

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);
    }
}
}

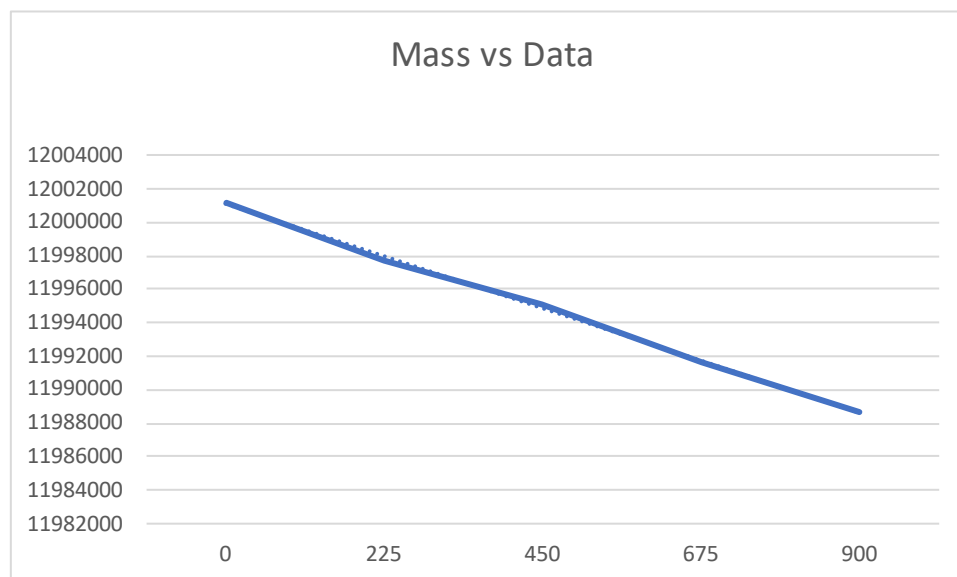
```

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

```
COM11 - PuTTY
Force: 52728.750000

Raw Data: 11995660
Mass: 243.769226
Force: 53405.640000

Raw Data: 11995843
Mass: 229.692322
Force: 51610.410000

Raw Data: 11995804
Mass: 232.692322
Force: 51993.000000

Raw Data: 11995638
Mass: 245.461548
Force: 53621.460000

Raw Data: 11995750
Mass: 236.846161
Force: 52522.740000

Raw Data: 11995561
Mass: 251.384613
Force: 54376.830000

Raw Data: 11995219
Mass: 277.692322
Force: 57731.850000

Raw Data: 11995193
Mass: 279.692322
Force: 57986.910000

Raw Data: 11995434
Mass: 261.153839
Force: 55622.700000

Raw Data: 11995402
Mass: 263.615387
Force: 55936.620000
```

- 450g weight:

```
COM11 - PuTTY
Force: 81756.540000

Raw Data: 11992740
Mass: 468.384644
Force: 82050.840000

Raw Data: 11992957
Mass: 451.692322
Force: 79922.070000

Raw Data: 11992735
Mass: 468.769226
Force: 82099.890000

Raw Data: 11992737
Mass: 468.615356
Force: 82080.270000

Raw Data: 11992717
Mass: 470.153870
Force: 82276.470000

Raw Data: 11992852
Mass: 459.769226
Force: 80952.120000

Raw Data: 11992981
Mass: 449.846130
Force: 79686.630000

Raw Data: 11992682
Mass: 472.846130
Force: 82619.820000

Raw Data: 11992813
Mass: 462.769226
Force: 81334.710000

Raw Data: 11992570
Mass: 481.461548
Force: 83718.540000
```

- 675g weight:

```
COM11 - PuTTY
Force: 110853.000000
Raw Data: 11989938
Mass: 683.523096
Force: 109538.460000
Raw Data: 11989924
Mass: 685.000000
Force: 109675.800000
Raw Data: 11989915
Mass: 685.692322
Force: 109764.090000
Raw Data: 11989749
Mass: 698.461548
Force: 111392.550000
Raw Data: 11989688
Mass: 703.153870
Force: 111990.960000
Raw Data: 11989768
Mass: 697.000000
Force: 111206.160000
Raw Data: 11989645
Mass: 706.461548
Force: 112412.790000
Raw Data: 11989758
Mass: 697.769226
Force: 111304.260000
Raw Data: 11989670
Mass: 704.538452
Force: 112167.540000
Raw Data: 11989696
Mass: 702.538452
Force: 111912.480000
```

- 900g weight:

```
COM11 - PuTTY
Force: 46430.730000
Raw Data: 11997998
Mass: 63.923080
Force: 30469.860000
Raw Data: 11998208
Mass: 47.769226
Force: 28409.760000
Raw Data: 11998402
Mass: 32.846161
Force: 26506.620000
Raw Data: 11998188
Mass: 49.307683
Force: 28605.960000
Raw Data: 11998284
Mass: 41.923080
Force: 27664.200000
Raw Data: 11986086
Mass: 980.230713
Force: 147326.580000
Raw Data: 11986159
Mass: 974.615356
Force: 146610.450000
Raw Data: 11986041
Mass: 983.692261
Force: 147768.030000
Raw Data: 11985984
Mass: 988.076904
Force: 148327.200000
Raw Data: 11986264
Mass: 966.538452
Force: 145580.400000
```