CSE2209: Digital Electronics and Pulse Techniques

Course Conducted By:

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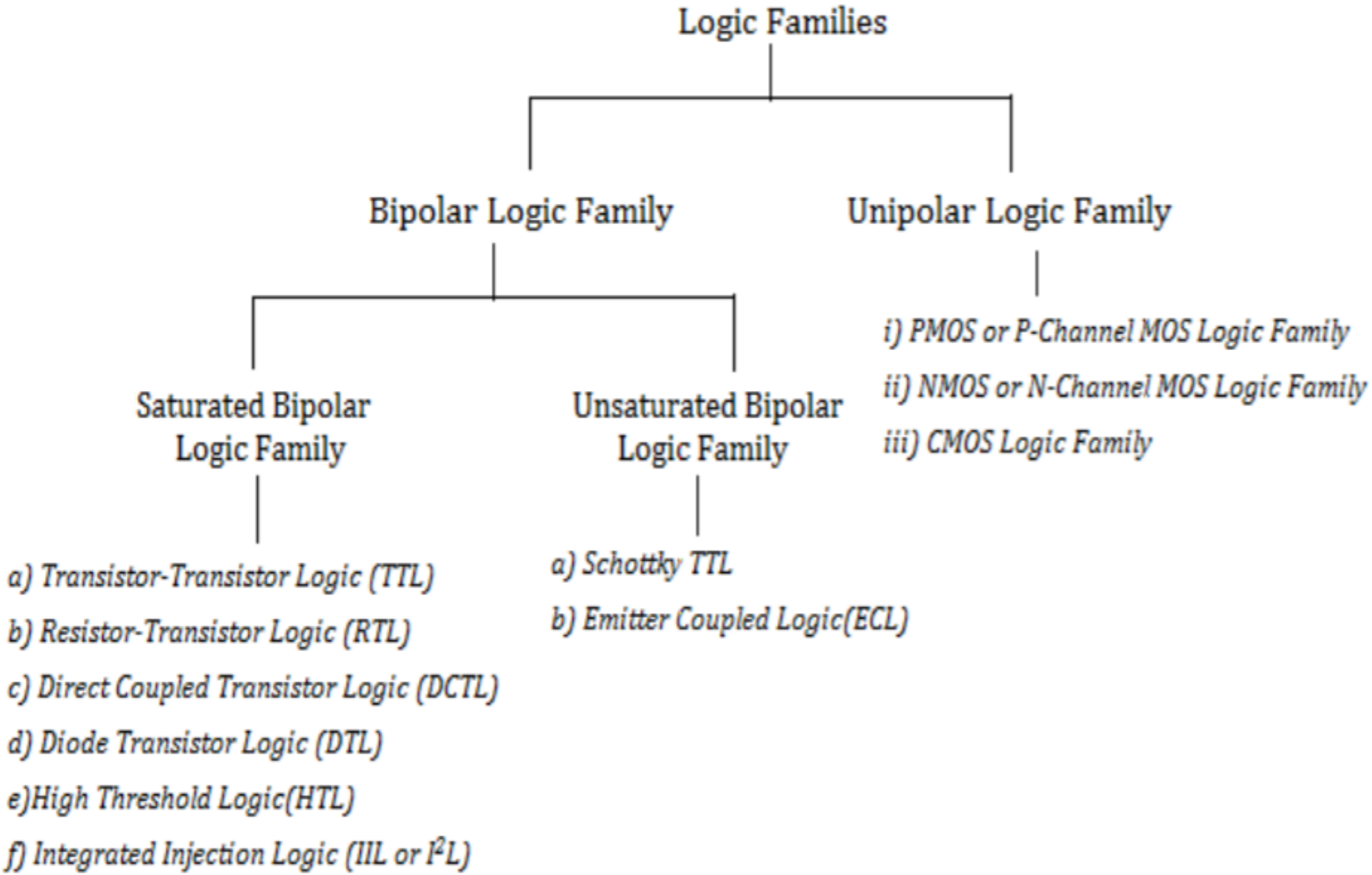
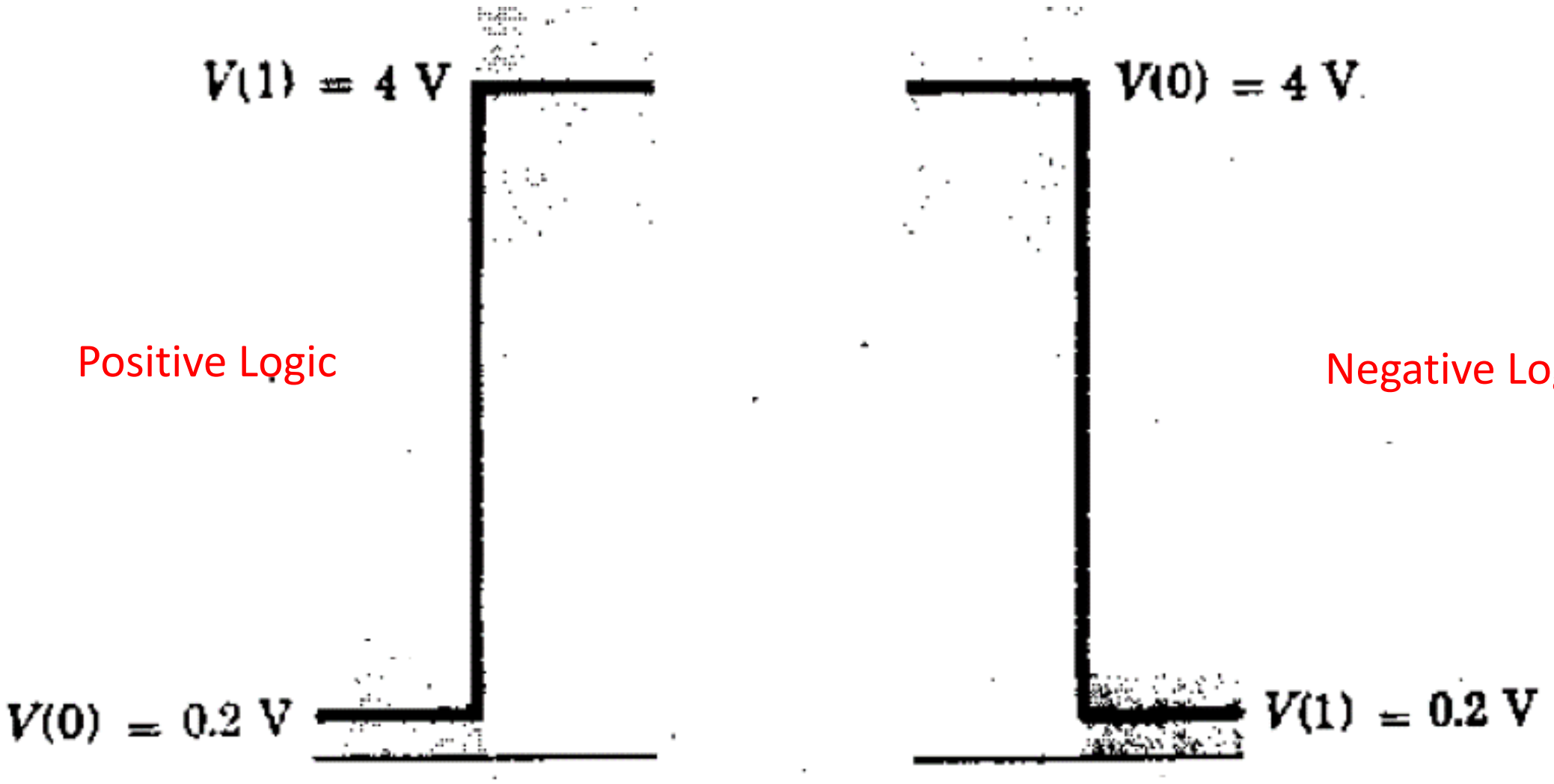

Logic Families
Bipolar Logic Family
Unipolar Logic Family
Saturated Bipolar Logic Family
Unsaturated Bipolar Logic Family
i) PMOS or P-Channel MOS Logic Family
ii) NMOS or N-Channel MOS Logic Family
iii) CMOS Logic Family
a) Transistor-Transistor Logic (TTL)
b) Resistor-Transistor Logic (RTL)
c) Direct Coupled Transistor Logic (DCTL)
d) Diode Transistor Logic (DTL)
e)High Threshold Logic(HTL)
f) Integrated Injection Logic (IIL or I2L)
a) Schottky TTL
b) Emitter Coupled Logic(ECL)

Logic Families

- **Diode Logic (DL)**
- **Diode Transistor Logic (DTL)**
- **Transistor - Transistor Logic (TTL)**
- **Resistor-Transistor Logic (RTL)**
- **Direct Coupled Transistor Logic (DCTL)**
- **Emitter Carbon Logic (ECL)**
- **High Threshold Logic (HTL)**
- **Complementary Metal Oxide Semiconductor Logic (CMOS)**

Logic System


V(1) = 4 V
V(0) = 0.2 V
Positive Logic
V(0) = 4 V
V(1) = 0.2 V
Negative Logic

AND Operation

A	B	V_0
0 V	0 V	0 V
0 V	5 V	0 V
5 V	0 V	0 V
5 V	5 V	5 V

A	B	V_0
V(0)	V(0)	V(0)
V(0)	V(1)	V(0)
V(1)	V(0)	V(0)
V(1)	V(1)	V(1)

Positive Logic

AND Gate

A	B	V_0
V(1)	V(1)	V(1)
V(1)	V(0)	V(1)
V(0)	V(1)	V(1)
V(0)	V(0)	V(0)

Negative Logic

OR Gate

Diode Logic (DL)

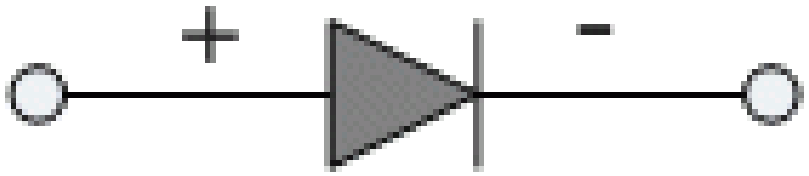
A diode is a terminal electrical device that allows current to flow in one direction.

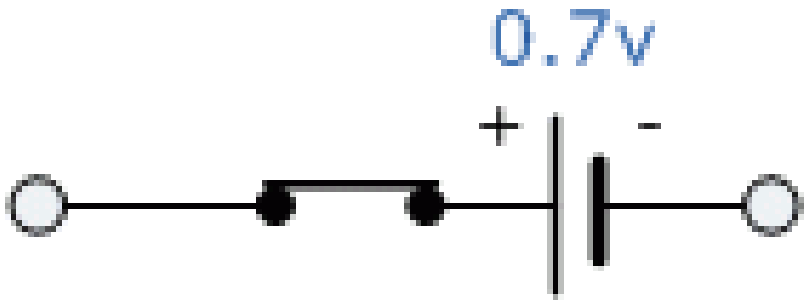
- Registers and diodes are used to implement logic.

- The purpose of diode is to perform OR and AND operation, and logic switch.

- Disadvantages: diodes can not perform NOT operation, diode cannot work for multiple states, states, only one stage at a time, tend to degrade signals quickly.

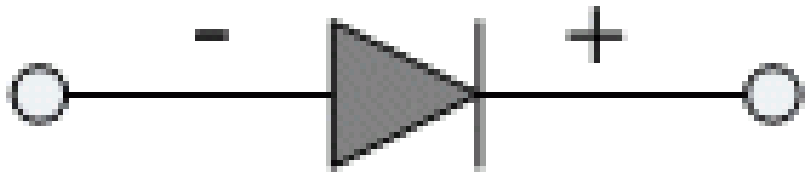
Forward Biased

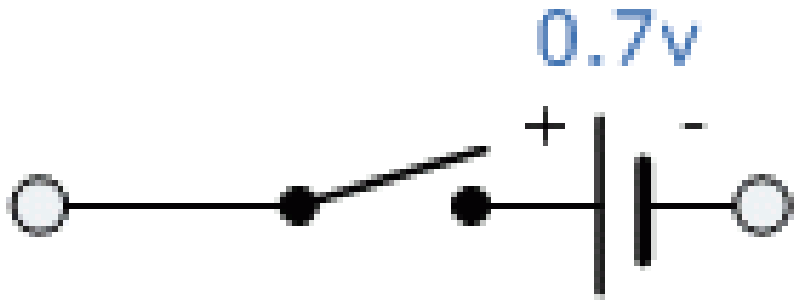




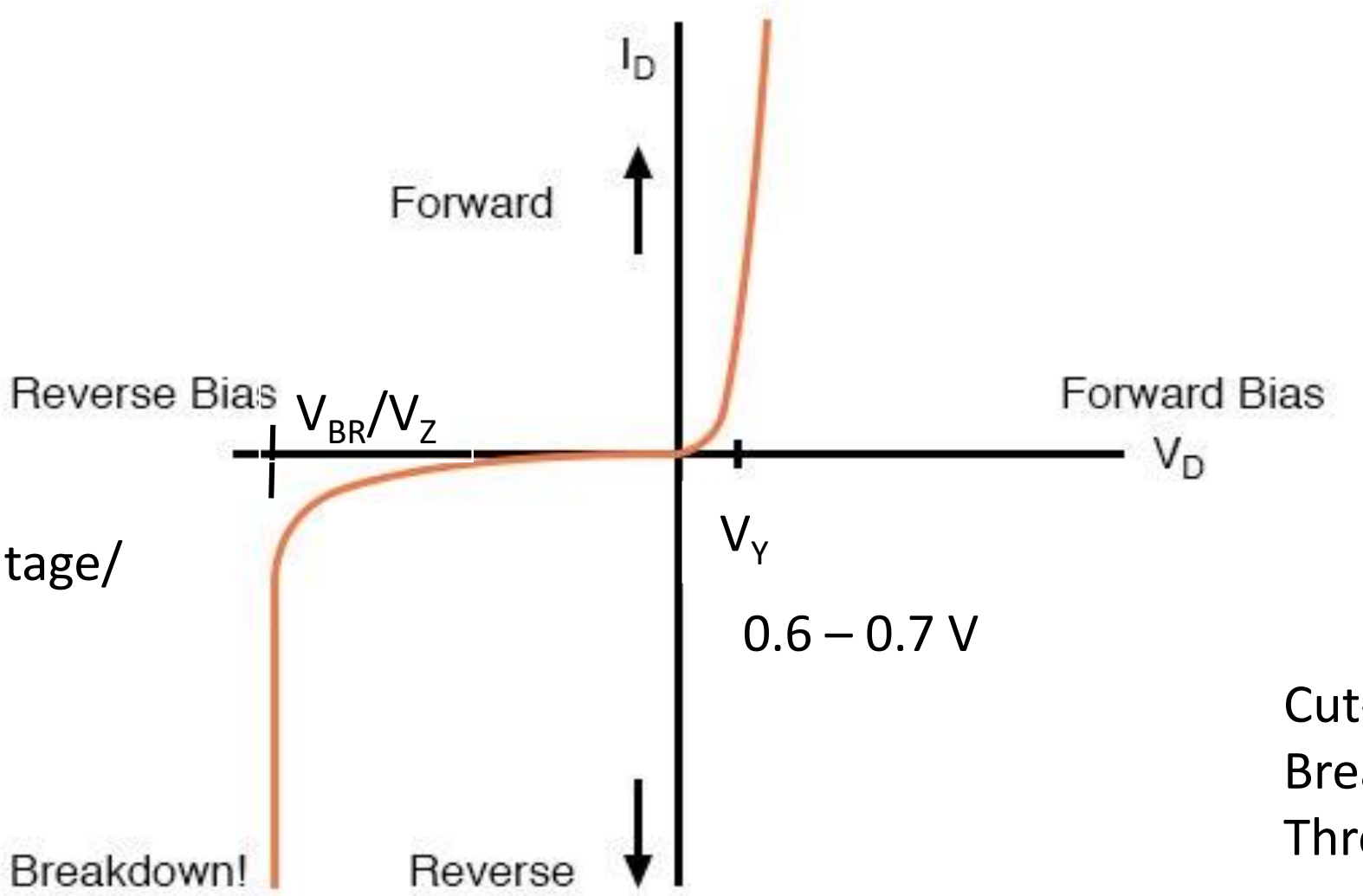
Forward Bias
(switch closed)

Reversed Biased





Reverse Bias
(switch open)



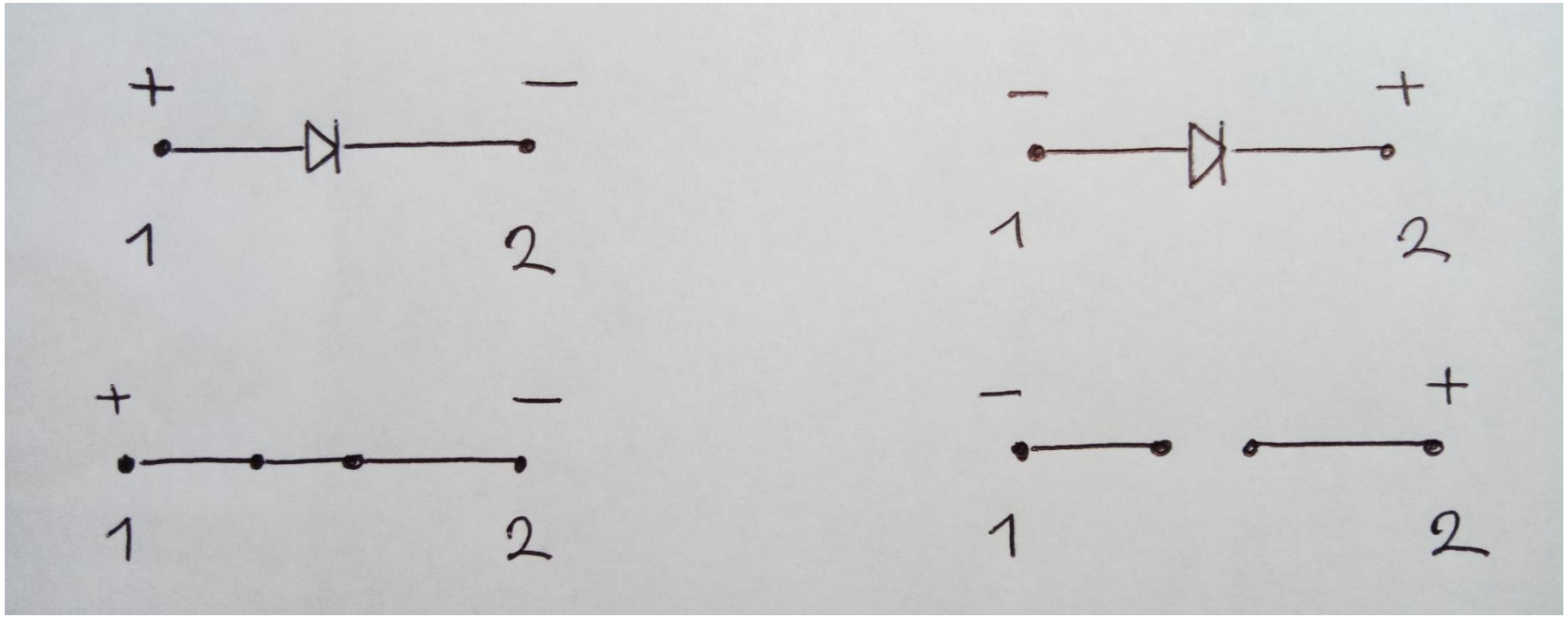
Breakdown voltage/
Zener Voltage

0.6 – 0.7 V

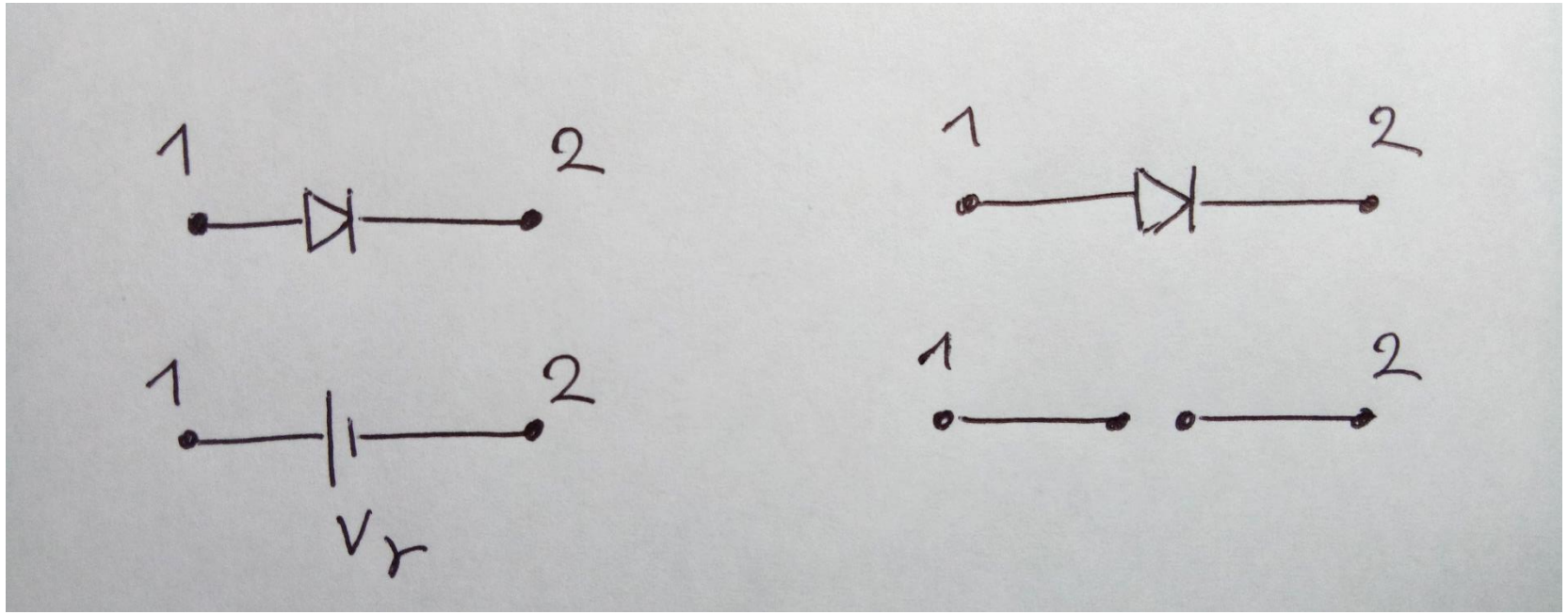
V_Y
Cut-in voltage/
Breakpoint voltage/
Threshold/ offset

V-I characteristics of Silicon Diode

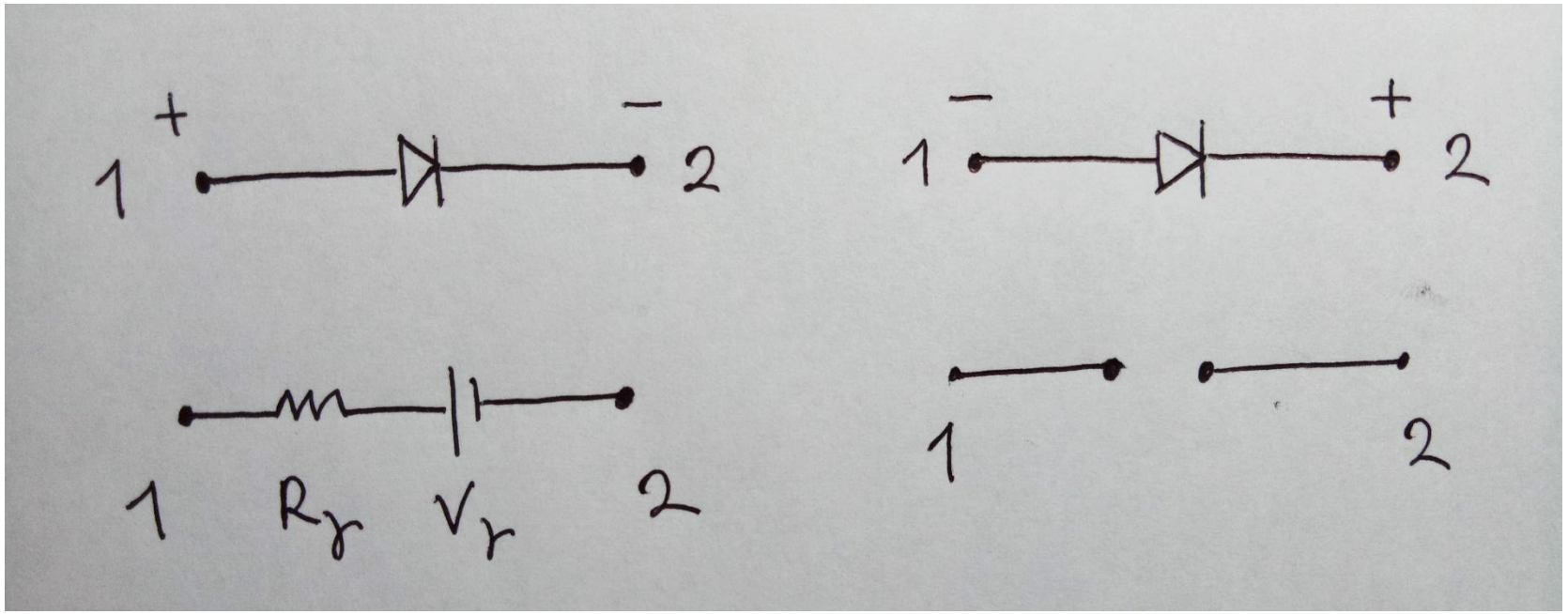
Ideal Case



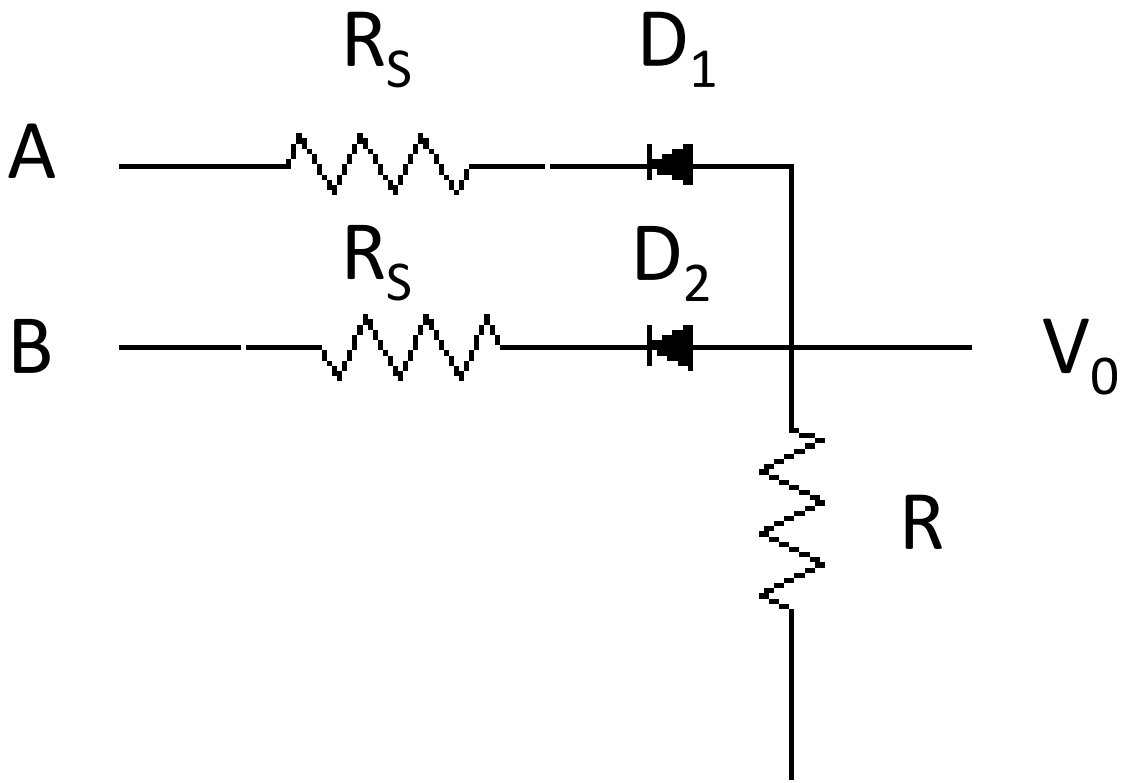
Constant Voltage Source Model



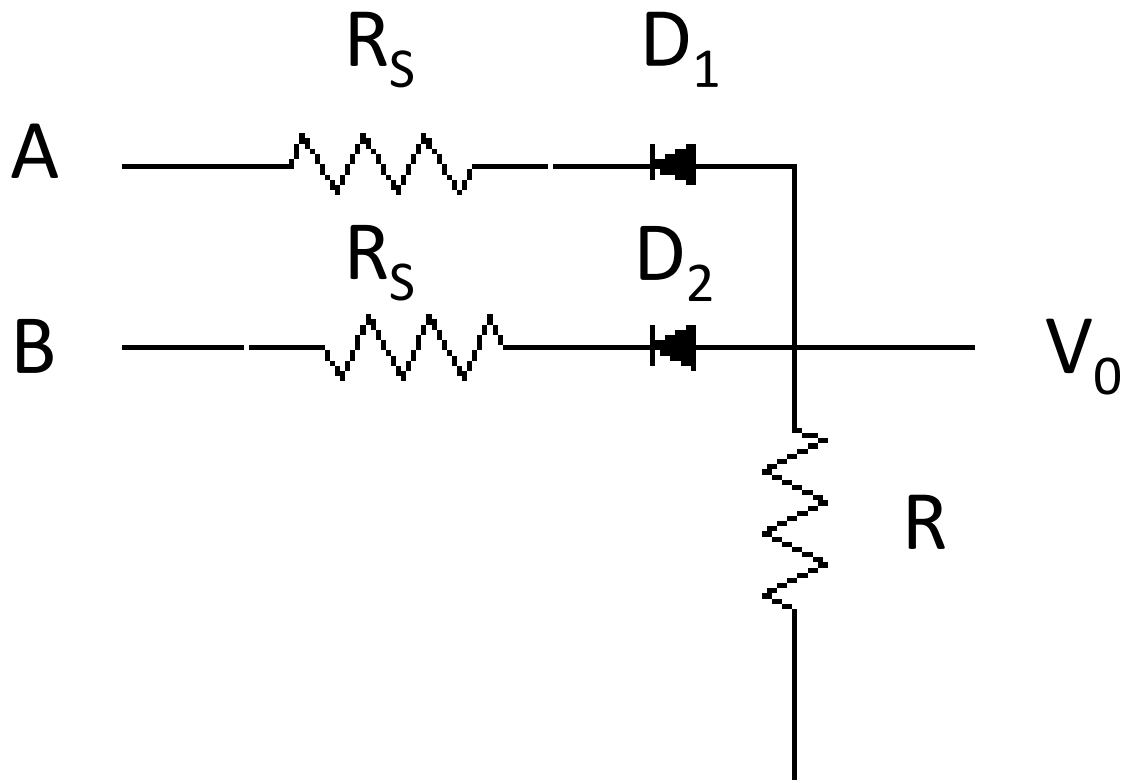
Piece-wise Linear Model



Prove that this circuit works like a negative logic OR gate.



Prove that this circuit works like a positive logic AND gate.



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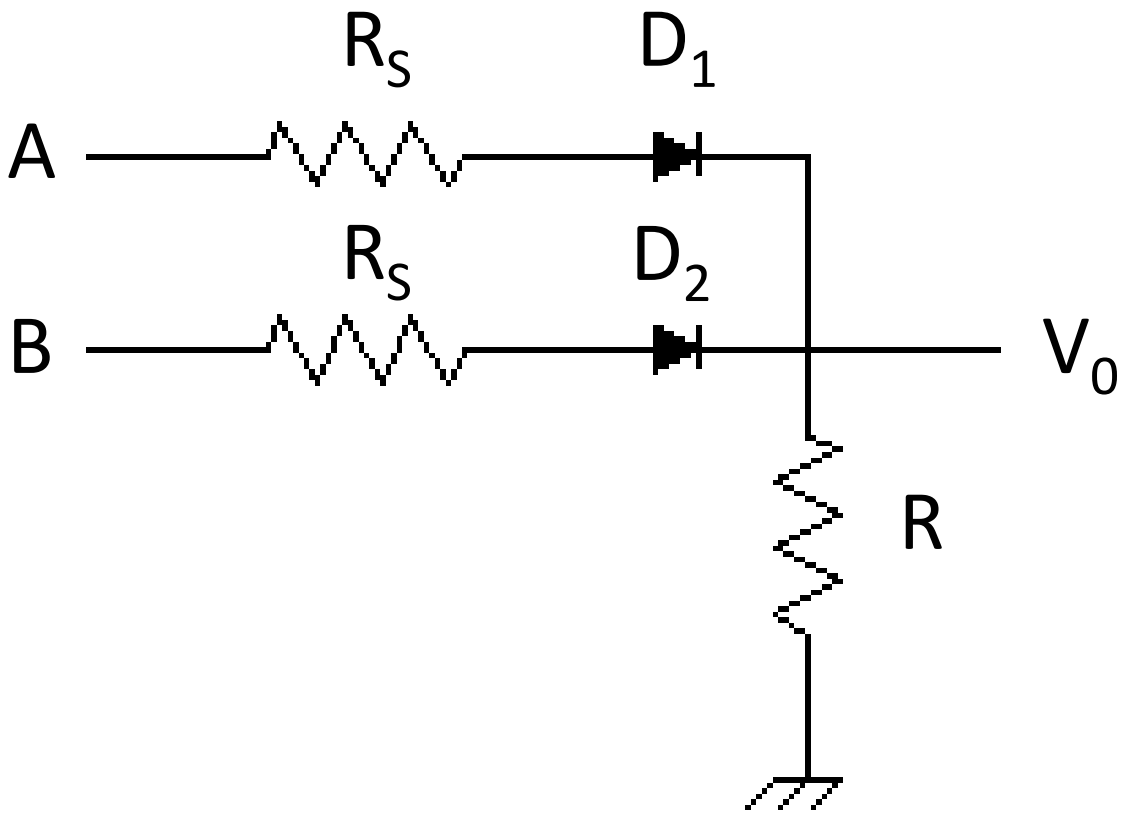
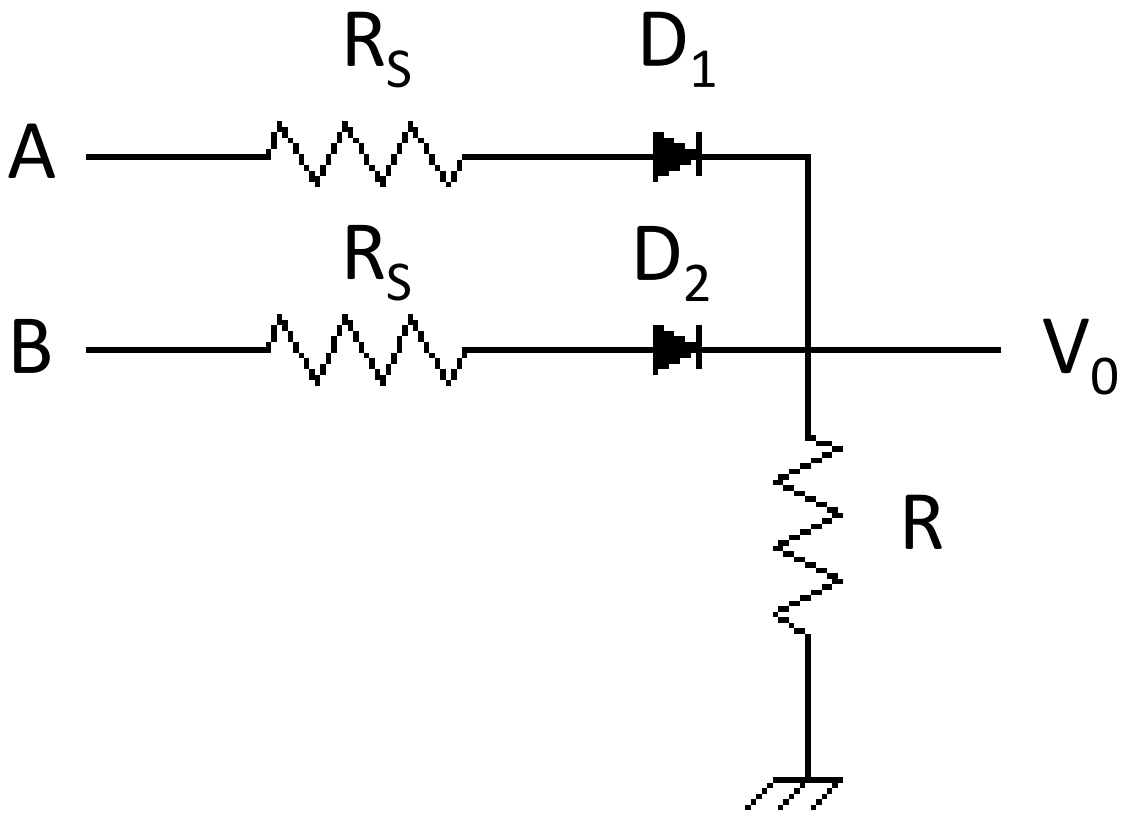


Prove that this circuit works like a positive logic OR gate.

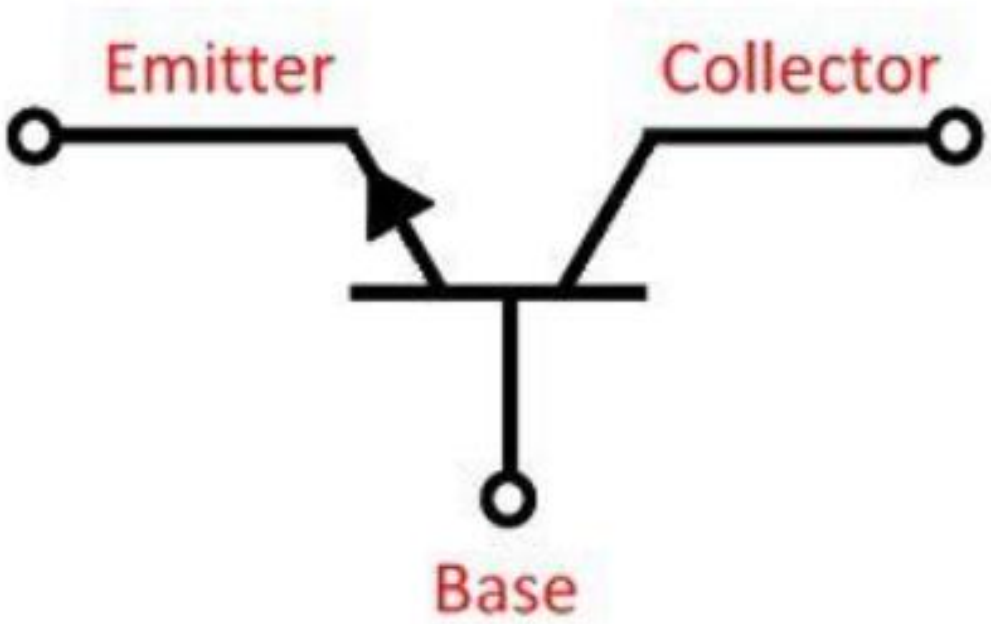


Transistor

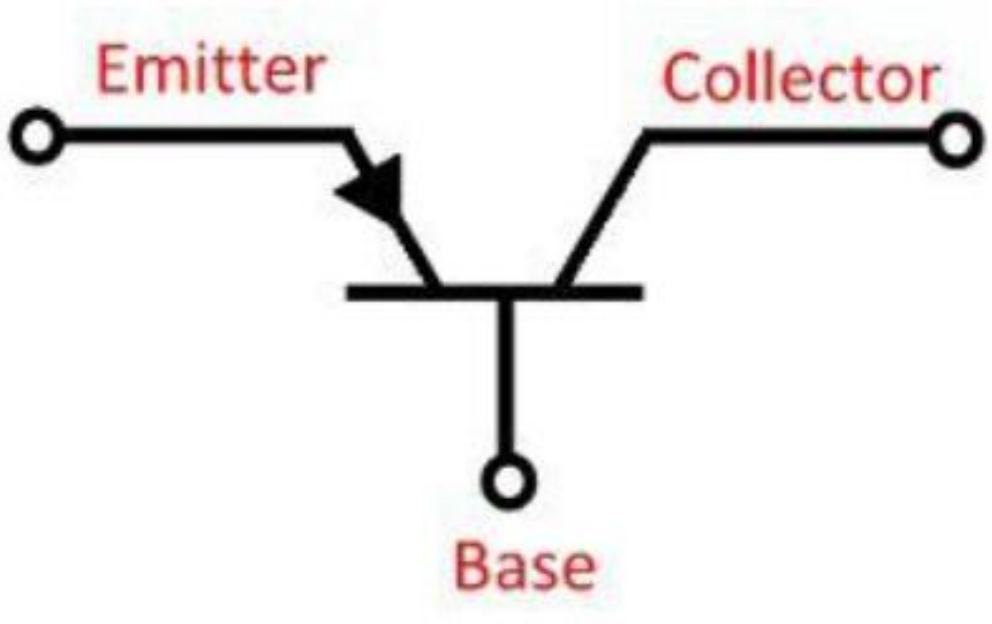
A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power.

There are two types of transistor, namely NPN transistor and PNP transistor.

- The transistor which has two blocks of n-type semiconductor material and one block of P-type semiconductor material is known as NPN transistor.
- Similarly, if the material has one layer of N-type material and two layers of P-type material then it is called PNP transistor.



NPN Transistor

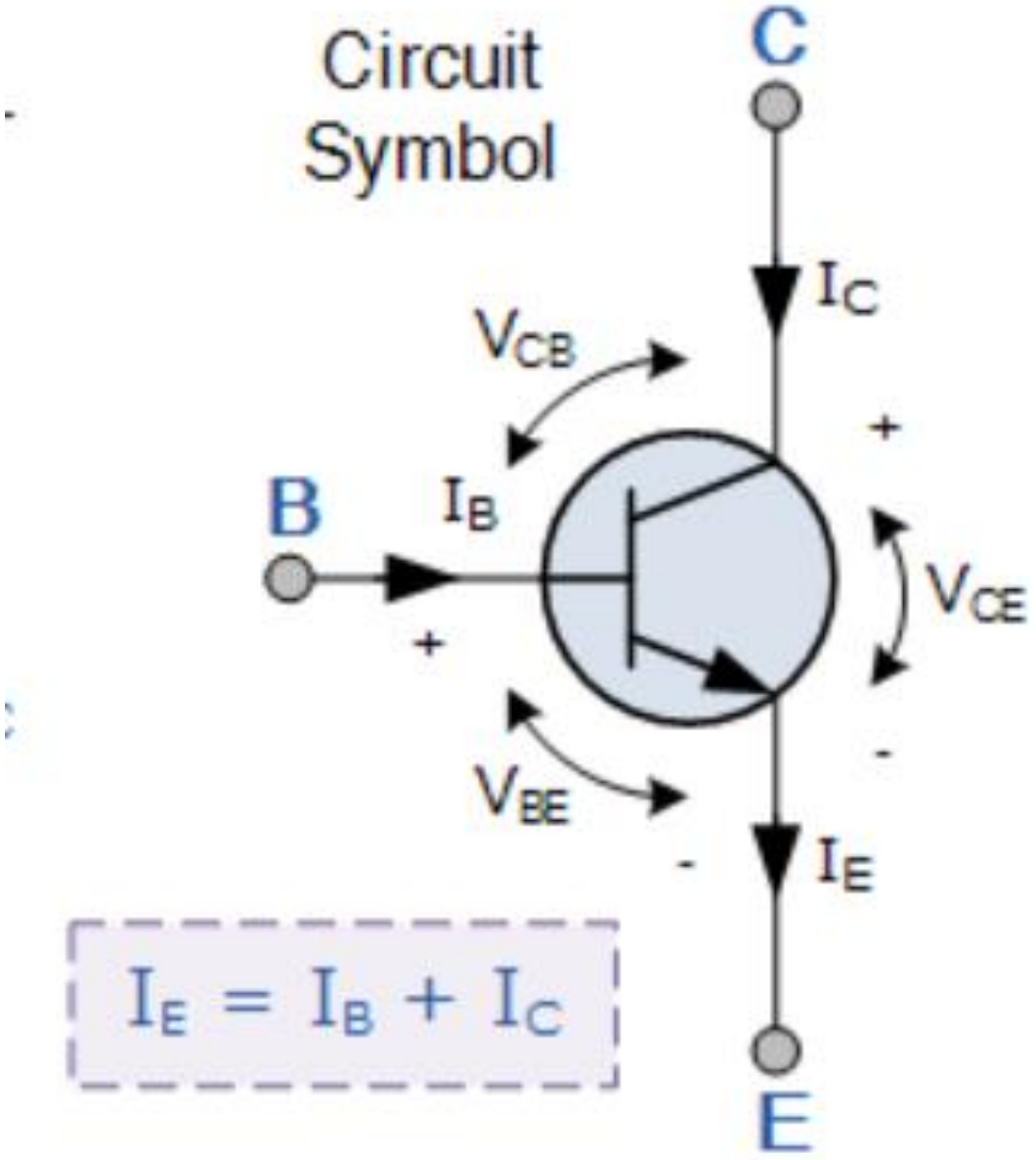


PNP Transistor

Circuit Globe

Common Emitter Gain,

$h_{fe} = \frac{I_c}{I_B}$



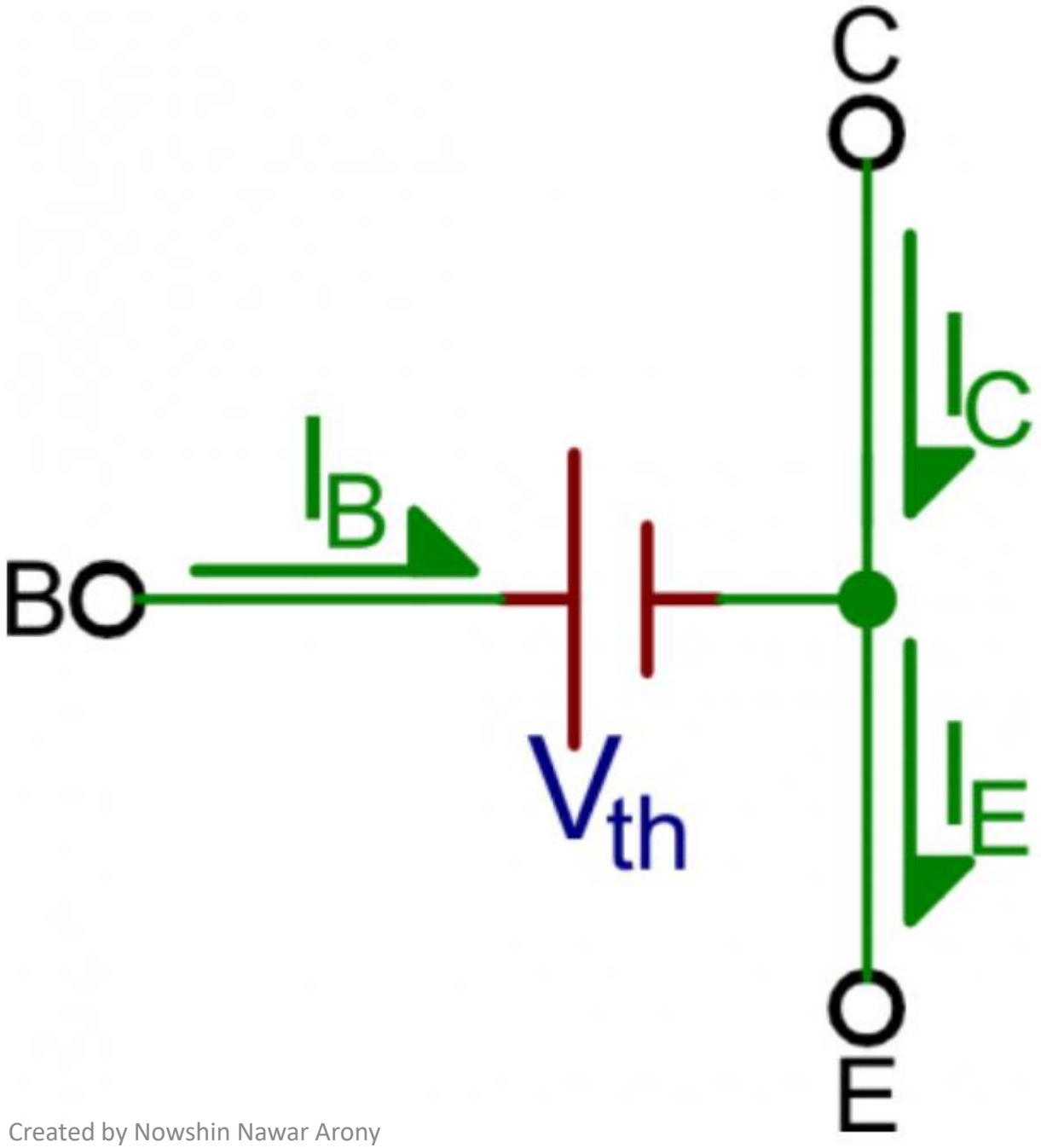
Transistor Operation Modes

Four distinct modes of operation-

- Saturation -- The transistor acts like a short circuit. Current freely flows from collector to emitter.
- Cut-off -- The transistor acts like an open circuit. No current flows from collector to emitter.
- Active -- The current from collector to emitter is proportional to the current flowing into the base.
- Reverse-Active -- Like active mode, the current is proportional to the base current, but it flows in reverse. Current flows from emitter to collector.

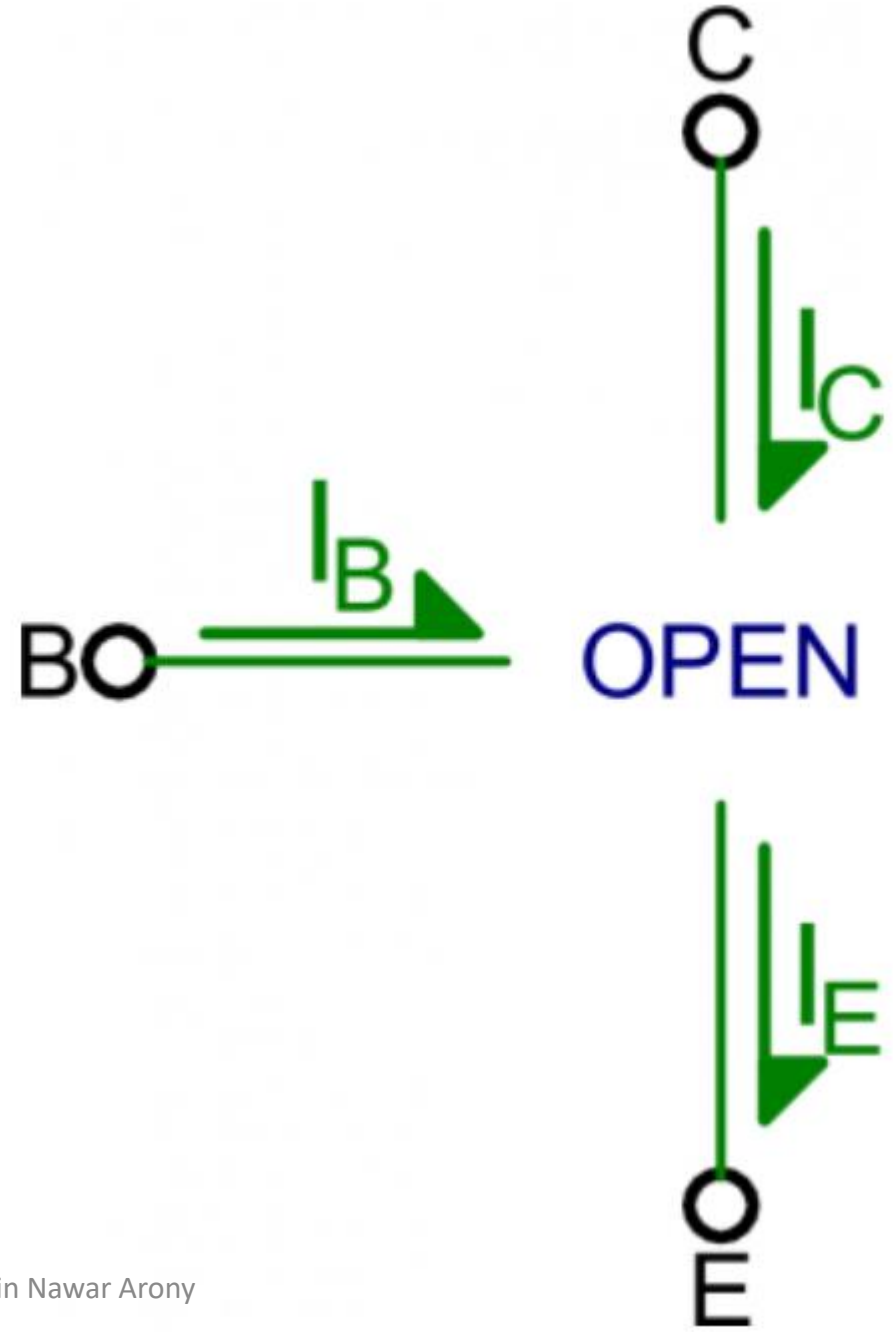
Saturation Mode

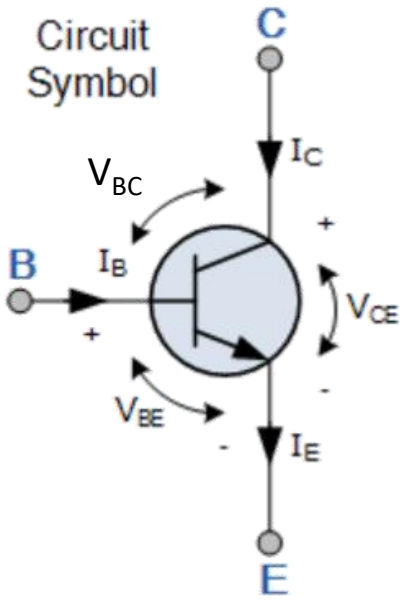
Saturation is the on mode of a transistor. A transistor in saturation mode acts like a short circuit between collector and emitter.



Cutoff Mode

Cutoff mode is the opposite of saturation. A transistor in cutoff mode is off -- there is no collector current, and therefore no emitter current. It almost looks like an open circuit.





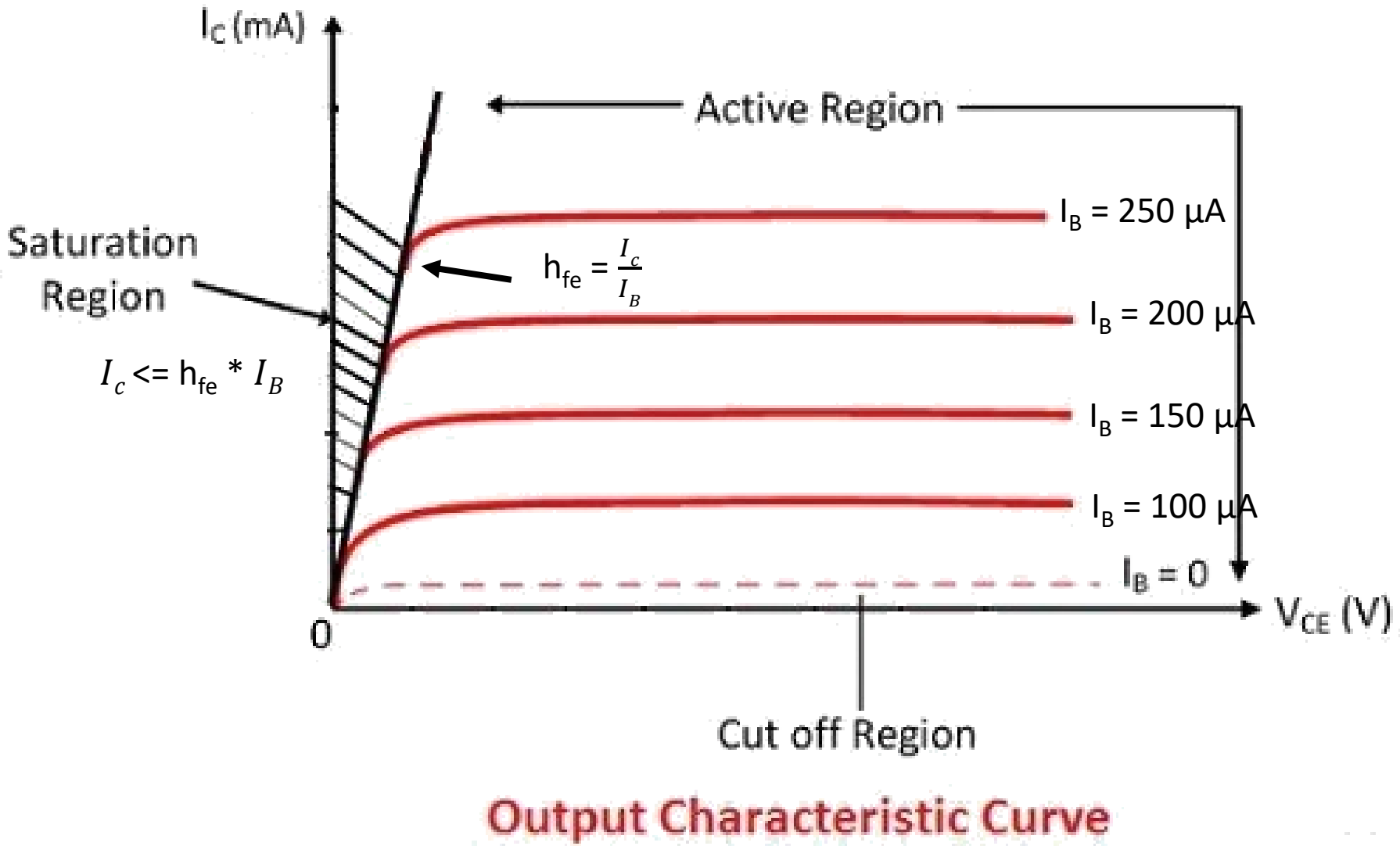
BE	BC	Transistor State
(V_{BE} < 0.7V) R	(V_{BC} < 0.7V) R	Cut off $I_C = I_B = I_E = 0$
(V_{BE} > 0.7V) F	(V_{BC} < 0.7V) R	Active $I_C = h_{fe} * I_B$
(V_{BE} < 0.7V) R	(V_{BC} > 0.7V) F	Inverse active
(V_{BE} > 0.7V) F	(V_{BC} > 0.7V) F	Saturation $I_C <= h_{fe} * I_B$ V_{CE} (sat) = 0.2V V_{BE} (sat) = 0.8V

Table 3-1 Typical *n-p-n* transistor-junction voltages† at 25°C

Material	$V_{CE(sat)}$	$V_{BE(sat)} \equiv V_\sigma$	$V_{BE(active)}$	$V_{BE(cutin)} \equiv V_\gamma$	$V_{BE(cutoff)}$
Si	0.2	0.8	0.7	0.5	0.0
Ge	0.1	0.3	0.2	0.1	−0.1

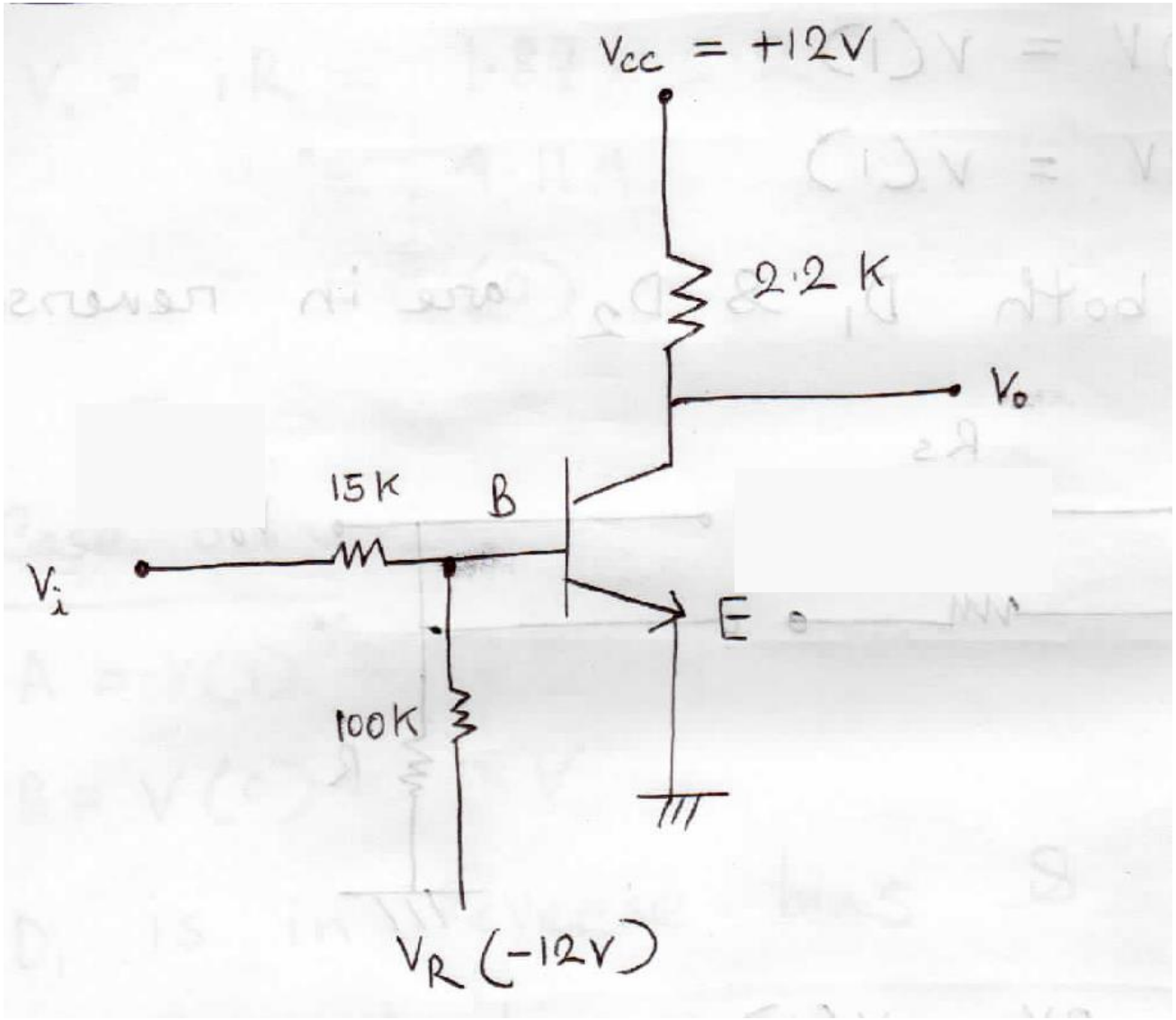
Pg = 79 in Book

Output characteristics of npn transistor



Transistorized NOT Gate (Positive Logic)

- Prove that the circuit works like a positive logic NOT gate.
- Find the minimum value of h_{fe} for proper operation of the circuit.



DTL Positive Logic NAND Gate

- Prove that the circuit works like a positive logic NAND gate.
- Prove that the circuit works like a negative logic NOR gate.
- Find the minimum value of h_{fe} and mode operation of the circuit.