Understanding and Operating Your Crystal Radio

Your crystal radio receiver is designed to tune stations on the AM broadcast band (radio frequencies of 540 to 1610 kHz). You will be limited in the number of stations you can hear when operating the radio without amplification. Keep in mind that a crystal radio operates ONLY on the power received from the radio station transmitter. Therefore, your ability to hear a station will depend to a great extent on the distance from the radio transmitter to your house and the amount of power the station uses to broadcast their signal. Another important factor will be the antenna you use with your radio.

Most of our club members live in Geauga County. As far as I know, there is no radio station broadcasting on the AM band in our county (at least not a powerful station). From my home in Chesterland, the strongest station tuned on my crystal radio is WTAM. This station broadcasts with 50,000 watts of power on a frequency of 1100 kHz. The radio transmitter is located at 8200 Snowville Road, Brecksville, Ohio. The distance from the transmitter to Chesterland is about 23 miles (21 miles to Auburn Twp and 31 miles to Chardon). Figure 1 is an aerial view of the WTAM transmitting antenna, which is 480 feet tall.

Figure 1 WTAM transmitting antenna

As radio waves travel away from the transmitter, the power density of the radio energy varies inversely with the square of the distance. What does that mean? We can write this as a proportion:

$$power\ density\ \propto \frac{1}{distance^2}$$

Let me give some examples. The power density of a radio wave at a distance of 10 miles from the transmitter is:

$$power\ density\ \propto \frac{1}{10\ \times\ 10} = \frac{1}{100} = 0.01$$

The power density at 20 miles is:

$$power\ density\ \propto \frac{1}{20\ \times 20}\ = \frac{1}{400}\ = 0.0025$$

Therefore, the power density at 20 miles is 1/4th the power density at a distance of 10 miles. At a distance of 40 miles, the power density will be 1/16th the power density at 10 miles. All other things being equal, if your crystal radio is located 40 miles from the transmitter, the signal strength delivered to the radio will be 1/16th what it would be if located 10 miles from the transmitter. This is why you will have a better chance of hearing a station, the closer you are to its transmitter. Of course the amount of power used in transmitting makes a difference. If two stations are the same distance away, but one transmits with 1,000 watts of power and another transmits with 50,000 watts, the 50,000 watt station will be considerably louder than the one with 1,000 watts.

Antenna for the Crystal Radio

The antenna you connect to your crystal radio will determine to a great extent the number of stations you can hear. It is doubtful that an indoor antenna will be sufficient unless you live within a few miles of an AM radio transmitter. Provided that you have permission from your parents, you can install an outdoor antenna. You should ask your parents for assistance in erecting the antenna. This can be a temporary antenna, put up only when you are using the radio, or a more permanent installation. Again, you should ask your parents which kind of installation they will allow. Some people think that antennas are not attractive and you must keep this in mind.

The antenna that I use for my crystal radio is of the long wire type (14 gauge, stranded and insulated). It is permanently installed. I drilled a hole through the window frame to allow the antenna wire to exit from the GEAR workshop to the outside. I installed a hook on the edge of the roof and with an insulator, attached the wire antenna. The wire length from window to the edge of the roof is 11 feet. Then the wire runs to a tree 50 feet from the roof. The attachment to the tree is 18 feet above the ground. The wire then runs to another tree 61 feet from the first tree and also 18 feet above the ground. At the second tree the wire goes through a pulley and then down to the ground where it is attached to a weight. The total length of the antenna wire, from the window to the end is 140 feet (you will also need additional length inside the house to reach the radio). The pulley is used as part of the antenna tensioning system. When the wind moves the tree branches, the wire moves through the pulley to prevent breakage of the wire. The weight at the end of the wire provides the tensioning of the antenna so that it does not dip excessively toward the ground between its supports. This antenna works well and I can hear four or five stations during the day.

When you work 18 feet above the ground, there is danger of a serious or fatal injury from a fall. If you want to erect an antenna like the one I have described, **DO NOT ATTEMPT THIS ON YOUR OWN. PLEASE HAVE YOUR PARENTS HELP YOU**. I used a ladder to attach the antenna wire to the trees. This kind of work can be very dangerous and you must use proper safety procedures. The job takes a minimum of two people, one to hold the ladder while the other person climbs the ladder. The ladder should be secured with ropes so that it will not slip off the tree. It is also a good idea to use a safety harness that connects the climber to the ladder in case they slip on a ladder rung.

