NCR CAMPUS, MODINAGAR

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Analog and Digital Electronics Laboratory (18CSS201J)

Title of Experiment	: **Experiment No. 3 : Square/Rectangular Waveform Generator**
Name of the candidate	**: ANANYA GUYPTA**
Register Number	**: RA1911003030265**
Branch-Section	**: CSE-I**

Experiment No. 3 : Square/Rectangular Waveform Generator

Aim: Design and implement using simulator a Square/rectangular waveform generator (Op-Amp relaxation oscillator).

Apparatus Require:

LM 741/OP27 or its equivalent
Capacitor – 0.1μF
Resistors – 10KΩ (2), 1KΩ (2)
AD Kit
Bread Board.

Theory:

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 comparator uses positive feedback that increases the gain of the amplifier. In a comparator circuit this offer two advantages. First, the high gain causes the op-amp's output to switch very quickly from one state to another and vice-versa. Second, the use of positive feedback gives the circuit hysteresis. In the op-amp square-wave generator circuit given in figure, the output voltage v_{out} is shunted to ground by two Zener diodes Z_1 and Z_2 connected back-to-back and is limited to either $V_{Z\,2}$ or $-V_{Z\,1}$. A fraction of the output is fedback to the non-inverting (+) input terminal. Combination of IL and C acting as a low-pass R-C circuit is used to integrate the output voltage v_{out} and the capacitor voltage v_c is applied to the inverting input terminal in place of external signal.
The differential input voltage is given as $\mathbf{v_{in} = v_c - \beta\, v_{out}}$
When v_{in} is positive, $v_{out} = -V_{z1}$ and when v_{in} is negative $v_{out} = +V_{z}\,2$. Consider an instant of time when $v_{in} < 0$. At this instant $v_{out} = +V_{z\,2}$, and the voltage at the non-inverting (+) input terminal is $\beta\, V_{z\,2}$, the capacitor C charges exponentially towards $V_{z\,2}$, with a time constant $R_f C$.
The output voltage remains constant at $V_{z\,2}$ until v_c equal $\beta\, V_{z\,2}$.
When it happens, comparator output reverses to $-V_{z\,1}$. Now v_c changes exponentially towards $-V_{z1}$ with the same time constant and again the output makes a transition from $-V_{z1}$ to $+V_{z\,2}$. when v_c equals $-\beta V_{z\,1}$

Let $V_{z1} = V_{z\,2}$

The time period, T, of the output square wave is determined using the charging and discharging phenomena of the capacitor C. The voltage across the capacitor, v_c when it is charging from $-\beta\, V_z$ to $+V_z$ is given by

$$\mathbf{V_c = [1-(1+\beta)]e^{-T/2\tau}}$$

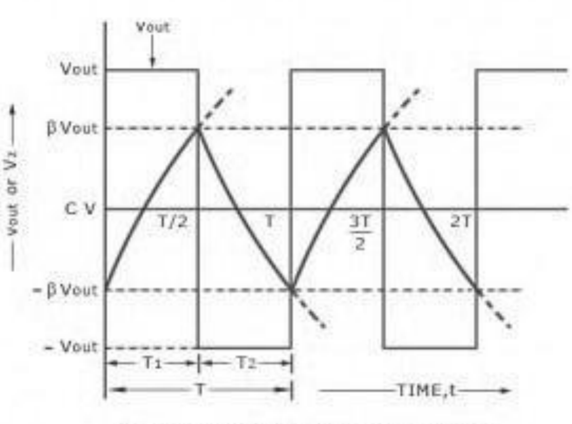
Where $\tau = R_f C$
The waveforms of the capacitor voltage v_c and output voltage v_{out} (or v_z) are shown in figure.
When t = t/2

$$\mathbf{V_c = +\beta\, V_z \text{ or } + \beta\, V_{out}}$$

Therefore $\beta\, V_z = V_z\,[1-(1+\beta)e^{-T/2\tau}]$

$$\mathbf{\text{Or } e^{-T/2\tau} = 1-\beta/1+\beta}$$

$$\mathbf{\text{Or } T = 2\tau \log_e 1+\beta/1-\beta = 2R_f C \log_e [1+(2R_3/R_2)]}$$

