Timer circuits

CEAB Graduate Attributes:

3.1.4 Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

4a) Demonstrate the ability to frame a complex, open-ended problem in engineering terms.

3.1.12 Life-long learning: An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

12a) Demonstrate the ability to independently summarize, analyze, synthesize and evaluate information from a wide variety of sources (learning independently).

Before beginning this lab, you should be able to:

- Know principle of monostabel, astabel and multivibrator operations
- Use oscilloscope and signal generators for capturing measurement results

After completing this lab, you should be able to:

- Apply the 555 timer circuit in a variety of applications!

In these labs we are going to use an important IC; the 555 timer!

The 555 is a single-chip version of a commonly used circuit called a multivibrator, which is useful in a wide variety of electronic circuits. Introduced in 1971 by Signetics, the 555 is still in widespread use due to its ease of use, low price, and stability. It is now made by many companies in the original bipolar and also in low-power CMOS types. As of 2003, it was estimated that 1 billion units are manufactured every year.

The 555 timer chip is probably the most popular integrated circuit ever made. It is used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element. Derivatives provide up to four timing circuits in one package.

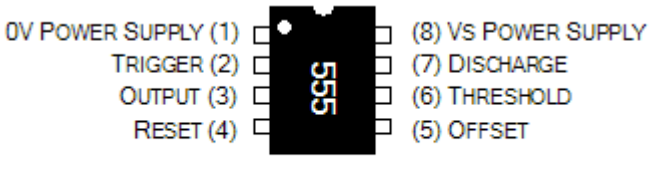


Figure 1: Pin-out diagram of the 555

Image is taken from http://www.eleinmec.com/article.asp?1

Pin 1 (Ground): Connects to the 0v power supply.

Pin 2 (Trigger): Detects 1/3 of rail voltage to make output HIGH. Pin 2 has control over pin 6. If pin 2 is LOW, and pin 6 is LOW, output goes and stays HIGH. If pin 6 is HIGH, and pin 2 goes LOW, output goes

LOW while pin 2 LOW. This pin has a very high impedance (about 10M) and will trigger with about 1uA.

Pin 3 (Output): (Pins 3 and 7 are "in phase.") Goes HIGH (about 2v less than rail) and LOW (about 0.5v less than 0v) and will deliver up to 200mA.

Pin 4 (Reset): Internally connected HIGH via 100k. To rest the chip it should go below 0.8v.
Pin 5 (Control):A voltage applied to this pin will vary the timing of the RC network (quite considerably).

Pin 6 (Threshold): Detects 2/3 of rail voltage to make output LOW only if pin 2 is HIGH. This pin has a very high impedance (about 10M) and will trigger with about 0.2uA.

Pin 7 (Discharge): Goes LOW when pin 6 detects 2/3 rail voltage but pin 2 must be HIGH. If pin 2 is HIGH, pin 6 can be HIGH or LOW and pin 7 remains LOW. Goes OPEN (HIGH) and stays HIGH when pin 2 detects 1/3 rail voltage (even as a LOW pulse) when pin 6 is LOW. (Pins 7 and 3 are "in phase.") Pin 7 is equal to pin 3 but pin 7 does not go high - it goes OPEN. But it goes LOW and will sink about 200mA.

Pin 8 (Supply): Connects to the positive power supply (Vs). This can be any voltage between 4.5V and 15V DC, but is commonly 5V DC when working with digital ICs.

The 555 timer relies on both analogue and digital electronic techniques. If we consider its output only, it can be thought of as a digital device. The output can be in one of two states at any time, the first state is the 'low' state, which is 0v. The second state is the 'high' state, which is the voltage Vs (The voltage of your power supply which can be anything from 4.5 to 15v. The most common types of outputs can be categorized by the following:

- **Monostable mode:** in this mode, the 555 functions as a "one-shot". Applications include timers, missing pulse detection, bouncefree switches, touch switches, frequency divider, capacitance measurement, pulse-width modulation (PWM), etc

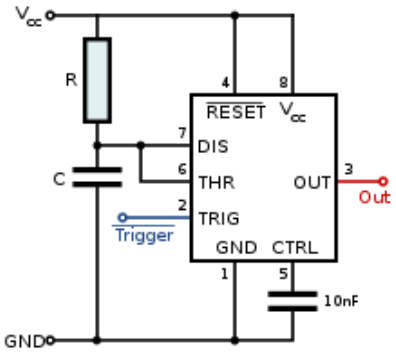


Image is taken from http://en.wikipedia.org/wiki/555_timer_IC

- **Astable mode:** or free running mode. In this mode, the 555 can operate as an oscillator. It can be used in this mode for application such as LED and lamp flashers, pulse generation, logic clocks, tone generation, security alarms, pulse position modulation, etc.

