



EENG 385 - Electronic Devices and Circuits
BJT Curve Tracer: Intro to MultiSim and the 555 Timer
Lab Document

Objective

Two main objectives of this lab are: (1) To introduce the 555 Timer and (2) To present the MultiSim Live tool. You will create the 555 Timer circuit in this lab and use it in a subsequent lab as part of the BJT curve tracer. You will use the MultiSim Live tool throughout the remainder of the term to test circuit ideas before building them.

Analysis 555 Timer

We will start by examining the behavior of today's circuit and then use our understanding of the circuit to quantify the behavior of the circuit. The circuit shown Figure 1 is built around the 555 Timer, a chip seen since the early 1970s. Its use is now limited to niche applications; it is not something you are likely to use much in industry. That said, an analysis of the circuit Figure 1 will allow us to practice valuable skills.

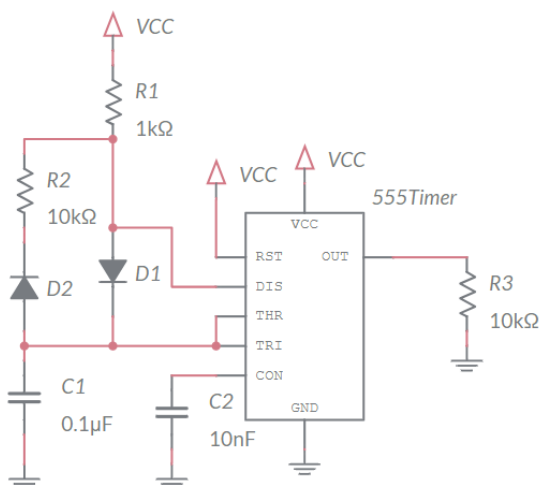
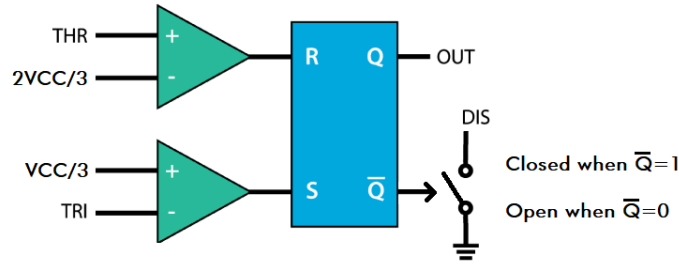


Figure 1: The output of the 555 Timer oscillates with a predictable period and duty cycle.

In order to analyze the circuit in Figure 1, you first need to understand the internal operation of the 555 Timer chip. A highly simplified view of its internal structure is shown in Figure 2. You will notice some of the pins shown in Figure 1 are not shown in Figure 2. These omitted pins do not affect the behavior of the circuit shown in Figure 1, so to simplify the explanation, they are omitted.

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Finally, note that VCC is the system voltage in Figure 1, for simplicity, we will assume throughout



the lab that $VCC = 9V$.

Figure 2: A highly simplified rendering of a 555 Timer's internals.

Let's start our exploration of Figure 2 by examining the pair of green triangles called comparators. We will call the upper comparator the "R-comparator" because it is connected to the R input of the blue box. Likewise, we will call the lower comparator the "S-comparator". Notice each comparator has a + and - input on its left, and its output on the right. The behavior of a comparator is described by the following two statements.

- When the voltage on the + input is larger than the voltage on the - input, the output of the comparator equals VCC.
- When the voltage on the - input is larger than the voltage on the + input, the output of the comparator equals GND.

Use these definitions and the schematic in Figure 2 to answer the following two questions. Assume that $VCC = 9V$, so state your answers in terms of numerical volts, not symbolically in terms of VCC.

1. For what range of voltages on THR does the R-comparator output VCC?
2. For what range of voltages on TRI does the S-comparator output VCC?

Notice the THR and TRI inputs to the 555 Timer are tied together in Figure 1. We will call this common voltage V_t in the following text. Make note of this assignment now. Next, let's look at the blue box in the middle of Figure 2 known as an SR-latch. The input voltages to the SR-latch come from the comparator. When the comparator outputs VCC, the SR-latch interprets this as a logic 1. A comparator output of GND is interpreted by the SR-latch as logic 0.

Table 1: State table for an SR-latch

S	R	Q	\bar{Q}	Name
0	0	Q	\bar{Q}	Hold
0	1	0	1	Reset
1	0	1	0	Set
1	1	X	X	Forbidden

The last element of Figure 2 is the voltage-controlled switch connected to the \bar{Q} output of the SR-latch. This switch opens and closes under the control of the \bar{Q} signal, hence the arrow head. When $\bar{Q} = 1$, the switch is closed, connecting the DIS pin to ground. When $\bar{Q} = 0$, the switch is open, leaving the DIS pin “floating”, not connected to any voltage. In reality, this voltage-controlled switch is an NPN bipolar junction field effect transistor. However, since we have not studied them, I have replaced it with something more intuitive.

