Robotic Flange Assembly

Group 18

Antonio Buda (EE)
Alana Icenroad (CpE)
Cassidy Lyons (CpE)
Viviana Gonzalez Pascual (CpE/EE)

University of Central Florida
College of Engineering & Computer Science
Opportunity Starts Here

Introduction

A Multidisciplinary Effort

- Sponsored by Siemens
- 17 Students
- Computer Engineers
- Electrical Engineers
- Mechanical Engineers
- Industrial Engineers
- Computer Science

Motivation

- Chance to work with other disciplines
- Work directly with wants and needs of customer
- Guidance that comes with a sponsored project

What is a Flange?

A flange is a pipe fitting that is often used to attach pipes carrying fluids and gases

FLANGE

The process to assemble a flange is time consuming, physically demanding, and requires careful control.

Project Goals & Objectives

- ★ Ensure accurate control is applied to every flange
- ★ Reduce the manual effort that leads to worker fatigue
- ★ Deliver consistent performance

Improve quality,
increase productivity,
and provide better workplace safety

Requirement Specifications and Standards

- Safe lifting weight for a single worker- OSHA weight limit (< 50 lbs)
- Adhere to torque sequencing patterns in accordance with ASME standards
- Apply torque in stages as to prevent damage or uneven pressure to seal
- 8” nominal pipe size - test case
- American Society of Mechanical Engineers (ASME) grade 150 PVC pipe
- Define a target torque value

Proposed Implementation

- Two robotic arms capable of working together
- Carousel arrangement to serve as the platform
- Tighten threaded fasteners to the specified torque in a programmed sequence

Design Approach

Pros

- ★ Pre assembled
- ★ Immediate Testing
- ★ Sponsor requested

Cons

- ★ Limited Mechanical Engineering involvement
- ★ Robot arms are difficult to control

