Physical Design Proposal
Seal Team 6

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Activity Report

1 Proposed Solution

Targeting a significant increase in accuracy and precision along with an accessible architecture, the new system introduces a number of measured improvements. In terms of construction, a sophisticated yet simple clamp design is implemented along with a mounted S-beam load cell capable of greater flexibility in applied force as well as improved accuracy. A linear actuator applies uni-axial force to lift the top clamp upward, eliminating human error and providing uniform data collection. With accessibility in mind, an LCD screen guides users through the calibration and testing, minimizing barriers to entry otherwise prevalent with software. The features collectively combine under a new, custom frame designed for the aforementioned features.

2 System Architecture

A small wooden base holds the foundation for the system with a S-beam load cell being attached to the back center of the wood. Above, the carefully aligned bottom clamp attaches to the top of the load cell. The opposing clamp rests adjacent to the bottom clamp, effectively mirroring about the x-axis. When conducting a test, the head of the top clamp is pulled upwards by a linear actuator that rests above. Back at the base, an LCD screen with trivial button inputs guides users through calibration, starting and ending tests, and sending collected data to a preferred destination.

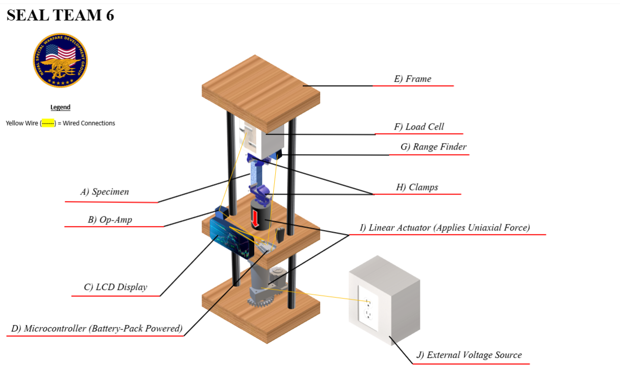

Figure 1. Prototype physical design model of the tensile strength tester with added features.

A mounted breadboard and Arduino microcontroller connect to the load cell, distance sensor, and linear actuator. Specialized algorithms in a finite state machine are the basis for the design. As seen in Figure 2, the load cell becomes operational through connection to the HX711 board which uses the amplified value to perform a ADC conversion and then communicates the results using the I2C communication standard with the attached micro-controller. The load cell itself uses a wheatstone bridge to detect slight changes in voltage when an applied force is present. Additionally, the HC-SR04 distance sensor calculates distance with a trigger pin that sends a signal and an echo pin

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which receives the signal. The time difference along with the speed of sound is used to calculate distance. Furthermore, one must discuss the nucleus of the design, a uniaxial drive system. The current working model incorporates the abilities of a ”L298N DC Motor Driver Module” and that of an ”Eco-Worthy 300mm Stroke Linear Actuator”. Including the L298N component allows for rotational direction control utilizing H-bridge properties. The motor driver also allows a user access to direction control pins that are easily interfaced with the Arduino micro-controller.

2.1 System Components

When considering the variety of materials to be tested in the prospective system especially those with higher ultimate tensile strengths, it became apparent that limiting exerted force to 5kg would be insufficient. It was also clear under the previous load-cell model that the application of force could only be done accurately in a precise, impractical environment. As such, a 50kg S-beam load cell has been implemented to vastly expand force possible while simultaneously maintaining accurate readings across extensive design elements. S-beam load cells vary in both cost and mass rating, though generally it should be noted that a number of these variants can be considered appropriate; 20kg, 40kg, and even 100kg are mass ratings that can be potentially utilized for distinct testing purposes. Observe, higher mass ratings yield higher inaccuracies in data readings and thus finding a balance between accuracy and capability should be evaluated.

User accessibility is another design criteria taken with consideration with the addition of an LCD screen interface. A 20x4 LCD screen guides users to navigate between testing phases such as running a test, calibration, and sending resultant data. A low cost LCD screen essentially gives users the ability to bypass complex software interfaces like the Arduino IDE and MATLAB. Rather than choose the somewhat more common 16x2 dimension, a 20x4 screen can print the entire menu concurrently without need for scrolling operations. An attached I2C board also simplifies wiring and congestion on the Arduino micro-controller. To interface with the screen, users interact with a linked membrane keypad implemented to register simple selections as well as recognizing a manual calibration input.

In the context of implementing a uniaxial drive system the available components on the market were rather limited due to the imposed budget cap. Ultimately the ”L298N DC Motor Driver Module” and ”Eco-Worthy 300mm Stroke Linear Actuator” were chosen due to their ease of use and affordability. Furthermore, a unique aspect of the L298N module is that it also powers the Arduino micro-controlller. As such, designers may advertise the final product as an entirely stand-alone system, this notion is a desirable quality that further emphasizes the ergonomic nature of the apparatus.

Reference Figure 3 for an overview of incurred costs.

2.1.1 Load Cell (50kg) / HX711 Amplifier

Functionality in the load cell effectively mirrors the previous model with enhanced precision, mass range, and accessibility in terms of mounting.

2.1.2 Ultrasonic Range Sensor

Preexisting in base model; see previous documentation.

2.1.3 Micro-controller

Preexisting in base model; see previous documentation.

2.1.4 Graphical Display

The new system gives users a membrane keypad to interact with a 20x4 LCD interface whereby navigation moves across four different states: menu, run test, calibration, and send data.

