High Cycle Fatigue of Electroactive Membranes

Project Update

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Team 20:

Nicholas Dawkins

Matthew Drys

Kristina Dukes

Adriane Guettler

Victor Odewale

Advisor: Dr. Oates

Sponsors: Dr. Clark and Dr. Oates

Instructor: Dr. Gupta

Project Scope

Need Statement: There is a lack of information on the fatigue of electroactive membranes.

- Electroactive membranes are being studied for application onto robots.
- There is insufficient data on the fatigue behavior for electroactive membranes [1]
- The purpose of this project is the design and implementation of a fatigue mechanism for electroactive membranes

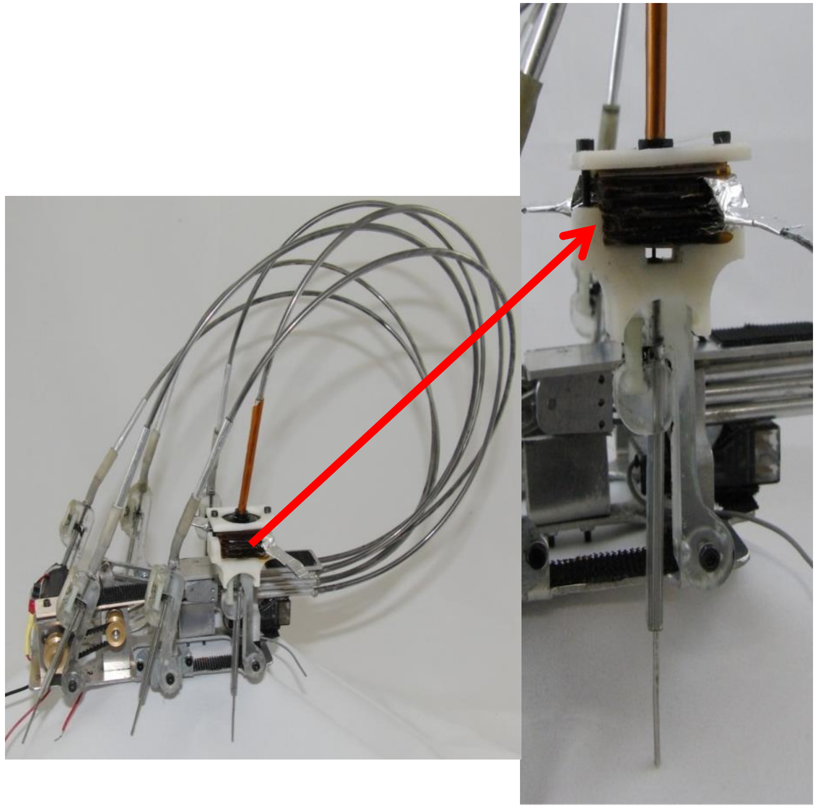


Figure 1. iSprawl Robot with VHB membrane stack[2]

[1] Oates, William and Jonathan Clark. “High Cycle Fatigue of Electroactive Membranes.” Florida A&M/Florida State University, 2014. Print.
[2] Newton, Jason. "Design And Characterization Of A Dielectric Elastomer Based Variable Stiffness Mechanism For Implementation Onto A Dynamic Running Robot." Thesis. Florida State University - College Of Engineering, 2014. Print

Project Scope

Goal Statement: Design and build a device that produces high cycle sinusoidal mechanical fatigue of electroactive membranes.

Objectives:

- Accurately measure the fatigue placed on the specimen
- Produce various frequencies of cycling
- Produce varying stroke distances to displace the membrane
- Allow for tracking of the displacements controlled by the fatigue machine
- Measure the load associated with the stroke by implementing with the MTS machine

Project Scope

Updated Constraints

- System should be a tabletop mechanism that is mounted to the MTS machine
- **Vary stroke - 2.5mm, 5mm, 7.5mm**
- Vary frequency from 0 to 25 Hz
- **Implement LVDT (Linear Variable Differential Transducer)**
- Produce consistent functionality for various specimens
- Test 1 to 5 specimens at a time
- Complete within the budget

