



# Vibrotactile Stimulator

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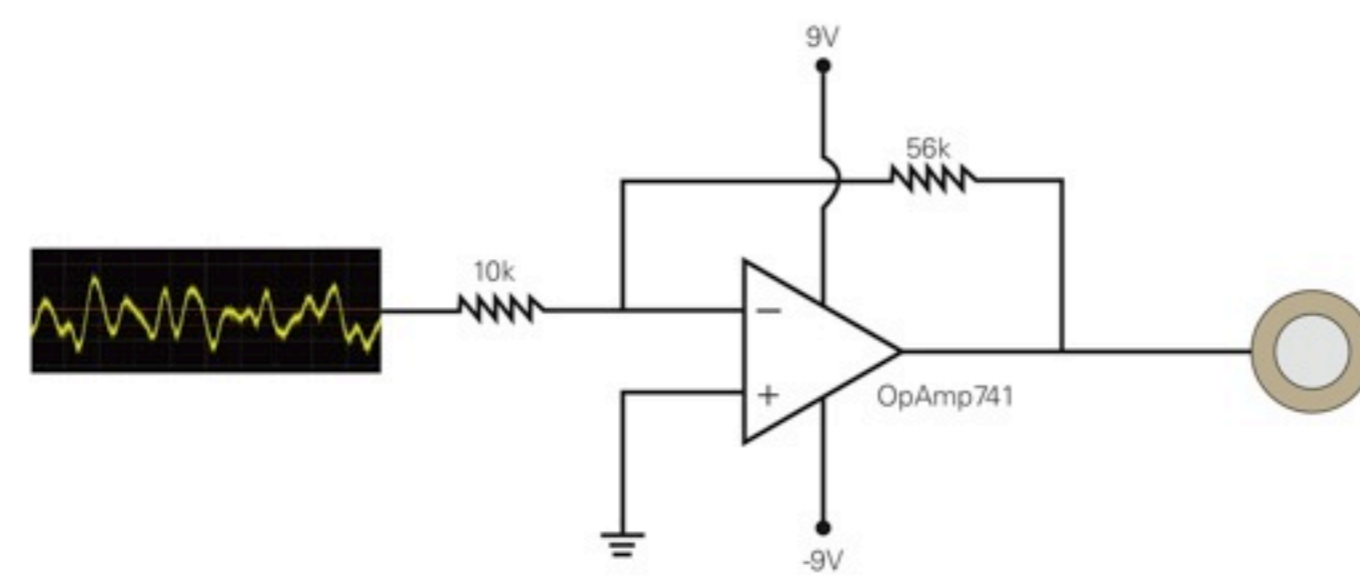


## ABSTRACT

It is important to understand stochastic resonance on the hands in order to prove how it effectively enhances vibrosensory perception. To do this, an MR-compatible factor is needed to provide a vibration stimulus to the hand during an MRI of the brain. The key design requirements of the device are that it must run at a frequency range of 30-300 Hz, and be small enough to fit on the subject's finger while maintaining a 1 mm thickness. In order to achieve these requirements, three design options were evaluated: solenoid, piezoelectric, and pneumatic. Of these three options, the piezoelectric device was determined to be the best suited design. Optimal materials for the tactor were determined, as well as the required circuitry needed to drive the system.

## FINAL DESIGN

### Circuitry



#### OpAmp 741

- Amplification of input voltage
- Theoretical Gain = 5.6
- Experimental Gain = 4.5

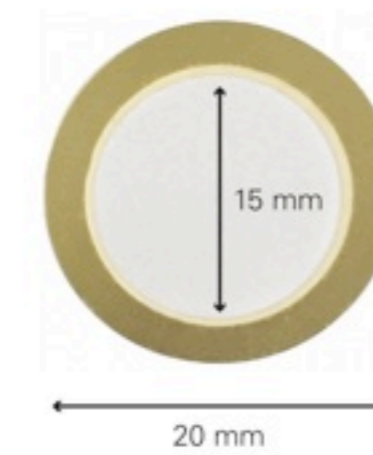
#### Piezoelectric buzzer

- Resonance Frequency = 2.5k Hz
- Vibration Frequency = 30 ~300 Hz

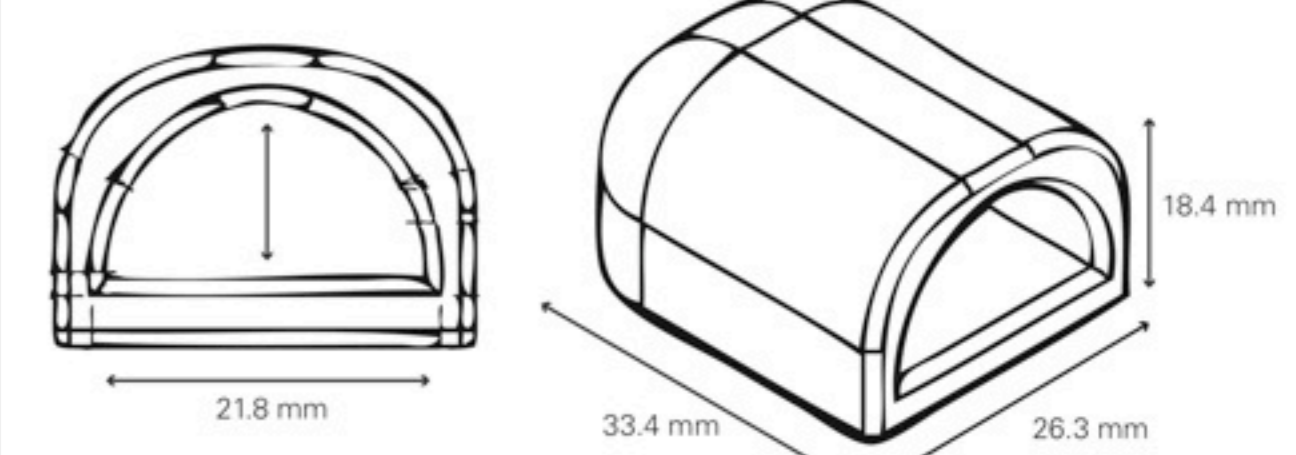
#### Audio File

- Generated from various sources
- Random frequency

### Piezo Buzzer



### Finger Holder



## PROBLEM STATEMENT

### Motivation

According to the U.S. Bureau of Labor Statistics, the leading cause of disabling injuries and second leading cause of fatalities in the workplace is falling from a ladder or scaffold. In order to reduce these injuries, a device must be developed to improve the worker's response time by stimulating their sense of touch through a vibration to stimulate the nerves in their hands. The average response time to a vibration stimulus to the hand is 100 milliseconds, including a 60 ms delay period for the stimulus to reach the nerves through the skin. Using stochastic resonance, it is possible to reduce this 60 ms delay time, allowing a person to sense vibrations earlier and prevent a fall from a ladder or scaffold.

### Stochastic Resonance

Stochastic resonance is the phenomenon that occurs when a sub-threshold signal is enhanced by the presence of noise.

For this particular application, the noise from a vibrotactile stimulator will add to a vibration stimulus, making it easier to reach the nerve threshold and allow a person to sense vibrations that would otherwise go unnoticed. It is important to develop a device to allow researchers to observe stochastic resonance in order to determine its applicability in industry to reduce the number of workplace injuries. Magnetic resonance imaging (MRI) is the most effective method for viewing the brain activity due to vibration stimuli; thus, an MR-compatible stimulation device must be created.

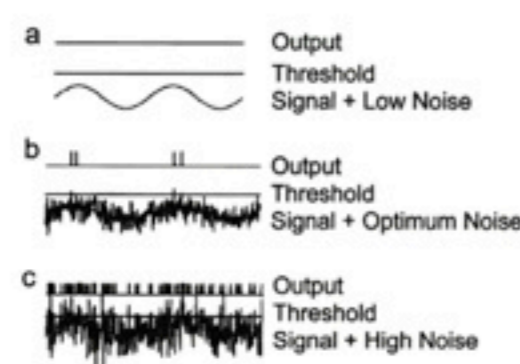


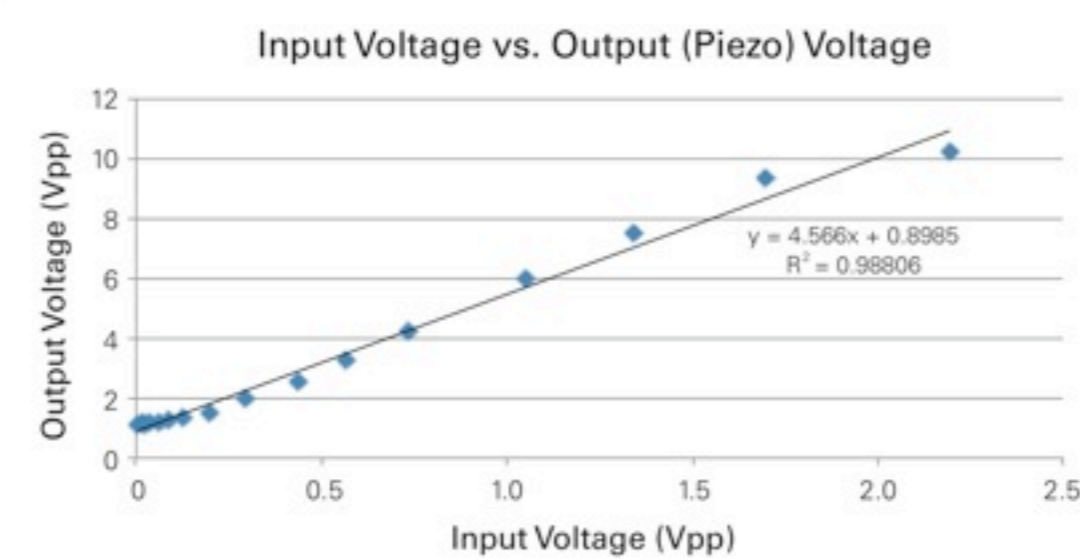
Figure 1. Stochastic resonance waveforms

