voltage, VIL	BINH, INIT		0.6	V
ECHO and OSC output voltage		6.8	V	
Delay time, power up to INIT high	5		ms	
Recycle period	80		ms	
Operating free-air temperature, TA	0	40	°C	

# TABLE 2:ELECTRICAL CHARACTERISTICS OVER RECOMMENDED RANGES OF SUPPLY<br/>VOLTAGE AND OPERATING FREE-AIR TEMPERATURE (UNLESS OTHERWISE<br/>NOTED)

Parameter	Test Conditions	Min.	Тур.	Max.	Unit		
Input current	BINH, INIT	V1 = 2.1V			1	mA	
High-level output current, IOH	ECHO, OSC	Vон = 5.5V			100	μΑ	
Low-level output voltage, VoL	ECHO, OSC	IOL = 1.6 mA			0.4	V	
Transducer bias voltage	TA = 25°C		200		V		
Transducer output voltage (peak-to-	TA = 25°C		400		V		
Number of cycles for XDCR output	C= 500 pF			7			
Internal blanking interval			2.38*		ms		
Frequency during 16-pulse trans-	OSC output			49.4*		– kHz	
mit period	XMIT output			49.4*			
Frequency after 16 pulse transmit	OSC output			93.3*			
period	XMIT output			0			
Querale summer las	During transmit period				2000	mA	
Supply current, Icc	After transmit period				100		

\* These typical values apply for a 420 kHz ceramic resonator.

Please check the Microchip BBS for the latest version of the source code. For BBS access information, see Section 6, Microchip Bulletin Board Service information, page 6-3.

#### **APPENDIX B: FIRMWARE LISTING**

```
MPASM 01.02 Released
                        XDCR.ASM 11-14-1994 9:29:15
                                                                      PAGE 1
LOC OBJECT CODE LINE SOURCE TEXT
 VALUE
          0001 ; XDCR.ASM
          0002 ;
          0003 ; This routine continually executes ranging cycles in the
          0004 ; following order:
          0005 ;
          0006 ;
                     1) Timers and Flags are cleared
          0007 ;
                     2) Ranging Cycle Executes
          ; 8000
                     3) Distance is Calculated (to 0.5 inch)
          0009 ;
                    4) HW is re-initialized for next cycle
          0010 ;
          0011 ; The processor uses a 4MHz oscillator, so all timing
          0012 ; calculations are referenced to that. The calculated
          0013 ; distance is a 16-bit result in the ACCbHI:ACCbLO registers.
          0014 ;
          0015
          0016
                       LIST P=16C74, F=INHX8M
          0017 ;
          0029
          0030 ;***************
          0031 ; Bank 0 Registers
          0032 ;**************
          0033 ;
          0034 ; TMR1 is off, Prescaler is 1 for a capture timeout of 65 msec
0000 0190 0035 clrf
                       T1CON
          0036 ; Set to capture on every rising edge
0001 3005 0037 movlw 0x05
0002 0097 0038 movwf CCP1CON
          0039 ; Clear the Ports
0003 0185 0040 clrf PORT_A
0004 0186 0041
                clrf
                         PORT B
                clrf
0005 0187
          0042
                         PORT C
0006 0188
          0043
                 clrf
                         PORT D
0007 0189
          0044
                 clrf
                         PORT_E
          0045 ;
          0046 ;**************
          0047 ; Bank 1 Registers
          0048 ;**************
          0049 ;
0008 1683 0050 bsf
                       STATUS, RPO
                                      ; Set RPO
          0051 ; Port A is Digital, Port E is Digital
0009 3007 0052 movlw 0x07
                 movwf ADCON1
000A 009F 0053
          0054 ; Configure CCP1 (RC2) as an input, and all other ports
          0055 ; as Outputs, (RE0 = INIT, RE1 = BINH)
000B 0185 0056 clrf TRIS_A
000C 0186 0057
                 clrf
                         TRIS B
000D 3004
          0058
                 movlw
                         0x04
000E 0087
          0059
                 movwf
                         TRIS C
000F 0188
          0060
                 clrf
                         TRIS_D
0010 0189
          0061
                 clrf
                         TRIS E
0011 1283 0062
                 bcf
                        STATUS, RPO
                                       ; Clear RPO
0012
          0063 Xdcr
          0064 ;
          0065 ; Initialize Timers and Flags
          0066 ;
0012 1010
          0067
                 bcf
                         T1CON,0
                                         ; Disable TMR1
0013 018C 0068
                 clrf
                         PIR1
                                         ; Clear Timer1 Overflow Flag & Timer1 Capture Flag
```

0014 018E 0069 clrf TMRL ; Clear TMRLH 0015 018F 0070 clrf TMRLH ; Clear CCPRIH 0016 0195 0071 clrf CCPRIH ; Clear CCPRIH 0018 1409 0073 baf PORT_K,0 ; Set INIT Migh on Ranging Module 0019 1410 0074 baf PORT_K,0 ; Set INIT Migh on Ranging Module 0019 1410 0074 baf PORT_K,0 ; Set INIT Migh on Ranging Module 0019 1410 0074 baf PORT_K,1 ; Enable TMRL 0010 1907 chk.tl 0011 1409 0078 bifso FIRI.2 ; Check for Capture 0010 1907 0018 bifso FIRI.2 ; Check for CAPLURE 0012 1907 0018 bifso FIRI.2 ; Check for TMRL Overflow 0011 1000 0020 bof TlcON,0 ; Turn off TMRL 0022 0079 goto chk.tl 0021 0010 0020 bof TlcON,0 ; Turn off TMRL 0022 0014 chk.done 0086 ; Calculate distance to 0.5 inch resolution 0087 ; 0086 ; Calculate distance to 0.5 inch resolution 0087 ; 0086 ; Calculate distance to 0.5 inch resolution 0087 in 0087 bof TlCON,0 ; Turn off TMRL 0021 0010 0088 bof TlCON,0 ; Turn off TMRL 0022 0010 0088 bof TlCON,0 ; Turn off TMRL 0023 0010 0088 bof TlCON,0 ; Turn off TMRL 0024 0002 0090 movef ACChLO ; MOVer LSB into MC 0025 0018 0091 movef ACChLI ; MOVE MSB into ACChLI 0027 0040 0093 moviw 0x4A ; MOVE MSB into ACCALI 0028 00A0 0993 moviw 0x4A ; MOVE MSB into ACCALI 0029 01A1 0995 clrf ACCALI ; MOVE MSB into ACCALI 0027 0098 0094 movef ACCALO ; MOVE LSB into ACCALI 0029 01A1 0995 clrf ACCALI ; MOVE MSB into ACCALI 0020 0031 0049 movef ACCALO ; MOVE LSB into ACCALI 0032 0031 0041 movef ACCALI ; MOVE MSB into ACCALI 0032 0031 0031 0044 movef ACCALI ; Clear MSB (ACCALI) 0032 0031 0031 013 bifso STATUS,CALV ; If Memainder < (0.5 * Divisor), skip 0032 0131 0095 movef ACCALI ; MOVE MSB into ACCALI 0032 0131 0035 0140 off ACCALI ; Clear MSB (ACCALI) 0030 0130 0131 bifso STATUS,CALV ; If Memainder < (0.5 * Divisor), skip 0031 0130 0141 bifso STATUS,CALV ; If Move LSB INT 0032 0131 0131 bifso STATUS,CALV ; If Move LSB INT 0035 0100 0112 bifs STATUS,CALV ; Mait 100 mace before clearing HW. 0035 0110 ding 0114 ACCHI 0035 0110 0114 csl1 DML_100 ; Wait 100 mace before enabling HW. 0035 0110 011					
