A

Seminar report

On

Transistor

Submitted in partial fulfillment of the requirement for the award of degree of ECE

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Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

Preface

I have made this report file on the topic **Transistor**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to ………….who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

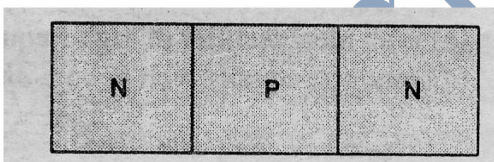
Introduction:

The transistor is a main building block of all modern electronic systems.It is a three terminal device whose output current, voltage and/ or power are controlled by its input current. In digital computer electronics , the transistor is used as a high speed electronic switch that is capable of switching between two operating states(open and closed) at a rate of several billions of times per second. There are two types of transistors namely

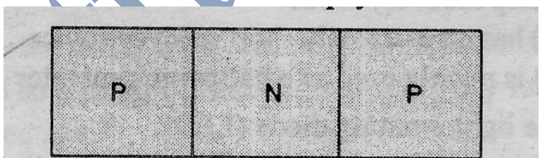
1. Bipolar Junction transistor (BJT)
2. Field effect transistor (FET)

Bipolar Junction transistor (BJT) is commonly known as Junction transistor or simply transistor. Two types of BJT's are

1. NPN
2. PNP



(a)

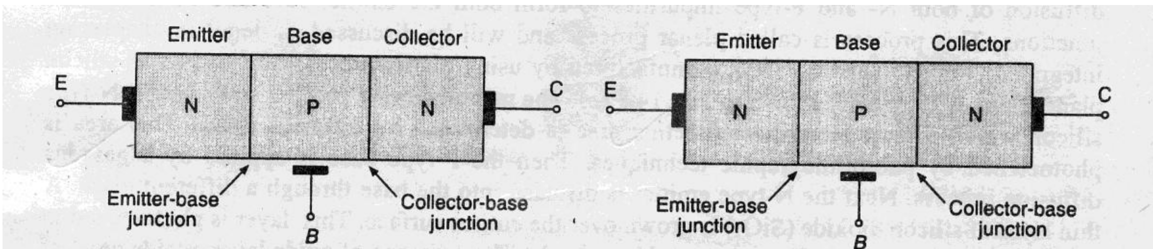


(b)

Transistor

Transistor Construction: -

A transistor has three regions.They are 1. Emitter 2. Base 3. Collector Regions.

