![MICROCHIP]

AN1450

Delay Block/Debouncer

| Author: | Stephen Allen |
| | Microchip Technology Inc. |

INTRODUCTION

In this application note, a PIC10F322 is being used to implement a delay block/debouncer. The delay can be set between 2 µs and 193 µs. This can be used effectively as a noise discriminator, or for switch debouncing.

When used as a delay block, the application can be used to fix low-level timing issues on signals. When used as a debouncer, it can debounce signals from a mechanical switch so that a clean signal can feed other circuitry.

The application makes use of the Configurable Logic Cell (CLC) peripheral to produce fast switching on the output (if desired). If the same application were written using port logic only, there would be multiple instruction cycles before the output would change in response to an input. Using the CLC the signal can be routed directly and only have propagation and gate delay between the input and output signals. In order to get the highest performance possible from the application, it has been written in assembly.

The code has been written in-line (without subroutines) to maximize switching performance of the application. The code uses only 43 locations of program memory (512 available), and one byte of RAM.

This application note was developed using a PIC10F322 demo board (part # AC103011). Language tool versions: MPASMWIN.exe v5.45, mplink.exe v4.43, mplib.exe v4.43.

DELAY SETTINGS AND VALUES

Delays can be set between 2 µs and 193 µs in 750 ns increments (using the 16 MHz internal clock). Delays can easily be made longer if desired, by reducing the clock speed or increasing the size of the delay loop. Enabling/disabling of delays is configured in the code by commenting/uncommenting the following lines of code:

```
;; 2 lines below enable rising and falling
edge delays
#define    RISING_EDGE_DELAY
#define    FALLING_EDGE_DELAY
```

Independent rising and falling edge delay times can be set in the following lines of code:

```
;; specify length of falling and rising edge
below
RISE_EDGE_DELAY    equ    0x01
FALL_EDGE_DELAY    equ    0x01
```

Voltage: 2.3 to 5.5V.

CALCULATING DELAY VALUES

There are two options for setting delay values, and they are determined by commenting/uncommenting the MS_DELAY definition:

1. 1 millisecond step size – this is useful for switch debouncing with recommended settings of FALLING_EDGE_DELAY = 100 ms, and RISING_EDGE_DELAY disabled.

```
#define MS_DELAY
```

Delays are set in milliseconds.

2. 750 ns step size

```
;#define MS_DELAY
```

With the part running at 16 MHz, there are 250 ns per instruction cycle. The delay loop takes three instruction cycles to execute, so 750 ns are added for each incremental change in the countdown timer. There are approximately eight instructions (2 µs) that will be executed between an input change and an output change, if the shortest possible delay is selected (RISING_EDGE_DELAY or FALLING_EDGE_DELAY = 1).

delay = 2 µs + (delay_value x 750 ns)

Operating current: ~ 2.4 mA (but can be reduced with lower clock speed).

MODES OF OPERATION

Rising Edge Delay

In this mode, only the rising edge has a delay, and the falling edge will drop immediately.

AN1450

Falling Edge Delay (Pulse Extender)

In this mode, the rising edge will come up immediately, and the falling edge will be delayed.
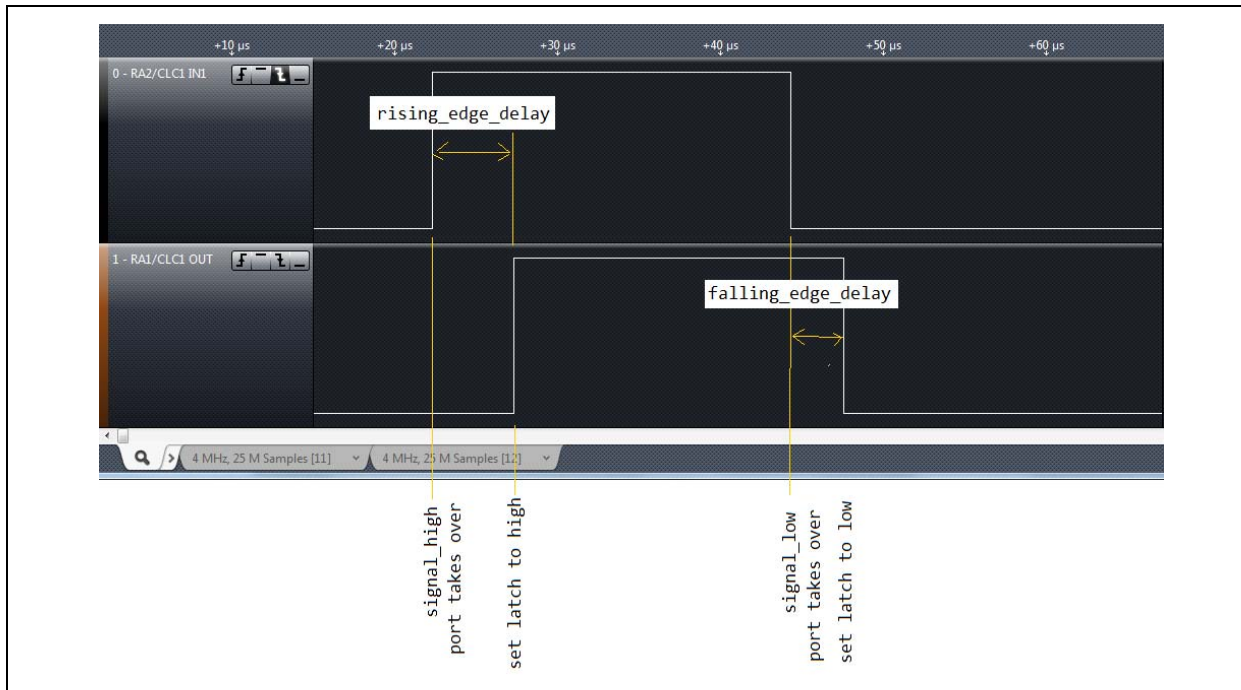
Rising and Falling Edge Delay