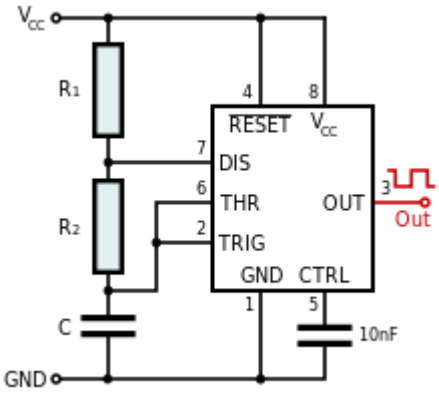
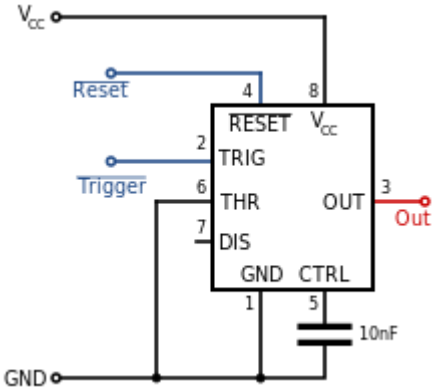


Image is taken from http://en.wikipedia.org/wiki/555_timer_IC

- **Bistable mode:** or Schmitt trigger. The 555 can operate as a flip-flop, if the pin 7 is not connected and no capacitor is used. It can be used in bouncefree latched switches, etc.



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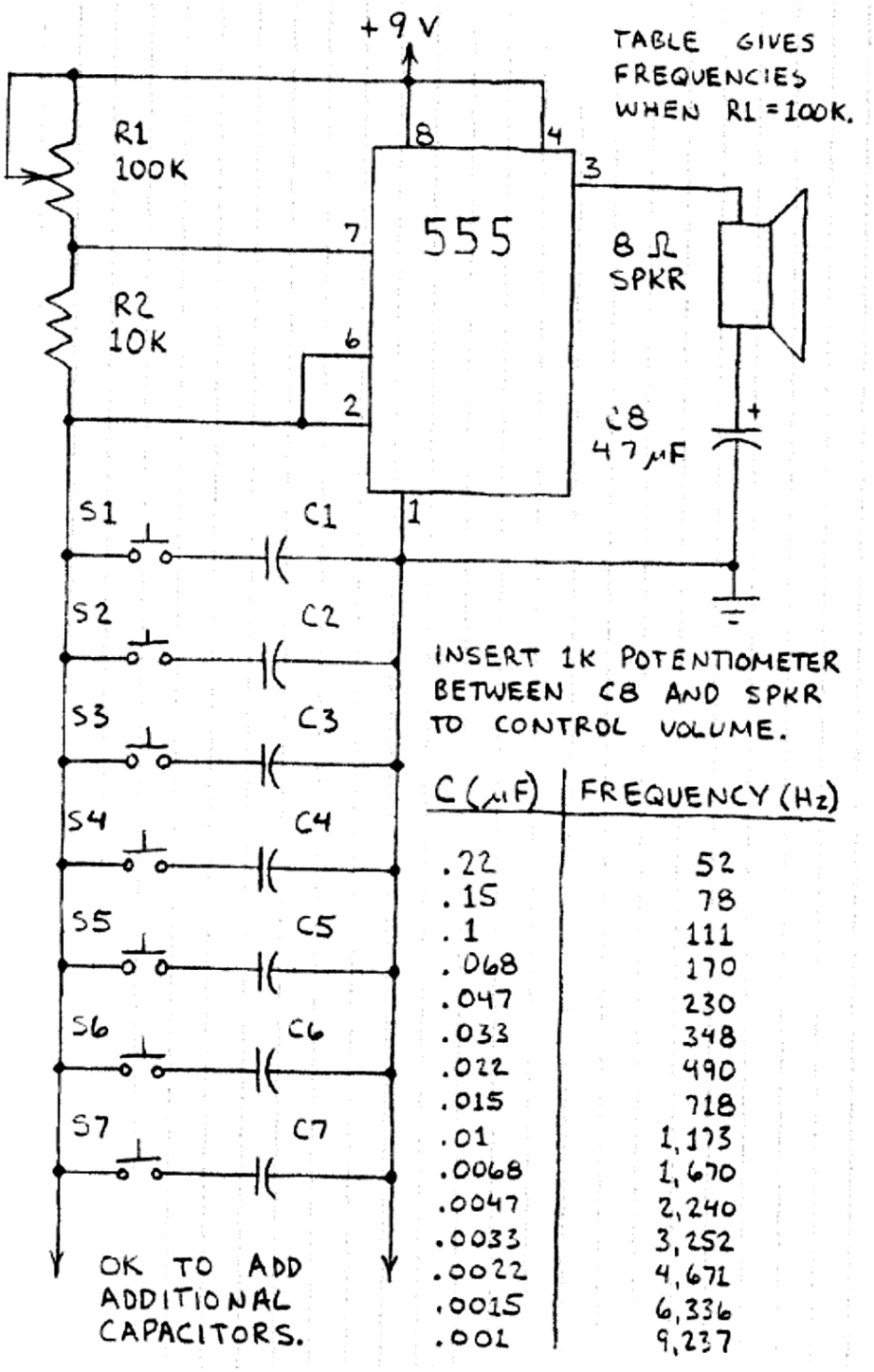
You may wonder what is inside the 555 timer chip or what makes it work. Well, the 555 timer chip an Integrated Circuit (IC) and therefore it contains a miniaturized circuit surrounded by silicon. Each of the pins is connected to the circuit which consists of over 20 transistors, 2 diodes and 15 resistors.

