Universidad del Valle de Guatemala
Electrónica Digital 2 – Sección 11
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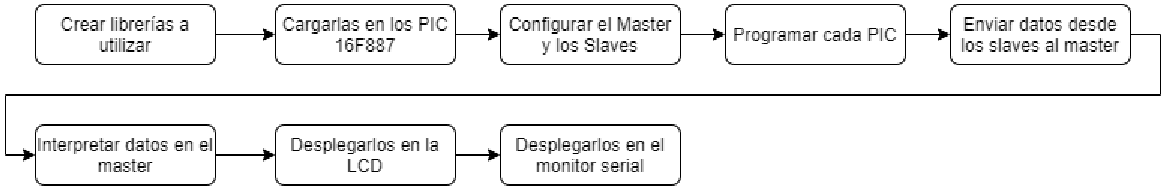
Mini Proyecto #1

SPI

Link de GitHub: https://github.com/mon19379/DIGITAL2.git

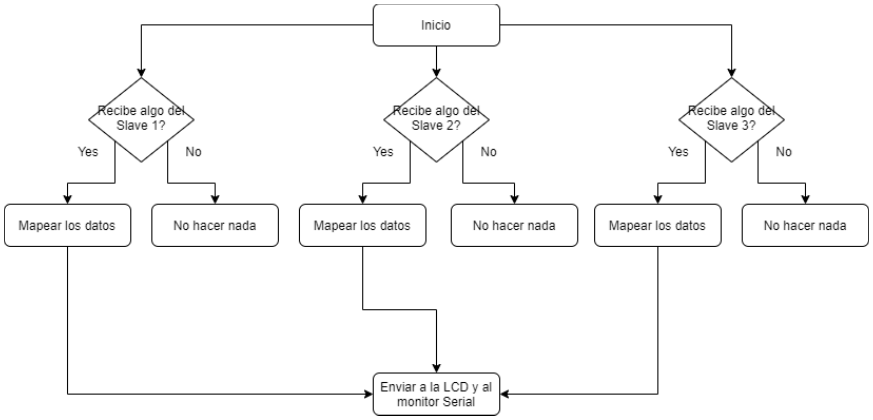
Link Video: **https://youtu.be/eyKU6VjGp8Q**

Diagrama de flujo:

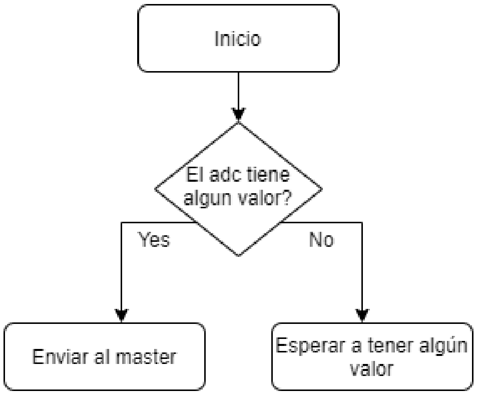

Crear librerías a utilizar
Cargarlas en los PIC 16F887
Configurar el Master y los Slaves
Programar cada PIC
Enviar datos desde los slaves al master
Interpretar datos en el master
Desplegarlos en la LCD
Desplegarlos en el monitor serial

Pseudocódigo:

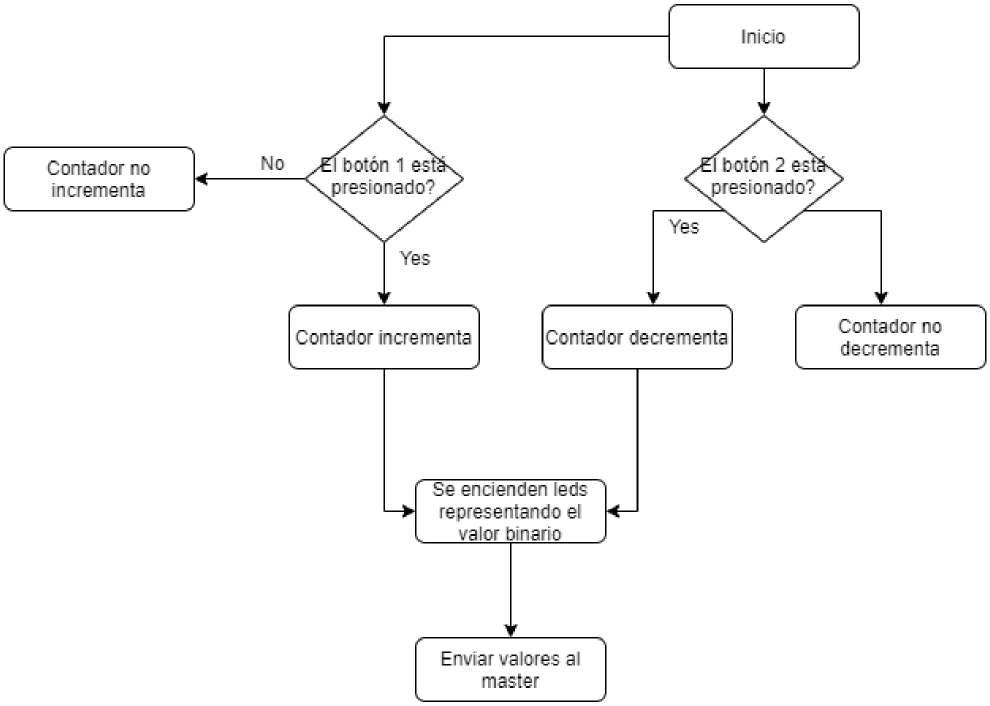
Master:



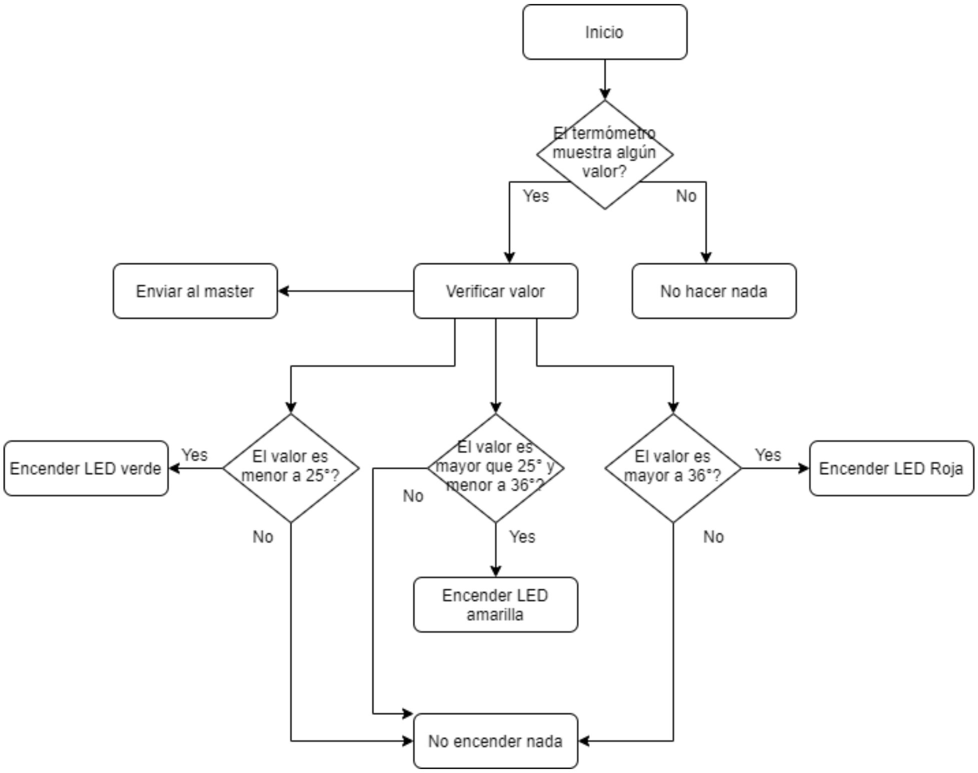
Slave 1:



Slave 2:



Slave 3:



Código:

Librerías Master:

Headers:

```
#ifndef LCDM_H
#define        LCDM_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <stdint.h>
#define _XTAL_FREQ 4000000

#ifndef EN
#define        EN PORTEbits.RE0
#endif
#ifndef RS
#define        RS PORTEbits.RE1
#endif

#ifndef RW
```

```
#define     RW
#endif

void Lcd_Port(char a);
void Lcd_Cmd(char a);
void Lcd_Set_Cursor(char a, char b);
void Lcd_Init();
void Lcd_Write_Char(char a);
void Lcd_Write_String(char *a);
void Lcd_Shift_Right();
void Lcd_Shift_Left();
#endif      /* LCDM_H */

// This is a guard condition so that contents of this file are not included
// more than once.
#ifndef OSCM_H
#define     OSCM_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <stdint.h>

void initOscm(uint8_t IRCF);



#endif      /* OSCM_H */

/*
 * File           : spi.h
 * Author         : Ligo George
 * Company        : electroSome
 * Project        : SPI Library for MPLAB XC8
 * Microcontroller : PIC 16F877A
 * Created on April 15, 2017, 5:59 PM
 */

// This is a guard condition so that contents of this file are not included
// more than once.
#ifndef __SSP_H
#define     __SSP_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <pic16f887.h>
```

```
typedef enum
{
    SPI_MASTER_OSC_DIV4  = 0b00100000,
    SPI_MASTER_OSC_DIV16 = 0b00100001,
    SPI_MASTER_OSC_DIV64 = 0b00100010,
    SPI_MASTER_TMR2      = 0b00100011,
    SPI_SLAVE_SS_EN      = 0b00100100,
    SPI_SLAVE_SS_DIS     = 0b00100101
}Spi_Type;

typedef enum
{
    SPI_DATA_SAMPLE_MIDDLE   = 0b00000000,
    SPI_DATA_SAMPLE_END      = 0b10000000
}Spi_Data_Sample;

typedef enum
{
    SPI_CLOCK_IDLE_HIGH  = 0b00010000,
    SPI_CLOCK_IDLE_LOW   = 0b00000000
}Spi_Clock_Idle;

typedef enum
{
    SPI_IDLE_2_ACTIVE    = 0b00000000,
    SPI_ACTIVE_2_IDLE    = 0b01000000
}Spi_Transmit_Edge;


void spiInit(Spi_Type, Spi_Data_Sample, Spi_Clock_Idle, Spi_Transmit_Edge);
void spiWrite(char);
unsigned spiDataReady();
char spiRead();

#endif          /* SSP_H */

//#ifndef SSP_H
//#define      SSP_H
//
//#include <xc.h> // include processor files - each processor file is guarded.
//#include <stdint.h>
//
```

```
////void configSSP(uint8_t sspm, uint8_t ckp, uint8_t cke, uint8_t smp);
//
//
//#endif        /* SSP_H */
#ifndef USARTM_H
#define        USARTM_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <stdint.h>
void usartm(void);



#endif          /* USARTM_H */
```

C:

```
/*
 * File:   LCD.c
 * Author: Extraído de electrosome.com
 *
 * Created on 4 de febrero de 2021, 12:52 PM
 */

#include <xc.h>
#include <stdint.h>
#include "LCDM.h"

void Lcd_Port(char a) {
    PORTA = a;
}

void Lcd_Cmd(char a) {
    Lcd_Port(a);
    RS = 0; // => RS = 0

    EN = 1; // => E = 1
    __delay_ms(5);
    EN = 0; // => E = 0
}

Lcd_Clear() {
    Lcd_Cmd(0);
    Lcd_Cmd(1);
}
```

```
void Lcd_Set_Cursor(char a, char b) {
    char temp;
    if (a == 1) {
        temp = 0x80 + b - 1;
        Lcd_Cmd(temp);
    } else if (a == 2) {
        temp = 0xC0 + b - 1;
        Lcd_Cmd(temp);
    }
}

void Lcd_Init() {

    ////////////////////////////////////////////////////

    Lcd_Cmd(0x38);
    Lcd_Cmd(0x0C);
    Lcd_Cmd(0x06);
    Lcd_Cmd(0x80);
}

void Lcd_Write_Char(char a) {
    RS = 1;             // => RS = 1
   Lcd_Port(a);             //Data transfer
   EN = 1;
   __delay_us(40);
   EN = 0;
   RS = 0;
}

void Lcd_Write_String(char *a) {
   int i;
                    for(i=0;a[i]!='\0';i++)
                       Lcd_Write_Char(a[i]);
}

void Lcd_Shift_Right() {
    Lcd_Cmd(0x1C);

}
```

```
void Lcd_Shift_Left() {
    Lcd_Cmd(0x18);

}
#include <pic16f887.h>
#include <xc.h>
#include "oscm.h"
//******************************************************************************
//Inicialización del oscilador interno pg. 62
//******************************************************************************
void initOscm(uint8_t IRCF){

    switch (IRCF){

        case 0: //OSCILADOR DE 31 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 0;

            break;

        case 1: //OSCILADOR DE 125 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 1;
            break;

        case 2: //OSCILADOR DE 250 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 0;
            break;

        case 3: //OSCILADOR DE 500kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 1;
            break;

        case 4: //OSCILADOR DE 1MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 0;
            break;

        case 5: //OSCILADOR DE 2MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 1;
            break;


        case 6: //OSCILADOR DE 4MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 0;
            break;

        case 7: //OSCILADOR DE 8MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 1;
            break;




        default: //OSCILADOR DE 4MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 0;
            break;

    }

    OSCCONbits.SCS = 1; //SE VA A USAR EL OSCILADOR INTERNO


}
/*
 * File           : spi.c
 * Author         : Ligo George
 * Company        : electroSome
 * Project        : SPI Library for MPLAB XC8
 * Microcontroller : PIC 16F877A
 * Created on April 15, 2017, 5:59 PM
 */
#include <pic16f887.h>
#include <xc.h>
#include "SSP.h"

void spiInit(Spi_Type sType, Spi_Data_Sample sDataSample, Spi_Clock_Idle sClockIdle, Spi_Transmit_Edge sTransmitEdge)
{
    TRISC5 = 0;
    if(sType & 0b00000100) //If Slave Mode
    {
        SSPSTAT = sTransmitEdge;
        TRISC3 = 1;
    }
    else             //If Master Mode
    {
        SSPSTAT = sDataSample | sTransmitEdge;
        TRISC3 = 0;
    }

    SSPCON = sType | sClockIdle;
}

static void spiReceiveWait()
{
    while ( !SSPSTATbits.BF ); // Wait for Data Receive complete
}

void spiWrite(char dat)  //Write data to SPI bus
{
    SSPBUF = dat;
}

unsigned spiDataReady() //Check whether the data is ready to read
{
    if(SSPSTATbits.BF){
        return 1;
    }
    else{
        return 0;
    }
```

```
}

char spiRead() //REad the received data
{
    spiReceiveWait();        // wait until the all bits receive
    return(SSPBUF); // read the received data from the buffer
}



//#include <pic16f887.h>
//#include <xc.h>
//#include "SSP.h"
//
//void configSSP(uint8_t sspm, uint8_t ckp, uint8_t cke, uint8_t smp) {

//    SSPCONbits.SSPEN = 1;
//    switch (sspm) {
//
//        case 0: //MASTER, FOSC/4
//            SSPCONbits.SSPM3 = 0;
//            SSPCONbits.SSPM2 = 0;
//            SSPCONbits.SSPM1 = 0;
//            SSPCONbits.SSPM0 = 0;
//            switch (SMP) {
//                case 0:
//                    SSPSTATbits.SMP = 0;
//                    break;
//
//                case 1:
//                    SSPSTATbits.SMP = 1;
//                    break;
//            }
//            break;
//
//        case 1: //MASTER, FOSC/16
//            SSPCONbits.SSPM3 = 0;
//            SSPCONbits.SSPM2 = 0;
//            SSPCONbits.SSPM1 = 0;
//            SSPCONbits.SSPM0 = 1;
//            switch (SMP) {
//                case 0:
//                    SSPSTATbits.SMP = 0;
//          break;
//
//        case 1:
//          SSPSTATbits.SMP = 1;
//          break;
//      }
//      break;
//
//    case 2: //MASTER, FOSC/64
//      SSPCONbits.SSPM3 = 0;
//      SSPCONbits.SSPM2 = 0;
//      SSPCONbits.SSPM1 = 1;
//      SSPCONbits.SSPM0 = 0;
//      switch (SMP) {
//        case 0:
//          SSPSTATbits.SMP = 0;
//          break;
//
//        case 1:
//          SSPSTATbits.SMP = 1;
//          break;
//      }
//      break;
//
//    case 3: //MASTER, TMR2 OUTPUT/2
//      SSPCONbits.SSPM3 = 0;
//      SSPCONbits.SSPM2 = 0;
//      SSPCONbits.SSPM1 = 1;
//      SSPCONbits.SSPM0 = 1;
//      switch (SMP) {
//        case 0:
//          SSPSTATbits.SMP = 0;
//          break;
//
//        case 1:
//          SSPSTATbits.SMP = 1;
//          break;
//      }
//      break;
//
//    case 4: //SLAVE, SCK,SS ENABLED
//      SSPCONbits.SSPM3 = 0;
//     SSPCONbits.SSPM2 = 1;
//     SSPCONbits.SSPM1 = 0;
//     SSPCONbits.SSPM0 = 0;
//     switch (SMP) {
//       case 0:
//         SSPSTATbits.SMP = 0;
//         break;
//     }
//     break;
//
//
//   case 5: //SLAVE, SCK, SS DISABLED
//     SSPCONbits.SSPM3 = 0;
//     SSPCONbits.SSPM2 = 1;
//     SSPCONbits.SSPM1 = 0;
//     SSPCONbits.SSPM0 = 1;
//
//     switch (SMP) {
//       case 0:
//         SSPSTATbits.SMP = 0;
//         break;
//     }
//     break;
//
//   default: //MASTER, FOSC/64
//     SSPCONbits.SSPM3 = 0;
//     SSPCONbits.SSPM2 = 0;
//     SSPCONbits.SSPM1 = 1;
//     SSPCONbits.SSPM0 = 0;
//     switch (SMP) {
//       case 0:
//         SSPSTATbits.SMP = 0;
//         break;
//
//       case 1:
//         SSPSTATbits.SMP = 1;
//         break;
//     }
//     break;
//
// }
//
```

```
                                    ;

//    switch (ckp) {
//        case 0:
//            SSPCONbits.CKP = 0;
//            switch (CKE) {
//                case 0:
//                    SSPSTATbits.CKE = 1;
//                    break;
//                case 1:
//                    SSPSTATbits.CKE = 0;
//            }
//
//            break;
//        case 1:
//            SSPCONbits.CKP = 1;
//            switch (CKE) {
//                case 0:
//                    SSPSTATbits.CKE = 1;
//                    break;
//                case 1:
//                    SSPSTATbits.CKE = 0;
//
//            }
//            break;
//
//    }



#include <pic16f887.h>

#include "usartm.h"

void usartm(void){

    //CONFIG TX
    TXSTAbits.TX9 = 0; //TRANSMISION DE 8 BITS
    TXSTAbits.SYNC = 0; //ASINCRONO
    TXSTAbits.BRGH = 1; //HIGH SPEED
    BAUDCTLbits.BRG16 = 0; //BAUD RATE DE 8 BITS
    SPBRGH = 0;
    SPBRG = 25;
    PIE1bits.TXIE = 1;
    TXSTAbits.TXEN = 1;
    //CONFIG RX

    RCSTAbits.SPEN = 1;

    RCSTAbits. RX9 = 0;

    RCSTAbits.CREN = 1;





}
```

