Audible Tone Reproduction via High-Voltage Arc Gap

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Abstract
This project is a circuit that plays music by repeatedly firing high-voltage arcs of electricity. When these arcs fire through the air at hundreds of hertz, the human ear will perceive a tone. Changing the arc frequency will change the tone, allowing music to be created by rapidly changing the arc frequency.

Theory
Generating the arc:
25,000 volts per inch are needed to arc through air. To generate this level of voltage we need a transformer, a device composed of two coils of wire that changes the ratio of voltage and current in a signal. This change is determined by the "turns ratio" of the two coils, which is found using the equation below:

\[ \text{Turns ratio} = \frac{N_1}{N_2} \]

When power is supplied to the primary coil, current and voltage are induced in the secondary coil proportionate to the turns ratio. Increasing the turns ratio increases the output voltage to hundreds or thousands of times the level of input signal.

Making the music:
The audible tone is created when a high-voltage arc jumps to the ground rod, displacing the air that it passes through. Since a periodic wave (musical sound) crosses zero volts twice per Hz, two arcs are required per Hz to create the tone. Arcs are created by switching a large power supply on and off at a musical frequency. The musical frequencies we are targeting exist between 20Hz and 1.2kHz, so up to 2,400 switches per second are required. To accomplish this we use a power transistor, a device designed to switch large power loads at high frequency.

The audio is created with a program called Audacity, which can output music as square waves. Square waves, which have only two voltage levels, are better suited for switching applications.

The switch takes the 12 volt square wave from the amplifier and uses it to change its state between on and off. The power transistor is capable of switching a high power source on and off very rapidly. By quickly changing the power through our coil, it changes our audio frequency into a series of high-voltage arcs. However, sustaining this rapid high power switching is difficult, and requires a heat sink to prevent the transistor from burning out.

The coil generates the high voltage needed to arc based on the changing state of the switch. This component performs a very large voltage transformation. When current is passed through it, it charges the arcing rod to dozens of kilovolts. When that current is shut off, all the charge jumps from the arcing rod to the ground rod, creating the audible arc. This process is repeated every time the switch changes state, often at hundreds of hertz.

The coil is only capable of playing one frequency at a time, so the music it plays is similar to what you would hear if you played a melody one note at a time on a piano. Also, the frequency response is limited due to the coil’s natural low-pass tendencies. The arc length shrinks and eventually disappears at higher notes (frequencies). This limits the number of available musical octaves, but still leaves enough to play music.