



Interfacing PICmicroTM to an LCD Module

Author: Mark Palmer
Code: Mark Palmer/Scott Fink
Microchip Technology Inc.

INTRODUCTION

This application note interfaces a micrange PICmicro device to a Hitachi[®] LM032L LCD character display module, with a two line by twenty character display. LCD modules are useful for displaying text information from a system. In large volume applications, the use of custom LCD displays becomes economical. The routines provided should be a good starting point for users whose applications implement a custom LCD. This source code should be compatible with the PIC16C5X devices, after modifications for the special function register initialization, but has not been verified on those devices.

OPERATION

The Hitachi LM032L LCD character display module can operate in one of two modes. The first (and default) mode is the 4-bit data interface mode. The second is the 8-bit data interface mode. When operating in 4-bit mode, two transfers per character / command are required. 8-bit mode, though easier to implement (less program memory) requires four additional I/O lines. The use of 8-bit mode is strictly a program memory size vs. I/O trade-off. The three most common data interfaces from the microcontroller are:

- 1. An 8-bit interface.
2. A 4-bit interface, with data transfers on the high nibble of the port.
3. A 4-bit interface, with data transfers on the low nibble of the port.

The LCD module also has three control signals, Enable (E), Read/Write (R_W), and Register Select (RS). The function of each control signal is shown in Table 1.

TABLE 1: CONTROL SIGNAL FUNCTIONS

Table with 2 columns: Control Signal, Function. Rows include E (Latches control state/data), RS (Register Select Control), and R_W (Read / Write control).

A single source file, with conditional assembly is used to generate each of these three options. This requires two flags. The flags and their results are shown in Table 2.

TABLE 2: CONDITIONAL ASSEMBLY FLAGS

Table with 3 columns: Four_bit, Data_HI, Result. Shows combinations of flags leading to 4-bit mode (low/high nibble) or 8-bit mode.

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Figure 1, Figure 2, and Figure 3 show the block diagrams for the three different data interfaces. The LCD_CNTL and LCD_DATA lines are user definable to

their port assignment. This is accomplished with EQUate statements in the source code. See Appendices B, C, and D.

FIGURE 1: 8-BIT DATA INTERFACE

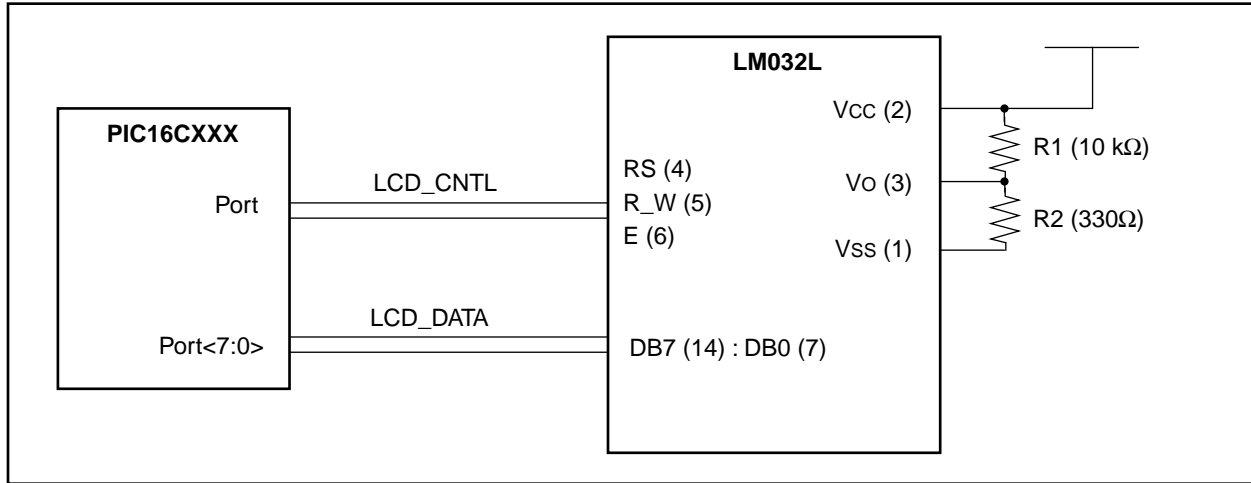


FIGURE 2: 4-BIT MODE; DATA TRANSFERRED ON THE HIGH NIBBLE OF THE PORT

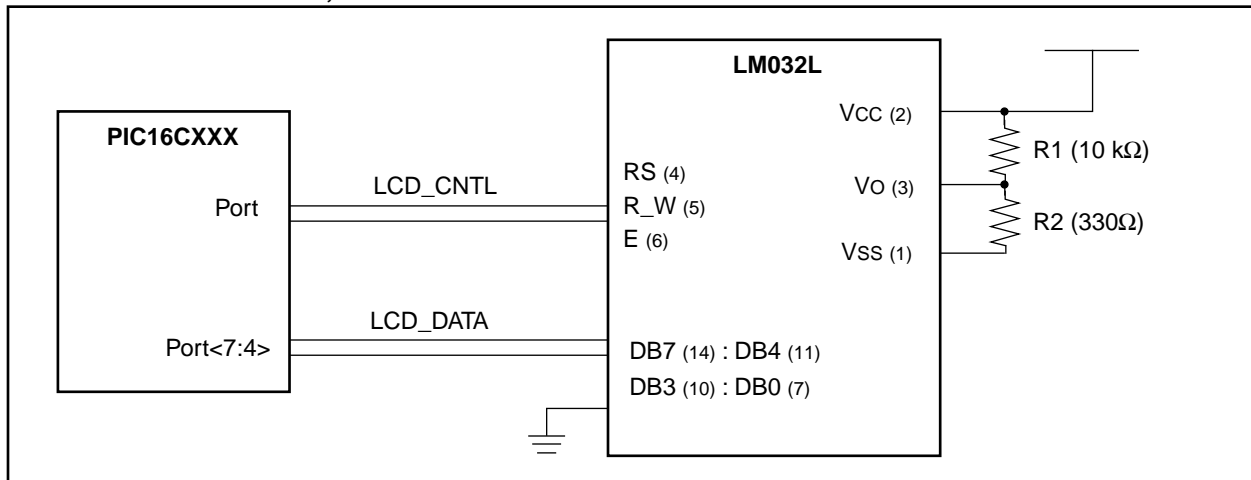
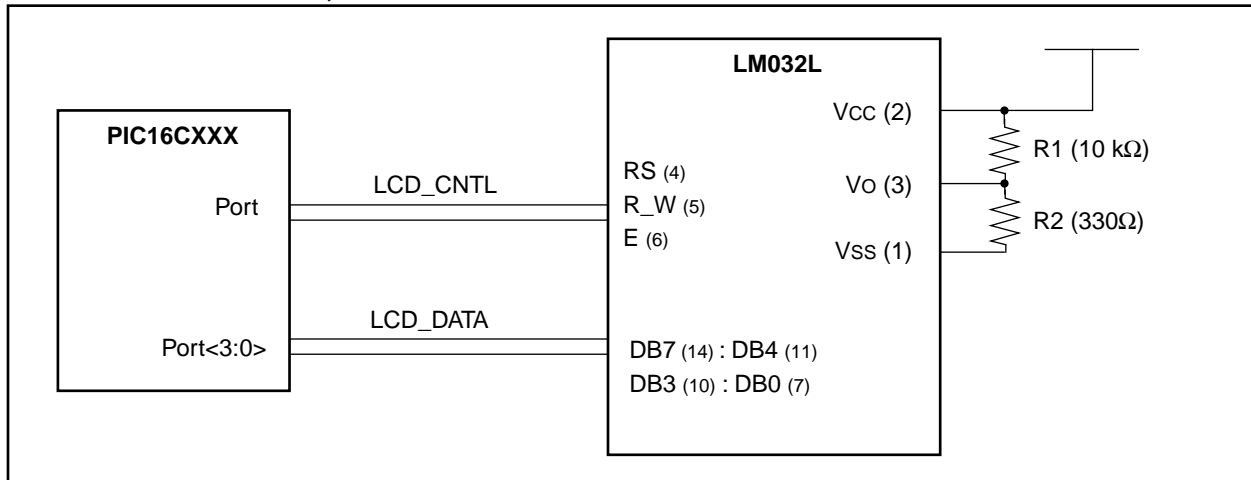


FIGURE 3: 4-BIT MODE; DATA TRANSFERRED ON THE LOW NIBBLE OF THE PORT



LCD's (drivers) are slow devices when compared to microcontrollers. Care must be taken from having communication occur too quickly. The software will need to control communication speed and timing to ensure the slow LCD and fast microcontroller can stay synchronized. The timing requirements of the LM032L are shown in Appendix A. We recommend that the complete specifications of the LM032L be acquired from Hitachi or a Hitachi distributor. The literature numbers are CE-E613Q and M24T013 for a LM032L display driver.

