Analytical Report on Sensing for the BiOM Testing Apparatus

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Overview:

This report contains the basis and research that supports the choices made for sensor implementation in the BTA. Team SkyeNet was asked by the project clients, Uzma Tahir and Dr. John Tester, to implement sensors that have the ability to return a velocity reading on the dead weight drop as well as a value associated with the total weight that is being dropped. The team decided upon an actuator controlled dead drop that given a user's input and a fully rested position, the weights can drop at the push of a button.

Accelerometer Research:

Table 1 shows the three different accelerometers that were chosen as possible implementations to the design. All three choices were constrained to compatibility with Arduino hardware programming libraries. This table lists the four categories each accelerometer, and eventually the chosen accelerometer, were rated by.

Name	**Sensing Range (+- coupling return value)**	**Cost Per Unit**	**Resolution**	**Size**	**Input Voltage (Volts)**
SparkFun Triple Axis Accelerometer Breakout - ADXL335	1	$13.46	13-bit	4 mm x 4 mm x 1.45 mm	1.8-3.6V
SparkFun Triple Axis Accelerometer Breakout - ADXL345	User selectable 2, 4, 8, 16	$16.16	13-bit	3 mm × 5 mm × 1 mm	2.0-3.6V
3 Axis Accelerometer, Raspberry Pi, Arduino Compatible Sensor (Based on ADXL345 architecture)	User selectable 2, 4, 8, 16	$4.95	13-bit	1” x 9/16” x ½”	0.3-3.9V

Table 1

Accelerometer Selection:

After a careful selection process that ended up having cost as the deciding factor, the “3 Axis Accelerometer, Raspberry Pi, Arduino Compatible Sensor”, found in Table 1, was selected to deliver the acceleration of the weight drop. The small size of the accelerometer is something that team SkyeNet found to be crucial because the overall design of the BTA is something that has to be portable. The reason the team selected an accelerometer is because given time and acceleration, velocity can be found. The equation ($v = v0 + at$) for this can be found within “The Physics Hyper Textbook” [1]. In order to find the readable acceleration that the device returns, a scale factor of .0001 has to be multiplied as well as a standardized gravity scalar which in this case we will use 9.8 meters per second.

Input/Output (I/O) Layout and Functional Block Diagram [2]:

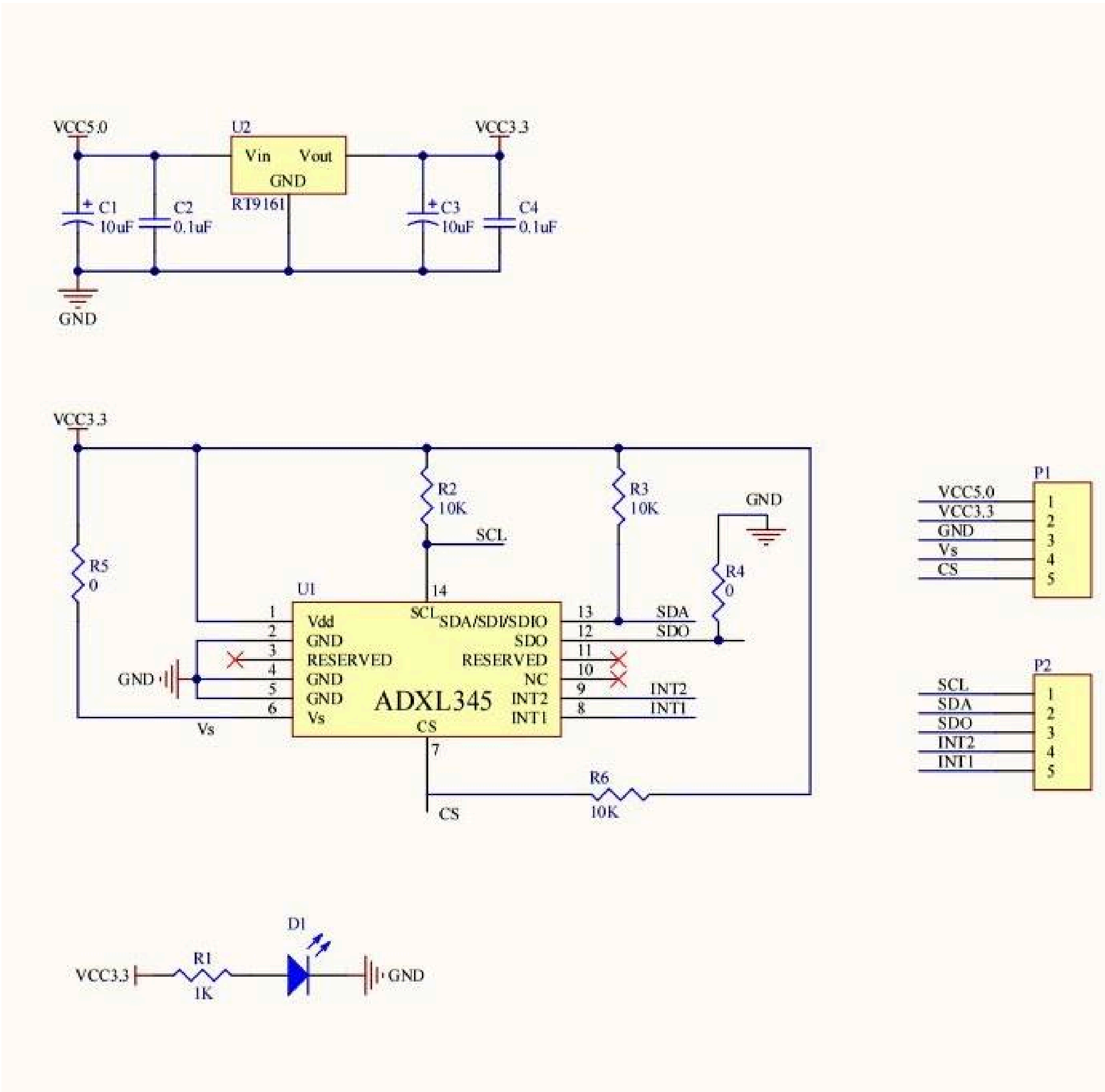


Figure 1

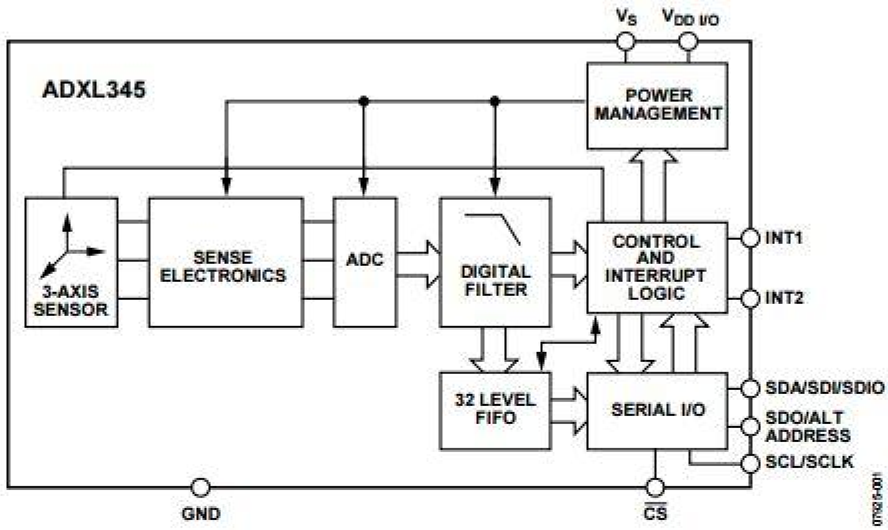


Figure 2

Breadboard Layout with Schematic:

Figure 3 is a virtual breadboard layout created through the program “Fritzing.” As this is an analog I/O heavy chip, most of the analog ports on the Arduino Uno (the blue controller board) have been used.

