Physical Design Proposal Team 2

Jan Karl Galia, Abdullah Qureshi, Max Manier

Activity Report

1 Proposed Solution

The proposed design is simplistic in nature and follows the designs constraints. The system consists of sturdy wooden frame and uses two pulleys to efficiently transfer force from an adjacent crank to apply a vertical load. The lower clamp is attached to the base and the upper clamp is attached to the shuttle with the load cell. The material under observation will be placed between these clamps. The laser sensor attached to the shuttle will measure the distance from the base as the rope is pulled through the pulley. The data will be read by both the load sensor and range sensor through micro-controller and processed accordingly. The LCD screen will display commands to help the calibration process and operation of the device. Commands can range from calibration instructions to operation instructions like "Pull" or "Stop".

2 System Architecture

The main focus of the proposed design is to add a crank in order to apply a vertical load. In order to add a crank two pulleys have to be added on top of the device in order to have a linear and uniform pulling force on the shuttle.

- *Jan Karl Galia,*
  E-mail: jgalia@albany.edu,
- *Abdullah Qureshi,*
  E-mail: aqureshi@albany.edu,
- *Max Manier,*
  E-mail: mmanier@albany.edu,
  University at Albany.

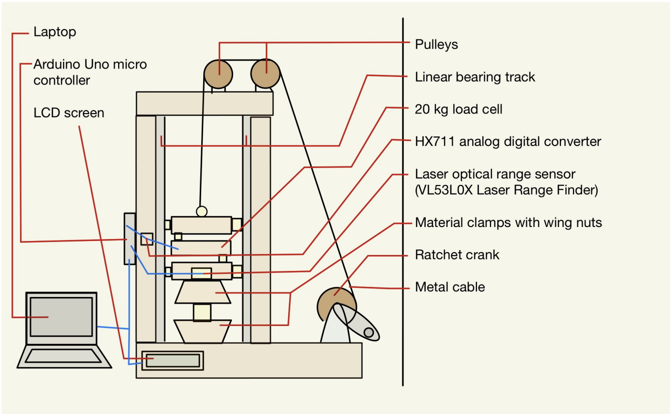

Figure 1. Current state of the tensiometer physical design.

Figure 1 depicts the current system physical design with a crank for applying a vertical load, and pulleys for linear force implementation on shuttle. The system also consists of LCD screen in order to aid in the calibration process and provide user with operation instructions.

The addition of the LCD screen will change the circuitry of the system. Figure 2 depicts the current system circuitry with the load cell acting a wheatstone bridge and the resulting output voltage amplified to the range of the ADC. The HX711 board uses the amplifed value to perform a ADC conversion and then communicates the results using the I2C communication standard with the attached microcontroller. Figure 3 depicts Arduino and LCD schematic. The LCD screen also uses the I2C communication standard with the attached microcontroller in order to make circuitry and wire management easier. The LCD screen typically uses 16 pins to

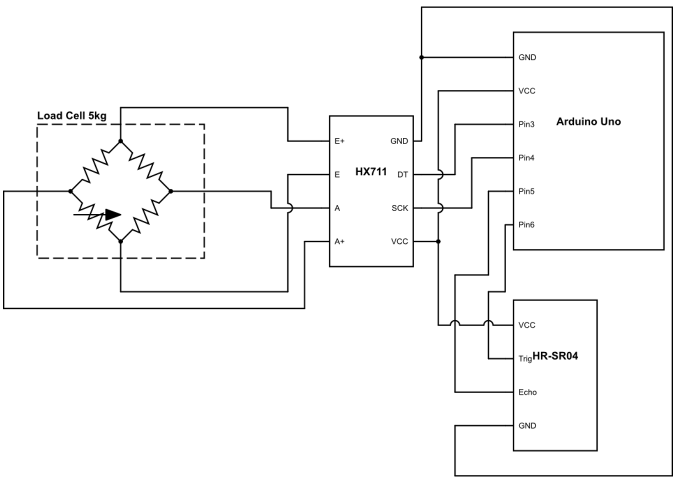

Figure 2. Schematic diagram of tensiometer electronics.

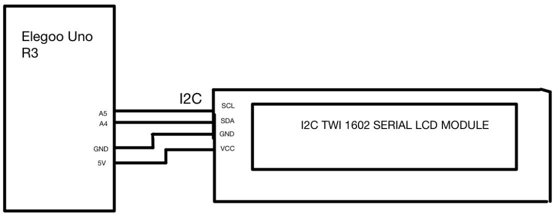

Figure 3. Schematic diagram of LCD screen With I2C.

work and display data on it, but by sing the I2C communication standard it can be reduced to 4 pins as shown in Figure 2. The LCD can work only by using pin VCC for power, SDA pin for data transmission, SCL pin for clock signal, GND pin for ground.

2.1 System Components

Some of the problems with the old system included non uniform application of force on the material under observation due to pulling the rope by hand. It was decided by the the team to use a Ratchet crank to pull the rope for uniform application of force, and because of its ability to stop the shuttle from returning to its original position. The following improvement has potential to greatly improve the accuracy, precision, and ease of use of the tensiometer. In order to have the crank apply linear force it was decided by the team to add pulleys onto the system. Another problem with the old system included the elasticity of the rope being used. It was decided by the team to replace that with a metal cable to reduce uncertainty in the data collection. Moreover, in order to reduce human error the team decided to use an LCD to display commands to help with the calibration process and operation of the device. Following are the new components of the system.

Item	Part #	Cost
Ultrasonic Range Sensor	HR-SR04	$4
Load Cell 20kg	SEN-14729	$12
Amplifier	HX711	$10
Microcontoller	Ard. Uno	$15
LCD Screen With I2C	TWI 1602 LCD	$5
Ratchet Crank	Crank	$20
Pulleys	Pulley	$20
Metal Cable	Cable	$3
TOTAL		**$89**

Table 1
Table 1 displays an overview of parts purchased and their estimated price.

2.1.1 *Ratchet Crank*

The Ratchet Crank allows a user to apply uniform force on the material being stretched, and enables the user to stop the shuttle from going back to its original position without the need of force being applied from the user.

2.1.2 *Pulleys*

Pulleys are used in order to make the crank apply linear force on the material being stretched, and enables smooth pulling mechanism because of reduction in friction.

2.1.3 *Metal Cable*

The Metal Cable has negligible elasticity which reduces the errors and uncertainties in the data collected and the final result of Young's Modulus and Ultimate Tensile Strength.

2.1.4 *LCD Screen with I2C*

The LCD screen will display commands to help the calibration process and operation of the device. Commands can range from calibration instructions to operation instructions like "Pull" or "Stop".

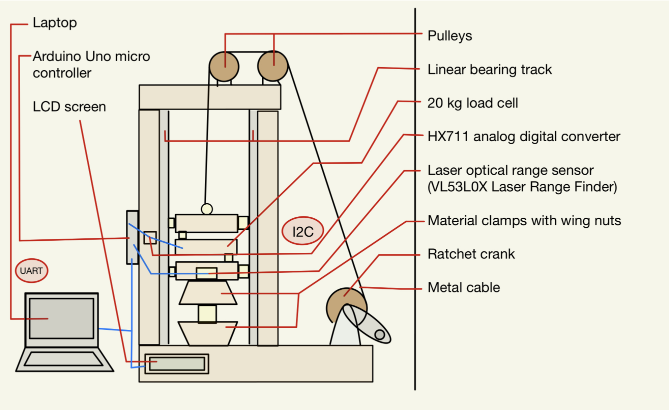

Figure 4. The current tensiometer system implements two communication standards (protocol) I2C and UART.

2.2 Engineering Standards

The current system utilizes I2C and UART protocols. I2C protocol is a serial communication protocol in which data is transferred bit by bit along a single wire (the SDA line). UART stands for Universal Asynchronous Receiver/Transmitter. It's not a communication protocol like I2C, but a physical circuit in a microcontroller. A UART's main purpose is to transmit and receive serial data.

2.2.1 I2C Protocol

I2C uses two wires to transmit data between devices. The current Tensiometer design uses Arduiono Uno which contains only one SCL (Pin 5) and SDA (Pin 4) pin. These same pins are connected to HX711, HR-SR04, and LCD screen. The SDA pin sends and receives data to and from the sensors and the LCD screen. SCK pin only sends a clock signal to the sensors and LCD screen to indicate data transmission and completion in data transmission.

2.2.2 UART Protocol

The main purpose of UART protocol is to send and receive data. The current Tensiometer design uses Arduino Uno which uses UART protocol to transmit and receive data to and from user's laptop. In order for the communication to work the user must set the baud rate in the code. Any speed up to 115200 baud is viable but current code uses 9600 baud speed.

2.2.3 Data Standards

The current Tensiometer design uses Ardu Plotter tool in order to upload data calculated from the load cell and distance sensor to a CSV file. The data form CSV file is then uploaded to Matlab for creating stress vs strain curve, and calculate Young's Modulus and Ultimate Tensile Strength.