Remote Euthanasia System

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Abstract

Decompression sickness is an illness that humans can get while under extreme external pressure like sailors trapped in sunken submarines under 5 atmospheres of pressure. The clients, Dr. Sobakin and Dr. Eldridge, were contracted by the Navy to determine how long humans could survive under this pressure while being rescued to evaluate the Navy's rescue protocol for sailors in a sunken submarine. The clients will be monitoring sheep in a hyperbaric chamber set to five atmospheres of pressure over the course of a 172 hour period. The sheep within the chamber have the possibility of getting decompression sickness which would cause great trauma and can ultimately lead to death. In order to prevent this traumatic end, the team has been tasked with producing a remote euthanasia system. There are commercially available syringe pumps that can serve this purpose; however, the pumps won't operate correctly under such high pressures. After careful consideration with the help of a design matrix, the team decided to use a lead screw/stepper motor design. The team's design utilizes a lead screw and stepper motor to generate linear motion to force the euthanasia solution from the syringe, which can be activated remotely from outside the chamber. The team plans to stress test the assembled system to ensure that it functions within a pressurized environment, the stepper motor will be tested to ensure a consistent speed, and that the euthanasia solution is completely forced out of the syringe when activated by the researcher.

Background and Motivation

Background

- Hyperbaric chambers are often utilized to help fight infection or minimize injury. They are usually used at around 1.5 atm [1].
- Too much exposure in a hyperbaric chamber may result in lung collapse caused by air pressure changes (barotrauma) and seizures as a result of too much oxygen (oxygen toxicity) [2].
- The current competing devices are Infusion Pumps made by Baxter Sigma Spectrum [3]. They are designed for consistent injection of fluid, however they're only rated for up to 1.4 atm and are expensive.

Figure 1: An image of a typical hyperbaric chamber in use.

Motivation

- In order to test the Navy's standard operation to rescue sailors in a disabled submarine, our clients will be utilizing a high pressure hyperbaric chamber and sheep. Our goal is to create a device that is able to remotely euthanize sheep when they are inside of the hyperbaric chamber prior to a rapid drop-out decompression in order to avoid unnecessary trauma.

Figure 2: A Baxter Sigma Spectrum Infusion pump.

Design Specifications

- Operate and withstand pressure changes induced by the hyperbaric chamber
- Must be remote controlled (wired)
- Efficiently force the euthansia solution from syringe while having a slow, controlled, and complete release of euthanasia solution

Figure 3: Example of sheep that are being used in the research

Final Design

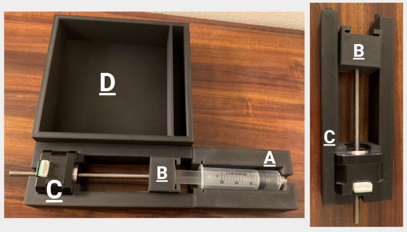

Figure 4: Structural pieces of the remote euthanasia device that will hold the syringe, motor, and electrical equipment

Structural Overview:

A. ***Syringe Holder*** - utilized to pin the syringe at its holders to prevent backward motion caused by compression and allows for easy removal
B. ***Holding Cap*** - utilized to attach and pin the plunger of the syringe to the leadscrew of the stepper motor so that the plunger moves as the leadscrew moves
C. ***Motor Holder*** - utilized to pin the stepper motor in place to only allow for the forward/backward movement of the leadscrew
D. ***Electronics Base*** - utilized to house the battery packs, electrical components, and printed circuit boards that coordinate the function of the stepper motor

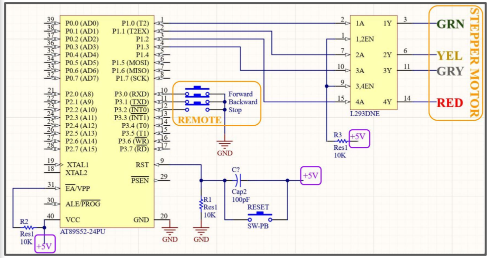

Figure 5: Altium Schematic of the wiring of the AT89S52 microcontroller to the L293D driver IC which controls a stepper motor based on a user input from an external remote.

Overview:

- AT89S52 microcontroller *(left)* interfaces with the L293D driver IC *(right)* which drives the stepper motor. The driver IC is responsible for motor movement.
- AT89S52 waits for user input from an external remote to determine if forward, backward, or no motion is desired.
- Power sources will be created via a 5V voltage regulator (MAX751CPA+) and 12V battery pack.

Testing and Results

Battery Life Validation

- 172 hour test with stop pin grounded
- Aiming for 10 replicates to ensure battery life

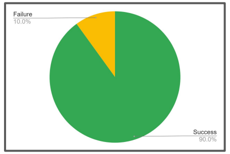

Figure 7: Minimum acceptable results from the battery life validation testing

Lead Screw Speed Validation

- Determine time for leadscrew to travel 2.75in in order to calculate velocity for each replicate
- Desired speed is .275in/s

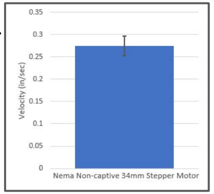

Figure 8: Expected results from the lead screw speed validation testing

Software

Overview:

- HEX Program burned onto AT89S52 via Arduino
- Waits for user input from remote in order to initiate motor movement
- There are consistent checkpoints throughout to check if user input has changed to stop or reverse movement of syringe plunging
- Motor will continue movement until signalled to "stop" by user

Improvements:

- Instituting a strict movement cap in order to disengage movement after the syringe has been fully plunged or retracted to prevent housing damage

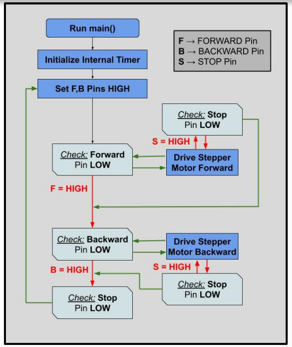

Figure 6: Software flow diagram of how the microcontroller operates

Future work

Client Requirement:

- Duplicate the design in order to account for two sheep in the chamber

Validation:

- Conduct repeated testing of device for consistent delivery of desired results
- Find an alternative to the wired remote currently being used in the design

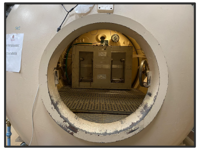

Figure 9: Entrance and interior of the hyperbaric chamber

Acknowledgements

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References

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[2] Mayoclinic.org. 2020. Hyperbaric Oxygen Therapy - Mayo Clinic. [online] Available at: <https://www.mayoclinic.org/tests-procedures/hyperbaric-oxygen-therapy/about/pac-20394380#:~:text=Potential%20risks%20include%3A,by%20air%20pressure%20changes%20(barotrauma)> [Accessed 10 September 2020].

[3] Sigma international, *Sigma Spectrum Operators Manual*. Sigma International, Medina, NY, 2008.