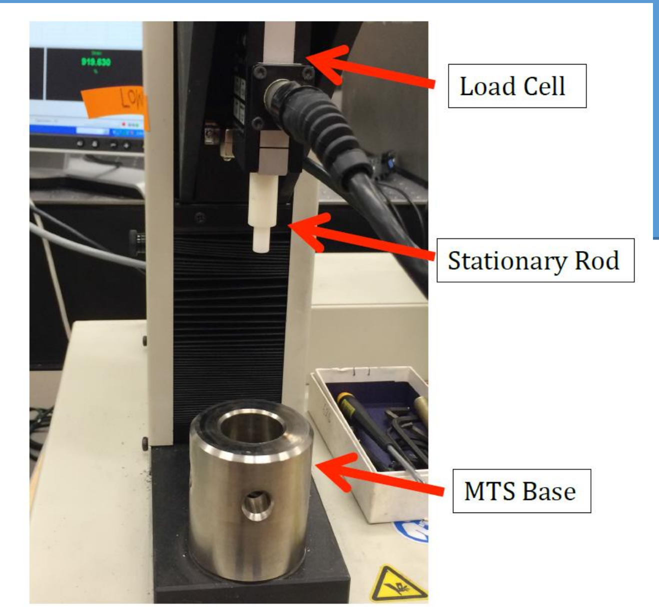


Figure 2. MTS machine

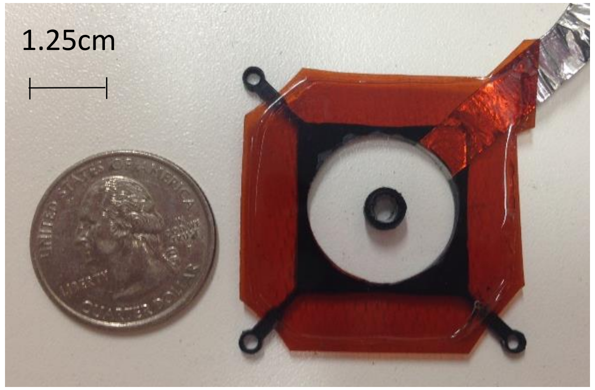
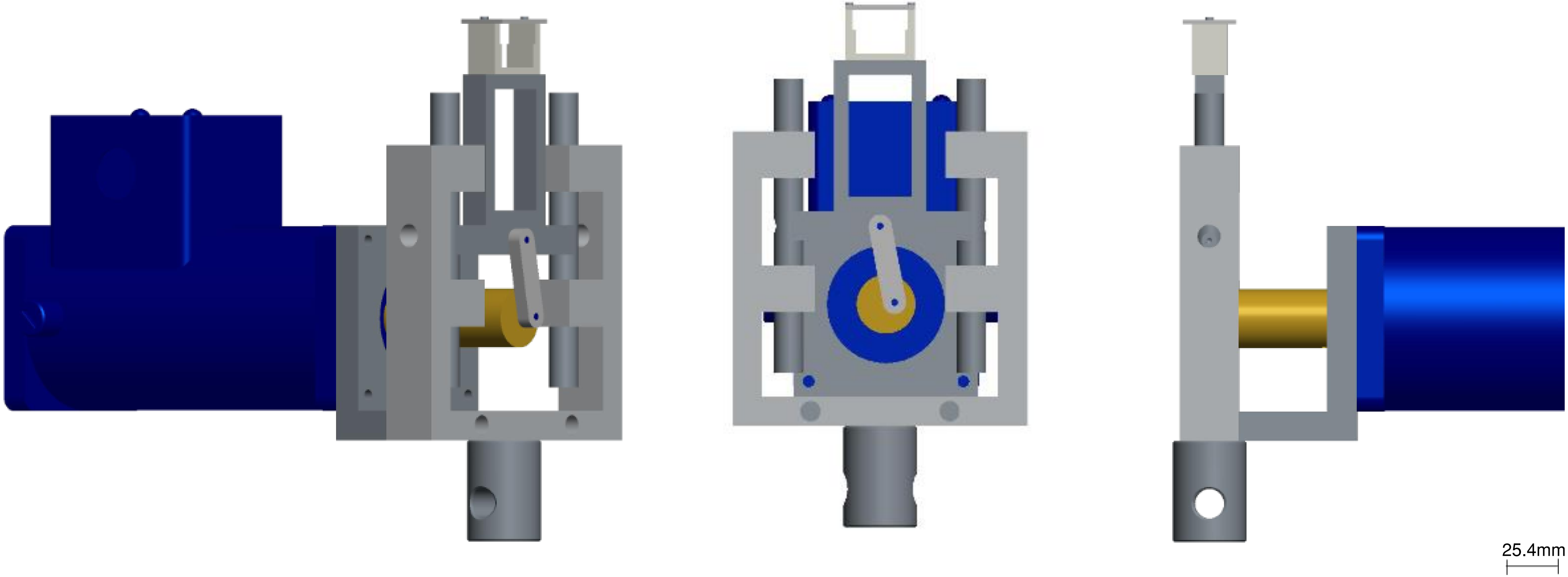