In this mode, the user has the option to set independent rising and falling edge values.

The diagram below (Figure 1) shows the relationship between the rising and falling edges. Signal edges are marked for reference in the source assembly code (*delay.asm*).

FIGURE 1:   **MEASUREMENT OF RISING AND FALLING EDGE DELAYS**

When falling edge delay is not selected, the signal is routed through the CLC and has approximately 50 ns of propogation delay. Figure 2 shows the input and output signals.

FIGURE 2: **PROPAGATION DELAY**
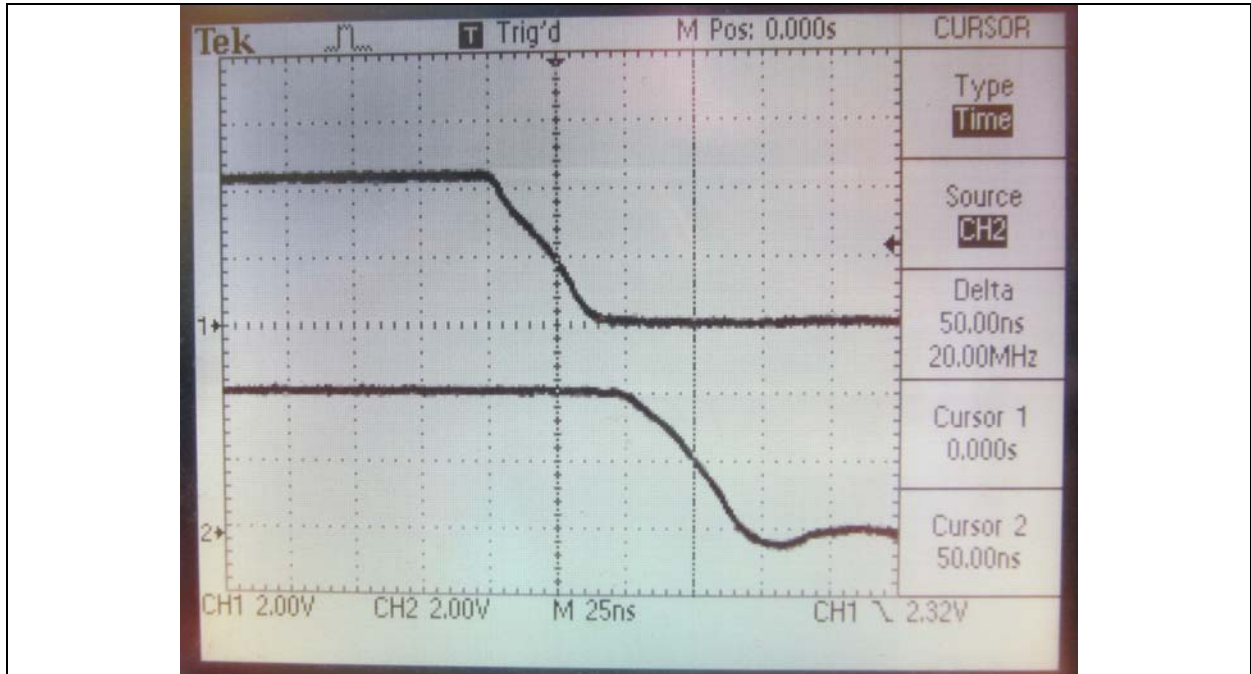
BLOCK DIAGRAM

With the CLC block configured as a pass-through, it is possible to quickly route signals to the output when no delay is desired, and the PIC® device core (port function) will create edge delays when desired. The MUX (CLC1CON, LC1OE) selects whether the pin is driven by the CLC or by the port logic (Figure 3).

