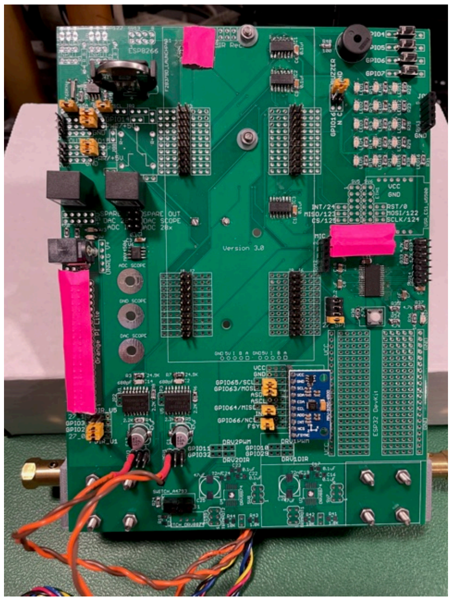
ME461 Semester Project #1
Building most of your kit and a C Programming Exercise.
Due September 15th 2:00PM

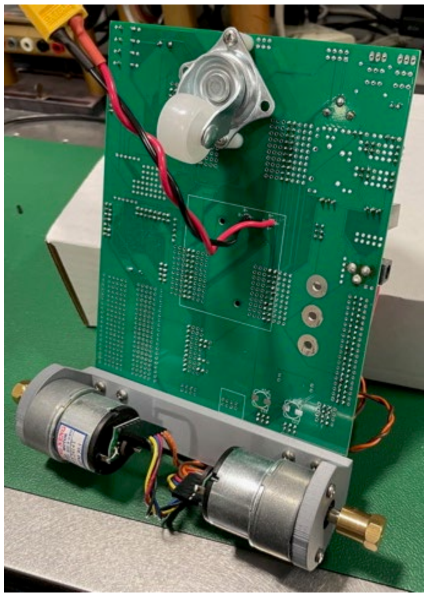
The first part of this project coincides with Lab #1 which has you solder your breakout board. In addition to soldering your breakout board, you need to assemble much of your robot kit and get it tested by me. Some of these parts need to be soldered by myself and/or the TAs. I put these items in the below list just so you know to look for those items.

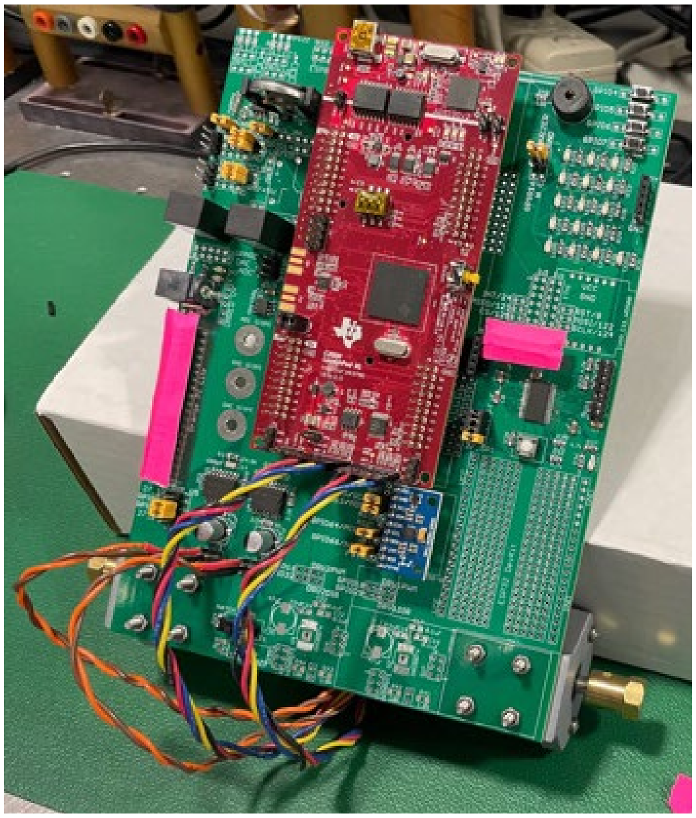
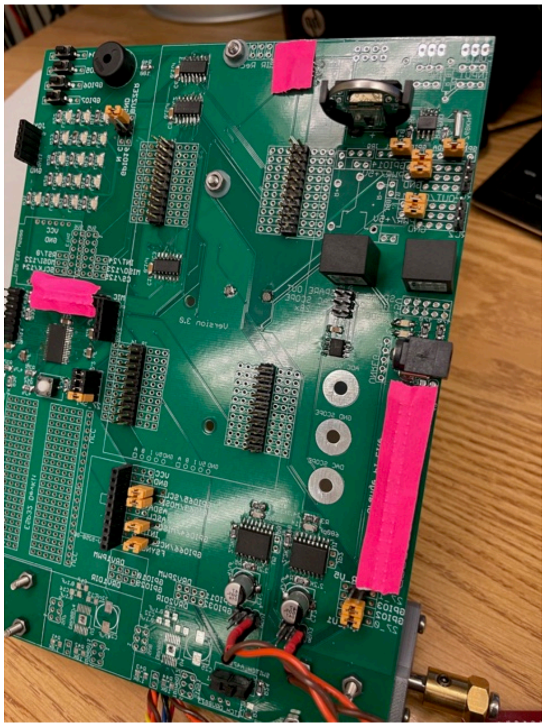
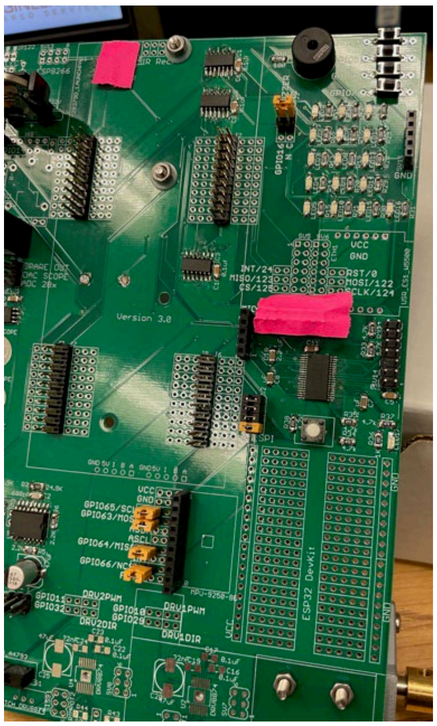
Items to Complete by Due Date:

1. Any other items that I have not thought of as of this writing and announce later in lecture.
2. Finish soldering your break out board and have it tested by the TA and one final test by me.
3. Receive two DC geared motors from me that I have soldered on a magnetic encoder sensor. I am currently working on getting these all soldered.
4. Attach your caster to the breakout board.
5. Solder your battery voltage meter to your break out board after you have enclosed it in shrink tube.
6. Solder a header to your microphone MAX9814 board and your MPU9250 board.
7. Assemble motors to your break out board. Screws are in the lab.
8. Solder a battery connector cable to your breakout board. Make sure to double check that you have the polarity correct.
9. Make an appointment with me and get your entire kit tested to verify that it is working correctly.

Pictures (the pink tape is covering up headers and ICs that we will not solder until maybe the end of the semester):





C programming Exercise: Below is an introduction to the starter code given to you for labs. I used green for the code and black for my commentary. This listing leaves out quite a bit of the starter code to keep

```
//#############################################################################
// FILE:   labstarter_main.c
//
// TITLE:  Lab Starter
//#############################################################################

// Included Files
#include <stdio.h>
#include <stdlib.h>
#include <stdarg.h>
#include <string.h>
#include <math.h>
#include <limits.h>
#include "F28x_Project.h"
#include "driverlib.h"
#include "device.h"
#include "f28379dSerial.h"
#include "LEDPatterns.h"
#include "song.h"
#include "dsp.h"
#include "fpu32/fpu_rfft.h"

#define PI          3.1415926535897932384626433832795
#define TWOPI       6.283185307179586476925286766559
#define HALFPI      1.5707963267948966192313216916398


// Interrupt Service Routines predefinition
__interrupt void cpu_timer0_isr(void);
__interrupt void cpu_timer1_isr(void);
__interrupt void cpu_timer2_isr(void);
__interrupt void SWI_isr(void);

void serialRXA(serial_t *s, char data);

// Count variables
uint32_t numTimer0calls = 0;
uint32_t numSWIcalls = 0;
uint32_t numRXA = 0;
uint16_t UARTPrint = 0;
uint16_t LEDdisplaynum = 0;
```

