17.2 UJT (UNIJUNCTION TRANSISTOR) RELAXATION OSCILLATOR

UJT is a three terminal semiconductor switching device. As it has only one PN junction and three leads, it is commonly called as Unijunction transistor.

The basic structure of UJT is shown in Fig. 17.1(a). It consists of a lightly doped N-type Silicon bar with a heavily doped P-type material alloyed to its one side closer to B_2 for producing single PN junction. The circuit symbol of UJT is shown in Fig. 17.1(b). Here the emitter leg is drawn at an angle to the vertical and the arrow indicates the direction of the conventional current.

Characteristics of UJT Referring to Fig. 17.1(c), the interbase resistance between B_2 and B_1 of the silicon bar is $R_{BB} = R_{B1} + R_{B2}$. With emitter terminal open, if voltage V_{BB} is applied between the two bases, a voltage gradient is established along the N-type bar. The voltage drop across R_{B1} is given by $V_1 = \eta V_{BB}$, where the *intrinsic stand-off ratio* $\eta = R_{B1}/(R_{B1} + R_{B2})$. The typical value of η ranges from 0.56 to 0.75. This voltage V_1 reverse biases the PN junction and emitter current is cut-off. But a small leakage current flows from B_2 to emitter due to minority carriers. If a positive voltage V_E is applied to the emitter, the PN junction will remain reverse biased so long as V_E is less than V_1. If V_E exceeds V_1 by the cutin voltage V_γ, the diode becomes forward biased. Under this condition, holes are injected into N-type bar. These holes are repelled by the terminal B_2 and are attracted by the terminal B_1. Accumulation of holes in E to B_1 region reduces the resistance in this section and hence emitter current I_E is increased and is limited by V_E. The device is now in the 'ON' state.

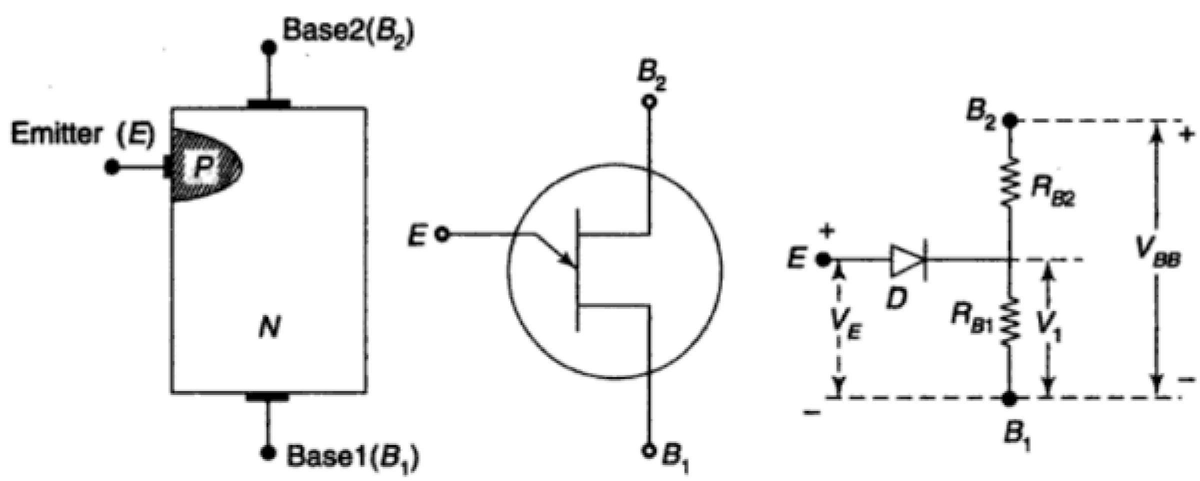

Fig. 17.1 UJT (a) Basic structure, (b) Circuit symbol, and (c) Equivalent circuit

If a negative voltage is applied to the emitter, PN junction remains reverse biased and the emitter current is cut off. The device is now in the 'OFF' state.

Figure 17.2 shows a family of input characteristics of UJT. Here, up to the peak point P, the diode is reverse biased and hence, the region to the left of the peak point is called *cut-off region*. The UJT has a stable firing voltage V_P which depends linearly on V_{BB} and a small firing current I_P ($\approx$ 25 μA). At P, the peak voltage $V_P = \eta V_{BB} + V_\gamma$, the diode starts conducting and holes are injected into N-layer. Hence, resistance decreases thereby decreasing V_E for the increase in I_E. So, there is a *negative resistance region* from peak point P to valley point V. After the valley point, the device is driven into saturation and behaves like a conventional forward biased PN junction diode. The region to the right of the valley point is called saturation region. In the vallley point, the resistance changes from negative to positive. The resistance remains positive in the saturation region. For very large I_E, the characteristic asymptotically approaches the curve for $I_{B2} = 0$.

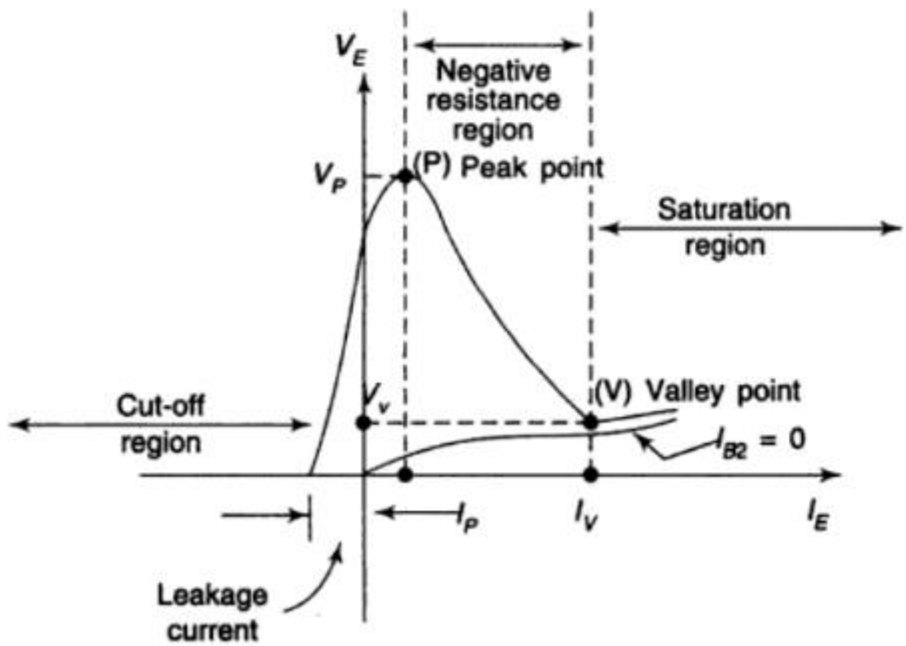

Fig. 17.2 Input characteristics of UJT

A unique characteristic of UJT is, when it is triggered, the emitter current increases regeneratively until it is limited by emitter power supply. Due to this negative resistance property, a UJT can be employed in a variety of applications, viz. sawtooth wave generator, pulse generator, switching, timing and phase control circuits.

UJT relaxation oscillator The relaxation oscillator using UJT which is meant for generating sawtooth waveform is shown in Fig. 17.3. It consists of a UJT and a capacitor C_E which is charged through R_E as the supply voltage V_{BB} is switched ON.

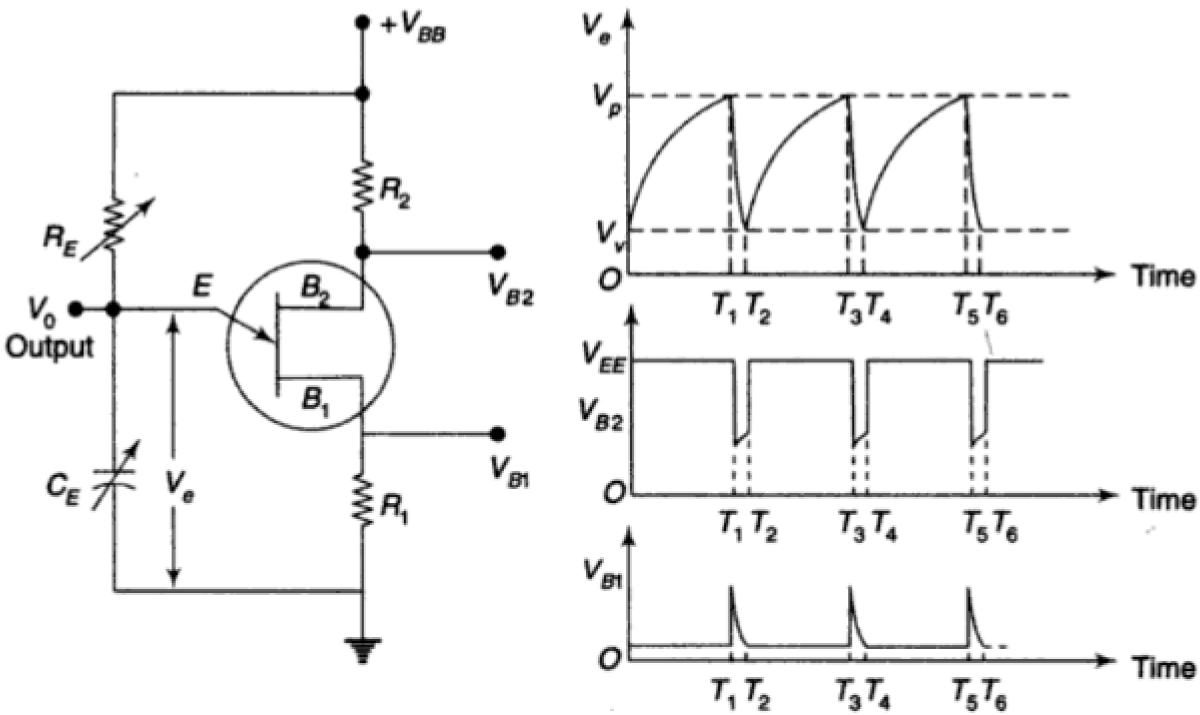

Fig. 17.3 UJT Relaxation oscillator

The voltage across the capacitor increases exponentially and when the capacitor voltage reaches the peak point voltage V_P, the UJT starts conducting and the capacitor voltage is discharged rapidly through EB_1 and R_1. After the peak point voltage of UJT is reached, it provides negative resistance to the discharge path which is useful in the working of the relaxation oscillator. As the capacitor voltage reaches zero, the device then cuts off and capacitor C_E starts to charge again. This cycle is repeated continuously generating a *sawtooth waveform* across C_E.

The inclusion of external resistors R_2 and R_1 in series with B_2 and B_1 provides spike waveforms. When the UJT fires, the sudden surge of current through B_1 causes drop across R_1, which provides positive going spikes. Also, at the time of firing, fall of V_{EBl} causes I_2 to increase rapidly which generates negative going spikes across R_2.

By changing the values of capacitance C_E or resistance R_E, frequency of the output waveform can be changed as desired, since these values control the time constant $R_E C_E$ of the capacitor charging circuit.