## DESIGN REQUIREMENTS

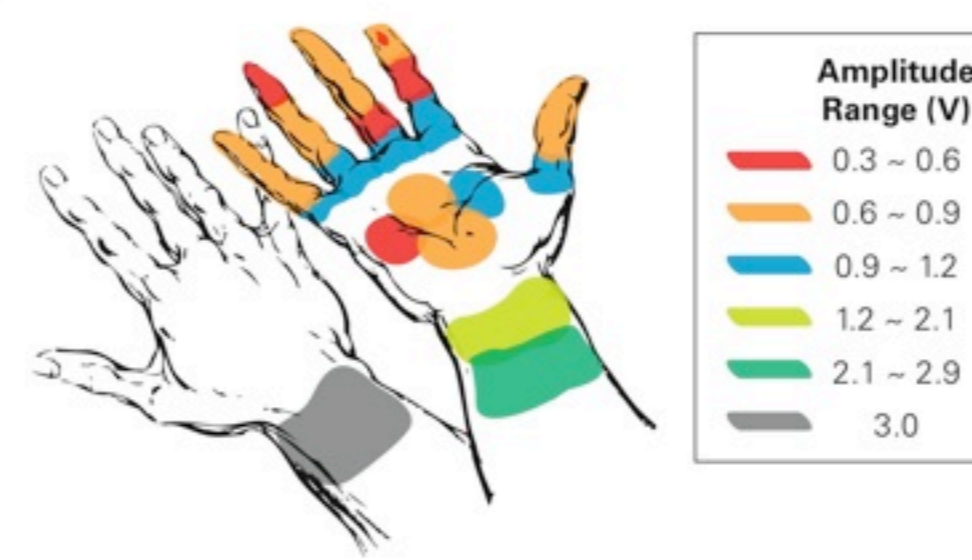
- Prototype must be MR-compatible
- Frequency: 30-300 Hz (random)
- Displacement: 10-500 μm
- Thickness: under 2 mm
- Diameter: 1 cm
- Accommodate varying hand sensitivities
- Stimulation must be sub-threshold
- The device should fit on the tip of a person's finger

## TESTING

### Input vs. Output Voltage



### Sensitivity Mapping



### Input vs. Output Voltage

The OpAmp 741 amplifies the input signal from the audio file and induce a total gain of 4.5.

