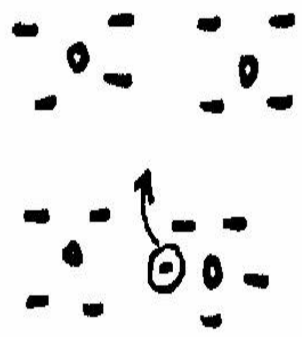
**Semiconductor theory (taking Germanium as an example)**

Germanium has four electrons in its outer orbit and it is these that are used in current flow. It is said to a have a Valency of 4.Pure Germanium does not conduct electricity, however, if a minute quantity of a certain impurity is added, its resistance is greatly reduced.

The impurity chosen is one that has different number of valency electrons.

For example, Arsenic has five valency electrons. Very small, but precise quantities of the impurity are added to the germanium. The fifth electron often jumps away from its atom.

This leaves this Arsenic atom with a positive charge, thus attracting another wandering electron.

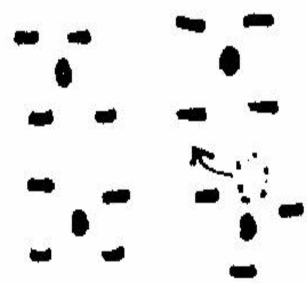


The addition of this extremely small impurity results in a dramatic increase in the conductivity of the Germanium.

This is known as N-type as is due to the mobility of negative electrons.

If, however, a small quantity of an impurity of valency 3 (Indium) is introduced into another piece of Germanium a similar electron mobility takes place. But in this case the impurity has one less electron than the Germanium so it can be thought as the mobility of a missing electron (called a hole).

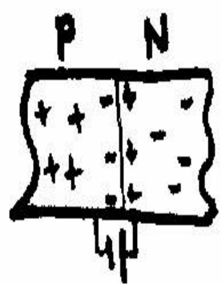
A hole is effectively a positive charge.



This impure Germanium is known as P-type as its conductivity is due to the mobility of positive holes.

**Semicondutor Diode**

A piece of P type Germanium is jointed to a piece of N-type Germanium to form a PN junction.

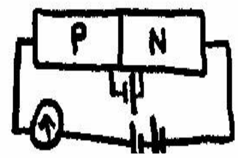



Each half has no overall charge but due the very rapid movement of the elecrons (in the N-type) and holes (in the P-type), some pass through the junction into the other half.

This gives an excess of electrons at the 'P' side of the junction and an excess of holes at the 'N' side of the junction.

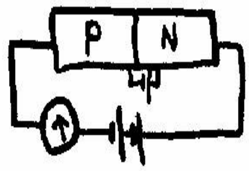
 

This results in a potential barrier that acts as there were a little battery connected across the PN junction and so :-




If the external circuitis connected with the positive to the the 'P' type material then this will be 'series aiding' with the potential barrier, and current will flow.

*The junction is forward biassed.*

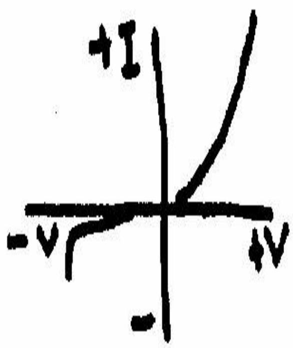



If the external circuit is connected with the negative to the 'P' type material then this will be series-opposing with the potential barrier and no current will flow.

*The junction is reverse biassed.*

Thus 'PN' junction forms semiconductor. IE it will *only pass a current in one direction*.

**The characteristic of a diode**




This shows a 'graph' of a diode.

Current flows when the voltage is positive.

Virtually no current when the voltage is negative.

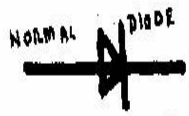
Even the forward part of the characteristic is not linear.

A diode needs a small positive voltage before the current start to flow.

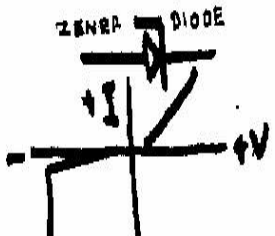
This is 0.3 Volts for Germanium & 0.7 Volts for Silicon diodes.

In the reverse (-V) direction just a few uA flows unless the breakdown voltage is exceeded.

Diodes are usually designed just to pass a current in one direction but they can be designed to advantage of other characteristics.

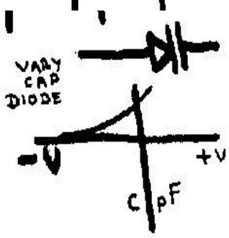



**Zener Diode**




The reverse characteristic can be designed to pass a considerable current at a pre-designed critical voltage. The Zener current is used in voltage stabiliser circuits.

**Variable capacitance diode**




The self capacitance of a diode varies as the voltage is changed. The reverse characteristic can be designed so that this change in capacitance can be used in electronic tuning circuits.

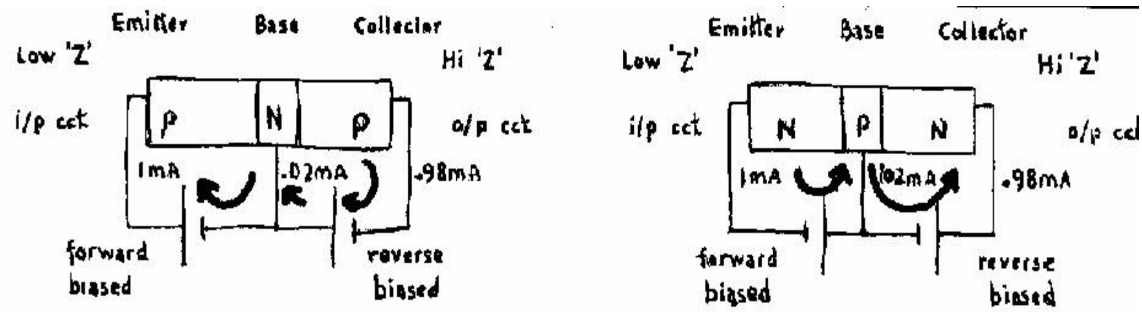
**Bi-polar transistors**

A transistor can be thought of as two diodes connected back to back and sharing a central section. They can be made in either P/N/P or N/P/N configurations.
The three parts are called: emitter, base and collector.
As in the diode, there is a potential barrier at each PN junction.

**Transistor biasing**

A transistor is connected so that its emitter/base junction is **forward biased** and its base/collector junction is **reverse biased**.

PNP (usually Germanium) NPN (usually Silicon)




The base is so very thin that a change in one current will effect the other currents.

IE all three currents are interdependent.

The input circuit (emitter/base) is forward biased so it will have a low impedance.
Whereas the output circuit (base/collector) is reverse biased, giving it a higher impedance.

The i/p and o/p currents are almost the same. It is this large difference between the i/p and o/p impedances that is the key to transistor amplification.
Remember that power = $I^2$ x R. As roughly the same current is flowing in a higher resistance (or impedance) circuit power amplification has taken place.
In fact, even with a slight current loss the power gain could be several hundred times.

The symbol of a PNP transistor The symbol of a NPN transistor


B B

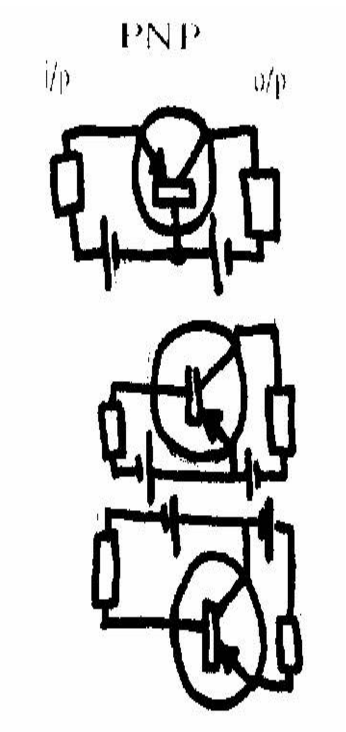
**Modes of transistor operation**

The above configuration is known as the Common Base Mode. It gets its name from the fact that the base is common to both the input and the output circuits...
Being a three terminal device, there are three ways that a transistor can be connected into a circuit: Common Base, Common Emitter or Common Collector.

.

**Modes of transistor operation**




**Common Base**

Current gain <1

Power Gain:1000

i/p Z = Low

o/p Z = Hi

**Common Emitter**

Current Gain 49

Power Gain 1000

i/p Z = Med

o/p Z = Med

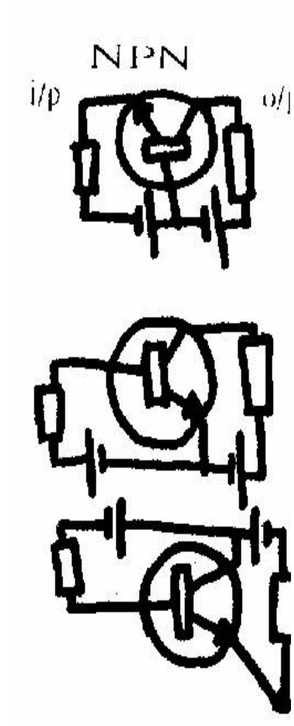
**Common Collector***

Current Gain 50

Power Gain <1

i/p Z = Hi

o/p Z = Lo




*The common collector mode is also known as a emitter follower

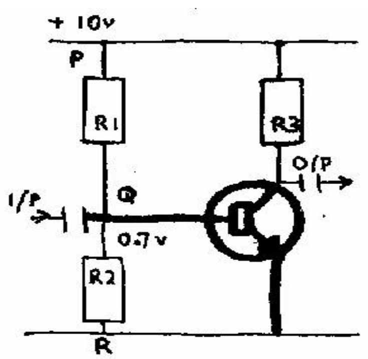
**Practical transistor biasing**

In each circuit the transistor must be correctly biased.
The base should be:
0.3v more negative than the emitter, for a PNP Germanium transistor
0.7v more positive than the emitter, for NPN Silicon transistor
0.3v more positive than the emitter, for PNP Silicon transistor
0.7v more negative than the emitter, for NPN Germanium transistor

**A simple transistor amplifier**

Of course, it is not convenient to use two separate bias batteries. Actual

curcuits used one supply and use two series resistors to form a *potential divider.*




This is the circuit of a simple audio amplifier using a NPN silicon transistor operating in the common emitter mode.The base must be biased to be 0.7 V positive, relative to the emitter. This is achieved by careful choice of potential divider resistors R1 and R2.

EG. Assume that 10v is connected across at P and R. The voltage at Q will depend on the ratio of the two resistor.
In a very simple NPN audio transistor circuit, the voltage required at Q is 0.7v. If R1 = 36kΩ and R2 = 2.7kΩ will achieve this while only draining 0.26mA from the supply.

**Transistor Amplifier Operation**

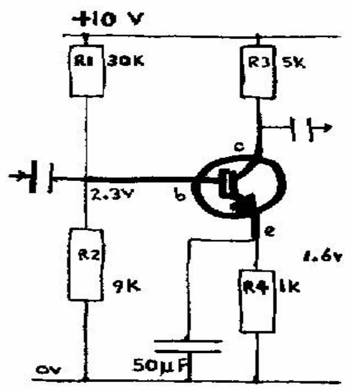
The input signal is superimposed on the base via the coupling capacitor thus varying the base voltage slightly. Thus results in a small variation in the base current. This will cause larger changes in the emitter and collector currents.

The collector current flows through the collector load resistor.
Remember! I = V/R. Thus if the collector current is varying then the voltage across the load resistor will also be varying.

In this example the load resistance is 5kΩ. A variation of just 1mA would result in 5v AC being developed across this load resistor. This AC is 'separated' from the DC on the collector by the output coupling capacitor. This is very much greater than the signal at the input, *amplification has taken place...*

**Thermal Runaway**

This is self destruction of the transistor!
If the current passing through a transistor increases, heat is generated. This heat increases electron mobility and furtherraises the current. This vicious circle cancontinue until thetransistor burns out.This thermal runaway can be avoided by havinga resistor in the Emitter lead.




If the current through the collector and the emitter increases dramatically, the increase in voltage across the emitter resistor will act in opposition to the base bias and reduce the current.

Note that base bias resistors (R1 & R2) will have to changed to take account of the volts dropped across the emitter resistor. The base should be 0.7v more positive than the emitter so the base should be biassed 0.7v + 1.6v above ground .

A by-pass (decoupling) capacitor is usually connected across the emitter resistor to avoid a reduction of the A by-wanted AC signal

.

QUESTIONS.

*For some of the answers to these questions you may have to consult your RAE Manual or "How to become a Radio Amateur" or BR68.*

Question: 6.1 Draw the symbol for a "NPN" bipolar transistor.

Question: 6.2 Draw the symbol for "N" channel Field Effect Transistor.

Question :6.3 ..question deleted

Question:6.4 What would be the result if the *by-pass capacitor* across the *thermal runnaway* were removed? (See amplifier on page 5)

Question:6.5 Is the *forward characteristic* of a diode , *linear* or *non-linear*?

Question:6.6 Draw the characteristic of a varactor diode.

Question:6.7 The circuit of a simple audio amplifier is shown on page 5.

(1) What would be the effect of disconnecting R1 ?

(2) What would be the effect of disconnecting R2 ?

Question:6.8 A sine-wave mains supply has a frequency of 60Hz and a peak voltage of 250 Volts. What is the RMS voltage of this supply?

Question:6.9 What is the meaning of "QRS" and "QRM?" ? (Note the question mark)

Question:6.10 Which mode of transmission is represented by "F3E" ?

Question:6.11 What are the phonetics for your first name?

Question:6.12 Draw the circuit of a simple *high pass filter*?

Question:6.13 What is meant by *resonance* ?

Question:6.14 What is the formula for the resonant frequency of a parallel tuned circuit?

Question:6.15 Draw, in block form, a microphone feeding an audio amplifier whose output can be switched to either a pair of head-phones or a loud-speaker.

Question:6.16 What is the advantage of a "thermo-couple meter" ?

Question:6.17 What is the maximum permitted height of an amateur aerial that is to be errected 600 Metres from an aerodrome ?

Question:6.18 What is the wavelength of a transmission on 1.0Mhz ?