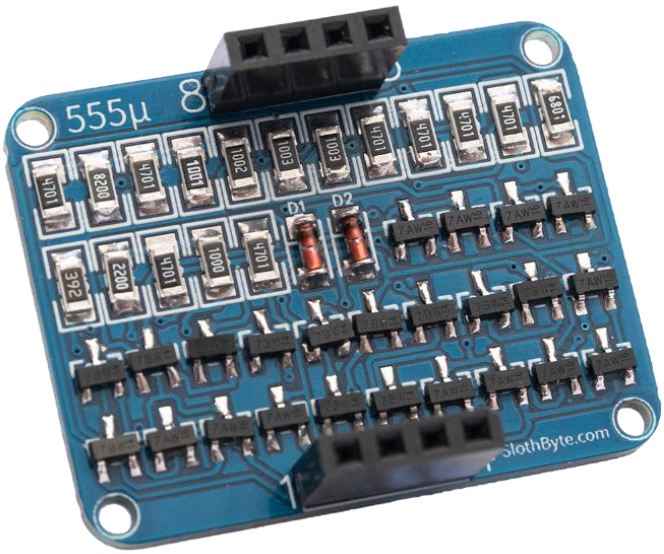
Sloth Byte Limited

The 555 Micro Kit



Assembly & User Manual

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Disclaimer: This kit contains small parts which present a choking hazard to small children. Please keep this kit out of reach of small children. Children old enough to assemble the kit should be supervised, during assembly and during use of the completed kit. This is an educational hobby kit; it is not for use in life-critical systems or where failure could lead to the risk of injury or death. Switch off when leaving unattended. The technical data contained herein has been provided solely for informational purposes and is not legally binding. This manual is subject to change, technical or otherwise.

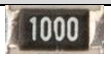
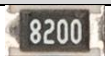
Attention: This kit is designed to work with a **5 volt dc** power supply!

Kit Contents

Before you begin, take some time to check that you have received all the components. If you ordered the PCB only and not the kit, the following list can be used as a shopping guide. The pictures are meant as a guide as the actual component design may differ slightly, for example in size or colour.

We have tried our best to ensure that your kit has everything included, if however, something is missing, please contact us at info@slothbyte.com.

Tip: Surface-mount components are extremely small and easy to drop and loose. It is therefore recommended that you clear a suitable and well-lit workspace before opening the components, and then only open one at a time.

Picture	Value	Component number	Description	Quantity
	PCB	-	Circuit Board	1
	LL4148	D1, D2	Small signal diode	2
	100 Ω	R16	Resistor 1000	1
	220 Ω	R14	Resistor 2200	1
	820 Ω	R2	Resistor 8200	1
	1 kΩ	R4	Resistor 1001	1
	3.9 kΩ	R13	Resistor 392	1
	4.7 kΩ	R1, R3, R8, R9, R10, R11, R15, R17	Resistor 4701	8
	6.8 kΩ	R12	Resistor 6801	1
	10 kΩ	R5	Resistor 1002	1
	100 kΩ	R6, R7	Resistor 1003	2
	MMBT3904	Q1, Q2, Q3, Q4, Q14, Q16, Q17, Q18, Q21, Q22, Q23, Q24	Transistor – NPN 7AW	12
	MMBT3906	Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q15, Q19, Q20	Transistor – PNP 7BW	12
	Header	H1, H2	Connector	2

Introduction

This guide will help you to construct and test the surface-mount version of our popular discrete 555 timer kit. Since this is the more advanced version of the kit in terms of soldering skills required, it is assumed that you already have a basic understanding of electronics and previous through-hole component soldering skills.

There are two main methods that can be used to solder this kit at home: a traditional soldering iron, albeit with a fine tip or the use of solder paste and a hot air gun.

The images in this manual and instructions will follow the traditional soldering iron route as it is expected that more people have access to this over a hot air gun.

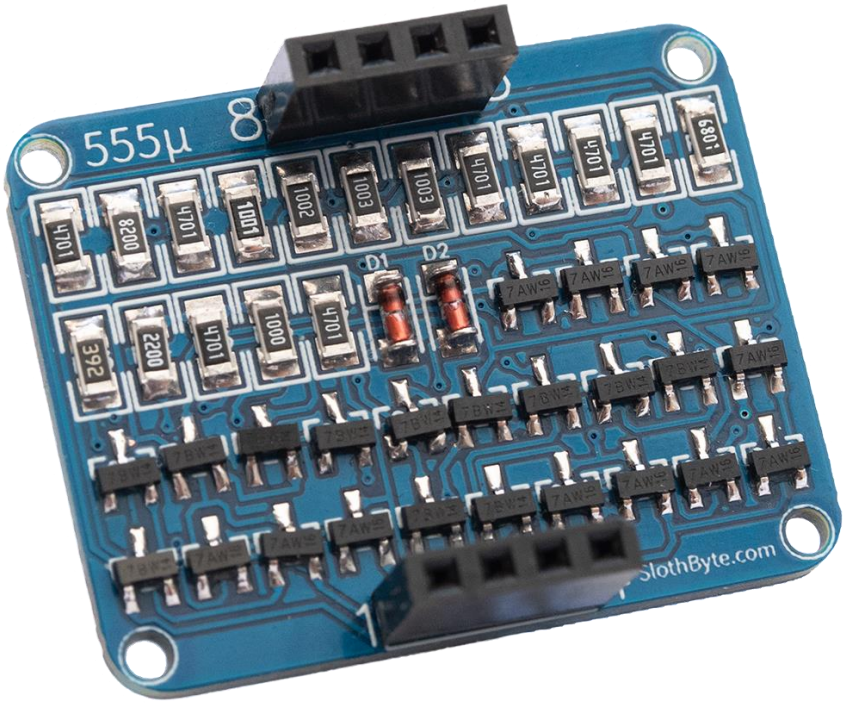


Figure 1 - Constructed 555 Micro Kit

Components Overview

Surface-mount components are generally supplied on tape in reels. These reels are loaded into automatic pick and place machines which run through a predefined program, picking and then placing the components onto the PCB that has already had solder paste applied to the exposed pads. The PCB is then heated in an oven to melt the solder paste and solder the component in place.

The photograph below shows reels of surface-mount components loaded into a pick and place machine.