0016 0195 0071         clrf         CCPRLI         ; Clear CCPRLH           0017 0196 0072         off         CCPRL ;; Clear CCPRLH           0018 1409 0073         bef         PORP.E.O.         ; Set INIT High on Ranging Module           0018 21P3 0075         call DBL_9         ; Delay 0.9 macc for transducer to stabilize           0018 1489 0076         call DBL_9         ; Delay 0.9 macc for transducer to keceive (BINN)           00112 022 0079         got chk_chone         ; Jump if Capture           0012 022 0079         oot chk_chone         ; Jump if Capture           0012 023 0081 got ovr_flo         ; Capture event did not occur           0022 0030 ovr_flo         ; Turn off TRRI           0022 0030 movef ACCDEL,         ; Move LSB into M           0023 0815 089 movef ACCDEL,         ; Move KSB into W           0024 0032 0816 0091 movef ACCDEL,         ; Move KSB into ACCDHI           0024 0032 0816 0091 movef ACCDEL,         ; Move KSB into ACCDHI           0027 0034 movef ACCDHI ; Move KSB into ACCDHI         ; Move KSB into ACCDHI           0028 00A0 0094 movef ACCALO ; Move KSB into ACCDHI         ; Move KSB into ACCDHI           0029 01A1 0095         off ACCAHI ; Clear KMSA (ACCAHI)           0028 02A0 0094 movef ACCALO ; Wove KSB into ACCDHI         ; Move KSB into ACCDHI           0028 02A1 0095	0014 018E 006	9 clrf	TMR1L	;	Clear TMR1L
0017 0196         0073         baf         PORT_F,0         ; Set INT High on Ranging Module           0018 1400         0074         baf         PORT_F,0         ; Set INT High on Ranging Module           0018 1409         0075         call DEL_9         ; Pelay 0.9 msec for transducer to stabilize           0018 1409         0077         chk_din         ; Check for Capture           0011 0100         0077         chk_din         ; Jump if Capture           0012 1000         0080         bifse PIRI,0         ; Check for TMMI Overflow           0018 1000         0080         pito or chk_t1         ; Loop if nothing happened           0021 010         0082         pito or chk_t1         ; Loop if nothing happened           0022 0101         0082         calculate distance to 0.5 inch resolution           0085 ; Calculate distance to 0.5 inch resolution         0086 ; Calculate distance to 0.5 inch resolution           0022 0101 0088         bcf TiCON,0         ; Turn off TMRI           0023 0101 0088         bcf TiCON,0         ; Turn off TMRI           0024 00A2 0090         mover ACChLO         ; Move LSB into ACChLO           0024 00A2 0090         mover ACCHLO         ; Move CBB into ACChLO           0025 0101         mover ACCALO         ; Move CBB <td< td=""><td>0015 018F 007</td><td>0 clrf</td><td>TMR1H</td><td>;</td><td>Clear TMR1H</td></td<>	0015 018F 007	0 clrf	TMR1H	;	Clear TMR1H
0019         1409         0074         bsf         PORT_F.0         ; Set INIT High on Ranging Module           0019         1410         0074         bsf         PORT_F.1         ; Enable Transducer to Receive (BINH)           0012         0077         cht_1         ; Enable Transducer to Receive (BINH)           0012         0077         cht_1         ; Enable Transducer to Receive (BINH)           0012         0077         cht_1         ; Loop if nothins happened           0012         0081         oto cht_1         ; Loop if nothins happened           0021         0083         oto cott_1         ; Capture event did not occur           0022         0084         cht_done         ; Jump if Capture           0021         0233         083         goto ort.1         ; Capture event did not occur           0022         0084         cht_done         ; Move LSB into ACCLO           0023         0815         ooff attance to 0.5         into free           0023         0815         ooff attance         ; Move LSB into ACCLO           0023         0815         ooff attance         ; Move MSB into ACCLO           0024         0040         movef ACCLO         ; Move LSB into ACCLO           0028         0040	0016 0195 007	1 clrf	CCPR1L	;	Clear CCPR1L
0019         1410         0074         ksf         TICON,0         ; Enable TWRL           0018         218         0075         call         DRL         )         Delay 0.9         smcd for transducer to Receive (BINE)           0011         1007         cht_t1         ; Check for Capture         (BINE)           0011         1007         cht_c1         ; Check for Capture         (BINE)           0011         1007         cost         FIL1.2         ; Check for TMRI Overflow           0011         1007         0080         bft.se         FIL1.0         ; Check for TMRI Overflow           0012         1010         0082         bft.         TLON,0         ; Turn off TWR1           0021         01010         0083         cft.ad.cone         (0085         ;           0023         0110         0088         bft.         TLON,0         ; Turn off TWR1           0024         0004         0084         cht_chane         (0087         ;           0023         0815         0080         movf         CCAPLL,N         ; Move LSB into %           0024         0004         0093         movf         CCAPLL,N         ; Move CAPLL           0024         004004	0017 0196 007	2 clrf	CCPR1H	;	Clear CCPR1H
001A 21F3         0075         call DEL_9'         ; Delay 0.9 msec for transducer to stabilize           001B 1489         0076         bdf         PORT_E.1         ; Enable Transducer to Receive (BINH)           001C         0007         chk_t1         ; Check for TMSI Overflow           001D 2822         0009         goto chk_tan         ; Jump if Capture           001E 2812         0081         goto chk_tan         ; Jump if Capture           001E 2812         0081         goto chk_tan         ; Jump if Capture           0021 2833         0083         goto chk_tan         ; Loop if nothing happened           0022         0084         chk_dome         ; Turn off TMRI           0023         0085 ;         Calculate distance to 0.5 inch resolution         0085 ;           0024         0086 bcf         TICON,0         ; Turn off TMRI           0023         0086 bcf         TICON,0         ; Move LSB into W           0024         0080         0099         movf         CCPRIH,W           0024         0080         0090         movf         ACCBAI           0025         016         ACCAH         ; Move LSB into ACCAH           0026         0141         0095         clrf         ACCAH	0018 1409 007	3 bsf	port_e,0	;	Set INIT High on Ranging Module