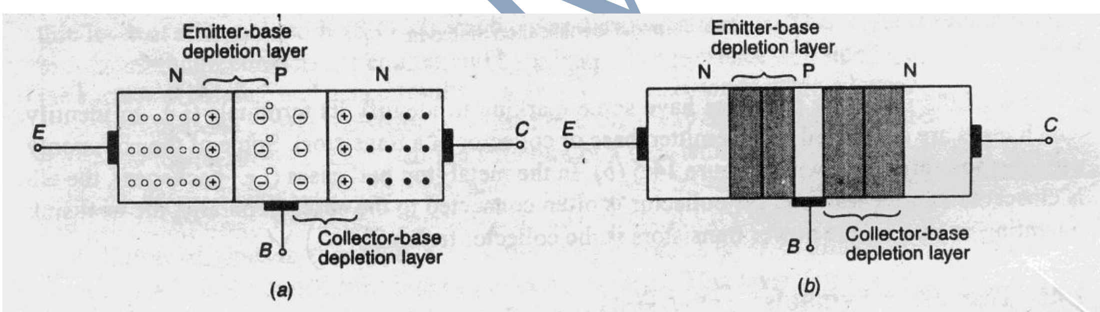


Transistor Construction

Transistor symbol :-

Unbiased Transistor:-

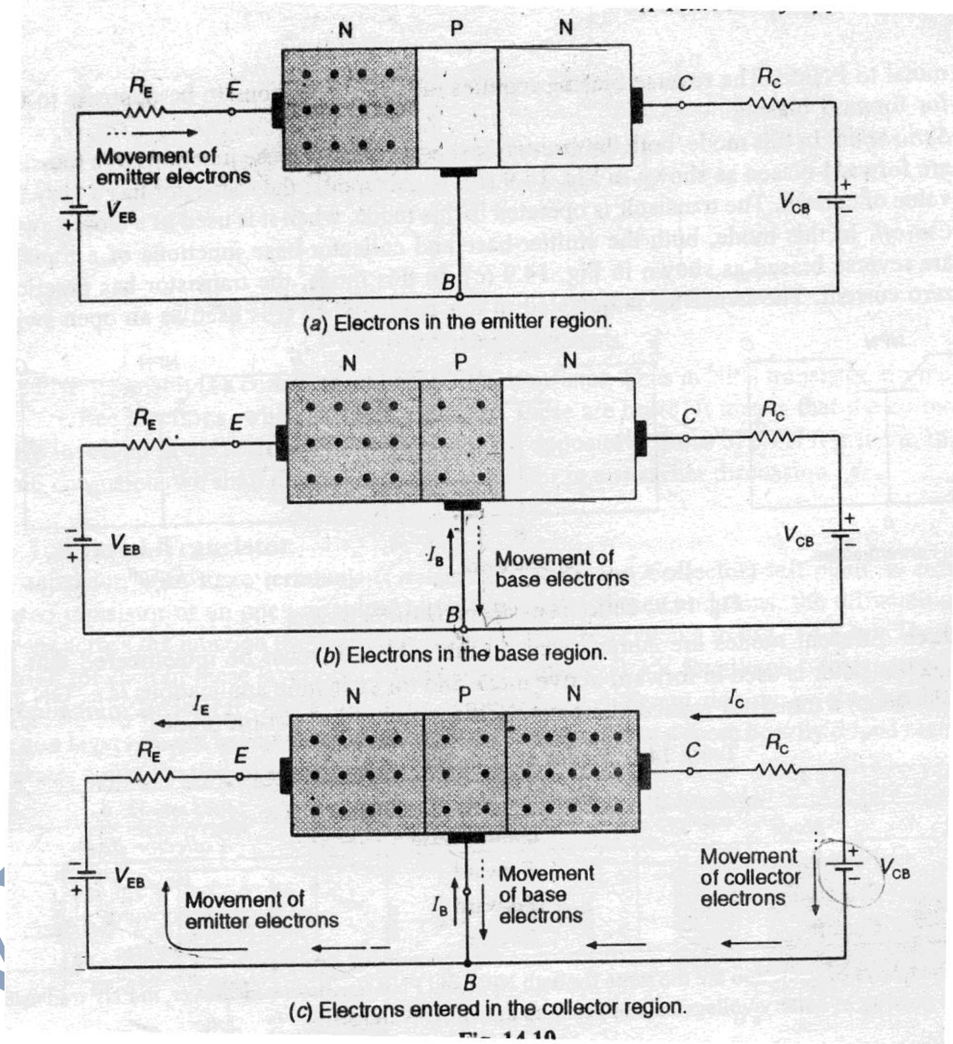
A transistor with three terminals left open is called an unbiased transistor or open circuited transistor.Under these conditions diffusion of free electrons across the junction produces two depletion layers.



Unbiased Transistor

Principle of transistor operation:

Operation of an NPN Transistor:-



(a) Electrons in the emitter region.
(b) Electrons in the base region.
(c) Electrons entered in the collector region.

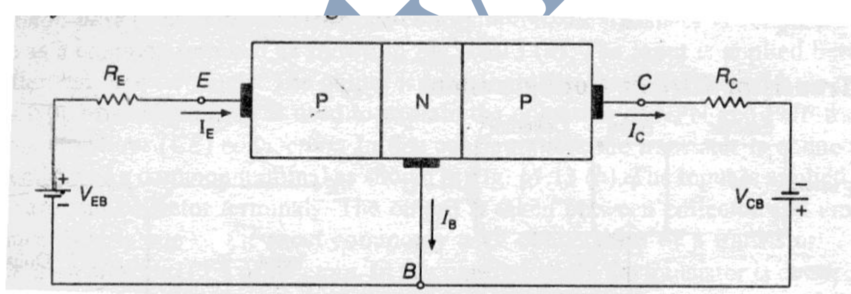
Figure shows an NPN transistor biased in Forward active mode. (ie) the emitter-base of a transistor is forward biased and collector-base junction is reverse biased. If the Applied forward bias voltage is greater than the barrier potential, the free electrons in the N type emitter flows towards the base region.this constitutes the emitter current (I_E). It may be noted that the direction of Conventional current is opposite to the flow of electrons.Therefore electrons after reaching the base region tend to combine with the holes in the base.If these free electrons combine with the holes in the base, they constitute base current (I_B). However most of the free electrons do not combine with the holes in the base. This is because of the fact that the base region is lightly doped.

The most of the electrons will diffuse to the collector region as shown in figure.C and constitutes collector current(I_C). The collector current is also called injected current because this current is injected from emitter region. There is another component of collector current due to the thermally generated carriers. This current component is called reverse saturation current and is quite small.

Note:

Thus the emitter current of a transistor consists of two components namely base current and collector current. The base current is about 2% of the emitter current, while collector current is about 98% of the emitter current.

Operation of a PNP Transistor:-



Operation of a PNP Transistor

The operation of a PNP transistor is similar to that of an NPN transistor. However the current with in a PNP transistor is due to the movement of holes, whereas in an NPN transistor it is due to the movement of free electrons.

Figure shows a PNP transitor with its emitter-base junction forward biased and collector base junction as reverse biased.

II. Transistor and Transistor Application

1. Transistors

° Typical, basic characteristics

2. Some basic transistor circuits

- Transistor switch
- "Transistor man"
- Emitter follower
- Emitter follower as voltage regulator
- Transistor current source

1. Transistor

The transistor is the most important example of an **active element**. It is a device that can amplify and produce an output signal with **more power** than the input signal. The additional power comes from an external source i.e. the power supply.
The transistor is the essential ingredient of every electronic circuit: amplifiers, oscillators and computers. Integrated circuits (**IC**s), which have replaced circuits constructed from individual, discrete transistors, are themselves **arrays of transistors** and other components built as a single chip of semiconductor material.
A transistor is a 3-terminal device (Fig.1) available in 2 kinds: **npn** and **pnp** transistors.

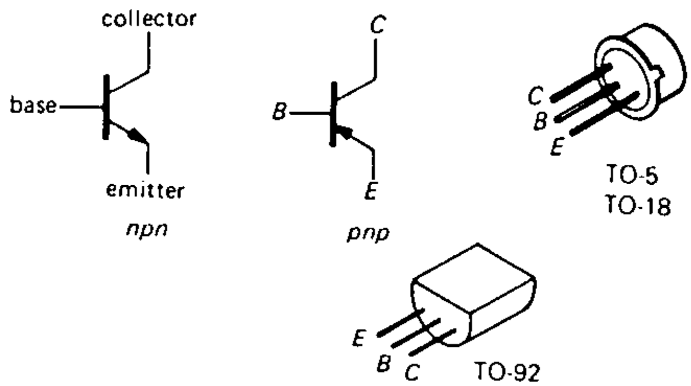


Fig.1. Transistor symbols and transistor packages.

The terminals are called: collector (C), base (B) and emitter (E). Voltage at a transistor terminal (relative to ground) is indicated by a single subscript, V_C is the collector voltage, for instance. Voltage between 2 terminals is indicated by a double subscript: V_{BE} is base-to-emitter drop. If the same letter is doubled, it means power supply voltage: V_{CC} (positive) is power supply voltage associated with the collector and V_{EE} (negative) is power supply voltage associated with the emitter.

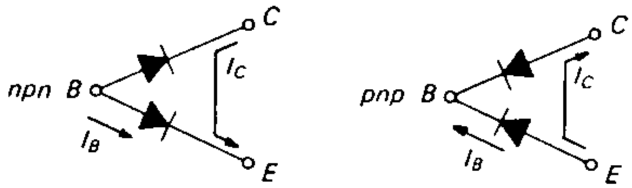


Fig.2. Direction of currents flow **npn** and **pnp** transistors.

The properties of **npn** transistors are:

1. The collector is more positive that the emitter.
2. The B-E and the B-C circuits behave like diodes (Fig.2): one of them is conducting and the other is polarized in the opposite direction.
3. Any transistor has maximum values of current and voltage, which can be applied without damage and costing the price of a new transistor (for instance, for general-purpose transistors I_C=200-500 mA, V_{CE}=20-40 V).
4. When 1-3 are obeyed, I_C is (roughly) proportional to I_B as follows: $I_C=h_{FE}I_B=\beta I_B$. The current gain h_{FE}, also called beta, is typically about β=100. Both I_C and I_B flow to the emitter.

Note: the collector current I_C does not flow forwards the B-C diode - it has reverse polarity. Do not think of the collector current as diode conduction. This is just "transistor action".