Design Approach

Sawyer Chain Beveling

Design Concept Benefits

- ★ Easy set up
- ★ Simplified control

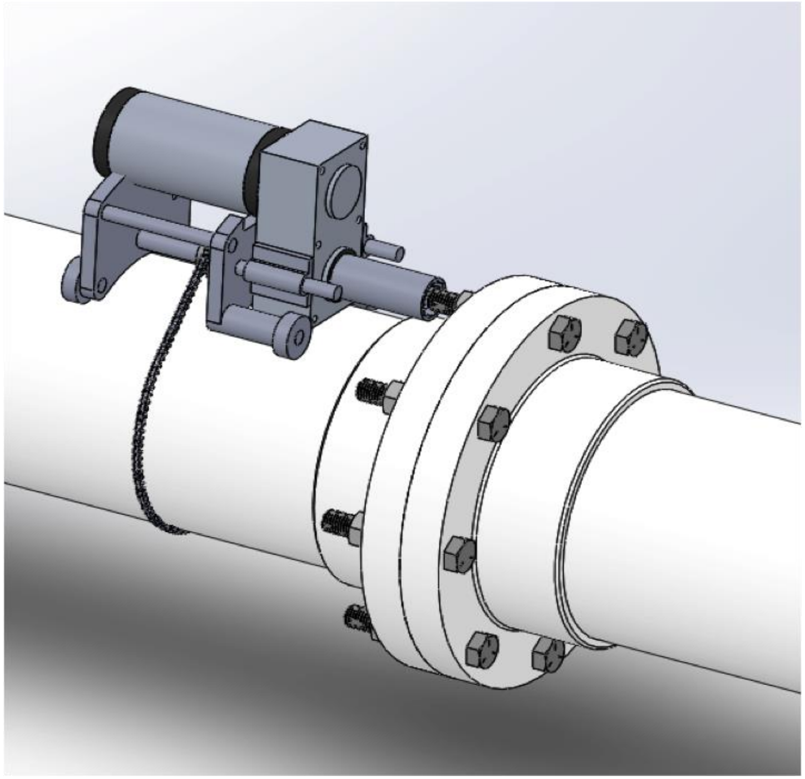
Design Concept Tradeoffs

- ★ Initially difficult to envision
- ★ Hard to test

Design Approach

COBOT

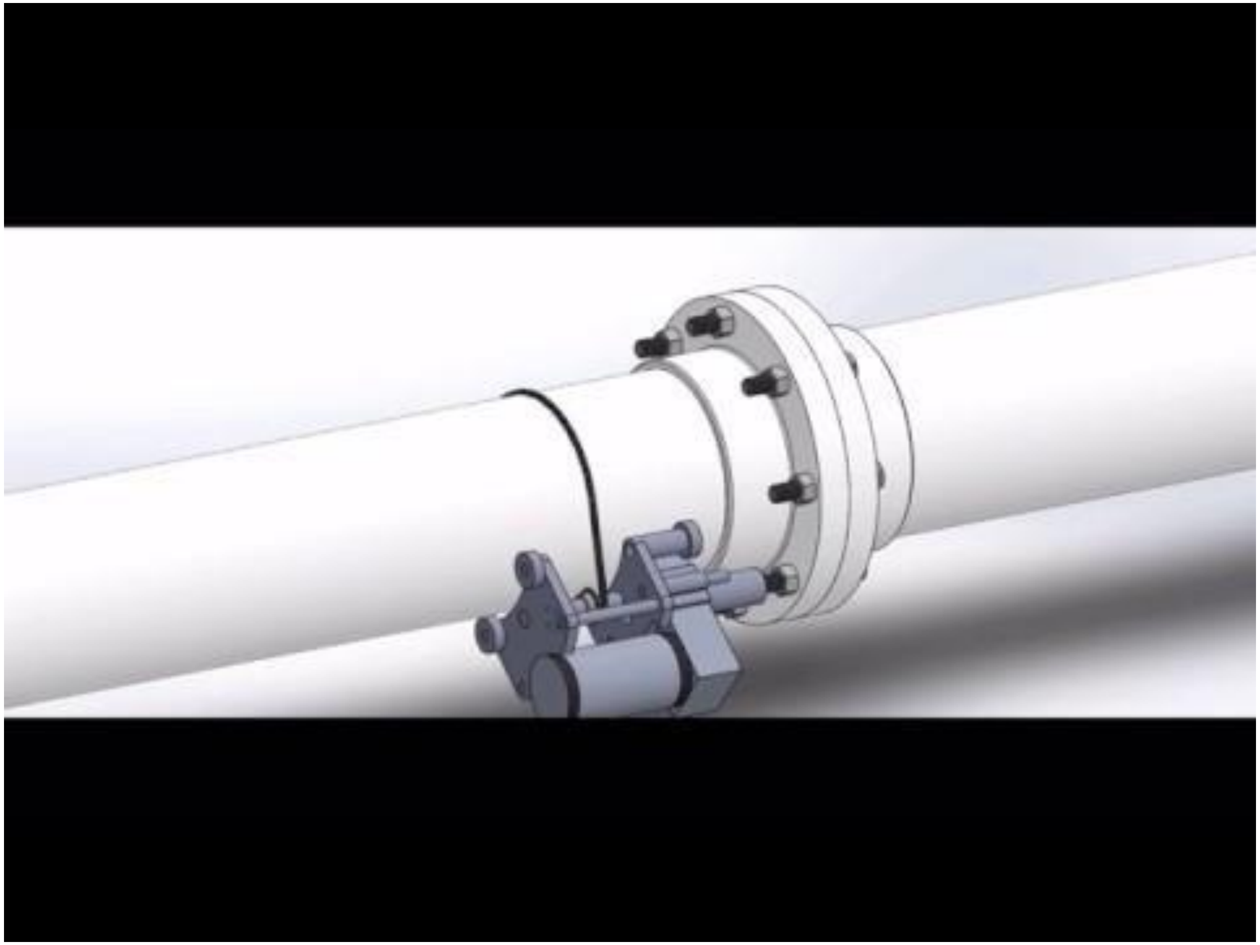
- Carriage
  - Component housing
  - Includes wheels
- Three motors
  - Carriage Drive
  - Articulation
  - Torque Drive
- Chain attachment
  - Similar to a timing belt



Project Structure

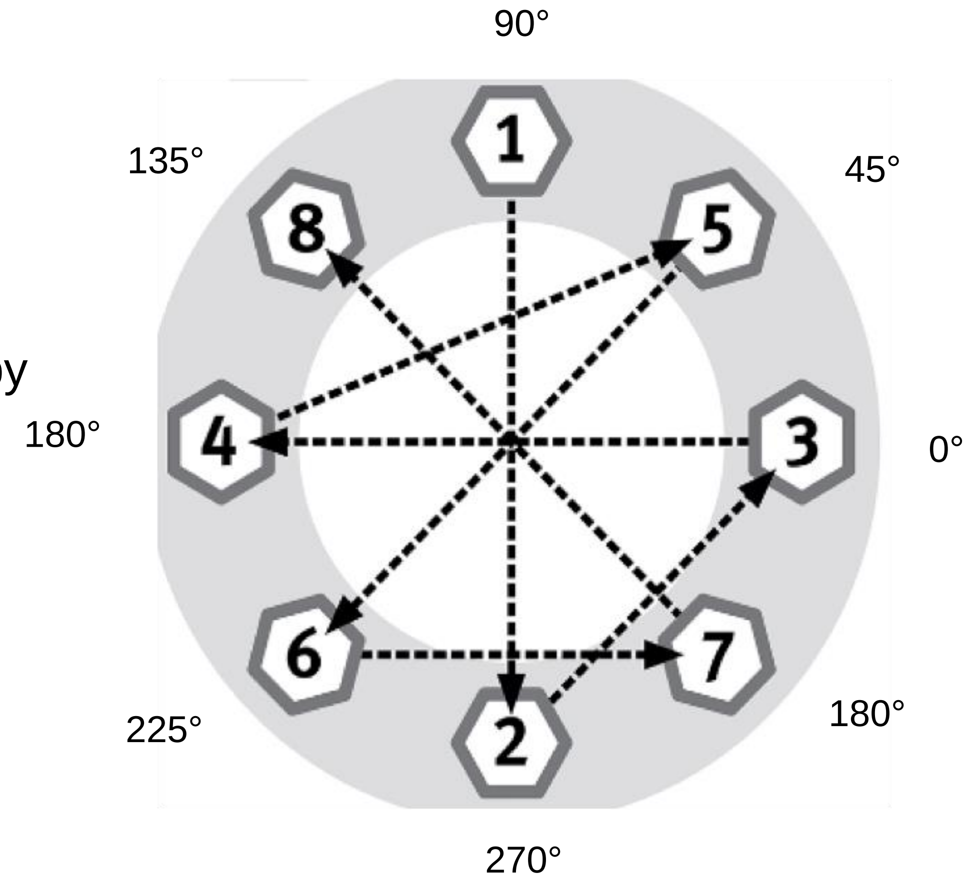
Carriage Subsystem	Articulation Subsystem	Torque Drive Subsystem
Cassidy & Viviana + 3 Mechanical Engineers	**Alana + 2 Mechanical Engineers**	**Tony + 1 Mechanical Engineer**
Step 1 Move to commanded location when told to do so	**Step 2** Engage and disengage socket with bolt	**Step 3** Apply target torque

Process



Carriage Subsystem - Objectives

- ★ Maintain a static position while tightening bolts
- ★ Withstand the torque produced by the motors
- ★ Prevent slippage
- ★ Move to bolts in order of ASME torque sequencing pattern