Figure 3. VHB membrane specimen

Selected Design - Crank Slider Mechanism



Approach to Assembly - Mechanical

Challenge: Easily change coupler to vary stroke distance

Spring Pins

- OD 3mm
- Length 26mm

Ball Bearings

- OD 6mm
- ID 3mm

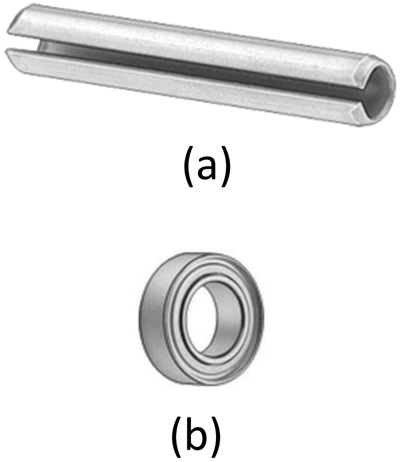


Figure 4. (a)Spring pin and (b)bearing. [3]

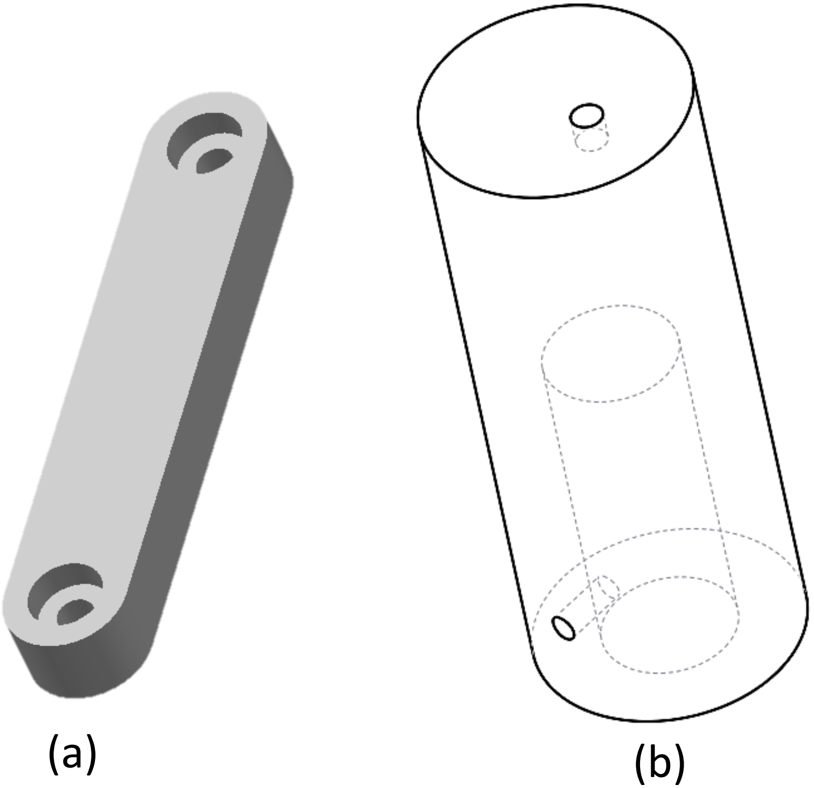
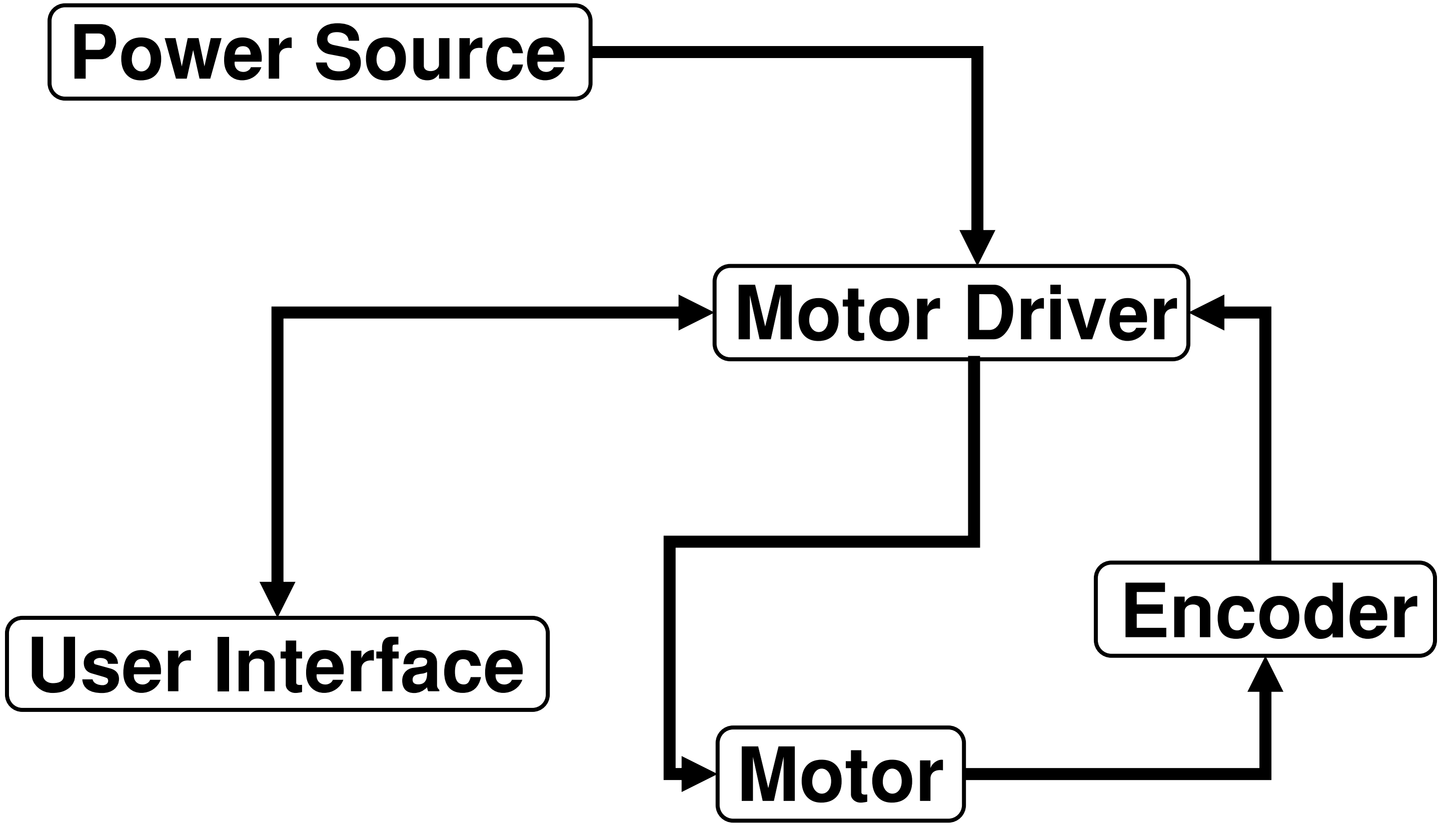


Figure 5. (a)Linkage and (b)coupler.

