AMATEUR RADIO SYLLABUS MADE SIMPLE

Date Updated : Sep 2010 – **MORSE , RADIO REGULATIONS & OPERATING PROCEDURE**
Amdt2 on 06/06/11

Those who want to enjoy the HAM RADIO Hobby, They can start Learning the in-out of this Enjoyable Hobby. YOU NEED NOT HAVE ANY QUALIFICATION.
HAMS are from different different qualification/profession. There are many Farmers/Doctors/Engineers/Professors/Teachers/Technicians/Business people/Defence person/Physically handicapped/Blind/Truck Drivers & students who range from the age 14 to 100+ years whom I have talked to.This hobby does not know the cast & community.

Did you know that most of the astronauts sent up to the International Space Station (ISS) in the last five to ten years have been licensed radio amateurs? They use the amateur radio station on board the ISS to communicate with school groups all over the world as they are flying over.

THERE IS ONLY ONE & ONLY ONE cast all over the WORLD, that is HAM RADIO.
So Get set to ENJOY this HOBBY. Make friends all over the WORLD. Talk to them BINDAAS.
Who Knows you may render your services during Natural calamities. Hams have helped during Cyclone, Earth Quake, Fire, and During Recent TSUNAMI.

SYLLABUS : page 1 & 2

PART – I I

MORSE CODE

PART –I SECTION - B
RADIO REGULATIONS

(Additional knowledge - Need to Know : Daily Nets , Checking-in-Nets, Providing Disaster communication, Traffic handling, Contests, Awards)

INTRODUCTION to Morse Code: (ONLY FOR GENERAL GRADE)

Ham Radio say Amateur radio is a fascinating hobby for people of all ages of all walks of life irrespective of their age, educational qualifications and status. It is also well suited to the handicapped and elder citizens who are looking for new friends in the country and
World wide. Few to mention : King of Jordan - JY1, Late Rajiv Gandhi - VU2RG;
Mrs Sonia Gandhi - VU2SON; etc ….

Radiotelegraphy (CW) Morse code is named after its inventor Samuel Finely Brees Morse, 1791-1872, an American artist and promoter of the telegraph.

Efficient:

Morse code is the most efficient means of radio communication. Nothing beats code for providing vital communication through noise and interference under marginal conditions.
For few hours The operators at Andaman & Nicobar Islands during the recent Tsunami resorted to Morse code because of low power rig with him and had only battery to operate.

Language:

Radiotelegraphy by itself is a language. Not every amateur understands English but through a recognized systems and combinations of DITS and DASHES every ham can communicate in a common language, the MORSE CODE.

ONE OF THE AMATEUR LOGO IS
"ONE WORLD ONE LANGUAGE"
BECAUSE OF THIS MORSE CODE.

Advantages :

Continuous Wave and Distant Stations go hand in hand. With less crowded amateur bands, increased efficiency, CW affords the opportunity for every Amateur to work his share of the rare ones. On Morse Code much more modest stations can compete successfully.

A majority of public service, health, welfare and emergency messages can be handled quickly and with greater accuracy on Morse code.

The amateur bands are narrow and often very crowded. The CW occupies a small fraction of the band comparing to phone mode. Many CW stations can squeeze in to the same band reducing interference thus conserving spectrum.

Morse Code is economical, compact, less expensive, uses low power. Gives global coverage and free from disturbances. It is the proud language of the amateur and is thoroughly enjoyable.

International Morse Code Alphabets : O = dit —— = dah

A = o —	J = o — — —	S = ooo
B = — ooo	K = — o —	T = —
C = — o — o	L = o — oo	U = oo —
D = — oo	M = — —	V = ooo —
E = o	N = — o	W = o — —
F = oo — o	O = — — —	X = — oo —
G = — — o	P = o — — o	Y = — o — —
H = oooo	Q = — — o —	Z = — — oo
I = oo	R = o — o	

Numerals :

1 = • — — — — 2 = • • — — — 3 = • • • — — 4 = • • • • —

5 = • • • • • 6 = — • • • • 7 = — — • • • 8 = — — — • •

9 = — — — — • Ø = — — — — —

Punctuations :

• — • — • — (aaa) Full stop •

— — • • — — (gw) Comma ,

• • — — • • (imi) Question mark **?** or repeat
— • • • • — (du) Hyphen ——
— • • • — (bt) (Break-in) or Double dash **=**
— • • — • (xe) Slant or division mark **/**
• — • • • (as) Wait
• — • — • (ar) End of Transmission
• • • — • — (va) End of work

TIMING OF MORSE CODE ELEMENTS AND SPACES BETWEEN THEM

The basic unit of time in Morse Code is the length of the dot. The duration of the dash is three times that of the dot. The term "element " is used to indicate both dots and dashes. The space between two elements forming the same character is also the length of the dot. The space between letters is equal to three dots and the space between words is equal to five dots. This relationship is explained below :

O Dit (One Unit)	——— **Dah** (Three Units)
Character to Character	One Dit (Unit)
Letter to letter	Three Dits (Units)
Word to Word	Five Dits (Units)

To calculate one word : five letters to be counted as one word. (i.e. THESE = 1 WORD)

To count characters in 8 wpm in 5 minutes passage:
8 x 5 = 40 words,
1 word = 5 letters/characters
So, 40 x 5 = 200 characters.

EASY WAY TO LEARN MORSE CODE:

There is no magic, mystery or formula connected to this code. Remember you are learning the language of SOUND or THE MUSIC.

Learn to listen to the sound or the Music of the letters and avoid memorizing dots and dashes.

Write down each letter immediately as it is received and ignore doubtful ones.

Do not guess but leave a blank space and concentrate on the next letter.

Avoid thinking back, you may lose more letters.

Practice Morse an hour a day and think of it rest of the day.

Start writing the code as you learn and do not use capitals. This helps in picking up higher speed. Once you pick up the speed up to 8 words per minute you may practice writing in capital letters.

Set aside a definite time every day and stick to the schedule of daily practice.

Concentrate on writing what you hear and read it later. Try and copy with eyes closed or the paper covered.

Practice Morse Code with a friend together and send to one another. Attend to Ham radio classes.

Easy way to remember morse code

O = dit   **___ = dah**

O	E	___	T
O O	I	___ ___	M
OOO	S	___ ___ ___	O
OOOO	H		

O ____	A	___ O	N
O O ___	U	___ ___ O	G
O O O ___	V		
O ___ ___	W	___ O O	D
O ___ ___ ___	J	___ O O O	B

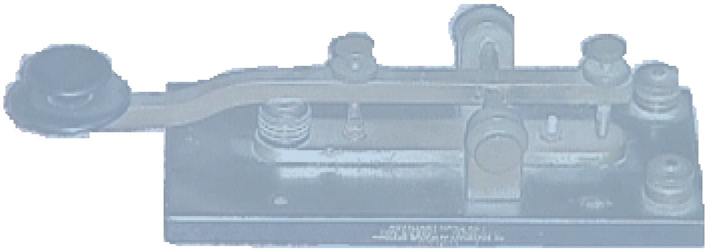
MIX characters

___ O ___	K	O ___ O	R
___ O ___ O	C	O ___ O O	L
___ O O ___	X	O O ___ O	F
___ ___ O ___	Q	O ___ ___ O	P
___ ___ O O	Z	___ O ___ ___	Y

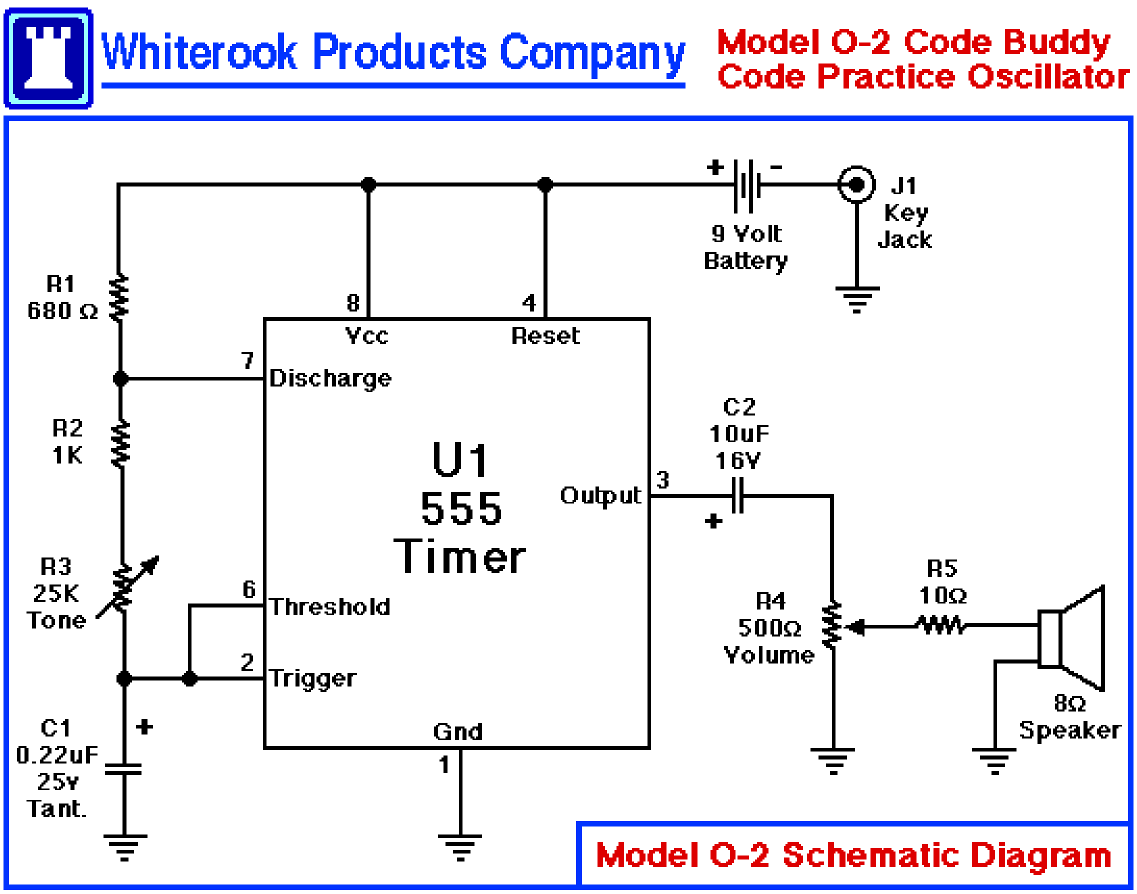
Figures : -

• — — — —	1	— • • • •	6
• • — — —	2	— — • • •	7
• • • — —	3	— — — • •	8
• • • • —	4	— — — — •	9
• • • • •	5	• • • • • •	ø

MORSE KEY :



CODE PRACTICE OSCILLATOR



Abbreviations :

ABBREVIATIONS OR SIGNALS

Abbreviation or signal	Definition
AA	All after ……(used after a question mark in radio telegraphy or in radio telephony after RPT, to request a repetition)
AB	All before … used after a question mark in radio telegraphy or in radio telephony after RPT, to request a repetition)
AR	End of Transmission
AS	Waiting period
C	Yes
CFM	Confirm (or I confirm)
CL	I am closing my station
CQ	General call to all stations
DE	This is
K	Invitation to transmit
NIL	I have nothing to send to you
OK	We agree (or It is correct)
R	Received
TU	Thank you
VA	End of work
WA	Word after … used after a question mark in radio telegraphy or in radio telephony after RPT, to request a repetition)
WB	Word before …. used after a question mark in radio telegraphy or in radio telephony after RPT, to request a repetition)
WX	Weather Report
TU	Thank You
73	Best Regards
SWL	Short Wave Listener
YL	Yong Lady
XYL	Wife of a HAM
Handle	Name
Ragchew	Longer time , Discussion on the air .

Hours of service are expressed in the form of one of the following symbols:

H24	**continuous service throughout the twenty-four hours;**
H16	**16-hour service provided by a ship station of the second category;**
H8	**8-hour service provided by a ship station of the third category;**
HX	**Intermittent service throughout the twenty-four hours, or station having no specific working hours**
HJ	**day service.**
HN	**night service.**

Q CODES :

Q Code	Question	Answer or Advice
QRA	What is the Name of your station ?	The Name of my station is …….
QRG	Will you tell me my exact frequency ….	Your Exact frequency is ….kHz (or MHz)
QRH	Does my frequency vary ?	Your frequency varies.
QRI	How is the tone of my transmission ?	The tone of your transmission is … 1. good, 2. Variable. 3. Bad
QRK	What is the intelligibility of my signals (or Those of … (name and/ or callsign)) ?	The intelligibility of your signals (or those of … (name and/or callsign is … 1. bad 2.poor 3.fair 4. Good 5.excellent
QRL	Are you busy ?	I am busy (or I am busy with …name/callsign). Please do not interfere
QRM	Is my transmission being interfered with ?	Your transmission is being interfered with.. 1.Nil 2.Slightly 3. Moderately 4. severely 5. Extremely
QRN	Are you troubled with static ?	I am troubled by static .. 1. nil 2.slightly 3.moderately 4. severely 5.extremely
~~QRO~~	~~Shall I increase Tx power ?~~	~~Increase Tx power~~
~~QRP~~	~~Shall I decrease Tx power ?~~	~~Decrease Tx power~~
QRQ	Shall I send faster ?	Send faster (……. Words per minute)
QRS	Shall I send more slowly ?	Send more slowly (….. words per minute)
QRT	Shall I stop sending ?	Stop sending.
QRU	Have you anything for me ?	I have nothing for you
QRV	Are you ready ?	I am ready
QRW	Shall I inform….that you are calling him On …kHz (or MHz) ?	Please inform … that I am calling him (On …. KHz (or MHz))
QRX	When will you call me again ?	I will call you again at … hours (on …kHz/MHz)
QRZ	Who is calling me ?	You are being called by … (on kHz/MHz)
QSA	What is the strength of my signals	The strength of your signals is … 1. scarcely perceptible 2. Weak 3. Fairly good 4. Good 5. Very good
QSB	Are my signals fading ?	Your signals are fading.
QSK	*Can you hear me between you signals and if So can I break in on you transmission?*	*I can hear you between my signals; break In on my transmission.*
QSL	Can you acknowledge my receipt ?	I am acknowledging receipt.
QSO	Can you communicate with… (c/s) direct (or by relay)	I can communicate with .. (c/s) direct (or By relay through…)
~~QSP~~	~~Will you relay to….(c/s)~~	~~I will relay to … (c/s)~~
QSU	Shall I send or reply on this frequency ?	Send or reply on this frequency.
QSV	Shall I send a series of V's (for adjustments On this frequency (or on ..kHz/MHz) ?	Send a series of V's (for adjustments on this Frequency (or on … KHz/MHz)
QSW	Will you send on this frequency (or on …kHz/MHz) with emission of class	I am going to send on this frequency (or on …kHz/MHz) with emission of class
QSX	Will you listen to …(c/s) on …kHz/MHz	I am listening to …(c/s) on …kHz/MHz
QSY	Shall I change to transmission on another frequency ?	Change to transmission on another frequency (or on …..kHz/MHz)
QSZ	Shall I send each word or group more than once ?	Send each word or group twice (or … times)
QTC	How many telegrams/msgs have you to send?	I have …telegrams/msgs for you (or for … Name/callsigns)
QTH	What is your posn. In lat and long (or according to any other indication) ?	My position is …lat…long… (or according to any other indication)
QTR	What is correct time ?	The correct time is…… hours
QUM	May I resume normal working ?	Normal working may be resumed.

DISTRESS, URGENCY AND SAFETY COMMUNICATIONS

Distress Signal

International Distress frequency on CW … 500 kHz
SSB/Voice … 2182 kHz , (156.80 MHz – normally know as channel 16 - not in Amateur Radio band)

In Radiotelegraphy (CW) the distress signal consists of the group

o o o __ __ __ o o o (symbolised by $\overline{\text{SOS}}$) transmitted as a single signal in which the dashes are emphasised so as to be distinguished clearly from the dots.

In radiotelephone (Voice) distress signal consists of the word **MAYDAY** pronounced as the French expression "m'aider".

This signal indicates that a ship, aircraft or other vehicle is threatened by grave and imminent danger and requests immediate assistance.

Distress Call

The distress call sent by radiotelegraphy (CW) consists of :

--- the distress signal $\overline{\text{SOS}}$ sent three times;

--- the word DE ;

--- the call sign of the station in distress, sent three times.

e.g. $\overline{\text{SOS}}$ $\overline{\text{SOS}}$ $\overline{\text{SOS}}$ DE ATP ATP ATP

The radiotelephone (voice) distress call consists of :

--- the distress signal **MAYDAY**, spoken three times ;

--- the words **THIS IS** (or **DE** spoken as DELTA ECHO in case of language difficulties);

--- the name , or other identification, of the station in distress, spoken three times.

e.g. MAYDAY MAYDAY MAYDAY THIS IS ALPHA TANGO PAPA, ALPHA TANGO PAPA,
ALPHA TANGO PAPA

This call has absolute priority over all other transmissions. All stations hearing it , or the alarm signal preceding it, must immediately cease any transmission which could cause interference to the distress traffic, and continue to listen on the frequency for the sending of the distress message which follows.

Distress Message

The distress message consists of : **(on Voice)**

--- the distress signal MAYDAY ;

--- the name, or other identification, of the station in distress ;

--- the particulars of its position;

--- the nature of the distress and the kind of assistance desired ;

--- any other information which might facilitate the rescue.

Example of Distress procedure
ON TELEPHONY (SSB)

Lets assume the name of the station as NONSUCH

MAYDAY MAYDAY MAYDAY THIS IS NONSUCH NONSUCH NONSUCH
MAYDAY NONSUCH
NEAR SKERRIES OFF HOLYHEAD
STRUCK ROCK AND IN SINKING CONDITION REQUIRE IMMEDIATE ASSISTANCE
WILL FIRE A DISTRESS ROCKET AT INTERVALS
OVER

Example of Distress procedure
ON TELEGRAPHY (CW)

Lets assume the name of the station as NONSUCH

$\overline{\text{SOS}}$ $\overline{\text{SOS}}$ $\overline{\text{SOS}}$ DE NONSUCH NONSUCH NONSUCH
SOS NONSUCH
NEAR SKERRIES OFF HOLYHEAD
STRUCK ROCK AND IN SINKING CONDITION REQUIRE IMMEDIATE ASSISTANCE
WILL FIRE A DISTRESS ROCKET AT INTERVALS AR K

URGENCY SIGNAL

It consists of three repetitions of the group of words **PAN PAN** in **VOICE** mode (Pronounced as French word *PANNE*) and **X X X in CW** mode. The urgency signal indicates that the station sending it has a very urgent message to transmit concerning the safety of a ship, aircraft or other vehicle, or the safety of a person. It shall be transmitted before the call.

The urgency signal has priority over all other communications, except distress. All stations which hear it shall take care not to interfere with the transmission of the message which follows it.

The urgency signal and the message which follows are sent on either or both of the international distress frequencies (2182 kHz, 156.80 MHz)

SAFETY SIGNAL

In CW mode , It consists of three repetitions of the group **T T T** , the individual letters of each group, and the successive groups being clearly separated from each other, It is sent before the call.

In Voice mode , It consists of the word " **SECURITE** " (pronounced SAY-CURE-E-TAY) sent three times before the call.
It indicates that the station is about to transmit a message containing an important navigational or important meteorological warning.
All stations hearing the safety signal must listen to the safety message until they are satisfied that it is of no concern to them. They shall not make any transmission likely to interfere with the message.
The safety signal and call should be sent on either or both of the international distress frequencies (2182 kHz, 156.80 MHz) but may be sent on any other designated frequency for distress.

SECTION I I

REDIO REGULATIONS -(APPENDIX 14, Edition 2008)

Phonetic for Voice Communications:

Phonetics are necessary because of the similarity of many English alphabets, similarity in pronounces, Pronounces/ascents of different operators of different countries. All operators having communication over voice mode find it necessary to use a standard list of words to signify each letter to avoid any confusion while exchanging messages. This standard list of phonetics is suggested by the ITU to all the member countries.
The list as follows :

A=Alpha, B=Bravo, C=Charlie, D=Delta, E=Echo, F=foxtrot,
G=Golf, H=Hotel, I= India, J=Juliet, K=Kilo, L=Lima
M=Mike, N=November, O=Oscar, P= Papa, Q=Quebec
R=Romeo, S=Sierra, T=Tango, U=Uniform, V=Victor
W=Whiskey, X=Xray, Y= Yankee, Z=Zulu

Figures : Ǿ = Nada Zero, 1= Una One, 2= Besso two
3= Terra Three, 4= Karte Four, 5=Panta Five, 6= Soxi six
7= Sette Seven, 8= Okto Eight 9= Nove Nine

Amateur service

Means a service of self training, inter-communication and technical investigations carried on by amateurs that is, by persons duly authorized under these rules interested in radio technique solely with a personal aim and without pecuniary interest.

Amateur Radio Beacon means a station in the Amateur Service having transmitter (s) emitting carrier wave along with identification signals at regular interval. Normally they transmit their callsign in morse code. Such beacons can be directional or non-directional; These beacons are very useful to find out the Propagation condition. You can hear the Beacons on 14100Khz, 21150Khz, 28200Khz etc.
There can be only one beacon on one band. Power power o/p will be not more than 100watts.

Amateur Satellite Service: A radio communication service using stations on earth satellites for the same purpose as those of Amateur service is called “Amateur Satellite service”. An Amateur satellite is a repeater in space with a large coverage on the earth. Except for geo-stationary orbits, satellites don’t stay in one spot. Orbiting Satellites Carrying Amateur radio is called OSCAR. It is intended for multiple access by Amateur stations in all countries.
Recently The ISRO launched the HAMSAT along with its remote sensing satellite ,CARTOSAT. HAMSAT is a Micro satellite for providing satellite based Amateur Radio services to the national as well as the international community of Amateur Radio Operators (HAMs). It operates in the UHF/VHF band. One of the transponders of HAMSAT has been developed indigenously involving Indian Amateurs, with the expertise of ISRO and the experience of AMSAT-INDIA. HAMSAT is India’s contribution to the international community of Amateur Radio Operators.

Geostationary satellite

A geostationary satellite is an earth-orbiting satellite, placed at an altitude of approximately 35,800 kilometers (22,300 miles) directly over the equator, that revolves in the same direction the earth rotates (west to east). At this altitude, one orbit takes 24 hours, the same length of time as the earth requires to rotate once on its axis. The term geostationary comes from the fact that such a satellite appears nearly stationary in the sky as seen by a ground-based observer. BGAN, the new global mobile communications network, uses geostationary satellites.

Types of Messages :

(1) Permitted: Radio communications may be exchanged with other stations similarly authorised. Transmissions shall be made in plain language and limited to messages of a technical nature relating to tests and to remarks of personal character (excluding business affairs or transactions) in which the licensee, or the person with whom he is in communication, are directly concerned and for which, by reason of their unimportance, recourse to the public telecommunication service is not justified.

(2) Forbidden : The licensee is forbidden to transmit,-

(a) Messages like the reproduction of broadcast programs or tape recordings or transmissions of entertainment value or music.

(b) False or misleading calls, or signals, news, advertisements, communications of business, statements on topics of political or industrial controversy;

(c) Superfluous signals, indecent or of obscene language, topics which are likely to arouse racial, religious, or communal animosity;

(d) Messages for pecuniary reward, monetary benefit or any messages for, or on behalf of third parties

(e) We are also forbidden to contact stations of any other countries whose administration have informed the ITU of their objections to such radio communications.

(3) Third party Messages : In case of failure of normal telecommunication facilities, Amateurs are permitted to handle third party messages, relating to natural calamities such as earthquake, floods, cyclones and wide spread fires, originating from and addressed to a competent civil authority namely:

(a) District Magistrates or Deputy Commissioners or Collectors of the district and

(b) Any other officer authorised by authorities mentioned at (a) above. The licensee shall inform by letter addressed to the licensing authority regarding the use of his amateur station for such purposes on each such occasions**.**

Secrecy of Correspondence : If any message which is not entitled to be received is never received. We shall not make it known its contents, its origin and destination, its existence or the fact of its receipt to any person other than a duly authorized officer of the Central govt. or competent legal tribunal. It shall not be reproduced in writing, copied or made use of.

Licensing Procedure : The license is issued by The Wireless Planning & Co-ordination Wing (WPC) of the Ministry of Communications and IT , Dept. of Telecommunications, New Delhi.

Category of Licenses :

There are TWO categories of licences :

(ii) Amateur Wireless Telegraph Station Licence, GENERAL

(iii) Amateur Wireless Telegraph Station Licence, RESTRICTED

Eligibility:

1. (a) who is a citizen of India;
   (b) who is not less than 12 years of age;
   (c) who qualifies the Amateur Station Operators' Examination for the award of licence or holds either of the following certificate of proficiency, namely:
   (i) Radio-communication Operators' General Certificates;
   (ii) First or Second Class Radio-telegraph Operators' Certificate:

The holder of a Special Radio Telegraph Operator's Certificate (*Normally they are called as Radio Officers of Merchant ships*) also considered eligible for Restricted License Grade

(iii) The Amateur radio society, club, a school, college, an institution or an University in India, which has the aim of participating in the "amateur service". Provided that the license shall be issued in the name of an authorized official of the society, club, school, college, institute or University in India, holding a category of licence appropriate to the transmission to be conducted by the station, including amateur radio beacon transmissions.

2. The Central Government may grant, to ***bonafide experimenters:***
   (a) Between the ages of 14 and 18 years, Amateur Wireless Telegraph Station Licence, Grade GENERAL
   (b) to those between the ages of 12 and 18 years, Restricted Amateur Wireless Telegraph Station Licence or Short Wave Listeners' Amateur Wireless Telegraph Station Licence :

Provided that the application for the grant of such licences (above licenses) shall be accompanied by a certificate from the head of the educational institution, recognised by a Board or University in India, attended by the applicant of from his legal guardian that the applicant is interested in and is competent to conduct experiments in wireless telegraphy.

Renewal of Licence :
The licence is issued for 20 years. It can be renewed for LIFE LONG or for 20 years by paying the prescribed fees before the expiry of the licence. One must also send log extract of contacting 40 occasions per year. After attaining the age 80, Upon request, License is renewed for 10 yrs, without Fee.

Location of Amateur Station :
The location of the amateur station shall be specified in the licence along with the usual residence of the licensee endorsed therein and it shall be operated only from the place so fixed. The Central Government may, permit the change of location if the licensee applies for it in writing giving particulars of the change and submits the license for endorsement, and pays a fee of Rupees 200.

Mobile/Portable Stations:
Permission for operating a station as mobile from a vehicle or as a portable station from another location for demonstrations or for experiments can be obtained by General Grade or Advanced grade operators by paying Rs.200. The application also must include the area of operation and purpose. It shall be issued up to 90 days initially and for another 90 days upon request and **by paying Rs.200**. The suffix "MO" must be added to the callsign followed by the location of the station. The licencee's amateur station at the fixed location and mobile station must not communicate with each other.

Amateur station on Board SHIP :
Permission can be obtained for operating the amateur station from ships registered in India. Applications for such authorization must be accompanied by a written approval from the Master of owner of the ship. It shall be operated while the ship is in International waters or in Indian territorial waters. Its operation from another country's territorial waters shall be according to the rules of that country. It shall not be operated while the ship is in any harbor in India. The callsign allotted shall have suffix "MS" followed by the callsign of the ships in case of Morse code or the name of the ship in case of voice communication. It shall be independent of the ship's radio communication, radio navigation and other safety services. It shall be operated in such a way not to cause any interference to the services of the ship. It shall have independent power supply and must discontinue operations on request from central Govt,. the Master or radio Officer of the ship or any land station.

INTERNATIONAL TELECOMMUNICATION UNION (I T U)

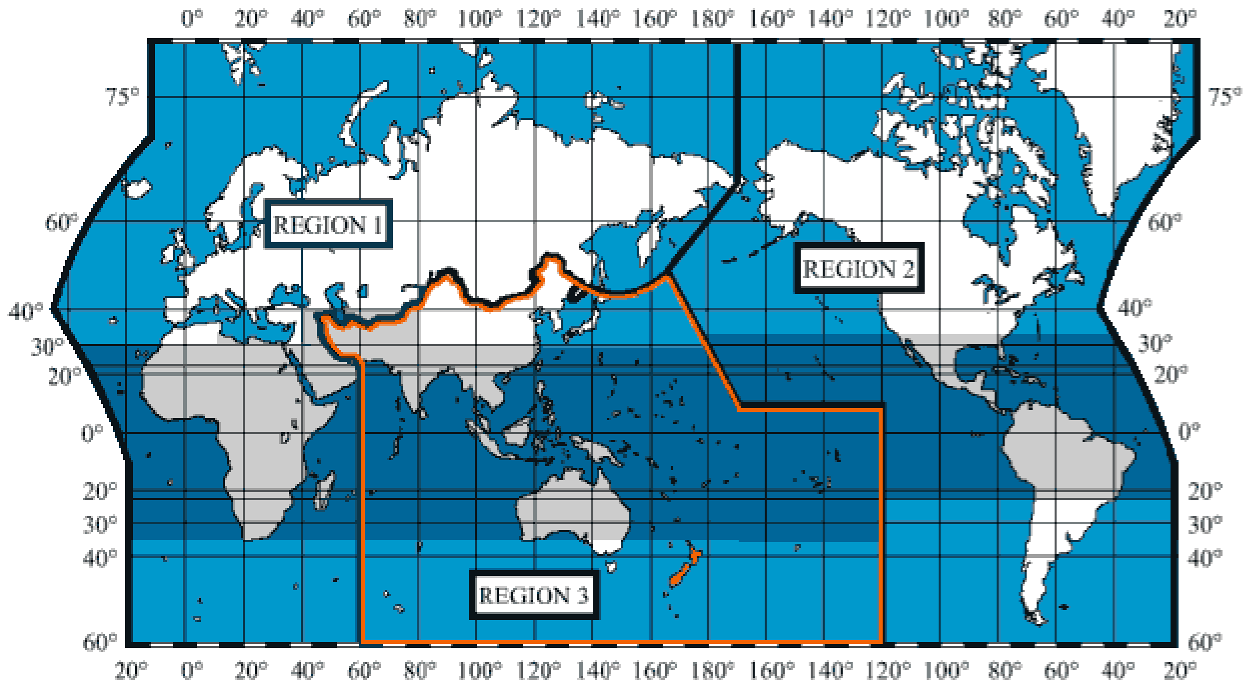
ITU plays a vital role in the management of the radio frequency spectrum and satellite orbits, finite natural resources which are increasingly in demand from a large number of services such as fixed, mobile, broadcasting, amateur, space research, meteorology, global positioning systems, environmental monitoring and last but not least, those communication services that ensure safety of life at sea and in the skies.
This is headquartered at Geneva, Switzerland.
At present there are 189 members (Countries). India became member of ITU On 1st January 1869.
ITU is divided into three regions: a) Region 1 b) Region 2 c) Region 3

India comes under region 3.

