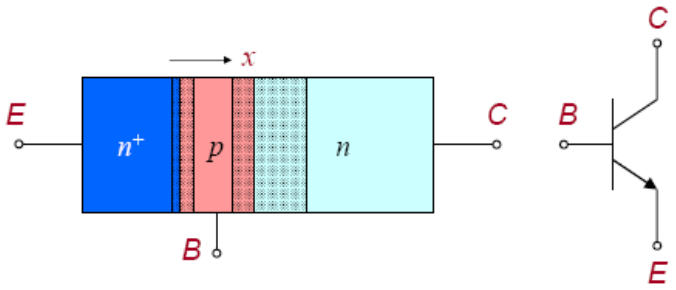
Lecture 16

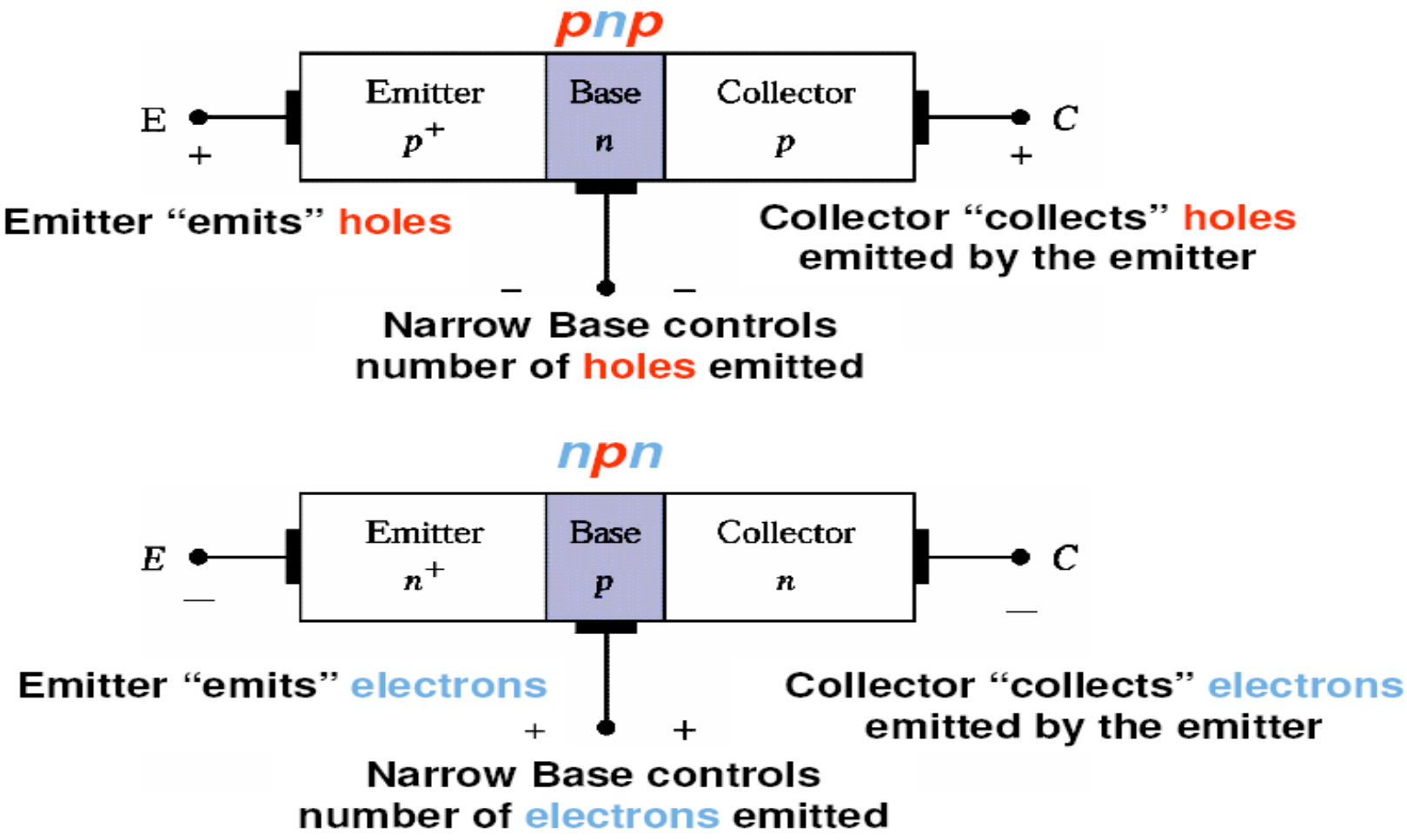
BJT

Terminals & Ope



- Three terminals:
  - Base (B): very thin and lightly doped central region (little recombination).
  - Emitter (E) and collector (C) are two outer regions sandwiching B.
- Normal operation (linear or active region):
  - B-E junction forward biased; B-C junction reverse biased.
  - The emitter emits (injects) majority charge into base region and because the base very thin, most will ultimately reach the collector.
  - The emitter is highly doped while the collector is lightly doped.
  - The collector is usually at higher voltage than the emitter.

Terminals & Operations



Operation Mode

Operation mode	Biasing polarity *B-E* junction	Biasing polarity *B-C* junction
Active	Forward	Reverse
Saturation	Forward	Forward
Cutoff	Reverse	Reverse

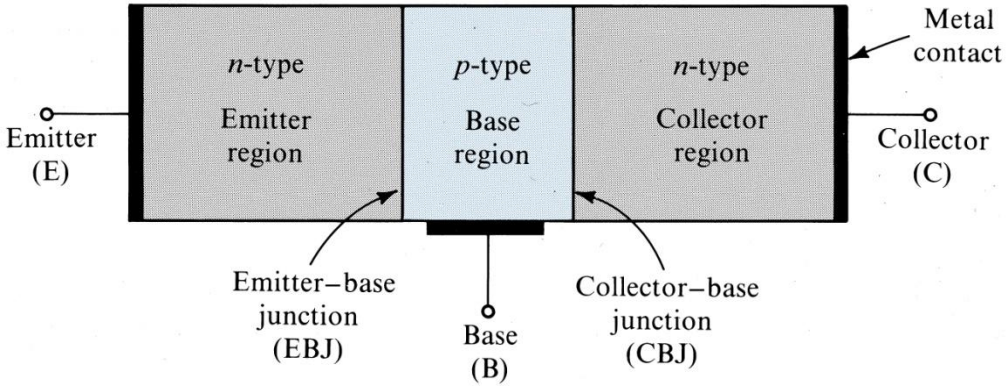
* Note: There is also a mode of operation called inverted (active), which is rarely used.

Active: Most widely encountered operation, e.g., as amplifiers.
Large signal gain, small signal distortion (i-v: flat region)

Saturation: Equivalent to an on state when BJT is used as a Switch
High current flow, Low voltage (in digital circuit "zero" logic level)

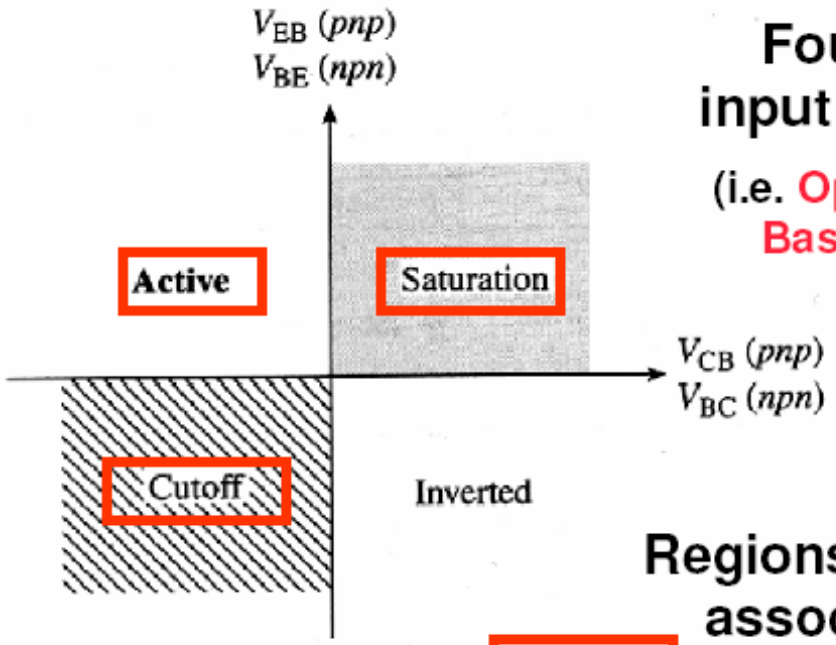
Cutoff: Equivalent to an off state when BJT is used as a Switch
Low current flow, High voltage (in digital circuit "one" logic level)

Operati



- Active:
  - Most importance mode, e.g. for amplifier operation.
  - The region where current curves are practically flat.
- Saturation:
  - Barrier potential of the junctions cancel each other out causing a virtual short.
  - Ideal transistor behaves like a closed switch.
- Cutoff:
  - Current reduced to zero
  - Ideal transistor behaves like an open switch.

Operation Mode

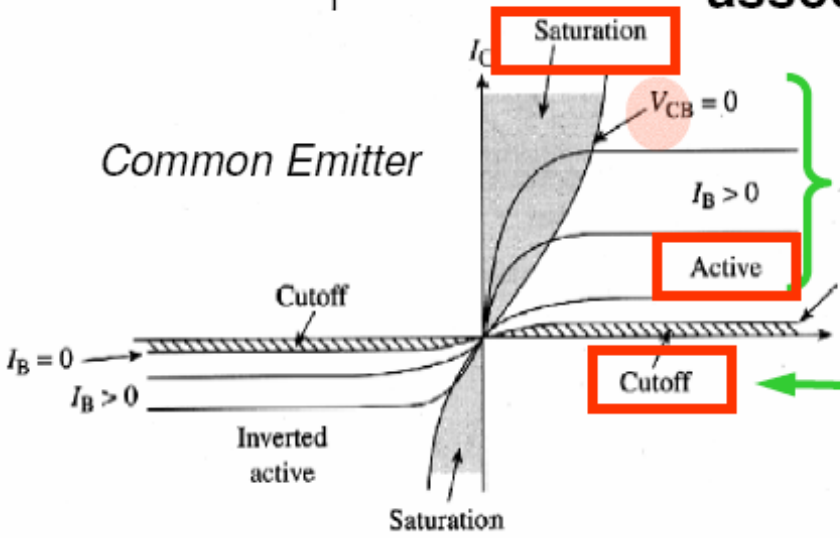


Four BJT operation modes vs. input and output voltage combinations

(i.e. Operational modes can be defined based on Base-Emitter voltage and Base-Collector voltage)

Note: the inverted (active) mode is rarely used!

Regions of the BJT CE output characteristics associate with the four operation modes.

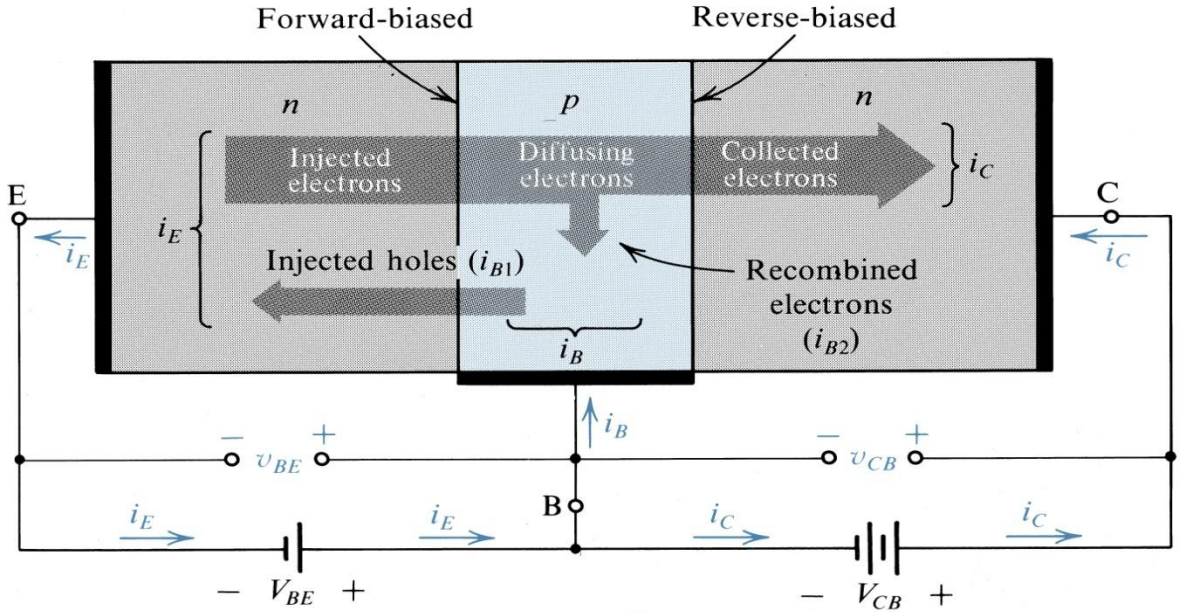


When Base current flows, a Collector current can flow.

The device is then a current controlled current device.

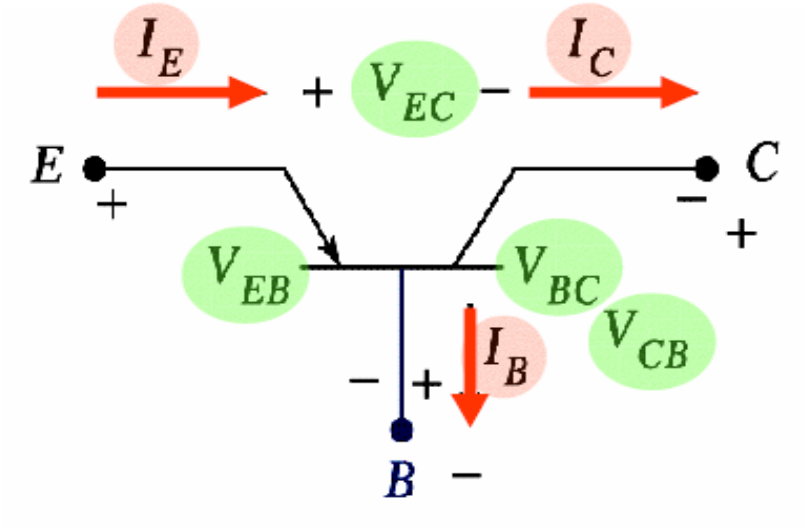
When there is no Base current, almost no Collector current flows.

BJT in Active Mode



- Operation
  - Forward bias of EBJ injects electrons from emitter into base (small number of holes injected from base into emitter)
  - Most electrons shoot through the base into the collector across the reverse bias junction (think about band diagram)
  - Some electrons recombine with majority carrier in (P-type) base region

Circuit Symbols



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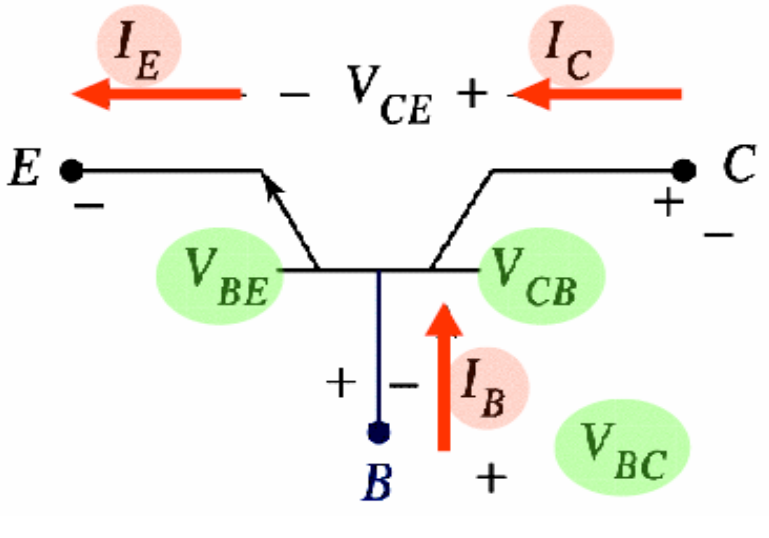

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Two of the currents and two of the voltages are independent.
If two of the currents or voltages are known, third terminal current or voltage is determined.

$$I_E = I_B + I_C$$
$$V_{EB} + V_{BC} + V_{CE} = 0$$

Current flowing into a device
= current flowing out of device

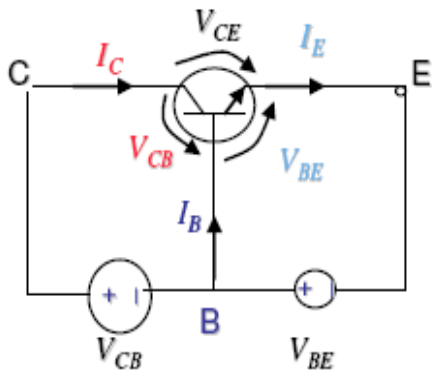
$$(V_{CE} = - V_{EC})$$

Circuit Configuration

Common-Base (CB)

input = V_{EB} & I_E

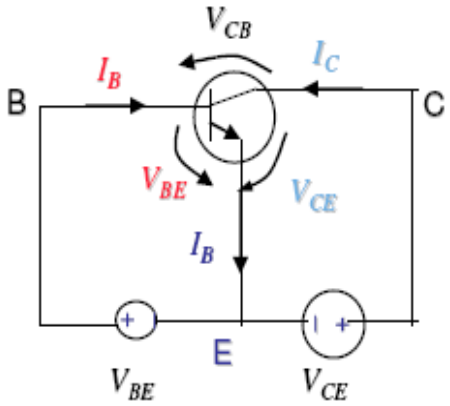
output = V_{CB} & I_C



Common-Emitter (CE)

input = V_{BE} & I_B

output = V_{CE} & I_C



Common-Collector (CC)

input = V_{CB} & I_B

output = V_{CE} & I_E