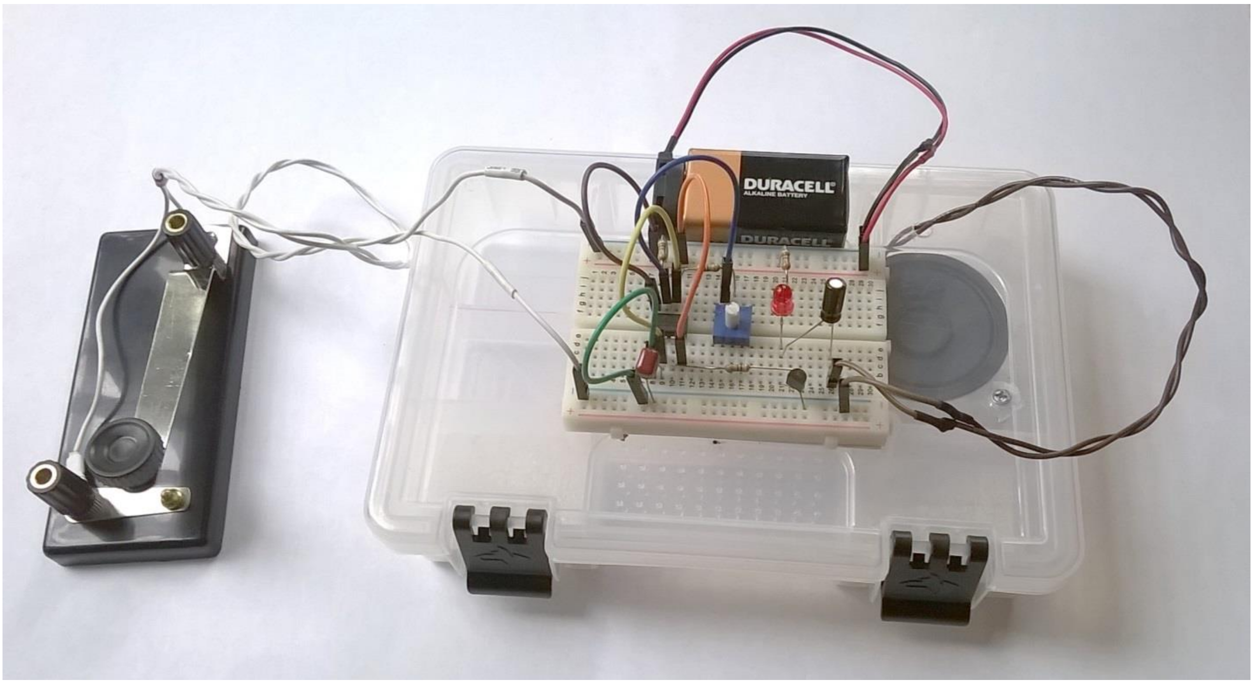
555 Morse Code Practice Oscillator Kit *(Version 4.0)*



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!

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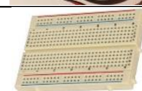
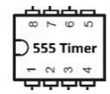
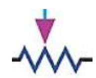
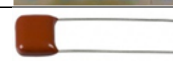
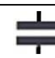
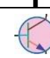
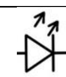
Parts List

Quantity	Description	Picture	Schematic Symbol
1	Morse Code Key		
1	8 Ohm speaker w/wires (mounted inside kit case)		
1	400-tie point breadboard (mounted on top of kit case)		**?**
10	Jumper wires		**?**
1	"555" integrated circuit (a.k.a. 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		
1	Kit Document w/assembly instructions and theory of operation		

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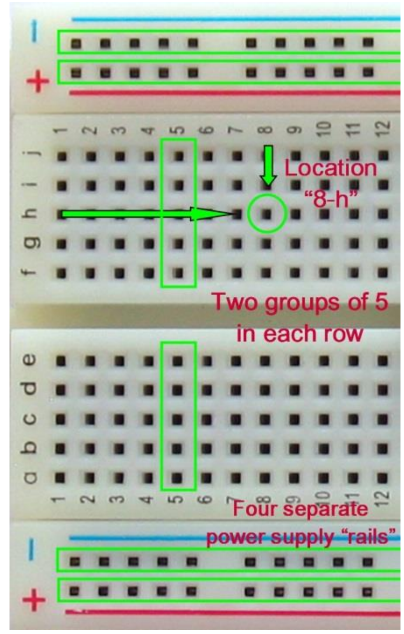
Understanding the breadboard's layout

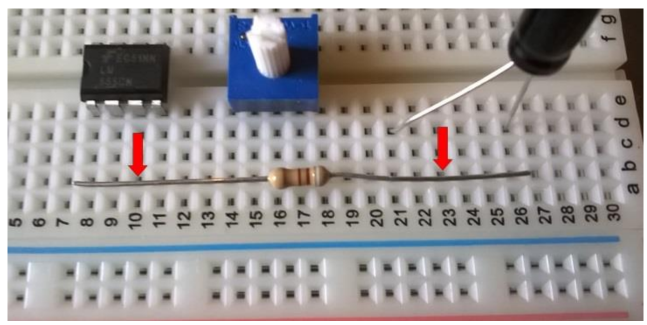
Breadboards are used for quickly constructing electronic circuits. Connections are made with jumper wires on top *as well as* underneath the breadboard. It is important to understand which "holes" (i.e. contacts) inside the breadboard connect to each other and which do not.

