TYR 7: CROSS DISCIPLINE ENGINEERING

Electrical & Mechanical Engineering

CO-AXIAL ROTARY ACTUATOR

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Abstract

The purpose of this project is to design and build a manufacturing ready system for remote control of air outlets in commercial Heat, Ventilation, and Air Conditioning (HVAC) units. This system is capable of collecting and communicating data related to HVAC, wirelessly to the cloud, through IoT. This applied research project is sponsored by an industrial partner – HVAC Manufacturing in Athens, TX. A team of undergraduate students carried out this project as their senior engineering year design project.

Concept

To design and build a rotary coaxial actuator that will have the ability to control a dual or single damping HVAC terminal unit, allowing for a greater overall control of air flow. In addition, a secondary focus will be to integrate IoT (Internet of Things) connectivity to allow for wireless monitoring.

Background

Currently there are no rotary co-axial actuators available for this type of HVAC dual damper

However, on the market the following does exist:

- Rotary actuator
  - Applicable for single blade damper design **only**
  - Incremental movements are not accurate
  - No IoT integration
- Linear coaxial actuator
  - Available for a dual damper design
  - Linear motion to rotary motion is problematic
  - Incremental movements are not accurate
  - No IoT integration

Customer Initial Requirements

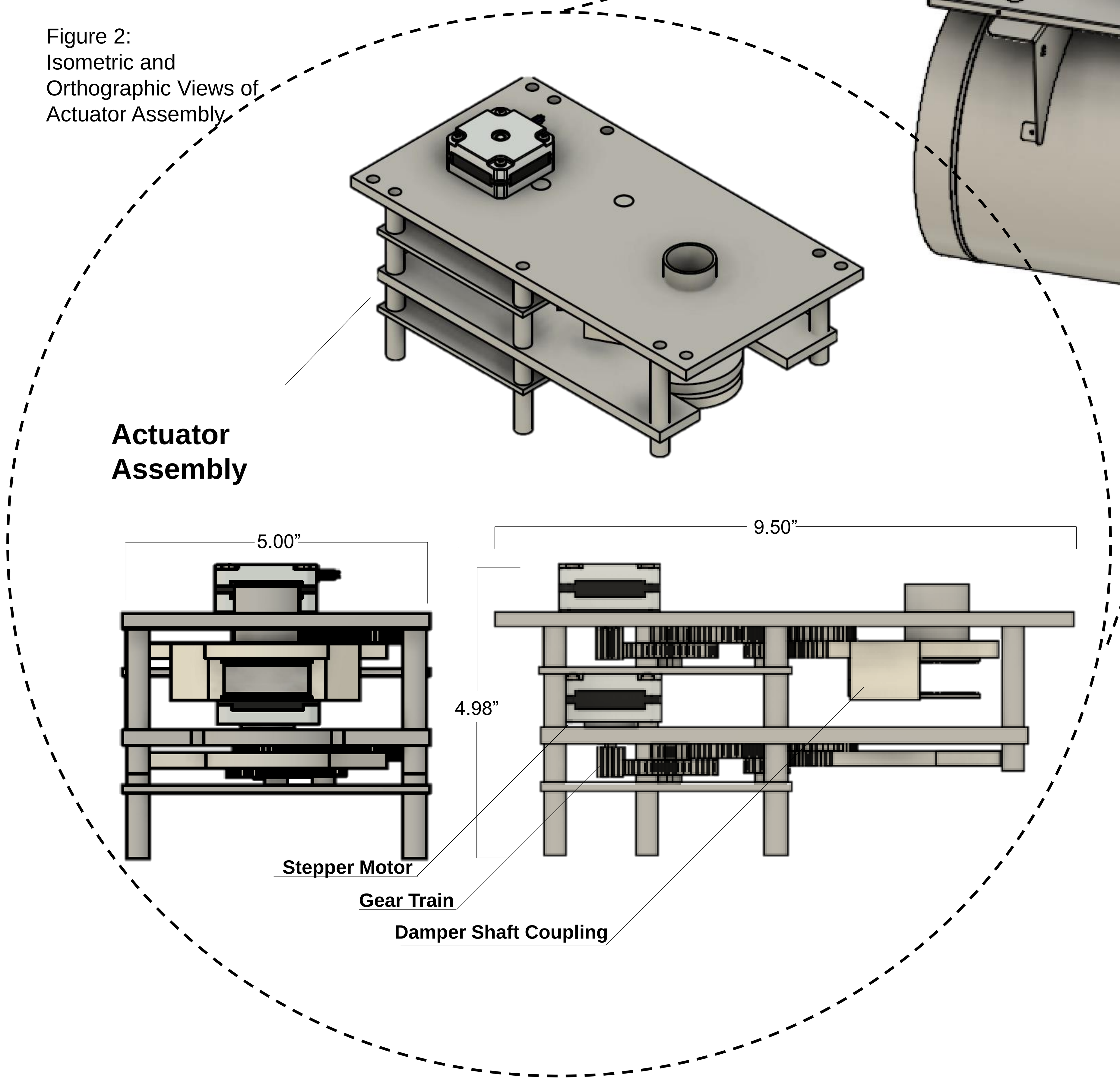
Mechanical requirements

- Motor assembly must be universal to single and dual damper applications
- Fits within a L19"xW9.0"xH6.6" enclosure
- Minimal noise generation
- Minimum output torque value of 55 lbs·in
- Gear lubricant must last lifetime of gear train

Electrical Requirements

- System to be powered by existing 24VAC system
- Must accept 0-10VDC input signal
- Real time tracking of dampers for feedback
- Reset button to bring motors to "home" position

Figure 2: Isometric and Orthographic Views of Actuator Assembly



Final Specifications

- Actuator dimensions – L9.50"xW5.00"xH4.98"
- Gear ratio – 1:180
- Compounded spur gears
- PCB dimensions – L6.00"xW3.50"
- Electrically driven by stepper motors.
- Resolution of damper shaft – 0.5 °
- Electrical step size - 0.05 volts (200 steps)
- IoT capable

Figure 1: Damper Unit

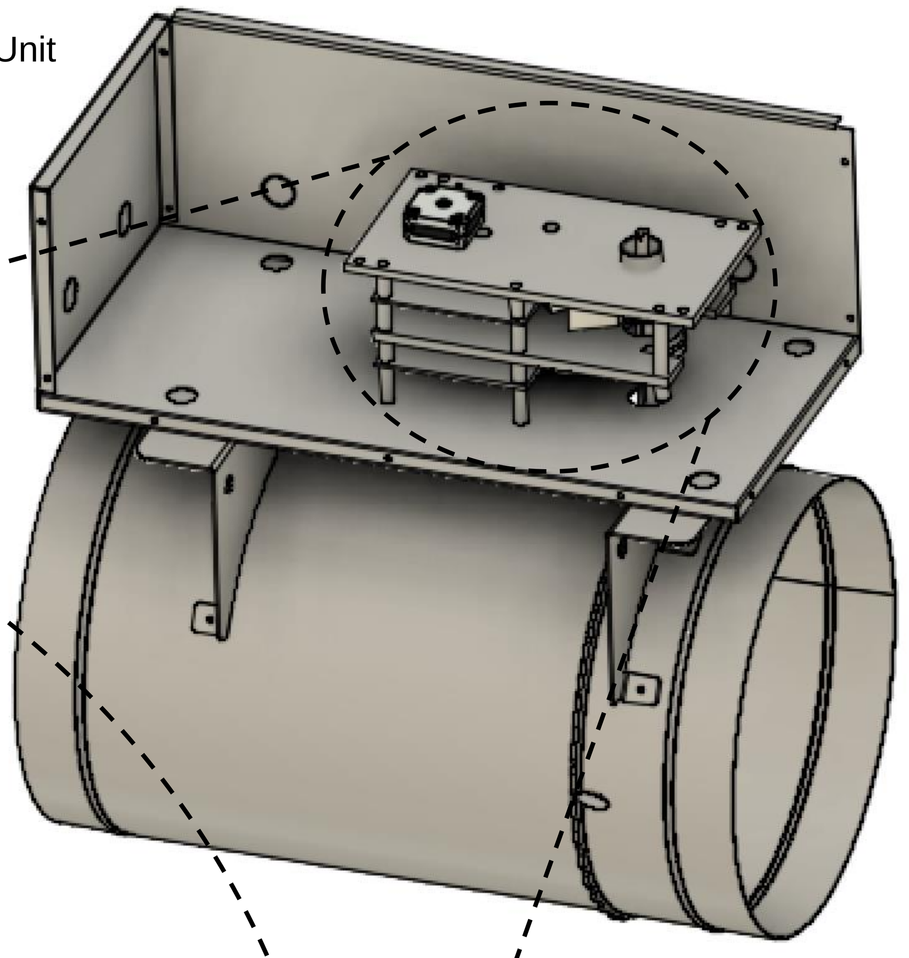
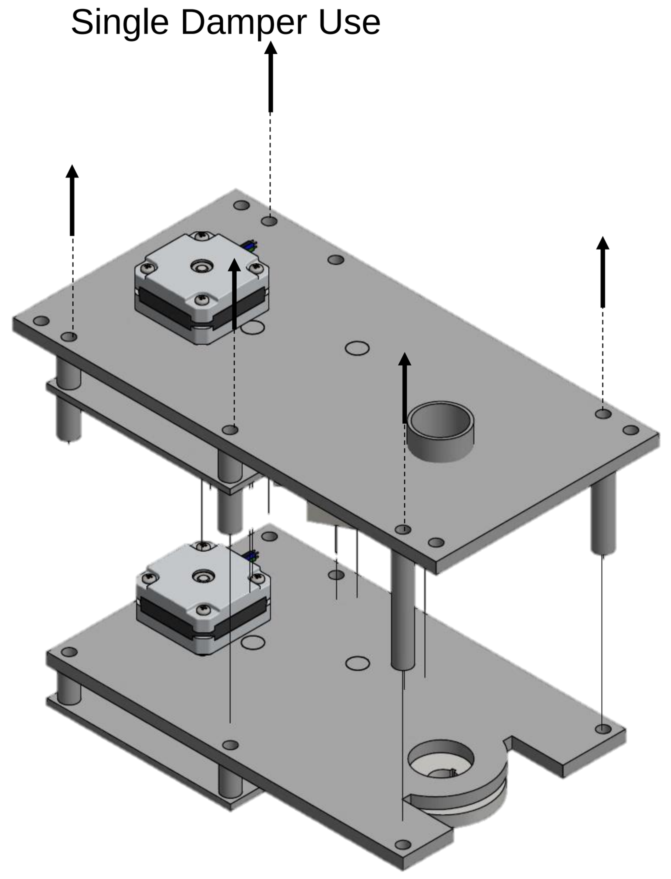