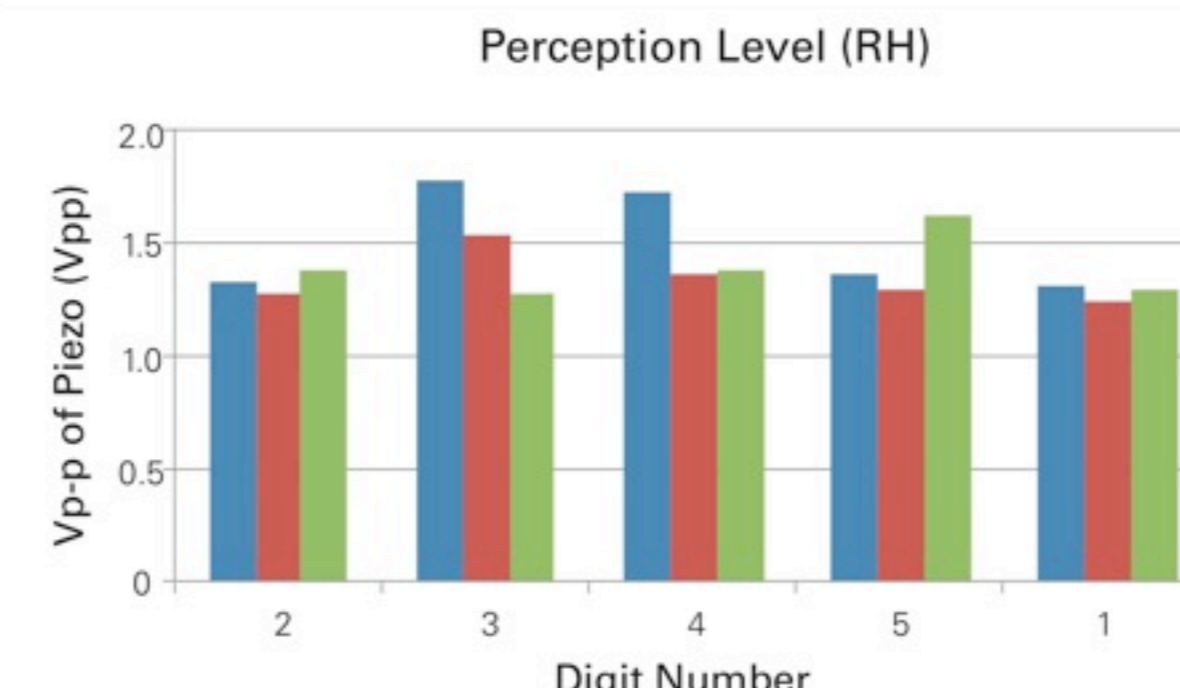
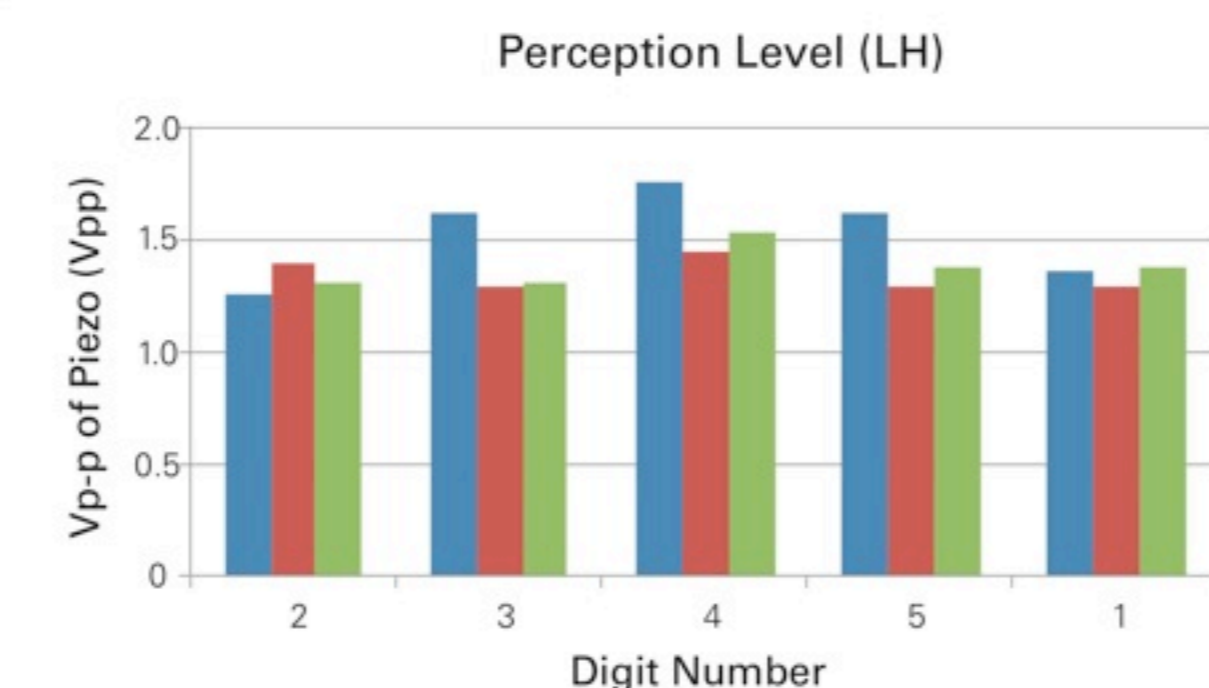
### Sensitivity Mapping

The levels of sensitivity for various spots on the hand are mapped out based on the different amplitude ranges that each location can sense.

### Fingertip Threshold Testing

Varying perception levels of stimulus using the device.

### Fingertip Threshold Testing



## FUTURE WORK



Figure 2. Magnetic Resonance Imaging (MRI)

- Human subject testing in MRI to monitor the brain activity and investigate the enhancement of reaction time of the subject
- Multiple-finger compatibility of the finger holder to enhance the research efficiency
- Practical applications including glove fabrication and treatment device for stroke patients

### References

Alawieh, N. (2011). Tactor to optimize skin response to vibration. Magnetic Resonance Imaging. (2006). Interdisciplinary Education Group. Retrieved on 2012/04/30. <http://mrsec.wisc.edu/Edetc/background/NMR/MRI.htm>  
Schulz, MJ, Naser, AS. Development new techniques in theoretical and experimental structural dynamics for the aerospace community. North Carolina A&T State University.  
Wells C, Ward LM, Chua R, Inglis JT. (2005). Touch noise increases vibrotactile sensitivity in old and young. Psychological Science. 16:313-32

### Acknowledgement

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