CSE 4355/5355 - Mechatronics Lab 7

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Introduction: This report outlines the steps, results, and code implementation of a lab project aimed at measuring force and mass using a strain gauge and the HX711 analog-to-digital (A/D) converter. The project involves configuring the hardware, soldering and gluing a strain gauge to an aluminum beam, reading the data through a microcontroller, and empirically deriving an equation for converting A/D results to physical force and mass measurements.

1. Circuit Assembly: The circuit involves connecting the HX711 device to the controller and setting up the strain gauge as described:

- **DATA** and **PD_CLK** lines of HX711 are connected to the controller.
- 350-ohm resistors are connected between:
    - E+ to A+
    - E+ to A-
    - E- to A+
- The strain gauge block uses:
    - **RED**: Excitation + (E+)
    - **BLACK**: Excitation – (E-)
    - **GREEN**: Signal + (A+)
    - **YELLOW**: Signal - (A-)
- The **BLACK** jack is connected to E-, and the **YELLOW** jack to A-.

2. Strain Gauge Preparation:

- 30 AWG bare wires were soldered to the strain gauge while it rested on a glass plate for stability.
- The strain gauge was then glued to the aluminum beam, ensuring strong adhesion for accurate strain measurement.
- The wires were clipped to the **BLACK** and **YELLOW** banana jacks with toothless alligator clips to maintain secure connections.

3. Microcontroller Configuration: The PD_CLK was configured as a General-Purpose Output (GPO), and the DATA line was configured as a General-Purpose Input (GPI).

4. Code Implementation: The following code was used to read the voltage data from the HX711 and display the raw data, calculated mass, and force:

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```
#include <stdio.h>
#include <stdint.h>
#include <stdbool.h>
#include "wait.h"
#include "uart0.h"
#include "tm4c123gh6pm.h"
#include "gpio.h"
#include "clock.h"

#define DATA PORTC,6
#define PD_CLK PORTC,7

uint32_t data = 0;

void initHw() {
   initSystemClockTo40Mhz();
   enablePort(PORTC);
   _delay_cycles(3);
   selectPinDigitalInput(DATA);
   enablePinPulldown(DATA);
   selectPinPushPullOutput(PD_CLK);
}

// main function
void main(void) {
   initHw();
   initUart0();
```

```
setUart0BaudRate(115200, 40e6);
uint8_t i;
char str[40];
float mass = 0, force = 0;

while(true) {
   if(getPinValue(DATA) == 1) {
      data = 0;
      for (i = 0; i < 24; i++) {
         setPinValue(PD_CLK, 1);
         waitMicrosecond(40);
         data <<= 1;
         data |= getPinValue(DATA);
         setPinValue(PD_CLK, 0);
         waitMicrosecond(1);
      }

      setPinValue(PD_CLK, 1);
      waitMicrosecond(40);
      setPinValue(PD_CLK, 0);

      snprintf(str, sizeof(str), "Raw Data: %d", data);
      putsUart0(str);
      putsUart0("\n");
      mass = abs(data - 12001104);
      snprintf(str, sizeof(str), "Mass: %f", (mass / 13) - 175);
      putsUart0(str);
      putsUart0("\n");
      snprintf(str, sizeof(str), "Force: %f", mass * 9.81);
      putsUart0(str);
      putsUart0("\n\n");
```

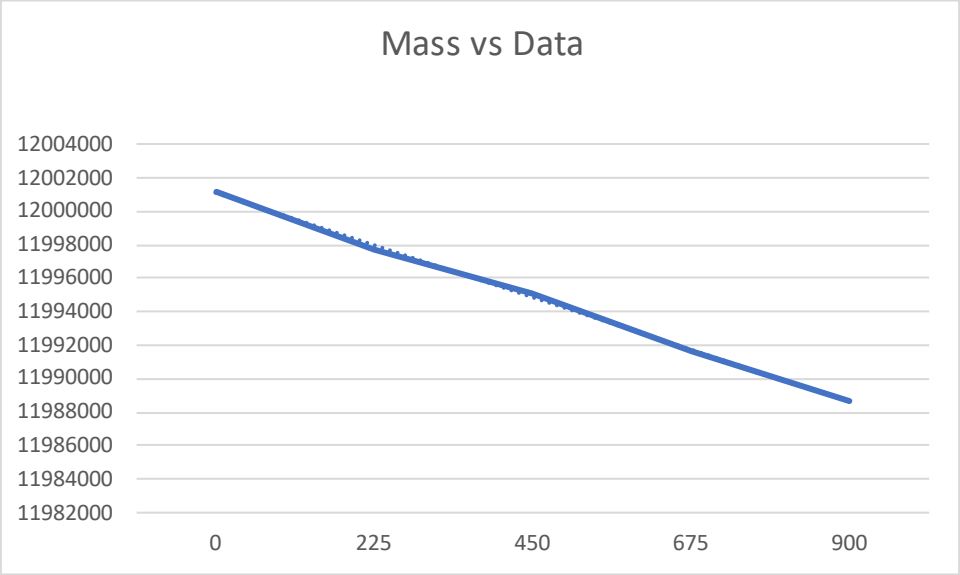
```
        waitMicrosecond(1000000);
      }
    }
}
```

5. Data Acquisition and Results: Empirical data was collected by placing known weights on the beam to calibrate the A/D output to physical units of force (N) and mass (g). The derived equation for converting the 24-bit result was calibrated and refined to achieve accurate outputs.

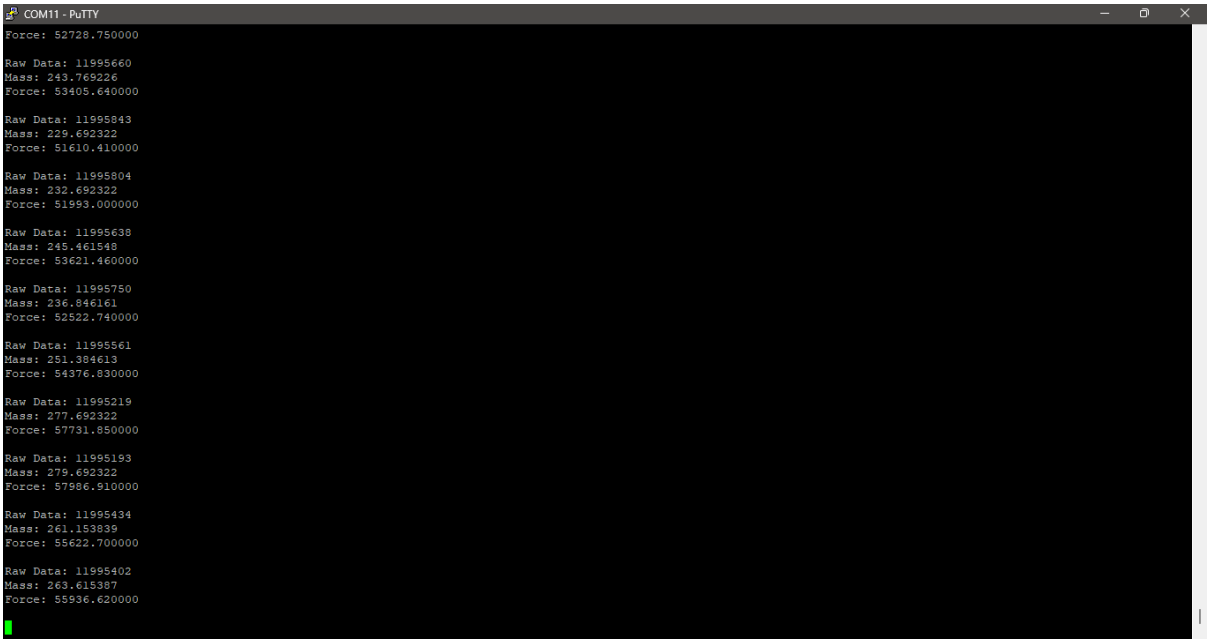
6. Observations and Error Analysis: When pressing on the end of the beam, a force was detected, indicating compression and tension in the strain gauge. Additional strain gauges arranged in a full Wheatstone bridge could be added to eliminate the effect of non-uniform stress and provide temperature compensation.

Conclusion: The lab successfully demonstrated how to set up and calibrate a strain gauge system using an HX711 A/D converter. The process included hardware preparation, soldering, gluing, circuit connection, and programming. The measured data was accurately converted to real-world mass and force units through empirical calibration.

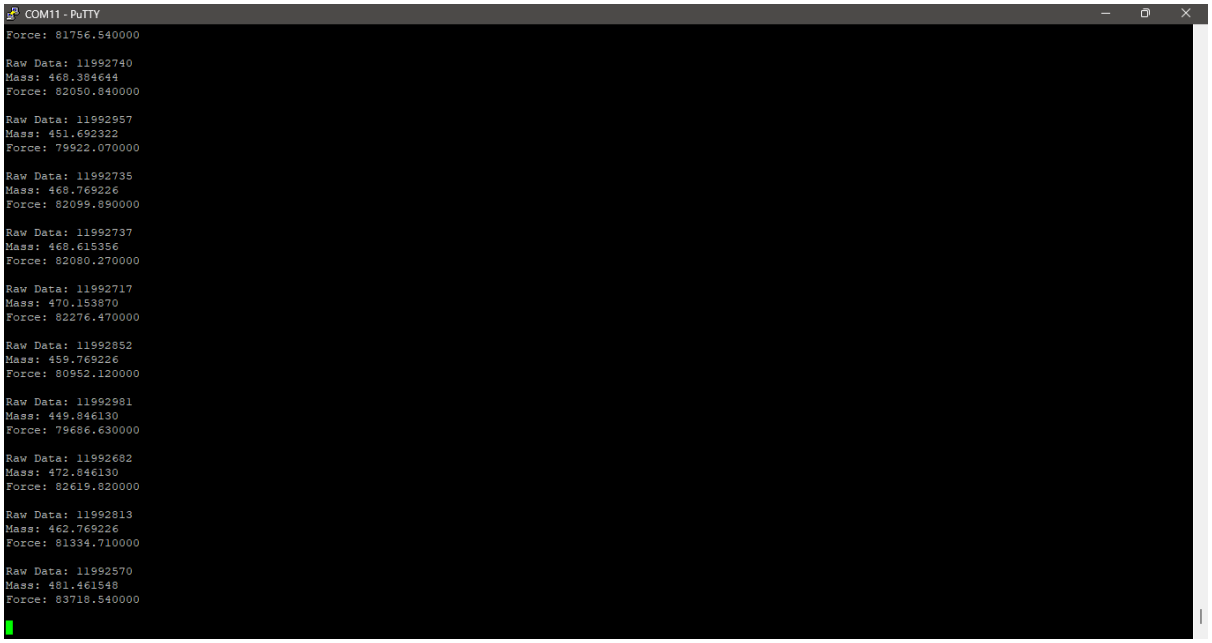
Observations:



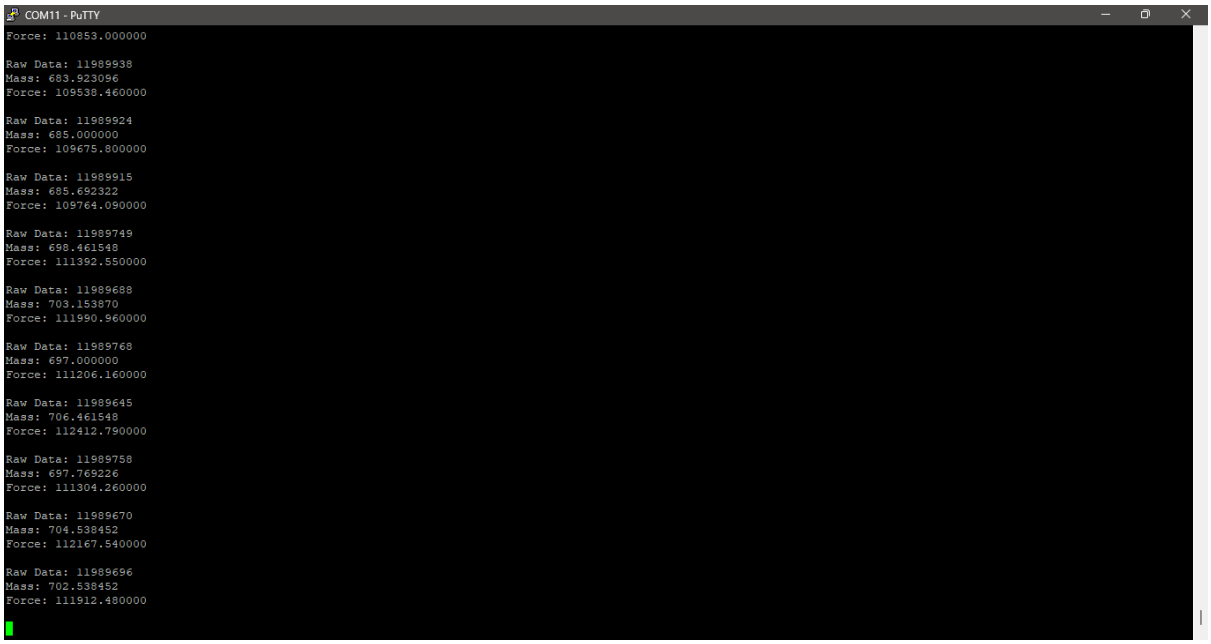
- 224g weight



- 450g weight:



- 675g weight:



- 900g weight: