Electronic Morse Code Practice Oscillator Kit

This kit was designed to be assembled in about 30 minutes and accomplish the following learning goals:

1. Learn to associate schematic symbols with actual electronic components;
2. Provide a little experience soldering electronic components without consuming too much time;
3. Have fun by assembling a working Morse code practice oscillator you can keep!

Parts List

Quantity	Description
1	Morse Code Key
1	8 Ohm speaker w/leads
1	6-terminal connector block
1	100 kOhm Potentiometer (the “knob”)
2	910 Ohm resistors
1	10 kOhm resistor
1	0.47 uF capacitor (marked “474”)
1	2N2222A NPN transistor
1	2N2907A PNP transistor
1	Red LED
1	9 Volt battery clip
1	9 Volt battery
1	Kit Document w/assembly instructions and theory of operation

Electronic Morse Code Practice Oscillator Kit

Assembly Instructions

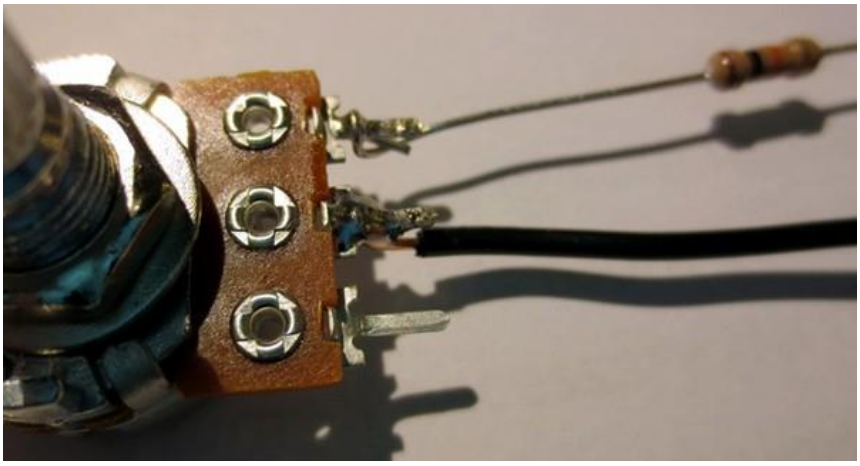
While some of these steps may be performed in a different order to coordinate use of the soldering station, ***do NOT hook up the battery until the kit is fully completed*** (and inspected by your instructor if you are unsure of anything). The components in this kit can be permanently damaged by assembling it incorrectly or by unintentional contact between components. For example, a "hot" wire touching the metal transistor case can easily burn it out.

"Don't panic" when you find that you have two extra parts at the end of these instructions! The extra 910 Ohm resistor and red LED (light emitting diode) have been provided in case you would like to try some additional soldering and assembly during free time.

1. Ensure the kit contains all of the parts listed above. To keep the parts from getting damaged or lost, please leave them on the card and/or in the bag until ready to use.

2. **NOTE: If the soldering station is not available, this step may be skipped until later.**

