# Somatosensory Stimulation Apparatus for Rodent Cages


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## ABSTRACT


An electrode device has been designed to address the problem of phantom limb pain, a neuropathic pain caused by nerve damage during limb amputation. Before this device can be tested in humans, it must prove successful in animal models. In order to receive functional outcome data from rats, a healthy rat can be trained to respond in a certain way to a somatosensory stimulus. A peripheral nerve can then be surgically deafferented and the electrode implanted. The device can then be used to apply the same stimulus and the rat's response can be observed. The goal of this project was to produce the somatosensory stimulation necessary to train the rats. The device consists of an enclosure for the rat as well as electronics to apply a graded stimulus to the two hindlimbs individually. The final design features a clear plexiglass enclosure with two platforms that vibrate via speaker actuator motors underneath. The motors are connected using a vibration damping foam to ensure isolation. The Arduino Due with corresponding code produces sine waves to drive the motors, and the frequencies are set between 150-350 Hz by the user via the I/O console. Testing has shown that the current device is able to successfully output vibrational frequencies within 3.8% error of those set by the user. Using this device for animal testing will be crucial for determining the efficacy of the electrodes and completing the FDA requirements


## INTRODUCTION

**Motivation:**

- 185,000 amputee surgeries per year in US [1]
  - 42.2-78.8% of amputees suffer from phantom limb pain [2]
- New device to treat phantom limb pain and restore tactile sensation
  - Currently in need of method for testing device in rat models
- Current plan for rat testing
  - Train healthy rat to respond to somatosensory stimulus on hindlimbs
  - De-afferent hindlimb and implant device
  - Stimulate hindlimbs with device and observe if rat responds as trained

**Background:**

- Somatosensory system: System of neurons connecting peripherals to brain
- Merkel cells
  - Sense low frequency vibrations 5-15Hz
- Tactile Corpuscles
  - Sense 5-50Hz frequencies
- Lamellar Corpuscles
  - Optimal sense at 250Hz

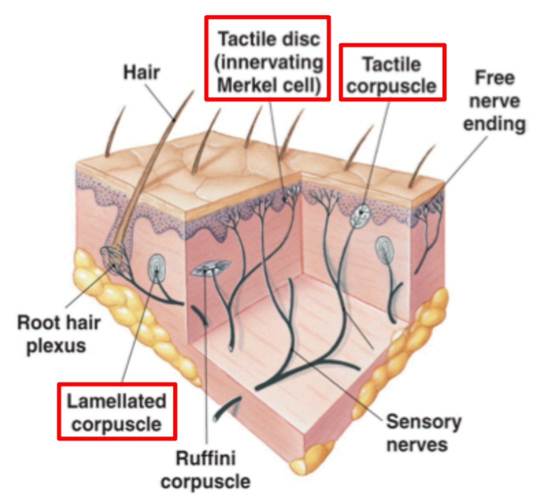


**Figure 1.** The cell types of the somatosensory system that must be stimulated to train the rats.

## DESIGN CRITERIA

**Performance:**

- Stimulation isolated to individual hindlimbs
- Varying frequencies must be allowable
- Stimulation must not interfere with electrode device

**Size:**

- Enclosure must not limit rat's ability to respond to stimulation
- Weight under 2.27 kg (5 lbs)
- Dimensions 0.25 x 0.28 x 0.3 m (10 x 11 x 12 in)