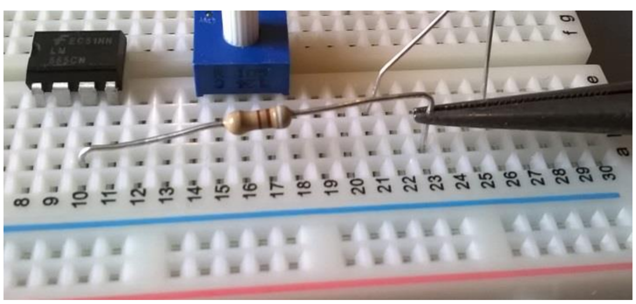
The breadboard included in this kit is labeled with letters, numbers, colored lines, and "+" and "-" symbols. The center "groove" is the proper width for small "DIP chips" – **D**ual **I**nline **P**ackage integrated circuits – to "straddle." As shown in the picture on the right, there are internal connections 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.***



Breadboarding Tips & Tricks

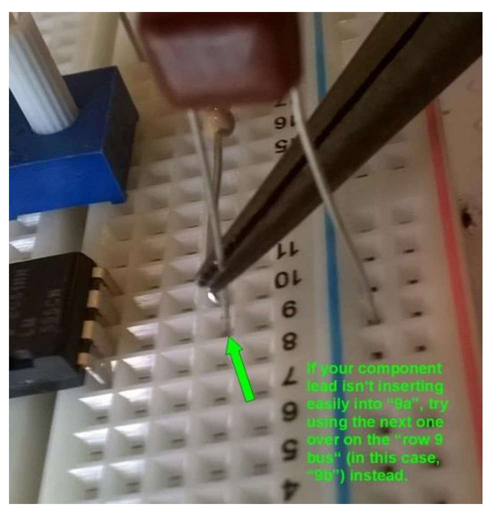
- It is sometimes helpful to lay a component on the breadboard to get an idea of where to bend the leads so it will fit better and go in easier.





- If the component leads are not inserting easily, use needle nose pliers to grab the lead and push it in.

- If a lead just isn't going to go in easily even with needle-nose pliers, try using an adjacent hole that's connected underneath instead.



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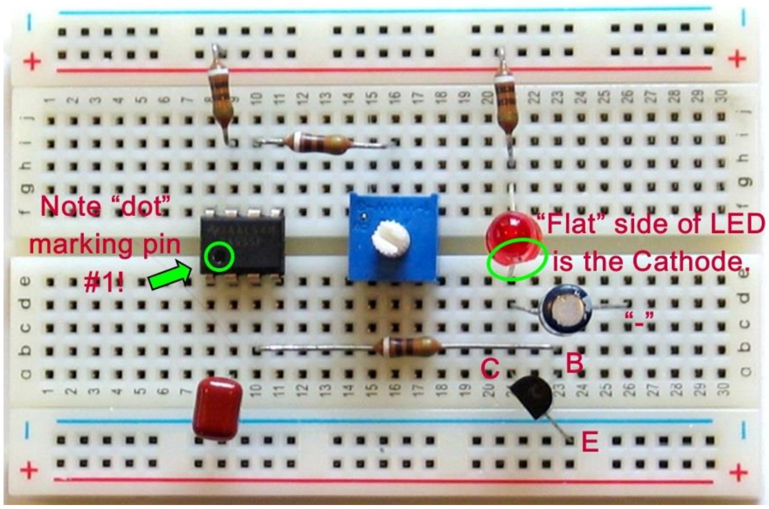
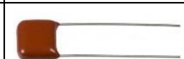
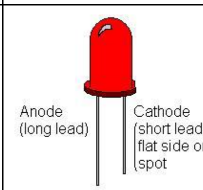
Place the components



