Name: _____ Perm Number: _____ TA: _____

Circuit Assembly Boot Camp

Version 1.01 Spring 2014 Professor Everett Lipman

Due **Friday, May 16, at 9:45 P.M.**
Please note: I am giving you several extra days to complete this lab, since the project assembly requires machining, and can be time consuming. There will be another lab due on Monday, May 19, so **do not wait to get started!**

This boot camp will count as one lab. Each question or task has the point value shown in the corresponding box. You should have any available TA initial and score the box once you have completed the assigned question or task.

1. Assemble a 555 Oscillator Circuit. Begin where you left off in the Practical Electronics Boot Camp (available on the course web page). Turn off the potentiometer switch and your power supply. Cut and strip four 20 cm 22 AWG leads. Identify the front of the speaker from your boot camp project kit. The front has sound holes and a protected ring of adhesive around the rim. Solder the wires to the speaker terminals so that when the speaker faces you, the wires project away from you. The front of the speaker will eventually be attached to the inside wall of your project box.

Take one of the 500 kΩ potentiometers from your boot camp project kit and determine across which two terminals the resistance is minimized when the shaft is turned clockwise. This potentiometer will control frequency. We are choosing the terminals so that turning the shaft clockwise will raise the frequency, as one would expect intuitively. Keeping in mind that the wires must project away from you if the shaft is facing you, solder the two remaining leads to the terminals you selected.

Have the TA check your speaker and 500 kΩ potentiometer. | *(4)* ____ ____

Read about the 555 timer integrated circuit (IC) on pages 286–291 in AoE. Although you may not yet understand how the 555 works, you should be able to learn what it does.

Get a 7555 IC from the drawer in the lab. The 7555 is the CMOS version of the 555, and can be used in its place. Locate the 1 kΩ resistor and one of the 0.01 µF capacitors from your boot camp project kit, and the 500 kΩ potentiometer onto which you soldered the leads. Leave the LED power indicator circuit in place on your breadboard.

Orient the 7555 IC so that you are looking down at the top of the package, and the indented notch or circle you see is to your left. The part numbers on the top of the package should now be upright. Carefully insert the IC into an unused section of your lower breadboard so that it straddles the center groove. If there is an IC insertion tool available in the lab, use it; this will help you avoid damaging the pins. Push the IC straight in so that the pins are properly seated in the sockets. With the notch to the left, pin 1 is at the lower left. Pin numbers increase going counterclockwise around the IC, so pin 4 is at the lower right, pin 5 is at the upper right, and pin 8 is at the upper left, above pin 1. See page 153 in MkE if you are confused.

Using the multimeter, set the resistive part of your 5 kΩ potentiometer to about 50 Ω. Set the 500 kΩ potentiometer to about 300 kΩ. Neatly assemble on your breadboard the oscillator circuit shown in Fig. 1. Connect pin 3 of the IC to one of the leads from the resistive part of your 5 kΩ potentiometer. Connect the other 5 kΩ potentiometer lead to one of your speaker leads. Connect the remaining speaker lead to the positive rail.

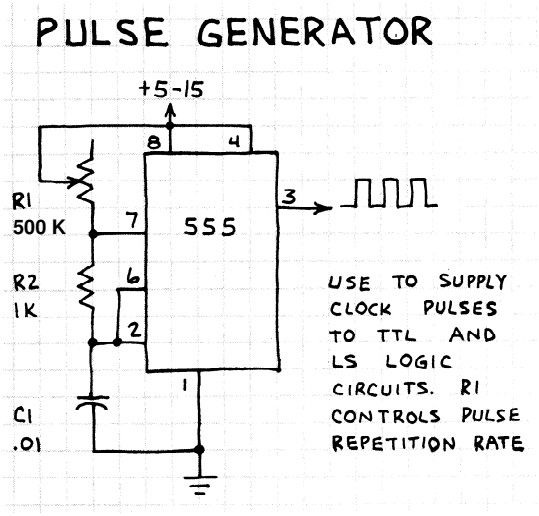

Figure 1: 555 oscillator circuit.

Make sure that the power indicator circuit switch is between the "+5–15" V *terminal in Fig. 1 and the supply, so that you can turn off the circuit with the switch.*

Check all of the connections in your circuit. When you are done, check all of the connections in your circuit. After that, make sure all of the connections in your circuit are correct. Then turn on your power supply, the power supply output, and the potentiometer power switch.