3. Now, let’s summarize our understanding of the components in Figure 2 to complete Figure 3. In this figure, the vertical axis represents the voltage of V_t (the common voltage of the TRI and THR pins in Figure 1). The voltage range of V_t is split into 3 ranges, 9V-6V, 6V-3V, and 3V-0V. For each of these ranges:
 - Describe the logic values on the S and R inputs of the SR-latch. (You already did this in a previous question.) Write 0 or 1 as the value of S and R.
 - Use the S, R logic levels to determine the Q output. Write 0, 1, or Q as the value of Q.
 - Use the Q output to determine the state of the switch. The value of the switch should be “open”, “closed,” or “hold”. Use “hold” when SR-latch is holding its output.
 - Use the switch value to determine the state of the DIS signal. The value of the DIS should be “open”, “GND,” or “hold”. Use “hold” when the Switch is holding its output.

V_t					
↑					
9V					
	S =	R =	Q =	Switch =	DIS =
6V					
	S =	R =	Q =	Switch =	DIS =
3V					
	S =	R =	Q =	Switch =	DIS =
0V					

Figure 3: Determine the effect of V_t on the SR latch. Assume that $V_{CC} = 9V$.

With our new understanding of the 555 Timer, let’s return to the circuit shown in Figure 1 so that we can understand the role of the external components in the operation of the circuit. We will approach this question by replacing the 555 Timer with the V_t and DIS signals examined in Figure 3. The resulting circuit, shown in Figure 4, contains resistors, capacitors, a 555 Timer, and D1, D2, diodes. We will study diodes in much more detail later, but for now, consider them as circuit elements allowing current to flow in one direction as indicated by the triangle. So, for example, D1 will only allow current to flow downwards and D2 will only allow current to flow upwards.

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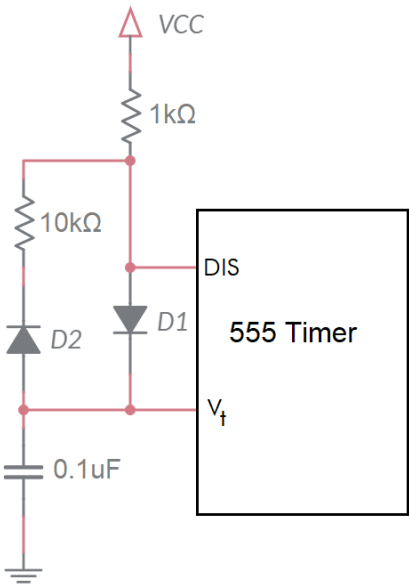


Figure 4: The circuit in Figure 1 with the 555 Timer replaced with the two signals examined in Figure 3.

Now, you will use the information from Figure 3 to determine to describe what the external circuit in Figure 4 functions like as V_t changes. Complete the sentence or write an expression for each of the bulleted items in questions 4 and 5. When two **bold** choices are separated by a “/”, replace them with the correct answer. Fill in underlines with values.

4. Determine the circuit behavior in Figure 4 when V_t is between 0V-3V.
 - If V_t is between 0V-3V, then DIS is **open/closed** ($Q=1$).
 - If DIS is **open/closed**, then current wants to flow from VCC through D1 to ground.
 - This current flow will **charge/discharge** the capacitor with time constant $RC = \underline{\hspace{2cm}}$.
 - The equation describing the **charging/discharging** capacitor is $V_t(t) = 9(1 - e^{-t/\underline{\hspace{2cm}}})$. Fill in the denominator of the exponent.
 - Determine the time required for the capacitor to **charge** from 3V to 6V.
 - Set the $V_t(t)$ equation equal to 3V and solve for t . This result is the time to charge from 0V to 3V. Represent your answer in microseconds and round to the nearest integer.
 - Set the $V_t(t)$ equation equal to 6V and solve for t . This result is the time to charge from 0V to 6V. Represent your answer in microseconds and round to the nearest integer.
 - To get the time to **charge/discharge** from 3V to 6V, subtract the time to get to 3V from the time to get to 6V.
5. Determine the circuit behavior in Figure 4 when V_t is between 6V-9V.
 - If V_t is between 6V-9V, then DIS is **open/closed**, ($Q=0$).
 - If DIS is **open/closed**, then charge on the capacitor wants to flow through D2 to the grounded DIS.
 - This current flow will **charge/discharge** the capacitor with time constant $RC = \underline{\hspace{2cm}}$.
 - The equation describing the **charging/discharging** capacitor is $V_t(t) = 9e^{-t/\underline{\hspace{2cm}}}$ Fill in the denominator of the exponent.
 - Determine the time required for the capacitor to **charge/discharge** from 6V to 3V.

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- Set the $V_t(t)$ equation equal to 6V and solve for t . This result is the time to discharge from 9V to 6V. Represent your answer in microseconds and round to the nearest integer.
- Set the $V_t(t)$ equation equal to 3V and solve for t . This result is the time to discharge from 9V to 3V. Represent your answer in microseconds and round to the nearest integer.
- To get the time to **discharge** from 6V to 3V, subtract the time to get to 6V from the time to get to 3V.

Let's now put all the pieces together to see how the external components and the internal structure of the 555 Timer, together, produce a periodic waveform. To do this, we will use Figure 5.

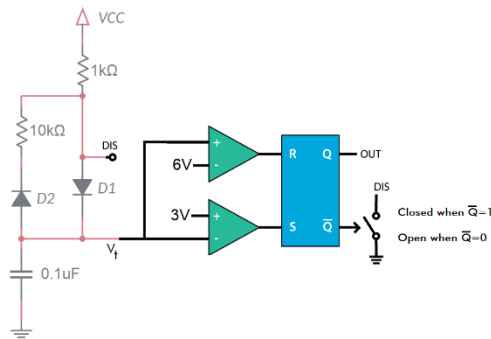


Figure 5: External circuits and internal organization of the 555 Timer .

You will examine the behavior of the system in terms of V_t . Complete the following set of statements using Figure 5 and the answers you provided to previous questions. When two answers are separated by a “/”, circle the correct answer. Fill in underlines with values.

6. Assume V_t is less than 3V.
 - a. Then $S = \underline{\hspace{1cm}}$ and $R = \underline{\hspace{1cm}}$.
 - b. Then $Q = 1$ and $\bar{Q} = 0$.
 - c. Then DIS is **open/closed**.
 - d. Then the capacitor is **charging/discharging**.
 - e. Then it takes $\underline{\hspace{1cm}}$ us to **charge** the capacitor from 3V to 6V.

So, whenever V_t drops below 3V, the capacitor starts charging, increasing V_t .

7. Assume V_t is greater than 6V.
 - a. Then $S = \underline{\hspace{1cm}}$ and $R = \underline{\hspace{1cm}}$.
 - b. Then $Q = 0$ and $\bar{Q} = 1$.
 - c. Then DIS is **open/closed**.
 - d. Then the capacitor is **charging/discharging**.
 - e. Then it takes $\underline{\hspace{1cm}}$ μs to **discharge** the capacitor from 6V to 3V.

So, whenever V_t rises above 6V, the capacitor starts discharging, decreasing V_t .

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8. Assume V_t is between 3V and 6V. The answers are given to you so that you can better follow what the circuit does.
- Then $S = 0$ and $R = 0$.
 - Then Q and \bar{Q} are unchanged.
 - Then DIS remains unchanged.
 - Then the capacitor charging state remains unchanged until V_t goes below 3V or above 6V

So, whenever V_t is between 3V and 6V, the capacitor continues behaving as it was before V_t entered the range 3V to 6V.

Note, V_t continuously oscillates between charging and discharging. As soon as V_t increases above 6V, the SR-latch changes state causing V_t to decrease. As soon as V_t drops below 3V, the SR-latch changes state causing V_t to start increasing. The cycle continues indefinitely.

9. Plot V_t vs. *time*. To help you, I have plotted voltage vs. time for V_t for the charging and discharging states. You can cut-and-paste the relevant pieces of the curves from Figure 6 to form your answer. Draw as many charge/discharge cycles as will fit.

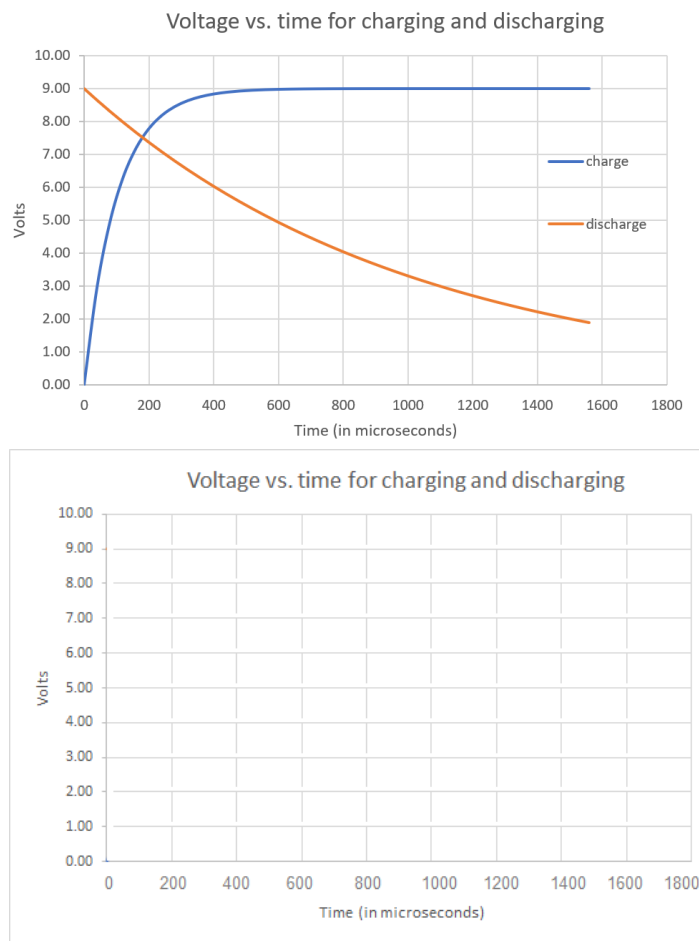


Figure 6: Voltage vs. time for V_t in both the charging and discharging configurations.

10. Use this information to determine the rise time, fall time, and period of the waveform. Note the rise time corresponds to the output of the 555 Timer being high. The fall time corresponds to the output of the 555 Timer being 0V.
11. Use the period to determine the frequency of the waveform.
12. The duty cycle of a waveform is the percentage of time when it is at a high voltage level.
What is the duty cycle of the OUT pin?

Simulation 555 Timer

Use the skills learned in Lab 0 to build the 555 Timer circuit analyzed in the previous section. Complete the schematic in Figure 7.

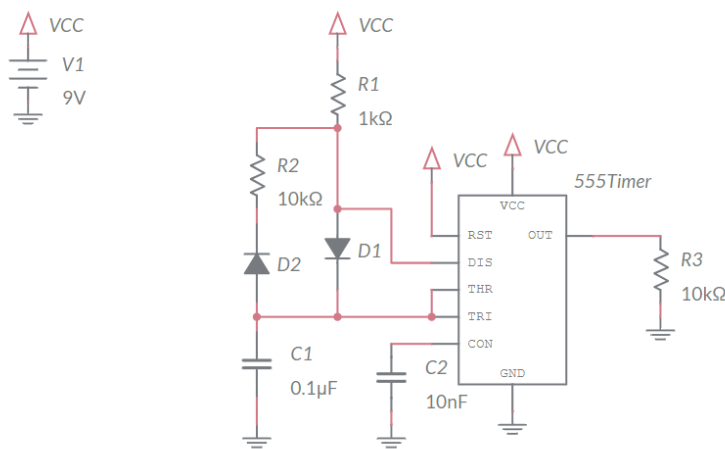


Figure 7: 555 Timer circuit to construct in MultiSim Live.

You will find the components to build the MultiSim Live simulation using the information listed in the table below.

- Make sure to give the resistors and capacitors the correct values.
- Make sure to include the probes on the TRI and OUT pins.

Component	Tool Category	Name
DC Voltage Supply	Sources	DC Voltage
Ground	Schematic connectors	Ground
VCC	Schematic connectors	Connector
Resistor	Passive	Resistor
Capacitor	Passive	Capacitor
Diode	Diodes	Diode
555 Timer	Analog	555 Timer

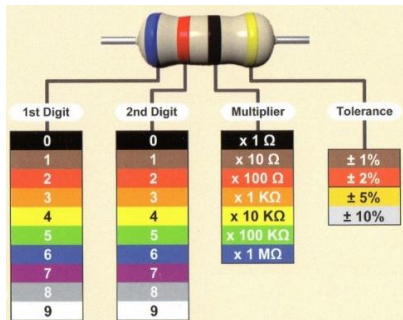
Save your file by clicking on the 3x3 grid of squares in the upper left corner and select “Save”.

1. Export an image of your schematic using the export option in the main menu to output a PNG file of the schematic.
2. Simulate your circuit for 5 ms. Export an image of your timing diagram using the export option in the main menu to output a PNG file of the schematic. Note, the duration of the time high and low of the output signal will be different from your analysis.
3. Use the timing diagram to measure the time high, time low, period, frequency, and duty cycle of the waveform on the OUT pin. You may find the Cursor function in the Item tab to come in handy. You should find these values very close to those in the analysis.
4. Use the timing diagram to measure the high and low voltages of the TRI pin. You may find the Cursor function in the Item tab to come in handy.

Assembly 555 Timer

We will build and test our circuits in parallel with their analysis and modeling. This week, you will solder the POWER INPUT and 555 TIMER subsystems. Before we explore exactly what parts we will be soldering in, let's get to know the parts better.

The BJT Curve Tracer Kit has many loose thru-hole resistors of different values. It is worth your time to become familiar on how to interpret the resistors' color bands. We will use the handy table in Figure 8 as our guide.



1st Digit	2nd Digit	Multiplier	Tolerance
0	0	x 1 Ω	± 1%
1	1	x 10 Ω	± 2%
2	2	x 100 Ω	± 5%
3	3	x 1 KΩ	± 10%
4	4	x 10 KΩ	
5	5	x 100 KΩ	
6	6	x 1 MΩ	
7	7		
8	8		
9	9		

Figure 8: The colored bands on resistors indicate their resistance value.

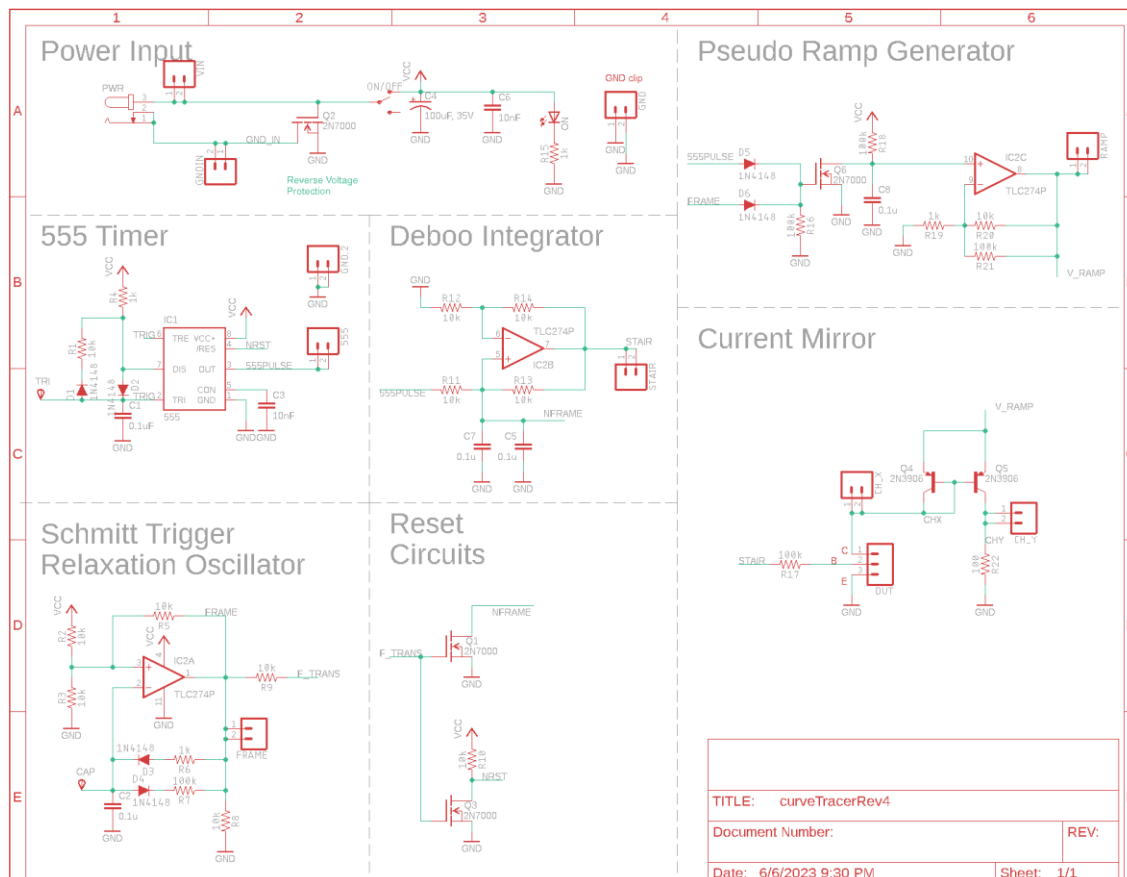
The resistors provided with the curve tracer kit have 4 colored bands. When looking at a resistor, hold it so that the metallic gold band is to the right – all our resistors have 5% tolerance. With the resistor correctly positioned, read the color bands from left to right, converting the colors into the numerical codes given in Figure 8. For example, let's say that from left to right the color bands are red, red, orange, gold. This pattern converts to 22x1kΩ ±5% The first three bands are the resistance, in this case 22 kΩ. The fourth band is the range of resistances you can expect the resistor to have. This phrase means the actual resistance of the example resistor could be as low as $22 \text{ k}\Omega - 0.05 \times 22 \text{ k}\Omega = 22 \text{ k}\Omega - 1.1 \text{ k}\Omega = 20.9 \text{ k}\Omega$ or as high as 23.1 kΩ. To make sure you are ready for the lab, complete the blank space in Table 2 with the color or resistance code.

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Table 2: Complete the missing entries in the table of resistance color codes.

Value	Band 1	Band 2	Band 3	Band 4
220				
2.2k				
3.3k				Gold
4.7k		Purple		
6.8k				
10k				
15k	Brown			
33k				
47k			Orange	
100k				
470k				

This week, you will be soldering in the components associated with the POWER INPUT, 555 TIMER subsystems. These subsystems are names in Figure 9. It is important you do not solder in any of the other components in any of the other subsystems.



POWER INPUT Subsystem

Take a look at the POWER INPUT area of the schematic in Figure 9. This subsystem allows you to supply power to the BJT curve tracer board from either an AC/DC converter or through a pair of test points VIN and GND. A SPDT slide switch allows the user to turn the BJT curve tracer on or off while leaving the power input connected. An indicator LED confirms the BJT curve tracer is powered on when it is illuminated. A pair of capacitors smooths out the power delivered to the BJT curve tracer. Finally, a MOSFET disconnects the power input if you accidentally reverse the positive and negative power leads.

555 TIMER Subsystem

The 555 TIMER subsystem in Figure 9 is identical to the circuit analyzed in in Figure 4.

Most of the parts in this schematic have a designator and a value. The designator is a letter followed by a number. The designator letter tells you what type of part it is, “R” for resistor, “C” for capacitor, etc. The designator number tells you the index of that part in the entire collection of that part type.

The schematic in Figure 9 is the starting point for the layout shown in Figure 10. The physical position of the parts in the schematic and layout are unrelated. The schematic is an abstraction of the finished layout. The layout contains all the data used in the fabrication of the PCBs – the layout and the fabricated PCB are identical. Take a moment to look at the layout and compare it to the PCB for the curve tracer paying attention to the following bullet points.

- The green circles in Figure 10 are the layout are plated through holes in the PCB.
- The red lines in Figure 10 are traces (wires) on the top side of the PCB.
- The blue lines in Figure 10 are traces (wires) on the bottom side of the PCB.
- The grey lines and text in Figure 10 are white silk screen on the PCB.

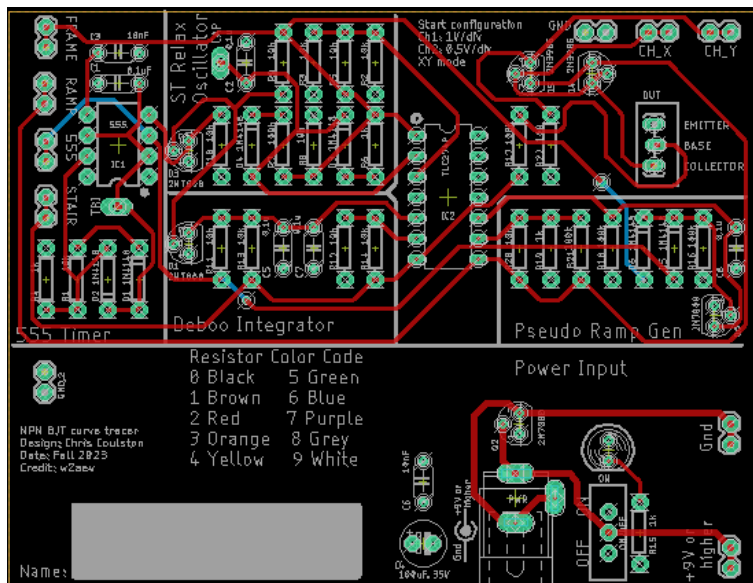


Figure 10: The layout of the BJT curve tracer.

The parts’ designators are important because they are the same in the schematic and the layout, providing you with a means to find a part. You should take a moment to notice parts which are logically related in the schematic are physically proximal in the layout.

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Table 3: List of parts to be soldered into the PCB this week. Shaded cells are polarized components. Watch their orientation.

POWER INPUT	555 TIMER
PWR JACK	R4/1k Ω
ON/OFF	R1/10k Ω
C4/100 μ F	D1/1N4148
C6/10nF	D2/1N4148
LED1	C1/0.1 μ F
R15/1k Ω	C3/10nF
Q2/2N7000	IC1/555

Polarized Parts

Most of the parts you will solder into the PCB can be installed in more than one way. Parts which must be installed in a correct orientation are called polarized. Polarized parts have some physical indication of their orientation and the silk screen will have some marking to show you where this physical indicator should be aligned. Let's walk through all the polarized parts and how you will install them in the PCB.

- 555 Timer
The chip has a small round indentation in the corner which indicates Pin 1. This indentation should align with the white circle on the PCB silk screen.
- Diodes
The diodes are orange with a black stripe on one end. The black strip needs to align with the white stripe on the PCB silk screen. Caution, the diodes do not have a consistent orientation – pay close attention when stuffing parts into the PCB.
- Red 100 μ F capacitors
The 100 μ F capacitors have a white stripe which indicates the negative terminal. The negative terminal should align with the white bar (opposite the "+" bar) on the PCB silk screen.
- Green LED
The green LED has a flat side which indicates the negative terminal. This flat side should align with the flat side of the PCB silk screen.
- 2N7000 MOSFET
The 2N7000 MOSFET is a 3-pin device with an asymmetrical package. You will have to bend the center lead of the MOSFET to make it fit. Make sure to align the flat side of the MOSFET with the flat side of the silk screen.

Test Points

Test points are electrical connections to important points in the circuit and frequently are the target of test and measurement equipment. All the test points on the BJT curve tracer PCB are formed with pairs of pads. You will connect together each pair of test-point pads with an approximately 1 cm

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long piece of wire – you can use the cut off end of resistor lead for this. You will do this for all the test-point connections listed below – their names are labeled in white silk screen on the PCB.

- 1) CH_X
- 2) CH_Y
- 3) GND (adjacent to CH_X and CH_Y)
- 4) 555PULSE
- 5) STAIR
- 6) FRAME
- 7) GND (adjacent to 555PULSE)
- 8) +9V or higher
- 9) GND (adjacent to +9V)

An example of a test point that you will solder in this lab is shown in Figure 11. Note the TRI pad does NOT get a test point soldered into it.
















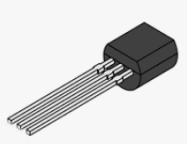
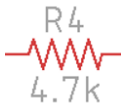

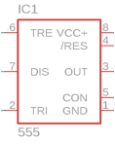



Figure 11: Wire loops soldered to the 555PULSE and FRAME test points. Do not solder in a wire loop to the TRI pin (just below the 555 timer).

Part Identification

To make sure you can positively identify all the elements in the schematic complete Table 4 by filling in the **Match** column with the letter corresponding to the **Schematic Symbol** for a **Physical Part**.

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Table 4: Match the schematic symbol with the corresponding part.

Schematic Symbol	Match	Physical Part
<p>A</p> 		
<p>B</p> 		
<p>C</p> 		
<p>D</p> 		
<p>E</p> 		
<p>F</p> 		
<p>G</p> 	J	
<p>H</p> 		
<p>I</p> 		
<p>J</p> 		

Assembly and Testing

You should take care and align the resistors so their gold tolerance bands all face the bottom of the board. This positioning will make it easier to read their values and compare your work to pictures of the assembled board. This aspect will be part of the grading rubric. Look at the **How To: Solder** posted on Canvas for recommendation on how to solder through hole parts.

Assemble POWER INPUT Subsystem

You should start your soldering with the POWER INPUT subsystem. The subsystem will include the following parts. Note, please check the component values of your capacitor and resistor with the component tester on top of the blue cabinet in the North West corner of Brown 304.

- 1) 100 μ F capacitor – *POLARIZED!*
- 2) Green LED – *POLARIZED!*
- 3) 2N7000 MOSFET – *POLARIZED!*
- 4) 10nF capacitor
- 5) Power jack
- 6) ON/OFF slide switch
- 7) 1k Ω resistor
- 8) +9V or higher test point
- 9) GND test point

After you solder in all the components, test and correct any problems before soldering any other components.

Test POWER INPUT Subsystem

- 1) Check the resistance between the “+9V or higher” and GND test points with the ON/OFF switch in the OFF position. You should get an overload condition on the DMM – there is essentially infinite resistance with the switch in the OFF position.
- 2) Check the resistance between the “+9V or higher” and GND test points with the ON/OFF switch in the ON position. You should get a very high resistance due to the reverse voltage protection provided by the 2N7000.
- 3) Power up the BJT curve tracer:
 - Put the ON/OFF switch in the OFF position,
 - Apply power to the board either through your AC/DC converter or using the lab power supply through the “+9V or Higher” and GND in the Power Input area. DO NOT USE ANY OF OTHER GND CONNECTIONS AS THE GROUND POWER INPUT. If you are using the lab power supply, set the voltage to 9V and the current to 100 mA.
 - Throw the ON/OFF switch to the ON position,
 - The green LED should illuminate.
 - If you are using an AC/DC converter to supply power, check the voltage at the “+9V or higher” and GND test points with a DMM. You should expect a volt or two higher than the AC/DC rated output voltage – they run high under low load conditions.
 - If you are using the lab power supply to provide power, the current should be less than 20 mA.

Debugging POWER INPUT Subsystem

Doing anything drastically wrong when assembling the POWER INPUT subsystem is not common. I would expect most of the problems to be failures in your test procedure rather than failures of the board. If your BJT curve tracer board fails, one of the test steps in the previous section, I will provide some guidance on what may have happened and how you can correct it.

- 1) If you are getting low resistance with the ON/OFF switch in the OFF position:
 - Make sure the ON/OFF switch is in the OFF position
 - Check you do not have a solder bridge on the rear of your PCB
 - Make sure you are reading the DMM correctly. The reading when the ON/OFF switch in the OFF position should be the same as when you hold the probes apart in air.
- 2) If you are getting a different resistance with the ON/OFF switch in the ON position:
 - Make sure the ON/OFF switch is in the ON position
 - Make sure you are reading the DMM correctly. The reading when the ON/OFF switch in the ON position should be the same as when you hold the probes across a spare 1 k Ω resistor.
 - Check the orientation of the green LED. The part may be installed backwards.
- 3) If the green LED does not illuminate when power is applied to the ON/OFF switch when it is in the ON position:
 - Test you are applying power. Put a DMM in voltage mode and check the +9V and GND test points.
 - Check the orientation of the green LED. The part may be installed backwards.
 - Check the solder joints on the 1 k Ω resistor and the green LED. When you attempt to wiggle either of these two components, they should not move at all.

Assemble 555 TIMER Subsystem

You should start your soldering with the POWER INPUT subsystem. After you solder in all the components, you should test and correct any problems. This soldering task will include the following parts. Note, please check the component values of your capacitor and resistor with the component tester on top of the blue cabinet in the North West corner of Brown 304.

- 1) 8-pin socket for 555 Timer – Install so that circular indent aligns with silk screen.
- 2) 555 Timer IC – *POLARIZED!*
- 3) 1N4148 diodes – *POLARIZED!*
- 4) 10 nF and 0.1 μ F capacitors
- 5) 1 k Ω and 10 k Ω resistors
- 6) 555PULSE test point

Test 555 TIMER Subsystem

- 1) Power up the BJT curve tracer.
 - Put the ON/OFF switch in the OFF position.
 - Apply power to the board either through your AC/DC converter or using the lab power supply. If you are using the lab power supply, set the voltage to 9V and the current to 100 mA.

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- Throw the ON/OFF switch to the ON position.
- The green LED should illuminate.
 - If you are using an AC/DC converter to supply power, check the voltage at the “+9V or higher” and “Gnd” test points with a DMM. You should expect a voltage higher than the AC/DC rated output voltage. Converters run high under low load conditions.
 - If you are using the lab power supply to provide power, the current should be less than 50 mA.

2) Power up an oscilloscope, attach a probe to Channel 1 and configure it as follows.

Ch 1 probe	555PULSE testpoint
Ch 1 ground clip	BJT ground loop
Horizontal (scale)	200 μ s
Ch 1 (scale)	1V or 2V (whatever fits better)
Ch 2 probe	TRI pin of 555 Timer
Ch 2 (scale)	2V
Trigger mode	Auto
Trigger source	Ch 1
Trigger slope	\uparrow
Trigger level	4.5V

3) Set the GND reference of Ch 1 and Ch 2 to the lowest visible reticule. The waveforms will overlap the same as they did in the MultiSim simulation. The TRI pin of the 555 Timer is available by remove the end of the oscilloscope probe and putting the tip into the yellow circled pad in Figure 12. Note that this pad is labeled “TRI”.

BJT Curve Tracer: Intro to MultiSim and the 555 Timer

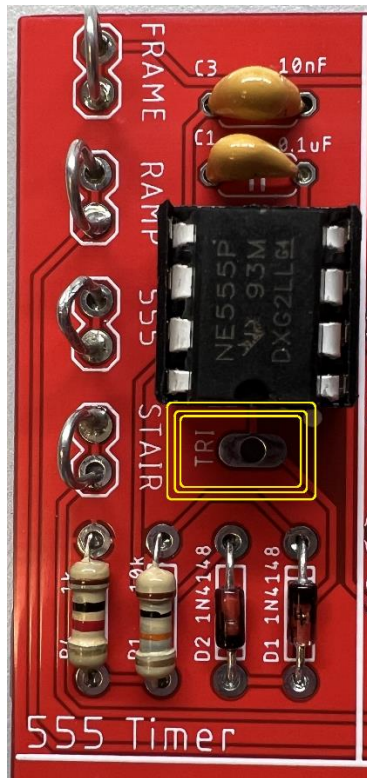
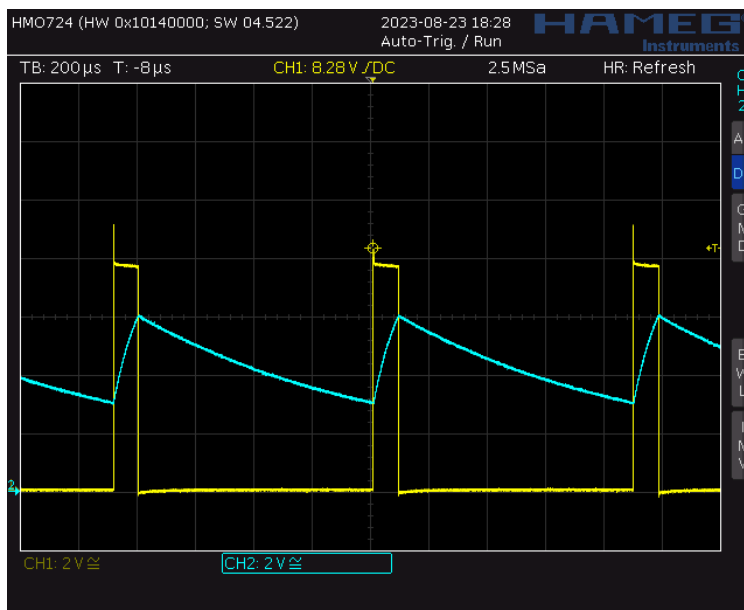


Figure 12: The TRI pin of the 555 Timer is available at the circled pad.

- 4) Take a screen shot the two waveforms and include in your lab report.



Note, this oscilloscope trace was captured on a Rhode&Schwarz HMO724.

Debugging 555 TIMER Subsystem

Compare to the POWER INPUT subsystem, there are many more ways to foul up the 555 TIMER subsystem. If your BJT curve tracer board fails one of the test steps in the previous section, I will provide some guidance on what may have happened and how to correct it.

- 1) If the green LED is no longer illuminating when you apply power to the BJT curve tracer:
 - Verify you are applying power to the BJT curve tracer by probing the +9V and Gnd test points with a DMM in voltage mode and with the ON/OFF switch in the ON position.
 - Verify the ON/OFF switch is in the ON position.
 - Check the orientation of the 555 Timer IC.
- 2) If the 555 Timer is not generating a proper waveform:
 - Make sure the 555 TIMER parts are inserted in the correct location.
 - Check the orientation of all the 555 TIMER parts.

Turn In:

- 1) Make a record of your response to numbered items below and turn in a single copy as your team's solution on Canvas using the instructions posted there.
- 2) Include the names of both team members at the top of your solutions.
- 3) Use complete English sentences to introduce what each of the items listed below is and how it was derived.

Analysis:	Question 1, 2	Voltage to assert S and R
Analysis:	Question 3	SR Latch truth table
Analysis:	Question 4	V_t vs. TRI state
Analysis:	Question 5	Time to charge 3V to 6V
Analysis:	Question 6	Time to discharge 6V to 3V
Analysis:	Question 7	Behavior when V_t is less than 3V
Analysis:	Question 8	Behavior when V_t is greater than 6V
Analysis:	Question 9	Plot V_t vs. <i>time</i>
Analysis:	Question 10	Determine rise, fall and period
Analysis:	Question 11	Frequency of waveform
Analysis:	Question 12	Duty cycle of the OUT pin

Simulation	Question 1	Schematic output from simulation
	Question 2	Grapher output from simulation
	Question 3	OUT waveform characteristics
	Question 4	TRI waveform characteristics

Assembly	Table 2	Resistance color code
	Table 4	Parts Identification
	Screen capture of 555 Timer output	

BJT Curve Tracer: Intro to MultiSim and the 555 Timer

Analysis

Complete the columns of the following table using the information you found throughout this lab. Represent your answer to 3 significant figures using the units given in the **Quantity** column. You will be completing this table in Lab 2, so save your answers.

Quantity	Analysis	Simulation	Assembly
Time high (μs)			
Time low (μs)			
Period (μs)	660 μs		
Frequency (kHz)			
Duty Cycle		8.70%	