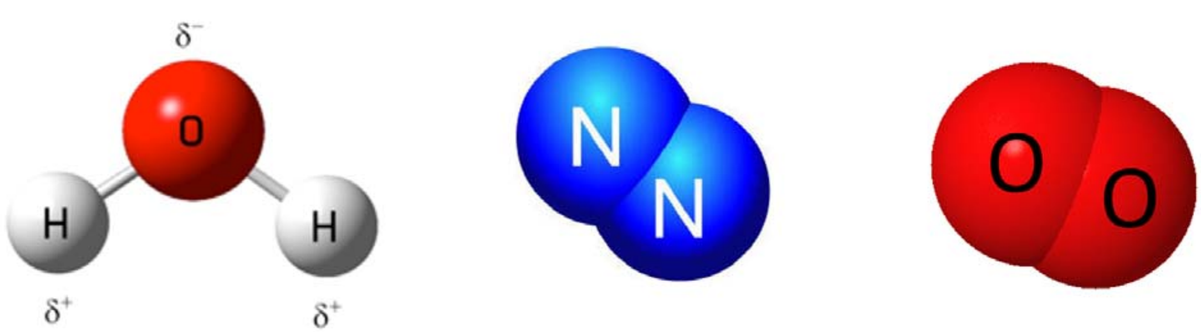
Joseph Strehlow
Physics 406
Spring 2015

Electro-Acoustic Monopole Sound Source

In a summer during the 1990s, David Swenson of the 3M Corporation observed an invisible wall generated by rapidly-rolled polypropylene sheets. The polypropylene sheets were rolled up rapidly by machine rollers in an open-air warehouse in the south, which was exposed to the humidity of the outdoors. When rolled, these sheets trapped massive amounts of ions that were deposited from the humid air, creating a large repository of electric charge. When Swenson attempted to physically approach these sheets, there was an invisible barrier preventing him from reaching proximity. The large amount of charge stored generated an electric field that repelled the water molecules in the human body.

Professor Steven Errede gave me the idea of using such an invisible wall to make electro-acoustic monopole sound source. Humid air is largely composed of molecularly ionized dioxygen, dinitrogen, and water. Each of these ions have their own characteristic mobilities, which are dependent on pressure and temperature. Theoretically, these ions can be physically manipulated to create a speaker membrane composed of moisture.

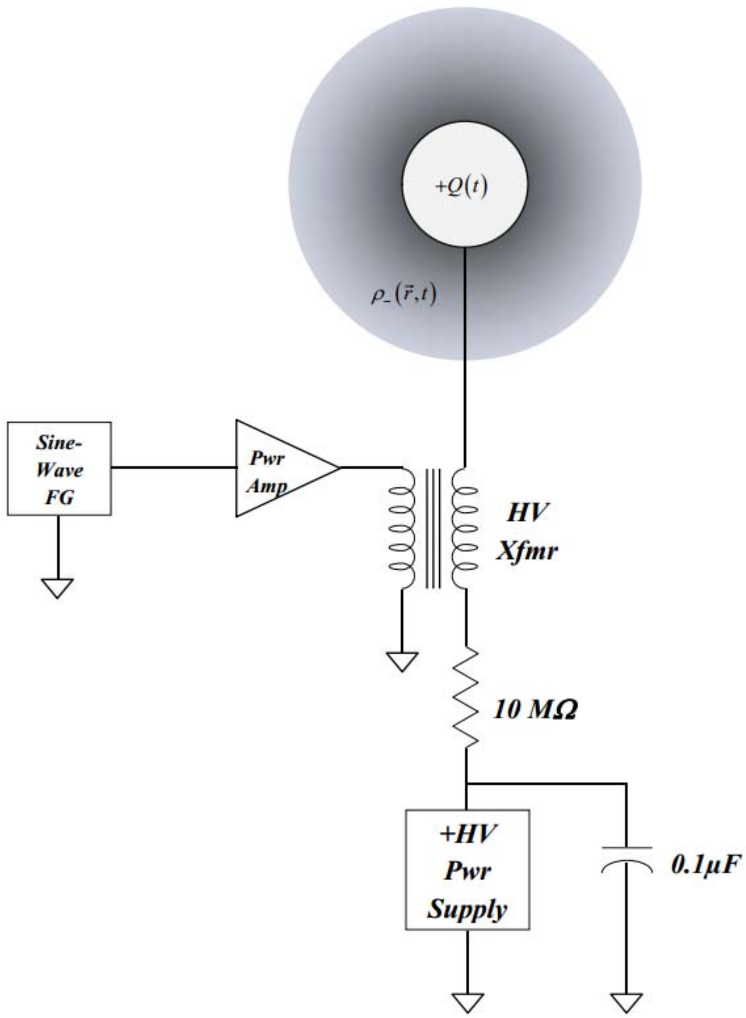
Figure 1: Diagram of Water, Dinitrogen, and Dioxygen Molecules



