Operations Manual

EML 4551C – Senior Design – Spring 2013 Deliverable

Active Surface Shaping for Reflectors

Team # 9

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Table of Contents

Function Analysis

The diagram in Figure 1 shows how the automated adjustment mechanism works, which components are controlled by an input, and how the displacement is measured. It is broken up into 2 subsystems, the adjustment mechanism and the tabletop visual demonstration used to test it.

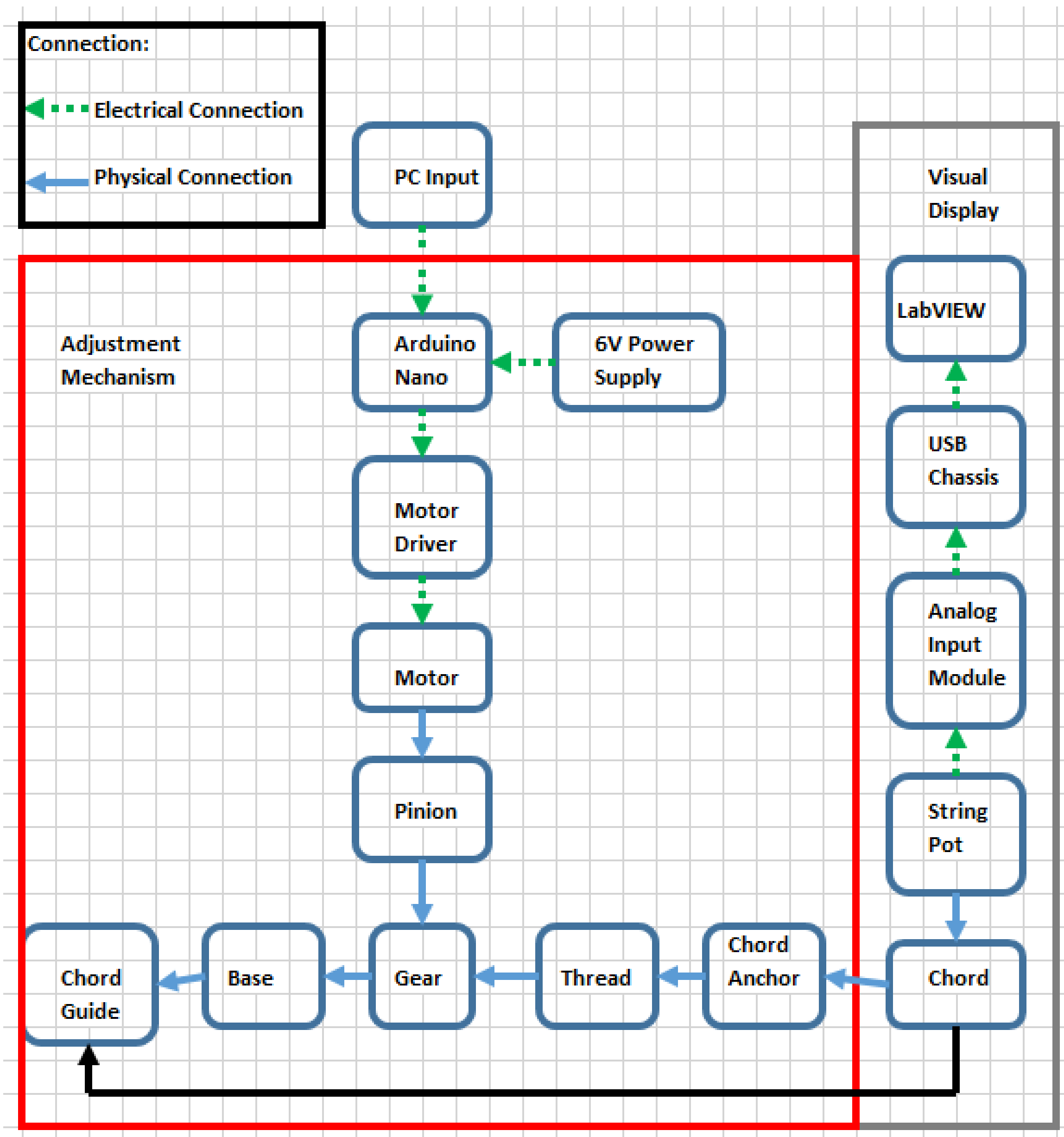

Figure 1 Functional Diagram for Automated Adjustment Mechanism and Testing Platform

Product Specifications

Our sponsor has explicitly stated the objectives our team must achieve. We are to build one automated, high precision adjustment mechanism. This mechanism is to be used as a visual demonstration model for the open house that must be able to measure the displacement of the cords accurately. The linear resolution must be 0.001” with a linear range of 0.001”, and a life span of 10,000 linear inches. It is also desired that each unit be as lightweight as possible, preferably under 80 grams, and cost under $800.