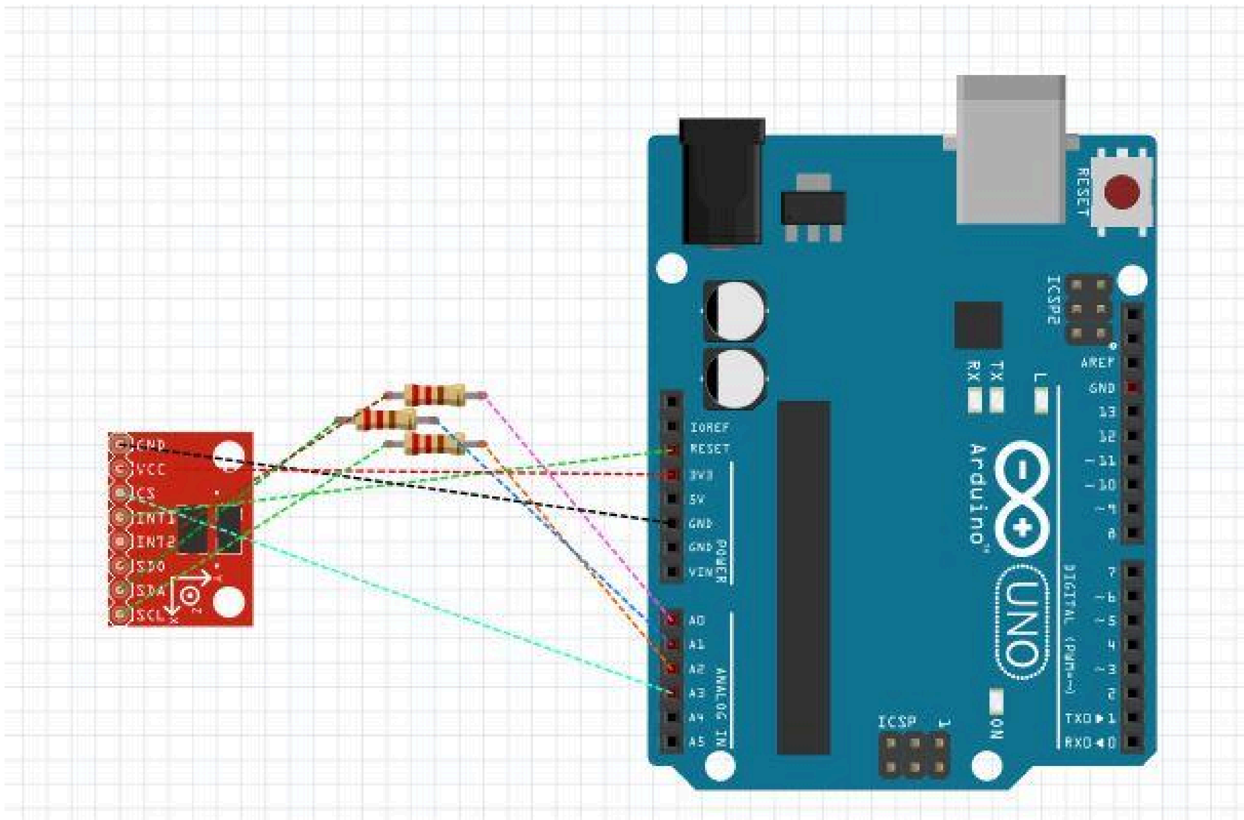


Figure 3

Figure 4 is the base level design schematic between the Arduino Uno and the Triple Axis Accelerometer that will be used to measure the acceleration of the weight drop. Note the resistance values of 220 Ohms on each analog output.