You should hear a tone of about 480 Hz. If you don't, and the power indicator LED is on, immediately remove power from the circuit. If your IC is hot to the touch, it has probably been destroyed. If the circuit didn't work, check your connections again.

Demonstrate your circuit for the TA. Include volume and frequency adjustments. *(5)* ____ ____

2. Measure the 555 oscillator circuit. Using BNC cables and clips (not the oscilloscope probes), connect the CH 1 oscilloscope input between pin 6 (or 2) and ground, and CH 2 between pin 3 and ground. Notice that at this point, you have connected the power supply ground to the oscilloscope ground. That's ok, because for our equipment they are the same (both connected to earth ground), but for some instruments you can't do this, so be aware of ground connections when using more than one piece of test equipment.

Set the oscilloscope to display both channels clearly at the same time. Set the output frequency of your circuit to 530 Hz.

Demonstrate for the TA that you can use the oscilloscope to display the waveforms and measure the frequencies, amplitudes, and relative phases of the signals at pins 6 and 3 as you vary the resistance of your potentiomenter. *(6)* ____ ____

With the volume all the way up, what is the highest frequency you can hear? ____

(3) ____ ____

3. Assemble a 556 Sound Synthesizer. In the remainder of this boot camp, we will assemble a circuit on the breadboard, test it, and then solder it together on a perforated board ("perfboard"). We will then mount the circuit board and external components in a box to make a complete electronic device. The 556 is two 555 timers in a single package. See the datasheet on the course web page if you are interested in the pin connections.

Solder two 20 cm 22 AWG leads to your remaining 500 kΩ potentiometer using the same terminals and wire orientation you did with the first one.

Find a soldering heat sink in the lab. It is a small spring clip designed to grip a lead between a solder connection and the body of a component. Cut and strip two 20 cm 22 AWG leads of different colors. Using the heat sink, solder the 22 AWG leads to the leads on your LED. Insulate the connections with heat shrink tubing.

Make sure your power supply is off, and turn off the switch in your power indicator circuit. Using the new leads, replace the LED in your power indicator circuit, and leave it in place. Remove the 555 circuit from your breadboard. Using the 556 IC and remaining capacitor from your boot camp parts kit, neatly assemble on your breadboard the circuit shown in Fig. 2. *Make sure that the power indicator circuit switch is between the* "+5–15" V *terminal in Fig. 2 and the supply, so that you can turn off the circuit with the switch.* Avoid running components and wires over the IC when you assemble this circuit. Instead, route them to the side. This will make your life a lot easier when you transfer the circuit to the perfboard.

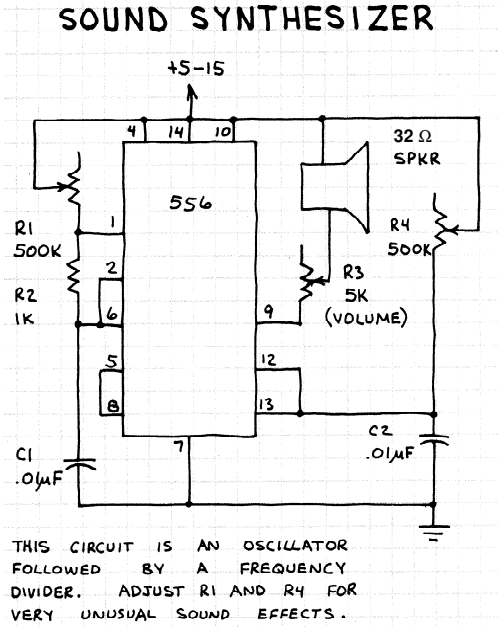

Figure 2: 556 sound synthesizer circuit from the *Engineer's Notebook II* by Forrest Mims.

Turn on the power supply and set it to +9 V. Check your connections, then turn on the circuit switch. Experiment with the two 500 kΩ potentiometers.

Demonstrate your circuit for the TA. *(5)* ____ _____

4. Solder the 556 Sound Synthesizer Circuit. Read pages 137–139 in MkE. Locate and examine the perfboard and IC socket in your boot camp parts kit. We will use the IC socket when soldering the circuit together in order to avoid the risk of permanent heat damage to the IC.

Check the layout of your 556 circuit on the breadboard. If there are any improvements to be made, now is the time. Recheck the circuit after each change.