Carriage Subsystem - Motor

Specification	Bison Gear & Motor	Milwaukee Power Drill
Operating Voltage:	90V	18V
No Load RPM:	6.5*	0 - 400 / 0 - 1,800
Torque:	40 ft-lbs	40 ft-lbs
Battery:	-	18V Li-Ion
Weight:	10 lbs	2.9 lbs
Cost:	$456.07	$119.00

Purpose:
Selected for it's lightweight capability to provide the power and stability necessary to move the COBOT around the pipe

Bison Gear Motor

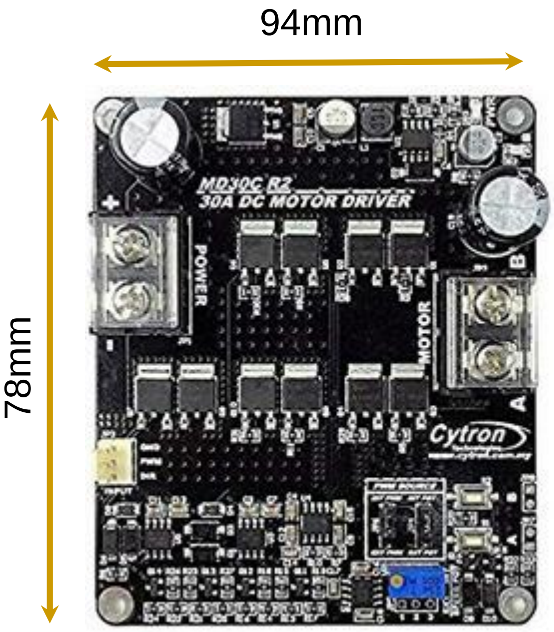
M18 2606-20

Carriage Subsystem - Motor Driver

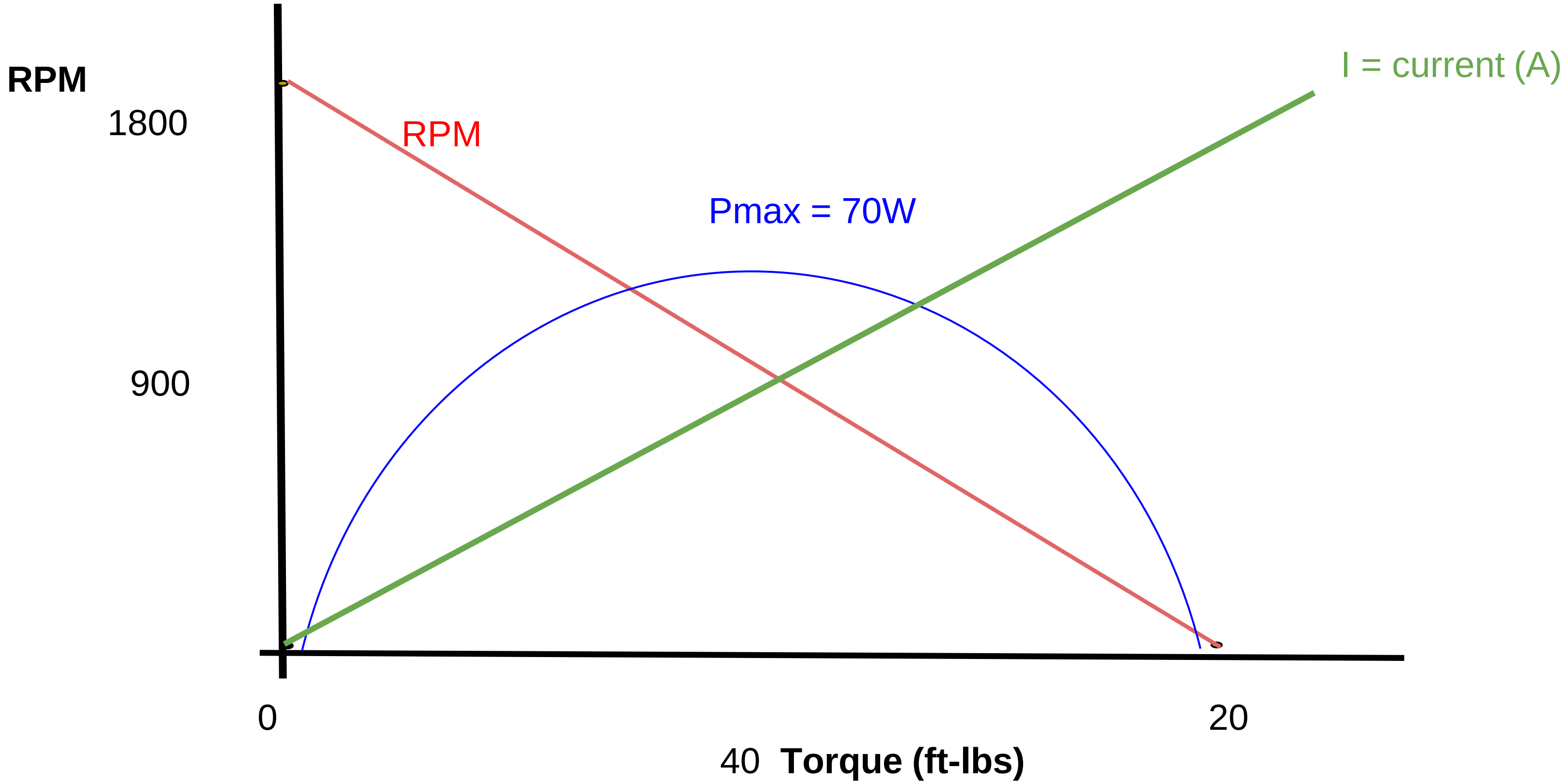
Cytron Brushed DC Motor Driver	**Specification**
Motor Voltage Support:	5V - 30V
Max Current:	80A (peak) 30A (continuous)
Additions:	Reverse Polarity Protection PWM Generator
Cost:	$35.00

Purpose:

To drive 18V Motor



No load Speed Vs Torque

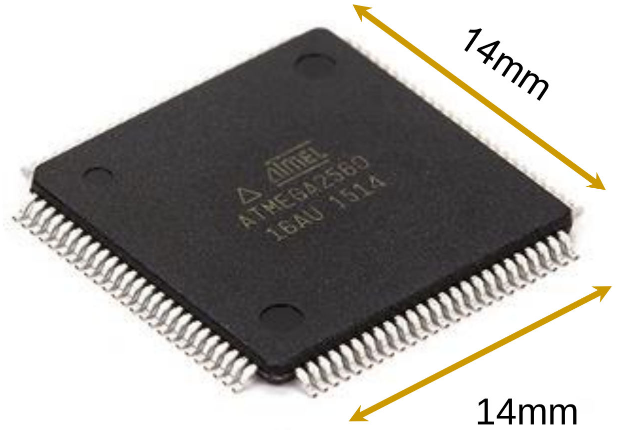


Carriage Subsystem - MCU

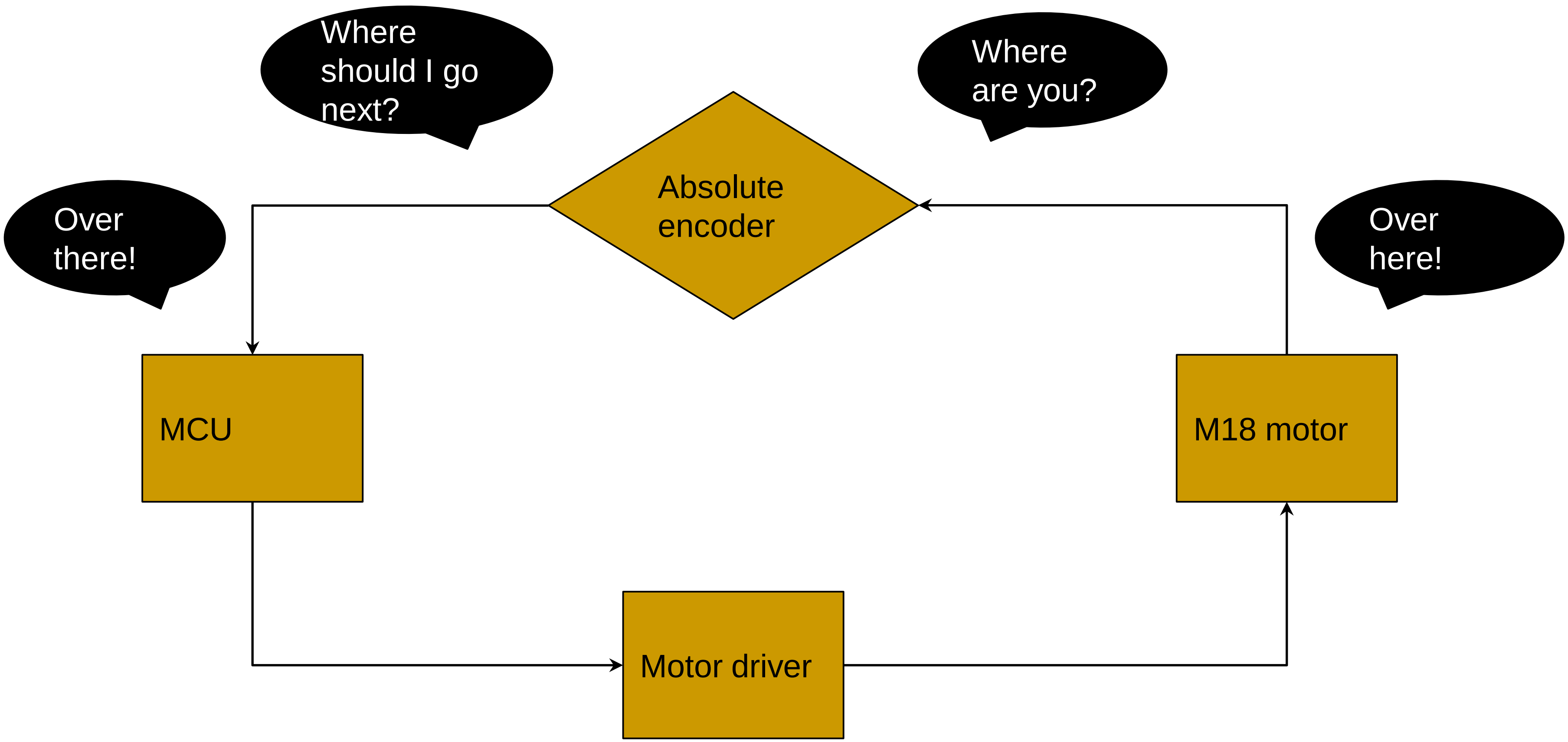
Arduino MEGA 2560	Specification
MCU	ATmega2560
Operating Voltage	5V
Digital I/O:	54 pins
Analog I/O:	16 pins
Flash Memory:	256KB
Cost:	$12.00

Purpose:

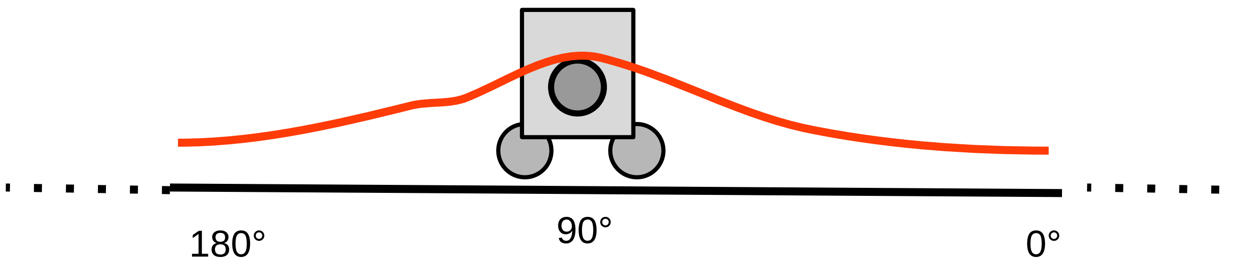
The brains of the cobot

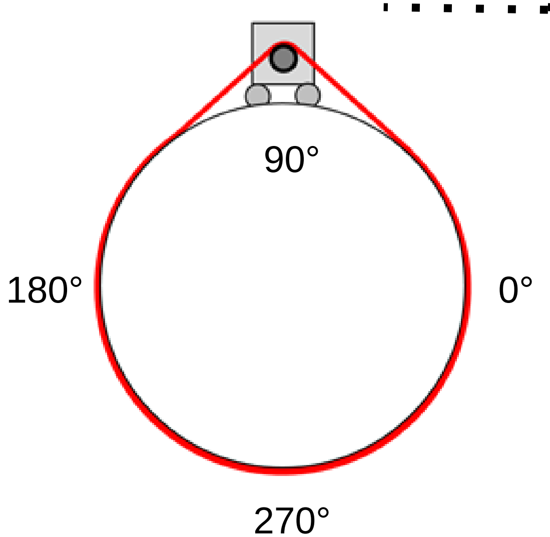


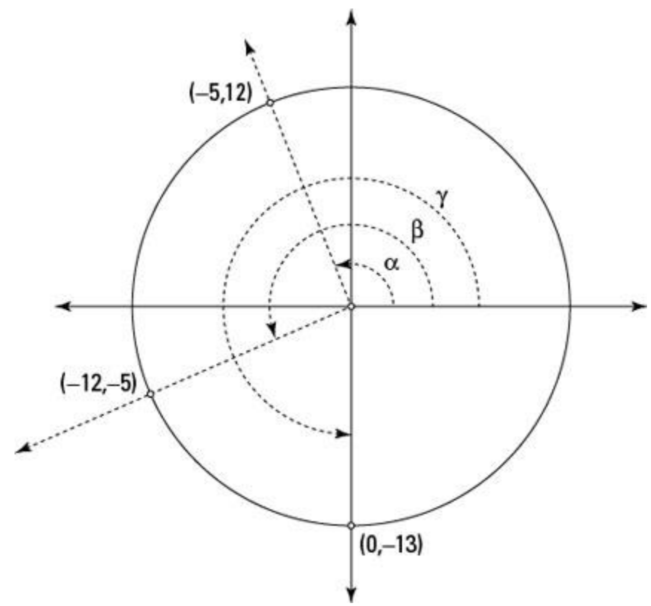
Position Control



Carriage Subsystem - Testing







Carriage Subsystem - Success/Challenges

Success

- Change in motor selection resulted in major weight reduction
- Developed test plan for all objectives

Challenges

- Change in motor selection delayed housing development
- Absolute encoder not yet selected

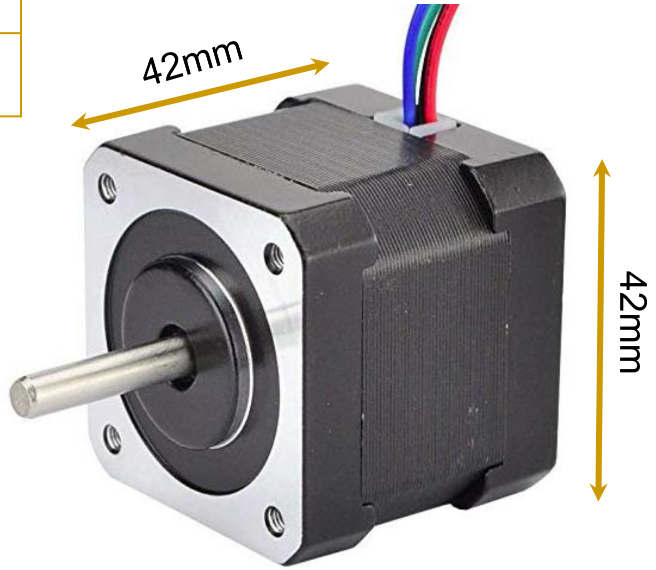
Articulation Subsystem - Objectives

- ★ Move the necessary components towards the bolt head as it is being tightened
- ★ Move components away from bolt after proper tightening has been completed

Articulation Subsystem - Motor Selection

Stepper Motor Nema 17	**Specifications**
Operating Voltage:	< 36V
Rated Current:	2A
Step Angle:	200 steps/rev
Cost:	$12.99

Purpose:
To drive the Articulation subsystem with accurate position control

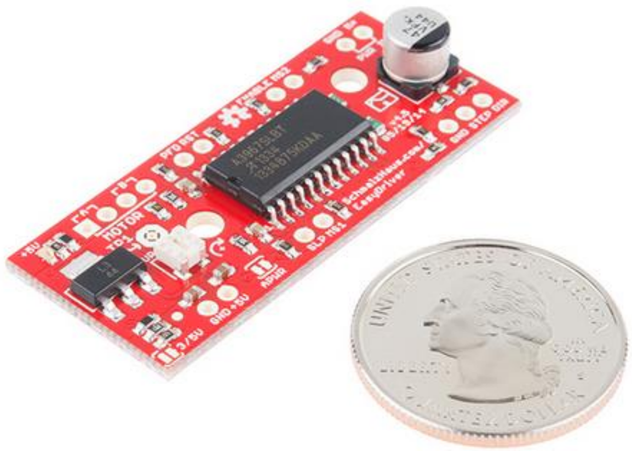


Articulation Subsystem - Motor Control

EasyDriver Stepper Motor Driver	**Specifications**
Operating Voltage:	7V - 30V
Current Control:	150mA/phase to 750mA/phase
Additions:	Voltage Regulator: 3.3V or 5V
Cost:	$16.95