Individual Component Specifications

String potentiometer – Celesco M150

Full stroke length: 0 – 1.5inches

Accuracy: ±1% full stroke

Input Resistance: 5K ± 10% ohms

Voltage divider output

Microcontroller – Arduino Nano

Microcontroller: Atmel ATmega328

Operating Voltage (logic level): 5V

Input Voltage (recommended): 7 – 12V

Digital I/O Pins: 14

Dimensions 0.73” x 1.70”

Weight: 9g

Motor Driver Chip – TI SN754410

Quad Half-H Driver

Input Voltage: -0.5 – 36V

Continuous Output Current: ±1.1A

Weight: 1g

Stepper Motor – Faulhaber AM1524

Nominal Voltage: 6V

Nominal Current: 0.15A

Torque: 6mNm

Step angle: 15° – 24 steps per revolution

Weight: 12g

Drive System – 2:1 gear ratio

Material: brass

Pressure angle: 20°

Teeth on gears: 18

Operation Procedures

The following section outlines the process for operating the automated adjustment mechanism and the equipment to test the accuracy. It is necessary that all steps be taken with extreme caution to prevent damage to any components or hardware.

1) Hardware connection
   a) Arduino Nano
      i) Plug in mini USB to Arduino and USB male connector to computer
      ii) Connect 6V battery to male connector on PCB
   b) Data acquisition hardware
      i) Connect NI 9205 analog input module to cDAQ-9174 USB chassis
      ii) Connect cDAQ chassis to computer via USB
      iii) Plug in power cord from chassis to power outlet
      iv) Plug in 10V constant voltage power supply to power outlet
      v) Ground cDaq chassis

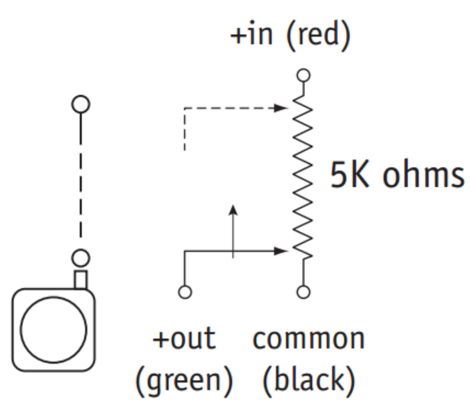

Figure 2 Electrical Connection Schematic for Celesco M150 String Pot

      vi) Connect positive (red) wire from the power supply to the red wire on the string pot
      vii) Connect the negative (black) wire from the power supply to the black wire on the string pot or the ground cable as seen in Figure 2

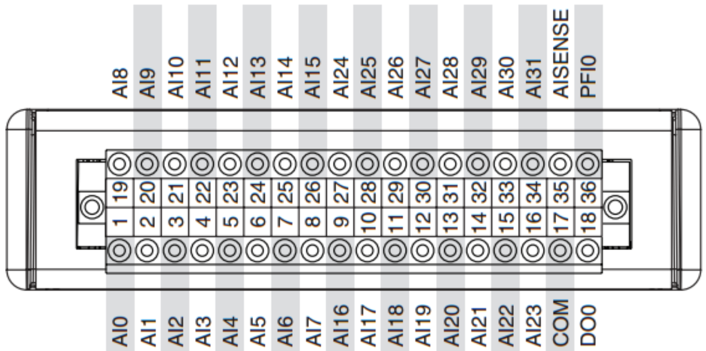

Figure 3 NI 9205 Analog Input Module Terminal and Pin Assignment

viii) Connect the green wire from the string pot to the AI0 terminal as seen in Figure 3

ix) Jump the common (black) cable to the AI8 terminal as seen in Figure 3

2) User Interface Startup Sequence

a) Arduino

i) Open Arduino Integrated Development Environment (IDE)

ii) Go to Tools > Board > select Arduino Nano w/ ATmega328

iii) Go to Tools > Serial Port > select COM Port #

iv) Open file: Harris_Adjustment_Mechanism_Protocol.ino

v) Click upload

vi) Open Serial Monitor with  button or Ctrl + Shift + M Command

vii) Follow serial monitor input screen to adjust mechanism

b) LabVIEW

i) Open up LabVIEW

ii) Open file: Harris_Adjustment_Mechanism_Protocol.VI

iii) Click run on the LabVIEW front panel screen

3) Shutdown Sequence

a) Turn off 10V power supply

b) Unplug 6V battery from Arduino Nano

c) Shut down Arduino IDE program

d) Shut down LabVIEW program

e) Shut down computer

Assembly Instructions

As multiple systems are necessary to run the adjustment mechanism, assembly instructions are included below for the electronic systems, the mechanism itself, and the tabletop platform for testing purposes.