For these C exercises, this is where I would like you to create any global variables or global functions. Actually, the only kind of functions we will create this semester will be global functions. We will never need to create a function inside another function and that includes not creating functions inside your main() function. You can of course put your global functions anywhere outside of other functions. It is just nice to have all your functions defined in one spot of your code so they are easier for you to find. The same goes for global variables.

```
void main(void)
{
    // PLL, WatchDog, enable Peripheral Clocks
    // This example function is found in the F2837xD_SysCtrl.c file.
    InitSysCtrl();

    InitGpio();

        // Blue LED on LaunchPad
    GPIO_SetupPinMux(31, GPIO_MUX_CPU1, 0);
    GPIO_SetupPinOptions(31, GPIO_OUTPUT, GPIO_PUSHPULL);
    GpioDataRegs.GPASET.bit.GPIO31 = 1;

        // Red LED on LaunchPad
    GPIO_SetupPinMux(34, GPIO_MUX_CPU1, 0);
    GPIO_SetupPinOptions(34, GPIO_OUTPUT, GPIO_PUSHPULL);
    GpioDataRegs.GPBSET.bit.GPIO34 = 1;
```

… Purposely left code out here in this listing because it is all initializations that we will discuss in future labs and not important here …

```
    EALLOW;  // This is needed to write to EALLOW protected registers
    PieVectTable.TIMER0_INT = &cpu_timer0_isr;
    PieVectTable.TIMER1_INT = &cpu_timer1_isr;
    PieVectTable.TIMER2_INT = &cpu_timer2_isr;
```

… Purposely left code out of listing …

```
     // Configure CPU-Timer 0, 1, and 2 to interrupt every second:
    // 200MHz CPU Freq, 1 second Period (in uSeconds)
    ConfigCpuTimer(&CpuTimer0, 200, 10000);
    ConfigCpuTimer(&CpuTimer1, 200, 20000);
    ConfigCpuTimer(&CpuTimer2, 200, 40000);

    // Enable CpuTimer Interrupt bit TIE
    CpuTimer0Regs.TCR.all = 0x4000;
    CpuTimer1Regs.TCR.all = 0x4000;
    CpuTimer2Regs.TCR.all = 0x4000;

    init_serial(&SerialA,115200,serialRXA);
```

… Purposely left code out of listing …

```
    // Enable global Interrupts and higher priority real-time debug events
    EINT;  // Enable Global interrupt INTM
    ERTM;  // Enable Global realtime interrupt DBGM

    // IDLE loop. Just sit and loop forever (optional):
    while(1)
    {
```

Look below in the timer 2's interrupt function, cpu_timer2_isr(), and you will see that UARTPrint is set to 1 every 50th time the timer 2's function is entered. So both the rate at which timer 2's function is called and this modulus 50 determines the rate at which the serial_printf function is called. serial_printf prints text to Tera Term or some other serial terminal program. Also notice that after the serial_printf function call, UARTPrint is set back to 0. Think about why that is important. Add a comment to the UARTPrint = 0; line of code explaining why it must be set back to zero here to make this code work correctly. (Correctly means that the serial_printf function is called at a periodic rate.)

```
      if (UARTPrint == 1 ) {
```

For this exercise, I would like you to put most of your written code here. In future labs you will find that code run here, in this continuous while loop "while(1)", is less important code. It will be your lower priority code that does not have as strict of timing. Also this is the only place in your code that you should call serial_printf. serial_printf is somewhat of a large function and depending on how many variables you print can take some time and is not deterministic. Technically, you can call multiple serial_printf functions in a row here but it is better if you just call serial_printf once with all the variables you want to print.

```
        serial_printf(&SerialA,"Num Timer2:%ld Num SerialRX: %ld\r\n",CpuTimer2.InterruptCount,numRXA);
        UARTPrint = 0;
      }
    }
}
```

Right now consider the calling of this function, cpu_timer0_isr() "magic". (We will explain this in detail soon in the course.) "cpu_timer0_isr() is called every 10ms, without fail, in this starter code. (It actually "interrupts" the code running in the main() "while(1)" while loop.) In main() you can change the 10000 (microseconds) in the line of code "ConfigCpuTimer(&CpuTimer0, 200, 10000);" to have it be called at a different rate.

```
// cpu_timer0_isr - CPU Timer0 ISR
__interrupt void cpu_timer0_isr(void)
{
    CpuTimer0.InterruptCount++;

    numTimer0calls++;

    if ((numTimer0calls%250) == 0) {
        displayLEDletter(LEDdisplaynum);
        LEDdisplaynum++;
        if (LEDdisplaynum == 0xFFFF) {  // prevent roll over exception
            LEDdisplaynum = 0;
        }
    }
    // Blink LaunchPad Red LED
    GpioDataRegs.GPBTOGGLE.bit.GPIO34 = 1;
    // Acknowledge this interrupt to receive more interrupts from group 1
    PieCtrlRegs.PIEACK.all = PIEACK_GROUP1;
}
```