ITU is responsible for distribution of the radio-frequency spectrum to radio services in different parts of the world and the regulatory provisions to be applied in order to access that spectrum.

In **India** the WPC Wing of the Ministry of Communications and IT, Department of Telecommunications is responsible for allocating and managing the Frequency spectrum in the country.

MAP OF ITU
REGIONS



Callsigns :

The Callsign Block allocated to India : ATA-AWZ, VTA-VWZ, 8TA-8YZ

Callsign formation for Indian Amateurs :

GENERAL GRADE — VU2 prefix with 2 OR 3 letter suffix. Eg.. VU2GT VU2AF
VU2 prefix with 3 letter suffix. Not ending X, Y, Z
Eg… VU2NLF VU2SWS VU2IZO

(Earlier before Sep 2010 – VU2AF .. was Advance grade. VU2UVS was Grade I. VU3AMY was Grade II or Restricted Grade)

RESTRICTED Grade — Eg…. VU3 prefix followed by 3 letter suffix. Eg…VU3DJQ VU3RSB

Q codes , distress and other signals which may cause confusions are not issued as suffix.

Prefix of some other Countries (DX Stations) :

Japan : JA-JS — Germany: DA-DR — USA : K, W, N
England : G, M — Srilanka : 4S — Russia : RA-RZ, UA-UI

General Radiotelegraph and Radiotelephone Procedure :

(1). (a) Before transmitting, the station shall take precautions to ensure that its emissions will not interfere with transmissions already in progress. If such interference is likely the transmission shall not commence till there is an appropriate break in the communications is progress.
(b) The callsign endorsed in the licence shall be sent for identification at the beginning and at the end of each period of transmission. When the period of transmission exceeds 10 minutes the call sign shall be repeated. Licensee shall not make transmission without identification or with false identification.
(c) Prolonged calls and transmissions shall be avoided.
(d) When it is necessary to spell out call sign, certain expressions, difficult words, abbreviations, figures etc., the phonetic alphabet and figure code given in the Convention shall be used.

(2) Call and Reply **Procedure:**

(a) The call shall consist of the call sign of the station called not more than three times;
the word DE (in case of radiotelegraphy) and the words "This is" (in case of radio telephony). the call sign of the calling station, not more than three times.

Eg. ON SSB : VU3WJM VU3WJM VU3WJM THIS IS VU2NKS VU2NKS VU2NKS OVER
ON CW : VU2UR VU2UR VU2UR DE VU2NXM VU2NXM VU2NXM AR K

(b) **The reply to call** shall consist of - the call sign of the calling station, not more than three times; the word DE (in case of a radiotelegraphy) and the words "This is" (in case of radio telephony). the call sign of the station called, not more than three times.

Eg. ON SSB : VU2NKS VU2NKS VU2NKS THIS IS VU3WJM VU3WJM VU3WJM OVER
ON CW : VU2NXM VU2NXM VU2NXM DE VU2UR VU2UR VU2UR AR K

(c) The call may be sent three times at intervals of two minutes; thereafter it shall not be repeated until an interval of 10 minutes during which the operator shall listen in the frequency band in which the call has been made.

(d) **In case of general call to all stations** the signal `CQ' (in case of radiotelegraphy/CW) and the words `Hello all stations' or the signal `CQ' (in case of radiotelephony) shall replace the call sign of the station called in the calling procedure.
Eg.. ON SSB : CQ CQ CQ THIS IS VU2SGW VU2SGW VU2SGW OVER
OR Hello all stations (three times) this is VU2SGW (three times) OVER
ON CW : CQ CQ CQ de VU2PAI VU2PAI VU2PAI AR K

(3) End of Transmission and Work :

(a) Transmission of a message shall be terminated by the signal AR (in case of radiotelegraphy) and the word `Over' (in case of radiotelephony).

(b) The end of work between two stations shall be indicated by each of them by means of signal VA (in case of radiotelegraph) and by the word `OUT' (or VA spoken as Victor Alfa) in case of radiotelephony.

Breaking in Procedure:

When two or more stations are in communication and the third station wants to join them, The third station should send the word “BREAK followed by the callsign.

Eg.. VU2SMN and VU2NKS are in communication, third station VU2AVG wants to join now :
Then he transmits : - BREAK VU2AVG (on voice) and
BK VU2AVG (on CW)

If either stations do not answer your break in then wait and call them after their communication is over.

RST System :

The RST system is used for giving reports of the signals received .
"R" stands for Readability, and has range from 1 to 5.
"S" stands for Signal Strength, and has range from 1 to 9.
"T" stands for Tone and has range from 1 to 9.
During voice communication only R and S report is given, whereas on Morse code Tone of the carrier also must be given.

Following statement shows the meanings of the figures used in the RST system :

This is normally used on CW

Readability

1. Unreadable
2. Barely readable, only some words are distinguishable
3. Readable with considerable difficulty
4. Readable with practically no difficulty
5. Perfect readable

Signal Strength

1. Faint signal barely readable
2. Very weak signals
3. Weak signals
4. Fair Signals
5. Fairly Good signals
6. Good signals.
7. Moderately Strong signals.
8. Strong signals
9. Extremely strong signals.

Tone (tone report is given on CW)

1. Very rough and broad AC
2. Very hard and broad AC
3. Rough AC Tone, rectified but not filtered
4. Rough tone, some traces of filtering.
5. Filtered rectified AC but strongly ripple modulated.
6. Filtered tone, definite trace of ripple modulation
7. Near pure tone, trace of ripple modulation
8. Near perfect tone, slight trace of modulation
9. Perfect tone, no traces of ripple or modulation of any kind.

LOG BOOK

Log (Dairy of the radio service):

A chronological record of all transmissions emanating from or received at the amateur station shall be kept in bound book (not loose-leaf) showing the following :

(a) Date and time of each transmission;
(b) a summary of the communications exchanged;
(c) a brief description of the experiments and tests undertaken;
(d) the callsign of station or stations with which messages have been exchanged, times and type of emission employed in each case;
(e) time of opening and closing down the amateur station;
(f) in case of portable or mobile amateur station the particulars of temporary location.

All times in the log shall be stated in the Indian Standard Time.
No gaps shall be left between entries in the log and they shall be made and initialed at the time of receiving and transmitting.
(4) In case the station is operated by a person other than the licensee (see rule 23), the licensee shall ensure that log is signed by that person indicating his name, callsign and licence number.

(5) Licensee shall preserve the log for a period of one year from the date of last entry therein before it is destroyed: Provided that no log shall be destroyed for such further period as the Central Government may direct.

AMATEUR RADIO LOG (Extract from original Log of VU2NXM)

Specimen Form of Log

S.No. of Contact	Date	Time IST	Frequency & Type of emission & power input to final stage F E P	Station Called	Station Called By	Station Heard or Worked R S T	Report Received R S T	Time of terminating Q S O	Record Experiment	Q S L Card R	Q S L Card S	Initials
01	11/12/04	0359	21MHZ, SSB, 50 WATTS	VU4RBI	VU2NXM	59	59	0402	VU4 DXPDTN	Y	Y	BK
02	25/12/04	1840	7MHZ, SSB,50W	VU4NRO	VU2NXM	57	57	1842	VU4 DXPDTN	Y	Y	BK
03	25/12/04	1845	14MHZ, SSB, 100W	VU4RBI	VU2NXM	59	59	1848	VU4, VOICE RECORDED	Y	Y	BK
04	27/12/04	0900	14 MHZ, SSB,50W	VU4RBI	VU2NXM	57	56	0905	SOS TFC	Y	Y	BK

Authorised Frequency Bands, Power and Emission

(Annx I to GOI, WPC ltr L-14011/255/2004-AMT dt 13/08/2010.)

Category of Licence	Frequency Bands	Emission	Max D.C.input power
RESTRICTED GRADE	1820-1860 * kHz (160M) 3500-3700 * kHz (80M) 3890-3900 kHz (75M) 7000-7200 kHz (40M) 14000-14350 kHz (20M) 18068-18168 kHz $ (17M) 21000-21450 kHz (15M) 24890-24990 kHz $ (12M) 28000-29700 kHz (10M)	A1A, A3E, H3E, J3E, R3E	50 Watts
	50 – 54 MHz (6M)	F1B, F2B, F3E, F3C	10 Watts
	144-146 MHz (2M) 434-438 MHz @ (70cm)	-DO – PLUS A1A, A2A	10 Watts
GENERAL GRADE	This is In addition to frequencies allotted to RSTD Grade	A1A, A2A, A3E, H3E, R3E, J3E, F1B, F2A, F3E,F3C, A3C, A3F	400 Watts
	50 – 54 MHz (6m)	F1B, F2B, F3E, F3C	25 Watts
	144-146 MHz (2m)	-do-	25 Watts
	434-438 @ MHz (70cm)	-do-	25 Watts
	5725-5840 MHz @ (0.05cm)	-do-	25 Watts

* On primary shared basis as per the relevant provisions of radio regulations.
& Authorization is on non-interference and non-protection basis.
@ On secondary basis as per the relevant provisions of radio regulations.

Note:

(i) All the allocation subject to the relevant provisions of the Radio Regulations. Amateur satellite service is permitted for General grade in the appropriate sub-bands in accordance with Radio Regulations and those cases the maximum output R F power (eirp) is 30 dBw.

(ii) The above authorization is subject to site clearance as per the procedure prescribed by the Standing Advisory committee on Radio Frequency Allocation (SACFA) as applicable.

(iii) For A3F emission, the transmission shall be restricted to call-sign of the station, location and other particular of the station. They shall be limited to point to point test transmission employing a standard interface and scanning with a bandwidth not more than 4 KHz.

(iv) DC input power is the total direct current power input to the final stage of the transmitter.

Emissions – Modes :

Class of emissions are designated by group of a minimum three characters :

First Symbol : Types of modulation of main carrier
Second Symbol : Nature of signals modulating the main carrier
Third Symbol : Type of information

A 1 A : Double sideband Telegraphy by on-off keying, without modulation (CW)

A 3 E : Amplitude modulation Telephony, voice

F 3 E : Telephony, (voice) Frequency modulation

J 3 E : Telephony, (voice) Single sideband , suppressed carrier ,

R 3 E : Telephony, (voice) Single sideband, Reduced carrier ,

H 3 E : Telephony, (voice) Single sideband, full carrier.

F 1 B : Frequency modulated , RTTY, Fast Morse

A 2 A : Double sideband Telegraphy by on –off keying with modulation (MCW)

C 3 F : Vestigial Sideband Television

First symbol – types of modulation of the main carrier

Emission in which the **main carrier is amplitude-modulated** :

Double – sideband	A
Single – sideband , full carrier	H
Single – sideband reduced carrier	R
Single – sideband suppressed carrier	J
Frequency modulation	F

Second symbol – Nature of signal(s) modulating the main carrier

Information without the use of a modulating sub-carrier	1
Information with the use of a modulating sub-carrier	2
Analogue Information (Telephony)	3

Third symbol – type of information to be transmitted

Telegraphy (CW)	A
Facsimile	C
Data transmission, telemetry	D
Telephony (including sound b/c)	E
Television (video)	F

Section I - Necessary Bandwidth (from ITU page)

§ 2. 1) The *necessary bandwidth*, as defined in No. **1.152** and determined in accordance with formulae and examples, shall be expressed by three numerals and one letter. The letter occupies the position of the decimal point and represents the unit of bandwidth. The first character shall be neither zero nor K, M or G.

2) Necessary bandwidths 1:

between 0.001 and 999 Hz shall be expressed in Hz (letter H);

between 1.00 and 999 kHz shall be expressed in kHz (letter K);

between 1.00 and 999 MHz shall be expressed in MHz (letter M);

between 1.00 and 999 GHz shall be expressed in GHz (letter G).

1 Examples:

0.002 Hz = H002	6 kHz = 6K00	1.25 MHz = 1M25
0.1 Hz = H100	12.5 kHz = 12K5	2 MHz = 2M00
25.3 Hz = 25H3	180.4 kHz = 180K	10 MHz = 10M0
400 Hz = 400H	180.5 kHz = 181K	202 MHz = 202M
2.4 kHz = 2K40	180.7 kHz = 181K	5.65 GHz = 5G65

3) For the full designation of an emission, the necessary bandwidth, indicated in four characters, shall be added just before the classification symbols. When used, the necessary bandwidth shall be determined by one of the following methods:

3.1) use of the formulae and examples of necessary bandwidths and designation of corresponding emissions given in Recommendation ITU-R SM.1138;

3.2) computation, in accordance with other ITU-R Recommendations;

3.3) measurement, in cases not covered by § 3.1) or 3.2) above.

Section II - Classification

§ 3. The class of emission is a set of characteristics conforming to § 4 below.

§ 4 Emissions shall be classified and symbolized according to their basic characteristics as given in Sub-Section IIA and any optional additional characteristics as provided for in Sub-Section IIB.

§ 5 The basic characteristics (see Sub-Section IIA) are:

1) first symbol - type of modulation of the main carrier;

2) second symbol - nature of signal(s) modulating the main carrier;

3) third symbol - type of information to be transmitted.

Modulation used only for short periods and for incidental purposes (such as, in many cases, for identification or calling) may be ignored provided that the necessary bandwidth as indicated is not thereby increased.

Sub-Section IIA – Basic characteristics

§ 6. 1) First symbol - type of modulation of the main carrier

1.1	Emission of an unmodulated carrier N	**N**
1.2	Emission in which the main carrier is amplitude-modulated (including cases where sub-carriers are angle-modulated)	
1.2.1	Double-sideband	**A**
1.2.2	Single-sideband, full carrier	**H**
1.2.3	Single-sideband, reduced or variable level carrier	**R**
1.2.4	Single-sideband, suppressed carrier	**J**
1.2.5	Independent sidebands	**B**
1.2.6	Vestigial sideband	**C**

1.3	Emission in which the main carrier is anglemodulated	
1.3.1	Frequency modulation	**F**
1.3.2	Phase modulation	**G**
1.4	Emission in which the main carrier is amplitude- and angle-modulated either simultaneously or in a pre-established sequence	**D**
1.5	Emission of pulses **2**	
1.5.1	Sequence of unmodulated pulses	**P**
1.5.2	A sequence of pulses	
1.5.2.1	modulated in amplitude	**K**
1.5.2.2	modulated in width/duration	**L**
1.5.2.3	modulated in position/phase	**M**
1.5.2.4	in which the carrier is angle-modulated during the period of the pulse	**Q**
1.5.2.5	which is a combination of the foregoing or is produced by other means	**V**
1.6	Cases not covered above, in which an emission consists of the main carrier modulated, either simultaneously or in a pre-established sequence, in a combination of two or more of the following modes: amplitude, angle, pulse	**W**
1.7	Cases not otherwise covered	**X**

2 Emissions where the main carrier is directly modulated by a signal which has been coded into quantized form (e.g. pulse code modulation) should be designated under § 1.2) or 1.3).

2) Second symbol - nature of signal(s) modulating the main carrier

2.1	No modulating signal	**0**
2.2	A single channel containing quantized or digital information without the use of a modulating sub-carrier**3**	**1**
2.3	A single channel containing quantized or digital information with the use of a modulating sub-carrier**3**	**2**
2.4	A single channel containing analogue information	**3**
2.5	Two or more channels containing quantized or digital information	**7**
2.6	Two or more channels containing analogue information	**8**
2.7	Composite system with one or more channels containing quantized or digital information, together with one or more channels containing analogue information	**8**
2.8	Cases not otherwise covered	**X**

3 This excludes time-division multiplex.

3) Third symbol - type of information to be transmitted 4

3.1	No information transmitted	**N**
3.2	Telegraphy - for aural reception	**A**
3.3	Telegraphy - for automatic reception	**B**
3.4	Facsimile	**C**
3.5	Data transmission, telemetry, telecommand	**D**
3.6	Telephony (including sound broadcasting)	**E**
3.7	Television (video)	**F**
3.8	Combination of the above	**W**
3.9	Cases not otherwise covered	**X**

Standard Time and frequency stations :
(following are the few)

5 MHz

ID Time / Lang	Call Sign	State	Station Name	Latitude	Longitude	BC Times UTC	Remarks
	ATA	INDIA	New Delhi	28 34 N	77 19 E	----	Inactive Freq

(From National Physiological Laboratory NPL)

10 MHz

ID Time / Lang	Call Sign	State	Station Name	Latitude	Longitude	BC Times UTC	Remarks
H + 14, 29, 44, 59	ATA	INDIA	New Delhi	28 34 N	77 19 E	Cont	Inactive Freq
H + 29, 59, CC	BPM	CHINA	Xian	35 00 N	109 31 E	H + 45-10, 15-40	

20 MHz

H + 00, 30	WWV	USA	Fort Collins, CO	40 40 49 N	105 02 27 W	Cont

IST / UTC / GMT :
I S T (Indian Standard Time) is 5.30 hrs ahead of UTC (Universal Co-ordinated Time). UTC is also known as GMT (Greenwich Mean Time) .(Normally UTC is maintained during DX QSOs), Therefore when it is 06.00 hrs IST It is 00.30 hrs UTC / GMT. When it is 1100 UTC, it is 1630 IST

QSL Cards : QSL card is a written confirmation of a contact, Exchanged between radio amateurs. These are of post card size. It must have your callsign, name and address, the particulars of the contact like date, time, frequency, RST, mode and callsign of the station contacted, power used, type of TX and antenna system etc. Collecting these cards is also part of this hobby. For sending and receiving the cards economically, QSL Bureaus of radio clubs are used. At present the Indian QSL bureau is in Mangalore with VU2PAI.

See some of the QSL cards

Nomenclature of Frequency & Wavelength

Frequency Range	Frequency band	Wave Length (M)	Waves
3 to 30 KHz	Very Low Freq (VLF)	30,000-10,000	Myriametric
30 to 300 KHz	Low Frequency (LF)	10,000-1000	Kilometric
300 to 3000 KHz	Medium Frequency (MF)	1000-100	Hectometric
3 to 30 MHz	High Frequency (HF)	100-10	Decametric
30 to 300 MHz	Very High Frequency (VHF)	10-1	Metric
300 to 3000 MHz	Ultra High Frequency (UHF)	1 m-10 cm	Decimetric
3 to 30 GHz	Super High Frequency (SHF)	10-1 cm	Centimetric
30 to 300 GHz	Extremely High Freq (EHF)	1- 0.1 cm	Millimetric
300 to 3000 GHz			Decimetric

Beacon Locations Chart: A worldwide network of high-frequency radio beacons on 14.100, 18.110, 21.150, 24.930, and 28.200 megaHertz. (CW Mode)

Slot	DX Entity	Call	Location	Latitude	Longitude	Grid Sq
1	United Nations	4U1UN	New York City	40º 45' N	73º 58' W	FN3Øas
2	Canada	VE8AT	Eureka, Nunavut	79º 59' N	85º 57' W	EQ79ax
3	United States	W6WX	Mt. Umunhum	37º 09' N	121º 54' W	CM97bd
4	Hawaii	KH6WO	Laie	21º 38' N	157º 55' W	BL11ap
5	New Zealand	ZL6B	Masterton	41º 03' S	175º 36' E	RE78tw
6	Australia	VK6RBP	Rolystone	32º 06' S	116º 03' E	OF87av
7	Japan	JA2IGY	Mt. Asama	34º 27' N	136º 47' E	PM84jk
8	Russia	RR9O	Novosibirsk	54º 59' N	82º 54' E	NO14kx
9	Hong Kong	VR2B	Hong Kong	22º 16' N	114º 09' E	OL72bg
10	Sri Lanka	4S7B	Colombo	6º 6' N	80º 13' E	NJ06cc
11	South Africa	ZS6DN	Pretoria	25º 54' S	28º 16' E	KG44dc
12	Kenya	5Z4B	Kiambu	1º 01' S	37º 03' E	KI88mx
13	Israel	4X6TU	Tel Aviv	32º 03' N	34º 46' E	KM72jb
14	Finland	OH2B	Karkkila	60º 32' N	24º 06' E	KP2Øbm
15	Madeira	CS3B	Santo da Serra	32º 43' N	16º 48' W	IM12or
16	Argentina	LU4AA	Buenos Aires	34º 37' S	58º 21' W	GFØ5tj
17	Peru	OA4B	Lima	12º 04' S	76º 57' W	FH17mw
18	Venezuela	YV5B	Caracas	10º 25' N	66º 51' W	FK6Ønj

End.

Thanks :

Many of my Old Timers who all encouraged me to make this simple Syllabus/write-up which would be sufficient for passing the ASOC exam in India.
If any suggestions or additions please send me the simple writeup.

My email : basappaji@yahoo.co.in

Mobile No. 9970175418 (amdt 2 (06/06/2011)

Updated : Sep 2010 (amdt 1 dt 07/06/2011)

SECTION III - TECHNICAL NOTES

My Words:

Can I really learn how to be an amateur radio operator from a simple manual like this?
Yes and No. This manual will help you get through your examination, but getting your license is only the beginning. There is still much to learn, and to get the most out of amateur radio, you will have to continually learn new things.
I am normally not a big fan of this type of approach to getting an amateur radio license. It will teach you the answers to the test questions, but not give you a deep understanding of electronics, radio, or the rules and regulations. That will be up to you after you get your license.
I hope that by helping you get your license that you'll be encouraged to become an active radio amateur and get on the air, participate in public service and emergency communications, join an amateur radio club, and experiment with radios, antennas, and circuits. These are the activities that will really help you learn about radio in depth, and in the end, help you be confident in your abilities as an amateur radio operator.

Good luck and have fun!

I hope that you find this study guide useful and that you'll become a radio amateur, Remember that getting your license is just a start, and that you will be continually learning new things.
If you have any comments, questions, compliments or complaints, I want to hear from you.
E-mail me at basappaji@yahoo.co.in my goal is to continually refine this study guide and to continually make it better.

Acknowledgement
I would like to acknowledge W8BBS/Bruce Spratling. N7XM/Josh & WX7M/Patric (Who helped with HF Tentec Rigs for practical purposes) and many more HAMs, ham radio websites, Kolkatta and AP Amateur Radio clubs whose notes I could read and used some text of their study material for preparing this study guide.

73 !

Basappa Arabole
VU2NXM /
KC2ZNJ

SECTION – I I I
BASIC RADIO THEORY

(i) Elementary Electricity and Magnetism :

1.Elementary theory of electricity, Passive Devices (Resistors, Inductors, Transformers, Capacitors) and Active Devices (Diodes, Transistors) :
conductors and insulators, units
(2) Kirchoff's current and voltage laws – Simple applications of the law.
(3) Conductors and Insulators – Properties, units circuit elements. Ohms Law.
(4) Conductance – Definition of self and mutual inductance.
(5) Power and energy – Definition, Units and simple applications.
(6) Permanent magnets and electromagnets – Definition, properties and their use.

Resistance in series and parallel conductance, Specific resistance,
Types of resistors, Standard color code chart,
Kirchoff's Current Law, Kirchoff's voltage Law,
Power and energy, Joules La, calories, Quantity of electricity, coloumb
Batteries : Types of cells, cells in series and parallel
Capacitors: Capacitance, Types, Series & Parallel
Magnetism: Magnetic field, Magnetic flux, Types and Properties of Magnets And their use in radio work
Inductors: Inductance, Types, Self Inductance, and Mutual Inductance.
Transformers : Types, Turns ratio, Current & Voltage ratio
Capacitance: Construction of various types of capacitors, series & parallel

(ii) Elementary Theory of Alternating Currents :

(1) Sinusoidal alternating quantities – definition of peak, instantaneous, frequency, period, Wave length, R.M.S. average values and simple applications.
(2) Phase; reactance, Impedance; power factor – definition, units and simple applications.
(3) Parallel and Series Circuits – series and parallel circuits containing resistance, inductance, capacitance, resonance in series and parallel circuits; coupled circuits;
(4) Rectifiers, voltage regulation and smoothing circuits – Their basic knowledge and simple application.

Transformers : Types, Turn ratio, current & voltage ratio,
Transformers for audio and radio frequencies;
Vacuum Tubes: (Thermionic valves)
Types of tubes, Applications, Triode as an amplifier,
Rectifiers, Half wave rectifier, full wave rectifier, Bridge rectifier and Filter circuits.
Amplifiers: Classification of Amplifiers, Push-Pull amplifier,
Distortion in amplifiers.
Oscillators: Basic tank circuit, Hartley Oscillator, Colpitts Oscillator,
Piezo electric effect, Transistor Crystal Oscillator.

(iii) Elementary theory of Semiconductor Devices:

1. Diodes and transistors- Properties use of these devices for construction of amplifiers, oscillators, detectors and frequency changers.

Semiconductor Devices: Transistor types, junction transistors,
Working of NPN & PNP transistors, relation between Beta & Alpha
Modulation: Amplitude, Frequency and Phase modulation.

(iv) Radio Receivers :

(1) Principles and operation of T.R.F. and super hetrodyne receivers,
(2) CW reception;
(3) Receiver characteristics - sensitivity, selectivity, fidelity;
adjacent channel and image interference; A.V.C. and squelch/circuits; signal to noise ratio.

BFO, AGC, Signal to Noise ratio, Rx noise,
Side Band, SSB Rx, Communication Rx, Comparison between TRF and SH Rx,

(v) Transmitter :
(1) Principles and operation of low power transmitter; crystal oscillators, stability of oscillators, Compare AM & FM,
(2) Basic knowledge about construction of Semiconductor based transmitters.

Microphones:
Types, Moving coil, Electro static, Piezo electric

(vi) Radio Wave Propagation :
(1) Basic knowledge of Electromagnetic Spectrum.
(2) Wave length, frequency, frequency bands.
(3) Nature and propagations of radio waves;
Ground and sky waves; space waves, skip distance; skip zone and fading.

(vii) Aerials:
Common types of transmitting and receiving aerials.
Dipole, Half-wave, Inverted Vee, Yagi, Folded dipole, Loop

(vii) Frequency Measurement :
Measurement of frequency and use of simple frequency meters.
SWR meter, Watt meter, Volt meter

Names of electrical units, DC and AC, radio signals, conductors and insulators, electrical components
****

You don't have to be an electronics engineer to get an Amateur Radio license, but it does help
To know the basics of electricity and some of the units we use in electronics. The most important units are current, voltage, resistance, power, and frequency.

ACTIVE AND PASSIVE DEVICES IN ELECTRONICS :
While learning Elementary theory of electricity, we will be coming across Some Passive Devices (Resistors, Inductors, Transformers and Capacitors)

Electronic components are classed into either being Passive devices or Active devices. Active devices are different from passive devices. These devices are capable of changing their operational performance, may deliver power to the circuit, and can perform interesting mathematical functions. While a device that does not require a source of energy for its operation.

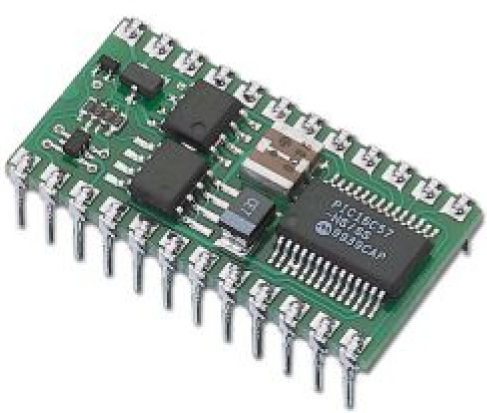
What are Active Devices? An active device is any type of circuit component with the ability to electrically control electron flow (electricity controlling electricity). In order for a circuit to be properly called electronic, it must contain at least one active device. Active devices include, but are not limited to, vacuum tubes, transistors, silicon-controlled rectifiers (SCRs), and TRIACs.

All active devices control the flow of electrons through them. Some active devices allow a voltage to control this current while other active devices allow another current to do the job. Devices utilizing a static voltage as the controlling signal are, not surprisingly, called voltage-controlled devices. Devices working on the principle of one current controlling another current are known as current-controlled devices. For the record, vacuum tubes are voltage-controlled devices while transistors are made as either voltage-controlled or current controlled types. The first type of transistor successfully demonstrated was a current-controlled device.

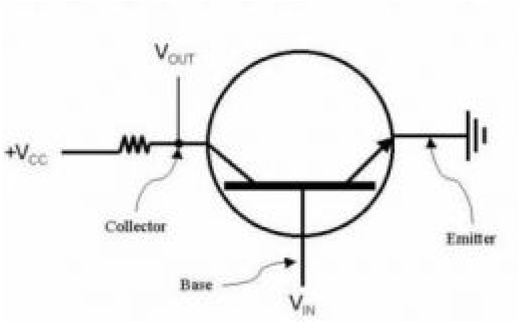
What are Passive Devices? Components incapable of controlling current by means of another electrical signal are called passive devices. Resistors, capacitors, inductors, transformers, and even diodes are all considered passive devices.

Passive devices are the resistors, capacitors, and inductors required to build electronic hardware. They always have a gain less than one, thus they can not oscillate or amplify a signal. A combination of passive components can multiply a signal by values less than one, they can shift the phase of a signal, they can reject a signal because it is not made up of the correct frequencies, they can control complex circuits, but they can not multiply by more than one because they lack gain

Diodes Diodes are basically a one-way valve for electrical current. They let it flow in one direction (from positive to negative) and not in the other direction. Most diodes are similar in appearance to a resistor and will have a painted line on one end showing the direction or flow (white side is negative). If the negative side is on the negative end of the circuit, current will flow. If the negative is on the positive side of the circuit no current will flow. More on diodes in later sections.



Integrated Circuits Integrated Circuits, or ICs, are complex circuits inside one simple package. Silicon and metals are used to simulate resistors, capacitors, transistors, etc. It is a space saving miracle. These components come in a wide variety of packages and sizes. You can tell them by their "monolithic shape" that has a ton of "pins" coming out of them. Their applications are as varied as their packages. It can be a simple timer, to a complex logic circuit, or even a microcontroller (microprocessor with a few added functions) with erasable memory built inside.



Transistors A transistor is a semiconductor device, commonly used as an amplifier or an electrically controlled switch. The transistor is the fundamental building block of the circuitry in computers, cellular phones, and all other modern electronic devices. Because of its fast response and accuracy, the transistor is used in a wide variety of digital and analog functions, including amplification, switching, voltage regulation, signal modulation, and oscillators. Transistors may be packaged individually or as part of an integrated circuit, some with over a billion transistors in a very small area - part of a trend of increasing transistor density known as Moore's Law.

Transistor stands for transit resistor, the temporary name, now permanent, that the inventors gave it. These semiconductors control the electrical current flowing between two terminals by applying voltage to a third terminal. You now have a miniature switch, presenting either a freeway to electrons or a brick wall to them, depending on whether a signal voltage exists. Bulky mechanical relays that used to switch calls, like the crossbar shown above, could now be replaced with transistors. There's more.

