Final Project: Digital Angle Gauge
Subject: Principles of Embedded Software
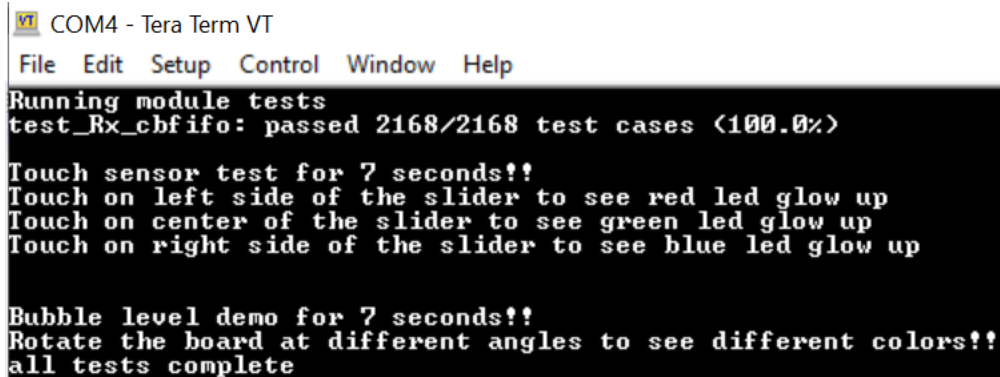
GITHUB URL: https://github.com/Mich2899/PES_Final_Project

Title: Digital Angle Gauge

Brief: The project focuses on using the in-built MMA8451Q 3-axis accelerometer on FRDM-KL25Z board using I2C and implement the logic for a digital angle gauge. Given project allows user to calibrate the accelerometer depending on the user defined reference surface. After that the user is prompted to enter a position using UART terminal. Once it reaches the user defined position, a steady led color is displayed. If there is a change in angle from that position it notifies the user by blinking the LED. The practical applications of the project include cutting tools used for bevels, miters and compound angles.

Procedure followed by the code

1. The program starts with testing different modules like test for circular buffers used in UART implementation, touch sensor test (for 7 seconds) by left, center and right detect, accelerometer testing using bubble level demo (for 7 seconds). Once all the tests are complete the user is informed using the terminal
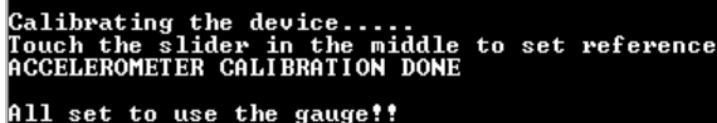

2. Next, the program prompts the user to calibrate the board according to the surface reference using the capacitive touch sensor on the board

3. Once it is calibrated the use, menu is displayed. Menu contains three options for the user

```
Welcome to Digital Angle Gauge!

Calibrating the device.....
Touch the slider in the middle to set reference
ACCELEROMETER CALIBRATION DONE

All set to use the gauge!!


Enter options from below menu:
1) Enter calibrate for re-calibration
2) Enter 'angle' and value in angle <value> format
for setting the gauge to specific angle(between -180 to +180)
3)If the reference is set to any flat surface you can also set the pitch!!
 Enter 'pitch' and value in pitch <value> format
for setting the gauge to specific pitch(between -90 to +90)
>>
```

-The user can recalibrate the system by setting a new reference if they enter 'calibrate'

-Entering data in angle <value> format allows user to set desired angle

-If the reference set by user is a flat surface (zero-level), they can also set the pitch by entering values in -90 to 90 range.

-Float values are accepted for both angle and pitch

-Turning anticlockwise sets +ve angle while turning clockwise sets -ve angle. This is true for both angle and pitch

4. By entering an angle between -180 to 180 (integer and float both formats supported), one can set the desired angle with respect to the reference

```
>>angle -90
Please rotate the accelerometer over y-axis to achieve required angle
Current angle: -7.914093
Current angle: -7.184380
Current angle: -6.807350
Current angle: -7.798683
Current angle: -8.479286
Current angle: -8.657745
Current angle: -7.961487
Current angle: -8.941917
Current angle: -8.647728
Current angle: -7.967392
Current angle: -6.897247
Current angle: -5.913368
Current angle: -6.177895
```

-The user is provided the current angle on the terminal emulator so they can set it to the desired value.