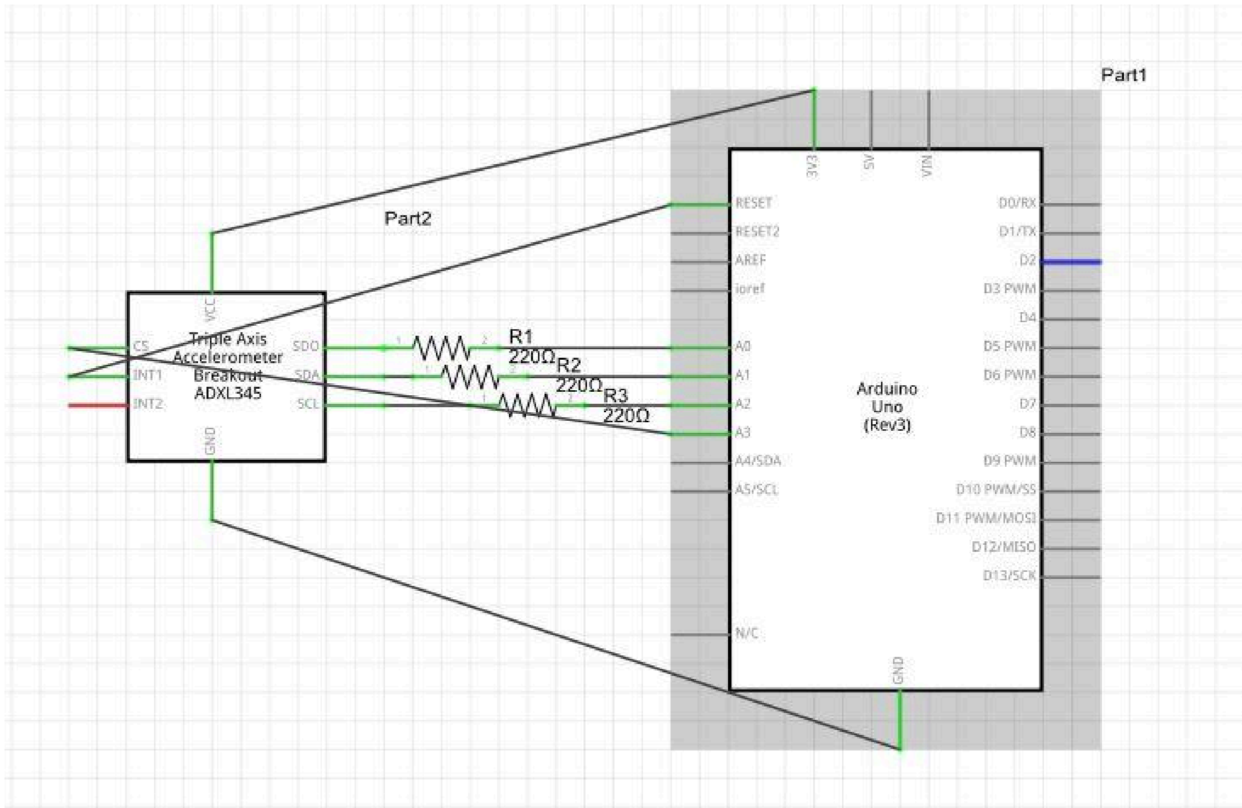


Figure 4

Working Sample Code (Arduino) for Triple Axis Accelerometer:

This code prints the X, Y, Z analog outputs of the Triple Axis Accelerometer. Note the values are multiplied by .001 and 9.8 to get suitable acceleration values.

Begin Code:

```
		//Bradley Racey
		//Begin Serial reading with serial.begin(maximum read value)
	void loop(){

		//Accelerometer serial return readings
		int x,y,z;
		adxl.readXYZ(&x * (.001 * 9.8), &y (.001 * 9.8), &z * (.001 * 9.8)); //read the
	accelerometer values and store them in variables  x,y,z
		// Output x,y,z values
		Serial.print("values of x , y , z: ");
```

```
        Serial.print(x);
        Serial.print(" , ");
        Serial.print(y);
        Serial.print(" , ");
        Serial.println(z);

        double xyz[3];
        double ax,ay,az;
        adxl.getAcceleration(xyz);
        ax = xyz[0];
        ay = xyz[1];
        az = xyz[2];
        Serial.print("X=");
        Serial.print(ax);
    Serial.println(" g");
        Serial.print("Y=");
        Serial.print(ay);
    Serial.println(" g");
        Serial.print("Z=");
        Serial.println(az);
    Serial.println(" g");
        Serial.println("***");
        delay(500);
```

Program Flowchart:

This is a flowchart illustrating how the user will see the interaction between the sensor and the program.