Transistors amplify when built into a proper circuit. A weak signal can be boosted tremendously. Let's say you have ten watts flowing into one side of the transistor. Your current stops because silicon normally isn't a good conductor. You now introduce a signal into the middle of the transistor, say, at one watt. That changes the transistor's internal crystalline structure, causing the silicon to go from an insulator to a conductor. It now allows the larger current to go through, picking up your weak signal along the way, impressing it on the larger voltage. Your one watt signal is now a ten watt signal.

Transistors use the properties of semi-conductors, seemingly innocuous materials like geranium and now mostly silicon. Materials like silver and copper conduct electricity well. Rubber and porcelain conduct electricity poorly. The difference between electrical conductors and insulators is their molecular structure, the stuff that makes them up. Weight, size, or shape doesn't matter, it's how tightly the material holds on to its electrons, preventing them from freely flowing through its atoms.

Capacitors

A **capacitor** is a passive electrical component that can store energy in the electric field between a pair of conductors (called "plates"). The process of storing energy in the capacitor is known as "charging", and involves electric charges of equal magnitude, but opposite polarity, building up on each plate. A capacitor's ability to store charge is measured by its capacitance, in units of farads.

Voltage is the force that causes electrons to flow in a circuit. Voltage is sometimes called electromotive force, or EMF. An automobile battery, for example, usually supplies about 12 volts. The instrument used to measure Electromotive Force (EMF), or voltage, between two points such as the poles of a battery is called a voltmeter.
Current is the name for the flow of electrons in an electric circuit. Electrical current is measured in Amperes. The instrument used to measure the flow of current in an electrical circuit is
Called an ammeter.
When current flows only in one direction, we call that direct current. The name of a current that reverses direction on a regular basis is **alternating current**. The number of times that the current reverses direction is called the **frequency**. The standard unit of frequency is the **Hertz.**
Conductors are materials that conduct electrical current well. Metals are usually good conductors. For example, copper, silver and gold are good electrical conductor.

Inductance is the property of an electrical circuit causing voltage to be generated proportional to the rate of change in current in a circuit. This property also is called **self inductance** to discriminate it from mutual inductance, describing the voltage induced in one electrical circuit by the rate of change of the electric current in another circuit.

Insulators are materials that do not conduct electrical current very well. Plastics, wood, mica and glass, for example, are good electrical insulators.
Semi conductors Materials whose conductivity is in between conductors and insulators are called semiconductors. Example.. germanium and silicon.
Resistance is the term used to describe current flow in ordinary conductors such as wires. The basic of resistance is the **Ohm.**

Electrical resistivity (also known as **resistivity**, **specific electrical resistance**, or **volume resistivity**) is a measure of how strongly a material opposes the flow of electric current. A low resistivity indicates a material that readily allows the movement of electric charge.

Electrical power is the rate at which electrical energy is generated or consumed. Electrical power is measured in **Watts.**

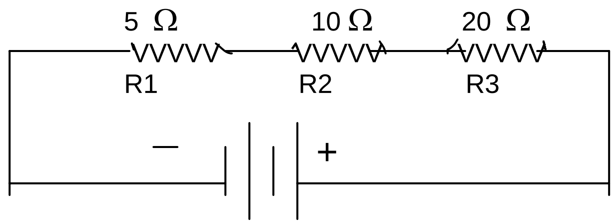
Ohms law relationships
Ohm's Law is the relationship between voltage (E), current (I), and resistance ® in a circuit.
The current, voltage and resistance in a direct-current situation are interdependent. If two of the quantities are known the third can be found by a simple equation.
The amplitude or size of the current that flows in a circuit is directly proportional to the amplitude of the applied emf and is inversely proportional to the resistance of the circuit. The relationship, known as ohms law, and is expressed symbolically as **I = V/R**
When you know the current and resistance, use the formula Voltage (E) equals current (I) Multiplied by resistance ® to calculate the voltage in a circuit. We can also write this **formula as E = I × R.**
When you know the voltage and resistance, use the formula Current (I) equals voltage (E) divided by resistance ® to calculate current in a circuit. We can also write this formula as **I = E ÷ R.**
When you know the voltage and current, use the formula Resistance ® equals voltage (E) divided by current (I) to calculate resistance in a circuit. We can also write this formula as **R = E ÷ I.**

Examples
The resistance of a circuit when a current of 3 amperes flows through a resistor connected to 90 volts is 30 ohms.
R = E ÷ I = 90 V ÷ 3 A = 30
The resistance in a circuit where the applied voltage is 12 volts and the current flow is 1.5 amperes is 8 ohms.
R = E ÷ I = 12 V ÷ 1.5 A = 8
The current flow in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms is 1.5 amperes.
I = E ÷ R = 120 V ÷ 80 O = 1.5 A
The voltage across the resistor if a current of 0.5 amperes flows through a 2 ohm resistor is 1 volt.
E = I × R = 0.5 A × 2 O = 1 V
The voltage across the resistor if a current of 1 ampere flows through a 10 ohm resistor is 10 volts.

E = I × R = 1 A × 10 O = 10 V
The voltage across the resistor if a current of 2 amperes flows through a 10 ohm resistor is 20 volts.
E = I × R = 2 A × 10 O = 1 V

The current flowing through a 100 ohm resistor connected across 200 volts is 2 amperes.
I = E ÷ R = 200 V ÷ 100 O = 2 A
The current flowing through a 24 ohm resistor connected across 240 volts is 10 amperes.
I = E ÷ R = 240 V ÷ 24 O = 10 A

Resistance in series: The total resistance of a circuit will be the sum total of all resistance.

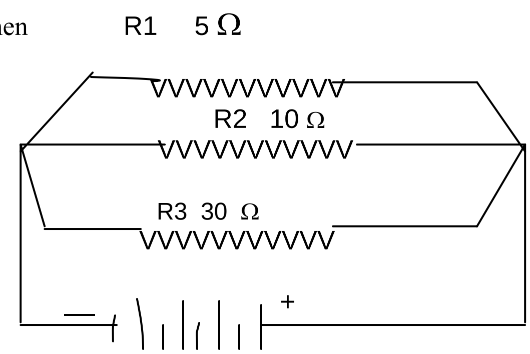


5 + 10 + 20 = 35 Ω

Resistance in Parallel :

The total effective resistance is R then

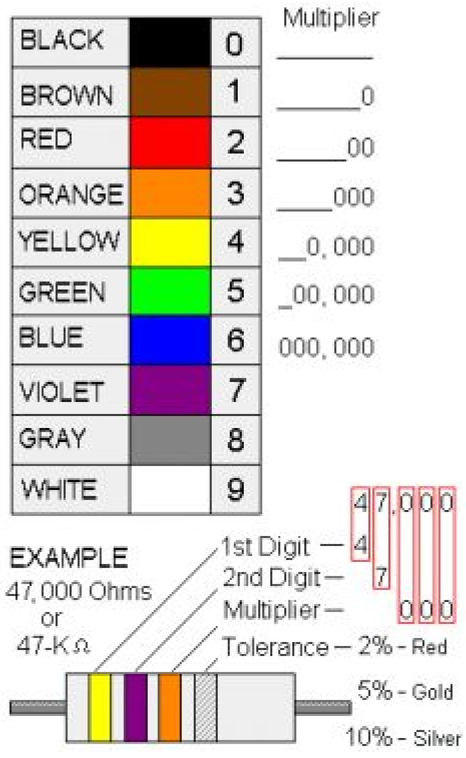
1/R = 1/r1+1/r2+1/r3



<u>TYPES OF RESISTORS:</u>

RESISTOR: A resistor restricts the flow of current.
a) Fixed Resistor b) Adjustable Resistor c) Potentiometer

Standard color code chart for Resistance, How values of resistances are determined by colour code?



Kirchoff's Law

(a) In any electrical network, the algebraic sum total of the **currents** flowing towards a point is equal to the sum total of the current flowing out of it.
(b) The **voltage** drop is equal to the voltage rise in any closed circuit.

Power & Energy : Power is the rate at which energy is expended or dissipated. Power is expressed in **joules** per second, more often called watts. In a DC circuit, the power is the product of voltage and the current.
Because the regulations spell out how much power you can use as a radio amateur, it is important to know the terminology and how to calculate power. The **watt** is the unit used to describe electrical power. The formula used to calculate electrical power in a DC circuit is power

(P) equals voltage (E) multiplied by current (I), or $P = E \times I$

So, for example, in a DC circuit where the power supply voltage of 13.8 volts DC and the current is 10 amperes, the power is $P = 13.8\ V \times 10\ A = 138$ watts
When the voltage is 120 volts DC and the current is 2.5 amperes, the power being used by a circuit is $P = 120\ V \times 2.5\ A = 300$ watts

You can use different forms of the equation, $P = E \times I$ to determine the current flowing in a circuit when you know how much power it is consuming and the voltage supplied to it. The equation to do this is $I = P \div E$

For example the number of amperes flowing in a circuit when the applied voltage is 120 volts DC and the load is 1200 watts is
$I = 1200 \div 120 = 10$ amperes

You can determine how many watts are being drawn by your transceiver when you are transmitting if you measure the DC voltage at the transceiver and multiply by the current drawn when you transmit.

When dealing with electrical parameters, such as voltage, resistance, current, and power, we use a set of prefixes to denote various orders of magnitude:

- **Micro**- is the prefix we use to denote 1 millionth of a quantity. A micro volt, for example, is 1 millionth of a volt, or .000001 V. Often you will see the Greek letter mu, or µ, to denote the prefix micro-. 1 microvolt is, therefore, 1 µV.
- **milli**- is the prefix we use to denote 1 one-thousandth of a quantity. A milliampere, for example, is 1 one-thousandth of an ampere, or .001 A. Often, the letter m is used instead of the prefix milli-. 1 milliampere is, therefore, 1 mA.
- **Kilo**- is the prefix we use to denote 1 thousand of a quantity. A kilovolt, for example, is 1000 volts. Often, the letter k is used instead of the prefix kilo-. 1 kilovolt is, therefore, 1 kV.
- **Mega**- is the prefix we use to denote 1 million of a quantity. A megahertz, for example, is 1 million Hertz. Often, the letter M is used instead of the prefix mega-. 1 megahertz is, therefore, 1 MHz. Here are some examples:
- 1.5 amperes is the same as 1500 mill amperes.
- Another way to specify the frequency of a radio signal that is oscillating at 1,500,000 Hertz is 1500 kHz.
- One thousand volts are equal to one kilovolt.
- One one-millionth of a volt is equal to one microvolt.
- If the output power of a hand-held transceiver is 500 mill watts, it is putting out 0.5 watts.

JOULES LAW

Joule is the standard unit of energy or work. When a current flows through a resistance heat is produced. This heat is called joule heat or joule effect. The amount of heat produced is proportional to the power dissipated.
Joule’s Law recognizes this, by stating that the amount of heat generated in a constant – resistance is proportional to the square of the current.
Joule’s Law : The amount of heat produced in a current carrying conductor is proportional to :
a) The square of the current i.e. I2
b) The resistance of the conductor i.e. R
c) The times of flow of current i.e. T
If H is the heat produced, then, H = I2 RT/J
Where J is joule’s mechanical equivalent of heat.

CALORIE The quantity of heat that will raise the temperature of 1gm of water through 1degree C.
A calorie is a kilocalorie.
Quantity of Electricity : The rate of flow of electricity gives current strength. The quantity of electricity is the product of current flowing and time it flows. Q = IT

Coulomb: It is that quantity of electricity that flows in one second past any point in a conductor when a current of 1 Amp flows through it.

BATTERY : **Batteries** are commonly used to power radios. They come in many different types, each having advantages and disadvantages. It is important to know how to select them and how to use them.
A lithium-ion battery offers the longest life when used with a hand-held radio, assuming each battery is the same physical size.
The nominal voltage per cell of a fully charged nickel-cadmium battery is 1.2 volts.
Carbon-zinc batteries are not designed to be re-charged.
To keep rechargeable batteries in good condition and ready for emergencies, they must be inspected for physical damage and replaced if necessary, they should be stored in a cool and dry location, and they must be given a maintenance recharge at least every 6 months.
The best way to get the most amount of energy from a battery is to draw current from the battery at the slowest rate needed.
Cells in series. Cells in parallel. (More in details)

Serial and parallel battery configurations

Battery packs get their desired operating voltage by connecting several cells in series. If higher capacity and current handling is required, the cells are connected in parallel. Some packs have a combination of serial and parallel connections. A laptop battery may have four 3.6 volts lithium-ion cells connected in series to achieve 14.4V and two cells in parallel to increase the capacity from 2000mAh to 4000mAh. Such a configuration is called 4S2P, meaning 4 cell are in series and 2 in parallel.

Single cell applications

Single cell batteries are used in watches, memory back up and cell phones. The nickel-based cell provides a nominal cell voltage of 1.2V; alkaline is 1.5V; silver-oxide 1.6V, lead-acid 2V; primary lithium 3V and lithium-ion 3.6V. Spinel, lithium-ion polymer and other lithium-based systems sometimes use 3.7V as the designated cell voltage. This explains the unfamiliar voltages such as 11.1V if three cells are connected in series. Modern microelectronics makes it possible to operate cell phones and other low power portable communications devices from a single 3.6V lithium-ion cell. Mercury, a popular cell for light meters in the 1960s has been discontinued because of environmental concerns.

Nickel-based cells are either marked 1.2V or 1.25V. There is no difference in the cells but only preference in marking. Most commercial batteries are identified with 1.2V/cell; industrial, aviation and military batteries are still marked with 1.25V/cell.

Serial connection

Portable equipment with high-energy needs is powered with battery packs in which two or more cell are connected in series. Figure 1 shows a battery pack with four 1.2-volt cells in series. The nominal voltage of the battery string is 4.8V.

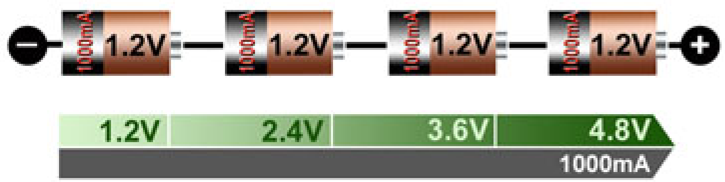


Figure 1: Serial connection of four cells.
Adding cells in a string increases the voltage but the current remains the same.

High voltage batteries have the advantage of keeping the conductor and switch sizes small. Medium-priced industrial power tools run on 12V to 19.2V batteries; high-end power tools go to 24V and 36V to get more power. The car industry will eventually increase the starter-light-ignition (SLI) battery from 12V (14V) to 36V, better known as 42V. These batteries have 18 lead-acid cells in series. The early hybrid cars are running on 148V batteries. Newer models feature batteries with 450-500V; mostly on nickel-based chemistry. A 480-volt nickel-metal-hydride battery has 400 cells in series. Some hybrid cars are also experimenting with lead acid.

42V car batteries are expensive and produce more arcing on the switches than the 12V. Another problem with higher voltage batteries is the possibility of one cell failing. Similar to a chain, the more links that are connected in series, the greater the odds of one failing. A faulty cell would produce a low voltage. In an extreme case, an open cell could break the current flow. Replacement of a faulty cell is difficult because of matching. The new cell will typically have a higher capacity than the aged cells.

Figure 2 illustrates a battery pack in which cell 3 produces only 0.6V instead of the full 1.2V. With the depressed operating voltage, the end-of-discharge point will be reached sooner than with a normal pack and the runtime is severely shortened. Once the equipment cuts off due to low voltage, the remaining three cells are unable to deliver the stored energy. Cell 3 could also exhibit a high internal resistance, causing the string to collapse under load. A weak cell in a battery string is like a blockage in a garden hose that restricts water flow. Cell 3 could also be shorted, which would lower the terminal voltage to 3.6V, or be open and cut off the current. A battery is only as good as the weakest cell in the pack.

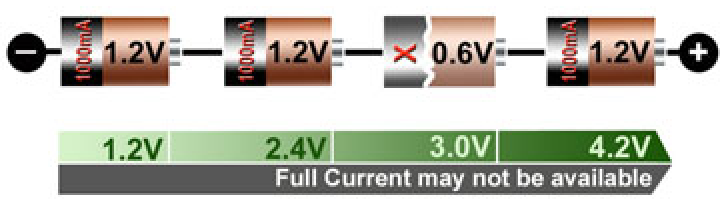


Figure 2: Serial connection with one faulty cell.
Faulty cell 3 lowers the overall voltage to 4.2V, causing the equipment to cut off prematurely.

Parallel connection

To obtain higher ampere-hour (Ah) ratings, two or more cells are connected in parallel. The alternative to parallel connection is using a larger cell. This option is not always available because of limited cell selection. In addition, bulky cell sizes do not lend themselves to build specialty battery shapes. Most chemistries allows parallel connection and lithium-ion is one of the best suited. Figure 3 illustrates four cells connected in parallel. The voltage of the pack remains at 1.2V but the current handling and runtime are increased four fold.

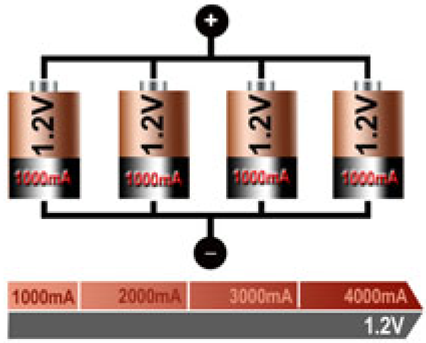


Figure 3: Parallel connection of four cells.
With parallel cells, the voltage stays the same but the current handling and runtime increases

A high resistance or open cell is less critical in a parallel circuit than the serial configuration but the parallel pack will have reduced load capability and a shorter runtime. It's like an engine running only on three cylinders. An electrical short would be more devastating because the faulty cell would drain the energy from the other cells, causing a fire hazard. Figure 4 illustrates a parallel configuration with one faulty cell.

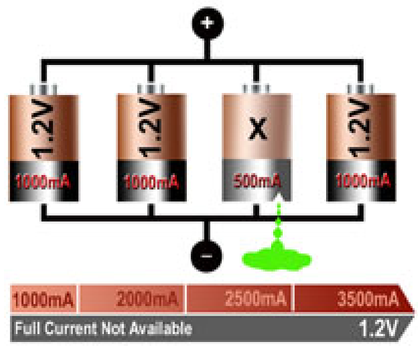
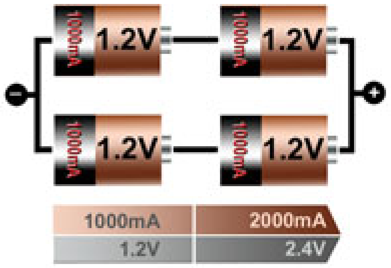


Figure 4: Parallel connection with one faulty cell.
A weak cell will not affect the voltage but provide a low runtime. A shorted cell could cause excessive heat and create a fire hazard.

Serial/parallel connection

Figure 5 illustrates a parallel/serial connection. This allows good design flexibility and attains the wanted voltage and current ratings by using a standard cell size. It should be noted that the total power does not change with different



configurations. The power is the product of voltage times current.

Figure 5: Serial/ parallel connection of four cells.
The configurations will not affect the overall power but provide the most suitable voltage and current source for the application.

Serial/parallel connections are common with lithium-ion. One of the most popular cells is the 18650 (18mm diameter; 650mm long). Because of the protection circuit, which must monitor each cell connected in series, the maximum practical voltage is 14.4V. The protection must also monitor strings placed in parallel.

Household batteries

The serial and parallel connections of cells described above addresses rechargeable battery packs in which the cells are permanently welded together. The same rules apply to household batteries except that we are dealing here with single cells that are put into a battery holder and form a serial configuration. When using single cells, some basic guidelines must be observed:

- Keep the battery contacts clean. A four-cell configuration has eight contacts (cell to holder and holder to next cell). Each contact exhibits some resistance which, when added, can affect the overall battery performance.
- Never mix batteries. Replace all cells when weak. (Remember the 'weak link of a chain' and 'a battery is only as good as the weakest cell'.) Use the same cell type for the whole string.
- Do not recharge non-rechargeable batteries. Charging primary cells will generate hydrogen that can lead to an explosion.
- Observe the right polarity. A reversed cell will deduct rather than add the cell voltage to the string.
- Charging a secondary battery with a reversed polarity will cause the affected cell to develop an electrical short. If left unattended, the damaged cell will heat up and create a fire hazard.
- Remove fully discharged batteries from the equipment. Old cells tend to leak and cause corrosion. Alkaline is less critical than carbon-zinc.
- Remove the batteries when the equipment is not used for a while to prevent corrosion.
- Do not store a box of cells in a way that can create an electrical short. A short cell will heat up and create a fire hazard. Place lose cells in small plastic bags for electrical insulation.
- Always keep batteries away from children.
- Primary batteries such as Alkaline can be disposed in regular trash. It is recommended, however, to bring the spent batteries to a depot for recycle or disposal.

Difference between primary cells and secondary cells :

PRIMARY CELLS	SECONDARY CELLS
1. If discharged once, cannot be recharged.	If discharged, can be recharged again.
2. Light in weight	Heavy in weight
3. Used for intermittent work with low current rate	Can be used for continuous work with high load current.
4. Low life	High life
5. Low cost	High cost
6. No maintenance	Constantly electrolyte strength and level to be maintained.

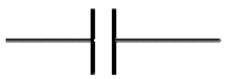
Capacitors

Capacitors are often used by engineers in electric and electronic circuits as energy-storage devices. They can also be used to differentiate between high-frequency and low-frequency signals. This property makes them useful in electronic filters. Practical capacitors have series resistance, internal leakage of charge, series inductance and other non-ideal properties not found in a theoretical, ideal, capacitor. A wide variety of capacitors have been invented, including small electrolytic capacitors used in electronic circuits, basic parallel-plate capacitors, mechanical variable capacitors, and the early Leyden jars, among numerous other types of capacitors.

Capacitance is the ability to store electric charge. The unit is '**FARAD**'.

- | | +

Symbol of capacitor



Capacitive reactance: The opposition offered by a capacitor to flow of current through an A.C. circuit is called capacitive reactance. It is measured in ohms.

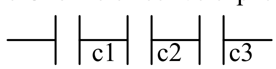
Capacitance (Symbol C) is a measure of a capacitor's ability to store charge. A large capacitance means that more charge can be stored. Capacitance is measured in farads, symbol F

Series capacitors

Capacitors connected in series are equivalent to increasing the thickness of dielectric, which means combined capacitance is less than the smallest individual value.

Formulae for finding effective capacitance of capacitors connected in series:

1/C = 1/c1+1/c2+1/c3….. where C is the effective capacitance and c1,c2,c3.. are the values of capacitors in series.



Lets find the effective capacitance when three capacitors of value 2mfd, 3mfd and 6mfd connected in series.
By the above formulae: 1/c=1/2+1/3+1/6 (mfd=microfarad)

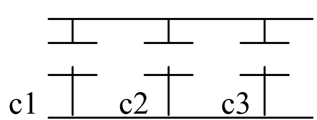
Parallel Capacitors:

Capacitors connected in parallel are equivalent to adding the plate area, which means the total capacitance is the sum of the individual capacitance.

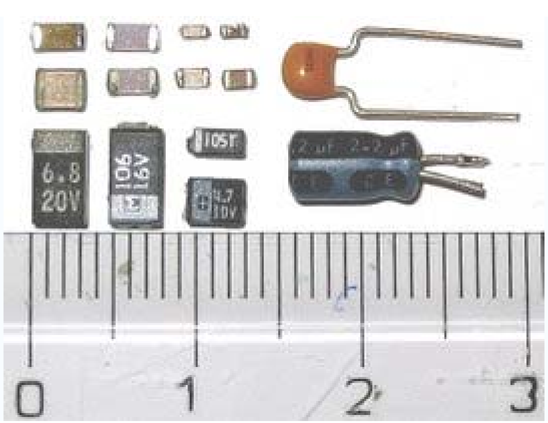
It is written as : C1 = c1+c2+c3 …..c7

If we calculate 2mfd, 3mfd and 4mfd connected in parallel:

C = c1+c2+c3
C = 2+3+4 = 9mfd.



Types of Capacitors :



Capacitor types

Listed by di-electric material.

Vacuum : Two metal, usually copper, electrodes are separated by a vacuum. The insulating envelope is usually glass or ceramic. Typically of low capacitance - 10 - 1000 pF and high voltage, up to tens of kilovolts, they are most often used in radio transmitters and other high voltage power devices. Both fixed and variable types are available. ***Variable vacuum capacitors*** can have a minimum to maximum capacitance ratio of up to 100, allowing any tuned circuit to cover a full decade of frequency. Vacuum is the most perfect of dielectrics with a zero loss tangent. This allows very high powers to be transmitted without significant loss and consequent heating.
Air : Air dielectric capacitors consist of metal plates separated by an air gap. The metal plates, of which there may be many interleaved, are most often made of aluminum or silver-plated brass. Nearly all air dielectric capacitors are variable and are used in radio tuning circuits.
Mica: Similar to metal film. Often high voltage. Suitable for high frequencies. Expensive. Excellent tolerance.
Paper: Used for relatively high voltages. Now obsolete.
Glass: Used for high voltages. Expensive. Stable temperature coefficient in a wide range of temperatures.
Ceramic: Chips of alternating layers of metal and ceramic. Depending on their dielectric, whether Class 1 or Class 2, their degree of temperature/capacity dependence varies.
Natural capacitor: A capacitance formed when two conductors are placed near each other but separated by an insulator
Artificial Capacitor: In almost all radio circuits capacitance is required for various purposes. The capacitance is introduced in the circuit by means of built in capacitors of different types are artificial.

Capacitors can mainly be divided into two categories:

Fixed Type and Variable Type

Fixed capacitors: The fixed capacitors are further classified according to the material used for the dielectric. *The types of Fixed capacitors are*:

1. Paper Dielectric Capacitors 2. Mica 3.Ceramic 4.Glass Dielectric
5 .Vacuum and Gas dielectric 6. Oil dielectric 7. Electrolytic

VARIABLE CAPACITORS: The capacitance can be varied either by altering the distance between the plates or by altering the area of the plates.

TYPES OF VARIABLE CAPACITORS:

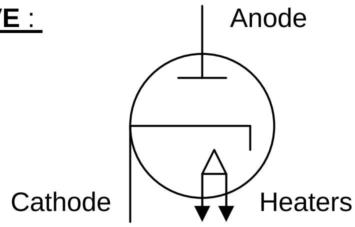
1. Air dielectric variable capacitors.
2. Straight-line capacity variation capacitors.
3. Straight-line wavelength capacitors.
4. Straight-line frequency capacitors.
5. Multiple of gang capacitors
6. midget and Micro capacitors
7. Differential capacitors
8. Split stator capacitors

The charging of the capacitor continues until the Potential Difference across the capacitor is equal to the applied voltage.

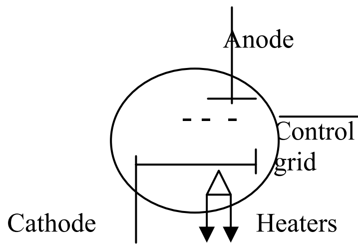
THERMIONIC VALVES

A vacuum tube diode has two electrodes. Anode and Cathode. The electrode that emits electrons is called cathode and the electrode that collects the emitted electrons is called Anode or Plate. The plate has higher positive potential with respect to cathode, which attracts electrons when later is heated by the filament heater. Anode current flows in on direction and therefore it is used mainly to convert A.C. to D.C.

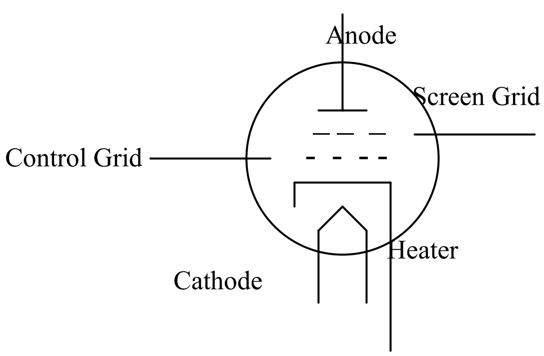
DIODE VALVE :



TRIODE VALVE: Triode is a three electrode vacuum tube - anode, cathode and a control grid between anode and cathode. Grid controls the flow of electrons from cathode to anode. When filament is heated and in the absence of any voltage on the grid, electrons flow through cathode (which is connected to negative terminal of battery) to anode (connected to positive Terminal of the battery). A small +ve voltage to the grid Accelerate the flow of electrons and anode current increases. A Small –ve voltage to the grid repels the electrons and anode current decreases.

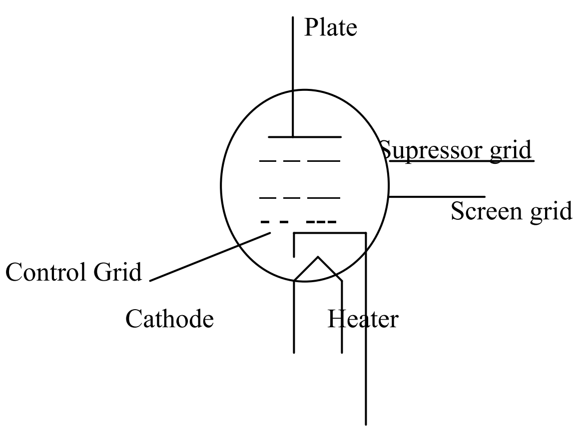


TETRODE VALVE: A second grid is inserted between the control grid and the plate as a screen between the two. An electron tube containing both control grid and screen grid is called Tetrode.



In tetrodes there will be secondary emitted Electrons and are attracted by the screen Grid which will decrease the plate current. This Is the reason tetrodes are not used as amplifiers.

PENTODE : The pentode has the same construction but with the addition of suppressor grid in between the screen greed and the plate. The secondary emission can be reduced by the introduction of suppressor grid.



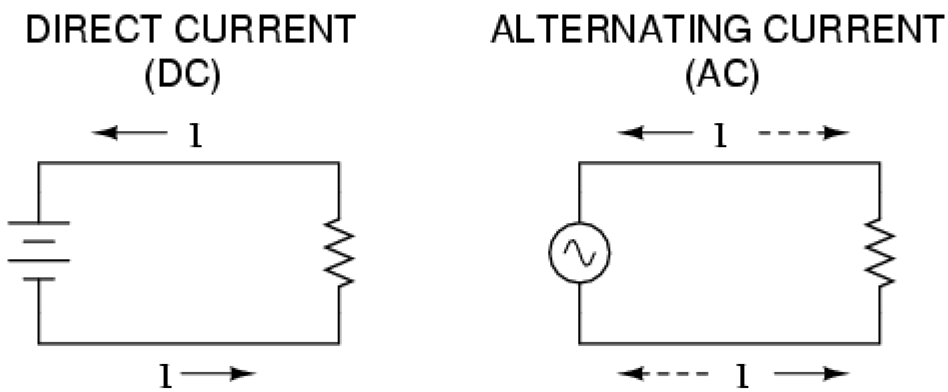
This grid is given cathode potential Which is negative with respect to plate And with that the secondary emitted Electrons are repelled back to the plate to increase plate current.

AC FUNDAMENTALS

What is alternating current (AC)?

Most students of electricity begin their study with what is known as *direct current* (DC), which is electricity flowing in a constant direction, and/or possessing a voltage with constant polarity. DC is the kind of electricity made by a battery (with definite positive and negative terminals), or the kind of charge generated by rubbing certain types of materials against each other.

As useful and as easy to understand as DC is, it is not the only "kind" of electricity in use. Certain sources of electricity (most notably, rotary electro-mechanical generators) naturally produce voltages alternating in polarity, reversing positive and negative over time. Either as a voltage switching polarity or as a current switching direction back and forth, this "kind" of electricity is known as Alternating Current (AC):



Whereas the familiar battery symbol is used as a generic symbol for any DC voltage source, the circuit with the wavy line inside is the generic symbol for any AC voltage source.

The sine wave is a pattern of instantaneous changes in the value of an alternating voltage or current.

FREQUENCY (F) ;
The number of cycles per second is the frequency.
The unit of the frequency is called hertz (Hz).
50 Hz = 50 cycles/second.

PERIOD (T) :
The amount of time taken to complete one cycle is the period.

WAVE LENGTH:
Wavelength is the length of one complete cycle. The wavelength depends upon the frequency of the variation and its velocity.

WAVE LENGTH OF RADIO WAVES:
For electro magnetic radio waves, the velocity in air is 186,000 miles/second or 3×10^{10} cm/sec. which is equal to speed of light.

DC Current vs. AC Current

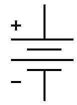
Direct current (**DC**) flows in one direction the circuit.

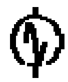
Alternating current (**AC**) flows first in one direction then in the opposite direction.

The same definitions apply to alternating voltage (AC voltage):

- DC voltage has a fixed polarity.
- AC voltage switches polarity back and forth.

There are numerous sources of DC and AC current and voltage. However:

Sources of DC are commonly shown as a cell or battery: 

Sources of AC are commonly shown as an AC generator: 

POWER MEASUREMENTS

AC Applications Only (Voltage & Current)	WATTS
Peak Value = 1.414 X RMS(Effective Value) Peak Value = 1. 571 X Average Value Peak to Peak Value = 3.142 X Average Value Peak to Peak Value = 2.828 X RMS(Effective Value) Peak to Peak Value = 2 X Peak Value Effective or RMS Value = 0.707 X Peak Value Effective or RMS Value = 1. 111 X Average Value Effective or RMS Value = 0.3535 X Peak to Peak Value Average Value = 0.637 X Peak Value. Average Value = 0.900 X RMS (Effective Value) Average Value = 0.318 X Peak to Peak Value	Average Value = RMS Volts X RMS Amperes Peak Value =Average Value X 2

PEAK AMPLITUDE (Voltage & Current)

One of the most frequently measured characteristics of a sine wave is its amplitude. Unlike DC measurement, the amount of alternating current or voltage present in a circuit can be measured in various ways. In one method of measurement, the maximum amplitude of either the positive or negative alternation is measured, an oscilloscope or peak reading meter is used. The value of current or voltage obtained is called the PEAK CURRENT or the PEAK VOLTAGE and will be found to be equal to the square root of 2 multiplied by the RMS Effective Value that is read on most multimeters.

EFFECTIVE OR RMS VALUE (Voltage & current)

As the use of alternating current gained popularity, it became increasingly apparent that some common basis was needed on which AC and DC could be compared. A 100-watt fight bulb, for example should work just as well on 120 volts AC as it does on 120 volts DC. It can be seen, however, that a sine wave of voltage having a peak value of 120 volts would not supply the lamp with as much power as a steady value of 120 volts DC. Since the power dissipated by the lamp is a result of current flow through the lamp, the problem resolves to one of finding a MEAN alternating current ampere which is equivalent to a steady ampere of direct current. A DC current having a value equal to the square root of the mean of the current squared (RMS) would produce the same average power as the original sine wave of current. One RMS ampere of alternating current is as effective in producing current as one steady ampere of direct current, for this reason an RMS ampere is also called an EFFECTIVE ampere.
In the figure above, the peak current of 1 ampere produces the same amount of average power as 0.707 amperes of effective (RMS) current, it is this Effective or RMS Value that is measured on most meters.

AVERAGE VALUE (Voltage & Current)

The Average Value of a complete cycle of a sine wave is zero, since the positive alternation is identical to the negative alternation. However, the Average Value of a single alternation could be computed by adding together a series of instantaneous values of the sine wave between 0, and 180 degrees, and then dividing the sum by the number of instantaneous values used. Such a computation would show one alternation of a sine wave to have an Average Value equal to 2 divided by "", multiplied by the Peak Value (Approx. 0.637 X Peak Value).

Power (Watts)

The measurement of power takes two forms. There is the Average power dissipated by a circuit (RMS volts X RMS amperes), and then there is the Peak power value as read on an oscilloscope (I squared) which is taken to be the peak volts multiplied by the peak amperes, or simply the Average power multiplied by 2.
It is the Average power that is most often referred to as watts, this is the true amount of power used. This is what your watt-meter is based on and the amount you actually pay for.

MAGNETISM :

It is the property of a substance by which it attracts small iron fillings and other magnetic materials,

TYPES OF MAGNETS:

Natural Magnets: Certain types of iron ore, occurring in nature as magnet is called natural Magnets.
Artificial Magnets: Magnets manufactured by artificial means in any required shape are called artificial magnets.
Permanent Magnets: Substances made into magnets and left to retain the magnetism for long times are termed permanent magnets.

PROPERTIES OF MAGNET:

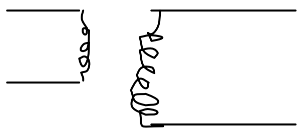
(a) A magnet attracts pieces of Iron.
(b) The magnetism appears to be concentrated at two points on the magnet known as the poles of the magnet.
(c) The line joining the poles is known as the magnetic axis and the distance between the poles as the magnetic length.
(d) When freely suspended so as to swing horizontally the magnet comes to rest with its poles in an approximately North-South direction. The pole pointing to the north is called the North Pole and that pointing to the south is called the South Pole.
(e) When two magnets are brought together it is found that like poles repel each other and unlike poles attract each other.

MAGNETIC FIELD DUE TO ELECTRIC CURRENT: In a conductor if you look along the wire in the direction of flow of current the magnetic field is anti-clockwise. The opposite direction of the current produces clockwise field.
VOLTAGE INDUCED IN A COIL : When a coil of wire is placed in between the magnetic flux, a voltage will be induced in the coil. When the circuit of the coil is completed through load, current will flow in the circuit. The induced voltage is directly proportional to the amount of flux, number of turns and time of rate of cutting.

TRANSFORMERS

Symbol 

A transformer consists of two or more coils on the same core so that flux lines on one coil will cut the turns of other. The winding that receives input electrical energy from an A.C. source is the primary
Winding (P) and the winding, which delivers induced, output voltage is the secondary windings (S).
If the secondary has more turns than the primary, the output voltage is higher than the input voltage and such a transformer is called step up transformer.



A step-down transformer has lesser secondary turns than the Primary and the output voltage will also be lesser.
A step-down transformer has lesser secondary turns than the Primary and the output voltage will also be lesser.

Primary Secondary

1. Voltage step up (Turn ratio of 1:20)
2. Voltage step down (Turn ratio of 10:1)

$$\frac{\text{Voltage of secondary}}{\text{Voltage of primary}} == \frac{\text{No. of turns of secondary}}{\text{No. of turns of primary}}$$

TRANSFORMER:

WHAT IS THE WORKING PRINCIPLE OF A TRANSFORMER?
The transformer is based on two principles: firstly, that an electric current can produce a magnetic field (electromagnetism) and secondly that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). Changing the current in the primary coil changes the magnitude of the applied magnetic field. The changing magnetic flux extends to the secondary coil where a voltage is induced across its ends.

A transformer is a device which is use to convert high alternating voltage to a low alternating voltage and vice versa.

WORKING PRINCIPLE

Transformer works on the principle of mutual induction of two coils. When current in the primary coil is changed the flux linked to the secondary coil also changes. Consequently an EMF is induced in the secondary coil.

CONSTRUCTION

A transformer consists of a rectangular core of soft iron in the form of sheets insulated from one another. Two separate coils of insulated wires, a primary coil and a secondary coil are wound on the core. These coils are well insulated from one another and from the core. The coil on the input side is called Primary coil and the coil on the output side is called Secondary coil.

Different Types of Transformers:

Auto Transformers: An autotransformer consists of one coil with a tapped connection. These can be either stepped up or stepped down. These are used often because they are compact, efficient and low price.

Audio Transformers: These are mainly used to increase the voltage of audio frequency signals. They are used in AF circuits as coupling devices and operate at frequency ranging between 100 to 5000 cycles. They consist of primary and secondary windings wound on laminated iron or steel one.

Intermediate Frequency Transformers: These are mainly used to increase the voltage of IF Frequency signals. They are used in IF circuits as coupling devices and operate at frequency ranging between 450 to 460 KHz. They consist of primary and secondary windings wound on laminated ferrite core.

Radio Frequency Transformers: These are used for coupling one stage of RF amplification to another. Because of the high frequencies involved core losses may become excessive. The windings are usually air-cored or core made of special powdered iron.

RECTIFIERS

RECTIFIER : An electronic device that converts alternating current into direct current is called rectifier.

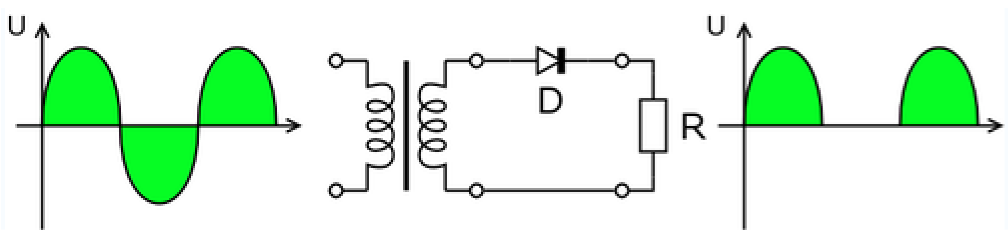
HALF-WAVE RECTIFIER : In half wave rectification the rectifier conducts only during the positive half cycles of input AC supply. The negative half cycles of AC supply is suppressed. Therefore current always flows in one direction through the load after every half cycle. This output is used after filtration of the ripples.
It has two **advantages** using this transformer.

1. It allows to step up or step down the AC input voltage according to the requirement.
2. The transformer isolates the rectifier circuit from power line to reduce the risk of electric shock.

Its disadvantage is the pulsating output across load contains alternating component and direct component
Alternating components basic frequency is equal to the supply frequency. Therefore wide filtering network is required to produce steady direct current.
The AC supply delivers power only half cycle. Therefore the output is low.

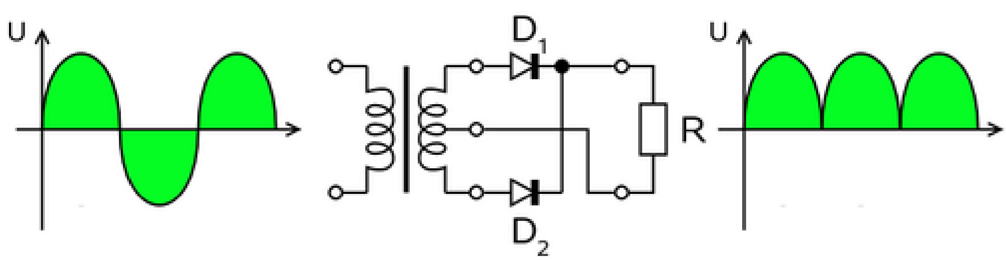
Half-wave rectification

A half wave rectifier is a special case of a clipper. In half wave rectification, either the positive or negative half of the AC wave is passed easily, while the other half is blocked, depending on the polarity of the rectifier. Because only one half of the input waveform reaches the output, it is very inefficient if used for power transfer. Half-wave rectification can be achieved with a single diode in a one phase supply.



FULL WAVE RECTIFIER :

In full wave rectification, current flows through the load in the same direction for both half cycles of input voltage. This can be achieved by using two diodes working alternately. I.e. for the positive half cycles, voltage flow through one diode supplies current to the load and for the negative half cycles the other diode. Therefore a full wave rectifier utilizes both half cycles of input AC voltage.



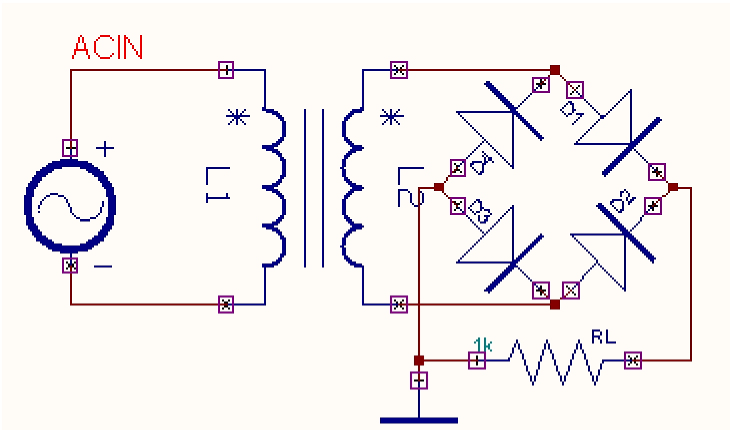
Difference between a half-wave and full-wave rectifier:

Half-wave Rectifier :
In half-wave rectification, the rectifier conducts current only during positive half cycles of input AC supply.
It consists of only single diode.
The efficiency of Half-wave rectifier is 40.6 %.
Centre tapped transformer is not necessary.

Full Wave Rectifier:
The current flows through the load in the same direction for both half cycles of input AC supply.
The efficiency of Full-wave rectifier is 81.2 %.
The output frequency is twice that of the AC supply frequency.

BRIDGE RECTIFIER:

The need of a center tapped power transformer is eliminated in the bridge rectifier.



It consists of four diodes D1, D2, D3 and D4 connected in the form of bridge. The AC supply is applied to the diagonally opposite ends of the bridge through the transformer. The other two ends of the bridge at one end of the load resistance RL is connected at the other end are grounded.

Operation : During the positive half cycle of secondary voltage the end (A) of the secondary winding becomes positive and end (B) is negative, This makes diode D1, and D3 are forward biased and while D2 and D4 are reverse biased. Therefore only D1 and D3 conduct. These two diodes will be in series through the load RL .
During the negative half cycle of secondary voltage end B becomes negative and end Q positive this makes diode D2 and D4 forward biased and D1 and D3 reverse biased. Therefore D2 and D4 conduct. These two diodes will be in series through the RL . Therefore, DC output is obtained across load RL .

Advantages:

1. The need for center-tapped transformer is eliminated.
2. The output is twice that of the center tap circuit for the same secondary voltage.

Disadvantages:

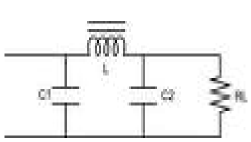
1. It requires four diodes.
2. During each half cycle of AC input voltage two diodes are conducting in series, so the voltage drop in the internal resistance of the rectifying unit will be twice. This is objectionable when secondary voltage is small.

FILTER CIRCUIT:

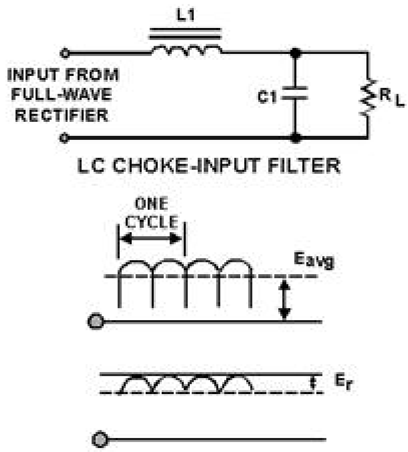
The rectifier output is not steady and is pulsating. So filter circuits must be used to smooth out the variations in output voltage in order to obtain a steady output of direct voltage.

TYPES OF FILTER CIRCUITS:

CAPACITOR INPUT FILTER



CHOKE INPUT FILTER.



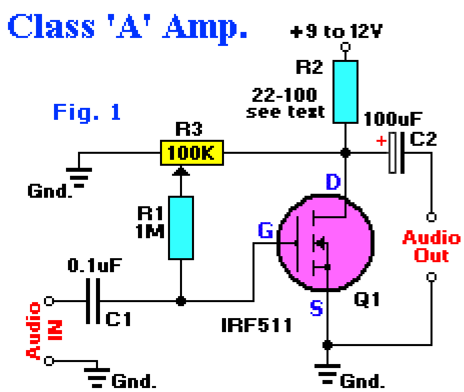
AMPLIFIERS

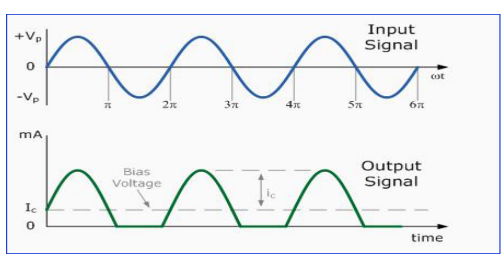
A device, which amplifies weak signals to strong signals, is called an amplifier.

CLASSIFICATION OF AMPLIFIERS
Power amplifiers use special valves or transistors capable of large output current values and able to dissipate power at anode through special arrangement.

CLASS 'A' AMPLIFIER:

Class 'A' Amplifiers are those in which the grid bias and plate voltage are so chosen that the tube operates over the linear portion of dynamic curve or it is an amplifier in which plate current flows over the entire cycle.





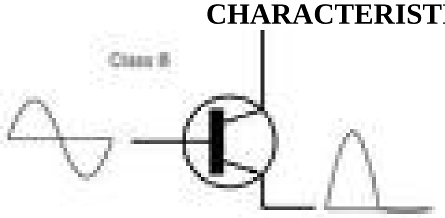
CHARACTERISTICS:

1. Since the tube operates over the linear portion of the dynamic curve, the waveform at the output is exactly similar to that of input. Therefore they are used where freedom from distortion is the main factor.
2. It has high voltage amplification and very little distortion.
3. In practice the power output is small because both current and voltage are restricted to comparatively small variations.

CLASS 'B' AMPLIFIER :

These amplifiers are biased to cut-off or approximately so, hence current flows during positive half cycle of the input voltage

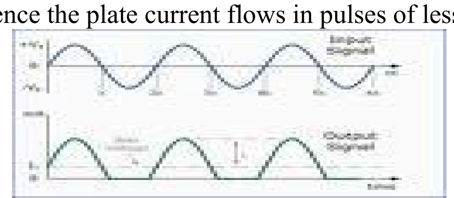
CHARACTERISTICS:



1. Since negative half cycles are totally absent in the output, the distortion is high as compared to that in class 'A' amplifiers.
2. Since voltage required in the input is large, voltage amplification is reduced.
3. The plate efficiency is 50%. This is due to the reason that plate current flows only when signal is applied.
4. For a given tube rating, the power output is relatively high.

CLASS 'C' AMPLIFIER:

In these types of amplifiers the tube is biased beyond cut off point, the grid bias is as much as twice the cut off value. Hence the plate current flows in pulses of less than one half cycle.



CHARACTERISTICS:

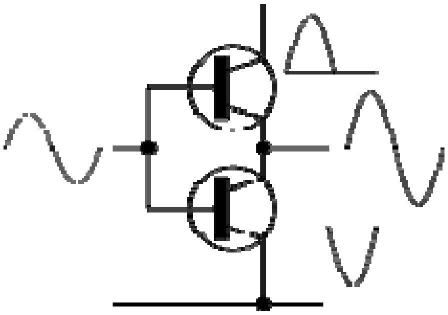
1. As the grid may be driven to the plate saturation value of grid voltage, the plate pulses beat no resemblance to the input waveform. Hence distortion is exceedingly high.
2. Since input signal used is vary large, the voltage amplification is very low.
3. Power output per tube is higher as compared to class 'B' amplifier.
4. Plate efficiency is as high as 85% to 90%. This is due to the fact that the plate current flows only when the grid is driven positive.

These amplifiers are not used as audio frequency amplifiers because of high distortion. But they are used as radio frequency amplifiers for high power output.

PUSH PULL AMPLIFIER:

In order to make up the deficiency in power amplification, two triode tubes are used in push pull arrangements in the output stage. One tube amplifies the +ve half cycle of the signal while the other tube amplifies –ve half cycle of the signal.

Class AB



Class B **push**–**pull** **amplifier**

In class AB **operation**, each device operates the same way as in class B over half the waveform, but also conducts a small amount on the other half. As a result, the region where both devices simultaneously are nearly off (the "dead zone") is reduced. The result is that when the waveforms from the two devices are combined, the crossover is greatly minimised or eliminated altogether. The exact choice of **quiescent current**, the standing current through both devices when there is no signal, makes a large difference to the level of distortion (and to the risk of thermal runaway, that may damage the devices); often the bias voltage applied to set this quiescent current has to be adjusted with the temperature of the output transistors (for example in the circuit at the beginning of the article the diodes would be mounted physically close to the output transistors, and chosen to have a matched temperature coefficient). Another approach (often used as well as thermally tracking bias voltages) is to include small value resistors in series with the emitters.

Class AB sacrifices some efficiency over class B in favor of linearity, thus is less efficient (below 78.5% for full-amplitude sinewaves in transistor amplifiers, typically; much less is common in class AB vacuum tube amplifiers). It is typically much more efficient than class A.

Push Pull Arrangement: When one tube is pushing (conducting), the other is pulling (stopping conduction).

Circuit details: Above figure shows the circuit where two tubes V1 and V2 are used in push pull. Both the tubes are operated in class B operation. The center tapped secondary of the input transformer T1 supplies equal and opposite voltage to the grid circuit of the two tubes. The output transformer T2 has center-tapped primary. The output is taken across the secondary of output transformer T2.

Operation: During the +ve half cycle of the signal, the end A of the input transformer is +ve and end B is –ve .
This does not mean that grid will actually become +ve. It cannot happen because the DC grid bias keeps both grids at a –ve potential. Thus valve V1 conducts and valve V2 is cut off. Therefore, this half cycle of the signal is amplified by valve V1 and appears in upper half of the output transformer primary. In the next half cycle of the signal, valve V2 conducts and valve V1 is cut off. Therefore this half cycle of the signal is amplified by valve V2 and appears in the lower half of the output transformer primary. The plate current flow on alternate half cycle of the signal through the center tapped primary of the output transformer and since they are in opposite direction, the effect is the same as a normal sine wave AC. This induces voltage in the secondary of the output transformer.

Advantage: Its efficiency is high (about 80%). For the same plate dissipation, the output power is nearly 5 times of a single tube amplifier. Generally used as power amplifiers.
I.e. Public address system.

DISTORTION IN AMPLIFIERS: The output of an amplifier is said to be distorted, if the output waveforms of the output voltage and currents are different from that of input.

(a) **NONLINEAR HARMONIC DISTORTION:** Due to the nonlinearity of the dynamic characteristic, the output current and voltage waves, in addition to the fundamental wave of input signal frequency Contain harmonic components, the number and magnitude of which depends on the amplitude of input signal.

(b) **FREQUENCY DISTORTION:** It is produced due to the unequal amplification of the different component frequencies present in the given signal. In the case of audio signals, frequency distortion leads to a change in quality of sound.

(c) **PHASE DISTORTION:** It is said to take place when the phase angles between the component waves of the output are not the same as the corresponding angles of the input. The changes in phase angles are due to the presence of reactive elements in the tube (grid-cathode capacitance).

The human ear is unable to distinguish the phase difference and is thus not sensitive to the distortion. Hence phase distortion is of no practical significance in audio amplifiers.

To revise :

11.18 What is Amplifier Class A? What is Class B? What is Class AB? What is Class C? What is Class D?

All of these terms refer to the operating characteristics of the output stages of amplifiers.

Briefly, Class A amps sound the best, cost the most, and are the least practical. They waste power and return very clean signals. Class AB amps dominate the market and rival the best Class A amps in sound quality. They use less power than Class A, and can be cheaper, smaller, cooler, and lighter. Class D amps are even smaller than Class AB amps and more efficient, because they use high-speed switching rather than linear control. Starting in the late 1990s, Class D amps have become quite good, and in some cases rivaling high quality amps in sound quality. Class B & Class C amps aren't used in audio.

In the following discussion, we will assume transistor output stages, with one transistor per function. In some amplifiers, the output devices are tubes. Most amps use more than one transistor or tube per function in the output stage to increase the power.

Class A refers to an output stage with bias current greater than the maximum output current, so that all output transistors are always conducting current. The biggest advantage of Class A is that it is most linear, ie: has the lowest distortion.

The biggest disadvantage of Class A is that it is inefficient, ie: it takes a very large Class A amplifier to deliver 50 watts, and that amplifier uses lots of electricity and gets very hot.

Some high-end amplifiers are Class A, but true Class A only accounts for perhaps 10% of the small high-end market and none of the middle or lower-end market.

Class B amps have output stages which have zero idle bias current. Typically, a Class B audio amplifier has zero bias current in a very small part of the power cycle, to avoid nonlinearities. Class B amplifiers have a significant advantage over Class A in efficiency because they use almost no electricity with small signals.

Class B amplifiers have a major disadvantage: very audible distortion with small signals. This distortion can be so bad that it is objectionable even with large signals. This distortion is called crossover distortion, because it occurs at the point when the output stage crosses between sourcing and sinking current. There are almost no Class B amplifiers on the market today.

Class C amplifiers are similar to Class B in that the output stage has zero idle bias current. However, Class C amplifiers have a region of zero idle current which is more than 50% of the total supply voltage. The disadvantages of Class B amplifiers are even more evident in Class C amplifiers, so Class C is likewise not practical for audio amps.

Class A amplifiers often consist of a driven transistor connected from output to positive power supply and a constant current transistor connected from output to negative power supply. The signal to the driven transistor modulates the output voltage and the output current. With no input signal, the constant bias current flows directly from the positive supply to the negative supply, resulting in no output current, yet lots of power consumed. More sophisticated Class A amps have both transistors driven (in a push-pull fashion).

Class B amplifiers consist of a driven transistor connected from output to positive power supply and another driven transistor connected from output to negative power supply. The signal drives one transistor on while the other is off, so in a Class B amp, no power is wasted going from the positive supply straight to the negative supply.

Class AB amplifiers are almost the same as Class B amplifiers in that they have two driven transistors. However, Class AB amplifiers differ from Class B amplifiers in that they have a small idle current flowing from positive supply to negative supply even when there is no input signal. This idle current slightly increases power consumption, but does not increase it anywhere near as much as Class A. This idle current also corrects almost all of the nonlinearity associated with crossover distortion. These amplifiers are called Class AB rather than Class A because with large signals, they behave like Class B amplifiers, but with small signals, they behave like Class A amplifiers. Most amplifiers on the market are Class AB.

Some good amplifiers today use variations on the above themes. For example, some "Class A" amplifiers have both transistors driven, yet also have both transistors always on. A specific example of this kind of amplifier is the "Stasis" (TM) amplifier topology promoted by Threshold, and used in a few different high-end amplifiers. Stasis (TM) amplifiers are indeed Class A, but are not the same as a classic Class A amplifier.

OSCILLATORS

An oscillator is a mechanical or electronic device that works on the principles of oscillation: a periodic fluctuation between two things based on changes in energy. Computers, clocks, watches, radios, and metal detectors are among the many devices that use oscillators.

A clock pendulum is a simple type of mechanical oscillator. The most accurate timepiece in the world, the atomic clock, keeps time according to the oscillation within atoms. Electronic oscillators are used to generate signals in computers, wireless

receivers and transmitters, and audio-frequency equipment, particularly music synthesizers. There are many types of electronic oscillators, but they all operate according to the same basic principle: an oscillator always employs a sensitive amplifier whose output is fed back to the input in phase. Thus, the signal regenerates and sustains itself. This is known as positive feedback. It is the same process that sometimes causes unwanted "howling" in public-address systems.

The frequency at which an oscillator works is usually determined by a quartz crystal. When a direct current is applied to such a crystal, it vibrates at a frequency that depends on its thickness, and on the manner in which it is cut from the original mineral rock. Some oscillators employ combinations of inductors, resistors, and/or capacitors to determine the frequency. However, the best stability (constancy of frequency) is obtained in oscillators that use quartz crystals.

In a computer, a specialized oscillator, called the clock, serves as a sort of pacemaker for the microprocessor. The clock frequency (or clock speed) is usually specified in megahertz (MHz), and is an important factor in determining the rate at which a computer can perform instructions.

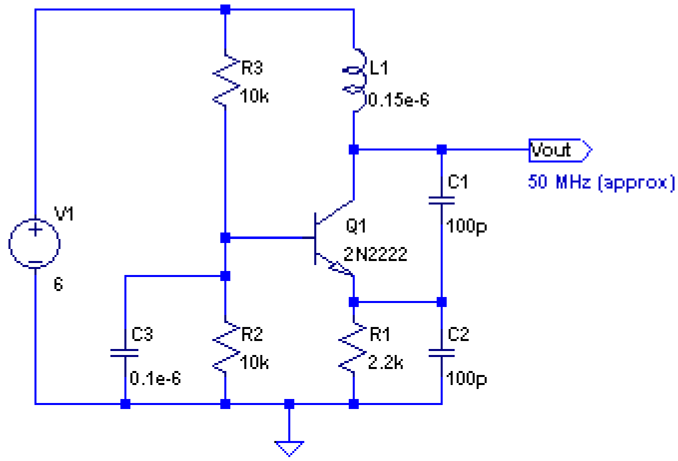
COLPITTS OSCILLATOR

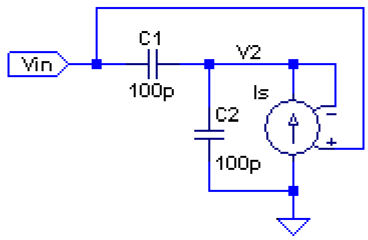
(From Wikipedia, the free encyclopedia)

A **Colpitts oscillator**, named after its inventor Edwin H. Colpitts, is one of a number of designs for electronic oscillator circuits. One of the key features of this type of oscillator is its simplicity and robustness. It is not difficult to achieve satisfactory results with little effort.

A Colpitts oscillator is the electrical dual of a Hartley oscillator. In the Colpitts circuit, two capacitors and one inductor determine the frequency of oscillation. The Hartley circuit uses two inductors (or a tapped single inductor) and one capacitor. (Note: the capacitor can be a variable device by using a varactor).