If one charges up a conducting sphere to a positive high voltage DC potential, the sphere will attract the negative water ions and repel the positive dioxygen and dinitrogen ions. If one then superposes an oscillating potential to the static DC potential, the moisture should oscillate much like a speaker membrane. Provided the static voltage and humidity are sufficiently high, this should produce a noticeable pressure wave through the air. In other words, one should be able to hear sound emitted from the source.

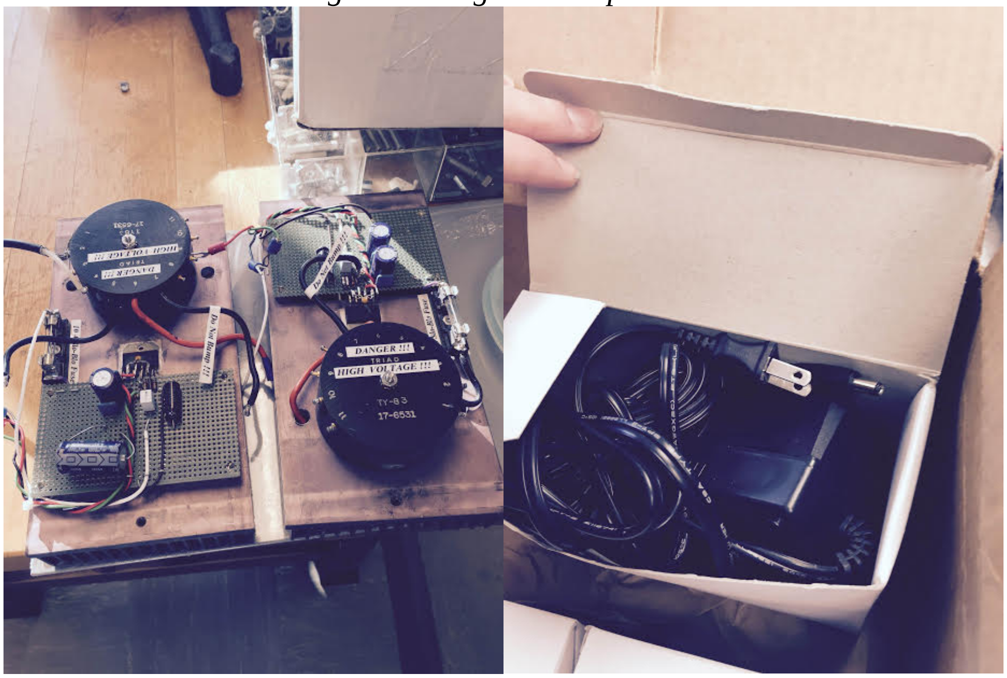
The original design (*Figure 2*) allows the metal sphere, labeled $+Q(t)$ to represent the oscillating charge, connected to a positive high voltage terminal. A function generator signal is transferred to the sphere through a transformer, causing the charge Q to oscillate.

Figure 2: The Original Design



Originally, we were going to use these two 24 Volt power supplies for the positive and negative terminals, one of the toroidal transformer setups for each terminal.

