



Army Robot Tension Control System

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Overview

- Mission Objectives
- Design Requirements
- Existing Solutions
- Designs
- Chosen Design
- Concept of Operation
- MATLAB Validation
- Future Work



Mission Objective:

To design a system to integrate with the existing robotic thermoplastic applicator which actuates the feed spool in order to maintain the desired tension of the thermoplastic tape, as determined by the operator, regardless of any vibrations or orientation of the end effector



Requirements

The following requirements must be satisfied in order to accomplish the mission objective:

- Maintain Safety
- Display Tension
- Set Tension
- Control Slack
- Allow for spool replacement
- Ease of maintenance
- Cost
- Accuracy/ Precision
- Reliability



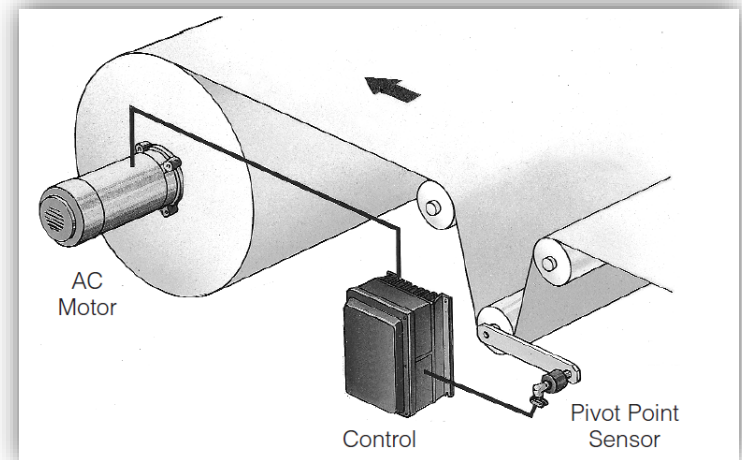
Technical Resource Budget Tracking

- Design weight must be less than 20 lbs.
- Design size is limited to $\sim 2500 \text{ in}^3$
- Voltage must not exceed 24 Volts
- Minimum Tension :1 lbs.
- Maximum Tension :50 lbs.
- Tension accuracy must be within ± 0.5 lbs.

Preliminary Research

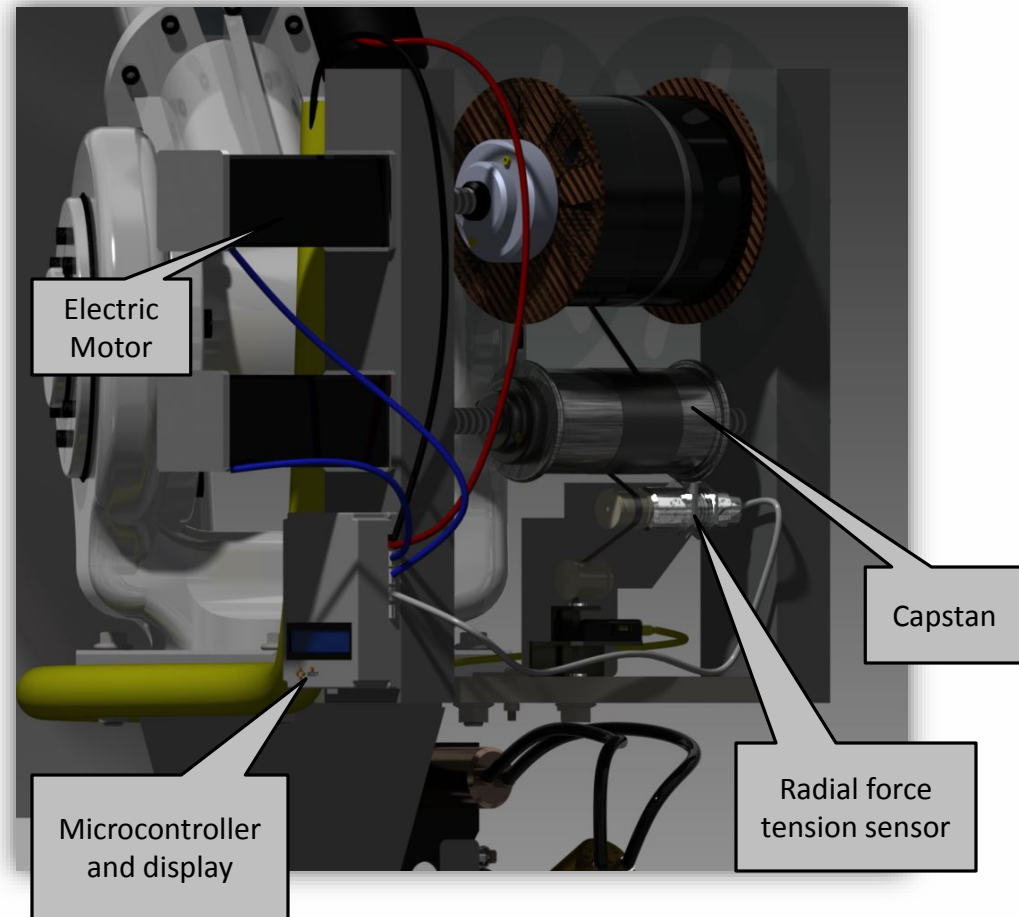
Disadvantages:

- Size
- Known input force or constant feed
- Inability to operate at different orientations



Concept 2:

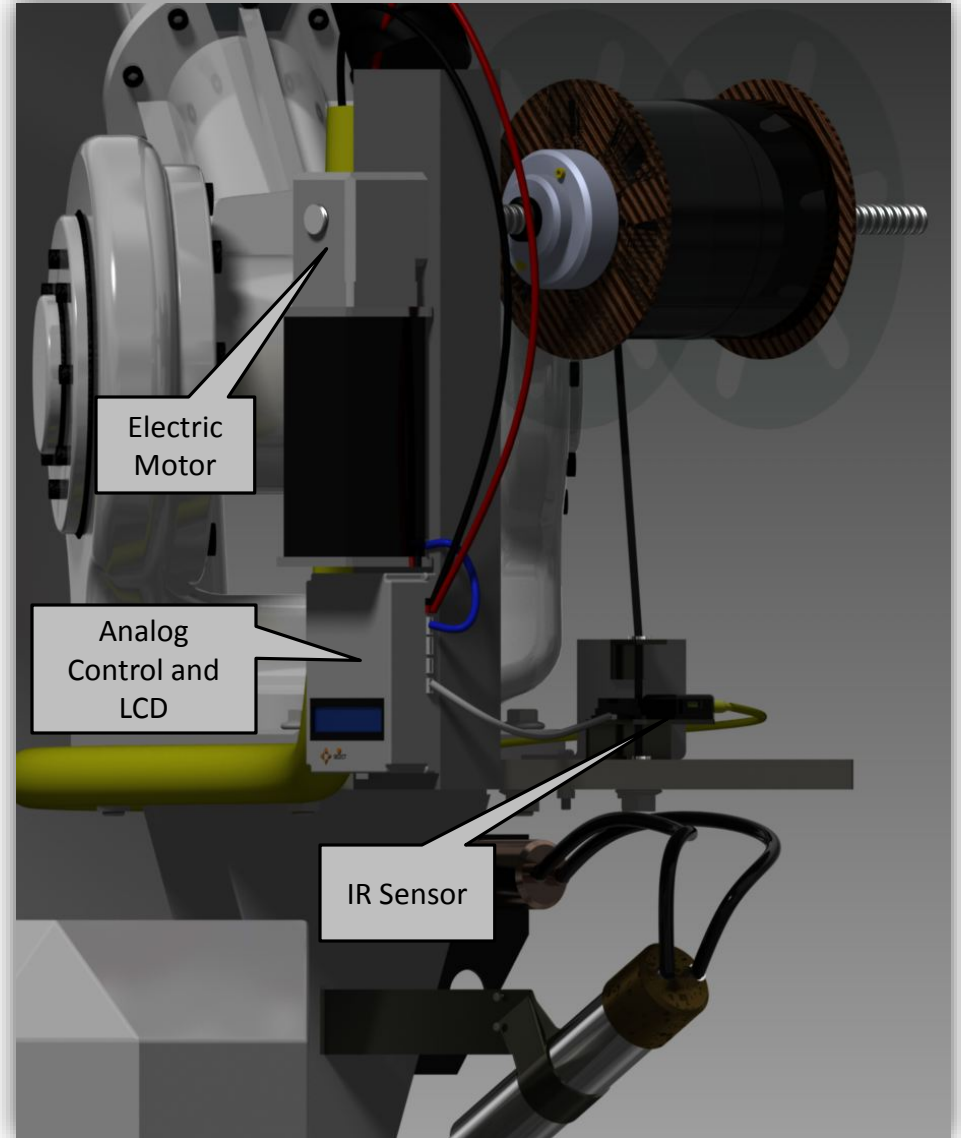
- Electric motor actuator
- Capstan to hold feed radius constant
- Radial force tension sensor for analog feedback control



