# Experiment 5

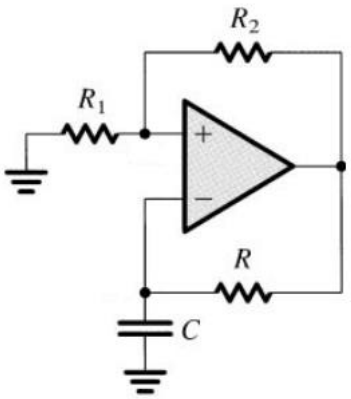
**Objective:** To build a Square Wave Generator and Triangular Wave Generator.

**Equipment Required:** Regulated Power Supply and CRO.

**Components Required:** 741 Op-Amps, Resistances (10KΩ, 12KΩ, 20KΩ, and 47KΩ), Capacitors (0.1 μF, 0.01 μF).

**Theory:**

- **Square Wave Generator:**




**Circuit Diagram**

The non-sinusoidal waveform generators are also called relaxation oscillators. The op-amp relaxation oscillator shown in figure is a square wave generator. In general, square waves are relatively easy to produce. The above circuit is also known as astable multivibrator.

The circuit's frequency of oscillation is dependent on the charge and discharge of a capacitor C through feedback resistor R. The comparator uses positive feedback that increases the gain of the amplifier. .There is no input provided to the circuit, the input which is used to generate the square wave here is provided by the noise generated in the component used to build this circuit. The frequency of oscillations is controlled by the values of R and C, thereby changing the time period of the generated wave. Hence the product of R and C is termed as time constant of the circuit. $R_1$ and $R_2$ provide the biasing which controls the maximum and minimum voltage up to which the capacitor could be charged or discharged.

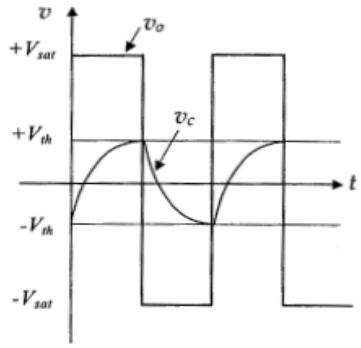
$\beta = R_1/(R_1+R_2)$
$V_{Threshold} = \pm\beta V_{sat} = \pm (R_1/(R_1+R_2))V_{sat}$
Time Period (T) = $2RC\ln((1+\beta)/(1-\beta))$

Maximum charging and discharging of capacitor is up to $\beta V_{sat}$, i.e. as soon as voltage of capacitor becomes greater than $\beta V_{sat}$, or less than $-\beta V_{sat}$ state of comparator changes.

**Procedure to build square wave generator:**

1. Connect the circuit as shown above. Connect pin numbers 7 and 4 of IC to regulated power supply (+12V, -12V).
2. Observe the output voltage (voltage at output pin (6) op op-amp).
3. Measure the time period of the output waveform.
4. Repeat the experiment different values Capacitor (C) and Resistor (R) given in the table below.

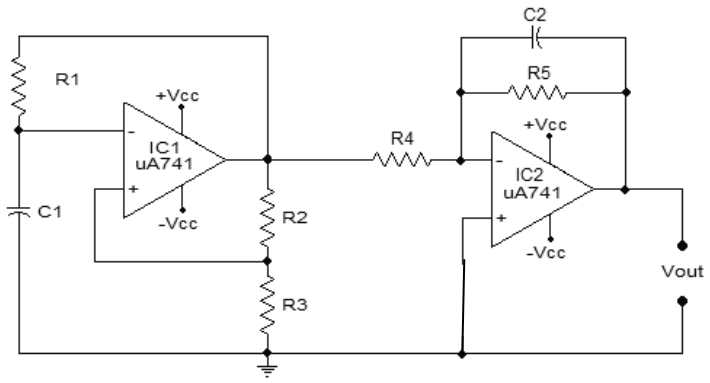
| Sr. No. | $R_1$ | $R_2$ | β | R | C | T (theoretical) | T (measured) |
|---|---|---|---|---|---|---|---|
| 1 | 10 K | 10 K | 0.5 | 10 K | 0.1 μF | | |
| 2 | 10 K | 10 K | 0.5 | 10 K | 0.01 μF | | |
| 3 | 10 K | 10 K | 0.5 | 20 K | 0.1 μF | | |




**Desired Waveform of Square Wave Generator**

- **Triangular Wave Generator:**

Operational amplifier based triangular wave form generator is simple circuit that is widely used in function generators. We know that the integrator output waveform will be triangular if the input to it is a square wave. It means that a triangular wave generator can be formed by simply cascading an integrator and a square wave generator, as illustrated in figure

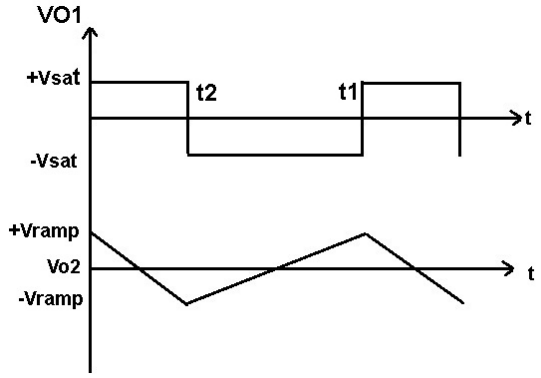



**Circuit Diagram of Triangular Wave Generator**

**Procedure to build triangular wave generator:**

1. Connect the circuit as shown above. Connect pin numbers 7 and 4 of IC to regulated power supply (+12V, -12V).
2. Observe the voltages at pin-6 (connect to Channel-1 of CRO) of op-amp-1and pin-6 (connect to Channel-2 of CRO) of op-amp-2 keeping the CRO in dual mode.
3. Measure the time period and slope of the output waveform (at pin-6 of op-amp-2).
4. Repeat the experiment different values $R_4$ in the table below.

| Sr. No. | $R_1$ | $R_2$ | $R_3$ | $R_4$ | $R_5$ | $C_1$ | $C_2$ | Slope (Theoretical.) | Slope (measured) | T (Th.) | T (Meas.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10 K | 10 K | 10 K | 10 K | 47 K | 0.1 μF | 0.1 μF | | | | |
| 2 | 10 K | 10 K | 10 K | 20 K | 47 K | 0.1 μF | 0.1 μF | | | | |
| 3 | 10 K | 10 K | 10 K | 12 K | 47 K | 0.1 μF | 0.1 μF | | | | |




**Desired Waveform of Triangular Wave Generator**

**Precautions to be taken:**

1. Ensure that all the discrete components are working properly.
2. Make sure all the connections in the circuit are correct before giving supply to circuit.
3. Remove the supply before changing any connections in circuit.