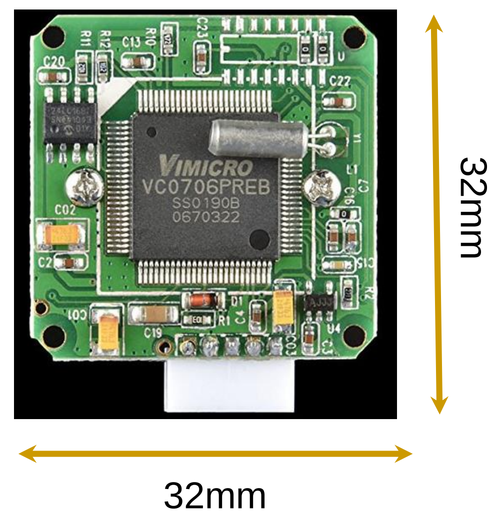
Purpose:

Stepper Motor Controller



Articulation Subsystem - Camera Module

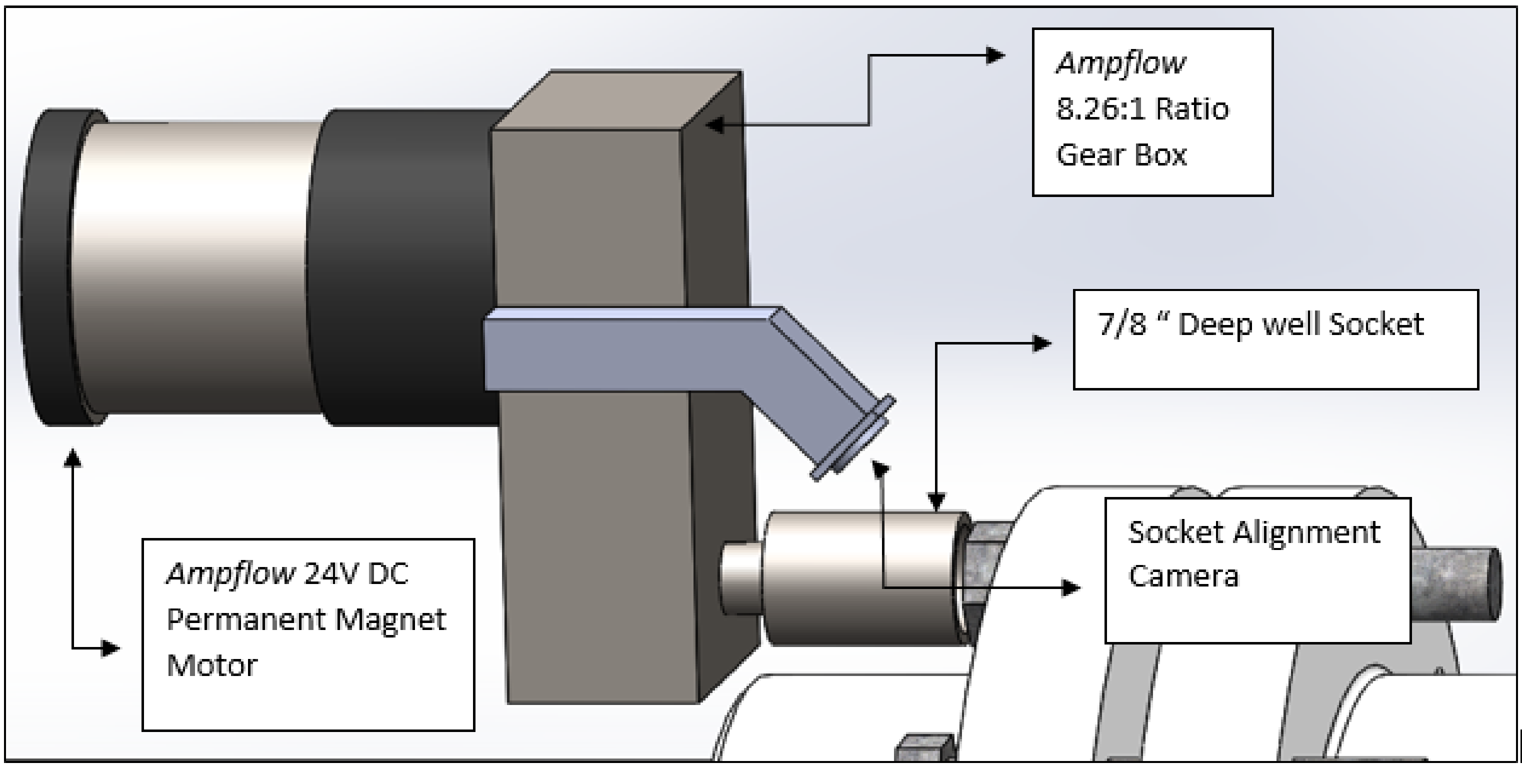
Serial JPEG Color Camera Module	**Specifications**
Module:	VC0706
Operating Voltage:	5V
Current Consumption:	75mA
Viewing Angle:	90°
Resolution:	680x480
Cost:	$35.00



Purpose:

Edge Detection Software

Articulation Subsystem



Articulation Subsystem Success/Challenges

Success

- Straight forward motor and motor controller selection

Challenges

- Little experience with edge detection software

Torque Drive Subsystem

Objectives

- Provide 40 ft lb of output torque
- 8 “ nominal pipe size
- Meter torque at specified levels such

  as 30%, 60%, 100% of specified

  torque

Torque Drive Subsystem

Class 150

Unrealistic ↑

Nominal Pipe Size	Torque FT. LB.
1/2	40
3/4	60
1	60
1 1/4	60
1 1/2	60
2	120
2 1/2	120
3	125
3 1/2	120
4	115
5	200
6	200
8	225
10	320
12	320
14	500
16	405
18	650
20	595
24	835

↓ Unrealistic

Torque Drive Subsystem

- Apply torque in stages
  - 30%
  - 60%
  - 100%
- Rotate shaft until socket is properly aligned to bolt

Torque Drive Subsystem - Success/Challenges

Success

- Test rig ready for gathering data
- Using same motor as carriage subsystem
- Change in motor selection resulted in 6 lb weight reduction

Challenges

- High cost of torque sensor
- Realizing a useful work around for sensing and controlling torque

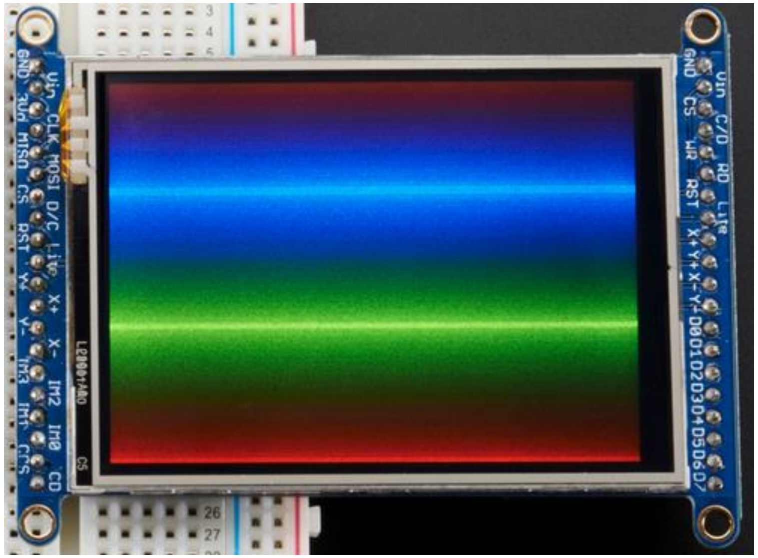
Touchscreen 2.8” LCD

By Adafruit

Specs:	
Operating Voltage:	3.3V - 5V
Current Consumption:	150mA
Interface:	8 bit digital
Pixels:	240x320
Display:	128x64
Cost:	$29.50

Purpose:

User Interface



16mm Illuminated PushButton

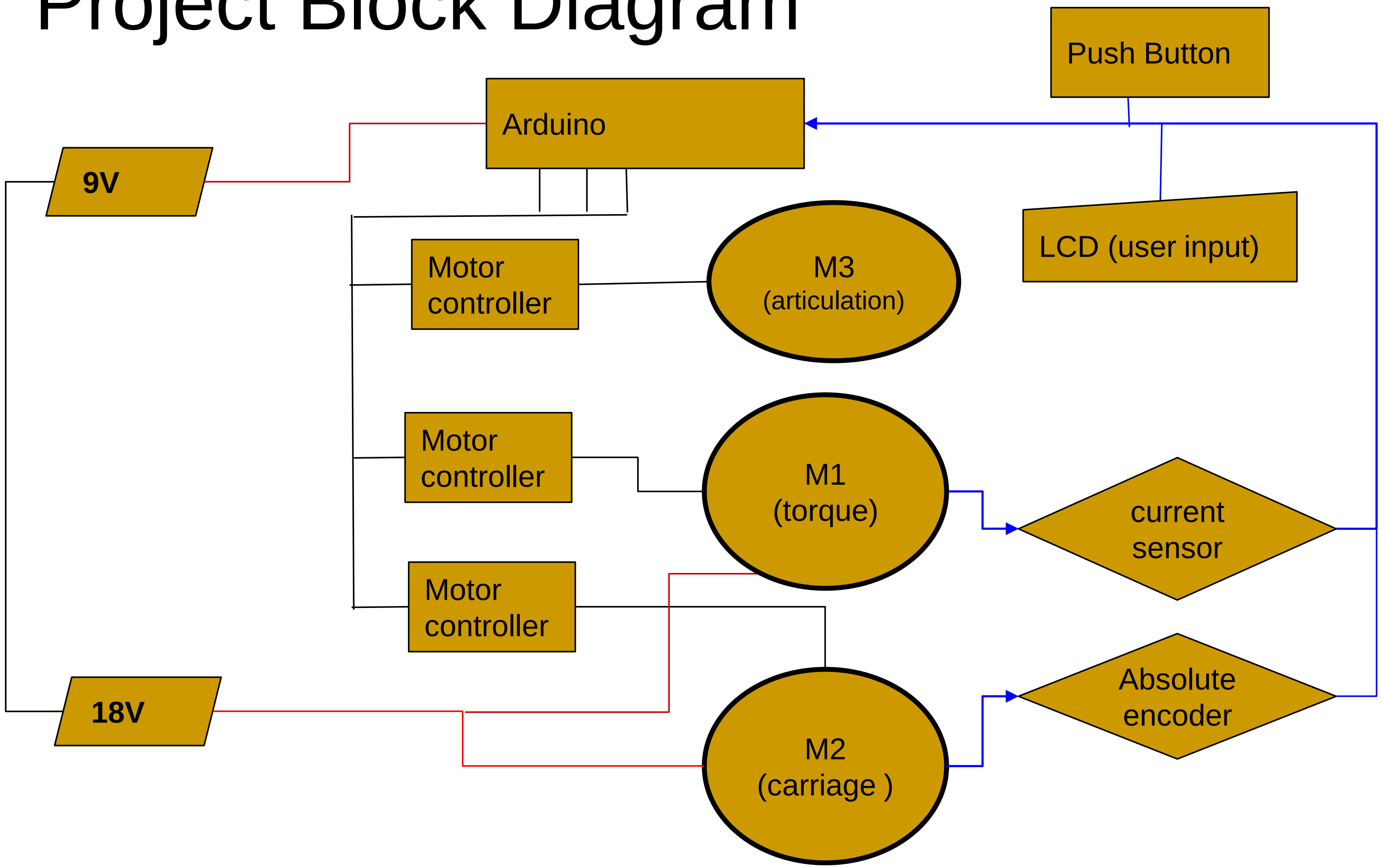
By Adafruit

Specs:	
Operating Voltage:	2.2V
Current Consumption:	75mA
Cost:	$1.50

Purpose:

Kill Switch

Project Block Diagram



Project Difficulties

- Multiple changes to motor selection
- Supplying Accurate Levels of Torque
- High cost associated with controlling and verifying torque

Bill of Materials

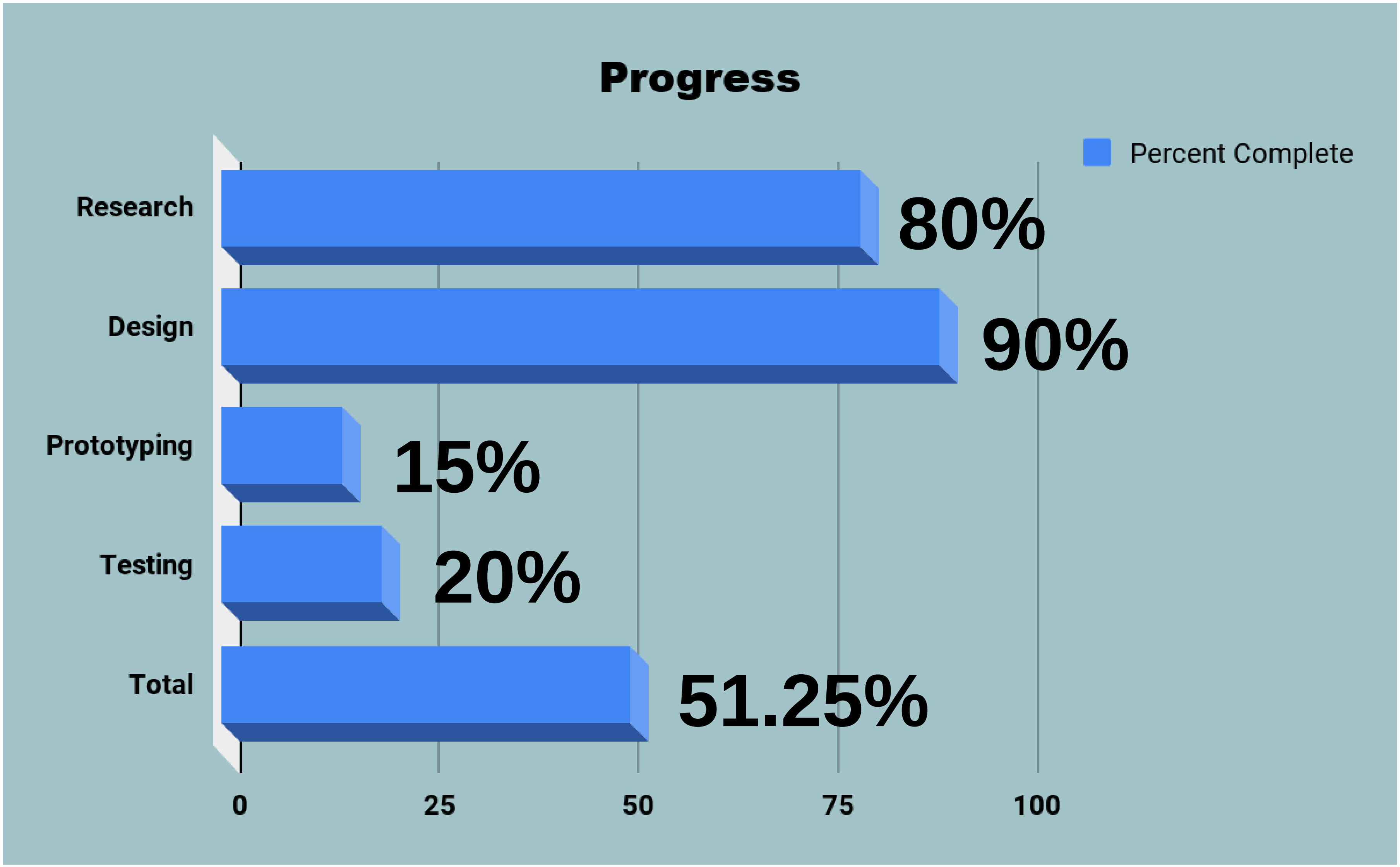
Product:	Quantity:	Total Price:
Arduino	1	$39.50
LCD Touchscreen	1	$29.95
PushButton	1	$1.50
Camera Module	1	$35.00
Milwaukee Drill Motor	2	$238.00
Cytron Motor Controller	1	$34.80
Stepper Motor Nema 17	1	$12.99
Sparkfun EasyDriver Motor Controller	1	$16.95
Total Budget: $1200		**$408.00**

Still to be Ordered...

Product:	Quantity:	Total Price:
PCB	-	$25
PCB Components	-	$10
Absolute Encoder	1	$200
Rotary Shaft Encoder	1	$50
Closed Loop Current Sensor	1	$200
Housing Materials/Components	1	$250
Misc	1	$50
Total Budget: $1200		**$1,193.00**

Current Status

- ★ Defined a target torque of 40 ft-lbs
- ★ Defined torque vs speed chart for no load case
- ★ Test plan in place for implementing torque sequencing pattern
- ★ Test plan in place for accurate speed control
- ★ Test rig built


Progress
Percent Complete
Research
Design
Prototyping
Testing
Total
80%
90%
15%
20%
51.25%
0
25
50
75
100

Immediate Plans for Successful Completion

- ★ Finalize encoder selection
- ★ Test limits of drill motor under various loads
- ★ Test logic with smaller components

Questions?

- **Securing the head of the bolt during torquing**
  - Current Concept: Annular Wrench
    - 3D printed with metal sockets embedded
    - Segmented into separate arcs
    - Light weight
    - Facilitate mounting other components