Make sure to read this entire document before getting started so you know all the parts of the project and can plan accordingly. Also if you would like, I have copied to the class Box folder four recorded lectures that I made Spring 2021 for my SE423 class. You can find them in the “I2CLectures_SE423_Spring21” folder. I will be lecturing on the I2C serial port this semester but you may find these additional lectures helpful.

The goal of this project is to teach you how to use the I2C serial port to communicate with external sensors and other peripherals. You will be programming the F28379D to use its I2C serial port to communicate with the “DAN777” chip and the DS1388Z Real-Time Clock chip. In this project, you will learn more how to use the I2C serial port compared to learning how to setup the registers of the F28379D’s I2C peripheral like many of the labs have done for other peripherals. Below you are given the initialization code for the F28379D’s I2C peripheral and some example functions using the I2C serial port. Following these examples, you will create “write” and “read” functions for both the DAN777 and DS1388Z.

Comparing SPI to I2C there are a number of differences you need to keep in mind when programming I2C. The biggest difference is that I2C has only one data line so it can be set to read data for a certain number of bytes or set to write a certain number of bytes. This makes I2C slower along with its maximum recommended bit rate of 400000 bits/second where SPI can go 20Mbits/second or higher. Additionally I2C does not use a chip select (or slave select) pin, but instead transmits a slave address to select the slave device. All this is done with the three wires, SCL, SDA and GND connecting the I2C master (F28379D) with many possible I2C slave devices.

Because the I2C serial port is usually used for slower devices, we will not be using the I2C interrupts. Instead, you will be “polling” the status of the I2C serial port to know when it is ready to send more data or has received new data. If you would like to learn more about the I2C serial port and use its interrupt capabilities, talk to me about using I2C in your class final project.

After studying the given examples and the datasheet of the DAN777 and DS1388Z, create separate functions for reading and writing the DAN777 and DS1388Z. Because these are “polling” functions they will need to be called inside main()’s while(1) loop.

```c
uint16_t WriteDAN777RCservo(uint16_t RC1, uint16_t RC2)
uint16_t ReadDAN777ADC(uint16_t *ADC1, uint16_t *ADC2)
uint16_t WriteDS1388Z(uint16_t second, uint16_t minute, uint16_t hour, uint16_t day, uint16_t date, uint16_t month, uint16_t year)
uint16_t ReadDS1388Z(uint16_t *second, uint16_t *minute, uint16_t *hour, uint16_t *day, uint16_t *date, uint16_t *month, uint16_t *year)
```
The TMS320F28379D I2C users guide can be found at http://coecsl.ece.illinois.edu/ME461/labs/I2CCondensed_TechRef.pdf
The DAN777 Datasheet can be found at http://coecsl.ece.illinois.edu/me461/Labs/DAN777_Datasheet.pdf
The DS1388Z Datasheet with some ME461 additions can be found at http://coecsl.ece.illinois.edu/me461/Labs/DS1388Condensed.pdf

Four wires you need to solder.
You will need to solder four wires to your green board connecting the Joystick voltages to the DAN777 ADCIN1 and ADCIN2 pins and connecting the DAN777 RCServo output pins to the 3 pin RCServo headers of your green board.

The DAN777 ADCIN1 pin is brought out at pin 2. Connect it to F28379D Launchpad pin 29 which is already wired to the joystick’s X axis. Shorter black wire in below picture.

The DAN777 ADCIN2 pin is brought out at pin 5. Connect it to F28379D Launchpad pin 26 which is already wired to the joystick’s Y axis. White wire in below picture.

The DAN777 RC1 pin is brought out at pin 10. Connect it to the higher of the three pin headers and the pin that is connected through a jumper to GPIO14. Make sure to remove this jumper so only RC1 is connected to the 3 pin header. This is the longer black wire in the below picture.

The DAN777 RC2 pin is brought out at pin 12. Connect it to the lower of the three pin headers and the pin that is connected through a jumper to GPIO15. Make sure to remove this jumper so only RC2 is connected to the 3 pin header. This is the red wire in the below picture.
**I2C initialization function**, cut and paste into your C file and call this function after the init_serial functions in main() and before the while(1) continuous loop (Not inside the loop).

```c
void I2C_Init(void)
{
    EALLOW;
    /* Enable internal pull-up for the selected I2C pins */
    GpioCtrlRegs.GPBPUD.bit.GPIO40 = 1;
    GpioCtrlRegs.GPBPUD.bit.GPIO41 = 1;

    /* Set qualification for the selected I2C pins */
    GpioCtrlRegs.GPBQSEL1.bit.GPIO40 = 3;
    GpioCtrlRegs.GPBQSEL1.bit.GPIO41 = 3;

    /* Configure which of the possible GPIO pins will be I2C B pins using GPIO regs */
    GpioCtrlRegs.GPBGMUX1.bit.GPIO40 = 1;
    GpioCtrlRegs.GPBMUX1.bit.GPIO40 = 2;
    GpioCtrlRegs.GPBGMUX1.bit.GPIO41 = 1;
    GpioCtrlRegs.GPBMUX1.bit.GPIO41 = 2;
    EDIS;

    // Initialize I2C
    I2cbRegs.I2CMDR.bit.IRS = 0;

    // 200MHz / 20 = 10MHz
    I2cbRegs.I2CPSC.all = 19;

    // 10MHz/40 = 250KHz
    I2cbRegs.I2CCLKL = 15; //psc > 2 so d = 5  See Usersguide
    I2cbRegs.I2CCLKH = 15; //psc > 2 so d = 5  See Usersguide

    I2cbRegs.I2CIER.all = 0x00;

    I2cbRegs.I2CMDR.bit.IRS = 1;
    DELAY_US(5000);
}
```
Example of an I2C write function. This is for a fictitious chip named CHIPXYZ. It has 16 registers inside the chip. Here the function is writing to registers 4, 5, 6 and 7. Registers 4 and 5 are each 8 bits and make up a 16 bit command to CHIPXYZ. Register 4 is the LSB (least significant byte) and Register 5 is the MSB (most significant byte). In the same way registers 6 and 7 make up another command to CHIPXYZ and register 6 is LSB and register 7 is MSB. CHIPXYZ’s slave address is 0x3A.

```c
//Write 2 16bit commands (LSB then MSB) to I2C Slave CHIPXYZ starting at CHIPXYZ's register 4,
uint16_t WriteTwo16BitValuesToCHIPXYZ(uint16_t Cmd16bit_1, uint16_t Cmd16bit_2) {
    uint16_t Cmd1LSB = 0;
    uint16_t Cmd1MSB = 0;
    uint16_t Cmd2LSB = 0;
    uint16_t Cmd2MSB = 0;
    Cmd1LSB = Cmd16bit_1 & 0xFF;  //Bottom 8 bits of command
    Cmd1MSB = (Cmd16bit_1 >> 8) & 0xFF; //Top 8 bits of command
    Cmd2LSB = Cmd16bit_2 & 0xFF;  //Bottom 8 bits of command
    Cmd2MSB = (Cmd16bit_2 >> 8) & 0xFF; //Top 8 bits of command

    DELAY_US(200);  // Allow time for I2C to finish up previous commands. It pains me to have this
    // delay here but I have not had time to figure out what status bit to poll on to
    // to check if the I2C peripheral is ready of the next command. I have tried the busy
    // bit but that gave me some issues especially at startup. This would be a great
    // choice for a part of your final project if you would like to learn more about I2C.

    if (I2cbRegs.I2CSTR.bit.BB == 1) {  // Check if I2C busy, if it is better
        return 2;      // to Exit and try again next sample
    }  // This should not happen too often
    while(!I2cbRegs.I2CSTR.bit.XRDY);  //Poll until I2C ready to Transmit

    I2cbRegs.I2CSAR.all = 0x3A;  // I2C address of ChipXYZ
    I2cbRegs.I2CCNT = 5;  //Num Values plus Start Register 4 + 1
    I2cbRegs.I2CDXR.all = 4;  // First need to transfer the Register value
    // to start writing data
    // I2C in master mode (MST), I2C is in transmit mode (TRX) with start and stop
    I2cbRegs.I2CMDR.all = 0x6E20;
    while(!I2cbRegs.I2CSTR.bit.XRDY);  //Poll until I2C ready to Transmit

    I2cbRegs.I2CDXR.all = Cmd1LSB;  // Write Command 1 LSB
    if (I2cbRegs.I2CSTR.bit.NACK == 1){  // Check for No Acknowledgement
        return 3;  // This should not happen
    }
    while(!I2cbRegs.I2CSTR.bit.XRDY);  //Poll until I2C ready to Transmit

    I2cbRegs.I2CDXR.all = Cmd1MSB;  // Write Command 1 MSB
    if (I2cbRegs.I2CSTR.bit.NACK == 1){  // Check for No Acknowledgement
        return 3;  // This should not happen
    }
    while(!I2cbRegs.I2CSTR.bit.XRDY);  //Poll until I2C ready to Transmit
```
I2cbRegs.I2CDXR.all = Cmd2LSB;  // Write Command 2 LSB
if (I2cbRegs.I2CSTR.bit.NACK == 1){  // Check for No Acknowledgement
    return 3;           // This should not happen
}
while(!I2cbRegs.I2CSTR.bit.XRDY);  //Poll until I2C ready to Transmit
I2cbRegs.I2CDXR.all = Cmd2MSB;  // Write Command 2 MSB
    // After this write since I2CCNT = 0
    // A Stop condition will be issued
if (I2cbRegs.I2CSTR.bit.NACK == 1){
    return 3;
}
return 0;

