Remotely Connected Electric Field Generator for Particle Separation in a Fluid

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This project is sponsored by Minnetronix, a health care company based in St. Paul, Minnesota, founded in 1996. Minnetronix continues to innovate landscape of health care technology with an emphasis on device development and commercialization of medical technologies. This project is apart of this effort.

Problem Statement

New research has shown that certain particles may be separated from fluids through dielectrophoresis. This process involves applying an electric field to a fluid. The electric field may then be manipulated in order to attract or repel certain particles. The particles the electric field will attract or repel depends on characteristics of the electric filed. These field characteristics may be controlled by varying the voltage and frequency of the electronics driving the field.

Our project is part of a larger design to exploit this phenomenon for use in medical equipment. There are many medical applications which utilize a method of separation. Centrifuging blood and testing spinal fluids are two examples of such systems. Current testing equipment is expensive therefore a cheaper device utilizing DEP would have a large competitive advantage if constructed.

Requirements

This device will need to be capable of operating in a laboratory environment. It is also a great benefit if this device is portable. Given these constraints proposed solution seeks to create a device which is:

- small form factor
- cheap
- capable of separating particles in a fluid utilizing DEP
  - produces 1 to 60_{Vpp}
  - produces 10_{Khz} to 1_{Mhz}

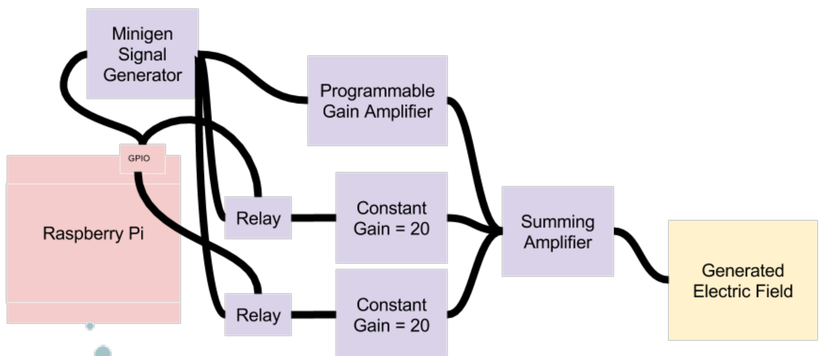
Solution

To fulfill the requirements we propose the use of a Raspberry Pi in combination with some circuit components connected to the the GPIO pins present on the Raspberry Pi.

The following components will be created and connected to the Raspberry Pi. This will allow for the output of the circuit to be controlled using any computer on the LAN.

- Voltage Control
  - Utilizes three Programmable Gain Amplifiers(PGA)
  - Summing Amplifier to sum the output of PGA's
- Frequency Control
  - Minigen Function Generator
  - Communicates with Raspberry Pi through SPI
- Web Interface
  - Apache 2 web server hosted on Raspberry Pi
  - provides user ability to set voltage and frequency output

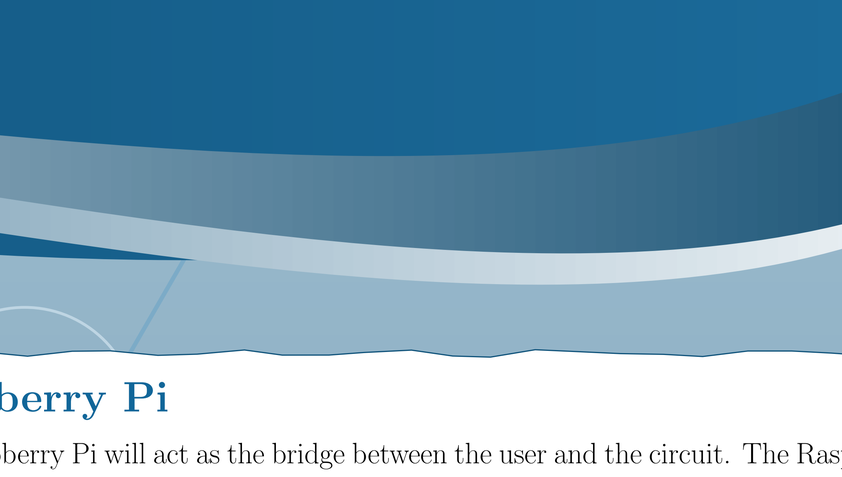
Block Diagram



Raspberry Pi

The Raspberry Pi will act as the bridge between the user and the circuit. The Raspberry Pi will host a web server allowing the user to interact with the system. Based on the results of this user interaction, the Raspberry Pi will update the state of the GPIO pins. The GPIO pins connect to a circuit causing the output to change based on their state.

In addition to hosting the web server the Raspberry pi is used to communicate with the Minigen Signal Generator and amplifier circuit. This communication is accomplished via the Raspberry Pi's SPI interface and GPIO pins respectively.



Web Interface

The web interface is hosted on the Raspberry Pi using an Apache web server. This web server displays an interface which allows the user to set a voltage and frequency output by the system. The interface is simple and interactive, implemented using cgi-scripts on the Apache web server.

Our implementation provides several functionalities. Among these are the ability to set: voltage and frequency, sine or triangle or square waveforms, and the ability to set a voltage and frequency for an amount of time. The table displayed in the figure below provides the ability to set voltage and frequency for the number of minutes specified. The "Go" button will cause the first voltage and frequency to be set for the corresponding amount of time. After the time has expired, the next voltage and frequency will be set for the corresponding amount of time. This process continues until the table entries are completed or the user presses the "Stop" button.