

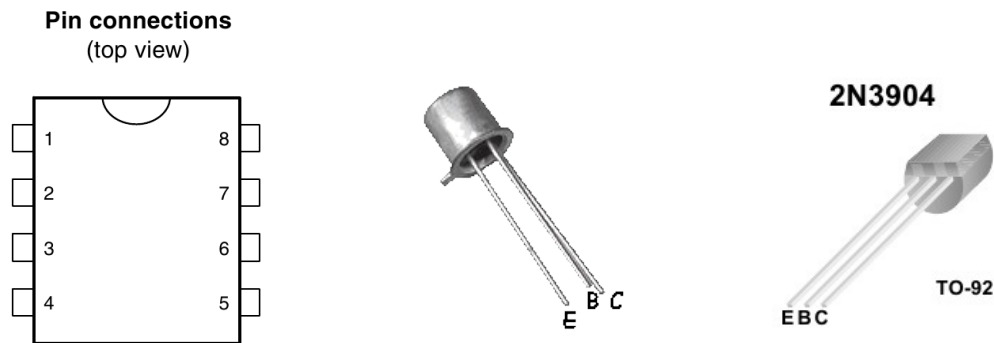
## Lab 12: Timing sequencer (Version 1.3)

**WARNING:** Use electrical test equipment with care! Always double-check connections before applying power. Look for short circuits, which can quickly destroy expensive equipment.

Sketch a timing diagram to help design the circuit. There are 4 traces on the timing diagram: 1) master oscillator, 2) green light, 3) yellow light, and 4) red light. The master oscillator (~ 10 sec period) will be a rectangular wave. The green light turns on when the master oscillator waveform has a falling (negative) edge. The green lamp stays on for a selected time (3—4 seconds) that is independent of the master oscillator. When the green light turns off (falling edge), it triggers a second rectangular pulse to turn on and off the yellow light (~ 2 sec). When both green and yellow lights are off, the system defaults to red light on. It then waits for the next trigger pulse from the master oscillator and the cycle repeats.

### Pinout diagrams

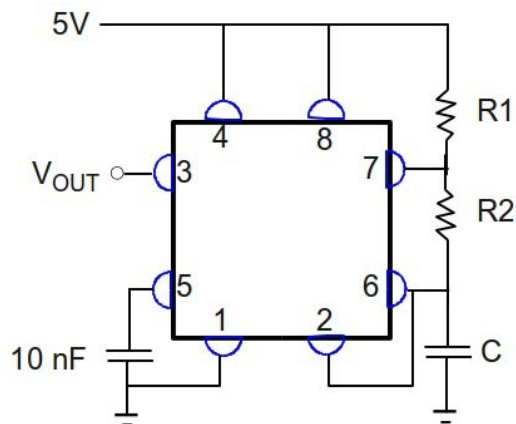
The connection diagrams for electronic components that are used in this lab are (from left to right) the 555 timer, 2N2222 transistor or 2N3904 transistor.



This lab requires three 555 timers and two switching transistors.

### Master oscillator

The master oscillator or clock that runs the circuit is implemented with a 555 timer chip in the astable configuration; it generates a periodic rectangular wave. This circuit was built and analyzed in Lab 11 and is configured as shown in the following diagram:



Use the 5V power supply located on the lower left of the Elvis board. Choose the values of  $R1$  ( $> 1 \text{ k}\Omega$ ),  $R2$ , and  $C$  to produce a sufficiently long period (8—10 sec) with frequency defined as follows:

$$f = \frac{1.44}{(R1 + 2R2)C}$$

and positive duty cycle calculated by:

$$\text{Duty cycle: } \frac{R1 + R2}{R1 + 2R2}$$

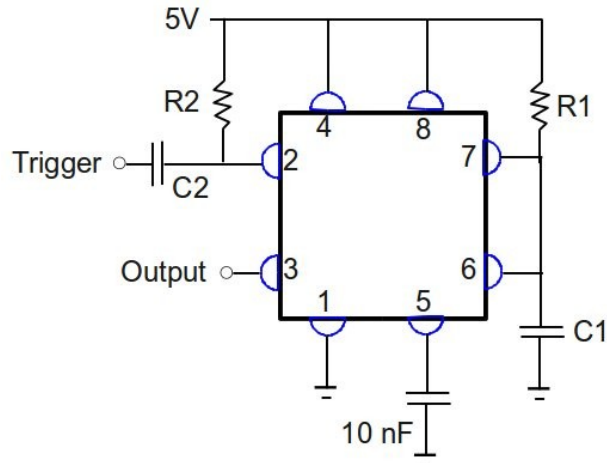
The duty cycle is not critical, but the circuit will be easier to troubleshoot if it is made much larger than 50%. When configuring 555 timers, it is convenient to run long jumper wires from pins 6 and 7 to an uncluttered area of the breadboard to allow easy component substitution. Confirm proper operation of the master oscillator with the stand-alone oscilloscope and a scope probe. Because the frequencies are small, it is important that the scope input is set on DC coupling.

### Single square pulse generator

The 555 timer can be built in a monostable configuration in which it can be triggered to output a single square pulse. Two separate pulse generators will be used to turn the green and yellow lights on and off. Referring to the following diagram, the pulse duration (green or yellow lamp on-time) is given by:

$$T = 1.1R1C1$$

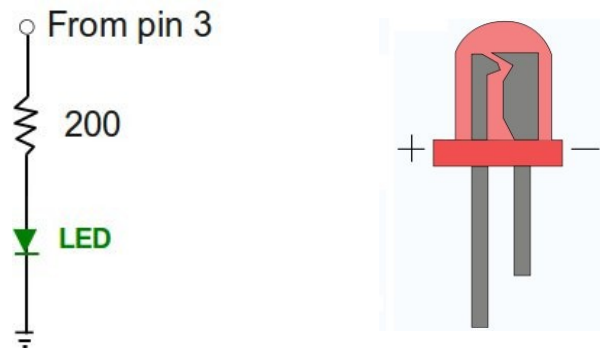
The trigger signal for the green lamp pulser (*not* the yellow lamp) comes from the output of the master oscillator. The trigger point occurs on the negative slope of the oscillator waveform.



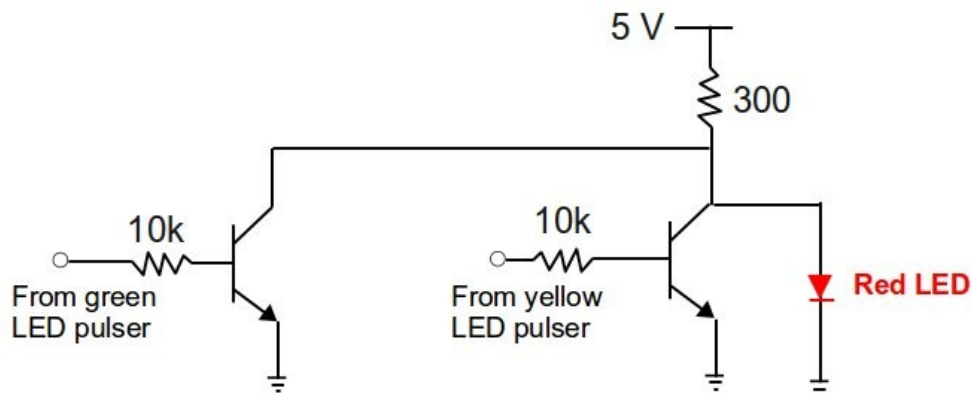
It is important that this trigger signal stays at ground for a time that is less than the pulse it is producing. Otherwise, the output pulse will just invert the trigger pulse. To make sure this stage operates correctly, the input pulse is differentiated with the high-pass RC filter defined by R2 and C2. Pin 2 will see only the positive and negative edges of the input waveform on a 5V DC offset. The component values are not critical; R2 = 47 k $\Omega$  and C2 at or below 100 nF should work well. Build the green lamp pulse generator and use the scope, a second scope probe on CH 2, and DC coupling to verify that the master oscillator triggers it correctly. Do not connect any of the LEDs until instructed to do so.

The output of this pulse generator will do two things: 1) turn the green LED on and off and 2) trigger the second pulse generator for the yellow LED. When the green LED turns off, it will trigger the second pulse generator. For the second (yellow light) pulse generator, select values of R1 and C1 to get an on-time of about 2 seconds. Use values of R2 and C2 close to that used in the first pulse generator. Verify proper timing operation with the oscilloscope.

Arrange the R-Y-G LEDs in the pattern of a traffic light on the circuit breadboard. The current in each diode should be limited with a 100--200  $\Omega$  series resistor as shown in the diagram. Unlike a resistor, a diode cannot be placed in a circuit arbitrarily. The anode (+ terminal) should be connected to the resistor and the cathode (- terminal) to ground. Proper orientation of the LED can be verified by connecting it through a resistor to the 5V supply. Do not connect any LED to a voltage source without a current limiting resistor in place.



The final step is to wire the logic for the red lamp. This can be done, in principle, with another 555 pulse generator. It is more straightforward and reliable to enable the red light with a logical NOR gate connected to the green and yellow lamp driver pulses. This is done using a transistor switching circuit as described and built in Lab 5.

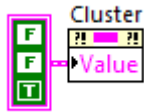


Use either 2N2222 or 2N3904 NPN bipolar junction transistors (see pin diagrams above) to build the NOR gate. When you have a complete working circuit, have it evaluated by the instructor.

### Simulation

Simulate the traffic light circuit in LabView using a State Machine. Download the custom traffic light indicator (light.ctl) from the class website and place it on the Front Panel of your VI (right click on the Front Panel to select a control). On the Block Diagram, it takes a cluster input of three Booleans corresponding to the state (TRUE or FALSE) of the red, yellow, and green LEDs. This indicator is a Strict Type Def with a custom decoration depicting the traffic light structure.

There are several options for implementing the state machine. For example, the indicator can be placed inside or outside the state selector. If the indicator is inside the state selector, a Property Node could be written for each state; the Green Light state would be configured as follows:



If you choose to place the indicator outside the state selector, bundle the three Boolean outputs from the state selector structure and wire the resulting cluster to its input terminal. Due to the timing of data flow programming, the location of the Wait constants that define how long each light is illuminated will be different in these two layouts. Have different ON times for the three states with the yellow light being the shortest.

Evaluate your VI with instructor before the next class meeting. Each student must produce a working VI to get full credit for this lab.