The following schematic is an example using an NPN transistor in the common base configuration. Frequency of oscillation is roughly 50 MHz:





Colpitts oscillator model

One method of oscillator analysis is to determine the input impedance of an input port neglecting any reactive components. If the impedance yields a negative resistance term, oscillation is possible. This method will be used here to determine conditions of oscillation and the frequency of oscillation.
An ideal model is shown to the right. This configuration models the common collector circuit in the section above. For initial analysis, parasitic elements and device non-linearities will be ignored. These terms can be included later in a more rigorous analysis. Even with these approximations, acceptable comparison with experimental results is possible.

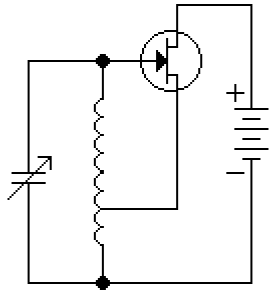
Ignoring the inductor, the input impedance can be written as

$$Z_{in} = \frac{v_1}{i_1}$$

Where v_1 is the input voltage and i_1 is the input current. The voltage v_2 is given by
$v_2 = i_2 Z_2$

Ref: Razavi, B. Design of Analog CMOS Integrated Circuits. McGraw-Hill. 2001.
Lee, T. The Design of CMOS Radio-Frequency Integrated Circuits. Cambridge University Press. 2004.

Hartley oscillator
(From Wikipedia, the free encyclopedia)



Schematic diagram

The **Hartley oscillator** is an LC electronic oscillator that derives its feedback from a tapped coil in parallel with a capacitor (the *tank circuit*). Although there is no requirement for there to be mutual coupling between the two coil segments, the circuit is usually implemented as such. A Hartley oscillator is essentially any configuration that uses a pair of series-connected coils and a single capacitor.
Hartley oscillators may be series or shunt fed.
A Hartley oscillator is made up of the following:
Two inductors coupled by mutual inductance (may be a two-winding transformer) One tuning capacitor

Advantages of the Hartley oscillator include:
The frequency is varied using a variable capacitor
The output amplitude remains constant over the frequency range
The feedback ratio of the tapped inductor remains constant

Disadvantages include:
Harmonic-rich content of the output
It is not suitable for a pure sine wave

TRANSISTOR CRYSTAL OSCILLATOR
Advantages:
1) They have high order of frequency stability
2) The quality factor Q of the crystal is very high it is high as 10,000 compared to about 100 of LC tank.

Disadvantage:
1) They are used in low power circuits.
2) The frequency of oscillators cannot be changed.

SEMICONDUCTOR DEVICES

There are two main types of semiconductor materials:

- *intrinsic* - where the semiconducting properties of the material occur naturally i.e. they are intrinsic to the material's nature.
- *extrinsic* - they semiconducting properties of the material are manufactured, by us, to make the material behave in the manner which we require.

Nearly all the semiconductors used in modern electronics are *extrinsic*. This means that they have been created by altering the electronic properties of the material.

Several different semiconducting materials exist, but the most common semiconductor material is Silicon and the two most common methods of modifying the electronic properties are:

- Doping - the addition of 'foreign' atoms to the material.
- Junction effects - the things that happen when we join differing materials together.

TRANSISTORS

Function

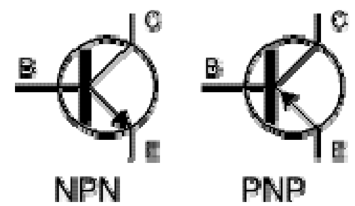
Transistors **amplify current**, for example they can be used to amplify the small output current from a logic IC so that it can operate a lamp, relay or other high current device. In many circuits a resistor is used to convert the changing current to a changing voltage, so the transistor is being used to **amplify voltage**.

A transistor may be used as a **switch** (either fully on with maximum current, or fully off with no current) and as an **amplifier** (always partly on).

The amount of current amplification is called the **current gain**, symbol h_{FE}.
For further information please see the Transistor Circuits page.

Types of transistor

There are two types of standard transistors, **NPN** and **PNP**, with different circuit symbols. The letters refer to the layers of semiconductor material used to make the transistor. Most transistors used today are NPN because this is the easiest type to make from silicon. If you are new to electronics it is best to start by learning how to use NPN transistors.



Transistor circuit symbols

The leads are labeled **base** (B), **collector** (C) and **emitter** (E).
These terms refer to the internal operation of a transistor but they are not much help in understanding how a transistor is used, so just treat them as labels!

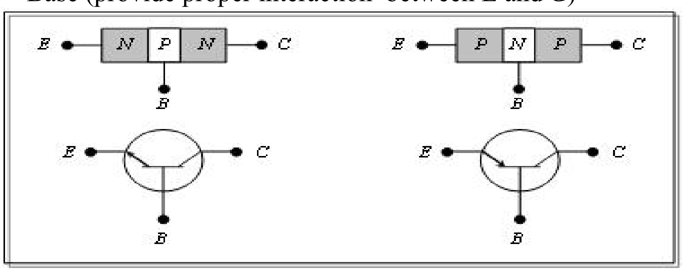
Junction Transistor

A **junction transistor** is formed by sandwiching a thin layer of P-type semiconductor between two N-type semiconductors or by sandwiching a thin layer of n-type semiconductor between two P-type semiconductors.

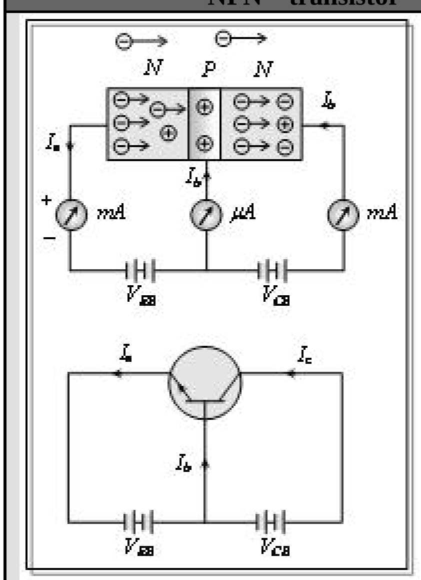
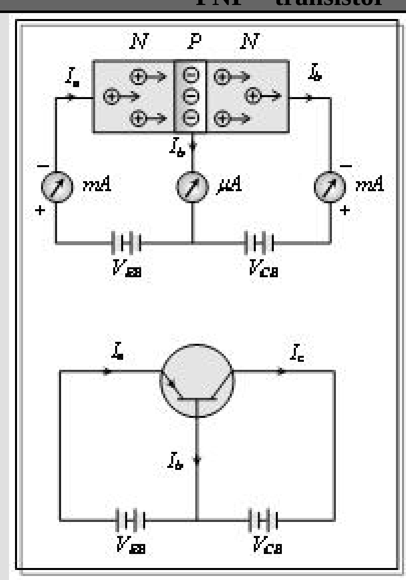
E – Emitter (emits majority charge carriers)

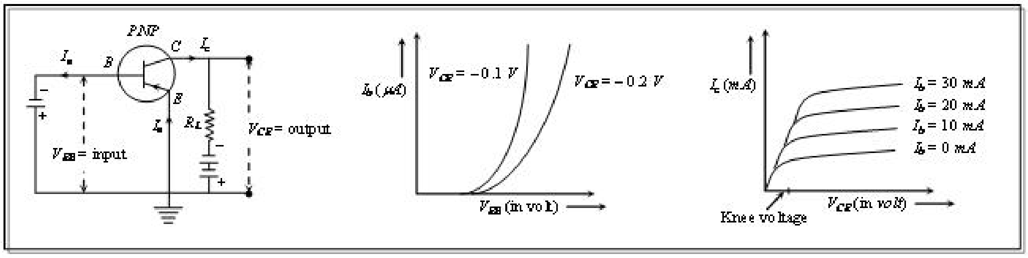
C – Collects majority charge carriers

B – Base (provide proper interaction between E and *C*)

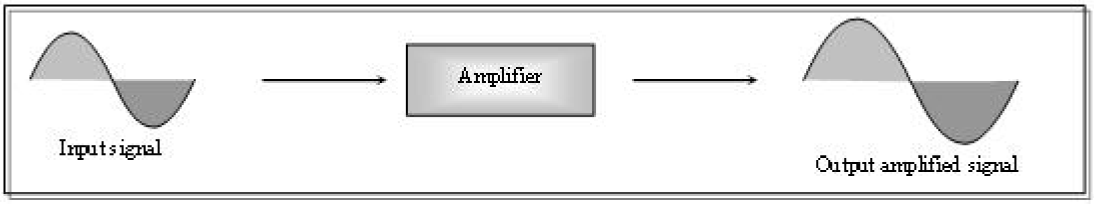


Working of Transistor: In both **transistor PNP NPN** emitter - base junction is forward biased and collector – base junction is reverse biased.

NPN – transistor	PNP – transistor
	
5% emitter electron combine with the holes in the base region resulting in small base current. Remaining 95% electrons enter the collector region.	5% emitter holes combine with the electrons in the base region resulting in small base current. Remaining 95% holes enter the collector region.
$I_e > I_c$, and $I_c = I_b + I_c$	$I_e > I_c$, and $I_c = I_b + I_c$

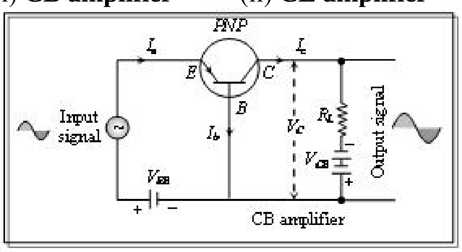


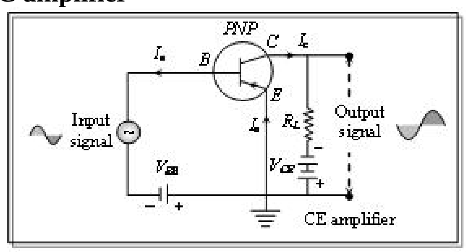
Transistor as an amplifier: A device which increases the amplitude of the input signal is called amplifier.



The **junction transistor** can be used as an amplifier in the following three configurations

(i) **CB amplifier** (ii) **CE amplifier** (iii) **CC amplifier**

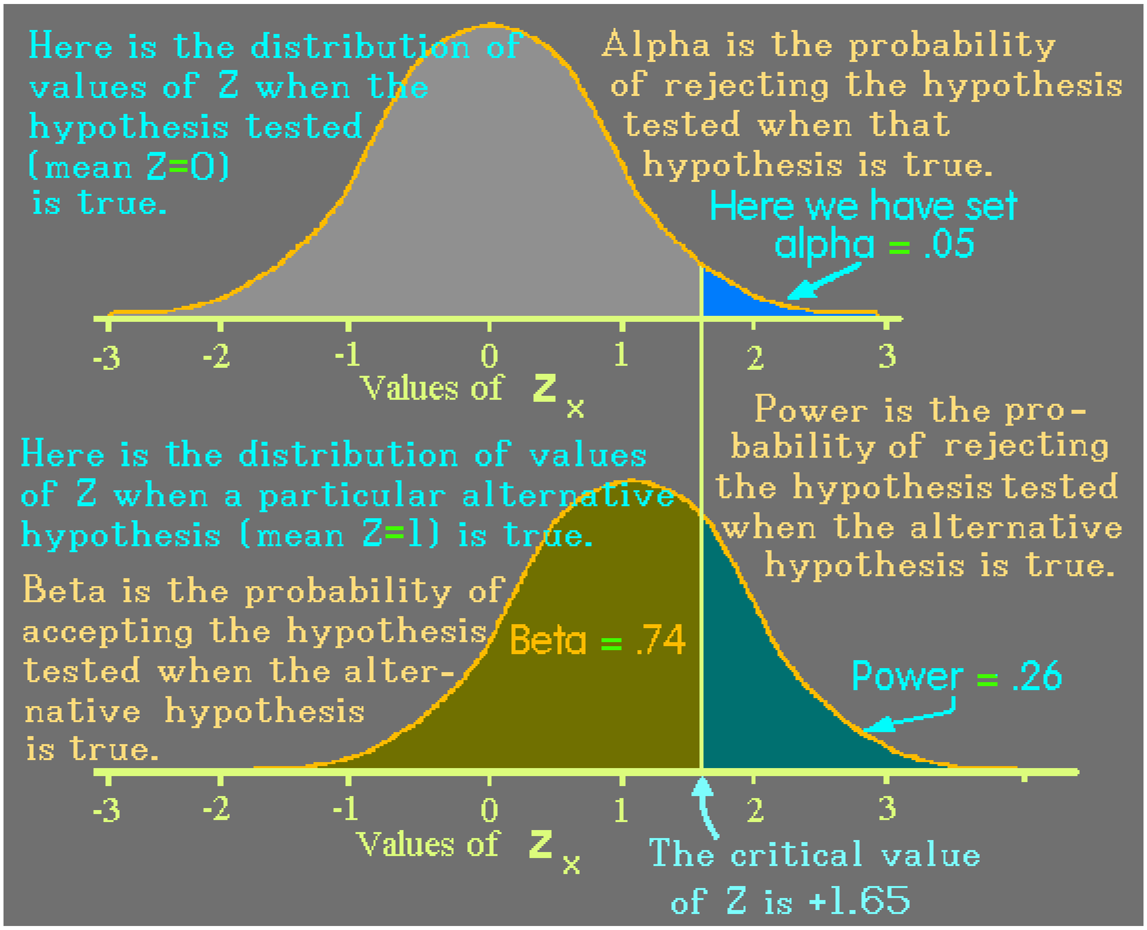




Parameters of CE/CB amplifiers:

Transistor as CE amplifier	Transistor as CB amplifier
(i) **Current gain** (a)	(i) **Current gain** (ß)
(a) ;α_{ac} = small change in collector current (Δi_c) / small change in emitter current (Δi_e) V_B (constant)	(a) ßac = ($\Delta i_c / \Delta i_b$) V_{CE} = constant
(b) α_{dc} = collector current i_c / emitter current i_e valve of α_{dc} lies between 0.95 to 0.99	(b) $ß_{dc} = i_c / i_b$ value of $ß_{ac}$ lies between 15 and 20
(ii) **Voltage gain** A_v = (change in output voltage ΔV_o)/ (change in input voltage ΔVi) $A_v = \alpha_{ac}$ x Resistance gain	(ii) **Voltage gain** Av = $\Delta V_o / \Delta V_i = ß_{ac}$ x Resistance Gain
(iii) Power Gain = (change in output power ΔP_o)/ (change in input power ΔP_i) Power Gain = α^2_{ac} x Resistance Gain	(iii) Power Gain = $\Delta P_o / \Delta P_i = ß^2_{ac}$ x Resistance Gain

RELATION BETWEEN ALPHA & BETA

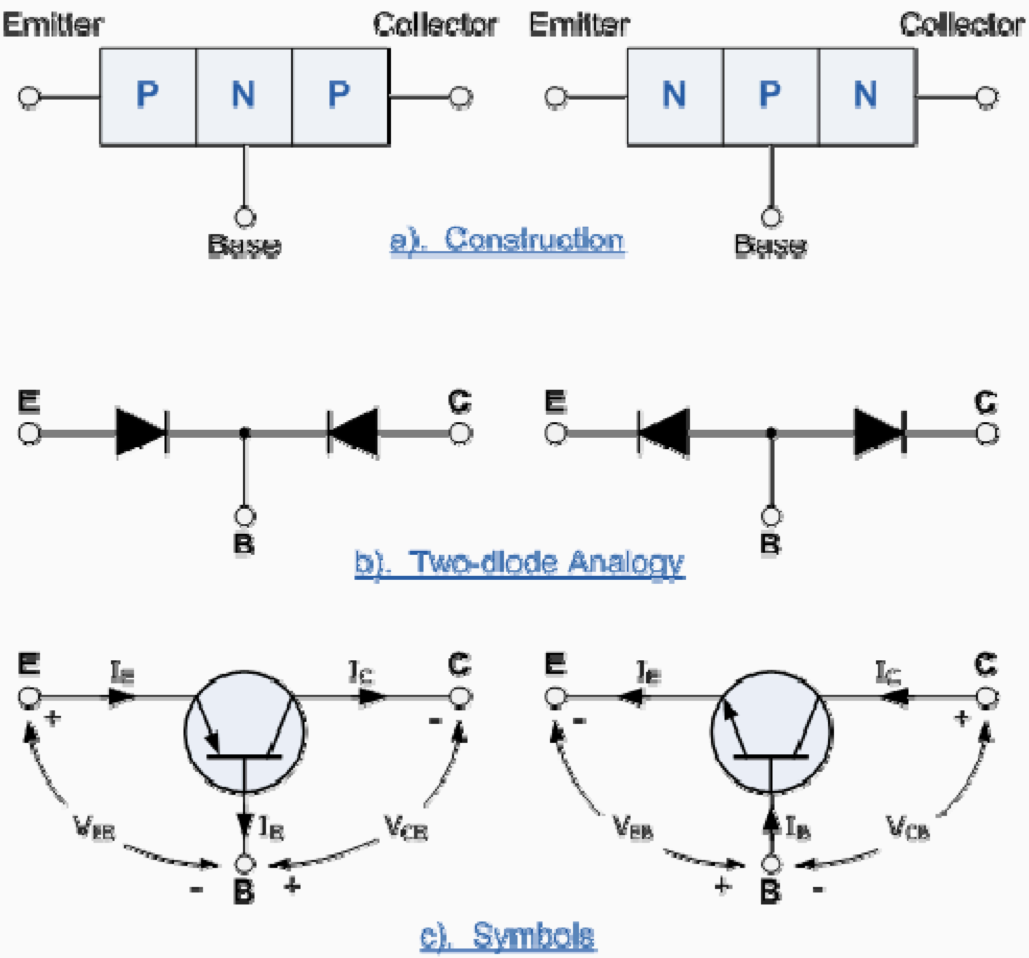


Bipolar Transistor Basics

In the **Diode** tutorials we saw that simple diodes are made up from two pieces of semiconductor material, either Silicon or Germanium to form a simple PN-junction and we also learnt about their properties and characteristics. If we now join together two individual diodes end to end giving two PN-junctions connected together in series, we now have a three layer, two junction, three terminal device forming the basis of a **Bipolar Junction Transistor**, or **BJT** for short. This type of transistor is generally known as a **Bipolar Transistor**, because its basic construction consists of two PN-junctions with each terminal or connection being given a name to identify it and these are known as the Emitter, Base and Collector respectively.

The word Transistor is an acronym, and is a combination of the words Transfer Varistor used to describe their mode of operation way back in their early days of development. There are two basic types of bipolar transistor construction, NPN and PNP, which basically describes the physical arrangement of the P-type and N-type semiconductor materials from which they are made. Bipolar Transistors are "CURRENT" Amplifying or current regulating devices that control the amount of current flowing through them in proportion to the amount of biasing current applied to their base terminal. The principle of operation of the two transistor types NPN and PNP, is exactly the same the only difference being in the biasing (base current) and the polarity of the power supply for each type.

Bipolar Transistor Construction



a). Construction

b). Two-diode Analogy

c). Symbols

The construction and circuit symbols for both the NPN and PNP bipolar transistor are shown above with the arrow in the circuit symbol always showing the direction of conventional current flow between the base terminal and its emitter terminal, with the direction of the arrow pointing from the positive P-type region to the negative N-type region, exactly the same as for the standard diode symbol.

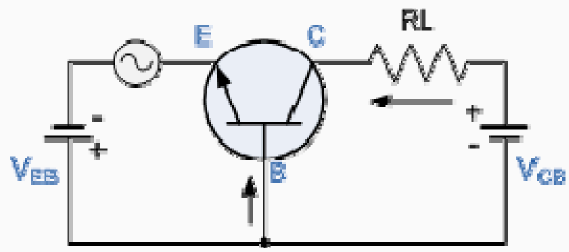
There are basically three possible ways to connect a **Bipolar Transistor** within an electronic circuit with each method of connection responding differently to its input signal as the static characteristics of the transistor vary with each circuit arrangement.

1. Common Base Configuration - has Voltage Gain but no Current Gain.
2. Common Emitter Configuration - has both Current and Voltage Gain.
3. Common Collector Configuration - has Current Gain but no Voltage Gain.

The Common Base Configuration.

As its name suggests, in the **Common Base** or Grounded Base configuration, the BASE connection is common to both the input signal AND the output signal with the input signal being applied between the base and the emitter terminals. The corresponding output signal is taken from between the base and the collector terminals as shown with the base terminal grounded or connected to a fixed reference voltage point. The input current flowing into the emitter is quite large as its the sum of both the base current and collector current respectively therefore, the collector current output is less than the emitter current input resulting in a Current Gain for this type of circuit of less than "1", or in other words it "Attenuates" the signal.

The Common Base Amplifier Circuit



This type of amplifier configuration is a non-inverting voltage amplifier circuit, in that the signal voltages Vin and Vout are In-Phase. This type of arrangement is not very common due to its unusually high voltage gain characteristics. Its Output characteristics represent that of a forward biased diode while the Input characteristics represent that of an illuminated photo-diode. Also this type of configuration has a high ratio of Output to Input resistance or more importantly "Load" resistance (RL) to "Input" resistance (Rin) giving it a value of "Resistance Gain". Then the Voltage Gain for a common base can therefore be given as:

Common Base Voltage Gain

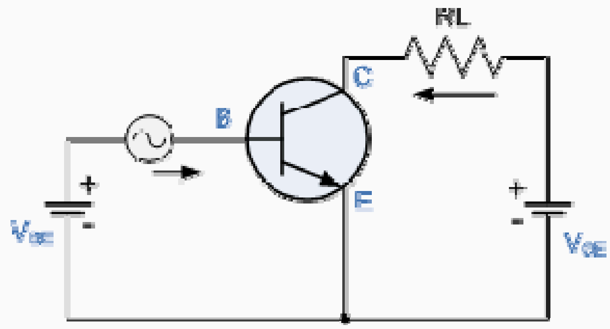
$$A_V = \frac{I_c \times R_L}{I_e \times R_{IN}} = \alpha \times \frac{R_L}{R_{IN}}$$

The Common Base circuit is generally only used in single stage amplifier circuits such as microphone pre-amplifier or RF radio amplifiers due to its very good high frequency response.

The Common Emitter Configuration.

In the **Common Emitter** or Grounded Emitter configuration, the input signal is applied between the base, while the output is taken from between the collector and the emitter as shown. This type of configuration is the most commonly used circuit for transistor based amplifiers and which represents the "normal" method of connection. The common emitter amplifier configuration produces the highest current and power gain of all the three bipolar transistor configurations. This is mainly because the input impedance is LOW as it is connected to a forward-biased junction, while the output impedance is HIGH as it is taken from a reverse-biased junction.

The Common Emitter Amplifier Circuit



In this type of configuration, the current flowing out of the transistor must be equal to the currents flowing into the transistor as the emitter current is given as Ie = Ic + Ib. Also, as the load resistance (RL) is connected in series with the collector, the Current gain of the Common Emitter Transistor Amplifier is quite large as it is the ratio of Ic/Ib and is given the symbol of Beta, (β). Since the relationship between these three currents is determined by the transistor itself, any small change in the base current will result in a large change in the collector current. Then, small changes in base current will thus control the current in the Emitter/Collector circuit.

By combining the expressions for both Alpha, α and Beta, β the mathematical relationship between these parameters and therefore the current gain of the amplifier can be given as:

$$I_E = I_C + I_B$$

$$\alpha = \frac{I_C}{I_E} \quad \text{and} \quad \beta = \frac{I_C}{I_B}$$

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

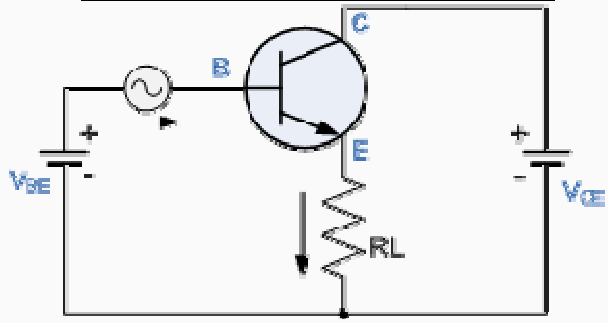
Where: "Ic" is the current flowing into the collector terminal, "Ib" is the current flowing into the base terminal and "Ie" is the current flowing out of the emitter terminal.

Then to summarise, this type of bipolar transistor configuration has a greater input impedance, Current and Power gain than that of the common Base configuration but its Voltage gain is much lower. The common emitter is an inverting amplifier circuit resulting in the output signal being 180^o out of phase with the input voltage signal.

The Common Collector Configuration.

In the **Common Collector** or Grounded Collector configuration, the collector is now common and the input signal is connected to the Base, while the output is taken from the Emitter load as shown. This type of configuration is commonly known as a **Voltage Follower** or **Emitter Follower** circuit. The Emitter follower configuration is very useful for impedance matching applications because of the very high input impedance, in the region of hundreds of thousands of Ohms, and it has relatively low output impedance.

The Common Collector Amplifier Circuit



The Common Emitter configuration has a current gain equal to the β value of the transistor itself. In the common collector configuration the load resistance is situated in series with the emitter so its current is equal to that of the emitter current. As the emitter current is the combination of the collector AND base currents combined, the load resistance in this type of amplifier configuration also has both the collector current and the input current of the base flowing through it. Then the current gain of the circuit is given as:

$$I_E = I_C + I_B$$

$$A_i = \frac{I_E}{I_B} = \frac{I_C + I_B}{I_B}$$

$$A_i - \frac{I_C}{I_B} + 1$$

$$\therefore A_i = \beta + 1$$

This type of bipolar transistor configuration is a non-inverting amplifier circuit in that the signal voltages of Vin and Vout are "In-Phase". It has a voltage gain that is always less than "1" (unity). The load resistance of the voltage gain.

Bipolar Transistor Summary.

The behavior of the bipolar transistor in each one of the above circuit configurations is very different and produces different circuit characteristics with regards to Input impedance, Output impedance and Gain

Transistor Characteristics

The static characteristics for **Bipolar Transistor** amplifiers can be divided into the following main groups.

Input Characteristics:-	Common Base -	$I_E \div V_{EB}$
	Common Emitter -	$I_B \div V_{BE}$
Output Characteristics:-	Common Base -	$I_C \div V_C$
	Common Emitter -	$I_C \div V_C$
Transfer Characteristics:-	Common Base -	$I_E \div I_C$
	Common Emitter -	$I_B \div I_C$

with the characteristics of the different transistor configurations given in the following table:

Characteristic	Common Base	Common Emitter	Common Collector
Input impedance	Low	Medium	High
Output impedance	Very High	High	Low
Phase Angle	0^o	180^o	0^o
Voltage Gain	High	Medium	Low
Current Gain	Low	Medium	High
Power Gain	Low	Very High	Medium

External Links about the Bipolar Transistor
NPN Common Collector Amplifier - Basic Tutorial about Amplifier Configurations.
Hyperphysics
Bipolar Junction Transistor - Tutorial about Bipolar Junction Transistors (BJT).
EncycloBEAMia
The Bipolar Transistor - Lecture notes about Bipolar Transistors.
University of Queensland – Australia

Link to : http://www.electronics-tutorials.ws/transistor/tran_1.html

Bipolar junction transistor

A **bipolar (junction) transistor** (**BJT**) is a three-terminal electronic device constructed of doped semiconductor material and may be used in amplifying or switching applications. *Bipolar* transistors are so named because their operation involves both electrons and holes. Charge flow in a BJT is due to bidirectional diffusion of charge carriers across a junction between two regions of different charge concentrations. This mode of operation is contrasted with *unipolar transistors*, such as field-effect transistors, in which only one carrier type is involved in charge flow due to drift. By design, most of the BJT collector current is due to the flow of charges injected from a high-concentration emitter into the base where they are minority carriers that diffuse toward the collector, and so BJTs are classified as *minority-carrier* devices.

NPN BJT with forward-biased E–B junction and reverse-biased B–C junction

An NPN transistor can be considered as two diodes with a shared anode. In typical operation, the base-emitter junction is forward biased and the base–collector junction is reverse biased. In an NPN transistor, for example, when a positive voltage is applied to the base–emitter junction, the equilibrium between thermally generated carriers and the repelling electric field of the depletion region becomes unbalanced, allowing thermally excited electrons to inject into the base region. These electrons wander (or "diffuse") through the base from the region of high concentration near the emitter towards the region of low concentration near the collector. The electrons in the base are called *minority carriers* because the base is doped p-type which would make holes the *majority carrier* in the base.

To minimize the percentage of carriers that recombine before reaching the collector–base junction, the transistor's base region must be thin enough that carriers can diffuse across it in much less time than the semiconductor's minority carrier lifetime. In particular, the thickness of the base must be much less than the diffusion length of the electrons. The collector–base junction is reverse-biased, and so little electron injection occurs from the collector to the base, but electrons that diffuse through the base towards the collector are swept into the collector by the electric field in the depletion region of the collector–base junction. The thin *shared* base and asymmetric collector–emitter doping is what differentiates a bipolar transistor from two *separate* and oppositely biased diodes connected in series.

Voltage, current, and charge control

The collector–emitter current can be viewed as being controlled by the base–emitter current (current control), or by the base–emitter voltage (voltage control). These views are related by the current–voltage relation of the base–emitter junction, which is just the usual exponential current–voltage curve of a p-n junction (diode).[1]

The physical explanation for collector current is the amount of minority-carrier charge in the base region.[1][2][3] Detailed models of transistor action, such as the Gummel–Poon model, account for the distribution of this charge explicitly to explain transistor behavior more exactly.[4] The charge-control view easily handles phototransistors, where minority carriers in the base region are created by the absorption of photons, and handles the dynamics of turn-off, or recovery time, which depends on charge in the base region recombining. However, because base charge is not a signal that is visible at the terminals, the current- and voltage-control views are generally used in circuit design and analysis.

In analog circuit design, the current-control view is sometimes used because it is approximately linear. That is, the collector current is approximately β_F times the base current. Some basic circuits can be designed by assuming that the emitter–base voltage is approximately constant, and that collector current is beta times the base current. However, to accurately and reliably design production BJT circuits, the voltage-control (for example, Ebers–Moll) model is required[1]. The voltage-control model requires an exponential function to be taken into account, but when it is linearized such that the transistor can be modeled as a transconductance, as in the Ebers–Moll model, design for circuits such as differential amplifiers again becomes a mostly linear problem, so the voltage-control view is often preferred. For translinear circuits, in which the exponential I–V curve is key to the operation, the transistors are usually modeled as voltage controlled with transconductance proportional to collector current. In general, transistor level circuit design is performed using SPICE or a comparable analogue circuit simulator, so model complexity is usually not of much concern to the designer.

Turn-on, turn-off, and storage delay

The Bipolar transistor exhibits a few delay characteristics when turning on and off. Most transistors, and especially power transistors, exhibit long base storage time that limits maximum frequency of operation in switching applications. One method for reducing this storage time is by using a Baker clamp.