Experiments:

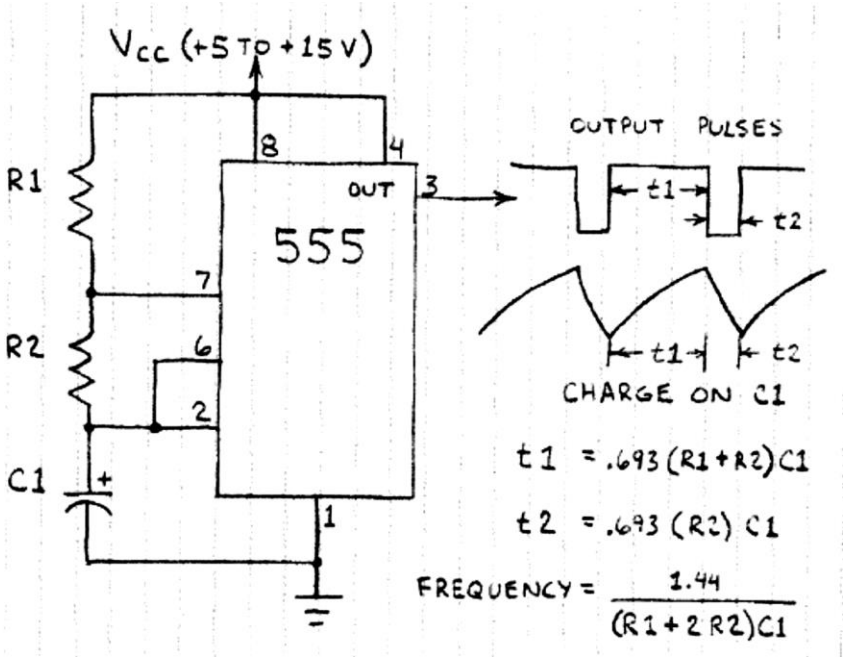
Toy organ:



C (μF)	FREQUENCY (Hz)
.22	52
.15	78
.1	111
.068	170
.047	230
.033	348
.022	490
.015	718
.01	1,173
.0068	1,670
.0047	2,240
.0033	3,252
.0022	4,671
.0015	6,336
.001	9,237

Figure curtsey of Timer. Op Amp and optoelectronic circuits and projects, by Forrest M. Mims III, Master Publishing Inc.