**FIGURE 3:** **BLOCK DIAGRAM – MUX BETWEEN PORT AND CLC LOGIC BLOCK**
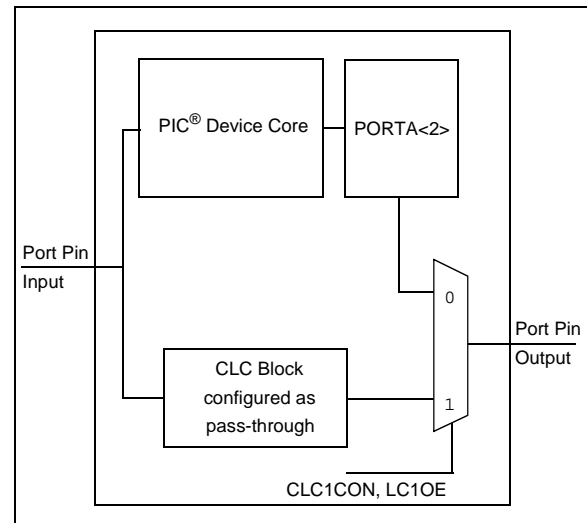
AN1450

CONFIGURING THE CLC BLOCK WITH THE CLC DESIGNER TOOL

The PIC10F322 has only one CLC block. The CLC block is configured as a pass-through by using the 'AND' logic tab of the CLC Designer tool. Unused 'OR' gates are inverted, so that they will produce a '1' at the output. The configuration is shown in the screen shot below (Figure 4).
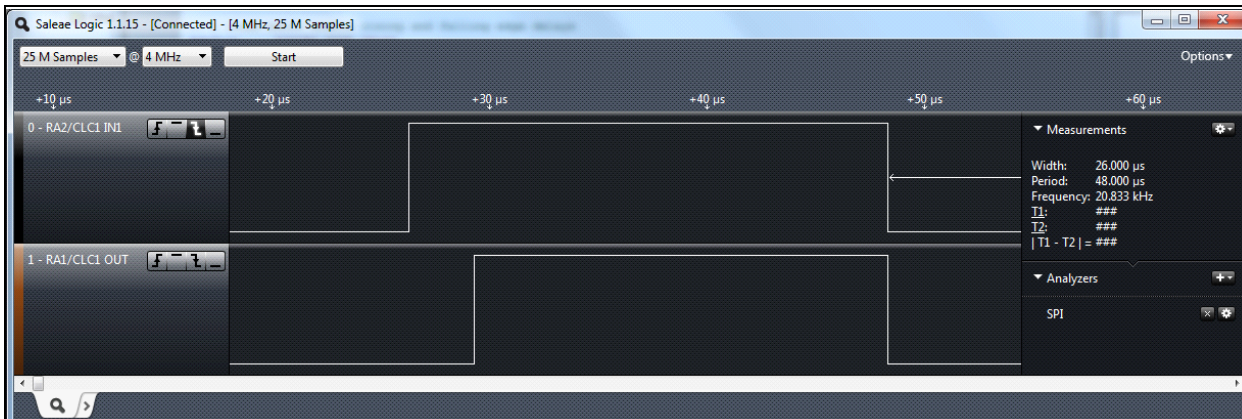
FIGURE 4: CONFIGURATION OF THE CLC BLOCK (CLC1)
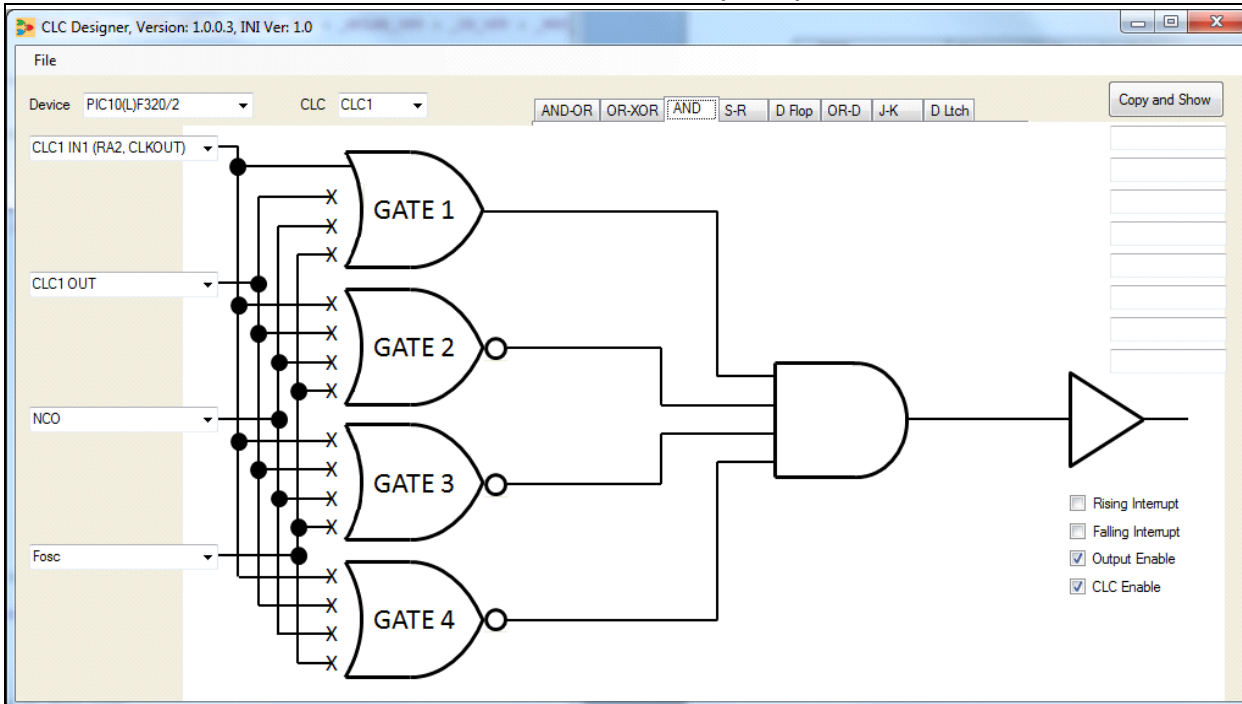
RISING EDGE DELAY

