

2.5 UNI JUNCTION TRANSISTOR (UJT)

Unijunction transistor (abbreviated as UJT), also called the double-base diode is a 2-layer, 3-terminal solid-state (silicon) switching device. The device has a unique characteristic that when it is triggered, its emitter current increases regenerative (due to negative resistance characteristic) until it is restricted by emitter power supply. Since the device has one p n junction and three leads p n junction and three leads

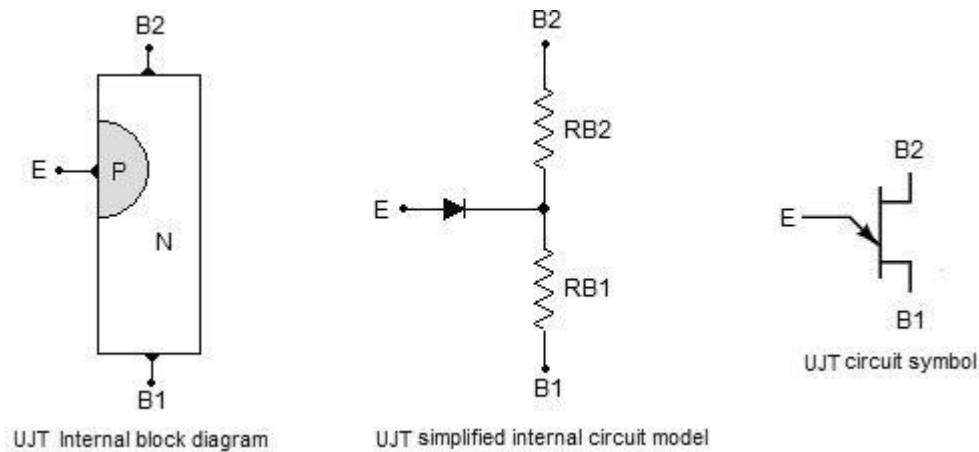


Figure 2.5.1 UJT structure, Equivalent circuit and Symbol

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 105]

Construction of a UJT

The basic structure of a unijunction transistor is shown in figure. It essentially consists of a lightly-doped N-type silicon bar with a small piece of heavily doped P-type material alloyed to its one side to produce single P-N junction. The single P-N junction accounts for the terminology unijunction. The silicon bar, at its ends, has two ohmic contacts designated as base-1 (B1) and base-2 (B2), as shown and the P-type region is termed the emitter (E). The emitter junction is usually located closer to base-2 (B2) than base-1 (B1) so that the device is not symmetrical, because symmetrical unit does not provide optimum electrical characteristics for most of the applications.

The symbol for unijunction transistor is shown in figure. The emitter leg is drawn at an angle to the vertical line representing the N-type material slab and the arrowhead points in the direction of conventional current when the device is forward-biased, active or in the conducting state. The basic arrangement for the UJT is shown in figure. A complementary UJT is formed by diffusing an N-type emitter terminal on a P-type

base. Except for the polarities of voltage and current, the characteristics of a complementary UJT are exactly the same as those of a conventional UJT.

- The device has only one junction, so it is called the unijunction device.
- The device, because of one P-N junction, is quite similar to a diode but it differs from an ordinary diode as it has three terminals.
- The structure of a UJT is quite similar to that of an N-channel JFET. The main difference is that P-type (gate) material surrounds the N-type (channel) material in case of JFET and the gate surface of the JFET is much larger than emitter junction of UJT.
- In a unijunction transistor the emitter is heavily doped while the N-region is lightly doped, so the resistance between the base terminals is relatively high, typically 4 to 10 kilo Ohm when the emitter is open.
- The N-type silicon bar has a high resistance and the resistance between emitter and base-1 is larger than that between emitter and base-2. It is because emitter is closer to base-2 than base-1.
- UJT is operated with emitter junction forward-biased while the JFET is normally operated with the gate junction reverse-biased.
- UJT does not have ability to amplify but it has the ability to control a large ac power with a small signal. It exhibits a negative resistance characteristic and so it can be employed as an oscillator.

Operation of a UJT

Imagine that the emitter supply voltage is turned down to zero. Then the intrinsic stand-off voltage reverse-biases the emitter diode, as mentioned above. If V_B is the barrier voltage of the emitter diode, then the total reverse bias voltage is $V_A + V_B = \eta V_{BB} + V_B$. For silicon $V_B = 0.7 \text{ V}$. Now let the emitter supply voltage V_E be slowly increased. When V_E becomes equal to ηV_{BB} , I_{Eo} will be reduced to zero. With equal voltage levels on each side of the diode, neither reverse nor forward current will flow

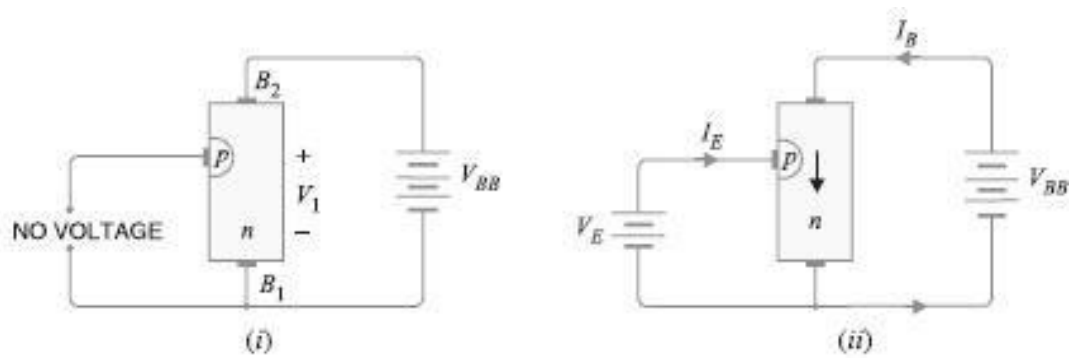


Figure 2.5.2 operation UJT under (i) $V_E=0$ (ii) applied V_E

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 105]

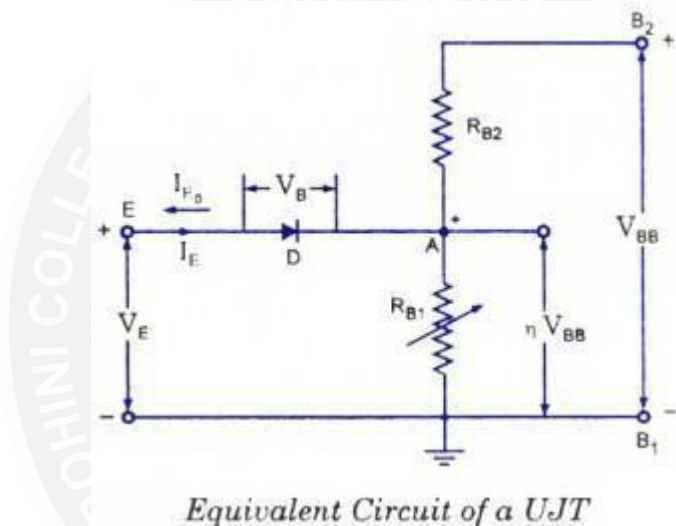


Figure 2.5.3 Equivalent circuit of UJT

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 106]

When emitter supply voltage is further increased, the diode becomes forward-biased as soon as it exceeds the total reverse bias voltage ($\eta V_{BB} + V_B$). This value of emitter voltage V_E is called the peak-point voltage and is denoted by V_P . When $V_E = V_P$, emitter current I_E starts to flow through R_{B1} to ground, that is B_1 . This is the minimum current that is required to trigger the UJT. This is called the peak-point emitter current and denoted by I_P . I_P is inversely proportional to the inter base voltage, V_{BB} .

Now when the emitter diode starts conducting, charge carriers are injected into the R_B region of the bar. Since the resistance of a semiconductor material depends upon doping, the resistance of region R_B decreases rapidly due to additional charge carriers (holes). With this decrease in resistance, the voltage drop across R_B also decrease,

because the emitter diode to be more heavily forward biased. This, in turn, results in larger forward current, and consequently more charge carriers are injected causing still further reduction in the resistance of the RB region. Thus the emitter current goes on increasing until it is limited by the emitter power supply. Since V_A decreases with the increase in emitter current, the UJT is said to have negative resistance characteristic. It is seen that the base-2 (B2) is used only for applying external voltage V_{BB} across it. Terminals E and B1 are the active terminals. UJT is usually triggered into conduction by applying a suitable positive pulse to the emitter. It can be turned off by applying a negative trigger pulse.

UJT Characteristics

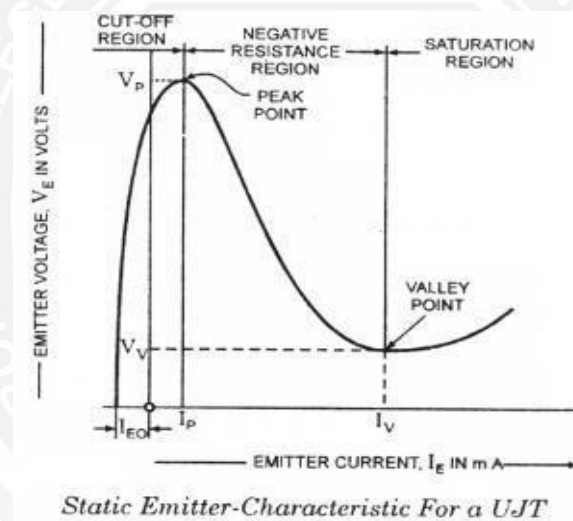


Figure 2.5.4 Static Emitter Characteristic for a UJT

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 106]

The static emitter characteristic (a curve showing the relation between emitter voltage V_E and emitter current I_E) of a UJT at a given inter base voltage V_{BB} is shown in figure. From figure it is noted that for emitter potentials to the left of peak point, emitter current I_E never exceeds I_{EO} . The current I_{EO} corresponds very closely to the reverse leakage current I_{CO} of the conventional BJT. This region, as shown in the figure, is called the cut-off region. Once conduction is established at $V_E = V_P$ the emitter potential V_E starts decreasing with the increase in emitter current I_E . This Corresponds exactly with the decrease in resistance R_B for increasing current I_E . This device, therefore, has a negative resistance region which is stable enough to be used with a great deal of reliability in the areas of applications listed earlier. Eventually, the

valley point reaches, and any further increase in emitter current I_E places the device in the saturation region, as shown in the figure 2.5.4.

Three other important parameters for the UJT are I_P , V_V and I_V and are defined below:

Peak-Point Emitter Current I_P : It is the emitter current at the peak point. It represents the minimum current that is required to trigger the device (UJT). It is inversely proportional to the inter base voltage V_{BB} .

Valley Point Voltage V_V : The valley point voltage is the emitter voltage at the valley point. The valley voltage increases with the increase in inter base voltage V_{BB} .

Valley Point Current I_V : The valley point current is the emitter current at the valley point. It increases with the increase in inter-base voltage V_{BB} .

Special Features of UJT.

The special features of a UJT are:

1. A stable triggering voltage (V_P) — a fixed fraction of applied inter base voltage V_{BB} .
2. A very low value of triggering current.
3. A high pulse current capability.
4. A negative resistance characteristic.
5. Low cost.

Applications of UJT.

- ✓ Relaxation oscillators.
- ✓ Switching Thyristors like SCR, TRIAC etc.
- ✓ Magnetic flux sensors.
- ✓ Voltage or current limiting circuit.
- ✓ Bistable oscillators.
- ✓ Voltage or current regulators.
- ✓ Phase control circuits.