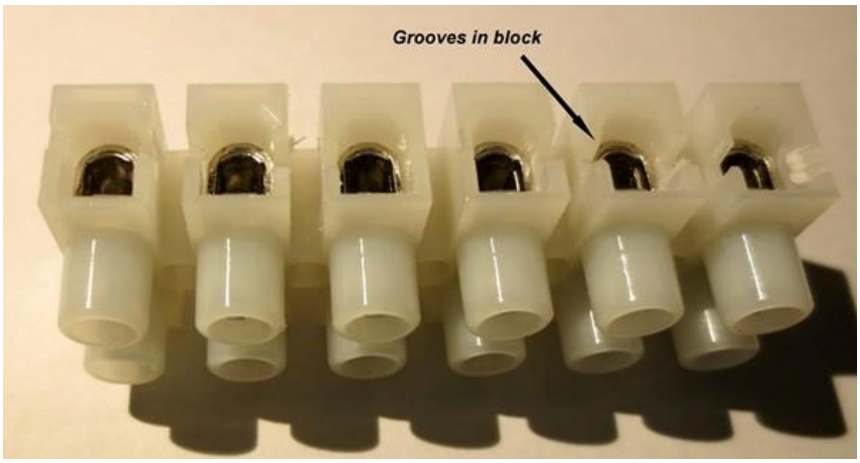
   Locate the potentiometer (the "knob"), the short jumper wire, and the 10 kOhm resistor (Brown-Black-Orange-Gold color bands) and complete the following steps:
   a. Using needle nose pliers, make a small "hook" in the end of one of the resistor leads.
   b. Holding the potentiometer with the shaft pointing towards you and the potentiometer leads facing to the right, wrap the hook you formed on the resistor lead around the top lead and wrapping the resistor lead around the potentiometer lead one complete turn for mechanical stability.
   c. Do the same with the short jumper wire around the potentiometer's center lead.
   d. Carefully solder each connection and set assembly aside for use in step 8 below.



3. Locate the white 6-terminal connector block and orient it with the "grooves" facing upwards and the screws facing you. Check to that all screws are "open" by verifying you can see light through the

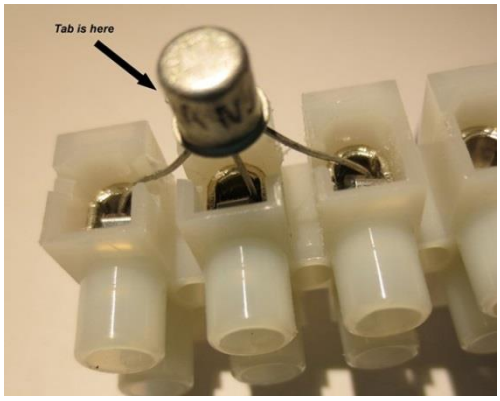
holes (so there is room to insert wires and component leads). If not, use a screwdriver to unscrew the terminals ***a few turns*** (NOT all the way out!).

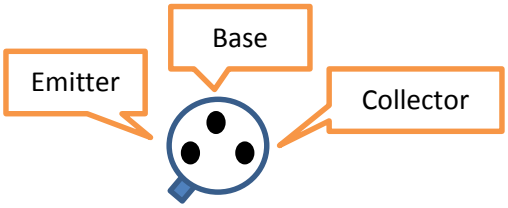
When holding the terminal block with the "grooves up" and the screws facing you, the terminal positions with the grooves will be referred to as the "top" terminals and the terminals on the opposite side the "bottom" terminals. Terminal number is counted from the left.



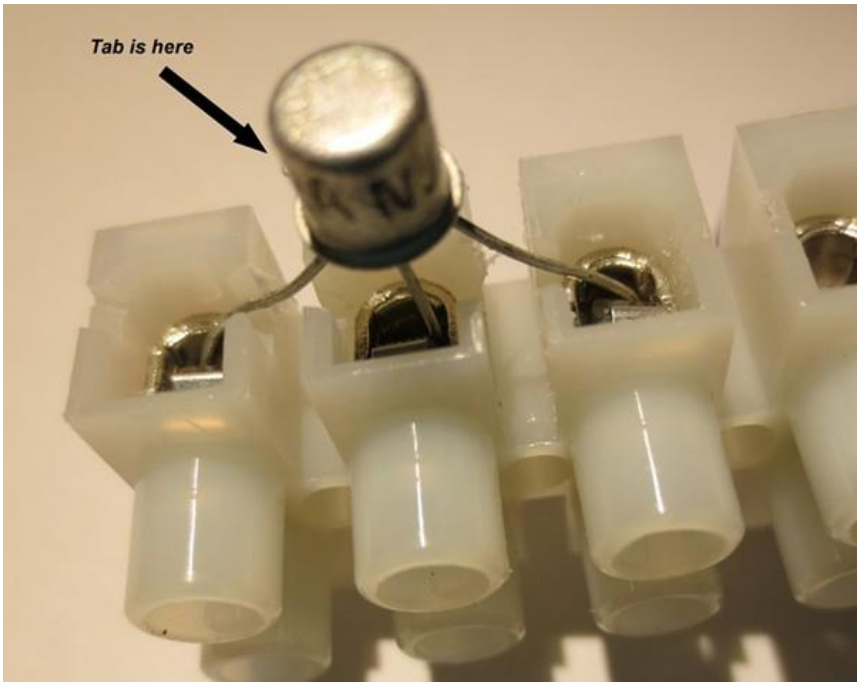
NOTE: When tightening screw terminals, do not over-tighten them. They should be just tight enough to hold the leads in place so that they do not come out with a gentle tug.