Example of an I2C read function.  This is for a fictitious chip named CHIPXYZ.  It has 16 registers inside the chip.  Here the function is reading registers 10, 11, 12 and 13.  Registers 10 and 11 are each 8bits and make up a 16bit sensor reading from CHIPXYZ.  Register 10 is the LSB (least significant byte) and Register 11 is the MSB (most significant byte).  In the same way registers 12 and 13 make up another 16bit sensor reading from CHIPXYZ and register 12 is LSB and register 13 is MSB.  CHIPXYZ’s slave address is 0x3A.  Notice how the function first writes the start register with one I2C start condition and then re-issues a second start condition to switch the I2C communication to a read command.

//Read Two 16 Bit values from I2C Slave CHIPXYZ starting at CHIPXYZ's register 10
//Notice the Rvalue1 and Rvalue2 passed as pointers (passed by reference)
//So pass address of uint16_t variable when using this function for example:
//  uint16_t Rval1 = 0;
//  uint16_t Rval2 = 0;
// err = ReadTwo16BitValuesFromCHIPXYZ(&Rval1,&Rval2);
// This allows Rval1 and Rval2 to be changed inside the function and return
// the values read inside the function.
uint16_t ReadTwo16BitValuesFromCHIPXYZ(uint16_t *Rvalue1,uint16_t *Rvalue2) {

    uint16_t Val1LSB = 0;
    uint16_t Val1MSB = 0;
    uint16_t Val2LSB = 0;
    uint16_t Val2MSB = 0;

    DELAY_US(200);  // Allow time for I2C to finish up previous commands.  It pains me to have this
    // delay here but I have not had time to figure out what status bit to poll on to
    // to check if the I2C peripheral is ready of the next command.  I have tried the busy
    // bit but that gave me some issues especially at startup.  This would be a great
    // choice for a part of your final project if you would like to learn more about I2C.
if (I2cbRegs.I2CSTR.bit.BB == 1) {
    return 2;
}
while(!I2cbRegs.I2CSTR.bit.XRDY);  //Poll until I2C ready to Transmit
I2cbRegs.I2CSAR.all = 0x3A;  // I2C address of ChipXYZ
I2cbRegs.I2CCNT = 1;  // Just Sending Address to start reading from
I2cbRegs.I2CDXR.all = 10;  // Start Reading at this Register location