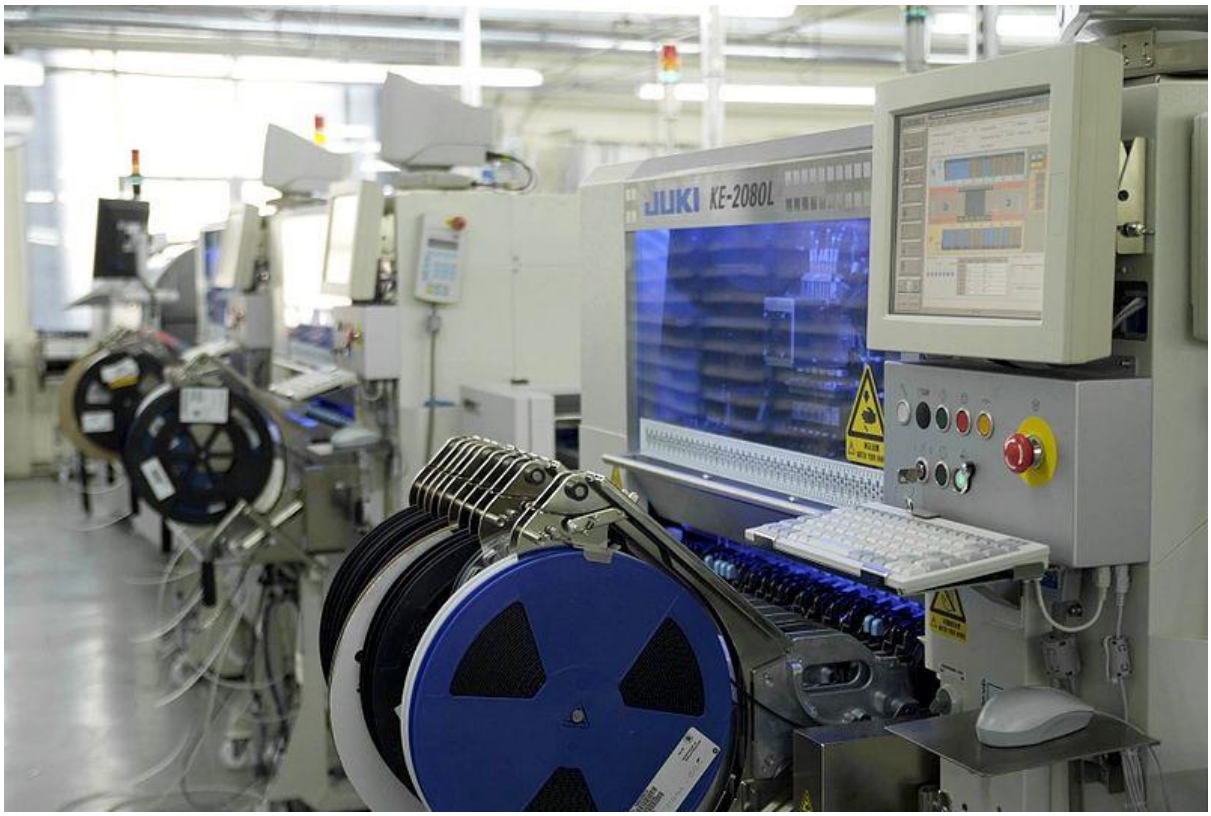


Figure 2 - Surface-mount pick and place machine
Credit: Wikipedia
Used under the Creative Commons Attribution 3.0 Unported license.

Surface-mount components are available in many package sizes. The package size of the resistors used in this kit are package type 1206 (imperial) / 3216 (metric), which measure 3.2 mm x 1.6 mm.

The components supplied with this kit are supplied on what is known as cut tape; they have been cut from the reel of tape. For easy identification and to avoid loss and/or mixing up, they have been attached to a labelled sheet of paper.

Before making a start on constructing the kit, it is recommended to familiarise yourself with the surface-mount components used by reading the following sections; **Resistors**, **Diodes** and **Transistors**.

Resistors

Surface-mount resistors don't use the resistor colour code that their through-hole equivalents use. Instead, they have their value printed on them as a numerical value. The right most digit is the multiplier (how many zeros to add).

Here are some examples of four-digit values.

- 8200 is read as 820 and 0 zeros, so 820Ω
- 4701 is read as 470 and 1 zero, so 4700Ω, or 4k7Ω
- 1003 is read as 100 and 3 zeros, so 100000Ω or 100kΩ



Figure 3 - Left: 1kΩ surface-mount resistor. Right: 4k7Ω surface-mount resistor

Diodes

The surface-mount diodes in this kit have a small black line at one end, this must be aligned with the markings on the PCB.



Figure 4 – Surface-mount Diode

Transistors

There are two types of transistor used in this kit; NPN and PNP.

Care must be taken not to mix them up. However, each transistor does have a small marking on the case that can be used to identify it.

7AW	NPN	Q1, Q2, Q3, Q4, Q14, Q16, Q17, Q18, Q21, Q22, Q23, Q24
7BW	PNP	Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q15, Q19, Q20



Figure 5 – Surface-mount Transistor

Tools

Required Tools

You will need some basic tools to complete this kit.

- Soldering iron with very fine tip
- Solder
- Flux
- Solder wick
- Tweezers
- Small cutters
- Magnifying glass
- Flux cleaner / isopropyl alcohol



Figure 6 - Tools

Optional but recommended tools

- Soldering matt to protect your desk
- Multimeter for measuring resistor values, fault finding and testing
- Oscilloscope for fault-finding and viewing the output of the 555 kit

Assembly Guide

Important: Ensure that you solder in a well-ventilated area and avoid breathing the fumes. Always wash your hands after handling solder or chemicals.

Tip: Different types of solder have different melting temperatures, and some are easier to work with. The wattage of your soldering iron and size of tip affects the ease of soldering.

When hand-soldering surface-mount component, one method is to;

- Apply flux to the pads.
- Apply a small amount of solder to only one of the pads.
- Using tweezers hold the component in place and heat the pad that solder was previously applied to. Still holding the component, remove the iron.
- If not happy with the position of the component, heat the joint and using tweezers gently reposition the component.
- When you are happy with the positioning of the component, apply solder to the other pad(s).
- After all components have been fitted and joints inspected, thoroughly clean the flux from the PCB using flux cleaner or isopropyl alcohol.

Resistors

There are nine different resistor values used in this kit. It's essential that the correct value is fitted in the correct position, or the kit will not work as intended.

The resistors have been labelled when the kit was packed. If, however, they have since been mixed up, the easiest way to identify them is by checking the number printed on them and comparing this to the **Kit Contents** section or the photo below.

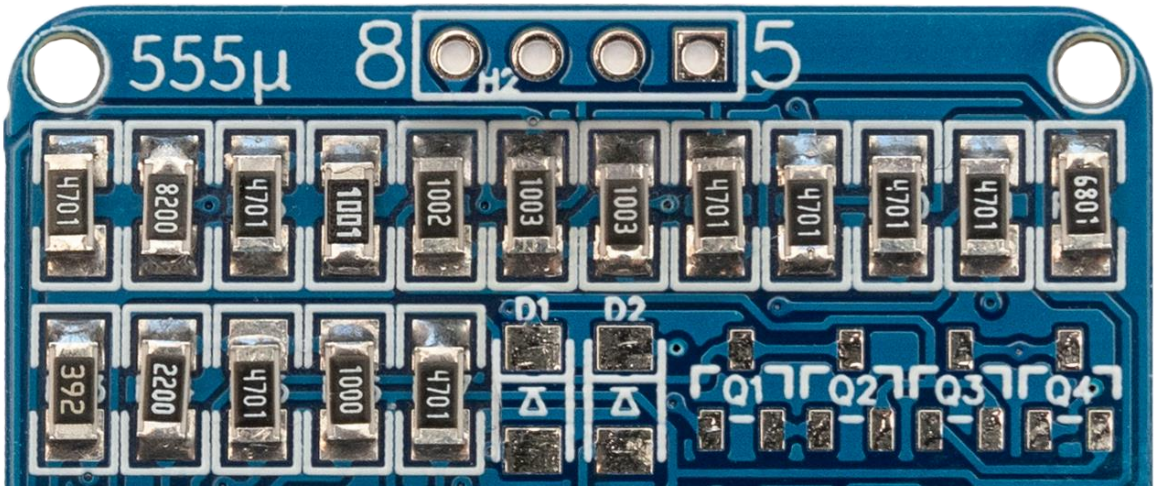


Figure 7 - PCB with all resistors soldered in place

Work in whatever order you prefer, e.g. R1, R2, R3, R4 etc. or by resistor value, e.g. all of the 4k7Ω resistors and then the next value and so on. Just be sure to take your time and not mix up the values.

Resistors can be soldered either way around. However, the finished kit will look nicer if they are all soldered the same way, i.e. all values orientated in the same direction.

Once complete, take time to inspect each joint with a magnifying glass before moving on to the next step.

Diodes

Both diodes are the same value, and the positions on the circuit board are labelled as D1 and D2. Pay attention to the black line printed on the diode, it matches the position of the line printed on the circuit board.

Once complete, take time to inspect each joint with a magnifying glass before moving on to the next step.

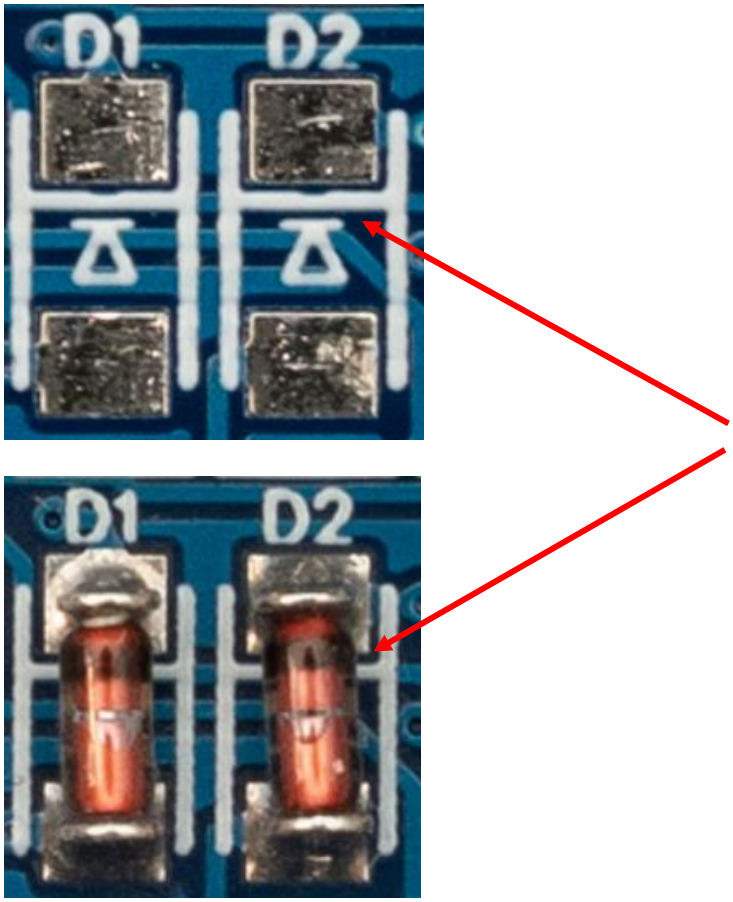


Figure 8 - Diodes

Transistors

There are two types of transistor used in this kit.

- 12 x MMBT3904 (NPN) – Component marking "7AW"
- 12 x MMBT3906 (PNP) – Component marking "7BW"

It is essential that the two types of transistor are not mixed up, although they look the same, they operate in the opposite way to each other.

Tip: For each transistor location, apply flux and a little solder a single pad. Heat this solder and position the transistor using tweezers, remove the iron. If happy with the position apply solder to the other two legs, or else heat the joint and reposition the transistor.

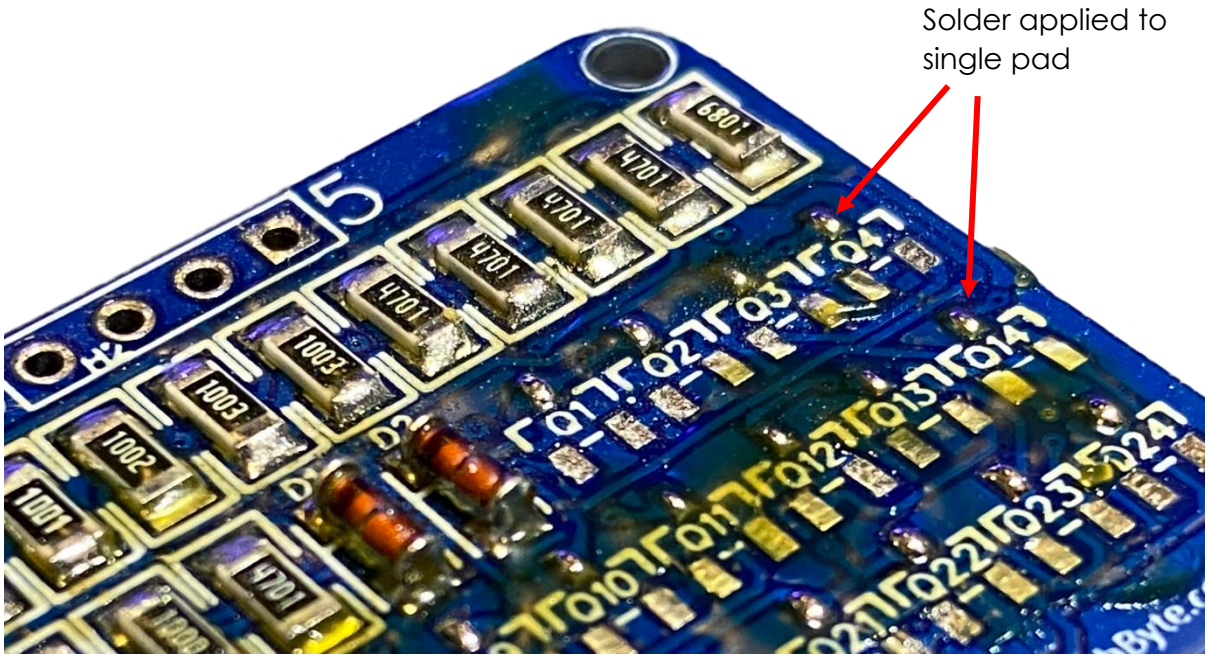


Figure 9 - Solder applied to single pad of transistor locations. Flux has been applied to help the solder flow.

Use a magnifying glass and/or multimeter to check for shorts. If there are any shorts between the transistor pads, then the kit will not work.

Tip: Three of the transistors (Q5, Q8 and Q19) will read a short between their base and collector, this is by design and shown on the schematic. To help identify the base, collector and emitter, see Figure 10 below.