4. Locate the 2N2222A transistor, hold it with the leads pointing towards you and note the lead orientation:



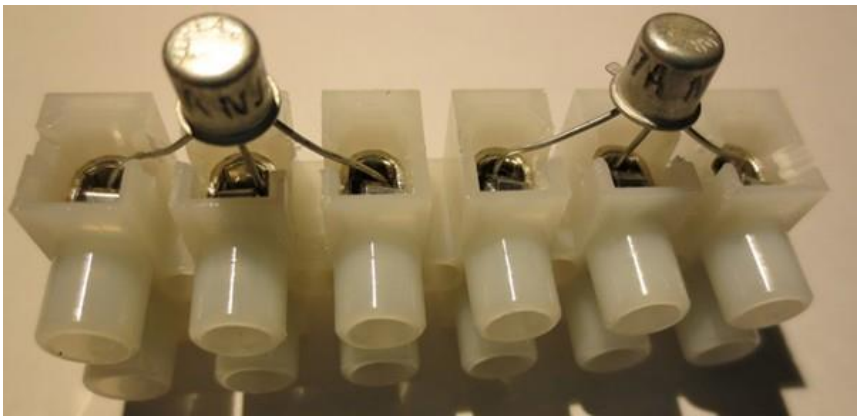


5. Form transistor leads with Emitter (closest to the "tab) on the left, Base in the center, and Collector on the right. Insert the transistor into top terminals 1, 2, and 3 respectively. As the transistor leads are relatively short, ensure the Emitter and Collector leads are laying in the grooves in the terminal block so they reach the set screws.



NOTE! If you tighten the Emitter (left) and Collector (right) screws *first* you can gently tug on the transistor and verify they are properly inserted into the terminal block. Once you are sure they are secure, tighten the middle screw. MAKE ABSOLUTELY SURE the leads are NOT touching the outside metel transistor case ("can"); back it out a little bit if necessary.

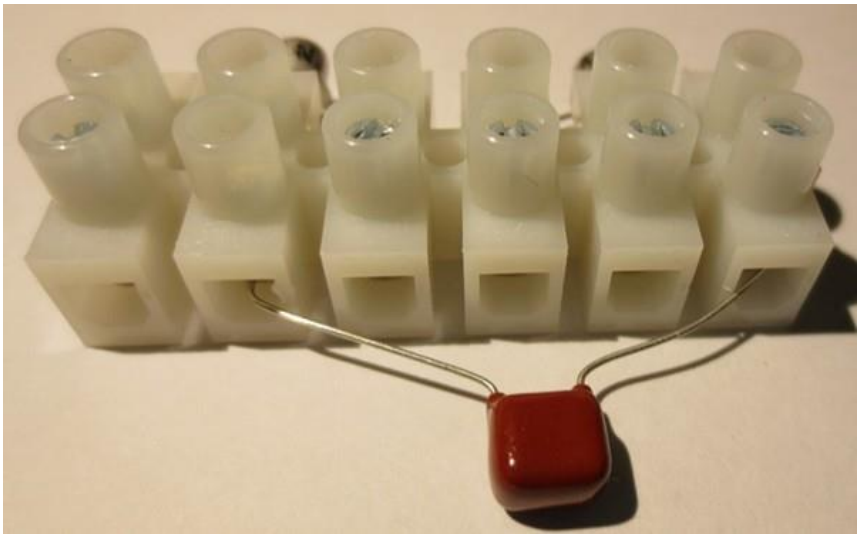
6. Repeat steps 4 and 5 using the 2N2907A and orienting the Emitter, Base, and Collector the same way using top terminal block positions 4, 5, and 6 respectively.



