

# Remotely Connected Electric Field Generator

for Particle Separation in a Fluid

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# Dielectrophoresis (DEP)

## Dielectrophoresis

### Project Overview

### Initial Implementation

### Intermediate Implementation 1

### Intermediate Implementation 2

### Final Design

### Current State

### Questions

- A dielectric particle in a non uniform electric field experiences a force
- Different potential fields and frequencies has an effect on the net force
- First studied in 1950s by Herbert Pohl
- Recently revived due to the ability to manipulate micro-particles and cells.

## Real World Application

### Dielectrophoresis

#### Project Overview

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#### Questions

- Potential to separate particles in spinal fluid
- Act as filter
- Research in separating cancerous cells from healthy cells
- Separate platelets from whole blood
- Separate red and white blood cells
- Strains of bacteria and viruses

# Project Description

Dielectrophoresis

Project Overview

Initial Implementation

Intermediate  
Implementation 1

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Final Design

Current State

Questions

- A system to aid in the research of DEP
- Allow for quicker setup times
- Control Voltage and Frequency via the web
  - 1 to 60 VPP
  - 10k to 1Mhz
- Hold output for long time periods
- Small Form Factor
- Easy to use
- Plug and play

# Project Structure

Dielectrophoresis

Project Overview

Initial Implementation

Intermediate  
Implementation 1

Intermediate  
Implementation 2

Final Design

Current State

Questions

- Raspberry Pi
- Web Interface
- Web Server
- Frequency Control Solution
- Voltage Control Solution

# Initial Implementation

Dielectrophoresis

Project Overview

Initial Implementation

Intermediate  
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Intermediate  
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Final Design

Current State

Questions

- Raspberry Pi
  - Host web server
  - Remote manipulation of circuit output
  - Web interface can provide additional functionality
  - GPIO pins input to circuit
- Circuit Output
  - Frequency generated by GPIO pin
  - GPIO waveform integrated to get sine wave
  - Sine wave amplified to form output

# Minigen Function Generator

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Project Overview

Initial Implementation

Intermediate  
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Intermediate  
Implementation 2

Final Design

Current State

Questions

- SPI communications
- Small form factor
- Output to

## Intermediate Implementation

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Project Overview

Initial Implementation

Intermediate  
Implementation 1

Intermediate  
Implementation 2

Final Design

Current State

Questions

- Raspberry Pi controls Integrated circuit components
- Produces frequency 10 Khz - 4 Mhz
- Digital Potentiometers
- SPI communications
- Vary resistance to control amplifier
- Amplifier controls voltage output from circuit



## Problems and Setbacks

Dielectrophoresis

Project Overview

Initial Implementation

Intermediate  
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Current State

Questions

- Mosfet Amplifier
- Digital Potentiometer
- Resistance drops with AC signal
- Distorted the sine wave
- Op Amps
- Slew Rates
- Gain Bandwidth
- Minigen
- B23 Bug

# Digital Potentiometer Amplifier Circuit

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Project Overview

Initial Implementation

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Intermediate  
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Final Design

Current State

Questions

- "image"

# MOSFET Amplifier

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Project Overview

Initial Implementation

Intermediate  
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Intermediate  
Implementation 2

Final Design

Current State

Questions

- picture"
- information

## Problems and Setbacks

Dielectrophoresis

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Current State

Questions

- Lost a group member
- BJT Switch
- Control through GPIO pin
- Current Leaks through when logically off
- Relay
- Operating Frequency not sufficient
- Brandon
- We have had to make quite a few adjustments from our original plan.
- This is especially the case with our digital potentiometers.

# SSR Circuit Implementation

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Implementation 2

Final Design

Current State

Questions

- "image"

# Overview

Dielectrophoresis

Project Overview

Initial Implementation

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Intermediate  
Implementation 2