Transistor 'alpha' and 'beta'

The proportion of electrons able to cross the base and reach the collector is a measure of the BJT efficiency. The heavy doping of the emitter region and light doping of the base region cause many more electrons to be injected from the emitter into the base than holes to be injected from the base into the emitter. The *common-emitter current gain* is represented by β_F or h_{fe}; it is approximately the ratio of the DC collector current to the DC base current in forward-active region. It is typically greater than 100 for small-signal transistors but can be smaller in transistors designed for high-power applications.

Another important parameter is the common-base current gain, α_F. The common-base current gain is approximately the gain of current from emitter to collector in the forward-active region. This ratio usually has a value close to unity; between 0.98 and 0.998. Alpha and beta are more precisely related by the following identities (NPN transistor):

The low-performance "lateral" bipolar transistors sometimes used in CMOS processes are sometimes designed symmetrically, that is, with no difference between forward and backward operation.

Small changes in the voltage applied across the base–emitter terminals causes the current that flows between the *emitter* and the *collector* to change significantly. This effect can be used to amplify the input voltage or current. BJTs can be thought of as voltage-controlled current sources, but are more simply characterized as current-controlled current sources, or current amplifiers, due to the low impedance at the base.

Early transistors were made from germanium but most modern BJTs are made from silicon. A significant minority are also now made from gallium arsenide, especially for very high speed applications (see HBT, below).

Heterojunction bipolar transistor

Bands in graded heterojunction NPN bipolar transistor. Barriers indicated for electrons to move from emitter to base, and for holes to be injected backward from base to emitter; Also, grading of bandgap in base assists electron transport in base region; Light colors indicate depleted regions

The heterojunction bipolar transistor (HBT) is an improvement of the BJT that can handle signals of very high frequencies up to several hundred GHz. It is common in modern ultrafast circuits, mostly RF systems.[6][7] Heterojunction transistors have different semiconductors for the elements of the transistor. Usually the emitter is composed of a larger bandgap material than the base. The figure shows that this difference in bandgap allows the barrier for holes to inject backward into the base, denoted in figure as $\Delta\varphi_p$, to be made large, while the barrier for electrons to inject into the base $\Delta\varphi_n$ is made low. This barrier arrangement helps reduce minority carrier injection from the base when the emitter-base junction is under forward bias, and thus reduces base current and increases emitter injection efficiency.

The improved injection of carriers into the base allows the base to have a higher doping level, resulting in lower resistance to access the base electrode. In the more traditional BJT, also referred to as homojunction BJT, the efficiency of carrier injection from the emitter to the base is primarily determined by the doping ratio between the emitter and base, which means the base must be lightly doped to obtain high injection efficiency, making its resistance relatively high. In addition, higher doping in the base can improve figures of merit like the Early voltage by lessening base narrowing.

The grading of composition in the base, for example, by progressively increasing the amount of germanium in a SiGe transistor, causes a gradient in bandgap in the neutral base, denoted in the figure by $\Delta\varphi_G$, providing a "built-in" field that assists electron transport across the base. That drift component of transport aids the normal diffusive transport, increasing the frequency response of the transistor by shortening the transit time across the base.

Two commonly used HBTs are silicon–germanium and aluminum gallium arsenide, though a wide variety of semiconductors may be used for the HBT structure. HBT structures are usually grown by epitaxy techniques like MOCVD and MBE.

Regions of operation

Applied voltages	**Mode**
E < B < C	Forward active
E < B > C	Saturation
E > B < C	Cut-off
E > B > C	Reverse-active

<u>Bipolar transistors have five distinct regions of operation, defined by BJT junction biases.</u>

The modes of operation can be described in terms of the applied voltages (this description applies to NPN transistors; polarities are reversed for PNP transistors):

- Forward active: base higher than emitter, collector higher than base (in this mode the collector current is proportional to base current by β_F).
- Saturation: base higher than emitter, but collector is not higher than base.
- Cut-Off: base lower than emitter, but collector is higher than base. It means the transistor is not letting conventional current to go through collector to emitter.
- Reverse-action: base lower than emitter, collector lower than base: reverse conventional current goes through transistor.

In terms of junction biasing: ('reverse biased base–collector junction' means Vbc < 0 for NPN, opposite for PNP)

- **Forward-active** (or simply, **active**): The base–emitter junction is forward biased and the base–collector junction is reverse biased. Most bipolar transistors are designed to afford the greatest common-emitter current gain, β_F, in forward-active mode. If this is the case, the collector–emitter current is approximately proportional to the base current, but many times larger, for small base current variations.
- **Reverse-active** (or **inverse-active** or **inverted**): By reversing the biasing conditions of the forward-active region, a bipolar transistor goes into reverse-active mode. In this mode, the emitter and collector regions switch roles. Because most BJTs are designed to maximize current gain in forward-active mode, the β_F in inverted mode is several (2–3 for the ordinary germanium transistor) times smaller. This transistor mode is seldom used, usually being considered only for failsafe conditions and some types of bipolar logic. The reverse bias breakdown voltage to the base may be an order of magnitude lower in this region.
- **Saturation**: With both junctions forward-biased, a BJT is in saturation mode and facilitates high current conduction from the emitter to the collector. This mode corresponds to a logical "on", or a closed switch.
- **Cutoff**: In cutoff, biasing conditions opposite of saturation (both junctions reverse biased) are present. There is very little current, which corresponds to a logical "off", or an open switch.
- **Avalanche breakdown region**

Although these regions are well defined for sufficiently large applied voltage, they overlap somewhat for small (less than a few hundred millivolts) biases. For example, in the typical grounded-emitter configuration of an NPN BJT used as a pulldown switch in digital logic, the "off" state never involves a reverse-biased junction because the base voltage never goes below ground; nevertheless the forward bias is close enough to zero that essentially no current flows, so this end of the forward active region can be regarded as the cutoff region.

Active-mode NPN transistors in circuits

Structure and use of NPN transistor. Arrow according to schematic.

The diagram opposite is a schematic representation of an NPN transistor connected to two voltage sources. To make the transistor conduct appreciable current (on the order of 1 mA) from C to E, V_{BE} must be above a minimum value sometimes referred to as the **cut-in voltage**. The cut-in voltage is usually about 600 mV for silicon BJTs at room temperature but can be different depending on the type of transistor and its biasing. This applied voltage causes the lower P-N junction to 'turn-on' allowing a flow of electrons from the emitter into the base. In active mode, the electric field existing between base and collector (caused by V_{CE}) will cause the majority of these electrons to cross the upper P-N junction into the collector to form the collector current I_C. The remainder of the electrons recombine with holes, the majority carriers in the base, making a current through the base connection to form the base current, I_B. As shown in the diagram, the emitter current, I_E, is the total transistor current, which is the sum of the other terminal currents (i.e.,).

In the diagram, the arrows representing current point in the direction of conventional current – the flow of electrons is in the opposite direction of the arrows because electrons carry negative electric charge. In active mode, the ratio of the collector current to the base current is called the *DC current gain*. This gain is usually 100 or more, but robust circuit designs do not depend on the exact value (for example see op-amp). The value of this gain for DC signals is referred to as h_{FE}, and the value of this gain for AC signals is referred to as h_{fe}. However, when there is no particular frequency range of interest, the symbol β is used[citation needed].

It should also be noted that the emitter current is related to V_{BE} exponentially. At room temperature, an increase in V_{BE} by approximately 60 mV increases the emitter current by a factor of 10. Because the base current is approximately proportional to the collector and emitter currents, they vary in the same way.

Active-mode PNP transistors in circuits

Structure and use of PNP transistor.

The diagram opposite is a schematic representation of a PNP transistor connected to two voltage sources. To make the transistor conduct appreciable current (on the order of 1 mA) from E to C, V_{EB} must be above a minimum value sometimes referred to as the **cut-in voltage**. The cut-in voltage is usually about 600 mV for silicon BJTs at room temperature but can be different depending on the type of transistor and its biasing. This applied voltage causes the upper P-N junction to 'turn-on' allowing a flow of holes from the emitter into the base. In active mode, the electric field existing between the emitter and the collector (caused by V_{CE}) causes the majority of these holes to cross the lower P-N junction into the collector to form the collector current I_C. The remainder of the holes recombine with electrons, the majority carriers in the base, making a current through the base connection to form the base current, I_B. As shown in the diagram, the emitter current, I_E, is the total transistor current, which is the sum of the other terminal currents (i.e.,).

In the diagram, the arrows representing current point in the direction of conventional current – the flow of holes is in the same direction of the arrows because holes carry positive electric charge. In active mode, the ratio of the collector current to the base current is called the *DC current gain*. This gain is usually 100 or more, but robust circuit designs do not depend on the exact value. The value of this gain for DC signals is referred to as h_{FE}, and the value of this gain for AC signals is referred to as h_{fe}. However, when there is no particular frequency range of interest, the symbol β is used[citation needed].

It should also be noted that the emitter current is related to V_{EB} exponentially. At room temperature, an increase in V_{EB} by approximately 60 mV increases the emitter current by a factor of 10. Because the base current is approximately proportional to the collector and emitter currents, they vary in the same way.

History

The bipolar point-contact transistor was invented in December 1947 at the Bell Telephone Laboratories by John Bardeen and Walter Brattain under the direction of William Shockley. The junction version known as the bipolar junction transistor, invented by Shockley in 1948, enjoyed three decades as the device of choice in the design of discrete and integrated circuits. Nowadays, the use of the BJT has declined in favor of CMOS technology in the design of digital integrated circuits.

Germanium transistors

The germanium transistor was more common in the 1950s and 1960s, and while it exhibits a lower "cut off" voltage, typically around 0.2 V, making it more suitable for some applications, it also has a greater tendency to exhibit thermal runaway.

OPERATING MODES

MODULATION

Modulation is the process where a Radio Frequency or Light Wave's amplitude, frequency, or phase is changed in order to transmit intelligence. The characteristics of the carrier wave are instantaneously varied by another "modulating" waveform.

There are many ways to modulate a signal:

Amplitude Modulation
Frequency Modulation
Phase Modulation
Pulse Modulation

Amplitude Modulation (AM)

Amplitude Modulation occurs when a voice signal's varying voltage is applied to a carrier frequency. The carrier frequency's amplitude changes in accordance with the modulated voice signal, while the carrier's frequency does not change.

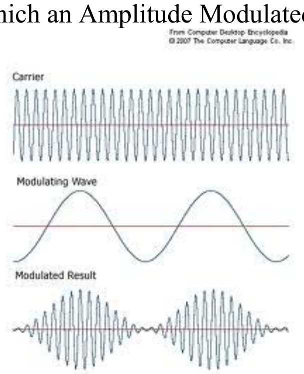
When combined the resultant AM signal consists of the carrier frequency, plus UPPER and LOWER sidebands. This is known as Double Sideband - Amplitude Modulation (DSB-AM), or more commonly referred to as plain AM.

The carrier frequency may be suppressed or transmitted at a relatively low level. This requires that the carrier frequency be generated, or otherwise derived, at the receiving site for demultiplexing. This type of transmission is known as Double Sideband - Suppressed Carrier (DSB-SC).

It is also possible to transmit a SINGLE sideband for a slight sacrifice in low frequency response (it is difficult to suppress the carrier and the unwanted sideband, without some low frequency filtering as well). The advantage is a reduction in analog bandwidth needed to transmit the signal. This type of modulation, known as Single Sideband - Suppressed Carrier (SSB-SC), is ideal for Frequency Division Multiplexing (FDM).

Another type of analog modulation is known as Vestigial Sideband. Vestigial Sideband modulation is a lot like Single Sideband, except that the carrier frequency is preserved and one of the sidebands is eliminated through filtering. Analog bandwidth requirements are a little more than Single Sideband however.

Vestigial Sideband transmission is usually found in television broadcasting. Such broadcast channels require 6 MHz of ANALOG bandwidth, in which an Amplitude Modulated PICTURE carrier is transmitted along with a Frequency

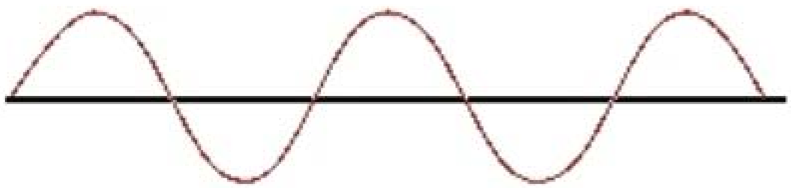


Modulated SOUND carrier.

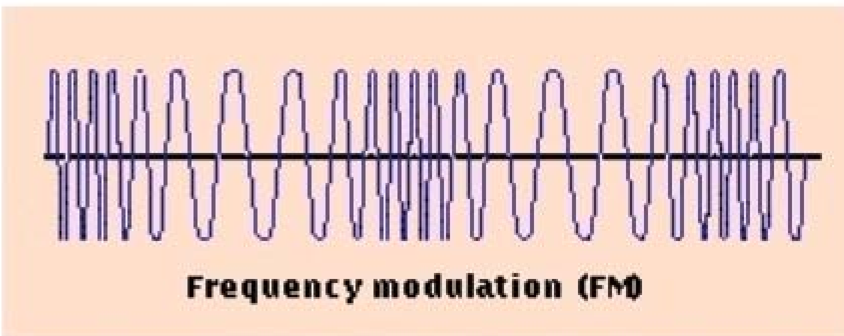
Frequency Modulation (FM)

Frequency Modulation occurs when a carrier's CENTER frequency is changed based upon the input signal's amplitude. Unlike Amplitude Modulation, the carrier signal's amplitude is UNCHANGED. This makes FM modulation more immune to noise than AM and improves the overall signal-to-noise ratio of the communications system. Power output is also constant, differing from the varying AM power output.

The amount of analog bandwidth necessary to transmit a FM signal is greater than the amount necessary for AM, a limiting constraint for some systems.

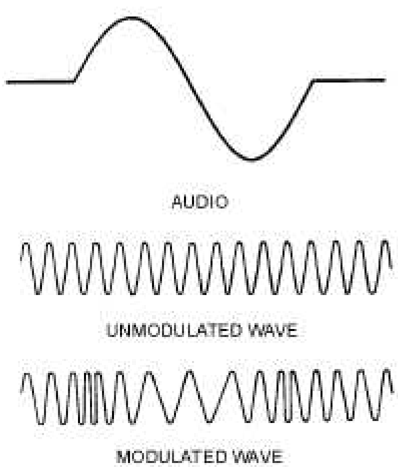


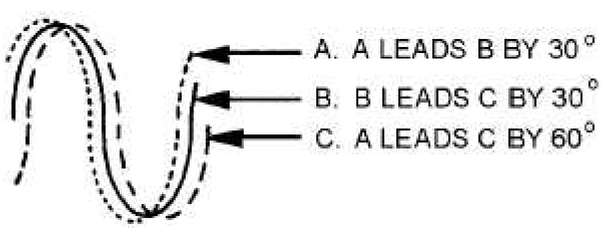
Audio-frequency waves



Phase Modulation

Phase Modulation is similar to Frequency Modulation. Instead of the frequency of the carrier wave changing, the PHASE of the carrier changes.





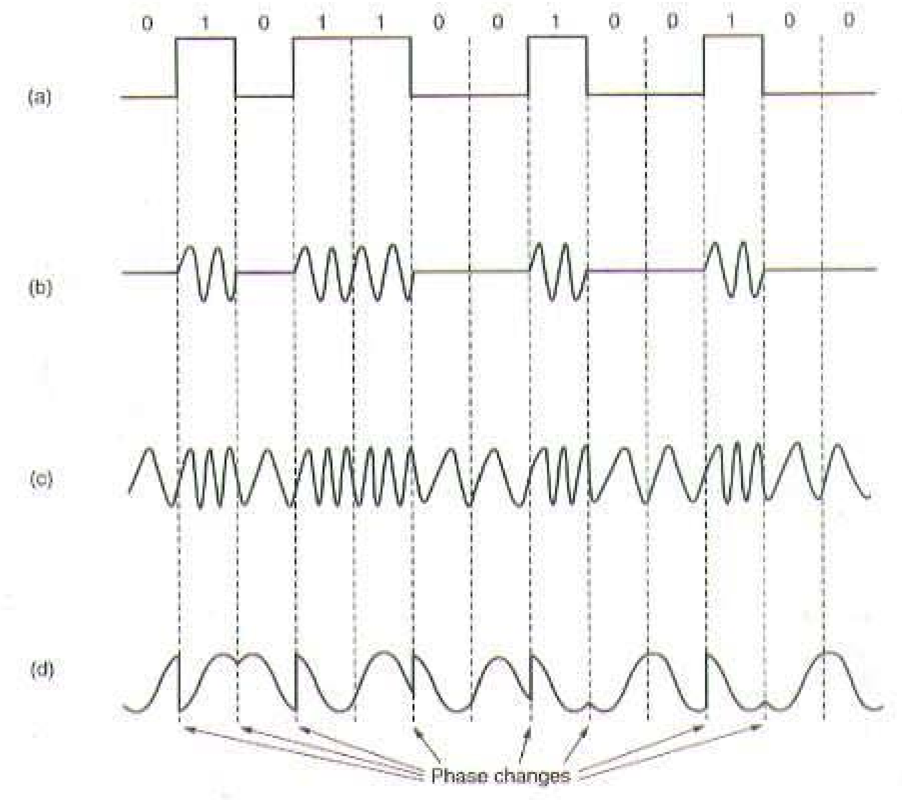
2-22 PHASE MODULATION Frequency modulation requires the oscillator frequency to deviate both above and below the carrier frequency. During the process of frequency modulation, the peaks of each successive cycle in the modulated waveform occur at times other than they would if the carrier were unmodulated. This is actually an incidental phase shift that takes place along with the frequency shift in fm. Just the opposite action takes place in phase modulation. The af signal is applied to a PHASE MODULATOR in pm. The resultant wave from the phase modulator shifts in phase, as illustrated in figure 2-17. Notice that the time period of each successive cycle varies in the modulated wave according to the audio-wave variation. Since frequency is a function of time period per cycle, we can see that such a phase shift in the carrier will cause its frequency to change. The frequency change in fm is vital, but in pm it is merely incidental. The amount of frequency change has nothing to do with the resultant modulated wave shape in pm. At this point the comparison of fm to pm may seem a little hazy, but it will clear up as we progress.

As you might imagine, this type of modulation is easily adaptable to data modulation applications.

Pulse Modulation (PM)

With Pulse Modulation, a "snapshot" (sample) of the waveform is taken at regular intervals. There are a variety of Pulse Modulation schemes:

Additionally, digital signals usually require an intermediate modulation step for transport across wideband, analog-oriented networks.



a) Binary signal b) Amplitude **modulation**. c) Frequency **modulation**. d) **Phase modulation**

Necessary of Modulation:

The original low frequency message/information signal cannot be transmitted to long distances, At the transmitter, information contained in the low frequency message signal is superimposed on a high frequency wave, which acts as a carrier of the information. This process is known as modulation. As will be explained later, there are several types of modulation, abbreviated as AM, FM and PM.

Demodulation : The process of retrieval of information from the carrier wave at the receiver is termed demodulation. This is the reverse process of modulation.

Bandwidth of signals :

In a communication system, the message signal can be voice, music, picture or computer date. Each of these signals has different ranges of frequencies. The type of communication system needed for a given signal depends on the band of frequencies which is considered essential for the communication process.

For speech signals, frequency range 300 Hz to 3100 Hz is considered adequate.
To transmit Music, approx bandwidth of 20kHz is required because of the high frequencies produced by the musical instruments.
The audible range of frequencies extends from 20 Hz to 20 kHz.
Video signals for transmission of pictures require about 4.2 MHz of bandwidth.
A TV signal contains both voice and picture and is usually allocated 6 MHz of bandwidth for transmission.

Amateur radio operators have a variety of modes to choose from when engaged in two way communication. A mode rerers to the way the signal is modulated during transmission. Commonly used forms of modulation are AM, FM, SSB, and digital. In order for a signal to be transmitted and received in a readable manner it is modulated electronically. Both TX and Rx must be using the same form of modulation for the communication to be successful.
Table of Preferred Modes for voice communication gives some idea of what to expect when you use a particular band. Some modes such as Rtty use LSB for all bands.

Each mode has its own unique characteristics. One of these is amount of bandwidth occupied by the signal. CW is quite narrow (less than 250 Hz) while FM is rather wide (15-20 kHz). A narrower signal means there is room for more signals and thus more activity on the band. On the other hand a narrow signal transmits less quality or information. CW requires the use of Morse code whereas FM results in a high quality signal for voice communication. In the following each of the more widely used modes are listed.

CW (A1A)

CW (continuous wave) is a simple unmodulated signal unlike others, which use some form of modulation. By interrupting the signal with a key, morse code is sent. Thus Morse code is not a mode but, as the name implies, a code which is used to communicate by controlling the CW signal. Although it takes some time and practice to become proficient with the code using CW. This is one of the most reliable forms of communication as it can generally make it through the most difficult conditions where other signals can't. I remember during Tsunami disaster One of the operator used CW to transmit messages from one the isolated island.

AM (A3E)

AM (amplitude modulation) was the early mode used by hams for voice transmission. In AM the signal is carrier (like CW) that has upper and lower sidebands that are modulated by varying the amplitude (strength) of the signal. Most shortwave broadcast stations use this method. If you tune to the BBC or some such station using either USB or LSB on your receiver you can hear the carrier as a continuous tone as you move slightly away from the center of the signal. If you listen around the upper end of the 80 meter band you may find some hams using this mode. However AM takes twice the bandwidth of SSB and so is not widely used in Amateur radio.

SSB (J3E and R3E)

SSB (single sideband) is a mode where the carrier and one sideband of the AM mode have been suppressed. Whether using USB (upper sideband) or LSB (lower sideband) more of the transmitter's signal is focused in the sideband used as compared to AM. As a result the signal travels farther and is easier to copy under many unfavorable conditions. SSB is the phone mode of choice for Amateur on the HF bands.

FM (F3E)

FM (Frequency modulation) is what you hear on 2 meters when using a handheld and working through the club repeater. It is the mode where most hams begin. FM has exceptional quality for voice communication and there is generally no noise or fading that you hear on HF with SSB or CW. However because of its wide bandwidth requirements it usually limited to bands such as 2m or 70 cm where there is lots of room. Some FM can also be heard on 10 meter band around 29 MHz.

DIGITAL MODES

Digital modes have been around since RTTY but really took off with the computer generation. To oversimplify digital modes use the off-on (binary 0-1) to send information. CW is really a form of this.

Most digital modes require a computer to be interfaced with the radio to assist with sending and receiving the data. Most also require a TNC (terminal node controller) with a chip that supports the particular mode. You send by typing on a keyboard and receive by viewing the information received on the screen. Some of the more popular digital modes are:

a) **RTTY –** Radioteletype (RTTY) uses a baudot (5 bits per character) or ASCII code (7 bits per character) to communicate. RTTY is almost as reliable as CW and there are many hams who use this mode on a regular basis on HF bands.

b) **Packet** – Uses the complete ASCII character set, which permits both upper and lowercase characters in a transmission. Packet is error-free which is achieved by sending data in small packets with a check bit. If an error is detected by the receiving station it replies and requests that the packet be resent. This is repeated as needed to receive the packet correctly. When signals are good a packet rarely needs to be sent twice but under poor conditions the resending of error packets slows down the exchange of information.

c) **PSK-31 -** Is a relative newcomer to the digital scene and is fast becoming a primary digital mode. One reason for its appeal is that it uses the sound card in the computer to send and receive through the radio. No other special equipment is needed. PSK-31 uses very little bandwidth, less than CW and can function very well at low signals strengths. Unlike Packet and TOR it is not error-free.

FSTV and SSTV

Fast scan TV (FSTV) and slow scan TV (SSTV) are modes used to send pictures or images over the radio. SSTV is generally used on the HF bands and can only send a still picture due to its low data rate and bandwidth. FSTV on the other hand is generally used on the UHF bands and can send moving picture. Recently several HT manufacturers have produced handheld radios with built-in cameras and screens for use in this mode.

Class of emissions are designated by group of a minimum three characters :

First Symbol : Types of modulation of main carrier

Second Symbol : Nature of signals modulating the main carrier

Third Symbol : Type of information

A 1 A : Double sideband Telegraphy by on-off keying, without modulation (CW)

A 3 E : Amplitude modulation Telephony, voice

F 3 E : Telephony, (voice) Frequency modulation

J 3 E : Telephony, (voice) Single sideband , suppressed carrier,

R 3 E : Telephony, (voice) Single sideband, Reduced carrier ,

H 3 E : Telephony, (voice) Single sideband, full carrier.

F 1 B : Frequency modulated , RTTY, Fast Morse

A 2 A : Double sideband Telegraphy by on –off keying with modulation (MCW)

C 3 F : Vestigal sideband TV

First symbol – types of modulation of the main carrier
Emission in which the main carrier is amplitude-modulated :

Double – sideband A
Single – sideband , full carrier H
Single – sideband reduced carrier R
Single – sideband suppressed carrier J
Frequency modulation F

Second symbol – Nature of signal(s) modulating the main carrier

Information without the use of a modulating sub-carrier : 1

Information with the use of a modulating sub-carrier: 2

Analogue Information (Telephony) : 3

Third symbol – type of information to be transmitted

Telegraphy (CW) : A
Facsimile : C
Data transmission, telemetry : D
Telephony (including sound b/c) : E
Television (video) : F

RADIO RECEIVERS

CHARACTERISTICS OF RECEIVER

SENSITIVITY:

The ability of a radio receiver to pick up and reproduce weak radio signals called sensitivity.
The sensitivity of a radio receiver is determined by the value of high frequency voltage that must be fed to its input circuit (between the aerial earth terminals) in order to secure a normal output power. I.e. to secure a normal reception. The lower is such input voltage necessary for the normal reception; the higher is the receiver sensitivity. The sensitivity of modern radio receivers ranges from several microvolts to several mill volts and depends upon the number of amplification stages and upon their quality.

SELECTIVITY:

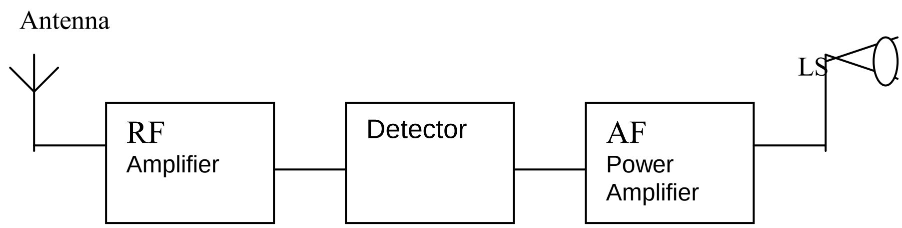
The ability of a radio receiver to separate the signal of a required radio station from the signals of unwanted stations, operating on other frequencies, called selectivity. In other words, the selectivity of radio receiver is its ability of receiving radio signals within a comparatively narrow frequency band.
The selectivity of radio is of great importance when a great number of radio stations, in many cases operating on nearly equal frequencies, are on the air.
The selectivity of a radio receiver depends upon the number and the quality of tuned circuits employed by the receiver. The greater the number of tuned circuits adjusted to resonance in a radio receive and the higher the quality of such tuned circuits, the higher is the selectivity of such a receiver.

FIDELITY:
It can be defined as the quality or precision with which the output is reproduced or (the lower the distortion introduced by a radio receiver, the higher is the quality of reproduction or fidelity of such a receiver.)

STABILITY:
Stability may be defined as a measure of the ability of a radio receiver to deliver a constant amount of output for a given period of time when the receiver is supplied with a signal of constant amplitude and frequency.
There are two types of stabilities.
1. Mechanical and 2. electrical stability.

T.R.F. RECEIVERS:

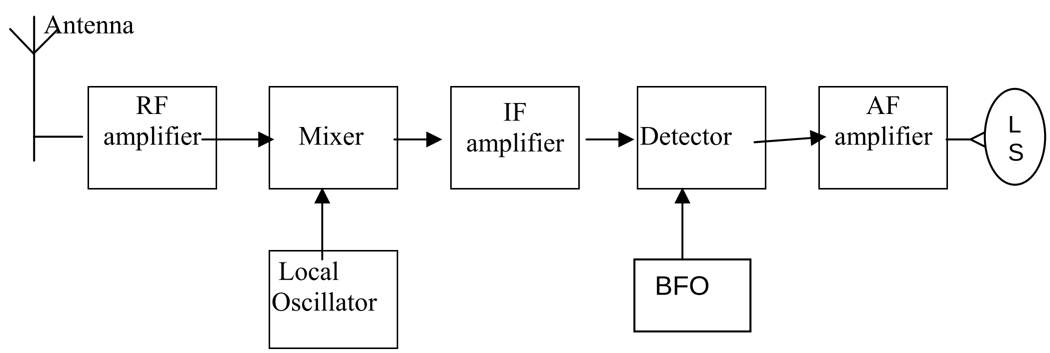
(Tuned Radio Frequency receiver). The general design principle of a T.R.F. receiver is shown in the block diagram below:



Block Diagram TRF receiver

The radio frequency waves picked up by the aerial are first fed to the tuned input circuit of the receiver this circuit being coupled to the aerial. The input circuit tuned to the frequency of the incoming signal, provides a certain amount of amplification and also gives some preliminary selectivity, separating the signal of a desired radio station from the signals of numerous other stations simultaneously picked up by the receiving aerial.
``The Radio frequency voltage built up across the tuned circuit at the input of the receiver is then applied to the first stage of RF amplification. The RF amplifier usually consists of not more than two stages.
Having passed through the RF amplifier, the amplified RF signal reaches the detector stage where it is rectified.
The low frequency (audio frequency) signal developed at the output of the detector is, then amplified in AF amplifier stages. The output of AF amplifier feeds the loudspeaker or a pair of headphone.

SUPER HETERODYNE RECEIVER - BLOCK DIAGRAM-



RF amplifier stage : The radio waves from various broadcasting stations are intercepted by the receiving aerial and are coupled to this stage. This stage selects the desired radio wave (using a tuned circuit) and amplifies the strength of the wave to the desired level.
`
Mixer stage: The amplified output of RF amplifier is fed to the mixer stage where it is combined with the output of a local oscillator. The two frequencies beat together and produce an intermediate frequency (IF). The IF is the difference between oscillator frequency and radio frequency. The IF is always 455 kHz regardless of the frequency to which the receiver is tuned.

Local oscillator: The locally generated oscillations in a superhetrodyne receiver are usually of a frequency higher than the frequency of the incoming signals.

IF amplifier stage: The output of mixer is always 455 kHz and is fed to fixed tuned IF amplifiers. These amplifiers are tuned to one frequency (i.e. 455 kHz) and render nice amplification.

Detector stage: The output from the IF amplifier stage is coupled to the input of the detector stage. Here, the audio signal is extracted from the IF output. Usually, diode detector circuit is used because of its low distortion and excellent audio fidelity.

Beat Frequency Oscillator: In order to make Morse code audible, the receiver has a Beat frequency oscillator at the detector. The BFO is not really a beat frequency oscillator at all; it is merely a LC oscillator.