Rising edge delay is enabled, while the falling edge is provided through the CLC block (Figure 5).

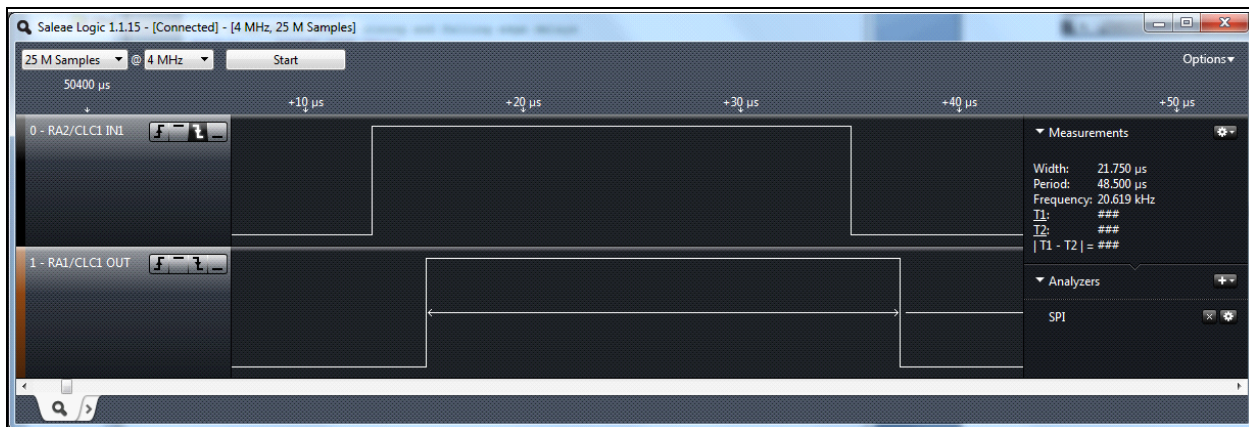FIGURE 5: RISING EDGE DELAY EXAMPLE

FALLING EDGE DELAY

Falling edge delay is enabled, while the rising edge is provided through the CLC block (Figure 6).
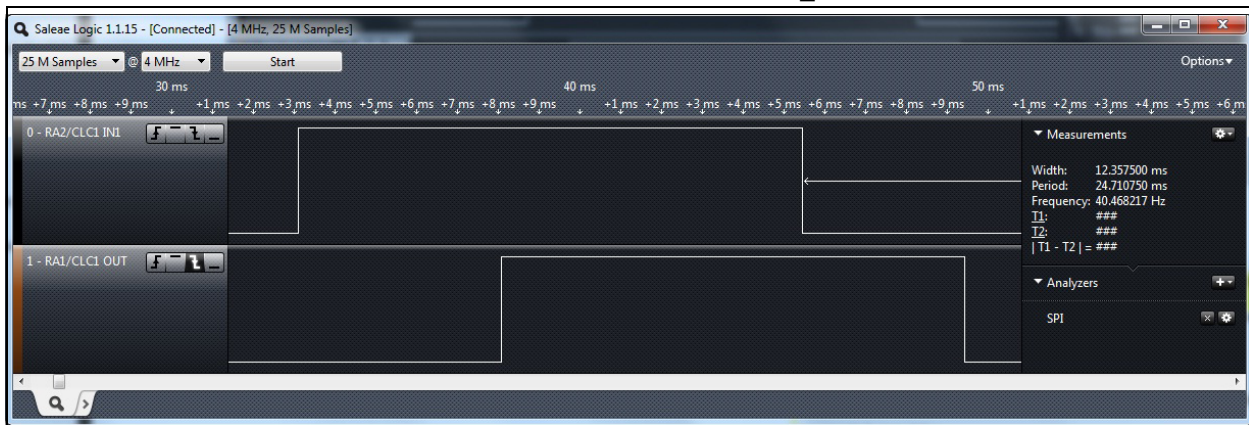
FIGURE 6: FALLING EDGE DELAY EXAMPLE

RISING AND FALLING EDGE DELAY

FIGURE 7: RISING AND FALLING EDGE DELAY EXAMPLE

Signal delay specified in milliseconds:

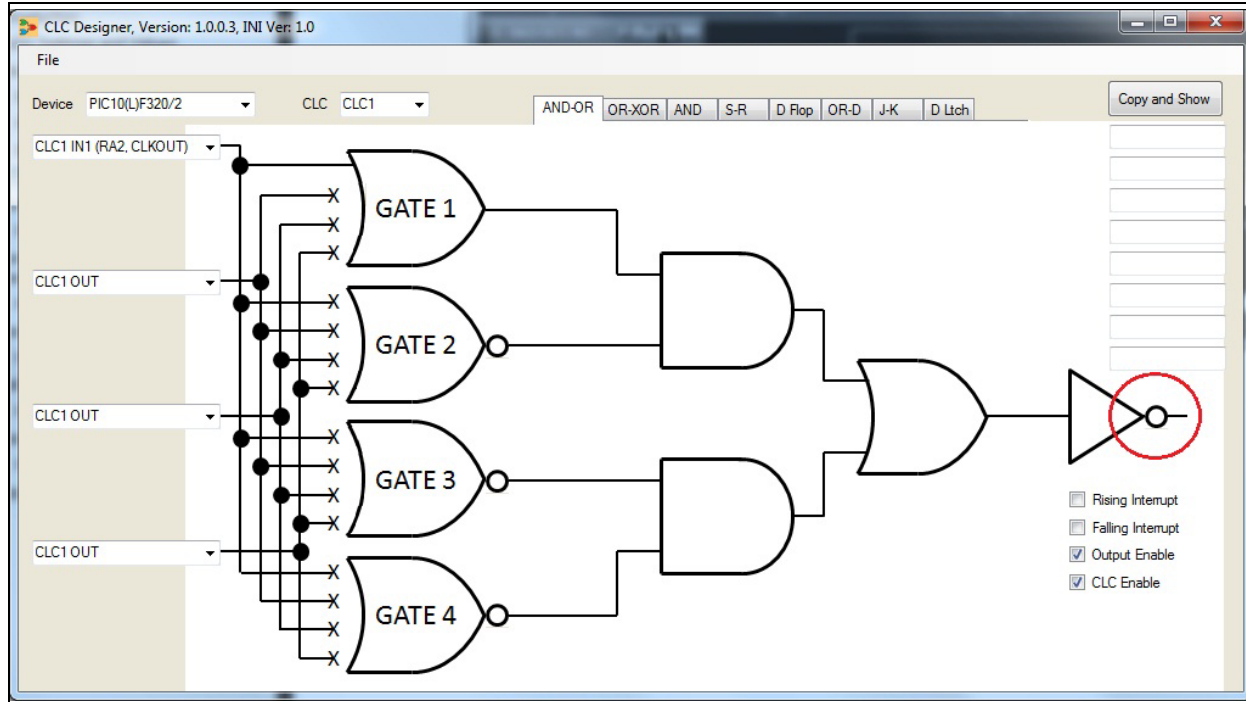FIGURE 8: RISING AND FALLING EDGE DELAY WITH MS_DELAY ENABLED

AN1450

INVERTING THE OUTPUT SIGNAL

The CLC output can be inverted with the CLC tool by clicking on the buffer output to enable the inverter (as shown circled in red in Figure 9 below).