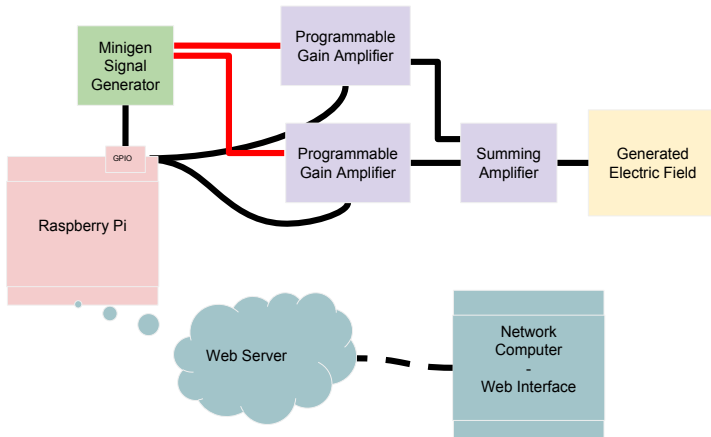
Final Design

Current State

Questions

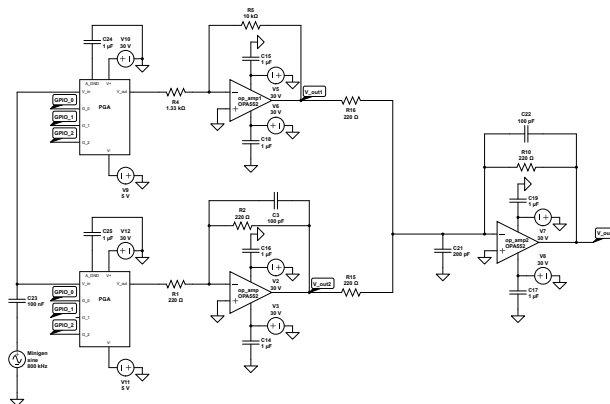
- Raspberry Pi controls integrated circuit components
- Minigen Function Generator
  - SPI communications
  - Produces frequency 10 Khz - 4 Mhz
- Programmable Gain Amplifier(PGA)
  - GPIO communications
  - 8 voltage options (0-7)
- Summing Amplifier
  - Sums output from amplification stages

# Systems Diagram



# Amplifier Circuit

- Two stages with PGA and constant gain amplifiers
  - Upper stage constant amplifier Gain 7.5
  - Lower stage constant amplifier Gain 1.07
  - PGA's both having variable gain
- Summing amplifier





# Web Interface

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Project Overview

Initial Implementation

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Final Design

Current State

Questions

- Hosted Locally
- Able to be seen on intranet
- Voltage and Frequency controls
- Provides Additional Functionality

## Set Voltage and Frequency

Voltage (V):

Frequency (KHz):

☒ Sine  
☐ Triangle  
☐ Square

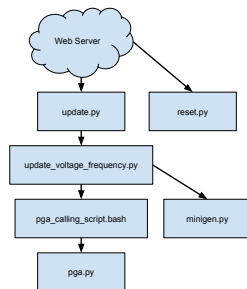
[Update](#)

Voltage(V)	Frequency(Khz)	Time(minutes)
<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
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<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>

[Go](#) [Stop](#) [Reset](#)

# Software Components

- a



# Current State

## Problems

- 1 Minigen B23 Bug
- 2 Current op-amps have insufficient Gain-Bandwidth Product
  - 1 Insufficient frequency
  - 2 Insufficient voltage
- 3 Current draw from Raspberry Pi

## Solutions

- 1 Most probably a hardware issue
- 2 An op-amp with necessary specifications exists, 598-1449-ND
- 3 Ensure few additional components connected to the Pi

# Cost

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## Itemized Expenditures

Item	Quantity	Price(\$)
<b>Raspberry Pi 3 Kit</b>	<b>1</b>	<b>49.99</b>
<b>Micro SD card</b>	<b>1</b>	<b>9.99</b>
<b>Minigen Function Generator</b>	<b>1</b>	<b>29.95</b>
<b>Op Amps</b>	<b>3</b>	<b>4.41</b>
<b>PGA</b>	<b>2</b>	<b>8.00</b>
<b>Miscellaneous Components</b>	<b>-</b>	<b>10.5</b>
<b>Total</b>	<b>-</b>	<b>104.84</b>

# Logistical Setbacks

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- Lack of manpower
- Loss of a team member at semester break
- Point of contact left company

# Deliverables

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- Raspberry Pi loaded with controlling code
- User manual
- Current circuit implementation
- PCB design
- Simulation files

# Questions?

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## Discussion Points

- Dielectrophoresis (DEP)
- Circuit Design
- Digital Potentiometer/ Operation Amplifier
- MOSFET/ Programmable Gain Amplifiers (PGA)
- Web Interface
- Final Documentation

# Work Breakdown

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## Items

- Initial Planning
- Project Website
- Reports and documentation
- Circuit Design
- Web Server
- SOC Communications
- PCB Design