

# Vibrotactile Stimulator

## Optimization of Skin Response to Vibration

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# Overview

- Problem Statement
- Rationale
- Design Specifications
- Previous Design
- Modifications
- Final Design
- Testing
- Future Work
- Acknowledgement
- References



# Problem Statement

- ◎ A device must be developed **to improve the workers' response time** by stimulating their sense of touch through **vibrations** in their hands
- ◎ The device must be **MR-compatible** for brain activity analysis during the stimulus to the hand

# Problem Statement

Rationale (Stochastic Resonance)

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graph TD; A[Rationale (Stochastic Resonance)] --> B[MR-compatible Vibration Device]; B --> C[Proof of Concept (MRI testing)]; C --> D[Applicable Device];
```

MR-compatible Vibration Device

Proof of Concept (MRI testing)

Applicable Device

# Rationale

## ◎ Hand Skin Receptors

- Meissner corpuscles (3~40Hz)
- Pacinian corpuscles (200~350Hz)
- Sensitive range: 30~300 Hz

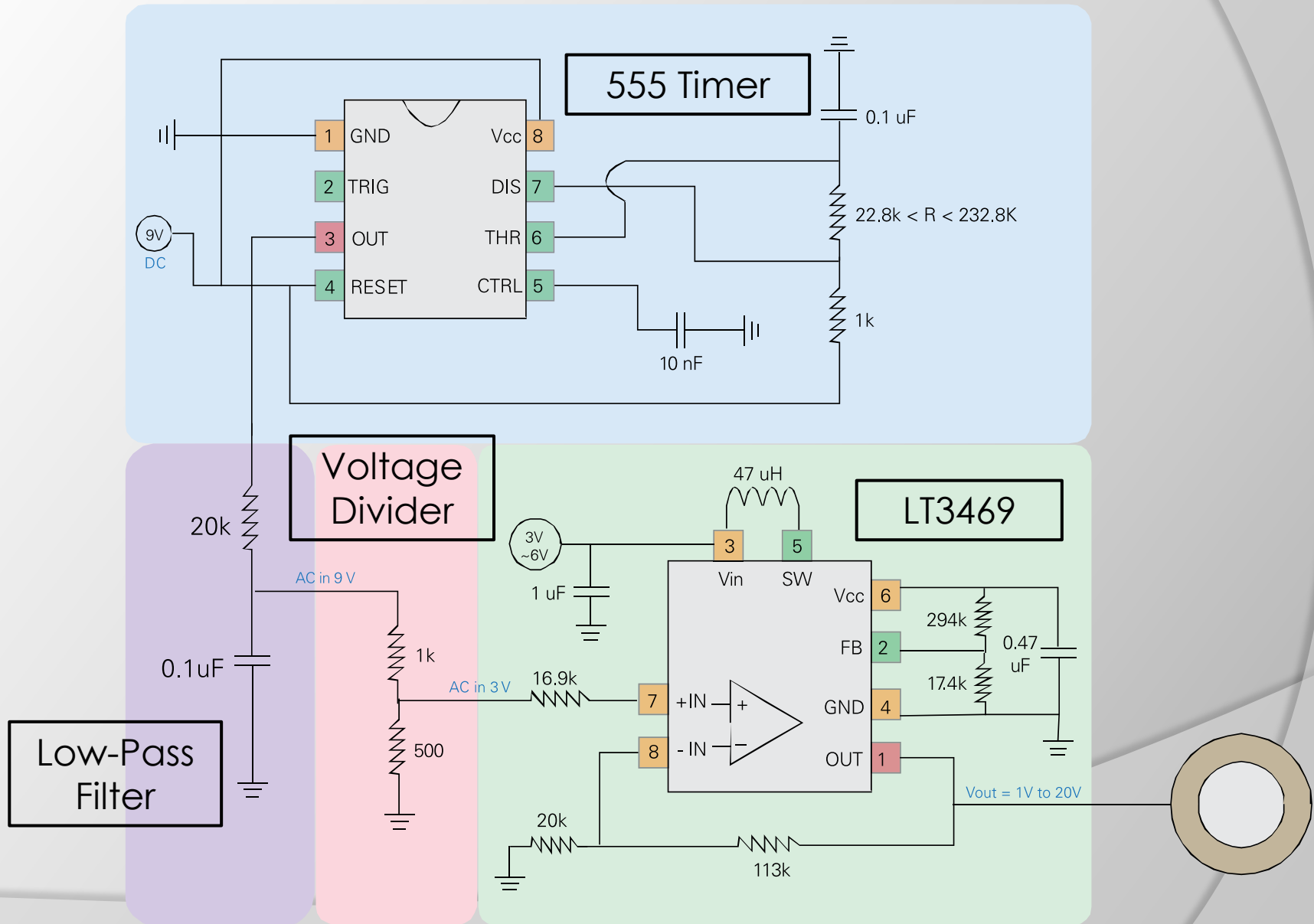
## ◎ Stochastic Resonance

- Enhancement of sub-threshold signal by adding adequate noise
- Effect shown in vibration stimulation on feet

# Design Specifications

- ◎ MR-compatibility
- ◎ Smaller tactor
  - 1 mm thickness, 1 cm diameter
- ◎ Random frequency within 30~300 Hz range

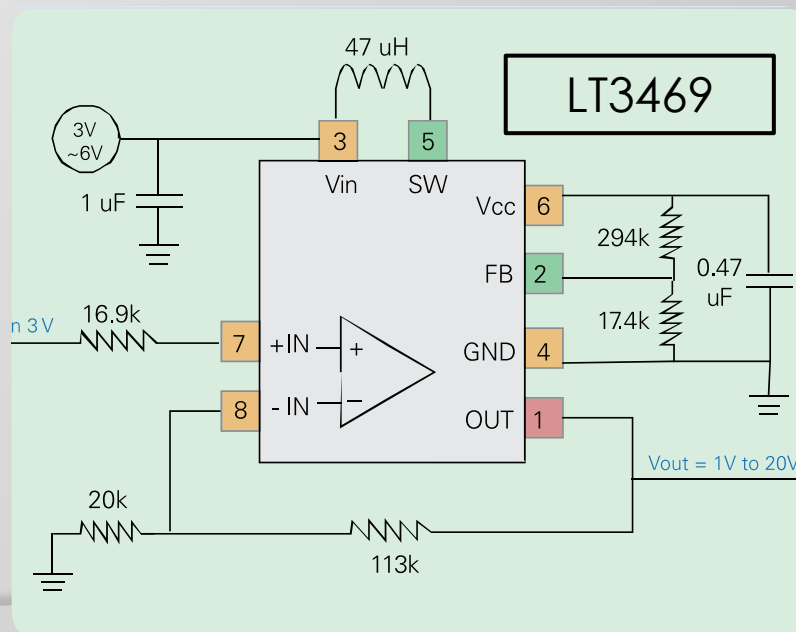
# Previous Design [Circuitry]



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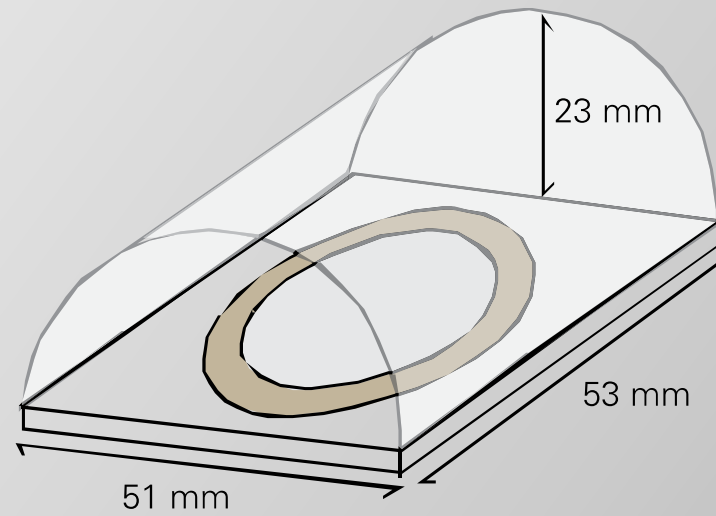
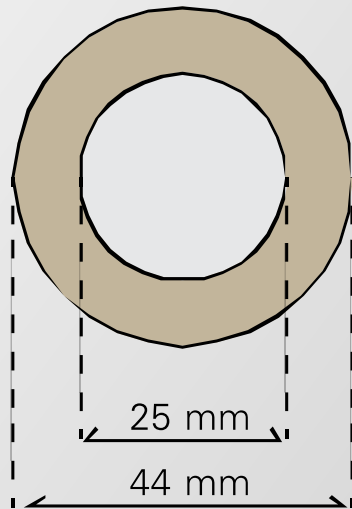