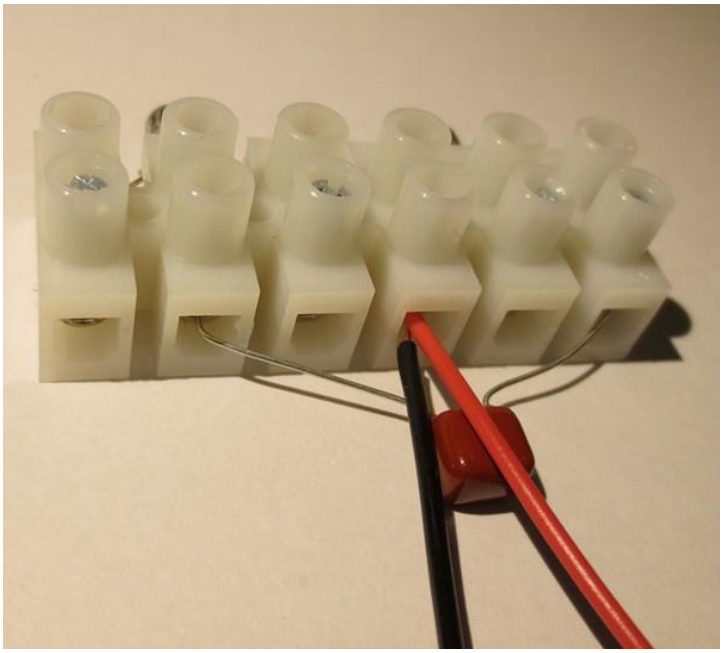
7. Locate the 0.47 uF capacitor. Form the leads so it can be inserted into bottom terminals 2 and 6 (*OPPOSITE* the transistor leads in the top terminals).

NOTE: <u>Only tighten terminal 6 at this time</u>; leave 2 loose until you complete the next step.