Concept 4:

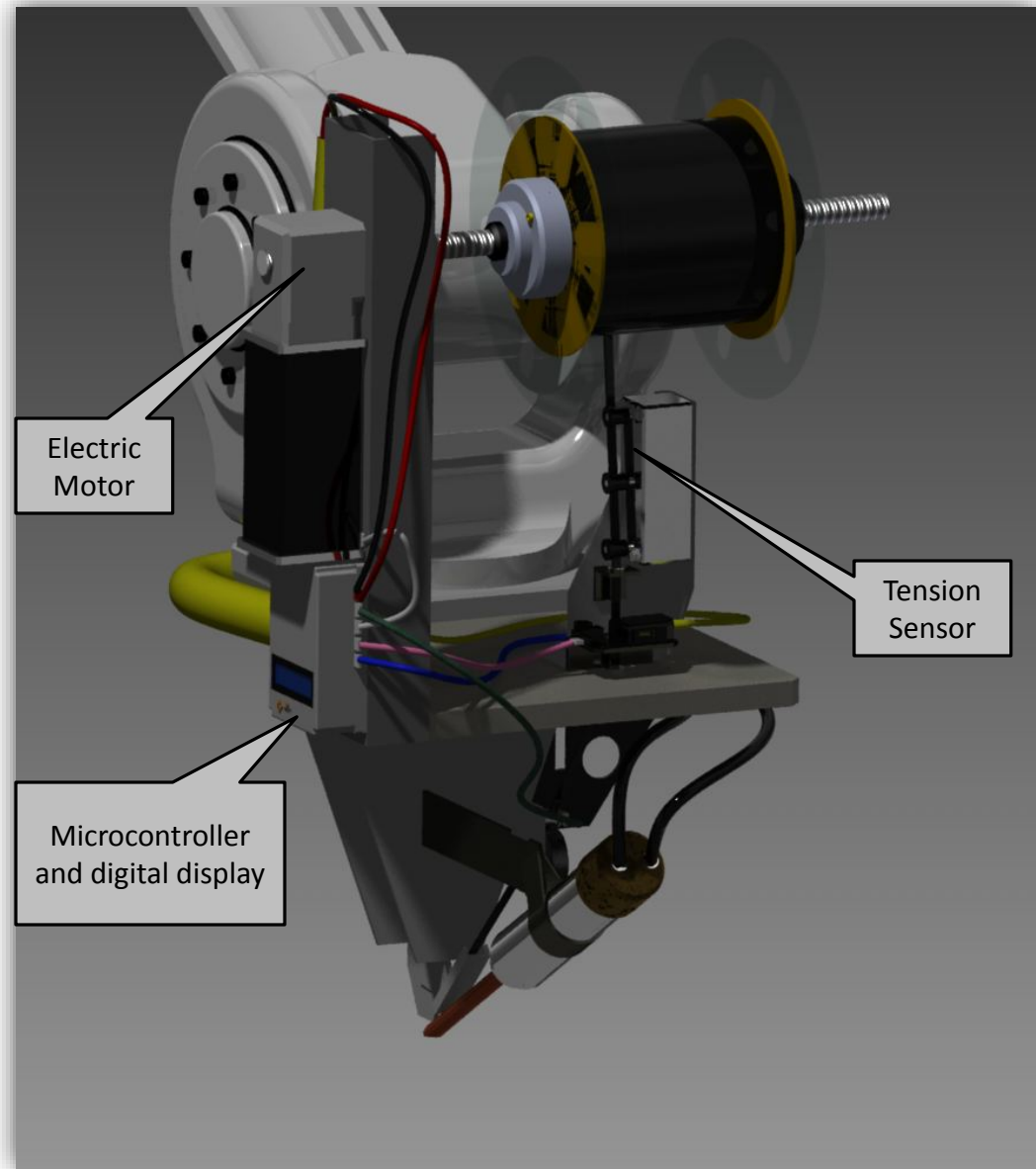
- Electric motor actuator with a built in tension control system
- Infrared depth sensor
- Open loop analog control