Código Master:

```
/*

 * File:   newmain.c

 * Author: franc

 *

 *

 */




#include <xc.h>

#include <stdint.h>

#include <pic16f887.h>

#include "LCDM.h"

#include "oscm.h"

#include "SSP.h"

#include "usartm.h"


//******************************************************************************

// Palabra de configuración

//******************************************************************************

// CONFIG1

#pragma config FOSC = INTRC_NOCLKOUT        // Oscillator Selection bits (XT oscillator: Crystal/resonator on RA6/OSC2/CLKOUT and RA7/OSC1/CLKIN)

#pragma config WDTE = OFF       // Watchdog Timer Enable bit (WDT disabled and can be enabled by SWDTEN bit of the WDTCON register)

#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)
```

```
#pragma config MCLRE = OFF      // RE3/MCLR pin function select bit (RE3/MCLR pin function is digital input, MCLR internally tied to VDD)
#pragma config CP = OFF         // Code Protection bit (Program memory code protection is disabled)
#pragma config CPD = OFF        // Data Code Protection bit (Data memory code protection is disabled)
#pragma config BOREN = OFF      // Brown Out Reset Selection bits (BOR disabled)
#pragma config IESO = OFF       // Internal External Switchover bit (Internal/External Switchover mode is disabled)
#pragma config FCMEN = OFF      // Fail-Safe Clock Monitor Enabled bit (Fail-Safe Clock Monitor is disabled)
#pragma config LVP = OFF        // Low Voltage Programming Enable bit (RB3 pin has digital I/O, HV on MCLR must be used for programming)

// CONFIG2
#pragma config BOR4V = BOR40V   // Brown-out Reset Selection bit (Brown-out Reset set to 4.0V)
#pragma config WRT = OFF        // Flash Program Memory Self Write Enable bits (Write protection off)
#define _XTAL_FREQ 4000000      //SE CONFIGURA EL OSCILADOR EXTERNO

//******************************************************************************
//Variables
//******************************************************************************
uint8_t desecho = 0;
uint8_t pot1 = 0;
uint8_t cont1 = 0;
uint8_t CP1 = 0;
uint8_t DP1 = 0;
uint8_t UP1 = 0;
uint8_t C1 = 0;
uint8_t D1 = 0;
uint8_t U1 = 0;
uint8_t INDIC = 0;
uint8_t CONTC = 0;
uint8_t CONTD = 0;
uint8_t CONTU = 0;
uint8_t CO1 = 0;
uint8_t CO2 = 0;
uint8_t CO3 = 0;
uint8_t SEND = 0;
uint8_t term1 = 0;
uint8_t TEMPC = 0;
uint8_t TEMPD = 0;
uint8_t TEMPU = 0;
uint8_t TEMPND = 0;
uint8_t TEMPNU = 0;
uint8_t T1 = 0;
uint8_t T2 = 0;
uint8_t T3 = 0;
```

```
uint8_t TN1 = 0;
uint8_t TN2 = 0;
uint8_t TEMP = 0;
uint8_t TEMPN = 0;



//*****************************************************************************
// Prototipos de funciones
//*****************************************************************************
void Setup(void);
void map(void);
void map2(void);
void map3(void);
void map4(void);
void mandar(void);
void temperatura(void);
void temperatura2(void);
//*****************************************************************************
//Interrupción
//*****************************************************************************

void __interrupt() ISR(void) {

    if (PIR1bits.TXIF == 1) {
        mandar();
        SEND++;
        PIE1bits.TXIE = 0;
        PIR1bits.TXIF = 0;

    }




}
//*****************************************************************************
//Ciclo pincipal
//*****************************************************************************

void main(void) {
```

```
Setup();
Lcd_Set_Cursor(1, 1);
Lcd_Write_String("ADC");
Lcd_Set_Cursor(1, 7);
Lcd_Write_String("CONT");
Lcd_Set_Cursor(1, 13);
Lcd_Write_String("TEMP");








//****************************************************************************
// Loop principal
//****************************************************************************
while (1) {
    INDIC++;
    map();
    map2();
    map3();


    PIE1bits.TXIE = 1;


    if (INDIC == 1) {
        PORTCbits.RC0 = 0;
        __delay_ms(1);
        spiWrite(desecho);
        pot1 = spiRead();

        __delay_ms(1);
        PORTCbits.RC0 = 1;
    }

    if (INDIC == 2) {
        PORTCbits.RC1 = 0;
        __delay_ms(1);
        spiWrite(desecho);
        cont1 = spiRead();


        __delay_ms(1);
        PORTCbits.RC1 = 1;


    }




    if (INDIC == 3) {
        PORTCbits.RC2 = 0;
        __delay_ms(1);
        spiWrite(desecho);
        term1 = spiRead();


        __delay_ms(1);
        PORTCbits.RC2 = 1;
        INDIC = 0;
    }






    Lcd_Set_Cursor(2, 1);
    Lcd_Write_Char(C1);
    Lcd_Set_Cursor(2, 2);
    Lcd_Write_String(".");
    Lcd_Write_Char(D1);
    Lcd_Set_Cursor(2, 4);
    Lcd_Write_Char(U1);


    Lcd_Set_Cursor(2, 7);
    Lcd_Write_Char(CO1);
    Lcd_Set_Cursor(2, 8);
    Lcd_Write_Char(CO2);
    Lcd_Set_Cursor(2, 9);
    Lcd_Write_Char(CO3);
```

```
    }
}
//*****************************************************************************
//Configuracion
//*****************************************************************************

void Setup(void) {
    TRISA = 0;
    TRISE = 0; //PUERTO E SALIDAS
    initOscm(6);
    usartm();
    Lcd_Init();
    Lcd_Cmd(0x8A);
    spiInit(SPI_MASTER_OSC_DIV4, SPI_DATA_SAMPLE_MIDDLE, SPI_CLOCK_IDLE_LOW, SPI_IDLE_2_ACTIVE);
    ANSEL = 0; // ENTRADAS DIGITALES Y BIT 0 ANALÓGICA
    ANSELH = 0;
    PORTA = 0; //PUERTO A EN 0
    PORTB = 0; //PUERTO B EN 0
    PORTC = 0; //PUERTO C EN 0
    PORTD = 0; //PUERTO D EN 0
    PORTE = 0; //PUERTO E EN 0
    //PINES RA0 Y RA2 COMO ENTRADAS, LOS DEMAS COMO SALIDAS
    TRISC = 0b00010000; //PUERTO C SALIDAS
    TRISD = 0; //PUERTO D SALIDAS
    TRISB = 0; //PUERTO B
    OPTION_REG = 0b10000111; //SE APAGAN LAS PULLUPS DEL PUERTO B
    INTCONbits.GIE = 1; //SE HABILITAN LAS INTERRUPCIONES GLOBALES
    //    INTCONbits.T0IE = 1; //SE HABILITA LA INTERRUPCION DEL TIMER0
    INTCONbits.PEIE = 1; //SE HABILITAN LAS INTERRUPCIONES PERIFERICAS
    //    PIE1bits.ADIE = 1; //SE HABILITA LA INTERRUPCION DEL ADC
    //    INTCONbits.T0IF = 0; // SE LIMPIA LA BANDERA DE INTERRUPCION DEL TIMER 0
    //    PIR1bits.ADIF = 0; //SE LIMPIOA LA BANDERA DE INTERRUPCION DEL ADC
    PIR1bits.TXIF = 0;
    PIE1bits.TXIE = 1;




}
```

```
//********************************************************************************
// Subrutinas
//********************************************************************************

void map(void) {

    CP1 = ((pot1) / 51);
    DP1 = (((pot1 * 100) / 51)-(CP1 * 100)) / 10;
    UP1 = (((pot1 * 100) / 51)-(CP1 * 100)-(DP1 * 10));

    C1 = (CP1 + 0x30);
    D1 = (DP1 + 0x30);
    U1 = (UP1 + 0x30);


}

void map2(void) {
    CONTC = (cont1 / 100);
    CONTD = (cont1 - (CONTC * 100)) / 10;
    CONTU = (cont1 - (CONTC * 100)-(CONTD * 10));

    CO1 = (CONTC + 0x30);
    CO2 = (CONTD + 0x30);
    CO3 = (CONTU + 0x30);

}

void map3(void) {


    if (term1 >= 68) {

        TEMP = (((term1 - 68)*150) / 187);

        TEMPC = (TEMP / 100);
        TEMPD = (TEMP - (TEMPC * 100)) / 10;
        TEMPU = (TEMP - (TEMPC * 100)-(TEMPD * 10));

        T1 = (TEMPC + 0x30);
        T2 = (TEMPD + 0x30);
        T3 = (TEMPU + 0x30);
        temperatura();

    } else if (term1 < 68) {

        TEMPN = (((term1 * (-55)) / 68) + 55);

        TEMPND = (TEMPN / 10);
        TEMPNU = (TEMPN - (TEMPND * 10));

        TN1 = (TEMPND + 0x30);
        TN2 = (TEMPNU + 0x30);

        temperatura2();

    }





}

void mandar(void) {
    switch (SEND) {

        case 0:
            TXREG = 0x20;
            break;
        case 1:
            TXREG = 0x28;
            break;

        case 2:
            TXREG = C1;
            break;

        case 3:
            TXREG = 0x2E;
            break;
        case 4:
            TXREG = D1;
            break;
```

```
case 5:
    TXREG = U1;
    break;
case 6:
    TXREG = 0x29;
    break;

case 7:
    TXREG = 0x2C;
    break;

case 8:
    TXREG = 0x20;
    break;

case 9:
    TXREG = 0x28;
    break;

case 10:
    TXREG = CO1;
    break;

case 11:
    TXREG = CO2;
    break;
case 12:
    TXREG = CO3;
    break;

case 13:
    TXREG = 0x29;
    break;
case 14:
    TXREG = 0x2C;
    break;

case 15:
    TXREG = 0x20;
    break;
case 16:
    TXREG = 0x28;
```

```
            break;
        case 17:
            if (term1 >= 68) {
                TXREG = T1;
            } else if (term1 < 68) {
                TXREG = 45;
            }
            break;
        case 18:
            if (term1 >= 68) {
                TXREG = T2;
            } else if (term1 < 68) {
                TXREG = TN1;
            }
            break;

        case 19:
            if (term1 >= 68) {
                TXREG = T3;
            } else if (term1 < 68) {
                TXREG = TN2;
            }
            break;

        case 20:
            TXREG = 0x29;
            break;

        case 21:
            TXREG = 0x0D;
            SEND = 0;
            break;
    }

}

void temperatura(void) {
    Lcd_Set_Cursor(2, 12);
    Lcd_Write_String("+");
    Lcd_Set_Cursor(2, 13);
    Lcd_Write_Char(T1);
    Lcd_Set_Cursor(2, 14);
    Lcd_Write_Char(T2);
    Lcd_Set_Cursor(2, 15);
    Lcd_Write_Char(T3);

}

void temperatura2(void) {
    Lcd_Set_Cursor(2, 12);
    Lcd_Write_String("-");
    Lcd_Set_Cursor(2, 14);
    Lcd_Write_Char(TN1);
    Lcd_Set_Cursor(2, 15);
    Lcd_Write_Char(TN2);
}
```