2.1.5 Uniaxial Drive System

Composed of a L298N DC Motor Driver Module and an Eco-Worthy 300mm Stroke Linear Actuator. The motor driver employs the use of an H-bridge to allow for direct control over rotational direction. Moreover users have access to input pins, this allows for seamless automation given an appropriate script.

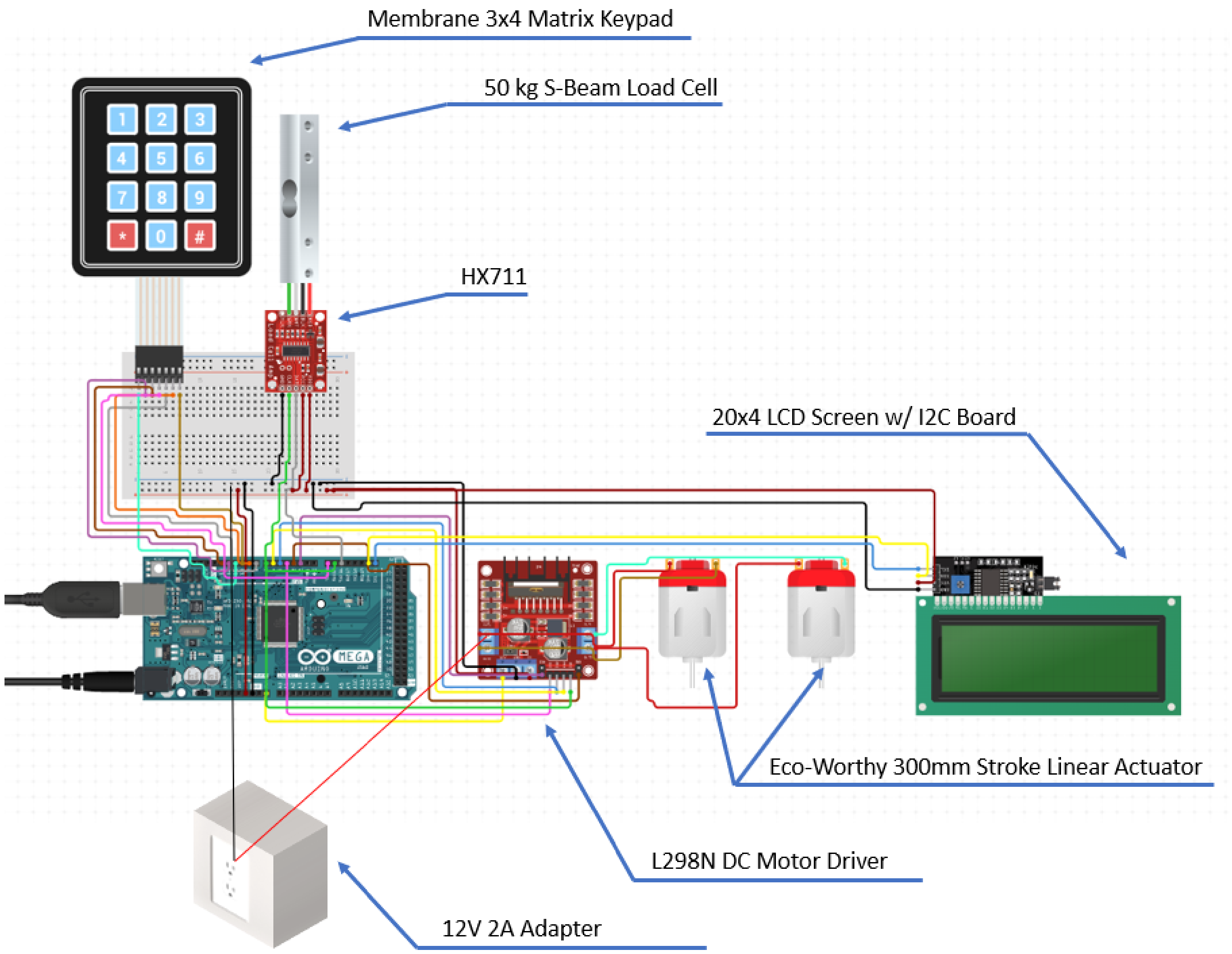

Figure 2. Schematic diagram of tensiometer electronics with additional actuator, LCD screen, and membrane keypad.

Item	Cost
50kg S-beam Load Cell	$52.42
Linear Actuator	$60
Clamp Accessories	$5
20x4 LCD Screen w/ I2C Board	$14.03
Membrane Keypad	$10
Component Mounting Attachments	$10
Total	$151.45

Figure 3. Parts purchased and their respective costs.

2.2 Engineering Standards

Engineering standards establish technical criteria, methods, processes and practices. In the current system, there are two communication standards (protocols) that are utilized: I2C and UART.

2.2.1 *I2C Protocol*

I2C supports multiple controllers and peripherals using just two wires (data and clock). In any new communication sequence, the address frame of 7 bits is always first followed by the ACK/NACK bit which gives confirmation that each frame is transferred successfully. Limited to 8 bits, the data frame begins transmitting data as the controller continues generating clock pulses at a regular interval and the data is placed on SDA by either the controller or the peripheral. Once all the data frames have been sent, the controller will generate a stop condition.

2.2.2 UART Protocol

UART ports communicate between only two devices (transmit and receive). Both devices must agree on data and communication speed ahead of time and requires complex hardware. There is no control over when the data is sent and no guarantee that both sides are running at the same rate. To achieve reduced data rates, at least one start and stop bit is a part of each frame of data.