Study the perfboard rails until you understand that *the connections are not the same as those in the solderless breadboard!* Carefully examine the boot camp project photographs on the course web page. Transfer the power indicator and 556 sound synthesizer circuits from the breadboard to the perfboard. Solder one component at a time, and use the socket in place of the IC. Find the notch in the IC socket, and position it on your perfboard so that it will match the notch or circle on the 556 IC. Replace the power supply connections with your 9 V battery clip.

Use the "Helping Hand" holder to keep your hands free while you solder. You can temporarily hold components in place with tape. Do not bend leads across the board to hold components. If you do this, you run the risk of shorting adjacent pads when you solder.

When you are finished, check your connections. Then, check your connections. Fix any mistakes you find. Paying very careful attention to proper orientation and pin alignment, push the 556 IC into the socket. If one is available in the lab, use an IC insertion tool to do this. Check your connections and the IC orientation. Connect the battery to the clip and turn on the power.

Demonstrate your circuit for the TA.

(20) ____ _____

In order for you to proceed, your soldered 556 sound synthesizer circuit, including the power indicator LED, must be completely functional.

Demonstrate for the TA that your circuit is functioning flawlessly. *(P/F)* ____ _____

5. Build an Enclosure for the 556 Sound Synthesizer. Using the project box supplied in your boot camp parts kit, you will now build an enclosure for the sound synthesizer circuit.

Begin by examining the example project photographs on the course web page. Notice how the mounted components, battery, and circuit board have been placed in the box so that there is no contact between them when the lid is closed. The wires have been coiled so that when the box is opened, they will stretch without getting tangled. The exterior layout has been designed rationally, so that the power indicator is closest to the shaft that turns on the device. The two control potentiometer shafts have been placed using a symmetric arrangement that suggests their functions are different from that of the volume/power shaft. The shafts all have sufficient clearance to allow for installation of knobs. Notice which hardware is screwed onto the potentiometer shafts from outside the box, and pay attention to how the bent tabs protruding from the potentiometer cases prevent rotation.

You are welcome to copy the layout of the example project, or design your own. Either way, you must carefully mark *and double-check* the locations and sizes of the holes you will drill in your project box. If you design your own layout, be extremely careful to avoid interference between parts and attached wires inside and outside of the box.

You will need to drill holes in your project box for

- The four circuit board mounting posts.
- The battery clip.
- The power indicator LED mount.
- The three potentiometer shafts.
- The three potentiometer anchor tabs.
- The speaker, so that the sound can easily be heard.

It is up to you to determine how large these holes should be. If you don't already know, ask the student shop supervisor how to use calipers. You can then measure your parts and determine the appropriate hole sizes. If you have not previously used the physics department student shop, you will need to ask your TA or the student shop supervisor to show you how to use the drill press safely and effectively. Always use safety glasses, and **tie back long hair and loose clothing when using the drill press!** Be sure your parts are securely clamped before you begin drilling. **Make sure you have removed the chuck key before you turn on the drill press!**

6. Install the 556 Sound Synthesizer in your Enclosure. Once you have finished drilling your project box, install the components, circuit board, and battery. When closing your project box, make sure the lid is properly seated, then tighten the screws until they are slightly snug. *Do not overtighten the screws!* It is very easy to destroy the plastic threads in the project box. Test your project thoroughly and fix any problems before having it graded.

Your grade will be based on the quality of your final project, as determined by the TAs using the guidelines below. Please present your finished project to a TA for grading.

The exterior appearance of the project should be professional, with the controls, power indicator, and speaker rationally placed. There should be no visible flaws. (10) ____ _____

The device should turn on and off when the switch on the volume control potentiometer is flipped.

(3) ____ _____

The power indicator LED should be mounted properly, and should function correctly.

(3) ____ _____

The volume control potentiometer should be mounted properly, and should function correctly. The volume should increase when the shaft is turned clockwise.

(4) ____ _____

The speaker should be mounted properly, and should function correctly. It should have enough vent holes so that it is easily heard. (4) ____ _____

The control knobs should be mounted properly, and both should affect the output sound in the expected manner. Turning either shaft clockwise should increase frequency. (10) ____ _____

Inside the box, the circuit board should be mounted securely on all four posts. (4) ____ _____

The battery and clip should be mounted properly.

(4) ____ _____

There should be proper clearance for all components and wires when the box is open and closed.

(5) ____ _____

The wiring inside the box should be correct, neat, easy to follow, and not prone to tangling. Opening the box should not cause any wiring problems. There should not be any excess bare wire that could cause short circuits. (10) ____ _____