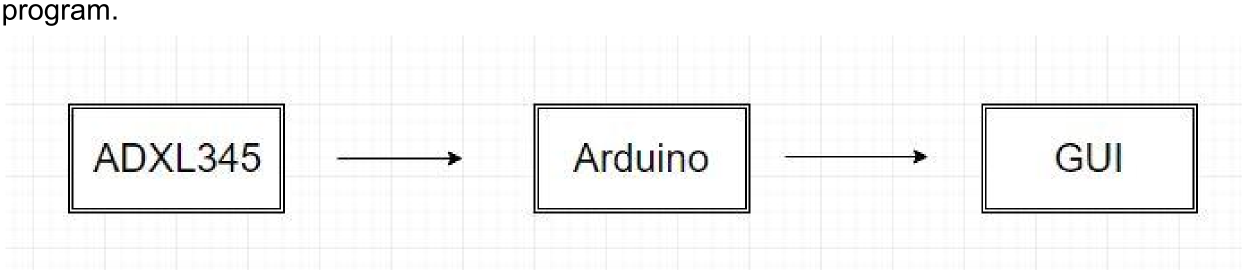


Figure 5

Digital Scale Research:

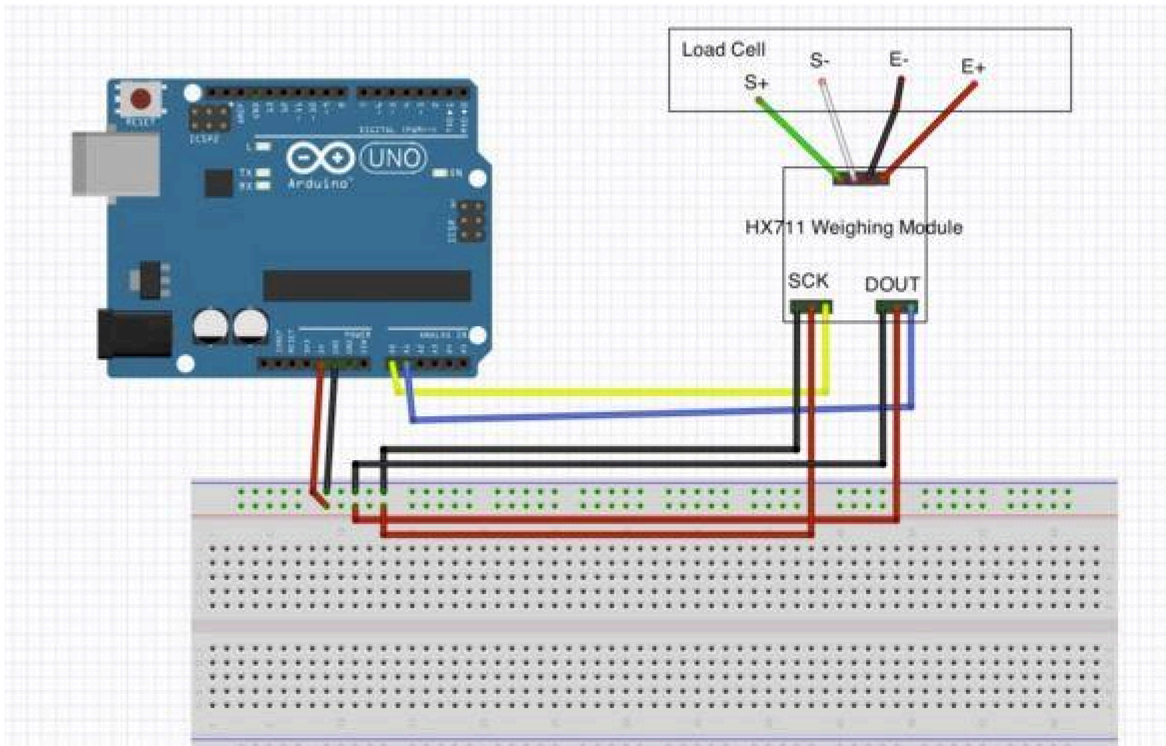
After researching heavily into finding a suitable apparatus that mimics a scale, the team found that a load cell paired with an Arduino board would be the best implementation for trying to measure the total weight of the drop. There are not many load cells that pair with the Arduino however the HX711 load cell is easy to use and pairs very well with the Arduino. It's small size and very cheap cost makes for a great choice. The idea is to have the unit placed below the weights being dropped on its own platform so an accurate reading can be obtained.