## FINAL DESIGN

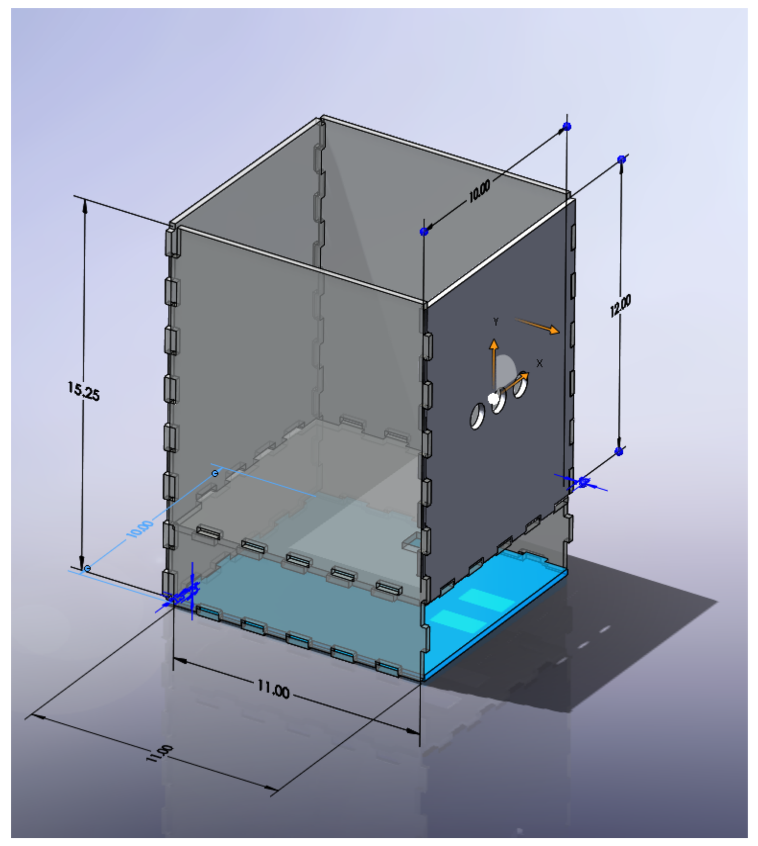

**Figure 2.** Solidworks model of the enclosure with dimensions (in).

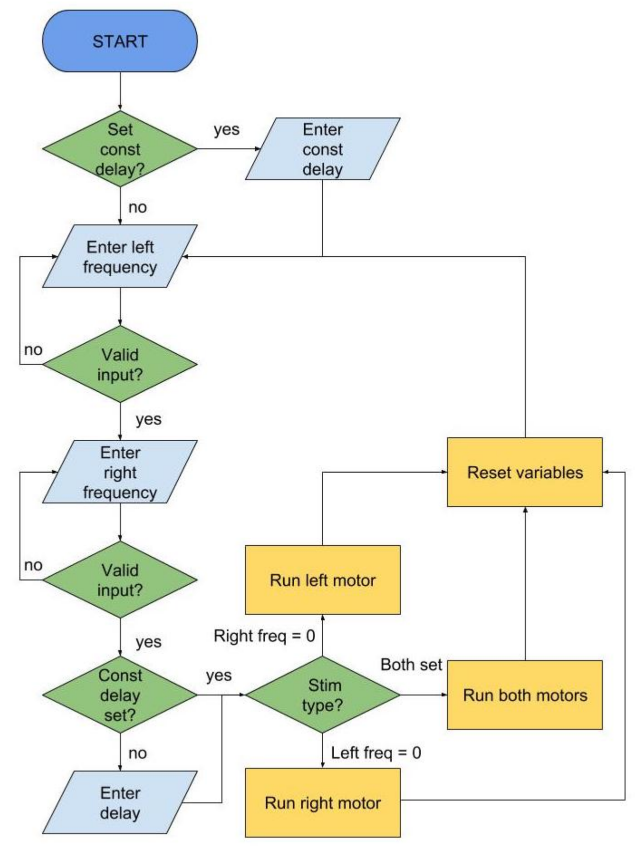


**Figure 3.** Software Block Diagram

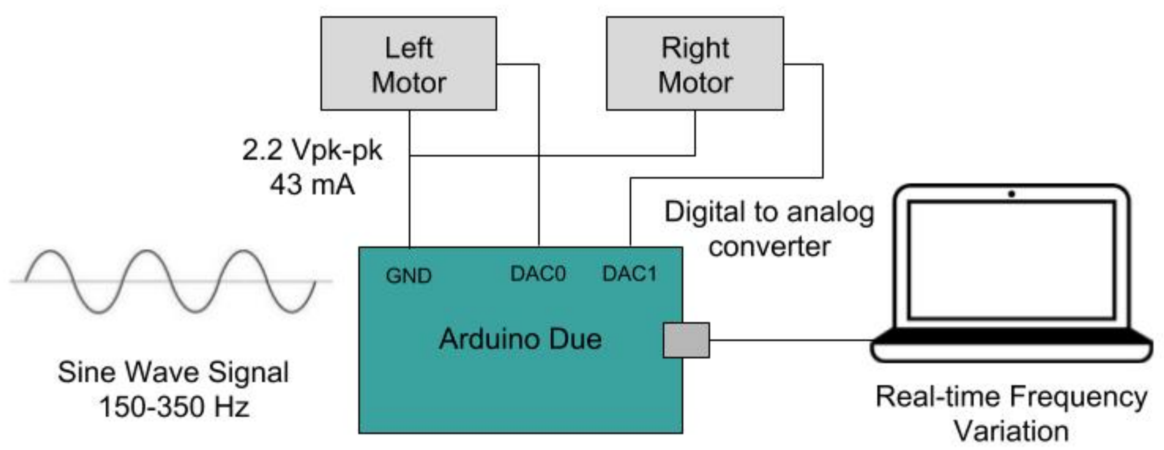


**Figure 4.** System Diagram of the electrical connection

## RESULTS


**Figure 5.** Comparison of the percent error of the input and output frequencies for both the output from the Arduino and the output from the accelerometer. Data points were taken every 50 Hz from 150-350 Hz.