5. Once the angle is set, message is displayed on terminal emulator as well as green led stays on until there is change in angle. If the angle changes more than 10 degrees, led blinks for three times and the menu is displayed again.

```
ANGLE SET

All set to use the gauge!!
ANGLE CHANGED

Enter options from below menu:
1) Enter calibrate for re-calibration
2) Enter 'angle' and value in angle <value> format
for setting the gauge to specific angle(between -180 to +180)
3)If the reference is set to original position you can also set the pitch!!
 Enter 'pitch' and value in pitch <value> format
for setting the gauge to specific pitch(between -90 to +90)
>>angle 90
```

-If the user enters value out of range (-180 to 180), invalid input message is displayed, and the menu is provided again

```
Enter options from below menu:
1) Enter calibrate for re-calibration
2) Enter 'angle' and value in angle <value> format
for setting the gauge to specific angle(between -180 to +180)
3)If the reference is set to any flat surface you can also set the pitch!!
 Enter 'pitch' and value in pitch <value> format
for setting the gauge to specific pitch(between -90 to +90)
>>angle 234
Please enter a valid angle!!

Enter options from below menu:
1) Enter calibrate for re-calibration
2) Enter 'angle' and value in angle <value> format
for setting the gauge to specific angle(between -180 to +180)
3)If the reference is set to any flat surface you can also set the pitch!!
 Enter 'pitch' and value in pitch <value> format
for setting the gauge to specific pitch(between -90 to +90)
>>angle -198.567
Please enter a valid angle!!
```

6. By setting the reference to zero level, user can also set pitch angle in the range -90 to +90

```
Enter options from below menu:
1> Enter calibrate for re-calibration
2> Enter 'angle' and value in angle <value> format
for setting the gauge to specific angle<between -180 to +180>
3>If the reference is set to any flat surface you can also set the pitch!!
 Enter 'pitch' and value in pitch <value> format
for setting the gauge to specific pitch<between -90 to +90>
>>pitch 56
Please rotate the accelerometer over x-axis to achieve required angle
Current pitch: 1.520347
Current pitch: 1.623562
Current pitch: 1.395650
Current pitch: 1.282768
Current pitch: 1.517611
Current pitch: 1.673018
Current pitch: 1.555412
Current pitch: 1.341151
Current pitch: 1.398395
Current pitch: 1.505866
Current pitch: 1.283985
Current pitch: 1.561492
Current pitch: 1.559999
```

-The pitch angle is also displayed on the terminal emulator for the user to set it at desired angle.

 7. Once it is set to specific pitch angle blue led glows and if there is more than 10 degree change in pitch angle, the led blinks and the user is informed on the terminal.

```
Current pitch: 55.000992
Current pitch: 54.884758
Current pitch: 55.131046
Current pitch: 55.004967
Current pitch: 55.141602
Current pitch: 55.868656
Current pitch: 55.818504
Current pitch: 57.290375
PITCH SET
PITCH CHANGED

Enter options from below menu:
1> Enter calibrate for re-calibration
2> Enter 'angle' and value in angle <value> format
for setting the gauge to specific angle<between -180 to +180>
3>If the reference is set to any flat surface you can also set the pitch!!
 Enter 'pitch' and value in pitch <value> format
for setting the gauge to specific pitch<between -90 to +90>
>>pitch -67
Please rotate the accelerometer over x-axis to achieve required angle
```

8. Float values accepted upto 2 decimals for both angle and pitch angle

```
Enter options from below menu:
1) Enter calibrate for re-calibration
2) Enter 'angle' and value in angle <value> format
for setting the gauge to specific angle(between -180 to +180)
3)If the reference is set to any flat surface you can also set the pitch!!
 Enter 'pitch' and value in pitch <value> format
for setting the gauge to specific pitch(between -90 to +90)
>>angle -110.56
Please rotate the accelerometer over y-axis to achieve required angle
Current angle: 14.263484
Current angle: 14.384743
Current angle: 13.856284
Current angle: 14.564425
Current angle: 14.320896
Current angle: 14.562008
```

```
Enter options from below menu:
1) Enter calibrate for re-calibration
2) Enter 'angle' and value in angle <value> format
for setting the gauge to specific angle(between -180 to +180)
3)If the reference is set to any flat surface you can also set the pitch!!
 Enter 'pitch' and value in pitch <value> format
for setting the gauge to specific pitch(between -90 to +90)
>>pitch 45.67
Please rotate the accelerometer over x-axis to achieve required angle
Current pitch: 18.746656
Current pitch: 18.851856
Current pitch: 18.539562
Current pitch: 19.018232
Current pitch: 18.116093
Current pitch: 18.382387
Current pitch: 17.860815
Current pitch: 18.406281
Current pitch: 18.177324
Current pitch: 18.405272
Current pitch: 18.280455
Current pitch: 18.570910
Current pitch: 18.396969
```