0011         0077         bbf         PORT_E.1         ; Enable Transducer to Receive (BINH)           0011         0077         btfsc         PIE1.2         ; Check for Capture           0011         1002         0078         btfsc         PIE1.2         ; Check for Capture           0011         1002         0080         btfss         PIE1.0         ; Check for TMRI Overflow           0012         1010         0082         btfss         PIE1.0         ; Check for TMRI Overflow           0022         1008         std.dome         ; Turn off TMRI           0022         0084         chk.dome         ; Outro off TMRI           0023         0081         colo 0.082         bef TICON.0         ; Turn off TMRI           0024         0010         0088         bef TICON.0         ; Turn off TMRI           0022         0081         movef ACCPRIL, W         ; Move LSB into W           0023         0815         0099         movef ACCPRIL, W         ; Move LSB into W           0024         0002         0034         movef ACCPRIL, W         ; Move LSB into W           0025         0810         091         movef ACCPRIL, W         ; Move LSB into W           0024         0040         092	0019 1410 007	4 bsf	T1CON,0	;	Enable TMR1
001C         0077         chk_t1           001C         0079         goto         chk_done         ; Jump if Capture           001D         2822         0079         goto         chk_t1         ; Loop if Capture           001F 281C         0081         goto         chk_t1         ; Loop if nothing happened           0021         0083         goto         ork_t1         ; Loop if nothing happened           0022         0084         chk_done         ; Capture event did not occur           0022         0084         chk_done         ; Turn off TMR1           0021         0083         pot         rtron off TMR1           0022         0084         chk_done         ; Move LSB into W           0023         0010         movf         CCPRIL,W         ; Move LSB into ACCLO           0024         0042         0043         movf         CCPRIL,W         ; Move LSB into ACCLO           0025         0015         movf         CCELO         ; Move ACCLO         ; Move CACLO           0026         0043         movf         ACCALO         ; Wore 75usec/0.50in into W           0027         clear MSB         inco ACCALO         ; Move ACCALO           0028         0040 <td< td=""><td>001A 21F3 007</td><td>5 call</td><td>DEL_9</td><td>;</td><td>Delay 0.9 msec for transducer to stabilize</td></td<>	001A 21F3 007	5 call	DEL_9	;	Delay 0.9 msec for transducer to stabilize
<pre>0010 190C 0078 btfsc PIR1,2 ; Check for Capture 001D 2822 0079 goto chk_done ; Jump if Capture 001E 100C 0080 btfss PIR1,0 ; Check for TMEL Overflow 001E 120C 0081 goto chk_t1 ; Loop if nothing happened 0021 0101 0082 bef TICON,0 ; Turn off TMR1 0022 0084 cfk_done 0085; 0086 ; Calculate distance to 0.5 inch resolution 0087; 0022 01010 0088 bef TICON,0 ; Turn off TMR1 0023 0815 0089 movrf ACCELO ; Nove LSB into W 0024 0000 0094 movrf ACCELO ; Nove LSB into ACCELO 0025 0816 0091 movrf ACCELO ; Nove LSB into ACCELO 0025 0816 0091 movrf ACCELI ; Nove MSB into ACCELO 0026 0033 0092 movrf ACCELI ; Nove MSB into ACCELO 0026 0030 0094 movrf ACCELI ; Nove MSB into ACCELI 0027 0040 0094 movrf ACCELO ; Nove LSB into ACCELI 0028 0040 0094 movrf ACCELO ; Nove LSB into ACCELI 0029 01A1 0095 clrf ACCELI ; Nove MSB into ACCELI 0097 ; Call 16-bit/8-bit routine 0097 ; Call 16-bit/8-bit routine 0097 ; Which is described in 0098 ; Application Note 544 002D 1803 0101 btfsc STATUS,CARRY ; If Remainder to see if 0027 1003 0103 btfsc STATUS,CARRY ; If Remainder &lt; (0.5 * Divisor), skip 002E 1003 0101 btfsc STATUS,Z ; Check remainder to wrap around 0031 1003 0101 btfsc STATUS,Z ; Check low byte for wrap around 0031 0103 0101 btfsc STATUS,Z ; Check low byte for wrap around 0031 0103 0105 btfss STATUS,Z ; Check low byte for wrap around 0031 0103 0105 btfss STATUS,Z ; Check low byte for wrap around 0032 0124 incf ACCELI,F ; If LSB wrapped, increment high byte 0035 0100 done ; High byte didn't wrap 0036 0109 olig ACCELI ACCELI 0036 0109 0112 btf PORT_F,0 ; Disable INIT 0037 1089 0113 bcf PORT_F,1 ; Disable INIT 0037 1089 0113 bcf PORT_F,1 ; Disable INIT 0037 1089 0113 bcf PORT_F,1 ; Disable INIT 0038 21PD 0114 ccall DEL_100 ; Wait 100 msec before enabling HW. 0039 2812 0115 goto Xdor 0116 0116 0116 0116 0116 0116 0116 011</pre>	001B 1489 007	6 bsf	PORT_E,1	;	Enable Transducer to Receive (BINH)
001D 1222         0079         goto chk_done         ; Jupp if Capture           001F 201C         0080         bifs PIRL0         ; Check for TMRL Overflow           0012 2030         0081         goto chk_t1         ; Loop if nothing happened           0021 2030         0083         bof TLCON.0         ; Turn off TMRL           0022 0084         chk_done         ; Capture event did not occur           0023 0085         ;         Calculate distance to 0.5 inch resolution           0087 :         0088         bof TLCON.0         ; Turn off TMRL           0022 0084         chk_done         ; Move LSB into N           0022 0085         outs for CCPRLN.W         ; Move LSB into ACCLO           0024 0020         0090         movef CCPRLN.W         ; Move MSB into ACCLO           0026 00A3 0092         movef ACCLO         ; Move LSB into ACCLO           0027 00A1 0093         movef ACCLO         ; Move TSB into ACCLO           0028 00A0 0094         movef ACCLO         ; Move TSB into ACCLO           0028 00A0 0094         movef ACCLO         ; Watch is described in           0028 0026 0039         clf ACCALO         ; Which is described in           0028 0020 0099         movef ACCLO,W         ; Watch is described in           0028 0101	001C 007	7 chk_t1			
001E ICCC         0080         btfss         FIR1.0         ; Check for TMR1 Overflow           001F 281C         0081         goto         chk_l1         ; Loop if nothing happened           0021 101         0082         bcf         TICON.0         ; Turn off TMR1           0022         0084         chk_done         capture event did not occur           0085 ;         colstance         colstance         colstance           0085 ;         Calculate distance to 0.5 inch resolution         colstance           0087 ;         Curn off TMR1         colstance           0023 0815 0089         movf CCPRIL,W         ; Move LSB into ACCDLO           0024 0004 0034         movef CCPRIL,W         ; Move MSB into W           0025 0816 0091         movef ACCDHI         ; Move Sistico ACCDHI           0026 0031 0092         movef ACCALH         ; Move Sistico ACCAHI           0027 304A 0093         movef ACCALO         ; Move LSB into ACCAHI           0028 0101 0095 clrf ACCALH         ; Clear MSB (ACCAHI)         0028           0028 0280 0096 call D_divF         ; Clait 16-bit/8-bit routine         ; which is described in           0027 1042         0098         movef ACCALO,W         ; we hould round up           00202 02022         0100         movef AC	001C 190C 007	8 btfsc	PIR1,2	;	Check for Capture
001F 281C         0081         goto         chk_t1         ; Loop if nothing happened           0020         1010         0082         bcf         TICON,0         ; Turn off TMR1           0021         2833         0083         goto         ovr_flo         ; Capture event did not occur           0022         0084         chk_done         ;         0085;         ;           0085         ;         0086         ; Calculate distance to 0.5 inch resolution         ;           0022         1010         0088         bcf         TICON,0         ; Turn off TMR1           0023         0815         0809         movf         CCPRLL,W         ; Move LSB into ACCDLO           0024         0032         0033         movf         ACCAL         ; Move TSB into ACCDH           0025         0043         0094         movf         ACCAL         ; Move LSB into ACCALO           0028         0040         0094         movf         ACCALO         ; Move LSB into ACCALO           0028         0040         0094         movf         ACCALO         ; Move LSB into ACCALO           0028         0045         0097         ; which is described in         ; hope in othe Scalo           0029         0110 </td <td>001D 2822 007</td> <td>9 goto</td> <td>chk_done</td> <td>;</td> <td>Jump if Capture</td>	001D 2822 007	9 goto	chk_done	;	Jump if Capture
0020 1010         0082         bcf         TLCN,0         ; Turn off TMRI           0021 2833         0083         goto         ovr_flo         ; Capture event did not occur           0022         0084         chk_done         0085;           0086 ; Calculate distance to 0.5 inch resolution         0086;           0023 0815         0088         bcf         TLCON,0         ; Turn off TMRI           0023 0815         0089         movf         CCPRIL,W         ; Move LSB into ACCDLO           0024 0002         0090         mov# ACCLO         ; Move MSB into W         0026 0035           0025 0816         0091         mov# ACCLI         ; Move MSB into ACCDH         0027 304A           0028 0000         0094         mov# ACCLIC         ; Move LSB into ACCALO         0028 0040           0028 0010         0094         mov# ACCLIC         ; Wove LSB into ACCALO         0028 0020           0028 0026         0095         clrf         ACCLIC         ; Which is described in           0028 0026         0099         movW         0245         ; Check remainder to see if           0020 1803 0101         btfsc         STATUS,Z         ; Check low bte for wrap around           0021 103 0105         btfsc         STATUS,Z         ; C	001E 1COC 008	0 btfss	PIR1,0	;	Check for TMR1 Overflow
0021 2833 0083 goto ovr_flo ; Capture event did not occur 0022 0084 chk_done 0085; 0086; Calculate distance to 0.5 inch resolution 0087; 0022 1010 0088 bcf TICON,0 ; Turn off TMR1 0023 0815 0089 movf CCPR1L,W ; Move LSB into ACCDLO 0024 0022 0090 movf ACCDLO ; Move LSB into ACCDLO 0025 0816 0091 movf CCPR1H,W ; Move MSB into ACCDHI 0027 0304 0093 movlw 0x4A ; Move SB into ACCDHI 0027 0040 0094 movf ACCLO ; Move LSB into ACCDHI 0027 0040 0094 movf ACCLO ; Move LSB into ACCDHI 0028 0080 0094 movf ACCLO ; Move LSB into ACCDHI 0029 01A1 0095 clrf ACCAHI ; Clear MSB AcCCAIO 0029 01A1 0095 clrf ACCAHI ; Clear MSB AcCCAIO 0029 01A1 0095 clrf ACCAHI ; Clear MSB (ACCAHI) 0027 0098 ; Actor LSB AcCCAIO 0028 0080 0099 movlw 0x25 ; Check remainder to see if 0020 2024 0100 subwf ACCLO,F ; Round up 0027 1903 0101 btfsc STATUS,CARRY ; If Remainder < (0.5 * Divisor), skip 0027 0030 0A3 0104 incf ACCDLO,F ; Round up 0027 1903 0103 btfsc STATUS,Z ; Check low byte for wrap around 0030 0A3 0104 incf ACCDLO,F ; If LSB wrapped, increment high byte 0031 0A3 0105 btfss STATUS,Z ; Check high byte for wrap around 0032 0105 btfss STATUS,Z ; Check high byte for wrap around 0032 0106 goto done ; High byte didn't wrap 0033 0107 ovr_flo 0033 0108 clrf ACCDLO 0033 0110 done 0035 0110 done 0035 0110 done 0035 0110 done 0036 1099 0112 bcf PORT_E,0 ; Disable BINH 0036 113 bcf PORT_E,1 ; Disable BINH 0038 212P 0114 call DEL_100 ; Wait 100 msec before clearing HW. 0039 2812 0115 goto Xdcr 0149 0150 end 0151 MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	001F 281C 008	1 goto	chk_t1	;	Loop if nothing happened
