

# Motorola Semiconductor Application Note

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## AN1286

### MC68HC05C0 Bus Structure Design

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#### Introduction

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This application note explains the basics of designing a system with the MC68HC05C0, a ROM-less expanded bus microcontroller. This document is arranged in two sections. The first section is a question-and-answer format that answers questions that have been asked by people accustomed to designing with single-chip MCUs. The second section has two example schematics that illustrate the use of nonmuxed mode and muxed mode.



## Common Questions

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Doesn't an expanded bus mean using glue logic?

Due to the carefully chosen chip selects of the MC68HC05C0, glue logic is not required to interface with many common peripherals. The schematic in [Figure 2](#) shows a minimum system with 32 Kbytes of EPROM memory not using glue logic.

What is a minimum system for the MC68HC05C0?

With on-board parallel input/output (I/O), two timers, serial communications interface (SCI), and RAM, the MC68HC05C0 lacks only EPROM memory to execute. Using the  $\overline{A15}$  chip select, an industry standard EPROM, such as a 27C256, can be connected easily in nonmuxed mode. If muxed mode is used, an octal latch is required to latch the low byte of the address bus.

What's the difference between muxed mode and nonmuxed mode?

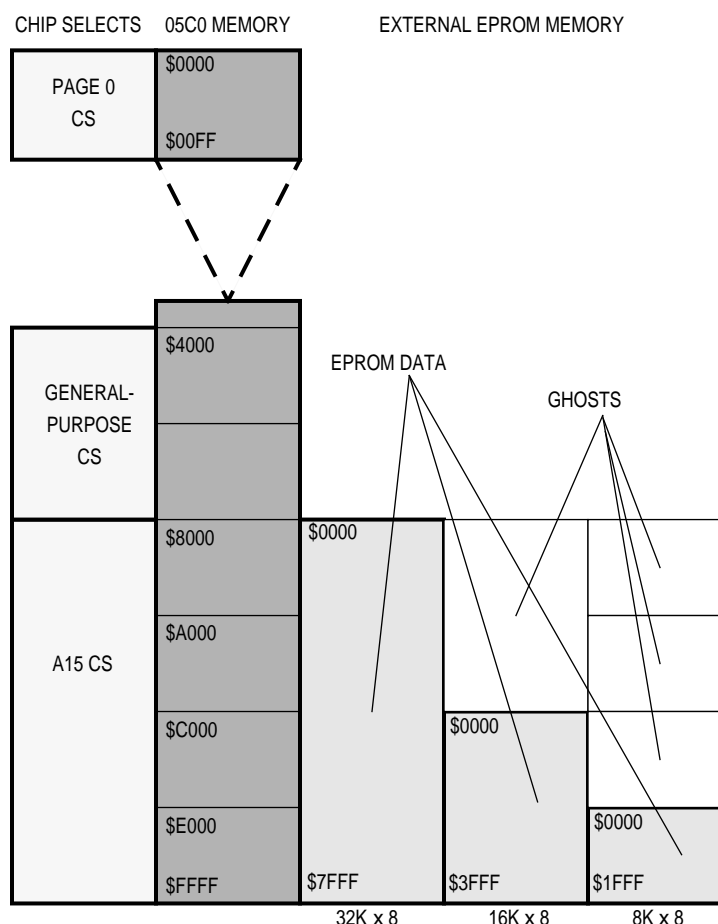
The nonmuxed mode of operation brings the data and address buses out separately. This allows for a pin-to-pin connection with a standard 27Cxxx EPROM chip. The maximum clock frequency is 16 MHz, yielding a bus frequency of 4 MHz.

The muxed mode uses the same eight pins to transmit the low order byte of the address and to transmit or receive data on the data bus. An extra pin (AS/ $\overline{CS2}$ ) is used to latch the low byte of the address into a latch such as a 74HC573. Muxed mode also lowers the maximum oscillator frequency to 8 MHz. This yields a maximum bus frequency of 2 MHz.

What can the chip selects do?

Three chip selects are provided on the MC68HC05C0. (See [Figure 1](#).)

Page 0 chip select is useful for external peripherals. It goes active only for addresses that are mapped as external within the first 256 bytes of the address. This includes \$00, \$04, \$1C–\$29, and \$30–\$3F (clock stretched addresses). In nonmuxed mode, \$03 and \$07 are also mapped external. The  $\overline{CS1}$ /PB5 pin can be used as a page 0 chip select in both muxed and nonmuxed modes.



**Figure 1. Comparison of MC68HC05C0 Chip Selects, the Memory Map, and the Memory Maps of Three Differently Sized External EPROMs**

The general-purpose chip select is active from \$4000 to \$7FFF. It is used for other external peripherals that do not require clock stretch or for external volatile memory, such as a 16K x 8 SRAM. This chip select is useful in applications requiring large amounts of data manipulation. The  $\overline{\text{CS1}}/\text{PB5}$  pin can be used as a general-purpose chip select in both muxed and nonmuxed modes. The  $\overline{\text{CS2}}/\text{AS}$  pin is always a general-purpose chip select in nonmuxed mode and is always AS in muxed mode.

The  $\overline{\text{A15}}$  chip select proves to be the most useful as it selects the entire upper half of the address map. Since memory is required at \$FFF0-\$FFFF for the RESET vectors, it makes sense to use this chip

select for EPROM memory space. Notice that if an EPROM smaller than 32 Kbytes is used, it is ghosted to fill the upper half of address space (see [Figure 1](#)). The  $\overline{A15}$  chip select is, of course, on the  $\overline{A15}$  pin.

**What does clock stretching do?**

The external addresses \$30–\$3F can be selected as clock-stretch addresses. This mode increases the read and write line low time from  $4 t_{OSC}$  to  $24 t_{OSC}$ . This is useful in a system that requires a high bus frequency, but must access a slow peripheral.

**A bus takes a lot of routing. Can it possibly be put on a single layer board?**

Yes it can. This is possible because the layout of the address and data bus pins on the MC68HC05C0 in non-muxed mode mirrors that of a 27C256 industry standard EPROM. See the layout of the nonmuxed minimum system in [Figure 3](#).

**How is an SRAM connected to the external bus?**

Connecting an SRAM without any glue logic to the MC68HC05C0 is possible because of the accommodating bus structure of the MC68HC05C0. For example, the MCM6206C 32K x 8 SRAM can be connected directly to the MC68HC05C0 address and data lines. In this case, an extra port pin could be used on the high order address line so that the entire 32K SRAM could be paged into the 16K space of the general-purpose chip select (\$4000–\$8000).

**How can the number of port pins be maximized?**

If the slower bus rate of muxed mode is acceptable, this frees eight extra I/O pins. Multiplexing the data and the lowest eight bits of the address leaves port D free for parallel I/O. Also note that the various package types have different numbers of I/O pins. The DIP has 14 in muxed mode. The SDIP package adds two pins and the PLCC adds two more, for a total of 18.

Extra port pins can be added in several ways. One way involves using the SCI to synchronously communicate with a set of serial shift registers. A 74HC164 could be used for output and a 74HC165 for input. Software serial peripheral interface (SPI) routines would need to be written for the

input, as the SCI on the MC68HC05C0 does only synchronous transmits, not receives.

Another way to add extra port pins is to use the external bus. This method takes advantage of the speed of a parallel interface. The bus structure makes it easy to use a part such as the 82C55 without glue logic. In addition, using the page 0 chip select to map the 82C55 into low memory allows the software programmer to take advantage of bit manipulation instructions.

How do I ORG my code and position my reset vectors correctly?

**Figure 1** shows how three common EPROM sizes fit into the memory map. For example, consider the 27C256. This is a 32K x 8 EPROM. When mapped to the  $\overline{A15}$  chip select, it uses the entire top half of the memory map. Therefore, you can begin coding at \$8000 and continue through \$FFF1, where the interrupt vectors begin.

The interrupt vectors reside from \$FFF2 to \$FFFF as shown below:

<u>Interrupt</u>	<u>Vector Address</u>
Keyboard Scan	\$FFF2–\$FFF3
Multi-Function Timer	\$FFF4–\$FFF5
Serial Communication Interface	\$FFF6–\$FFF7
16-Bit Timer	\$FFF8–\$FFF9
External Interrupt	\$FFFA–\$FFFB
Software	\$FFFC–\$FFFD
Reset	\$FFFE–\$FFFF

The RESET vector is always used, making it mandatory that the EPROM memory occupy this space.

It is important to note a difference between the physical location of the code in the EPROM's address space and the mapped location in the part's address space. The physical address of a 32K EPROM will consist of an address space from \$0000 to \$7FFF. However, this address space is mapped into the part's memory at \$8000 to \$FFFF. Similarly, for smaller EPROMs, the physical address space of that EPROM is mapped into the memory map of the part such that the last EPROM address is located at address \$FFFF in the part. The size of the EPROM will determine where its first address will map into the part (see **Figure 1**).

Therefore, absolute code written with ORG statements that match the part's memory map must be programmed into an external EPROM. Use the proper offset on the EPROM programmer such that the first EPROM address is mapped to the proper CPU address and the last EPROM address is mapped to the CPU address of \$FFFF. Always check that the last two locations of the EPROM contain the RESET vector.

**What is the purpose of the IRV bit?**

The internal read visibility (IRV) bit, located in the system configuration register (CNFGR), is used to control what memory and register accesses are visible on the external bus pins. The reset state of this bit is a zero, which is off. When this bit is off, any access to an internal memory location is not visible on the external bus. Thus, the address bus, the data bus, the chip select, and  $\overline{RD}$  and  $\overline{WR}$  pins will remain in the state they were during the cycle previous to the cycle containing the internal access. This is useful for reducing power consumption and radiated electromagnetic interference (EMI) emissions. The fewer pins that are switching states, the lower the noise and EMI that is generated.

If this bit is turned on, all cycles are displayed on the external pins. Although this is not optimal for noise considerations, it is helpful when debugging software. A logic analyzer or bus state analyzer can be attached to the part and every cycle can be monitored, thus making it easier to find errors.

**How do I minimize stop mode current?**

EPROMs draw significant current when they are enabled. For this reason, it is not desirable to have the EPROM enabled while the MCU is in stop mode. To minimize current draw, the EPROM should be put in its standby mode by bringing  $\overline{CE}$  high. This is accomplished by executing code out of internal RAM, therefore de-selecting the EPROM.

By default, internal bus cycles are not driven to the external bus. As stated above, this is to reduce radiated noise. This has the effect of leaving the external address bus in the same state it was during the last external cycle. Therefore, the  $\overline{A15}$  chip select is still active. The IRV bit in the configuration register can enable internal cycles to be driven out. With this enabled,  $\overline{A15}$  will be driven to an inactive state while executing in internal RAM. The EPROM will be put into standby mode.

Therefore, before jumping to the STOP instruction in RAM, turn the IRV bit on. See the code sample, C0STOP.MRT, for an example of this method. If desired, the appropriate interrupt handler used to service the interrupt that brings the part out of STOP mode should turn the IRV bit back off.

**What should be considered when interfacing to external memory devices?**

Most users of Motorola M68HC05 microcontrollers are used to accessing on-chip memories, and, therefore, don't worry about timing considerations when accessing these memories. The parts are designed so that all timing considerations are handled in the chip's hardware. When using a microcontroller with an external memory device, these timing considerations must be considered to select a memory device that will work reliably and correctly with the microcontroller.

For example, a typical Motorola SRAM device has connections for the address bus, data bus, and three other signals: chip enable, write enable, and output enable. To connect this device to the MC68HC05C0, the 8-bit data buses would have to be connected, as would all appropriate address lines. If the memory device does not fill the entire memory map of the MC68HC05C0, then some of the MC68HC05C0 upper address lines may not be connected to the memory device. The SRAM chip enable could be connected to the general-purpose chip enable on the MC68HC05C0. The SRAM write enable and output enable signals would then be connected to the MC68HC05C0  $\overline{WR}$  and  $\overline{RD}$  signals respectively.

Connecting the signals correctly isn't the only thing that must be considered. The external memory has minimum requirements for setup and hold times when reading or writing to it. Care must be taken to ensure that the MC68HC05C0 presents the necessary signals (address, data, chip enable,  $\overline{RD}$  and  $\overline{WR}$ ) for a long enough time for the external memory to reliably perform. To ensure compatibility between the devices, consult the MC68HC05C0 specification and the specification for the selected external memory device before designing any application.

## Bus Design

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**Nonmuxed Mode** **Figure 2** demonstrates the use of a 27C256 32K x 8 EPROM as the program memory in a minimum system. Nonmuxed mode is shown. This mode requires only the MC68HC05C0 and the 27C256, a 2-chip solution.

In **Figure 3**, a layout example also is shown, demonstrating the possibilities of a single layer layout. This is due to the MC68HC05C0 pinout, which is a mirror image of a 27C256.

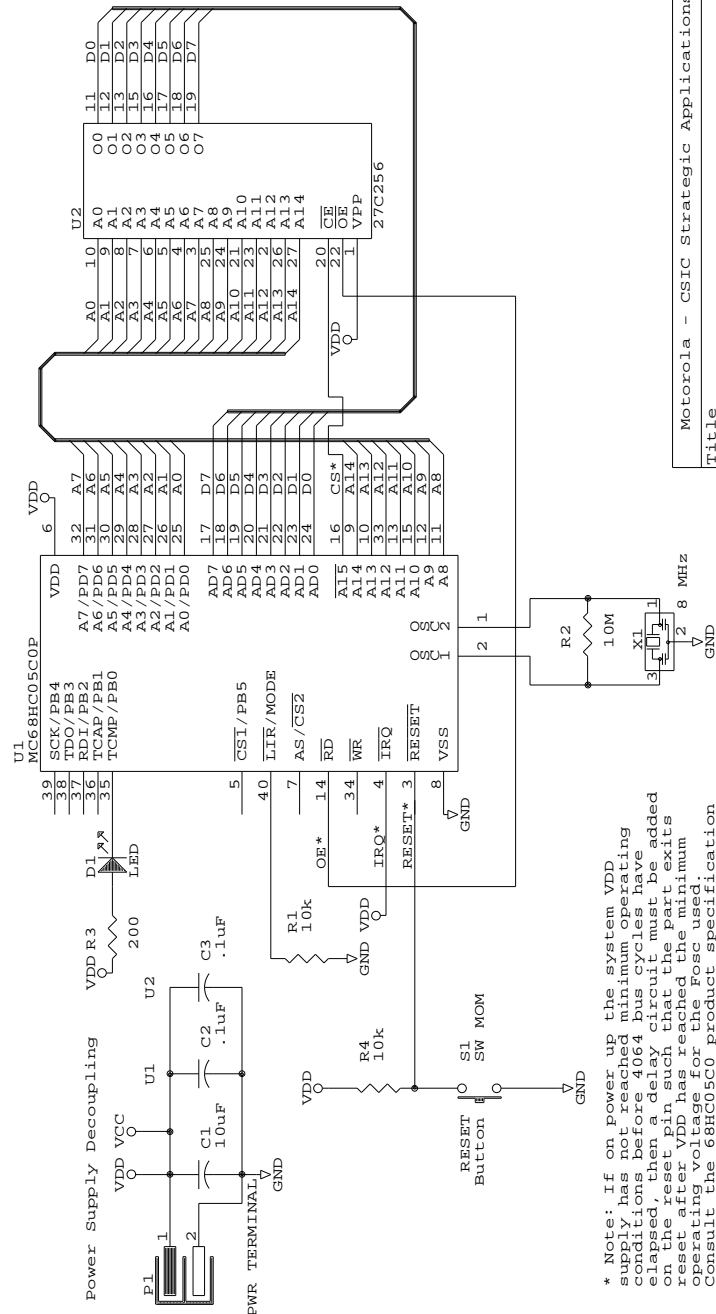
The simple program, CONME.MRT, checks that a few selected addresses contain the proper data. If this data is correct, the LED on port B pin 0 blinks twice per second. If the test fails, the LED lights steadily. If the LED does not light, something is wrong with the circuit or the EPROM.

**Muxed Mode** **Figure 4** demonstrates the use of a 27C256 32K x 8 EPROM as the program memory in a minimum system. Muxed mode is shown. This mode requires the addition of an HC573 transparent latch, but gives eight extra I/O port pins.

The same program, CONME.MRT, is used to demonstrate the system. It simply checks that a few selected addresses contain the proper data. If this data is correct, the LED on port B pin 0 blinks twice per second. If the test fails, the LED lights steadily. If the LED does not light, something is wrong with the circuit or the EPROM.



## C0 Nonmuxed EPROM System



\* Note: If on power up the system VDD supply has not reached the minimum operating conditions before 4064 bus cycles have elapsed, then a delay circuit must be added on the reset pin such that the part exits reset after the VDD has reached the minimum operating conditions before the bus cycles. Consult the 68HC050 product specification for more info on the minimum operating voltage.

Motorola - CSIC Strategic Applications	
Title	
C0 Non Mixed EPROM	
Size	Document Number
A	SYSTEM: SCH
Date:	June 19 1996/Sheet 2 of 2
REV	P10

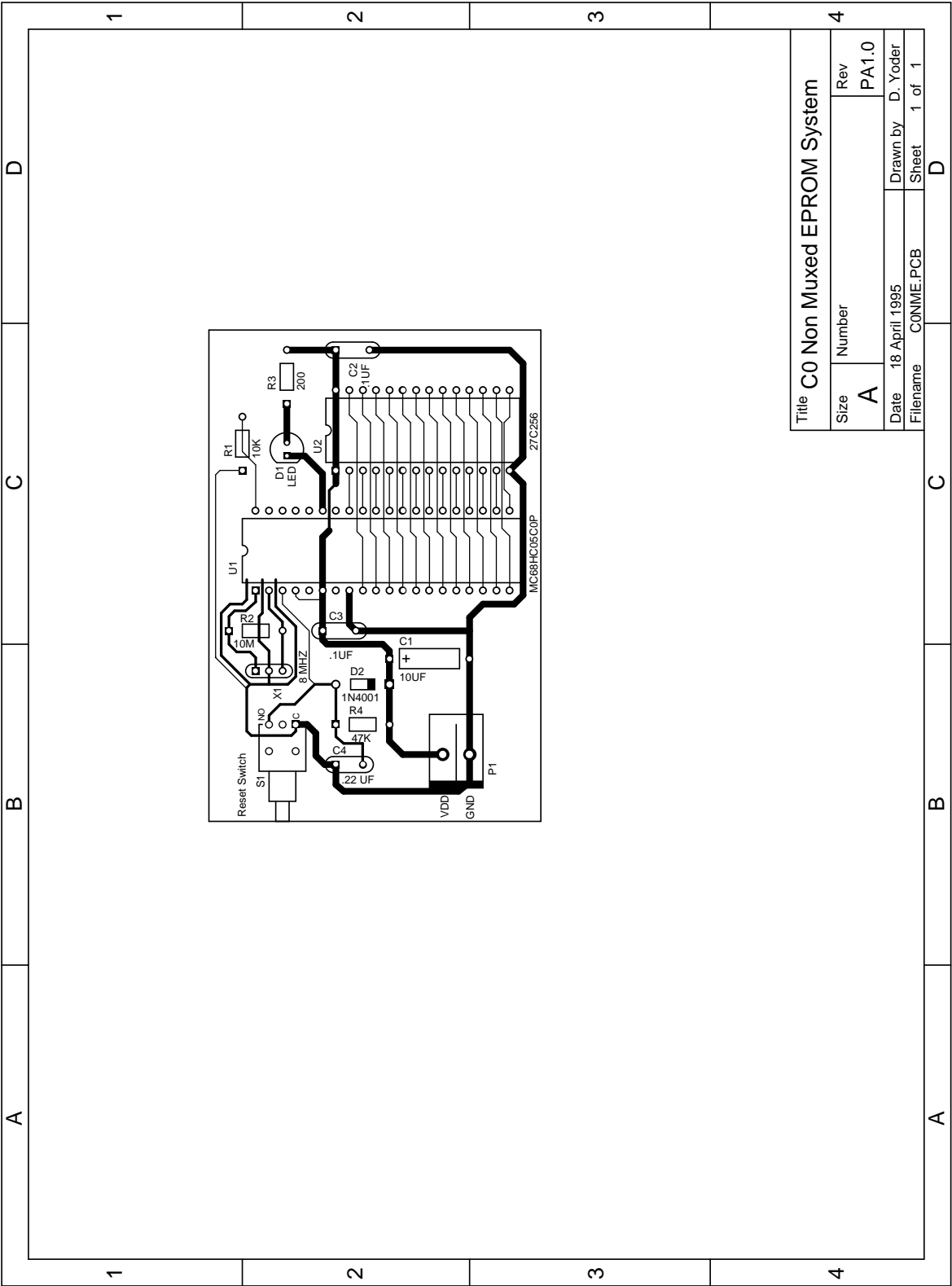


Figure 3. MC68HC05C0 Non-Muxed-Mode Layout



## MC68HC05C0 to 27C256 Interface Test Program

---

```

*****
*****
*
*      CONME - C0 to 27C256 Interface Test Program
*
*****
*
* File Name: CONME.MRT                      Copyright (c) Motorola 1994
*
* Current Revision: 1.0
* Current Release Level: PA
* Current Revision Release Date: 04/20/95
*
* Current Release Written By: David Yoder
*                               Motorola CSIC Applications - Austin, Texas
*
* Assembled Under: IASM05 (P&E Microcomputer Systems, Inc.)    Ver.: 3.02m
*
* Project Folder Name: C0AppN
*
*
* Part Family Software Routine Works With: HC05
* Part Module(s) Software Routine Works With:
*
* Routine Size (Bytes):      156
* Stack Space Used (Bytes):  0
* RAM Used (Bytes):          0
*
* Global Variables Used:     None
* Subroutines Called:        DelaymS
*
* Full Functional Description Of Routine Design:
*
*      The intent of this routine is to test the external bus connections
*      of the schematic CONME.SCH which is an example of interfacing the
*      MC68HC05C0 to a 27C256 EPROM.
*
*      This is accomplished by accessing addresses that take each of the
*      address lines high individually. Data in these addresses is unique
*      ensuring that the correct address was accessed.
*
*      Use DB directives to define the following data:
*
*      Address:      Data:
*      8001          FE
*      8002          FD
*      8004          FC
*      8008          FB

```

```

*          8010          FA          *
*          8020          F9          *
*          8040          F8          *
*          8080          F7          *
*          8100          F6          *
*          8200          F5          *
*          8400          F4          *
*          8800          F3          *
*          9000          F2          *
*          A000          F1          *
*          C000          F0          *
*
*      All other address locations in the 27C256 EPROM should be erased
*      to FF.
*
*      Get data from 8001.
*      Compare to FE
*      If not equal, branch to error routine
*      Repeat for all table entries.
*      Blink LED with 512mS period if correct.
*      Error routine: Solid LED if incorrect.
*
*****
*
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*
*

```

```

*****
*
*           Part Specific Framework Includes Section
*
* Place the assembler statement ($INCLUDE) to include the part specific
* framework for the target part.
*
*****

```

```

$NOLIST
$INCLUDE 'H05C0.FRK'           ;Include equates for the HC05C0.
$LIST

```

```

*****
*
*           Macros for Main Routine
*
*****

```

```

$MACRO Check                                ;Macro to test one address.
        lda      %1                        ;Get the value.
        cmp      #%2                       ;Check the value.
        bne      CONME_090                 ;Branch if not what expected.
$MACROEND

```

```

*****
*
*           Constant Definitions for Main Routine
*
*****

```

```

        org      $8001                    ;Define bytes to test the address
        db       $FE                      ; bus.
        org      $8002
        db       $FD
        org      $8004
        db       $FC
        org      $8008
        db       $FB
        org      $8010
        db       $FA
        org      $8020
        db       $F9
        org      $8040
        db       $F8
        org      $8080
        db       $F7
        org      $8100

```

```
db      $F6
org      $8200
db      $F5
org      $8400
db      $F4
org      $8800
db      $F3
org      $9000
db      $F2
org      $A000
db      $F1
org      $C000
db      $F0
```

```
*****
*
*                      Program Initialization
*
* Code needed to initialize processor resources is placed here.
* For any subroutines that have initialization routines which need
* to be executed once out of RESET, a jump (JSR) to the initialization
* section of the subroutine should be placed in this section.
*
*****
```

```
org      $E000
Start:
CONME_Init:  bset    0,portb      ;Preset PortB0 to high(LED off) to
                                ; prevent glitches.
              bset    0,ddrb      ;Enable PortB0 to output.
```

```

*****
*
*                               Main Program Loop
*
* This section will contain the main program loop. It's purpose is to check
* the values placed in the external EPROM and then activate an LED according
* to whether the data verified correctly or not. If the data verifies
* correctly, the LED will blink. If the data fails verify, the LED will stay
* lit all the time.
*
*****

```

Main:

CONME\_Body:

```

                Check    $8001, $FE
                Check    $8002, $FD
                Check    $8004, $FC
                Check    $8008, $FB
                Check    $8010, $FA
                Check    $8020, $F9
                Check    $8040, $F8
                Check    $8080, $F7
                Check    $8100, $F6
                Check    $8200, $F5
                Check    $8400, $F4
                Check    $8800, $F3
                Check    $9000, $F2
                Check    $A000, $F1
                Check    $C000, $F0

CONME_070:      bclr     0,PORTB      ;Pass signal - blinking LED
                lda      #$00        ;Turn on LED
                jsr      DelayMS_Body ;Set up acc for 256mS delay
CONME_080:      bset     0,PORTB      ;Delay for 256mS
                lda      #$00        ;Turn off LED
                jsr      DelayMS_Body ;Set up acc for 256mS delay
                lda      #$00        ;Delay for 256mS
                sta      COPR         ;Clear the COP Watchdog timer
                bra      CONME_070    ;Infinite loop blinking LED

CONME_090:      bclr     0,PORTB      ;Fail signal - solid LED
CONME_095:      lda      #$00        ;Turn on LED
                sta      COPR         ;Clear the COP Watchdog timer
                bra      CONME_095    ;Infinite loop with solid LED

```



```

*****
*
*           Subroutine Body Includes Section
*
* Place the assembler statement ($INCLUDE) to include any subroutines which
* are called in the main routine.
*
*****

$INCLUDE 'DelaymS.SRT'           ;Include subroutine for delay.


*****
*
*           Interrupt and Reset Vectors for Main Routine
*
* Place Vector ORG and FDB statements here. Use the labels defined in the
* part-specific framework file.
*
*****

        org      $FFFE
        fdb      START


*****
*****
*
*           Subroutine DelaymS - Delay for whole number of milliseconds
*
*****
*
* File Name: delayms.SUB           Copyright (c) Motorola 1994
*
* Curent Revision: 1.00
* Current Release Level: PA
* Current Revision Release Date: 04/20/95
*
* Current Release Written By: David Yoder
*                               Motorola CMCU Applications - Austin, Texas
*
* Assembled Under: IASM05 (P&E Microcomputer Systems, Inc.)   Ver.: 3.02m
*
* Documentation File Name: n/a           Revision: n/a
*
* Brief Description of Module Purpose:
*       The routine delays for a whole number of milliseconds.
*       Minimum = 1mS, Maximum = 256mS.
*       Assumes an HC05 CPU with 4MHz crystal, 2MHz bus speed
*

```

```

* Part Family Software Module Works With:  HC05
* Part Module Software Module Works With:  only CPU05 is required
* Part Module Software Module Tested With:  HC705C8A
*
* Calling Sequence: LDA #desired number of milliseconds
*                   JSR DelaymS_Body
*
* Entry Label:      DelaymS_Body
* Module Size (Bytes): 17T bytes
* Stack Space Used (Bytes): 2T bytes (1 jsr stack frame)
* RAM Used (Bytes): 0
* Worst Case Execution (Cycles): 512006T cycles (with $00 in Acc)
* Entry Conditions:  # of mS to delay in Acc
* Part Resources Needed: CPU05 running at 2.00MHz bus frequency
* External Variables Used: none
* Subroutines Used: none
* Number of Exit Points: 1
*   Exit Label:      DelaymS015
*   Exit Conditions:  Acc = 0 after being decremented
*
* Full Functional Description of Module Design:
*
* This routine delays operation for a whole number of milliseconds.
* The number of milliseconds to delay is passed in the accumulator
* The routine alters Acc, X and CCR.
* A 4MHz clock (2MHz bus) is assumed.
* The smallest delay is 2011 cycles which occurs when Acc = 1. (1mS)
* The largest delay is 512006 cycles which occurs when Acc = 0. (256mS)
*
* Please note that passing 0 will NOT result in zero delay, but 256mS delay.
*
* The number of milliseconds to delay is passed in the accumulator. The
* routine is formed by two loops. The inner loop (DelaymS020) executes in
* 1989 cycles. The outer loop executes once for each millisecond and adds
* 11 bus cycles each time through the loop. This creates 2000 cycles for
* each millisecond of delay. The RTS used to exit the routine add 06 bus
* cycles to the total time. By my convention, the JSR is not counted in
* this routine, but in the calling routine.
*
* The exact number of cycles for this routine to execute may be calculated
* from:
*
*           cycles = 11 + ( Acc * 2000 )
*
* Upon exit, the accumulator and index register will be zero.

```

```

*****
*
* Update History:
* Rev:      Author:      Date:      Description of Change:
* ----      -
*
* PA 1.0     Yoder        04/20/95    Original Release
*
*****
*****
*
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*
*****
*****
.PAGE
*****
*
* Delay for XmS
*
* This calls the 1mS delay routine below.
* Number of mS in passed through the accumulator.
*
*****
DelaymS_Body    equ      *
DelaymS010      jsr      DelaymS020      ;Jump to 1mS delay counter
                brn      DelaymS010      ;burn 3 bus cycles
                nop       ;burn 2 bus cycles
                deca      ;decrement # of mS to delay
                bne      DelaymS010      ;branch if not done
DelaymS015      rts       ;all done - return to calling routine

```

```

*****
*
* Delay for 1mS
*
* Takes 1989 cycles to execute.
*
*****
DelaymS020      ldx      #$F7          ;Load delay into X
DelaymS030      decx     ;Decrement delay
                nop      ;burn 2 bus cycles
                bne      DelaymS030    ;Branch in not done
                rts
*****

*****
*****
*
*      C0STOP - STOP mode example for external bus HC05C0
*
*****
*
* File Name: C0STOP.MRT                      Copyright (c) Motorola 1994
*
* Current Revision: 1.0
* Current Release Level: PA
* Current Revision Release Date: 04/20/95
*
* Current Release Written By: David Yoder
*                               Motorola CSIC Applications - Austin, Texas
*
* Assembled Under: IASM05 (P&E Microcomputer Systems, Inc.)    Ver.: 3.02m
*
* Project Folder Name: C0AppN
*
* Part Family Software Routine Works With: HC05
* Part Module(s) Software Routine Works With:
*
* Routine Size (Bytes):      26
* Stack Space Used (Bytes):  0
* RAM Used (Bytes):          0
*
* Global Variables Used:      None
* Subroutines Called:         DelaymS
*

```

```
* Full Functional Description Of Routine Design:
*
*   The intent of this routine is to test the STOP mode of the C0 with
*   respect to chip selects. That is, the chip selects should be
*   when a STOP instruction is executed from internal RAM.
*
*   This will be tested by:
*       Copying a STOP and RTS instruction to RAM.
*       Enabling Internal Read Visibility.
*       Enable STOP Instruction.
*       JSR to the STOP instruction.
*       Measure the level of the A15_ pin.
*
*****
*
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*
*
*****
*
*           Part Specific Framework Includes Section
*
* Place the assembler statement ($INCLUDE) to include the part specific
* framework for the target part.
*
*****

$NOLIST
$INCLUDE 'H05C0.FRK'           ;Include equates for the HC05C0.
$LIST
```

```
*****
*
*                               RAM Variable Definition
*
*****
```

```
RAM_Subroutine      org      RAM
                    rmb       2          ;Reserve two bytes for STOP subroutine.
```

```
*****
*
*                               Program Initialization
*
* Code needed to initialize processor resources is placed here.
* For any subroutines that have initialization routines which need
* to be executed once out of RESET, a jump (JSR) to the initialization
* section of the subroutine should be placed in this section.
*
*****
```

```
COSTOP_Init:        org      $E000
                    LDA       #$FF          ;Write all available port pins to
                    STA       PORTB         ; output high. This will reduce STOP
                    STA       PORTD         ; current for measurement.
                    STA       DDRB
                    STA       DDRD
```

```

*****
*
*                               Main Program Loop
*
* This section will contain the main program loop. It's purpose is to set
* up the CONFIG register to enable STOP mode and the Internal Read
* Visibility (IRV) option. It then loads the RAM with a STOP instruction and
* an RTS instruction to create a subroutine in RAM. Since our purpose is
* to disable the EPROM to minimize current draw in STOP mode, we want to run
* this code from RAM. When this subroutine is executed, the CE of the EPROM
* is brought high, thus disabling it. This example program assumes there is
* some method of supplying the part an interrupt, thus bringing the part out
* of STOP mode. Upon exiting STOP mode, the main loop simply branches back
* to the beginning, creating an infinite loop.
*
*****

C0STOP_Body:
        lda    #$F3                ;Enable STOP, IRV on, others at
        sta    CNFGR                ; POR default.
        sta    CNFGR                ;Write to configuration register.

        lda    #$8E                ;Write STOP instruction to RAM.
        sta    RAM_Subroutine
        lda    #$81                ;Write RTS instruction to RAM.
        sta    RAM_Subroutine+1
        jsr    RAM_Subroutine      ;Jump to STOP subroutine.
        bra    C0STOP_Body         ;Infinite loop.

C0STOP_ISR:
        rti                        ;Just return from interrupt.

*****
*
*                               Interrupt and Reset Vectors for Main Routine
*
* Place Vector ORG and FDB statements here. Use the labels defined in the
* part-specific framework file.
*
*****

        org    IRQ_INT
        dw     C0STOP_ISR

        org    RESET
        fdb    C0STOP_Init

*****

```

```

*****
*
*                               HC705J1A Part Specific FrameWork
*
*****
*
* File Name: H05C0.FRK                      Copyright (c) Motorola 1994
*
* Curent Revision: 1.1
* Current Release Level: ES
* Current Revision Release Date: 04/11/95
*
* Current Release Written By: David Yoder
*                               Motorola CMCU Applications - Austin, Texas
*
* Assembled Under: IASM05 (P&E Microcomputer Systems, Inc.)
*                   Version: 2.2, 3.01m, 3.02m
*                   CASM05 (P&E Microcomputer Systems, Inc.)
*                   Version: 3.02, 3.04
*
* Documentation File Name:                      Revision:
*
* Program Description:
*       This FrameWork contains part specific information such as
*       register equates, memory map specifics, and reset/interrupt
*       vector addresses. This file is meant to be used in conjunction
*       with the Austin CSIC applications group's software library.
*
*       For bit equates:
*       Use bit names without a dot in BSET..BRCLR
*       Use bit names followed by a dot in expressions such as
*       #ELAT.+EPGM. to form a bit mask
*
*****
*
* Update History:
* Rev:      Author:      Date:      Description of Change:
* ----      -
* ESS 1.0   Yoder       12/21/94    Original Release
*
*****
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*
```

```
*****
*****
```

#Page

```
*****
```

```
*
*
*           Register Equates
*
*****
```

PORTB	equ	\$01	; Port B byte address
PORTC	equ	\$02	; Port C byte address
PORTD	equ	\$03	; Port D byte address
DDRB	equ	\$05	; Port B Data Direction Register
DDRC	equ	\$06	; Port C Data Direction Register
DDRD	equ	\$06	; Port D Data Direction Register
TSCR	equ	\$08	; Timer Status and Control Register
TCR	equ	\$09	; Timer-Counter Register
*TCR	equ	\$0A	; Timer Control Register
*TSR	equ	\$0B	; Timer Status Register
*ICR_MSB	equ	\$0C	; Input Capture Register - MSB
*ICR_LSB	equ	\$0D	; Input Capture Register - LSB
*OCR_MSB	equ	\$0E	; Output Compare Register - MSB
*OCR_LSB	equ	\$0F	; Output Compare Register - LSB
*Timer_MSB	equ	\$10	; Timer Count Register - MSB
*Timer_LSB	equ	\$11	; Timer Count Register - LSB
*AltTimer_MSB	equ	\$12	; Alt. Timer Count Register - MSB
*AltTimer_LSB	equ	\$13	; Alt. Timer Count Register - LSB
BAUD	equ	\$0D	; SCI BAUD Rate Register
SCCR1	equ	\$0E	; SCI Control Register 1
SCCR2	equ	\$0F	; SCI Control Register 2
SCSR	equ	\$10	; SCI Status Register
SCDAT	equ	\$11	; SCI Data Register
CNFR	equ	\$19	; Configuration Register
COPR	equ	\$FFFF	; COP Reset Register

\$PAGE

```

*****
*
*                               Bit Equates
*
* Use bit names without a dot in BSET..BRCLR
* Use bit names followed by a dot in expressions such as #ELAT.+EPM. to
* form a bit mask
*****
* Port A Data Register (PORTA -> $00)
PA0    equ    0        ; Port A Bit 0
PA1    equ    1        ; Port A Bit 1
PA2    equ    2        ; Port A Bit 2
PA3    equ    3        ; Port A Bit 3
PA4    equ    4        ; Port A Bit 4
PA5    equ    5        ; Port A Bit 5
PA6    equ    6        ; Port A Bit 6
PA7    equ    7        ; Port A Bit 7
PA0.   equ    $01      ; Port A Bit 0
PA1.   equ    $02      ; Port A Bit 1
PA2.   equ    $04      ; Port A Bit 2
PA3.   equ    $08      ; Port A Bit 3
PA4.   equ    $10      ; Port A Bit 4
PA5.   equ    $20      ; Port A Bit 5
PA6.   equ    $40      ; Port A Bit 6
PA7.   equ    $80      ; Port A Bit 7

* Port B Data Register (PORTB -> $01)
PB0    equ    0        ; Port B bit 0
PB1    equ    1        ; Port B bit 1
PB2    equ    2        ; Port B bit 2
PB3    equ    3        ; Port B bit 3
PB4    equ    4        ; Port B bit 4
PB5    equ    5        ; Port B bit 5
PB0.   equ    $01      ; Port B bit 0
PB1.   equ    $02      ; Port B bit 1
PB2.   equ    $04      ; Port B bit 2
PB3.   equ    $08      ; Port B bit 3
PB4.   equ    $10      ; Port B bit 4
PB5.   equ    $20      ; Port B bit 5

```

\* Port A Data Direction Register (DDRA -> \$04)

DDRA0	equ	0	;	Port A Data Direction bit 0
DDRA1	equ	1	;	Port A Data Direction bit 1
DDRA2	equ	2	;	Port A Data Direction bit 2
DDRA3	equ	3	;	Port A Data Direction bit 3
DDRA4	equ	4	;	Port A Data Direction bit 4
DDRA5	equ	5	;	Port A Data Direction bit 5
DDRA6	equ	6	;	Port A Data Direction bit 6
DDRA7	equ	7	;	Port A Data Direction bit 7
DDRA0.	equ	\$01	;	Port A Data Direction bit 0
DDRA1.	equ	\$02	;	Port A Data Direction bit 1
DDRA2.	equ	\$04	;	Port A Data Direction bit 2
DDRA3.	equ	\$08	;	Port A Data Direction bit 3
DDRA4.	equ	\$10	;	Port A Data Direction bit 4
DDRA5.	equ	\$20	;	Port A Data Direction bit 5
DDRA6.	equ	\$40	;	Port A Data Direction bit 6
DDRA7.	equ	\$80	;	Port A Data Direction bit 7

\* Port B Data Direction Register (DDRB -> \$05)

DDRB0	equ	0	;	Port B Data Direction bit 0
DDRB1	equ	1	;	Port B Data Direction bit 1
DDRB2	equ	2	;	Port B Data Direction bit 2
DDRB3	equ	3	;	Port B Data Direction bit 3
DDRB4	equ	4	;	Port B Data Direction bit 4
DDRB5	equ	5	;	Port B Data Direction bit 5
DDRB0.	equ	\$01	;	Port B Data Direction bit 0
DDRB1.	equ	\$02	;	Port B Data Direction bit 1
DDRB2.	equ	\$04	;	Port B Data Direction bit 2
DDRB3.	equ	\$08	;	Port B Data Direction bit 3
DDRB4.	equ	\$10	;	Port B Data Direction bit 4
DDRB5.	equ	\$20	;	Port B Data Direction bit 5

\* Timer Status and Control Register (TSCR -> \$08)

RT0	equ	0	;	Real-Time Interrupt Rate Select bit 0
RT1	equ	1	;	Real-Time Interrupt Rate Select bit 1
RTIFR	equ	2	;	Real-Time Interrupt Flag Reset
TOFR	equ	3	;	Timer Overflow Flag Reset
RTIE	equ	4	;	Real-Time Interrupt Enable
TOIE	equ	5	;	Timer Overflow Interrupt Enable
RTIF	equ	6	;	Real-Time Interrupt Flag
TOF	equ	7	;	Timer Overflow Flag
RT0.	equ	\$01	;	Real-Time Interrupt Rate Select bit 0
RT1.	equ	\$02	;	Real-Time Interrupt Rate Select bit 1
RTIFR.	equ	\$04	;	Real-Time Interrupt Flag Reset
TOFR.	equ	\$08	;	Timer Overflow Flag Reset
RTIE.	equ	\$10	;	Real-Time Interrupt Enable
TOIE.	equ	\$20	;	Timer Overflow Interrupt Enable
RTIF.	equ	\$40	;	Real-Time Interrupt Flag
TOF.	equ	\$80	;	Timer Overflow Flag

```

* Timer Control Register (TCR -> $12)
*ICIE.      equ      %10000000      ;Input Capture Interrupt Enable
*OCIE.      equ      %01000000      ;Output Compare Interrupt Enable
*TOIE.      equ      %00100000      ;Timer Overflow Interrupt Enable
*IEDG.      equ      %00000010      ;Input Capture Input Edge Select
*OLVL.      equ      %00000001      ;Output Compare Output Level

*ICIE      equ      7      ;Input Capture Interrupt Enable
*OCIE      equ      6      ;Output Compare Interrupt Enable
*TOIE      equ      5      ;Timer Overflow Interrupt Enable
*IEDG      equ      1      ;Input Capture Input Edge Select
*OLVL      equ      0      ;Output Compare Output Level

* Timer Status Register (TSR -> $13)
*ICF.      equ      %10000000      ;Input Capture Flag
*OCF.      equ      %01000000      ;Output Compare Flag
*TOF.      equ      %00100000      ;Timer Overflow Flag

*ICF      equ      7      ;Input Capture Flag
*OCF      equ      6      ;Output Compare Flag
*TOF      equ      5      ;Timer Overflow Flag

* SCI Baud Rate Register (SCBR -> $0D)
SCP1.      equ      %00100000      ;SCI Baud Rate Prescaler Bit 1
SCP0.      equ      %00010000      ;SCI Baud Rate Prescaler Bit 0
SCR2.      equ      %00000100      ;SCI Baud Rate Select Bit 2
SCR1.      equ      %00000010      ;SCI Baud Rate Select Bit 1
SCR0.      equ      %00000001      ;SCI Baud Rate Select Bit 0

SCP1      equ      5      ;SCI Baud Rate Prescaler Bit 1
SCP0      equ      4      ;SCI Baud Rate Prescaler Bit 0
SCR2      equ      2      ;SCI Baud Rate Select Bit 2
SCR1      equ      1      ;SCI Baud Rate Select Bit 1
SCR0      equ      0      ;SCI Baud Rate Select Bit 0

* SCI Control Register 1 (SCCR1 -> $0E)
R8.      equ      %10000000      ;SCI Receive Data Bit 8
T8.      equ      %01000000      ;SCI Transmit Data Bit 8
M.      equ      %00010000      ;SCI Character Word Length
WAKE.      equ      %00001000      ;SCI Wakeup Method Select

R8      equ      7      ;SCI Receive Data Bit 8
T8      equ      6      ;SCI Transmit Data Bit 8
M      equ      4      ;SCI Character Word Length
WAKE      equ      3      ;SCI Wakeup Method Select

```

\* SCI Control Register 2 (SCC2 -> \$0F)

TIE.	equ	%10000000	;SCI Transmit Interrupt Enable
TCIE.	equ	%01000000	;SCI Transmit Complete Int. Enable
RIE.	equ	%00100000	;SCI Receive Interrupt Enable
ILIE.	equ	%00010000	;SCI Idle Line Interrupt Enable
TE.	equ	%00001000	;SCI Transmitter Enable
RE.	equ	%00000100	;SCI Receiver Enable
RWU.	equ	%00000010	;SCI Receiver Wakeup Enable
SBK.	equ	%00000001	;SCI Send Break

TIE	equ	7	;SCI Transmit Interrupt Enable
TCIE	equ	6	;SCI Transmit Complete Int. Enable
RIE	equ	5	;SCI Receive Interrupt Enable
ILIE	equ	4	;SCI Idle Line Interrupt Enable
TE	equ	3	;SCI Transmitter Enable
RE	equ	2	;SCI Receiver Enable
RWU	equ	1	;SCI Receiver Wakeup Enable
SBK	equ	0	;SCI Send Break

\* SCI Status Register (SCSR -> \$10)

TDRE.	equ	%10000000	;Transmit Data Register Empty Flag
TC.	equ	%01000000	;Transmit Complete Flag
RDRF.	equ	%00100000	;Receive Data Register Full Flag
IDLE.	equ	%00010000	;Idle Line Detect Flag
OR.	equ	%00001000	;Overrun Error Flag
NF.	equ	%00000100	;Noise Error Flag
FE.	equ	%00000010	;Framing Error Flag

TDRE	equ	7	;SCI Transmit Data Register Empty
TC	equ	6	;SCI Transmit Complete Flag
RDRF	equ	5	;SCI Receive Data Register Full
IDLE	equ	4	;Idle Line Detect Flag
OR	equ	3	;Overrun Error Flag
NF	equ	2	;Noise Error Flag
FE	equ	1	;Framing Error Flag

\* Configuration Register (CNFGR -> \$19)

STPEN.	equ	%10000000	;STOP Enable
STREC.	equ	%01000000	;STOP Recovery
COPEN.	equ	%00100000	;COP Enable
IRV.	equ	%00010000	;Internal Read Visibility
LIRV.	equ	%00001000	;Load Instruction Register Visibility
LVREN.	equ	%00000100	;Low Voltage Reset Enable
CS1P1.	equ	%00000010	;Chip Select 1 Parameter bit 1
CS1P0.	equ	%00000001	;Chip Select 1 Parameter bit 0

```

STPEN          equ      7           ;STOP Enable
STREC          equ      6           ;STOP Recovery
COPEN          equ      5           ;COP Enable
IRV            equ      4           ;Internal Read Visibility
LIRV           equ      3           ;Load Instruction Register Visibility
LVREN          equ      2           ;Low Voltage Reset Enable
CS1P1          equ      1           ;Chip Select 1 Parameter bit 1
CS1P0          equ      0           ;Chip Select 1 Parameter bit 0

```

\* COP Register (COPR -> \$FFFF)

```

COPC           equ      0           ; COP Clear
COPC.          equ      $01        ; COP Clear

```

\$PAGE


```

*****
*
*                               Memory Map Equates
*
*****
RAM          equ      $0040      ; Start of on chip RAM
Vectors      equ      $07F8      ; Start of Reset/Interrupt vectors
Keyboard_INT equ      $FFF2      ; Keyboard Scan Interrupt Vector
MFT_INT      equ      $FFF4      ; Multifunction Timer Vector
SCI_INT      equ      $FFF6      ; Serial Comm. Interface Vector
TIM_INT      equ      $FFF8      ; 16 bit Timer Interrupt Vector
IRQ_INT      equ      $FFFA      ; External Interrupt Vector
SWI_INT      equ      $FFFC      ; Software Interrupt Vector
RESET        equ      $FFFE      ; Reset Vector

```

```
*****
*
*                      RESET and Interrupt Vectors
*
* For any interrupts used, the ORG and FDB statement given below must be
* placed in the routine using the interrupt.
*
*****
*
*          org      Vectors
*
*          org      Timer_INT
*          fdb      Timer_SVR
*
*          org      IRQ_INT
*          fdb      IRQ_SVR
*
*          org      SWI_INT
*          fdb      SWI_SVR
*
*          org      RESET
*          fdb      Start
*
*****
```

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