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

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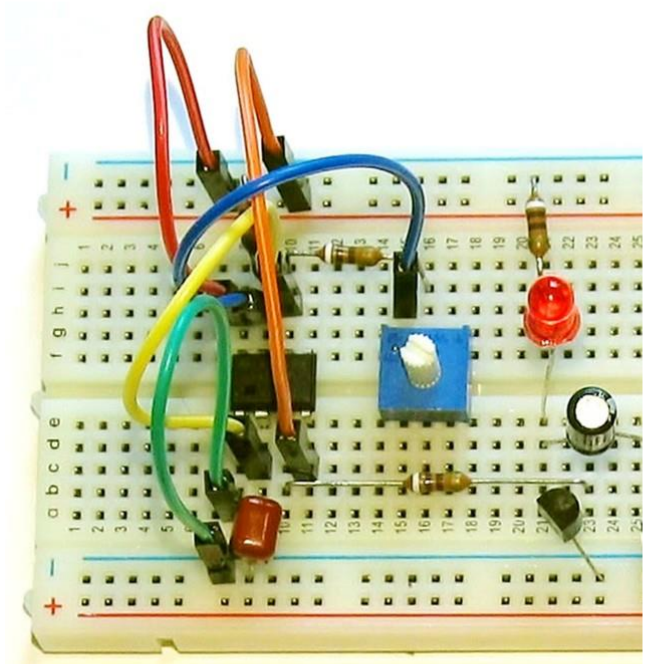
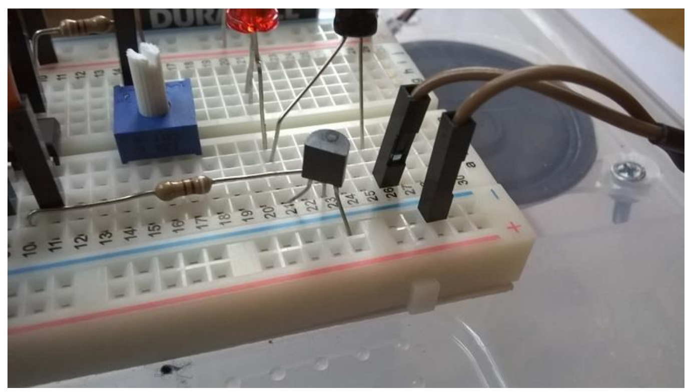
Place jumper wires



- 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

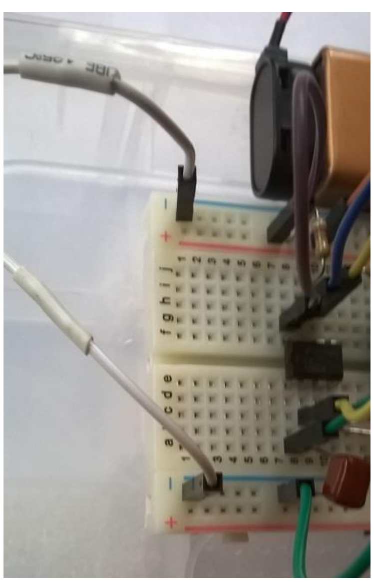
Connect the speaker wires



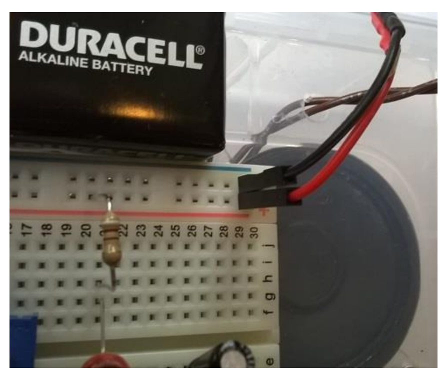
The speaker mounted inside the kit case has some wires with jumper pins on them which you can use to connect it to your circuit.

26-a → -

Connect the battery clip and key



Connect the black wire from the battery clip to the UNUSED "-" blue power rail on the opposite side of the breadboard that you used for the circuit. Then connect the wires from the key to each blue "-" power rail on the breadboard. When the key is closed, the circuit is completed!



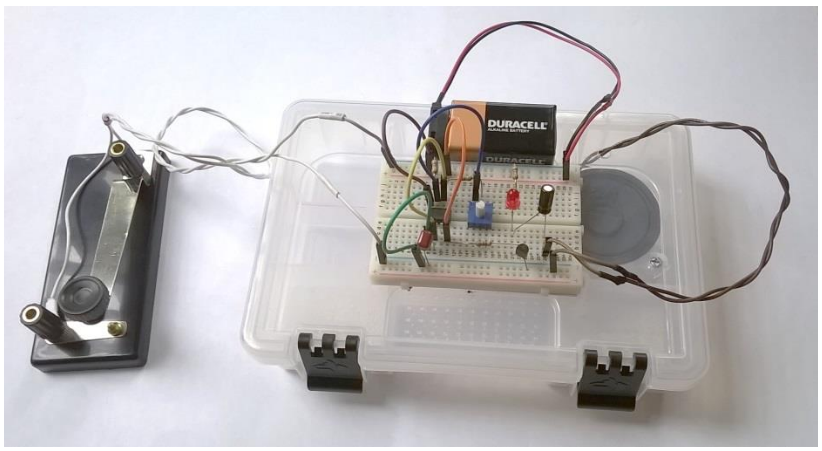
Black battery clip lead ("-")→ *<u>UNUSED</u>* blue power rail ("-")
Each key wire → blue power rails ("-") on each side of breadboard

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!