AF Amplifier: The audio signal output of detector stage is fed to a multistage audio amplifier. Here, the signal is amplified until it is sufficiently strong to drive the speaker. The speaker converts the audio signal into sound waves corresponding to the original sound at the broadcasting station.

BFO: In order to make Morse code audible, the receiver has a Beat frequency oscillator at the detector. The BFO is not really a beat frequency oscillator at all; it is merely a simple LC oscillator.

COMPARISON OF T.R.F. AND SUPERHETRODYNE RECEIVERS:

When compared to a T.R.F. receiver, a superhetrodyne receiver offers the following advantages:

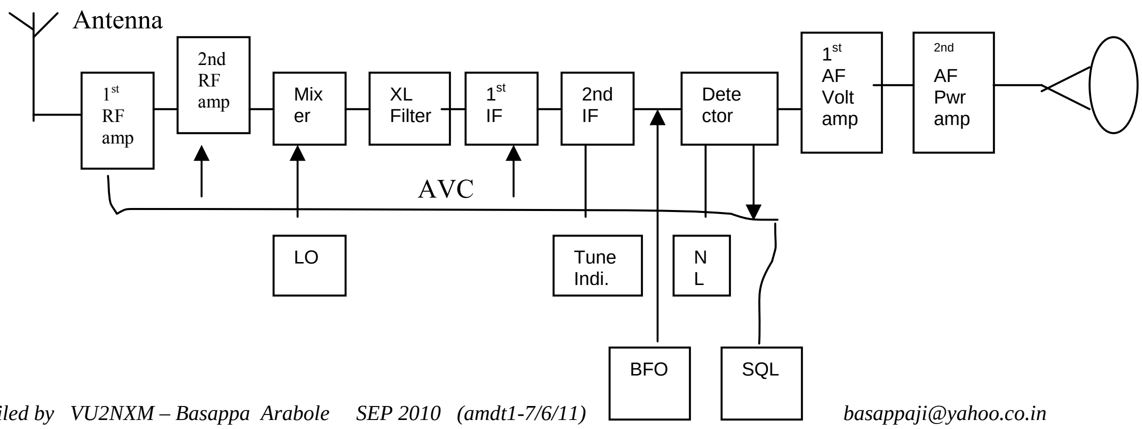
1. High sensitivity, attributed to the greater number of stages and to the higher gain attained in the i.f. amplifier.
2. High selectivity, attributed to the greater number of tuned circuits.
3. Better sensitivity and selectivity over the entire tuning range of the receiver.
4. Adaptability to the incorporation of various improvements such as the automatic gain control, electronic optical tuning indicators and other improvements, which can be introduced only when the receiver gain is high.

ADVANTAGES OF A SUPERHETRODYNE RECEIVERS OVER T.R.F.:

1. The superhetrodyne receiver is having good sensitivity. This is because of the fact that the signal, after the frequency conversion is amplified at a single and convenient frequency for amplification.
2. The selectivity is good as the I.F. amplifier stages use tuned stages with good selectivity and required bandwidth.
3. Continuous tuning is limited to the three tuned circuits namely the R.F. amplifier, Mixer (Frequency converter) and the local oscillator.
4. The fidelity of the receiver will be better as the bandwidth of the I.F. amplifier is of the required value.
5. The R.F. amplifier stage improves signal to noise ratio, reduces I.F. interference and it offers a better coupling between antenna and the input of the receiver.

COMMUNICATION RECEIVER:

It uses the principal of Superhetrodyne reception. In addition it uses two stages of mixers, with two local oscillators. The two mixers produce different intermediate frequencies. This receiver is provided with good adjacent channel selectivity as well as good image rejection ratio.
The first block indicates the special provisions for the antenna coupling circuit. It is followed by a stage of RF amplification. The output of the RF amplifier goes to the mixer. The 1st local oscillator supplies the required frequency to get the intermediate frequency to the second mixer stage. Where another frequency conversion takes place.



BLOCK DIAGRAM OF COMMUNICATION RECEIVER

The first intermediate frequency signal obtained from the first mixer stage is sufficiently amplified using one or two stages of IF amplification. The second mixer produces the 2^{nd} IF. This signal is sufficiently amplified in one or two stages of 2^{nd} IF amplifiers. The second mixer is provided with a crystal local oscillator, which does not suffer from frequency drift. Thus it is ensured that always correct IF output is obtained.

The IF amplifier after the second mixer uses a beat frequency oscillator, which can be switched in to the circuit or switched off. This is useful in the reception of morse code signals.

AGC is provided to the IF and RF amplifier sections. The detector and the audio amplifier sections follow the IF amplifier.

These are salient features in a communication receiver, which the block diagram cannot cover. They are as follows:
A rotary switch or the like will be provided for the selection of the frequency band. Usually the frequency range will be from 200 kHz to 30 MHz, divided into six to eight wave ranges. A fine-tuning control will be provided for getting the optimum signal strength.

It is provided with a high gain RF amplifier stage. An RF gain control is also provided.

Communication receivers are provided with amplified and delayed AGC. These will be provision to select the AGC and to work the receiver without the AGC.

The selectivity of the receiver is adjustable. Narrow medium and wide bandwidth selection will be provided with a selector switch, which modifies the circuit accordingly.

A BFO is provided to receive CW signals.

Usually the second mixer is provided with a fixed frequency crystal oscillator as the local oscillator. The same oscillator can be used for the calibration of the dial of the receiver periodically to maintain the accuracy of tuning.

A noise limiter circuit is provided.

It also has inter-channel noise suppressor or muting circuit.

Automatic frequency control circuit is provided.

Tuning indicator is provided.

An 'S' meter is provided to measure the incoming signal strength.

Circuit design is made to receive FM signals.

The Rx is provided with facilities to receive SSB signals.

Frequency synthesizer may be provided in certain communication receivers.

Microprocessor control may be used in some of the communication receiver.

The power supply used is fully regulated power supply.

Noise Limiter:
The noise limiter simply removes the voltage that is excess of a predetermined level from the output of a radio receiver.

Tuning Indicator: Tuning indicator is a visual display that indicates the proper tuning of the station in a radio receiver.

Muting circuit: The other names for this circuit is **inter channel noise suppressor, squelch, tuning silencer** and **CODAN** (Carrier Operated Device Anti-noise). Radio telephone receivers and communication receivers use this circuit.

Automatic Gain Control: When the variations in signal strength encountered at the antenna terminal the AGC (sometimes called "Automatic volume control or **A.V.C.)**, smoothes out variations in signal loudness.
The job of the A.G.C. is to increase the gain on weak signals and decrease it on strong signals.
Squelch: It enables the receiver's output to remain cut off unless the carrier is present. Apart from eliminating inconvenience this system naturally increases the efficiency of the operator.
Squelch is also called **Muting** or **Quieting**.

Automatic Volume control (AVC): It is also called automatic volume control. It prevents overloading of the receiver and at the same time, keeps the output signal level at a comparatively constant value inspite of fading of the HF signal level in the aerial.

Image interference or Image Frequency signals: Sometime it so happens that the desired value of IF can be obtained from two different carrier frequencies at the same time. For example an RF signal of 550 KHz and an oscillator frequency of 1005 KHz, will produce an IF signal of 455 KHz. It is also possible to obtain 455 KHz IF signal with the same oscillator frequency if an RF signal of 1460 KHz reaches the first detector
of these two 455 KHz. If only one signal is desired, ***the undesired signal is called the image frequency signal or image interference.*** This can be minimized by providing one or more stages of RF tuning or pre-selection.

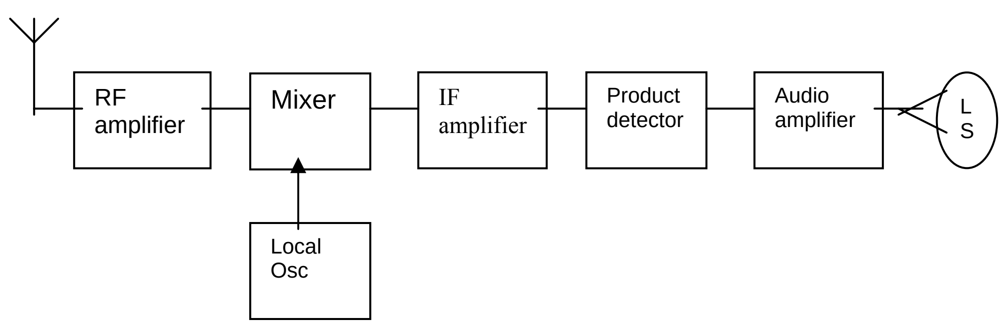
Signal to noise ratio: An ideal receiver would not generate noise and the minimum detectable signal would be limited only by the thermal noise in the antenna. In practical receiver, the limit is determined by how well the amplified antenna noise overrides the other noise of the input stage.
Since the noise figure is a ratio, it is usually given in decibels; it is around 5 to 10dB (Decibels) for a good communications receiver below 30 MHz.

Receiver Noise: All types of radio receivers develop a certain amount of internal noise, which is reproduced as interference at the output of the receiver. This internal noise, referred to as the receiver noise. This is caused by various irregularities of the emission in the electron valves and also by the haphazard thermal movement of the electrons in receiver wiring and resistances. Because of the greater number of valves employed by superheterodyne receivers and because of the greater gain provided by such receivers, the internal noise is much higher in a superheterodyne receiver than in a t.r.f. receiver.

Side Band : When an R.F. carrier is modulated by a single audio note, two additional frequencies are produced they are the upper frequency, which is equal to the sum of the R.F. carrier, and the frequency of audio. The lower frequency is the difference between the R.F. carrier frequency and the audio frequency. The frequency, which is higher than the carrier frequency, is called the upper side and the one lower than the carrier frequency is called lower side frequency. The band of frequencies containing the side frequencies is called Side Band.
The Side Band containing the sum of the carrier and the modulating frequencies is known as the upper side band and the band containing the difference frequencies is known as the lower side band.

SINGLE SIDEBAND RECEIVER:

The electromagnetic waves from the antenna are passed to the RF amplifier. All the unwanted Radio waves are bypassed at this stage and only the frequency selected by the tuning circuit is amplified and passed to the next stage i.e. mixer

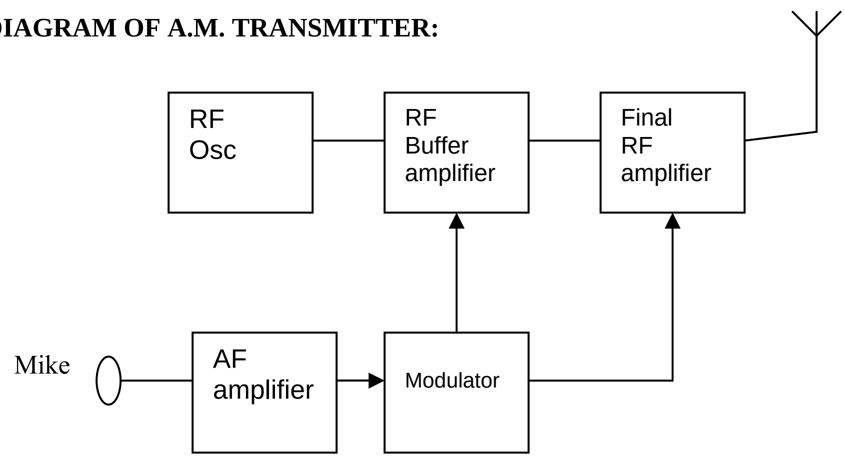


The mixer converts the incoming Radio signal to the intermediate frequency i.e. around 455 kHz. The local oscillator generates a standard frequency, which is to be used by the mixer to generate output signal at a fixed intermediate frequency. The signal is then passed on to the next stage. IF amplifier.
The signal level is received from the mixer stage are quite low, the IF section must have sufficient gain to provide a usable signal level at the detector.
Product detectors are preferable for SSB reception, because they minimize the generation of inter modulation distortion in the demodulating process. The desired audio product is selected among the several undesired products that appear in the product detector and the signal is fed to the next stage i.e. audio amplifier.
The desired audio signal is amplified to a level that it can drive the speaker and a clear audio is heard using a loud speaker.

TRANSMITTER:

Principal and operation of low power transmitter

BLOCK DIAGRAM OF A.M. TRANSMITTER:



Microphone: Converts audio signal to electric wave.

Audio Amplifier: Amplifies audio signal of microphone.

RF Oscillator: Produces carrier frequency.

Balance Modulator: Here carrier wave is modulated by audio frequency.

RF Buffer amplifier: Its function is to simply amplify the power without making any change in the frequency. It is class 'A' Amplifier and improves the frequency stability.

RF Power amplifier: The final stage of transmitter is the power amplifier. Sometimes this stage is referred as the "Final Stage". This amplifies the R.F. to be transmitted.

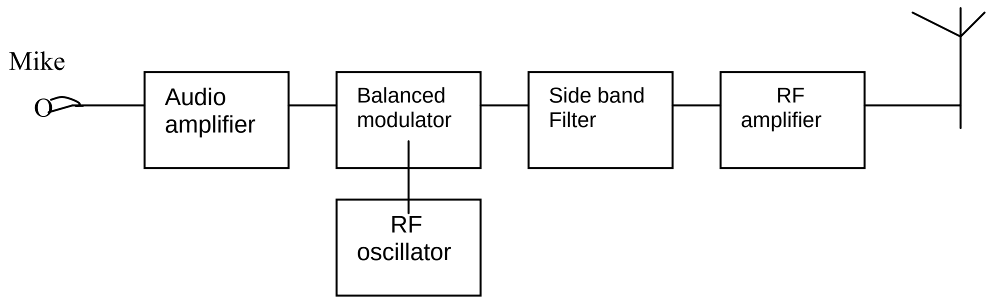
Antenna: Radiates the R.F.

SSB TRANSMITTER

We understand that both sidebands of an amplitude-modulated signal contain all of the intelligence being transmitted. So, to recover the intelligence, all that is required is one sideband and the carrier. If one of the sideband were removed from the modulator carrier immediately after modulation, it would have no harmful effects on the transmission of the intelligence. The intelligence would be transmitted in the other sideband and the unmodulated carrier would accompany it for later use in converting the intelligence to its original lower frequency.
The technique of removing one sideband from an AM signal is called SSB. It has certain advantages over conventional transmission in which both side bands are used. The most important advantage to be gained by eliminating one side band is that the bandwidth of the signal is cut in half.

We know that in both side bands, half of the bandwidth is above the carrier frequency and half below. But both halves represent the same intelligence, only at different frequencies. So by eliminating one side band, the range of frequencies that carry intelligence is cut in half. This reduction in bandwidth improves reception of the signal.
Narrow the bandwidth, the less atmospheric noise or static that will enter the receiving circuits with signal.
Also if each carrier uses less bandwidth in given range, more carrier signals can be sent or there will be less interference between different carrier signals.
Thus, SSB is a method of radio transmission in which one side band and the carrier are suppressed; only one intelligence bearing side band is transmitted.

Antenna



BLOCK DIAGRAM OF SSB TRANSMITTER

FUNCTION OF EACH BLOCK:

Microphone (Mic) : The microphone converts the audio signal into electrical signals, which is fed to the AF amplifier stage.

Audio Amplifier: The output from the mic is fed to the speech amplifier where the electrical signal is amplified to a required level.

RF Oscillator : The carrier frequency intended is generated by using either crystal or an LC tank circuit. It is designed to have frequency stability. It can be operated with low voltage power supply with little dissipation of heat.

Balance Modulator: In this modulator the audio is super imposed on the carrier frequency. The output contains two side band frequencies carrying audio intelligence without carrier frequency.

Side Band filter: It eliminates (filters) anyone of the side bands.

RF Amplifier : RF power amplification is done and is coupled to the antenna through antenna impedance matching circuit at this stage.

Antenna : The output of the RF amplifier is fed to the antenna for broadcasting.

COMPARISION BETWEEN AM & FM

AM :

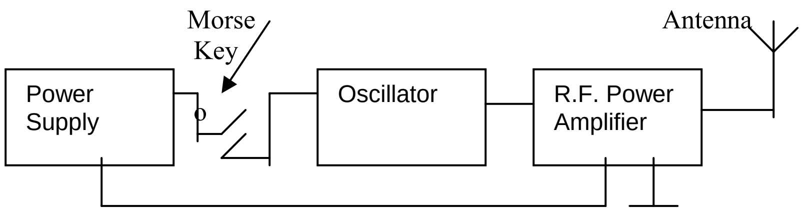
a) It has two side bands. LSB and USB
b) In AM the amplitude of the carrier is varied but frequency remains constant.
c) Modulation index is independent of modulating frequency.
d) Transmitted power by the AM includes carrier power and side bands power. Thus it needs more power.
e) Increased modulation index increases the total transmitted power.
f) Noise is more, so fidelity is less.
g) Mainly used for mono transmission.

FM:

a) It has infinite number of sidebands. They are separated by Fm, 2Fm, 3Fm and so on from the carrier frequency.
b) In the Fm, the frequency of the carrier is varied but amplitude of the carrier remains constant.
c) Modulation index is inversely proportion to the modulating frequency.
d) It needs less modulation power.
e) Increased modulation index increases the bandwidth but transmitted power remains constant.
f) Noise is less, so fidelity is more.
g) Mainly used for stereo transmission.

CONTINUOUS WAVE OR C.W. TRANSMITTER.

C.W. transmitter essentially consists of an oscillator whose plate supply is connected to a morse key and morse coded message is transmitted by turning the plate supply on and off by the morse key.



A Simple C.W. Transmitter

MICROPHONES

MICROPHONE: sometimes referred to as a **mike** or **mic**, is an acoustic to electric transducer or sensor that converts sound into an electrical signal.

DIFFERENT TYPES OF MICROPHONES :

1) Moving coil microphones also called dynamic or electrodynamics Microphones.

This is medium priced and has high sensitivity. It is generally used in broadcasting work and in applications where long cables are required. These are also used where rapid fluctuations or extremes in temperature and humidity is expected.
The dynamic principle is exactly the same as in a loudspeaker, only reversed.

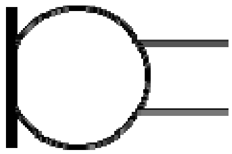
2) Carbon microphones

A carbon microphone, formerly used in telephone handsets, is a capsule containing carbon granules pressed between two metal plates. Carbon microphones were once commonly used in telephones; they have extremely low-quality sound reproduction and a very limited frequency response range, but are very robust devices. Low cost.

3) Piezo microphones

A piezo microphone uses piezoelectric crystal that works as a transducer, both as a microphone and as a slimline loudspeaker component.

Usage
Piezo transducers are often used as contact microphones to amplify sound from acoustic musical instruments, public address system or to record sounds in unusual environments (underwater, for instance). Saddle mounted pickups on acoustic guitars are generally piezos that are mechanically connected to the strings through the saddle. This type of microphone is not to be confused with magnetic coil pickups commonly visible on typical electric guitars.



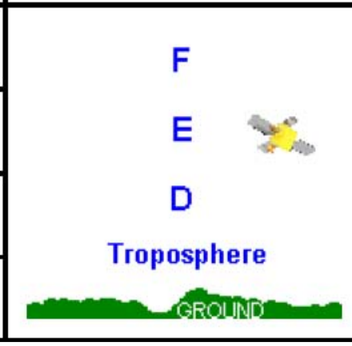
Electronic symbol **for a microphone.**

Connectors (Not in syllabus)
The most common connectors used by microphones are:
1. Male XLR connector on professional microphones
2. ¼ inch mono phone plug on less expensive consumer microphones
3. 3.5 mm (Commonly referred to as 1/8 inch mini) mono mini phone plug on very inexpensive and computer microphones

PROPAGATION

You should be aware that HF propagation is predominantly due to ionisation of the ionosphere. An ionosphere is made up of layers of gases. We must now consider what these layers of gasses are called Ionosphere. These layers are simply called the D E and F

there is no A B C layers.

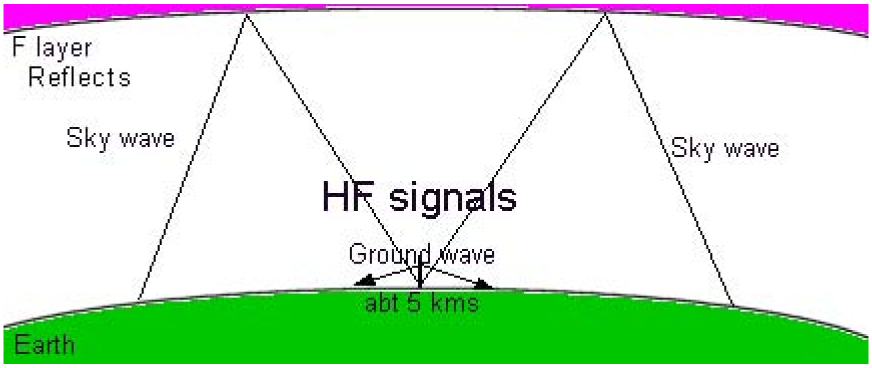
Layer	Approx Height	Diagram
F	400 kms	
E	Varies	
D	70 kms	
Troposphere is below the D Layer		

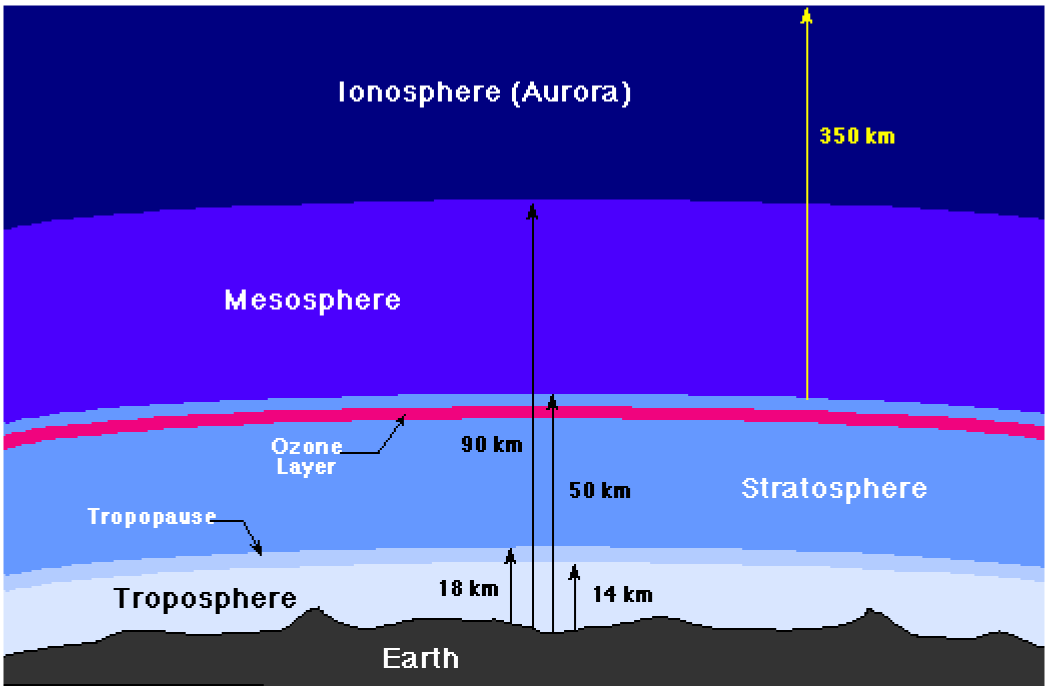
The D layer is nearest to the earth at about 70kms and the top layer, the F layer is at about 400kms.
E between the D and the F layers.
It is the ionisation of the gases, caused mainly by ultra violet rays from the sun, that makes them conductive and which gives the ability to refract (reflect) the HF radio waves back to earth. This "bounce and forth can happen several times. The level of ionisation changes with the time of day, the time of the year, and according year sunspot cycle. Understand that the sunspot number is an indicator of solar activity. More sunspot better HF propagation as a result of increased ionisation.

(more detail on : http://www.amradioinfo.org.uk/ilc/p1.htm)

The amount of ionisation that occurs is dependent upon :
1. the time of day
2. the time of year (season) and
3. changes in sun spot activity in its 11 year cycle.

Recall that reflection from the F layer is the main mode of HF propagation.
The word propagation means to increase the distance that your radio signal travels.
Over and above the signal that can travel as a Ground Wave.
As you will see from the diagram below that GROUND WAVE are the radio waves that quickly become weaker with ranges of a few kms at best. Thus at whatever frequency you are operating on HF bands any distance you achieve is dependent upon bouncing / deflecting off the "F" layer in the ionosphere.





F layer ionisation during daylight enhances propagation. It is the F layer which plays the greatest part in HF propagation.
The sun causes the ionisation during daylight with a peak in the early afternoon (local time).
F layer looses much of its ionisation during night particularly at the higher HF Fequencies.
Whilst the F layer remains ionised over night it is much weaker than during the day and hence propagation at night dwindles on the higher HF bands.

In Winter F layer remains relatively constant at the daylight levels
During the winter the ionisation tends to remain higher as the WX is colder.

F layer has enhance propagation during sun spot activities
During the 11 sun spot cycle the more sun spots there are the higher the ionisation which lead to better and the higher the radio frequency that can be reflected.

Understand the meaning of ground wave, sky wave, skip distance, and skip zone (dead zone).

There are certain terms associated with propagation.

GROUND WAVE = the radio waves that hug the earth but quickly become weaker with a ranges of about some kms at best.

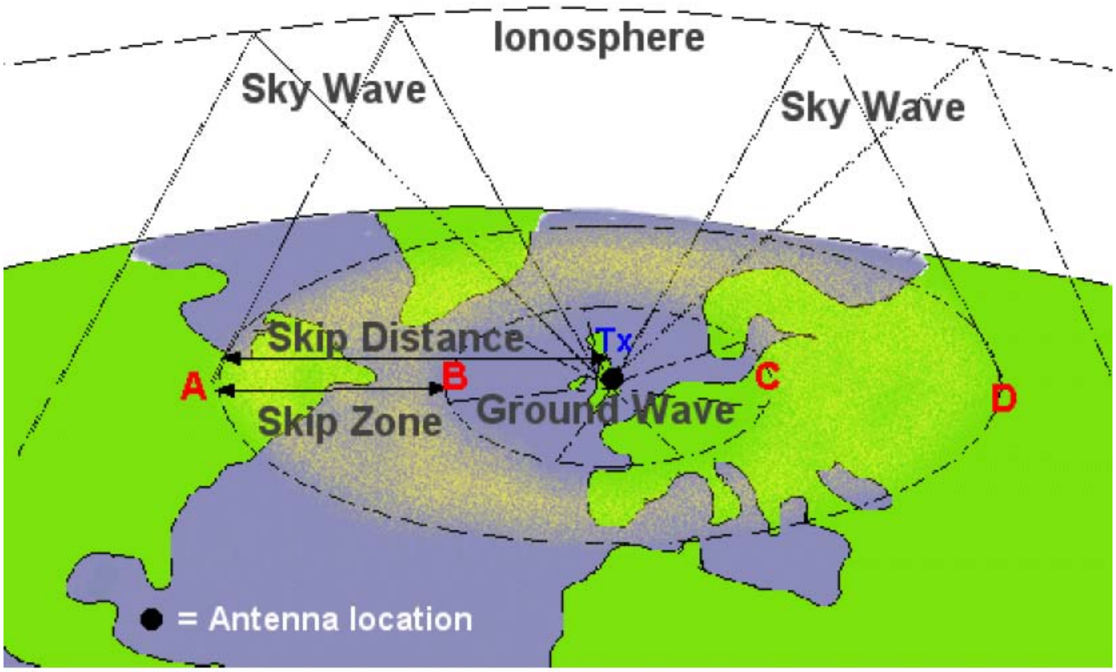
SKY WAVE = the radio waves that are reflected back to earth by the ionosphere. Even very low HF transmitters are capable of having their signals reflected back from the ionosphere as it is not the poor transmitter that is needed to make the signal reach the ionosphere, the power is only needed to be sufficient signal to be heard by the receiving station. QRP operation on less than 5 watts has reached North America.

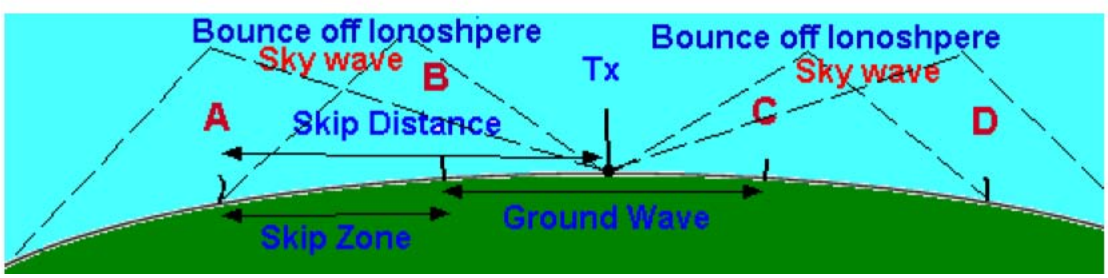
SKIP DISTANCE = the distance from the transmitter to the first point at which returning signal received back on earth having been reflected by the ionosphere.

SKIP ZONE = The zone is between the end of Ground Wave coverage and the point at which sky wave is first received back on earth. Thus the SKIP ZONE (also called the Dead Zone) is signal as communication is concerned as nothing is heard from the transmitting station.

All the distances change as the ionosphere changes so you cannot state the Skip Zone is such a distance and the same goes for the Skip Distance.
Skip distance minus ground wave distance = the skip zone distance

Note:-NO SIGNALS are received in the SKIP ZONE from the transmitting station's antenna location.





The TX indicates where the Transmitting station is located. Stations at A, B, C, and D will hear the signal at different reasons.

Ground Wave
Stations B and C are near enough to hear the grounds wave signal
Sky wave
Stations A and D are far enough away (outside the Skip Zone or DEAD ZONE) to hear the signals from off the ionosphere.

Skip Zone or DEAD ZONE

The Skip Zone or DEAD ZONE is as it says no signals will be heard from the transmitting station. so between A and B and C and D will not hear the transmissions.

High atmospheric pressure can cause ducting in the troposphere, which increases the VHF and UHF signals. Recall that the range of VHF signals can occasionally be significantly increase reflection from highly ionised areas in the E layer (Sporadic E).

Ducting is the enhancement of VHF and UHF

When there is high atmospheric pressure, enhanced VHF and UHF propagation can take place , what is called "Ducting" in the troposphere.