Electronic Morse Code Practice Oscillator Kit

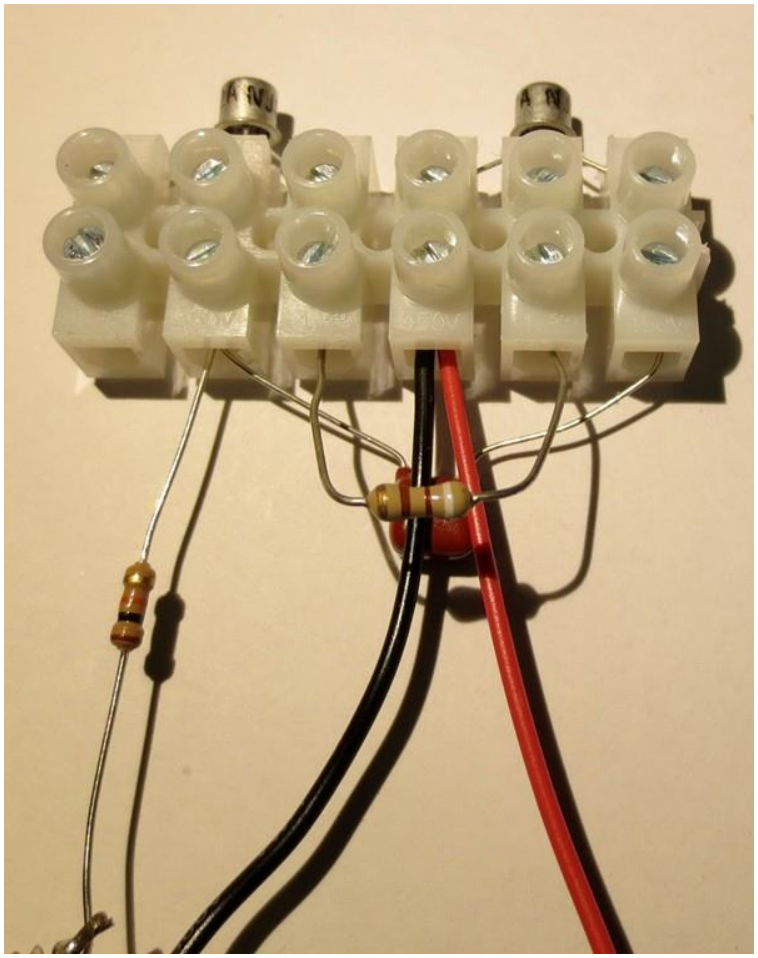


8. ***IF*** step #2 above has been completed, locate the 9-Volt battery clip. Insert the red lead of the battery clip ***and*** the jumper lead from the potentiometer assembly into bottom terminal position 4 and tighten.



9. Insert the other end of the 10 kOhm resistor that is soldered to the potentiometer into bottom terminal position 2 along with the other capacitor and tighten.

10. Locate one of the 910 Ohm resistors (White-Brown-Brown-Gold stripes) and insert it into bottom terminal positions 3 and 5 (this connects the Collector of the 2N2222A to the Base of the 2N2907A transistors) and tighten

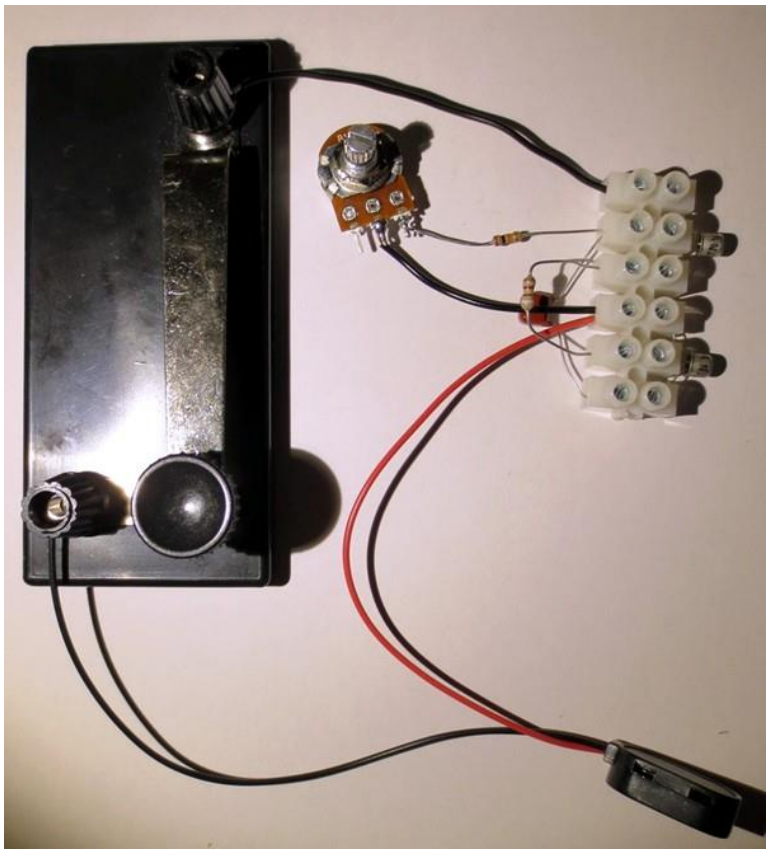


NOTE: Bend the component leads as needed to ensure the bare leads are NOT TOUCHING each other.

11. Locate the long jumper wire and attach one end to bottom terminal 1 and tighten. Attach to other end to the key terminal towards the rear of the key.