## LT3469 Piezo Actuator Driving Circuit

- Designed for specific piezo
- Output voltage varied from 0~33 V
- Adjustability of displacement

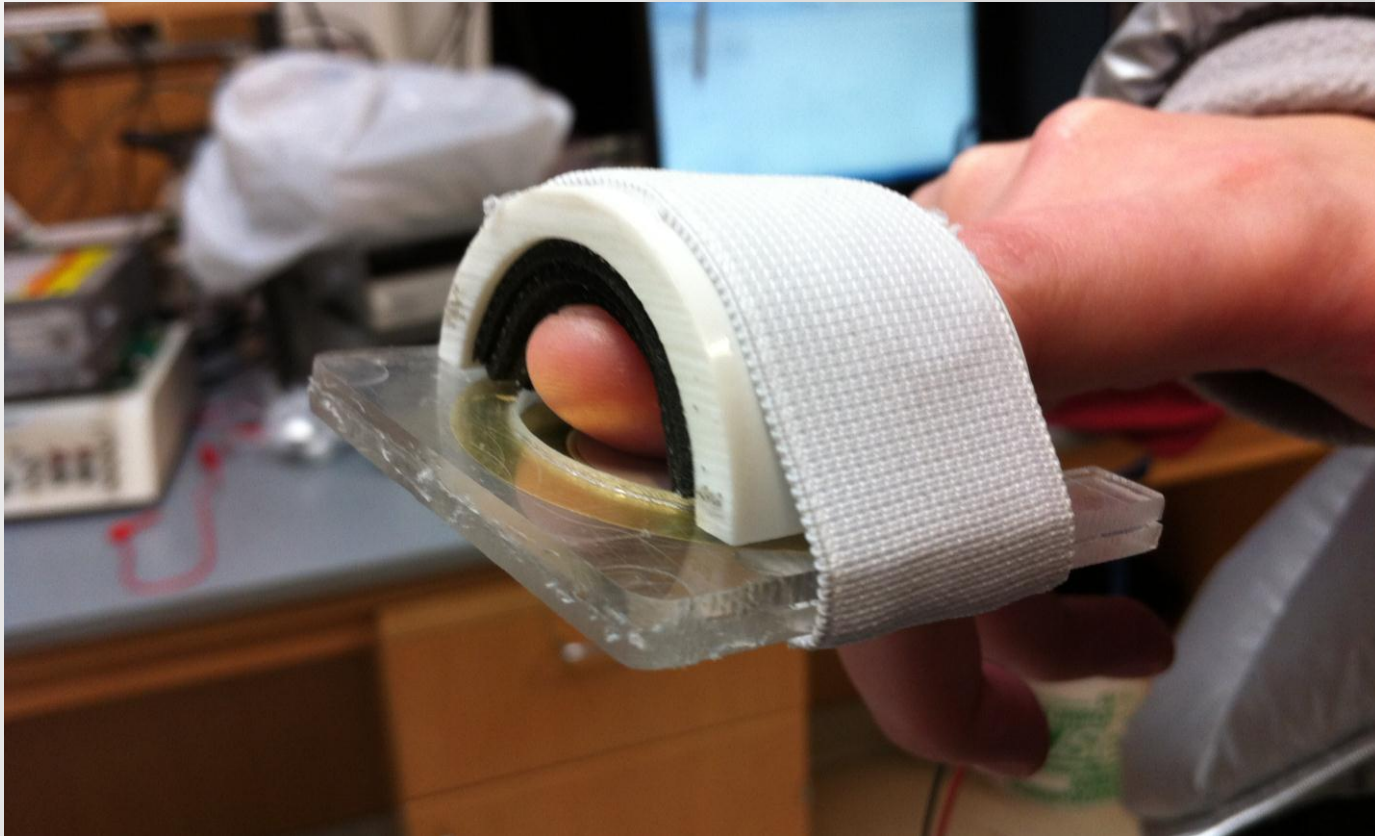




# Previous Design [Finger Attachment]

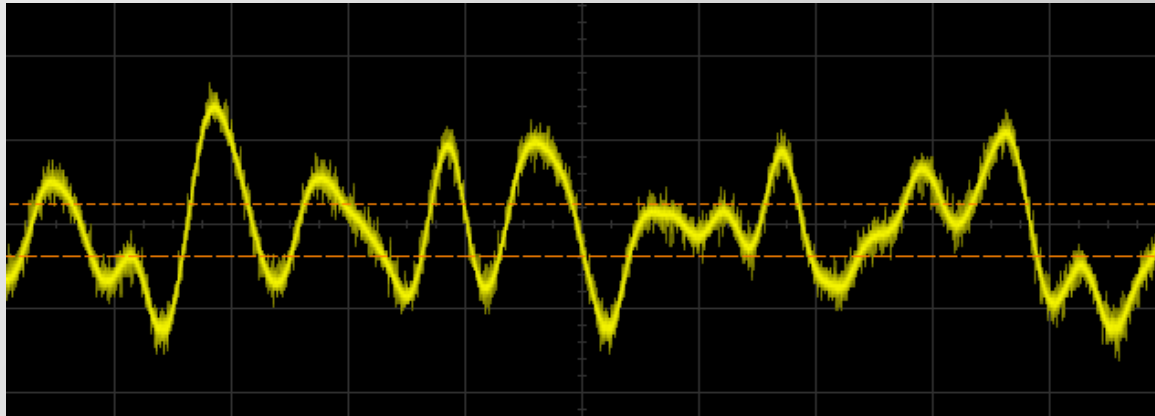


# Previous Design [Finger Attachment]



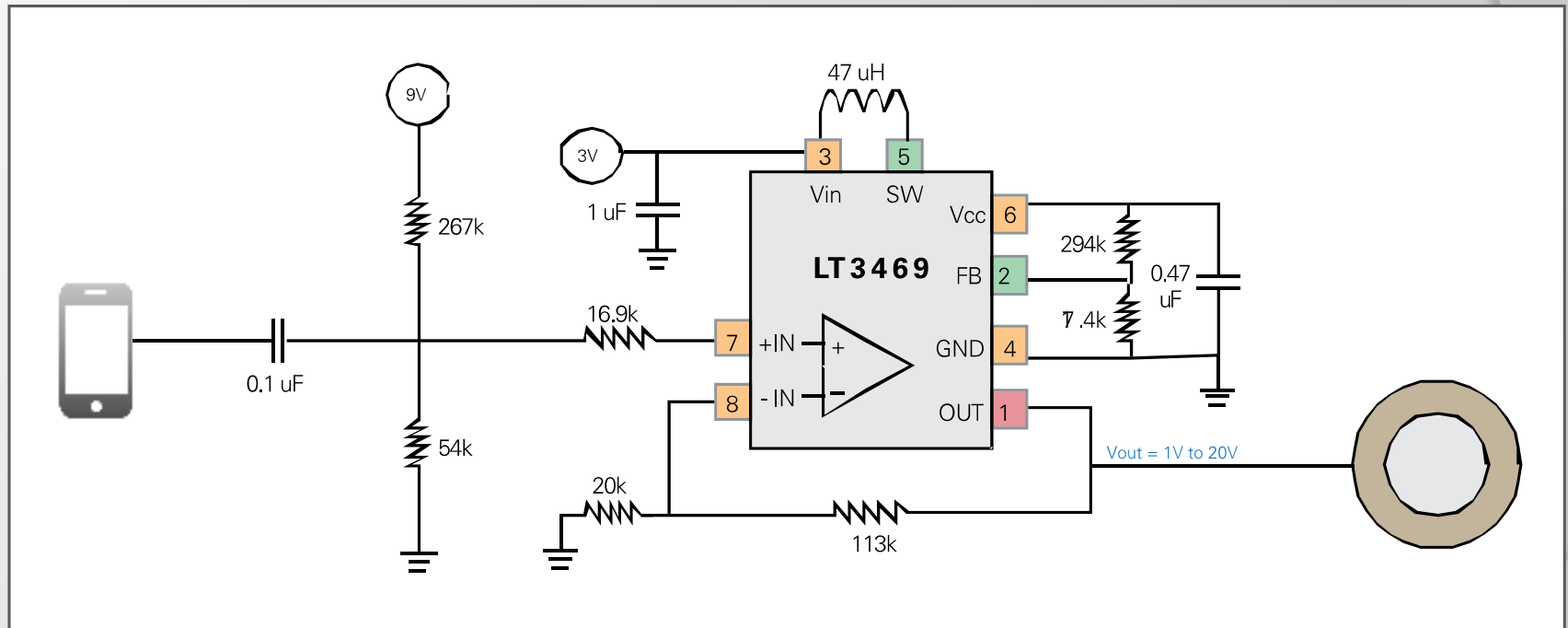
# Modifications

- ⦿ Random frequency
  - Continuous
  - 30~300 Hz
  - Audio file (mp3)



# Modifications

## ● Circuits Modification (Option 1 – LT3469)



Audio File