A safer procedure, although possibly more frustrating, is to throw a light line over a tree branch from the ground. Attach a weight to the end of a string and attempt to throw the weight over a branch. If that does not work you might try using a slingshot. It would be a good idea to wear a hard hat or bicycle helmet while doing this in case the thrown weight comes back down on your head! If you have a very long pole, you might use that as well to hoist the wire over a branch. These methods are preferred over the ladder since they are safer. After you are successful in getting a string line over a tree branch, connect the string to your antenna wire and pull the string to hoist the antenna wire in place.

Ground Connection for the Crystal Radio

In addition to the antenna, a connection to ground is required. The ground connection is actually part of the antenna system. For the antenna I have described, I used a grounding rod, which you can find in the electrical department at a hardware store. The rod is 8 feet long and all but a few inches are driven into the ground with a sledge hammer. Make sure there are no pipes or underground electrical wires in the area where you install the grounding rod. It is best to install the rod near where the antenna wire exits the house. The rod is copper-clad steel. A special bronze clamp is used to attach a ground wire to the rod. The other end of this ground wire is connected to the ground connection (black wire) of the antenna coil of the radio. The grounding rod must be in moist soil to work well. Of course it is difficult to know how moist your soil is 8 feet below the surface. But if your antenna does not seem to be working very well, you may need to water the soil around the grounding rod.

If you are not sure you will use your radio very much, you may decide to erect a shorter outdoor antenna. I erected a temporary long wire antenna, 11 feet from window to edge of roof, 50 feet to a tree branch that was 7 feet off the ground, then ran the wire to the ground and tied to a weight (total of 68 feet of wire from the window to the end of the wire). For this antenna I did not use a grounding rod. Instead, I connected the ground wire of the antenna coil to the ground system of the house electrical wiring. This can be done by connecting a wire to the screw of a faceplate for an electrical receptacle – see Figure 2 (**DO NOT PUSH THE WIRE INTO ONE OF THE RECEPTICLE SLOTS AS THIS COULD RESULT IN A FATAL ELECTRIC SHOCK**).

Figure 2 ground wire connected to faceplate

Using the shorter antenna and ground to faceplate, I could only hear station WTAM 1100. After you have completed the audio amplifier for your crystal radio, you will be able to hear more stations with the shorter antenna. However, if you have an interest in hearing distant stations, the longer antenna with grounding rod will be better.

When there is a chance of an electrical storm in your area, it is advisable to disconnect your antenna at a location outside your house. While lighting strikes on an antenna like yours are rare, it is better to be safe and prevent the very high current and voltage from entering your house. It is best if your exterior antenna is connected to ground outside the house when not in use.

Calibrating the Tuning Dial

The knob connected to the variable capacitor of the radio has a white pointing line to indicate the position of the variable capacitor. The position of the variable capacitor determines the radio frequency tuned (the station). However, the front face of the radio does not have any markings to indicate the frequencies for various positions of the knob. Mr. La Favre will help you mark the face of the radio at intervals of frequency. To do this we will use a signal generator. The signal generator will be connected to a coil that will substitute for the antenna coil. The signal generator can be adjusted to any radio frequency desired. In addition, the radio frequency can be modulated (AM - amplitude modulation) with an audio frequency, which you can hear as a tone in the radio earphone. We will start by adjusting the signal generator to a radio frequency of 600 kHz, modulated with an audio frequency of 400 Hz (400 Hz is a tone just a bit lower than the musical note A above middle C – that A is 440 Hz). The coil attached to the signal generator is placed next to the tuning coil of the radio. Then the tuning knob of the radio is adjusted until the 400 Hz tone is heard clearly in the radio earphone. The knob is adjusted to the position where the tone is heard with the highest volume. At that point a felt-tipped pen is used to place a mark on the front plate of the radio to match the position of the white line of the tuning knob. Then that line is labeled with the number 600 (600 kHz). We will continue by adjusting the signal generator in increments of 100 kHz, marking each knob position for each frequency. When finished, you will have marks on the face of the radio for 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500 and 1600 kHz. These marks will be helpful in adjusting the variable capacitor to tune a specific station.

