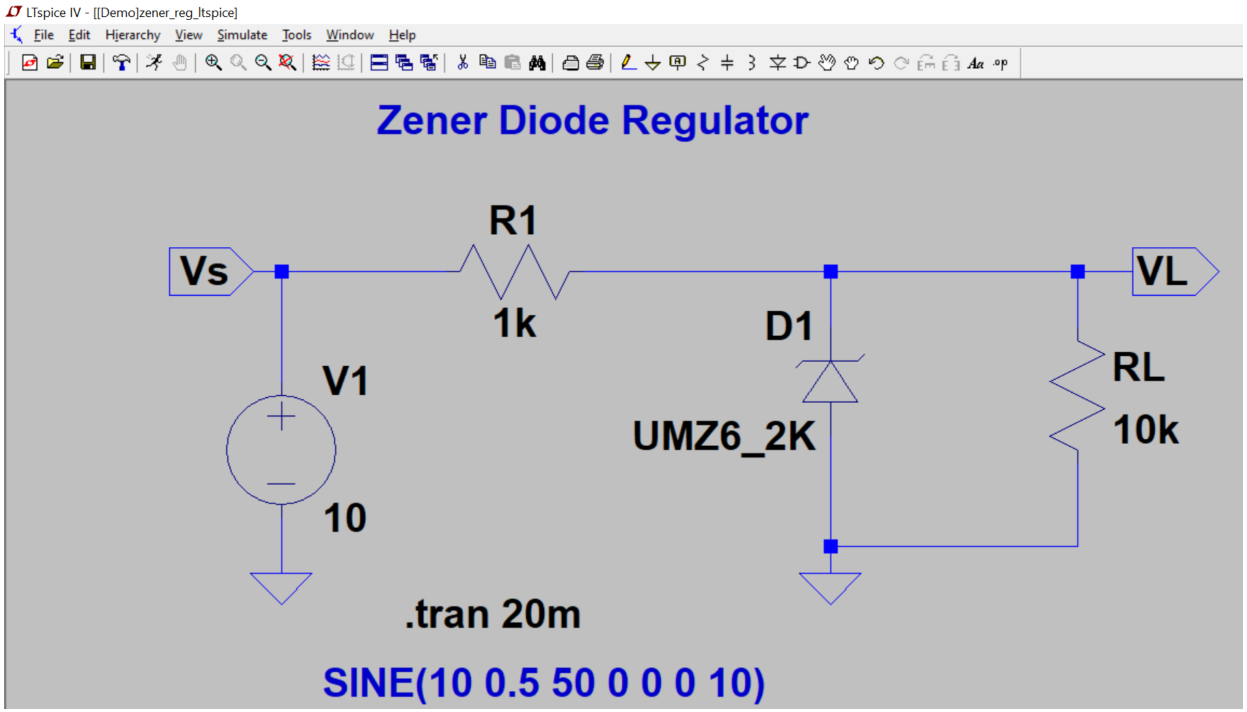
Week 5

Supplementation

Diode applications

Zener Diode



$V_Z = 6.2$ V
I_{R1} = ?
I_{RL} = ?

Note: .op

```
--- Operating Point ---

V(vl):   6.19223       voltage
V(vs):   10      voltage
I(D1):   -0.00318854   device_current
I(Rl):   0.000619223   device_current
I(R1):   -0.00380777   device_current
I(V1):   -0.00380777   device_current
```

EDZV6.2B

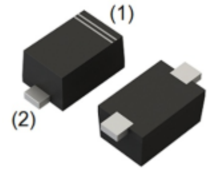
Zener Diode

Data sheet

P_D	150	mW

● Outline

Package Code	SOD-523
JEITA Code	SC-79
ROHM Code	EMD2

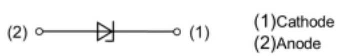


● Feature

High reliability

Small mold type

● Inner Circuit



● Application

Voltage regulation

● Packaging Specification

Packing	Embossed Tape
Reel Size(mm)	180
Taping Width(mm)	8
Quantity(pcs)	8000
Taping Code	T2R
Marking	E2

● Structure

Silicon Epitaxial Planar

● Absolute Maximum Rating (T_a = 25℃)

Parameter	Symbol	Limits	Unit
Power dissipation	P_D	150	mW
Junction temperature	T_j	150	℃
Storage temperature	T_{stg}	-55 ~ 150	℃

EDZV Series

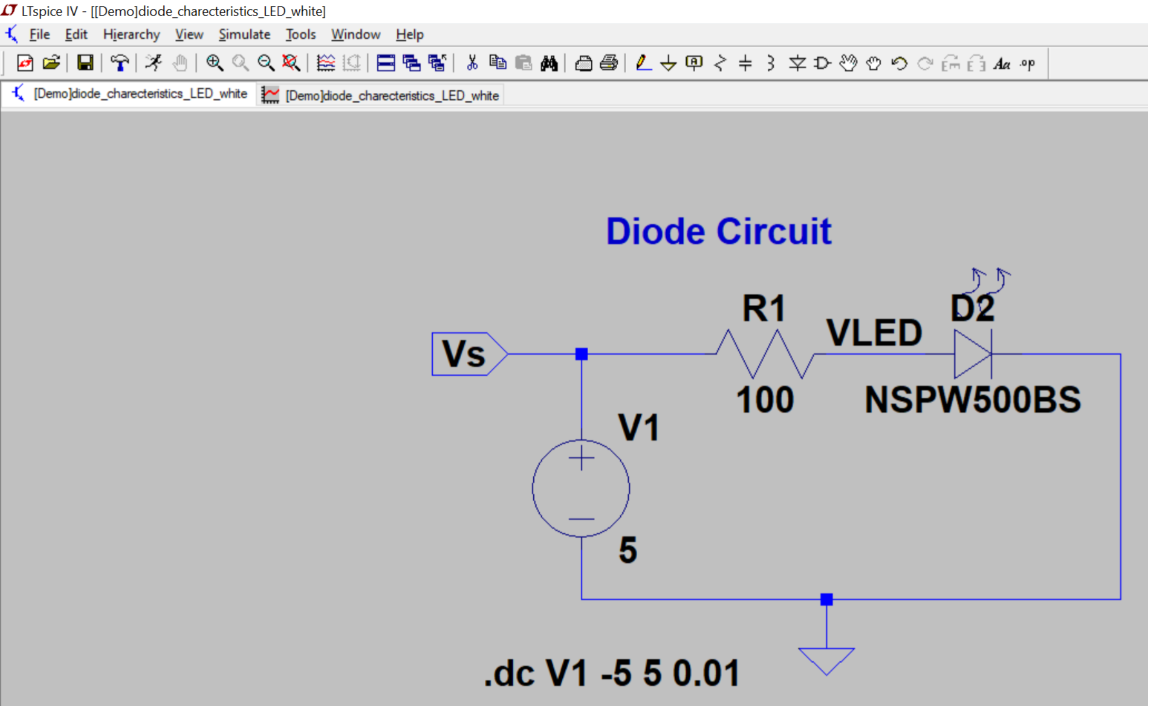
Data sheet

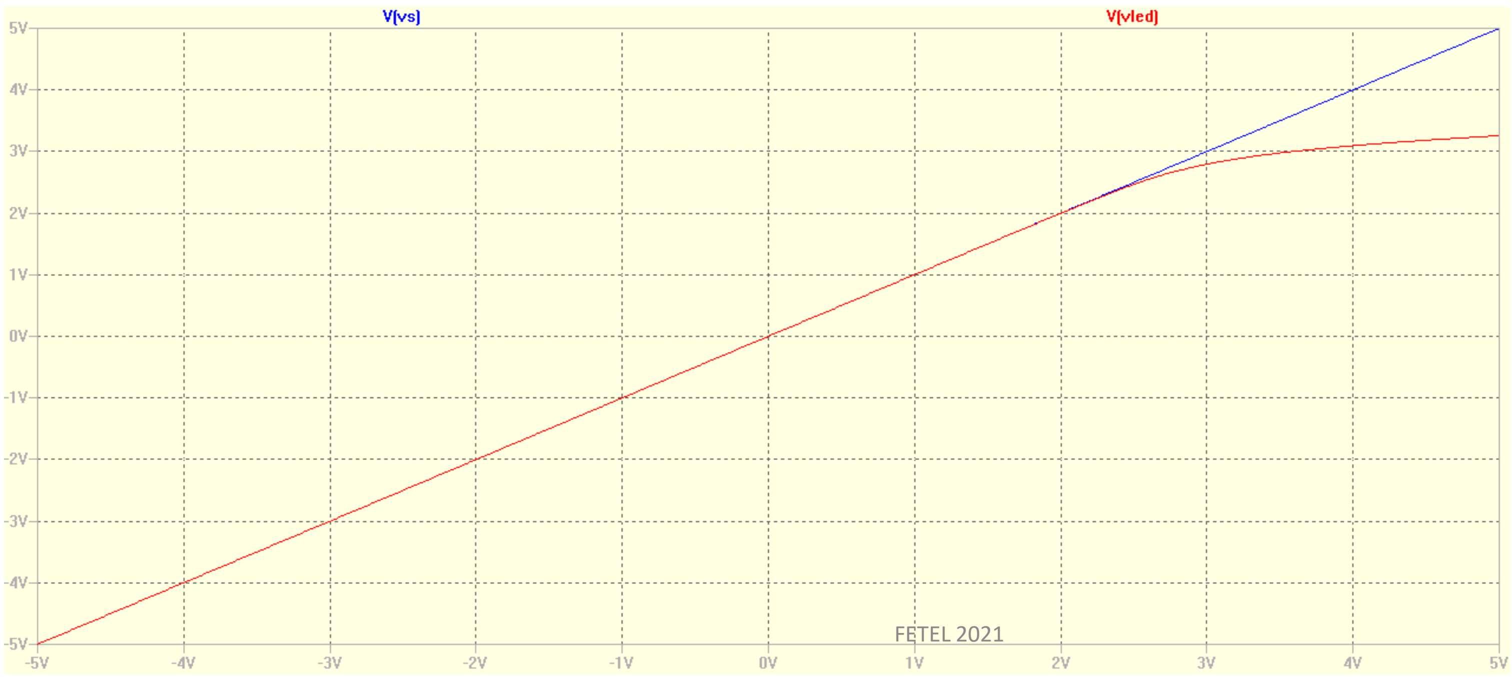
● Characteristic (T_a = 25ºC)

P/N	Zener Voltage: V_Z(V)			Dynamic Impedance: Z_Z(Ω)		Zener Impedance: Z_{ZK}(Ω)		Reverse Current: I_R(μA)	
	MIN.	MAX.	I_Z(mA)	MAX.	I_Z(mA)	MAX.	I_Z(mA)	MAX.	V_R(V)
EDZV 2.0B	2.020	2.200	5.0	100	5.0	1000	0.5	120	0.5
EDZV 2.2B	2.220	2.410	5.0	100	5.0	1000	0.5	120	0.7
EDZV 2.4B	2.430	2.630	5.0	100	5.0	1000	0.5	120	1.0
EDZV 2.7B	2.690	2.910	5.0	110	5.0	1000	0.5	100	1.0
EDZV 3.0B	3.010	3.220	5.0	120	5.0	1000	0.5	50.0	1.0
EDZV 3.3B	3.320	3.530	5.0	120	5.0	1000	0.5	20.0	1.0
EDZV 3.6B	3.600	3.845	5.0	100	5.0	1000	1.0	10.0	1.0
EDZV 3.9B	3.890	4.160	5.0	100	5.0	1000	1.0	5.0	1.0
EDZV 4.3B	4.170	4.430	5.0	100	5.0	1000	1.0	5.0	1.0
EDZV 4.7B	4.550	4.750	5.0	100	5.0	800	0.5	2.0	1.0
EDZV 5.1B	4.980	5.200	5.0	80	5.0	500	0.5	2.0	1.5
EDZV 5.6B	5.490	5.730	5.0	60	5.0	200	0.5	1.0	2.5
EDZV 6.2B	6.060	6.330	5.0	60	5.0	100	0.5	1.0	3.0

LED Diode

How to choose R1?





SPECIFICATIONS FOR NICHIA **WHITE** LED

MODEL : **NSPW500GS-K1**

1.SPECIFICATIONS

(1) Absolute Maximum Ratings

(Ta=25°C)

Item	Symbol	Absolute Maximum Rating	Unit
Forward Current	I_F	30	mA
Pulse Forward Current	I_{FP}	100	mA
Reverse Voltage	V_R	5	V
Power Dissipation	P_D	105	mW
Operating Temperature	T_{opr}	-30 ~ + 85	°C
Storage Temperature	T_{stg}	-40 ~ +100	°C
Soldering Temperature	T_{sld}	265°C for 10sec.	

I_{FP} Conditions : Pulse Width ≦ 10msec. and Duty ≦ 1/10

(2) Initial Electrical/Optical Characteristics

(Ta=25°C)

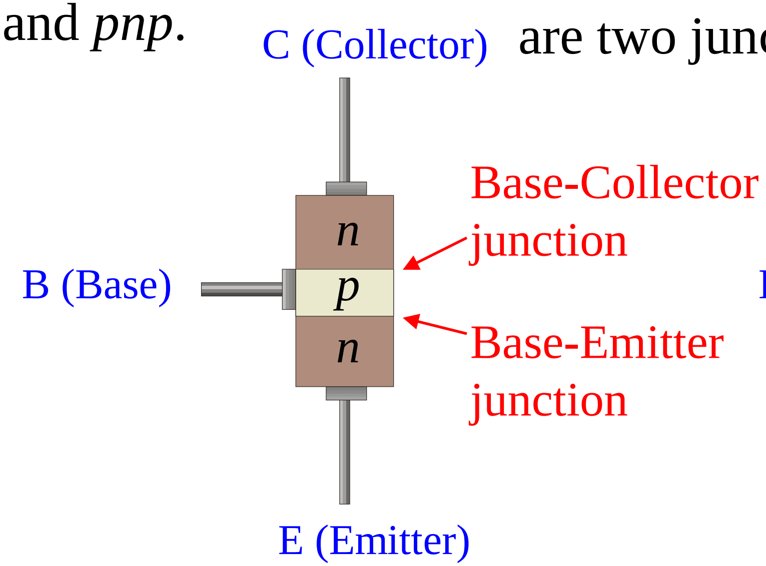
Item		Symbol	Condition	Typ.	Max.	Unit
Forward Voltage		V_F	I_F=20[mA]	(3.2)	3.5	V
Reverse Current		I_R	V_R= 5[V]	-	50	µA
Luminous Intensity		I_V	I_F=20[mA]	(30000)	-	mcd
Chromaticity Coordinate *	x	-	I_F=20[mA]	0.31	-	-
	y	-	I_F=20[mA]	0.32	-	-

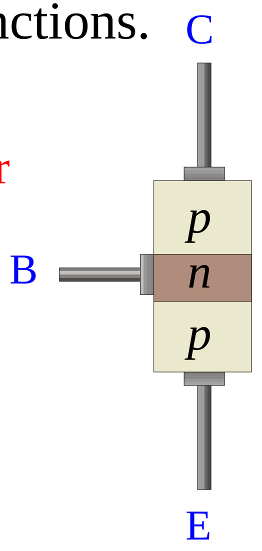
Bipolar junction transistors (BJTs)

The BJT is a transistor with three regions and two *pn* junctions. The regions are named the **emitter**, the **base**, and the **collector** and each is connected to a lead.

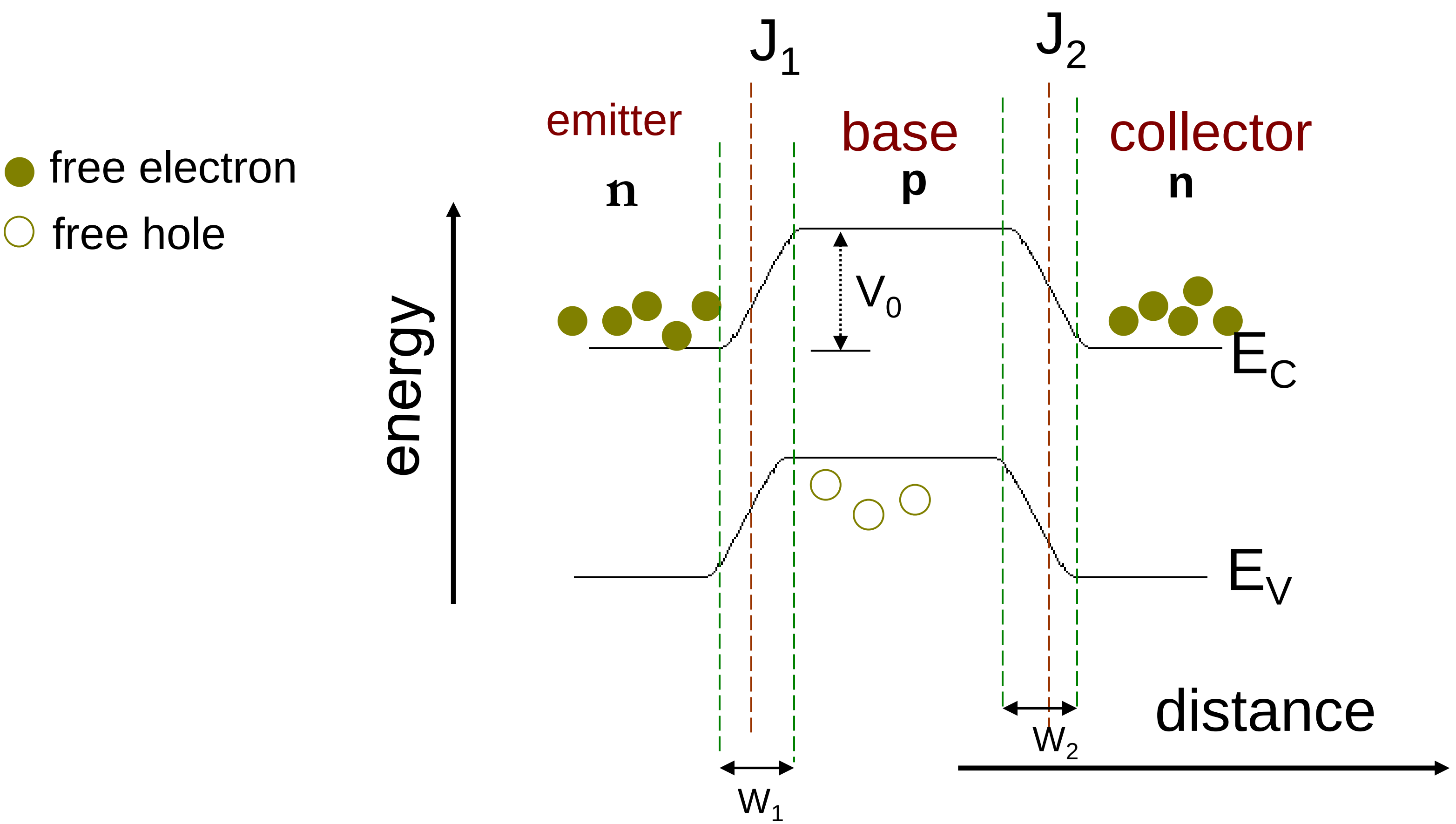
There are two types of BJTs – *npn* and *pnp*.

Separating the regions are two junctions.





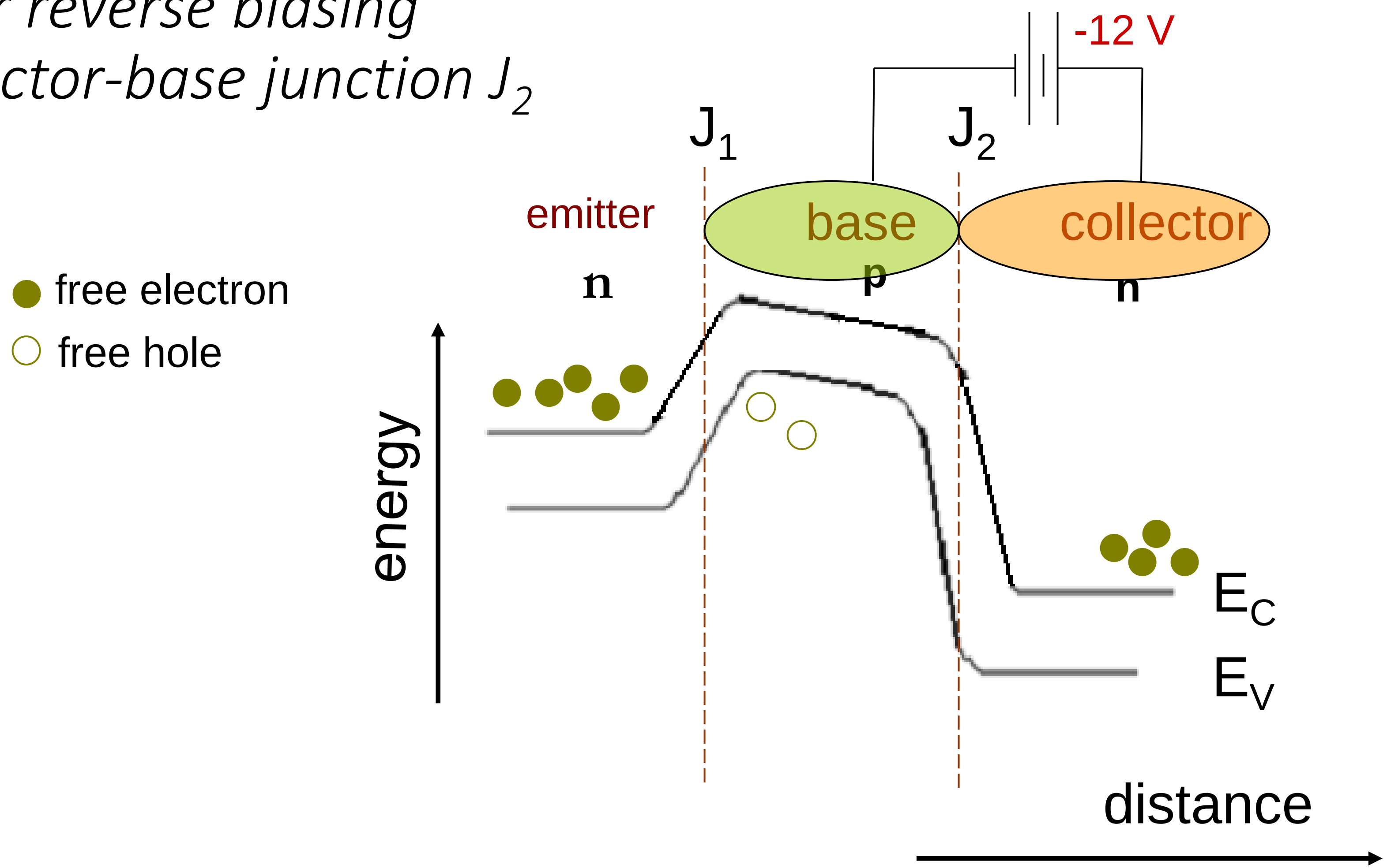
Transistor working: energy levels point of view



The potential barriers at the junctions for unbiased npn transistor.

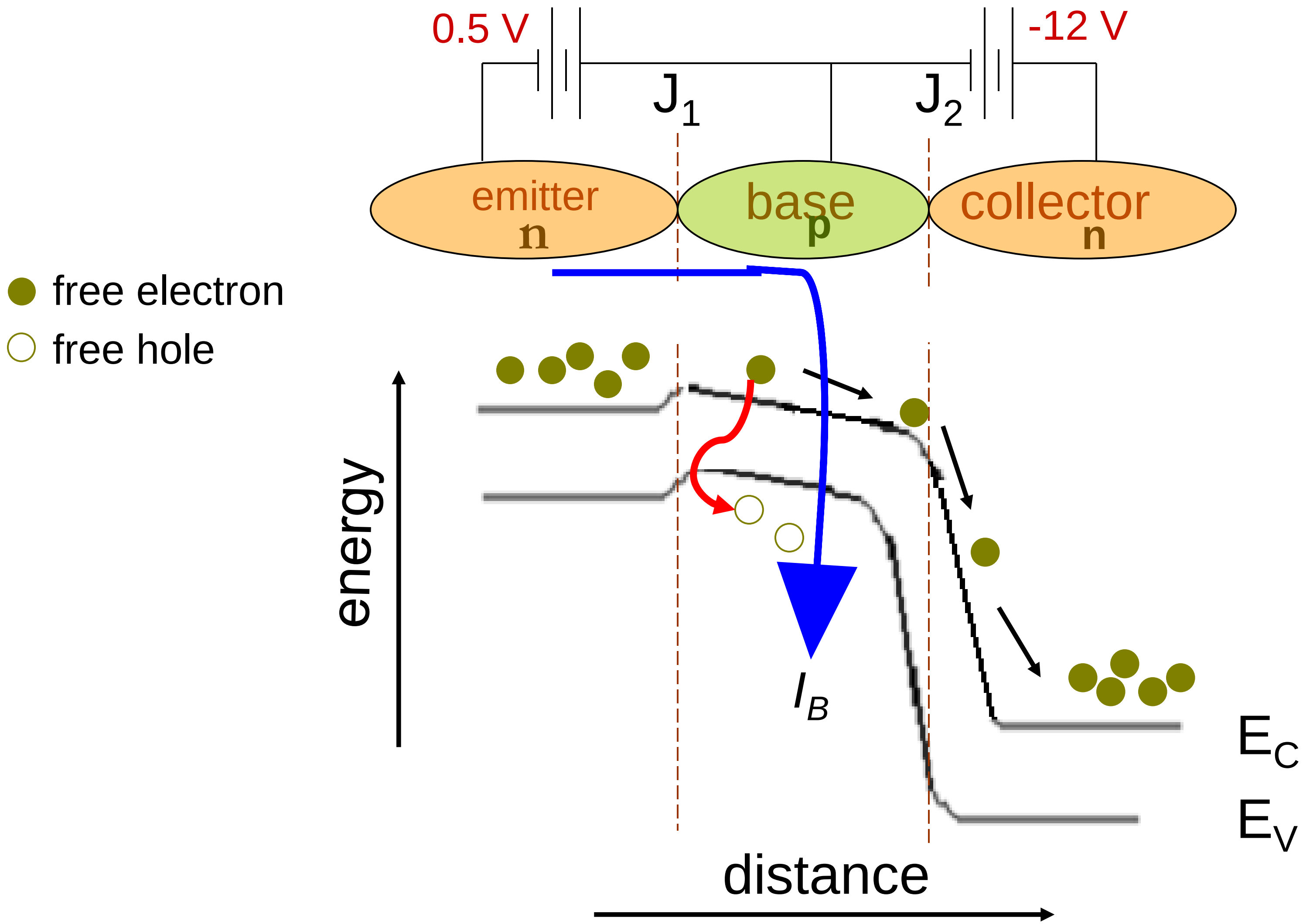
In the absence of applied voltage, the potential barriers at junctions adjust themselves to a height V_0 so that no current flows across each junction.

After reverse biasing collector-base junction J_2



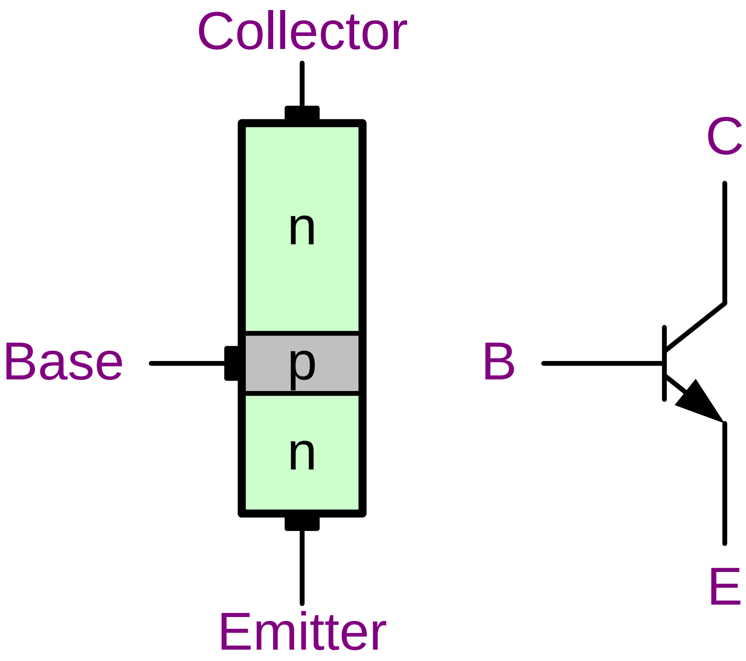
In reverse biasing J_2, the potential barrier at Base-collector increases and only a small reverse saturation current flows. The polarity of the applied voltage is chosen to increase the force pulling the n-type electrons and p-type holes apart. (i.e. we make the Collector positive with respect to the Base.)

After forward biasing emitter-base junction J_2

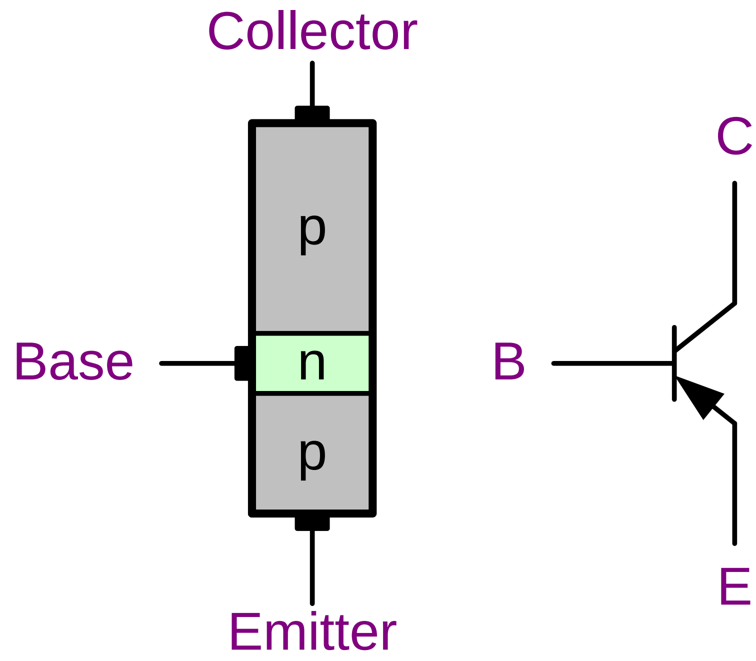


It is very much important to understand the role of depletion layer at both the junctions J_1 and J_2.

BJT construction and schematic symbols



npn transistor

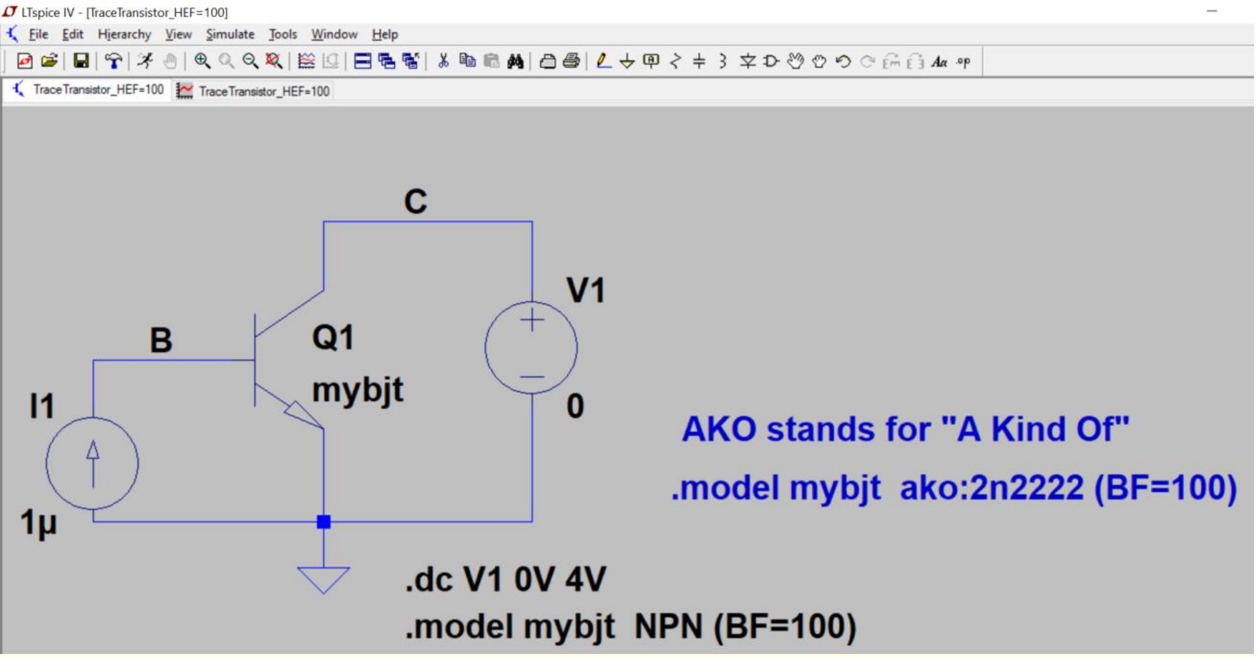


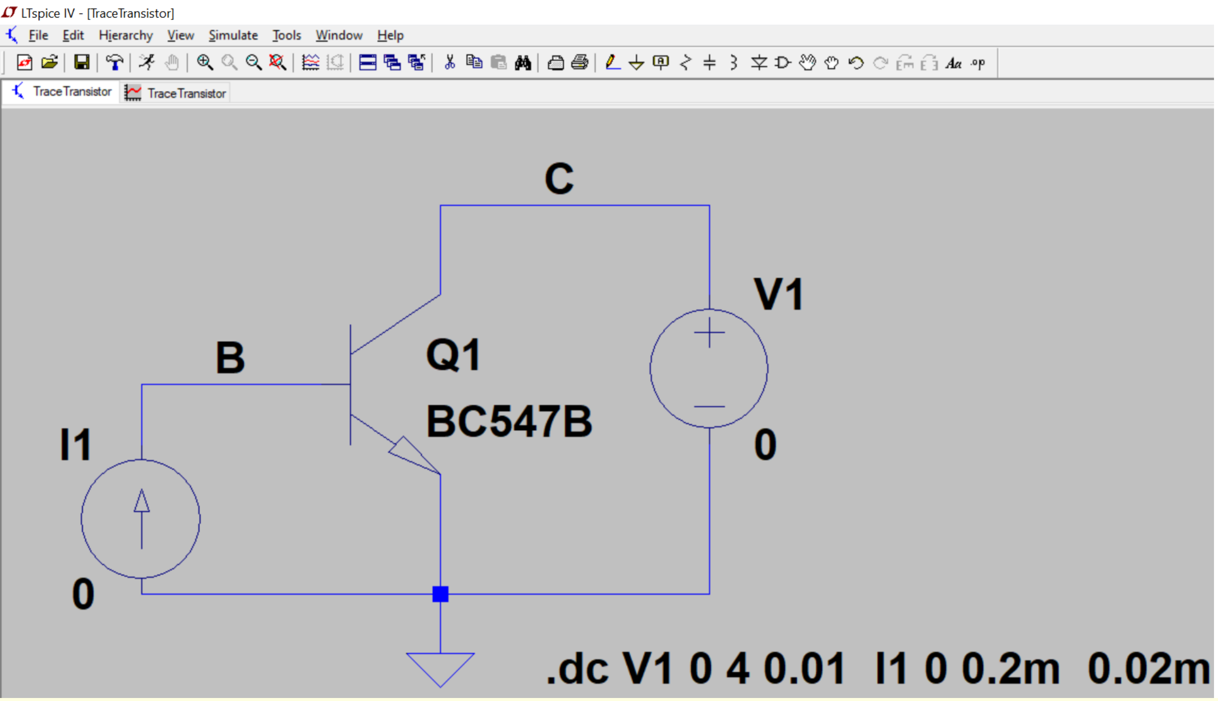
pnp transistor

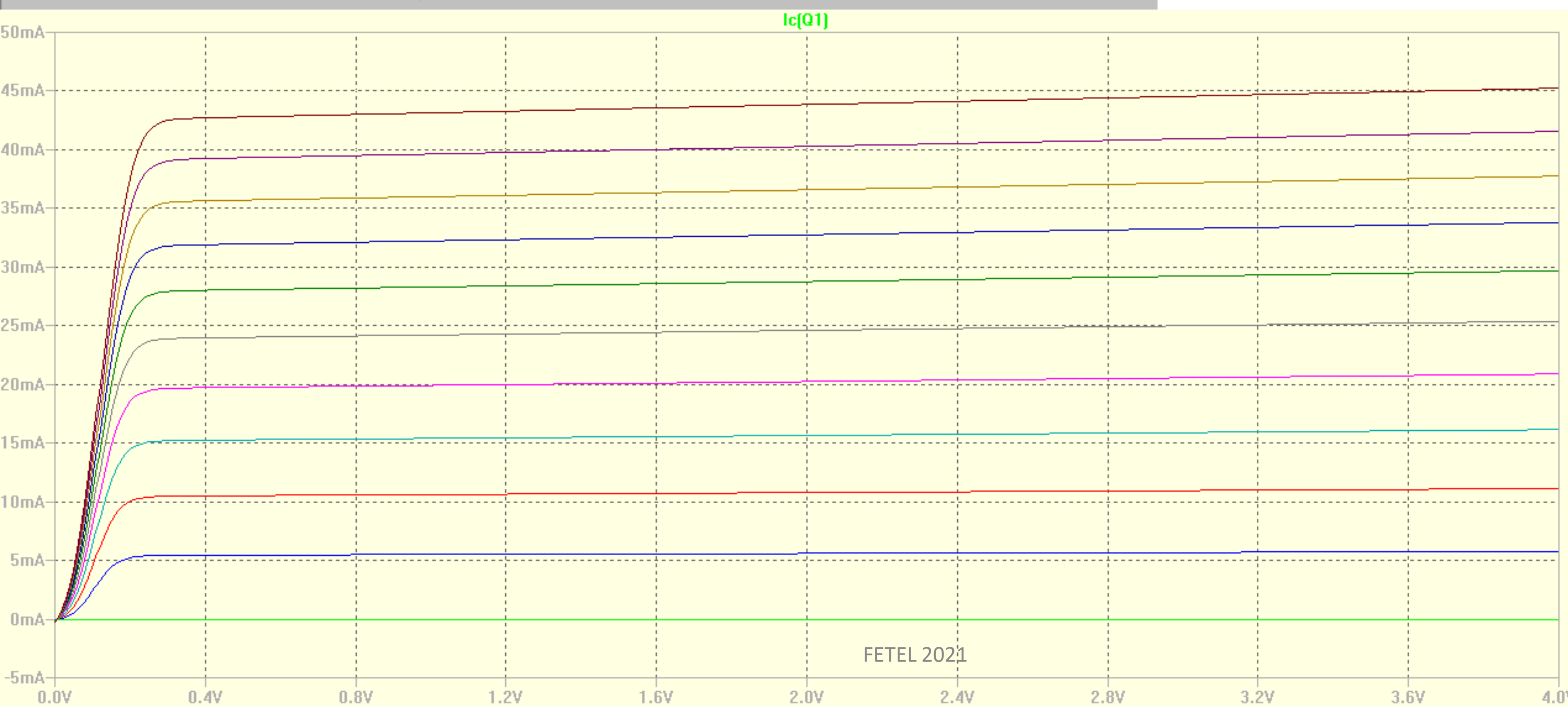
Transistor amplifier voltages

Voltage Abbreviation	Definition
V_{CC}	Collector supply voltage
V_{BB}	Base supply voltage
V_{EE}	Emitter supply voltage
V_C	Voltage between collector and ground
V_B	Voltage between base and ground
V_E	Voltage between emitter and ground
V_{CE}	Voltage between collector and emitter
V_{BE}	Voltage between base and emitter
V_{CB}	Voltage between collector and base

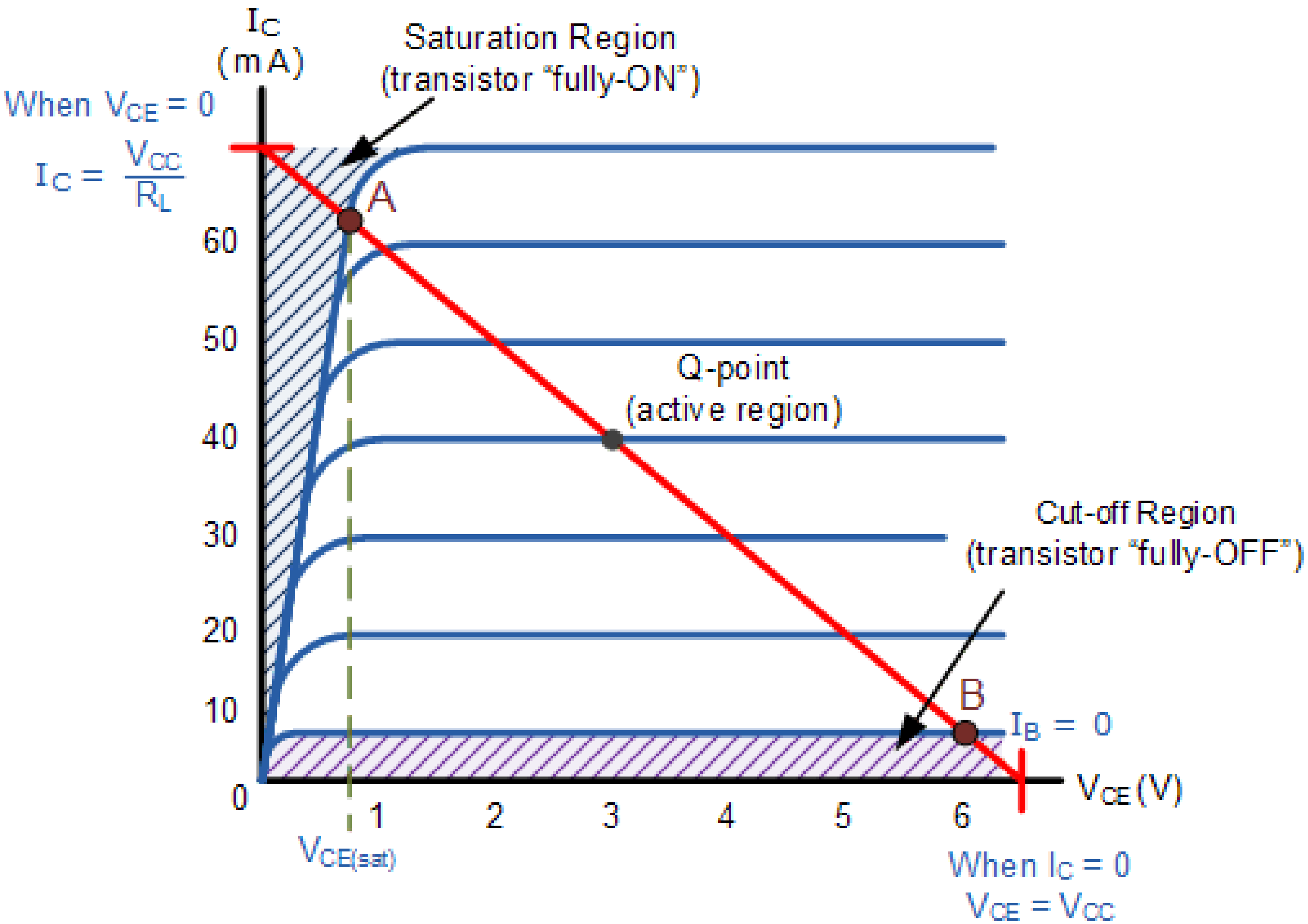
Transistor NPN



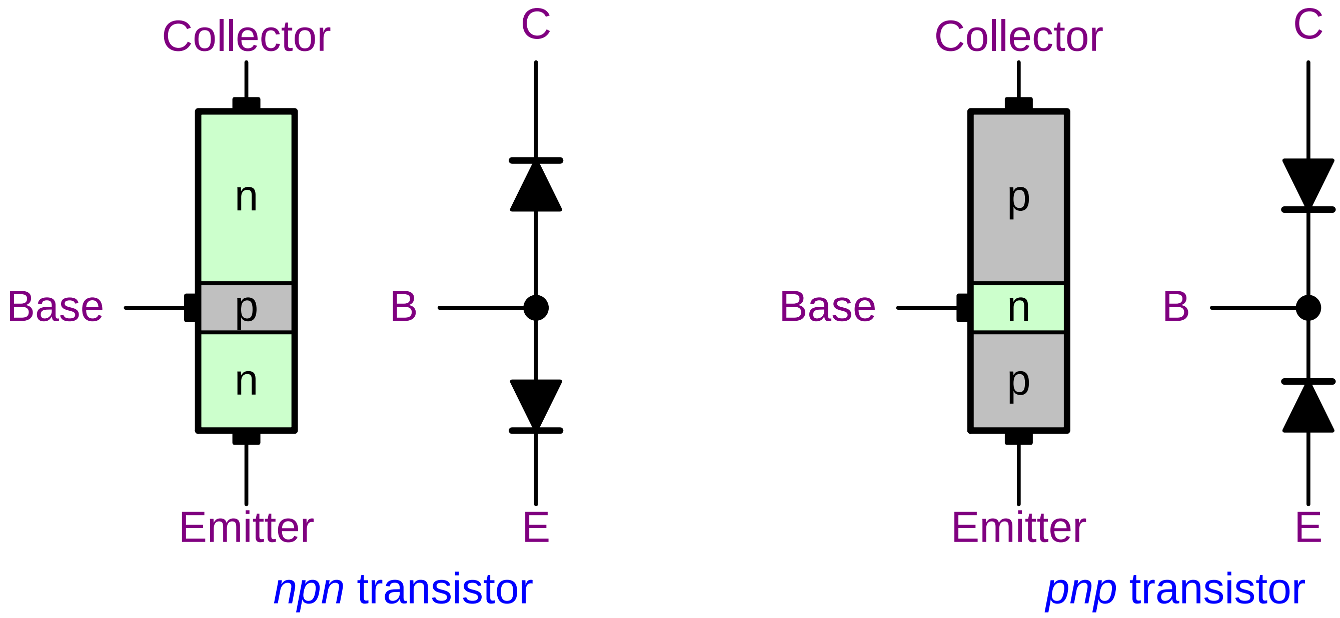

LTspice IV - [TraceTransistor]
TraceTransistor
TraceTransistor
C
V1
B
Q1
BC547B
I1
0
0
.dc V1 0 4 0.01 I1 0 0.2m 0.02m


Ic(Q1)
50mA
45mA
40mA
35mA
30mA
25mA
20mA
15mA
10mA
5mA
0mA
-5mA
0.0V
0.4V
0.8V
1.2V
1.6V
2.0V
2.4V
2.8V
3.2V
3.6V
4.0V

The operating **point** of a device, also known as bias **point**, **quiescent point**, or **Q-point**

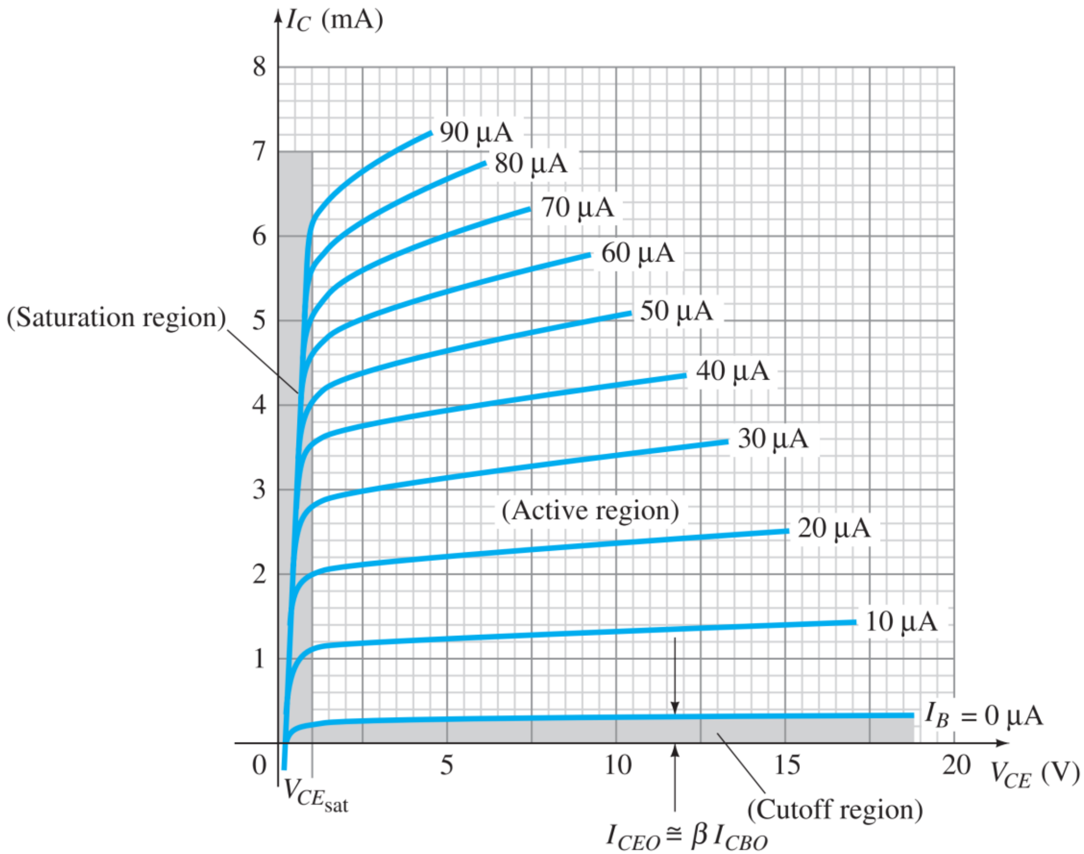


BJT construction

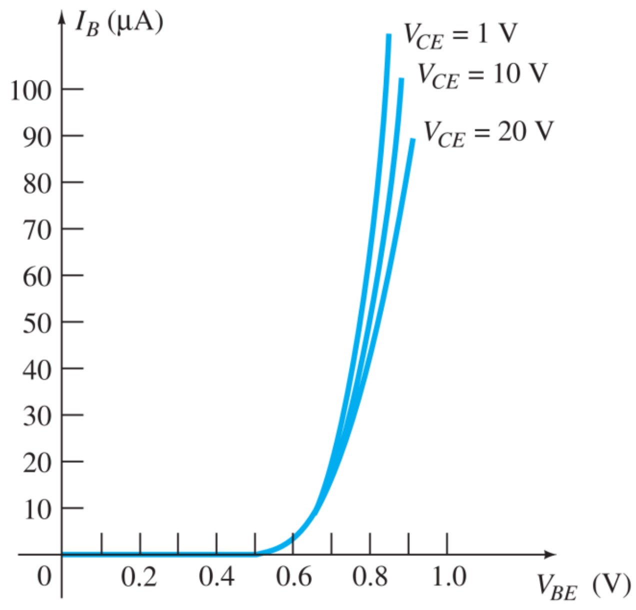


Base-Emitter Junc.	Collector-Base Junc.	Operating Region
Reverse	Reverse	Cutoff (switch-off)
Forward	Reverse	Active (amplifier)
Forward	Forward	Saturation (switch-on)

Operating regions



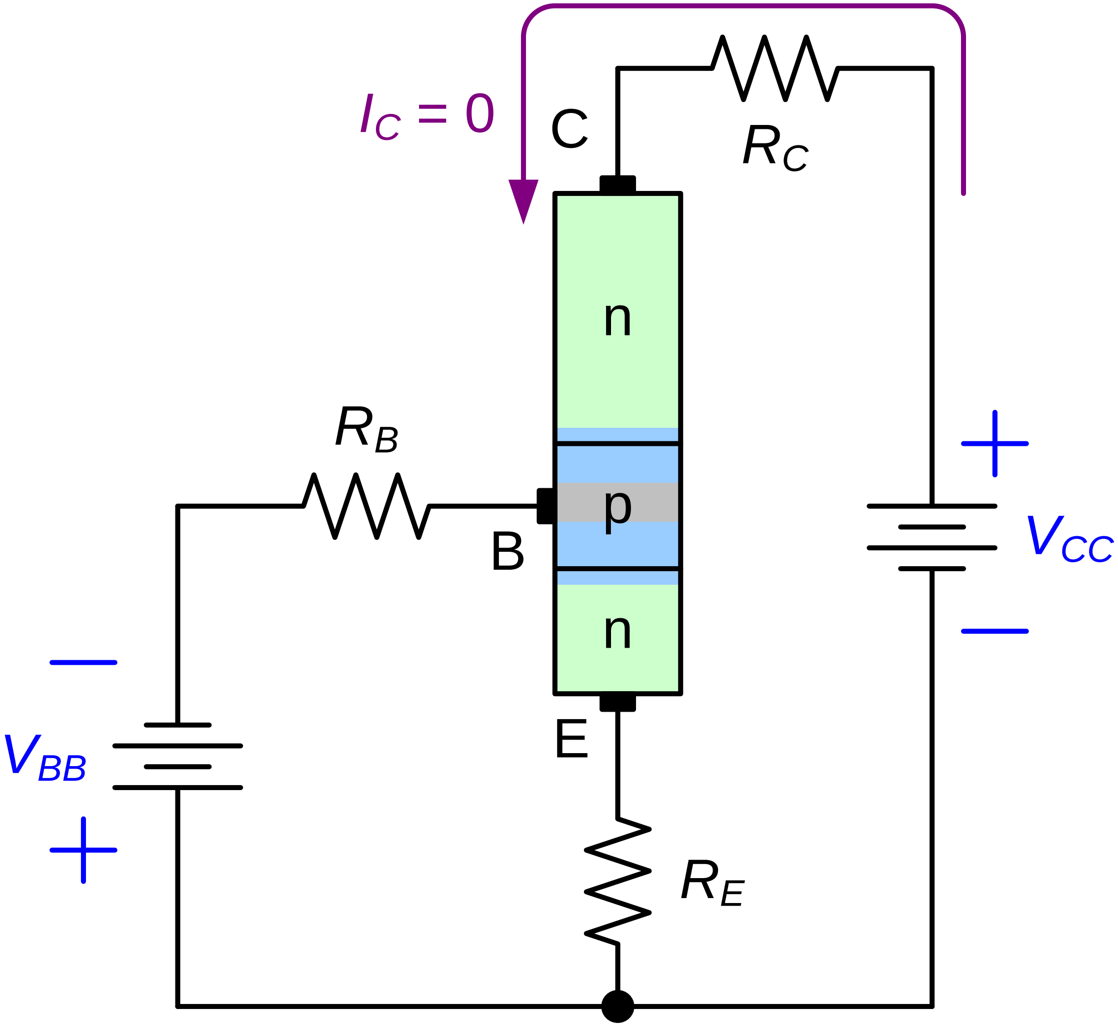
(a)



(b)

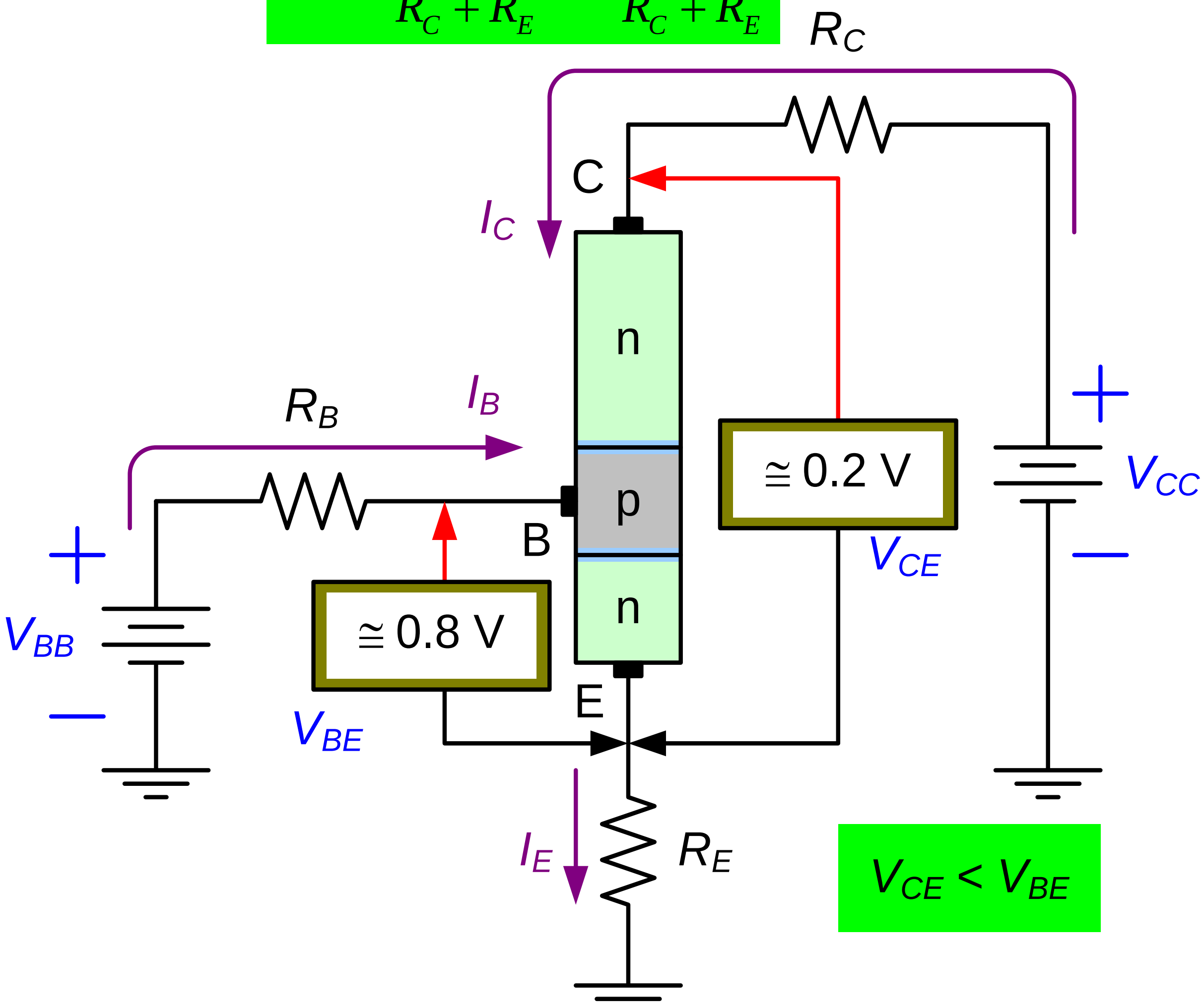
Note : $I_C = I_{C_{majority}} + I_{CO_{minority}}$

Cutoff

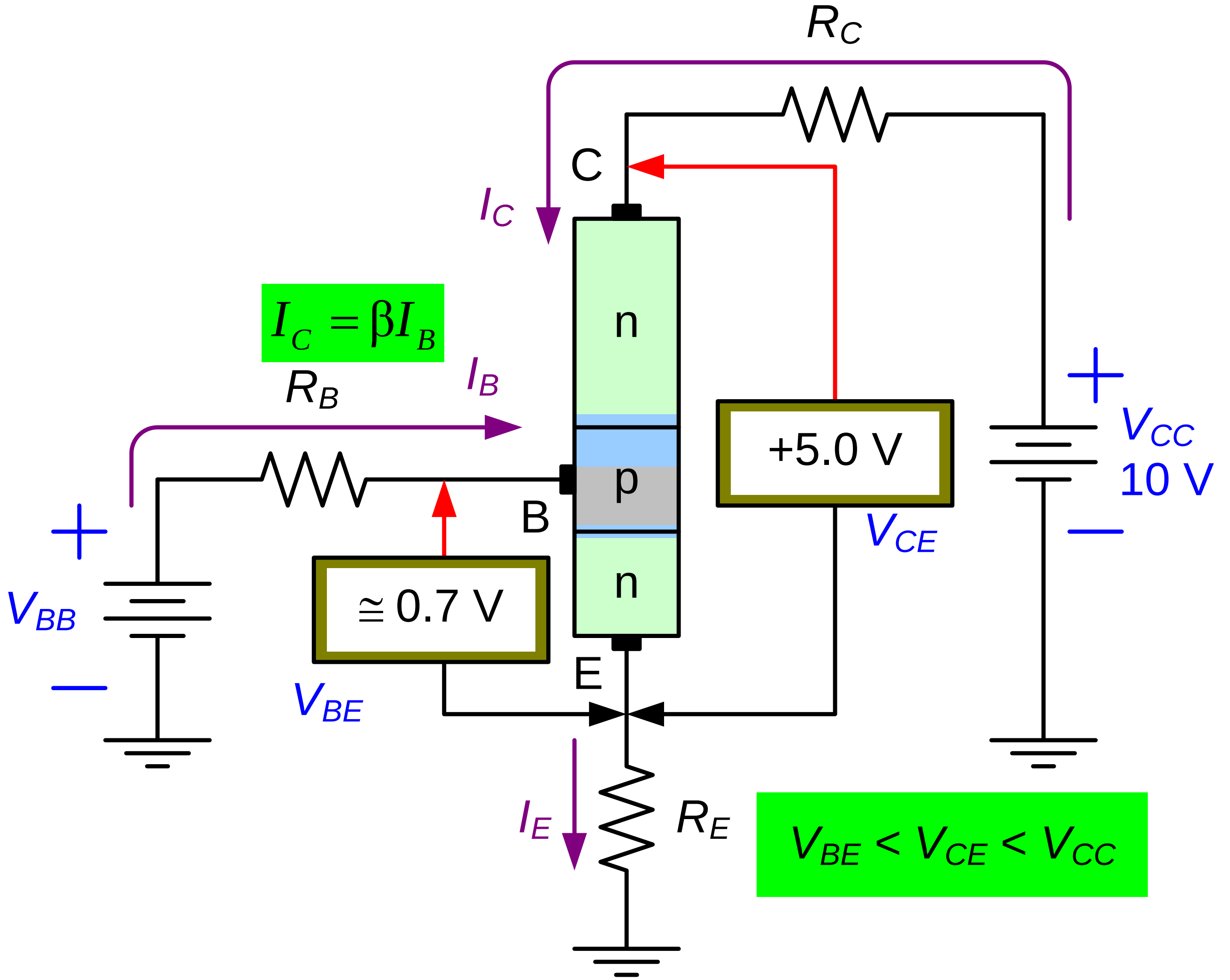


Saturation circuit condition

$$I_C \cong \frac{V_{CC} - 0.2\text{V}}{R_C + R_E} \cong \frac{V_{CC}}{R_C + R_E}$$



Active operation



Transistor operating region summary

(Assume that $R_E = 0\ \Omega$)

Operating Condition	V_{BE}	I_C	V_{CE}	V_{RC}
Cutoff	< 0.5 V	= 0 A	$= V_{CC}$	= 0 V
Active	» 0.7 V	$= \beta\ I_B$	$= V_{CC} - I_C R_C$	$= I_C R_C$
Saturation	» 0.8 V	$\cong (V_{CC} - 0.2\text{ V}) / R_C$ $\cong V_{CC} / R_C$	» 0.2 V	$\cong V_{CC} - 0.2\text{ V}$ $\cong V_{CC}$

Relationship Among I_E, I_C, and I_B

$$I_E = I_C + I_B.$$

If active, then

$$I_C = \beta I_B.$$

So

$$I_E = (\beta + 1) I_B.$$

If $\beta >> 1$, then

$$I_E \cong I_C = \beta I_B.$$

DC Alpha

$$\alpha = \frac{I_C}{I_E}$$

Since I_E is always greater than I_C, $\alpha < 1$.

$$I_C = \alpha I_E$$

$$I_B = I_E(1-\alpha)$$

$$\alpha = \frac{\beta}{\beta+1}$$

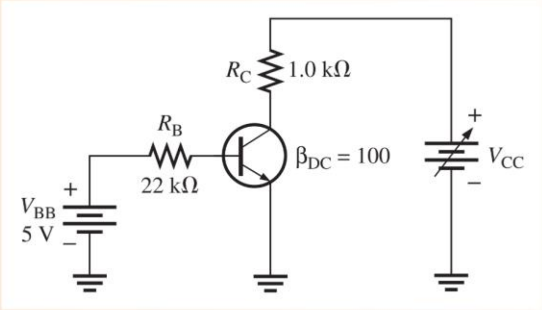
$$\beta = \frac{\alpha}{1-\alpha}$$

$P_{D(max)} = P_{tot}$

dissipation

The transistor in Figure A has the following maximum ratings: $P_{D(max)} = 800$ mW, $V_{CE(max)} = 15$ V, and $I_{C(max)} = 100$ mA. Determine the maximum value to which V_{CC} can be adjusted without exceeding a rating. Which rating would be exceeded first?

A



Solution First, find I_B so that you can determine I_C.

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{5\text{ V} - 0.7\text{ V}}{22\text{ k}\Omega} = 195\ \mu\text{A}$$

$$I_C = \beta_{DC} I_B = (100)(195\ \mu\text{A}) = 19.5\text{ mA}$$

I_C is much less than $I_{C(max)}$ and ideally will not change with V_{CC}. It is determined only by I_B and β_{DC}.

The voltage drop across R_C is

$$V_{R_C} = I_C R_C = (19.5\text{ mA})(1.0\text{ k}\Omega) = 19.5\text{ V}$$

Now you can determine the value of V_{CC} when $V_{CE} = V_{CE(max)} = 15$ V.

$$V_{R_C} = V_{CC} - V_{CE}$$

So,

$$V_{CC(max)} = V_{CE(max)} + (V_{R_C} = 15\text{ V} + 19.5\text{ V} = \mathbf{34.5\text{ V}}$$

V_{CC} can be increased to 34.5 V, under the existing conditions, before $V_{CE(max)}$ is exceeded. However, at this point it is not known whether or not $P_{D(max)}$ has been exceeded.

$$P_D = V_{CE(max)} I_C = (15\text{ V})(19.5\text{ mA}) = 293\text{ mW}$$

Since $P_{D(max)}$ is 800 mW, it is *not* exceeded when $V_{CC} = 34.5$ V. So, $V_{CE(max)} = 15$ V is the limiting rating in this case. If the base current is removed causing the transistor to turn off, **$V_{CE(max)}$ will be exceeded first** because the entire supply voltage, V_{CC}, will be dropped across the transistor.