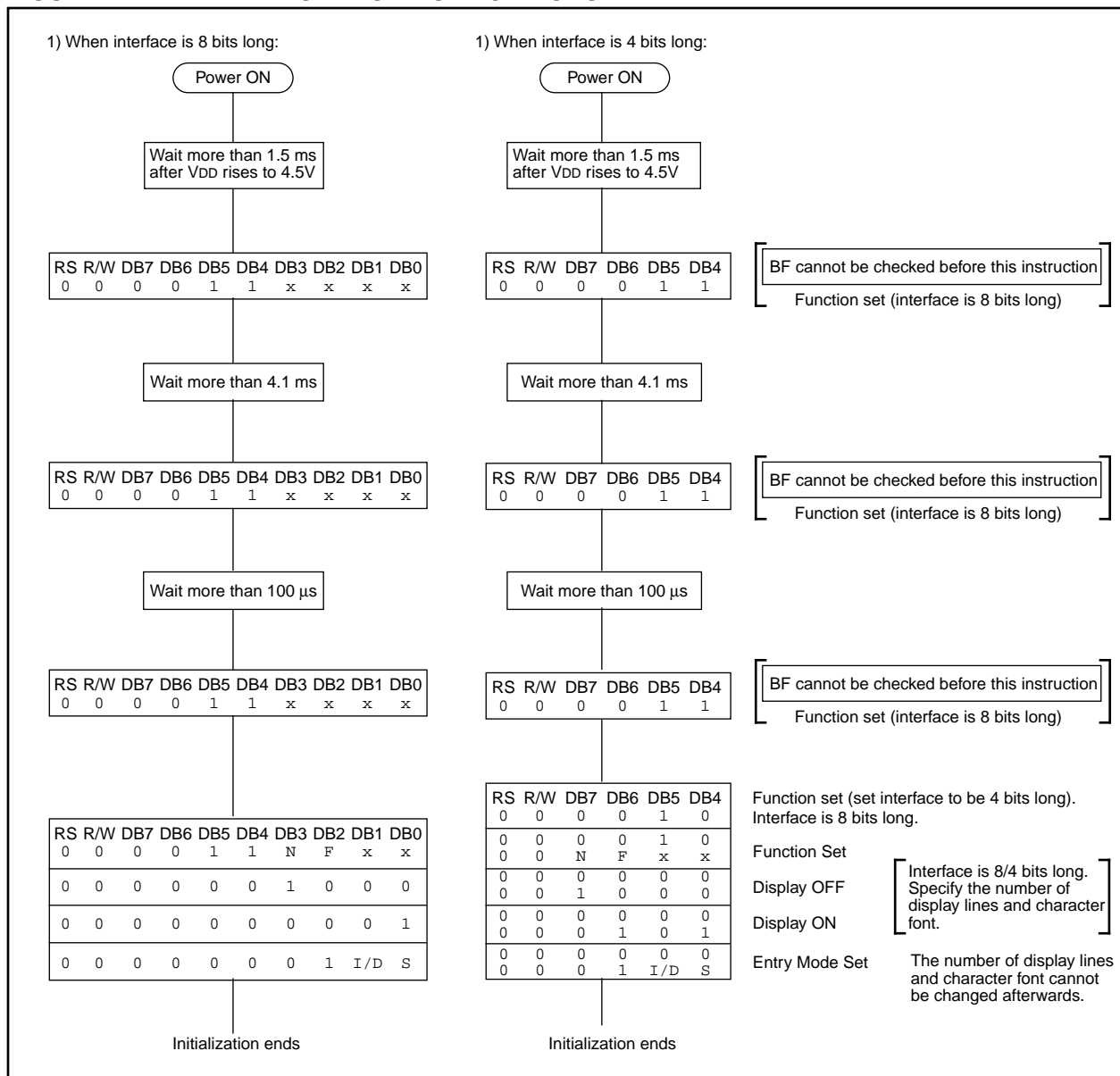
When the module powers up, the default data transfer mode is 8-bit. The initialization sequence only requires commands that are 4-bit in length. The last initialization

command needs to specify the data transfer width (4-or 8-bit). Then a delay of 4.6 ms must be executed before the LCD module can be initialized. Some of the LCD module commands are:

- 1 or 2 lines of characters
- Display on /off
- Clear display
- Increment / do not increment character address pointer after each character
- Load character address pointer

The initialization flow for the module is shown in Figure 4.

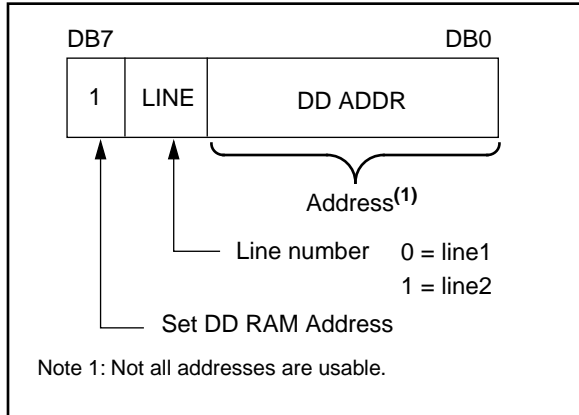
FIGURE 4: INITIALIZATION FLOW FOR LCD MODULE



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After initialization, each character address is individually addressable. Figure 5 shows the structure of the command to specify the character address.

FIGURE 5: CHARACTER ADDRESS COMMAND FORMAT



The Hitachi Display Drive (HD44780A) has 80 bytes of RAM. The LM032L modules only use 40 bytes of the available RAM (2 x 20 characters). It is possible to use the remaining RAM locations for storage of other information.

Figure 6 shows the display data positions supported by the display driver as well as the characters actually displayed by the module (the non-shaded addresses).

The program example implemented here uses the character auto increment feature. This automatically increments the character address pointer after each character is written to the display.

CONCLUSION

The Hitachi LM032L character display module is well suited for displaying information. The selection of 4-bit or 8-bit data transfer mode is strictly a program memory size vs. I/O resource trade-off. The supplied code is easily used in any of three common data interfaces. The source is easily modifiable to a designers specific application needs. Other display modules/drivers may be implemented with the appropriate modifications. Table 3 shows the resource requirements for the three subroutines SEND_CHAR, SEND_COMMAND, and BUSY_CHECK in the various data interface modes.

FIGURE 6: DISPLAY DRIVER (DD) RAM LOCATIONS

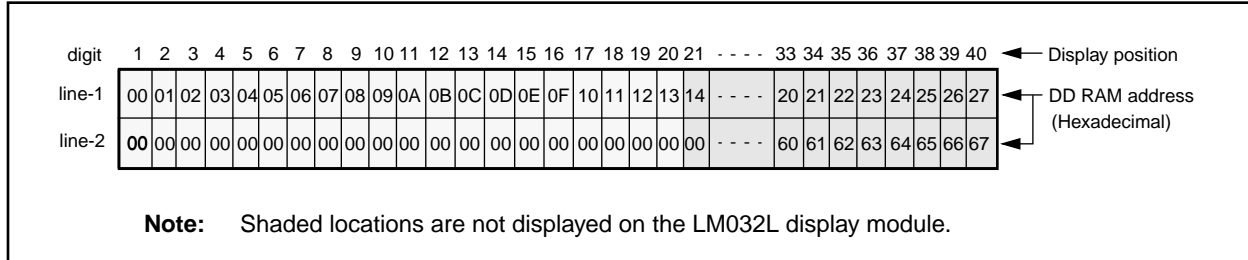


TABLE 3: RESOURCE REQUIREMENTS

Mode	Program Memory	Data Memory	Verified On
8-bit	32	3	PICDEM-2 ⁽¹⁾
4-bit, Data transferred on the high nibble of the port.	53	3	PICDEM-2 ⁽¹⁾
4-bit, Data transferred on the high nibble of the port.	53	3	Low-Power Real-Time Clock Board (AN582)

Note 1: Jumper J6 must be removed.

APPENDIX A: LM032L TIMING REQUIREMENTS

TABLE A-1: TIMING CHARACTERISTICS

Parameter #	Symbol	Characteristics	Min.	Typ.	Max.	Unit
1	TCYC	Enable cycle time	1.0	—	—	μs
2	PWEH	Enable pulse width	450	—	—	μs
3	TER, TEF	Enable rise / fall time	—	—	25	μs
4	TAS	RS, R/W set-up time	140	—	—	μs
5	TDDR	Data delay time	—	—	320	μs
6	Tdsu	Data setup time	195	—	—	μs
7	TH	Hold time	20	—	—	μs

FIGURE A-1: DATA WRITE INTERFACE TIMING

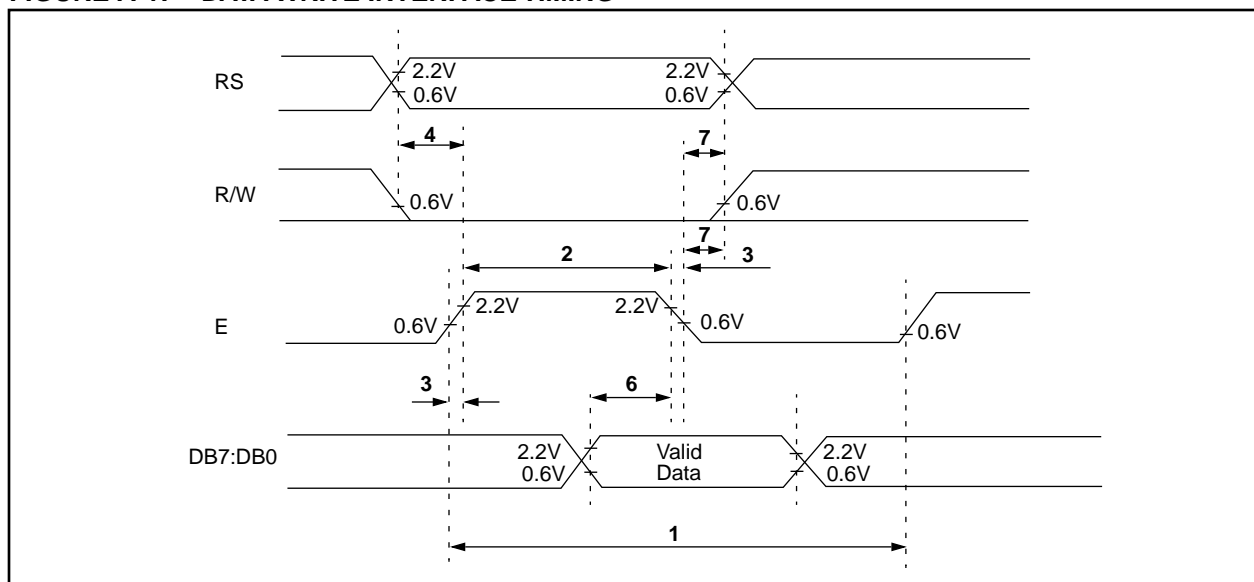
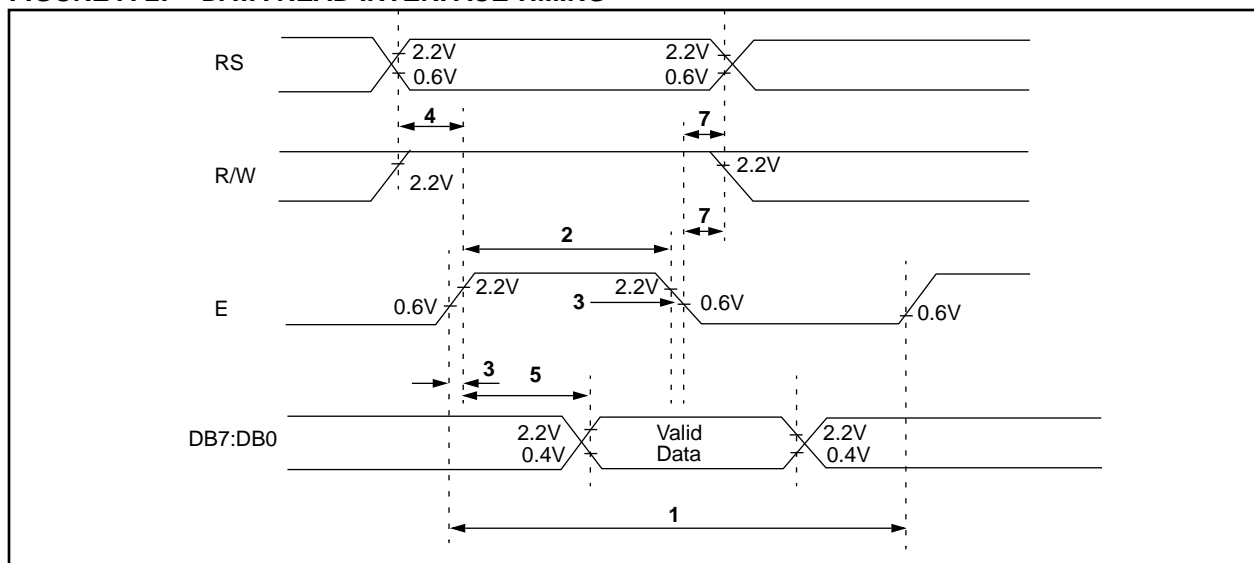


FIGURE A-2: DATA READ INTERFACE TIMING



Note: Refer to Hitachi documentation for the most current timing specifications.

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TABLE A-2: LM032L PIN CONNECTION

Pin No.	Symbol	Level	Function	
1	VSS	—	0V	Ground
2	VDD	—	+5V	Power Supply(+)
3	Vo	—	—	Ground
4	RS	H/L	L: Instruction Code Input H: Data Input	
5	R/W	H/L	H: Data Read (LCD module→MPU) L: Data Write (LCD module←MPU)	
6	E	H,H→L	Enable Signal	
7	DB0	H/L	Data Bus Line Note (1), (2)	
8	DB1	H/L		
9	DB2	H/L		
10	DB3	H/L		
11	DB4	H/L		
12	DB5	H/L		
13	DB6	H/L		
14	DB7	H/L		

In the HD44780, the data can be sent in either two 4-bit operations or one 8-bit operation, This flexibility allows an interface to both 4- and 8-bit MPUs.

- Note 1: When interface data is 4-bits long, data is transferred using only 4 lines of DB7:DB4 (DB3:DB0 are not used). Data transfer between the HD44780 and the MPU completes when 4-bits of data is transferred twice. Data of the higher order 4 bits (contents of DB7:DB4 when interface data is 8-bits long) is transferred first and then lower order 4 bits (contents of DB3:DB0 when interface data is 8-bits long).
- 2: When interface data is 8-bits long, data is transferred using 8 data lines of DB7:DB0.

Please check the Microchip BBS for the latest version of the source code. Microchip's Worldwide Web Address: www.microchip.com; Bulletin Board Support: MCHIPBBS using CompuServe® (CompuServe membership not required).

APPENDIX B: 8-BIT DATA INTERFACE LISTING

MPASM 01.40.01 Intermediate LM032L.ASM 4-7-1997 9:43:02 PAGE 1

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LOC  OBJECT CODE      LINE SOURCE TEXT
VALUE

00001          LIST P=16C64
00002          ERRORLEVEL  -302
00003 ;
00004 ; This program interfaces to a Hitachi (LM032L) 2 line by 20 character display
00005 ; module. The program assembles for either 4-bit or 8-bit data interface, depending
00006 ; on the value of the 4bit flag. LCD_DATA is the port which supplies the data to
00007 ; the LM032L, while LCD_CNTL is the port that has the control lines ( E, RS, RW ).
00008 ; In 4-bit mode the data is transfer on the high nibble of the port ( PORT<7:4> ).
00009 ;
00010 ;      Program = LM032L.ASM
00011 ;      Revision Date:      5-10-94
00012 ;                        1-22-97      Compatibility with MPASMWIN 1.40
00013 ;
00014 ;
00015          include <p16c64.inc>
00001          LIST
00002 ; P16C64.INC Standard Header File, Version 1.01 Microchip Technology, Inc.
00238          LIST
00016
0000009F      00017 ADCON1          EQU  9F
00018
00000000      00019 FALSE              EQU  0
00000001      00020 TRUE               EQU  1
00021
00022          include <lm032l.h>
00069          list
00023 ;
00000001      00024 Four_bit          EQU  TRUE          ; Selects 4- or 8-bit data transfers
00000000      00025 Data_HI           EQU  FALSE         ; If 4-bit transfers, Hi or Low nibble of PORT
00026 ;
00027 ;
00028          if ( Four_bit && !Data_HI )
00029 ;
00000006      00030 LCD_DATA          EQU  PORTB
00000086      00031 LCD_DATA_TRIS     EQU  TRISB

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00032 ;
00033     else
00034 ;
00035 LCD_DATA      EQU  PORTD
00036 LCD_DATA_TRIS EQU  TRISD
00037 ;
00038     endif
00039 ;
00000005 00040 LCD_CNTL      EQU  PORTA
00041 ;
00042 ;
00043 ;
00044 ; LCD Display Commands and Control Signal names.
00045 ;
00046     if ( Four_bit && !Data_HI )
00047 ;
00000000 00048 E              EQU  0          ; LCD Enable control line
00000001 00049 RW          EQU  1          ; LCD Read/Write control line
00000002 00050 RS          EQU  2          ; LCD Register Select control line
00051 ;
00052     else
00053 ;
00054 E              EQU  3          ; LCD Enable control line
00055 RW          EQU  2          ; LCD Read/Write control line
00056 RS          EQU  1          ; LCD Register Select control line
00057 ;
00058     endif
00059 ;
00060 ;
00000030 00061 TEMP1        EQU  0x030
00062 ;
0000     00063     org      RESET_V      ; RESET vector location
0000 2808 00064 RESET      GOTO    START    ;
00065 ;
00066 ; This is the Periperal Interrupt routine. Should NOT get here
00067 ;
00068     page
0004     00069     org      ISR_V        ; Interrupt vector location
0004     00070 PER_INT_V
0004 1283 00071 ERROR1      BCF  STATUS, RP0    ; Bank 0
0005 1407 00072          BSF  PORTC, 0
0006 1007 00073          BCF  PORTC, 0
0007 2804 00074          GOTO  ERROR1
00075 ;
00076 ;
00077 ;
0008     00078 START          ; POWER_ON Reset (Beginning of program)

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0008 0183      00079      CLRf  STATUS      ; Do initialization (Bank 0)
0009 018B      00080      CLRf  INTCON
000A 018C      00081      CLRf  PIR1
000B 1683      00082      BSf   STATUS, RP0      ; Bank 1
000C 3000      00083      MOVLW 0x00          ; The LCD module does not like to work w/ weak pull-ups
000D 0081      00084      MOVWF OPTION_REG    ;
000E 018C      00085      CLRf  PIE1          ; Disable all peripheral interrupts
                00086 ;***
                00087 ;***   If using device with A/D, these two instructions are required.
                00088 ;***
                00089 ;           MOVLW  0xFF          ;
                00090 ;           MOVWF  ADCON1       ; Port A is Digital.
                00091 ;
                00092 ;
000F 1283      00093      BCF   STATUS, RP0      ; Bank 0
0010 0185      00094      CLRf  PORTA          ; ALL PORT output should output Low.
0011 0186      00095      CLRf  PORTB
0012 0187      00096      CLRf  PORTC
0013 0188      00097      CLRf  PORTD
0014 0189      00098      CLRf  PORTE
0015 1010      00099      BCF   T1CON, TMR1ON   ; Timer 1 is NOT incrementing
                00100 ;
0016 1683      00101      BSf   STATUS, RP0      ; Select Bank 1
0017 0185      00102      CLRf  TRISA          ; RA5 - 0 outputs
0018 30F0      00103      MOVLW 0xF0          ;
0019 0086      00104      MOVWF TRISB          ; RB7 - 4 inputs, RB3 - 0 outputs
001A 0187      00105      CLRf  TRISC          ; RC Port are outputs
001B 1407      00106      BSf   TRISC, T1OSO    ; RC0 needs to be input for the oscillator to function
001C 0188      00107      CLRf  TRISD          ; RD Port are outputs
001D 0189      00108      CLRf  TRISE          ; RE Port are outputs
001E 140C      00109      BSf   PIE1, TMR1IE    ; Enable TMR1 Interrupt
001F 1781      00110      BSf   OPTION_REG,NOT_RBPU ; Disable PORTB pull-ups
0020 1283      00111      BCF   STATUS, RP0      ; Select Bank 0
                00112 ;
                00113   page
                00114 ;
                00115 ; Initialize the LCD Display Module
                00116 ;
0021 0185      00117      CLRf  LCD_CNTL       ; ALL PORT output should output Low.
                00118 ;
0022          00119 DISPLAY_INIT
                00120   if ( Four_bit && !Data_HI )
0022 3002      00121      MOVLW 0x02          ; Command for 4-bit interface low nibble
                00122   endif
                00123 ;
                00124   if ( Four_bit && Data_HI )
                00125      MOVLW 0x020          ; Command for 4-bit interface high nibble