Functions of the Various Components of the Crystal Radio

The most important reason for completing the Crystal Radio project is to learn how a radio works. Of course I also hope you will enjoy using your radio. To begin, let us take a look at the schematic for the radio provided below.

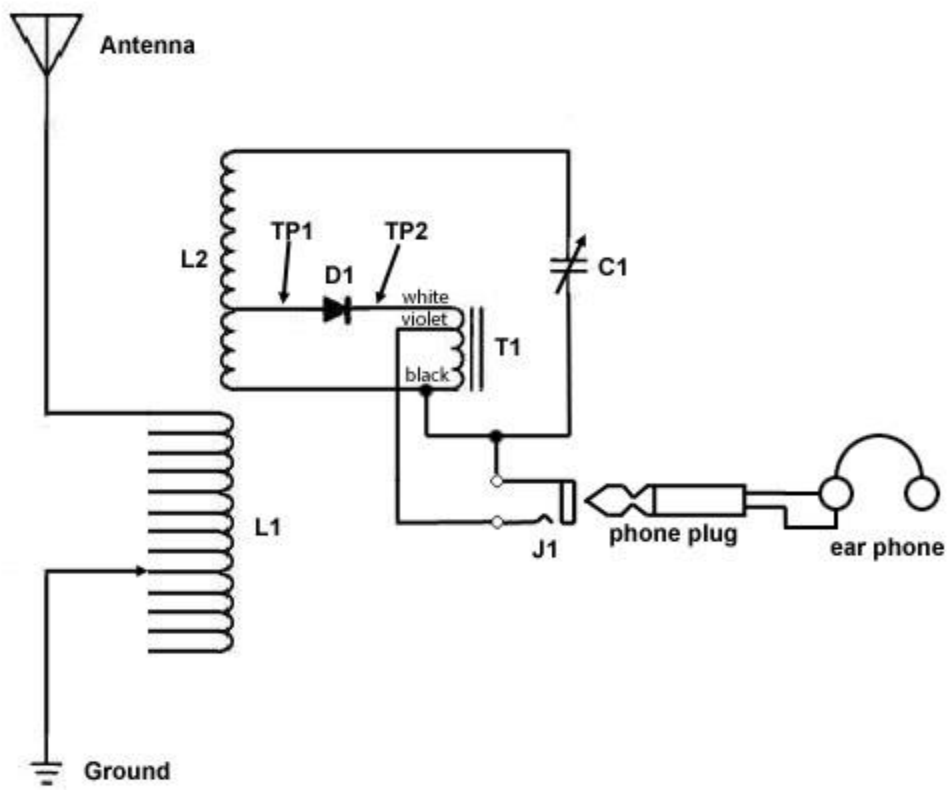

Figure 3 schematic of the Crystal Radio

L1 is the antenna coil and L2 is the tuning coil. The antenna coil has 12 taps. The ground wire is terminated with an alligator clip, which is used to connect to one of the taps. After tuning a specific station with the variable capacitor, C1, the ground wire is connected to the tap of coil L1 which gives the loudest signal as heard in the earphone. By selecting the best tap on coil L1, you are actually tuning the antenna to *resonate* at the tuned frequency. An antenna that is tuned to a specific radio frequency will deliver the strongest signal to the radio. When you adjust the variable capacitor to tune another station, you may need to adjust the tap connection on L1, especially if the new station tuned is of a significantly different frequency than the previously tuned station. Higher frequency stations will require connection to a tap closer to the antenna end of the coil. As you tune stations of lower frequency, you will need to adjust the tap connection to a tap further from the antenna end of the coil. In other words, a station of lower frequency will require the signal to travel through more coil turns than one of higher frequency. The exact tap to use will also depend on the length of your antenna.

Therefore, it is not possible for me to tell you which tap to use for a specific station. You will need to establish this by trial and error. If you are not able to find a tap on the coil that provides a stronger signal than other taps, then it is likely that your antenna is too short to tune to resonance. Nevertheless, this will not prevent you from hearing stronger stations.

