IRE 105 ELECTRONICS DEVICES AND APPLICATIONS

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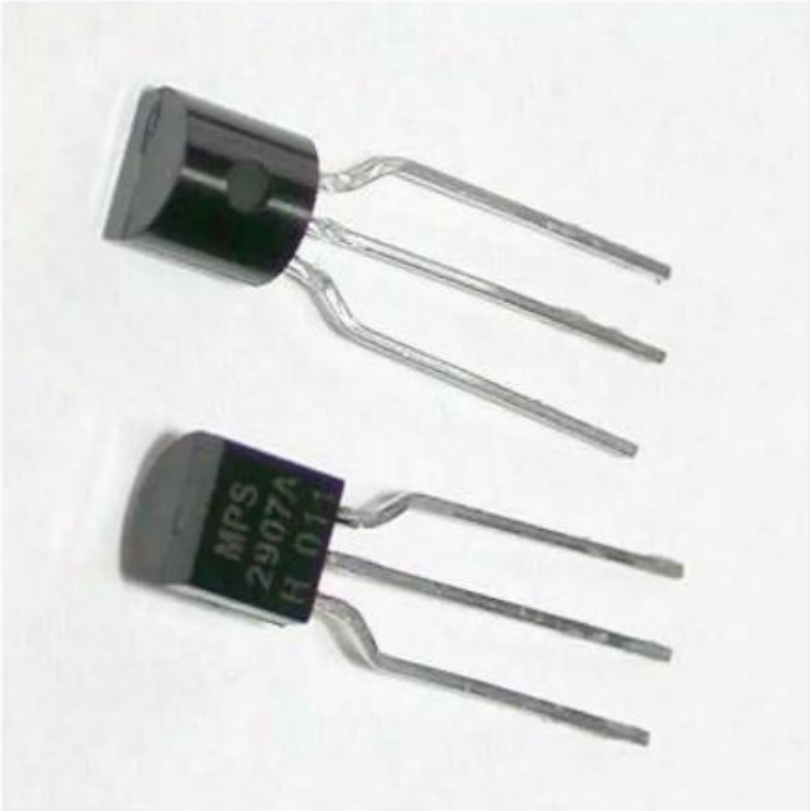
BIPOLAR JUNCTION TRANSISTORS (BJT)

- Semiconductors: ability to change from conductor to insulator
- Can either allow current or prohibit current to flow
- Useful as a switch, but also as an amplifier
- Essential part of many technological advances



A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power.

WHY BJT?

- **Bipolar** transistors are called *bi*polar because the main flow of current through them takes place in *two* types of semiconductor material: P and N, as the main current goes from emitter to collector (or vice versa). In other words, two types of charge carriers—electrons and holes—comprise this main current through the transistor.
- **Junction** refers to the two junctions between emitter-base and collector-base
- **Transistor** Transfer+Resistor which means it transfers signals from high resistance portion to the low resistance portion or vice-versa

BJT

- A bipolar transistor consists of a three-layer “sandwich” of doped (extrinsic) semiconductor materials, (a and c) either P-N-P or N-P-N (b and c). Each layer forming the transistor has a specific name, and each layer is provided with a wire contact for connection to a circuit. The schematic symbols are shown in the figure (a) and (c).

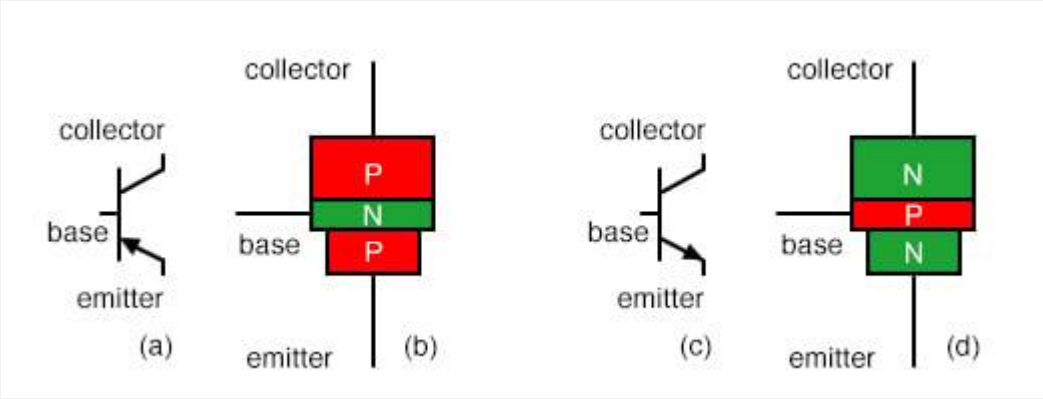


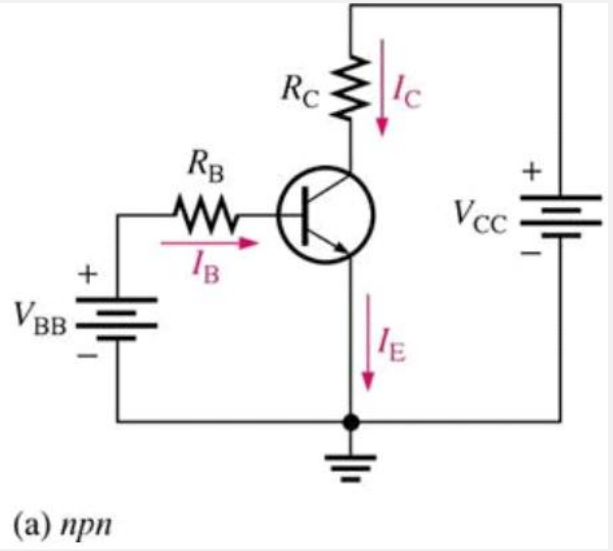
Figure 1. BJT transistor: (a) PNP schematic symbol, (b) layout, (c) NPN schematic symbol, and (d) layout.

TRANSISTOR CONSTRUCTION

- A transistor has three regions known as emitter, base and collector
- Emitter: it is a region situated in one side of a transistor, which supplies charge carriers (ie., electrons and holes) to the other two regions
- Emitter is heavily doped region
- Base: It is the middle region that forms two P-N junction in the transistor
- The base of the transistor is thin as compared to the emitter and is a lightly doped region
- Collector: It is a region situated in the other side of a transistor (ie., side opposite to the emitter) which collects the charge carriers
- The collector of the transistor is always larger than the emitter and base of a transistor
- The doping level of the collector is intermediate between the heavy doping of emitter and the light doping of the base

OPERATION OF NPN TRANSISTOR

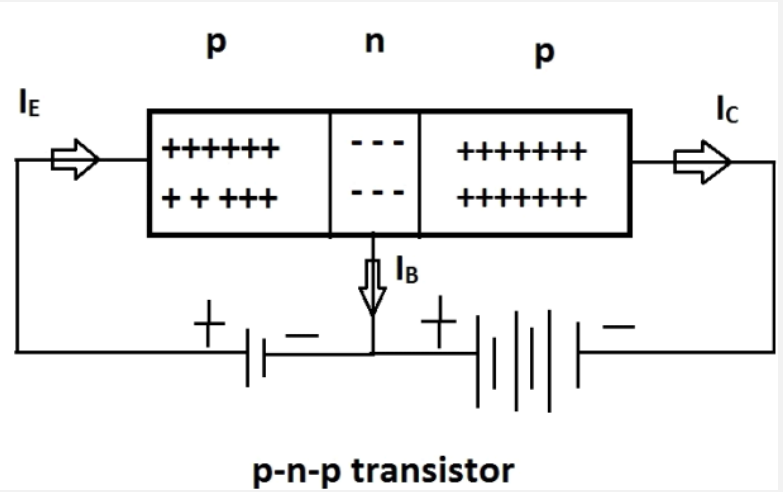
- The NPN transistor is biased in forward active mode ie., emitter – base of transistor is forward biased and collector base junction is reverse biased
- The emitter – base junction is forward biased only if V is greater than barrier potential which is 0.7v for silicon and 0.3v for germanium transistor
- The forward bias on the emitter- base junction causes the free electrons in the N –type emitter to flow towards the base region. This constitutes the emitter current . Direction of conventional current is opposite to the flow of electrons
- Electrons after reaching the base region tend to combine with the holes
- If these free electron combine with holes in the base, they constitute base current ().
- Most of the free electrons do not combine with the holes in the base
- This is because of the fact that the base and the width is made extremely small and electrons do not get sufficient holes for recombination
- Thus most of the electrons will diffuse to the collector region and constitutes collector current. This collector current is also called injected current, because of this current is produced due to electrons injected from the emitter region
- There is another component of collector current due to the thermal generated carriers.
- This is called as reverse saturation current and is quite small



(a) *npn*

OPERATION OF PNP TRANSISTOR

- Operation of a PNP transistor is similar to npn transistor
- The current within the PNP transistor is due to the movement of holes where as, in an NPN transistor it is due to the movement of free electrons
- In PNP transistor, its emitter – base junction is forward biased and collector base junction is reverse biased.
- The forward bias on the emitter – base junction causes the holes in the emitter region to flow towards the base region
- This constitutes the emitter current ( ).
- The holes after reaching the base region, combine with the electrons in the base and constitutes base current.
- Most of the holes do not combine with the electrons in the base region
- This is due to the fact that base width is made extremely small, and holes does not get sufficient electrons for recombination.
- Thus most of the holes diffuse to the collector region and constitutes collector region
- This current is called injected current, because it is produced due to the holes injected from the emitter region
- There is small component of collector current due to the thermally generated carriers
- This is called reverse saturation current.



p-n-p transistor

MODES OF OPERATION OF BJT

- Active Mode

  → Base- Emitter junction is forward and Base-Collector junction is reverse biased.

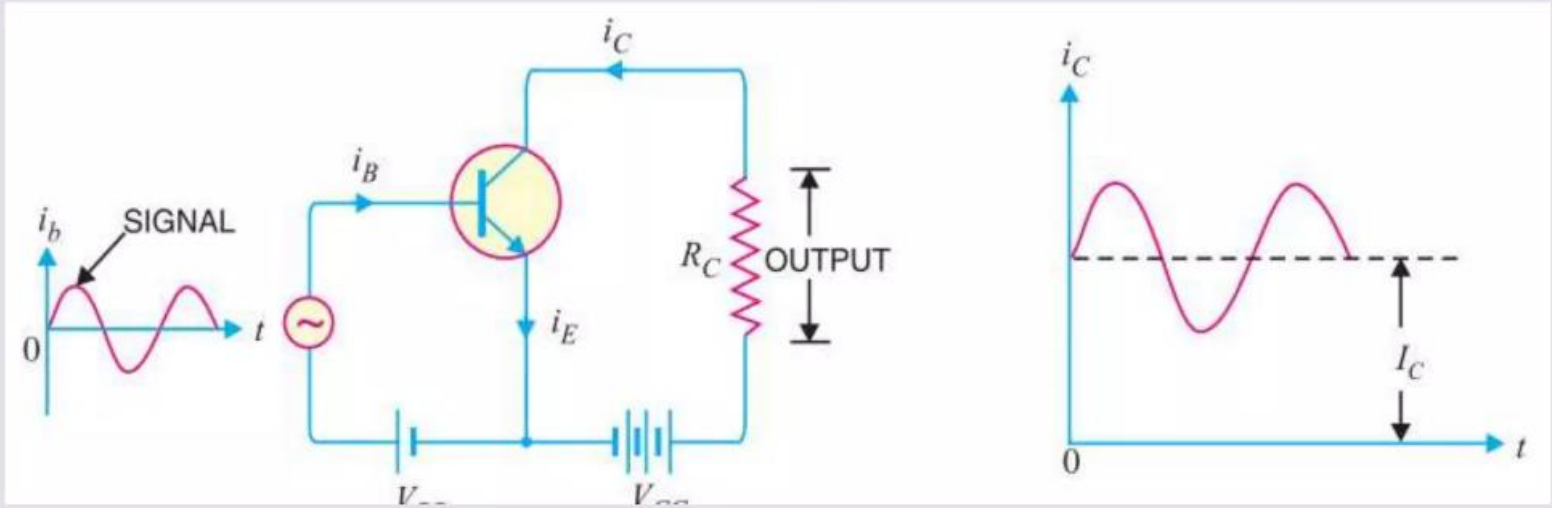
- Saturation Mode

  → Base- Emitter junction is forward and Base-Collector junction is forward biased.

- Cut-off Mode

  → Both junctions are reverse biased.

BJT AS AN AMPLIFIER IN CE CONNECTION

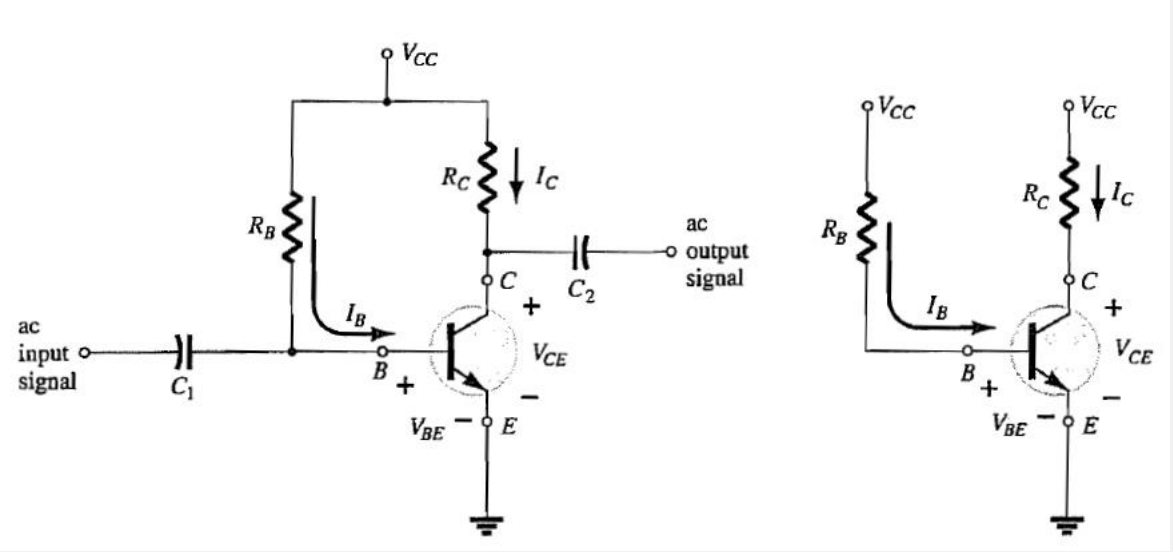


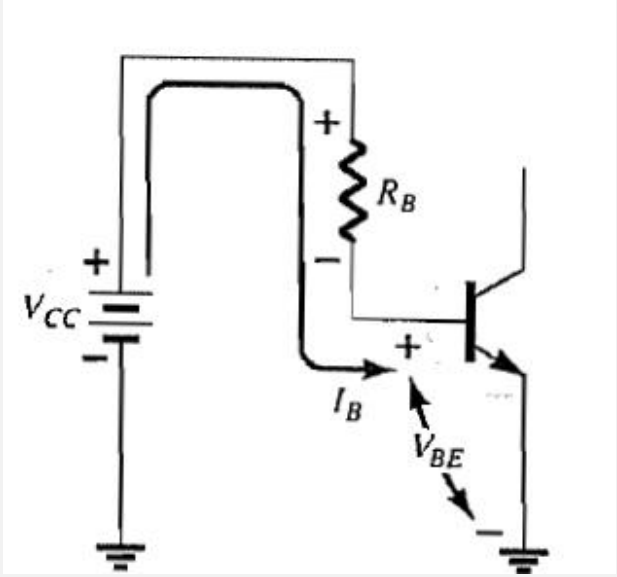
- Figure shows CE amplifier for npn transistor.
- Battery V_{BB} is connected with base in-order to make base forward biased, regardless of input ac polarity.
- Output is taken across Load R

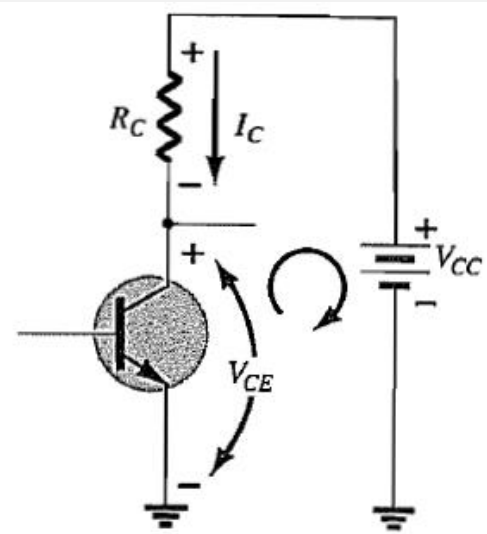
BJT AS AN AMPLIFIER IN CE CONNECTION

- During positive half cycle input ac will keep the emitter-base junction more forward biased. So, more carrier will be emitted by emitter, this huge current will flow through load and we will find output amplified signal.
- During negative half cycle input ac will keep the emitter-base junction less forward biased. So, less carrier will be emitted by emitter. Hence collector current decreases.
- This results in decreased output voltage (In opposite direction).

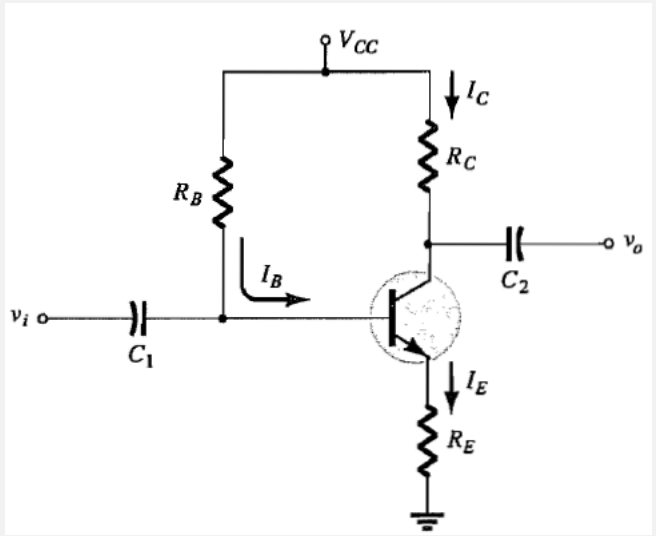
CONNECTIONS OF BJT
FIXED BIAS CONFIGURATION

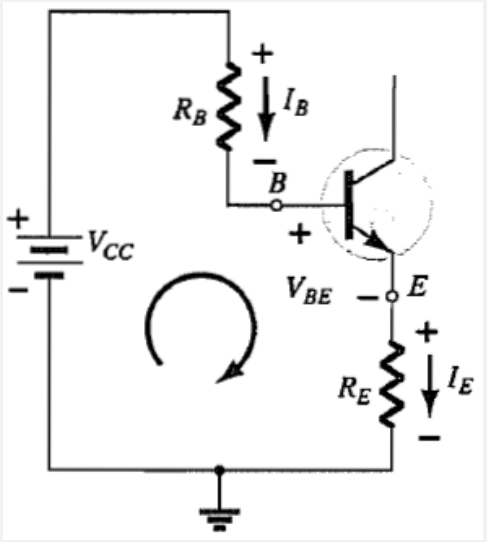


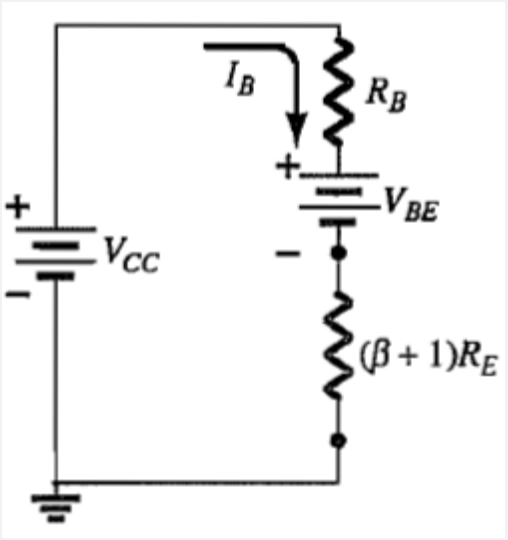


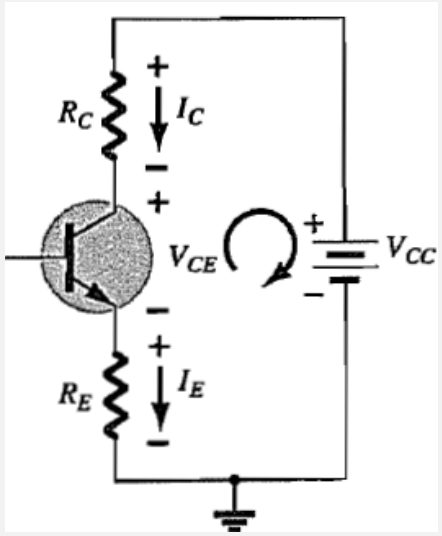


EMITTER BIAS

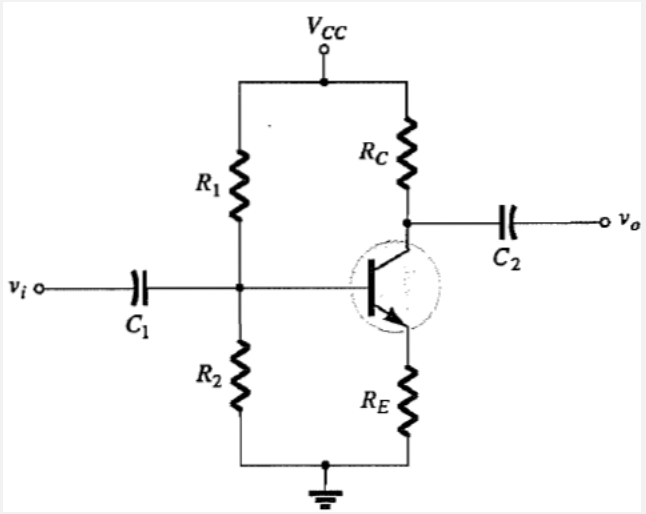


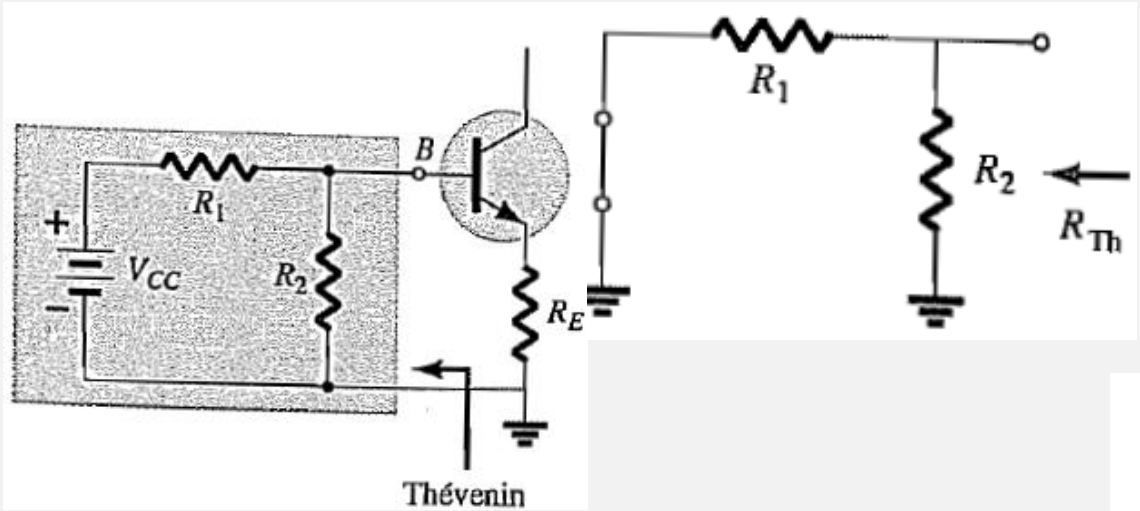


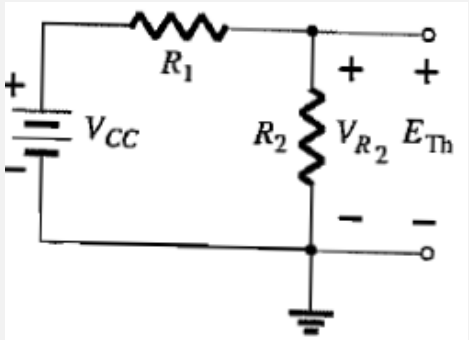


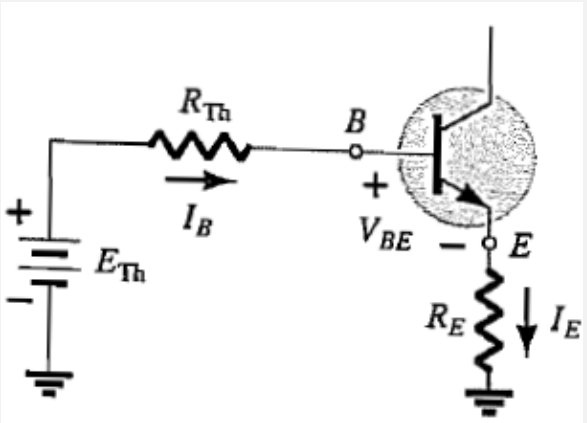


VOLTAGE DIVIDER BIAS









DC BIAS WITH VOLTAGE FEEDBACK