FIGURE 9: INVERTING THE OUTPUT SIGNAL

The example below (Figure 10) has no delay enabled, so the input signal is routed through the CLC block.
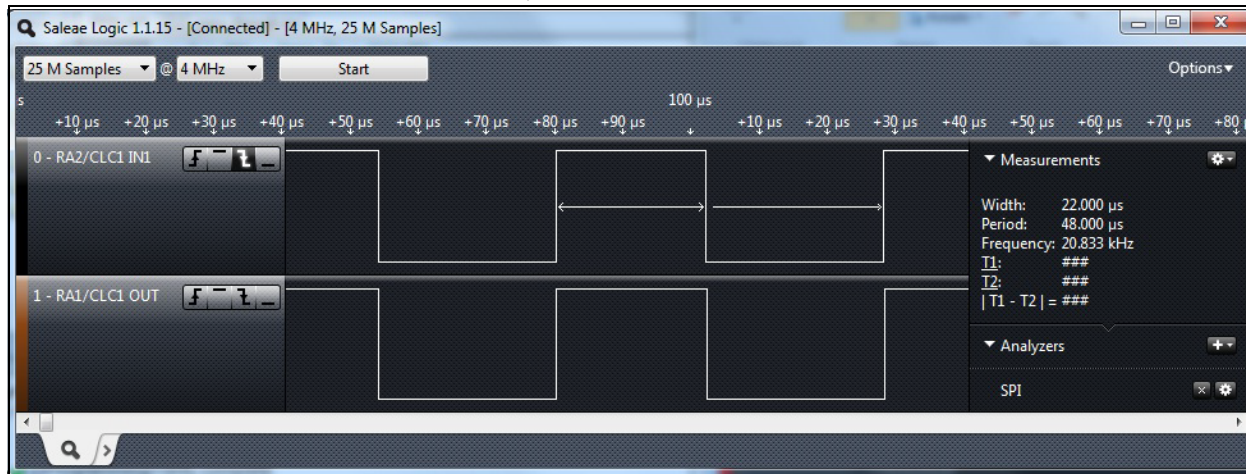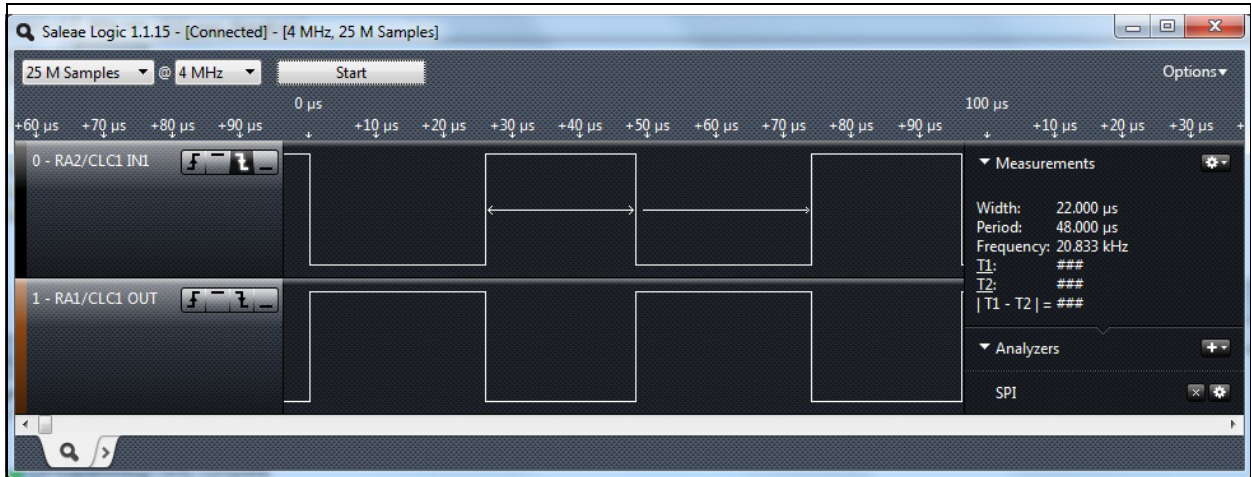
FIGURE 10: SIGNAL NOT INVERTED, ZERO DELAY