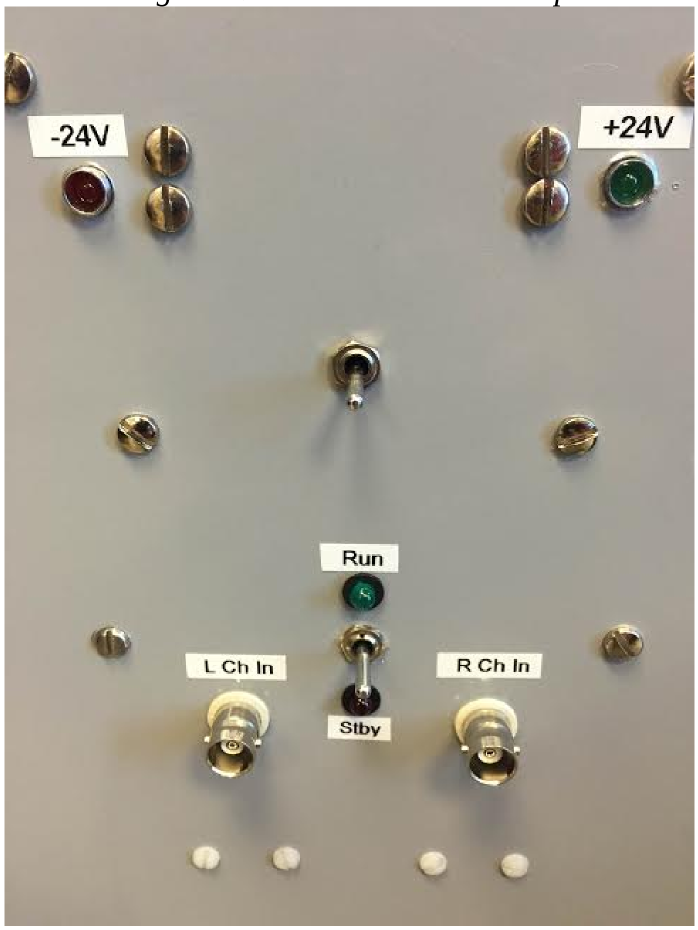
Figure 3: Original Components



We ended up mounting the toroidal transformer circuits to the back of a control panel that we designed, with a control switch and LED indicator lights. However, we decided that the power supplies were not good enough, and they also shocked people even when unplugged. The power supplies we ended up using are shown in the complete setup in *Figure 7*.

When mounting the switches and LEDS to the control panel, we wanted to insulate the power supply terminals from the metal control panel. To do so, we mounted the control panel inputs on rubber sheet squares, and bolted down the inputs using plastic bolts. I would include a picture of the mounting mechanism in the report, but to take a picture of the design, I would have to disassemble the capacitor bank on the back of the control panel. After completing assembly and labeling, the close up of the control panel looked as in *Figure 4*. In this setup, one can see where the insulating plastic bolts were used (below the *L Ch In* and *R Ch In* channels).