[3] www.mcmaster.com

Approach to Assembly - Electrical



Adriane Guettler

Prototyping

ABS Prototype

- Showed proof of concept
- Successful sinusoidal motion

Challenges

- Friction
- Alignment
- Vibration

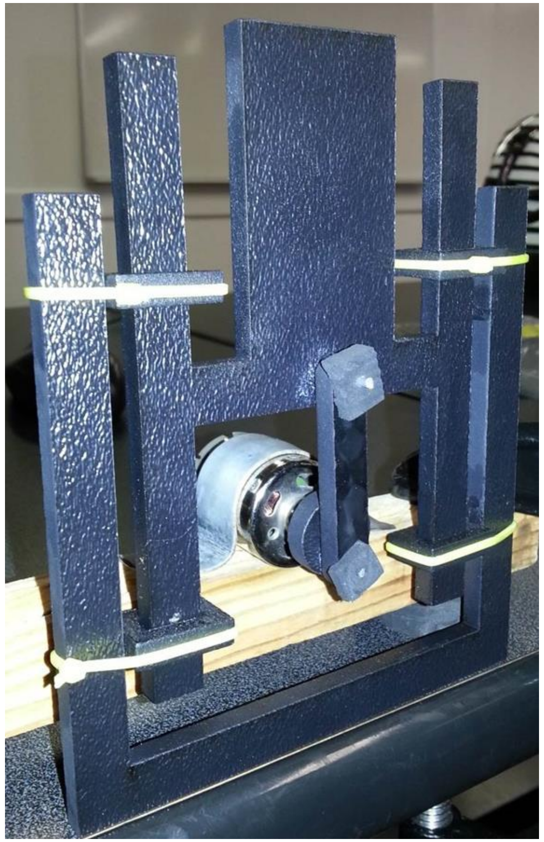


Figure 6. ABS Prototype

Updated Motor Requirements

Most Extreme Conditions

Displacement, **x = 7.5mm**

Radius, r = 3.75mm

Frequency, f = 25 Hz

Mass, **m ~ 0.5 kg**

Acceleration: $\ddot{x} = x_o \omega^2 \sin(\omega t)$

Total Force: $F = m * a = m * \ddot{x}$

Max. Allowable Force (F.S. of 2) = **185N**

Minimum Required Torque

$$Torque = F_{max} \cdot r = 185N \cdot 3.75mm$$

$$\boxed{\boldsymbol{Torque = 0.7\ N \cdot m}}$$

Minimum Required Angular Velocity

$$\omega = 2\pi \cdot f = 2\pi \cdot 25Hz \cdot \frac{60s}{1\,min} \cdot \frac{1\,rev}{2\pi}$$

$$\boxed{\omega = 1500\,rpm}$$

Selected Motor & Controller

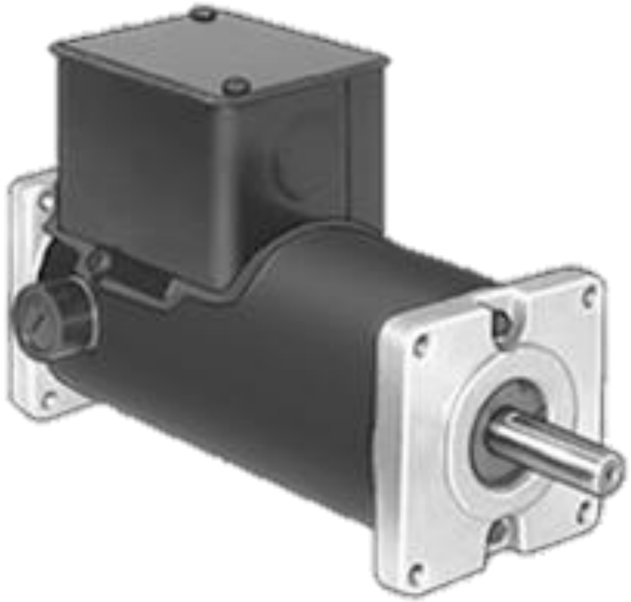


Figure 7. Compact DC Motor [3]

Figure 8. Motor Controller[4]