Figure 4 below is a photo of the assembled radio. The green wire labeled A is the antenna wire and the black wire labeled B is the ground wire which connects to the grounding rod just outside the window of the GEAR workshop. D is the antenna coil (L1 in schematic). C is the alligator clip, attached to one of the taps of the coil. The red wire of the antenna coil connects to the antenna wire and the black wire connects to the ground wire. After making these connections, and placing the antenna coil (D) near the tuning coil (E), your radio is ready for use.

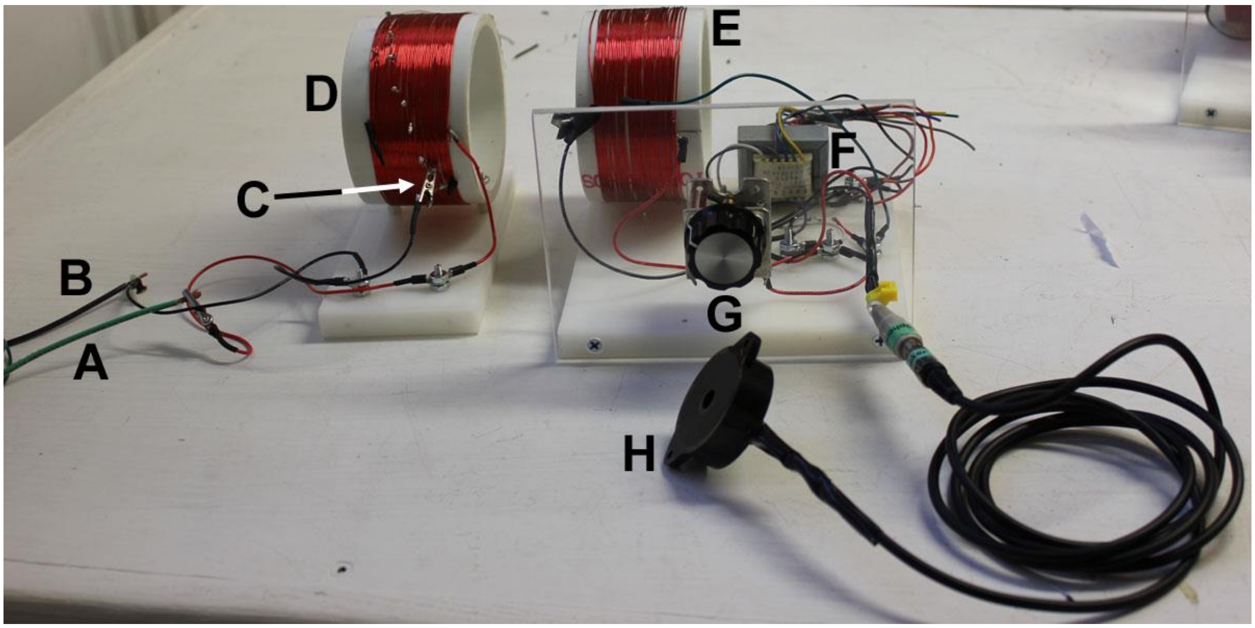

Figure 4 assembled crystal radio

F is the audio transformer, which is labeled as T1 in the schematic of Figure 3. The audio transformer is used to match the impedance of the earphone (H). G is the knob attached to the variable capacitor.

The radio signal present in the antenna coil (D) is transferred to the tuning coil (E) by the magnetic field generated by the antenna coil. When current flows through a coil, a magnetic field develops around the coil. If another coil is placed near that coil, then the second coil is also immersed in the magnetic field created by the first coil. This is the means for transferring the radio signal from the antenna coil to the tuning coil.

The transfer of the signal between the coils can only occur if the current flowing in the antenna coil is alternating current. As it happens, the current established in the antenna coil is alternating current. When an antenna captures radio waves, the radio waves are converted to an alternating current in the antenna circuit, which includes the antenna coil. As the current flows back and forth through the antenna coil, the magnetic field builds and then collapses around the antenna coil. It is the changing magnetic field which is required to transfer the electrical energy from the antenna coil to the tuning coil.

If the current flowing in the antenna coil was a constant direct current, there would be no transfer of electrical energy to the tuning coil.

The antenna coil and tuning coil together constitute a type of transformer. Transformers play important roles in electrical systems. The usual function of a transformer is conversion of voltage from one level to another. There is a transformer mounted to the electric pole near our house. It converts the high voltage (several thousand volts) of the electric line down to 240/120 volts for service to our house. In the case of our radio, we are not so much interested in converting the voltage of the signal in our antenna circuit as just transferring that signal to the tuning coil. We could just use one coil and connect the antenna, ground and variable capacitor to that coil. However, better results are obtained by using separate coils to tune the antenna and then transfer that tuned signal to the tuning coil via a magnetic field.

The antenna coil and tuning coil are mounted on separate bases so that you can adjust the distance between the coils. There will be a specific distance between the coils that results in the strongest signal received in the tuning coil and this may vary with the radio frequency tuned. The optimum spacing is not necessarily the closest spacing. As part of the process of tuning a station, you should adjust the space between the coils for maximum loudness heard in the earphone. In any case, the distance between the coils for best transfer of signal will be similar to that seen in Figure 4. For example, if you place the coils 12 inches apart, there will be little signal transfer.

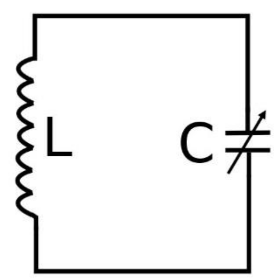

Figure 5 simple LC circuit with coil and variable capacitor

The variable capacitor C1 works together with the tuning coil (L2 schematic or E in photo) to tune a specific radio frequency. The tuning coil has a fixed amount of *inductance* and it is the adjustment in *capacitance* of C1 that allows tuning of different frequencies. Figure 5 shows a simplified version of the LC circuit of the crystal radio. The actual circuit for our radio contains a tap on the coil for diode D1 as well as other connections. But let us concentrate only on the coil L and capacitor C. In a certain respect the circuit of Figure 5 is an open circuit because current cannot pass through capacitor C. To be more precise, the circuit is open as far as direct current is concerned. However, we can consider the circuit closed in respect of alternating current. Capacitors behave in a fashion that allows current to flow temporarily in a circuit as the capacitor charges. With alternating current, the current flows for a short period only in one direction, especially at radio frequency rates of alternating current. As the current charges the capacitor, current is allowed to flow in the circuit. Once the capacitor is fully charged, current will no longer flow. What we must keep in mind is that at radio frequencies, current flows in one direction for a very short period of time. Let us take a frequency of 1000 kHz as an example, a frequency in the middle of the AM broadcast band. That frequency is equivalent to 1,000,000 cycles per second. Each cycle results in current flow in one direction followed by current flow in the opposite direction. The duration of flow in one direction is only 1/2,000,000th of a second or 0.5 microseconds. A microsecond is one millionth of a second. That is a very short amount of time. Even so, the electric current in the circuit in Figure 5 could travel around the circuit in much less time than 0.5 microseconds IF we did not include the capacitor and inductor (coil).

In order to tune the circuit for resonance at a specific radio frequency, we want the capacitor to charge and discharge at a rate that equals the frequency. If we removed the inductor (L) from the circuit, the capacitor would charge and discharge much faster than the rate required for tuning the circuit to resonance. By including the inductor, we slow down the rate of current flow, which in turn results in a slower charge and discharge of the capacitor. It is the interesting behavior of an inductor (coil) that we have employed to establish resonance. When voltage is first applied across an inductor, very little current is allowed to flow through the coil. Instead, a magnetic field starts to build around the coil. As time wears on (here we are talking about very little time), more current is allowed to flow through the inductor. The degree of hindrance in current flow by an inductor depends on the amount of inductance of the coil. We measure this in units named Henries, just as capacitance of a capacitor in measured in units of the Farad. An LC circuit containing a coil of a specific value of inductance and a capacitor of a specific value of capacitance will be resonant at a specific radio frequency.

Resonance can be a difficult thing to understand. Let us take the analogy of a child on a swing. As the child swings back and forth, the parent gives a push just as the backward movement stops. The end result of these timed pushes is that the child continues to swing. The swinging of the child is in resonance with the pushes given by the parent and the child will continue to swing indefinitely. Now suppose that the parent delivered the pushes while the child was still moving backward. In this case, with each cycle of the swinging back and forth, the amount of the swing will diminish until it ceases. In this case there is not resonance of the swinging and pushes.