0022         0084         chk_done           0085;         Calculate distance to 0.5 inch resolution           0086;         Calculate distance to 0.5 inch resolution           0022         0088         bcf         TICON,0         ; Turn off TMR1           0023         0815         0089         movf         CCPRLL,W         ; Move LSB into W           0024         0080         movef         ACCDLO         ; Move MSB into ACCDA           0026         0816         0091         movef         ACCDHI         ; Move MSB into ACCDHI           0027         304A         0093         movef         ACCAHI         ; Move MSB into ACCDHI           0028         0040         0094         movef         ACCAHI         ; Clear MSB (ACCAHI)           0028         0040         0094         movef         ACCAHI         ; Clear MSB (ACCAHI)           0028         0040         0094         movef         ACCALO         ; Which is described in           0028         0095         clrf         ACCALO,W         ; We should round up           0020         1003         btfsc STATUS, CARRY         ; If Remainder < (0.5* bivisor), skip	0020 1010 008	2 bcf	T1CON,0	;	Turn off TMR1
0085 ; 0086 ; Calculate distance to 0.5 inch resolution 0087 ; 0022 1010 0088 bcf TLCON,0 ; Turn off TMR1 0023 0815 0089 movf CCPRLL,W ; Move LSB into W 0024 00A2 0090 movwf ACCbLO ; Move LSB into ACCbLO 0025 0816 0091 movf CCPRLH,W ; Move MSB into ACCHI 0027 304A 0093 movwf ACCbHI ; Move MSB into ACCCHI 0027 304A 0093 movwf ACCaLO ; Move LSB into ACCALO 0028 00A0 0094 movwf ACCaLO ; Move LSB into ACCALO 0029 01A1 0095 clrf ACCaHI ; Clear MSB (ACCAHI) 0028 00A0 0099 movW MXA ; Clear MSB (ACCAHI) 0028 00A0 0099 movW MX25 ; Clear MSB (ACCAHI) 0028 0099 movW MX25 ; Check remainder to see if 0097 ; Which is described in 0098 ; Application Note 544 0020 2022 0099 movW 0X25 ; Check low byte for wrap around 0020 1010 btfsc STATUS,CARRY ; If Remainder < (0.5 * Divisor), skip 0020 103 0101 btfsc STATUS,2 ; Check low byte for wrap around 0030 0AA3 0104 incf ACCbHJ,F ; If LSB wrapped, increment high byte 0033 0107 ovr_flo 0033 0107 ovr_flo 0033 0107 ovr_flo 0033 0107 ovr_flo 0035 21FD 0111 call DEL_100 ; Wait 100 msec before clearing HW. 0036 1009 0112 bcf PORT_E,0 ; Disable INIH 0038 21FD 0113 bcf PORT_E,0 ; Disable INIH 0038 21FD 0114 call DEL_100 ; Wait 100 msec before clearing HW. 0039 2812 0115 goto Xdcr 0116 0130 015 btfsv XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	0021 2833 008	3 goto	ovr_flo	;	Capture event did not occur
0086 ; Calculate distance to 0.5 inch resolution           0021 1010         0088           0022 1010         0088           0023 0015         0089           0024 0024         0090           0025 0816         0091           0027 3040         0092           0027 3040         0093           0027 3040         0093           0028 00A0         0094           0027 3040         0093           0028 00A0         0094           0028 011         0055           0028 011         0056           0029 0111         0056           0029 0111         0056           0020         0096           0021         0096           0021         0096           0022         0096           0021         0031           0022         0099           0024         0009           0025         0099           0026         0101           0027         0103           0028         0101           0029         0103           0102         166           0103         1016           0102         167 <td>0022 008</td> <td>4 chk_doi</td> <td>ne</td> <td></td> <td></td>	0022 008	4 chk_doi	ne		
0027 ;           0021 000 0088 bcf TlCON,0 ; Turn off TMR1           0023 0815 0088 movf CCPRIL,W ; Move LSB into W           0024 00A2 0090 movwf ACCbL0 ; Move KSB into ACCbL0           0025 0816 0091 movf CCPRIH,W ; Move MSB into ACCbHI           0026 00A3 0092 movwf ACCbHI ; Move MSB into ACCbHI           0027 304A 0093 moviw 0x4A ; Move TSB into ACCaL0           0028 00A0 0094 movwf ACCLO ; Move LSB into ACCaL0           0028 00A0 0094 movwf ACCLO ; Move LSB into ACCaL0           0028 00A0 0095 clrf ACCAHI ; Clear MSB (ACCAHI)           0029 01A1 0095 clrf ACCAHI ; Clear MSB (ACCAH)           0028 0040 0096 call D_divF ; Call 16-bit/8-bit routine           0097 ; which is described in           0098 ; Application Note 544           00202 0224 0100 subwf ACCCLO,W ; we should round up           0021 803 0101 btfss STATUS,Z ; Check low byte for wrap around           0030 0AA3 0104 incf ACCLOF; F ; Round up           0031 1003 0105 btfss STATUS,Z ; Check high byte for wrap around           0032 2835 0106 goto done ; High byte didn't wrap           0033 01A2 0108 clrf ACCBHI           0034 01A3 0109 clrf ACCBHI           0035 1010 done           0036 1019 btfs goto Xdcr           0037 1089 0113 bcf PORT_E,0 ; Disable INIT           0038 21FD 0114 call DEL_100 ; Wait 100 msec before clearing HW.           0039 2812 0115 goto Xdcr      <	008	5;			
0022 1010 0088 bcf TICON,0 ; Turn off TMR1 0023 00815 0089 movf CCPRIL,W ; Move LSB into ACCDLO 0025 0016 0091 movf CCPRIL,W ; Move KSB into ACCDLO 0026 00A3 0092 movmf ACCDHI ; Move MSB into ACCDHI 0027 004A 0093 movlw 0x4A ; Move 75uec/0.50in into W 0028 00A0 0094 movmf ACCALO ; Move LSB into ACCALO 0029 01A1 0095 clrf ACCAHI ; Clear MSB (ACCAHI) 0028 0086 0096 call D_divF ; Call 16-bit/8-bit routine 0097 ; Which is described in 0098 (ACCALO ); Move TSUEC/0.50in Note 544 0028 0020 0109 movlw 0x25 ; Check remainder to see if 0020 1010 subwf ACCCLO,W ; We should round up 0021 0103 0101 btfsc STATUS,CRRY ; If Remainder < (0.5 * Divisor), skip 0022 0AA2 0102 incf ACCLO,F ; Round up 0021 903 0103 btfsc STATUS,Z ; Check low byte for wrap around 0030 0AA3 0104 incf ACCHI,F ; If LSB wrapped, increment high byte 0031 0103 0105 btfss STATUS,Z ; Check high byte for wrap around 0032 0A33 0107 ovr_flo 0033 0107 ovr_flo 0034 0113 0109 0112 bcf PORT_E,1 ; Disable INIT 0035 0110 done 0035 0110 done 0150 end 0150 016 0150 end 0151 MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	008	6 ; Calcula	te distance to 0.5	in	ch resolution