Electronic System Assembly Instructions

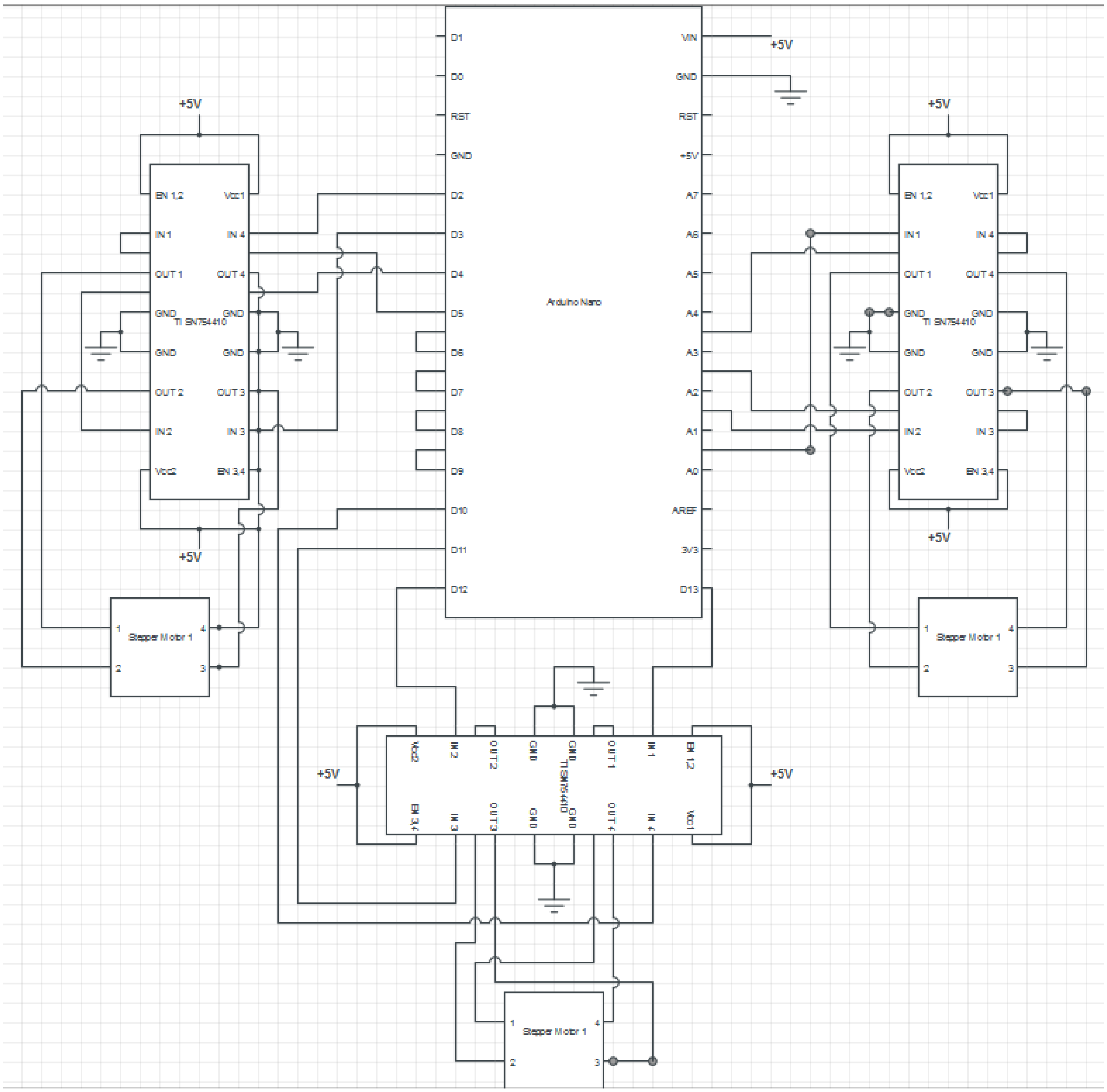

Figure 4 Electrical Systems Schematic for Adjustment Mechanism

The picture above shows the basic layout of the electronics system to compact them. The motor driver chips inputs are connected to the digital I/O pins of the Arduino. The motors are then connected to the corresponding output pins of the motor driver chips. The mini USB port is used to directly connect the microcontroller to a computer USB in order to use the software interface for input adjustments.