The LC circuit is much the same. At a specific radio frequency, the frequency of resonance, the current flows back and forth in the circuit, timed exactly to match the rate of capacitor charging and discharging (the capacitor is somewhat like the parent pushing). At frequencies other than the resonance frequency, the current flowing back and forth in the circuit does not match the charging and discharging rate of the capacitor. Thus, the electrical energies of the non-resonant frequencies are absorbed in the LC circuit and not passed on to the remaining circuits of the radio. It is by this method that a signal of a specific frequency is allowed to pass through the radio while other frequency are not. If this did not happen, then we would be hearing many radio stations at one time.

Two important characteristics of a radio are **sensitivity** and **selectivity**. Sensitivity is the ability of a radio to deliver a sound that you can hear, derived from a weak radio signal received. Radios other than the crystal type include some type of signal amplification so that stations with weak signals can be heard. Sensitivity can be measured as the minimum signal voltage received that results in audible sound. Crystal radios have poor sensitivity because they rely only on the power received from the tuned radio waves. The efficiency of the radio antenna in capturing energy from the passing radio waves affects the signal strength received by the radio. Since crystal radios do not amplify the signal, it is especially important to use efficient antennas with crystal radios.

Crystal radios are also known in general for poor selectivity, although better designs have better selectivity. It is not uncommon for more than one station to be heard at a particular setting of the variable capacitor due to poor selectivity in the crystal radio. Nevertheless, you will be able to find some stations that you can hear clearly without interference from another station. It just depends on the separation in frequencies of the strong radio stations received at your location. More advanced radios, of the kind you are familiar with, have much better selectivity and usually tune only one station at a time, even when strong stations have frequencies very close to each other. I will not detail the reasons for this any further at this point as the improvements in selectivity require a discussion of circuits not found in crystal radios.

Figure 6 is a portion of the radio schematic showing part of the tuning coil, the detector diode D1 and the audio transformer T1. Two test points are marked on the schematic. We will connect an oscilloscope to these test points so that we can visualize the radio signal at these points in the radio. This will help in understanding the radio.

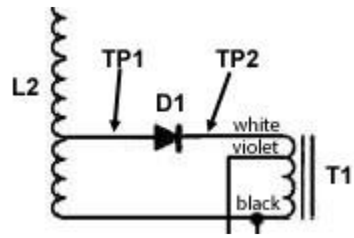

Figure 6 detector schematic of radio

An oscilloscope is an instrument that can be used to visualize rapidly changing electric signals. Figure 7 is the oscilloscope traces at test points one and two (see Figure 6 for locations of test points). A signal generator is connected to the radio providing a radio frequency of 1100 kHz, modulated by an audio frequency of 400 Hz. The blue trace displays the radio frequency at test point one modulated by the audio frequency. In the trace you can only see the waves of the audio signal. The waves of the radio frequency are so numerous that they appear as a solid blue color. It would be necessary to stretch the display to a great extent in the horizontal direction before we could see the individual radio frequency waves in the blue colored trace.

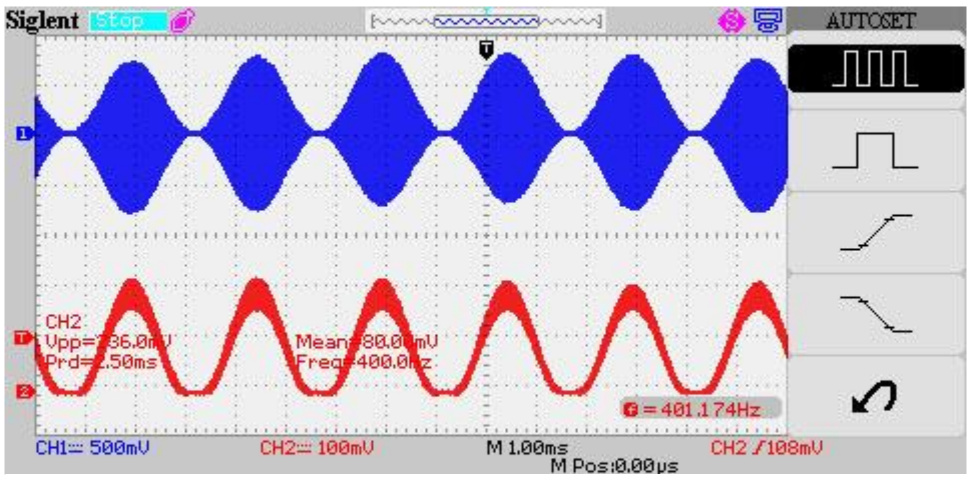

Figure 7 oscilloscope traces at test point 1 (blue) and test point 2 (red)

