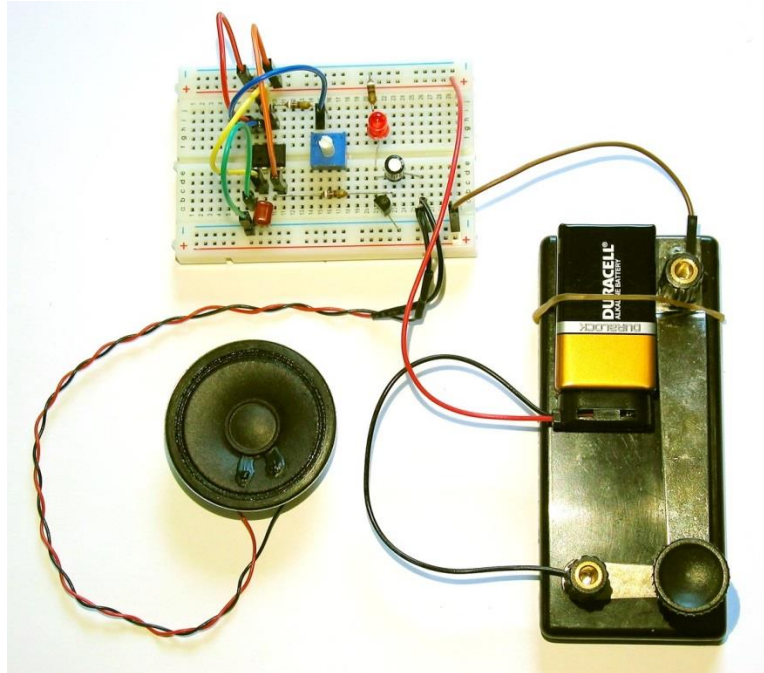


## 555 Morse Code Practice Oscillator Kit *(Version 3.1)*




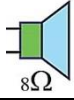
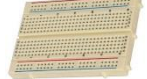





















### Learning Goals:

1. Associate schematic symbols with actual electronic components;
2. Create a working electronics circuit using a breadboard;
3. Build a working Morse Code practice oscillator (“audio control circuit”);
4. Have a little soldering experience;
5. Discover that electronics can be fun!

## 555 Morse Code Practice Oscillator Kit *(Version 3.1)*

### Parts List

Quantity	Description	Picture	Schematic Symbol
1	Morse Code Key		
1	8 Ohm speaker w/wires		
1	400-tie point breadboard		?
10	Jumper wires		?
1	"555" integrated circuit (the black "spider")		
1	1M Ohm Potentiometer (the "knob")		
4	910 Ohm resistors		
1	0.47 μF capacitor (marked "474")		
1	10 μF capacitor		
1	NPN transistor (BC337)		
1	Red LED		
1	9 Volt battery clip		?
1	9 Volt battery		
2	Heat-shrink tubing (¼ inch)		
1	Kit Document w/assembly instructions and theory of operation		

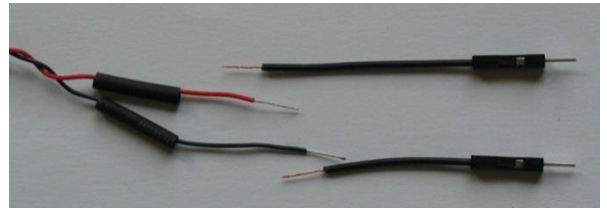
NOTE! Extra components may have been included for other projects; set aside for now.