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…

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. Use a Voltmeter to check for supply Voltage on 555 pins 4 and 8 when the key is closed.

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!)

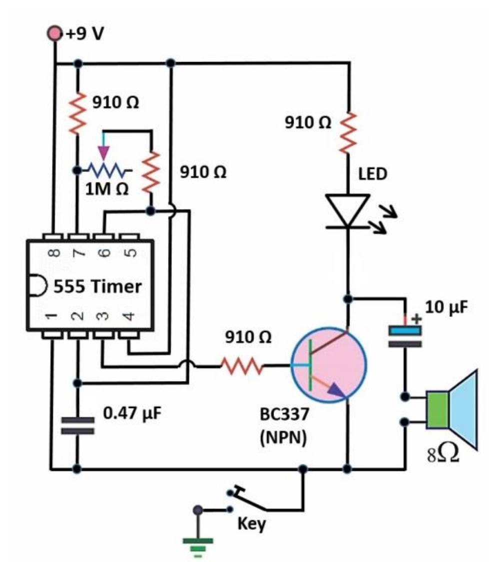
6. Temporarily bypass the potentiometer by connecting the blue jumper wire (as seen on page 5) directly to the end of the 910 Ohm resistor that normally connects to the POT. This will set the output tone to the highest frequency.

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.

8. **OR…** Study the **Theory of Operation** section and see if you can find the problem yourself!!

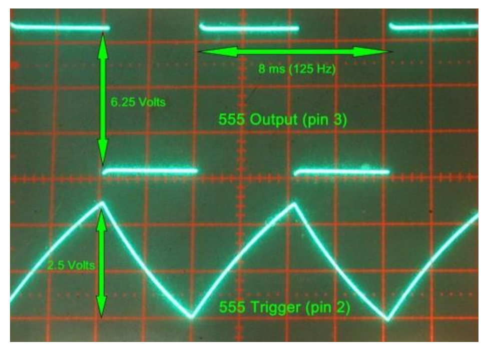
Theory of Operation

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



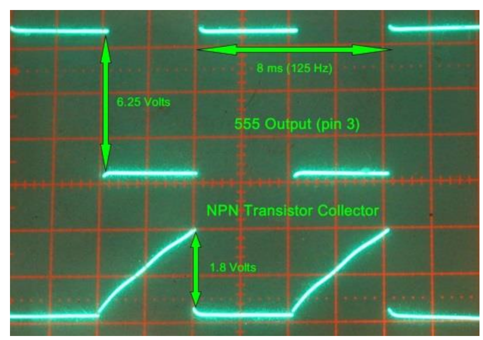
The 555 timer chip is capable of several "modes" of operation. In "astable" mode – which means "never stable" – the output never stays high or low. The capacitor connected to pin 6 (via pin 2) is charged and discharged through the resistors connected to pins 6 ("threshold") and 7 ("discharge"). Because 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.[1]

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.

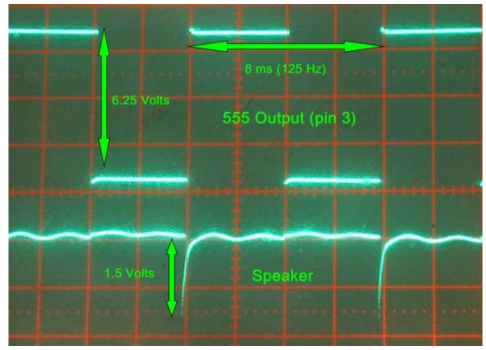
To create a sound, the speaker must use its cone to create air movement. The speaker cone is connected to a small coil of wire which can freely move back and forth over a permanent magnet inside the speaker. The magnetic field created by the current flowing through the coil of wire interacts with the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

[1] 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).

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).[2]

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!

[2] 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.

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	http://www.555-timer-circuits.com/
50 555 Circuits Free eBook PDF download	http://bit.ly/1H7SabI http://bit.ly/1xGPi5T
47 projects to do with a 555! (Instructables.com)	http://bit.ly/1rhHCQ5
Electroschematics	http://www.electroschematics.com/555-circuits/
555 Timer Circuits and Projects	http://www.circuitstoday.com/555-timer-circuits-and-projects
Makezine: 555 Timer Weekend Projects	http://bit.ly/1ykAzYS
Circuits Gallery: Top 10 Simple 555 Timer Projects Kits for Students	http://bit.ly/1BQF2mm

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

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

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