0023 0815 0089 movf CCPRLL,W ; Move LSB into W 0024 00A2 0090 movf ACCbLO ; Move LSB into ACCbLO 0025 0816 0091 movf ACCbHI ; Move MSB into ACCbHI 0027 304A 0093 movlw 0x4A ; Move MSB into ACCaLO 0028 00A0 0094 movmf ACCaLO ; Move LSB into ACCaLO 0029 01A1 0095 clrf ACCaHI ; Clear MSB (ACCaHI) 002A 208F 0096 call D_divF ; Call 16-bit/8-bit routine 0097 ; which is described in 0098 ; Application Note 544 002D 1003 0101 btfsc STATUS,Z ; Check remainder to see if 002E 1002 1010 subwf ACCALO,W ; We should round up 002D 1030 0101 btfsc STATUS,Z ; Check low byte for wrap around 0030 0AA3 0104 inef ACCALI,F ; If LSB wrapped, increment high byte 0031 1003 0105 btfss STATUS,Z ; Check high byte for wrap around 0032 2035 0110 done ; High byte didn't wrap 0033 0107 ovr_flo 0034 01A3 0109 clrf ACCALI 0035 0110 done ; High byte didn't wrap 0035 0110 done 0035 0110 done 0035 0110 done 0035 21FD 0111 call DEL_100 ; Wait 100 msec before clearing HW. 0036 1009 0112 bcf PORT_E,1 ; Disable INIT 0037 1089 0113 bcf PORT_E,1 ; Disable BINH 0038 21FD 0114 call DEL_100 ; Wait 100 msec before enabling HW. 0039 2160 0114 call DEL_100 ; Wait 100 msec before enabling HW. 0039 2160 0114 call DEL_100 ; Wait 100 msec before enabling HW. 0039 2160 0114 call DEL_100 ; Wait 100 msec before enabling HW. 0039 2160 0114 call DEL_100 ; Wait 100 msec before enabling HW. 0039 2160 0114 call DEL_100 ; Wait 100 msec before enabling HW. 0039 2160 0114 call DEL_100 ; Wait 100 msec before enabling HW. 0039 2160 end 0150 end 0150 end 0151 H MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	008	7;			
0024       0042       0090       movuf       ACCbLO       ; Move LSB into ACCbLO         0025       0046       0091       movuf       CCPRIH,W       ; Move MSB into ACCbHI         0027       304A       0093       movuf       ACCbHI       ; Move MSB into ACCAHI         0028       00A0       0094       movuf       ACCaLO       ; Move LSB into ACCAHI         0028       00A1       0095       clrf       ACCaLI       ; Clear MSB (ACCaHI)         0024       0096       call       D_divF       ; Call 16-bit/8-bit routine         0097       ; Which is described in       0097       ; Application Note 544         0022       0100       subwf       ACCLO,F       ; Round up         0022       0101       btfsc       STATUS,Z       ; Check low byte for wrap around         0030       0A3       0104       incf       ACCbH,F       ; High byte didn't wrap         0031       1003       0105       btfss       STATUS,Z       ; Check high byte for wrap around         0033       0107       ovr_flo       ;       Status in the sec before clearing HW.       ;         0033       0109       clrf       ACCbLO       ;       Mait 100 msec before enabling HW.      <	0022 1010 008	8 bcf	T1CON,0	;	Turn off TMR1
0025 0816 0091         movf         CCPRIH,W         ; Move MSB into W           0026 00A3 0092         movuf         ACCHI         ; Move MSB into ACCHI           0027 00A4 0093         movuf         ACCLAI         ; Move MSB into ACCALO           0028 00A0 0094         movuf         ACCALO         ; Move MSB into ACCALO           0028 00A0 0094         movuf         ACCALO         ; Move SB into ACCALO           0028 01A1 0095         clrf         ACCALI         ; Clear MSB (ACCALI)           0020 01A1 0095         clrf         ACCALI         ; Clear MSB (ACCALI)           0021 0103         0096         ; Application Note 544         0097           0022 0224 0100         subwf ACCLO,W         ; we should round up         0021 0030 0101         btfsc STATUS,Z         ; Check how byte for wrap around           0021 1003 0103         btfsc STATUS,Z         ; Check high byte for wrap around         0031 1003 0105         btfss STATUS,Z         ; Check high byte for wrap around           0032 2835 0106         got done         ; High byte didn't wrap         0033 0107         ovr_flo           0033 0107         ovr_flo          josable INIT         josable INIT           0035 0110         done          josable BINH         josable BINH	0023 0815 008	9 movf	CCPR1L,W	;	Move LSB into W
0026         00A3         0092         movuf         ACCHH         ; Move MSB into ACCHI           0027         304A         0093         movuf         0x4A         ; Move 75usec/0.501n into W           0028         00A0         0094         movuf         ACCaLO         ; Move ASB into ACCALO           0029         01A1         0095         clrf         ACCaLI         ; Clear MSB (ACCAHI)           0024         2087         0096         call         D_divF         ; Call 16-bit/8-bit routine           0097         ; Which is described in         0098         ; Application Note 544           0022         0220         0100         subwf         ACCLO,F         ; Round up           0021         0103         0105         btfsc         STATUS,Z         ; Check low byte for wrap around           0030         0A3         0104         incf         ACCHI,F         ; If LSB wrapped, increment high byte           0031         1003         0105         btfss         STATUS,Z         ; Check high byte for wrap around           0032         2835         0106         goto         done         ; High byte didn't wrap           0033         01A2         0108         clrf         ACCHI         incs	0024 00A2 009	0 movwf	ACCbLO	;	Move LSB into ACCbLO
0027 304A       0093       movlw       0x4A       ; Move 75usec/0.50in into W         0028 00A0       0094       movwf       ACCaLo       ; Move LSB into ACCALO         0029 01A1       0095       clrf       ACCaLo       ; Move 75usec/0.50in into W         0024 208F       0096       call       D_divF       ; Clear MSB (ACCaHI)         0028 208F       0096       call       D_divF       ; Call 16-bit/8-bit routine         0028 3025       0099       movlw       0x25       ; Check remainder to see if         0020 1803       0101       btfsc       STATUS, CARRY       ; If Remainder < (0.5 * Divisor), skip	0025 0816 009	1 movf	CCPR1H,W	;	Move MSB into W
0028 00A0       0094       movwf       ACCaLO       ; Move LSB into ACCaLO         0029 01A1       0095       clf       ACCaHI       ; Clear MSB (ACCAHI         002A 208F       0096       call       D_divF       ; Clear MSB (ACCAHI         0097       ; which is described in       ; Application Note 544         002B 3025       0099       movlw 0x25       ; Check remainder to see if         002C 0224       0100       subwf ACCcLO,W       ; we should round up         002D 1033       0101       btfsc STATUS,CARRY       ; If Remainder < (0.5 * Divisor), skip	0026 00A3 009	2 movwf	ACCbHI	;	Move MSB into ACCbHI