The height of the blue radio waves is *modulated* by the audio signal (amplitude modulation or AM). The audio signal is much lower in frequency than the radio frequency (the number of audio modulations are much fewer than the number of radio frequency waves). Notice the blue tab labeled "1" on the left side of the blue trace. That tab marks the position of 0 volts. Any time the wave is above the tab, the voltage will be greater than 0. Any time the wave is below the tab, the voltage will be below 0 (a negative voltage). The radio frequency must have alternating positive and negative voltage in order to force periodic reversal in the direction of current flow (like quickly switching the connections to a battery). Otherwise, the current would not change directions and it would not be alternating current.

You should notice that the red trace, representing the signal at test point two, looks very different. Test point two is on the opposite side of the detector diode from test point one. Also note that for this test the diode connection to the transformer T1 was disconnected. Since the diode blocks current flow in one direction, we should not expect to see positions of negative and positive voltage on the wave trace here. In fact, notice where the 0 volt red tab with the label "2" is located. The bottoms of the red waves are at 0 volts. All positions of the waves are at 0 volts or higher because the diode has rectified the radio signal. We call this *detection*. The diode has converted the alternating current radio signal into a pulsating direct current audio signal. It is the audio signal that we need to apply to the earphone in order to hear the sound. If we were to just apply the radio frequency itself to the earphone we could not hear any sound. Humans are not capable of hearing sound at a frequency higher than 20,000 Hz.

After passing through the detector diode D1, the extracted audio signal passes through the audio transformer. The transformer transfers the audio signal to the earphone where the electric signal is converted into sound waves that you can hear. The transformer performs an important function in matching the *impedance* requirement of the tuning circuit to the impedance requirement of the device used to convert the electric signal to sound. The transformer has many taps that represent different impedances. The tuning circuit is attached to the white and black wires of the transformer, which provide about 40,000 ohms of impedance. The earphone is attached to the violet and black wires of the transformer, which provides 10,000 ohms of impedance. This is the best impedance matching I have found by listening to the signal in the earphone and selecting the loudest sound produced when testing all possible connections on the transformer. If you happen to have another high impedance earphone or headset you would like to use with your radio, you may need to use another tap on the audio transformer to connect to the device. The black wire should always be used as one connection. The gray wire provides 20,000 ohms, the blue wire 5,000 ohms, the green wire 2,500 ohms, the yellow wire 1,200 ohms, the orange wire 600 ohms and the red wire 300 ohms. I happen to have a very old pair of high impedance headphones from about 1920 that are designed for crystal radios. It works well when connected to the yellow wire of 1,200 ohms impedance. Modern headsets and earbuds are mostly low impedance devices that will not work with the crystal radio. However, if you pass the signal through the amplifier you will build (which has a high impedance input and low impedance output), then you can use your modern headphones to listen to your crystal radio. The amplifier works well using the 10,000 ohm violet wire connection to the transformer, the same as the earphone supplied with the radio kit.

Impedance is a measure of the resistance to alternating current that a device presents to a connected signal. It is not the exact same thing as a pure resistance, which we can call ohmic resistance. Impedance also accounts for something called *reactance*. Inductors (coils) have reactance, a kind of resistance to current flow as already mentioned. Impedance is a measure of resistance that accounts for the combined effects of ohmic resistance (like a resistor) and reactance (like a coil). In fact, the speakers that are used in radios that you typically use employ a voice coil attached to a diaphragm to convert an electrical signal to sound. The long length of wire used in the coil presents some ohmic resistance to current flow. Since the wire is wound into a coil, it also presents some reactance to current flow. Both of these are combined into a measure of resistance known as impedance. Typical speakers have impedances of 4 or 8 ohms and require much too much power to work with a crystal radio.