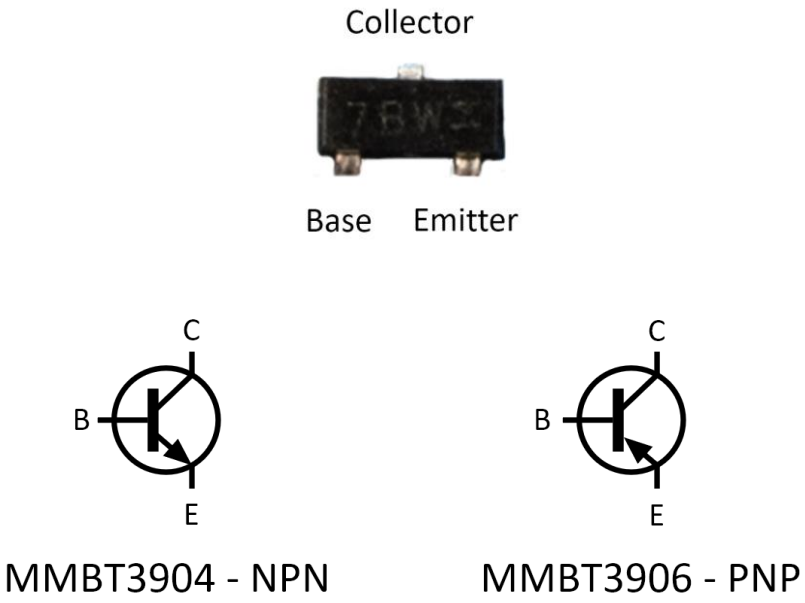


Figure 10 - Transistor pinouts

Connection Header

The last two components to solder in place are the connection headers, H1 and H2. These connectors are the same style as used on the popular Arduino microcontroller boards. After it is soldered in place, a connection is made by inserting a solid core wire into the hole. The recommended gauge of wire is 22 awg.

The orientation of the header doesn't matter. To solder in place, start by soldering just one of the outer pins. Check if the header is level, if not heat the joint and move the header so that it is. Once correctly positioned, solder the remaining pins.

The pinouts are labelled on the circuit board either side of each header. H1 runs from pin 1 on its left, through to pin 4 on its right. H2 runs from pin 5 on its right, through to pin 8 on its left. You might find it strange that the numbers run in opposite directions on each header, however, this is the same as the pin numbers on an actual 555 timer chip.

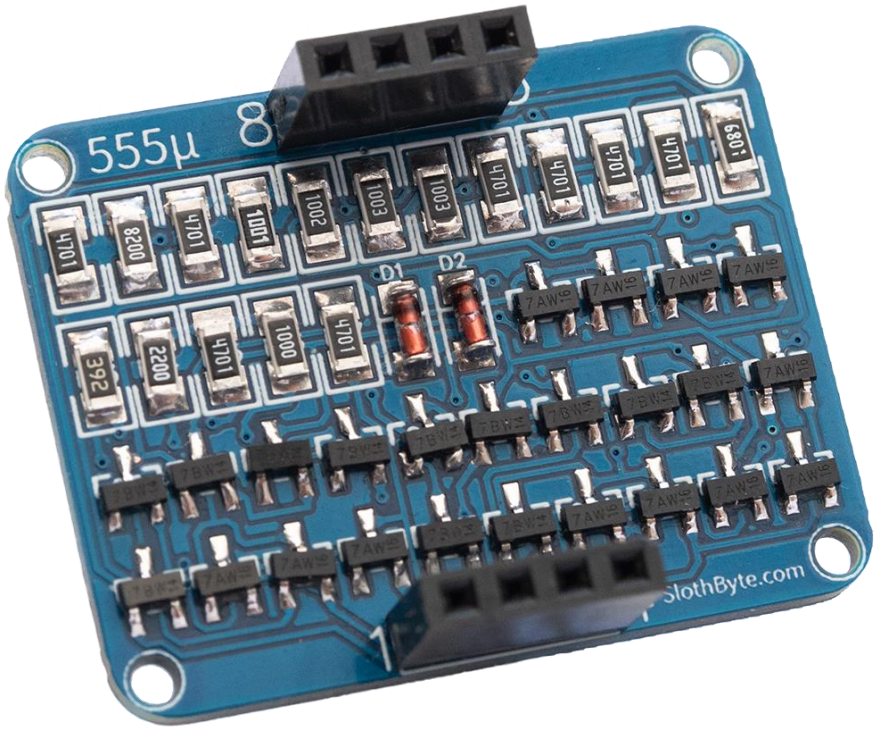


Figure 11 – Connection headers soldered in place

Congratulations your 555 Micro is now complete!

You kit will need a though clean to remove the flux residue.

You can test the completed kit by building it into one of the circuits in the **Example Circuits** section. My favourite is the astable circuit; this will repeatedly pulse the output (pin 3) on and off in a square wave. You can use the output to drive an LED but remember to protect the LED using a resistor.

Power

Throughout this kit, all circuit diagrams will refer to the supply + volts dc as "VCC" and the supply 0V as "GND". Any number shown in brackets after the label VCC or GND simply refers to the pin number of the connection header on the circuit board.

Important: This kit is designed to work with a **5 volt dc** power supply! That means +5V connects to VCC and 0V connects to GND.

Example Circuits

Astable

When the 555 Micro kit is used in an astable configuration, its output is a square wave that switches between on (≈5 volts) and off (0 volts).

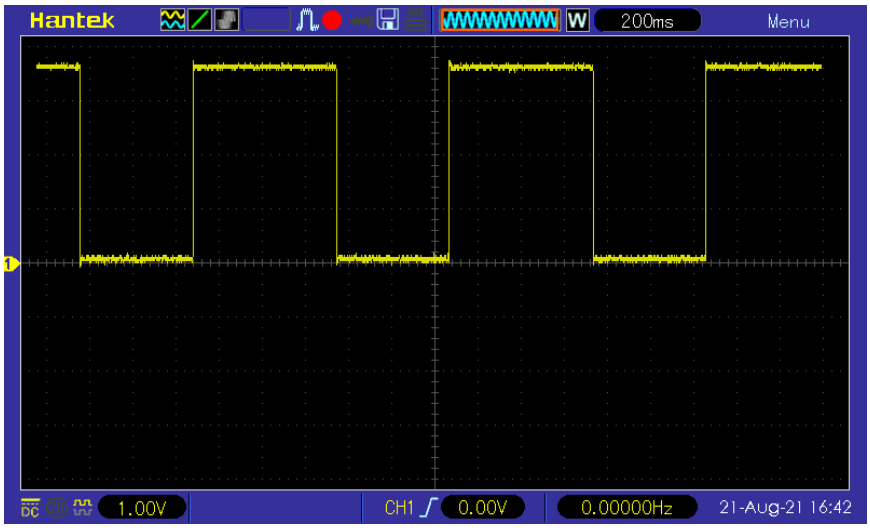


Figure 12 - Oscilloscope capture of astable output

The number of on/off cycles that occur in one second is known as the frequency and is measured using the unit Hertz (Hz). The output frequency of the 555 can be changed by selecting different external component values.

The image above is a screenshot from an oscilloscope showing the output voltage of the 555 Micro kit plotted against time. The vertical axis measures voltage, 0 volts being the centre line. Each vertical division is equal to 1 volts, so we can see that when the output is on (top of the square wave) it is around 4.5 volts.

The horizontal axis plots time and each division is equal to 200 ms (0.2 seconds). If we count the horizontal divisions for one complete cycle (on/off) we can see that one cycle is 5.8 divisions.

So, the time (T) taken for one cycle is;

T = 5.8 x 200 ms

T = 1160 ms (1.160 seconds)

The formula to calculate frequency is as follows, where the frequency is in Hertz and time is in seconds.

$$f = \frac{1}{T}$$

$$f = \frac{1}{1.160}$$

$$\boldsymbol{f = 0.862\ Hz}$$

Build Your Own Astable Circuit

In the circuit below, the 555 Micro kit is represented by the rectangle labelled "555". Its pins are labelled with text and numbers that correspond to the connection header labels on the circuit board. All other components shown in this circuit are external to the 555 Micro Kit. You can probably get away without including C2.

By changing the values of R1, R2 and C1, it is possible to change the output frequency. A suitable value for RL must also be selected in order to protect the LED, selecting this value will be covered later.

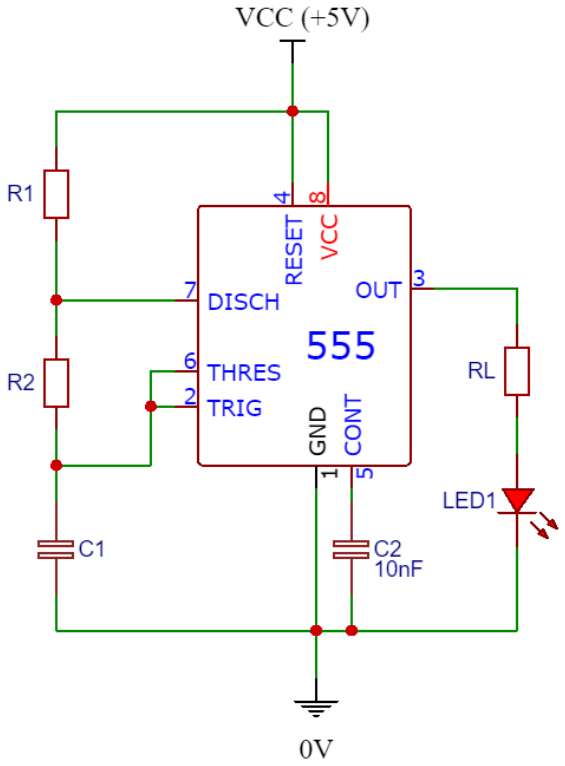


Figure 13 - 555 timer connected in astable configuration

The formula for calculating the frequency in Hertz is below.

$$f = \frac{1.44}{(R_1 + 2R_2)C_1} Hz$$

R1 and R2 are in ohms, C1 is in farads. So, let's see what the frequency would be if we used the following values;

- R1 = 10 kΩ
- R2 = 100 kΩ
- C1 = 10 µF

$$f = \frac{1.44}{(10000 + 2 \times 100000)0.00001} Hz$$

$$f = \frac{1.44}{210000 \times 0.00001} Hz$$

$$f = \frac{1.44}{2.1} Hz$$

$$\boldsymbol{f = 0.686\ Hz}$$

Therefore, by using these values; R1 = 10 kΩ, R2 = 100 kΩ and C1 = 10 µF, we can make the output have a frequency of 0.686 Hz. But what does that look like in time?

Since we know that the time of one cycle is equal to 1 divided by the frequency, we can substitute in the frequency that we just calculated to give;

$$T = \frac{1}{f}\ seconds$$

$$T = \frac{1}{0.686}\ seconds$$

$$\boldsymbol{T = 1.46\ seconds}$$

This means that if we use the values for R1, R2 and C1 as defined above, then the time for one on/off cycle of the output will be 1.46 seconds. This time can be decreased by or increased by adjusting the values chosen for R1, R2 and C1.

Tip: Increase C1 to reduce the frequency (increase the period).

Tip: There are two online 555 calculators at https://www.slothbyte.com/555-calculator The first calculator shows the time and frequency for specified component values. The second calculator gives component values for a specified frequency.

Using an LED for the Output

If you plan to flash an LED from the output, then you must use a resistor to protect the LED. We can use ohms law to calculate the value of resistor that should be used.

Let's assume that the output of the 555 timer is at 5 volts. Let's also assume that the LED has a forward voltage of around 1.85 volts and a forward current of 15 mA (check the manufacturer datasheet of your LED for this information). Then we can calculate the resistance of RL as follows.

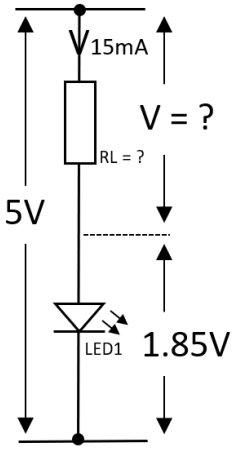


Figure 14 – LED voltage drop

Ohms law tells us the following, where R is resistance in ohms, V is volts, and I is current in Amps.

$$R = \frac{V}{I}$$

Since we need to know two out of three values to solve the above formula, we must approach this by first calculating the voltage drop across the resistor.

We know the supply voltage is 5 volts and that the LED will drop 1.85 volts, this means that the voltage drop across RL must be 5 volts minus 1.85 volts. We know that the current through the LED should be 15 mA, so substituting in these values gives us the following.

$$\boldsymbol{RL} = \frac{5 - 1.85}{0.015} = \frac{3.15}{0.015} = \mathbf{210}\Omega$$

You may find that the exact resistance that you calculate isn't available, this is because manufactures only make resistors in specific values. If this is the case, just choose the closest available value. In some circumstances, it may be that you need to combine resistors to obtain a suitable value.

Important: Only connect the output of this kit to low current devices such as an LED (using a resistor) or the input of other TTL logic devices that operate at 5 volts. If you wish to drive something that will draw a lot of current, then you must switch this by using a transistor that is capable of switching the required current. Remember that this kit is powered using 5 volts dc and not designed to switch anything that uses more voltage than this.

The photograph below shows the 555 Micro kit connected in an astable configuration using components on a breadboard. The output is connected to an LED through a resistor. The output is also being monitored on an oscilloscope. Oscilloscopes are expensive but worth the investment if you are serious about pursuing electronics.

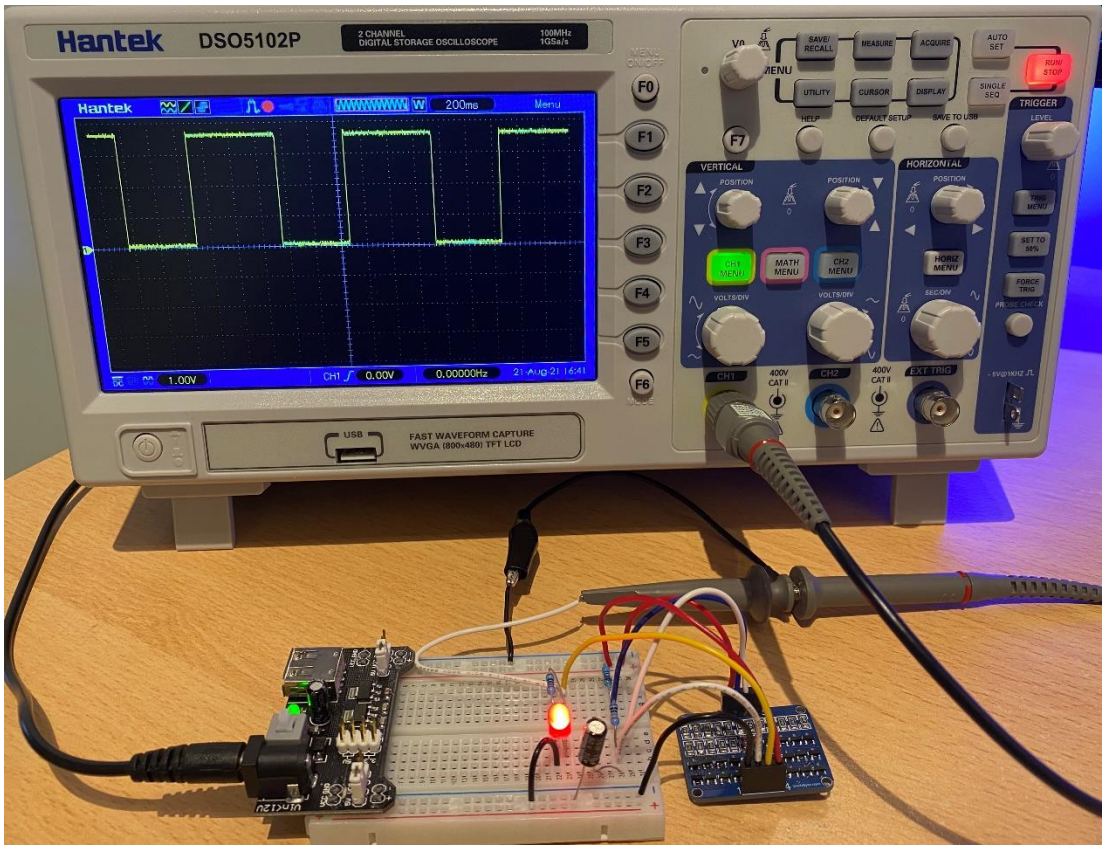


Figure 15 - Oscilloscope capture of astable output

Monostable

When the 555 Micro kit is used in a monostable configuration, its output remains off until the trigger pin is pulsed low. The output then goes high (on) for a defined time period before going low (off) again. The output will remain off until the trigger pin is pulsed low again.

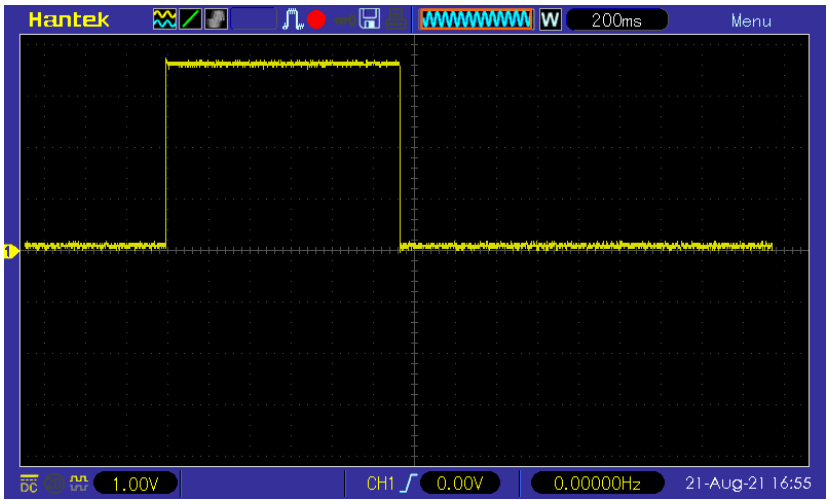


Figure 16 - Oscilloscope capture of monostable output

The image above is a screenshot from an oscilloscope showing the output voltage of the 555 Micro kit configured in monostable mode plotted against time. The vertical axis measures voltage, 0 volts being the centre line. Each vertical division is equal to 1 volts, so we can see that when the output is on (top of the pulse) it is around 4.5 volts.

The horizontal axis plots time and each division is equal to 200 ms (0.2 seconds). If we count the horizontal divisions for the pulse, we can see that it is about 5.7 divisions.

So, the time (T) taken for the pulse is;

T = 5.7 x 200 ms

T = 1140 ms (1.140 seconds)

It is possible to adjust the time pulse by selecting different external component values, which is covered in the next section.

Build Your Own Monostable Circuit

The circuit below shows how to connect the 555 Micro kit to operate in monostable mode. Note that you can most likely get away without the need for C2.

R4 and C3 are included to give a "delayed start" to the circuit. They will hold pin 4 (reset pin) of the 555 momentarily low at first power on. Pin 4 turns on/off the 555, when pin 4 is held high, the 555 is on, when pin 4 is held low, the 555 is off.

The delayed start is necessary as upon first power on, some states internally are unknown/invalid and cause the 555 to trigger its monostable output right away. We can easily implement the delayed start using a resistor (R4) and a capacitor (C3).

How does this "delayed start" work? Electricity is like water in that it wants to take the path of least resistance. In this case, it is easier for the electricity to flow into C3 than it is pin 4 of the 555. As C3 begins to charge the voltage at pin 4 begins to rise until it is high enough to turn on the 555.

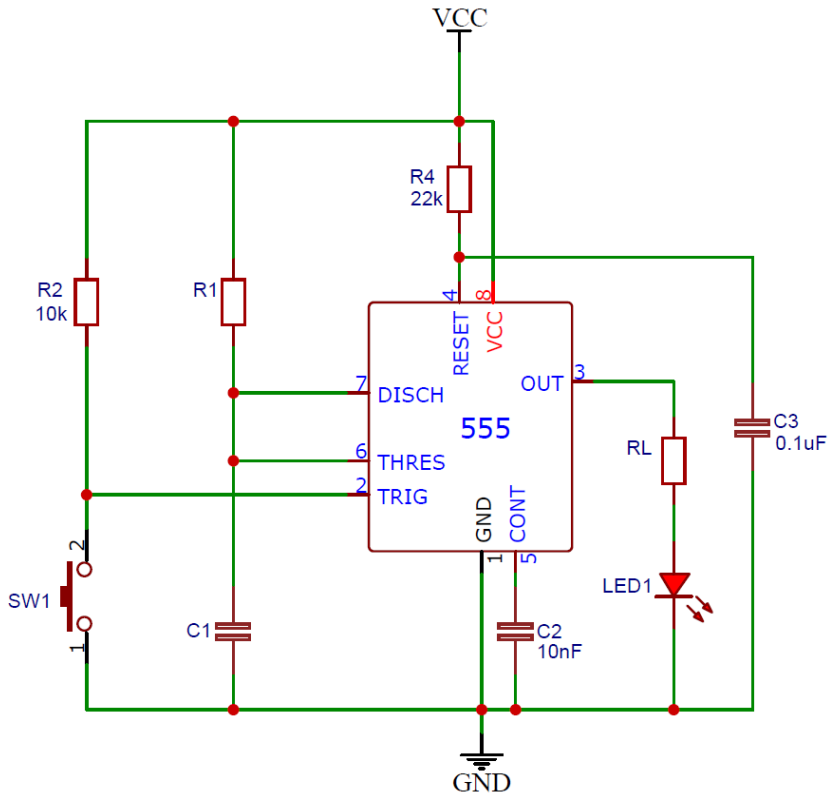


Figure 17 - 555 timer connected in monostable configuration

The formula to calculate the time pulse output on pin 3 is as follow.

$$T = 1.1R_1 \times C_1$$

So, let's use 100 kΩ for R1 and 10 µF for C1 to get a feel for what sort of time pulse these values will give.

$$T = 1.1 \times 100000 \times 0.00001$$

$$\boldsymbol{T = 1.1\ seconds}$$

Or if you have a specific time in mind, for example, 10 seconds, then pick a suitable value for C1, again let's say 10 µF and rearrange the formula to solve for R1.

$$R_1 = \frac{T}{1.1C_1}$$

$$R_1 = \frac{10}{1.1\ \times 0.00001}$$

$$\boldsymbol{R_1 = 909\ k\Omega}$$

If the resistor value calculated for your desired time is not a standard value, then you can either choose the nearest standard value or combine several resistors to form your calculated resistance.

Finally, if you wish to test the output with an LED, then you must select a suitable value resistor to limit the current flow through the LED. See the section **Using an LED for the Output** for how to do this.

The photograph below shows the 555 Micro kit connected in a monostable configuration using components on a breadboard. The output is connected to an LED through a resistor. The output is also being monitored on an oscilloscope. Oscilloscopes are expensive but worth the investment if you are serious about pursuing electronics.

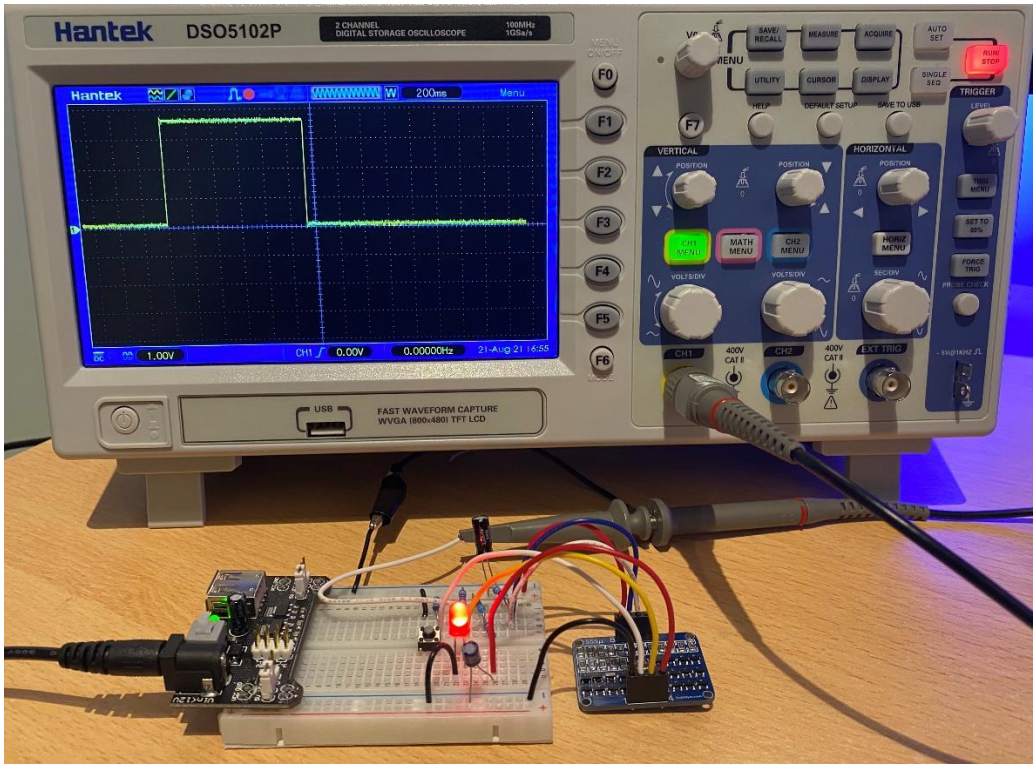


Figure 18 - Oscilloscope capture of monostable output

Appendix

Schematics

When dealing with complex circuits, it can be easier to get an overview of what's going on by concentrating on the bigger picture. Instead of worrying about each individual component, the function of several components can be grouped together into a block that describes how that group of components function.

In the case of this kit the entire circuit can be represented by the block diagram below. Now it just becomes a case of understanding how the following parts work; voltage divider, comparator, flip-flop, the output and the discharge pin.

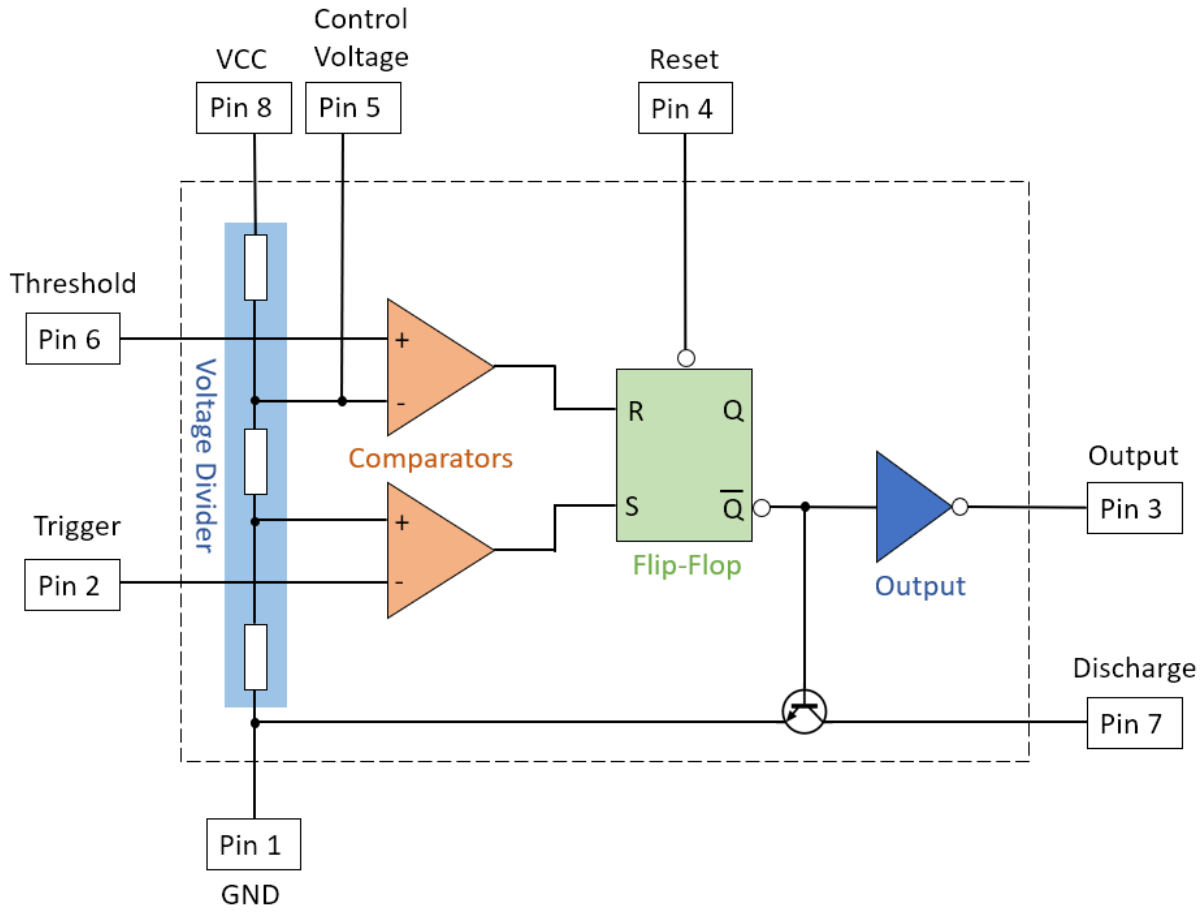
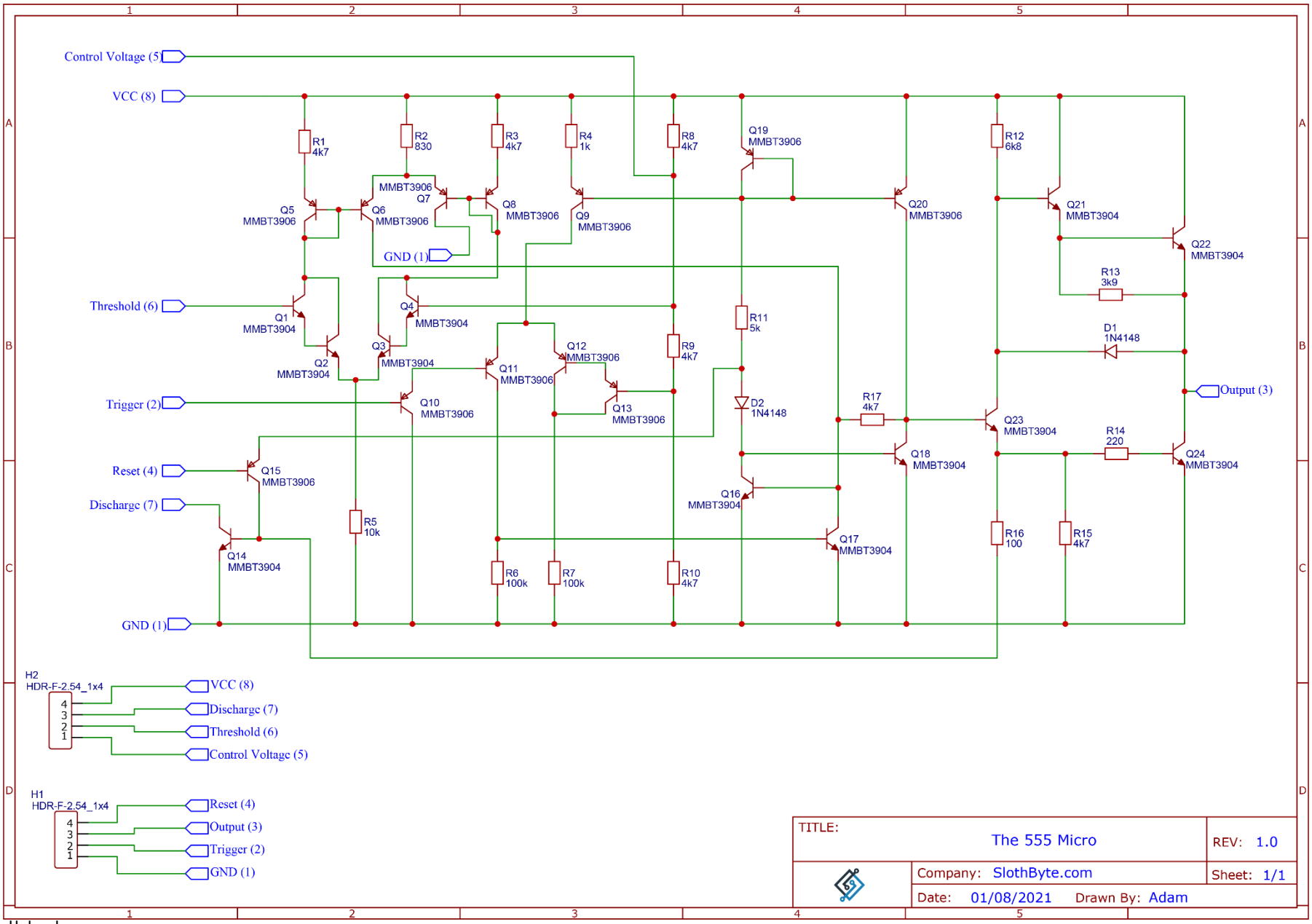


Figure 19 – 555 Block Diagram


Control Voltage (5)
VCC (8)
Threshold (6)
Trigger (2)
Reset (4)
Discharge (7)
GND (1)
Output (3)
R1 4k7
R2 830
R3 4k7
R4 1k
R5 10k
R6 100k
R7 100k
R8 4k7
R9 4k7
R10 4k7
R11 5k
R12 6k8
R13 3k9
R14 220
R15 4k7
R16 100
R17 4k7
D1 1N4148
D2 1N4148
Q1 MMBT3904
Q2 MMBT3904
Q3 MMBT3904
Q4 MMBT3904
Q5 MMBT3906
Q6 MMBT3906
Q7 MMBT3906
Q8 MMBT3906
Q9 MMBT3906
Q10 MMBT3906
Q11 MMBT3906
Q12 MMBT3906
Q13 MMBT3906
Q14 MMBT3904
Q15 MMBT3906
Q16 MMBT3904
Q17 MMBT3904
Q18 MMBT3904
Q19 MMBT3906
Q20 MMBT3906
Q21 MMBT3904
Q22 MMBT3904
Q23 MMBT3904
Q24 MMBT3904
H2
HDR-F-2.54_1x4
VCC (8)
Discharge (7)
Threshold (6)
Control Voltage (5)
H1
HDR-F-2.54_1x4
Reset (4)
Output (3)
Trigger (2)
GND (1)
TITLE:
The 555 Micro
REV: 1.0
Company: SlothByte.com
Sheet: 1/1
Date: 01/08/2021
Drawn By: Adam