FIGURE 11: **SIGNAL INVERTED, ZERO DELAY**

APPENDIX A: CLC_PASS_THROUGH.INC

```
; File: CLC_pass_through.inc
; Generated by CLC Designer, Version: 1.0.0.3
; Date: 6/4/2012 11:49 AM
; Device:PIC10(L)F320/2
; BANKSEL  CLC1GLS0    - this instruction not needed for PIC10LF322
  movlw  H'02'
  movwf  CLC1GLS0
  movlw  H'00'
  movwf  CLC1GLS1
  movlw  H'00'
  movwf  CLC1GLS2
  movlw  H'00'
  movwf  CLC1GLS3
  movlw  H'02'
  movwf  CLC1SEL0
  movlw  H'65'
  movwf  CLC1SEL1

  movlw  H'0E'

  movwf  CLC1POL
  movlw  H'C2'

  movwf  CLC1CON
```

APPENDIX B: DELAY.ASM

```
;/*****************************************************************
;* FileName:delay.asm
;* Dependencies:
;* Processor:PIC10F322
;* Hardware:
;* Compiler:MPASM 5.45 or later
;* Company:Microchip Technology, Inc.
;*
;* Copyright © 2007-2012 Microchip Technology Inc. All rights reserved.

;*
;* You may use this software, and any derivatives, exclusively with Microchip's products.
;* Microchip and its licensors retain all ownership and intellectual property rights in
;* the accompanying software and in all derivatives hereto. This software and any
;* accompanying information is for suggestion only. It does not modify Microchip's
;* standard warranty for its products. You agree that you are solely responsible for
;* testing the software and determining its suitability. Microchip has no obligation
;* to modify, test, certify, or support the software.
;*
;* THIS SOFTWARE IS SUPPLIED BY MICROCHIP "AS IS". NO WARRANTIES, WHETHER EXPRESS,
;* IMPLIED OR STATUTORY, INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTIES OF NON-
   INFRINGEMENT,
;* MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE APPLY TO THIS SOFTWARE, ITS
;* INTERACTION WITH MICROCHIP'S PRODUCTS, COMBINATION WITH ANY OTHER PRODUCTS, OR USE IN
;* ANY APPLICATION.
;*
;* IN NO EVENT, WILL MICROCHIP BE LIABLE, WHETHER IN CONTRACT, WARRANTY, TORT
;* (INCLUDING NEGLIGENCE OR BREACH OF STATUTORY DUTY), STRICT LIABILITY, INDEMNITY,
;* CONTRIBUTION, OR OTHERWISE, FOR ANY INDIRECT, SPECIAL, PUNITIVE, EXEMPLARY, INCIDENTAL
;* OR CONSEQUENTIAL LOSS, DAMAGE, FOR COST OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO
;* THE SOFTWARE, HOWSOEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY
;* OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWABLE BY LAW, MICROCHIP'S
;* TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THIS SOFTWARE WILL NOT EXCEED THE
;* AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THIS SOFTWARE.
;*
;* MICROCHIP PROVIDES THIS SOFTWARE CONDITIONALLY UPON YOUR ACCEPTANCE OF THESE TERMS.
;*
;*
;*/
```

```
#include <p10f322.inc>

     list p=p10f322

;; Define parameters here

;; 2 lines below enable rising and falling edge delays
#define     RISING_EDGE_DELAY
#define     FALLING_EDGE_DELAY

;; specify length of falling and rising edge below
RISE_EDGE_DELAY  equ    0x05
FALL_EDGE_DELAY  equ    0x04

#define MS_DELAY

;; Configuration Fuses

     __config  _FOSC_INTOSC & _BOREN_OFF & _WDTE_OFF & _PWRTE_OFF & _MCLRE_OFF & _CP_OFF
     & _WRT_OFF

;; pin-out
;; 1 - RA0 - pin available for use as scope trigger.
;; 2 - VSS
;; 3 - RA1 - Data Out / CLC1
;; 4 - RA2 - Data In / CLC1IN2
;; 5 - VDD
;; 6 - MCLR

#define input_signal    PORTA,2
#define output_signal   LATA,1

; single RAM location used for countdown_timer
countdown_timer  equ  0x51

;; additional RAM location required if millisecond delay is enabled.
     #ifdef MS_DELAY
ms_timer        equ  0x52        ; delay counter for specifying time delay in millisec-
