Nalanda Open University

M.SC Part-1

Course : Physics

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Topic- The Unijunction Transistor (Electronic device)

The Unijunction Transistor

The unijunction transistor (UJT) is a three terminal device having one emitter and two base contacts. It exhibits a stable "N" type negative resistance characteristic resembling the characteristic of a gas thyratron. It was originally developed by Shockley et. al (1949) from the alloyed germanium bar structure, and was, at that time, called a filamentary transistor. The first UJT was in the form of a bar. The cube structure (1964) was developed subsequently and recently the planar type unijunction (1967) has been reported. Utilizing modern integrated circuit fabrication techniques, a newer type called the complementary unijunction transistor (1968) has also been constructed.

Inspite of the progress made in the construction of newer types of unijunction transistors, there is no denying the fact that the theory of operation of these transistors is not yet well developed. There are in fact a number of unsolved problems in our knowledge about these transistors of which we shall consider only two specific problems in this chapter. The first problem to be considered relates to a study of the variation of the peak point current with interbase voltage. The second problem concerns operation of the UJT as a relaxation oscillator and determination of the switching speed of such oscillators.

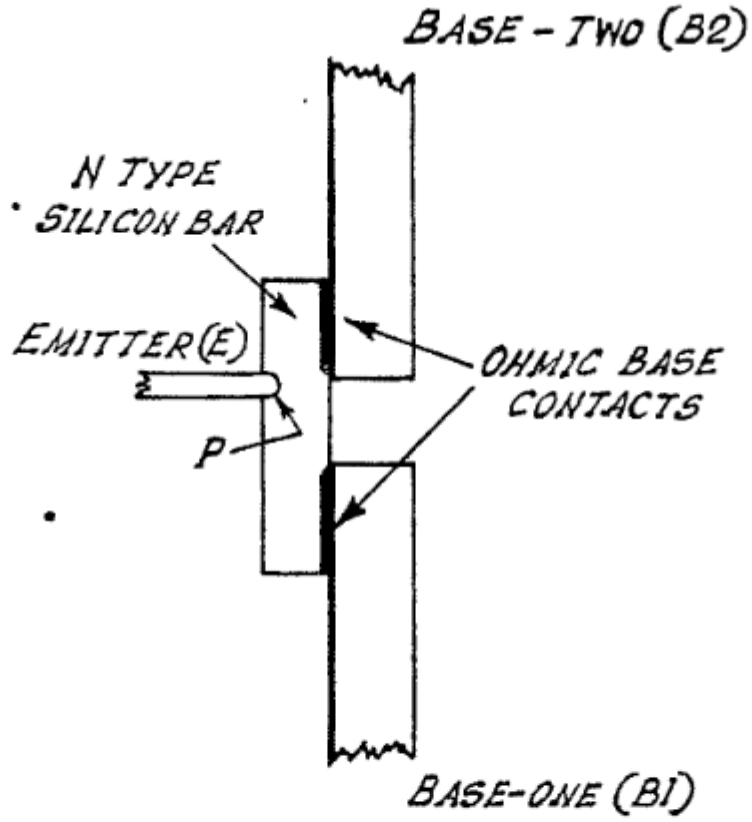

Fig.4.1(a). Showing schematic diagram of a unijunction transistor.

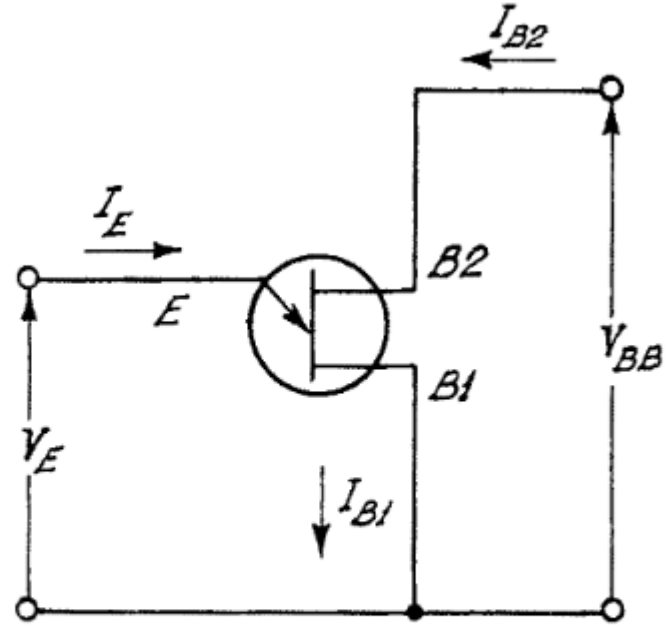

Fig.4.1(b). Showing circuit symbol of a unijunction transistor.

Since the characteristics, symbols, equivalent circuits, etc. as applicable to unijunction transistors are in most cases different from those we have so for used in this thesis, it may not be out of the way to discuss some basic concepts about the UJT both as a device and as a circuit element. After this introductory discussion, we shall consider in turn the two problems referred to above.

4.2. Some Basic Concepts.

A schemetic diagram of a UJT is shown in Fig.4.1(a). N represents a single crystal n-type silicon bar having two ohmic contacts B1 and B2. These two contacts are respectively called base-one and base-two. P is the p-type emitter (E) junction formed on one side of the silicon bar. The circuit symbol of the UJT is shown in Fig.4.1(b). In this figure, I_E I_{B1} and I_{B2} represent respectively the emitter current flowing into the emitter terminal, the base-one current and the base-two current.

V_E is the emitter voltage measured between the emitter terminal and ground and V_{BB} represents the interbase voltage measured between the base-one and base-two terminal.

There are two important electrical characteristics of the UJT, namely (i) emitter characteristic and (ii) interbase characteristic. We shall describe these two characteristics briefly in the following two sub-sections. A short discussion on equivalent circuit of the UJT will thereafter be made at the end of the present section.

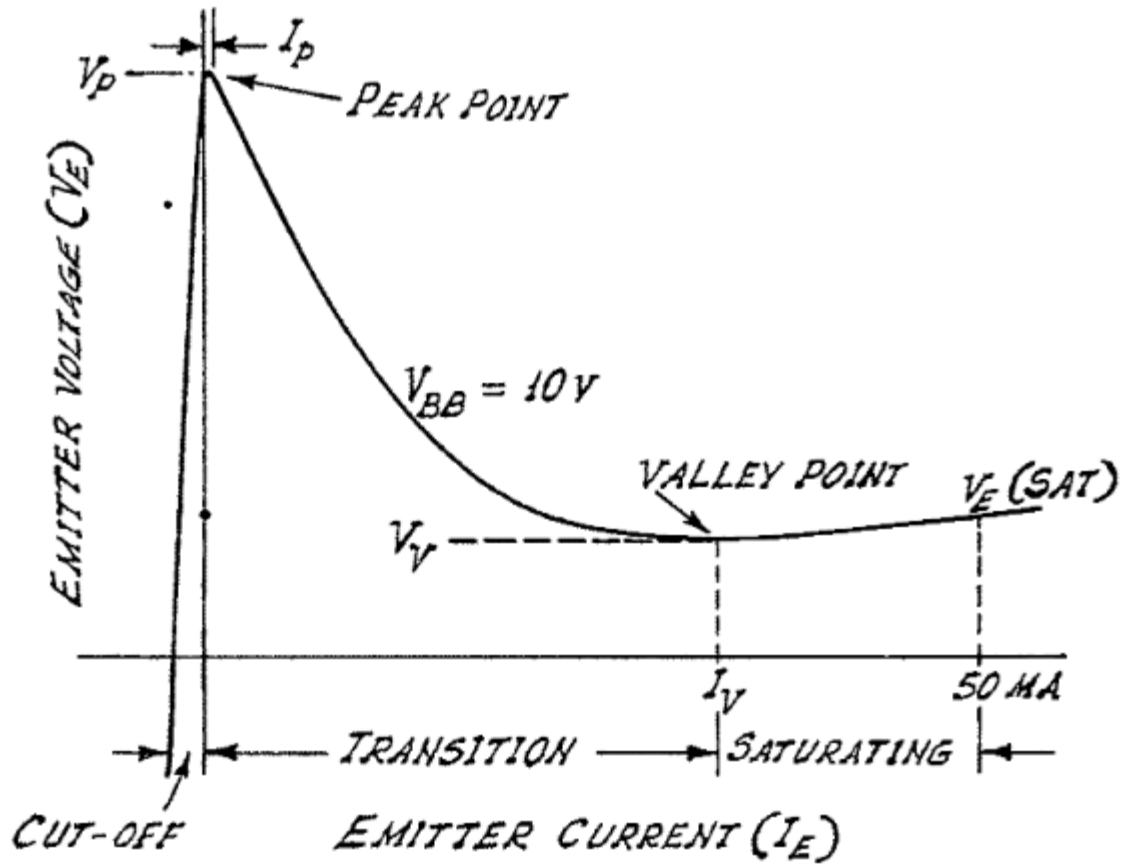

Fig.4.2. Static emitter characteristic curve showing important parameters of a unijunction transistor.

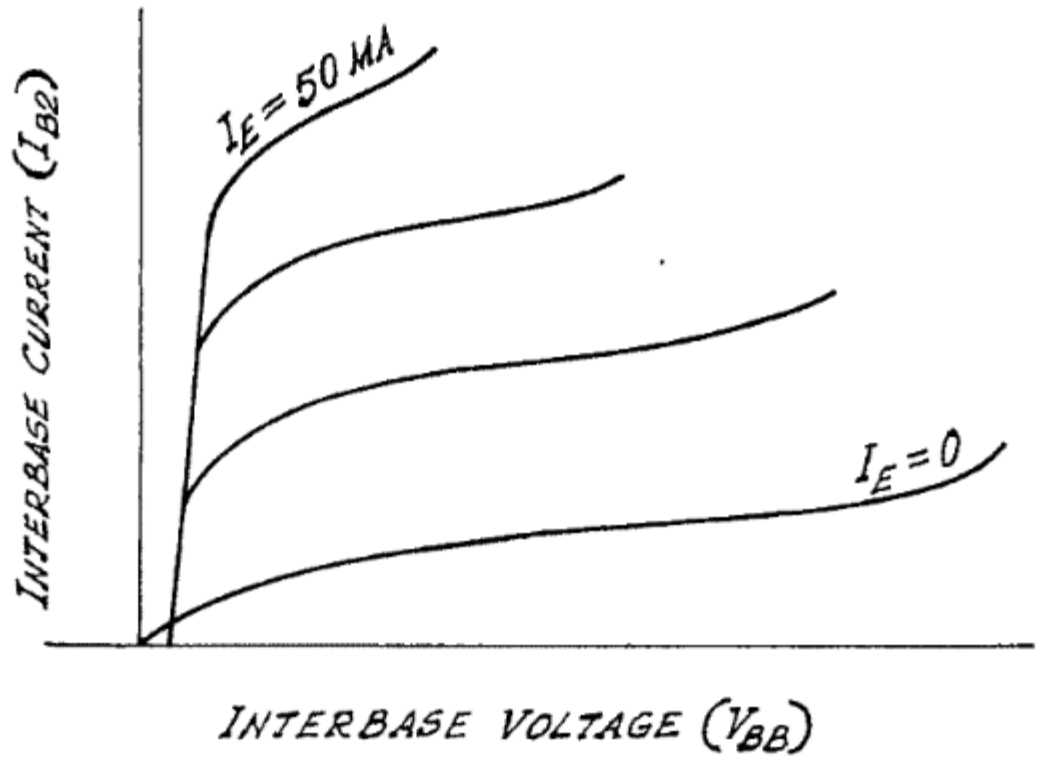

Fig.4.3. Static interbase characteristic curves of a unijunction transistor.

Emitter Characteristic. A typical unijunction transistor static emitter characteristic curve and its essential features are shown in Fig.4.2. As shown in this figure, there are three distinct operating regions of the UJT. These are : (i) cut-off, (ii) transition and (iii) saturation regions. These regions are characterized by a very high input impedance, a negative input resistance and a very low input resistance respectively. Referring to the cut-off region, it is seen that V_p denotes the maximum voltage which the UJT can sustain before switching to the transition region and the emitter current corresponding to this voltage is defined as the peak point current, I_p. V_v describes the emitter to base-one voltage when the UJT is biased at the valley point and the emitter current flowing at

the valley point is called the emitter valley current, I_v. At these two points, the slope of the emitter characteristic curve is zero. In the same figure, $V_{E(Sat)}$ denotes the emitter saturation voltage which is measured by convention at an emitter current of 50 ma and an interbase voltage of 10 volts.

Interbase Characteristic. The static interbase characteristic curves shown in fig.4.3 are used in conjunction with the emitter characteristic curves for a complete description of the static characteristics of the UJT. These are generally given as a plot of interbase voltage, V_{BB}, against base-two current, I_{B2}, for constant values of the emitter current, I_E. It may be noted that a base-two current can flow even when the

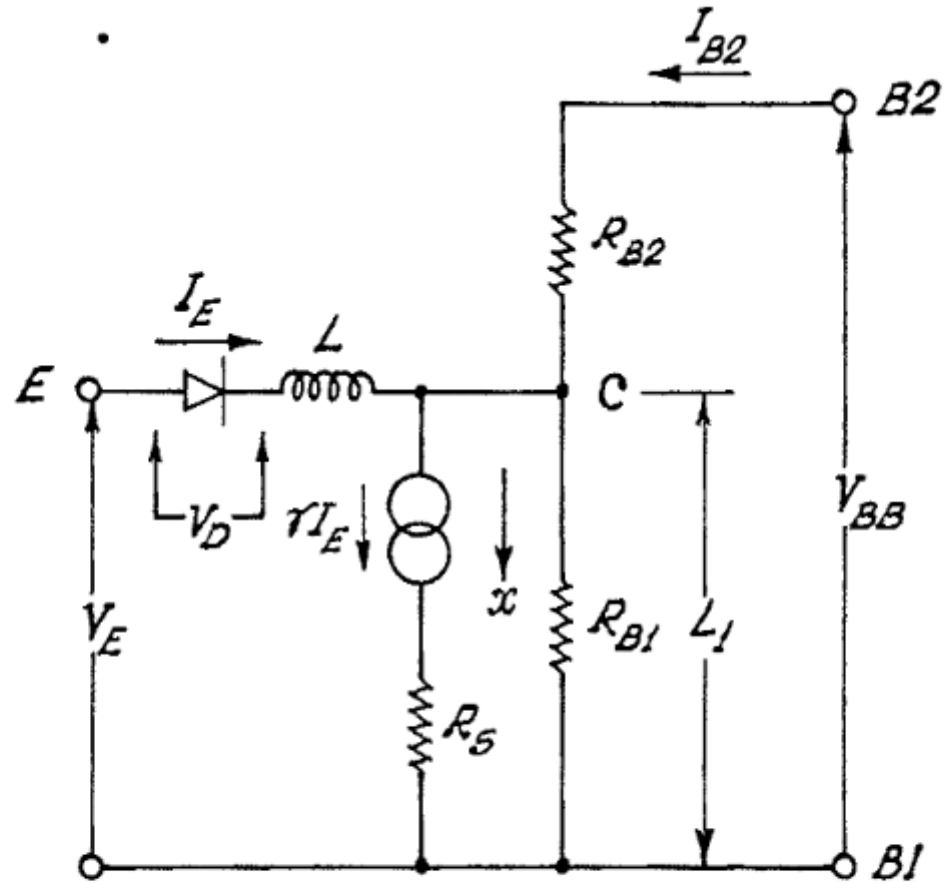

Fig.4.4. Equivalent circuit of a unijunction transistor showing the various symbols used.

emitter current is zero. The ratio V_{BB}/I_{B2} for any point on the $I_E = 0$ curve gives the interbase resistance, R_{BB}, corresponding to that bias point. The nonlinearity of this curve is caused by the heating effect of the interbase current and the consequent increase of R_{BB} with temperature.