PH1C04 Electronics

Lecture 1: Triangular and Sawtooth wave generators

Lecturer: Dr. Shinoj V K

1.1 Triangular wave generator

It consists of a comparator (A) and an integrator (B) as shown in figure 1.1. The output of comparator A is a square wave of amplitude $\pm V_{sat}$ and is applied to the inverting (-) input terminal of the integrator B. The output of integrator is a triangular wave and it is feedback as input to the comparator A through a voltage divider R_2R_3.

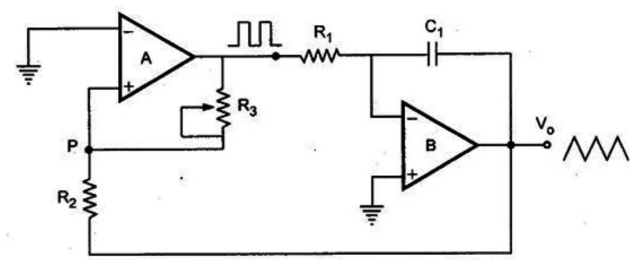

Figure 1.1: Schematic of Triangular wave generator

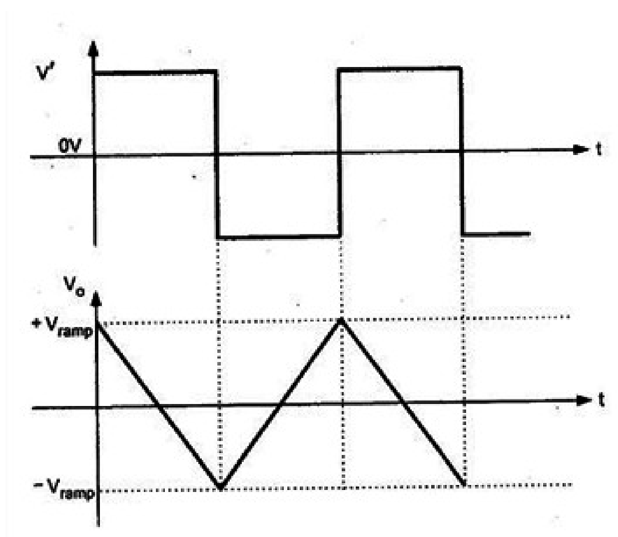

Figure 1.2: Output of comparator and integrator

To understand circuit operation, assume that the output of comparator A is at $+V_{sat}$. This forces a constant current through C to give a negative going ramp at the output of the integrator, as shown in the Fig **??**. Therefore, one end of voltage divider is at a voltage $+V_{sat}$ and the other at the negative going ramp. When the negative going ramp reaches a certain value $-V_{ramp}$, the output of comparator A switches from positive saturation to negative saturation ($-V_{sat}$). This forces a reverse constant current (right to left) through C to give a positive going ramp at the output of the integrator, as shown in the figure. When positive going ramp reaches $+V_{ramp}$, the effective voltage at point p becomes slightly above O V. As a result, the output of comparator A switches from negative saturation to positive saturation ($+V_{sat}$). The sequence then repeats to give triangular wave at the output of integrator B.

1.1.1 Amplitude and frequency calculations

The frequency and amplitude of the Triangular Wave Generator Using Op amp wave can be determined as follows: Just before switching occurs from $+V_{sat}$ to $-V_{sat}$, the voltage at point P is zero. This means the $-V_{ramp}$ must be developed across R_2 and $+V_{sat}$ must be developed across R_3. i.e.

$$\frac{-V_{ramp}}{R_2} = -\frac{+V_{sat}}{R_3} \tag{1.1}$$

$$-V_{ramp} = -\frac{R_2}{R_3}(+V_{sat}) \tag{1.2}$$

Similarly, $+V_{ramp}$, the output of integrator at which the output of comparator switches from $-V_{sat}$ to $+V_{sat}$, is given by,

$$+V_{ramp} = -\frac{R_2}{R_3}(-V_{sat}) \tag{1.3}$$

The peak to peak output amplitude of triangular wave is,

$$V_o(pp) = +V_{ramp} - (-V_{ramp}) = 2\frac{R_2}{R_3}(V_{sat}) \tag{1.4}$$

Where $V_{sat} = |+V_{sat}| = |-V_{sat}|$.