# 555 Morse Code Practice Oscillator Kit (Version 3.1)

## Solder speaker wires to jumpers

**NOTE!!** Find a ventilated area for soldering and put on safety glasses.

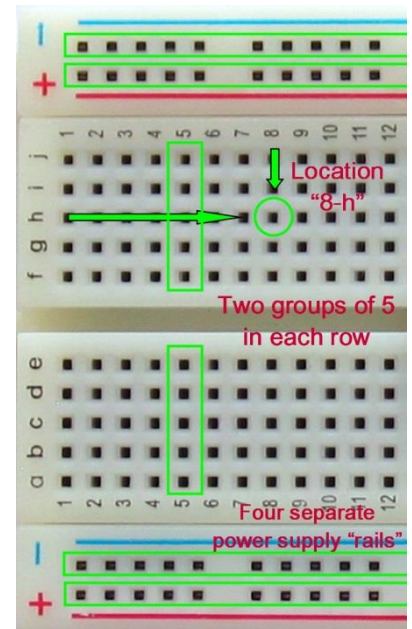
- Cut a jumper wire in half and strip ends;
- Strip speaker wire ends (if needed);
- Twist a bare speaker wire with a bare jumper wire (repeat for other wires);
- Solder the twisted connections (avoid breathing the fumes);
- Use a heat gun to shrink the tubing (or wrap with a small piece of electrical tape) around the connection for protection.



## Understand the breadboard's layout

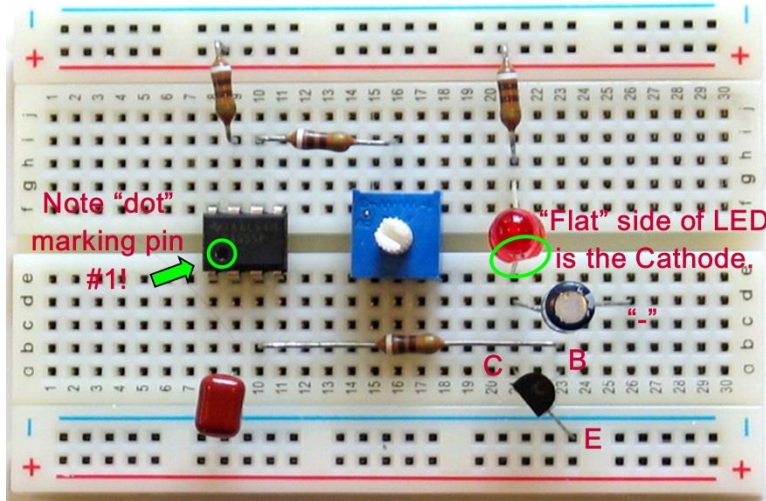
Breadboards are used for quickly constructing electronic circuits. Connections are made with jumper wires on top *as well as* underneath the breadboard. It is important to understand which “holes” (i.e. contacts) inside the breadboard connect to each other and which do not.

The breadboard included in this kit is labeled with letters, numbers, colored lines, and “+” and “-” symbols. The center “groove” is the proper width for small “DIP chips” – **D**ual **I**ncline **P**ackage integrated circuits – to “straddle.” As shown in the picture on the right, there are internal connections for column contacts **a-e** and **f-j** in each row **1-30** and the red and blue power “rails” – all the holes along the red and blue lines on each side. **All of these groups of contacts are separate from each other as highlighted on the picture.**



# 555 Morse Code Practice Oscillator Kit (Version 3.1)

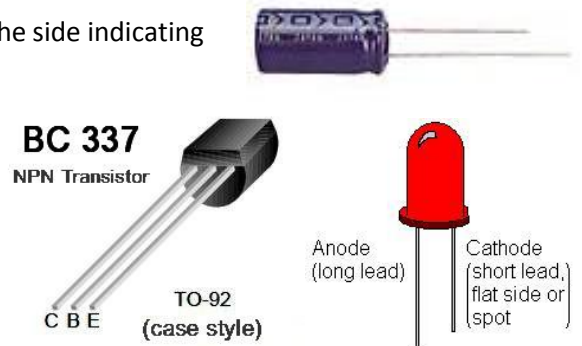
## Place the components



**NOTE!** Many electronic parts, including all semiconductors, are polarity sensitive and may be destroyed if connected incorrectly! (e.g. “+” and “-” reversed) Refer to the included diagrams and pictures for correct connections.

**TIP:** Use needle-nose pliers to “form” leads so parts fit better on the breadboard without touching other parts.

- 555 integrated circuit (note the “dot” indicating pin 1); [locations 8, 9, 10, 11-e/f]
- Four (4) 910 Ω resistors (white-brown-brown-gold bands); [locations + → 9-I, 10-I → 16-I, + / 21-H, 10-b / 23-b]
- 1M Ω potentiometer (the part with the “knob” and three wires; a blue one is pictured); [locations 15, 16, 17-f]
- 0.47 μF capacitor; [locations 9-a → “-”]
- 10 μF electrolytic capacitor (note the “-” stripe on the side indicating the negative lead); [locations 21-d → 26-d]
- NPN transistor ; [locations 21-a (C ), 23-a (B), “-” (E )]
- LED (the diagram on the right shows the correct lead orientation; the anode is “+” and the cathode is “-”); [locations 21-e, 21-g (anode)]

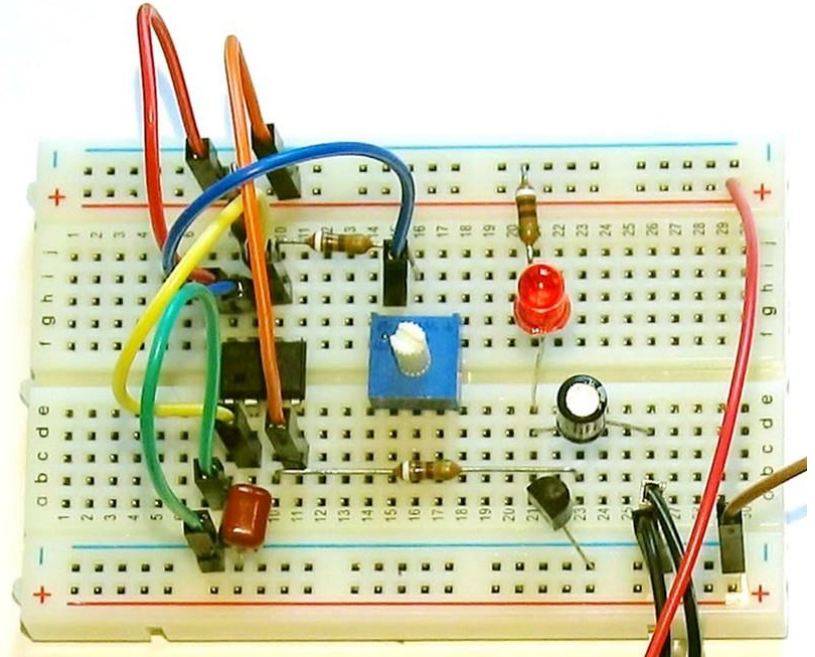


# 555 Morse Code Practice Oscillator Kit (Version 3.1)

## Place jumper wires

Remember, some of the circuit connections are already completed underneath the breadboard.

- + → 8-h
- + → 11-c
- - → 8-a
- 9-c → 10-h
- 9-h → 15-h



## Connect the speaker

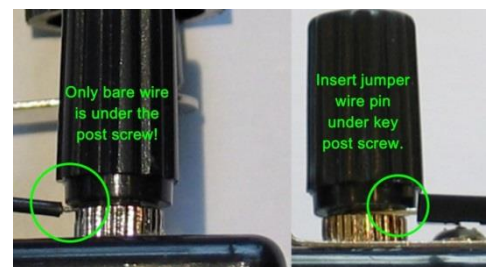
Use the jumper pins you soldered to the speaker wires earlier.

- 26-a
- “\_”


(These can be seen in the lower right corner underneath the red battery lead in the picture above.)

## Connect the battery clip and key

- **Red** lead of the battery clip to the “top red” row;
- **Black** lead of the battery clip to one of the screw posts on the key;
- Use a jumper to connect from the other screw post on the key to the “bottom blue” row on the breadboard.



