MULTIVIBRATOR CIRCUITS USING THE IC-555 TIMER

I. OBJECTIVES

a) To determine the applications that can be obtained by combining a fast PF and a slow NF: astable multivibrator, monostable multivibrator.
b) Understand how to use the IC-555 timer to obtain specific applications: astable multivibrator, monostable multivibrator, triangular wave signal generator.

II. COMPONENTS AND INSTRUMENTATION

We are using the experimental assembly equipped with the IC-555 timer and the IC 741, two potentiometers, capacitors and resistors of different values. For the assembly supply we use a dc voltage source. The visualization is done using a dual channel oscilloscope.

III. PREPARATION

Brief overview of the IC-555 timer

- Draw the internal block diagram of the IC-555 timer.
- Fill in the Table 1 that reflects the operation principle of the IC-555 (Vcc is the supply voltage).

The IC-555 can be considered equivalent to an inverting comparator with PF (with hysteresis), the input voltage being the voltage applied to the terminals Trigger and Threshold connected together. The thresholds of the comparator are internally fixed so we don't have access to the PF. The VTC is shown in Fig. 1.

Table 1.

Trigger terminal voltage	Threshold terminal voltage	Output voltage	Internal transistor state (off, a_F, saturation)
< 1/3 V^+	< 2/3 V^+		
< 1/3 V^+	>2/3 V^+	Forbidden	
> 1/3 V^+	< 2/3 V^+		
> 1/3 V^+	> 2/3 V^+		

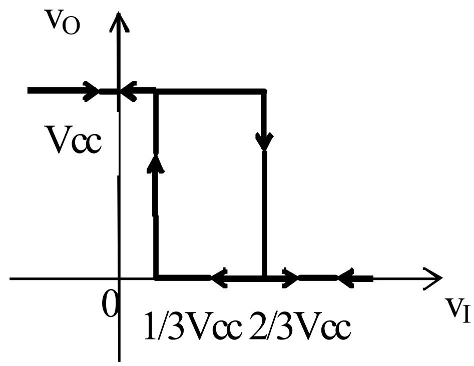

Fig. 1. The VTC of the equivalent hysteresis comparator

P.1.The astable multivibrator circuit

For the circuit in Fig. 2:

- Find the value of the threshold voltage of the equivalent hysteresis comparator for: (1) v_O=Vcc=15V;
  (2) v_O=0V.
- Plot $v_{C2}(t)$. Which are the charging and discharging paths of C_2?
- v_{C2} is considered the feedback voltage corresponding to the NF. Comment on the evolution in time of the NF.

P.2. Monostable multivibrator circuit triggered by sensor

The monostable multivibrator shown in Fig. 3 is triggered when the resistance of the sensor S drops to a value that causes the voltage at terminal Trigger to drop under 1/3 Vcc. This can be done by pressing with a finger both contacts of the sensor.

- Find the value of v_O and the state of the discharging transistor from the IC-555 before and right after pressing the sensor S.
- Prove that the duration of the pulse generated at the output of the monostable circuit is: $T_M=R_2C_2\ln 3=1{,}1R_2C_2$.
- Find the possible range of values for T_M.

P.3. Square wave and triangular wave generator

In Fig. 4, a circuit which generates a square wave at the output of the IC-555 (v_O) and a triangular wave across C_2 is presented. Therefore the charging and discharging of C_2 must be done with a constant current. The circuit that contains O.A., C_3, R_2, D is a constant current generator (I_2),

keeping the voltage across R_2 approximately constant when v_{C2} varies. This is done using the bootstrap method.
When v_{C2}=1/3Vcc, D is in on state and C_3 is charging with 10V (2/3Vcc). When v_{C2} starts to increase, D goes in off state and v_{C3} remains approximately constant, 2/3Vcc. The I_2 current is, in this case, provided by C_3.

- Prove that I_2 is constant (for the same cursor position of the potentiometer from R_2).
- Prove that: I_2=2Vcc/3R_2.

Another constant current generator, I_1, is formed from T_1, R_6 and R_5, keeping the voltage across R_4 constant when C_2 is discharging.

- Prove that I_1 is constant when C_2 is discharging and it has the value: I_1=4,75[V]/R_4.
- Find the relation that expresses the period of the generated signals.
- For what positions of the potentiometers' cursors the square wave signal has:

- maximum period?
- minimum period?
- maximum duty cycle?
- minimum duty cycle?

IV. EXPLORATIONS AND RESULTS

1. The astable multivibrator circuit

Explorations

Build the assembly shown in Fig. 2, connecting: *PS+PJ*, *IN*$^+$ with *PS*, *JR3*, *J1* with *J2* and *J4* with *J5*.

- Visualize simultaneously the voltages v_O (OUT) and v_{C2}. Modify the R_2 (using the potentiometer) and find the minimum and maximum frequencies of output signal.

Results

- v_O(t) and v_{C2}(t). v_{C2}(t) is the input voltage in the equivalent hysteresis comparator, and also the feedback voltage of the NF path.
- What are the values of the threshold voltages?
- The minimum and maximum period of generated signal.
- Did you know that this oscillator is called relaxation oscillator? What do you think, why?

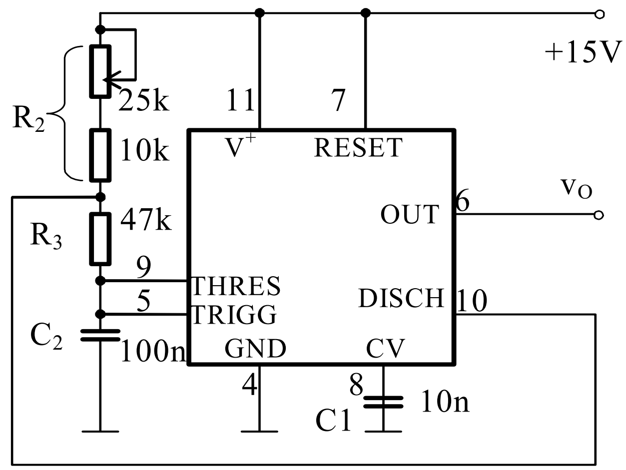

Fig. 2. The astable multivibrator circuit

2. Monostable multivibrator circuit triggered by sensor

Explorations

Build the assembly shown in Fig. 3. Disconnect all jumpers and connect: *DESC+ PS*, *PJ +S*, *PS* with *C2*, *J1* with *J2* and *J4* with *J5*.

- Visualize $v_O(t)$ after pressing the sensor with the finger (as explained before).
- Modify R2 from the 25kΩ potentiometer and examine its effect on the duration of the pulse generated at the output.

Results

- $v_O(t)$ for the maximum and minimum values of R_2.
- In what range can T_M vary? Compare with the result computed at P2.1.
- Those of you who are living in a block of flats, where do you think the applications of the monostable can be found in everyday life?

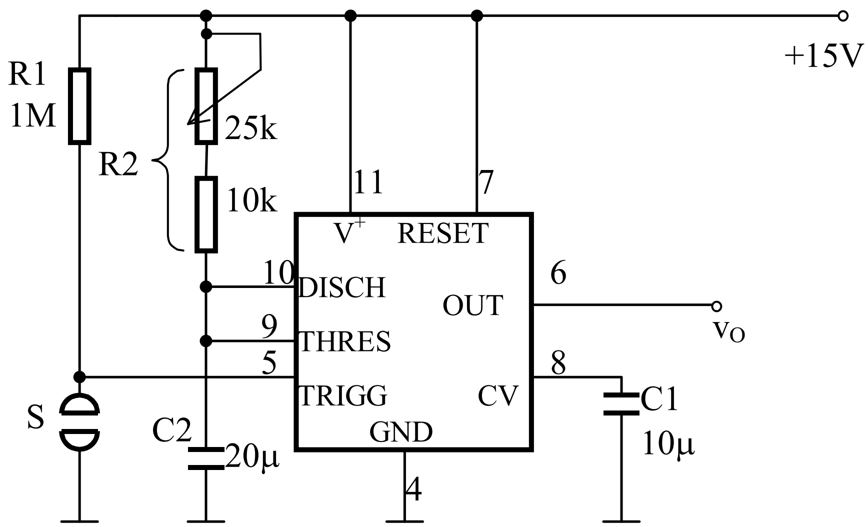

Fig. 3. Monostable multivibrator circuit triggered by sensor

3. Square wave and triangular wave generator

Explorations

Build the assembly shown in Fig. 4. Disconnect all jumpers and connect: *PS+PJ*, IN^+ with *PS*, *DESC+R4*, *J2* with *J3* and *J5* with *J6.*

- Make sure that the circuit generates the expected signals, namely v_{C2} - triangular wave and v_O - square wave.
- Visualize v_{R2} and find the value of I_2.
- Visualize simultaneously v_O and v_{C2}.
- Adjust the potentiometers one by one to derive the effect of each of them on the output signals.
- Set the potentiometers for the square wave signal (v_O) to be of:
  - maximum period
  - minimum period
  - maximum duty cycle
  - minimum duty cycle
- For which of the above mentioned situations do we get a linearly variable (saw-tooth signal) voltage on C_2?

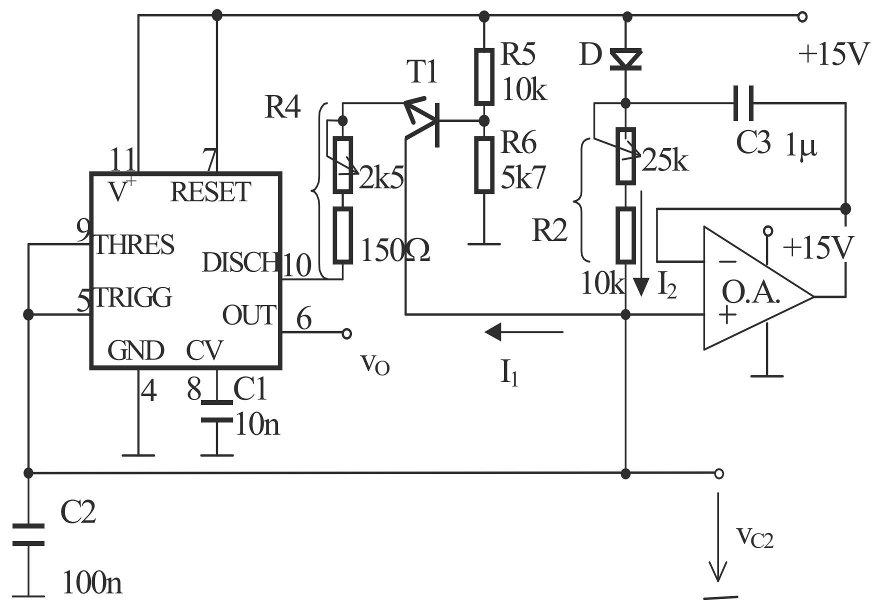

Fig. 4. Signal generator

Results

- $v_{C2}(t)$ and $v_O(t)$.
- $v_{R2}(t)$ and value of I_2.
- The maximum and minimum period of the generated signal.
- The maximum and minimum duty cycle of the square wave signal.
- How do you explain the possibility to set-up the period and the duty cycle?
- Can the period and the duty cycle be modified independently?
- How should R_2 and R_4 be modified to obtain a linearly variable (saw-tooth signal) $v_{C2}(t)$?
- Why do you think that the IC-555 is called timer?

REFERENCES

1. Oltean, G., Circuite Electronice, UT Pres, Cluj-Napoca, 2007, ISBN 978-973-662-300-4
2. Feştilă Lelia, Simion E., Miron C., Amplificatoare audio şi sisteme muzicale, Editura Dacia, Cluj-Napoca, 1990
3. http://www.bel.utcluj.ro/dce/didactic/fec/fec.htm

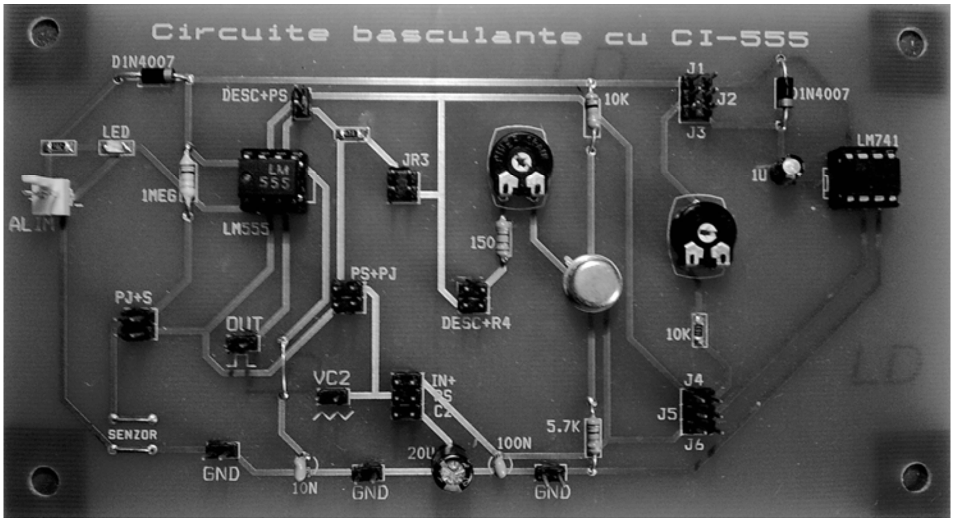

Fig. 5. Experimental assembly