From the property 4 results: a small current flowing into the base controls a much larger (approximately 100 times larger) current flowing into the collector.

Note the result of property 2: the base is more positive than the emitter because of the forward diode drop, which is equal to about 0.6-0.8 V. An operating transistor has $V_B=V_E+V_{BE}$, V_{BE}=0.6-0.8.

When **pnp** transistor is considered, just reverse polarities normally given for **npn** transistor. Also characteristics are the same and the only difference is that direction of currents and voltages are opposed.

- **Typical, basic characteristics**

U-I transistor characteristics are shown in Fig. 3a and Fig.3b. The characteristics show the following properties:

1. I_C almost does not depend on U_{CB} for fixed value of I_E (see Fig.3a). As long as I_E=constant, I_C does not change much when U_{CB} increases.

2. I_C almost does not depend on U_{CE} for fixed value of I_B (see Fig.3b). As long as I_B=constant, I_C does not change much when U_{CE} increases.
3. I_C is almost equal to I_E (see Fig.3a).

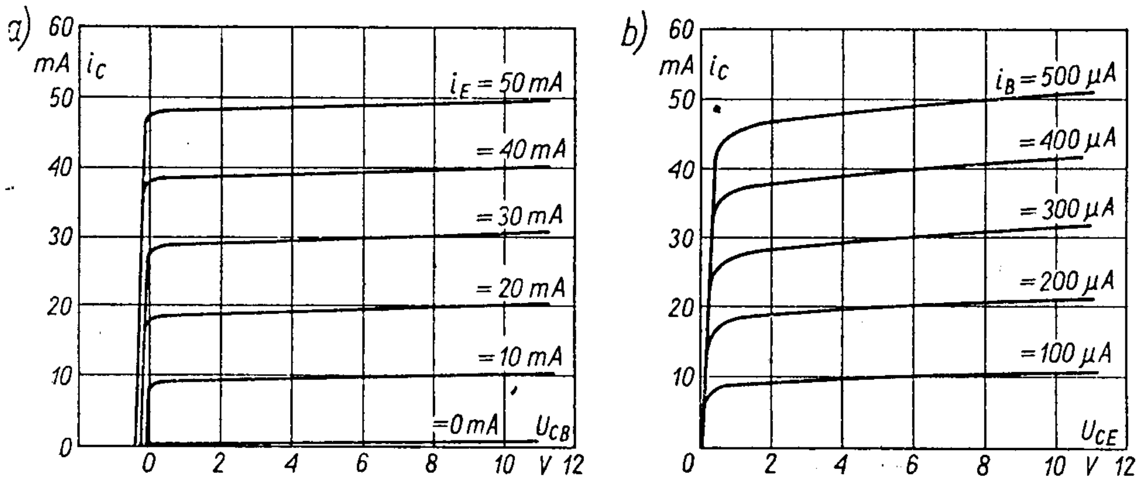


Fig.3. U-I transistor characteristics.

2. Some basic transistor circuits

° Transistor switch

Transistor switch example is shown in Fig.4.

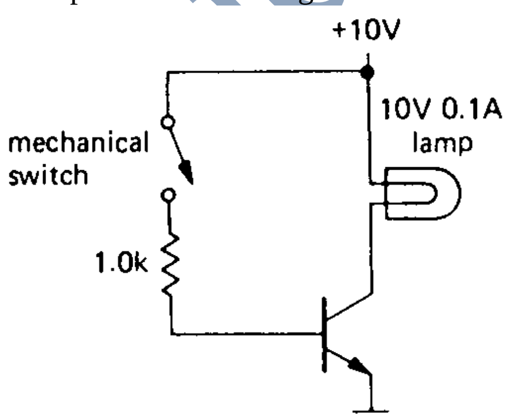


Fig.4. Transistor switch circuit.

In this application, a small control current enables a much larger current in another circuit. How it works?

1. When the mechanical switch is opened, there is no base current, therefore (see rule 4) there is no collector current. The lamp is off.

2. When the mechanical switch is closed, the base rises to 0.6 volts (base-emitter diode is forward conducting, emitter is at ground voltage level).
3. As collector is more positive than the emitter is (see rule 1) the collector current enables the lamp to emit light.

◦ **Transistor man**

The below cartoon will help you to understand principle of transistor operation.

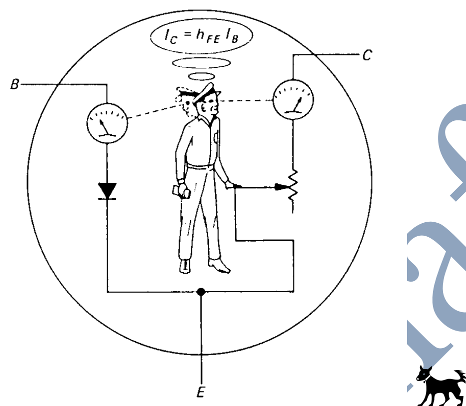


Fig.5. Transistor man observes the base current and adjust the adjustable resistor in an attempt to maintain the output current $\beta = h_{FE}$ times larger.

His only job is to try to keep $I_C = \beta I_B$ by means of adjustable resistor $\mathbf{R} = 0 \div \infty$. As the resistor can change from zero to infinity, thus he can go from a short circuit (saturation, large current flow) to an open circuit (transistor is in the "off" state, no current flow), or to anything in between. He is not allowed to use anything but the resistor.
At any given time, a transistor may be (see Fig.3):

1. Cut off, **no collector current**.
2. In the active region, **some collector current** flows.
3. In saturation, almost constant **maximal collector current** flows.

◦ **Emitter follower**

Fig.6 shows an example of an **emitter follower**.

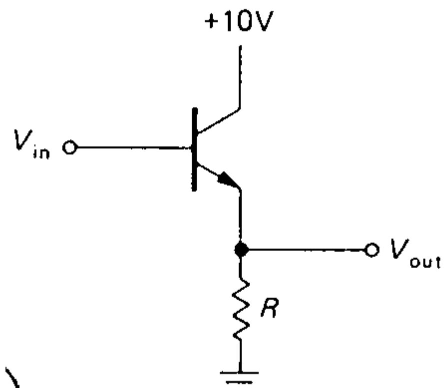


Fig.6. Emitter follower.

The output voltage (emitter) follows the input voltage (base), less one diode drop:

$V_E=V_B-0.6$ volt.

The output is replica of the input, but 0.6 volt less positive. The main features:

i. Emitter follower has no voltage gain, but it has current gain, therefore it has power gain.

ii. The most important feature of emitter follower is that it has input resistance much larger than its output resistance.

This circuit requires less power from signal source to drive a receiver (a load) that it would be in case if the signal source drove the receiver (the load) directly.

In general the loading effect causes a reduction of signal (as you have discussed earlier).

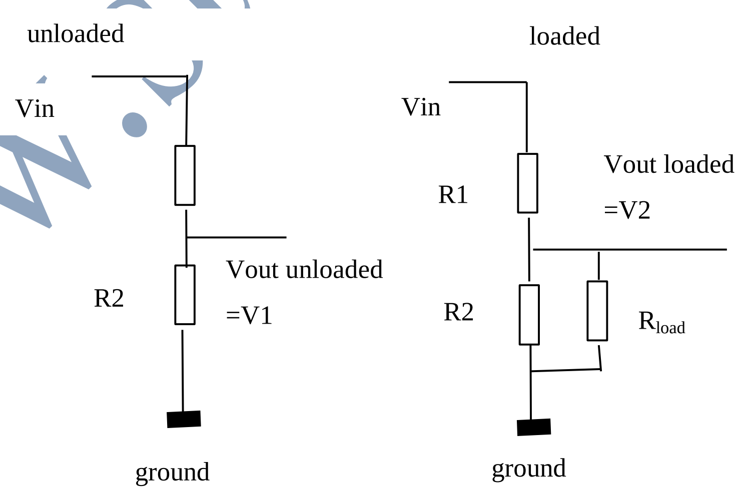


Fig. 7. The effect of loading the source with R_{load} .

It is always required that V2=V1. It depends on how strongly R_{load} is loading the output. When $R_{load} \to$infinity, there is no loading and V2=V1, when $R_{load} \to 0$ there is extreme loading and V2=0 – no output signal at all. Therefore: the bigger R_{load} the better. What mathematics says?

Unloaded circuit:

$$V1 = I * R_2$$

$$I = \frac{V_{input}}{R_1 + R_2}$$

$$V1 = V_{input} \frac{R_2}{R_1 + R_2}$$

Loaded circuit:

$$V2 = I * R_{equivalent},$$

$$\text{where } R_{equivalent} = R_2 \| R_{load} = \frac{R_2}{R_2 / R_{load} + 1}$$

$$I = \frac{V_{input}}{R_1 + R_{equivalent}}$$

$$V2 = V_{input} \frac{R_2 \left(\frac{1}{1 + R_2 / R_{equivalent}} \right)}{R_1 + R_2 \left(\frac{1}{1 + R_2 / R_{equivalent}} \right)}$$

Conclusion: When $R_{load} \to \infty$, then $R_{equivalent} \to R_2$ and $V_2 \to V_1$

The emitter follower is the circuit, which has $R_{load} \to \infty$.

◦ **Emitter follower as voltage regulator**

The simplest regulated supply of voltage is a zener diode. The zener diode is an element for which the ratio V/I is not constant (as it is for resistance R) but it depends on particular value of V. It is important to know how the resulting zener voltage will change with applied current. This is a measure of its "regulation" against changes in driving curent provided to it. So called dynamic resistance is defined:

$$R_{dyn} = \frac{\Delta V}{\Delta I}$$

It has different value for different region of V-I characteristic:

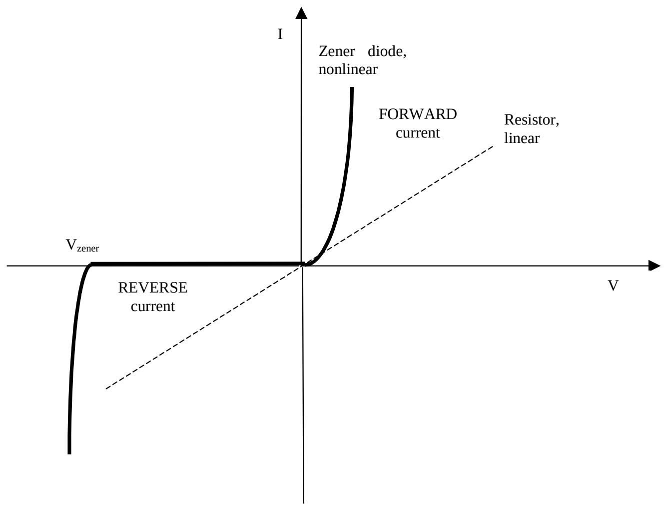
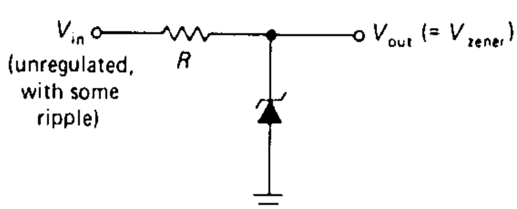


Fig. 8. V-I curves for linear (resistor) and for nonlinear (zener diode) elements.

For a certain negative value of V (zener voltage, typical value 5V) the reverse current rapidly increases and $\mathbf{R_{dyn}} = \frac{\Delta \mathbf{V}}{\Delta \mathbf{I}} \to 0$ (ideal case). Within 0 and V_{zener} the current is constant and $\mathbf{R_{dyn}} = \frac{\Delta \mathbf{V}}{\Delta \mathbf{I}} \to \infty$ (ideal case). The zener voltage is specific for a diode. It does not depend on value of current (in reasonable limits) and is constant. Zener diodes with reverse current are able to keep constant zener voltage even if the reverse current changes its value.

a) b)



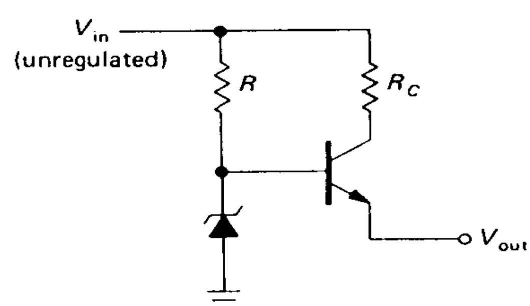


Fig.8. a) Simple zener voltage regulator. b) Zener regulator with follower. Zener current is much more independent of load current.

In Fig.8 are shown simple, exemplary voltage regulator circuits. They can be successfully adopted in noncritical (not very exacting) circuits. However it has some limitations:

1. V_{out} is not adjustable.
2. Gives only moderate ripple rejection.

- **Transistor current source**

The simplest approximation to a current source is shown in Fig. 9.