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Different modules

1)**CBFIFO**

- Rx and Tx fifo functionalities (initialization, enqueue, dequeue, length and capacity)

2)**MENU AND COMMAND**

- Contains menu, command processor and check function for change in angle and pitch

3)**SET GAUGE**

- Contains functions to calibrate the gauge, set the gauge at different roll and pitch angles

4)**I2C**

- i2c functions (read, write, busy, wait)

5)**DELAY**

- Provides a delay between initialization of functionalities

6)**MMA8451Q**

- Functions to read the values from accelerometer and process it to roll and pitch values

7)**SLIDER**

- Initialization of Capacitive touch slider

8)**STARTUP**

- Initialization modules and bubble level demo

9)**SYSCLOCK**

- Clock to configure uart at 24MHz

10)**SYSTICK**

- To conduct tests for 7 seconds for TSI and bubble level demo

11)**TPM**

- To display different colors and transitions, PWM module used

12)**UART**

- UART initialization, syswrite, sysread and UART0 interrupt handler
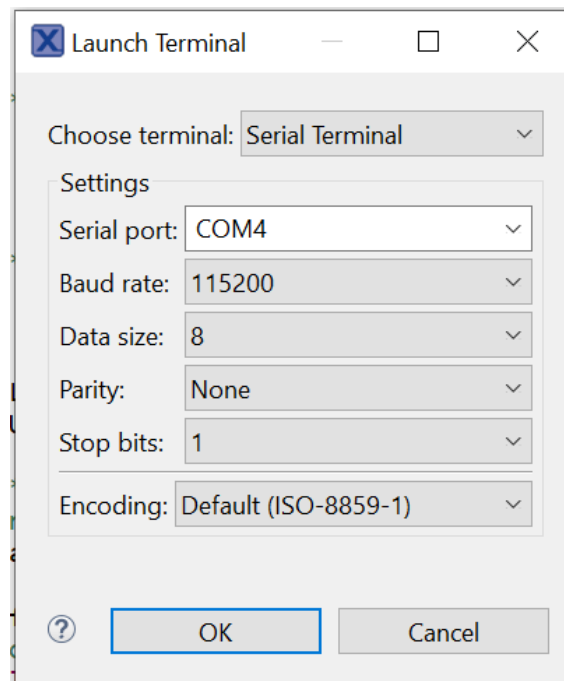
Tests used for different modules

MODULE	TEST
Cbfifo	assignment tester made by Prof. Howdy
UART	Debug prints at different stages
Accelerometer	bubble level demo
Capacitive touch	led display based on left, center, or right position of slider

EXTRA CREDIT

Third functionality added to set pitch angle entered by the user. This functionality works if the board is kept on a flat surface with ground level/ zero level reference.

UART terminal configurations are as mentioned below

Baud rate	115200
Stop bits	1
Data bits	8
Parity bits	0

Technologies and method of coding used

- For the in-built MMA8451Q **3-axis accelerometer**, **I2C** communication protocol is used. Polling method is used to determine the angle of accelerometer

- **UART** is used for displaying the menu and taking angle/position value from the user. (for recalibration and for user to enter a specified position). UART0 interrupt is used.

- For implementation of UART, (Tx and Rx buffers) the concept of **circular buffer** is used.

- In built **capacitive touch sensor, interrupt** method is used. Previously for buffahiti I used polling.

-Complete code works on 24MHz clock

-**Command Processing**

- **Low power modes** (in touch sensor configuration)

-**PWM**

Learning outcomes:

- I2C communication protocol for KL25Z

-use of MMA8451 in built accelerometer(how i2c reads are operated on MMA8451,how xyz position is read and converted into roll and pitch)

-interrupt method for Capacitive touch

- Command Processing

- Low power modes in touch sensor configuration

- Configuration of the clock system such that all the modules used work on 24MHz (not on system clock which is 48MHz)

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