Librerías slave 1:

Headers:

```
/*
 * File:
 * Author:
 * Comments:
 * Revision history:
 */

// This is a guard condition so that contents of this file are not included
// more than once.
#ifndef ADCS1_H
#define	ADCS1_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <stdint.h>

void configADC1(uint8_t fosc, uint8_t chan);



#endif	/* ADCS1_H*/
```

```
// This is a guard condition so that contents of this file are not included
// more than once.
#ifndef OSCS1_H
#define    OSCS1_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <stdint.h>

void initOscs1(uint8_t IRCF);



#endif    /* OSCS1_H */

//*
// * File        : spi.h
// * Author       : Ligo George
// * Company      : electroSome
// * Project      : SPI Library for MPLAB XC8
// * Microcontroller : PIC 16F877A
// * Created on April 15, 2017, 5:59 PM
// */

// This is a guard condition so that contents of this file are not included
// more than once.
#ifndef __SSP1_H
#define    __SSP1_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <pic16f887.h>
typedef enum
{
    SPI_MASTER_OSC_DIV4  = 0b00100000,
    SPI_MASTER_OSC_DIV16 = 0b00100001,
    SPI_MASTER_OSC_DIV64 = 0b00100010,
    SPI_MASTER_TMR2      = 0b00100011,
    SPI_SLAVE_SS_EN      = 0b00100100,
    SPI_SLAVE_SS_DIS     = 0b00100101
}Spi_Type;
```

```
typedef enum
{
    SPI_DATA_SAMPLE_MIDDLE   = 0b00000000,
    SPI_DATA_SAMPLE_END      = 0b10000000
}Spi_Data_Sample;

typedef enum
{
    SPI_CLOCK_IDLE_HIGH  = 0b00010000,
    SPI_CLOCK_IDLE_LOW   = 0b00000000
}Spi_Clock_Idle;

typedef enum
{
    SPI_IDLE_2_ACTIVE    = 0b00000000,
    SPI_ACTIVE_2_IDLE    = 0b01000000
}Spi_Transmit_Edge;


void spiInit(Spi_Type, Spi_Data_Sample, Spi_Clock_Idle, Spi_Transmit_Edge);
void spiWrite(char);
unsigned spiDataReady();
char spiRead();

#endif          /* SSP1_H */
```

C:

```
#include <pic16f887.h>
#include <xc.h>
#include "adcs1.h"




//******************************************************************************
// CONFIGURACION DEL ADC
//******************************************************************************

void configADC1(uint8_t fosc, uint8_t chan) {

    switch (fosc) {

        case 0:
```

```
        ADCON0bits.ADCS = 0b00;
        break;

    case 1:
        ADCON0bits.ADCS = 0b01;
        break;

    case 2:
        ADCON0bits.ADCS = 0b10;
        break;

    case 3:
        ADCON0bits.ADCS = 0b11;
        break;

    default:
        ADCON0bits.ADCS = 0b00;
        break;
}
switch (chan) {
    case 0:
        ADCON0bits.CHS = 0b0000;
        break;

    case 1:
        ADCON0bits.CHS = 0b0001;
        break;

    case 2:
        ADCON0bits.CHS = 0b0010;
        break;

    case 3:
        ADCON0bits.CHS = 0b0011;
        break;

    case 4:
        ADCON0bits.CHS = 0b0100;
        break;

    case 5:
        ADCON0bits.CHS = 0b0101;
        break;

    case 6:
        ADCON0bits.CHS = 0b0110;
        break;

    case 7:
        ADCON0bits.CHS = 0b0111;
        break;

    case 8:
        ADCON0bits.CHS = 0b1000;
        break;

    case 9:
        ADCON0bits.CHS = 0b1001;
        break;

    case 10:
        ADCON0bits.CHS = 0b1010;
        break;

    case 11:
        ADCON0bits.CHS = 0b1011;
        break;

    case 12:
        ADCON0bits.CHS = 0b1100;
        break;

    case 13:
        ADCON0bits.CHS = 0b1101;
        break;

    case 14:
        ADCON0bits.CHS = 0b1110;
        break;

    case 15:
        ADCON0bits.CHS = 0b1111;
        break;
```

```
        default:
            ADCON0bits.CHS = 0b0000;
            break;


    }


    ADCON0bits.GO_nDONE = 1;



    ADCON0bits.ADON = 1;
    ADCON1 = 0;



}

#include <pic16f887.h>
#include <xc.h>
#include "oscs1.h"
//**********************************************************************
//Inicialización del oscilador interno pg. 62
//**********************************************************************
void initOscs1(uint8_t IRCF){

    switch (IRCF){

        case 0: //OSCILADOR DE 31 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 0;

            break;

        case 1: //OSCILADOR DE 125 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 1;
            break;
```

```
case 2: //OSCILADOR DE 250 kHz
    OSCCONbits.IRCF2 = 0;
    OSCCONbits.IRCF1 = 1;
    OSCCONbits.IRCF0 = 0;
    break;

case 3: //OSCILADOR DE 500kHz
    OSCCONbits.IRCF2 = 0;
    OSCCONbits.IRCF1 = 1;
    OSCCONbits.IRCF0 = 1;
    break;

case 4: //OSCILADOR DE 1MHz
    OSCCONbits.IRCF2 = 1;
    OSCCONbits.IRCF1 = 0;
    OSCCONbits.IRCF0 = 0;
    break;

case 5: //OSCILADOR DE 2MHz
    OSCCONbits.IRCF2 = 1;
    OSCCONbits.IRCF1 = 0;
    OSCCONbits.IRCF0 = 1;
    break;


case 6: //OSCILADOR DE 4MHz
    OSCCONbits.IRCF2 = 1;
    OSCCONbits.IRCF1 = 1;
    OSCCONbits.IRCF0 = 0;
    break;

case 7: //OSCILADOR DE 8MHz
    OSCCONbits.IRCF2 = 1;
    OSCCONbits.IRCF1 = 1;
    OSCCONbits.IRCF0 = 1;
    break;



default: //OSCILADOR DE 4MHz
    OSCCONbits.IRCF2 = 1;
```

```
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 0;
            break;

    }

    OSCCONbits.SCS = 1; //SE VA A USAR EL OSCILADOR INTERNO


}

/*
 * File            : spi.c
 * Author          : Ligo George
 * Company         : electroSome
 * Project         : SPI Library for MPLAB XC8
 * Microcontroller : PIC 16F877A
 * Created on April 15, 2017, 5:59 PM
 */
#include <pic16f887.h>
#include <xc.h>
#include "SSP1.h"

void spiInit(Spi_Type sType, Spi_Data_Sample sDataSample, Spi_Clock_Idle sClockIdle, Spi_Transmit_Edge sTransmitEdge)
{
    TRISC5 = 0;
    if(sType & 0b00000100) //If Slave Mode
    {
        SSPSTAT = sTransmitEdge;
        TRISC3 = 1;
    }
    else              //If Master Mode
    {
        SSPSTAT = sDataSample | sTransmitEdge;
        TRISC3 = 0;
    }

    SSPCON = sType | sClockIdle;
}

static void spiReceiveWait()
{
    while ( !SSPSTATbits.BF ); // Wait for Data Receive complete

}


void spiWrite(char dat)  //Write data to SPI bus

{

    SSPBUF = dat;

}


unsigned spiDataReady() //Check whether the data is ready to read

{

    if(SSPSTATbits.BF){

        return 1;

    }

    else{

        return 0;

    }

}


char spiRead() //REad the received data

{

    spiReceiveWait();        // wait until the all bits receive

    return(SSPBUF); // read the received data from the buffer

}
```

Código slave 1:

```
#include <xc.h>

#include <stdint.h>

#include <pic16f887.h>

#include "adcs1.h"

#include "oscs1.h"

#include "SSP1.h"


//********************************************************************************

// Palabra de configuración

//********************************************************************************

// CONFIG1

#pragma config FOSC = INTRC_NOCLKOUT        // Oscillator Selection bits (XT oscillator: Crystal/resonator on RA6/OSC2/CLKOUT and RA7/OSC1/CLKIN)

#pragma config WDTE = OFF       // Watchdog Timer Enable bit (WDT disabled and can be enabled by SWDTEN bit of the WDTCON register)

#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)

#pragma config MCLRE = OFF      // RE3/MCLR pin function select bit (RE3/MCLR pin function is digital input, MCLR internally tied to VDD)

#pragma config CP = OFF         // Code Protection bit (Program memory code protection is disabled)
```

```
#pragma config CPD = OFF        // Data Code Protection bit (Data memory code protection is disabled)
#pragma config BOREN = OFF      // Brown Out Reset Selection bits (BOR disabled)
#pragma config IESO = OFF       // Internal External Switchover bit (Internal/External Switchover mode is disabled)
#pragma config FCMEN = OFF      // Fail-Safe Clock Monitor Enabled bit (Fail-Safe Clock Monitor is disabled)
#pragma config LVP = OFF        // Low Voltage Programming Enable bit (RB3 pin has digital I/O, HV on MCLR must be used for programming)

// CONFIG2
#pragma config BOR4V = BOR40V   // Brown-out Reset Selection bit (Brown-out Reset set to 4.0V)
#pragma config WRT = OFF        // Flash Program Memory Self Write Enable bits (Write protection off)
#define _XTAL_FREQ 4000000      //SE CONFIGURA EL OSCILADOR EXTERNO

//********************************************************************************
//Variables
//********************************************************************************

uint8_t pot = 0;
uint8_t CONTADC = 0;



//********************************************************************************
// Prototipos de funciones
//********************************************************************************
void Setup(void);

//********************************************************************************
//Interrupción
//********************************************************************************

void __interrupt() ISR(void) {

     if (INTCONbits.T0IF == 1) {
        TMR0 = 236;
        CONTADC++;
        INTCONbits.T0IF = 0;
    }

    if (PIR1bits.SSPIF == 1) {
        spiWrite(pot);
        PIR1bits.SSPIF = 0;
    }
    if (PIR1bits.ADIF == 1) {
        pot = ADRESH;
        PIR1bits.ADIF = 0;
    }

}

//******************************************************************************
//Ciclo pincipal
//******************************************************************************

void main(void) {

    Setup();









    //**************************************************************************
    // Loop principal
    //**************************************************************************
    while (1) {

        if (CONTADC > 20) {
            ADCON0bits.GO_nDONE = 1;
            CONTADC = 0;
        }
        PORTD = pot;

    }
```

```
}
//*****************************************************************************
//Configuracion
//*****************************************************************************

void Setup(void) {
   configADC1(1, 12); //SE LLAMA LA CONFIG DEL ADC
   initOscs1(6);
   spiInit(SPI_SLAVE_SS_EN, SPI_DATA_SAMPLE_MIDDLE, SPI_CLOCK_IDLE_LOW, SPI_IDLE_2_ACTIVE);
   ANSEL = 0; // ENTRADAS DIGITALES Y BIT 0 ANALÓGICA
   ANSELH = 0b00000001;
   PORTA = 0; //PUERTO A EN 0
   PORTB = 0; //PUERTO B EN 0
   PORTC = 0; //PUERTO C EN 0
   PORTD = 0; //PUERTO D EN 0
   PORTE = 0; //PUERTO E EN 0
   //PINES RA0 Y RA2 COMO ENTRADAS, LOS DEMAS COMO SALIDAS
   TRISC = 0b00001000; //PUERTO C SALIDAS
   TRISA = 0b00100000; //PUERTO A SALIDAS
   TRISB = 0b00000001; //PUERTO B
   TRISD = 0;
   TRISE = 0;
   OPTION_REG = 0b10000111; //SE APAGAN LAS PULLUPS DEL PUERTO B
   INTCONbits.GIE = 1; //SE HABILITAN LAS INTERRUPCIONES GLOBALES
   INTCONbits.PEIE = 1; //SE HABILITAN LAS INTERRUPCIONES PERIFERICAS
   PIE1bits.ADIE = 1; //SE HABILITA LA INTERRUPCION DEL ADC
   PIR1bits.ADIF = 0; //SE LIMPIOA LA BANDERA DE INTERRUPCION DEL ADC
   PIR1bits.SSPIF = 0;
   PIE1bits.SSPIE = 1;
   INTCONbits.T0IE = 1;
   INTCONbits.T0IF = 0;


}

//*****************************************************************************
// Subrutinas
```

```
//*****************************************************************************
```

Librerías slave 2:

Headers:

```
#include <xc.h>
#include <stdint.h>
#include <pic16f887.h>
#include "adcs1.h"
#include "oscs1.h"
#include "SSP1.h"

//*****************************************************************************
// Palabra de configuración
//*****************************************************************************
// CONFIG1
#pragma config FOSC = INTRC_NOCLKOUT        // Oscillator Selection bits (XT oscillator: Crystal/resonator on RA6/OSC2/CLKOUT and RA7/OSC1/CLKIN)
#pragma config WDTE = OFF       // Watchdog Timer Enable bit (WDT disabled and can be enabled by SWDTEN bit of the WDTCON register)
#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)
#pragma config MCLRE = OFF      // RE3/MCLR pin function select bit (RE3/MCLR pin function is digital input, MCLR internally tied to VDD)
#pragma config CP = OFF         // Code Protection bit (Program memory code protection is disabled)
#pragma config CPD = OFF        // Data Code Protection bit (Data memory code protection is disabled)
#pragma config BOREN = OFF      // Brown Out Reset Selection bits (BOR disabled)
#pragma config IESO = OFF       // Internal External Switchover bit (Internal/External Switchover mode is disabled)
#pragma config FCMEN = OFF      // Fail-Safe Clock Monitor Enabled bit (Fail-Safe Clock Monitor is disabled)
#pragma config LVP = OFF        // Low Voltage Programming Enable bit (RB3 pin has digital I/O, HV on MCLR must be used for programming)

// CONFIG2
#pragma config BOR4V = BOR40V   // Brown-out Reset Selection bit (Brown-out Reset set to 4.0V)
#pragma config WRT = OFF        // Flash Program Memory Self Write Enable bits (Write protection off)
#define _XTAL_FREQ 4000000      //SE CONFIGURA EL OSCILADOR EXTERNO

//*****************************************************************************
//Variables
//*****************************************************************************

uint8_t pot = 0;
```

```
uint8_t CONTADC = 0;



//******************************************************************************
// Prototipos de funciones
//******************************************************************************
void Setup(void);

//******************************************************************************
//Interrupción
//******************************************************************************

void __interrupt() ISR(void) {

     if (INTCONbits.T0IF == 1) {
        TMR0 = 236;
        CONTADC++;
        INTCONbits.T0IF = 0;
    }

    if (PIR1bits.SSPIF == 1) {
        spiWrite(pot);
        PIR1bits.SSPIF = 0;
    }



    if (PIR1bits.ADIF == 1) {
        pot = ADRESH;
        PIR1bits.ADIF = 0;
    }

}

//******************************************************************************
//Ciclo pincipal
//******************************************************************************

void main(void) {

    Setup();
    //*****************************************************************************
    // Loop principal
    //*****************************************************************************
    while (1) {

        if (CONTADC > 20) {
            ADCON0bits.GO_nDONE = 1;
            CONTADC = 0;
        }
        PORTD = pot;

    }

}
//********************************************************************************
//Configuracion
//********************************************************************************

void Setup(void) {
    configADC1(1, 12); //SE LLAMA LA CONFIG DEL ADC
    initOscs1(6);
    spiInit(SPI_SLAVE_SS_EN, SPI_DATA_SAMPLE_MIDDLE, SPI_CLOCK_IDLE_LOW, SPI_IDLE_2_ACTIVE);
    ANSEL = 0; // ENTRADAS DIGITALES Y BIT 0 ANALÓGICA
    ANSELH = 0b00000001;
    PORTA = 0; //PUERTO A EN 0
    PORTB = 0; //PUERTO B EN 0
    PORTC = 0; //PUERTO C EN 0
    PORTD = 0; //PUERTO D EN 0
    PORTE = 0; //PUERTO E EN 0
    //PINES RA0 Y RA2 COMO ENTRADAS, LOS DEMAS COMO SALIDAS
    TRISC = 0b00001000; //PUERTO C SALIDAS
    TRISA = 0b00100000; //PUERTO A SALIDAS
    TRISB = 0b00000001; //PUERTO B
    TRISD = 0;
    TRISE = 0;
    OPTION_REG = 0b10000111; //SE APAGAN LAS PULLUPS DEL PUERTO B
    INTCONbits.GIE = 1; //SE HABILITAN LAS INTERRUPCIONES GLOBALES
    INTCONbits.PEIE = 1; //SE HABILITAN LAS INTERRUPCIONES PERIFERICAS
    PIE1bits.ADIE = 1; //SE HABILITA LA INTERRUPCION DEL ADC
    PIR1bits.ADIF = 0; //SE LIMPIOA LA BANDERA DE INTERRUPCION DEL ADC
    PIR1bits.SSPIF = 0;
    PIE1bits.SSPIE = 1;
    INTCONbits.T0IE = 1;
    INTCONbits.T0IF = 0;


}

//*****************************************************************************
// Subrutinas
//*****************************************************************************




//*
// * File           : spi.h
// * Author         : Ligo George
// * Company        : electroSome
// * Project        : SPI Library for MPLAB XC8
// * Microcontroller : PIC 16F877A
// * Created on April 15, 2017, 5:59 PM
// */

// This is a guard condition so that contents of this file are not included
// more than once.
```

```
#ifndef __SSP2_H
#define     __SSP2_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <pic16f887.h>
typedef enum
{
    SPI_MASTER_OSC_DIV4  = 0b00100000,
    SPI_MASTER_OSC_DIV16 = 0b00100001,
    SPI_MASTER_OSC_DIV64 = 0b00100010,
    SPI_MASTER_TMR2      = 0b00100011,
    SPI_SLAVE_SS_EN      = 0b00100100,
    SPI_SLAVE_SS_DIS     = 0b00100101
}Spi_Type;

typedef enum
{
    SPI_DATA_SAMPLE_MIDDLE   = 0b00000000,
    SPI_DATA_SAMPLE_END      = 0b10000000
}Spi_Data_Sample;

typedef enum
{
    SPI_CLOCK_IDLE_HIGH  = 0b00010000,
    SPI_CLOCK_IDLE_LOW   = 0b00000000
}Spi_Clock_Idle;

typedef enum
{
    SPI_IDLE_2_ACTIVE    = 0b00000000,
    SPI_ACTIVE_2_IDLE    = 0b01000000
}Spi_Transmit_Edge;


void spiInit(Spi_Type, Spi_Data_Sample, Spi_Clock_Idle, Spi_Transmit_Edge);
void spiWrite(char);
unsigned spiDataReady();
char spiRead();

#endif      /* SSP2_H */
```

C:

```
#include <pic16f887.h>
#include <xc.h>
#include "osc2.h"
//******************************************************************************
//Inicialización del oscilador interno pg. 62
//******************************************************************************
void initOscs2(uint8_t IRCF){

    switch (IRCF){

        case 0: //OSCILADOR DE 31 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 0;

            break;

        case 1: //OSCILADOR DE 125 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 1;
            break;

        case 2: //OSCILADOR DE 250 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 0;
            break;

        case 3: //OSCILADOR DE 500kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 1;
            break;

        case 4: //OSCILADOR DE 1MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 0;
            break;

        case 5: //OSCILADOR DE 2MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 1;
            break;


        case 6: //OSCILADOR DE 4MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 0;
            break;

        case 7: //OSCILADOR DE 8MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 1;
            break;




        default: //OSCILADOR DE 4MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 0;
            break;

    }

    OSCCONbits.SCS = 1; //SE VA A USAR EL OSCILADOR INTERNO


}
/*
 * File            : spi.c
 * Author          : Ligo George
 * Company         : electroSome
 * Project         : SPI Library for MPLAB XC8
 * Microcontroller : PIC 16F877A
 * Created on April 15, 2017, 5:59 PM
 */
#include <pic16f887.h>
#include <xc.h>
#include "SSP2.h"

void spiInit(Spi_Type sType, Spi_Data_Sample sDataSample, Spi_Clock_Idle sClockIdle, Spi_Transmit_Edge sTransmitEdge)
{
    TRISC5 = 0;
    if(sType & 0b00000100) //If Slave Mode
    {
        SSPSTAT = sTransmitEdge;
        TRISC3 = 1;
    }
    else              //If Master Mode
    {
        SSPSTAT = sDataSample | sTransmitEdge;
        TRISC3 = 0;
    }

    SSPCON = sType | sClockIdle;
}

static void spiReceiveWait()
{
    while ( !SSPSTATbits.BF ); // Wait for Data Receive complete
}

void spiWrite(char dat)  //Write data to SPI bus
{
    SSPBUF = dat;
}

unsigned spiDataReady() //Check whether the data is ready to read
{
    if(SSPSTATbits.BF){
        return 1;
    }
    else{
        return 0;
    }
}
```

```
char spiRead() //REad the received data

{

    spiReceiveWait();        // wait until the all bits receive

    return(SSPBUF); // read the received data from the buffer

}
```

Código slave 2:

```
#include <xc.h>

#include <stdint.h>

#include <pic16f887.h>

#include "SSP2.h"

#include "osc2.h"

//*****************************************************************************

// Palabra de configuración

//*****************************************************************************

// CONFIG1

#pragma config FOSC = INTRC_NOCLKOUT        // Oscillator Selection bits (XT oscillator: Crystal/resonator on RA6/OSC2/CLKOUT and RA7/OSC1/CLKIN)

#pragma config WDTE = OFF       // Watchdog Timer Enable bit (WDT disabled and can be enabled by SWDTEN bit of the WDTCON register)

#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)

#pragma config MCLRE = OFF      // RE3/MCLR pin function select bit (RE3/MCLR pin function is digital input, MCLR internally tied to VDD)

#pragma config CP = OFF         // Code Protection bit (Program memory code protection is disabled)

#pragma config CPD = OFF        // Data Code Protection bit (Data memory code protection is disabled)

#pragma config BOREN = OFF      // Brown Out Reset Selection bits (BOR disabled)

#pragma config IESO = OFF       // Internal External Switchover bit (Internal/External Switchover mode is disabled)

#pragma config FCMEN = OFF      // Fail-Safe Clock Monitor Enabled bit (Fail-Safe Clock Monitor is disabled)

#pragma config LVP = OFF        // Low Voltage Programming Enable bit (RB3 pin has digital I/O, HV on MCLR must be used for programming)


// CONFIG2

#pragma config BOR4V = BOR40V   // Brown-out Reset Selection bit (Brown-out Reset set to 4.0V)

#pragma config WRT = OFF        // Flash Program Memory Self Write Enable bits (Write protection off)

#define _XTAL_FREQ 4000000      //SE CONFIGURA EL OSCILADOR EXTERNO


//*****************************************************************************

//Variables

//*****************************************************************************

uint8_t B1 = 0;
```

```
uint8_t B2 = 0;

uint8_t c1 = 0;






//*****************************************************************************

// Prototipos de funciones

//*****************************************************************************

void Setup(void);


//*****************************************************************************

//Interrupción

//*****************************************************************************


void __interrupt() ISR(void) {

    c1 = PORTD;

    if (RBIF == 1) { //SE REVISA LA BANDERA DE INTERRUPCION DEL PUERTO B

        if (PORTBbits.RB0 == 0) { //ANTIREBOTE, SI NO SE PRESIONA EL BOTON

            B1 = 1; // SE ENCIENDE LA BANDERA DEL BOTON DE INCREMENTO

        } else {

            if (B1 == 1 && PORTBbits.RB0 == 1) { //SE  PRESIONA EL BOTON

                B1 = 0; //SE APAGA LA BANDERA DE BOTON DE INCREMENTO

                PORTD++; // SE INCREMENTA EL PUERTOD




            }

        }


        if (PORTBbits.RB1 == 0) { //ANTIREBOTE, SI NO SE PRESIONA EL BOTON

            B2 = 1; // SE ENCIENDE LA BANDERA DEL BOTON DE DECREMENTO

        } else {

            if (B2 == 1 && PORTBbits.RB1 == 1) { //SE PRESIONA EL BOTON

                B2 = 0; //SE APAGA LA BANDERA DE BOTON DE DECREMENTO

                PORTD--; // SE DECREMENTA UN EL PUERTOD




            }

        }


        INTCONbits.RBIF = 0; //SE APAGA LA BANDERA DE INTERRUPION DEL PUERTO B
    }


    if (PIR1bits.SSPIF == 1) {
        spiWrite(c1);
        PIR1bits.SSPIF = 0;
    }


}
//*****************************************************************************
//Ciclo pincipal
//*****************************************************************************

void main(void) {

    Setup();









    //*************************************************************************
    // Loop principal
    //*************************************************************************
    while (1) {












    }
}
```

```
//********************************************************************************
//Configuracion
//********************************************************************************

void Setup(void) {
   initOscs2(6);
   spiInit(SPI_SLAVE_SS_EN, SPI_DATA_SAMPLE_MIDDLE, SPI_CLOCK_IDLE_LOW, SPI_IDLE_2_ACTIVE);
   TRISD = 0;
   TRISE = 0; //PUERTO E SALIDAS
   ANSEL = 0; // ENTRADAS DIGITALES Y BIT 0 ANALÓGICA
   ANSELH = 0;
   PORTA = 0; //PUERTO A EN 0
   PORTB = 0; //PUERTO B EN 0
   PORTC = 0; //PUERTO C EN 0
   PORTD = 0; //PUERTO D EN 0
   PORTE = 0; //PUERTO E EN 0
   //PINES RA0 Y RA2 COMO ENTRADAS, LOS DEMAS COMO SALIDAS
   TRISC = 0b00001000; //PUERTO C SALIDAS
   TRISA = 0b00100000; //PUERTO A SALIDAS
   TRISB = 0b00000011; //PUERTO B
   OPTION_REG = 0b00000111; //SE ENCIENDEN LAS PULLUPS DEL PUERTO B
   INTCONbits.GIE = 1; //SE HABILITAN LAS INTERRUPCIONES GLOBALES
   INTCONbits.PEIE = 1; //SE HABILITAN LAS INTERRUPCIONES PERIFERICAS
   INTCONbits.RBIE = 1; //SE HABILITA LA INTERRUPCION DEL PUERTO B
   INTCONbits.RBIF = 0; //SE LIMPIA LA BANDERA DEL INTERRUPCION DEL PUERTO B
   IOCB = 3; //SE HABILITA EL INTERRUPT ON CHANGE
   WPUB = 0b0000011;
   PIR1bits.SSPIF = 0;
   PIE1bits.SSPIE = 1;



}

//********************************************************************************
// Subrutinas
//********************************************************************************
```

Librerías slave 3:

Headers:

```
/*
 * File:
 * Author:
 * Comments:
 * Revision history:
 */

// This is a guard condition so that contents of this file are not included
// more than once.
#ifndef ADCS3_H
#define	ADCS3_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <stdint.h>

void configADC3(uint8_t fosc, uint8_t chan);




#endif	/* ADCS3_H*/

// This is a guard condition so that contents of this file are not included
// more than once.
#ifndef OSCS3_H
#define	OSCS3_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <stdint.h>

void initOscs3(uint8_t IRCF);




#endif	/* OSCS3_H */



//*
// * File		: spi.h
// * Author          : Ligo George
// * Company         : electroSome
// * Project         : SPI Library for MPLAB XC8
// * Microcontroller : PIC 16F877A
// * Created on April 15, 2017, 5:59 PM
// */

// This is a guard condition so that contents of this file are not included
// more than once.
#ifndef __SSP1_H
#define         __SSP1_H

#include <xc.h> // include processor files - each processor file is guarded.
#include <pic16f887.h>
typedef enum
{
    SPI_MASTER_OSC_DIV4  = 0b00100000,
    SPI_MASTER_OSC_DIV16 = 0b00100001,
    SPI_MASTER_OSC_DIV64 = 0b00100010,
    SPI_MASTER_TMR2      = 0b00100011,
    SPI_SLAVE_SS_EN      = 0b00100100,
    SPI_SLAVE_SS_DIS     = 0b00100101
}Spi_Type;

typedef enum
{
    SPI_DATA_SAMPLE_MIDDLE   = 0b00000000,
    SPI_DATA_SAMPLE_END      = 0b10000000
}Spi_Data_Sample;

typedef enum
{
    SPI_CLOCK_IDLE_HIGH  = 0b00010000,
    SPI_CLOCK_IDLE_LOW   = 0b00000000
}Spi_Clock_Idle;

typedef enum
{
    SPI_IDLE_2_ACTIVE    = 0b00000000,
    SPI_ACTIVE_2_IDLE    = 0b01000000
}Spi_Transmit_Edge;
```

```
void spiInit(Spi_Type, Spi_Data_Sample, Spi_Clock_Idle, Spi_Transmit_Edge);
void spiWrite(char);
unsigned spiDataReady();
char spiRead();

#endif      /* SSP1_H */
```

C:

```
#include <pic16f887.h>
#include <xc.h>
#include "adcs3.h"



//******************************************************************************
// CONFIGURACION DEL ADC
//******************************************************************************

void configADC3(uint8_t fosc, uint8_t chan) {

    switch (fosc) {

        case 0:
            ADCON0bits.ADCS = 0b00;
            break;

        case 1:
            ADCON0bits.ADCS = 0b01;
            break;

        case 2:
            ADCON0bits.ADCS = 0b10;
            break;

        case 3:
            ADCON0bits.ADCS = 0b11;
            break;

        default:
            ADCON0bits.ADCS = 0b00;
            break;
    }
    switch (chan) {
        case 0:
            ADCON0bits.CHS = 0b0000;
            break;

        case 1:
            ADCON0bits.CHS = 0b0001;
            break;

        case 2:
            ADCON0bits.CHS = 0b0010;
            break;

        case 3:
            ADCON0bits.CHS = 0b0011;
            break;

        case 4:
            ADCON0bits.CHS = 0b0100;
            break;

        case 5:
            ADCON0bits.CHS = 0b0101;
            break;

        case 6:
            ADCON0bits.CHS = 0b0110;
            break;

        case 7:
            ADCON0bits.CHS = 0b0111;
            break;

        case 8:
            ADCON0bits.CHS = 0b1000;
            break;

        case 9:
            ADCON0bits.CHS = 0b1001;
            break;
```

```
                  ;



  case 10:
    ADCON0bits.CHS = 0b1010;
    break;

  case 11:
    ADCON0bits.CHS = 0b1011;
    break;

  case 12:
    ADCON0bits.CHS = 0b1100;
    break;

  case 13:
    ADCON0bits.CHS = 0b1101;
    break;

  case 14:
    ADCON0bits.CHS = 0b1110;
    break;

  case 15:
    ADCON0bits.CHS = 0b1111;
    break;

  default:
    ADCON0bits.CHS = 0b0000;
    break;


}


ADCON0bits.GO_nDONE = 1;



ADCON0bits.ADON = 1;
ADCON1 = 0;

ADCON1bits.VCFG0 = 1;
ADCON1bits.VCFG1 = 1;
```

```
}
```

```
#include <pic16f887.h>
#include <xc.h>
#include "oscs3.h"
//********************************************************************************
//Inicialización del oscilador interno pg. 62
//********************************************************************************
void initOscs3(uint8_t IRCF){

    switch (IRCF){

        case 0: //OSCILADOR DE 31 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 0;

            break;

        case 1: //OSCILADOR DE 125 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 1;
            break;

        case 2: //OSCILADOR DE 250 kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 0;
            break;

        case 3: //OSCILADOR DE 500kHz
            OSCCONbits.IRCF2 = 0;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 1;
            break;
        case 4: //OSCILADOR DE 1MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 0;
            break;

        case 5: //OSCILADOR DE 2MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 0;
            OSCCONbits.IRCF0 = 1;
            break;


        case 6: //OSCILADOR DE 4MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 0;
            break;

        case 7: //OSCILADOR DE 8MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 1;
            break;




        default: //OSCILADOR DE 4MHz
            OSCCONbits.IRCF2 = 1;
            OSCCONbits.IRCF1 = 1;
            OSCCONbits.IRCF0 = 0;
            break;

    }

    OSCCONbits.SCS = 1; //SE VA A USAR EL OSCILADOR INTERNO


}
```

```
/*
 * File           : spi.c
 * Author         : Ligo George
 * Company        : electroSome
 * Project        : SPI Library for MPLAB XC8
 * Microcontroller : PIC 16F877A
 * Created on April 15, 2017, 5:59 PM
 */
#include <pic16f887.h>
#include <xc.h>
#include "SSP3.h"

void spiInit(Spi_Type sType, Spi_Data_Sample sDataSample, Spi_Clock_Idle sClockIdle, Spi_Transmit_Edge sTransmitEdge)
{
    TRISC5 = 0;
    if(sType & 0b00000100) //If Slave Mode
    {
        SSPSTAT = sTransmitEdge;
        TRISC3 = 1;
    }
    else              //If Master Mode
    {
        SSPSTAT = sDataSample | sTransmitEdge;
        TRISC3 = 0;
    }

    SSPCON = sType | sClockIdle;
}

static void spiReceiveWait()
{
    while ( !SSPSTATbits.BF ); // Wait for Data Receive complete
}

void spiWrite(char dat)  //Write data to SPI bus
{
    SSPBUF = dat;
}

unsigned spiDataReady() //Check whether the data is ready to read
{
    if(SSPSTATbits.BF){
        return 1;
    }
    else{
        return 0;
    }
}

char spiRead() //REad the received data
{
    spiReceiveWait();        // wait until the all bits receive
    return(SSPBUF); // read the received data from the buffer
}
```

Código slave 3:

```
#include <xc.h>
#include <stdint.h>
#include <pic16f887.h>
#include "oscs3.h"
#include "adcs3.h"
#include "SSP3.h"

//*****************************************************************************
// Palabra de configuración
//*****************************************************************************
// CONFIG1
#pragma config FOSC = INTRC_NOCLKOUT        // Oscillator Selection bits (XT oscillator: Crystal/resonator on RA6/OSC2/CLKOUT and RA7/OSC1/CLKIN)
#pragma config WDTE = OFF       // Watchdog Timer Enable bit (WDT disabled and can be enabled by SWDTEN bit of the WDTCON register)
#pragma config PWRTE = OFF      // Power-up Timer Enable bit (PWRT disabled)
#pragma config MCLRE = OFF      // RE3/MCLR pin function select bit (RE3/MCLR pin function is digital input, MCLR internally tied to VDD)
#pragma config CP = OFF         // Code Protection bit (Program memory code protection is disabled)
#pragma config CPD = OFF        // Data Code Protection bit (Data memory code protection is disabled)
#pragma config BOREN = OFF      // Brown Out Reset Selection bits (BOR disabled)
#pragma config IESO = OFF       // Internal External Switchover bit (Internal/External Switchover mode is disabled)
#pragma config FCMEN = OFF      // Fail-Safe Clock Monitor Enabled bit (Fail-Safe Clock Monitor is disabled)
#pragma config LVP = OFF        // Low Voltage Programming Enable bit (RB3 pin has digital I/O, HV on MCLR must be used for programming)

// CONFIG2
#pragma config BOR4V = BOR40V   // Brown-out Reset Selection bit (Brown-out Reset set to 4.0V)
#pragma config WRT = OFF        // Flash Program Memory Self Write Enable bits (Write protection off)
#define _XTAL_FREQ 4000000      //SE CONFIGURA EL OSCILADOR EXTERNO
```

```
//******************************************************************************
//Variables
//******************************************************************************

uint8_t term = 0;
uint8_t CONTERM = 0;




//******************************************************************************
// Prototipos de funciones
//******************************************************************************
void Setup(void);

//******************************************************************************
//Interrupción
//******************************************************************************

void __interrupt() ISR(void) {


     if (INTCONbits.T0IF == 1) {
        TMR0 = 236;
        CONTERM++;
        INTCONbits.T0IF = 0;
    }

    if (PIR1bits.SSPIF == 1) {
        spiWrite(term);
        PIR1bits.SSPIF = 0;
    }


     if (PIR1bits.ADIF == 1) {
        term = ADRESH;
        PIR1bits.ADIF = 0;
    }

     if (term < 100) {
        PORTEbits.RE2 = 1;
        PORTEbits.RE1 = 0;
        PORTEbits.RE0 = 0;
    }

    if (term > 100 && term < 113) {
        PORTEbits.RE2 = 0;
        PORTEbits.RE1 = 1;
        PORTEbits.RE0 = 0;

    }
    if (term > 113) {
        PORTEbits.RE2 = 0;
        PORTEbits.RE1 = 0;
        PORTEbits.RE0 = 1;

    }

}
//********************************************************************************
//Ciclo pincipal
//********************************************************************************

void main(void) {

    Setup();








    //*****************************************************************************
    // Loop principal
    //*****************************************************************************
    while (1) {
         if (CONTERM > 20) {
            ADCON0bits.GO_nDONE = 1;
            CONTERM = 0;
        }
    }

}

//********************************************************************************

//Configuracion

//********************************************************************************


void Setup(void) {

    configADC3(1, 10); //SE LLAMA LA CONFIG DEL ADC

    initOscs3(6);

    spiInit(SPI_SLAVE_SS_EN, SPI_DATA_SAMPLE_MIDDLE, SPI_CLOCK_IDLE_LOW, SPI_IDLE_2_ACTIVE);

    ANSEL = 0; // ENTRADAS DIGITALES Y BIT 0 ANALÓGICA

    ANSELH = 0b00000010;

    PORTA = 0; //PUERTO A EN 0

    PORTB = 0; //PUERTO B EN 0

    PORTC = 0; //PUERTO C EN 0

    PORTD = 0; //PUERTO D EN 0

    PORTE = 0; //PUERTO E EN 0

    //PINES RA0 Y RA2 COMO ENTRADAS, LOS DEMAS COMO SALIDAS

    TRISC = 0b00001000; //PUERTO C SALIDAS

    TRISA = 0b00100000; //PUERTO A SALIDAS

    TRISB = 0b00000010; //PUERTO B

    TRISD = 0;

    TRISE = 0;

    OPTION_REG = 0b10000111; //SE APAGAN LAS PULLUPS DEL PUERTO B

    INTCONbits.GIE = 1; //SE HABILITAN LAS INTERRUPCIONES GLOBALES

    INTCONbits.PEIE = 1; //SE HABILITAN LAS INTERRUPCIONES PERIFERICAS

    PIE1bits.ADIE = 1; //SE HABILITA LA INTERRUPCION DEL ADC

    PIR1bits.ADIF = 0; //SE LIMPIOA LA BANDERA DE INTERRUPCION DEL ADC

    PIR1bits.SSPIF = 0;

    PIE1bits.SSPIE = 1;

    INTCONbits.T0IE = 1;

    INTCONbits.T0IF = 0;
```

```
}




//****************************************************************************

// Subrutinas

//****************************************************************************
```