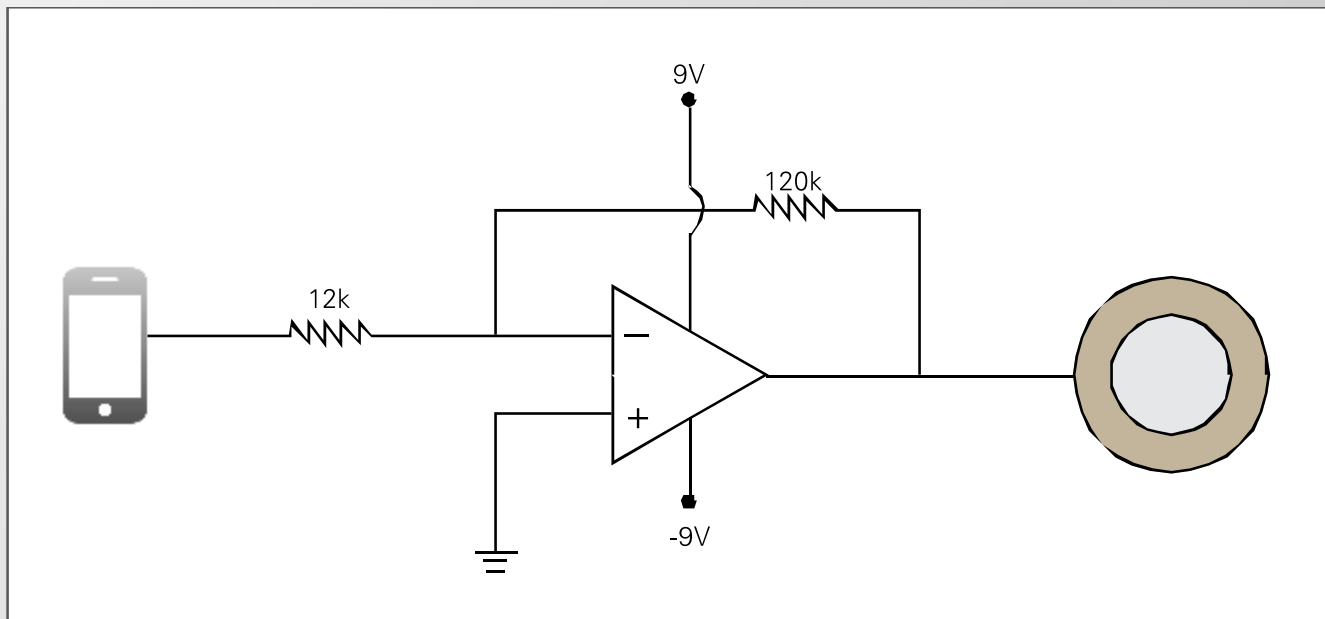
Voltage  
Shifter

LT3469

Piezo

# Modifications

- Circuits Modification (Option 2 – OpAmp 741)



Audio File

OpAmp 741

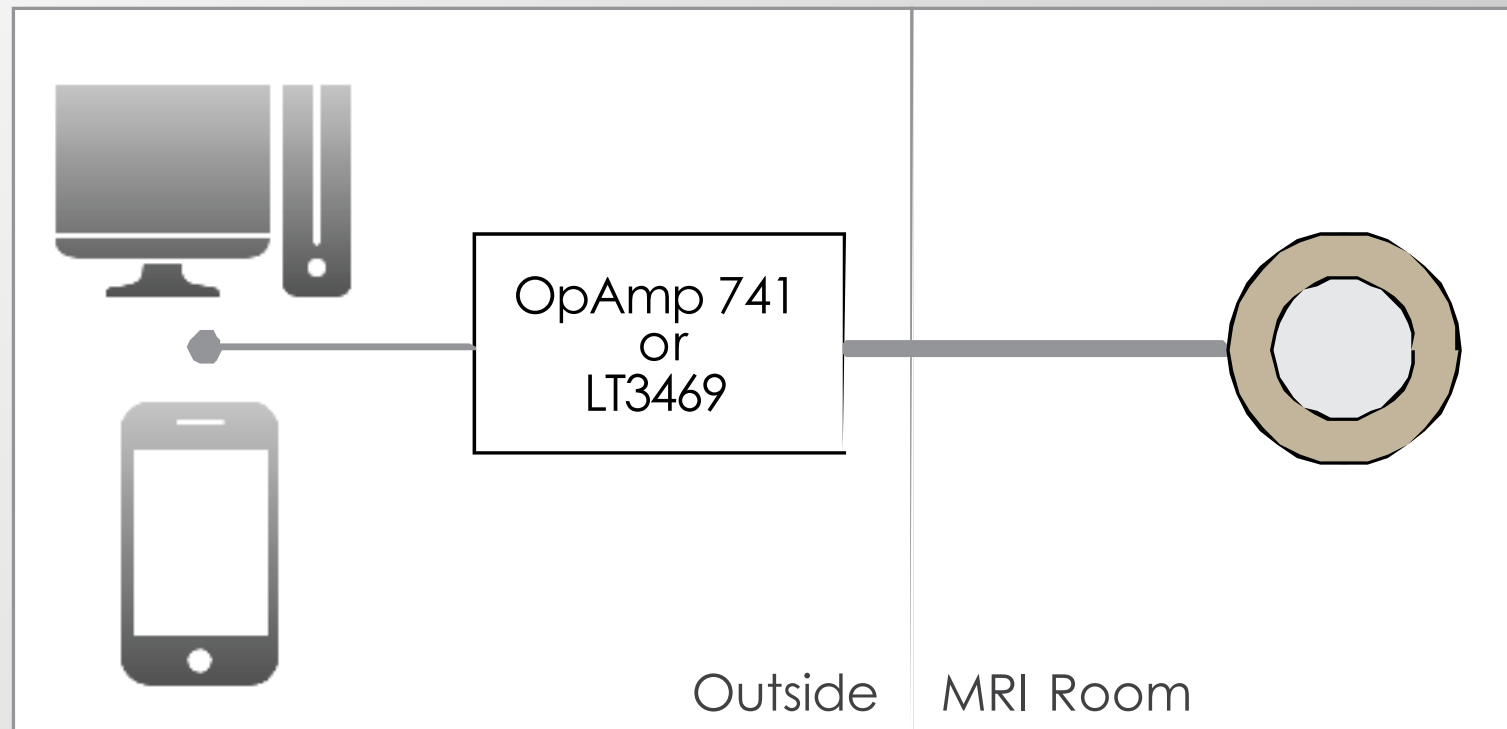
Piezo

# Modifications

## ⦿ Circuits Modification Comparison

	<b>LT3469</b>	<b>OpAmp 741</b>
Circuit	Complex	Simple
Cost	higher	lower
Voltage Range	Ideal	Acceptable
Voltage Source	Smaller	Larger

# Final Design (Revised)



# Final Design (Revised)

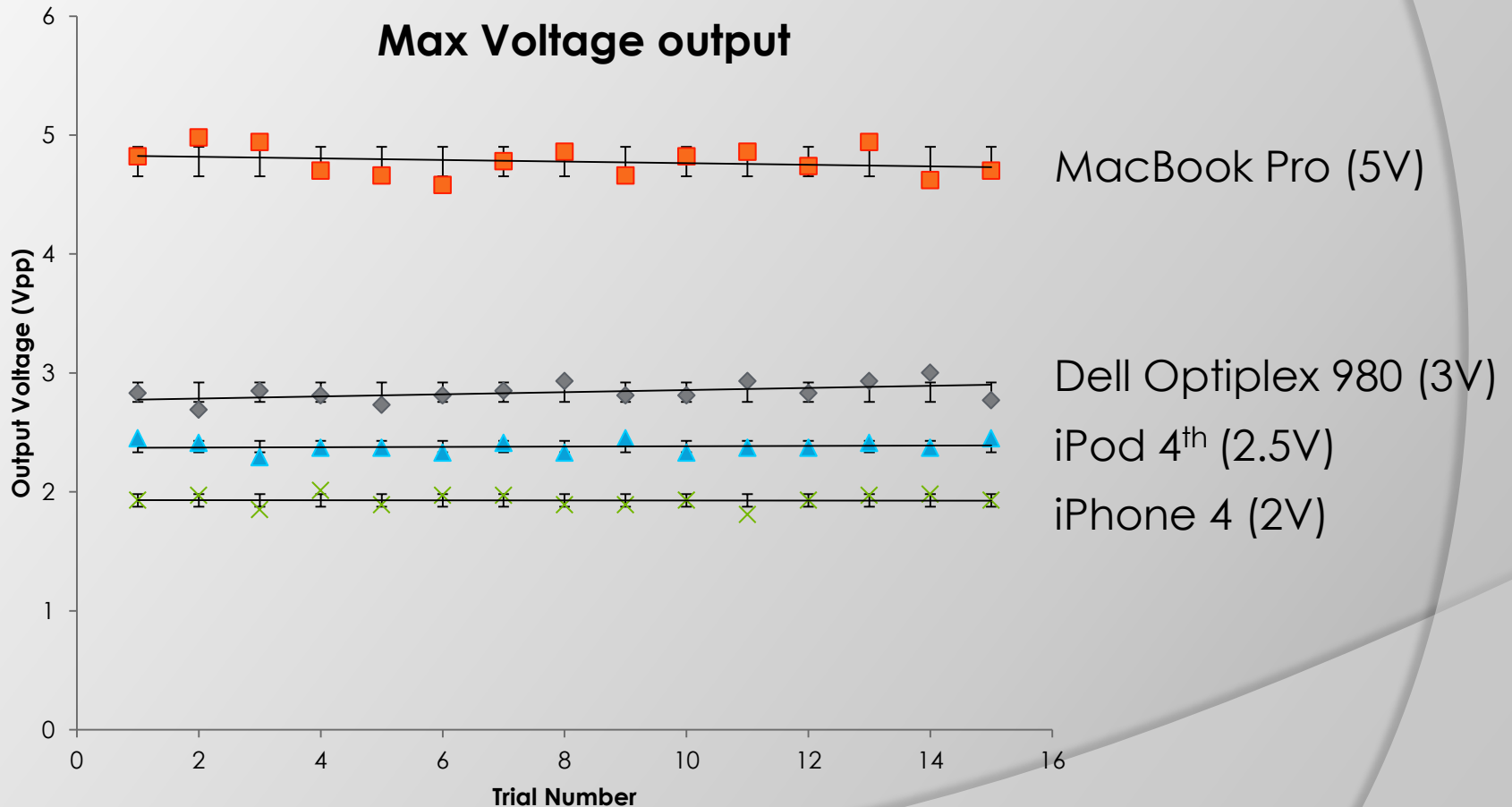