Figure 4: Control Panel Close-Up



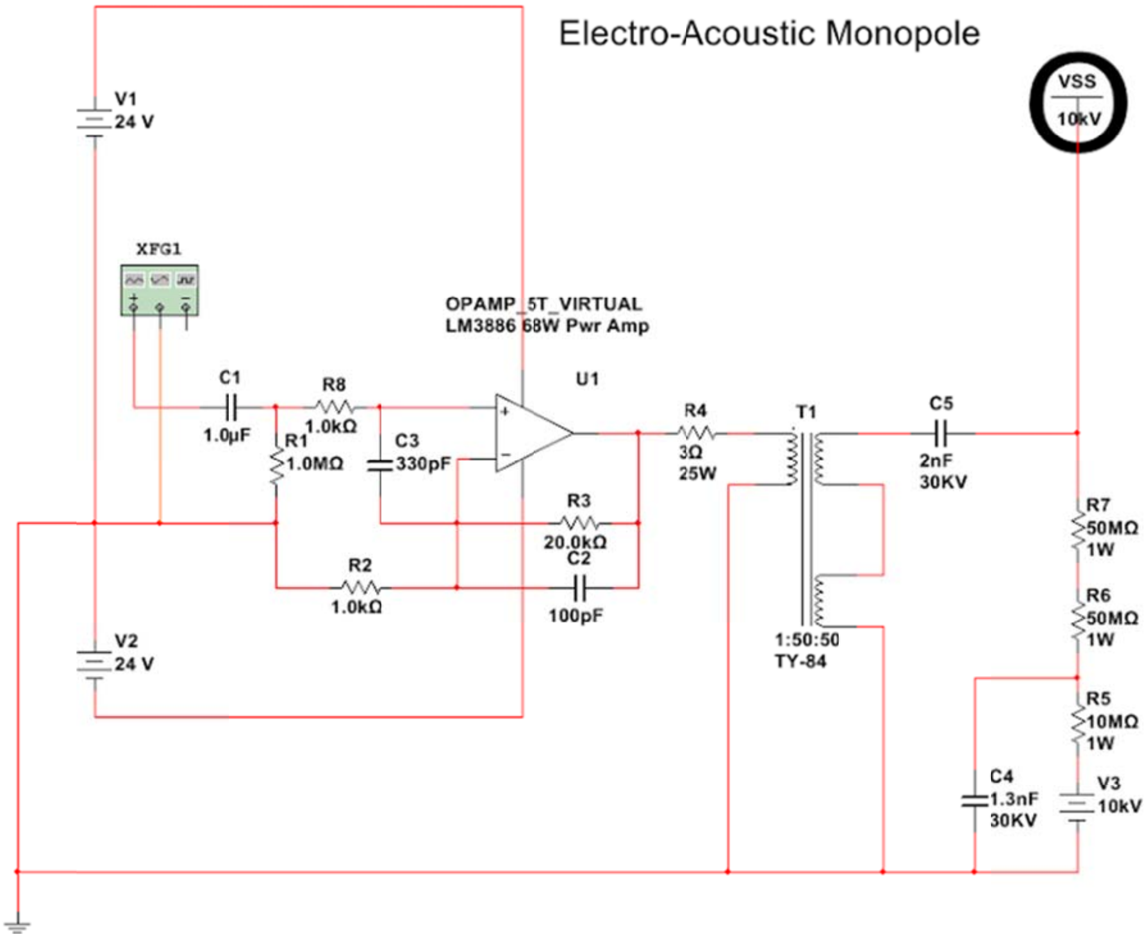
The *-24V* and *+24V* LEDs should light up when the system is powered on, indicating that each circuit is working properly. These lights shine red and green, respectively. The *L Ch In* and *R Ch In* terminals host BNC connections for the signal input. For now, we used a function generator. The unlabeled switch is there because we originally thought we would need it, though we ended up bypassing it. In other words, it does not do anything, and flipping it either way has no effect on the circuit. The *Run/Stby* switch indicates if the machine is operating, or simply on standby, with respective corresponding green and red indicator lights.

The back of the control panel (*Figure 5*) shows the toroidal transformer setup with the capacitor bank in between, hosting the ±24V inputs and the corresponding SHV outputs. The +24V circuit hosts a ground plate made of copper tape because we thought it would reduce the circuit noise. Unfortunately, there is no data to back this up yet because the device has not been fully tested.

Figure 5: Behind the Control Panel

The corresponding circuit for the experimental setup is shown in *Figure 6*. Throughout the semester, the system evolved from the circuit in *Figure 2* to the circuit below.

Figure 6: The Circuit Schematic



With the help of extra sets of hands, we then mounted everything to the rack (*Figure 7*). We added NIM modules to supply voltage and current, which occupy the top of the rack. Below the NIM modules is a cooling fan, which blows the air upward to cool the circuit below, behind the control panel. At the bottom lie the function generator to the left, and the power supplies to the right.

Figure 7: The Complete Setup

The SHV outputs, as labeled in *Figure 5*, connect to the conducting metal sphere from an old Van de Graff generator.

Figure 8: The Sound Source

We tested the device for the first time on Tuesday, April 28th, 2015. We plugged in the sound source, powered up the function generator, and set the power supplies to ±24 Volts. Unfortunately, after testing the system for both the left and right channels, the sphere failed to produce any sound. I hypothesize that this is due to the inadequacy of the high voltage power supplies in the NIM bin, as well as the lack of humidity in the air. The NIM power supplies failed to exceed 9kV, and ideally, we would be using power supplies in excess of 100 kV. Additionally, after measuring, we discovered the room was only at 27%. For the best acoustic output, the device should operate in an environment of near 100% humidity. Because the conditions are several factors lower than the ideal situation, we have yet to produce acoustical output from the electro-acoustic monopole sound source. To remedy the situation, Dr. Errede and I have discussed running the source in a humid environment, such as in proximity to a humidifier. Additionally, it would be advantageous to invest in new high voltage power supply of 100 kV or more.