onds.
     #endif

     org        0x00

start

     bcf             TRISA,0         ; RA0 output - this can be used as a scope trigger.

     bcf             TRISA,1         ; RA1 output
     clrf   ANSELA                   ; all pins are digital.

     movlw  0x70
     movwf  OSCCON                   ; 16 MHz clock - change this value for longer delay
                                       times
     ; and to lower current consumption.


;;  CLC is set up here with the following include:
```

```
#include "CLC_pass_through.inc"   ; Configure CLC for falling edge.

;     bsf              CLC1POL,LC1POL; option to invert signal through CLC block.

;; input level test

      btfss  input_signal          ; What is the current value of my input signal?
      goto   signal_low            ; Low.
      goto   signal_high           ; High.


;; ===== This is the start of my main loop

signal_high                        ; Signal just transitioned high.

#ifdef   RISING_EDGE_DELAY         ; If I have rising edge delay,
         movlw  RISE_EDGE_DELAY
         movwf  countdown_timer    ; load countdown timer with rising edge delay.
rising_edge_delay_loop             ; insert 'nop's' below this line to increase delay.

      #ifdef MS_DELAY              ; option for millisecond delay
      call   millisecond_delay
      #endif

      #ifndef MS_DELAY
      decfsz    countdown_timer,1  ; Has countdown timer expired?
      goto   rising_edge_delay_loop; no, continue delay loop
      #endif

      bsf              output_signal  ; and drive pin high.
      #endif

#ifdef FALLING_EDGE_DELAY
      bsf              output_signal  ; drive latch high
      bcf              CLC1CON,LC1OE  ; PORT -> pin
#endif

#ifndef FALLING_EDGE_DELAY
      bsf              CLC1CON,LC1OE  ; CLC -> pin
#endif

wait_for_falling_edge
      btfsc  input_signal
      goto   wait_for_falling_edge

signal_low                         ; Signal just transitioned low.

      #ifdef FALLING_EDGE_DELAY
      movlw  FALL_EDGE_DELAY
      movwf  countdown_timer       ; load countdown timer with falling edge delay.
      #endif
falling_edge_delay_loop            ; insert 'nop's' below this line to increase delay.

      #ifdef MS_DELAY              ; option for millisecond delay
      call   millisecond_delay
      #endif
```

```
    #ifndef MS_DELAY
    decfsz countdown_timer,1      ; Has countdown timer expired?
    goto   falling_edge_delay_loop ; no, continue delay loop
    #endif

    bcf              output_signal  ; and drive pin low.

#ifdef     RISING_EDGE_DELAY
    bcf              output_signal  ; drive latch low
    bcf              CLC1CON,LC1OE  ; PORT -> pin
#endif

#ifndef RISING_EDGE_DELAY
    bsf              CLC1CON,LC1OE     ; CLC -> pin
#endif


wait_for_rising_edge
    btfss  input_signal
    goto   wait_for_rising_edge
    goto   signal_high

    ;;;;;;  end of main loop

    #ifdef MS_DELAY
millisecond_delay
    movlw  .250                   ; 250 loops x 16 cycles per loop = 4000 Tcy = 1 ms
    movwf  ms_timer
millisecond_delay_loop
    nop
    nop
    nop
    nop
    nop
    nop
    nop
    nop
    nop
    nop
    nop
    nop
    nop
    decfsz  ms_timer               ; has countdown timer reached 0?
    goto    millisecond_delay_loop; No. continue looping
    decfsz  countdown_timer     ; Do I need to have another millisecond delay?
    goto    millisecond_delay   ; Yes.
    retlw 0x00                    ; No - done.
    #endif


    end
```