- 2011 Fall Model vs. 2012 Spring Model

	2011 Fall	2012 Spring
Frequency	Static	Dynamic
Waveform Source	555 Timer	Audio file
Circuitry	4 components	2 components
Tactor size (diameter)	44mm	20mm*



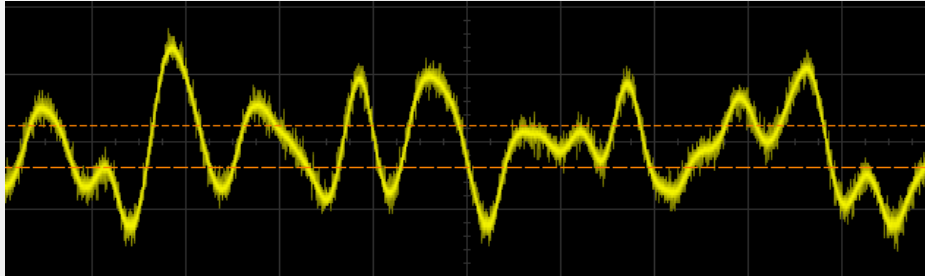
# Testing

- Voltage output from various devices

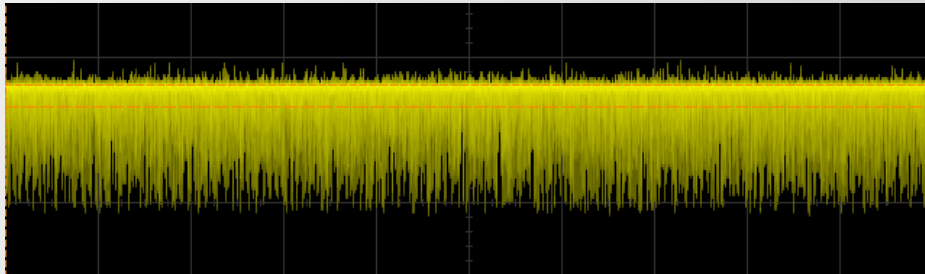


# Testing

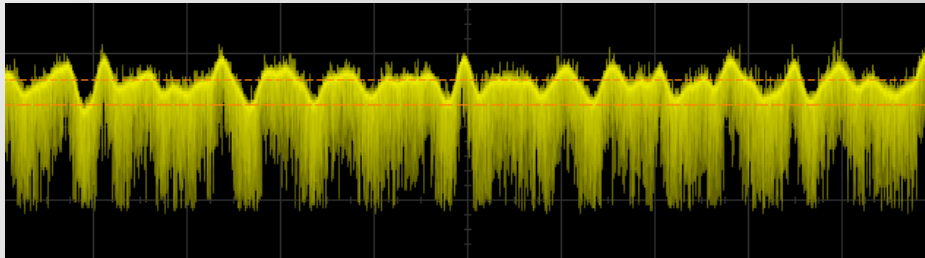
- Driving circuits – LT3469



Original waveform



Voltage shifter



Voltage shifter  
+ waveform

# Future Work

- ⊙ Debugging more ideal circuits
