# Unijunction Transistor (UJT)

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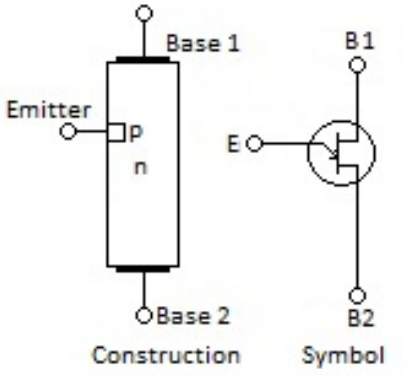
A Unijunction Transistor (UJT) is a three terminal semiconductor switching device. It consists of a bar of n-type silicon material with a terminal attached at its two ends known as base 1 and base 2. A third terminal is connected with a heavily doped p-type material alloyed into the bar part way along its length, and is known as the emitter. Since there is only one rectifying junction within the device, it is called a 'Unijunction' transistor. The unijunction transistor exhibits negative resistance in its characteristics. If finds use in relaxation oscillators in variety of applications.

## Construction of Unijunction Transistor (UJT)

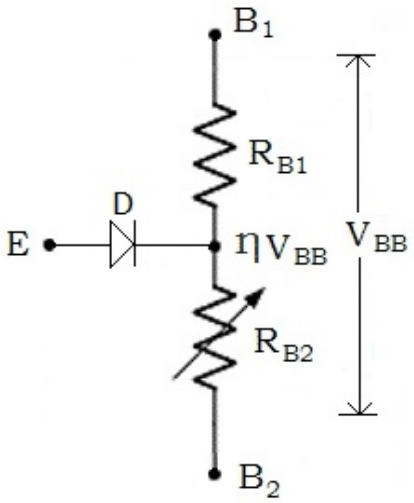
A Unijunction Transistor is constructed by forming a pn-Junction between a lightly doped N type silicon bar and a heavily doped P type material on one side as shown in the figure. The ohmic contact on either ends of the silicon bar is termed as Base 1 ($B_1$) and Base 2 ($B_2$) and P-type terminal is named as emitter.




The emitter junction is placed such that it is closer to Base 1 than to Base 2.The symbol of UJT is similar to that of JFET except that the emitter arrowhead for UJT is bent in the direction in which conventional current flows.

## How does a Unijunction Transistor (UJT) work

The simplified equivalent circuit (at Figure 3 below) shows that N-type channel consists of two resistors RB2 and RB1 in series with an equivalent diode, D representing the PN junction. The emitter PN junction is fixed along the ohmic channel during its manufacturing process.




The variable resistance RB2 is provided between the terminals Emitter (E) and Base 2 ($B_1$), the RB1 between the terminals Emitter (E) and Base 1 ($B_1$). Since the PN junction is closer to $B_1$, the value of RB1 will be less than the variable resistance RB2.

A voltage divider network is formed by the series combination of resistances RB2 and RB1. When a voltage is applied across the semiconductor device, the potential will be in proportion to the position of base points along the channel.

The Emitter (E) acts as input when employed in a circuit, as the terminal $B_2$ is grounded. The terminal $B_1$ is positively biased with respect to $B_2$ when a voltage ($V_{BB}$) applied across the terminals $B_1$

and $B_2$. When the emitter input is zero, the voltage across resistance RB2 of the voltage divider circuit is calculated by

$$V_{RB2} = \frac{R_{B2}}{R_{B1}+R_{B2}} V_{BB}$$

The 'intrinsic stand-off ratio' (η) of the Unijunction Transistor is defined applied as the ratio of $R_{B2}$ to $R_{BB}$. Most UJT's have η value ranging from 0.5 to 0.8. The PN junction is reverse biased if the voltage applied at the emitter is less than the sum of voltage developed across resistance $R_{B2}$ ($\eta V_{BB}$) and the voltage drop across a forward biased PN junction, $V_f$. i.e. $V_E < \eta V_{BB} + V_f$ A very high impedance is developed in this situation prompting device to move into non-conducting state i.e., it will be switched off and no current flows through it. The UJT begins to conduct when the PN junction is forward biased. This is achieved when voltage applied to the emitter terminal, $V_E > V_{RB1} + V_f$ , i.e. $V_E > \eta V_{BB} + V_f$ . This results in larger flow of emitter current from emitter region to base region. Increase in emitter current results in injection of large number of conduction electrons in the region between emitter and Base 2. This reduces the resistance between emitter and Base 2, resulting in a reduction in total resistance between Base 1 and base 2. As a result a large current flows between base 1 and base 2.

The Unijunction Transistor (UJT) will act as voltage breakdown device, when the input applied between emitter and base 1 reduces below breakdown value i.e., $R_{B1}$ increases to a higher value. This shows that $R_{B1}$ depends on the emitter current and it is variable.

## Characteristics Curve of Unijunction Transistor (UJT)

The characteristics of Unijunction Transistor (UJT) is given below. The figure shows Emitter current $I_E$ on the x-axis and $V_E$ on the y-axis. The curve has three regions: (1) Cutoff region (2) Negative Resistance region, (3) Saturation region.

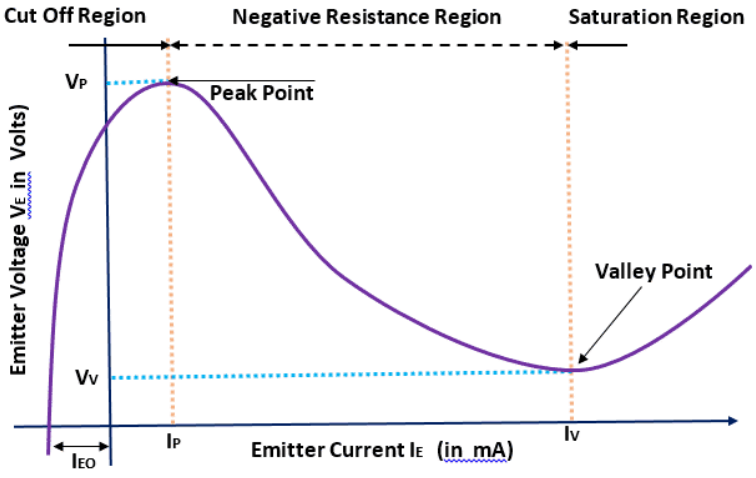



Fig. 4 – Characteristics of Unijunction Transistor (UJT)

## Cutoff region

Cutoff region is the area where the Unijunction Transistor (UJT) doesn't get sufficient voltage to turn on. The applied voltage $V_E$ hasn't reached the triggering point, thus making transistor to remain in off state.

## Negative Resistance region

When the emitter reaches the triggering voltage, $V_{TRIG}$, Unijunction Transistor (UJT) will turn on. After a certain time, if the voltage applied to the emitter lead increases, it will reach out at $V_{PEAK}$. The voltage drops from $V_{PEAK}$ to Valley Point even though the current increases (negative resistance).

## Saturation

Saturation region is the part of characteristic curve in which the current and voltage both increase, if the applied voltage to emitter terminal increases.

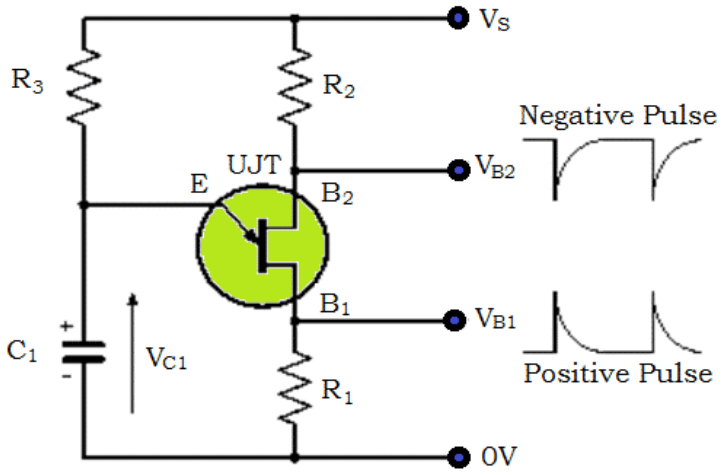
## Applications of Unijunction Transistor (UJT)

The Unijunction Transistor can be employed in variety of applications such as:

- Switching Device
- Triggering Device for Triacs and SCR's
- Timing Circuits
- For phase control
- In sawtooth generators
- In simple relaxation oscillators

## Application of Unijunction Transistor (UJT) in Relaxation Oscillator

UJT Relaxation Oscillator can be practically viewed by the following circuit.



### Use of Unijunction Transistor (UJT) in Relaxation Oscillator

A relaxation oscillator is circuit that generates a sawtooth waveform. A typical circuit is shown above. The capacitor $C_1$ is charged through the resistor $R_3$ until $V_E$ reaches the peak point. (The UJT's emitter terminal has no effect on C1 until peak point is reached). When the emitter voltage reaches peak voltage point, the emitter-base 1 resistance diminishes which results in rapid discharge of the capacitor $C_1$. The capacitor $C_1$ discharges until $V_E$ goes below the valley point. The emitter-base 1 resistance will then return back to high resistance state, thus completing the cycle. The capacitor $C_1$ is nowfree to charge again.

## Application of Unijunction Transistor (UJT) in Speed Control Circuit

Speed Control Circuit is one of the typical applications of UJT to produce set of pulses to trigger and control Thyristor. We can adjust the speed of universal motors by using UJT as triggering circuit in combination with SCR and Triacs.

## Advantages of Unijunction Transistor (UJT)

The advantages of Unijunction Transistor include:

- low cost
- negative resistance characteristics
- Requires low value of triggering current
- A stable triggering voltage
- Low power absorbing device

## Disadvantage of Unijunction Transistor (UJT)

The main disadvantage of Unijunction Transistor is its inability to provide appropriate amplification.

Further reading: https://electricalfundablog.com/unijunction-transistor-ujt-construction-working-characteristics-curve-applications/

Also see https://electricalfundablog.com/thyristor-working-vi-characteristics/

https://www.elprocus.com/introduction-to-uni-junction-transistor-construction-and-operation/