0029 01A1       0095       clrf       ACCAHI       ; Clear MSB (ACCaHI)         002A 208F       0096       cal1       D_divF       ; Cal1 16-bit/8-bit routine         0097       ; which is described in       0098       ; Application Note 544         002B 3025       0099       movlw       0x25       ; Check remainder to see if         002D 1030       butfsc STATUS,CARRY       ; If Remainder < (0.5 * Divisor), skip	0027 304A 009	3 movlw	0x4A	;	Move 75usec/0.50in into W
002A 208F       0096       call       D_divF       ; Call 16-bit/8-bit routine         0097       ; which is described in         0098       ; Application Note 544         002B 3025       0099       movlw       0x25       ; Check remainder to see if         002L 0224       0100       subwf       ACCLO,W       ; we should round up         002D 1803       0101       btfsc       STATUS,CARRY       ; If Remainder < (0.5 * Divisor), skip	0028 00A0 009	4 movwf	ACCaLO	;	Move LSB into ACCaLO
0097         ; which is described in           0098         ; Application Note 544           002E 3025         0099         moviw 0x25         ; Check remainder to see if           002C 0224         0100         subwf ACCcL0,W         ; we should round up           002D 1803         0101         btfsc STATUS,CARRY         ; If Remainder < (0.5 * Divisor), skip	0029 01A1 009	5 clrf	ACCaHI	;	Clear MSB (ACCaHI)
0098         ; Application Note 544           002E 3025         0099         movlw         0x25         ; Check remainder to see if           002C 0224         0100         subwf ACCcLO,W         ; we should round up           002D 1803         0101         btfsc STATUS,CARRY         ; If Remainder < (0.5 * Divisor), skip	002A 208F 009	6 call	D_divF	;	Call 16-bit/8-bit routine
002B 3025       0099       movlw       0x25       ; Check remainder to see if         002C 0224       0100       subwf       ACCcL0,W       ; we should round up         002D 1803       0101       btfsc       STATUS,CARRY       ; If Remainder < (0.5 * Divisor), skip	009	7		;	which is described in
002C 0224 0100       subwf ACCcLO,W       ; we should round up         002D 1803 0101       btfsc STATUS,CARRY       ; If Remainder < (0.5 * Divisor), skip	009	8		;	Application Note 544
002D 1803 0101       btfsc STATUS,CARRY       ; If Remainder < (0.5 * Divisor), skip	002B 3025 009	9 movlw	0x25	;	Check remainder to see if
002E 0AA2       0102       incf       ACCbLO,F       ; Round up         002F 1903       0103       btfsc       STATUS,Z       ; Check low byte for wrap around         0030       0AA3       0104       incf       ACCbHI,F       ; If LSB wrapped, increment high byte         0031       1003       0105       btfss       STATUS,Z       ; Check high byte for wrap around         0032       0105       btfss       STATUS,Z       ; Check high byte for wrap around         0032       0105       btfss       STATUS,Z       ; Check high byte for wrap around         0033       0107       ovr_flo       ; High byte didn't wrap         0033       0107       ovr_flo       ;         0034       01A3       0109       clrf       ACCbHI         0035       0110       done       ;       Disable INIT         0036       1009       0112       bcf       PORT_E,1       ;       Disable BINH         0038       21FD       0114       call       DEL_100       ; Wait 100 msec before enabling HW.         0039       2812       0115       goto       Xdcr	002C 0224 010	0 subwf	ACCcLO,W	;	we should round up
002F 1903 0103       btfsc STATUS,Z       ; Check low byte for wrap around         0030 0AA3 0104       incf ACCbHI,F       ; If LSB wrapped, increment high byte         0031 1D03 0105       btfss STATUS,Z       ; Check high byte for wrap around         0032 2835 0106       goto done       ; High byte didn't wrap         0033 0107       ovr_flo       0033 0107       ovr_flo         0033 012 0108       clrf ACCbLO       0034 01A3 0109       clrf ACCbHI         0035 0110       done       0035 0110       done         0036 1009 0112       bcf PORT_E,0       ; Disable INIT         0038 21FD 0114       call DEL_100       ; Wait 100 msec before clearing HW.         0038 21FD 0114       call DEL_100       ; Wait 100 msec before enabling HW.         0039 2812 0115       goto Xdcr       0116         0150       end       0151         MEMORY USAGE MAP ('X' = Used, '-' = Unused)       0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	002D 1803 010	1 btfsc	STATUS , CARRY	;	If Remainder < (0.5 * Divisor), skip
0030       0AA3       0104       incf       ACCbHI,F       ; If LSB wrapped, increment high byte         0031       1D03       0105       btfss       STATUS,Z       ; Check high byte for wrap around         0032       2835       0106       goto       done       ; High byte didn't wrap         0033       0107       ovr_flo       0033       0107       ovr_flo         0033       0108       clrf       ACCbLO       0034       01A3       0109       clrf       ACCbHI         0035       0110       done       0035       0110       done       0036       1009       0111       call       DEL_100       ; Wait 100 msec before clearing HW.         0036       1009       0112       bcf       PORT_E,0       ; Disable INIT         0037       1089       0113       bcf       PORT_E,1       ; Disable BINH         0038       21FD       0114       call       DEL_100       ; Wait 100 msec before enabling HW.         0039       2812       0115       goto       Xdcr       0116         0150       end       0151        MEMORY USAGE MAP ('X' = Used, '-' = Unused)         0000       XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	002E 0AA2 010	2 incf	ACCbLO,F	;	Round up
0031 1D03       0105       btfss       STATUS,Z       ; Check high byte for wrap around         0032 2835       0106       goto       done       ; High byte didn't wrap         0033       0107       ovr_flo         0033       0107       ovr_flo         0033       0107       ovr_flo         0033       0108       clrf       ACCbLO         0034       01A3       0109       clrf       ACCbHI         0035       0110       done       ; Wait 100 msec before clearing HW.         0036 1009       0112       bcf       PORT_E,0       ; Disable INIT         0037       1089       0113       bcf       PORT_E,1       ; Disable BINH         0038       21FD       0114       call       DEL_100       ; Wait 100 msec before enabling HW.         0039       2812       0115       goto       Xdcr	002F 1903 010	3 btfsc	STATUS , Z	;	Check low byte for wrap around