Compact Face Mount DC Motor

- 24V
- 13A
- 3500 rpm @ 0.72 Nm

RoboClaw Motor Controller

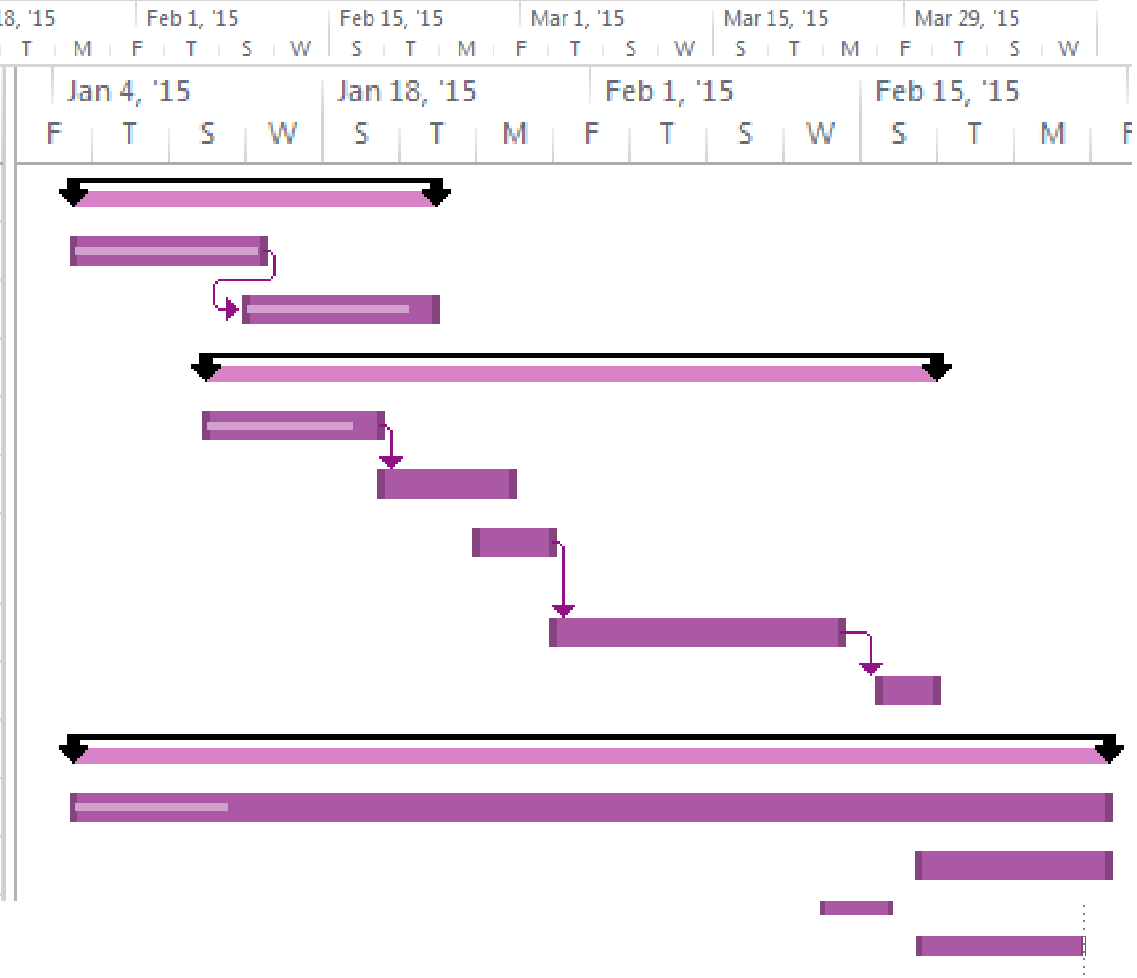
- USB or serial
- 2 channel
- 30A

[3] http://www.mcmaster.com/#59835k63/=vjpspd
[4] https://www.pololu.com/product/2393

Schedule

Task Name	Start	Finish
Material Procurement	**Mon 1/5/15**	**Fri 1/23/15**
Finalize materials list	Mon 1/5/15	Wed 1/14/15
Order materials and components	Wed 1/14/15	Fri 1/23/15
Production of Mechanism	**Mon 1/12/15**	**Wed 2/18/15**
Finalize all part drawings	Mon 1/12/15	Tue 1/20/15
Submit drawings to machine shop	Wed 1/21/15	Tue 1/27/15
Submit raw materials to shop for production - (subject to change due to	Mon 1/26/15	Thu 1/29/15
Machining and production of mechanisı	Fri 1/30/15	Fri 2/13/15
Assembly of mechanism	Mon 2/16/15	Wed 2/18/15
User Interface	**Mon 1/5/15**	**Fri 2/27/15**
Develop user interface	Mon 1/5/15	Fri 2/27/15
Integrate user interface with mechanism	Wed 2/18/15	Fri 2/27/15

Task Name	Start	Finish
Reassemble new mechanism	Mon 3/23/15	Fri 3/27/15
Implement and test redesigned mechani:	Mon 3/30/15	Fri 4/10/15