// I2C in master mode (MST), I2C is in transmit mode (TRX) with start
I2cbRegs.I2CMDR.all = 0x6620;

if (I2cbRegs.I2CSTR.bit.NACK == 1) {
    return 3;
}
while(!I2cbRegs.I2CSTR.bit.XRDY);  //Poll until I2C ready to Transmit
I2cbRegs.I2CSAR.all = 0x3A;  // I2C address of ChipXYZ
I2cbRegs.I2CCNT = 4;
// I2C in master mode (MST), TRX=0, receive mode start stop
I2cbRegs.I2CMDR.all = 0x6C20;  // Reissuing another Start with Read

if (I2cbRegs.I2CSTR.bit.NACK == 1) {
    return 3;
}
while(!I2cbRegs.I2CSTR.bit.RRDY);  //Poll until I2C has Recieved 8 bit value
Val1LSB = I2cbRegs.I2CDRR.all;  // Read CHIPXYZ
if (I2cbRegs.I2CSTR.bit.NACK == 1) {
    return 3;
}
while(!I2cbRegs.I2CSTR.bit.RRDY);  //Poll until I2C has Recieved 8 bit value
Val1MSB = I2cbRegs.I2CDRR.all;  // Read CHIPXYZ
if (I2cbRegs.I2CSTR.bit.NACK == 1) {
    return 3;
}
while(!I2cbRegs.I2CSTR.bit.RRDY);  //Poll until I2C has Recieved 8 bit value
Val2LSB = I2cbRegs.I2CDRR.all;  // Read CHIPXYZ
if (I2cbRegs.I2CSTR.bit.NACK == 1) {
    return 3;
}
while(!I2cbRegs.I2CSTR.bit.RRDY);  //Poll until I2C has Recieved 8 bit value
Val2MSB = I2cbRegs.I2CDRR.all; // Read CHIPXYZ
if (I2cbRegs.I2CSTR.bit.NACK == 1) {
    return 3;
}
    // After this read since I2CCNT = 0
    // A Stop condition will be issued
*Rvalue1 = (Val1MSB << 8) | (Val1LSB & 0xFF);
*Rvalue2 = (Val2MSB << 8) | (Val2LSB & 0xFF);
return 0;
}

Items to Complete by Due Date.  Your job is to pace yourself so you get everything done by the due date:

1. Demo/Checkoff in the lab, both your DAN777 and DS1388Z code working together calling the three functions WriteDAN777RCServo, ReadDAN777ADC and ReadDS1388Z one right after the other.  Call these three functions in a row every 20ms.  You will need to create a flag variable like “UARTPrint” to flag when you should run these three functions, in a row, inside your main() function’s “while(1)” loop.  Print to Teraterm, every 100 ms, the two DAN777 ADC readings and the current date and time in the format “day mm/dd/yy hour:minute:second.”  i.e. “Wednesday 03/24/21 23:16:34”.  In addition, command two the RC servo motors to continuously increase to approximately 90 degrees and then decrease to approximately -90 degrees just as we did in Lab 3.  Remember that you will need 4 AA batteries in your battery pack to provide power to the RCServos.  Don’t forget to turn on the battery packs ON switch.
2. In addition, demonstrate in lab that your WriteDS1388Z() works to set a new day, date and time.
3. Submit to your Box folder:
   a. Your commented main C file.  Should include the I2C functions you wrote.
   b. Tera Term screen shot showing the printout of your program working.
   c. Two pictures (with your phone) of the Oscilloscope displaying different PWM duty cycles produced by your I2C code transmitting new duty cycle commands.  At your check off, you will demonstrate the PWM duty cycle continuously varying.  Here you will just take two pictures.