12. Attach the black lead of the 9-Volt battery clip to the key terminal towards the front of the key (where your finger pushes).
13. Locate the speaker with the attached leads. (The loose ends should already be stripped and tinned.) Gently loosen top terminals 1 and 6, insert the speaker wires and re-tighten. (Refer to picture on front page.)
14. Rotate the potentiometer knob to about the "middle" of its range of rotation as a starting point for testing.
15. If assembly of electronic components is unfamiliar to you, have an instructor take a quick look at your kit before attaching the battery. ☺
16. Attach the 9-Volt battery to the clip and push the key. If all is well, you should hear a low-pitched tone from the speaker. Adjusting the potentiometer will change the tone's pitch. If you do not hear anything at all, it's time for some Troubleshooting (see below).

Electronic Morse Code Practice Oscillator Kit



Optional Assembly Steps

You can hook up the red LED so that it lights up when the key is pressed.

1. Disconnect the 9-Volt battery before proceeding.
2. Locate the red LED and extra 910 Ohm resistor (White-Brown-Brown-Gold stripes).
3. Gently twist one of the resistor leads around the “longer” of the two LED leads and solder.
4. Loosen top terminal 1 and insert the other “shorter” LED lead and retighten.
5. Loosen top terminal 4 and insert the other resistor lead and retighten. Bend LED and resistor up.
6. ***Make sure none of the component leads touch any of the other leads or wires.***
7. Reattach the 9-Volt battery and push the key. In addition to emitting a tone, the red LED should light up when the key is pushed.

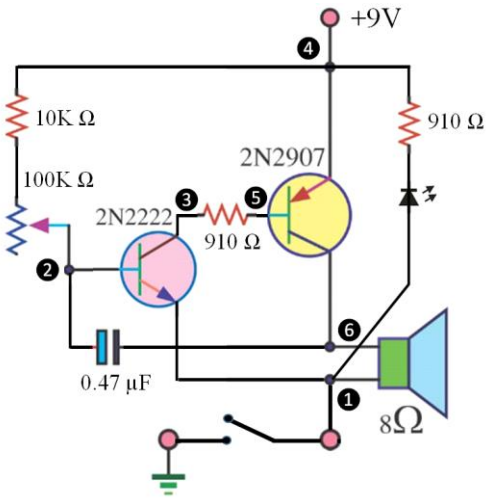
Electronic Morse Code Practice Oscillator Kit

Troubleshooting

If your circuit does not work, there are a few basic steps you can take to identify the problem:

1. Disconnect your battery and verify its condition by trying it on another circuit. (Or, if you're brave, touch your tongue on the battery terminals to test it! This is, of course, NOT "recommended." ☺) LEAVE THE BATTERY DISCONNECTED FOR THE FOLLOWING STEPS!
2. Carefully review all your connections to ensure they are correct. Do a "tug test" on all leads and components to ensure all the terminal screws are tight.
3. Carefully examine all wire connections to ensure that insulation on the wire is not creating a "disconnect" in the circuit.
4. If you have a multimeter with a semiconductor test feature, test the transistor junctions by putting the probes across the Base/Emitter and Base/Collector leads to ensure they conduct properly (remember, one is NPN and the other is PNP so their junction tests will be opposite of each other). Accidentally touching the transistor's metal cases with a "hot" (energized) wire can cause them to burn out.
5. Use an Ohmmeter to test the speaker to ensure it is functional. (You can test the resistors too if you want, but they are rarely a problem – unless they are in the wrong places!)
6. Use an Ohmmeter to test the potentiometer. It should read 100 kOhms across the "outer" leads and an amount that varies between 0 and 100 kOhms between the center and one of the outside leads as you turn the knob.
7. If all of the above fail, try "swapping" each component into a working oscillator to test them individually. (BE SURE TO DISCONNECT THE BATTERY BEFORE DOING THIS!)