**STOP!! DO NOT** connect the 9 Volt battery until you have double-checked your work!

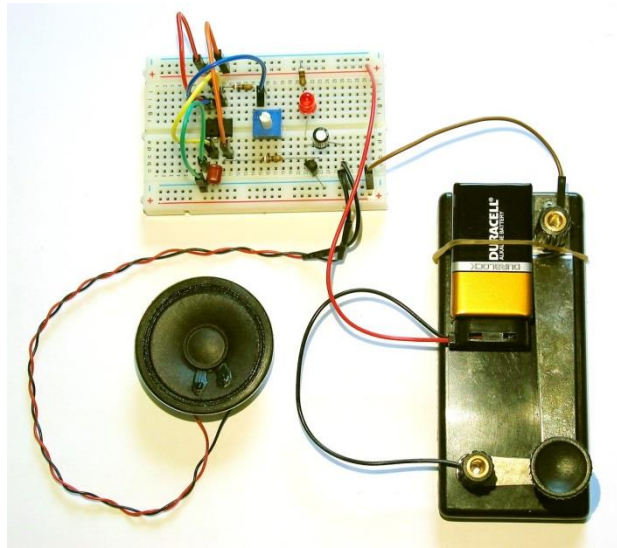
 ***It is always a good idea to ask for help if you are not sure your circuit is connected correctly!***



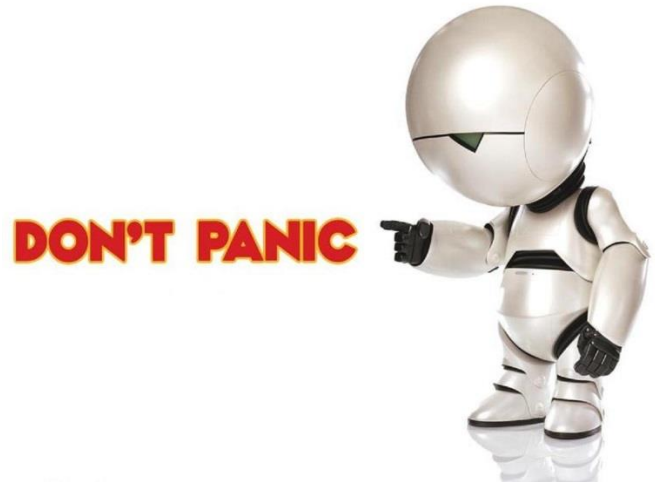
## 555 Morse Code Practice Oscillator Kit *(Version 3.1)*

### Connect the battery and test!

Try tapping the key a few times. If you hear a tone in the speaker and see the LED light when you tap, you have completed your circuit successfully! GOOD JOB! Adjusting the potentiometer will change the frequency of the tone. Check out how the very lowest frequency tones make the LED blink!



**IF your circuit does NOT work...**



**DON'T PANIC**

**Disconnect the battery** and jump to the **Troubleshooting** section.

Don't hesitate to ask for help!

## Troubleshooting

Here are a few basic steps you can take to identify the problem:

1. Try your battery on another working circuit. (You can also use a Voltmeter or a battery tester if one is available.)
2. Carefully review all your connections.
3. Make sure all connections are making metal-to-metal contact. (This typically happens with the battery clip wire connection to the screw post on the key.)
4. Test the semiconductor components (555, transistor, LED) in another working circuit. (ONE AT A TIME!)
5. Use an Ohmmeter to test the speaker and jumper wires to ensure they are functional. (You can test the resistors too if you want, but they are rarely a problem – unless they are in the wrong places!)
6. Temporarily bypass the potentiometer by connecting the blue jumper wire (as seen on page 5) directly to the end of the 910 Ohm resistor that normally connects to the POT. This will set the output tone to the highest frequency.
7. If all of the above steps fail, try “swapping” each component into a working kit to test them individually. (BE SURE TO DISCONNECT THE BATTERY BEFORE DOING THIS!) Test the semiconductor parts first (i.e. 555 chip, transistor, LED) as those are most-likely the problem. If those work, swap the other parts one at a time. If all of the parts work separately, but not together, there are other steps to try – ask for some help.

# 555 Morse Code Practice Oscillator Kit *(Version 3.1)*



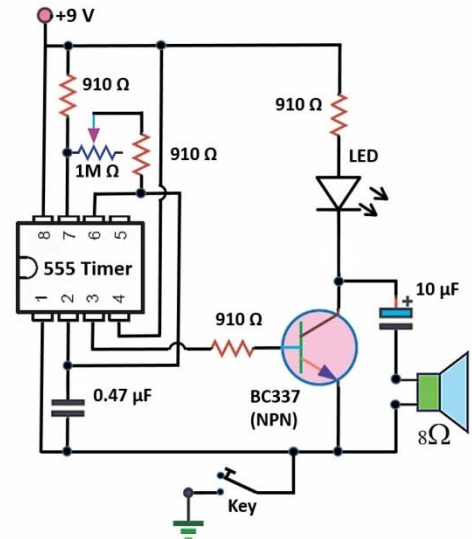
# 555 Morse Code Practice Oscillator Kit (Version 3.1)

## Theory of Operation

Use the circuit schematic to the right as a reference for this section.

The 555 timer chip is capable of several “modes” of operation. In “astable” mode – which means “never stable” – the output never stays high or low. The capacitor connected to pin 6 (via pin 2) is charged and discharged through the resistors connected to pins 6 (“threshold”) and 7 (“discharge”). Because pin 6 is also connected to pin 2 (“trigger”), it constantly retriggers itself resulting in a continuous stream of rectangular pulses (i.e. a “square wave”) on pin 3 (“output”) having a frequency that is determined by the “R” (resistor) and “C” (capacitor) values used.<sup>1</sup>

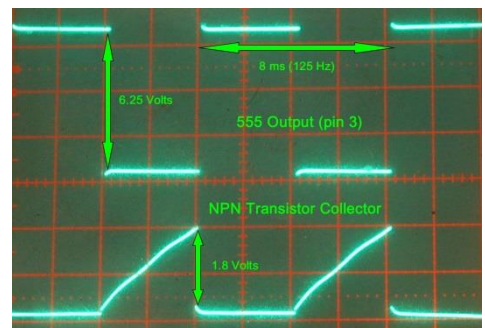
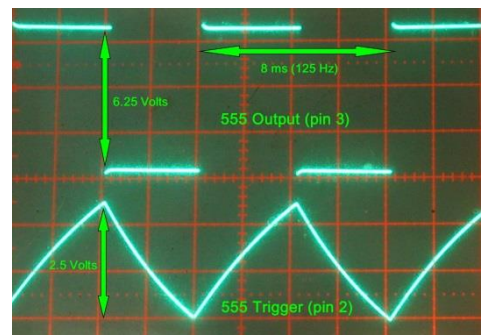
The picture on the right is a screen-capture of an oscilloscope display showing the output signal on pin 3 (upper trace) and what the signal on pin 2 is doing during each phase of the output (lower trace). This signal varies between about 1/3 and 2/3 of the supply voltage; that is, between about 3 and 6 Volts using a 9 Volt battery. As you can see, when pin 2 is brought low, it triggers a high output on pin 3.



This square wave output (on pin 3) is used to bias the NPN transistor (BC337) to switch an LED on and off in step with the 555 output pin.

To create a sound, the speaker must use its cone to create air movement. The speaker cone is connected to a small coil of wire which can freely move back and forth over a permanent magnet inside the speaker. The magnetic field created by the current flowing through the coil of wire interacts with the permanent magnet to push or pull the speaker cone thus creating sound through air movement.

A small capacitor (10 μF) is attached to the collector pin on the NPN transistor. While the 555’s output is low (pin 3’s signal on the upper trace), the NPN transistor is “turned off.” During this “down time,” current flows through the resistor and LED to charge the capacitor until the output goes high. When pin 3 (upper trace) goes high, the NPN transistor is “turned on” allowing enough current to flow to cause the LED to illuminate.