HX711 Specifications [3]:

Range	Cost Per Unit	Resolution	Size	Input Voltage (Volts)
1 kg/in^2	$8.96	24-bit	20.7mm x 37 mm	2.7V-5V

Table 2

HX711 Breadboard Layout:



Working Sample Code (Arduino) for HX711:

Begin Code:

```
//Bradley Racey

float ReadingA_Strain1 = 301.0;
float LoadA_Strain1 = 0.0; //  (Kg,lbs..)
float ReadingB_Strain1 = 302.0;
float LoadB_Strain1 = 80.0; //  (Kg,lbs..)
float ReadingA_Strain2 = 1.0;
float LoadA_Strain2 = 0.0; //  (Kg,lbs..)
float ReadingB_Strain2 = 60.0;
float LoadB_Strain2 = 80.0; //  (Kg,lbs..)


int time_step = 2500 ; // reading every 2.5s
long time = 0;

void setup() {
  Serial.begin(9600); //  setup serial baudrate
```

```
}

void loop() {
  float newReading_Strain1 = analogRead(0);  // analog in 0 for Strain 1
  float newReading_Strain2 = analogRead(1);  // analog in 1 for Strain 2

  // Calculate load (or weight)
  float load_Strain1 = ((LoadB_Strain1 - LoadA_Strain1)/(ReadingB_Strain1 -
ReadingA_Strain1)) * (newReading_Strain1 - ReadingA_Strain1) + LoadA_Strain1;
  float load_Strain2 = ((LoadB_Strain2 - LoadA_Strain2)/(ReadingB_Strain2 -
ReadingA_Strain2)) * (newReading_Strain2 - ReadingA_Strain2) + LoadA_Strain2;

  // Returns how long program has been running for
  if(millis() > time_step+time) {
    Serial.print("Reading_Strain1 : ");
    Serial.print(newReading_Strain1);     // display strain 1 reading
    Serial.print("  Load_Strain1 : ");
    Serial.println(load_Strain1);     // display strain 1 load
    Serial.println('\n');
    Serial.print("Reading_Strain2 : ");
    Serial.print(newReading_Strain2);     // display strain 2 reading
    Serial.print("  Load_Strain2 : ");
    Serial.println(load_Strain2);        // display strain 2 load
    Serial.println('\n');
    time = millis();
  }
}
```

Actuator Research:

After consulting with our client Dr. John Tester about how the team is going to initiate the weight drop, he recommended that the team use a pneumatic actuator. A lot of research went into how an actuator could be used with the team's design and assessing the pros and cons between a linear actuator and a pneumatic one found that a linear actuator would be the best bet in terms of ease of use and overall cost. The WindyNation 2 Inch Stroke Linear Actuator proved to fit the team's needs as it can be actuated using a remote control, note that this was something our clients needed, and it has an operating force of up to 900N. It is also the most cost effective of the two actuators assessed.

Name	Input Voltage (Volts)	Force Range (Newtons)	Price Per Unit
TSINY Stroke 50mm 2 inch Electric Linear Actuator	12V	0-750N	$51.88
WindyNation 2 Inch 2" Stroke Linear Actuator 12 Volt 12V 225 Pounds lbs Maximum Lift	12V	0-900N	$49.99

Table 3

Closing Statement:

Analyzing the right sensors and actuators for this project is one of the most crucial parts of the team's design process. After using some engineering math against our claims, the team can safely say that we will be using the Triple Axis Accelerometer to obtain the velocity of the weight drop, the HX711 load cell to measure the weight being dropped, and the WindyNation 2 inch stroke linear actuator to initiate the weight drop.

Appendix:

BTA - BiOM Testing Apparatus

References:

1. [1]"Speed & Velocity - The Physics Hypertextbook", *Physics.info*, 2016. [Online]. Available: http://physics.info/velocity/. [Accessed: 01- Apr- 2016].
2. [2]"ADXL345 - Analog Devices", *Analog Devices*, 2016. [Online]. Available: http://www.analog.com/media/en/technical-documentation/data-sheets/ADXL345.pdf. [Accessed: 01- Apr- 2016].
3. [3]"24-Bit Analog-to-Digital Converter (ADC) for Weigh Scales", *Analog Devices*, 2016. [Online]. Available: https://cdn.sparkfun.com/datasheets/Sensors/ForceFlex/hx711_english.pdf. [Accessed: 01- Apr- 2016].