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00126     endif
00127 ;
00128     if ( !Four_bit )
00129         MOVLW    0x038                ; Command for 8-bit interface
00130     endif
00131 ;
0023 0086 00132         MOVWF    LCD_DATA                ;
0024 1405 00133         BSF     LCD_CNTL, E                ;
0025 1005 00134         BCF     LCD_CNTL, E                ;
00135 ;
00136 ; This routine takes the calculated times that the delay loop needs to
00137 ; be executed, based on the LCD_INIT_DELAY EQUate that includes the
00138 ; frequency of operation. These uses registers before they are needed to
00139 ; store the time.
00140 ;
0026 3006 00141 LCD_DELAY  MOVLW    LCD_INIT_DELAY            ;
0027 00B3 00142         MOVWF    MSD                        ; Use MSD and LSD Registers to Initialize LCD
0028 01B4 00143         CLRWF    LSD                        ;
0029 0BB4 00144 LOOP2    DECFSZ   LSD, F                    ; Delay time = MSD * ((3 * 256) + 3) * Tcy
002A 2829 00145         GOTO    LOOP2                    ;
002B 0BB3 00146         DECFSZ   MSD, F                    ;
002C      00147 END_LCD_DELAY
002C 2829 00148         GOTO    LOOP2                    ;
00149 ;
00150 ; Command sequence for 2 lines of 5x7 characters
00151 ;
002D      00152 CMD_SEQ
00153 ;
00154         if ( Four_bit )
00155             if ( !Data_HI )
002D 3002 00156                 MOVLW    0X02                ; 4-bit low nibble xfer
00157             else
00158                 MOVLW    0X020                ; 4-bit high nibble xfer
00159             endif
00160 ;
00161         else                ; 8-bit mode
00162             MOVLW    0X038
00163         endif
00164 ;
002E 0086 00165         MOVWF    LCD_DATA                ; This code for both 4-bit and 8-bit modes
002F 1405 00166         BSF     LCD_CNTL, E                ;
0030 1005 00167         BCF     LCD_CNTL, E                ;
00168 ;
00169         if ( Four_bit )                ; This code for only 4-bit mode (2nd xfer)
00170             if ( !Data_HI )
0031 3008 00171                 MOVLW    0x08                ; 4-bit low nibble xfer
00172             else

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00173             MOVLW  0x080             ; 4-bit high nibble xfer
00174             endif
0032 0086        00175             MOVWF  LCD_DATA             ;
0033 1405        00176             BSF    LCD_CNTL, E         ;
0034 1005        00177             BCF    LCD_CNTL, E         ;
00178             endif
00179 ;
00180 ; Busy Flag should be valid after this point
00181 ;
0035 300C        00182             MOVLW  DISP_ON             ;
0036 2072        00183             CALL   SEND_CMD             ;
0037 3001        00184             MOVLW  CLR_DISP             ;
0038 2072        00185             CALL   SEND_CMD             ;
0039 3006        00186             MOVLW  ENTRY_INC           ;
003A 2072        00187             CALL   SEND_CMD             ;
003B 3080        00188             MOVLW  DD_RAM_ADDR         ;
003C 2072        00189             CALL   SEND_CMD             ;
00190 ;
00191             page
00192 ;
00193 ;Send a message the hard way
003D 304D        00194             movlw  'M'
003E 2063        00195             call   SEND_CHAR
003F 3069        00196             movlw  'i'
0040 2063        00197             call   SEND_CHAR
0041 3063        00198             movlw  'c'
0042 2063        00199             call   SEND_CHAR
0043 3072        00200             movlw  'r'
0044 2063        00201             call   SEND_CHAR
0045 306F        00202             movlw  'o'
0046 2063        00203             call   SEND_CHAR
0047 3063        00204             movlw  'c'
0048 2063        00205             call   SEND_CHAR
0049 3068        00206             movlw  'h'
004A 2063        00207             call   SEND_CHAR
004B 3069        00208             movlw  'i'
004C 2063        00209             call   SEND_CHAR
004D 3070        00210             movlw  'p'
004E 2063        00211             call   SEND_CHAR
00212
004F 30C0        00213             movlw  B'11000000'         ;Address DDRam first character, second line
0050 2072        00214             call   SEND_CMD
00215
00216             ;Demonstration of the use of a table to output a message
0051 3000        00217             movlw  0             ;Table address of start of message
0052             00218             dispmsg
0052 00B0        00219             movwf  TEMP1             ;TEMP1 holds start of message address

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0053 2099      00220      call    Table
0054 39FF      00221      andlw   0FFh           ;Check if at end of message (zero
0055 1903      00222      btfsc  STATUS,Z       ;returned at end)
0056 285B      00223      goto   out
0057 2063      00224      call   SEND_CHAR      ;Display character
0058 0830      00225      movf   TEMPl,w        ;Point to next character
0059 3E01      00226      addlw  1
005A 2852      00227      goto   dispmsg
005B          00228      out
005B          00229      loop
005B 285B      00230      goto   loop           ;Stay here forever
00231 ;
00232 ;
005C          00233      INIT_DISPLAY
005C 300C      00234      MOVLW  DISP_ON       ; Display On, Cursor On
005D 2072      00235      CALL   SEND_CMD       ; Send This command to the Display Module
005E 3001      00236      MOVLW  CLR_DISP       ; Clear the Display
005F 2072      00237      CALL   SEND_CMD       ; Send This command to the Display Module
0060 3006      00238      MOVLW  ENTRY_INC      ; Set Entry Mode Inc., No shift
0061 2072      00239      CALL   SEND_CMD       ; Send This command to the Display Module
0062 0008      00240      RETURN
00241 ;
00242      page
00243 ;
00244 ;*****
00245 ;* The LCD Module Subroutines *
00246 ;*****
00247 ;
00248      if ( Four_bit )      ; 4-bit Data transfers?
00249 ;
00250      if ( Data_HI )      ; 4-bit transfers on the high nibble of the PORT
00251 ;
00252 ;*****
00253 ;*SendChar - Sends character to LCD *
00254 ;*This routine splits the character into the upper and lower *
00255 ;*nibbles and sends them to the LCD, upper nibble first. *
00256 ;*****
00257 ;
00258 SEND_CHAR
00259      MOVWF  CHAR           ;Character to be sent is in W
00260      CALL  BUSY_CHECK      ;Wait for LCD to be ready
00261      MOVF   CHAR, w
00262      ANDLW 0xF0           ;Get upper nibble
00263      MOVWF  LCD_DATA      ;Send data to LCD
00264      BCF   LCD_CNTRL, RW   ;Set LCD to read
00265      BSF   LCD_CNTRL, RS   ;Set LCD to data mode
00266      BSF   LCD_CNTRL, E    ;toggle E for LCD

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00267          BCF      LCD_CNTL, E
00268          SWAPF   CHAR, w
00269          ANDLW   0xF0          ;Get lower nibble
00270          MOVWF   LCD_DATA      ;Send data to LCD
00271          BSF     LCD_CNTL, E   ;toggle E for LCD
00272          BCF     LCD_CNTL, E
00273          RETURN
00274 ;
00275          else                ; 4-bit transfers on the low nibble of the PORT
00276 ;
00277 ;*****
00278 ;* SEND_CHAR - Sends character to LCD *
00279 ;* This routine splits the character into the upper and lower *
00280 ;* nibbles and sends them to the LCD, upper nibble first. *
00281 ;* The data is transmitted on the PORT<3:0> pins *
00282 ;*****
00283 ;
0063          00284 SEND_CHAR
0063 00B6          00285          MOVWF   CHAR          ; Character to be sent is in W
0064 2081          00286          CALL    BUSY_CHECK      ; Wait for LCD to be ready
0065 0E36          00287          SWAPF   CHAR, W
0066 390F          00288          ANDLW   0x0F          ; Get upper nibble
0067 0086          00289          MOVWF   LCD_DATA      ; Send data to LCD
0068 1085          00290          BCF     LCD_CNTL, RW   ; Set LCD to read
0069 1505          00291          BSF     LCD_CNTL, RS   ; Set LCD to data mode
006A 1405          00292          BSF     LCD_CNTL, E   ; toggle E for LCD
006B 1005          00293          BCF     LCD_CNTL, E
006C 0836          00294          MOVF    CHAR, W
006D 390F          00295          ANDLW   0x0F          ; Get lower nibble
006E 0086          00296          MOVWF   LCD_DATA      ; Send data to LCD
006F 1405          00297          BSF     LCD_CNTL, E   ; toggle E for LCD
0070 1005          00298          BCF     LCD_CNTL, E
0071 0008          00299          RETURN
00300 ;
00301          endif
00302          else
00303 ;
00304 ;*****
00305 ;* SEND_CHAR - Sends character contained in register W to LCD *
00306 ;* This routine sends the entire character to the PORT *
00307 ;* The data is transmitted on the PORT<7:0> pins *
00308 ;*****
00309 ;
00310          00310 SEND_CHAR
00311          00311          MOVWF   CHAR          ; Character to be sent is in W
00312          00312          CALL    BUSY_CHECK      ; Wait for LCD to be ready
00313          00313          MOVF    CHAR, w

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00314         MOVWF    LCD_DATA        ; Send data to LCD
00315         BCF     LCD_CNTL, RW     ; Set LCD in read mode
00316         BSF     LCD_CNTL, RS     ; Set LCD in data mode
00317         BSF     LCD_CNTL, E       ; toggle E for LCD
00318         BCF     LCD_CNTL, E
00319         RETURN
00320 ;
00321     endif
00322 ;
00323     page
00324 ;
00325 ;*****
00326 ;* SendCmd - Sends command to LCD *
00327 ;* This routine splits the command into the upper and lower *
00328 ;* nibbles and sends them to the LCD, upper nibble first. *
00329 ;* The data is transmitted on the PORT<3:0> pins *
00330 ;*****
00331 ;
00332     if ( Four_bit )           ; 4-bit Data transfers?
00333 ;
00334         if ( Data_HI )       ; 4-bit transfers on the high nibble of the PORT
00335 ;
00336 ;*****
00337 ;* SEND_CMD - Sends command to LCD *
00338 ;* This routine splits the command into the upper and lower *
00339 ;* nibbles and sends them to the LCD, upper nibble first. *
00340 ;*****
00341
00342 SEND_CMD
00343     MOVWF    CHAR                ; Character to be sent is in W
00344     CALL    BUSY_CHECK           ; Wait for LCD to be ready
00345     MOVF    CHAR,w
00346     ANDLW  0xF0                 ; Get upper nibble
00347     MOVWF    LCD_DATA           ; Send data to LCD
00348     BCF     LCD_CNTL,RW         ; Set LCD to read
00349     BCF     LCD_CNTL,RS         ; Set LCD to command mode
00350     BSF     LCD_CNTL,E         ; toggle E for LCD
00351     BCF     LCD_CNTL,E
00352     SWAPF   CHAR,w
00353     ANDLW  0xF0                 ; Get lower nibble
00354     MOVWF    LCD_DATA           ; Send data to LCD
00355     BSF     LCD_CNTL,E         ; toggle E for LCD
00356     BCF     LCD_CNTL,E
00357     RETURN
00358 ;
00359     else                       ; 4-bit transfers on the low nibble of the PORT
00360 ;