Theory of Operation

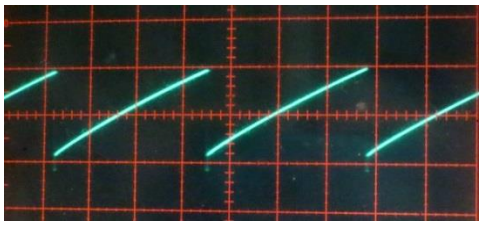


When power is applied to the circuit, current flows through the 10 kOhm resistor and potentiometer to charge the 0.47 uF capacitor. (This is referred to as an "R-C" circuit.) This charge-discharge cycle happens at a rate that is determined by the value of the resistor and capacitor. The resistor controls the "volume" of electrons flowing into the capacitor whose value determines the "volume" of charge accumulated. The larger the capacitor, the long it takes to get charged. The kit's potentiometer – a "variable" resistor – allows you to vary the rate at which the R-C circuit charges which varies the frequency of pulses sent to the speaker's coil.

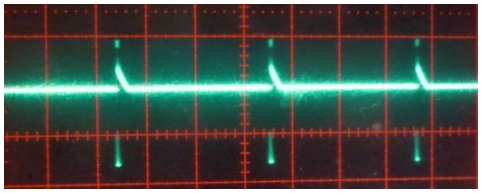
The electron current is like water flowing through a hose with a "restricted" diameter into a bucket of a certain size. An oscilloscope can be used to see this charging cycle in action at the base of the 2N2222A transistor.

Electronic Morse Code Practice Oscillator Kit

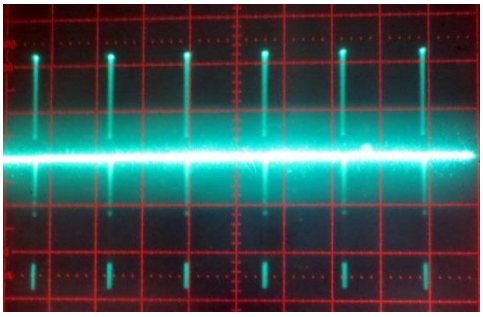
During this process, the voltage at the base of the 2N2222A rises high enough to forward-bias it "on" which in turn forward-biases the 2N2907A thus passing current to the speaker (AND interrupting the flow of charging current to the capacitor).



The next picture to the right shows this on-off cycle at the base of the 2N2907A transistor.



When the speaker coil is briefly energized, it interacts with the speaker's permanent magnet causing the coil to move the paper cone of the speaker which creates an air pressure wave that our ears can hear. We can see these "pulses" of current to the speaker's coil on a scope.



When the speaker coil is energized, the voltage potential across the capacitor is lost and the R-C circuit is effectively "reset" for another cycle. The voltage at the base of the 2N2222 drops below the forward bias level and the transistors cease to pass current. When the speaker is not energized, it effectively provides a low resistance ground path to complete the R-C circuit which then charges again for another cycle.

Creating a Telegraph Network

From 1838 well into the mid-1900's, telegraph stations were connected together for communicating over long-distances. By 1902 when the trans-Pacific link was completed, telegraph lines literally encircled the entire world! Messages received were transcribed onto "Telegrams" and delivered to recipients in-person much like registered mail and overnight letters are today.

You can connect your practice oscillator with others to create a telegraph network!

1. Disconnect the 9-Volt batteries of each kit before proceeding. ☺
2. Find a long pair of "telegraph" wires to use.
3. Connect one of the long "telegraph" wires to ***all*** of the key terminals with the long jumper wire attached.
4. Connect the other long wire to all of the key terminals with the black battery lead attached. (If you really want to be "authentic," skip the wire entirely and simply attach all of the black battery leads to an earth ground instead! With only 9 Volt batteries, distance will likely be compromised.)
5. Reattach the 9-Volt batteries of each "telegraph station."
6. When any telegraph key is pressed, ALL oscillators should sound simultaneously!
7. Try sending messages to each other using Morse Code!

This document including the assembly instructions is available for download at: