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Physics II Honors Project

Crystal Radio

Due: 4/25/12

With the turn of the ninetieth century, human beings were able to hear something unprecedented. Through a simple invention, they could listen to an opera, a song, anything, miles away from the source. This device would lay the groundwork for many modern day technologies taken for granted such as television, cell phones, and RC toys. What humanity was first experiencing a hundred years ago was the radio.

It is due to electromagnetic waves that a radio is able to transmit information across hundreds or even thousands of miles. To be specific, a radio functions because of electromagnetic waves that range from a millimeter to kilometer in wavelength, which are known as radio waves. Because radio waves have a relatively static wavelength and frequency, it is possible to have information piggyback on these waves and use these constants to extract the information. This process of getting information to ride on radio waves is known as modulation. A few examples of modulation are amplitude modulation and frequency modulation. One might recognize these better by the acronyms AM and FM. Amplitude modulation is done by using the changes in the amplitude to store the information. Frequency modulation, on the other hand, is implemented by varying the frequency of the wave. These waves may then be caught and be extracted for the information in a process known as demodulation. While there are several different methods to demodulatize a signal, the method which is used by the radio constructed is known as envelope detector and will later be discussed more in depth. Once the information has been extracted, it is processed through an audio device to produce sound. For this project, a crystal radio was developed. The radio consists of an antenna, a tuned circuit, and germanium diode, a ground, and a listening device.

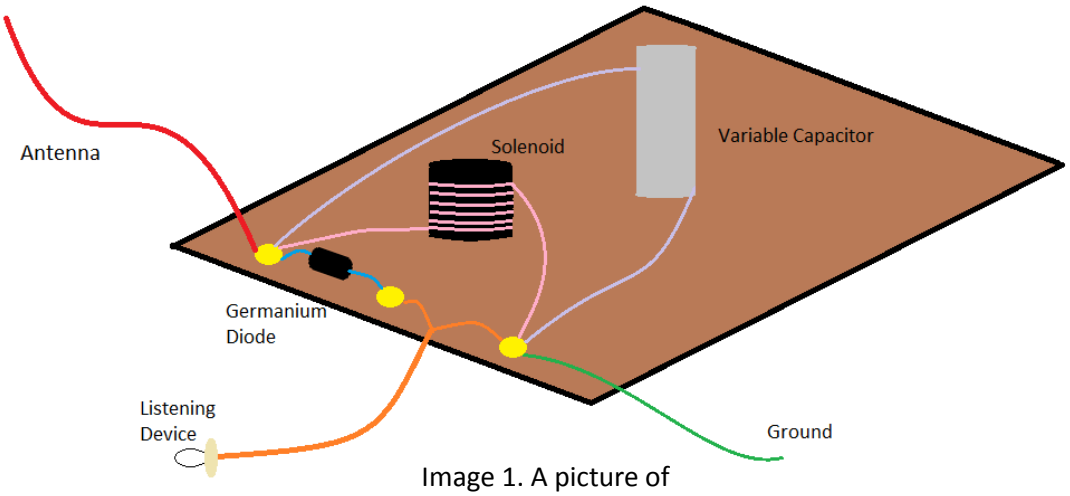

Image 1. A picture of the crystal radio built

The first portion of the device is the antenna. Its purpose is to acquire radio waves for the radio to process. The antenna consists of a long piece of wire, forming a monopole antenna. (Lescarboura) The energy from the radio waves collected then flows as an alternating electric current toward a tuned circuit. (Lescarboura) Due to the design of the radio it is only possible for AM waves to be processed, although both AM and FM waves can be caught.

The second component of the radio is the tuned circuit. The circuit built consisted of a wire solenoid and variable capacitor, though other designs are possible. (Khun) It is here that resonant frequency is determined. That is, the radio channel that one will receive as output. (Khun) The resonant frequency is dependent on the capacitance of the capacitor and the inductance of the coil, as exemplified in Equation 1. (Khun)

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Equation 1. Resonant Frequency's relationship with inductance and capacitance

Because the solenoid's features are constant, the inductance is also constant. As such, it is up to the variable capacitor to allow the user to tune to which frequency is desired by increasing or decreasing capacitance based on the amount of area the two plates share. Upon tuning to the desired frequency, all other frequencies possibly acquired will be removed due to electrical impedance, the measure of the opposition that a circuit presents the current when a voltage is applied (Kennelly). The reason why will be expounded upon during the explanation of the next two components, the ground and diode.

The ground and germanium diode make up the next two pieces of the radio. Because the antenna used is a monopole, it is necessary for there to be ground in order for the circuit to have a potential voltage. This potential voltage, in combination with the previously mentioned electrical impedance, allow for the purification of the current created the radio. This is because, frequencies that are not the desired frequency will have currents with low impedance, meaning low opposition. The diode acts as gate, allowing only currents with a high impedance to pass through. (Campbell) The low impedance currents are then short circuited and forced to go to the ground where they are dispersed and removed from the radio system. (Campbell) It is in the diode that desired alternating current is converted into an equivalent pulsing direct current containing the information. This current then goes to its final destination, the listening device.

The final component is the listening device, which is in this case an earbud. It is in the earbud that pulsing direct current creates vibrations. These vibrations are dependent on the information in the current causing the pulses. The vibrations are then received by the ear and heard.

It has been a century since the radio first awed its first listeners with sound that came from the seemly the air. And, although it has been a hundred years the same principles that allowed the radio to be invented were used once more to successfully create a crystal radio that was capable of obtaining not one, not two, but three distinct radio channels.

References

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