Right now consider the calling of this function, cpu_timer2_isr() "magic". (We will explain this in detail soon in the course.) "cpu_timer2_isr() is called every 40ms, without fail, in this starter code. (It actually "interrupts" the code running in the main() "while(1)" while loop.) In main() you can change the 40000 (microseconds) in the line of code "ConfigCpuTimer(&CpuTimer2, 200, 40000);" to have it be called at a different rate.

```
// cpu_timer2_isr CPU Timer2 ISR
__interrupt void cpu_timer2_isr(void)
{
    // Blink LaunchPad Blue LED
    GpioDataRegs.GPATOGGLE.bit.GPIO31 = 1;

    CpuTimer2.InterruptCount++;
```

Since "CpuTimer2.InterruptCount" increments by 1 each time in this function, this below if statement sets UARTPrint to 1 every 50th time into this function "cpu_timer2_isr()". The % in C is modulus. Modulus returns the remainder of the divide operation. So 23 % 50 equals 23, 67 % 50 equals 17, etc.

```
    if ((CpuTimer2.InterruptCount % 50) == 0) {
        UARTPrint = 1;
    }
}


// This function is called each time a char is received over UARTA.
void serialRXA(serial_t *s, char data) {
    numRXA ++;

}
```

Tasks:

1. Study the above partial code listing and read through my commentary in black.
2. First, change either the periodic rate that Timer 2's interrupt function is called or the 50 modulus in Timer 2's interrupt function to make the default serial_printf function be called every 250ms.

Debug your code and check that the default text is being printed, to the TeraTerm Windows application, 4 times a second.

3. Answer this question after finishing Task 2 above. “CpuTimer2.InterruptCount” is incremented by 1 each time cpu_timer2_isr() function is run. (Remember the processor, “by magic”, runs this function at the periodic rate you set in “ConfigCpuTimer”.) If CpuTimer2.InterruptCount has incremented to 2457, how much time has gone by? This answer could be different from another student depending on what you changed to make serial_printf print every 250ms. Show your math for this calculation.
4. Write a global function and name it “saturate”. Do not use any global variables in this function. This function should have two float parameters, “input” and “saturation_limit” and return a float. This return value is saturated by “saturation_limit”. “input” is the input signal (or input value) that will be saturated if its value is greater than +saturation_limit or less than –saturation_limit. For example if “input” is passed 3.4 and “saturation_limit” is passed 5.5 then “saturate” will return 3.4. If “input” is passed 9.5 and “saturation_limit” is passed 5.5 then “saturate” will return 5.5. If “input” is passed -7.4 and “saturation_limit” is passed 5.5 then “saturate” will return -5.5. You will test this function in Task 5.
5. We are going to use the “sin()” function to generate a sine wave at the sample rate of 250ms. Create five global float variables and one globel 32 bit integer:
    a. float sinvalue = 0;
    b. float time = 0;
    c. float ampl = 3.0;
    d. float frequency = 0.05;
    e. float offset = 0.25;.
    f. int32_t timeint = 0;.

    Then inside the same if statement where “serial_printf” is called and before “serial_printf” write three lines of code:

    g. timeint = timeint+1;
    h. time = timeint*0.25;
    i. sinvalue = ampl*sin(2*PI*frequency*time) + offset;
    j. Create one more global float variable, float satvalue = 0;
    k. In another line of C code, set “satvalue” equal to your “saturate” function that is passed “sinvalue” to the “input” parameter and constant 2.65 passed to the “saturation_limit” parameter.
    l. As a final step, modify the serial_printf statement so that it prints on one line: timeint, time with 2 digits of precision, sinvalue with 3 digits of precision and satvalue with 2 digits of precision. %.3f is the formatter for printing a float with 3 digits of precision. %ld is the formatter to print a 32 bit integer.
    m. Build and run this code on your Launchpad (red board). Does everything work correctly? Check TeraTerm for the prints. Demo this code working to your TA. The print out should look something like

```
Timeint = 30, Time = 7.50sec, Input = 2.371, SatOut = 2.37

Timeint = 31, Time = 7.75sec, Input = 2.198, SatOut = 2.20

Etc.
```

n. A common mistake with serial_printf is to use the %d formatter for 32 bit integers. (%d is for 16 bit integers only on the F28379D processor.) In the serial_printf statement change the %ld formatter to %d and see what happens. Also demo this to your TA.

o. In your Box folder for this class create a Project1 folder. In this folder put your commented code file, a screen shot of TeraTerm printing the correct text for part m and a screen shot of TeraTerm printing out incorrect values seen in part n due to using %d instead of %ld.