Equation 1.4 represents amplitude of triangular wave decreases with increase in R_3.

The time taken by the output to swing from $-V_{ramp}$ to $+V_{ramp}$ (or from $+V_{ramp}$ to $-V_{ramp}$) is equal to half the time period (T/2). This time can be calculated from the integrator output equation as follows:

$$V_o(pp) = -\frac{1}{R_1C_1}\int_0^{T/2}(-V_{sat})dt = \frac{V_{sat}}{R_1C_1}\left(\frac{T}{2}\right) \tag{1.5}$$

$$\frac{T}{2} = \frac{V_o(pp}{V_{sat}}(R_1C_1) \tag{1.6}$$

$$T = (2R_1C_1)\frac{V_o(pp}{V_{sat}} \tag{1.7}$$

substituting for $V_o(pp)$ from equation 1.4,

$$T = \frac{4R_1C_1R_2}{R_3} \tag{1.8}$$

Thus, the frequency of oscillation is,

$$f_o = \frac{R_3}{4R_1C_1R_2} \tag{1.9}$$

Thus the frequency of oscillation increases with increase in R_3.

1.2 Sawtooth wave generator

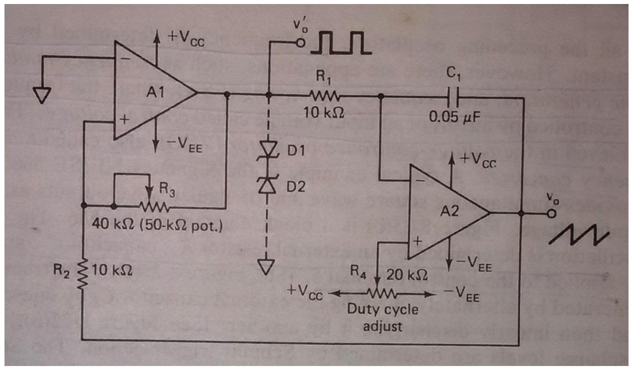

Figure 1.3: Schematic of Sawtooth wave generator

Sawtooth waveform can be also generated by an asymmetrical astable multivibrator followed by an integrator as shown in figure 1.3. The sawtooth wave generators have wide application in time-base generators and pulse width modulation circuits. The difference between the triangular wave and sawtooth waveform is that the rise time of triangular wave is always equal to its fall of time while in saw tooth generator, rise time may be much higher than its fall of time , vice versa. The triangular wave generator can be converted in to a sawtooth wave generator by injecting a variable dc voltage into the non-inverting terminal of the integrator.

In this circuit a potentiometer is used. Now the output of integrator is a triangular wave riding on some dc level that is a function of R_4 setting. The duty cycle of square wave will be determined by the polarity and amplitude of dc level. A duty cycle less than 50% will cause output of integrator be a sawtooth. With the wiper at the centre of R_4, the output of integrator is square wave. Use of the potentiometer is when the wiper moves towards $-V_{EE}$,the rise time of the sawtooth become longer than the fall time (see fig. 1.4. If the wiper moves towards $+V_{CC}$, the fall time becomes more than the rise time.

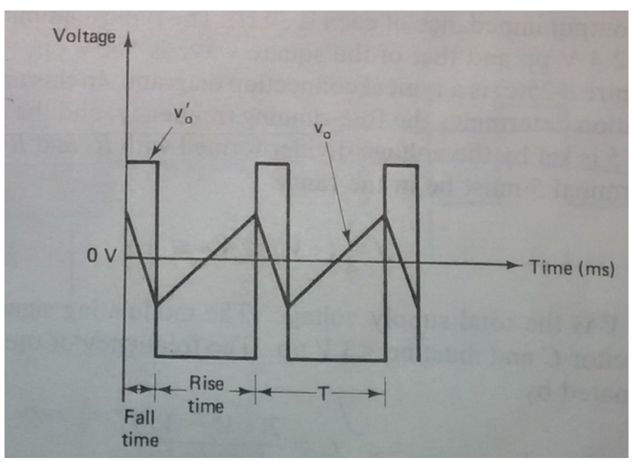

Figure 1.4: Output of sawtooth wave generator when noninverting of intergrator is at some negative dc level.