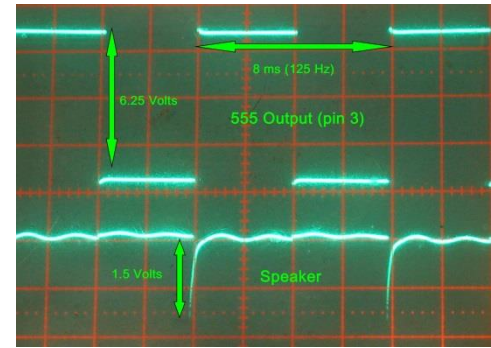
<sup>1</sup> A vastly simplified excerpt from an excellent article by Tim Surtell on the Electronics in Meccano web site (<http://www.eleinmec.com/article.asp?1>).

## 555 Morse Code Practice Oscillator Kit (Version 3.1)

Simultaneously, the stored charge in the capacitor is essentially “shorted” to ground causing a current to flow through the speaker’s coil as described above to create sound.

This process repeats itself with the frequency determined by the resistor and capacitor values used for the 555 (pins 6, 7, and 2).<sup>2</sup>

The final oscilloscope capture shows the output of the 555 (upper trace) and the voltage on the speaker during the capacitor’s quick discharge (lower trace). The speaker is essentially being “popped” each time the NPN transistor shunts the capacitor’s charge to ground.



### Create 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 breadboard jumper wire attached.
4. Connect the other “telegraph” wire to all of the key terminals with the black battery lead attached. (If you really want to be “authentic,” skip using this wire entirely and simply attach all of the black battery leads to an earth ground instead! However, 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!

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<sup>2</sup> Also, as the frequency increases, there is less time for the capacitor to charge resulting in a smaller current through the speaker resulting in a softer output; that is, the oscillator is louder at lower frequencies and softer at higher frequencies.

## 555 Morse Code Practice Oscillator Kit *(Version 3.1)*

If you enjoyed this project and want to dive deeper into other fun 555-based projects, here are some great links to check out. Other parts will almost certainly be required, but there are various places both locally as well as online where you can buy electronic parts at reasonable prices.

Site	URL
555 Timer Circuits – awesome site	<a href="http://www.555-timer-circuits.com/">http://www.555-timer-circuits.com/</a>
50 555 Circuits Free eBook PDF download	<a href="http://bit.ly/1H7Sabl">http://bit.ly/1H7Sabl</a> <a href="http://bit.ly/1xGPI5T">http://bit.ly/1xGPI5T</a>
47 projects to do with a 555! (Instructables.com)	<a href="http://bit.ly/1rhHCQ5">http://bit.ly/1rhHCQ5</a>
Electroschematics	<a href="http://www.electroschematics.com/555-circuits/">http://www.electroschematics.com/555-circuits/</a>
555 Timer Circuits and Projects	<a href="http://www.circuitstoday.com/555-timer-circuits-and-projects">http://www.circuitstoday.com/555-timer-circuits-and-projects</a>
Makezine: 555 Timer Weekend Projects	<a href="http://bit.ly/1ykAzYS">http://bit.ly/1ykAzYS</a>
Circuits Gallery: Top 10 Simple 555 Timer Projects Kits for Students	<a href="http://bit.ly/1BQF2mm">http://bit.ly/1BQF2mm</a>

Electronic Parts Store	URL
Jameco Electronics (most of the parts for these kits were purchased here)	<a href="http://www.jameco.com/">http://www.jameco.com/</a>
Radio Shack (yep, they still carry parts)	<a href="http://www.radioshack.com/">http://www.radioshack.com/</a>
Vetco Electronics (located in Bellevue; discount for LWHC members)	<a href="http://www.vetco.net/">http://www.vetco.net/</a>

These assembly instructions, as well as other great resources, are available for download at:

<http://www.lakewashingtonhamclub.org/scouting-and-youth/>