Note the following details of the code protection feature on Microchip devices:

• Microchip products meet the specification contained in their particular Microchip Data Sheet.

• Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.

• There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.

• Microchip is willing to work with the customer who is concerned about the integrity of their code.

• Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Trademarks

The Microchip name and logo, the Microchip logo, dsPIC, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, PIC^{32} logo, rfPIC and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MXDEV, MXLAB, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniscient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICkit, PICtail, REAL ICE, rfLAB, Select Mode, Total Endurance, TSHARC, UniWinDriver, WiperLock and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2012, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

Printed on recycled paper.

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
═ ISO/TS 16949 ═

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Cleveland
Independence, OH
Tel: 216-447-0464
Fax: 216-447-0643

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

Santa Clara
Santa Clara, CA
Tel: 408-961-6444
Fax: 408-961-6445

Toronto
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon
Hong Kong
Tel: 852-2401-1200
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8569-7000
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

China - Hangzhou
Tel: 86-571-2819-3187
Fax: 86-571-2819-3189

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

Japan - Osaka
Tel: 81-66-152-7160
Fax: 81-66-152-9310

Japan - Yokohama
Tel: 81-45-471- 6166
Fax: 81-45-471-6122

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-5778-366
Fax: 886-3-5770-955

Taiwan - Kaohsiung
Tel: 886-7-536-4818
Fax: 886-7-330-9305

Taiwan - Taipei
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

UK - Wokingham
Tel: 44-118-921-5869
Fax: 44-118-921-5820

11/29/11