Keeping a Log for Your Radio Listening

Most people listen to radio for the programming content. However, if you are serious about radio technology, you may wish to maintain a log of your listening. It can be fun to see how many stations you can hear with your radio. The conditions for propagation of radio waves varies over time and it is probable that you will hear some stations at certain times and not at other times. Therefore, you should listen at different times of the day and night. By keeping a log, recording the stations you can hear, and the date and time, you will create a log of your listening. From this log you may discover some interesting trends. For example, some stations can be heard at night but not during the day.

Even though your radio is calibrated, you cannot know for sure the exact frequency for a station until you hear an announcement of the frequency by the radio announcer. Some stations announce this many times each hour and some do not announce their broadcast frequency very often. So it may be an exercise in patience on your part. The strong station in Cleveland, WTAM, broadcasts on 1100 kHz and announces their broadcast frequency several times per hour. The announcement may sound something like this: “This is WTAM eleven hundred.” You may need to listen carefully to catch the announcement because it is usually done fairly fast. Don’t expect to hear something like this: “This is station WTAM broadcasting on a frequency of eleven hundred kilohertz.” You might have heard something like that 50 years ago but not today!

There are some amateur radio operators (Ham Radio) that have become big fans of the crystal radio. They have studied the construction of crystal radios and compete with each other to design radios capable of tuning stations from distant locations. In fact, one Ham Radio operator located in Hawaii was able to tune a station in Cuba with his special crystal radio. In the case of the radio you have constructed, we cannot expect that level of performance. In fact, if you hope to hear distant stations with your crystal radio, you will probably need to use an amplifier. After you finish your crystal radio you will build an amplifier to use with your radio. Then you will be able to tune many more local AM stations and also distant stations at night if you have a good antenna.

There are different modes of radio wave propagation that determine which radio stations you can hear and at what time of day or night. This also varies with the frequency of the radio signal. For long distance reception, frequencies above those of the AM broadcast band are more useful. These frequencies, between 2 to 30 MHz, are sometimes referred to as shortwave radio or high frequency (HF) radio. Some of the Ham Radio bands are included in this range. International radio stations also broadcast in this frequency range.

Radio wave propagation can be divided into two broad types called ground waves and sky waves. Ground waves travel close to the surface of the Earth and sky waves bounce off the Earth’s upper atmosphere (ionosphere), which allows propagation to more distant locations. The bouncing of radio waves off the ionosphere depends on the amount of ionization. The ionization is caused by high energy radiation (UV light) from the Sun. Therefore, there is more ionization in the upper atmosphere during the day than at night. That is why radio propagation varies between day and night. This subject is considerably more complex than my short description might suggest, but we will leave it at this point for now.

During the day radio wave propagation in the AM band is generally confined to the ground wave type. Ground waves don’t travel much farther than the horizon. The distance to the horizon depends on the height of the radio transmitting antenna and its elevation above sea level. Nevertheless, propagation by ground wave is usually limited to 100 miles or less.

During the night the Sun does not shine on Earth’s upper atmosphere and the degree of ionization of air molecules and atoms decreases. With these changes, radio waves of the frequencies used in the AM band can bounce off the ionosphere. When this happens it becomes possible to tune in AM stations hundreds of miles from your location. Therefore, if you want to try tuning in distant stations, you will need to try this at night. The signal strength of these stations will be weak and you will have much better luck hearing these stations if you connect an amplifier to your crystal radio. In addition, it is especially important to use a good outdoor antenna if you are trying to tune in distant stations.

As you build a log of listening, you may wish to gather more technical information about the distant stations you have been able to hear. A good web site to consult is the FCC (Federal Communications Commission) site for AM stations: https://www.fcc.gov/encyclopedia/am-query-broadcast-station-search . The information at this site includes the location of the station's transmitter (given in longitude and latitude) and the amount of power used by the station. Some AM stations are required to broadcast with lower power at night in order to avoid interfering with other radio stations operating on the same frequency (due to longer transmission distances at night). The FCC licenses a limited number of "clear channel" stations in various locations in the United States. These stations are required to transmit with 50,000 watts of power day and night and these clear channel stations are the most likely ones you will be able to hear from distant locations. There is a list of clear channels at this web site: https://en.wikipedia.org/wiki/Clear-channel_station . Our strong AM station in Cleveland, WTAM 1100, is a clear channel.