The perma-proto breadboard is the platform on which all electronic systems are mounted. The electronic systems are composed of the following parts:

- 3x TI SN754410 Motor Driver Chip
- Arduino Nano
- 6V Battery Pack

To assemble the electronic systems, the following steps are necessary:

1. With the setup of the electronics finalized on a breadboard, the wiring can be transferred to a perma-proto breadboard to be soldered.
2. Holes will then be drilled on the board in order mount it to its designated space on the base of the mechanism.
3. The perma-proto breadboard will then be cut down to further reduce weight and size.

Adjustment Mechanism Assembly Instructions

The base is the platform on which all other components are mounted. The mechanism is comprised of the following parts:

- 3x Faulhaber 1524 Stepper Motor
- 3x 4-40 all thread rod milled flat on top and bottom
- 3x 2:1 ratio gear trains
- Preassembled electronic systems on perma-proto breadboard

To assemble the mechanism, the following steps are needed:

1. Cord guide is assembled and attached to base with a pin.
2. Cord anchors are screwed on and bonded to end of 4-40 all thread rod.

3. The washers are lined up with the holes on both sides of the gear to be inserted into respective slots on the base.
4. With the gears and washers in place, the 4-40 all thread rods are inserted in designated slots to be screwed into gears.
5. The pinions are placed onto the stepper motors and secured using M2 set screws.
6. With motor and pinion assembly, the motors are carefully slid into the motor sleeves until the teeth of the pinion and gear mesh then the motor is secured using set screw.
7. A premade circuit board with the Arduino Nano and 3 motor driver chips are mounted onto the base and secured using screws with spacers.
8. Non-stretch braided fishing line is used as the representative cord material that is guided from the cord anchor, through the holes in the base, then through the cord guide.

Tabletop Demonstration Assembly Instructions

The tabletop platform is where the adjustment mechanism and string potentiometers are mounted to test the accuracy of the mechanism. The tabletop is comprised of the following parts:

- 80/20 aluminum frame
- Associated bracket and fasteners
- Adjustment mechanism
- 2x Celesco M150 String Potentiometer

To assemble the tabletop demonstration, the following steps are needed:

1. Assemble the cut 80/20 aluminum sections for cubic frame, using L-brackets and fasteners.
2. Attach adjuster mechanism at straw anchor and cord guide locations.
3. Attach string potentiometers to frame using fabricated mounts.
4. Route cords through adjuster mechanism, attach to cord anchors and string pots.
5. Connect all control and DAQ equipment from the hardware connection section

6.

Maintenance / Troubleshooting

The adjustment mechanism will need routine maintenance to increase the lifespan of the mechanism and its components. If a problem should arise, common problems and their solutions are listed below in this section.

Drive System

After long periods of use or inactivity, the mechanism's drive system should be completely cleaned and lubricated. This system consists of the gears and threads that must be disassembled from the base then cleaned to remove any debris that may impinge system. After cleaning and application of lubrication, the drive system can be reassembled.

String Potentiometers

The string potentiometers should be checked using calipers and a multi-meter to ensure their accuracy according the manufacturer's specifications. If the string potentiometers are not reading correctly within the specifications, a replacement may be necessary to ensure the correct data is displayed.

Power Supply

The 6V batteries should be replaced/recharged regularly to ensure that the mechanism has a consistent power supply for the electronic systems to run at full capacity. Voltage can be checked through use of a multimeter to determine if the battery is fully charged. If the voltage reading is less than 6V, it needs to be replaced/recharged.

Pinion Tightening

Over time, the set screws that hold the stepper motors in the sleeves or the pinions to the motor shafts may need to be tightened to ensure proper component security. Be careful not to over tighten, as it may strip the threads.

Future Work

Possible improvements for the automated adjustment prototype mechanism, the testing platform or possibly future projects include, but are not limited to:

- Stronger material from a 3D printer for the base and other essential components
- Thinner gears to further reduce weight
- Multiplex motor driver chip to reduce weight
- Build multiple adjustment mechanisms that can be synced up to feedback system such as photogrammetry camera to adjust representative reflector surface
- Replace stepper motors with higher resolution alternatives (More than 24 steps per revolution)
- For our project, the string potentiometers should be replaced with spring loaded linear variable differential transformers (LVDTs) to provide higher resolution for measurement

Spare Parts

This section is a list of recommended parts that should be set aside to ensure quick repair if any component in the mechanism or testing structure should fail.

- Faulhaber 1524 stepper motor
- 4-40 all thread rod milled on top and bottom
- SN744510 motor driver chip
- Arduino Nano
- 6V power supply
- Celesco M150 string potentiometer
- M2 set screws
- Gears/pinions