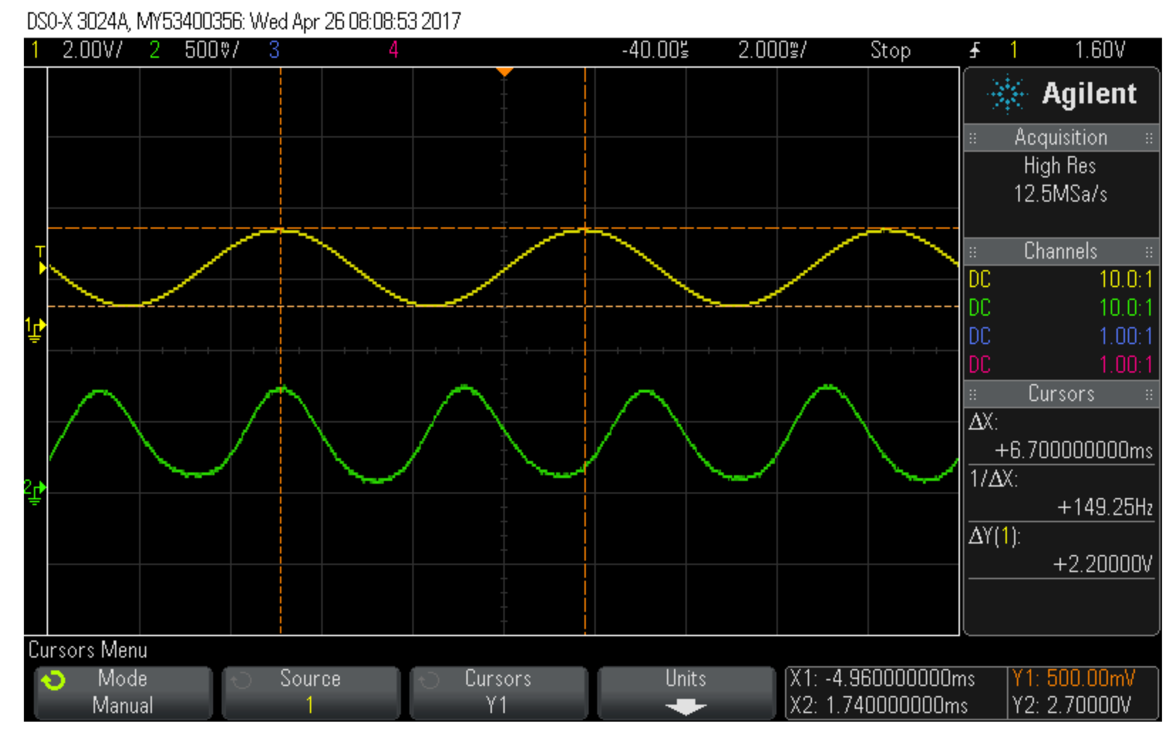


**Figure 6.** Sine wave output from the Arduino. One DAC outputting at 150 Hz and the other at 250 Hz.

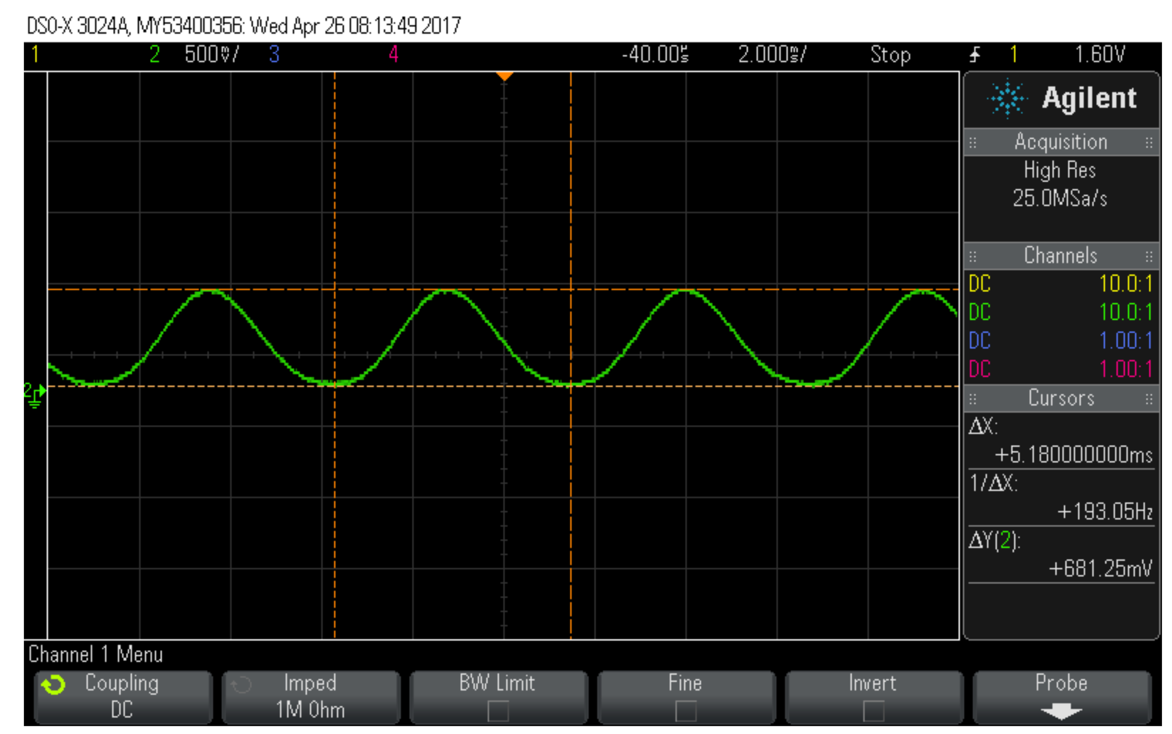


**Figure 7.** Output from the accelerometer when driving the motor at 200 Hz.

## FUTURE WORK

- Improve sine wave algorithm to reduce the percent error
- Explore new amplification options
- Test with live rats
- Replace Arduino Due to get a functioning DAC0 port

## ACKNOWLEDGEMENTS


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## REFERENCES


[1] "Limb Prosthetics Services and Devices", Semantic Scholar, 2017. [Online]. Available: https://pdfs.semanticscholar.org/c3ae/f3563844e2e2835411fcbc2b0fe3091ac30b.pdf. [Accessed: 20- Sep- 2017].

[2] B. Subedi and G. Grossberg, "Phantom Limb Pain: Mechanisms and Treatment Approaches", *Pain Research and Treatment*, vol. 2011, pp. 1-8, 2011.

[3] A. Basbaum, *The Senses: A Comprehensive Reference.* Oxford, U.K.: Elsevier, 2008, pp. 33-38.