0032 2835 0106 goto done ; High byte didn't wrap 0033 0107 ovr_flo 0033 0102 0108 clrf ACCbLO 0034 01A3 0109 clrf ACCbHI 0035 0110 done 0035 21FD 0111 call DEL_100 ; Wait 100 msec before clearing HW. 0036 1009 0112 bcf PORT_E,0 ; Disable INIT 0037 1089 0113 bcf PORT_E,1 ; Disable BINH 0038 21FD 0114 call DEL_100 ; Wait 100 msec before enabling HW. 0039 2812 0115 goto Xdcr 0116 0120 0149 0150 end 0151 MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	0030 0AA3 010	4 incf	ACCbHI,F	;	If LSB wrapped, increment high byte
0033 0107 ovr_flo 0033 01A2 0108 clrf ACCbLO 0034 01A3 0109 clrf ACCbHI 0035 0110 done 0035 21FD 0111 call DEL_100 ; Wait 100 msec before clearing HW. 0036 1009 0112 bcf PORT_E,0 ; Disable INIT 0037 1089 0113 bcf PORT_E,1 ; Disable BINH 0038 21FD 0114 call DEL_100 ; Wait 100 msec before enabling HW. 0039 2812 0115 goto Xdcr 0116 0120 0149 0150 end 0151 MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	0031 1D03 010	5 btfss	STATUS , Z	;	Check high byte for wrap around
0033 01A2       0108       clrf       ACCbLO         0034 01A3       0109       clrf       ACCbHI         0035       0110       done         0035 21FD       0111       call       DEL_100       ; Wait 100 msec before clearing HW.         0036 1009       0112       bcf       PORT_E,0       ; Disable INIT         0037 1089       0113       bcf       PORT_E,1       ; Disable BINH         0038 21FD       0114       call       DEL_100       ; Wait 100 msec before enabling HW.         0039 2812       0115       goto       Xdcr       0116         0120       0149       0150       end       0151         MEMORY USAGE MAP ('X' = Used, '-' = Unused)       0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	0032 2835 010	6 goto	done	;	High byte didn't wrap
0034 01A3       0109       clrf       ACCbHI         0035       0110       done         0035 21FD       0111       call       DEL_100       ; Wait 100 msec before clearing HW.         0036 1009       0112       bcf       PORT_E,0       ; Disable INIT         0037 1089       0113       bcf       PORT_E,1       ; Disable BINH         0038 21FD       0114       call       DEL_100       ; Wait 100 msec before enabling HW.         0039 2812       0115       goto       Xdcr       0116         0116       0120       0149       0150       end         0150       end       0151        MEMORY USAGE MAP ('X' = Used, '-' = Unused)         00000 :       XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	0033 010	7 ovr_fl	C		
0035       0110       done         0035 21FD       0111       call       DEL_100       ; Wait 100 msec before clearing HW.         0036 1009       0112       bcf       PORT_E,0       ; Disable INIT         0037 1089       0113       bcf       PORT_E,1       ; Disable BINH         0038 21FD       0114       call       DEL_100       ; Wait 100 msec before enabling HW.         0039 2812       0115       goto       Xdcr       0116         0120       0149       0150       end       0151         MEMORY USAGE MAP ('X' = Used, '-' = Unused)       0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	0033 01A2 010	8 clrf	ACCbLO		
0035 21FD 0111       call DEL_100       ; Wait 100 msec before clearing HW.         0036 1009 0112       bcf PORT_E,0       ; Disable INIT         0037 1089 0113       bcf PORT_E,1       ; Disable BINH         0038 21FD 0114       call DEL_100       ; Wait 100 msec before enabling HW.         0039 2812 0115       goto Xdcr       0116         0120       0149       0150       end         0151       MEMORY USAGE MAP ('X' = Used, '-' = Unused)       0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	0034 01A3 010	9 clrf	ACCbHI		
0036 1009       0112       bcf       PORT_E,0       ; Disable INIT         0037 1089       0113       bcf       PORT_E,1       ; Disable BINH         0038 21FD       0114       call       DEL_100       ; Wait 100 msec before enabling HW.         0039 2812       0115       goto       Xdcr       0116         0120       0149       0150       end         0151       MEMORY USAGE MAP ('X' = Used, '-' = Unused)       0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	0035 011	0 done			
0037 1089       0113       bcf       PORT_E,1       ; Disable BINH         0038 21FD       0114       call       DEL_100       ; Wait 100 msec before enabling HW.         0039 2812       0115       goto       Xdcr         0116       0120       0149         0150       end       0151         MEMORY USAGE MAP ('X' = Used, '-' = Unused)       0000 : XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX					
0038 21FD 0114 call DEL_100 ; Wait 100 msec before enabling HW.         0039 2812 0115 goto Xdcr         0116         0120         0149         0150 end         0151         MEMORY USAGE MAP ('X' = Used, '-' = Unused)         0000 : XXXXXXXXXXXX XXXXXXXXXXXXXXXXXXX			—		
0039 2812 0115 goto Xdcr 0116 0120 0149 0150 end 0151 MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX					
0116 0120 0149 0150 end 0151 MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX				;	Wait 100 msec before enabling HW.
0120 0149 0150 end 0151 MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX	0039 2812 011	5 goto	Xdcr		
0149 0150 end 0151 MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX					
0150 end 0151 MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX	012	0			
0151 MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX	014	9			
<pre>MEMORY USAGE MAP ('X' = Used, '-' = Unused) 0000 : XXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX</pre>					
0000 : XXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX					
0040 : All other memory blocks unused. Errors : 0 Warnings : 0					
All other memory blocks unused. Errors : 0 Warnings : 0					
Errors : 0 Warnings : 0					
Warnings : 0		-	nused.		
-					
Messages : U	-				
	messages :	J			

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