PHYS 344 Experimental Techniques  
Laboratory #10  
MONOSTABLE MULTIVIBRATORS AND THE 555 TIMER  
Due February 2

Equipment

Solderless breadboard, 5-v supply, LED’s, resistors, pushbutton switch, signal generator, oscilloscope, diode, capacitors, 74LS122 monostable multivibrator, and 555 timer.

Preliminary

Make pin-out diagrams in your notebook for the 74LS122 one-shot and for the 555 timer. Also copy the function table for the 74LS122.

Special note: it is wise to use “despiking” capacitors in this circuit. (Some would say it is foolhardy not to.) Use 0.01μF to 0.1μF capacitors, hooking them across the ground and V_{cc} connection of each chip.

1 The 74LS122 monostable multivibrator.

74LS122 function table:

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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</thead>
<tbody>
<tr>
<td>CLEAR</td>
<td>A1</td>
</tr>
<tr>
<td>L</td>
<td>X</td>
</tr>
<tr>
<td>X</td>
<td>H</td>
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<tr>
<td>X</td>
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<tr>
<td>H</td>
<td>↓</td>
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<tr>
<td>↑</td>
<td>L</td>
</tr>
<tr>
<td>↑</td>
<td>X</td>
</tr>
</tbody>
</table>

H = High Logic Level  
L = Low Logic Level  
X = Can be either low or high  
↑ = Positive-going transition  
↓ = Negative-going transition  
↑↑ = A positive pulse  
↓↓ = A negative pulse
Hook up the 74LS122 as shown. **Use the TTL output from the function generator.** This output is 0 and +5 v: DO NOT use a square wave which goes negative, as this may destroy the chips.

Observe the waveform you obtain. Draw it in your notebook, showing the triggering on the negative edge of the “A1” input. Measure the width of the pulse. We show here a graph similar to the one found in the National Semiconductor TTL Logic Databook, showing pulse length as a function of R and C. Is the pulse length you measure consistent with what you would predict using the graph?

For $C_{ext} \gg 1000$ pf, $T_w = (0.37)R C_{ext}$.

Replace the capacitor with a 0.1μF value, and again measure the pulse width. Now, adjust the frequency of the square wave generator until its period is about 1/3 of the period of the one-shot’s pulse output period. Draw the waveform and explain the behavior. (Hint: the one-shot is *retriggerable*). Now, disconnect B1 from the pullup resistor and hook $\overline{Q}$ (not Q) to the B1 input. This should make the one-shot nonretriggerable. (Do you understand why?) Draw your output waveform and explain the difference between this and your previously drawn waveform. You may have to adjust the frequency slightly to get a stable signal.
2 The 555 Timer.

There is no lack of documentation on this chip. The blue National Semiconductor Linear Data book has an extensive section on the 555 timer, as does the red Fairchild data book (where it is called the $\mu$A555.) It would be a good idea to look some of this over, as well as your text’s description of the chip.

2.1 Monostable operation.

Hook up the circuit shown, being careful of capacitor polarity since the capacitors are electrolytic. The 555 triggers on a negative-going pulse. (One could also use a Hall effect switch here.) Time the output pulse length by using the storage scope or by another method of your devising. Is the pulse length consistent with the equation $T = 1.1 \, RC$? If it is not, then calculate the effective capacitance of the capacitor. Electrolytic capacitors can be way off from their marked values, so don’t be too worried about a 10% to 30% discrepancy.

Observe what happens when you ground pin 4 during the period when the output is high. Explain.
2.2 Astable operation.

Hook up the circuit shown and use the storage scope to time the duration of the high and low states of the output. Draw the capacitor voltage waveform and the output waveform on the same graph.

Why does it take the capacitor longer to charge up than to discharge?

The period of the output is given by 

\[ T = 0.693(2R_2 + R_1)C \]

The duty cycle is defined as the ratio

\[ \text{Duty cycle} = \frac{\text{Period the output is high}}{\text{Total period}} \]

It therefore works out to

\[ \text{Duty cycle} = \frac{R_1 + R_2}{2R_2 + R_1} \]

This is different that the expression found in National’s linear data book, apparently since they use a different definition of duty cycle. Calculate what the total period and duty cycle should be, and compare it with your measurements. What values for the resistors would you choose to obtain the same period you calculated above, but with a nearly 50% duty cycle?

In the circuit above, hook a diode from pin 7 to pin 6 (Note: forward conduction from 7 to 6). Describe the change in waveform and draw the capacitor voltage waveform. Explain what is happening.

2.3 Problem

Suppose you are designing a burglar alarm in which the presence of an intruder is sensed by a phototransistor — when the intruder breaks a beam of light, the circuit sends a low-going pulse to a 555 chip.

You want the circuit to wait 30 seconds and then sound an alarm for 2 minutes. You will accomplish this by using the first 555 as a delay, and using a second 555 to trigger the alarm. We will assume that the alarm sounds as long as the second 555 is putting out a high signal.

Configure two 555 chips to accomplish this. (If you wish, use a 556 chip, which is a dual 555). A hint is given below.
A final note. Last term you were given a reference sheet containing codes for resistor and capacitor markings. You should review the capacitor codes. For instance, a capacitor marked “103” is $10 \times 10^3$ picofarads, or 10 nf, or 0.01 μF. A capacitor marked “.047” is 0.047 μF, since it could not be 0.047 pf (too small). This capacitor could also be marked “47 nf” or “473”. When in doubt, measure it with one of the DVMs that has a capacitance meter!

Also, you should learn to recognize the various types of capacitors, since this gives a clue to interpreting the markings. Tantalum caps are sometimes misleading because they are so small. You can recognize them because they are polar, with a “+” mark and unequal lead lengths. A tantulum cap marked “1 35 v” is 1 μF capacitance (large for its size) and 35 v maximum working voltage.