Figure 3: Breakdown Showing Removable Assembly for Single Damper Use



Electrical Design Selection

Figure 4: ESP-32

Espressif ESP-32

- Operating temperature -40°C - 85°C
- Low power consumption 3.3VDC
- WiFi capable 802.11b/g/n
  - Security – IEEE 802.11 WFA/WPA/WPA2/WAPI
- Multi-programming language capable
- 34 I/O ports

Figure 5: Stepper Motor

NEMA 17 stepper motor (stand alone)

- 1.8° step angle
- Maximum Holding toque - 1.15 lbs·in
- Maximum Pull-out torque – 1.05 lbs·in

NEMA 17 stepper motor (adapted to gear train)

- 0.2° step angle
- Maximum Holding toque – 96.6 lbs·in
- Maximum Pull-out torque – 88.2 lbs·in

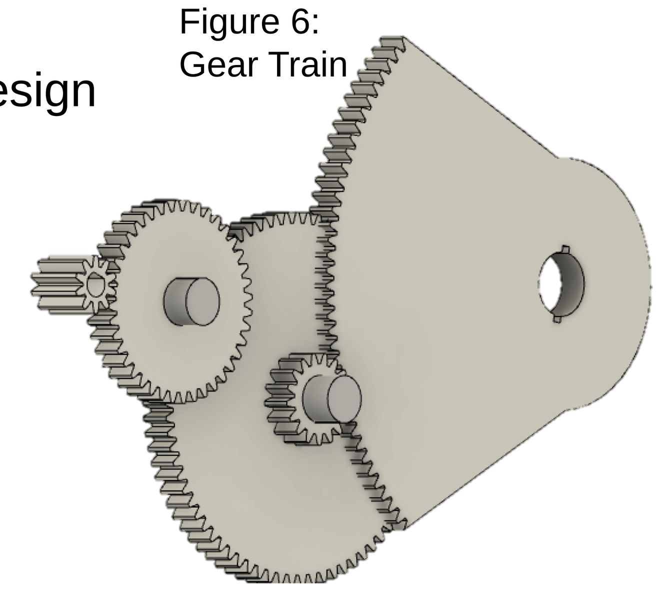
Meets desired specifications

Mechanical Gear Selection

Spur gears

- Reliable operation
- Simple and compact design
- Easy to manufacture
- Economical

Figure 6: Gear Train



Design Specs

- 105° Final gear
- 0.25" gear thickness

Material Selection

- Polylactic acid (PLA)
  - Used in prototyping gear train via 3D printing
- Acrylic Plastic (Plexiglass)
  - Used in Gear and motor housing

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