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0072          00361 SEND_CMD
0072 00B6      00362          MOVWF  CHAR           ; Character to be sent is in W
0073 2081      00363          CALL   BUSY_CHECK        ; Wait for LCD to be ready
0074 0E36      00364          SWAPF  CHAR, W
0075 390F      00365          ANDLW  0x0F           ; Get upper nibble
0076 0086      00366          MOVWF  LCD_DATA        ; Send data to LCD
0077 1085      00367          BCF   LCD_CNTRL, RW      ; Set LCD to read
0078 1105      00368          BCF   LCD_CNTRL, RS      ; Set LCD to command mode
0079 1405      00369          BSF   LCD_CNTRL, E      ; toggle E for LCD
007A 1005      00370          BCF   LCD_CNTRL, E
007B 0836      00371          MOVF   CHAR, W
007C 390F      00372          ANDLW  0x0F           ; Get lower nibble
007D 0086      00373          MOVWF  LCD_DATA        ; Send data to LCD
007E 1405      00374          BSF   LCD_CNTRL, E      ; toggle E for LCD
007F 1005      00375          BCF   LCD_CNTRL, E
0080 0008      00376          RETURN
00377 ;
00378          endif
00379          else
00380 ;
00381 ;*****
00382 ;* SEND_CND - Sends command contained in register W to LCD *
00383 ;* This routine sends the entire character to the PORT *
00384 ;* The data is transmitted on the PORT<7:0> pins *
00385 ;*****
00386
00387 SEND_CMD
00388          MOVWF  CHAR           ; Command to be sent is in W
00389          CALL   BUSY_CHECK        ; Wait for LCD to be ready
00390          MOVF   CHAR, w
00391          MOVWF  LCD_DATA        ; Send data to LCD
00392          BCF   LCD_CNTRL, RW      ; Set LCD in read mode
00393          BCF   LCD_CNTRL, RS      ; Set LCD in command mode
00394          BSF   LCD_CNTRL, E      ; toggle E for LCD
00395          BCF   LCD_CNTRL, E
00396          RETURN
00397 ;
00398          endif
00399 ;
00400          page
00401 ;
00402          if ( Four_bit )           ; 4-bit Data transfers?
00403 ;
00404          if ( Data_HI )           ; 4-bit transfers on the high nibble of the PORT
00405 ;
00406 ;*****
00407 ;* This routine checks the busy flag, returns when not busy *

```

```

00408 ;* Affects:
00409 ;*     TEMP - Returned with busy/address
00410 ;*****
00411 ;
00412 BUSY_CHECK
00413     BSF     STATUS, RP0     ; Select Register Bank1
00414     MOVLW  0xFF           ; Set Port_D for input
00415     MOVWF  LCD_DATA_TRIS
00416     BCF     STATUS, RP0     ; Select Register Bank0
00417     BCF     LCD_CNTL, RS    ; Set LCD for Command mode
00418     BSF     LCD_CNTL, RW    ; Setup to read busy flag
00419     BSF     LCD_CNTL, E     ; Set E high
00420     BCF     LCD_CNTL, E     ; Set E low
00421     MOVF   LCD_DATA, W     ; Read upper nibble busy flag, DDRam address
00422     ANDLW  0xF0           ; Mask out lower nibble
00423     MOVWF  TEMP
00424     BSF     LCD_CNTL, E     ; Toggle E to get lower nibble
00425     BCF     LCD_CNTL, E
00426     SWAPF  LCD_DATA, w     ; Read lower nibble busy flag, DDRam address
00427     ANDLW  0x0F           ; Mask out upper nibble
00428     IORWF  TEMP
00429     BTFSC  TEMP, 7         ; Check busy flag, high = busy
00430     GOTO   BUSY_CHECK     ; If busy, check again
00431     BCF     LCD_CNTL, RW
00432     BSF     STATUS, RP0     ; Select Register Bank1
00433     MOVLW  0x0F
00434     MOVWF  LCD_DATA_TRIS  ; Set Port_D for output
00435     BCF     STATUS, RP0     ; Select Register Bank0
00436     RETURN
00437 ;
00438     else                 ; 4-bit transfers on the low nibble of the PORT
00439 ;
00440 ;*****
00441 ;* This routine checks the busy flag, returns when not busy
00442 ;* Affects:
00443 ;*     TEMP - Returned with busy/address
00444 ;*****
00445 ;
0081 00446 BUSY_CHECK
0081 1683 00447     BSF     STATUS, RP0     ; Bank 1
0082 30FF 00448     MOVLW  0xFF           ; Set PortB for input
0083 0086 00449     MOVWF  LCD_DATA_TRIS
0084 1283 00450     BCF     STATUS, RP0     ; Bank 0
0085 1105 00451     BCF     LCD_CNTL, RS    ; Set LCD for Command mode
0086 1485 00452     BSF     LCD_CNTL, RW    ; Setup to read busy flag
0087 1405 00453     BSF     LCD_CNTL, E     ; Set E high
0088 1005 00454     BCF     LCD_CNTL, E     ; Set E low

```



```

0089 0E06      00455      SWAPF   LCD_DATA, W      ; Read upper nibble busy flag, DDRam address
008A 39F0      00456      ANDLW   0xF0             ; Mask out lower nibble
008B 00B5      00457      MOVWF   TEMP            ;
008C 1405      00458      BSF     LCD_CNTL, E     ; Toggle E to get lower nibble
008D 1005      00459      BCF     LCD_CNTL, E     ;
008E 0806      00460      MOVF    LCD_DATA, W     ; Read lower nibble busy flag, DDRam address
008F 390F      00461      ANDLW   0x0F           ; Mask out upper nibble
0090 04B5      00462      IORWF   TEMP, F        ; Combine nibbles
0091 1BB5      00463      BTFSC   TEMP, 7        ; Check busy flag, high = busy
0092 2881      00464      GOTO    BUSY_CHECK     ; If busy, check again
0093 1085      00465      BCF     LCD_CNTL, RW   ;
0094 1683      00466      BSF     STATUS, RP0    ; Bank 1
0095 30F0      00467      MOVLW   0xF0           ;
0096 0086      00468      MOVWF   LCD_DATA_TRIS ; RB7 - 4 = inputs, RB3 - 0 = output
0097 1283      00469      BCF     STATUS, RP0    ; Bank 0
0098 0008      00470      RETURN
00471 ;
00472         endif
00473     else
00474 ;
00475 ;*****
00476 ;* This routine checks the busy flag, returns when not busy *
00477 ;* Affects: *
00478 ;*     TEMP - Returned with busy/address *
00479 ;*****
00480 ;
00481 BUSY_CHECK
00482     BSF     STATUS,RP0    ; Select Register Bank1
00483     MOVLW   0xFF         ; Set port_D for input
00484     MOVWF   LCD_DATA_TRIS
00485     BCF     STATUS, RP0  ; Select Register Bank0
00486     BCF     LCD_CNTL, RS ; Set LCD for command mode
00487     BSF     LCD_CNTL, RW ; Setup to read busy flag
00488     BSF     LCD_CNTL, E  ; Set E high
00489     BCF     LCD_CNTL, E  ; Set E low
00490     MOVF    LCD_DATA, w  ; Read busy flag, DDRam address
00491     MOVWF   TEMP
00492     BTFSC   TEMP, 7     ; Check busy flag, high=busy
00493     GOTO    BUSY_CHECK
00494     BCF     LCD_CNTL, RW
00495     BSF     STATUS, RP0  ; Select Register Bank1
00496     MOVLW   0x00
00497     MOVWF   LCD_DATA_TRIS ; Set port_D for output
00498     BCF     STATUS, RP0  ; Select Register Bank0
00499     RETURN
00500 ;
00501     endif

```

```

00502     page
00503 ;
0099     00504 Table
0099 0782     00505     addwf PCL, F           ;Jump to char pointed to in W reg
009A 344D     00506     retlw 'M'
009B 3469     00507     retlw 'i'
009C 3463     00508     retlw 'c'
009D 3472     00509     retlw 'r'
009E 346F     00510     retlw 'o'
009F 3463     00511     retlw 'c'
00A0 3468     00512     retlw 'h'
00A1 3469     00513     retlw 'i'
00A2 3470     00514     retlw 'p'
00A3 3420     00515     retlw ' '
00A4 3454     00516     retlw 'T'
00A5 3465     00517     retlw 'e'
00A6 3463     00518     retlw 'c'
00A7 3468     00519     retlw 'h'
00A8 346E     00520     retlw 'n'
00A9 346F     00521     retlw 'o'
00AA 346C     00522     retlw 'l'
00AB 346F     00523     retlw 'o'
00AC 3467     00524     retlw 'g'
00AD 3479     00525     retlw 'y'
00AE     00526 Table_End
00AE 3400     00527     retlw 0
00528 ;
00529     if ( (Table & 0x0FF) >= (Table_End & 0x0FF) )
00530         MESSG "Warning - User Definded: Table Table crosses page boundry in computed jump"
00531     endif
00532 ;
00533
00534
00535
00536     end
MEMORY USAGE MAP ('X' = Used, '-' = Unused)

0000 : X--XXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX
0040 : XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX
0080 : XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX- -----

All other memory blocks unused.

Program Memory Words Used: 172
Program Memory Words Free: 1876

```

Errors : 0
Warnings : 0 reported, 0 suppressed
Messages : 0 reported, 12 suppressed

Please check the Microchip BBS for the latest version of the source code. Microchip's Worldwide Web Address: www.microchip.com; Bulletin Board Support: MCHIPBBS using CompuServe® (CompuServe membership not required).

APPENDIX C: 4-BIT DATA INTERFACE, HIGH NIBBLE LISTING

MPASM 01.40.01 Intermediate LM032L.ASM 4-7-1997 9:50:32 PAGE 1

```

LOC  OBJECT CODE      LINE SOURCE TEXT
VALUE

00001          LIST P=16C64
00002          ERRORLEVEL  -302
00003 ;
00004 ; This program interfaces to a Hitachi (LM032L) 2 line by 20 character display
00005 ; module. The program assembles for either 4-bit or 8-bit data interface, depending
00006 ; on the value of the 4bit flag. LCD_DATA is the port which supplies the data to
00007 ; the LM032L, while LCD_CNTL is the port that has the control lines ( E, RS, RW ).
00008 ; In 4-bit mode the data is transfer on the high nibble of the port ( PORT<7:4> ).
00009 ;
00010 ;      Program = LM032L.ASM
00011 ;      Revision Date:   5-10-94
00012 ;                      1-22-97      Compatibility with MPASMWIN 1.40
00013 ;
00014 ;
00015          include <p16c64.inc>
00001          LIST
00002 ; P16C64.INC Standard Header File, Version 1.01      Microchip Technology, Inc.
00238          LIST
00016
0000009F      00017 ADCON1          EQU      9F
00018
00000000      00019 FALSE             EQU      0
00000001      00020 TRUE              EQU      1
00021
00022          include <lm032l.h>
00069          list
00023 ;
00000000      00024 Four_bit          EQU      FALSE      ; Selects 4- or 8-bit data transfers
00000001      00025 Data_HI           EQU      TRUE       ; If 4-bit transfers, Hi or Low nibble of PORT
00026 ;
00027 ;
00028          if ( Four_bit && !Data_HI )
00029 ;
00030 LCD_DATA          EQU      PORTB
00031 LCD_DATA_TRIS     EQU      TRISB

```

```

00032 ;
00033     else
00034 ;
00000008 00035 LCD_DATA      EQU    PORTD
00000088 00036 LCD_DATA_TRIS  EQU    TRISD
00037 ;
00038     endif
00039 ;
00000005 00040 LCD_CNTL      EQU    PORTA
00041 ;
00042 ;
00043 ;
00044 ; LCD Display Commands and Control Signal names.
00045 ;
00046     if ( Four_bit && !Data_HI )
00047 ;
00048 E            EQU    0            ; LCD Enable control line
00049 RW          EQU    1            ; LCD Read/Write control line
00050 RS          EQU    2            ; LCD Register Select control line
00051 ;
00052     else
00053 ;
00000003 00054 E            EQU    3            ; LCD Enable control line
00000002 00055 RW          EQU    2            ; LCD Read/Write control line
00000001 00056 RS          EQU    1            ; LCD Register Select control line
00057 ;
00058     endif
00059 ;
00060 ;
00000030 00061 TEMP1      EQU    0x030
00062 ;
0000      00063     org    RESET_V            ; RESET vector location
0000 2808 00064 RESET      GOTO    START            ;
00065 ;
00066 ; This is the Peripheral Interrupt routine. Should NOT get here
00067 ;
00068     page
0004      00069     org    ISR_V            ; Interrupt vector location
0004      00070 PER_INT_V
0004 1283 00071 ERROR1      BCF    STATUS, RP0        ; Bank 0
0005 1407 00072          BSF    PORTC, 0
0006 1007 00073          BCF    PORTC, 0
0007 2804 00074          GOTO    ERROR1
00075 ;
00076 ;
00077 ;
0008      00078 START          ; POWER_ON Reset (Beginning of program)

```

```

0008 0183      00079      CLRFB  STATUS      ; Do initialization (Bank 0)
0009 018B      00080      CLRFB  INTCON
000A 018C      00081      CLRFB  PIR1
000B 1683      00082      BSFB  STATUS, RP0  ; Bank 1
000C 3000      00083      MOVLW 0x00        ; The LCD module does not like to work w/ weak pull-ups
000D 0081      00084      MOVWF OPTION_REG ;
000E 018C      00085      CLRFB  PIE1        ; Disable all peripheral interrupts
00086 ;***
00087 ;*** If using device with A/D, these two instructions are required.
00088 ;***
00089 ;          MOVLW  0xFF          ;
00090 ;          MOVWF  ADCON1       ; Port A is Digital.
00091 ;
00092 ;
000F 1283      00093      BCFB  STATUS, RP0  ; Bank 0
0010 0185      00094      CLRFB  PORTA       ; ALL PORT output should output Low.
0011 0186      00095      CLRFB  PORTB
0012 0187      00096      CLRFB  PORTC
0013 0188      00097      CLRFB  PORTD
0014 0189      00098      CLRFB  PORTE
0015 1010      00099      BCFB  T1CON, TMR1ON ; Timer 1 is NOT incrementing
00100 ;
0016 1683      00101      BSFB  STATUS, RP0  ; Select Bank 1
0017 0185      00102      CLRFB  TRISA       ; RA5 - 0 outputs
0018 30F0      00103      MOVLW 0xF0        ;
0019 0086      00104      MOVWF  TRISB       ; RB7 - 4 inputs, RB3 - 0 outputs
001A 0187      00105      CLRFB  TRISC       ; RC Port are outputs
001B 1407      00106      BSFB  TRISC, T1OSO ; RC0 needs to be input for the oscillator to function
001C 0188      00107      CLRFB  TRISD       ; RD Port are outputs
001D 0189      00108      CLRFB  TRISE       ; RE Port are outputs
001E 140C      00109      BSFB  PIE1, TMR1IE ; Enable TMR1 Interrupt
001F 1781      00110      BSFB  OPTION_REG, NOT_RBPU ; Disable PORTB pull-ups
0020 1283      00111      BCFB  STATUS, RP0  ; Select Bank 0
00112 ;
00113      page
00114 ;
00115 ; Initilize the LCD Display Module
00116 ;
0021 0185      00117      CLRFB  LCD_CNTL    ; ALL PORT output should output Low.
00118
0022      00119 DISPLAY_INIT
00120      if ( Four_bit && !Data_HI )
00121          MOVLW 0x02          ; Command for 4-bit interface low nibble
00122      endif
00123 ;
00124      if ( Four_bit && Data_HI )
00125          MOVLW 0x020        ; Command for 4-bit interface high nibble

```

```

00126     endif
00127 ;
00128     if ( !Four_bit )
0022 3038 00129         MOVLW   0x038             ; Command for 8-bit interface
00130     endif
00131 ;
00132         MOVWF   LCD_DATA             ;
0023 0088 00133         BSF     LCD_CNTL, E         ;
0024 1585 00134         BCF     LCD_CNTL, E         ;
0025 1185 00135 ;
00136 ; This routine takes the calculated times that the delay loop needs to
00137 ; be executed, based on the LCD_INIT_DELAY EQUate that includes the
00138 ; frequency of operation. These use registers before they are needed to
00139 ; store the time.
00140 ;
0026 3006 00141 LCD_DELAY MOVLW   LCD_INIT_DELAY     ;
0027 00B3 00142         MOVWF   MSD                 ; Use MSD and LSD Registers to Initilize LCD
0028 01B4 00143         CLRF    LSD                 ;
0029 0BB4 00144 LOOP2   DECFSZ  LSD, F             ; Delay time = MSD * ((3 * 256) + 3) * Tcy
002A 2829 00145         GOTO   LOOP2             ;
002B 0BB3 00146         DECFSZ  MSD, F             ;
002C      00147 END_LCD_DELAY
002C 2829 00148         GOTO   LOOP2             ;
00149 ;
00150 ; Command sequence for 2 lines of 5x7 characters
00151 ;
002D      00152 CMD_SEQ
00153 ;
00154     if ( Four_bit )
00155         if ( !Data_HI )
00156             MOVLW   0X02             ; 4-bit low nibble xfer
00157         else
00158             MOVLW   0X020           ; 4-bit high nibble xfer
00159         endif
00160 ;
00161     else
00162         MOVLW   0X038             ; 8-bit mode
002D 3038 00163     endif
00164 ;
002E 0088 00165         MOVWF   LCD_DATA             ; This code for both 4-bit and 8-bit modes
002F 1585 00166         BSF     LCD_CNTL, E         ;
0030 1185 00167         BCF     LCD_CNTL, E         ;
00168 ;
00169     if ( Four_bit )
00170         if ( !Data_HI )
00171             MOVLW   0x08             ; 4-bit low nibble xfer
00172         else

```

```

00173             MOVLW  0x080             ; 4-bit high nibble xfer
00174             endif
00175             MOVWF   LCD_DATA         ;
00176             BSF    LCD_CNTRL, E     ;
00177             BCF    LCD_CNTRL, E     ;
00178             endif
00179             ;
00180             ; Busy Flag should be valid after this point
00181             ;
0031 300C        MOVLW  DISP_ON         ;
0032 2068        CALL  SEND_CMD        ;
0033 3001        MOVLW  CLR_DISP       ;
0034 2068        CALL  SEND_CMD        ;
0035 3006        MOVLW  ENTRY_INC      ;
0036 2068        CALL  SEND_CMD        ;
0037 3080        MOVLW  DD_RAM_ADDR    ;
0038 2068        CALL  SEND_CMD        ;
00190             ;
00191             page
00192             ;
00193             ;Send a message the hard way
00194             movlw  'M'
003A 205F        call  SEND_CHAR
003B 3069        movlw  'i'
003C 205F        call  SEND_CHAR
003D 3063        movlw  'c'
003E 205F        call  SEND_CHAR
003F 3072        movlw  'r'
0040 205F        call  SEND_CHAR
0041 306F        movlw  'o'
0042 205F        call  SEND_CHAR
0043 3063        movlw  'c'
0044 205F        call  SEND_CHAR
0045 3068        movlw  'h'
0046 205F        call  SEND_CHAR
0047 3069        movlw  'i'
0048 205F        call  SEND_CHAR
0049 3070        movlw  'p'
004A 205F        call  SEND_CHAR
00212             ;
004B 30C0        movlw  B'11000000'    ;Address DDRam first character, second line
004C 2068        call  SEND_CMD
00215             ;
00216             ;Demonstration of the use of a table to output a message
004D 3000        movlw  0                ;Table address of start of message
004E             dispmsg
004E 00B0        movwf  TEMP1           ;TEMP1 holds start of message address

```