  - OpAmp 741 or LT3469
- ⊙ Testing for smaller piezo factors
- ⊙ Remodeling of finger attachment
  - Size reduction
- ⊙ Shielding wires
  
- ⊙ Displacement measurement
  - Laser vibrometer
- ⊙ Human subject testing in MRI

# Acknowledgment

## ◎ Prof. Na Jin Seo (Client)

- UW-Milwaukee
- Dpt. of Industrial & Manufacturing Engineering

## ◎ Pilwon Hur (Client Assistance)

- UW-Milwaukee
- Dpt. of Industrial & Manufacturing Engineering

## ◎ Prof. John Webster (Advisor)

- Ph.D., UW-Madison
- Dpt. of Biomedical Engineering

## ◎ Pete Klomberg

- UW-Madison BME
- Bioinstrumentation Lab

# References

## Journals

- [1] Motawar BR, Hur P, Seo NJ. (2011). Roles of cutaneous sensation and gloves with different coefficients of friction on fall recovery during simulated ladder falls. *The 35<sup>th</sup> Annual Meeting of the American Society of Biomechanics*.
- [2] Wells, C., Ward, L.M., Chua, R., Inglis, J.T. (2005). Touch Noise Increases Vibrotactile Sensitivity in Old and Young. *Psychological Science*. 16(4). 313-320.

**Questions?**