AERIALS

ANTENNAS FOR HAM TRANSMITTERS

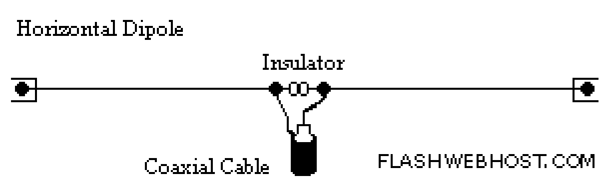
Antenna is the means by which a wireless operator puts his signal into the space and also through which he picks up the signals of the stations with which he wants to communicate. Hence after having a good Receiver and a Transmitter (or Transceiver), the next important item one should have to set up a ham radio station is a good antenna. The radio frequency power that is generated in the transmitter should be radiated in the form of electro magnetic waves. It is the job of the antenna to convert the RF power into radio waves and radiate them into the desired direction for effective communication. For this purpose, the antenna should be located well above the ground and it should be kept away from any tall buildings, trees, electrical power conductors, telephone and telegraph wires and other metal objects that will absorb the energy. The antenna should be erected as high as possible for the best results.

Antennas have reciprocity in that a good transmitting antenna will also work as a good receiving antenna. So if an amateur takes proper care and bestow attention in installing a good antenna, it will pay him rich dividends. Otherwise, however sophisticated may be the transmitting system, it will not be possible to get satisfactory performance. On the other hand, by using an efficient antenna system, best result can be obtained from even a home brew QRP transmitter.

The transmitter that generates the RF power is located in the shack and the antenna is erected high up in the air. To transfer the RF energy from the transmitter to the antenna, a transmission line is used. It links the transmitter (generator of RF) to the antenna (load). Though ordinary plastic wires will do the job, there will be the energy loss and the efficiency will be less and hence it is not suitable for use as transmission line, especially with QRP transmitter. The output stage of the transmitter has certain impedance as also the antenna. Maximum transfer of energy from a source to the load will take place only when the impedance is matched**. It is important that the out put impedance of the transmitter should match the input impedance of the antenna.** Generally, a co-axial is used by amateurs, which offer maximum efficiency and minimum loss of energy. RG-58/U is small coaxial and RG-8/U is medium and impedance is 53.5 Ohms and 52 Ohms respectively. RG-59/U is small co-axial cable and impedance is 73 Ohms.

Other stations will judge the performance of an amateur station from the strength of the signal they hear. Remember that antenna is the part that makes all the difference to an amateur's signal, a weak one or a blasting 59+.

HORIZONTAL DIPOLE



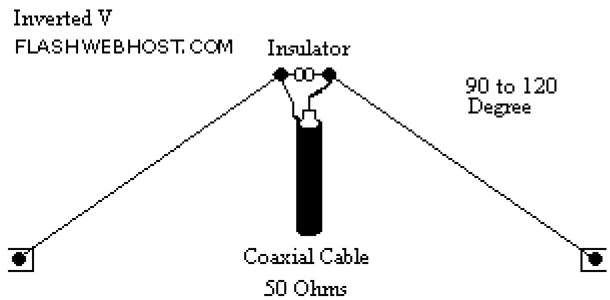
Dipole is a simple antenna, easy to construct. It is widely used by amateurs and it gives satisfactory results in HF Bands. It requires only two points to hook it up. The height should be about 30 to 35 feet above the ground, or as high as possible. Dipole is considered to be a fundamental antenna based on which more complex types of antennas are designed.

The overall length of the dipole is half the wavelength of the frequency for it is used. The length in feet can be calculated by using the formula **468/f MHz**. It is cut into two halves and an insulator is used in the center. The radiation pattern of a dipole is like the figure '8'. The radiation is maximum in the broadside of the axis and least in the axis line. The impedance of the dipole is 70 Ohms and a coaxial cable with the impedance of 73 Ohms like RG-59/U is used to match it. Rightly, the dipole can be called the common man's antenna due to its many advantages, like low cost, simple construction, ease of transport, satisfactory results etc. The materials for the dipole are easily obtained and inexpensive. Dipole can be used for local as well a DX working.

For 160 through 40 meter, they are almost mandatory. On the other bands, dipoles are pretty effective, especially installed over 30 feet height"

For the time and money an amateur spends on a dipole, it certainly gives best results and good value for money.

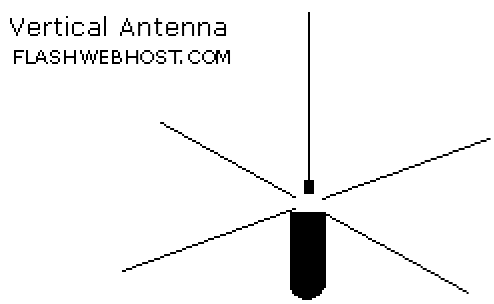
INVERTED V



This antenna is a variation of dipole in which the center position is raised to a high point than the ends and hence only one support is required. The ends are to be kept about 10 feet above the ground. The length is little shorter than the dipole. The formula for finding the length of inverted V in feet is **464/f MHz**. The angle at the center between the two halves should be between 90 and 120 degree to get best results.

The impedance of inverted V is lower than that of the dipole, i.e. 50 Ohms. Therefore RG-58/U or RG-8/U co-axial cable is used for the transmission line. Inverted V is a popular and effective antenna and amateurs use it for 20, 40 and 80 meter working.

VERTICAL ANTENNA



If one has no space to put up a dipole or inverted V antenna, don't lose heart. Many other hams have faced this problem too. Perhaps it may be possible to go up. So one can try a vertical antenna.

In a vertical antenna the radiating part is quarter wavelength and is called the radiator. Copper wire or aluminum tubing can be used for radiator.

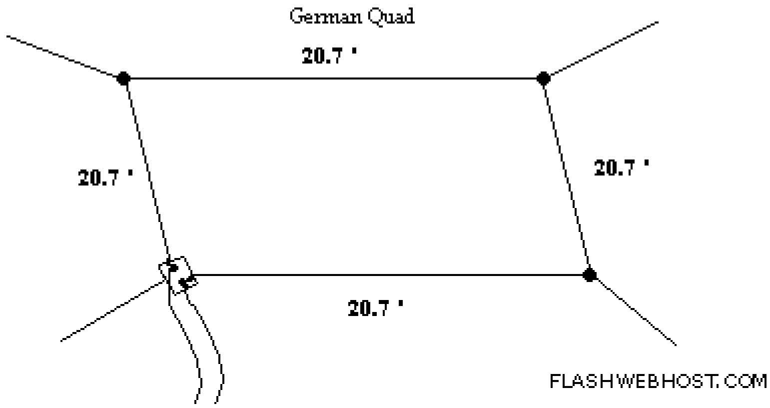
There are two types: ground vertical and ground plane vertical. For ground vertical quarter wave length radials are connected to the base and buried in the ground. A ground plane vertical uses an artificial metallic ground usually four rods or wires perpendicular to the antenna.

The radiation resistance of ground plane vertical varies with the diameter of the vertical element. For transmission line a 50 Ohms or 75 Ohms co-axial cable can be used.

The vertical antenna is omni-directional. It radiates or picks up RF energy equally well in/from all direction. This property offers an advantage in DX and contest working. Vertical antenna can be used to monitor even week DX signals and then one can change over to any directional antenna and work that station. Because of its low angle of radiation the signals reach many miles away due to skip propagation. So vertical antenna is better suited for DX working. Hams use it for 80 and 40 meter working.

Multi band vertical can be constructed wherein the vertical section will be quarter wavelength at the lowest frequency. For best results, the vertical antenna should be erected as high as possible and far away from metallic objects and tall buildings and trees.

QUAD ANTENNA (Each side measures in meters)



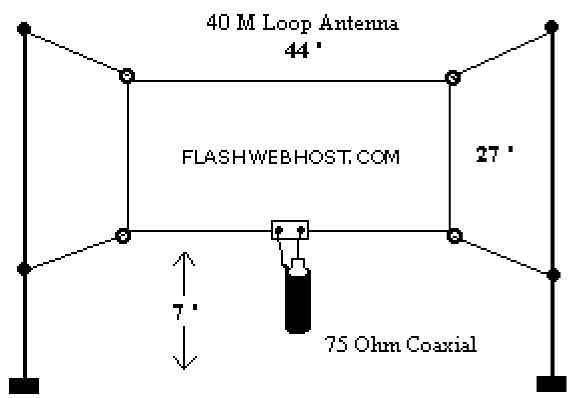
Most city dwellers face the problem of limited space for putting up an antenna of their choice. But if one is lucky and owns a couple of acres of land in a quiet place and the neighbors are co-operative, one can try the 'GERMAN Quad Antenna' designed by a German ham DL3ISA. It is reported that it works well on six bands 80, 40, 20, 15, 10 and even on 2 meters.

The construction is simple and straightforward. Take 83 meters of wire and mount it in the form of a big quad about 30 feet above the ground in a horizontal position. Each side will have a length 20.7 meters. For feed line, use a 75 Ohms co-axial cable. Antenna wire is 2.5 mm soft drawn copper wire. The four preferred directions are the extensions of the quad's diagonals. The ground serves as the reflector for 80 and 30 meters working.

The antenna offers a gain of 6 DB over a dipole mounted at the same height. On 80 meter, it has a high angle of radiation and distance of 600 miles has been covered. On 40 meters, the radiation pattern is at a lower angle than 80 meters and it has no directivity.

If one has enough space and time he can try this multi-band antenna and work all the six bands and it has no directivity.

40 METER LOOP ANTENNA (Each side measures in feet)

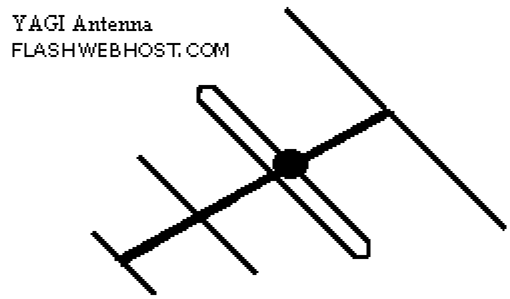


If one is interested mostly only on 40 meters working, he can think of a loop antenna. It is simple and at the same time very effective. For best results, it should be made as square as possible. It should not be made more rectangular as the efficiency will suffer. The overall length of the antenna in feet can be found out by the formula **1005/f MHz**. For a resonant frequency of 7.05 MHz the total length of the wire will be 142 feet 6 inches. For antenna wire 16 or 14 SWG wire can be used. Use 75 Ohms co-axial cable for the transmission line. The antenna should be kept at a height of about 6 feet from the ground level.

If vertical polarization is desired, feed the loop in the center of the vertical sides. This will give low angle radiation. If one desires horizontal polarization, feed either to the horizontal sides.

The directivity of the loop antenna is broadside from the loop. So the antenna may be hung in such a way for maximum direction. This loop antenna has 2 DB gain over the dipole. It works well on 20 and 15 meter also with compromising results. For an experimenter, it is an antenna worth giving a trial.

BEAM (YAGI) ANTENNA



In a beam antenna, two or more dipole elements are used, so the radiated power from the transmitter is added up and focused in some desired direction, cutting the radiation in other directions. A dipole is used in a beam antenna is called an element and a combination of such elements are called an array. Is an antenna that concentrates signals in one direction.

The simplest beam antenna has two elements. The element into which the power from the transmitter is fed is called the driven element. The second element placed close and parallel to it is called the reflector. RF power from the driven element is induced in the reflector by way of electro magnetic coupling, but it is reflected back and added up the power in the first element and radiated in the forward direction. There is not much power loss in the reflector and all the RF power it receives from the driven element is radiated back. A third element can also be added in the same manner to increase the radiation. This additional element is called director and it is placed in front of the driven element.

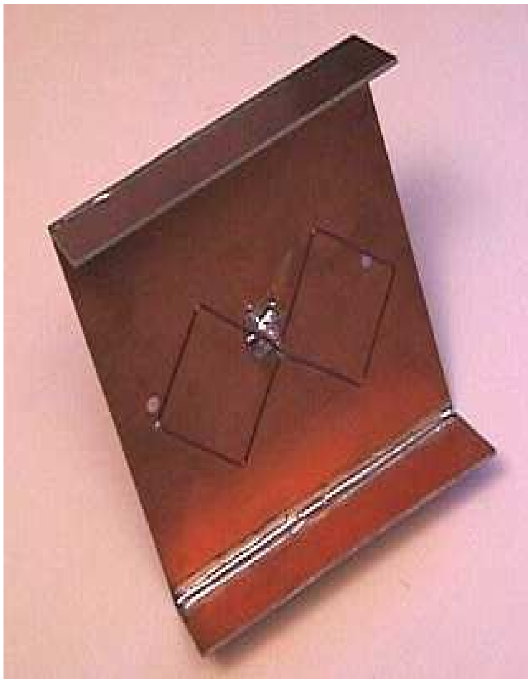
The length of the driven element is calculated as half of the wavelength and the reflector is 5% longer and director is 5% shorter in length. The spacing between the driven element and the reflector is 0.15 wavelengths and between director and driven element are 0.1 to 0.2 wavelengths. The gain obtained from a two element beam antenna is 5 DB and three element antenna offers about 7 DB gain.

It should be noted that the construction of a beam antenna is a complicated job and some construction practice and workshop experience will be necessary. Since the beam antenna radiates all the energy only in the same direction to which it points, a rotator has to be used along with it, to rotate the antenna in all directions to make best use of its directional property.

Many handheld transceivers come with a short antenna called a "**rubber duck**."
A disadvantage of the "rubber duck" antenna supplied with most hand held radio transceivers is that it does not transmit or receive as effectively as a full sized antenna. They are even less effective inside a vehicle.
A good reason not to use a "rubber duck" antenna inside your car is that signals can be 10 to 20 times weaker than when you are outside of the vehicle.

Many mobile antennas are **5/8 wavelengths** long. The advantage of 5/8 wavelengths over 1/4 wavelength vertical antennas is that their radiation pattern concentrates energy at lower angles.
One type of antenna that offers good efficiency when operating mobile and can be easily installed or removed is a magnet mount vertical antenna.

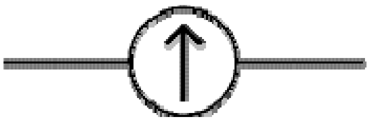
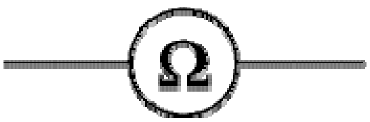
MICROWAVE ANTENNAS



A 6dBi Vertical Polarized  Omni

directional Antenna 

USE OF METERS

Meters and Oscilloscope		
Component	**Circuit Symbol**	**Function of Component**
Voltmeter		A voltmeter is used to measure voltage. The proper name for voltage is 'potential difference', but most people prefer to say voltage!
Ammeter		An ammeter is used to measure current.
Galvanometer		A galvanometer is a very sensitive meter which is used to measure tiny currents, usually 1mA or less.
Ohmmeter		An ohmmeter is used to measure resistance. Most multimeters have an ohmmeter setting.
Oscilloscope		An oscilloscope is used to display the shape of electrical signals and it can be used to measure their voltage and time period.

The **SWR meter** or **VSWR meter** measures the standing wave ratio in a transmission line. This is an item of radio equipment used to check the quality of the match between the antenna and the transmission line.
The VSWR meter should be connected in the line as close as possible to the antenna. This is because all practical transmission lines have a certain amount of loss, causing the reflected power to be attenuated as it travels back along the cable, and producing an artificially low VSWR reading on the meter. If the meter is installed close to the antenna, then this problem is minimised.

GENERAL KNOWLEDGE

Electrical and RF Safety

AC power circuits, hazardous voltages, fuses and circuit breakers, grounding, lightning protection, battery safety, electrical code compliance

As amateur radio operators, it's certainly possible to come into contact with dangerous voltages and currents. Because it would be a shame to lose a single person, it's important to know how to be safe when working with electricity. Having said that, 30 volts a commonly accepted value for the lowest voltage that can cause a dangerous electric shock, and 100 milliamperes is the lowest amount of electrical current flowing through the human body that is likely to cause death.

Three-wire electrical outlets and plugs are safer than two-wire outlets and plugs. The reason for this is an independent ground. Ground is connected to the green wire in a three-wire electrical plug. To guard against electrical shock at your station, all of these answers are correct:

• Use 3-wire cords and plugs for all AC powered equipment
• Connect all AC powered station equipment to a common ground
• Use a ground-fault interrupter at each electrical outlet

Metal cabinets are generally connected to this ground. Should an internal short occur that would put a dangerous voltage on the metal cabinet, an overload condition will occur and a fuse will blow. The purpose of a fuse in an electrical circuit is to interrupt power in case of overload.

Fuses also protect your equipment. That's why you should never replace a blown fuse with a Fuse of a higher value. For example, if you install a 20-ampere fuse in your transceiver in the Place of a 5-ampere fuse, an electrical fault could cause a high value of current to flow, and that excessive current could cause a fire.

Some amateurs install emergency disconnect switches. The most important thing to consider when installing an emergency disconnect switch at your station is that everyone should know where it is and how to use it.

Electrical storms are also safety concerns. A direct lightning hit can cause a fire, so fire prevention is the most important reason to have a lightning protection system for your amateur radio station. When a lightning storm is expected, all of these precautions that you should take:

- Disconnect the antenna cables from your station and move them away from your radio equipment
- Unplug all power cords from AC outlets
- Stop using your radio equipment and move to another room until the storm passes

Even though 30 volts is the commonly accepted value for the lowest voltage that can cause a dangerous electric shock, you must be careful when handling 12-volt batteries.

These are the hazards presented by a conventional 12-volt storage battery:

- It contains dangerous acid that can spill and cause injury
- Short circuits can damage wiring and possibly cause a fire
- Explosive gas can collect if not properly vented

If a storage battery is charged or discharged too quickly, the battery could overheat and give off dangerous gas or explode.

Even when disconnected, equipment might be a safety hazard. For example, you might receive an electric shock from stored charge in large capacitors in a power supply when it is turned off and disconnected.

Antenna installation, tower safety, overhead power lines

You should also be careful when working on antennas and towers. Perhaps the important consideration when putting up an antenna is to make sure people cannot accidentally come into contact with it.
You should wear a hard hat and safety glasses if you are on the ground helping someone work on an antenna tower to protect your head and eyes in case something accidentally falls from the tower.

Before you climb a tower / Tree, follow the advice :

- Arrange for a helper or observer
- Inspect the tower for damage or loose hardware
- Make sure there are no electrical storms nearby

Be sure to put on your safety belt and safety glasses before climbing an antenna tower, and also remember that the most important safety rule to remember when using a crank-up tower is that a crank-up tower should never be climbed unless it is in the fully lowered position.

The most important safety precaution to observe when putting up an antenna tower is to look for and stay clear of any overhead electrical wires. When installing an antenna or tower, make sure that it is a safe distance from power lines. Install it so that if the antenna falls unexpectedly, no part of it can come closer than 10 feet to the power wires.

Make sure that you install the guy wires for an antenna tower. When erecting a tower or an antenna near an airport, make sure that it is lower than the maximum allowed height with regard to nearby airports.

Towers also need to be properly grounded to protect them from lightning strikes. An adequate ground for a tower is separate 8 foot long ground rods for each tower leg, bonded to the tower and each other.

You can also make towers and antennas safer by using the appropriate materials. For example, stainless steel hardware used on many antennas instead of other metals because stainless steel parts are much less likely to corrode than other metals. This makes them safer because they will be less likely to fail and cause an injury.

Even though VHF and UHF radio signals are non-ionizing radiation, exposure to high levels of radio frequency radiation can cause injury.

Radio waves cause injury to the human body only if the combination of signal strength and frequency cause excessive power to be absorbed. Milliwatt per square centimeter is the unit of measurement is used to measure RF radiation exposure.

All of these factors affect the RF exposure of people near an amateur transmitter:

- Frequency and power level of the RF field
- Distance from the antenna to a person
- Radiation pattern of the antenna

Another factor used to determine safe RF radiation exposure levels is duty cycle. It takes into account the amount of time the transmitter is operating.

The frequency of an RF source be considered when evaluating RF radiation exposure because the human body absorbs more RF energy at some frequencies than others.

If a person accidentally touched your antenna while you were transmitting, they might receive a painful RF burn injury.

When testing a transmitter or transceiver, you may not want to connect it to an antenna because the test transmissions may cause interference to other amateur radio stations. Instead, connect the transmitter or transceiver to a dummy load. **A dummy load** does not radiate interfering signals when making tests.

Here are a couple final tips on UHF and VHF signals:

- UHF signals often work better inside of buildings than VHF signals because the shorter wavelength of UHF signals allows them to more easily penetrate urban areas and buildings.
- If buildings or obstructions are blocking the direct line of sight path, try using a directional antenna to find a path that reflects signals to the repeater to reach a distant repeater.

(Dan Romanchik KB6NU)

FAILURE OF COAXIAL CABLES:

The most common reason for failure of coaxial cables is moisture contamination. If coaxial cables are exposed to weather and sunlight for several years, losses can increase dramatically. The outer sheath of most coaxial cables is black in color because black provides protection against ultraviolet damage

Coaxial cable is used more often than any other feed line for amateur radio antenna systems because it is easy to use and requires few special installation considerations.
The impedance of the most commonly used coaxial cable in typical amateur radio installations is 50 ohms.To achieve a 1 to 1 SWR, the impedance of the transmitter and the antenna should also be 50 ohms.

Station setup and operation

Station hookup - microphone, speaker, headphones, filters, power source, connecting a computer

A microphone connects to the transmitter in a basic amateur radio station. **A speaker** converts electrical signals to sound waves. When a microphone and speaker are too close to each other, audio feedback may occur. Use a set of headphones in place of a regular speaker to help you copy signals in a noisy area.

A good reason for using a regulated power supply for communications equipment is to protect equipment from voltage fluctuations.

To reduce spurious emissions install a filter at the transmitter. A notch filter should be connected to a TV receiver as the first steps in trying to prevent RF overload from a nearby 2meter transmitter.

A terminal node controller is connected between the transceiver and computer terminal in a packet radio station. A packet radio station requires a power source, transceiver, and antenna, but not a microphone. For some digital modes, you use a sound card to connect a radio with a computer for data transmission.

Operating controls

If a transmitter is operated with the microphone gain set too high, it may cause the signal to become distorted and unreadable.

One way to select a frequency on which to operate is to use the keypad or VFO knob to enter the correct frequency. To enable quick access to a favorite frequency, you can store the frequency in a memory channel on your transceiver.

A VHF/UHF transceiver be capable of storing all of the following in memory:

• Transmit and receive operating frequency
• CTCSS tone frequency
• Transmit power level

The purpose of the buttons labeled "up" and "down" on many microphones is to allow easy frequency or memory selection.

A squelch control on a transceiver is used to quiet noise when no signal is being received. To improve the situation if the station you are listening to is hard to copy because of ignition noise interference, turn on the noise blanker.

The purpose of the **"shift"** control found on many VHF/UHF transceivers is to adjust the offset between transmit and receive frequency.

RIT means Receiver Incremental Tuning.

The "step" menu function found on many transceivers sets the tuning rate when changing frequencies.

The "function" or "F" key found on many transceivers selects an alternate action for some control buttons.

Repeaters; repeater and simplex operating techniques, offsets, selective squelch, open and closed repeaters, linked repeaters

To extend the usable range of mobile and low-power stations, you might use a repeater.
The most important information to know before using a repeater is the repeater input and output frequencies. A repeater receives on one frequency and transmits on another.
This is what is meant by the terms input and output frequency when referring to repeater operations.

The most common input/output frequency **offset** for repeaters in the 2-meter band is 0.6 MHz.
The most common input/output frequency offset for repeaters in the 70-centimeter band is 5.0 MHz.

A courtesy tone is a tone used to indicate when a transmission is complete.
When using a repeater, you should pause briefly between transmissions to listen for anyone wanting to break in.

Linked repeater system the term for a series of repeaters that can be connected to one another to provide users with a wider coverage.

Simplex operation means transmitting and receiving on the same frequency. One reason to use simplex instead of a repeater is to avoid tying up the repeater when direct contact is possible. To find out if you could communicate with a station using simplex instead of a repeater, check the repeater input frequency to see if you can hear the other station.

Recognition and correction of problems, symptoms of overload and overdrive, distortion, over and under modulation, RF feedback, off frequency signals, fading and noise, problems with digital communications links

One of the most likely causes of telephone interference from a nearby transmitter is that the transmitter's signals are causing the telephone to act like a radio receiver. A logical first step when attempting to cure a radio frequency interference problem in a nearby telephone is to install an RF filter at the telephone.

When a neighbor reports that your radio signals are interfering with something in his home, check your station and make sure it meets the standards of good amateur practice.
For example, if someone tells you that your transmissions are interfering with their TV reception, make sure that your station is operating properly and that it does not cause interference to your own television.

The following may all be useful in correcting a radio frequency interference problem:
• snap-on ferrite chokes,
• low-pass and high-pass filters, and
• notch and band-pass filters.
You should do all of the following if a "Part 15" device in your neighbor’s home is causing harmful interference to your amateur station:
• Work with your neighbor to identify the offending device
• Politely inform your neighbor about the rules that require him to stop using the device if it causes interference
• Check your station and make sure it meets the standards of good amateur practice
If another operator tells you he is hearing a variable high-pitched whine on the signals from your mobile transmitter, the power wiring for your radio is picking up noise from the vehicle's electrical system. If another operator reports that your SSB signal is very garbled and breaks up, the problem may be RF energy may be getting into the microphone circuit and causing feedback.

If you receive a report that your signal through the repeater is distorted or weak,

all of the following might be the cause:
• your transmitter may be slightly off frequency,
• your batteries may be running low, or
• you could be in a bad location.
One of the reasons to use digital signals instead of analog signals to communicate with another station is that many digital systems can automatically correct errors caused by noise and interference.

ARES: ARES supports agencies like the Red Cross, Salvation Army, and National Weather Service. Before you can join an ARES group, you must have an amateur radio license.

In an emergency, alternate sources of power must often be used. Alternate sources of power to operate radio equipment during emergencies include all of these answers:

• The battery in a car or truck
• A bicycle generator
• A portable solar panel

Amateurs are often called upon to provide communications for public service events, such as Ganesh Visarjan, parades or bicycle tours. Even though communications are less critical during these events, casual conversation between stations during a public service event should be avoided because idle chatter may interfere with important traffic.

If a reporter asks to use your amateur radio transceiver **to make a news report in an emergency** situation or during a public service event, advise them that **it is prohibited.**

In an emergency situation or during a public service event, there may be many amateur radio stations operating on the same frequency. To prevent confusion, amateurs set up nets, which have specific procedures for their operation.

To control net operation, one station is designated net control station. Of primary importance for a net control station is a strong and clear signal. **If a large scale emergency has just occurred** and no net control station is available, open the emergency net immediately and ask for check-ins.

Other stations on the net, check in to the net by giving their call signs to the net control station. To minimize disruptions to an emergency traffic net once you have checked in do not transmit on the net frequency until asked to do so by the net control station. If someone breaks into a net with emergency traffic, the net control station should stop all net activity until the emergency has been handled.

A message passed over a net is called traffic, and there are several different kinds of traffic. **Emergency traffic has the highest priority**. When passing emergency messages, you must include the name of the **person originating the message**.

Personal information concerning victims should not be transmitted over amateur radio frequencies during emergencies. One way to reduce the chances of casual listeners overhearing sensitive emergency traffic is to pass messages using a non-voice mode such as packet radio or Morse code.

(Text Copied from - Dan Romanchik KB6NU's website)

SPECIAL OPERATIONS

Operating in the field, radio direction finding, radio control, contests, special event stations

For many new Hams, their first radio is a handheld VHF or UHF transceiver. Here are **some tips for operating** this type of radio:

• When operating a hand-held transceiver away from home, it is a good idea to bring along one or more fully charged spare battery packs.

• To make the signal from a hand-held radio stronger when operating in the field, use an external antenna instead of the rubber-duck antenna.

• When operating from a location that includes lots of crowd noise, use a combination headset and microphone.

Often, radio amateurs are called on to help out in an emergency. Many hams maintain an emergency response kits, often call a "**jump kit**" or "**go kit**," that they can quickly grab when they are called to provide emergency communications.

This jump kit might include:

- an external antenna and several feet of connecting cable,
- a cable and clips for connecting your transceiver to an external battery, and
- a listing of repeater frequencies and nets in your area

Many amateurs find hidden transmitter hunts, also called **"fox hunts,"** to be an enjoyable activity.
To find the "fox," they use radio direction finding techniques to locate a small transmitter. Honing these skills can also be very useful, because radio direction finding is a method used to locate sources of noise interference or jamming. A directional antenna is the item that would be the most useful for a hidden transmitter hunt.

Contesting is another popular activity. During a contest, the objective is to contact as many stations as possible during a specified period of time. In some contests, stations exchange grid locators. A grid locator is a letter-number designator assigned to a geographic location.

For some events, such as a local festival or a sporting event like the Himalayan Car rally, Ganesh visarjan amateur radio operators set up **special event stations**. A special event station is a temporary station that operates in conjunction with an activity of special significance.

By hearing the beacon transmission you can come to know about the propagation and the band condition. All beacons transmit their callsign only on CW mode.

Beacon Locations Chart: A worldwide network of high-frequency radio beacons on 14.100, 18.110, 21.150, 24.930, and 28.200 megahertz. (CW Mode)

Slot	DX Entity	Call	Location	Latitude	Longitude	Grid Sq
1	United Nations	**4U1UN**	New York City	40º 45' N	73º 58' W	FN3Øas
2	Canada	**VE8AT**	Eureka, Nunavut	79º 59' N	85º 57' W	EQ79ax
3	United States	**W6WX**	Mt. Umunhum	37º 09' N	121º 54' W	CM97bd
4	Hawaii	**KH6WO**	Laie	21º 38' N	157º 55' W	BL11ap
5	New Zealand	**ZL6B**	Masterton	41º 03' S	175º 36' E	RE78tw
6	Australia	**VK6RBP**	Rolystone	32º 06' S	116º 03' E	OF87av
7	Japan	**JA2IGY**	Mt. Asama	34º 27' N	136º 47' E	PM84jk
8	Russia	**RR9O**	Novosibirsk	54º 59' N	82º 54' E	NO14kx
9	Hong Kong	**VR2B**	Hong Kong	22º 16' N	114º 09' E	OL72bg
10	Sri Lanka	**4S7B**	Colombo	6º 6' N	80º 13' E	NJ06cc
11	South Africa	**ZS6DN**	Pretoria	25º 54' S	28º 16' E	KG44dc
12	Kenya	**5Z4B**	Kiambu	1º 01' S	37º 03' E	KI88mx
13	Israel	**4X6TU**	Tel Aviv	32º 03' N	34º 46' E	KM72jb
14	Finland	**OH2B**	Karkkila	60º 32' N	24º 06' E	KP2Øbm
15	Madeira	**CS3B**	Santo da Serra	32º 43' N	16º 48' W	IM12or
16	Argentina	**LU4AA**	Buenos Aires	34º 37' S	58º 21' W	GFØ5tj
17	Peru	**OA4B**	Lima	12º 04' S	76º 57' W	FH17mw
18	Venezuela	**YV5B**	Caracas	10º 25' N	66º 51' W	FK6Ønj

E N D