Basic Astable Circuit



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Basic Oscillator

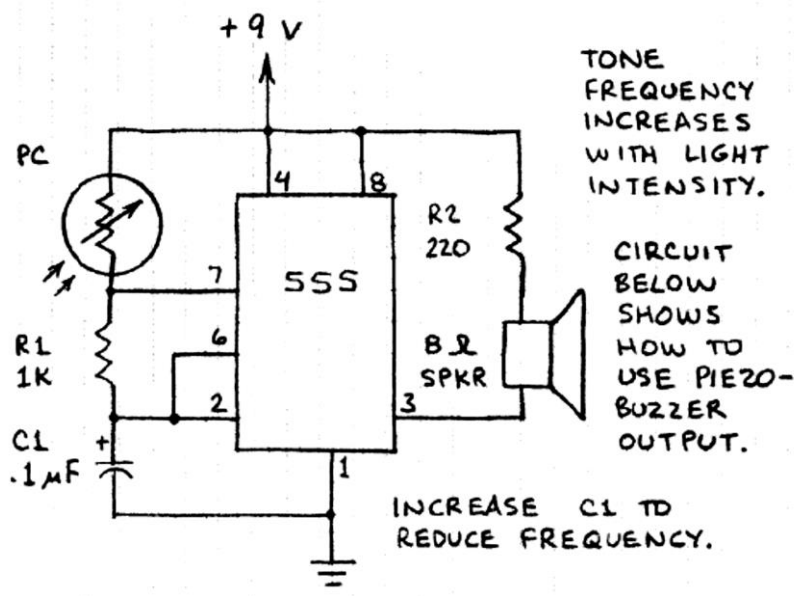

Figure curtsey of Timer. Op Amp and optoelectronic circuits and projects, by Forrest M. Mims III, Master Publishing Inc.

Course Project:

The 555 timer can be used for a variety of circuits such as sensors, pulse generators, alarms, etc.

- The course project is open ended; this means that you have freedom in choosing your circuit, but it needs to have at least one 555timer.
- It is preferred to use the timer in junction with a sensor. Simply oscillating circuits are basic and not considered design.
- You cannot use digital components. There is course project using 555 timer circuits in combination with transistors.
- Each project can have two people in its team, and they should decide on a project.
- This project must be conceived in terms of a "product'' that your team will design, with a set of overall objectives and especially with a set of minimum specifications which it must meet.
- Each team will then compete to design the best product (most elegant design, best performance, most closely meets specifications, most intuitively operated, lowest parts count and parts cost, etc.).
- You may want to take the design in steps: First decide on a general project in terms of what you may want your circuit to do.
- Perform a circuit analysis and confirm the result using LTspice. Your primary design should be submitted as your proposal by Oct. 22nd. Your project needs approval before you can move on.
    - Provide enough information about your project; it will make the evaluation easier, and you get the approval faster. I will start by reading those reports that are clearer, and then get to the more unpleasant ones!
    - Your list of required parts should be included in the proposal.
- You have until Nov. 21 to complete your design.
    - Project is evaluated based on both your report and demonstration. We need an operational circuit.
    - If your circuit needs parts that are not in your kit, you can go to analog devices website and order the parts. They are free of charge for students, but need to have a project description. Parts generally arrive within a week, but make sure you order what you need on time.
    - Start by transferring your LTspice simulation to breadboard, and when operational, you can transfer it to PCB. PCB is not required.
        - I do not want you to spend time on PCB and soldering. There are automated and very inexpensive services that you use to fabricate your circuit. You can easily find one on the internet.
        - Budget for sending your circuit to external sources for fabrication is not granted by the department yet. I'll keep you posted.
- Design idea can be from variety of sources, or you may come up with your own design. Make sure to properly cite and address your resource. If you are going for your own design, make sure to search and find out if anyone else had the same idea or not.

Some Project Ideas

- Motor PWM
- Reaction Timer Game

- 4 Way Traffic Lights
- Driving many LEDs
- 3x3x3 Cube
- Bike Turning Signal
- Police Lights
- Roulette
- Automatic Curtain Closer
- Burglar Alarm 4-Zone
- Clap on, clap off circuit