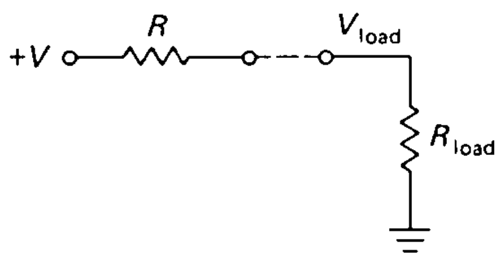


Fig.9. The simplest current source approximation.

As long as R_{load}<<R (which means V_{load}<<V) the current I is nearly constant and is equal to I=V/R. The current does not depend on R_{load} therefore the circuit can be consider as current source. The simplest solution has an inconvenience: in order to make good approximation of current source it is necessary to use large voltages. It causes lots of power dissipation in the resistor.

It is possible to make a very good current source with a transistor (Fig. 10).

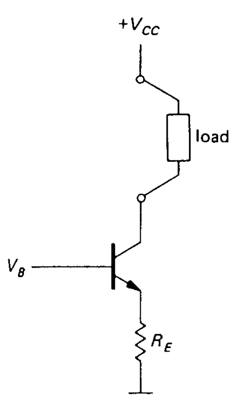


Fig.10. Transistor current source: basic concept.

V_B>0.6 volt applied to the base assures that the emitter is always conducting and $V_E=V_B$-0.6 volt. So:

$\mathbf{I_E} = \frac{\mathbf{V_E}}{\mathbf{R_E}} = \frac{\mathbf{V_B} - 0.6}{\mathbf{R_E}}$. Let us notice that $\mathbf{I_E} \cong \mathbf{I_C}$ (see Fig. 3). Therefore $\mathbf{I_C} \cong \frac{\mathbf{V_B} - 0.6}{\mathbf{R_E}}$

and it does not depend on V_C as long as the transistor is not saturated ($V_C>V_E+0.2$ volt). This is current source.

Modes of biasing:

Following are the different modes of transistor base biasing:

1. Current biasing:

As shown in the Fig.1, two resistors RC and RB are used to set the base bias. These resistors establish the initial operating region of the transistor with a fixed current bias.

The transistor forward biases with a positive base bias voltage through RB. The forward base-Emitter voltage drop is 0.7 volts. Therefore the current through RB is $I_B = (V_{cc} - V_{BE}) / I_B$

2. Feedback biasing:

Fig.2 shows the transistor biasing by the use of a feedback resistor. The base bias is obtained from the collector voltage. The collector feedback ensures that the transistor is always biased in the active region. When the collector current increases, the voltage at the collector drops. This reduces the base drive which in turn reduces the collector current. This feedback configuration is ideal for transistor amplifier designs.

3. Double Feedback Biasing:

Fig.3 shows how the biasing is achieved using double feedback resistors.

By using two resistors RB1 and RB2 increases the stability with respect to the variations in Beta by increasing the current flow through the base bias resistors. In this configuration, the current in RB1 is equal to 10 % of the collector current.

4. Voltage Dividing Biasing:

Fig.4 shows the Voltage divider biasing in which two resistors RB1 and RB2 are connected to the base of the transistor forming a voltage divider network. The transistor gets biases by the voltage drop across RB2. This kind of biasing configuration is used widely in amplifier circuits.

5. Double Base Biasing:

Fig.5 shows a double feedback for stabilization. It uses both Emitter and Collector base feedback to improve the stabilization through controlling the collector current. Resistor values should be selected so as to set the voltage drop across the Emitter resistor 10% of the supply voltage and the current through RB1, 10% of the collector current.

Advantages of Transistor:

1. Smaller mechanical sensitivity.
2. Lower cost and smaller in size, especially in small-signal circuits.
3. Low operating voltages for greater safety, lower costs and tighter clearances.
4. Extremely long life.
5. No power consumption by a cathode heater.
6. Fast switching.

Disadvantages of a Transistor

1. When they blow, they need to be replced BUT they are so small (that an advantage) it can be difficult to find the offending transistor.
   2. Manufacturing techniques are complex.

3. Manufacturing techniques require clean rooms.
4. They can be put into the circuit board the wrong way and therefore not work.
5. Removing them from a circuit board involves unsoldering whereas valves were plugged.
6. If they are on an integrated circuit and blow, the ENTIRE integrated circuit must be replaced.

REFERENCES

1. www.google.com
2. www.wikipedia.org
3. www.studymafia.org
4. www.pptplanet.com