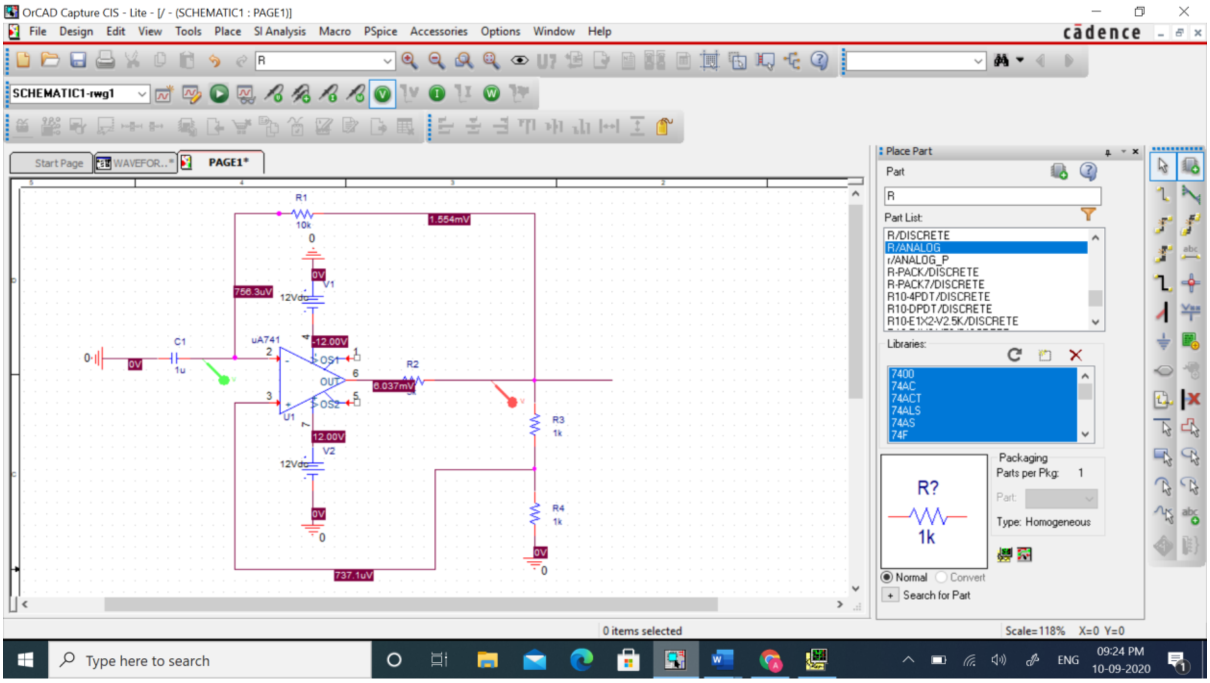


Output and Capacitor Voltage Waveforms

The frequency, $f = 1/T$, of the square-wave is independent of output voltage V_{out}. ***This circuit is also known as free-running or astable multivibrator because it has two***

quasi-stable states. The output remains in one state for time T_1 and then makes an abrupt transition to the second state and remains in that state for time T_2. The cycle repeats itself after time $\mathbf{T = (T_1 + T_2)}$ where T is the time period of the square-wave.
The op-amp square-wave generator is useful in the frequency range of about 10 Hz -10 kHz. At higher frequencies, the op-amp's slew rate limits the slope of the output square wave. The symmetry of the output waveform depends on the matching of two Zener diodes Z_1 and Z_2. The
unsymmetrical square-wave (T_1 not equal to t_2) can be had by using different constants for charging the capacitor C to $+V_{out}$ and $-V_{out}$

Circuit Diagram:



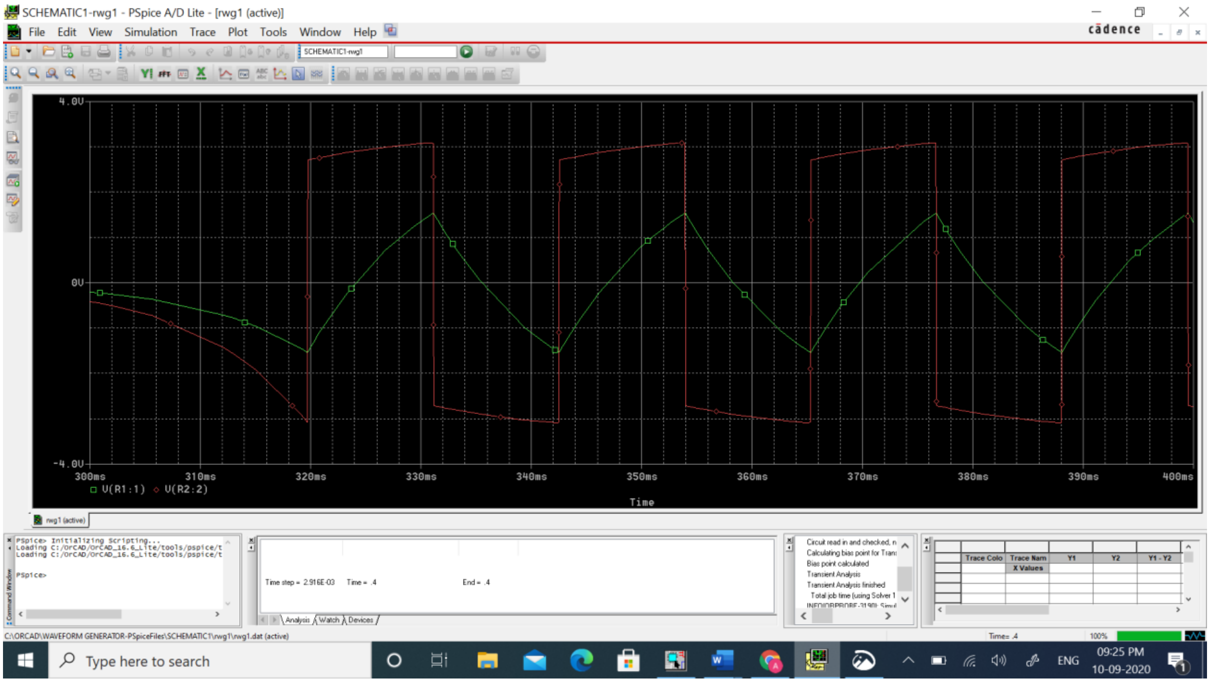
Procedure:

1. Expression for the frequency of oscillation,

   $f = 1/\ (2RC\log_e(1+\ \beta/1\text{-}\beta))$, where $\beta = (R_3/R_3+R_2)$.

2. Choose any frequency between 1 kHz and 5 kHz and select the values of R_1, R_2, R, and C.
3. Connect the circuit as per the circuit diagram and give the supply volt age.
4. Observe the frequency of operation of the circuit and compare with the theoretical values.
5. Change the R and C values to change the frequency and oscillation and verify with the theoretical values.
6. Trace the output waveform for inverting and non-inverting inputs.

Graphs:


SCHEMATIC1-rwg1 - PSpice A/D Lite - [rwg1 (active)]
File Edit View Simulation Trace Plot Tools Window Help
cadence
4.0V
0V
-4.0V
300ms
310ms
320ms
330ms
340ms
350ms
360ms
370ms
380ms
390ms
400ms
V(R1:1) V(R2:2)
Time
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