```

004F 2083      00220      call    Table
0050 39FF      00221      andlw   0FFh           ;Check if at end of message (zero
0051 1903      00222      btfs   STATUS,Z       ;returned at end)
0052 2857      00223      goto   out
0053 205F      00224      call   SEND_CHAR      ;Display character
0054 0830      00225      movf   TEMP1,w         ;Point to next character
0055 3E01      00226      addlw  1
0056 284E      00227      goto   dispmsg
0057          00228      out
0057          00229      loop
0057 2857      00230      goto   loop           ;Stay here forever
00231 ;
00232 ;
0058          00233      INIT_DISPLAY
0058 300C      00234      MOVLW  DISP_ON        ; Display On, Cursor On
0059 2068      00235      CALL   SEND_CMD       ; Send This command to the Display Module
005A 3001      00236      MOVLW  CLR_DISP       ; Clear the Display
005B 2068      00237      CALL   SEND_CMD       ; Send This command to the Display Module
005C 3006      00238      MOVLW  ENTRY_INC      ; Set Entry Mode Inc., No shift
005D 2068      00239      CALL   SEND_CMD       ; Send This command to the Display Module
005E 0008      00240      RETURN
00241 ;
00242      page
00243 ;
00244 ;*****
00245 ;* The LCD Module Subroutines *
00246 ;*****
00247 ;
00248      if ( Four_bit )      ; 4-bit Data transfers?
00249 ;
00250      if ( Data_HI )      ; 4-bit transfers on the high nibble of the PORT
00251 ;
00252 ;*****
00253 ;*SendChar - Sends character to LCD *
00254 ;*This routine splits the character into the upper and lower *
00255 ;*nibbles and sends them to the LCD, upper nibble first. *
00256 ;*****
00257 ;
00258 SEND_CHAR
00259      MOVWF  CHAR          ;Character to be sent is in W
00260      CALL  BUSY_CHECK     ;Wait for LCD to be ready
00261      MOVF  CHAR, w
00262      ANDLW 0xF0          ;Get upper nibble
00263      MOVWF LCD_DATA      ;Send data to LCD
00264      BCF  LCD_CNTRL, RW   ;Set LCD to read
00265      BSF  LCD_CNTRL, RS   ;Set LCD to data mode
00266      BSF  LCD_CNTRL, E   ;toggle E for LCD

```

```

00267         BCF      LCD_CNTL, E
00268         SWAPF   CHAR, w
00269         ANDLW   0xF0           ; Get lower nibble
00270         MOVWF   LCD_DATA       ; Send data to LCD
00271         BSF     LCD_CNTL, E     ; toggle E for LCD
00272         BCF     LCD_CNTL, E
00273         RETURN
00274 ;
00275         else                   ; 4-bit transfers on the low nibble of the PORT
00276 ;
00277 ;*****
00278 ;* SEND_CHAR - Sends character to LCD *
00279 ;* This routine splits the character into the upper and lower *
00280 ;* nibbles and sends them to the LCD, upper nibble first. *
00281 ;* The data is transmitted on the PORT<3:0> pins *
00282 ;*****
00283 ;
00284 SEND_CHAR
00285         MOVWF   CHAR           ; Character to be sent is in W
00286         CALL    BUSY_CHECK     ; Wait for LCD to be ready
00287         SWAPF   CHAR, W
00288         ANDLW   0x0F           ; Get upper nibble
00289         MOVWF   LCD_DATA       ; Send data to LCD
00290         BCF     LCD_CNTL, RW   ; Set LCD to read
00291         BSF     LCD_CNTL, RS   ; Set LCD to data mode
00292         BSF     LCD_CNTL, E     ; toggle E for LCD
00293         BCF     LCD_CNTL, E
00294         MOVF    CHAR, W
00295         ANDLW   0x0F           ; Get lower nibble
00296         MOVWF   LCD_DATA       ; Send data to LCD
00297         BSF     LCD_CNTL, E     ; toggle E for LCD
00298         BCF     LCD_CNTL, E
00299         RETURN
00300 ;
00301         endif
00302         else
00303 ;
00304 ;*****
00305 ;* SEND_CHAR - Sends character contained in register W to LCD *
00306 ;* This routine sends the entire character to the PORT *
00307 ;* The data is transmitted on the PORT<7:0> pins *
00308 ;*****
00309 ;
00310 SEND_CHAR
00311         MOVWF   CHAR           ; Character to be sent is in W
00312         CALL    BUSY_CHECK     ; Wait for LCD to be ready
00313         MOVF    CHAR, w

```

```

005F
005F 00B6
0060 2071
0061 0836

```

```

0062 0088      00314      MOVWF  LCD_DATA      ; Send data to LCD
0063 1105      00315      BCF    LCD_CNTL, RW  ; Set LCD in read mode
0064 1485      00316      BSF    LCD_CNTL, RS  ; Set LCD in data mode
0065 1585      00317      BSF    LCD_CNTL, E   ; toggle E for LCD
0066 1185      00318      BCF    LCD_CNTL, E   ;
0067 0008      00319      RETURN
00320 ;
00321      endif
00322 ;
00323      page
00324 ;
00325 ;*****
00326 ;* SendCmd - Sends command to LCD *
00327 ;* This routine splits the command into the upper and lower *
00328 ;* nibbles and sends them to the LCD, upper nibble first. *
00329 ;* The data is transmitted on the PORT<3:0> pins *
00330 ;*****
00331 ;
00332      if ( Four_bit )      ; 4-bit Data transfers?
00333 ;
00334      if ( Data_HI )      ; 4-bit transfers on the high nibble of the PORT
00335 ;
00336 ;*****
00337 ;* SEND_CMD - Sends command to LCD *
00338 ;* This routine splits the command into the upper and lower *
00339 ;* nibbles and sends them to the LCD, upper nibble first. *
00340 ;*****
00341
00342 SEND_CMD
00343      MOVWF  CHAR      ; Character to be sent is in W
00344      CALL  BUSY_CHECK  ; Wait for LCD to be ready
00345      MOVF  CHAR,w
00346      ANDLW 0xF0      ; Get upper nibble
00347      MOVWF  LCD_DATA  ; Send data to LCD
00348      BCF   LCD_CNTL,RW ; Set LCD to read
00349      BCF   LCD_CNTL,RS ; Set LCD to command mode
00350      BSF   LCD_CNTL,E   ; toggle E for LCD
00351      BCF   LCD_CNTL,E
00352      SWAPF CHAR,w
00353      ANDLW 0xF0      ; Get lower nibble
00354      MOVWF  LCD_DATA  ; Send data to LCD
00355      BSF   LCD_CNTL,E   ; toggle E for LCD
00356      BCF   LCD_CNTL,E
00357      RETURN
00358 ;
00359      else      ; 4-bit transfers on the low nibble of the PORT
00360 ;

```

```

00361 SEND_CMD
00362     MOVWF  CHAR           ; Character to be sent is in W
00363     CALL   BUSY_CHECK    ; Wait for LCD to be ready
00364     SWAPF  CHAR, W
00365     ANDLW  0x0F          ; Get upper nibble
00366     MOVWF  LCD_DATA      ; Send data to LCD
00367     BCF   LCD_CNTL, RW   ; Set LCD to read
00368     BCF   LCD_CNTL, RS   ; Set LCD to command mode
00369     BSF   LCD_CNTL, E    ; toggle E for LCD
00370     BCF   LCD_CNTL, E
00371     MOVF   CHAR, W
00372     ANDLW  0x0F          ; Get lower nibble
00373     MOVWF  LCD_DATA      ; Send data to LCD
00374     BSF   LCD_CNTL, E    ; toggle E for LCD
00375     BCF   LCD_CNTL, E
00376     RETURN
00377 ;
00378     endif
00379     else
00380 ;
00381 ;*****
00382 ;* SEND_CND - Sends command contained in register W to LCD      *
00383 ;* This routine sends the entire character to the PORT          *
00384 ;* The data is transmitted on the PORT<7:0> pins                *
00385 ;*****
00386
0068 0068 0068 00387 SEND_CMD
0068 00B6 00388     MOVWF  CHAR           ; Command to be sent is in W
0069 2071 00389     CALL   BUSY_CHECK    ; Wait for LCD to be ready
006A 0836 00390     MOVF   CHAR, w
006B 0088 00391     MOVWF  LCD_DATA      ; Send data to LCD
006C 1105 00392     BCF   LCD_CNTL, RW   ; Set LCD in read mode
006D 1085 00393     BCF   LCD_CNTL, RS   ; Set LCD in command mode
006E 1585 00394     BSF   LCD_CNTL, E    ; toggle E for LCD
006F 1185 00395     BCF   LCD_CNTL, E
0070 0008 00396     RETURN
00397 ;
00398     endif
00399 ;
00400     page
00401 ;
00402     if ( Four_bit )           ; 4-bit Data transfers?
00403 ;
00404         if ( Data_HI )       ; 4-bit transfers on the high nibble of the PORT
00405 ;
00406 ;*****
00407 ;* This routine checks the busy flag, returns when not busy      *

```