Budget & Procurement

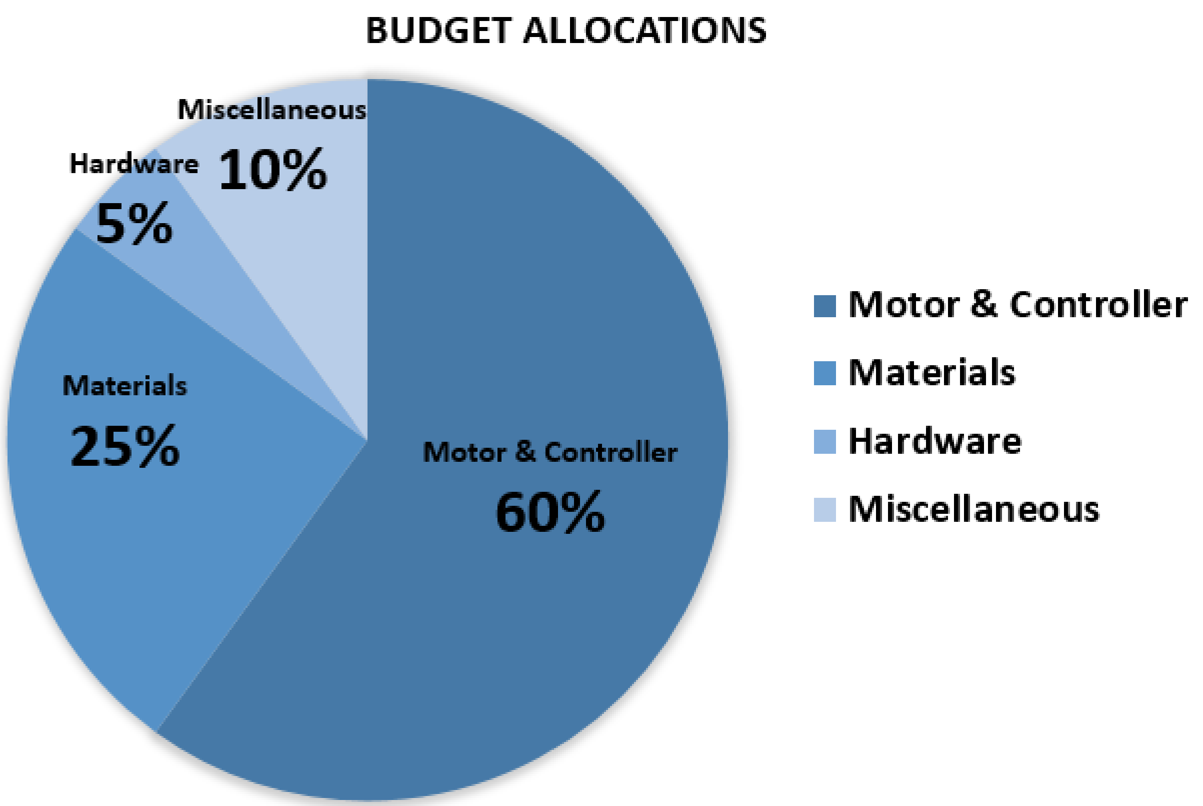


Figure 9. Pie Chart of Budget Allocation

Budget: approx. $2000

Purchasing Estimates:

- Raw Materials ~10%
- Motor & Controller ~20%
- Hardware ~30%
  - Power supply
  - LVDT
  - Encoder

Summary

Need Statement: There is a lack of information on the fatigue of electroactive membranes.

Goal Statement: Design and build a device that produces high cycle sinusoidal mechanical fatigue of electroactive membranes.

- Vary frequency - 0 to 25 Hz
- Vary stroke - 2.5mm, 5mm, 7.5mm

Mechanism Design: Crank Slider

Latest Achieved Milestone: Purchased motor and raw materials.

Key Next Step: Submit raw materials and drawings for machining.
Purchase LVDT, power supply, and encoder.

References

[1] Oates, William and Jonathan Clark. “High Cycle Fatigue of Electroactive Membranes.” Florida A&M/Florida State University, 2014. Print.

[2] Newton, Jason. "Design And Characterization Of A Dielectric Elastomer Based Variable Stiffness Mechanism For Implementation Onto A Dynamic Running Robot." Thesis. Florida State University - College Of Engineering, 2014. Print

[3] http://www.mcmaster.com/#59835k63/=vjpspd

[4] https://www.pololu.com/product/2393

Questions?

For more information visit our website:
www.eng.fsu.edu/me/senior_design/2015/team20/