Unijunction Transistor

T.Y.B.Sc - Eletronics

POWER ELETRONICS
Unijunction Transistor Symbol and Construction

The Unijunction Transistor is a solid-state three-terminal device that can be used in gate pulse, timing circuits, and trigger generator applications to switch and control either thyristors and triacs for AC power control type applications.
Unijunction Transistor has the name of a transistor, its switching characteristics are very different from those of a conventional bipolar or field effect transistor as it can not be used to amplify a signal but instead is used as a ON-OFF switching transistor.

UJT’s have unidirectional conductivity and negative impedance characteristics acting more like a variable voltage divider during breakdown.

The UJT consists of a single solid piece of N-type semiconductor material forming the main current carrying channel with its two outer connections marked as Base 2 (B₂) and Base 1 (B₁). The third terminal marked as the Emitter (E) is located along the channel.

The emitter terminal is represented by an arrow pointing from the P-type emitter to the N-type base.
From the equivalent circuit, that the N-type channel basically consists of two resistors $R_{B2}$ and $R_{B1}$ in series with an equivalent (ideal) diode, $D$ representing the p-n junction connected to their center point. This Emitter p-n junction is fixed in position along the ohmic channel during manufacture and can therefore not be changed.

Resistance $R_{B1}$ is given between the Emitter, $E$ and terminal $B_1$, while resistance $R_{B2}$ is given between the Emitter, $E$ and terminal $B_2$. As the physical position of the p-n junction is closer to terminal $B_2$ than $B_1$ the resistive value of $R_{B2}$ will be less than $R_{B1}$.

These two series resistances produce a voltage divider network between the two base terminals of the unijunction transistor and since this channel stretches from $B_2$ to $B_1$, when a voltage is applied across the device, the potential at any point along the channel will be in proportion to its position between terminals $B_2$ and $B_1$. The level of the voltage gradient therefore depends upon the amount of supply voltage.

When used in a circuit, terminal $B_1$ is connected to ground and the Emitter serves as the input to the device. Suppose a voltage $V_{BB}$ is applied across the UJT between $B_2$ and $B_1$ so that $B_2$ is biased positive relative to $B_1$. With zero Emitter input applied, the voltage developed across $R_{B1}$ (the lower resistance) of the resistive voltage divider can be calculated as
Unijunction Transistor $R_{B1}$ Voltage

$$V_{RB1} = \frac{R_{B1}}{R_{B1} + R_{B2}} \times V_{BB}$$

- For a unijunction transistor, the resistive ratio of $R_{B1}$ to $R_{BB}$ shown above is called the **intrinsic stand-off ratio** and is given the Greek symbol: $\eta$ (eta). Typical standard values of $\eta$ range from 0.5 to 0.8 for most common UJT’s.

- If a small positive input voltage which is less than the voltage developed across resistance, $R_{B1} \ (\eta V_{BB})$ is now applied to the Emitter input terminal, the diode p-n junction is reverse biased, thus offering a very high impedance and the device does not conduct. The UJT is switched “OFF” and zero current flows.

- However, when the Emitter input voltage is increased and becomes greater than $V_{RB1}$ (or $\eta V_{BB} + 0.7V$, where 0.7V equals the p-n junction diode volt drop) the p-n junction becomes forward biased and the unijunction transistor begins to conduct. The result is that Emitter current, $\eta I_E$ now flows from the Emitter into the Base region.

- The effect of the additional Emitter current flowing into the Base reduces the resistive portion of the channel between the Emitter junction and the $B_1$ terminal. This reduction in the value of $R_{B1}$ resistance to a very low value means that the Emitter junction becomes even more forward biased resulting in a larger current flow. The effect of this results in a negative resistance at the Emitter terminal.
The most common application of a unijunction transistor is as a triggering device for SCR and Triac but other UJT applications include saw-toothed generators, simple oscillators, phase control, and timing circuits. The simplest of all UJT circuits is the Relaxation Oscillator producing non-sinusoidal waveforms.

In a basic and typical UJT relaxation oscillator circuit, the Emitter terminal of the unijunction transistor is connected to the junction of a series connected resistor and capacitor, RC circuit as shown below.
When a voltage (Vs) is firstly applied, the unijunction transistor is “OFF” and the capacitor C1 is fully discharged but begins to charge up exponentially through resistor R3. As the Emitter of the UJT is connected to the capacitor, when the charging voltage Vc across the capacitor becomes greater than the diode volt drop value, the p-n junction behaves as a normal diode and becomes forward biased triggering the UJT into conduction. The unijunction transistor is “ON”. At this point the Emitter to B1 impedance collapses as the Emitter goes into a low impedance saturated state with the flow of Emitter current through R1 taking place.

As the ohmic value of resistor R1 is very low, the capacitor discharges rapidly through the UJT and a fast rising voltage pulse appears across R1. Also, because the capacitor discharges more quickly through the UJT than it does charging up through resistor R3, the discharging time is a lot less than the charging time as the capacitor discharges through the low resistance UJT.

When the voltage across the capacitor decreases below the holding point of the p-n junction (V_{off}), the UJT turns “OFF” and no current flows into the Emitter junction so once again the capacitor charges up through resistor R3 and this charging and discharging process between V_{on} and V_{off} is constantly repeated while there is a supply voltage, Vs applied.

**UJT Oscillator Waveforms**
UJT Oscillator Waveforms

The frequency of operation of the oscillator is directly affected by the value of the charging resistance R3, in series with the capacitor C1 and the value of \( \eta \). The output pulse shape generated from the Base1 (B1) terminal is that of a sawtooth waveform and to regulate the time period, you only have to change the ohmic value of resistance, R3 since it sets the RC time constant for charging the capacitor.

The time period, \( T \) of the sawtoothed waveform will be given as the charging time plus the discharging time of the capacitor. As the discharge time, \( \tau_1 \) is generally very short in comparison to the larger RC charging time, \( \tau_2 \) the time period of oscillation is more or less equivalent to \( T \cong \tau_2 \). The frequency of oscillation is therefore given by \( f = 1/T \).
UJT Speed Control Circuit
One typical application of the unijunction transistor circuit above is to generate a series of pulses to fire and control a thyristor. By using the UJT as a phase control triggering circuit in conjunction with an SCR or Triac, we can adjust the speed of a universal AC or DC motor as shown.

Using the circuit above, we can control the speed of a universal series motor (or whichever type of load we want, heaters, lamps, etc) by regulating the current flowing through the SCR. To control the motors speed, simply change the frequency of the sawtooth pulse, which is achieved by varying the value of the potentiometer.