- Ideal for constant feed only
- No measured feedback of actual tension in tape



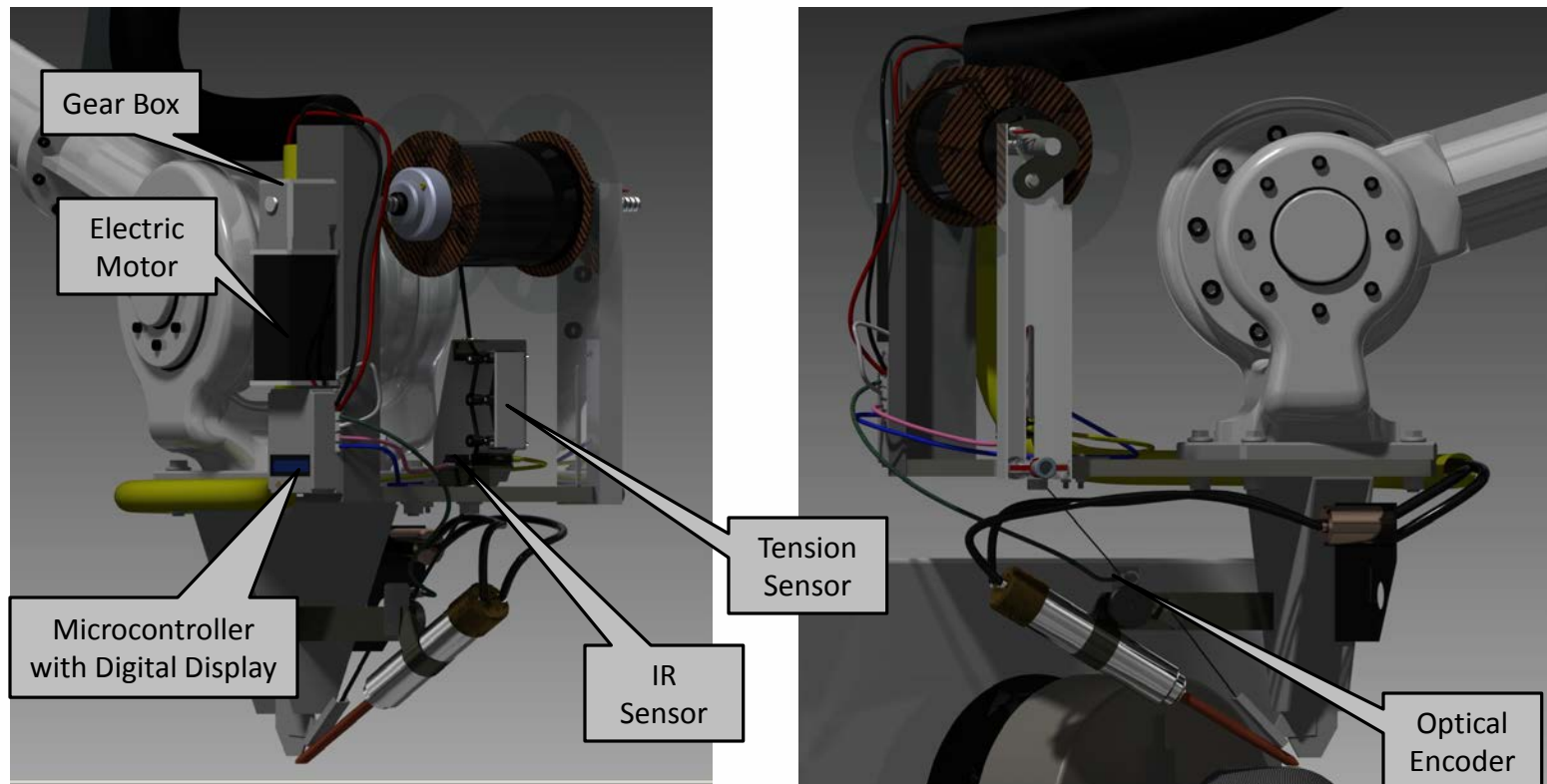
Concept 1:

- Electric motor actuator
- Infrared depth sensor
- Three spool tension sensor for feedback control
- Microcontroller with digital display