```

00408 ;* Affects:
00409 ;*     TEMP - Returned with busy/address
00410 ;*****
00411 ;
00412 BUSY_CHECK
00413     BSF     STATUS, RP0      ; Select Register Bank1
00414     MOVLW  0xFF             ; Set Port_D for input
00415     MOVWF  LCD_DATA_TRIS
00416     BCF     STATUS, RP0      ; Select Register Bank0
00417     BCF     LCD_CNTL, RS     ; Set LCD for Command mode
00418     BSF     LCD_CNTL, RW     ; Setup to read busy flag
00419     BSF     LCD_CNTL, E      ; Set E high
00420     BCF     LCD_CNTL, E      ; Set E low
00421     MOVF   LCD_DATA, W      ; Read upper nibble busy flag, DDRam address
00422     ANDLW  0xF0             ; Mask out lower nibble
00423     MOVWF  TEMP
00424     BSF     LCD_CNTL, E      ; Toggle E to get lower nibble
00425     BCF     LCD_CNTL, E
00426     SWAPF  LCD_DATA, w      ; Read lower nibble busy flag, DDRam address
00427     ANDLW  0x0F             ; Mask out upper nibble
00428     IORWF  TEMP, F          ; Combine nibbles
00429     BTFSC  TEMP, 7          ; Check busy flag, high = busy
00430     GOTO   BUSY_CHECK       ; If busy, check again
00431     BCF     LCD_CNTL, RW
00432     BSF     STATUS, RP0      ; Select Register Bank1
00433     MOVLW  0x0F
00434     MOVWF  LCD_DATA_TRIS    ; Set Port_D for output
00435     BCF     STATUS, RP0      ; Select Register Bank0
00436     RETURN
00437 ;
00438     else                    ; 4-bit transfers on the low nibble of the PORT
00439 ;
00440 ;*****
00441 ;* This routine checks the busy flag, returns when not busy
00442 ;* Affects:
00443 ;*     TEMP - Returned with busy/address
00444 ;*****
00445 ;
00446 BUSY_CHECK
00447     BSF     STATUS, RP0      ; Bank 1
00448     MOVLW  0xFF             ; Set PortB for input
00449     MOVWF  LCD_DATA_TRIS
00450     BCF     STATUS, RP0      ; Bank 0
00451     BCF     LCD_CNTL, RS     ; Set LCD for Command mode
00452     BSF     LCD_CNTL, RW     ; Setup to read busy flag
00453     BSF     LCD_CNTL, E      ; Set E high
00454     BCF     LCD_CNTL, E      ; Set E low

```

```

00455          SWAPF   LCD_DATA, W           ; Read upper nibble busy flag, DDRam address
00456          ANDLW   0xF0                   ; Mask out lower nibble
00457          MOVWF   TEMP                   ;
00458          BSF     LCD_CNTL, E           ; Toggle E to get lower nibble
00459          BCF     LCD_CNTL, E
00460          MOVF    LCD_DATA, W           ; Read lower nibble busy flag, DDRam address
00461          ANDLW   0x0F                   ; Mask out upper nibble
00462          IORWF   TEMP, F               ; Combine nibbles
00463          BTFSC   TEMP, 7               ; Check busy flag, high = busy
00464          GOTO    BUSY_CHECK            ; If busy, check again
00465          BCF     LCD_CNTL, RW
00466          BSF     STATUS, RP0           ; Bank 1
00467          MOVLW   0xF0                   ;
00468          MOVWF   LCD_DATA_TRIS        ; RB7 - 4 = inputs, RB3 - 0 = output
00469          BCF     STATUS, RP0           ; Bank 0
00470          RETURN
00471 ;
00472          endif
00473          else
00474 ;
00475 ;*****
00476 ;* This routine checks the busy flag, returns when not busy *
00477 ;* Affects: *
00478 ;*     TEMP - Returned with busy/address *
00479 ;*****
00480 ;
0071          00481 BUSY_CHECK
0071 1683          00482          BSF     STATUS,RP0           ; Select Register Bank1
0072 30FF          00483          MOVLW   0xFF                   ; Set port_D for input
0073 0088          00484          MOVWF   LCD_DATA_TRIS
0074 1283          00485          BCF     STATUS, RP0           ; Select Register Bank0
0075 1085          00486          BCF     LCD_CNTL, RS           ; Set LCD for command mode
0076 1505          00487          BSF     LCD_CNTL, RW           ; Setup to read busy flag
0077 1585          00488          BSF     LCD_CNTL, E           ; Set E high
0078 1185          00489          BCF     LCD_CNTL, E           ; Set E low
0079 0808          00490          MOVF    LCD_DATA, w           ; Read busy flag, DDRam address
007A 00B5          00491          MOVWF   TEMP
007B 1BB5          00492          BTFSC   TEMP, 7               ; Check busy flag, high=busy
007C 2871          00493          GOTO    BUSY_CHECK
007D 1105          00494          BCF     LCD_CNTL, RW
007E 1683          00495          BSF     STATUS, RP0           ; Select Register Bank1
007F 3000          00496          MOVLW   0x00
0080 0088          00497          MOVWF   LCD_DATA_TRIS        ; Set port_D for output
0081 1283          00498          BCF     STATUS, RP0           ; Select Register Bank0
0082 0008          00499          RETURN
00500 ;
00501          endif

```

```
00502     page
00503 ;
0083      00504 Table
0083 0782     00505     addwf   PCL, F           ; Jump to char pointed to in W reg
0084 344D     00506     retlw   'M'
0085 3469     00507     retlw   'i'
0086 3463     00508     retlw   'c'
0087 3472     00509     retlw   'r'
0088 346F     00510     retlw   'o'
0089 3463     00511     retlw   'c'
008A 3468     00512     retlw   'h'
008B 3469     00513     retlw   'i'
008C 3470     00514     retlw   'p'
008D 3420     00515     retlw   ' '
008E 3454     00516     retlw   'T'
008F 3465     00517     retlw   'e'
0090 3463     00518     retlw   'c'
0091 3468     00519     retlw   'h'
0092 346E     00520     retlw   'n'
0093 346F     00521     retlw   'o'
0094 346C     00522     retlw   'l'
0095 346F     00523     retlw   'o'
0096 3467     00524     retlw   'g'
0097 3479     00525     retlw   'y'
0098      00526 Table_End
0098 3400     00527     retlw   0
00528 ;
00529     if ( (Table & 0xFF) >= (Table_End & 0xFF) )
00530         MESSG   "Warning - User Defined: Table Table crosses page boundry in computed jump"
00531     endif
00532 ;
00533
00534
00535
00536     end
```

MEMORY USAGE MAP ('X' = Used, '-' = Unused)

```
0000 : X--XXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX
0040 : XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX
0080 : XXXXXXXXXXXXXXXXX XXXXXXXX----- -----
```

All other memory blocks unused.

Program Memory Words Used: 150
Program Memory Words Free: 1898

Errors : 0
Warnings : 0 reported, 0 suppressed
Messages : 0 reported, 12 suppressed

WORLDWIDE SALES & SERVICE

AMERICAS

Corporate Office

Microchip Technology Inc.
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 602-786-7200 Fax: 602-786-7277
Technical Support 602 786-7627
Web: <http://www.microchip.com>

Atlanta

Microchip Technology Inc.
500 Sugar Mill Road, Suite 200B
Atlanta, GA 30350
Tel: 770-640-0034 Fax: 770-640-0307

Boston

Microchip Technology Inc.
5 Mount Royal Avenue
Marlborough, MA 01752
Tel: 508-480-9990 Fax: 508-480-8575

Chicago

Microchip Technology Inc.
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Itasca, IL 60143
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Dallas

Microchip Technology Inc.
14651 Dallas Parkway, Suite 816
Dallas, TX 75240-8809
Tel: 972-991-7177 Fax: 972-991-8588

Dayton

Microchip Technology Inc.
Two Prestige Place, Suite 150
Miami, OH 45342
Tel: 937-291-1654 Fax: 937-291-9175

Los Angeles

Microchip Technology Inc.
18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 714-263-1888 Fax: 714-263-1338

New York

Microchip Technology Inc.
150 Motor Parkway, Suite 416
Hauppauge, NY 11788
Tel: 516-273-5305 Fax: 516-273-5335

San Jose

Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

Toronto

Microchip Technology Inc.
5925 Airport Road, Suite 200
Mississauga, Ontario L4V 1W1, Canada
Tel: 905-405-6279 Fax: 905-405-6253

ASIA/PACIFIC

Hong Kong

Microchip Asia Pacific
RM 3801B, Tower Two
Metroplaza
223 Hing Fong Road
Kwai Fong, N. T., Hong Kong
Tel: 852-2-401-1200 Fax: 852-2-401-3431

India

Microchip Technology India
No. 6, Legacy, Convent Road
Bangalore 560 025, India
Tel: 91-80-229-0061 Fax: 91-80-229-0062

Korea

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

Shanghai

Microchip Technology
RM 406 Shanghai Golden Bridge Bldg.
2077 Yan'an Road West, Hongjiao District
Shanghai, PRC 200335
Tel: 86-21-6275-5700
Fax: 86-21-6275-5060

Singapore

Microchip Technology Taiwan
Singapore Branch
200 Middle Road
#10-03 Prime Centre
Singapore 188980
Tel: 65-334-8870 Fax: 65-334-8850

Taiwan, R.O.C

Microchip Technology Taiwan
10F-1C 207
Tung Hua North Road
Taipei, Taiwan, ROC
Tel: 886 2-717-7175 Fax: 886-2-545-0139

EUROPE

United Kingdom

Arizona Microchip Technology Ltd.
Unit 6, The Courtyard
Meadow Bank, Furong Road
Bourne End, Buckinghamshire SL8 5AJ
Tel: 44-1628-851077 Fax: 44-1628-850259

France

Arizona Microchip Technology SARL
Zone Industrielle de la Bonde
2 Rue du Buisson aux Fraises
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany

Arizona Microchip Technology GmbH
Gustav-Heinemann-Ring 125
D-81739 München, Germany
Tel: 49-89-627-1440 Fax: 49-89-627-144-44

Italy

Arizona Microchip Technology SRL
Centro Direzionale Colleone
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-39-6899939 Fax: 39-39-6899883

JAPAN

Microchip Technology Intl. Inc.
Benex S-1 6F
3-18-20, Shin Yokohama
Kohoku-Ku, Yokohama
Kanagawa 222 Japan
Tel: 81-4-5471-6166 Fax: 81-4-5471-6122

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