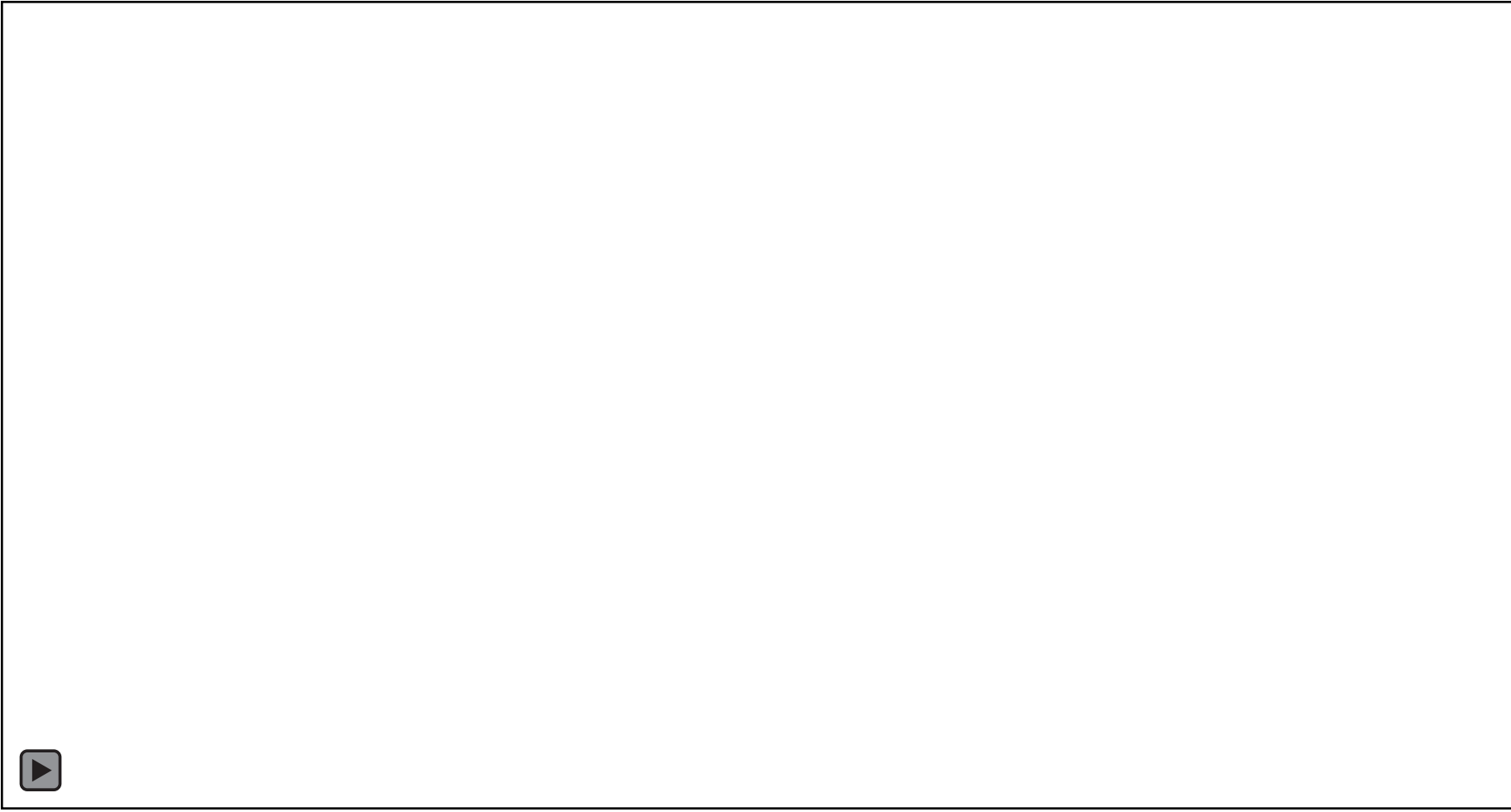
Final Conceptual Design: Modified Design 1

- Electric motor actuator
- Three spool tension sensor
- Microcontroller with digital display
- Infrared spool radius sensor
- Extra mechanical support to handle vibrations





Video



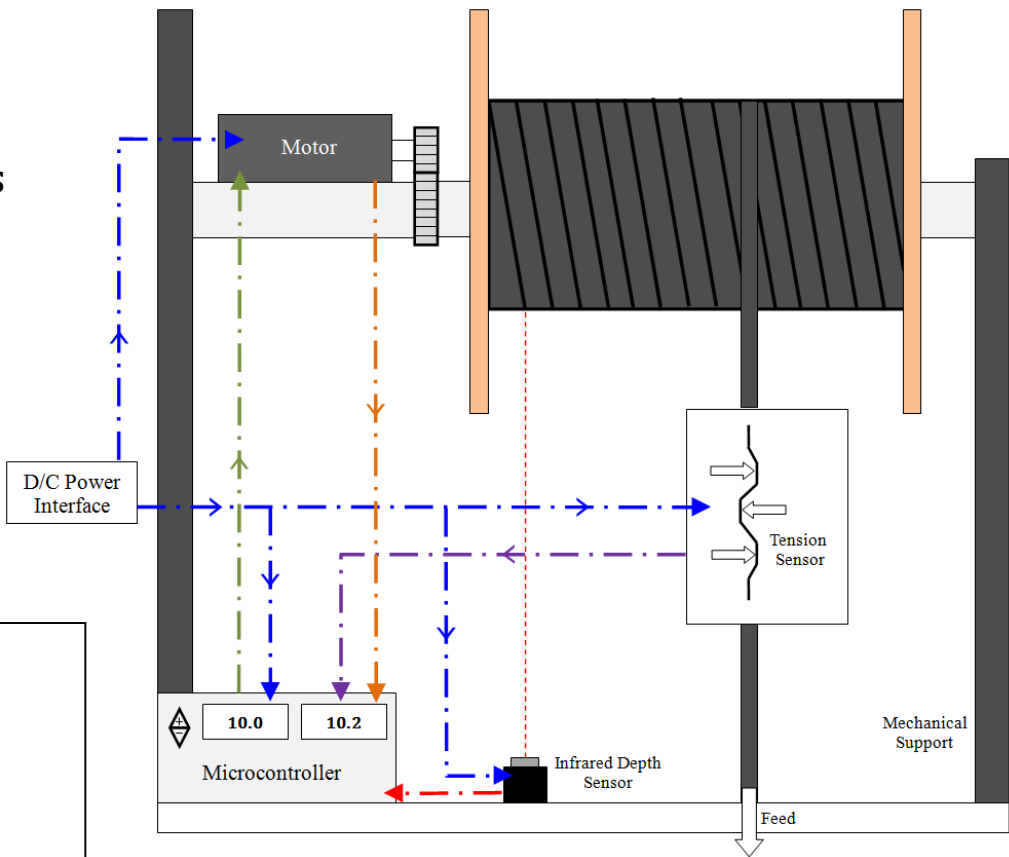


Concepts of Operation

- Load spool and tape feed
- Input desired tension
- Tension sensor sends signal to microcontroller for error calculations
- Infrared depth sensor sends value of spool radius
- Tachometer sends spool feed rate
- Microcontroller actively calculates a voltage to send to motor to actuate tension
- Safety features

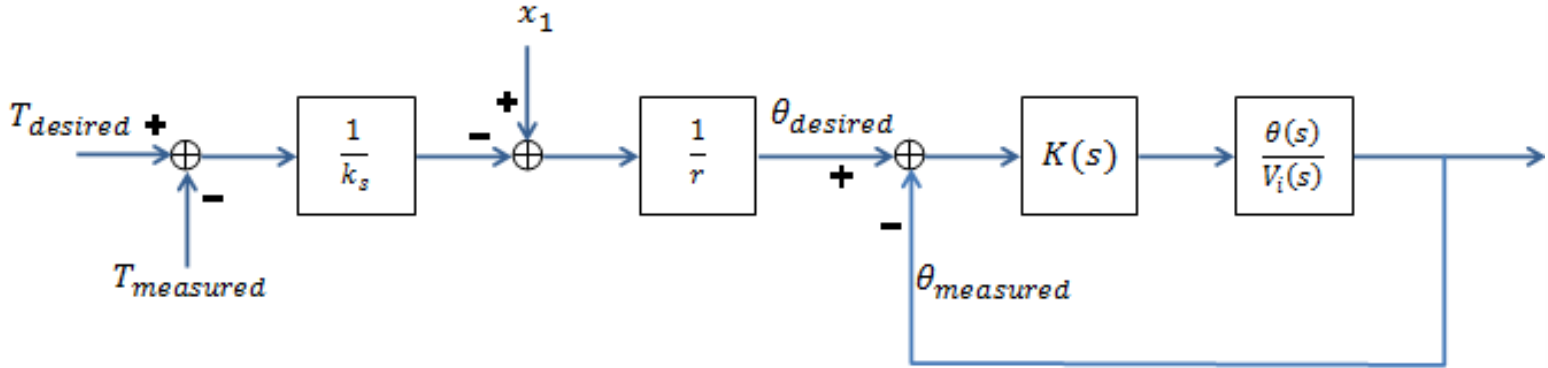
	Electric Power Distribution [Volts D/C]
	Tension Signal [lbf]
	Radius Signal [in]
	Tachometer Signal [rad]
	Control Voltage Signal [Volts D/C]

*All signals are in Volts D/C





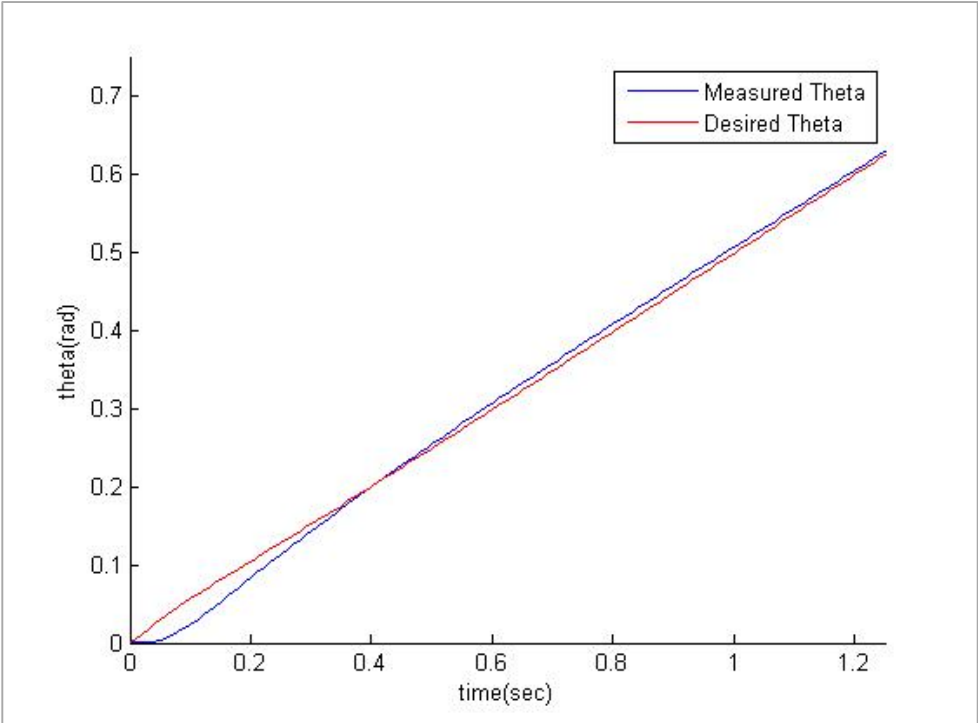
Controller Design



$$T = k(x_1 - x_2)$$

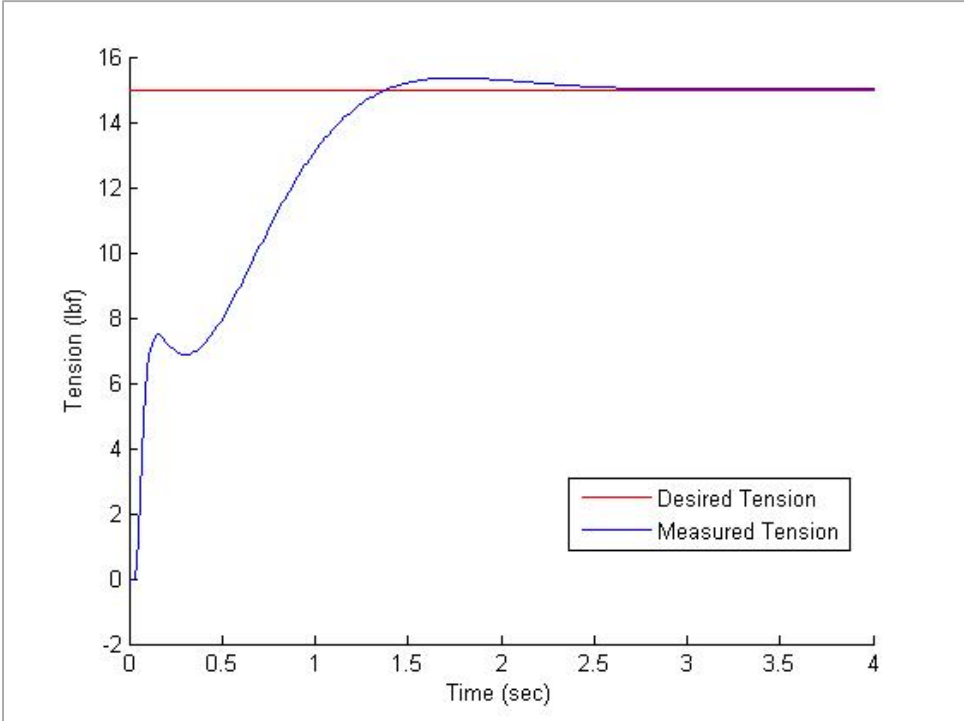


Validate and Verify

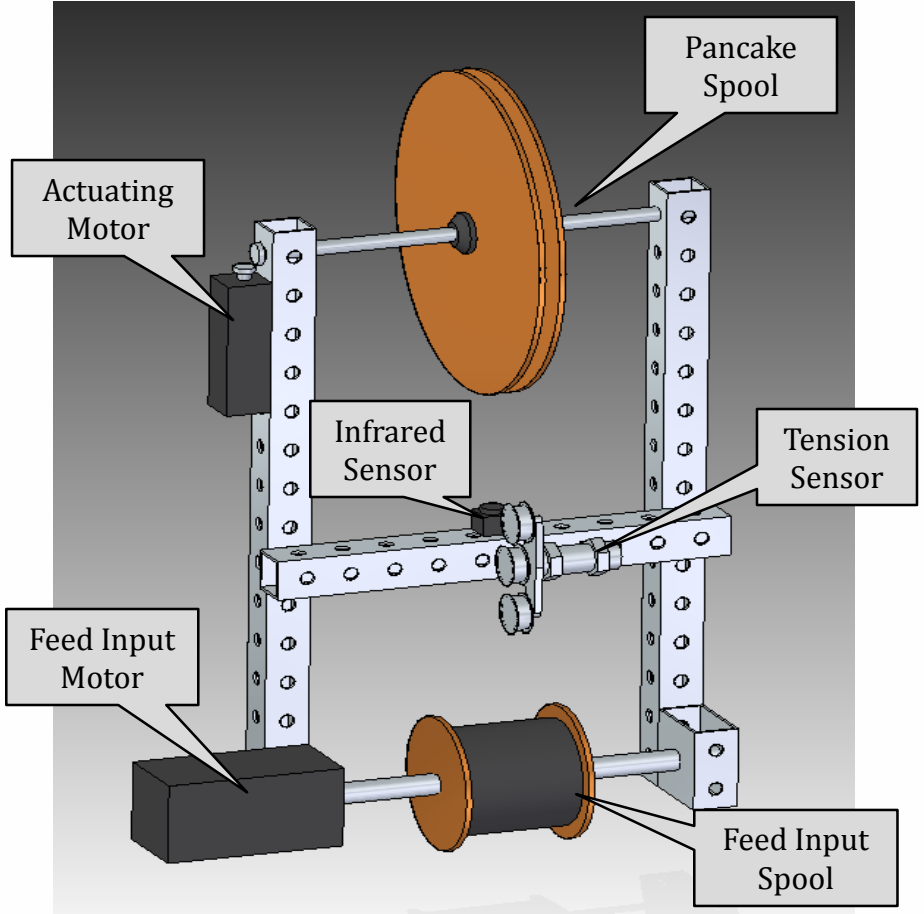




Validate and Verify



Future Testing





Bill of Materials

Part	Quantity	Cost
Arduino Mega 2560 Microcontroller	1	\$38.95
Motor and Gear Box*	1	\$1,500
Sharp IR Sensor	1	\$14.50
Sabertooth 2x25 Motor Controller	1	\$124.99
Lumex LCD	1	\$24.58
TERX Tape & Band Tension Sensor + Amplifier	1	\$1,500
Automation Direct Incremental Encoder	1	\$90.00
Test Apparatus Supplies	1	\$500.00
	Total	\$3,793.02



Recap

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