Study Manual

for

Amateur Station Operator's Certificate Examination

(Restricted & General)

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FOREWORD

The development in the field of wireless communication have reached great heights over the last century and continue to forge ahead into 21st century making it an era of Information Technology .The Radio Amateurs since the beginning have pioneered communication techniques and protocols, working endlessly in diverse ways: Morse code, Voice, Radio teletype, Television, Moon bounce, Packet Radio (i.e. Computer to Computer communication over Amateur Radio) and satellite communication. Amateur Radio has managed to keep its enthusiasts interested and abreast of communication technology, lured first by the novelty of talking across town across the nation, across the world and ultimately with hams orbiting the earth in spacecraft,

Amateur Radio works as a catalyst to enhance the standards of quality productivity, workmanship amongst the people that will lay a foundation for faster economic growth in the country. Understanding the abilities and prospects f Amateur Radio, the developed countries have taken the lead and as a result are enjoying the benefits of technological advances and faster economic growth.

The National Institute of Amateur Radio (NIAR) established in the year 1983.(Formerly known as A.P. Amateur Radio Society since 1975) ever since the institute has been working for promotion of Amateur Radio in the country .The institute has made commendable progress in propagating the ideals of Amateur Radio to create a multifold development in Science & Technology, education and empowering people with knowledge and information .The institute has received several awards, appreciations from national international agencies for its role in promoting Amateur Radio in the country .

Today, Amateur Radio is recognized as a major national resource in India and abroad. Service to the society in times of natural / manmade calamities by providing much needed complication has brought this activity much closer to the people and in a way producing more responsible citizens of the society.

Society at large will widely benefit from the scientific culture developed through Amateur Radio which enables individuals to achieve their full potential and efficient functioning by encouraging self–learning, intercommunication and conducting technical investigation .In short ,we will achieve standards for high quality of life in the new millennium.

S.Suri, VU2MY
Founder
National Institute of Amateur Radio

PREFACE

The Study Manual deals with syllabus prescribed for general course in Amateur Station Operator Certificate (ASOC) examination .The contents of this book are specifically compiled for the advantage of students appearing for ASOC Restricted / General Grade examination.

We would like to format remind the reader that this is not a formal textbook. It is written for the advantage of beginners who are willing to pursue Amateur Radio activity .We have taken good care to present the topics in simplest possible manner, limited to the requirements of the course .

Our sincere thanks to Mr.S.Suri, VU2MY, Founder, National Institute of Amateur Radio for giving all encouragement and resources for compiling the book.

We would like to specially thank Mr. S.Ram Mohan, VU2MYH, Executive Vice Chairman & Director, National Institute of Amateur Radio for guiding and advising us for bringing the book in the present.

K. Ravi Shastry, VU2RAT
Jose Jacob,VU2JOS

Contents

FREQUENTLY ASKED QUESTIONS (FAQs) REGARDING AMATEUR EXAMINATION/LICENCE

1. Who can become a HAM?

Answer: Any citizen of India who is above 12 years of age can become a ham by qualifying the Amateur Station Operators Licence (RESTRICTED) examination and obtaining a valid license.

2. Can I apply for the examination if I am below 18 years?

Answer: Yes. Applicants between 12-18years can apply for the RESTRICTED grade examination by providing an Undertaking by the parent/guardian in the prescribed format. For GENERAL grade- Applicants between 12-18years can apply for the GENERAL grade examination by providing an Undertaking by the parent/guardian in the prescribed format. Applicant above the age of 18 years can apply for both without any undertaking.

3. What are the various categories and fees of examination?

Answer: A candidate can apply for any of the below categories:

S. No.	Category	Examination Fee
1	Restricted	Rs. 100/-
2	General	Rs 100/-
3	General & Restricted	Rs 200/-

4. What are the examination centres?

Answer: Examination may be conducted at any of the Wireless Monitoring Station/International Monitoring Station in India.

The list of Monitoring Stations is given below:

1. Ahmedabad
2. Ajmer
3. Bengaluru
4. Bhopal
5. Bhubaneswar
6. Chennai
7. Dehradun
8. Dibrugarh
9. Goa
10. Gorakhpur
11. Hyderabad
12. Jalandhar
13. Jammu
14. Kolkata
15. Lucknow
16. Mangalore
17. Mumbai
18. Nagpur
19. New Delhi
20. Patna
21. Raipur
22. Ranchi
23. Shillong

24. Siliguri
25. Thiruvananthapuram
26. Vijayawada
27. Vishakapatnam

5. What is the pattern and duration of examination?

Answer: The examination consists of two parts; Part A: Basic Electronics and Part B: radio Regulations.

The Restricted Grade examination consists of 25 Questions each in Part A and Part B and is for one hour. The General Grade Examination consists of 50 Questions each in Part A and Part B and is for two hours. The General Grade candidates will have to additionally undertake an examination in Transmission and Reception of Morse Code.

For detailed syllabus, please refer to the circulars.

6. How many marks are needed to pass the examination?

Answer: For Restricted Grade, the maximum marks will be 100 and candidate must secure at least 40 % in each section and 50% in aggregate for a pass.

For General Grade, the maximum marks will be 100. A candidate must secure at least 50% in each section and 60% in aggregate for a pass. In addition, a candidate shall have to pass both Morse Reception and Sending simultaneously.

7. Can I take the examination at any centre?

Answer: The applicant can choose the examination centre at any Wireless Monitoring Station/International Monitoring Station as per their convenience. However, no change will be allowed after submission of application.

8. Can I change the centre of examination after application?

Answer: No change in Exam Centre is permitted after submission of application.

9. Can I change the category of examination after submission of application?

Answer: No change in category will be permitted after submission of the application.

10. Can I apply for both GENERAL and RESTRICTED?

Answer: Yes. A candidate can apply for both General and Restricted categories. If a candidate passes in Part I and II, he/she will be issued a GENERAL Licence. If a candidate passes only in Part I of the examination he/she will be issued a RESTRICTED Licence.

11. Can I take the General Grade examination after passing Restricted Grade?

Answer: Yes. You will need to apply again for General Grade after the completion of the Restricted Grade examination.

12. Are there any exemptions from the exam?

Answer: Candidates having the following Qualifications are exempted from appearing in Part A of the Examination

(i) B. Tech/BE Degree in Electronics or Telecommunication
(ii) B.Sc/M.Sc with Electronics or Telecommunication
(iii) Diploma in Engineering with Electronics or Telecommunication

13. How do I check the status of application?
Answer: The status of the application can be checked on the Saral Sanchar portal.

14. When will the examination be conducted?
Answer: The Date, Venue and Time of the examination will be intimated to the candidate by the respective Monitoring Station. The examination will be conducted as and when there are sufficient number of candidates.

15. What if I reside in another city in which no monitoring station is situated?
Answer: For examination venues in cities other than where Wireless Monitoring Stations/ International Monitoring Stations are situated, there should be a minimum of 20 candidates and the centre should be either a School/University/Education Centre/Amateur Radio Society or Club. The application may be submitted to the nearest monitoring station.

16. What documents do I need to carry for the examination?
Answer: The Admit Card is to be produced for verification at the time of the test. At least one original valid Photo Identification Card (such as Aadhaar Card, Driving Licence, Passport, PAN Card, Voter ID,) should also be presented.
Date of Birth Proof, Address proof, Proof for Exemption in Part A and Undertaking certificate (For students between ages 12 and 18) may also be produced to the examiner for verification.

17. Does WPC provide any training?
Answer: No, WPC does not provide any training for the examination.

18. What should I do after passing the examination?
Answer: After passing the examination, you may apply for Amateur Wireless Telegraph Station Licence/ Certificate on the Saral Sanchar Portal.

8. Can I choose my own call sign?
Answer: You can give a choice of 3 callsigns. Based on availability, a callsign would be assigned.

19. What is the licence fee?
Answer: A licence fee as below is payable after passing the examination.

Category of Licence	Fees	
	20 Years	Life Long (up to 80 years)
Amateur Wireless Telegraph Station Licence (GENERAL)	1000	2000
Amateur Wireless Telegraph Station Licence (RESTRICTED)	1000	2000

20. Do I need to take permission to participate in a hamfest at some other location?
Answer: No permission is required for a temporary change of location.

21. Do I need to inform WPC for a permanent change of address?
Answer: Yes, you need to intimate WPC when there is a permanent change of location. You can apply on the Saral Sanchar portal when there is a permanent change of location and pay the requisite fee of Rs 200/- for re-issue of the licence.

22. Can I get a duplicate copy of the licence?
Answer: Yes. In case of loss/damage of original licence, you can apply for a Duplicate copy of licence on the Saral Sanchar Portal and pay the requisite fee of Rs 100/-.

23. How can I get a special call sign?
Answer: The following documents may be submitted to WPC Wing for the issue of special call sign.
a) Application
b) Individual Consent
c) Copy of valid Amateur License

24. How to pay the examination fee?
Answer: The prescribed license fee is to be paid through Non Tax Receipt Portal (NTRP) available on webpage http://bharatkosh.gov.in under the following accounts heads:
a. Purpose head: "Amateur Exam conducted by Wireless Monitoring Stations and RHQs b. Payment type: "Exam fee"
c. Function head: "127500103050100 - Proficiency Certificate"
d. PAO and DDO details are as under: -

Regional Headquarters	**Name of the pay & Account Office (PAO) under NTRP**	**Corresponding Centre of Examinations (Monitoring Stations)**
Western Regional Hq, Mumbai	077148-Controller of Communication Accounts, Maharashtra Drawing & Disbursing Officer: - 201562 DDO CCA	Ahmedabad, Bhopal, Goa, Mumbai, Nagpur, Raipur
Northern Regional Hq, New Delhi	077177-Controller of Communication Accounts, New Delhi Drawing & Disbursing Officer:- 201540 DDO CCA	Ajmer, Dehradun, Gorakhpur, Jalandhar, Jammu, Lucknow, New Delhi
Southern Regional Hq, Chennai	077153-Controller of Communication Accounts, Tamil Nadu Drawing & Disbursing Officer: - 201579 DDO CCA	Bengaluru, Chennai, Hyderabad, Mangalore, Thiruvananthapuram, Vijayawada, Vishakhapatnam
Eastern Regional Hq, Kolkata	077155-Controller of Communication Accounts, West Bengal. Drawing & Disbursing Officer: - 201589	Bhubaneswar, Dibrugarh, Kolkata, Patna, Ranchi, Shillong, Silliguri

	DDO CCA	

25. How to pay the license fee?
Answer: For issue of licence, renewal, issue of duplicate licence, issue of reciprocal licence or change of location, the details of payment head for making payment through NTRP is as under:

a) Purpose: Amateur license
b) Payment Type: License Fee/ License Renewal Fee/ Late Fee/ Fee for issue of duplicate license
c) Pay & Account Office (PAO): 077188-Controller of Communication Accounts, PAO HQ
d) Correspondence Address: Assistant Wireless Adviser (COP), WPC Wing, DOT, 6th Floor, Sanchar Bhawan, 20 Ashok Road, New Delhi-110001

26. Whom should I contact for any further queries?
Answer: For any further queries, please reach us on 011-2303 6534; 6539

SYLLABUS AND THE DETAILS OF EXAMINATIONS FOR THE AWARD OF AMATEUR STATION OPERATOR'S LICENCE (Restricted) and (General)

1. The examination shall consist of the following two parts:

PART 1 - Written Test

It shall comprise of one paper containing two sections as under:

Section A: Radio Theory and Practice

Note - Applicants holding degree in Engineering/Science or Diploma in Engineering and having studied electronics or telecommunications shall be exempted from appearing in Section A of Part-I of the test.

Section B: National and international Telecommunication Union (ITU) Radio Regulations applicable to the operation of amateur station and those relating to the working of station generally.

PART II - Morse (Only for General Certificate)

Morse reception and sending (8 wpm)

2. Detailed syllabus:

2.1 Amateur Station Operator's Licence (Restricted) Examination

Part I - Written Test

Section A: Radio Theory and Practice

(i) Elementary Electricity and Magnetism:

1. Elementary theory of electricity- Passive Devices (Resistors; Inductors, Transformers, Capacitors) and Active Devices (Diodes; Transistors).

2. Kirchoff's current and voltage laws- Simple applications of the law.

3. Conductors and Insulators — Properties; units of circuit elements, Ohm's 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.

(ii) Elementary Theory of Alternating Currents:

1. Sinusoidal alternating quantities - Definition of peak, instantaneous, R.M.S., average values and its simple application.

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.

(iii) Elementary theory of Semiconductor Devices:

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

(iv) Radio Receivers:

1. Principles and operation of T.R.F. and super heterodyne 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.

(v) Transmitter:

1. Principles and operation of low power transmitter, crystal oscillators, stability of oscillators.

2. Basic knowledge about construction of Semiconductor based transmitters.

(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.

(viii) Frequency Measurement: Measurement of frequency and use of simple frequency meters.

Section B: Radio Regulations

(a) Knowledge of :- (i) the Indian Wireless Telegraphs Rules, 1973.

(ii) The Indian Wireless Telegraphs (Amateur Service) Rules, 1978 and amendments.

(b) Knowledge of ITU Radio Regulations as relating to the operation of amateur stations with particular emphasis on the following:

Item	Provision of Radio Regulation (2008 edition)
Designation of Emission	Appendix I
Phonetic alphabets and figure code	Appendix 14
Nomenclature of the Frequency & Wavelength	Article 2
Frequency allocation for Amateur Services	Article 5
Interference, measures against interference & tests	Article 15
Identification of Stations	Article 19
Distress Signal, Call and Message. Transmissions	Article 30, 31, 32 & 33.
Urgency Signal, Call and Message Transmissions	Article 30, 31, 32 & 33.
Amateur Station	Article 25
Call Sign series allocated to India	Appendix 42

(c) Standard Frequency and Time Signals Services in the World.

d) The following 'Q' codes and abbreviations shall have the same meaning as assigned to them in the Convention.

QRA, QRG, QRH, QRI, QRK, QRL, QRM, QRN, QRO, QRS, QRT, QRU, QRV, QRW, QRX, QRZ, QSA, QSB, QSL,QSO, QSU, QSV, QSW, QSX, QSY, QSZ, QTC, QTH, QTR, and QUM.

Abbreviations: AA, AB, AR, AS, C, CFM, CL, CQ, DE, K, NIL, OK, R, TU, VA, WA, WB.

Note:-

1. The written test will be of one hour duration. The maximum marks will be 100 and candidate must secure at least 40 % in each section and 50% in aggregate for a pass.

2. There will be no Morse test for Restricted Grade.

2.2. Amateur Station Operators' License (General) Examination

Part I - Written Test

Section A: Radio Theory and Practice

In addition to the syllabus prescribed for Amateur Station Operator's License (Restricted) examination, following items shall be included in the syllabus of Amateur Station Operators' license (General) examinations:

(i) Principles of Communications:

1. Elementary idea of analog and digital communication.
2. Need for modulation; Modulation- amplitude, frequency and pulse modulation.
3. Elementary idea about demodulation.

(ii) Alternating current:

1. Basic concepts on construction of transformers.
2. Definition of Transformer losses.
3. Transformer as a matching device

(iii) Semi Conductor devices and Transistors:

1. Elementary principles of conduction and construction;
2. Symbols and biasing methods.

(iv) Power Supplies:

1. Basic knowledge of half wave and full wave rectifiers.
2. Definition and application of Bridge rectifier, smoothing and regulating circuits.

(v) Transmitters and Receivers:

1. Elementary principles of transmission and reception of Facsimile and Television signals,

(vi) Propagation:

1. Characteristics of ionosphere and troposphere.
2. Properties of ionosphere layers.
3. Critical frequency and day / night frequencies.

(vii) Aerials:

1. Principles of radiation.
2. Aerials for different frequency bands including aerials for microwave,

(viii) Space Communications

1. Elementary principles of communication via satellites.

Section B: Radio Regulations

Same syllabus as prescribed for Amateur Station Operators' License (Restricted) examination.

The above written test will be of two hour duration. The maximum marks will be 100. A candidate must secure at least 50 % in each section and 60% in aggregate for a pass.

Part Il-Morse Code

Morse receiving: (Speed: 8 words per minute)

The test piece will consist of a plain language passage of 200 characters which may comprise of letters, figures. Test piece may also contain the following punctuations i.e. full stop; comma; semi colon; break-sign; hyphen and question mark. The average words shall contain five characters and each figure and punctuation will be counted as two characters. The test will be for five consecutive minutes at a speed of 8 words per minute. A short practice piece of one minute shall be sent at the prescribed speed before the start of the actual test. Candidates will not be allowed more than one attempt in Morse reception and sending test; the test may be written in ink or pencil but must be legible. Over-writing will be treated as error. If any correction is required the candidate may struck the wrong character and write the correct above the character. More than 5 errors will disqualify a candidate. However ii a candidate receives without any error in any part of the passage continuously for one minute duration will be declared successful in the Morse reception test.

Morse Sending : (Speed: 8 words per minute)

The test piece will be similar to Morse Receiving test for Amateur Station Operators' License (General) examination. Candidates are required to send for five consecutive minutes at a speed not less than 8 words per minute. Other conditions are the same as applicable to Amateur Station Operators' License (General) examination.

Note- A candidate shall have to pass both receiving and sending simultaneously.

Part 1

Section A: Radio Theory and Practice

(For Restricted Grade & General Grade)

1. ATOMIC STRUCTURE

Everything in the world you can see or touch, and even the many things invisible to the naked eye but known to exist, make up the matter of the universe. Matter exists in solid, liquid or gaseous states, and can be further divided into molecules and atoms.

The atom consists of positively charged nucleus surrounded by a group of negatively charged moving electrons in definite orbits. The nucleus consists of positively charged protons and neutrons which have no charge. The atomic weight is determined by the total number of protons and neutrons in the nucleus. The number of negative electrons is assumed equal to atomic number.

A normal atom is considered to be electrically neutral. The negative charge of the electrons is balanced by a positive charge in the nucleus attributed to the presence of an appropriate number of protons. The electrons are arranged in the ever expanding orbits around the nucleus. The electrons in the outermost orbit are called as 'Valance electrons'. These valance electrons determine the chemical properties of the element.

In the atom of a conductor the outer most shell is partially filled. Outer most electrons are likely to become free and move about in the substance and when a voltage is applied across the substance an electron current results. In an Insulator, the outer most shell is completely filled with electrons and hence electrons cannot break free.

CONDUCTOR

Conductor is the name assigned to a broad category of materials through which a practical amount of electric current can flow under normal conditions. Most conductors are metallic in nature. Conductors are materials through which electric current flows under normal conditions.

Ex: Silver, copper, aluminum, iron, tin, nichrome etc., are examples of good conductors.

The usefulness of metal to conduct electric current stores from the abundance of free electrons in the material, the free electrons being available to be moved through the metal when the material is part of a complete electrical system.

INSULATORS prevent the flow of electric current. Ex: Glass, Ceramic, Plastic, Paper etc.

SEMICONDUCTORS are neither good conductors nor good insulators. Ex: Silicon, Germanium.

CONDUCTANCE

This can be stated as the ability of a conductor to allow free flow of electrons with minimum or least resistance. Conductance is the mathematical reciprocal of resistance. The unit of conductance is the mho (ohm spelled backwards). Mathematically, if R is the resistance in ohms, then the conductance, G is in mho (℧)

$$G=1/R$$

CURRENT

It is the flow of free electric charge carriers from one point to another. The charge carriers can be electrons, holes, or ions.

Electric current is measured in units called Amperes. A current of one ampere consists of the transfer of one coulomb of charge per second.

Current can be either alternate or direct. Current is symbolized by the letter 'I' in most equations involving electrical quantities.

ELECTROMOTIVE FORCE

Electromotive force is the force that causes movement of electrons in a conductor. The greater the electromotive force, the greater the tendency of electrons to move. Other charge carriers can also be moved by electromotive force. A source of electromotive force can be described as a device in which electrons are forcibly separated from atoms and causes free movement of electrons.

POTENTIAL DIFFERENCE

Two points in a circuit are said to have a difference of potential when the electric charge at one point is not the same as the electric charge at the other point. Potential difference is measured in 'Volts'.

OHMS LAW

Ohm's law is a simple relation between the Current, Voltage 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. This relationship, known as ohms law is expressed symbolically as

$$I = V/R$$

where I is the current in amperes, V is the EMF in volts, R is the resistance in ohms. In practical units, I is measured in amperes, V in volts and R in ohms. The formula can be restated as

$$V = IR \text{ and } R = V/I$$

Ex: - A heater with a resistance of 10 Ω is connected across 250 V power line. Find the current. Ans. The amount of current flowing in the circuit can be obtained by using ohms law

$I = V/R$

where $V = 250$ V

$R = 10\ \Omega$

$I = V/R = 250/10 = 25A$

2. RESISTOR

A resistor is an electronic component that is deliberately designed to have a specific amount of resistance. Resistors are available in many different forms. An often used type of resistor in electronic devices is the carbon variety, values range from less than 1 ohm to millions of ohms.

Resistor is a package of resistance made up into a single unit. The unit is Ohms and measured by Ohm meter.

RESISTANCE

The opposition that a substance offers to the free flow of electric current in a circuit is called resistance. It is often introduced into a circuit deliberately to limit the current and I or to provide various levels of voltage. This is done with components called Resistors.

The standard unit of resistance is ohms (Ω), Resistance is mathematical reciprocal of conductance.

SPECIFIC RESISTANCE

This is the resistance of a body of unit length and cross section. If ρ (roe) is the specific resistance of material of the body then the resistance of the body is given by

$R=\rho*L/A$

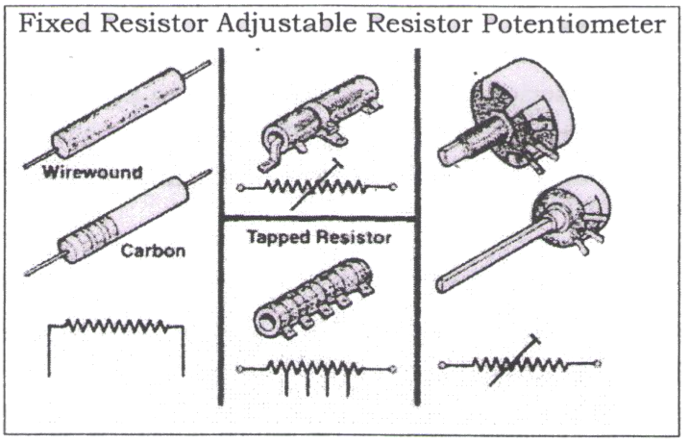
Where L = Length of the body in cms.

A = Area of cross section in cm^2

ρ = Specific Resistance in Ohm - cm

TYPES OF RESISTORS

Most of the resistors used today are carbon resistors, composition type: film resistors, carbon and metal film, resistors and wire wound resistors.

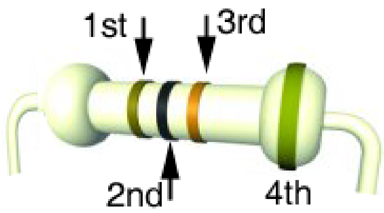


STANDARD COLOUR CODE

The usefulness of a resistor is measured by its electrical rating. There are three factors used to determine this rating. The ohmic value, the heat dissipating capability, and the resistance tolerance. The tolerance of a resistor is the variation from the expected value. The ohmic value cannot be recognized merely by looking at the resistor, hence the resistor is labeled. The resistors usually have three values stamped on them. In the case of carbon film resistor, a color code indicates the ohmic value and tolerance. To read the value of a resistor the resistor must be held such that the colored bands appear on the left and the value read from left to right. If no tolerance indication is given, a tolerance of 20% can be assumed. In the resistance color code, the first two bands represent the figure of resistance value and the third band represents the multiplying factor. The fourth band represents the tolerance.

RESISTANCE COLOUR CODE CHART

Colour	First band	Second band	Third band (Multiplier)	Fourth band (Tolerance)
BLACK	0	0	10^0	-
BROWN	1	1	10^1	±1%
RED	2	2	10^2	±2%
ORANGE	3	3	10^3	±3%
YELLOW	4	4	10^4	±4%
GREEN	5	5	10^5	±5%
BLUE	6	6	10^6	-
VIOLET	7	7	-	-
GREY	8	8	-	-
WHITE	9	9	-	-
GOLD	-	-	0.1	± 5%
SILVER	-	-	0.01	±10%
NO COLOUR	-	-	-	±20%



Ex: - A resistor is color coded Yellow, Violet. Orange and Silver.

It would read FOUR, SEVEN, THREE ZEROS AND 10% tolerance meaning = 47000 ohms ± 10%

First Second Third Fourth

Colour Colour Colour Colour =47000 Ω ± 10%

RESISTORS IN SERIES

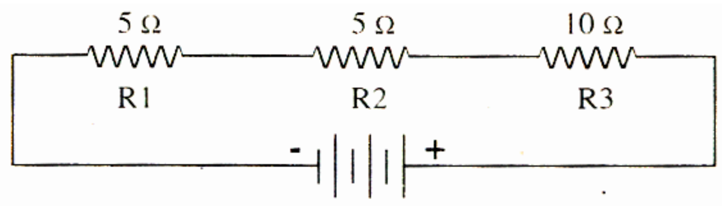
In series resistance circuit the total applied voltage is divided across each resistor and the current flowing in each resistor remains same.

The total resistance of a series resistance circuit is given by

$R_t = R_1 + R_2 + R_3 + \ldots\ldots + R_n$

Ex:- Three resistors of 5, 5 and 10 respectively are connected in series, with 80V applied voltage. Find the current in each resistor.

DC Source 80 V



$R_t = R_1 + R_2 + R_3 + \ldots\ldots + R_n$

$R_t = 5+5+10=20\Omega$

I = V/R = 80/20 = 4 amps

As current remains same in series circuit, 4 amps. Current flows through each resistor.

RESISTORS IN PARALLEL

In parallel circuit the applied voltage remains same across each branch but the current is divided among the branches.

Total resistance of a circuit, when resistors are connected in parallel is given by

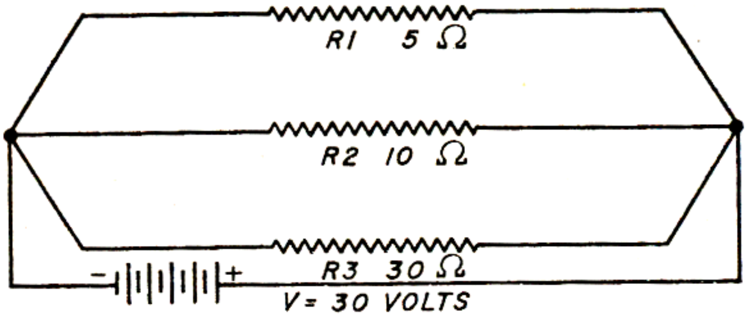
$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 + \ldots\ldots + 1/R_n$$

Ex: - Three resistances of 5 ohms, 10 ohms, 30 ohms respectively are connected in parallel, when 30V is the applied volts what is the total resistance and total current?

$1/R_T = 1/5 + 1/10 + 1/30 =$

$R_T = 3\ \Omega$

Total Resistance of the circuit is 3 Ω



RT =3 Ω V=30V

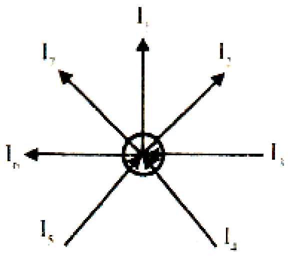
Using Ohm's Law $I_T = V/R_T = 30 / 3 = 10$ A

Total current flowing in the Circuit is 1OA

KIRCHOFF'S CURRENT LAW

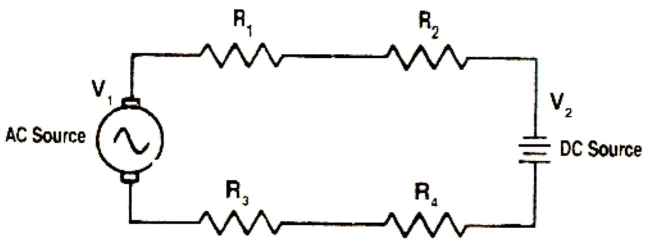
It deals with the distribution of current in a circuit. It states that the sum of all currents flowing into a point or junction in a circuit is equal to the sum of all the currents flowing away from that point or junction.

$$I_1 + I_2 + I_6 + I_7 = I_3 + I_4 + I_5$$



KIRCHOFF'S VOLTAGE LAW

It deals with the distribution of voltage in a closed circuit. It states that sum of all the individual voltage drops in a closed circuit is equal to the applied voltage.



$$V_1+V_2=IR_1 +IR_2+ IR_3+ IR_4$$

POWER & ENERGY

POWER is the time rate at which work is done or energy is transferred. In calculus terms, power is the derivative of work with respect to time.

The SI unit of power is the watt (W) or joule per second (J/s). Horsepower is a unit of power in the British system of measurement.

In a DC circuit, the power is the product of voltage and the current. A source of V volts, delivering I ampere to a circuit produces P watts as follows P = VI

Using ohms law we can find the power in terms of current and resistance, R in ohms. Similarly in terms of $P = I^{2x}R$ voltage and the resistance: $P = V^2 /R$

ENERGY

It is the capacity of a physical system to perform work. Energy exists in several forms such as heat, kinetic or mechanical energy, light, potential energy, electrical, or other forms.

According to the law of conservation of energy, the total energy of a system remains constant, though energy may transform into another form. Two billiard balls colliding, for example, may come to rest, with the resulting energy becoming sound and perhaps a bit of heat at the point of collision.

The SI unit of energy is the Joule (J) or Newton-meter (N x m). The joule is also the SI unit.

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.

Joules Law: The amount of heat produced in a current carrying conductor is proportional to:-

The square of the current i.e. I^2

The resistance of the conductor i.e. R

The time of flow of current i.e. T

if H is the heat produced, then, $H = I^2 RT/J$

Where 'J' is Joule's mechanical equivalent of heat.

CALORIE

The quantity of heat that will raise the temperature of 1gm. of water through 1°C. 1000 calories 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

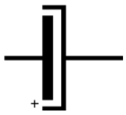
It is that quantity of electricity which flows in one second past any point in a conductor when a current of 1 Amp flows through it.

3. CAPACITORS

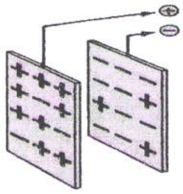
When two conducting plates are separated by dielectric and connected to a Potential Difference then one of the plates becomes negatively charged with respect to the other plate. This means a Potential Difference is created by dielectric.

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

Symbol of capacitor



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



THE CHARGED CAPACITOR

While one plate has excess of positive charges(electricity)
the other plate has excess of negative charges(electricity)

CAPACITANCE

It is the ability of a component by which the amount of electrical charge is stored.

The capacitance of a condenser is directly proportional to the plate area and inversely proportional to the distance between the plates and also depends on the dielectric constant of the dielectric. $C=K*A/D$

Where C is the capacitance.
A is the area of the plates.
K is the dielectric Constant.
D is the distance between the plates

NATURAL CAPACITOR

A capacitance formed when two conductors are placed near each other but separated by an insulator.

ARTIFICIAL CAPACITOR

In almost all radio circuit's capacitance is required for various purposes. The capacitance is introduced in the circuit by means of built in capacitors of different types are artificial.

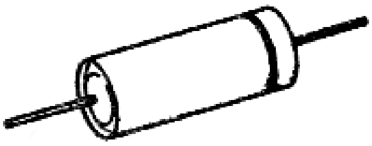
Capacitors can be mainly divided into two categories.

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:

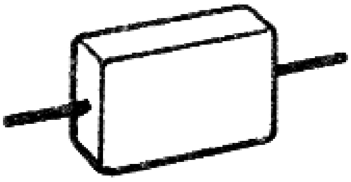
1. Paper Dielectric Capacitors
2. Mica Capacitors
3. Ceramic Capacitors
4. Glass Dielectric Capacitors
5. Vacuum and Gas Dielectric Capacitors
6. Oil Dielectric Capacitors

7. Electrolytic Capacitors

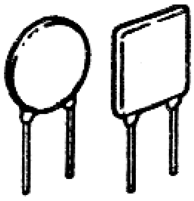


METALLIZED TYPE
(Sealed in metal tube)

PAPER TUBULAR

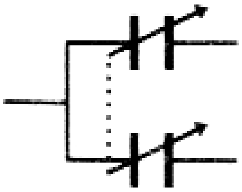


SILVER MICA



CERAMIC DISC

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



Gang Capacitor

Trimmer

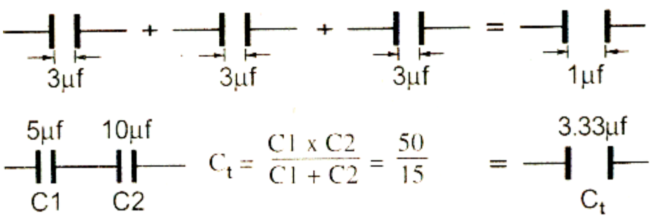
TYPES OF VARIABLE CAPACITORS

1. Air Dielectric Variable capacitors.
2. Straight Line Capacity Variation Capacitors.
3. Straight Line wave length Capacitors.
4. Straight Line frequency Capacitors.
5. Multiple or 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.

SERIES CAPACITANCE

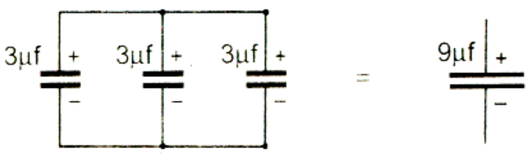
Capacitors connected in series is equivalent to increasing the thickness of dielectric, which means combined capacitance is less than the smallest individual value. It can be written as



To calculate capacitance in series use the formula: 1/CT = 1/C1 +1/C2 +1/C3 + ...+ 1/Cn

PARALLEL CAPACITANCE

Capacitors connected in parallel is equivalent to adding the plate area, which means the total capacitance is the sum of the individual capacitance. It can be written as

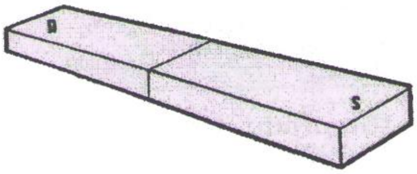


To calculate capacitances in parallel use the formula: $C_T = C_1 + C_2 + C_3 = \dots + C_n$

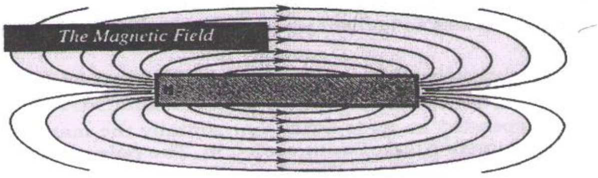
4. MAGNETISM

A piece of iron, nickel, cobalt, steel, alloy (e.g. alloy made from non-magnetic copper, manganese and aluminum) etc. usually in the form of a bar having properties of attracting or repelling iron is called a magnet.

In a magnetic bar, there are two poles: North and South. They are marked as ‘North’ and ‘South’ poles because, when the magnetic bar is suspended horizontally, one of the ends will always point towards the Earth’s geographical north and the other pole towards the Earth’s geographical south. This is because of the fact that the Earth itself behaves like a huge magnet. In a magnet, the like poles repel and the unlike poles attract-a reason for the specific alignment of the magnetic bar.



The magnetic bar is surrounded by the invisible lines of forces which originate from the ‘North’ pole and terminate in the ‘South’ pole.



MAGNETIC FLUX: The entire group of magnetic field lines which flow outward from the North Pole to the south pole of a magnetic is called flux. It’s C.G.S. unit is MAXWELL (MX) and it’s M.K.S. unit is WEBER (WB).

1 Weber = 10 Maxwell

FLUX DENSITY (B): It is the number of magnetic field lines per unit area of a section perpendicular to the direction of flux.

$B = \varnothing/A$ or Flux density = total Flux/area

In CGS system the unit is GAUSS (g) and in MKS system it is TESLA (T).

PERMANENT MAGNETS

Permanent magnets are those we are most familiar with, such as the magnets hanging onto our refrigerator doors. They are permanent in the sense that once they are magnetized, they retain a level of magnetism. As we will see, different types of permanent magnets have different characteristics or properties concerning how easily they can be demagnetized, how strong they can be, how their strength varies with temperature, and so on.

Use of Permanent magnets in Electronics:

Permanent magnets are used in electronics to make electric meters, headphones, loudspeakers, radar transmitting tubes etc.

ELECTROMAGNETS

An electromagnet is a tightly wound helical coil of wire, usually with an iron core, which acts like a permanent magnet when current is flowing in the wire. The strength and polarity of the magnetic field created by the electromagnet are adjustable by changing the magnitude of the current flowing through the wire and by changing the direction of the current flow.

MATERIALS USED FOR PERMANENT MAGNETS

There are four classes of permanent magnets:

Neodymium Iron Boron (NdFeB or NIB)

Samarium Cobalt (SmCo)

Alnico

Ceramic or Ferrite

MAGNETO-MOTIVE FORCE (MMF): This is called magnetizing force or magnetic potential. The current (I) and number of turns (N) together produces flux.

MMF = NI

In MKS System the unit is Ampere turn/meter

RELUCTANCE

Opposition to the production of flux is called reluctance.

PROPERTIES OF MAGNETS

(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.

5. INDUCTOR

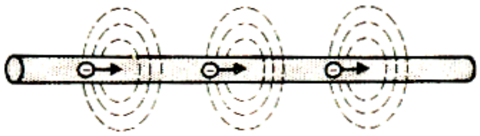
A coil or loop, which has the property to oppose any change in alternating current is called an inductor.

INDUCTANCE

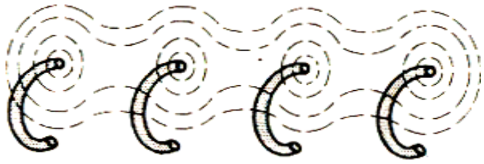
It is the property of a circuit or a component that opposes a change in current. Represented by L and the unit is Henry (H).

Inductance of a coil depends on

1. The number of turns; more the number of turns, greater is the inductance of the coil.
2. Permeability



Conductor Contains Inductance



Flux between coils

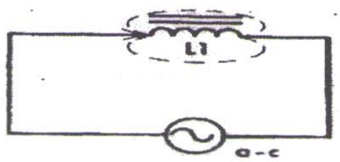
3. Cross section larger the cross section of the core, higher is the inductance,
4. Spacing of the turns: the smaller the spacing between turns of the coil, the higher is the inductance.

INDUCTANCE IS OF TWO TYPES

1. SELF INDUCTACNE   2. MUTUAL INDUCATANCE

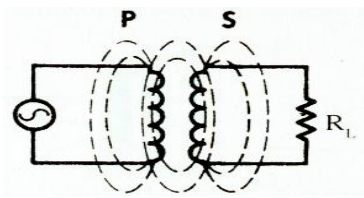
SELF-INDUCTANCE

The ability of a conductor to induce voltage in itself when the current changes. When current flows through a coil, a magnetic field is developed around the coil. If this current is changed the lines of force around the coil will also change, which will induce a voltage in the coil. This is called self-inductance.



MUTUAL INDUCTANCE

When two coils are placed nearby and one of the coils is carrying current then flux is produced in it, which also links with second coil thereby inducing an emf in it. The transformer works on the principle of Mutual Inductance.



Maximum coupling (unity or 1) occurs when all the flux lines from each coil cuts all the turns of the opposite coil

COEFFICIENT OF COUPLING

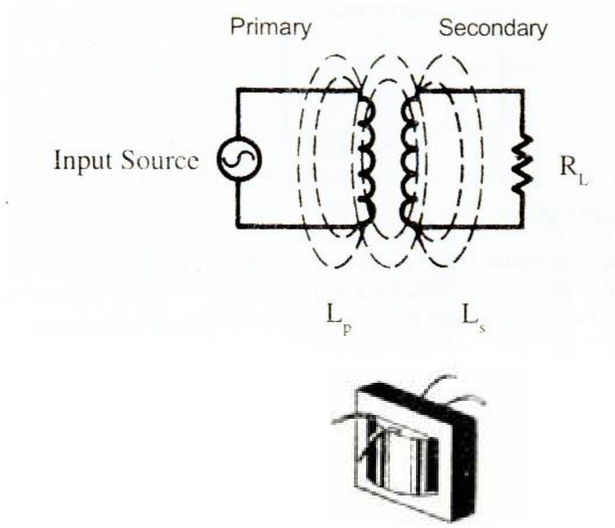
The fraction of magnetic flux from one coil linking another coil is the coefficient of coupling between two coils and is denoted by letter K. If all the flux of L1 links L2, then the coefficient of coupling K is 1. Generally it can be expressed as

K = flux linkages between Li and L2 / flux produced by L1.

The coefficient of coupling increases if the coils are closely placed. A high value of K is called high coupling, induces more voltage in the other coil. A low value of K is called loose coupling and induces less voltage. If coils are kept far apart there is no mutual inductance and the coefficient of coupling is zero.

6. TRANSFORMER

Transformer is a device used to transfer electrical energy from one Alternating current circuit to another of the same frequency. In the process of transfer, the voltage or current is transformed from one set of values to another.



TRANSFORMER

The transformer essentially consists of two windings separated magnetically through a Ferro magnetic core. The windings are insulated from each other. The coil connected to the power supply is called the primary and the one connected to the load is called the secondary.

The Transformer is an important application of mutual inductance.

It has the primary winding L connected to an alternating voltage while the secondary winding L5 is connected across to load Resistance RL. The purpose of the transformer is to transfer power from the primary to the secondary.

The secondary voltage can be increased or decreased with respect to the primary voltage depending on the number of turns of secondary winding with respect to primary winding

TURNS RATIO: It is the Ratio of the number of turns in the secondary to the number of turns in the primary. Turns Ratio = N_S/N_P

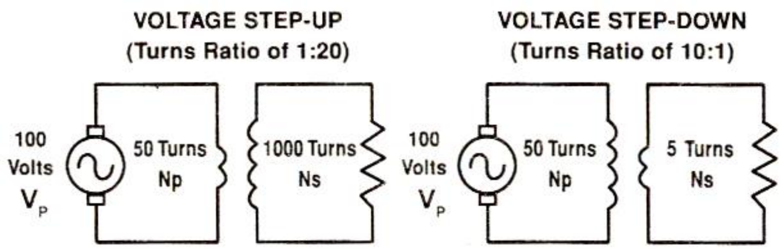
Where N_S is the number of turns in secondary N_P is the number of turns in primary.

VOLTAGE RATIO: With unity turns ratio between primary and secondary the voltage induced in secondary is equal to the voltage available in primary.

CURRENT RATIO: When zero losses are assumed for the transformer, power at the secondary equals to the power in primary.

$$V_P I_P = V_S I_S$$

STEP UP AND STEP DOWN TRANSFORMERS



$$V_P I_{PS} = V_S I_S$$
$$V_S = V_P (N_S/N_P) = 100 \times (1000/50) = 2000 \text{ volts}$$
$$V_S = V_P (N_S/N_P) = 100 \times (5/50)\ 10 \text{ volts}$$

Depending on the relative number of turns in the primary and secondary, the applied voltage may be stepped up or down when the voltage is taken out from the transformer. If secondary windings are greater to that of primary it means step up, its transformation ratio is more than one. When secondary windings are less than primary it means step down transformer. Its ratio is less than one.

DIFFERENT TYPES OF TRANSFORMERS

1. Auto Transformers 2. Power transformers 3. Audio transformers 4. Radio Frequency transformers 5. Intermediate frequency transformers 6. Instrument transformers 7. Three phase transformers.

STEP-UP STEP - DOWN

AUTO TRANSFORMER

An Auto transformer 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 TRANSFORMER

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 core.

INTERMEDIATE FREQUENCY TRANSFORMER

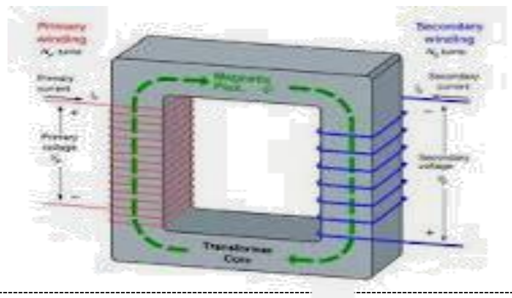
These are mainly used to increase the voltage of IF frequency signals. They are used in IF circuits as coupling devices and operate at frequency ranging between 450 to 460 KHz. They consist of primary and secondary windings wound on laminated ferrite core.

RADIO FREQUENCY TRANSFORMER

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.

BASIC TRANSFORMER CONSTRUCTION

An alternating current or a varying DC current flowing in one coil can induce a varying voltage in a neighboring coil. The changing magnetic lines of force from the varying current in one coil (which we call the primary) cuts the turns of the other coil (called the secondary) and induces a changing voltage in each of the turns of the secondary. A changing current in one induces a voltage in the other, the combination of windings constitutes a transformer.



Basic Construction and working of a transformer

When two coil windings are arranged so that transformer has a primary winding and one or more secondary windings. The primary winding (usually labeled P) receives the input electrical energy from a voltage source, whereas the secondary winding or windings (labeled S) delivers the induced output voltage to a load.

The transformer serves many functions. It enables the transfer of electrical energy from one electrical circuit to another by using changing magnetic lines of force as the link between the two. N this way it behaves as a coupling device. Also, it provide a means whereby an alternating voltage of a given amount can be changed (transformed) to higher or lower amounts, making electrical power distribution practical. Such transformation can be applied to current and impedance.

Transformers designed to operate at high frequencies (above audio range) are referred to as intermediate-frequency and radio frequency types.

TRANSFORMER LOSSES

We have stated that the transformer can be made almost a 100% efficient device. There are however certain inherent losses in a transformer that can be minimized but never completely eliminated. The most apparent losses are called copper losses. Since the primary and secondary are wound with many turns of copper wire, there will be wasted I^2R losses. This accounts for the secondary voltage being slightly lower under load than when unloaded. These losses are reduced by using the largest practical cross sectional area wire.

HYSTERESIS LOSSES

Hysteresis losses are due to the lagging of the magnetization and demagnetization of the soft steel core behind the alternating current in the circuit. The atoms of the core material must keep changing polarity, and a sort of frictional loss is developed. The use of material such as soft silicon steel for the core greatly reduces hysteresis losses.

EDDY CURRENT LOSS

Ferromagnetic Materials are also good conductors, and a core made from such a material also constitutes a single short-circuited turn throughout its entire length. Eddy currents therefore circulate within the core in al plane normal to the flux, and are responsible for resistive heating of the core material. The eddy current loss is a complex function of the square of supply frequency and Inverse Square of the material thickness. Eddy current losses can be reduced by making the core of a stack of plates electrically insulated from each other, rather than a solid block; all transformers operating at low frequencies use laminated cores.

IMPEDANCE MATCHING

In the transfer of power from any electrical source of its load, the impedance of the load must be equal to or match the internal impedance of the source for maximum transfer of power. The transformer is a useful device for matching the impedance of a generator to that of its load. This is important because in radio work, it is often necessary to connect a low-impedance load to a high-impedance generator, and vice versa. Unless there is an impedance match, there will not be maximum transfer of power. Assuming a source or generator impedance of 10,000 ohms, we will match it to a load of 400 ohms. Using a transformer, the primary impedance must match the load impedance. The turns ratio of the transformer must be:

$Ns/Np = \sqrt{Zp/Zs} = \sqrt{10{,}000/400} = \sqrt{25/1}$, then $\sqrt{Np/Ns} = 5:1$

If 100 volts are applied to the primary, the secondary voltage is 20 volts. Secondary current is 20/400m is 0.05 ampere. The primary current is 100/10,000, or 0.01 ampere. Since the primary power (1 watt) is equal to the secondary power, the transformer has matched a 400-ohm load to a 10,000ohm source with maximum transfer of power. We can say that the source sees the primary impedance as matching impedance, and the secondary which by transformer action receives the primary power, sees the load impedance as matching impedance.

SUMMARY

Any change of current flowing in a circuit containing inductance produces a counter emf which opposes the change taking place. This self-induced emf tends to prevent an increasing current from increasing and a decreasing current from decreasing. Basically, Lenz's law states, "A changing current induces an emf whose polarity is such as to oppose the change in current.

The greater the coil inductance, the higher the induced emf, and the greater the opposition to the increase and decrease of current in the coil. Mutual induction occurs when a changing magnetic field produced by one coil cuts the winding of a second coil and induces an emf in the second coil. Inductive reactance (X_L) is the opposition presented by an inductance to an alternating current. $X_L=2\Pi fl$. In a series R-L circuit, the voltage drops across R and L are 90^o out of phase. In a circuit containing both inductance and resistance, impedance (Z) is the total opposition to the flow of alternating current, and is a combination of X_L and R. It is expressed in ohms. $Z= \sqrt{X_L^2+R^2}$.Ohm's law for a-c circuits is : E=IZ; I=E/Z; and Z=E/I. The vectorial sum of all the voltage drops in a series R-L circuit is equal to the applied voltage. The primary winding of a transformer absorbs the input electrical energy from a voltage source; the secondary winding delivers the induced output voltage to a load.

The turns ratio between the secondary and primary winding of a transformer determines whether the secondary voltage is greater or less than the primary voltage. The primary–secondary current ratio is opposite to that of the primary secondary voltage ratio. In the transfer of power from an electrical source to a load, the load impedance must be equal to, or match, the internal impedance of the source for maximum transfer of power.

TURNS RATIO

Each winding of a transformer contains a certain number of turns of wire. The turns ratio is defined as the ratio of turns of wire in the primary winding to the number of turns of wire in the secondary winding. Turns ratio can be expressed as: N_p N_s where N_p= number of turns on the primary coil and N_s= number of turns on the secondary coil.

The coil of a transformer that is energized from an AC source is called the primary windi ng(coil), and the coil that delivers this AC to the load is called the secondary winding.

IMPEDANCE RATIO

Maximum power is transferred from one circuit to another through a transformer when the impedances are equal, or matched. A transformer winding constructed with a definite turns ratio can perform an impedance matching function. The turn's ratio will establish the proper relationship between the primary and secondary winding impedances.

The sinusoidal (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).

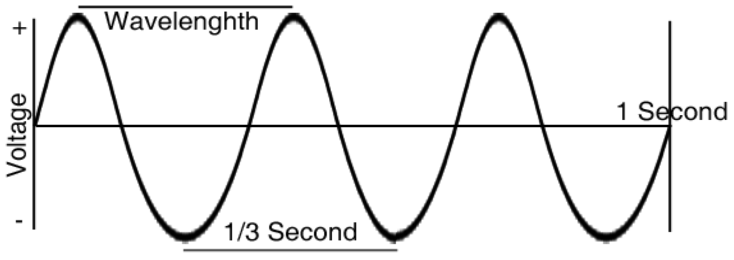
50 Hz 50 cycles/seconds

PERIOD (T)

The amount of time taken to complete one cycle is the period.

WAVE LENGTH

Wave length is the length of one complete cycle. The wave length depends upon the frequency of the variation and its velocity.

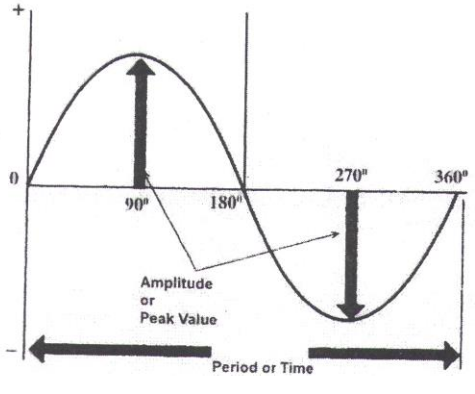


WAVE LENGTH OF RADIO WAVES

For electro magnetic radio waves, the velocity in air is 186,000 miles for second or 3 x 10^{10} cm/sec. which is equal to speed of light.

VOLTAGE AND CURRENT VALUES FOR A SINEWAVE

PEAK VALUE: This is the maximum value VM or IM. The peak value applies either to positive or negative peak



AVERAGE VALUE

This is an arithmetical average of all values in half a cycle. This average value equals to 0.637 of peak value.

$$V_{avg} = 0.637 \text{ x } V_{Peak}$$

RMS VALUE

RMS value of an alternating current is defined as the value of the equivalent direct current which can produce the same average heating effect in a conductor as the given alternating current The value is termed as RMS value because it is obtained by finding the mean of the squares of the instantaneous currents and then taking the square root.

$$V_{RMS} = V_{Peak}\ 1 / \sqrt{2} \text{ or } 0.707\ V_{Peak}$$

PHASE

It is the angular position of Armature in A.C generator. One sine wave consists of two phases i.e. +ve and -ve. The alternating quantities which rise and fall in step alternating their individual maximum and minimum values simultaneously is said to be in phase.

PHASE ANGLE

Suppose the voltage A started its cycle where maximum output voltage is produced at the same time B starting at zero output. This angular difference is the phase angle between Wave A leading wave B by 90 degrees.

REACTANCE

Reactance is the property of resisting or impeding the flow of ac current or ac voltage in inductors and capacitors. Note particularly we speak of alternating current only ac, which expression includes audio af and radio frequencies rf. NOT direct current dc.

INDUCTIVE REACTANCE

When ac current flows through an inductance a back emf or voltage develops opposing any change in the initial current. This opposition or impedance to a change in current flow is measured in terms of inductive reactance.

Inductive reactance is determined by the formula: $2\pi fL$ [*or says 2 * pi * f * L]*

where: $2 * \pi = 6.2832$; f = frequency in hertz and L = inductance in Henries

CAPACITIVE REACTANCE

When ac voltage flows through a capacitance an opposing change in the initial voltage occurs, this opposition or impedance to a change in voltage is measured in terms of capacitive reactance.

Capacitive reactance is determined by the formula: $1 / (2\pi fC)$

Where: $2 * \pi = 6.2832$; f = frequency in hertz and C = capacitance in Farads

EXAMPLES OF REACTANCE

What reactance does a 6.8 μH inductor present at 7 MHz?

Using the formula above we get: $XL = 2 * \pi * f * L$

where: $2 * \pi = 6.2832$; f = 7,000,000 Hz and L = .0000068 Henries

Answer: = 299 ohms

What reactance does a 33 pF capacitor present at 7 MHz?

Using the formula above we get: $XC = 1 / (2 * \pi * f * C)$

where: $2 * \pi = 6.2832$; f = 7,000,000 Hz and C = .0000000000033 Farads

Answer: = 689 ohms

IMPEDANCE

The opposition offered to the current in the combination of one or more components like inductor, resistor or capacitor is called impedance.

POWER FACTOR

It is defined as the ratio of True power to the apparent power.

$$P.F = R/Z = \cos\varnothing$$

CIRCUIT

This is a closed path comprising of a few components like resistors, capacitors, inductors, voltage source etc. There are two types: one is open and second is short circuit.

RESONANCE

Resonance occurs when the reactance of an inductor balances the reactance of a capacitor at some given frequency. In such a resonant circuit where it is in series resonance, the current will be maximum and offering minimum impedance. In parallel resonant circuits the opposite is true.

In series A.C. circuit, inductive reactance leads the zero reference angle of resistance by 90 degrees while capacitive reactance lags by 90 degrees. Therefore X_L and X_C are 180 degrees out of phase which means they are opposite and get cancelled. Then the only opposition to the current is the coil resistance. At resonance impedance is minimum and resistive. The current at resonant frequency is maximum. The formula for resonance is: $2\pi fL = 1/(2\pi fC)$

where: $2\pi = 6.2832$; f = frequency in hertz L = inductance in Henries and C = capacitance in Farads

Which leads us on to: $f = 1 / [2\pi (\text{sqrt } LC)]$ where: 2 * pi = 6.2832; f = frequency in hertz L = inductance in Henries and C = capacitance in Farads

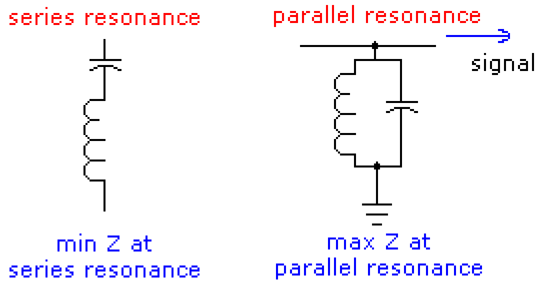
A particularly simpler formula for radio frequencies (make sure you learn it) is:

$LC = 25330.3 / f^2$ where: f = frequency in Megahertz (MHz) L = inductance in microhenries (uH) and C = capacitance in picofarads (pF) Following on from that by using simple algebra we can determine:

$LC = 25330.3 / f^2$ and $L = 25330.3 / f^2 C$ and $C = 25330.3 / f^2 L$

Impedance at Resonance

In a series resonant circuit the impedance is at its lowest for the resonant frequency whereas in a parallel resonant circuit the impedance is at its greatest for the resonant frequency. See figure below.



Resonance in series and parallel circuits

"For a series circuit at resonance, frequencies becoming far removed from resonance see an ever increasing impedance. For a parallel circuit at resonance, frequencies becoming far removed from resonance see an ever decreasing impedance". That was a profoundly important statement. Please read it several times to fully understand it.

A typical example to illustrate that statement are the numerous parallel circuits used in radio. Look at the parallel resonant circuit above. At resonance that circuit presents such a high impedance to the resonant circuit to the extent it is almost invisible and the signal passes by. As the circuit departs from its resonant frequency, up or down, it presents a lessening impedance and progressively allows other signals to leak to ground. At frequencies far removed from resonance, the parallel resonant circuit looks like a short path to ground. For series resonance the opposite is true.

Exercice

1) Resistivity of a wire depends on

(A) length (B) material (C) cross section area (D) none of the above

2) Resistance of a wire is r ohms. The wire is stretched to double its length, then its resistance in ohms is

(A) r / 2 (B) 4 r (C) 2 r (D) r / 4

3) Ampere second could be the unit of

(A) power (B) conductance (C) energy (D) charge

4) Conductance is expressed in terms of

(A) ohm / m (B) m / ohm (C) mho / m (D) mho

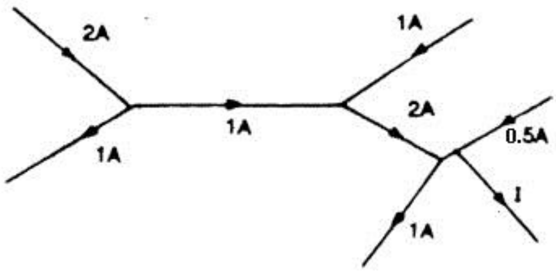
5) We have three resistances of values 2 Ω, 3 Ω and 6 Ω. Which of the following combination will give an effective resistance of 4 Ω?

(A) All the three resistances in parallel
(B) 2 Ω resistance in series with parallel combination of 3 Ω and 6 Ω resistance
(C) 3 Ω resistance in series with parallel combination of 2 Ω and 6 Ω resistance
(D) 6 Ω resistance in series with parallel combination of 2 Ω and 3 Ω resistance

6) Three equal resistors connected in series across a source of emf together dissipate 10 watts of power. What would be the power dissipated in the same resistors when they are connected in parallel across the same source of emf?

(A) 10 watts (B) 30 watts (C) 90 watts (D) 270 watts

7) Current I in the figure is



(A)1.5A
(B)0.5A
(C)3.5A
(D)2.5A

8) Four identical resistors are first connected in parallel and then in series. The resultant resistance of the first combination to the second will be

(A) 1 / 16 times (B) 1 / 4 times (C) 4 times (D) 16 times

9) The unit of electrical conductivity is

(A) mho / metre (B) mho / sq. m (C) ohm / metre (D) ohm / sq. m

10) Which of the following bulbs will have the least resistance?

(A) 220 V, 60 W (B) 220 V, 100 W (C) 115 V, 60 W (D) 115 V, 100 W

11) The ratio of the resistance of a 100 W, 220 V lamp to that of a 100 W, 110 V lamp will be nearly

(A) 4 (B)2 (C) 1 / 2 (D) 1 / 4

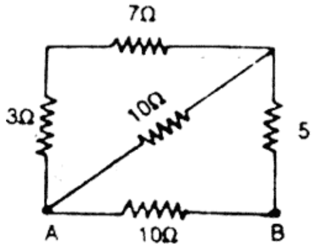
12) Two 1 kilo ohm, 1/2 W resistors are connected in series. Their combined resistance value and wattage will be

(A) 2 kΩ, 1/2 W (B) 2 kΩ, 1 W (C) 2 kΩ, 2 W (D) 1 kΩ, 1/2 W

13) Three 3 ohm resistors are connected to form a triangle. What is the resistance between any two of the corners?

(A) 3 / 4 ohms (B) 3 ohms (C) 2 ohms (D) 4/3 ohm

14) Five resistances are connected as shown in figure below. The equivalent resistance between the points A and B will be



(A) 35 ohms (B) 25 ohms (C) 15 ohms (D) 5 ohms

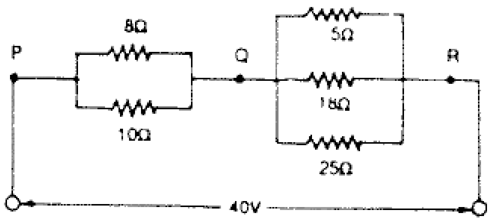
15) How many different combinations may be obtained with three resistors, each having the resistance R?

(A) 3 (B) 4 (C) 5 (D) 6

16) Ohm's law is not applicable to

(A) DC circuits (B) high currents (C) small resistors (D) semi-conductors

For next 3 Questions refer to Figure given below.



17) Five resistances are connected as shown and the combination is connected to a 40 V supply. Voltage between point P and Q will be

(A) 40 V (B) 22.5 V (C) 20 V (D) 17.5 V

18) The current in 5 ohm resistor will be

(A) 2.1 A (B) 2.7 A (C) 3.0 A (D) 3.5 A

19) Least current will flow through

(A) 25 ohm resistor (B) 18 ohm resistor (C) 10 ohm resistor (D) 5 ohm resistor

20) Total power loss in the circuit is

(A) 10 W (B) 50.2 W (C) 205 W (D) 410 W

21) A resistance of 5 ohms is further drawn so that its length becomes double. Its resistance will now be

(A) 5 ohms (B) 7.5 ohms (C) 10 ohms (D) 20 ohms.

22) Specific resistance of a substance is measured in

(A) ohms (B) mhos (C) ohm-m (D) cm/ohm.

23) A wire of resistance R has it length and cross-section both doubled. Its resistance will become

(A) 4 R (B)2 R (C) R (D) R / 4

24) Ohm's law is not applicable in all the following cases Except

(A) Electrolytes (B) Arc lamps
(C) Insulators (D) Vacuum radio valves.

25) The element of electric heater is made of

(A) copper (B) steel (C) carbon (D) nichrome

26) Two aluminum conductors have equal length. The cross-sectional area of one conductor is four times that of the other. If the conductor having smaller cross-sectional area has a resistance of 100 ohms the resistance of other conductor will be

(A) 400 ohms (B) 100 ohms (C) 50 ohms (D) 25 ohms

27) Variable resistors are

(A)Wire wound resistors (B)Thin film resistors
(C)Thick film resistors (D)All of the above

28) Temperature coefficient of resistance is expressed in terms of

(A) ohms / ohms ^{o}C (B) mhos / ohm ^{o}C
(C) mhos / ^{o}C (D) ohms / ^{o}C

29) Which material is expected to have least resistivity?

(A) Copper (B) Lead (C) Mercury (D) Zinc

30) A fuse is always installed in a circuit is

(A) Series (B) Parallel

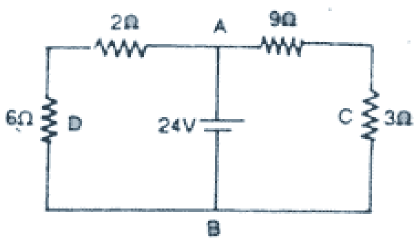
31) The rating of fuse wire is expressed in terms of

(A) Ohms (B) Mhos (C) Amperes (D) Watts

32) Which of the following material is not used as fuse material?

(A) Silver (B) Copper (C) Aluminium (D) Carbon

For next 5 Questions refer to Figure below



33) The voltage drop across the resistor 9 ohm will be

(A) 18 V (B) 12 V (C) 9 V (D) 6 V

34) The voltage drop will be least in which resistor?

(A) 2 ohm (B) 3 ohm (C) 6 ohm (D) 3 ohm and 2 ohm

35) The current through 6 ohm resistor will be

(A) 1 A (B) 2 A (C) 3 A (D) 4 A

36) The ratio of power dissipated in circuit ADB to that in circuit ABC will be

(A) 1 (B) 1.5 (C)0.67 (D) 2

37) Total power dissipated in the circuit is

(A) 80 W (B)100 W (C)120 W (D) 150 W

38) The current carrying capacity of the fuse material depends on

(A) cross-sectional area (B) length (C) material (D) all of the above

39) Two 1 kilo ohm, 1/2 W resistors are connected in series. Their combined resistance value and wattage will be

(A) 2 kohm, 1 / 2 W (B) 2 kohm, 1 W (C) 2kohm, 2 W (D) 1 kohm, 1 / 2 W

40) Ohm's law is not applicable in all the following cases except

(A) Electrolysis (B) Arc lamps (C) Insulators (D) Vacuum radio valves

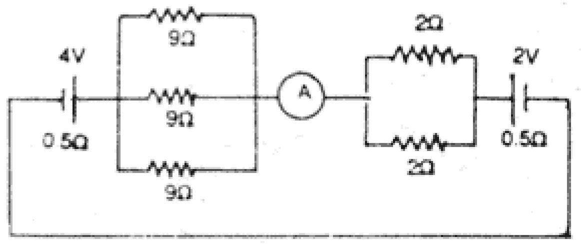
41) In which of the following circuits will the voltage source produce the most current?

(A) 10 V across a 10 ohm resistance
(B) 10 V across two 10 ohm resistance in series
(C) 10 V across two 10 ohm resistances in parallel
(D) 1000 V across Mega ohm resistance

42) The unit of conductivity is

(A) mho / m (B) mho / sq. m (C) ohm / m (D) ohm / sq. m

43) For the circuit shown in figure given below, the reading in the ammeter A w ill be



(A) 2 A (B) 0.5 A (C) 0.4 A (D) 0.2 A

44) In the color code for resistances black color represents the number

(A) 0 (B) 1 (C) 2 (D) 3

45) In the color code white color represents the number

(A) 9 (B) 8 (C) 6 (D) 5

46) In the color code number 3 is represented by

(A) blue (B) orange (C) grey (D) violet

47) The condition for the validity under Ohm's law is

(A) Temperature at positive end should be more than the temperature at negative end
(B) Current should be proportional to the size of resistance
(C) Resistance must be wire wound type
(D) Resistance must be uniform

48) Two resistors R_1 = 47 k ohm, 1 W and R_2 = 0 ohm, 1 W are connected in parallel. The combined value will be

(A) 47 k ohm, 1 W (B) 47 k ohm, 2W
(C) 47 kohm, 1 / 2 W (D) 0 kohm, 1W

49) A rheostat differs from potentiometer in the respect that

(A) rheostat has large number of turns
(B) rheostat offers larger number of tapings
(C) rheostat has lower wattage rating
(D) rheostat has higher wattage ratings

50) Which consists of two plates separated by a dielectric and can store a charge?

1) Inductor 2) Capacitor 3) Transistor 4) Relay

8. SEMICONDUCTOR DEVICES

Materials can be categorized into conductors, semiconductors or insulators by their ability to conduct electricity.

Insulators do not conduct electricity because their valence electrons are not free to wander throughout the material.

Metals conduct electricity easily because the energy levels between the conduction and valence band are closely spaced or there are more energy levels available than there are electrons to fill them so very little energy is required to find new energies for electrons to occupy.

The resistivity of a material is a measure of how difficult it is for a current to flow.

The band theory of materials explains qualitatively the difference between these types of materials.

Elemental semiconductors are semiconductors where each atom is of the same type such as Germanium (Ge), Silicon (Si). These atoms are bound together by covalent bonds, so that each atom shares an electron with its nearest neighbor, forming strong bonds.

Compound semiconductors are made of two or more elements. Common examples are gallium arsenide (GaAs) or Indium Phosphorus (InC). In compound semiconductors, the difference in electro-negativity leads to a combination of covalent and ionic bounding.

Intrinsic semiconductors are essentially pure semiconductor material. The semiconductor material structure should contain no impurity atoms. Elemental and compound semiconductors can be intrinsic semiconductors.

At room temperature, the thermal energy of the atoms may allow a small number of the electrons to participate in the conduction process. Unlike metals where the resistance of semiconductor material decreases with temperature for semiconductors, as the temperature increases, the thermal energy of the valence electrons increases, allowing more of them to breach the energy gap into the conduction band. When an electron gains enough energy to escape the electrostatic attraction of its parent atom, it leaves behind a vacancy which may be filled by another electron. The vacancy produced can be thought of as a second carrier of positive charge. It is known as a hole.

As electrons flow through the semiconductor, holes flow in the opposite direction. If there are n free electrons in an intrinsic semiconductor, then there must also be n holes. Holes and electrons created in this way are known as intrinsic charge carriers. The carrier concentration or charge density defines the number of charge carriers per unit volume. This relationship can be expressed as n=p where n is the number of electrons and p the number of holes per unit volume.

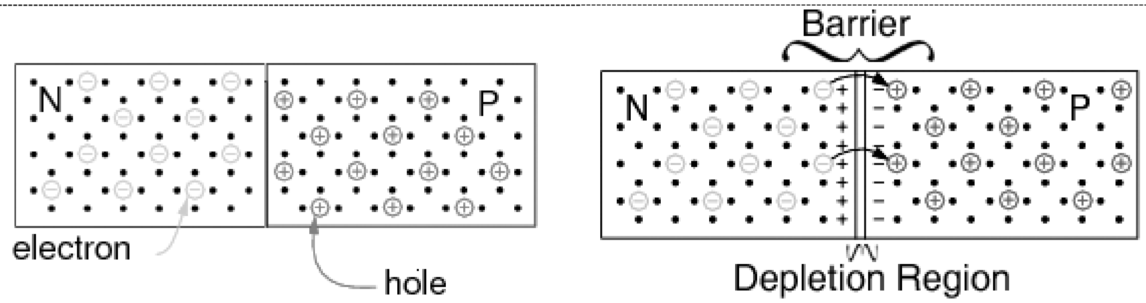
Extrinsic Semiconductor can be formed from an intrinsic semiconductor by adding impurity atoms to the crystal in a process known as doping.

Silicon belongs to group IV of the periodic table, it has four valence electrons. In the crystal form, each atom shares an electron with a neighboring atom. In this state it is an intrinsic semiconductor.

Boron (B), Aluminum (Al), Indium (In), Gallium (Ga) all have three electrons in the valence band. When a small proportion of these atoms, (less than 1 in 10^6), is incorporated into the crystal the dopant atom has an insufficient number of bonds to share bonds with the surrounding Silicon atoms. One of the Silicon atoms has a vacancy for an electron. It creates a hole that contributes to the conduction process at all temperatures. Dopants that create holes in this manner are known as acceptors. This type of extrinsic semiconductor is known as P-Type as it create positive charge carriers.

Elements that belong to group V of the periodic table such as

Arsenic (As), Phosphorus (P), Antimony (Sb,) Bismuth (Bi) have an extra electron in the valence band. When added as a dopant to intrinsic Silicon, the dopant atom contributes an additional electron to the crystal. Dopants that add electrons to the crystal are known as donors and the semiconductor material is said to be N-Type as it create negative charge carriers.



If a block of P-type semiconductor is placed in contact with a block of N-type semiconductor in Figure.

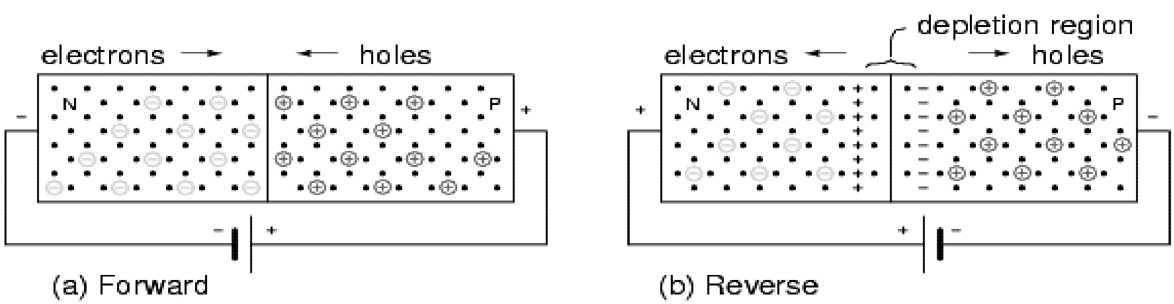
The result is of no value. We have two conductive blocks in contact with each other, showing no unique properties. The problem is two separate and distinct crystal bodies. The number of electrons is balanced by the number of protons in both blocks. Thus, neither block has any net charge.

However, a single semiconductor crystal manufactured with P-type material at one end and N-type material at the other in Figure below (b) has some unique properties. The P-type material has positive majority charge carriers, holes, which are free to move about the crystal lattice. The N-type material has mobile negative majority carriers, electrons. Near the junction, the N-type material electrons diffuse across the junction, combining with holes in P-type material. The region of the P-type material near the junction takes on a net negative charge because of the electrons attracted. Since electrons departed the N-type region, it takes on a localized positive charge. The thin layer of the crystal lattice between these charges has been depleted of majority carriers, thus, is known as the depletion region. It becomes nonconductive intrinsic semiconductor material. In effect, we have nearly an insulator separating the conductive P and N doped regions.

(a) Blocks of P and N semiconductor in contact have no exploitable properties. (b) Single crystal doped with P and N type impurities develops a potential barrier.

This separation of charges at the PN junction constitutes a potential barrier. This potential barrier must be overcome by an external voltage source to make the junction conduct. The formation of the junction and potential barrier happens during the manufacturing process. The magnitude of the potential barrier is a function of the materials used in manufacturing. Silicon PN junctions have a higher potential barrier than germanium junctions.

In Figure below (a) the battery is arranged so that the negative terminal supplies electrons to the N-type material. These electrons diffuse toward the junction. The positive terminal removes electrons from the P-type semiconductor, creating holes that diffuse toward the junction. If the battery voltage is great enough to overcome the junction potential (0.6V in Si), the N-type electrons and P-holes combine annihilating each other. This frees up space within the lattice for more carriers to flow toward the junction. Thus, currents of N-type and P-type majority carriers flow toward the junction. The recombination at the junction allows a battery current to flow through the PN junction diode. Such a junction is said to be forward biased.

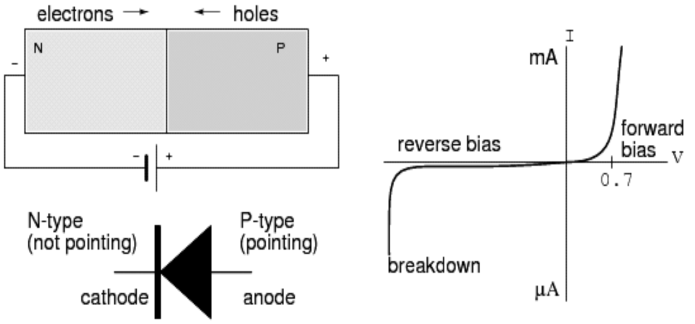


(a) Forward battery bias repels carriers toward junction, where recombination results in battery current. (b) Reverse battery bias attracts carriers toward battery terminals, away from junction. Depletion region thickness increases. No sustained battery current flows.

If the battery polarity is reversed as in Figure above (b) majority carriers are attracted away from the junction toward the battery terminals. The positive battery terminal attracts N-type majority carriers, electrons, away from the junction. The negative terminal attracts P-type majority carriers, holes, away from the junction. This increases the thickness of the non conducting depletion region. There is no recombination of majority carriers; thus, no conduction. This arrangement of battery polarity is called reverse bias.

The crystal PN Junction called Diode

The diode schematic symbol is illustrated in Figure below corresponding to the doped semiconductor bar. The diode is a unidirectional device. Electron current only flows in one direction, against the arrow, corresponding to forward bias. The cathode, bar, of the diode symbol corresponds to N-type semiconductor. The anode, arrow, corresponds to the P-type semiconductor. To remember this relationship, Not-pointing (bar) on the symbol corresponds to N-type semiconductor. Pointing (arrow) corresponds to P-type.



Forward biased PN junction (left above) Corresponding diode schematic (right above) Silicon Diode I vs V characteristic curve.

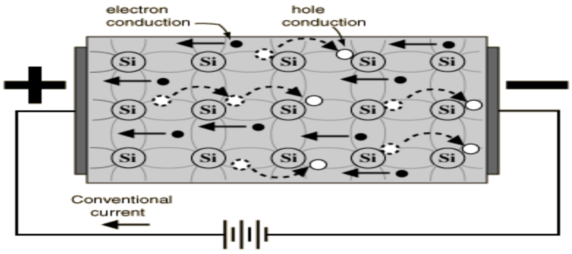
If a diode is forward biased as in Figure above, current will increase slightly as voltage is increased from 0 V. In the case of a silicon diode a measurable current flows when the voltage approaches 0.6 V at. As the voltage increases past 0.6 V, current increases considerably after the knee. Increasing the voltage well beyond 0.7 V may result in high enough current to destroy the diode. The forward voltage, VF, is a characteristic of the semiconductor: 0.6 to 0.7 V for silicon, 0.2 V for germanium, a few volts for Light Emitting Diodes (LED). The forward current ranges from a few mA for point contact diodes to 100 mA for small signal diodes to tens or thousands of amperes for power diodes.

If the diode is reverse biased, only the leakage current of the intrinsic semiconductor flows. This is plotted to the left of the origin in Figure above(c). This current will only be as high as 1 µA for the most extreme conditions for silicon small signal diodes. This current does not increase appreciably with increasing reverse bias until the diode breaks down. At breakdown, the current increases so greatly that the diode will be destroyed unless a high series resistance limits current. We normally select a diode with a higher reverse voltage rating than any applied voltage to prevent this. Silicon diodes are typically available with reverse break down ratings of 50, 100, 200, 400, 800 V and higher. It is possible to fabricate diodes with a lower rating of a few volts for use as voltage standards.

We previously mentioned that the reverse leakage current of under a µA for silicon diodes was due to conduction of the intrinsic semiconductor. This is the leakage that can be explained by theory. Thermal energy produces few electron hole pairs, which conduct leakage current until recombination. In actual practice this predictable current is only part of the leakage current. Much of the leakage current is due to surface conduction, related to the lack of cleanliness of the semiconductor surface. Both leakage currents increase with increasing temperature, approaching a µA for small silicon diodes.

For germanium, the leakage current is orders of magnitude higher. Since germanium semiconductors are rarely used today, this is not a problem in practice.

Electron and Hole conduction



If a piece of P-type material is joined to a piece of N-type material and a voltage is applied to the pair, current will flow across the boundary or junction between the two when the battery has the polarity indicated. Electrons, indicated by the minus symbol, are attracted across the junction from the N material through the P material to the positive terminal of the battery. Holes, indicated by the plus symbol, are attracted in the opposite direction across the junction by the negative potential of the battery. Thus, current flows through the circuit by means of electrons moving one way and holes the other.

If the battery polarity is reversed, the excess electrons in the N material are attracted away from the junction and the holes in the P material are attracted by the negative potential of the battery away form the junction. This leaves the junction region without any current carriers; consequently, there is no Conduction.

In other words, a junction of P and N type materials constitutes a rectifier. It differs from the vacuum tube diode rectifier in that there is a measurable, although comparatively very small, reverse current. The reverse current results from the presence of some carriers of the type opposite to those that principally characterize the material.

With the two plates separated by practically zero spacing, the junction forms a capacitor of relatively high capacitance. This places a limit on the upper frequency at which semiconductor devices of this construction will operate, as compared with vacuum tubes. Also, the number of excess electrons and holes in the material depends on temperature, and since the conductivity in turn depends on the number of excess holes and electrons, the device is more temperature sensitive than a vacuum tube.

Capacitance may be reduced by making the contact area very small. This is done by means of a point contact, a tiny P-type region being formed under the contact point during manufacture when N-type material is used for the main body of the device.

Points to remember for PN junction

PN junctions are fabricated from a mono crystalline piece of semiconductor with both a P-type and N-type region in proximity at a junction.

The transfer of electrons from the N side of the junction to holes annihilated on the P side of the junction produces a barrier voltage. This is 0.6 to 0.7 V in silicon, and varies with other semiconductors.

A forward biased PN junction conducts a current once the barrier voltage is overcome. The external applied potential forces majority carriers toward the junction where recombination takes place, allowing current flow.

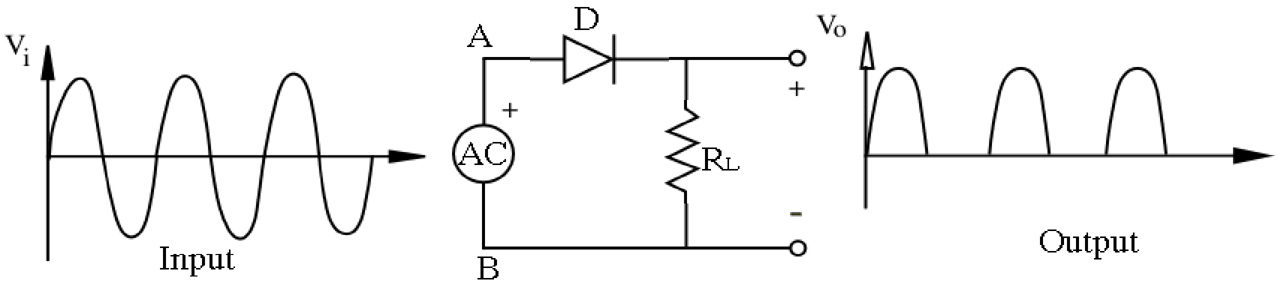
A reverse biased PN junction conducts almost no current. The applied reverse bias attracts majority carriers away from the junction. This increases the thickness of the non-conducting depletion region.

Reverse biased PN junctions show a temperature dependent reverse leakage current. This is less than a µA in small silicon diodes.

9. RECTIFIER

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

HALF-WAVE RECTIFIER: In half wave rectification the rectifier conducts current 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.



CIRCUIT DETAILS: A single crystal diode acts as a half wave rectifier. The AC supply is applied in series with the diode and load resistance R_L. AC supply is given through the transformer. There are two advantages using 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.

OPERATION: During positive half cycle of input AC voltage end A becomes positive with respect to end B. This makes the diode D forward biased and hence it conducts current. During the negative half cycle end A is negative with respect to B terminal. Under this condition the diode is reverse biased and it does not conduct current because semi-conductor diode conducts current only when it is forward biased. Therefore, the current flows through the diode during positive half cycles of input AC voltage only. It is blocked during the negative half cycles. In this way current flows through the load RL always in the same direction. DC output is obtained across R. The output across RL is pulsating DC. These pulsations in the output are removed with the help of filter circuits.

DISADVANTAGES:

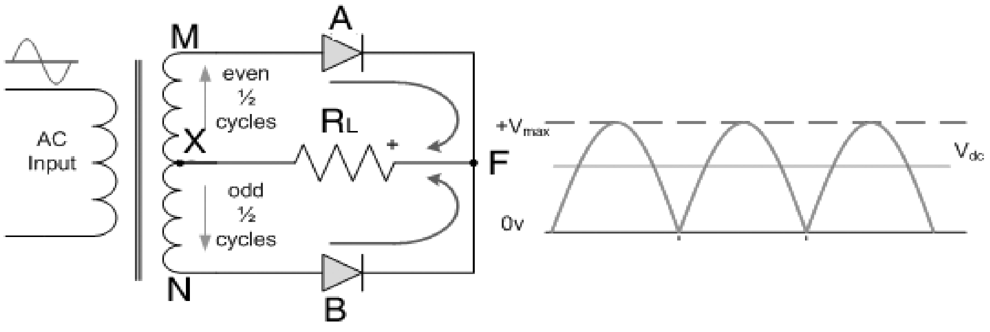
The pulsating output across load contains alternating component and direct Component.

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 halt cycle Therefore the output is low.

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 cycle the other diode. Therefore a full wave rectifier utilizes both half cycles of input AC voltage.



In the figure both the diodes are joined together at "F' to give the +ve end of the output. The secondary of the transformer is Centre tapped and its two ends are connected to the diodes.

The center point serves as the -ve end of the output. In one half cycle when "M" is at +ve potential and "N' is at -ve potential. The diode A conducts and the current flows along MAFX. In the next half cycle when N becomes +ve then diode B conducts and the currents flows along NBFX. So we find that output current keeps on flowing through load resistor RL in the same direction during both half cycles of AC input.

Difference between a half-wave and full-wave rectifier

In half-wave rectification, the rectifier conducts current only during the positive half cycles of input AC supply.

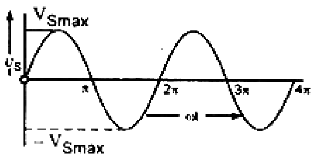
It consists of only single diode. The efficiency of Half-Wave rectifier is 40.6 %.Centre tapped transformer is not necessary.

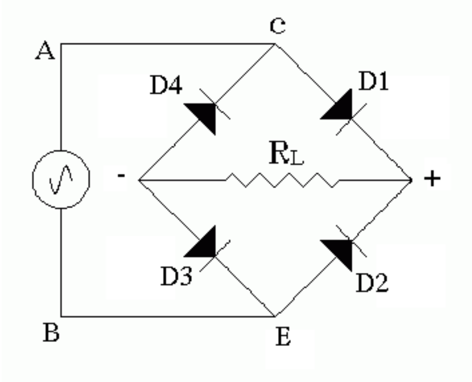
In full-wave rectification, current flows through the load in the same direction for both half cycles of input AC supply

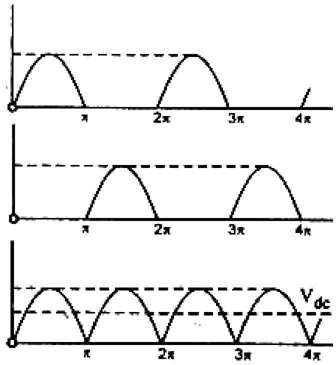
The efficiency of Full-Wave rectifier is 81 .2 %.

The output frequency is twice that of the AC supply frequency.

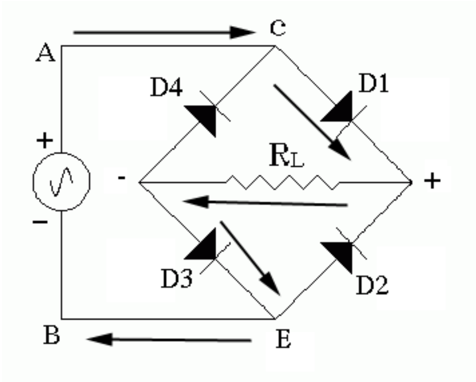
BRIDGE RECTIFIER

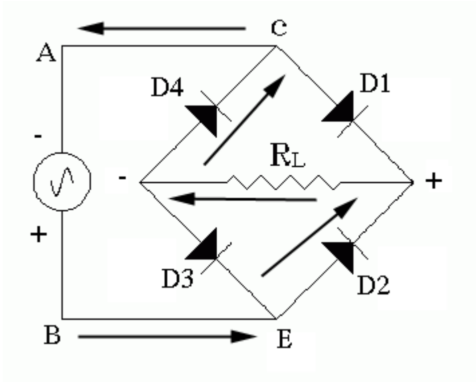






The need of a centre tapped power transformer is eliminated in the bridge rectifier. It consists of four diodes Dl, D2, D3 and D4 connected in the form of bridge. The AC supply is applied to the diagonally opposite ends of the bridge through the transformer. The other two ends of the bridge at one end of the load resistance R_L is connected at the other end are grounded.





Operation: During the positive half cycle of secondary voltage terminal ‘A’ becomes positive and ‘B’ is negative. This makes diode Dl, and D3 are forward biased and while D2 and D4 are reverse biased. Therefore only Dl and D3 conduct. These two diodes will be in series through the load RL.

During the negative half cycle, voltage at terminal ‘B’ becomes negative and terminal ‘A’ positive this makes diode D2 and D4 forward biased and Dl 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 centre tapped transformer is eliminated.

2) The output is twice that of the centre tap circuit for the same secondary voltage.

Disadvantages

It requires four diodes

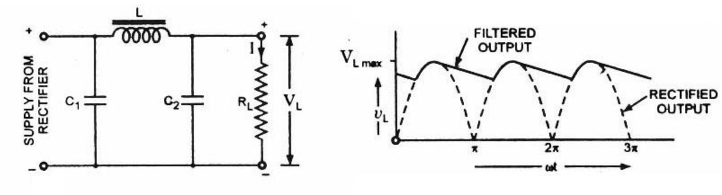
During each half cycle of AC input voltage two diodes are conducting in series so the voltage drop in the internal resistance of the rectifying unit will be twice. This is objectionable when secondary voltage is small.

SMOOTHING OR 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.

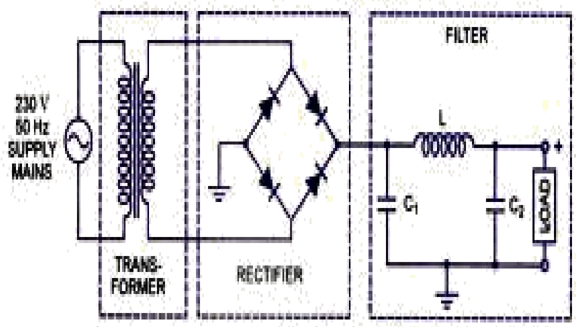


REGULATING CIRCUITS

Almost all electronic devices used in electronic circuits need a dc source of power to operate. The source of dc power is used to establish the dc operating points (Q-points) for the passive and active electronic devices incorporated in the system. The dc power supply is typically connected to each and every stage in an electronic system. It means that the single requirement common to all phases of electronics is the need for a supply of dc power. For portable low-power systems batteries may be used, but their operating period is limited. Thus for long time operation frequent recharging or replacement of batteries become much costlier and complicated. More frequently, however, electronic equipment is energized by a power supply, derived from the standard industrial or domestic ac supply by transformation, rectification, and filtering. The combination of a transformer, a rectifier and a filter constitutes an ordinary dc power supply, also called an unregulated power supply.

UNREGULATED POWER SUPPLY-BLOCK DIAGRAM

The block diagram of an ordinary power supply is depicted in the figure. Usually, a small dc voltage, in the range of 2—24 volts is required for the operation of different electronic circuits, while in India, single-phase ac supply is available at 230 V. A step-down transformer is used to reduce the voltage level. The rectifier converts the sinusoidal ac voltage into pulsating dc. The filter block reduces the ripples (ac components) from the rectifier output volt age. The filter passes dc component to the load and blocks ac components of the rectifier output.



Block Diagram of an Unregulated Power Supply

Poor Regulation

The output voltage is far from constant as the load varies. Voltage drop in the internal resistance of the supply increases directly with an increase in load current.

Variations in the ac supply mains

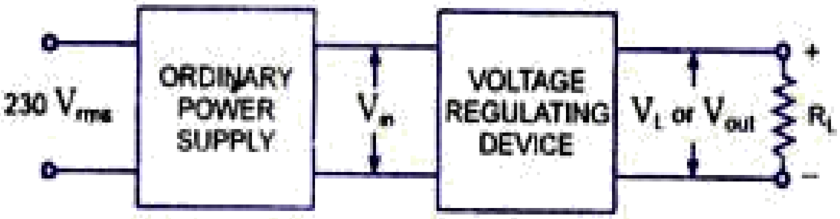
The dc output voltage is proportional to the input ac voltage, therefore, varies largely.

Variation in temperature

The DC output voltage varies with temperature, particularly if semiconductor devices are employed. For instance, in oscillators the frequency will shift, in transmitters output will get distorted, and in amplifiers the operating point will shift causing bias instability. Some feedback arrangement (acting as a voltage regulator) is employed in conjunction with an unregulated power supply to overcome the above mentioned three shortcomings and also to reduce the ripple voltage. Such a system is called a regulated power supply.

REGULATED POWER SUPPLY

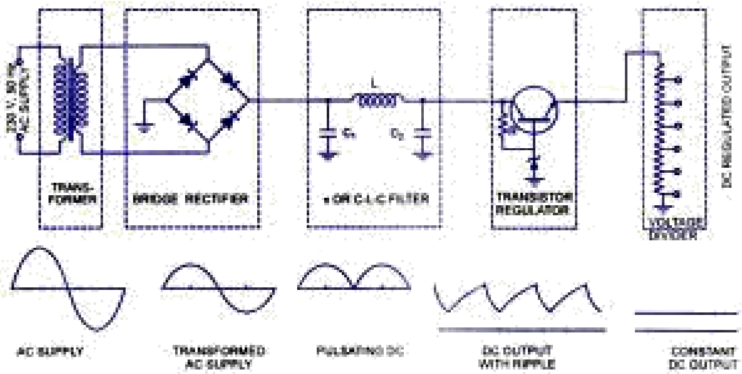
Regulated power supply is an electronic circuit that is designed to provide a constant DC voltage of predetermined value across load terminals irrespective of ac mains fluctuations or load variations.



Regulated Power Supply

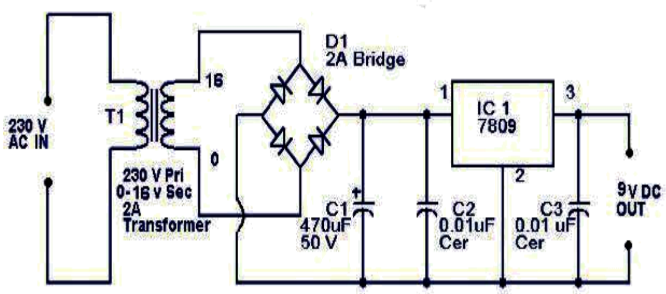
A regulated power supply essentially consists of an ordinary power supply and a voltage regulating device, as illustrated in the figure. The output from an ordinary power supply is fed to the voltage regulating device that provides the final output. The output voltage remains constant irrespective of variations in the ac input voltage or variations in output (or load) current.

Figure given below shows the complete circuit of a regulated power supply with a transistor series regulator as a regulating device. The ac voltage, typically 230 V_{rms} is connected to a transformer which transforms that ac voltage to the level for the desired dc output. A bridge rectifier then provides a full-wave rectified voltage that is initially filtered by a ∏ (or C-L-C) filter to produce a dc voltage. The resulting dc voltage usually has some ripple or ac voltage variation. A regulating circuit use this dc input to provide a dc voltage that not only has much less ripple voltage but also remains constant even if the input dc voltage varies somewhat or the load connected to the output dc voltage changes. The regulated dc supply is available across a voltage divider.



Complete Regulated Power Supply Circuit

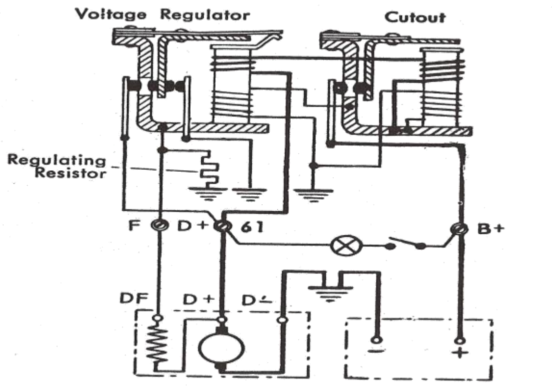
Regulated Power Supply Circuit



Often more than one DC voltage is required for the operation of electronic circuits. A single power supply can provide as many as voltages as are required by using a voltage (or potential) divider, as illustrated in the figure. As illustrated in the figure a potential divider is a single tapped resistor connected across the output terminals of the supply. The tapped resistor may consist of two or three resistors connected in series across the supply. In fact, bleeder resistor may also be employed as a potential divider.

REGULATION

The output voltage of a power supply always decreases as more current is drawn, not only because of increased voltage drops in the transformer and filter chokes, but also because the output voltage at light loads tends to soar to the peak value of the transformer voltage as a result of charging the first capacitor . Proper filter design can eliminate the soaring effect. The change in output voltage with load is called voltage regulation, and is expressed as a percentage.

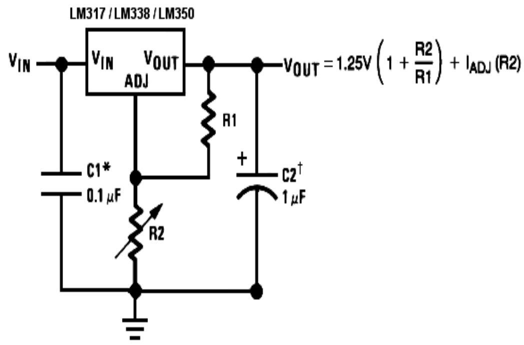


Wiring diagram of the regulator.

PERCENT REGULATION = 100(E1-E2)/E2 Where E1= the no-load voltage, E2= the full-load voltage A steady load ,such as represented by a receiver, speech amplifier or unkeyed stages of a transmitter, does not require good (low) regulation as long as proper voltage is obtained under load conditions. However, the filter capacitors must have a voltage rating safe for the highest value to which the voltage will soar when the external load is removed. When essentially constant voltage regardless of current variation is required (for stabilizing a oscillator), special voltage regulating circuits are used.

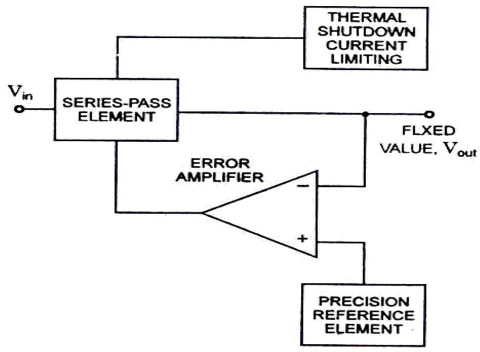
Electronic Voltage Regulation

When extremely low ripple is required or when the supply voltage must be constant with large fluctuations of load current and line voltage, a closed loop amplifier is used to regulate the supply. There are two main categories of electronic regulators: linear regulators, in which the condition of the control element is varied in direct proportion to the line voltage or load current; and switching regulators, in which the control device is switched ON and OFF, with the duty cycle proportion to the line or load conditions. Each system has relative ad vantages and disadvantages, and there are applications for both types in amateur radio equipment.



IC Voltage Regulators

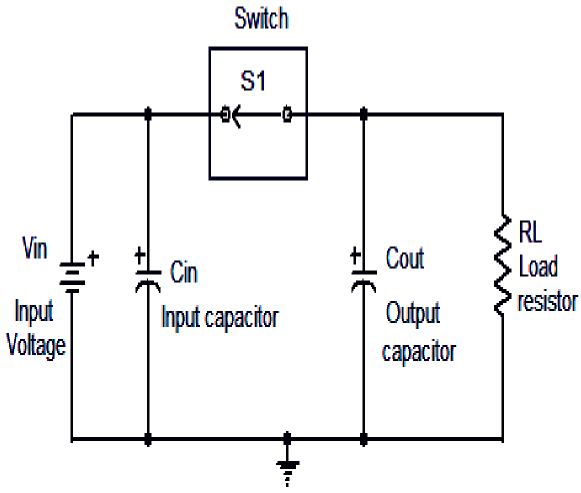
The modern trend in regulators is toward the use of three-terminal devices commonly referred to as three terminal regulators. Inside each regulator is a reference, a high gain error amplifier, temperature compensated voltage sensing resistors and transistors and a pass element. Many currently available units have thermal shutdown over voltage protection and current fold back, making them virtually fool proof.



Fundamental Block Diagram of a Three-Terminal IC Voltage Regulator

Three terminal regulators are available as positive or negative types. In most cases positive regulator is used to regulate a positive voltage and a negative regulator to a negative regulator. However, depending on the systems ground requirement each regulated type may be used to regulate the “opposite” voltage.

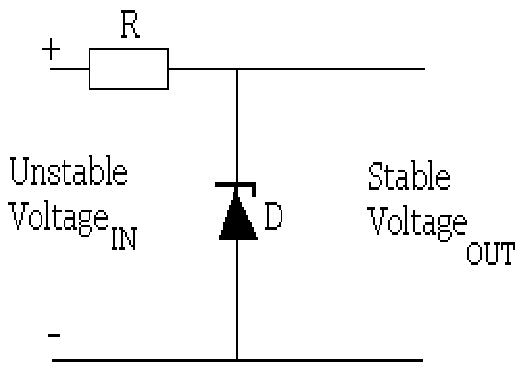
SWITCHING REGULATORS



Schematic of a simplified switching regulator

Just as the transistor has replaced the inefficient vacuum tube, the linear voltage regulator is rapidly being replaced by the switching regulator. This transition is being assisted by the availability of components made especially for switching supplies, such as high–speed switching transistors and diodes, capacitors, transformer cores and so on .The introduction of switching-regulator integrated circuits has also lowered the complexity of switchers to a degree that rivals linear regulators, and new circuit design techniques have reduced regulator noise and ripple to acceptable levels for communications equipment. The switching regulator (also known as a switching mode regulator or SMR) offers several advantages over the linear type: Much higher efficiency resulting from minimal regulator dissipation. Very desirable for battery–powered applications. Lighter in weight as a result of less heat sink material smaller in size.

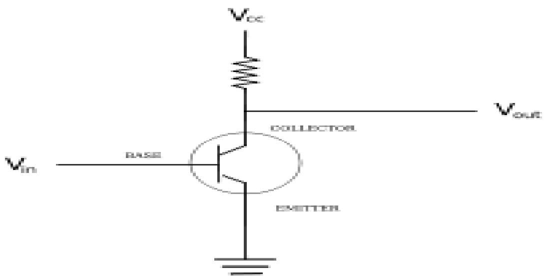
VOLTAGE STABILIZATION (Zener Diode Regulation)



Zener diode can be used to maintain the voltage applied to the circuit at a practically constant value, regardless of the voltage regulation of the power supply or variations in load current. The typical circuit is shown in the figure. Note that the cathode side is connected to the positive side of the supply. Zener diodes are available in a wide variety of voltages and power ratings. The voltages range from less than two to a few hundred, while the power ratings (power the diode can dissipate) run from less than 0.25 watt to 50 watts. The ability of the Zener diode to stabilize a voltage depends on the conducting impedance of the diode. This can be as low as one ohm or less in a low voltage, high-power diode or as high as a thousand ohms in a high voltage, low power diode.

10. TRANSISTOR

Solid –state devices are also called semi-conductors. The prefix semi means half. They have electrical properties between those of conductors and those of insulators. The conductivity of a material is proportional to the number of free electrons in the material. Pure Germanium and pure Silicon crystals have relatively few free electrons. If carefully controlled amount of impurities (materials having a different atomic structure, such as arsenic or antimony) are added, the number of free electrons, and consequently the conductivity, is increased. When certain other impurities are introduced (Such as Aluminum, Gallium or Indium), an electron deficiency, or hole, is produced. As in the case of free electrons, the presence of holes encourages the flow of electrons in the semiconductor material that conducts by virtue of the free electrons is called N-type material; material that conducts by virtue of an electron deficiency is called P-type.



The word "transistor" was chosen to describe the function of a three-terminal PN junction device that is able to amplify signal energy (current).

A thin **N** layer sandwich between two **P**-type layers semiconductor material. There are in effect two PN junction diodes back-to-back. If a positive bias is applied to the P-type material at the left current will flow through the left-hand junction, the holes moving to the right and the electrons from the N-type material will combine with the electrons there and be neutralized, but some of them also will travel to the region of the right-hand junction.

If the PN combination at the right is biased negatively there would normally be no current flow in this circuit. However, there are now additional holes available at the junction to travel to point and electrons can travel so, a current can flow even though this section of the sandwich is biased to prevent conduction. Most of the current is between the two points and does not flow out through the common connection to the N-type material is sandwich.

A semiconductor combination of this type is called a Transistor, and the three sections are known as the emitter, base and collector. The amplitude of the collector current depends principally on the amplitude of the emitter current i,e, the collector current is controlled by the emitter current.

Between each PN junction exits an area known as the depletion, or transition region. It is similar in characteristics to a dielectric layer, and its width varies in accordance with the operating voltage. The semiconductor materials either side of the depletion region constitute the plates of a capacitor. The capacitance from base to emitter and the base-collector capacitance are represented by C_{be} and C_{bc} Power Amplification.

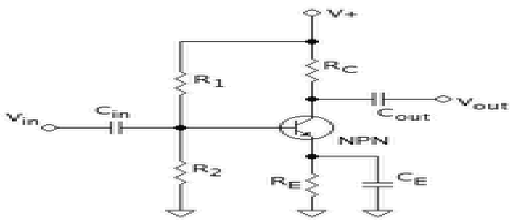
Because the collector biased in the back direction the collector to base resistance is high. On the other hand, the emitter and collector currents are substantially equal, so the power in the collector circuit is larger than the power in the emitter circuit (P=I2R, so the powers are proportional to the respective resistance, if the currents are the same). In practical transistors emitter resistance is on the order of a few ohms while the collector resistance is hundreds or thousands of times higher, so power gains of 20 to 40 db or even more are possible.

Transistor types

As shown in the figure the transistors may be one of PNP and NPN type. The assembly of P-type and N-Type materials may be reversed. The first two letters of the NPN and PNP designations indicate the respective polarities of the voltages applied to the emitter and collector in normal operation. In a PNP transistor, for example, the emitter is made positive with respect to both the collector and the base, and the collector is made negative with respect to both the emitter and the base.

Transistor Characteristics

An important characteristic of a transistor is its current amplification factor, which is sometimes expressed as static forward current transfer ratio or small signal forward current transfer ratio. Both relate to the grounded-emitter configuration.

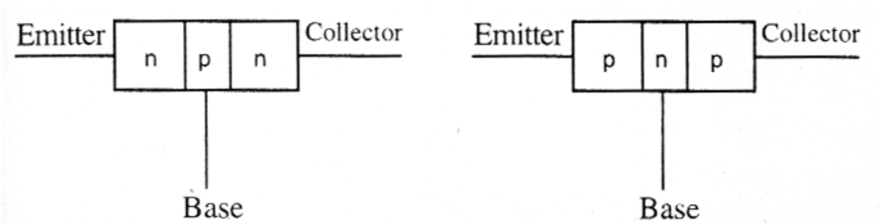


A transistor consists of two PN junctions formed by sandwiching either P-type or N-type semiconductor between a pair opposite types. Accordingly, there are two types of transistors namely:

(i) N-P-N transistor (ii) P-N-P transistor

An N-P-N transistor is composed of two N-type semiconductors separated by a thin section of P-type as shown below

(i) However, a P-N-P transistor is formed by two p-sections separated by a thin section of N-type as shown below.



When a third doped element is added to a crystal diode in such a way that two PN junctions are formed, the resulting device is known as a transistor.

A transistor consists of two PN junctions formed by sandwiching either p type or n-type semiconductor between a pair of opposite types. Accordingly; there are two types of transistors, namely

(I) P-N-P transistor (II) N-P-N transistor

An N-P-N transistor is composed of two N-type semiconductors separated by a thin section of P-type. A P-N-P transistor is formed by two p-sections separated by a thin section of N-type.

EMITTER

The section on one side that supplies charge carriers (electrons or holes) is called the emitter. The emitter is always forward biased w.r.t. Base so that it can supply a large number of majority carriers (Holes if emitter is p-type and electrons if the emitter is N-type). The emitter is heavily doped so that it can inject a large number of charge carriers (electrons or holes) into the base.

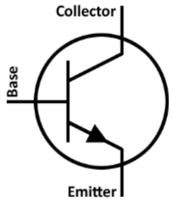
COLLECTOR

The section on the other side that collects the charges is called the collector. The collector is always reverse biased. Its function is to remove charges from its junction with the base. The collector is moderately doped.

BASE The middle section which forms two PN -junctions between the emitter and collector is called the base. The base-emitter junction is forward biased, allowing low resistance for the emitter circuit. The base-collector junction is reverse biased and provides high resistance in the collector circuit. The base is lightly doped and very thin: it passes most of the emitter injected charge carriers to the collector

WORKING OF NPN TRANSISTOR:

The below figure shows the NPN transistor with forward bias to emitter- base junction and reverse bias to collector-base junction. The forward bias causes the electrons in the n-type emitter to flow towards the base. This constitutes the emitter current le. As these electrons flow through the p-type base, they tend to combine with holes. As the base is lightly doped and very thin, therefore, only a few electrons (less than 5%) combine with holes to constitute base current lb (The electrons which combine with holes become valence electrons Then as valence electrons, they flow down through holes and into the external base lead This con lightly doped and very thin; it passes most of the emitter injected charge carriers to the collector.



N-P-N transistor

The reasons that most of the electrons from emitter continue their journey through the base to collector to form collector current are.

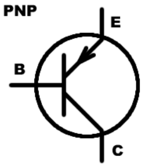
(i) The base is lightly doped and very thin. Therefore, there are a few holes, which find enough time to combine with electrons.

(ii) The reverse bias on collector is quite high and exerts attractive forces on these electrons

WORKING OF PNP TRANSISTOR:

The below figure shows the PNP transistor with forward bias causes the holes in the p-type emitter to flow towards the base. This constitutes the emitter current le. As these holes cross in to n-type base, they tend to combine with the electrons.

Beta = ΔIc/ΔIb



P-N-P transistor

As the base is lightly doped and very thin, therefore, only a few holes (less than 5%) combine with the electrons. The remainder (more than 95%) cross over into the collector region to constitute collector current IC. In this way, almost the entire emitter current flows in the collector circuit. It may be noted that current conduction within PNP transistor is by holes.

In this circuit input is applied between base and emitter and output is taken from the collector and emitter. Here emitter of the transistor is common to both input and output circuits and hence the name common emitter Connection.

Base current Amplification factor: In common emitter connection input current is ‘b and output current is I.

The ratio of change in collector current delta I to the change in base current delta ‘b is known as base current amplification factor. It is represented by letter Beta. In any transistor less than 5% of emitter current flows as the base current. Therefore the value of Beta is generally greater than 20.

Usually its value changes from 20 to 500. This type of connection is widely used because of appreciable current gain as well as voltage gain.

RELATION BETWEEN BETA AND ALPHA

When Alpha approaches unity, Beta approaches infinity that is the current gain in common emitter connection is very high. Because of this reason this circuit arrangement is used in about 90 to 95% of all transistor applications

Input characteristics: It is the curve between base current ‘b' and base - emitter voltage Vbe at constant collector - emitter voltage Vce.

By keeping Vce constant say at 10 volts note the base current lb for various values of Vbe. Then plot the readings obtained on the graph, taking lb along Y-axis and Vbe along X-axis. This gives the input characteristic at Vce = 10 volts. Following the similar procedure as above, a family of input characteristics can be drawn.

11. AMPLIFIER

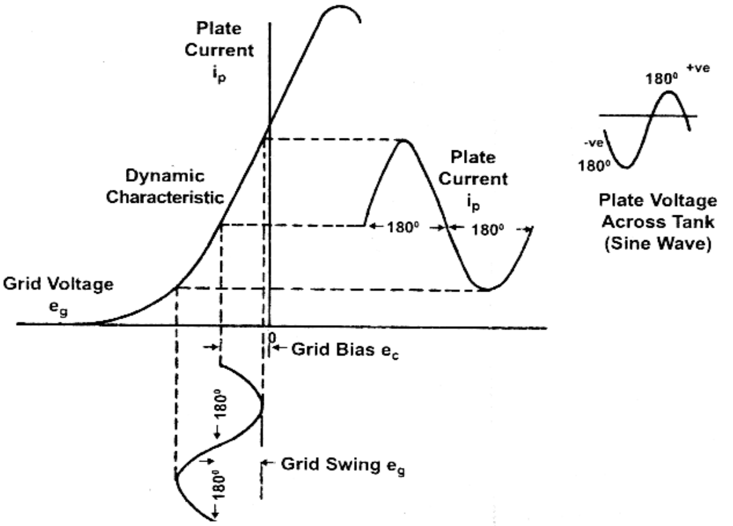
A device which amplifies weak signals to strong signals is called an amplifier.

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

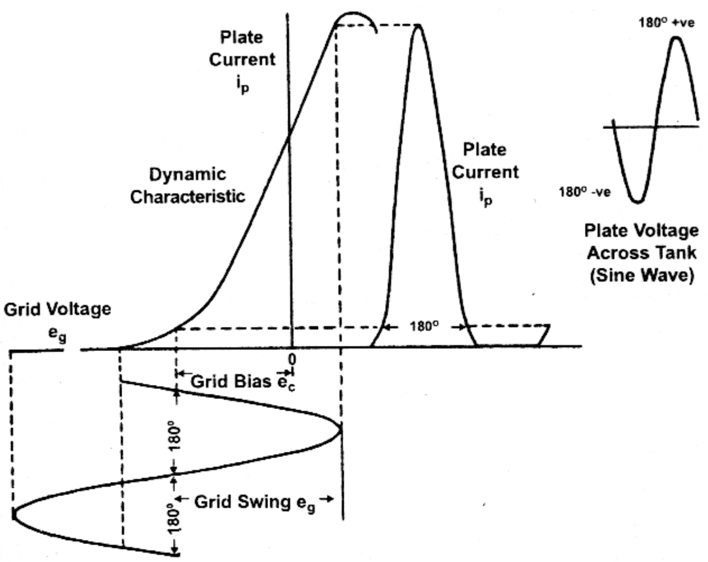
1. Since the tube operates over the linear portion of the dynamic curve, hence the waveform at the output is exactly similar to that of input. Therefore they are used where freedom from distortion is the main factor.

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 plate 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

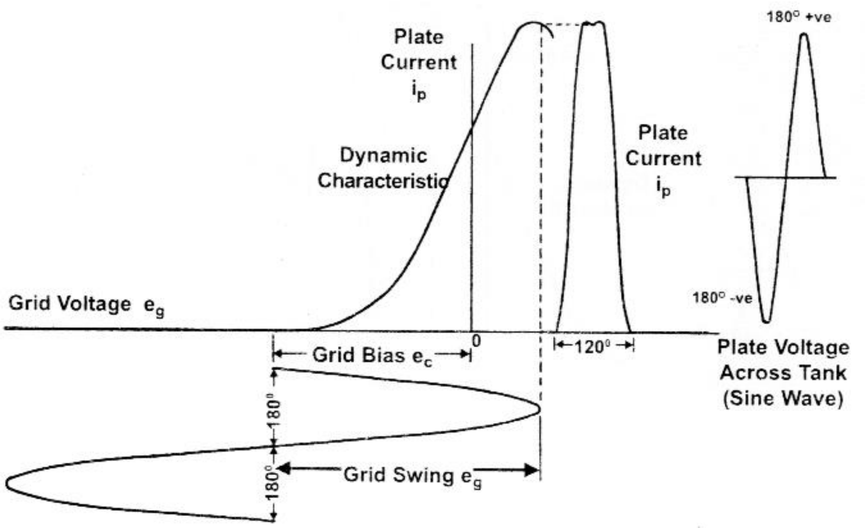
4. For a given tube rating, the power output is relatively high.

CLASS 'AB' AMPLIFIER

The grid bias and signal voltages are so adjusted that the plate current flows for more than half and less than entire cycle. The characteristic of this amplifier lie in between those of class A' and class 'B amplifiers.

CLASS 'C' AMPLIFIER

In these type of amplifiers the tube s 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. Since the grid may be driven to the plate saturation value of grid voltage, so 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.

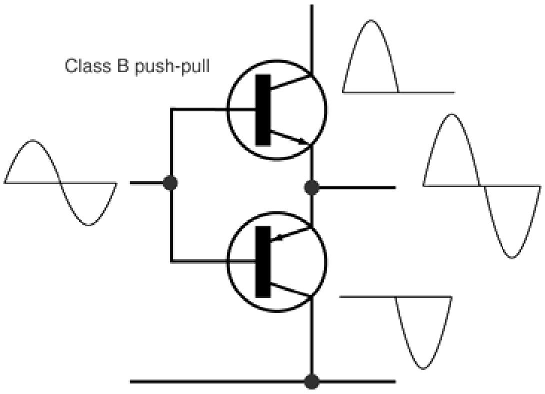
3. Power output per tube is higher as compared to class B' amplifier.

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

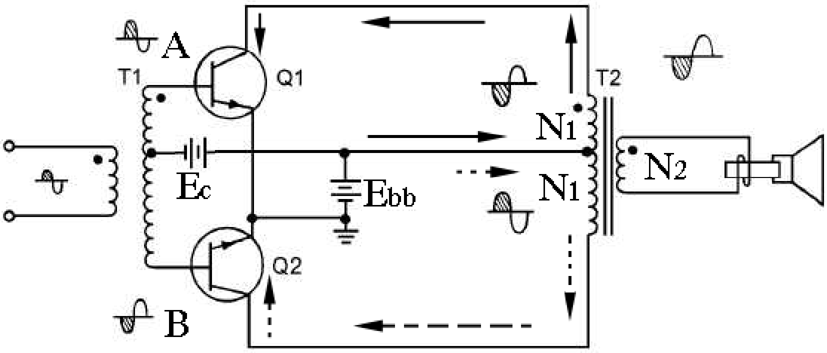
These amplifiers are not used as audio frequency amplifiers because of high distortion. But they are used as radio frequency amplifiers for high power output.

PUSH PULL AMPLIFIER

In order to increase the efficiency in power amplification, two Transistors are used in push pull arrangements in the output stage. One Transistor amplifies the +ve half cycle of the signal while the other Transistor amplifies the -ve half cycle of the signal



Push pull arrangement: when one Transistor is pushing (conduction), the other is pulling (stopping conduction).



Circuit details: Below figure shows the circuit where two Transistors Q1 and Q2 are used in push pull. Both the Transistors are operated in class B operation i.e. plate current is nearly zero in the absence of the signal. The centre tapped secondary of the input transformer T1 supplies equal and opposite voltage to the grid circuit of the two Transistors. The output transformer T2 has centre 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 will make the base of transistor Q1 more +ve and that of Transistor Q2 more -ve. This does not means that grid will actually become +ve. It cannot happen because the DC base bias keeps both base at a -ve potential. Thus transistor Q1 conducts and Transistor Q2 is cut off. Therefore, this half cycle of the signal is amplified by transistor Q1 and appears in upper half of the output transformer primary. ln the next half cycle of the signal, transistor Q2 conducts and transistor Q1 is cut off therefore this half cycle of the signal is amplified by transistor Q2 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.

Advantages: Its efficiency is high (About 80%)

For the same base current dissipation, the output power is nearly 5 times of a single Transistor amplifier.

Ex: 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.

(i) 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

(ii) 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.

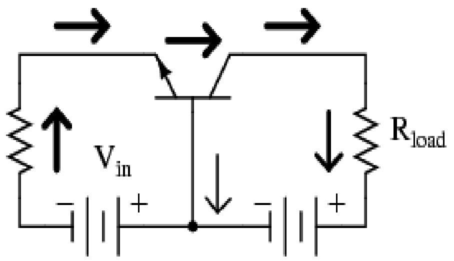
(iii) PHASE DISTORTION

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.

Transistor Amplifiers

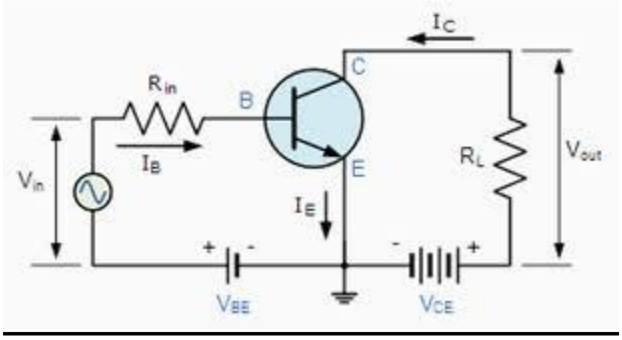
Amplifier circuits used with transistors fall into one of three types, known as the common-base, common-emitter and common-collector circuits. The three circuits shown in the figure correspond approximately to the grounded-grid, grounded-cathode and cathode-follower circuits, respectively, used with vacuum tubes.

Common Base Circuit



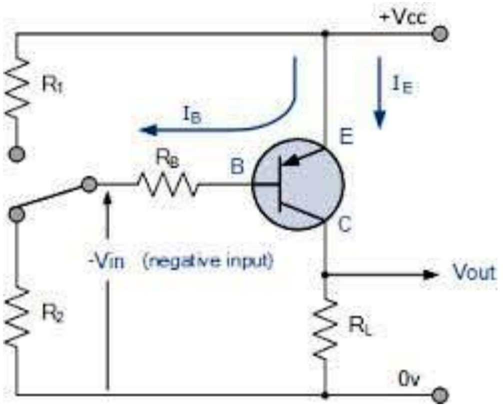
The input circuit of a common-base amplifier must be designed for low impedance, since the emitter-to-base resistance is of the order of $26/I_e$ ohms, where $I_{.e.}$ is the emitter current in milli amperes. The optimum output load impedance, R_L may range from a few thousand ohms to 100,000 depending on the requirements. In this circuit the phase of the output (collector) current is the same as that of the input emitter) current. The parts of these currents that flow through the base resistance are likewise in phase, so the circuit tends to be regenerative and will oscillate if the current amplification factor is greater than one.

Common Emitter Circuit



The common-emitter circuit shown in the figure corresponds to the ordinary grounded-cathode vacuum-tube amplifier. The base current is small and the input impedance is therefore fairly high-several thousand ohms in the average case. The collector resistance is some tens of thousands of ohms, depending on the signal source impedance. The common-emitter circuit has a lower cutoff frequency than does the common-base circuit, but it gives the highest power gain of the three configuration.

Common Collector Circuit



Like the vacuum tube cathode follower, the common-collector transistor amplifier has high input impedance and low output impedance. The input resistance depends on the load resistance. The input resistance is directly related to the load resistance is a disadvantage of this type of amplifier if the load is one whose resistance or impedance varies with frequency. The output and input currents are in phase.

12. OSCILLATOR

An oscillator is a mechanical or electronic device that works on the principles of Oscillations, 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 time piece 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.

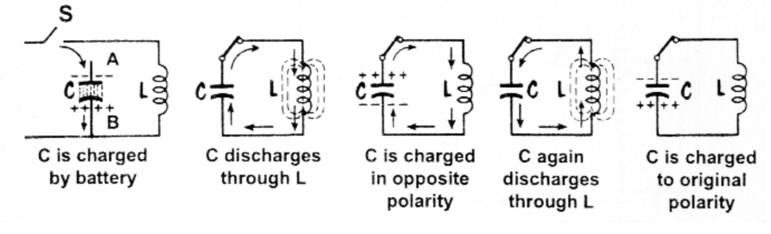
In a computer, a specialized oscillator, called the clock, serves as a sort of pacemaker for the microprocessor. The clock frequency (or Clock Speed) is usually specified in megahertz (MHz), and is an important factor in determining the rate at which a computer can perform instructions.

How Oscillators Work

A basic oscillator is a capacitor and inductor connected together. As the capacitor discharges, the current creates a magnetic field in the inductor. When the capacitor is fully discharged, the field collapses and induces an opposite current that charges the capacitor again. This cycle continues until all the energy is lost through resistance. The frequency of the oscillations depends on the size of the capacitor and inductor.

Every component has some inherent electrical noise, and this noise provides the initial signal for an oscillator. The output noise is sent back to the input as feedback to be filtered and amplified. This process eventually turns the noise into a steady signal.

OSCILLATIONS IN AN L-C TANK CIRCUIT



S- Switch *C – Capacitor L - Inductor*

First charge up the condenser, then

(i) When Switch S is closed, electrons move from plate A' to plate 'B' through coil L

(ii)As electronic current starts flowing, the self induction of the coil opposes the current flow hence the rate of discharge of electrons is somewhat slowed down.

(iii) As plate 'A' losses its electrons by discharge, the electron current has a tendency to die down because both the plates are reduced to the same potential. But due to self induction or electric inertia of the coil more electrons are transferred to 'B' than are required to fill the deficiency of electrons at B'.

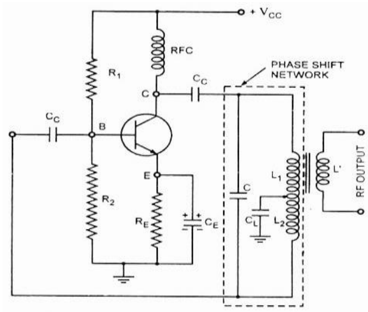
(iv) It means ‘B’ becomes negative with respect to A’ hence condenser ‘C’ charged again but in the opposite direction.

(v) After this, the condenser discharges in the opposite direction and charging the condenser again.

(vi) This sequence of charging and discharging continues and constitutes oscillating current.

But these oscillations are damped because some energy is dissipated in the form of heat and some in the form of electromagnetic waves.

HARTLEY OSCILLATOR



Here the plate coil is continues with grid con, the former having less number of turns than the latter, but is also tuned. The frequency is determined by LC. The feed back is adjusted by moving the tap upwards for including more plate coil turns.

1. On closing the switch ‘S’ an EMF is applied to L through C_1, hence damped oscillations are set upon the LC circuit.

2. The variations in grid voltage produced due to oscillatory discharge of C produces variations in plate current.

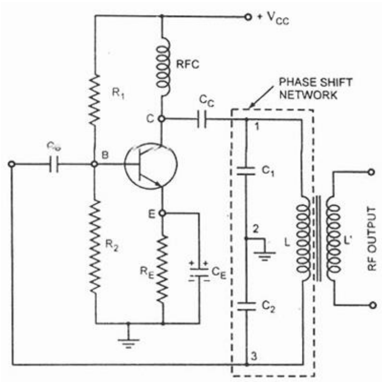
3. These variations in plate voltage are fed back to LC circuit through C1.

4. Due to the tapped construction of coil L, the phase of the feed back is correct. When end ‘A’ of coil L is positive the ‘B’ is negative or 180 degree out of phase with each other. Since A’ is connected to grid and C’ is connected to anode they are, at 180 degree out of phase. This results in total phase difference of 360 degrees. This makes AC plate energy feed back to grid exactly in phase with grid energy. Hence the oscillations can be maintained.

5. The function of radio frequency choke (RFC) is to prevent the RF energy set up in L from being short circuited through the battery supply.

COLPITT’S OSCILLATOR

In this circuit the tap is taken between two condensers instead of between two coils as in Hartley oscillator. Here the feed back is through electrostatic coupling whereas in Hartley circuit it is through electromagnetic coupling.



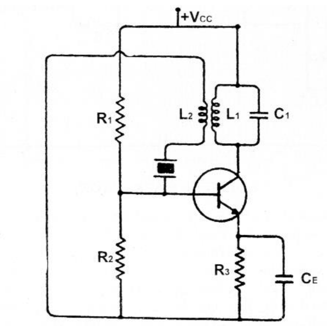
OPERATION: When switch S is closed the capacitors Cl and C2 are charged. These capacitors discharge through coil L, setting up oscillations of a given frequency. The oscillations across C2 are applied to the grid and appear in the amplified form in the plate circuit and supply losses to the tank circuit. The amount of feedback depends upon the relative capacitance values of Cl and C2. The smaller the capacitance Cl, the greater the feedback. It is easy to ascertain that energy feedback to tank circuit is of correct phase. The capacitors Cl and C2 act as a simple alternating voltage divider. Therefore, points A & B are 180 Degrees out of phase. The plate output produces a further phase shift of 180 Degrees. In this way, feedback is properly phased to produce continuous un-damped oscillations.

PIEZOELECTRIC EFFECT

Certain crystalline materials, namely; Rochelle salt, quartz and tourmaline exhibit the piezoelectric effect i.e. when we apply an AC voltage across them, they vibrate at the frequency of the applied voltage. Conversely, when they are compressed or placed under mechanical strain to vibrate, they produce an AC voltage. Such crystals, which exhibit piezoelectric effect, are called piezoelectric crystals. Of the various piezoelectric crystals, quartz is most commonly used because it is inexpensive and readily available in nature.

TRANSISTOR CRYSTAL OSCILLATOR

A tank circuit L1-C1 is placed in the collector and the crystal is connected in the base circuit. Feedback is obtained by coil L2 inductively coupled to coil Li. The crystal is connected in series with the feedback winding. The natural frequency of L C circuit is made nearly equal to the natural frequency of crystal.



CIRCUIT OPERATION: When the power is turned on, capacitor Cl is charged. When this capacitor discharges, it sets up oscillations. The voltage across Li is fed to coil L2 due to mutual inductance. This positive feedback causes the oscillator to produce oscillations. The crystal controls the frequency of oscillations in the circuit. It is because the crystal is connected in the base circuit and hence its influence on the frequency of the circuit is much more than LC circuits. Consequently, the entire circuit vibrates at the natural frequency of the crystal. As the frequency of crystal is independent of temperature etc, therefore, the circuit generates a constant frequency.

Advantages:

1) They have a 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.

Disadvantages:

1) They are used in low power circuits.

2) The frequency of oscillators cannot be changed.

Exercise

1) A semi-conductor is

(A) one which conducts only half of applied voltage

(B) a material whose conductivity is same as between that of a conductor and an insulator

(C) a material made of alternate layers of conducting material and insulator

(D) a material which has conductivity and having average value of conductivity of metal and insulator.

2) A p-n junction is said to be forward biased, when

(a) the positive pole of the battery is joined to the p-semiconductor and negative pole to the n-semiconductor

(b) the positive pole of the battery is joined to the n-semiconductor and negative pole of the battery is joined to the p-semiconductor

(c) the positive pole of the battery is connected to n- semiconductor and p-semiconductor

(d) a mechanical force is applied in the forward direction

3) At absolute zero, Si acts as?

(a) non-metal (b) metal (c) insulator (d) none of these

4) When N-type semiconductor is heated?

(a) number of electrons increases while that of holes decreases

(b) number of holes increases while that of electrons decreases

(c) number of electrons and holes remain same

(d) number of electron and holes increases equally.

5) Radio waves of constant amplitude can be generated with

(a) FET (b) filter (c) rectifier (d) oscillator

6) The depletion layer in the P-N junction region is caused by?

(a) drift of holes

(b) diffusion of charge carriers

(c) migration of impurity ions

(d) drift of electrons

7) To use a transistor as an amplifier

(a) The emitter base junction is forward biased and the base collector junction is reversed biased

(b) no bias voltage is required

(c) both junction are forward biased

(d) both junctions are reversed biased.

8) For amplification by a triode, the signal to be amplified is given to

(a) the cathode (b) the grid (c) the glass-envelope (d) the anode

9) A piece of copper and other of germanium are cooled from the room temperature to 80K, then

(a) resistance of each will increase

(b) resistance of copper will decrease

(c) the resistance of copper will increase while that of germanium will decrease

(d) the resistance of copper will decrease while that of germanium will increase

10) Diamond is very hard because?

(a) it is covalent solid

(b) it has large cohesive energy

(c) high melting point

(d) insoluble in all solvents

11) The part of the transistor which is heavily doped to produce large number of majority carriers is (a) emitter
(b) base
(c) collector
(d) any of the above depending upon the nature of transistor

12) An Oscillator is nothing but an amplifier with
(a) positive, feedback
(b) negative feedback
(c)large gain
(d) no feedback

13) When a P-N junction diode is reverse biased the flow of current across the junction is mainly due to
(a) diffusion of charge
(b) drift charges
(c) depends on the nature o material
(d) both drift and diffusion of charges

14) Which of the following, when added as an impurity, into the silicon, produces n-type semi conductor
(a)Phosphorous
(b) Aluminum
(c)Magnesium
(d) both ‘b’ and ‘c’

15) 21. When a n-p-n transistor is used as an amplifier then?
(a) the electrons flow from emitter to collector
(b) the holes flow from emitter to collector
(c) the electrons flow from collector to emitter
(d) the electrons flow from battery to emitter

16) When arsenic is added as an impurity to silicon, the resulting material is?
(a) n-type semiconductor
(b) p-type semiconductor
(c) n-type conductor
(d) Insulator

17) To obtain a p-type germanium semiconductor, it must be doped with?
(a)arsenic
(b)antimony
(c)indium
(d)phosphorus

18) A semi-conducting device is connected in a series circuit with a battery and a resistance. A current is found to pass through the circuit. If the polarity of the battery is reversed, the current drops to almost zero. The device may be
(a) A p-n junction
(b) An intrinsic semi-conductor
(c) A p-type semi-conductor
(d) An n-type semi-conductor

19) The cause of the potential barrier in a p-n diode is ?
(a) Depletion of positive charges near the junction
(b) Concentration of positive charges near the junction
(c) Depletion of negative charges near the junction
(d) Concentration of positive and negative charges near the junction

20) In forward bias, the width of potential barrier in a p-n junction diode?

(a) increases (b) decreases
(c) remains constant (d) first increases then decreases

21) A depletion lay consists of?

(a) electrons (b) protons
(c) mobile ions (d) immobile ions

22) Which of the following when added acts as an impurity into silicon produced n-type semi conductor?

(a) P (b) Al (c) B (d) Mg

23) In a junction diode, the holes are due to

(a) protons (b) extra electrons
(c) neutrons (d) missing electrons

24) The intrinsic semiconductor becomes an insulator at

(a)0°C (b)0 K (c) 300K (d) -100°C

25) In a p-n junction

(a) The potential of the p and n sides becomes higher alternately
(b) The p side is at higher electrical potential than the n side
(c) The n side is at higher electrical potential than the p side
(d) Both the p and n sides are at the same potential

26) if a full wave rectifier circuit is operating from 50 Hz mains, the fundamental frequency in the ripple will be

(a)100Hz (b) 25Hz (c)50Hz (d) 70.7 Hz

27) A n-p-n transistor conducts when?

(a) both collector and emitter are negative with respect to, the base
(b) both collector and emitter are positive with respect to the base
(c) collector is positive and emitter is negative with to the base
(d) collector is positive and emitter is at same potential as the base

28) Barrier potential of a p-n junction diode does not depend on?

(a)doping density (b) diode design
(c)temperature (d) forward bias

29) Reverse bias applied to a junction diode

(a) increases the minority carrier current
(b) lowers the potential barrier
(c) raises the potential barrier
(d) increases the majority carrier current

30) In semiconductors at a room temperature

(a) the conduction band is completely empty
(b) the valence band is partially empty and the conduction band is partially filled
(c) the valence band is completely filled and the conduction band is partially filled
(d) the valence band is completely filled

13. MODULATION

The audio frequency signals cannot be radiated out from the aerial directly because transmission at audio frequencies is not practical. For this purpose oscillations of very high frequency or radio frequency are produced with the help of oscillators. These electromagnetic waves so produced are of constant amplitude and of extremely high frequencies. The audio frequency signal is then super imposed on the RF waves which are known as Carrier waves (because they carry AF signals through space to distant places). The process by which AF signal is super imposed on the Carrier wave is known as Modulation. The RF and the AF travel through the space and at the receiving end they strike the receiver aerial and enter the receiver which separates the RF from the AF. The audio frequency signal is converted back into sound. This process by which RF waves and AF waves are separated is known as detection or demodulation (because it is the reverse of modulation). There are three types of Modulations, namely

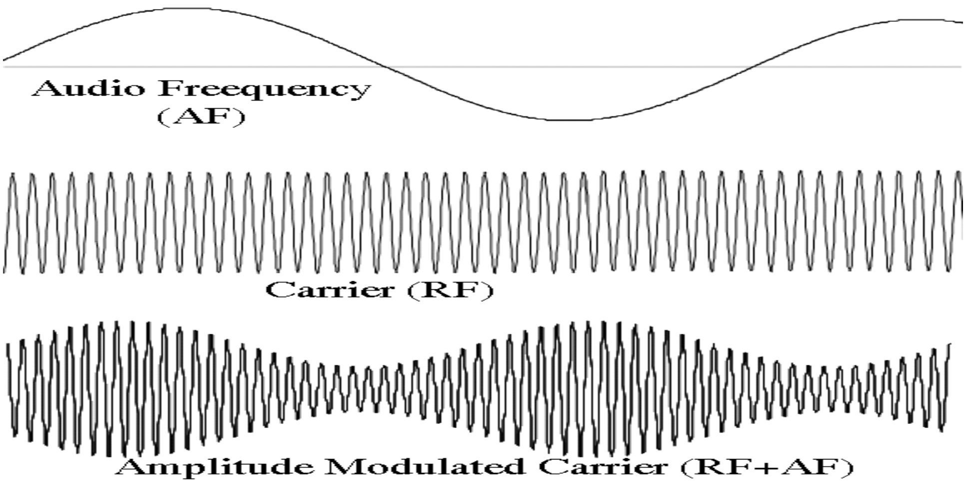
I) Amplitude Modulation

ii) Frequency Modulation

iii) Phase Modulation

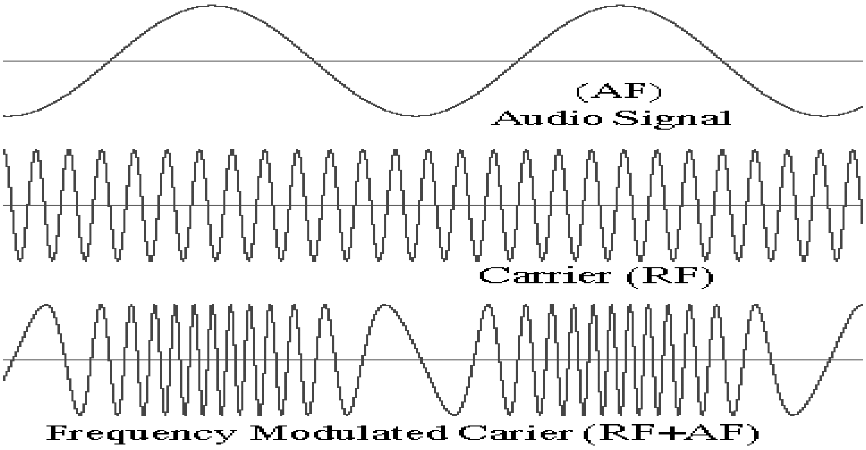
AMPLITUDE MODULATION

A method of transmission and reception of radio waves in which the amplitude of the carrier wave is made to vary in accordance with the audio frequency wave.

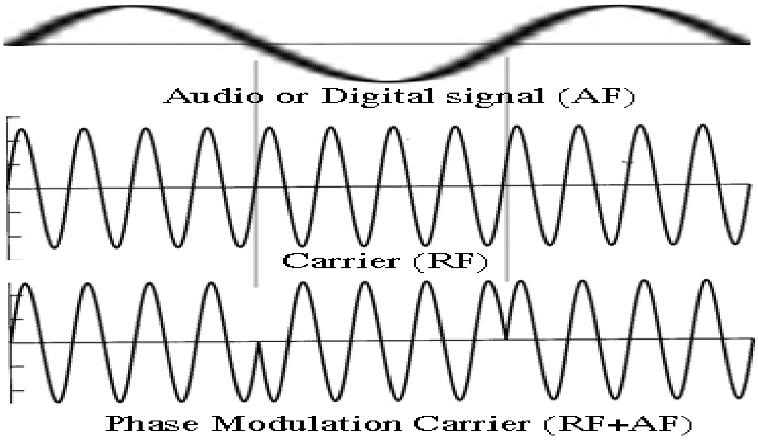


FREQUENCY MODULATION

In this method the carrier wave is modulated by changing its frequency in relation to the AF signal without changing its amplitude. This process is known as frequency modulation (FM).



PHASE MODULATION

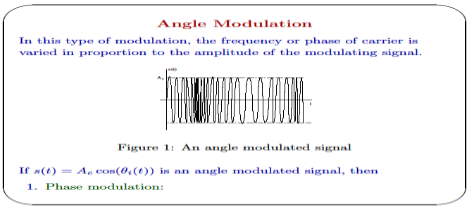


A method of conveying information via radio frequency carrier waves in which the instantaneous phase of the carrier is shifted in accordance with the audio frequency wave. Phase Modulation is very similar to FM wave.

Major Modulation Systems

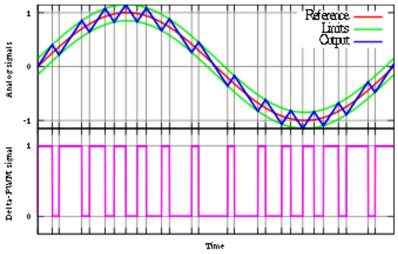
The broadcast category of modulation systems is how the main carrier is modulated. The major types are amplitude modulation, angle modulation and pulse modulation.

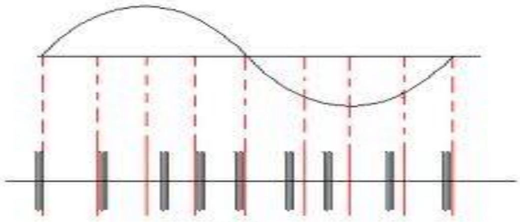
Angle Modulation



Two particular forms of angle modulation are frequency Modulation (FM) and Phase Modulation (PM). The term frequency modulation is often used to cover various forms of angle modulation. Amateurs use FM when referring to angle modulated VHF&UHF radios which may use either FM or PM. Frequency and Phase modulations are not independent, since the frequency cannot be varied without also varying the phase, and vice versa. The communications effectiveness of FM and PM depends almost entirely on the receiving methods. If the receiver will respond to frequency and phase changes but is insensitive to amplitude changes, it will discriminate against most forms of noise, particularly impulse noise such as that from ignition systems.

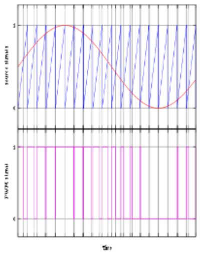
Pulse Modulation

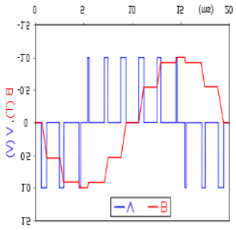


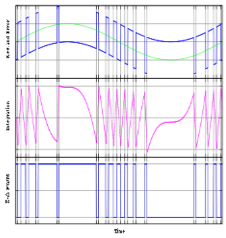


Pulse Modulated signals are usually sent as a series of short pulses separated by relatively long stretches of time with no signal being transmitted. (A typical pulse transmission might use1-µs pulses with a 1000-Hz pulse rate. Thus, the peak power of a pulse transmission is usually much greater than its average power.

PULSE WAVE SOLID – STATE BASICS







Demodulation is the process of deriving the original modulation signal from a modulated carrier wave. The received signal usually contains noise and distortion picked up along the way. Demodulation is part of the receiving process and is performed in a demodulator. While a demodulator is a normal part of a radio receiver, external demodulators are used for some types of communications.

14. RADIO RECEIVER

A radio receiver is an electronic device that takes a transmitted signal, extracts the original signal from it and amplifies that signal. The process of extracting the signal is called demodulation. A radio station, for example, will broadcast a signal which is then detected by a radio receiver. The receiver, in turn, will separate that signal from many others and then play it through its speakers. There are several different types of signals that the receiver can be designed to demodulate and decode including sounds, pictures and digital data, to name a few.

CHARACTERISTICS OF RECEIVER

SENSITIVITY

The ability of a radio receiver to pick up and reproduce weak radio signals is 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 micro volts 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, is called selectivity. In other words, the selectivity of a radio receiver is its ability of receiving radio signals within a comparatively narrow frequency band

The selectivity of radio receivers is of paramount 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 (i.e. higher the Q), the higher is the selectivity at 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.)

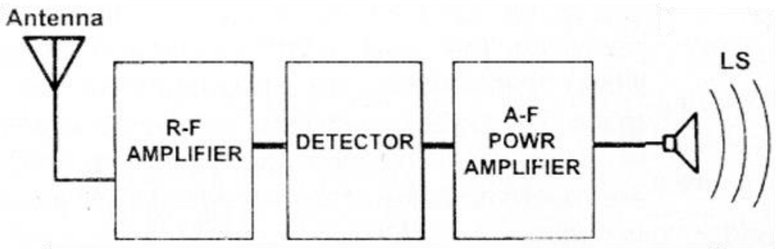
STABILITY

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 2. Electrical stability.

TUNED RADIO FREQUENCY (TRF) RECEIVER

The general design principle of a T R F receiver is shown in the block diagram below



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.

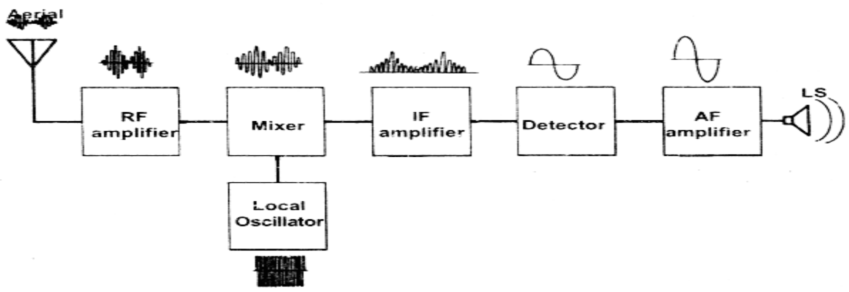
Having passed through the RF amplifier, the amplified RF signal reaches the detector stage where it is rectified.

The low frequency (audio frequency) signal developed at the output of the detector is, next, amplified in AF amplifier stages. The output of AF amplifier feeds the loudspeaker or a pair of earphones.

SUPER HETERODYNE RECEIVER

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 raises 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 intermediate frequency is the difference between oscillator frequency and radio frequency i.e. IF = oscillator frequency - radio frequency. The IF is always 455 kHz regardless of the frequency to which the receiver is tuned.

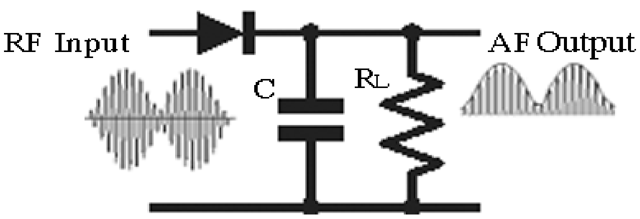


BLOCK DIAGRAM OF SUPERHETRODYNE RECEIVER

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.

The modulated wave of desired frequency is selected by the parallel tuned circuit and is applied to the Diode. During the positive half-cycles of modulated wave, the diode conducts while during negative half cycles, it does not. The result of this rectifying action is that output of the diode consists of positive half-cycles of modulated wave as shown.



AM DIODE DETECTOR

The rectified modulated wave contains radio frequency and the signal and cannot be fed to the speaker for sound reproduction. The RF Component is filtered by the capacitor C shunted

across the speaker. The value of this capacitor is sufficiently large to present low reactance to the RF Component while presenting a relatively high reactance to the audio signal. The result is that the RF components are by-passed by the capacitor C and the signal is passed on to the speaker for sound reproduction.

AF amplifier stage: The audio signal output of detector stage is fed to a multistage audio amplifier. Here, the signal is amplified until ii. 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.

ADVANTAGES OF A SUPERHETRODYNE RECEIVER 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 IF amplifier stages use tuned stages with good selectivity and required bandwidth.

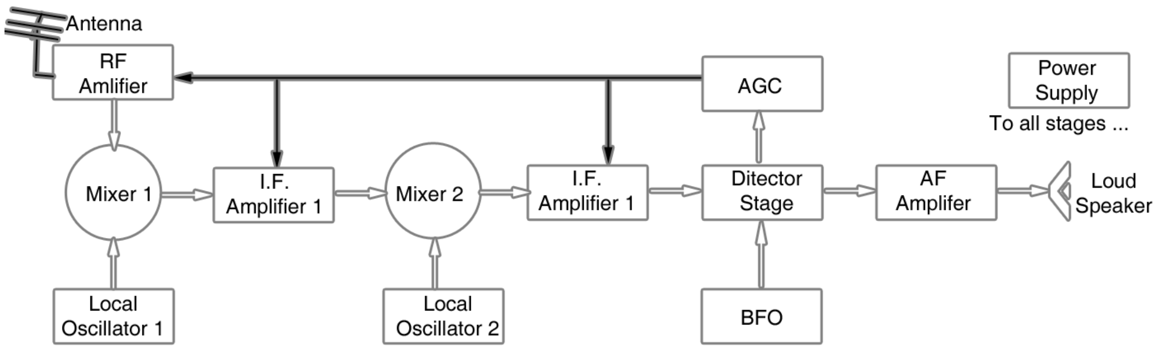
3. Continuous tuning is limited to the three tuned circuits namely the R.F. amplifier, Mixer (frequency converter) and the local oscillator.

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.E interference and it offers a better coupling between antenna and the input of the receiver

COMMUNICATION RECEIVER:

It uses the principle of Superhetrodyne reception. In addition it uses two stages of mixers, with two local oscillators The two mixers produce different intermediate frequencies (First at 2 MHZ 2^{nd} 200 KHz). 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 local oscillator supplies the required frequency to get the intermediate 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 II intermediate frequency. 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 beat frequency oscillator, provided to Detector stage which can be switched in to the circuit or switched off. This is useful in the reception of code signals transmitted by the radio telegraph transmitters.

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

SALIENT FEATURES OF A COMMUNICATION RECEIVER

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. There 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 band width selection will be provided with a selector switch which modifies the circuit accordingly.

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 with the inter-channel noise suppressor, or muting circuit.

Automatic frequency control circuit and a tuning indicator is provided.

An ‘S’ meter is provided from which the input signal strength can be measured.

Circuit design is made to receive FM signals and also to receive S.S.B. 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 a fully regulated power supply.

NOISE LIMITER

The noise limiter simply removes from the output of a radio receiver the voltage that is excess of a predetermined level. Normally this level will be adjustable.

TUNING INDICATOR

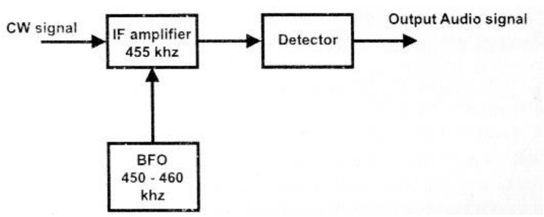
Tuning indicator is a visual display that indicates the proper tuning of the station in a radio receiver

MUTING CIRCUIT

The other names for this circuit arrangement are, inter channel noise suppressor. Squelch system, quieting system, tuning silencer and CODAN (Carrier Operated Device Anti-noise) Radio telephone receivers and communication receivers use this circuit.

BEAT FREQUENCY OSCILLATOR

A communication receiver should be capable of receiving transmissions of Morse code. i.e. pulse modulated RF carrier. In the diode detector of a normal receiver, there is no provision for registering the difference between the presence and the absence of a carrier. Accordingly, such pulse modulated dots, dashes and spaces would produce no output whatever from the detector.



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.

AUTOMATIC GAIN CONTROL

Automatic gain control is necessary in communication receivers because of the wide variations in signal strength encountered at the antenna terminal. The automatic gain control or AGC (also sometimes called “automatic volume control” or AVC), is used to smooth out variations in signal loudness as the radio is tuned across the band. There is a tremendous variation in the strength of radio signals picked up by the antenna. If there were no A.G.C circuit, the listener would turn up the volume to hear a weak station, then again it would be blasted out of the room when he tuned in a very strong station. The listener would turn up and down the gain to keep that from happening, and may miss weaker stations. The job of the A.G.C is to increase the gain on weak signals, and then decrease it on strong signals.

SQUELCH

When no carrier is present at the input, i.e. in the absence of transmissions on a given channel of between stations, a sensitive receiver will produce a disagreeable amount of loud noise. This is because AGC disappears in the absence of any carrier. So the receiver acquires its more sensitivity and analyses the noise present at its input. In some circumstances this is not particularly important, but in other situations it can be annoying and tiring. Systems such as those used by the police, ambulances and coast radio stations, in which a receiver must be monitored at all times but transmission is sporadic, are the principal benefits of squelch. It enables the receiver’s output to remain cut off unless the carrier is present Apart from eliminating inconvenience, such a system naturally increases the efficiency of the operator. Squelch is also called Muting or Quieting.

AUTOMATIC VOLUME CONTROL (AVC)

The purpose served by the automatic gain control sometimes referred to as automatic volume control is as follows. This control automatically equalizes the amplification of the radio receiver when the level of the incoming radio signal varies as a result of fading. Such automatic equalization prevents the overloading of the receiver and at the same time, keeps the output signal level at a comparatively constant value in spite of fading of the HF signal level in the aerial.

IMAGE INTERF ERENCE OR IMAGE FREQUENCY SIGNALS

It is possible that with a certain value of oscillator frequency, the desired value of intermediate frequency 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 a 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 a signal only one is desired, the undesired signal is called the image frequency signal or image interference. The effect of image frequency signals may be minimized or limited by providing one or more stages of RF tuning or pre-selection. The ratio of the output signal to that from the undesired RF signals is called the signal to image ratio or image ratio. The effect of the image frequency interference signals is present mostly in shortwave receivers.

SIGNAL TO NOISE RATIO

An ideal receiver would generate no noise in its tubes or semiconductors and circuits and the minimum detectable signal would be limited only by the thermal noise in the antenna. In a 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 10 dB (Decibels) for a good communications receiver below 30 MHz.

ADJACENT CHANNEL INTERFERENCE

The use of low IF values that is in the order 130,175 and 262 KHz has the advantage of improved selectivity of stations on adjacent channels This becomes apparent when the difference in frequency between stations on adjacent channels is expressed as a percentage frequency at which tuning and amplification takes place. As adjacent channels frequencies may be as little as 10 KHz apart this percentage for an IF of 175 KHz is 5.7% ,for 262 KHz it is 3.8% and for 455 KHz it is 2 1%.To reduce adjacent channel interference select higher value of IF preferably between 450 KHz to 470 KHz.

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, 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 superhetrodyne receivers and because of the greater gain provided by such receivers, the internal noise is much higher in a superhetrodyne receiver than in a T.R.F. Receiver

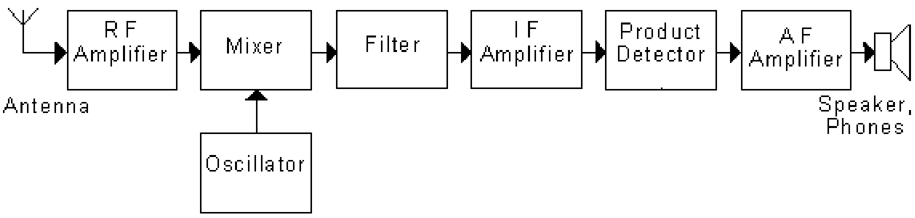
SIDE BAND

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 on 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 i.e. IF amplifier.



The signal level i.e. 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.

15. TRANSMITTER

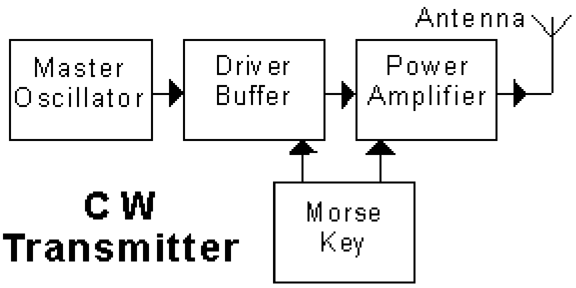
An electronic device that generates and amplifies a carrier wave, modulates it with a signal derived from speech or from other sources and then radiates the resulting signal from the antenna. The simplest of all transmitters is one for sending Morse code - a CW (Continuous Wave) transmitter as shown in the diagram below.

An oscillator generates the signal and it is then amplified to raise the power output to the desired level. A Morse key is used to chop the transmission up into the dots and dashes of Morse code. Oscillators Morse Code.

The oscillator runs continuously. The Driver/Buffer are isolation stages, to isolate the oscillator from the sudden load-changes due to the keying of the amplifier. This minimises frequency chirp on the transmitted signal.

The oscillator is usually supplied with DC from a voltage-regulated source to minimise chirp (slight changes in the output frequency) due to variations in the supply voltage.

Several driver and buffer stages may be used. The keying may be in the final amplifier alone - usually in the cathode or emitter lead - or may also be applied to the driver stage too.

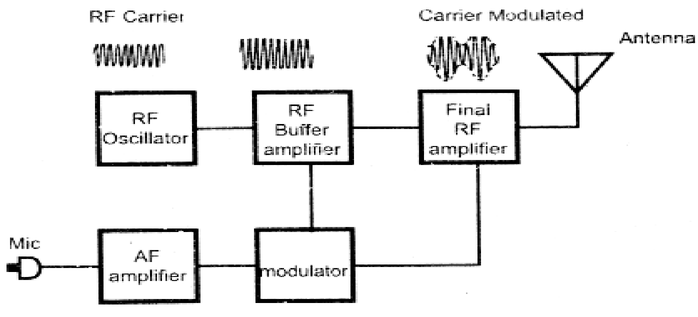


TRANSMITTER BLOCK DIAGRAM

A keying relay may be used to isolate the Morse key from the transmitter circuits, to keep high voltages away from the operator's Morse key. In the interests of operator safety, the moving bar of the Morse key is ALWAYS kept at earth potential.

A.M. TRANSMITTER

Amplitude modulated transmitters may use plate modulation or collector modulation for the generation of the modulated signal. The different stages of the transmitter are shown in the diagram.



BLOCK DIAGRAM OF AM TRANSMITTER

Microphone

The function of a microphone is to convert the variations in air pressure produced by the human voice or a musical instrument into the electrical voltage or current of the same frequency and corresponding amplitude.

RF Oscillator

It produces RF carrier wave which is amplified by the RF buffer amplifiers. The output of the AF modulator and RF buffer amplifiers are mixed in the final RF amplifier to produce the modulated carrier wave.

RF Buffer Amplifier

It is used to increase the power and isolate the oscillator. A Stage of amplification is placed between the oscillator and the antenna or following stages. This is called Buffer Amplifier. Its basic function is to simply amplify, making no frequency changes. This results in Isolating and reducing the load of the Oscillator and increased stability. It is generally biased to operate in class A mode.

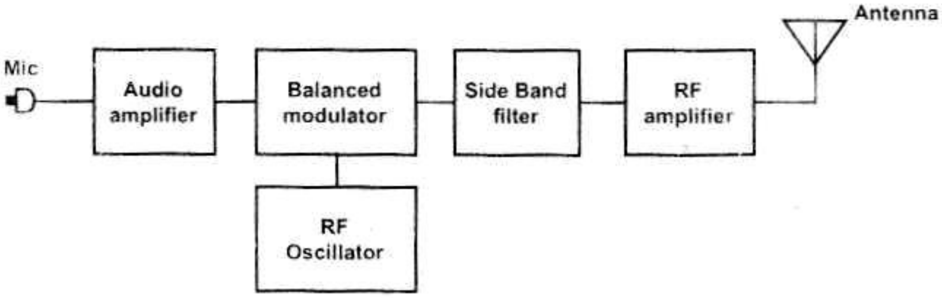
Modulator

The modulator section is essentially an audio amplifier. The speech amplifiers are of the voltage type, while the modulator being basically a power amplifier. The modulator delivers the required amount undistorted audio power to the modulator RF amplifier.

RF Power Amplifier

The final stage of a transmitter is the power amplifier. The RF power amplifier, sometimes referred to as the final is a Class-C tuned amplifier It is the last stage in the chain of amplification between the oscillator and the antenna.

SSB TRANSMITTER



BLOCK DIAGRAM OF SSB TRANSMITTER

We know 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 sidebands therefore was 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.

This technique of removing one sideband from an amplitude modulated signal is called single sideband modulation (SSB); and 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.

Narrower the bandwidth, the less atmospheric noise, or static, that will enter the receiving circuits with the signal

Also it each carrier uses less bandwidth in a given range, more carrier signals can be sent, or there will be less interference between different carrier signals.

Thus, Single side band (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.

FUNCTION OF EACH BLOCK:

Microphone (Mic): The microphone converts the audio signal into electrical signals which are 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.

Balanced 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 or discards) 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 Proper care is taken at this stage so that no harmonic frequency is generated which may cause interference in adjustment band or other bands

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

NEUTRALIZATION:

In circuits such as buffers, drivers and power amplifiers, where both the input and the output frequency are identical, while using triodes the positive feedback through the grid-to-plate inter-electrode capacitance may cause oscillations and instability. To prevent them, the simplest method called neutralization is used to counter or neutralize with an amount of compensatory feedback

COMPARISION BETWEEN AM & FM

AM

It has only two side bands LSB: Fc-Fm USB: Fc+Fm

In an AM the amplitude of the carrier is varied but frequency remains constant

Modulation Index is independent of modulating frequency.

Transmitted power by the AM includes carrier power and side bands power.

Thus it needs more modulation power.

Increased modulation index increases the total transmitted power.

Noise is more in the AM so fidelity is less.

Mainly used for mono transmission.

FM

It has infinite number of sidebands. They are separated by Fm, 2Frn, 3Fm and so on from the carrier frequency.

In the FM, the frequency of the carrier is varied but amplitude of the carrier remains constant.

Modulation index is inversely proportion to the modulating frequency.

It needs less modulation power. Increased modulation index increases the band width but transmitted power remains constant.

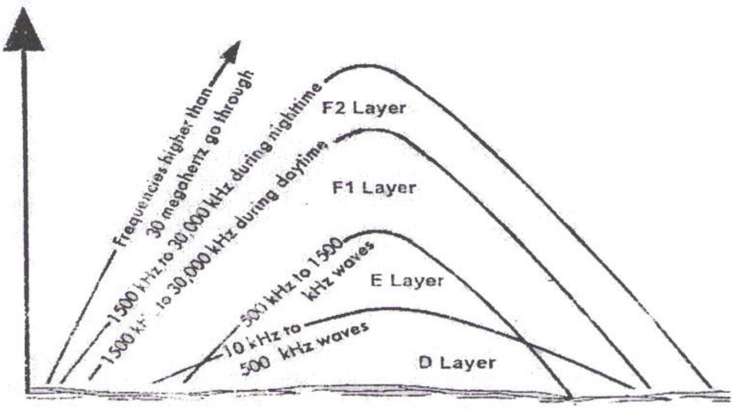
Noise is less in the FM, so fidelity is more.

Mainly used for stereo transmission

16. RADIO WAVE PROPAGATION

The ionosphere is a section of the atmosphere that acts like mirror for the reflection of HF waves, which makes long distance communication possible. The ionosphere is the upper portion of the atmosphere, which receives sufficient energy from the sun for its molecules to splits into positive and negative irons. They remain these ionized for long periods of time. There are variations in the physical properties of the atmosphere, such as temperature, density. At high altitudes the air of the atmosphere becomes ionized under the influence of the sunrays, cosmic rays and other factors.

The ionosphere has four main layers. They are D, E, Fl and F2 layer. Each layer reflects different frequencies of radio waves.



Refraction in the ionosphere bends sky-wave signals back to earth.

D LAYER: - It is the lowest, existing at an average height of 70 Km. This layer disappears at night is the least important layer from the point of HF propagation. It reflects some VLF and LF waves and absorbs MF and HF waves to certain extent.

E LAYER: - It is next in height, existing at about 100 Km. Like the D layer it disappears at night the reason for disappearances is the recombination of the ions into molecules. One more reason is due to the absence of the sun at night, when radiation is consequently no longer received. The main effect of the E layer is to reflect some HF waves in daytime.

F1 LAYER: It exists at a height of 180 Km in daytime and combines with the F2 layer at night. Although some HF waves are reflected from it, most pass through to be reflected from the F2 layer. The main effect of the Fl layer is to provide more absorption for HF waves.

F2 LAYER: It is the most important reflecting medium for HF radio waves. F2 layer height ranges from 250 to 400 km in daytime. At night it falls to a height of about 300-km because it combines with the Fl layer. It may be noted that the F layer exists at night. The reasons are

1. Since this is the top most layer, it is also the most highly ionized hence there is some chance for the ionization to remain at night, at least to some extent.

2. Although ionization density is high in this layer the air density is not, so most of the molecules in it are ionized. So the ionization does not disappear as soon as the sun sets.

3. Better HF reception is possible at night because of the combination of the Fl and F2 layers into one F layer.

SELECTIVE FADING

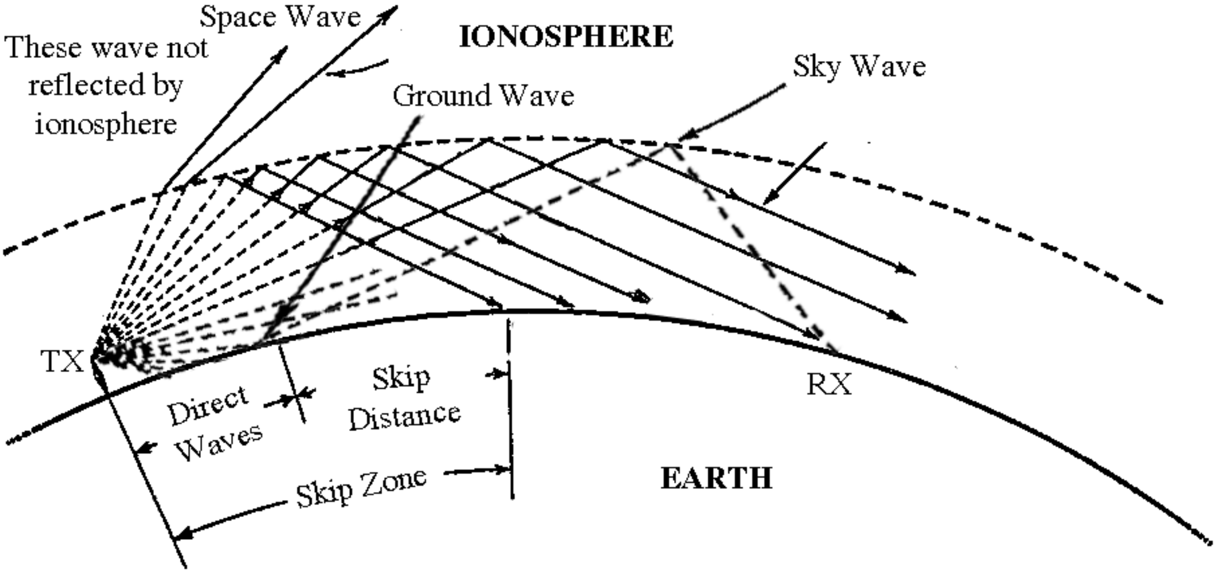
The variation in frequency in the sidebands of a modulated wave is differently affected giving rise to distortion of modulated wave. This effect is known as selective fading.

DIVERSITY RECEPTION

Automatic volume control is helpful in minimizing fading effects. However AVG is not a complete solution to the problem of fading signals. These fading effects are almost perfectly over-come by the use of a diversity receiving system of which two types

1. Space diversity and 2.frequency diversity.

Depending primarily on frequency, radio waves may travel from transmitting to receiving antenna in a number of line of sight and sky wave.



GROUND WAVE

The electromagnetic field is propagated parallel to the surface of the earth. The ground wave actually consists of three distinct components namely direct wave or line of sight, the reflected wave and the surface wave. Each of these three components contributes to the ground wave signal.

The direct wave or line of sight wave travels in a straight line from the transmitting antenna to the receiving antenna this phenomenon is observed very effectively at very high frequency where the path taken by electromagnetic wave is a straight line.

SKY WAVE

An electromagnetic wave is called a Sky Wave if it has been returned to the earth by the ionosphere. Sky Wave propagation can be used by either E Layer or F Layer of ionosphere. Sky Waves are observed at various times of day at different frequencies. It is this form of propagation that is responsible for the most of the long distance communication that takes place. Sky Waves are affected by the season of the year and the level of sunspot activity, as well as the time of the day and the operating frequency.

SKIP ZONE

Skip is actually the tendency of signals to pass over a certain geographical region. When skip occurs in an ionospheric F-Layer communication circuit, the signals from a transmitting station cannot be received by other stations located with in a certain a geographical area. This “dead” area is called skip zone.

At very low and medium frequencies skip zone is never observed. In high frequency spectrum skip zone is often present. In the upper part of the high frequency band, A skip zone is always observed.

An aerial is a system of wires used for the transmission of radio waves by transmitting stations and for the reception of waves by receiving installations. In other words, an aerial converts high frequency alternating current into the energy of radio waves, and conversely, converts the radio wave energy into high frequency alternating current energy. Radio waves are also electro magnetic waves.

The transmitting equipment generates the signal, amplifies it to a high power level, and then applies it to an antenna that radiates it into space. At the receiving end, antenna intercepts a portion of the radiated energy and then recovers the intelligence carried by the signal.

An antenna is basically a length of conductor that acts as a conversion device. It converts an electrical signal into electromagnetic energy, as well as electromagnetic energy into an electrical signal.

The first type of conversion takes place when an antenna is used for transmitting purposes. The transmitter output is applied to the antenna terminals and causes current to flow in the antenna. The antenna then converts the current flow into an electromagnetic signal that is radiated into space.

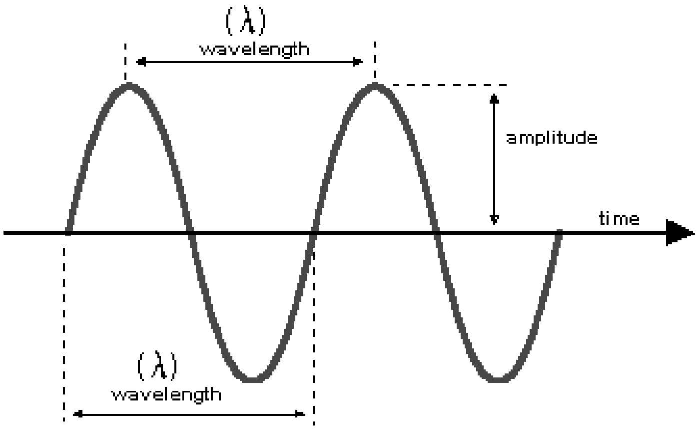
The second type of conversion occurs when an antenna is used for receiving. An electromagnetic signal, when passing an antenna, induces a current in it. The current is then applied as a signal input to the receiver.

For many purposes, any antenna performs both types of conversion equally well. Therefore, the same antenna can often be used either for transmitting or receiving. This is known as' antenna reciprocity'. Because of antenna reciprocity, a single antenna can be used in applications that do not require simultaneous transmitting and receiving. The most common example of this is in radar equipment, where the antenna is alternately connected to the output of the transmitter and to the input of the receiver.

WAVE LENGTH

The radio waves propagated outward from an antenna travel at approximately the speed of light, which is 186,000 miles per second, or 300 million meters per second. All radio waves travel at this speed, regardless of their frequency.

An important characteristic of a radio wave is its wavelength, which you recall, is the distance traveled by the wave in the time required for one cycle. To find the wave length, you divide the speed of the wave by its frequency.



The equation is $\gamma = c/f$ $c = 300{,}000{,}000$ meters/second
where γ = wave length in meters, and f is the frequency of the wave in cycles per second

ANTENNA IMPEDANCE

Most half-wave dipoles are fed at the centre because the maximum current point is the minimum voltage point, and it is easier to produce transmission lines for low voltage than for high voltage .Also, when the half-wave dipole is resonant, the capacitive reactance and inductive reactance cancel each other, leaving resistance only as the net impedance. Under such conditions the antenna impedance is resistive between any two points equidistant from the center along the antenna length.

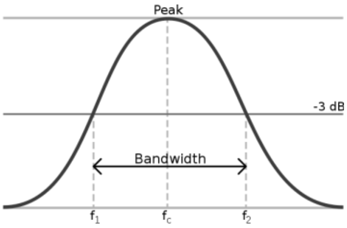
DIRECTIVITY

Radiation emitted by a point source radiator would extend outward equally in all directions. However, this is never true with practical antennas. Consequently, all antennas radiate more energy in some directions. In some directions the radiation is weak, or even zero. Thus every antenna has a characteristic radiation pattern. Graphs, called polar diagrams, are commonly used to give a pictorial representation of these radiation patterns. Thus a pictorial representation of the pattern of radiation is called the directivity pattern' and applies to reception and transmission.

TERMS RELATED WITH ANTENNA

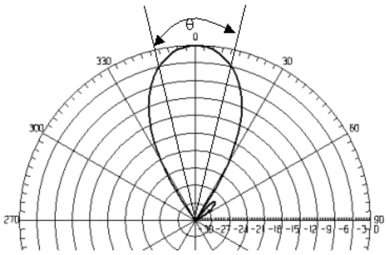
Band width, beam width and polarization are three important terms, dealing respectively with the operating frequency range of an antenna, the degree of concentration of its radiation, and the space orientation of the waves that it radiates.

BANDWIDTH



The bandwidth refers to the frequency range over which operation is satisfactory and is generally taken between the halt power points. Therefore, it is a width of frequency over which the antenna maintains certain required characteristics like gain, SWR (Standing Wave Ratio), pattern (shape or direction), Polarization and impedance.

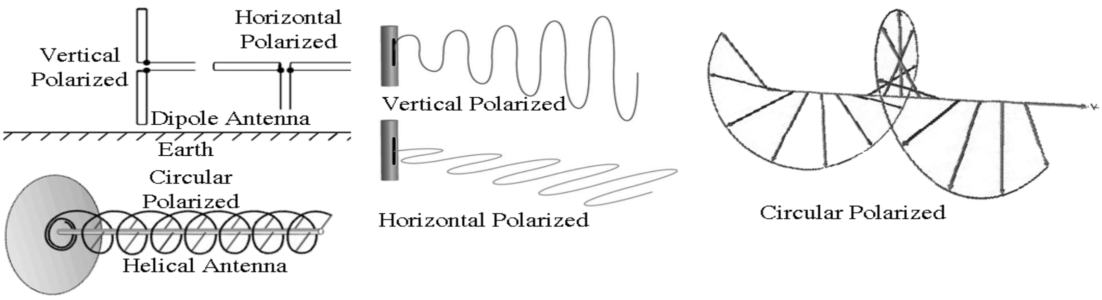
BEAMWIDTH



Value of θ in degree = 3 dB beamwidth.

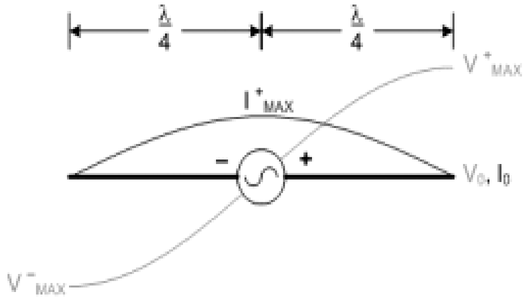
The beam width of an antenna is the angular separation between the two half power points on the power density radiation pattern. It is also, of course, the angular separation between the two 3-db down points on the field strength radiation pattern of an antenna. The term is used more frequently with narrow-beam antennas than with others and refers to the main lobe. Beam width is quoted in degrees.

POLARIZATION



This is defined as the direction of the electric-field component of the wave with respect to ground. As the wave travels through space, its electric field is vertical with respect to ground, the wave is vertically polarized, If the electric field is horizontal with respect to ground, it is horizontally polarized. With a simple antenna the position of the antenna determines the polarization of the wave. Vertically-positioned antennas produce vertically-polarized waves and horizontally-positioned antennas produce horizontally-polarized waves.

DIPOLE ANTENNA



The fundamental radio antenna is a metal rod or tubing which has a physical length approximately equal to one half wavelength in free space at the frequency of operation. Such a structure is known as a half-wave dipole. It is defined as a symmetrical antenna in which the two ends are at equal potential relative to the midpoint.

A half-wave dipole is usually positioned horizontally relative to the earth's surface. Another identity given the half wave dipole is zero-db gain antenna". This identification is useful only when some other structure used as an antenna affords certain advantages in the concentration or radiation, and is compared with the half-wave dipole.

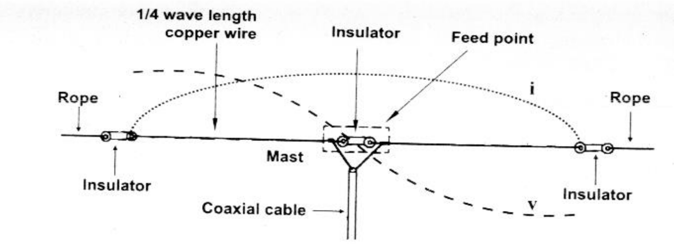
Every half-wave dipole (continuous rod split) is the equivalent of a resonant circuit. It has distributed L, C and R. The L is present in the metallic elements when current flows. The R takes the form of electrical losses associated with the r.f. currents rather than the d.c. resistance of the metal, although this too exists.

Like the conventional L-C circuit, a half-wave dipole antenna can be made resonant only to one frequency, the frequency for which it has been cut'. To change the resonant frequency, the length of the elements is altered as needed.

Although the half-wave dipole is dimensioned to a particular Radio frequency, it will like any resonant circuit, function over a narrow range of frequencies spread equally on both sides of circuit resonance. While it is impossible to set definite limits of the bandwidth of an antenna and apply it to every antenna. we can say that the usual bandwidths embrace several percent of the resonant frequency above and below resonance. Whether the antenna will tune' broadly or sharply, is a function of its 0', which in turn is a function of the outside diameter of the antenna. Hence, the broader the antenna is, larger its acceptance bandwidth.

VOLTAGE AND CURRENT IN HALF-WAVE DIPOLE

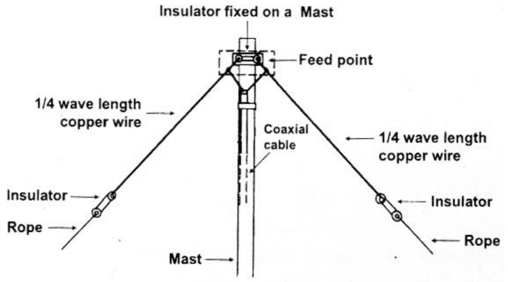
With very few exceptions all types of transmitting antennas function with standing waves of voltage and current along the elements. Voltage is fed to the antenna and current flows to the open end. It cannot go further, hence comes to zero. The related magnetic field collapses back into the antenna and makes the voltage maximum at the ends. A fixed pattern of standing waves develops in the half-wave dipole as long as energy is supplied to the antenna. In the half-wave metal rod (continuous or split) the standing wave pattern of voltage and current has the voltage maximum at the ends and minimum at the centre. The current is maximum at the centre and minimum



HALF WAVE DIPOLE

The standing wave of voltage and current is not influenced by the orientation of the antenna; it can be physically positioned horizontally, vertically, or obliquely. Neither is the standing wave pattern is influenced by the amount of energy supplied to the antenna; the pattern is the same for small and large amount of power, and it is the same for small diameter or large diameter elements.

THE "INVERTED V" ANTENNA



A popular non directional antenna is the so called "inverted V' or "drooping doublet". Its principal advantages are that it requires but one supporting structure, and that it exhibits more or less omni-directional radiation characteristics when cut bra single band. The multi band version is somewhat directional above 7 MHz off the ends (not broadside) of the antenna. This is because the legs of the "V' are long in terms of wavelength at 14,21 and 28 MHz The antenna offers a good compromise between vertical and horizontal polarization, thus making it effective for local as well as DX communications Its low-angle radiation compares favorably with that of a full size one quarter wavelength vertical worked against ground. When fed it serves as an excellent multi band antenna.

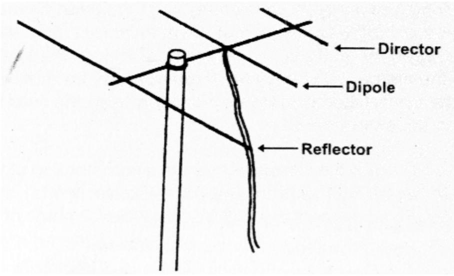
For single-band operation the "V" is cut to the same length as a half- wave length doublet, and is fed with 52-ohm coaxial line. Its center (feed point) should be as high above ground as possible, preferably one quarter wavelength or more at the operating frequency. The apex angle should be as close to 90 degrees results. Less than a 90 degree angle causes excessive cancellation of the signal, and should be avoided.

Though some operations have reported satisfactory results when supporting the "V" from a metal mast or tower, it is best to use a wooden mast to keep the field of the antenna unobstructed. Good results can be had by supporting the center of the antenna from a limb on a tall tree, provided the area below the limb is completely open.

Single-band, coax-fed inverted V will normally require some pruning to make them resonant at the desired frequency. The standard doublet formula is recommended for a starting point, but because the ends of the "V" are normally in close proximity to ground this antenna will be slightly shorter than a horizontal dipole. No formula can be given because of the variations in the ground properties in different areas. Also the actual height above ground in a particular installation, plus the proximity of the ends of the antenna to nearby objects, will have a marked effect upon resonance.

The best way to tune the antenna is to insert an SWR bridge in the coax feed line and prune an inch at a time off each end of the "V" until the lowest SWR is obtained.

PARASITIC ARRAY (YAGI ANTENNAS)



The Parasitic array is a way of using resonant half-wave dipoles to concentrate radiation in a desired direction and minimize radiation in undesired directions. This affords gain in the antenna. The reference is the half-wave resonant dipole previously identified as the zero-db gain antenna. If an antenna design is said to afford a gain of 3 db, the result relative to radiated energy in a chosen direction is the same as if the zero db gain resonant half-wave dipole had been used with twice as much power obtained from the transmitter (3 db = 2 times increase in power; 6 db = 4 times increase in power. 10 db = 10 times increase in power). An antenna with gain tends to concentrate the radiated energy into a narrower beam. Therefore, the antenna must be pointed more accurately.

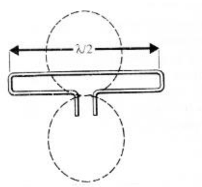
A parasitic array or beam antenna contains several elements viz a resonant half-wave dipole that receives power from the transmitter, or which delivers 1C received power to the receiver, and is called the driven element; also, one more continuous metal rods (the parasitic elements, which are parallel to e driven element at the same "line-of-sight" level). The rods are electrically coupled to, but not connected to, the driven element. The rod in front of the driven element is the director. Sometimes, two or more directors are used. The rod in back of the driven element is the reflector, of which only one is used. Frequently both director and reflector are used with the driven element in the same antenna.

When treated in terms of transmission, energy is delivered to the driven element. It radiates energy towards the front and the rear. Some of this energy induces current in the parasitic element(s), which in turn re-radiates virtually all the energy. By suitable dimensioning of the parasitic relative to the driven element, as well as the electrical distance between them, the electrical energy "-radiated by the parasitic is 'timed' to reinforce the current in the driven element. It also reinforces the radiation in front of the antenna, while tending to cancel the radiation towards the rear. The result is concentration of the radiation towards the front of the antenna (i.e. towards the desired direction).

When receiving, the parasitic element(s) and the driven element are acted upon by the approaching wave-front, but not at the exact moment because of the spacing between them. By suitable electrical timing (the spacing and the dimensions of the elements) energy received from the front of the antenna is reinforced in the driven element; energy arriving from the rear is effectively cancelled in the driven element. Because the current in the driven element is a combination of that received prom the transmitter as well as from the parasitic element(s), the feed point impedance of the driven element is much less than the 72 ohms of the resonant half-wave dipole.

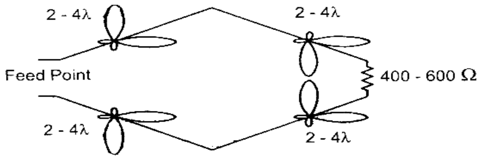
FOLDED DIPOLE

A variation of the conventional half-wave dipole is the folded dipole. In effect it is two half-wave length dipoles one a continuous rod and the other split in the center connected in parallel.



The transmission line is connected to the split dipole. Its half-wave dimensioning is done exactly as for the ordinary half-wave dipole. Its behavior differs from the conventional half-wave dipole in several respects. The directivity of the folded dipole is bidirectional, but because of the distribution of the currents in the parts of the folded dipole its input impedance is very much higher. If all parts of the antenna are made of like diameter rod of tubing, the feed point impedance is 288 ohms. In this way it is an excellent match for 300 ohm twin-lead transmission line.

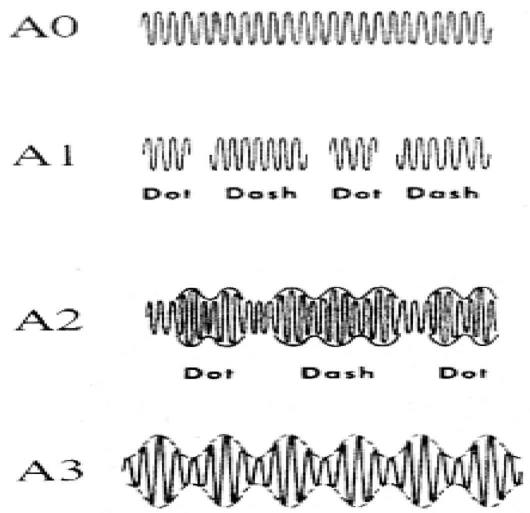
THE RHOMBIC ANTENNA



The Rhombic is a very efficient antenna of broad frequency capability, and is prominent in all radio communication facilities where the space necessary for the large structure is available. It can be said to be a double 'V" in which case it becomes a diamond shaped structure lying in the horizontal plane. It can be terminated or unterminated, the difference between the two being directivity

KINDS OF RADIO SIGNALS

We have already established that communication by radio is accomplished by electromagnetic energy (electromagnetic waves) which travel from a transmitting antenna to the receiving antenna. This broad statement does not however, identify the kinds of radio signals that come within the boundaries of electromagnetic waves. The differences among radio signals arise principally from the techniques employed in making the intelligence part of the radiated signal prior to radiation.



A0 : Continuous oscillations of constant amplitude and frequency, Nonmodulated waves

A1 : Continuous oscillations of constant amplitude and frequency, interrupted (keyed) in a sequence which corresponds to an International code

A2: Modulated telegraphy in which an audio tone amplitude modulates a carrier. The audio tone is keyed in accordance with an International Morse code.

A3: Telephony Constant-frequency oscillations modulated by the intelligence being transmitted.

These differences give rise to different identifications. The identity of each type of radio signal is called a type of emission. Modern communication technology has given rise to a great many kinds of modulation, hence, many kinds of emission.

Exercice

1) What does AM mean?

a) Angelo Marconi
b) Anno median
c) Amplitude modulation
d) Amperes

2) What frequency range is the High Frequency band?

a) 3-30 KHz
b) 30-300 KHz
c) 3 to 30 MHz
d) 30 to 300 MHz

3) Sometimes computers are connected to a UPS system. What does UPS mean?

a) United Parcel Service
b) Uniform Product Support
c) Under Paneling Storage
d) Uninterruptible Power Supply

4) A given signal's second harmonic is twice the given signal's __________ frequency...?

a) Fourier
b) Foundation
c) Fundamental
d) Field

5) Voltage is sometimes referred to as EMF or Electromotive...?

a) Field
b) Factor
c) Flash
d) Force

6) "FET" is a type of transistor; Its full name is ________ Effect Transistor...?

a) Field
b) Factor
c) Flash
d) Force

7) When measuring the characteristics of a small-signal amplifier, say for a radio receiver, one might be concerned with its "Noise..."?

a) Fundamental b) Fall c) Force d) Figure

8) Which of the following will have least wavelength

a) VHF b) EHF c) HF d) UHF

9) 30 to 300 MHz frequency is categorized as :

a) MF b) VHF c) UHF d) SHF

10) For a frequency of 30 MHz the wavelength will be :

a) 10m b) 1m c) 0.1m d) 0.01m

11) The range of audio frequency is :

a) 20kHz to 15 MHz
b) 20 kHz to 150 MHz
c) 20 Hz to 15MHz
d) 20 Hz to 15 kHz

12) The unit of electric field intensity E is :

a) Volts/metre
b) Ampere/metre
c) Coulombs/metre
d) Henry/metre

13) The current distribution on a half wave dipole is :

a) uniform b) sinusoidal c) triangular d) complex

14) For very high frequencies earth acts as a :

a) conductor b) dielectric c) resistor d) None of these

15) A wavelength of 15mm could be expected in :

a) VHF b) HF c) EHF d) SHF

16) The gain of an antenna :

a) varies inversely as wavelength
b) varies inversely as square of wavelength
c) is independent of wavelength
d) varies directly as wavelength

17) Yagi antenna is used for :

a) television
b) radar
c) medium wave broadcasting
d) None of these

18) Which of the following will increase the antenna radiation efficiency?

a) Use of larger section of conductor
b) providing insulation on conductor
c) top loading of antenna
d) any of the above

19) The director in a Yagi antenna :

a) is longer than the radiating element
b) is shorter than the radiating antenna
c) can be longer or shorter than the radiating element
d) does not exist.

20) Antenna used in radar is :

a) dipoles b) yagi antenna c) parabolic dishes d) None of these

21) Television receiver antenna is usually :

a) rhombic antenna b) yagi antenna c) parabolic dishes d) turnstile antenna

22) Which of the following antennas gives circular polarization :

a) yagi ± uda b) parabolic c) dipole d) helical

23) Which of the following statement is false?

a) A grounded l/4 antenna is one half the length of a l/2 dipole.
b) A vertical antenna transmits in all directions, in a circle in a horizontal plane.
c) A grounded vertical antenna transmits ground waves and sky waves.
d) A counter poise must be a good insulator.

24) Which of the following can make the antenna electrically longer?

a) Series capacitor
b) capacitive top loading
c) vertical polarisation
d) Circular polarsation

25) A unipole is also known as :

a) omnidirectional radiator
b) unidirectional radiator
c) line radiator
d) None of the above

26) Radiation intensity does not depend upon :

a) the antenna direction
b) distance from the radiator
c) both (a) and (b) above
d) None of the above

27) In case of antenna, the ratio of the power radiated in the desired direction to the power radiated in the opposite direction is known as :

a) transmission efficiency
b) front to back ratio
c) loss coefficient
d) None of the above

28) In case of antenna decreasing Q :

a) increases bandwidth
b) decreases bandwidth
c) independent of bandwidth
d) None of the above

29) The directional pattern of loop antennas:

a) depends on shape of antenna loc
b) is independent of shape of the loop
c) depends on number of turns of loop
d) None of the above

30) The ratio of radiation intensity in a particular direction to average radiated power is called

a) directive gain b) power gain c) directivity d) DIRP

Model Type Questions

1. The following Amplifier is not used as audio amplifier because of distortion.
   a) Class A b) Class B d) Class C d) Both A & B

2. It is desired to receive amplitude amplitude modulated signal of frequency of 2000 Hz. If the IF of the receiver is 465 KHz the LO frequency should be
   a) 2465 KHz b) 2000 KHz c) 465 KHz d) None

3. The range of MF is
   a) 30 to 300 KHz b) 300 to 3000 KHz c) 3 to 30 KHz d) None

4. The polarization of electromagnetic wave is defined by its
   a) Propagation b) The E field c) The H field d) The transmitting antenna

5. The half wave dipole aerial has a theoretical impedance of
   a) 650 Ohms b) 720 Ohms c) 800 Ohms d) None

6. A half wave antenna resonant on 7100 kHz is approx. the following meters long
   a) 20 Meters b) 40 Meters c) 80 Meters d) 160 Meters

7. As temperature increases, the resistance of a metallic conductor:
   a) Decreases b) Increases c) remains Constant d) Become negative

8. Impedance is a combination of
   a) Reactance with reluctance b) Resistance with conductance
   b) Resistance with reactance d) Reactance with radiation

9. An inductor and a capacitor are connected in series. At resonant frequency impedance is
   a) Minimum b) Maximum c) Totally resistive d) Reactance with radiation

10. The major charge carriers of a NPN transistor is
    a) Holes b) Electrons c) Ions d) None

11. A diode in proper biasing condition converts
    a) AC to DC b) DC to AC c) AC to pulsating DC d) None

12. One milli volt is equal to
    a) 0.01volt b) 0.0001 volt c) 0.001volt d) None

Additional Syllabus for General Grade

Radio Theory and Practice

18. PRINCIPLES OF COMMUNICATIONS

Analog and Digital Communication

ANALOG SIGNALS

Analog signals are signals with continuous values. Analog signals are used in many systems, although the use of analog signals has declined with the advent of cheap digital signals. Analog systems are less tolerant to noise, make good use of bandwidth, and are easy to manipulate mathematically. However, analog signals require hardware receivers and transmitters that are designed to perfectly fit the particular transmission. If you are working on a new system, and you decide to change your analog signal, you need to completely change your transmitters and receivers.

DIGITAL DIGNALS

Digital signals are signals that are represented by binary numbers, "1" or "0". The 1 and 0 values can correspond to different discrete voltage values, and any signal that *doesnt quite fit* into the scheme just gets rounded off. Digital signals are more tolerant to noise, but digital signals can be completely corrupted in the presence of excess noise. In digital signals, noise could cause a 1 to be interpreted as a 0 and vice versa, which makes the received data different than the original data. Imagine if the army transmitted a position coordinate to a missile digitally, and a single bit was received in error? This single bit error could cause a missile to miss its target by miles. Luckily, there are systems in place to prevent this sort of scenario, such as checksums and CRCs, which tell the receiver when a bit has been corrupted and ask the transmitter to resend the data. The primary benefit of digital signals is that they can be handled by simple, standardized receivers and transmitters, and the signal can be then dealt with in software (which is comparatively cheap to change).As compared to Analog Communications, the flexibility, Performance and efficiency of the Digital communications are much high.

Facsimile

The earliest operational system for image transmission, facsimile or FAX networks date back to the late 20s and early 30. Like any other imaging system, FAX compromises in some areas to gain advantages in others. Conventional fast –scan TV is capable of handling moving images of moderate resolution, but the rapid image repetition rate requires several megahertz of signal bandwidth, which confines it to the UHF range. FAX is used widely in a number of services. Weather chart distribution is perhaps the most common, using both HF and landline links to weather service and forecast centers throughout the world. News photographs, sometimes called “wire photos” are also distributed throughout the world in a similar manner. A wide variety of weather satellites transmit cloud-cover pictures back to Earth using FAX.

Image Transmission

A typical FAX transmitter consists of a drum driven by a synchronous motor operating from a crystal or tuning fork frequency standard. The material to be transmitted is wrapped around the drum, which rotates at a constant speed. A small spot of light is focused on the printed material (photo, text, map, etc), and the light reflected from the subject is picked up by a photocell, photomultiplier or phototransistor. The rotation of the drum provides the equivalent of the “horizontal scanning” of the material. A carriage, supporting the light source and pickup assembly is moved along the drum at a constant rate providing the “vertical scanning”. The carriage is usually operated by a threaded rod driven by another synchronous motor. As the carriage travels from one end of the drum to the other, the entire picture area is scanned. The voltage variations from the light pickup are amplified and used to modulate an audio sub carrier, using either amplitude or frequency modulation. For positive AM, the modulation is proportional to brightness which typically ranges from 4% for black through 90 to 100% for white. Negative modulation reverses this relationship with minimum modulation level corresponding to white and maximum to black. Amplitude modulated sub carrier systems are typically used with VHF microwave FM links (weather satellites using positive modulation) or weather chart and photo transmission via landline (typically negative modulation). FM sub carrier operation uses the voltage variations from the light pickup to shift the sub carrier frequency. Black material results in a 1500 Hz frequency, rising in linear fashion to 2300 Hz for white. The FM format is used with all FAX systems that operate on HF, reducing problems caused by the fading that is inevitable on any long distance short wave transmission circuit.

Image Display

The options for image display are far more varied than those for transmission. The device that displays the picture is known as the recorder and is found in a wide variety of configurations. Drum type recorders hold a single sheet of the recording medium on a drum that is quite similar to that used in the transmitter. By contrast continuous-feed FAX recorders are designed to display pictures using material fed from a roll. Such recorders do not require that material be reloaded for each picture but are typically more complex than drum –type recorders.

Facsimile recorders also differ widely in the nature of the recording medium. Photographic systems use film or photographic paper that is exposed by a modulated-light source and lens. Such systems require a darkroom and photographic processing chemicals and are not well suited for high volume use. The most advanced photographic systems use a dry silver paper and modulated laser light source. These are usually continuous read-out machines in which the paper is heat processed prior to emerging from the recorder. Such systems provide superb image quality and are convenient to use.

Standards

The essential standards for a FAX unit are defined by three parameters: Drum speed (Helix speed in the case of continuous read-out recorders), carriage or paper feed rate, and modulation characteristics. It also depends on the Drum Speed and Scanning Density.

Slow Scan Television

Slow –Scan television (SSTV) started in 1958 as the effort of a small band of Amateur Radio operators. The intention of the project was to send television pictures on the HF amateur bands. By virtue of HF radio design and propagation characteristics, the SSTV system design is tailored to allow operation in a 3-khz bandwidth which is considerably less than the 6-Mhz width of a commercial TV channel. Reception of SSTV is quite simple. The SSB voice of the transmitting amateur is tuned in so it sounds “natural”. When the SSTV transmission begins, the signal should be in tune. The picture can be improved by using a transceiver that has pass band tuning. Under ideal conditions the audio highs can be boosted to give higher resolution. When poorer conditions exits, the pass band can be tuned to minimize interference.

Receiving

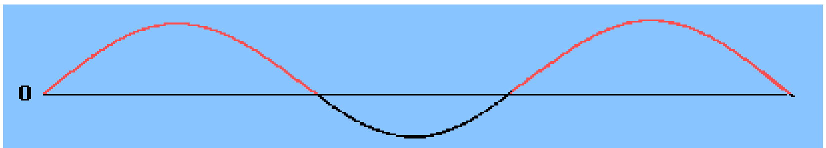
The converter has input detection circuitry to translate the SSTV audio frequency variations from the receiver audio output into digital pulses. These contain horizontal and vertical synchronization as well as binary values representing the gray scales being sent. The pulses are stored in memory. The information is then sent to a digital-to –analog converter, which converts the stored data into an analog video signal fully compatible with a standard TV monitor to produce a non decaying image.

Transmitting

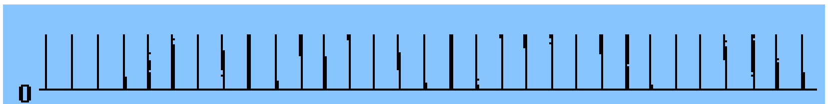
Output from a black and white TV camera is converted into horizontal and vertical pulses along with digitized gray-scale values. The image is “snapped” in 1/60 of a second from the TV camera. The information is stored in memory. The digital output from memory goes to circuitry that produces the audio-frequency-modulated signal conforming to the SSTV standards. This SSTV output is then fed to the microphone input of the transceiver. Since the SSTV FM audio signal to the transmitter is continuous, the transceiver/linear amplifier RF power should be reduced to safe dissipation levels under this high-duty cycle operation.

PULSE MODULATION

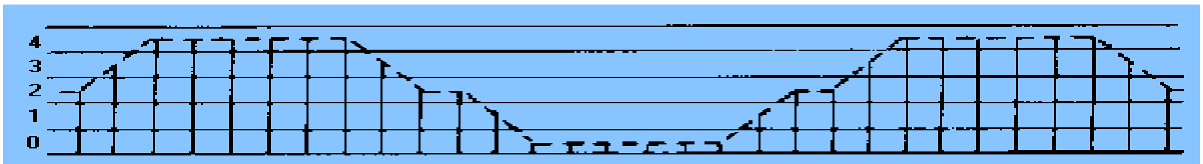
The Modulation of the amplitude, characteristic, ect of a sequence of pulses in order to convey information, often used in codes or the formation of an intermittent carrier wave by the generation and transmission of a sequence of short, periodic pulses is called Pulse Modulation normally used in Radar. PCM refers to a system in which the standard values of a QUANTIZED WAVE are indicated by a series of coded pulses. When these pulses are decoded, they indicate the standard values of the original quantized wave. These codes may be binary, in which the symbol for each quantized element will consist of pulses and spaces: The pulse-modulation provide methods of converting analog wave shapes to digital wave shapes.



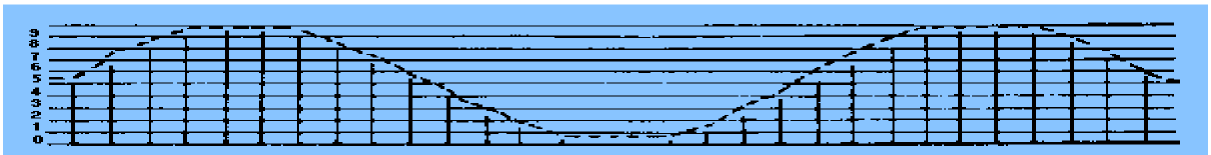
(A) MODULATION



(B) TIMING



(C) QUANTIZED 5-LEVEL


(D) QUANTIZED 10-LEVEL

ELEMENTARY IDEA ABOUT DEMODULATION

Since the early days of radio when all transmissions were in Morse Code, a demodulator has also been used called a detector. Early demodulators had only to detect the presence (or absence) of a radio wave using a device such as a Coherer, without necessarily making it audible. Demodulation is the act of extracting the original information bearing signal from a modulated Carrier Wave. A demodulator is an Electronic Circuit that is used to recover the information content from the modulated carrier wave. These terms are traditionally used in connection with Radio Receivers but many other systems use many kinds of demodulators. Another common one is in a Modem, which is a contraction of the terms Modulator/demodulator. There are several ways of demodulation depending on what parameters of the base-band signal are transmitted in the carrier signal, such as amplitude, frequency or phase. An example of a demodulation system is a Modem, which receives a signal (electrical signal) and turns this signal from the wire net into a binary signal for the computer.

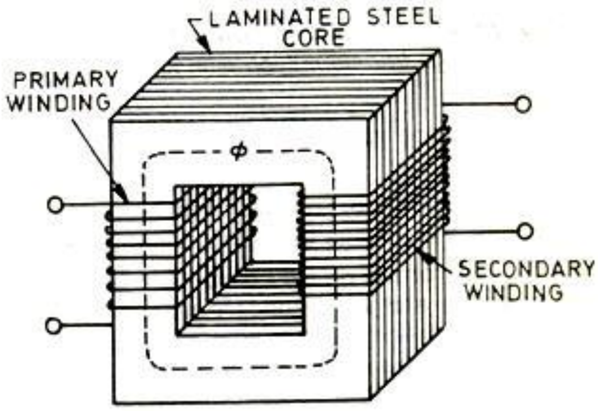
AM DEMODULATION

An AM signal can be rectified without requiring a Coherent Demodulator. For example, the signal can be passed through an Envelop Detector (a diode rectifier). The output will follow the same curve as the input Base Band signal. There are forms of AM in which the Carrier is reduced or suppressed entirely, which require coherent demodulation.

FM DEMODULATION

There are several ways to demodulate an FM signal. The most common is to use a discriminator. This is composed of an Electronic Filter, which decreases the amplitude of some frequencies relative to others, followed by an AM demodulator. If the filter response changes linearly with frequency, the final analog output will be proportional to the input frequency, as desired.

Basic Construction and Working Principle of Transformer



An elementary transformer consists of a soft iron or silicon steel core and two windings, placed on it. The windings are insulated from both the core and each other. The core is built up of thin soft iron or low reluctance to the magnetic flux. The winding connected to the magnetic flux. The winding connected to the supply main is called the primary and the winding connected to the load circuit is called the secondary. Although in the actual construction the two windings are usually wound one over the other, for the sake of simplicity, the figures for analyzing transformer theory show the windings on opposite sides of the core.

TRANSFORMERS LOSES

Transformer losses are produced by the electrical current flowing in the coils and the magnetic field alternating in the core. The losses associated with the coils are called the load losses, while the losses produced in the core are called no-load losses.

What Are Load Losses?

Load losses vary according to the loading on the transformer. They include heat losses and eddy currents in the primary and secondary conductors of the transformer. Heat losses, or I^2R losses, in the winding materials contribute the largest part of the load losses. They are created by resistance of the conductor to the flow of current or electrons. The electron motion causes the conductor molecules to move and produce friction and heat. The energy generated by this motion can be calculated using the formula: Watts = (volts)(amperes) or VI.

According to Ohm's law, V=RI, or the voltage drop across a resistor equals the amount of resistance in the resistor, R, multiplied by the current, I, flowing in the resistor. Hence, heat losses equal (I)(RI) or I^2R.

Transformer designers cannot change I, or the current portion of the I^2R losses, which are determined by the load requirements. They can only change the resistance or R part of the I^2R by using a material that has a low resistance per cross-sectional area without adding significantly to the cost of the transformer. Most transformer designers have found copper the best conductor considering the weight, size, cost and resistance of the conductor. Designers can also reduce the resistance of the conductor by increasing the cross-sectional area of the conductor.

What Are No load Losses?

No-load losses are caused by the magnetizing current needed to energize the core of the transformer, and do not vary according to the loading on the transformer. They are constant and occur 24 hours a day, 365 days a year, regardless of the load, hence the term no-load losses. They can be categorized into five components: hysteresis losses in the core laminations, eddy current losses in the core laminations, I^2R losses due to no-load current, stray eddy current losses in core

clamps, bolts and other core components, and dielectric losses. Hysteresis losses and eddy current losses contribute over 99% of the no-load losses, while stray eddy current, dielectric losses and I^2R losses due to no-load current are small and consequently often neglected. Thinner lamination of the core steel reduces eddy current losses.
The biggest contributor to no-load losses is hysteresis losses. Hysteresis losses come from the molecules in the core laminations resisting being magnetized and demagnetized by the alternating magnetic field. This resistance by the molecules causes friction that result in heat. The Greek word, hysteresis, means "to lag" and refers to the fact that the magnetic flux lags behind the magnetic force. Choice of size and type of core material reduces hysteresis losses.

TRANSFORMERS AS A MATCHING DEVICE

The term impedance is used for the opposition of a system to the flow of energy from an energy source. For constant signals, this impedance can also be constant. For varying signals, it usually changes with frequency. The energy involved can be electrical, mechanical, magnetic or even thermal.

Reflectionless or broadband matching

Impedance matching to minimize reflections and maximize power transfer over a (relatively) large bandwidth (also called reflectionless matching or broadband matching) is the most commonly used. To prevent all reflections of the signal back into the source, the load (which must be totally resistive) must be matched exactly to the source impedance

Complex conjugate matching

This is used in cases in which the source and load are reactive. This form of impedance matching can only maximize the power transfer between a reactive source and a reactive load at a single frequency.

IMPEDANCE MATCHING DEVICES

Adjusting the source impedance or the load impedance, in general, is called "impedance matching". There are three possible ways to improve an impedance mismatch, all of which are called "impedance matching":

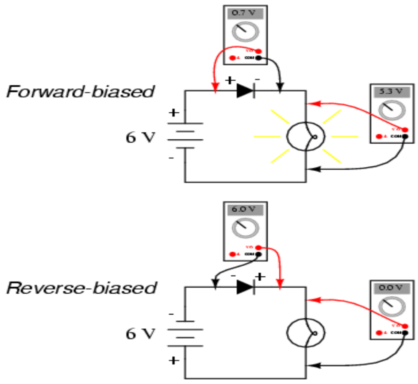
- devices intended to present an apparent load to the source.
- devices intended to present an apparent load of $R_{load} = R_{line}$ (complex impedance matching), to avoid echoes.
- devices intended to present an apparent source resistance as close to zero as possible, or presenting an apparent source voltage as high as possible. This is the only way to maximize energy efficiency, and so it is used at the beginning of electrical power lines. Such an impedance bridging connection also minimizes distortion and electromagnetic interference, and so it is also used in modern audio amplifiers and signal processing devices.

There are a variety of devices that are used between some source of energy and some load that perform "impedance matching". To match electrical impedances, engineers use combinations of Transformers, Resistors, Inductors, Capacitors and Transmission Lines.

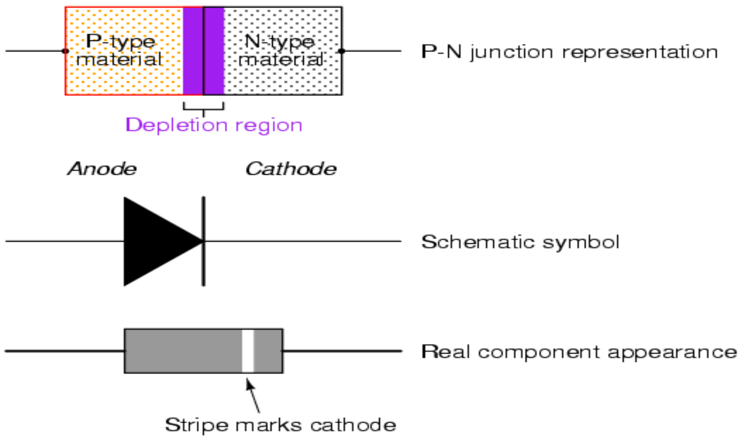
These passive and active impedance matching devices are optimized for different applications, and are called baluns, antenna tuners (sometimes called ATUs or roller coasters because of their appearance), acoustic horns, matching networks, and terminators. Transformers are sometimes used to match the impedances of circuits with different impedances. A transformer converts Alternating Current at one voltage to the same waveform at another voltage. The power input to the transformer and output from the transformer is the same (except for conversion losses). The side with the lower voltage is at low impedance, because this has the lower number of turns, and the side with the higher voltage is at higher impedance as it has more turns in its coil.

CONDUCTION AND CONSTRUCTION OF SEMICONDUCT DEVICES AND TRANSISITORS.

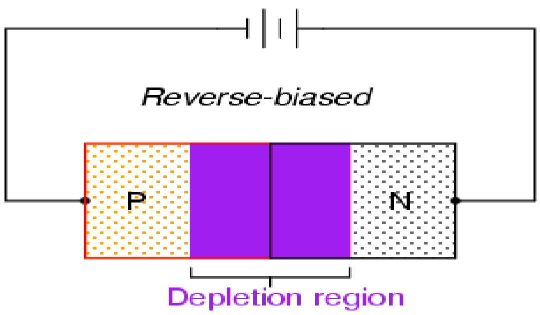
Diodes are essentially "pressure-" operated (voltage-operated) devices. The essential Difference between forward-bias and reverse-bias is the polarity of the voltage dropped across the diode. Let's take a closer look at the simple battery-diode-lamp as shown in the circuit.



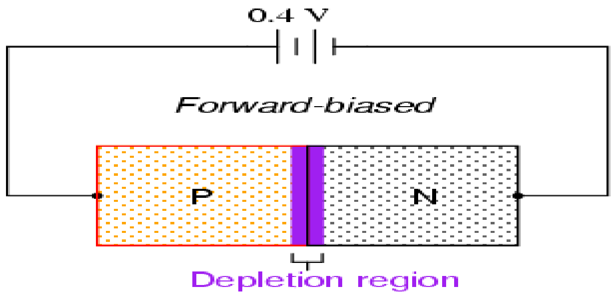
When the diode is forward-biased and conducting current, there is a small voltage dropped across it, leaving most of the battery voltage dropped across the lamp. When the battery's polarity is reversed and the diode becomes reverse-biased, it drops all of the battery's voltage and leaves none for the lamp.

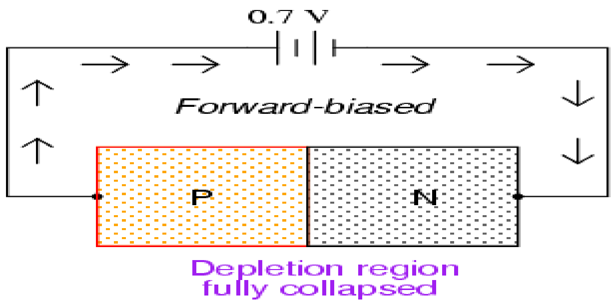


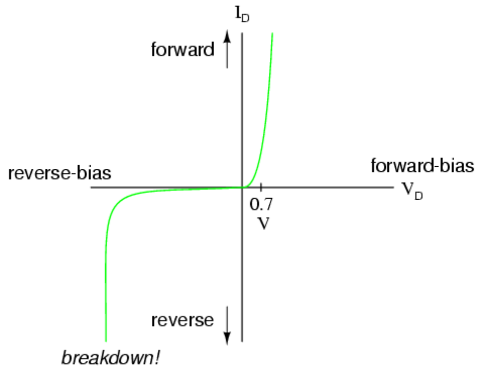
If a reverse-biasing voltage is applied across the P-N junction, this depletion region expands, further resisting any current through it:



Conversely, if a forward-biasing voltage is applied across the P-N junction, the depletion region will collapse and become thinner, so that the diode becomes less resistive to current through it. In order for a sustained current to go through the diode, though, the depletion region must be fully collapsed by the applied voltage. This takes a certain minimum voltage to accomplish, called the forward voltage:







- A diode is an electrical component acting as a one-way valve for current. When voltage is applied across a diode in such a way that the diode allows current, the diode is said to be forward-biased.
- When voltage is applied across a diode in such a way that the diode prohibits current, the diode is said to be reverse-biased. The voltage dropped across a conducting, forward-biased diode is called the forward voltage. Forward voltage for a diode varies only slightly for changes in forward current and temperature, and is fixed principally by the chemical composition of the P-N junction.
- Silicon diodes have a forward voltage of approximately 0.7 volts. Germanium diodes have a forward voltage of approximately 0.3 volts.
- The maximum reverse-bias voltage that a diode can withstand without "breaking down" is called the Peak Inverse Voltage, or PIV rating.

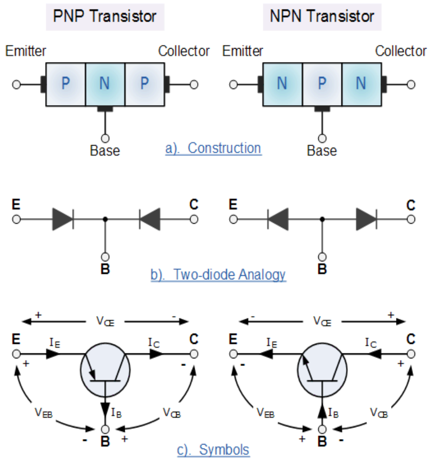
Transistors are three terminal active devices made from different semiconductor materials that can act as either an insulator or a conductor by the application of a small signal voltage. The transistor's ability to change between these two states enables it to have two basic functions: "switching" (digital electronics) or "amplification" (analogue electronics). Then bipolar transistors have the ability to operate within three different regions.

The Transistor basic construction consists of two PN-junctions producing three connecting terminals with each terminal being given a name to identify it from the other two. These three terminals are known and labeled as the Emitter (E), the Base (B) and the Collector (C) respectively.

Typical Bipolar Transistor

Transistors are current regulating devices that control the amount of current flowing through them in proportion to the amount of biasing voltage applied to their base terminal acting like a current-controlled switch. The principle of operation of the two transistor types PNP and NPN, is exactly the same the only difference being in their biasing and the polarity of the power supply for each.

Transistor construction



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

As a Transistor is a three terminal device, there are basically three possible ways to connect it within an electronic circuit with one terminal being common to both the input and output. Each method of connection responding differently to its input signal within a circuit as the static characteristics of the transistor varies with each circuit arrangement.

1. Common Base Configuration - has Voltage Gain but no Current Gain.

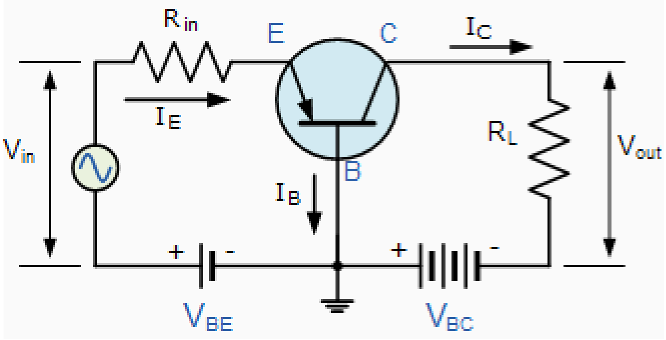
2. Common Emitter Configuration - has both Current and Voltage Gain.

3. Common Collector Configuration - has Current Gain but no Voltage Gain.

The Common Base (CB) Configuration

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 output signal is taken from the base and the collector terminals as shown with the base terminal grounded. The input current flowing into the emitter is high as it is the sum of the base current and collector current. Therefore, the collector current output is less than the emitter current input resulting in a current gain for this type of circuit of "1" (unity) or less, in other words the common base configuration "attenuates" the input signal.

The Common Base Transistor Circuit



Common Base Voltage Gain

$$A_V = \frac{Vout}{Vin} = \frac{I_C \times R_L}{I_E \times R_{IN}}$$

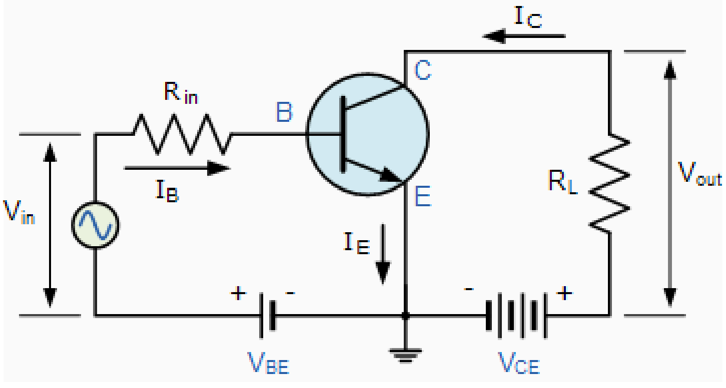
Where: Ic/Ie is the current gain, alpha (α) and RL/Rin is the resistance gain.

The common base circuit is generally used in single stage amplifier circuits such as microphone pre-amplifier or radio frequency (Rf) amplifiers due to its very good high frequency response.

The Common Emitter (CE) Configuration

In the Common Emitter or grounded emitter configuration, the input signal is applied between the base, while the output is taken 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 bipolar transistor 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 PN-junction, while the output impedance is HIGH as it is taken from a reverse-biased PN-junction.

The Common Emitter Amplifier Circuit



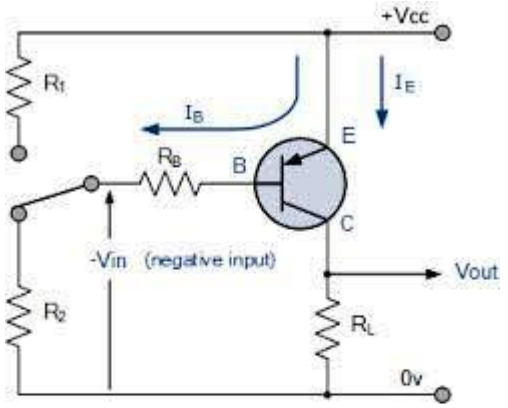
In this type of configuration, the current flowing out of the transistor must be equal to the currents flowing into the transistor as the emitter current is given as Ie = Ic + Ib. Also, as the load resistance (RL) is connected in series with the collector, the current gain of the common emitter transistor configuration is quite large as it is the ratio of Ic/Ib and is given the Greek symbol of Beta, (β). As the emitter current for a common emitter configuration is defined as Ie = Ic + Ib, the

This type of bipolar transistor configuration has greater input impedance, current and power gain than that of the common base configuration but its voltage gain is much lower. The common emitter configuration is an inverting amplifier circuit resulting in the output signal being 180^{o} out-of-phase with the input voltage signal.

The Common Collector (CC) Configuration

In the Common Collector or grounded collector configuration, the collector is now common through the supply. The input signal is connected directly 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 while having relatively low output impedance.

The Common Collector Transistor Circuit



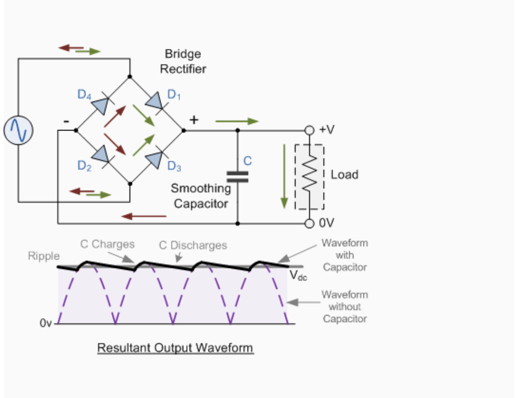
The common emitter configuration has a current gain approximately equal to the β value of the transistor itself. In the common collector configuration the load resistance is situated in series with the emitter so its current is equal to that of the emitter current. As the emitter current is the combination of the collector AND the base current combined, the load resistance in this type of transistor 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:

NPN Transistor in more detail when used in the common emitter configuration as an amplifier is the most widely used configuration due to its flexibility and high gain. We will also plot the output characteristics curves commonly associated with amplifier circuits as a function of the collector current to the base current.

(Smoothing and regulating circuits for a Full Wave Bridge Rectifiers)

The Smoothing Capacitor

The single phase half-wave rectifier produces an output wave every half cycle and that it was not practical to use this type of circuit to produce a steady DC supply. The full-wave bridge rectifier however, gives us a greater mean DC value (0.637 Vmax) with less superimposed ripple while the output waveform is twice that of the frequency of the input supply frequency. We can therefore increase its average DC output level even higher by connecting a suitable smoothing capacitor across the output of the bridge circuit as shown below.
Full-wave Rectifier with Smoothing Capacitor



The smoothing capacitor converts the full-wave rippled output of the rectifier into a smooth DC output voltage. Generally for DC power supply circuits the smoothing capacitor is an Aluminum Electrolytic type that has a capacitance value of 100uF or more with repeated DC voltage pulses from the rectifier charging up the capacitor to peak voltage.

22. TRANSMITTERS AND RECEIVERS

(Principles of Transmission and reception)

Facsimile

Facsimile (făksĭm`əlē) or fax, in communications, system for transmitting pictures or other graphic matter by wire or radio. Facsimile is used to transmit such materials as documents, telegrams, drawings, pictures taken from satellites, and even entire newspapers. The surface of the material to be sent is traversed by a light-beam and a photodiode that translates the light and dark areas of the material thus scanned into electric signals for transmission. A receiving station reproduces the transmitted material by a variety of means. Newspapers and television stations have long transmitted and recorded news photographs using a process in which the received electric signals activate a variable lamp that is used to scan a photographic film.

A modern office fax machine scans a page to make an electronic representation of its text or graphics, compresses the data to save transmission time, and transmits it to another fax machine (or computer emulating a fax machine). The receiving machine decrypts the signal and uses a printer (usually built in) to make a facsimile of the original page. Facsimile machines that produce higher-resolution images or color and gray-scale images are also available.

Western Union began a "Facsimile Telegraphy" service in 1935.

Television

In a method of transmitting and receiving Multiplexed Analog Component (MAC) television signals by producing first chrominance component and luminance component signals representing lines of a television signal capable of reconstruction in a conventional MAC television receiver to produce a first television picture having a first aspect ratio and a first number of lines and wherein the component signals for each line are time-compressed and placed sequentially at times appropriate to allow reconstruction of the television picture but occupying less than the whole line time, the improvement whereby further luminance component and chrominance component signals are generated and added to portions of the television signal not containing the first signals such that the further component signals are capable of being reproduced together with the first signals to produce an extended definition picture with the further component signals not interfering with the picture reproduction from the first chrominance and luminance component signals of a television picture having the first aspect ratio and first number of lines.

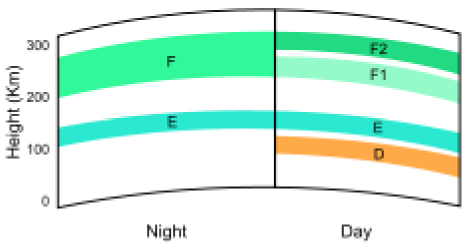
Television signal transmission and reception system includes a broadcasting centre, a transmission network and many reception terminals. In the broadcasting centre, plural television signals corresponding to individual channels are modulated into transmittable form, and a synthesis circuit synthesizes the television signals to produce a synthesis image signal for a multi – screen display comprising plural small screens. Both the ordinary television signal and the synthesis image signal is transmitted with control information to the reception terminals through the transmission network On the reception terminal, for selecting a desired channel out of the individual channels, the synthesis image signal is used for displaying a multi-screen, a moveable cursor image is superimposed on the multi-screen for designating one small screen corresponding to the desired channel. The channel designated by the cursor image is detected based on the control information, and the television signal of the designated channel is demodulated.

TROPOSPHERE

The word troposphere derived from the Greek word tropo and it means turbulence or mixing. This is the lower most layer of the atmosphere and is known as troposphere and is the most important layer because almost all the weather events (e.g fog, cloud, due, frost, hailstorm, storms, cloud-thunder, lightening etc) occur in this layer. Thus the troposphere is utmost significance for all life-forms including man because these are concentrated in the lowermost portion of the atmosphere. Temperature decreases with increasing height at the average rate of 6.5^0 C per 1000m (1 kilometer) which is called as normal lapse rate. The height of troposphere changes from equator towards the poles (decreases) and from one season of a year to the other season (increases during summer while decreases during winter). The average height of the troposphere is about 16km over the equator and 6km over the poles. The upper limits of the troposphere is called as TROPOPAUSE.

Troposphere Characteristics

1. Most of the weather phenomena take place in this layer. The troposphere contains almost all the water vapour and most of the dust.
2. This layer is subjected to intense mixing due both horizontal and vertical mixing.
3. Temperature decreases with height at an average rate of 1^0C per 167m of height above sea level. This is called the normal lapse rate.
4. The troposphere extends up to a height of about 18km at the equator and declines gradually to a height of 8km at the poles.
5. The upper limit of the troposphere is called the tropopause. The temperature stops decreasing in it. It may be as low as -58^0C.
6. All weather changes occur in the troposphere. Since it contains most of the water vapor, clouds form in this layer.



Critical Frequency changes with time of day, atmospheric conditions and angle of fire of the radio waves by antenna.

The existence of the critical frequency is the result of electron limitation, i.e., the inadequacy of the existing number of free electrons to support reflection at higher frequencies.

24. AERIALS

PRINCIPLES OF ANTENNA RADIATION

A tremendous amount of knowledge and information has been gained about the design of antennas and radio-wave propagation. Still, many old-time technicians will tell you that when it comes to designing the length of an antenna, the best procedure is to perform all calculations and try out the antenna. If it doesn't work right, use a cut-and-try method until it does. Fortunately, enough information has been collected over the last few decades that it is now possible to predict the behavior of antennas. This chapter will discuss and explain the basic design and operation of antennas

After an RF signal has been generated in a transmitter, some means must be used to radiate this signal through space to a receiver. The device that does this job is the antenna. The transmitter signal energy is sent into space by a TRANSMITTING ANTENNA; the RF signal is then picked up from space by a RECEIVING ANTENNA. The RF energy is transmitted into space in the form of an electromagnetic field. As the traveling electromagnetic field arrives at the receiving antenna, a voltage is induced into the antenna (a conductor). The RF voltages induced into the receiving antenna are then passed into the receiver and converted back into the transmitted RF information. The design of the antenna system is very important in a transmitting station. The antenna must be able to radiate efficiently so the power supplied by the transmitter is not wasted. An efficient transmitting antenna must have exact dimensions. The dimensions are determined by the transmitting frequencies. The dimensions of the receiving antenna are not critical for relatively low radio frequencies. However, as the frequency of the signal being received increases, the design and installation of the receiving antenna become more critical. An example of this is a television receiving antenna. If you raise it a few more inches from the ground or give a slight turn in direction, you can change a snowy blur into a clear picture.

Antennas are devices used to radiate electromagnetic energy into space. The characteristics of transmitting and receiving antennas are similar, so a good transmitting antenna is often a good receiving antenna. A single antenna performs both functions in many modern applications.

ANTENNA CHARACTERISTICS

Since the operating principles of low-frequency and microwave antennas are essentially the same, the electrical characteristics are also very similar. You will need a fundamental knowledge of radar and communications antenna electrical theory in your shipboard antenna maintenance work. Antenna theory is primarily a design consideration of antenna size and shape requirements that depend on the frequency used. A brief description of antenna electrical characteristics is sufficient for the needs of most students of electronics.

Antenna Efficiency

The effectiveness of an antenna depends upon its ability to couple or radiate energy into the air. An efficient antenna is one which wastes very little energy during the radiation process. The efficiency of an antenna is usually referred to as the POWER GAIN or POWER RATIO as compared to a standard reference antenna. The power gain of an antenna is a ratio of the radiated power to that of the reference antenna, which is usually a basic dipole. Both antennas must be fed RF energy in the same manner and must be in the same position when the energy is radiated. The power gain of a single dipole without a reflector is unity (one). An array of several dipoles in the same position as the single dipole, and fed with the same line, has a power gain of more than one.

The effectiveness of an entire transmitting/ receiving system depends largely on impedance matching between the elements of the system. Impedance matching is particularly critical at the antenna connection. If a good impedance match is maintained between the system and the antenna throughout the operating frequency band, power transfer to and from the antenna is always maximum. The transmission line or waveguide used to transport energy to and from the antenna should have characteristic impedance equal to that of the antenna. A proper impedance match allows all available power to be absorbed and radiated by the antenna without reflections back down the line.

If you have a transmission line or waveguide with impedance mismatch at the termination, standing waves are set up by the reflections. Standing waves cause losses in the form of unwanted radiations, heat losses in transmission lines, and arcing in waveguides.

25. SPACE COMMUNICATIONS

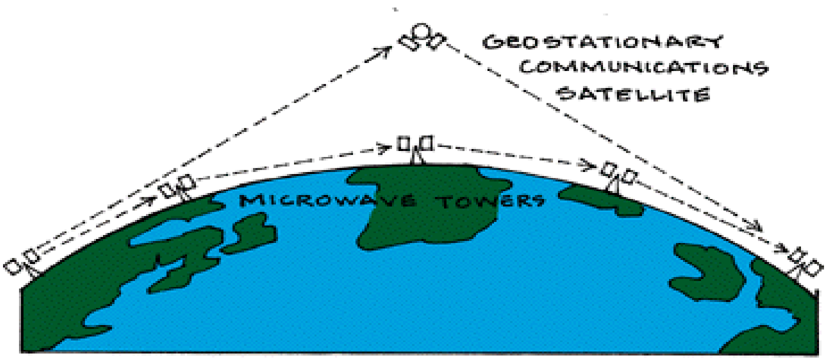
ELEMENTARY PRINCIPLES OF COMMUNICATION VIA SATELLITE

A communications satellite (sometimes abbreviated to COMSAT) is an artificial satellite stationed in space for the purpose of telecommunications. Modern communications satellites use a variety of orbits including geostationary orbits, Molniya orbits, other elliptical orbits and low (polar and non-polar) earth orbits.

For fixed (point to point) services communications satellites provide a microwave radio relay technology complementary to that of communication cables. They are also services used for mobile applications such as communications to ships, vehicles, planes and hand-held terminals, and for TV and radio broadcasting, for which application of other technologies, such as cable television, is impractical or impossible.

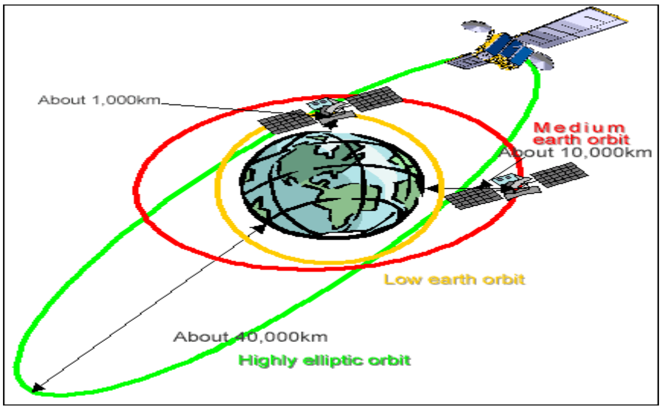
Geostationary orbits

A satellite in a geostationary orbit appears to be in a fixed position to an earth-based observer. A geostationary satellite revolves around the earth at the same angular velocity of the earth itself, 360 degrees every 24 hours in an equatorial orbit, and therefore it seems to be in a fixed position over the equator.



Low-Earth-Orbiting-Satellites

A Low Earth Orbit (LEO) typically is a circular orbit about 400 kilometers above the earth's surface and, correspondingly, a period (time to revolve around the earth) of about 90 minutes. Because of their low altitude, these satellites are only visible from within a radius of toward the satellite, can operate effectively without the need for expensive equipment to track the satellite's motion. Roughly 1000 kilometers from the sub-satellite point (The point at which a line between the satellite and the centre of the Earth intersects the Earth's surface is called the *sub-satellite point).* In addition, satellites in low earth orbit change their position relative to the ground position quickly. So even for local applications, a large number of satellites are needed if the mission requires uninterrupted connectivity.



Low earth orbiting satellites are less expensive to launch into orbit than geostationary satellites and, due to proximity to the ground, do not require as high Signal strength.

A group of satellites working in concert is known as a Satellite Constellation.

Structure of a Communications Satellite

Communications Satellites are usually composed of the following subsystems:

Communication Payload, normally composed of transponders, antenna, and switching systems.

Engines used to bring the satellite to its desired orbit.

Station Keeping Tracking and stabilization subsystem used to keep the satellite in the right orbit, with its antennas pointed in the right direction, and its power system pointed towards the sun.

Power subsystem, used to power the Satellite systems, normally composed of solar cells, and batteries that maintain power during solar eclipse.

Command and Control subsystem, which maintains communications with ground control stations. The ground control earth stations monitor the satellite performance and control its functionality during various phases of its life-cycle.

Bandwidth of a Satellite

The bandwidth available from a satellite depends upon the number of transponders provided by the satellite. Each service (TV, Voice, Internet, radio) requires a different amount of bandwidth for transmission. The bandwidth of transponder is used to carry these services.

Amateur Radio Satellites

Amateur radio operators have access to the amateur radio satellites that have been designed specifically to carry amateur radio traffic. Most such satellites operate as space borne repeaters, and are generally accessed by amateurs equipped with UHF or VHF radio equipment and highly directional antennas such as Yagis or dish antennas. Due to launch costs, most current amateur satellites are launched into fairly low Earth orbits, and are designed to deal with only a limited number of brief contacts at any given time. Some satellites also provide data-forwarding services using the AX.25 or similar protocols.

Terms related with Satellite Communications

Kepler's Law

Artificial satellites which orbit the earth follow the same laws that govern the motion of the planets around the sun. Johannes Kepler empirically derived three laws describing planetary motion.

Kepler's first law

The path followed by the satellite around the primary will be an ellipse.

Kepler's second law

For equal time intervals, the satellite will sweep areas in its orbital plane.

Kepler's third law

The square of periodic time of orbit is proportional to the cube of the mean distance between the two bodies.

Definitions and terms related to Earth Orbiting Satellites

Apogee: the point farthest from earth.

Perigee: the point of closest approach to earth.

Line of apsides: the line joining the perigee and apogee through the centre of the earth.

Ascending node: the point where the orbit crosses the equatorial plane going from south to north.

Descending node: the point where the orbit roses the equatorial plane going from north to south.

Line of nodes: the line joining the ascending and descending nodes through the centre of the earth.

Inclination: The angle between the orbital plane and the earth's equatorial plane.

Prograde orbit: An orbit in which the satellite moves in the same direction as the earth's rotation.

Retrograde orbit: An orbit in which the satellite moves in the same direction s the earth's rotation.

Argument of perigee

The angle from ascending node to perigee, measured in the orbital plane at the earth's centre in direction of satellite motion.

Mean anomaly

Mean anomaly gives an average value of the angular position of the satellite with reference to the perigee.

True anomaly

The true anomaly is the angle from perigee to the satellite position, measured at the earth's centre. This gives the true angular position of the satellite in the orbit as a function of time.

Satellite System

A satellite communication system can be broadly divided into two segments, a ground segment and a space segment. The space system includes satellite. Satellite system consists of the following 6(six) main systems.

Power supply

The primary electrical power for operation electronic equipment is obtained from solar cells. Individual cells can generate small amounts of power, and therefore array of cells in series –parallel connection are required.

Cylindrical solar arrays are used with spinning satellites. (The gyroscopic effect of the spin is used for mechanical orientational stability). Thus the array is only partially in sunshine at any given time. Another type of solar panel is the rectangular array or solar sail. Solar sail must be folded during the launch phase and extended when in geo-stationary orbit. Since the full component of solar cells are exposed to sun light, and since the sail rotate to track the sun they are capable of greater power output than cylindrical arrays having a comparable number of cells. To maintain service during an eclipse, storage batteries are provided.

Altitude control

The altitude of a satellite refers to its orientation in space. Much of equipment carried aboard a satellite is for the purpose of controlling its altitude. Altitude control is necessary to ensure that directional antennas point in the proper direction. In the case of earth environmental satellites the earth sensing instrument must cover the required regions of the earth, which also requires altitude control A number of forces, referred to as disturbance forces can alter altitude, some examples being the gravitational forces of earth and moon, solar radiation, and meteorite impacts.

Station keeping

A satellite that is normally in geo-stationary will also drift in latitude, the main forces being the gravitational pull of the sun and the moon. To prevent the shift in inclination from exceeding specified limits, jets may be pulled at the appropriate time to return the inclination to zero. Counteracting jets must be pulsed when the inclination is at zero to halt that change in inclination.

Thermal control

Satellites are subject to large thermal gradients, receiving the sun radiation on one side while the other side faces into space. In addition, thermal radiation from the earth, and the earths albedo, which is the fraction of the radiation falling on earth is reflected can be sighted for low altitude, earth-orbiting satellites, though negligible for geo-stationary satellites. Equipment in the satellite also generates heat which has to be removed, since the satellites equipment should operate as near as possible in a stable temperature environment, through various steps. Thermal blankets and shields may be used to provide insulation. Radiation mirrors are often used to remove heat from communication payload. These mirrored drums surround the communication equipment shelves in each case and provide good radiation paths for the generated heat to escape into surround space. In order to maintain constant-temperature conditions, heaters may be switched on to make up for the heat that occurs when transponders are switched off.

TT&C Subsystem

The Telemetry, Tracking, and Command (TT&C) performs several routine functions abroad a spacecraft.

Telemetry

Telemetry or telemetring function is measurement at a distance referring to the over all operation of generating an electrical signal proportional to the quantity being measured, as well as encoding and transmitting this to a distant station, which for satellite is one of the earth stations. Data that are transmitted as telemetry signals include information obtained from sun earth sensors; environmental information (magnetic field intensity and direction); the frequency of meteorite impact and so on; and spacecraft information such as temperatures and power supply voltages, and stored fuel pressure.

Tracking

Tracing of the satellite is accomplished by having the satellite transmit beacon signals which are received at the TT&C earth stations. Tracking is obviously important during the transmitter and drift orbital phases of the satellite launch. When on-station, a geo-stationary satellite will tend to be shifted as a result of the various distributing forces. It is necessary to be able to tract the satellites movements and send correction signals as required. Satellite range is also required for time to time. This can be determined by measurement of propagation delay of signals specially transmitted for ranging purposes.

Command systems

Command system receives instruction from ground system of satellite and decodes the instruction and sends commands to other systems as per the instructions.

Transponders

A transponder is the series of interconnected units which forms a single communication channel between the receiving and transmitting antennas in a communication satellite. Some of the units used by a transponder in a given channel may be common to a number of transponders. Thus, although reference may be made to specific transponder, this must be thought of as an equipment channel rather than single item of equipment. Transponder consists of wideband receivers, input de-multiplexer, power amplifier components.

Antenna sub system

The antennas carried abroad a satellite provide the dual functions of receiving the up-link and transmitting the down link signals. They range from dipole-type antennas, where omni directional characteristics are required, to the highly directional antennas required for telecommunications purposes and TV relay and broadcasting.

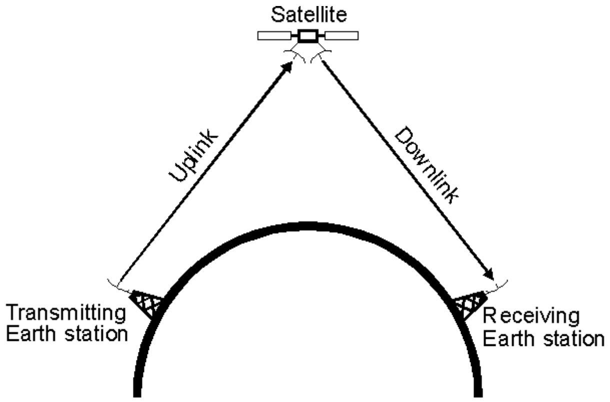
Doppler' effect

The *Doppler Effect* in satellite communications is the change in frequency of an electromagnetic signal that results from the relative speed of the satellite and the Earth terminal. When the orbital parameters of a satellite are known, Doppler shift can be used to determine the position of the Earth terminal. When an Earth terminal's position is known, Doppler shift can be used to estimate the orbital parameters of a satellite. When the satellite (or the Earth station) is moving quickly, the Doppler effects an important consideration in satellite communications.

Satellites are able to fulfill a number of roles. One of the major roles is for satellite communications. Here the satellite enables communications to be established over large distances - well beyond the line of sight. Communications satellites may be used for many applications including relaying telephone calls, providing communications to remote areas of the Earth, providing satellite communications to ships, aircraft and other mobile vehicles, and there are many more ways in which communications satellites can be used.

Basics of Satellite communications

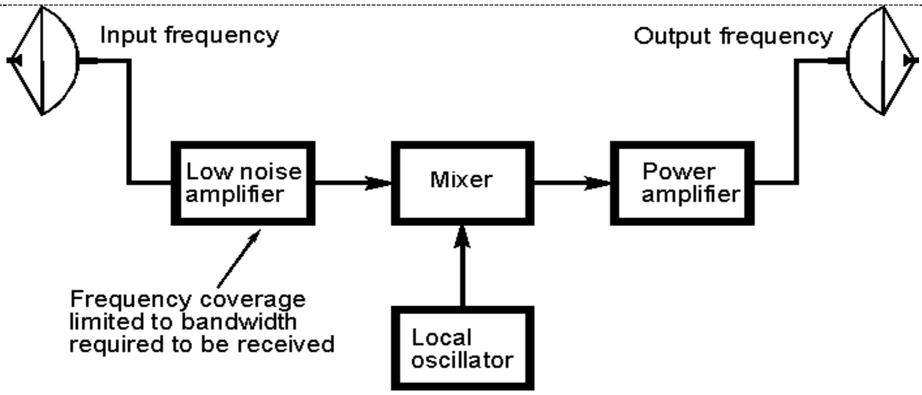
When used for communications, a satellite acts as a repeater. Its height above the Earth means that signals can be transmitted over distances that are very much greater than the line of sight. An earth station transmits the signal up to the satellite. This is called the up-link and is transmitted on one frequency. The satellite receives the signal and retransmits it on what is termed the down link which is on another frequency.



Using a satellite for long distance communications

The circuitry in the satellite that acts as the receiver, frequency changer, and transmitter is called a transponder. This basically consists of a low noise amplifier, a frequency changer consisting a mixer and local oscillator, and then a high power amplifier. The filter on the input is used to make sure that any out of band signals such as the transponder output are reduced to acceptable levels so that the amplifier is not overloaded. Similarly the output from the amplifiers is filtered to make sure that spurious signals are reduced to acceptable levels. Figures used in here are the same as those mentioned earlier, and are only given as an example. The signal is received and amplified to a suitable level. It is then applied to the mixer to change the frequency in the same way that occurs in a super heterodyne radio receiver. As a result the communications satellite receives in one band of frequencies and transmits in another.

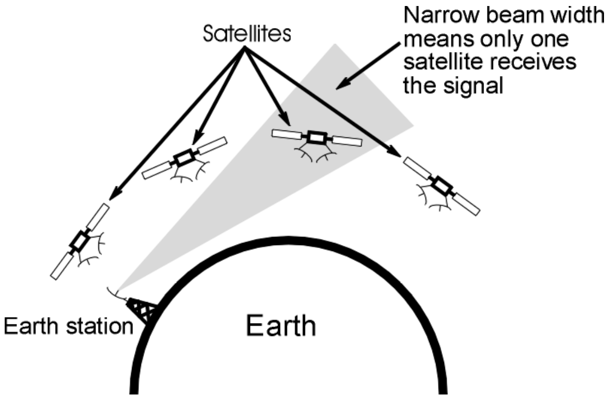
In view of the fact that the receiver and transmitter are operating at the same time and in close proximity, care has to be taken in the design of the satellite that the transmitter does not interfere with the receiver. This might result from spurious signals arising from the transmitter, or the receiver may become de-sensitised by the strong signal being received from the transmitter. The filters already mentioned are used to reduce these effects.



Block diagram of a basic satellite transponder

Signals transmitted to satellites usually consist of a large number of signals multiplexed onto a main transmission. In this way one transmission from the ground can carry a large number of telephone circuits or even a number of television signals. This approach is operationally far more effective than having a large number of individual transmitters.

Obviously one satellite will be unable to carry all the traffic across the Atlantic. Further capacity can be achieved using several satellites on different bands, or by physically separating them apart from one another. In this way the beam width of the antenna can be used to distinguish between different satellites. Normally antennas with very high gains are used, and these have very narrow beam widths, allowing satellites to be separated by just a few degrees.



Separating satellites by position

Telecommunications satellite links

Communications satellites are ideally placed to provide telecommunications links between different places across the globe. Traditional telecommunications links used direct "cables" linking different areas. As a result of the cost of installation and maintenance of these cables, satellites were seen as an ideal alternative. While still expensive to put in place, they provided a high bandwidth and were able to operate for many years.

In recent years the bandwidth that can be offered by cables has increased considerably, and this has negated some of the gains of satellites. Additionally the geostationary satellites used for telecommunications links introduce a significant time delay in view of the very large distances involved. This can be a problem for normal telephone calls.

Mobile satellite communications systems

There are many instances where communications need to be maintained over wide areas of the globe. Ships, aircraft and the like, need to be able to communicate from points all around the world. Traditionally HF radio communications ahs been used, but this is unreliable. Satellite communications provide an ideal solution to this problem as satellite communications are much more reliable and they are able to provide interference free stable communications links. As a result, Satellite communications is now fitted as standard to all maritime vessels, and it is becoming increasingly used by aircraft, although it is not yet adopted for Air Traffic Management (ATM).

In addition to these users, these services can be sued by many land mobile or land portable radio users. Satellite terminals provide are able to access the satellite and the users is able to achieve communications from almost anywhere on the globe. As these communications satellites are in geostationary orbits, communications is not possible towards the poles as in these regions it is not possible to see the satellites.

Direct broadcast communications satellites

Another variant of communications satellites is those used for direct broadcasting. This form of broadcasting has become very popular as it provides very high levels of bandwidth because of the high frequencies used. This means that large numbers of channels can be carried. It also enables large areas of the globe to be covered by one delivery system. For terrestrial broadcasting a large number of high power transmitters are required that are located around the country. Even then coverage may not be good in outlying areas.

These DBS satellites are very similar to ordinary communications satellites in concept. Naturally they require high levels of transmitted power because domestic users do not want very large antennas on their houses to be able to receive the signals. This means that very large arrays of solar cells are required along with large batteries to support the broadcasting in periods of darkness. They also have a number of antenna systems accurately directing the transmitted power to the required areas. Different antennas on the same satellite may have totally different footprints.

Satellite phone systems

Satellites have also been used for cellular style communications. They have not been nearly as successful as initially anticipated because of the enormously rapid growth of terrestrial cellular telecommunications, and its spread into far more countries and areas than predicted when the ideas for satellite personal communications was originally envisaged. Nevertheless these satellite phone systems are now well established and have established a specific market. Accordingly these satellite phone systems are now widely available for mobile communications over wide areas of the globe.

The satellite phone systems that are available have varying degrees of coverage. Some provide true global coverage, although others are restricted to the more densely populated areas of the globe.

The systems that were set up used low earth orbiting satellites, typically with a constellation of around 66 satellites. Handheld phones then communicated directly with the satellites which would then process and relay the signals as required.

Other satellite phone systems use a number of geostationary satellites, although these satellite phone systems generally require the use of a directional antenna in view of the larger distances that need to be covered to and from the satellite. Additionally the levels of latency are higher (i.e. time delay for the signal to travel to and from the satellite) in view of the much higher orbit required. However as the satellites is geostationary, satellite or beam handover is less of a problem.

The main advantage of the satellite system is that it is truly global and communications can be made from ships, in remote locations where there would be no possibility of there being a communications network. However against this the network is expensive to run because of the cost of building and maintaining the satellite network, as well as the more sophisticated and higher power handsets required to operate with the satellite. As a result calls are more expensive than those made over terrestrial mobile phone networks.

Satellite communications summary

Although the basics of satellite communications are fairly straightforward, there is a huge investment required in building the satellite and launching it into orbit. Nevertheless many communications satellites exist in orbit around the globe and they are widely used for a variety of applications from providing satellite telecommunications links to direct broadcasting and the use of satellite phone and individual satellite communication links.

Part 1

Section B: Radio Regulations

1. DEFINITION OF AMATEUR RADIO

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.

2. DETAILS OF EXAMINATION

Section A: Radio Theory and Practice **Section B**: Radio Regulations

The written test consists of Multi Choice Objective Type Questions.

Restricted Grade: The written test will be of one hour duration. The maximum marks will be 100 and candidate must secure at least 40% in each section and 50% in aggregate for a pass.

General Grade: The written test will be of two hour duration. The maximum marks will be 100 and the candidate must secure at least 50% in each section and 60% in aggregate for a pass. One must also qualify in Morse Code at 8 w.p.m.

Morse code (Only for General Grade): The test piece will consist of a plain language passage of 200 characters which may comprise of letters, figures. Test piece may also contain the following punctuations i.e. full stop; comma; semi colon; break-sign; hyphen and question mark. The average words shall contain five characters and each figure and punctuation will be counted as two characters. The test will be for five consecutive minutes at a speed of 8 words per minute. More than 5 errors will disqualify a candidate. However if a candidate receives without any error in any part of the passage continuously for one minute duration will be declared successful in the Morse reception test.

3. WHO ISSUES THE AMATEUR WIRELESS LICENCES IN INDIA?

The Wireless Planning & Co-ordination Wing (W.P.C. Wing) of the Ministry of Communications, Department of Telecommunications, New Delhi.

4. CATEGORIES OF AMATEUR LICENCES IN INDIA

i. Amateur Wireless Telegraph Station Licence, Restricted Grade.

ii. Amateur Wireless Telegraph Station Licence, General Grade.

5. WHO ARE ELIGIBLE FOR AMATEUR LICENCES IN INDIA?

i. The Amateur licence will be issued to citizens of India above 12 years old who passes the ASOC exam.

ii. Holders of Certificate of Proficiency like Radio Communication Operators General or Radio Telegraph Operators First or Second Class Certificate are eligible for Restricted Grade Amateur licence without writing any exams.

iii. Applicants holding Degree in Engineering / Science or Diploma in Engineering and having studied electronics or telecommunications is exempted from appearing in Section A of Part I of the test.

iv. Licences are also given to Radio Club, society, school, college or any institution interested in this hobby, provided that the office bearer is having General Licence.

6. RECIPROCAL LICENCE

Foreign nationals are eligible for reciprocal licence under the following conditions:

i. The country of which the applicant is a citizen should grant reciprocal licence to Indian nationals. It may also not apply if the Govt. thinks otherwise.

ii. The applicant must be above 18 years.

iii. The applicant must be holder of appropriate category of licence.

iv. The licence shall be initially granted for one year or for the validity of the visa, whichever is earlier.

7. FUNCTION OF AMATEUR STATION

The function of the amateur station is to communicate with other stations similarly licenced, in the authorised frequencies and modes. They can also conduct experiments.

8. TYPES OF MESSAGES THAT CAN BE TRANSMITTED BY RADIO AMATEURS

Radio communications can be made with similar stations. Transmissions must be in plain language and limited to messages of a technical nature relating to tests and to remarks of personal character for which use of normal telecommunication facility is not justified.

9. TYPES OF MESSAGES FORBIDDEN TO BE TRANSMITTED BY RADIO AMATEURS

Reproduction of broadcast programs, tape recordings, transmissions of entertainment value, music, false or misleading calls, news, advertisements, business communications, topics on political or industrial controversy, indecent language, topics that can arouse racial, religious or communal feelings, messages for monetary benefit and third party messages are forbidden. We are also forbidden to contact stations of any other countries whose administrations have informed the International Telecommunication Union (ITU) of their objection to such radio communications.

10. CONDITIONS UNDER WHICH THIRD PARTY MESSAGES ARE PERMITTED

In case of failure of normal telecommunication facilities, amateurs are permitted to handle third party messages, relating to natural calamities like earthquakes, floods, cyclones, widespread fires etc. The messages must originate from and must be addressed to District Collectors, District Magistrates, Deputy Commissioners or any other officials authorised by them. We have to inform our licensing authority regarding it.

11. SECRECY OF CORRESPONDENCE

If any message which is not entitled to be received is nevertheless 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 authorised officer of the Central Govt. or competent legal tribunal. It shall not be reproduced in writing, copied or made use of.

Exercise

1) Who issues Amateur Radio Licence in India?

a) WPC wing of Ministry of Communications & IT
b) Department of Posts c) Telephone Department d) State Government

2) What is the minimum age to become a radio amateur in India?

a) No age limit b) 18 years c) 12 years d) 21 years

3) How many types of Amateur Radio licences are there in India?

a) Five b) Two c) One d) Three

4) An Amateur Station is one which is

a) Operated by me holder of a General Amateur Operator certificate of Competency on the amateur radio bands

b) Owned and operated by a person who is not engaged professionally in radio communications

c) Used exclusively to provide two-way communication in connection with activities of amateur sporting organisation

d) Used primarily for emergency communications during floods, earthquakes and similar disasters

5) When are third party messages permitted?

a) Always
b) Upon failure of normal telecommunication facilities and upon request from the Government
c) Never d) When there are natural calamities

6) What is the speed of Morse Code exam for General Grade ASOC exam?

a) 20 WPM b) 12 WPM c) 8 WPM d) 5 WPM

7) Are Radio Amateurs in India permitted to broadcast news?

a) No b) Yes c) Occasionally d) Once per day

8) Which one of the following is not true regarding issue of reciprocal licence?

a) The applicant must have Amateur licence issued in his country.
b) The applicant must be above 20 years
c) The licence shall be initially granted for one year or for the validity of the visa, whichever is earlier
d) The country of which the applicant is a citizen should grant reciprocal licence to Indian nationals

9) The full form of ITU is

a) Indian Telecom University b) Indian Telecommunications Union
c) International Telecommunications Union d) International Television Union

10) The organization responsible for the International Radio Regulations is

a) European Radio communications Office

b) United Nations c) International Telecommunication Union

d) European Telecommunication Standards Institute

11) The Amateur Service may be briefly defined as

a) a private radio service for personal gain and public benefit

b) a public radio service used for public service Communications

c) <u>a radio communication service for the purpose of self training, intercommunication and technical investigation</u>

d) a private radio service intended only for emergency communications

12) An Amateur Station is a station

a) in the public radio service

b) using radio communications for a commercial purpose

c) using equipment for training new radio communications operators

d) <u>in the Amateur Service</u>

12. PHONETICS

Phonetics are necessary because of the similarity of many English alphabets. So all voice operated stations find it necessary to use a standard list of words to signify each letter to give the callsigns, name, location etc. This will avoid any confusion while exchanging messages. The standard list of phonetics suggested by the International Telecommunication Union is as follows:

Alphabet	Phonetics		Number	Phonetics
A	Alfa		**1**	Una one
B	Bravo		**2**	Bisso two
C	Charlie		**3**	Terra three
D	Delta		**4**	Karte four
E	Echo		**5**	Panta five
F	Foxtrot		**6**	Soxi six
G	Golf		**7**	Sette seven
H	Hotel		**8**	Okto eight
I	India		**9**	Nove nine
J	Juliett		**0**	Nada zero
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	X-ray			
Y	Yankee			
Z	Zulu			

13. ABBREVATIONS

AA	All After		**DE**	This is
AB	All Before		**K**	Go ahead
AR	Ending Signal		**NIL**	I have nothing for you
AS	Please Wait		**OK**	All correct
BK	Break		**R**	Roger (Received fully)
C	Yes		**TU**	Thank you
CFM	Confirm		**VA**	End of contact
CL	Closing down		**WA**	Word After
CQ	General call for all stations		**WB**	Word Before
73	Best Regards		**55**	Good Luck
OM	Old Man (Male operator of any age)		**YL**	Young Lady (Lady Operator of any age)

14. Q CODES

Q codes are groups of three letters starting with the letter Q used for Morse Code communications. Long sentences can be avoided in Morse Code communication by using them. When a Q code is followed by a question mark, it is a question and without it is an answer or advice. The Q Codes as per the ASOC examination syllabus is as follows.

Code	Question	Code	Answer or Message
QRA?	What is the name of your station?	**QRA**	The name of my station is …..
QRG?	What is the exact frequency?	**QRG**	The exact frequency is …
QRH?	Does my frequency vary?	**QRH**	Your frequency varies.
QRI?	How is the tone of my transmission?	**QRI**	The tone of your transmission is ... 1. Good 2. Variable 3. Bad
QRK?	What is the readability of my signals?	**QRK**	The readability of your signals is: 1: Bad 2: Fairly bad 3: Reasonably good 4: Good 5: Excellent
QRL?	Are you busy? Is the frequency in use?	**QRL**	I am busy. The frequency is in use.
QRM?	Are you being interfered with?	**QRM**	I am interfered with. 1: I am not at all interfered with 2: Slightly 3: Moderately 4: Strongly 5: Very strongly
QRN?	Are you bothered by atmospherics?	**QRN**	I am bothered by atmospherics. 1, Not at all 2. Slightly 3. Moderately 4. Strongly 5. Very strongly
QRO?	Shall I increase my power of my transmitter?	**QRO**	Increase Power
QRS?	Should I decrease my sending speed?	**QRS**	Decrease your sending speed.
QRT?	Should I stop my transmission?	**QRT**	Stop your transmission.
QRU?	Do you have you anything for me?	**QRU**	I have nothing for you.
QRV?	Are you ready?	**QRV**	I am ready.
QRW?	Shall I advise ... that you are calling him on ... kHz?	**QRW**	Please advise ... that I am calling him on ... kHz.
QRX?	When will you call me back?	**QRX**	I will call you back at … Also: wait, standby
QRZ?	Who was calling me?	**QRZ**	You are called by ...
QSA?	What is the strength of my signals?	**QSA**	The strength of your signals is: 1. Bad 2. Fairly bad 3. Reasonably good 4. Good 5. Excellent
QSB?	Is my signal fading?	**QSB**	Your signal is fading.
QSL?	Can you confirm reception?	**QSL**	I confirm reception.

QSO?	Can you make contact with … (me)?	**QSO**	I can make contact with … (you).
QSU?	Shall I send or reply on this frequency or on …..kHz with …emission of class	**QSU**	Send or reply on this frequency or on …kHz with … emission of class.
QSV?	Shall I send a series of VVV....?	**QSV**	Send a series of VVV.
QSW?	Will you send on this frequency or on …kHz with … emission of class?	**QSW**	I am going to send on this frequency or on … kHz with…. emission of class
QSX?	Can you listen on …?	**QSX**	Listen on …
QSY?	Shall I start transmitting on another frequency?	**QSY**	Start transmitting on … Also: change frequency (to …)
QSZ?	Shall I send each word or group twice?	**QSZ**	Send each word or group twice.
QTC?	Do you have a message for me?	**QTC**	I have a message for you.
QTH?	What is your location (latitude and longitude or by name of the location)?	**QTH**	My location is … latitude and … longitude or : my location is …
QTR?	What is the exact time?	**QTR**	The exact time is ....
QUM?	Is the Distress traffic over?	**QUM**	The Distress traffic is over

15. CALLSIGN

It is an identification of a station issued by a competent authority. The first part of the callsign is known as prefix which indicates the country from which the operator is transmitting and last part is the suffix which normally consists of up to three alphabets which indicates the individual operator. While contacting or monitoring stations, it is necessary to identify the station. This information is immediately known on hearing the callsign. In some cases one can also know from which part of the country the operator is working.

For Amateur Stations, the callsigns consist of one or two letters and a single digit followed by a group of not more than three letters. Q codes, distress and other signals which may cause confusions are not issued as suffix. The callsigns has to be given at the starting and ending of each period of communication and if it exceeds 10 minutes, the callsign must be repeated.

16. CALLSIGN BLOCKS ALLOTTED TO INDIA

Callsign blocks are issued to all countries by ITU.

Those issued to India are: ATA-AWZ, VTA-VWZ, 8TA-8YZ

17. CALLSIGN FORMATION FOR INDIAN AMATEURS

General Grade: Callsigns starting with VU2: Eg. VU2MY, VU2MYH

Restricted Grade: Callsigns starting with VU3: Eg. VU3SQB, VU3TMO

18. DETAILS OF LOCATION OF STATION

The amateur station shall be operated from anywhere in India (Except in Restricted areas).

19. MOBILE/PORTABLE STATION

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 the mobile station must not communicate with each other.

20. AMATEUR STATION ON BOARD SHIP

Permission can be obtained for operating the amateur station from ships registered in India. Applications for such authorisation must be accompanied by a written approval from the Master or 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.

21. DIFFERENT TYPES OF SIGNALS

a. Distress Signal

It indicates that a ship, aircraft or any other vehicle is threatened by grave and imminent danger and requests immediate assistance. The distress call in Morse Code consists of the letters SOS sent three times, the word DE and the callsign of the station in distress three times. In voice it is MAYDAY pronounced as the French expression 'maider', spoken three times, the words THIS IS and the callsign of the station three times. The distress message must consist of the callsign, exact location, type of distress, type of assistance required and any other information helpful for the rescue.

The distress call shall have priority over all other transmissions. All stations which hear it shall immediately stop any transmission capable of interfering with it and shall continue to listen on frequency and render any help if possible. The distress frequency in Morse Code (Radio Telegraphy) is 500 kHz while on voice (Radio Telephony) it is 2182 kHz.

b. Urgency Signal

It indicates that the calling station has a very urgent message regarding the safety of a ship, aircraft or any other vehicle, or the safety of a person. In Morse Code (Radio Telegraphy) it consists of three repetitions of the group XXX and in voice (Radio Telephony) the words PAN PAN pronounced as the French word "panne" followed by the urgency message. The urgency signal shall have priority over other communications except distress. Stations which hear it shall take care not to interfere with that transmission.

c. Safety Signal

It is sent for giving weather warnings. In Morse Code it consists of three repetitions of the letters T T T and in voice the words SECURTIE followed by the safety message. It has priority over other communications except distress and urgency signals.

d. Test Signal

Test signals are sent either for the adjustment of a transmitter or a receiver. It shall be sent not more than 30 seconds. In Morse Code it shall consist of three series of VVV and in voice the figures 1,2,3,4,5 followed by the callsign of the station. The Q code for sending test signal is QSV.

22. THE RST SYSTEM

The RST system is used for giving reports of the signals received. R stands for Readability and has a range from I to 5. S stands for Signal Strength and has a range from 1 to 9. T stands for Tone and has a range from 1 to 9. In voice only R and S report is to be given and on Morse Code, Tone report also must be given. Eg. For a perfectly readable and extremely strong voice signal, we can give 59 report. Given below are the meanings of the figures used in the RST system. (RS for Voice & RST for Morse Code)

READABILITY:	**SIGNAL STRENGTH:**	**TONE: (CW Morse Radiotelegraph only):**
1. Unreadable	1. Faint signals barely perceptible	1. Sixty-cycle ac or less, very rough and broad.
2. Barely readable, occasional words distinguishable	2. Very weak signals	2. Very rough ac, very harsh and broad
3. Readable with considerable difficulty	3. Weak signals	3. Rough ac tone, rectified but not filtered
4. Readable with practically no difficulty	4. Fair signals	4. Rough note, some trace of filtering
5. Perfectly readable	5. Fairly good signals	5. Filtered rectified ac but strongly ripple-modulated
	6. Good signals	6. Filtered tone, definite trace of ripple modulation
	7. Moderately strong signals	7. Near pure tone, trace of ripple modulation
	8. Strong signals	8. Near perfect tone, slight trace of modulation
	9. Extremely strong signals	9. Perfect tone, no trace of ripple or modulation of any kind

Exercise

25) What is the Phonetics for the alphabet R?

a)Romeo b)Rome c)Romania d)Royal

26) What is the normal prefix for Restricted Grade Amateur Radio Licence in India?

a) VU2 b) VU3 c) VU5 d) VU9

27) What is the Q Code for "My exact location is"?

a) QRL b) QSL c) QRA d) QTH

28) What is the meaning of QRZ?

a) What is the exact time?
b) What is your name?
c) Who is calling me?
d) When will we meet again?

29) The Distress signal in Morse Code is :

a) XXX b) SOS c) TTT d) V V V

30) Pan Pan means:

a)Urgency Signal
b)Test Signal
c) Weather warning
d)Normal message

31) What is meaning of CL in Morse code?

a) clearing down b) cloudy
c) see you later d) closing down

32) If in Morse code three series of v v v are sent what it represent?

a) I am busy b) Test Signal
c) Ending Signal d) General call

33) Which type of signal has the highest priority?

a) Urgent Signal b) Test Signal
c) Distress Signal d) Weather warning

34) What is the meaning of CQ?

a) General call for all stations
b) I have nothing for you
c) I am busy d) I am closing down

11) The Morse code signal SOS is sent by a station

a) with an urgent message
b) in grave and imminent danger and requiring immediate assistance
c) making a report about a shipping hazard
d) sending important weather information

23. PRECAUTIONS TO BE TAKEN TO ENSURE NON-INTERFERENCE TO OTHERS

Interference is unwanted radiation from antenna. It endangers the functioning of radio navigation or other safety services or obstructs or interrupts other radio communications and is called harmful interference. The station must be designed, constructed, erected, maintained and worked so as not to cause any interference to other stations. If interference is being caused by the amateur station, the licensee shall discontinue or restrict transmissions, pending adjustment of the equipment upon request from the Central Govt. or any land station. The signals must be free from harmonics, key clicks, hum or other spurious emissions. The transmitter must not be over modulated and use of class B emissions (damped waves) is forbidden. One must use only the minimum power needed to make the contact.

24. RULES GOVERNING ERECTION/ PLACING OF WIRELESS TELEGRAPH APPARATUS AND AERIALS BY AMATEURS

The equipments must be so arranged as not to endanger the safety of the operator or others. It must be kept in a safe condition so that it is not easily accessible to unauthorised persons. The aerial must be so erected, fixed or placed as not to cross above or fall on any power or telephone line. The height of the aerial must not cause hazard to aircrafts and must be within the limits specified by the Director General of Civil Aviation in India. If directed, beacon lights must be installed and maintained and the tower must also be painted.

25. CLASSIFICATION OF RADIO FREQENCIES

Symbols	Full Form	Frequency Range (lower limit exclusive, upper limit inclusive)	Corresponding Metric Subdivision
VLF	Very Low Frequency	3 to 30 kHz	Myria metric waves
LF	Low Frequency	30 to 300 kHz	Kilo metric waves
MF	Medium Frequency	300 to 3000 kHz	Hecto metric waves
HF	High Frequency	3 to 30 MHz	Deca metric waves
VHF	Very High Frequency	30 to 300 MHz	Metric waves
UHF	Ultra High Frequency	300 to 3000 MHz	Deci metric waves
SHF	Super High Frequency	3 to 30 GHz	Centi metric waves
EHF	Extremely High Frequency	30 to 300 GHz	Milli metric waves

26. EMISSIONS (Modes of communications)

Emissions are designated according to their necessary bandwidth and their classification.

Classes of emissions are designated by groups of a minimum of three characters.

First symbol	Type of modulation of main carrier
Second symbol	Nature of signals modulating the main carrier
Third symbol	Type of information to be transmitted

The emissions that are permitted for amateurs in India are as follows:

Description	Emission	First Symbol	Second Symbol	Third Symbol
Morse Telegraphy	**A1A**	Double Side Band	A single channel containing quantized or digital information without the use of a modulating sub-carrier	Telegraphy – for aural reception
Modulated CW Morse	A2A	Double Side Band	A single channel containing quantized or digital information with the use of a modulating sub-carrier	Telegraphy - for aural reception
Facsimile	A3C	Double Side Band	A single channel containing analogue information	Facsimile
AM Voice	**A3E**	Double Side Band	A single channel containing analogue information	Telephony (including sound broadcasting)
Fast Scan TV	A3F	Double Side Band	A single channel containing analogue information	Television (video)
RTTY (F.S.K.)	F1B	Frequency Modulation	A single channel containing quantized or digital information without the use of a modulating sub-carrier	Telegraphy - for automatic reception
RTTY (A.F.S.K.)	F2B	Frequency Modulation	A single channel containing quantized or digital information with the use of a modulating sub-carrier	Telegraphy - for automatic reception
FM Voice (Narrowband)	**F3E**	Frequency Modulation	A single channel containing analogue information	Telephony (including sound broadcasting)
Facsimile	F3C	Frequency Modulation	A single channel containing analogue information	Facsimile
SSB, Full carrier	H3E	Single Side Band, full carrier	A single channel containing analogue information	Telephony (including sound broadcasting)
SSB, Suppressed carrier	**J3E**	Single Side Band, suppressed carrier	A single channel containing analogue information	Telephony (including sound broadcasting)
SSB, Reduced carrier	R3E	Single Side Band, reduced or variable carrier	A single channel containing analogue information	Telephony (including sound broadcasting)

27. AUTHORISED FREQUENCY BANDS, POWER & EMISSIONS

Bands	Frequencies	Emissions	Max DC Input Power	Emissions	Max DC Input Power	Remarks
		Restricted Grade		General Grade		
160 M	1800-1825 kHz	A3E, H3E, J3E, R3E	50 watts	A1A, A2A, A3E, H3E, J3E, R3E, F1B, F2B, F3E, F3C, A3C, A3F	400 watts	Old Grade II Licensees are also authorised to use A1A emission in these bands
80 M	3500-3700* kHz					
75 M	3890-3900* kHz					
40 M	7000-7200 kHz					
30 M	10100-10150 kHz $					
20 M	14000-14350 kHz					
17 M	18068-18168 kHz $					
15 M	21000-21450 kHz $					
12 M	24890-24990 kHz					
10 M	28000 -29700 kHz					
6 M	50-52 MHz	F1B, F2B, F3E, F3C	10 watts	F1B, F2B, F3E, F3C	25 watts	
2 M	144-146 MHz	F1B, F2B, F3E, F3C		F1B, F2B, F3E, F3C	25 watts	Old Grade II Licensees are also authorised to use A1A and A2A emissions in these bands
70 CM	434-438 MHz #					
	5725-5840 MHz #	-	-			
* On primary shared basis as per the relevant provision of Radio Regulations.						
# On secondary basis as per the relevant provisions of Radio Regulations.						
$ Authorization is on non-interference and non protection basis.						

28. FREQUENCY CONTROL AND MEASUREMENT

The transmitter must be tuned accurately so that no energy is radiated outside the authorised bands. A reliable frequency measuring device must be available at the station to check the correct frequency of the signals.

29. REPEATER

An Amateur station that simultaneously retransmits the transmission of another station on a different channel is called repeater. It is mostly used in VHF band. The standard shift between transmitting and receiving frequency for Amateur Radio VHF band is 600 kHz. Repeaters are installed on hilltops or tall buildings and retransmits signals from walkie-talkies, mobile stations etc. The result is an increase in communication coverage.

30. 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.

31. PRECAUTIONS TO BE TAKEN BEFORE ESTABLISHING CONTACT WITH AN AMATEUR STATION

Before transmitting, the station shall take precautions to ensure that its signals will not interfere with transmissions already in progress. If such interference is likely, the transmission shall commence only when there is an appropriate break in communications.

32. PROCEDURE BY WHICH AN AMATEUR STATION ESTABLISHES CONTACT WITH ANOTHER STATION

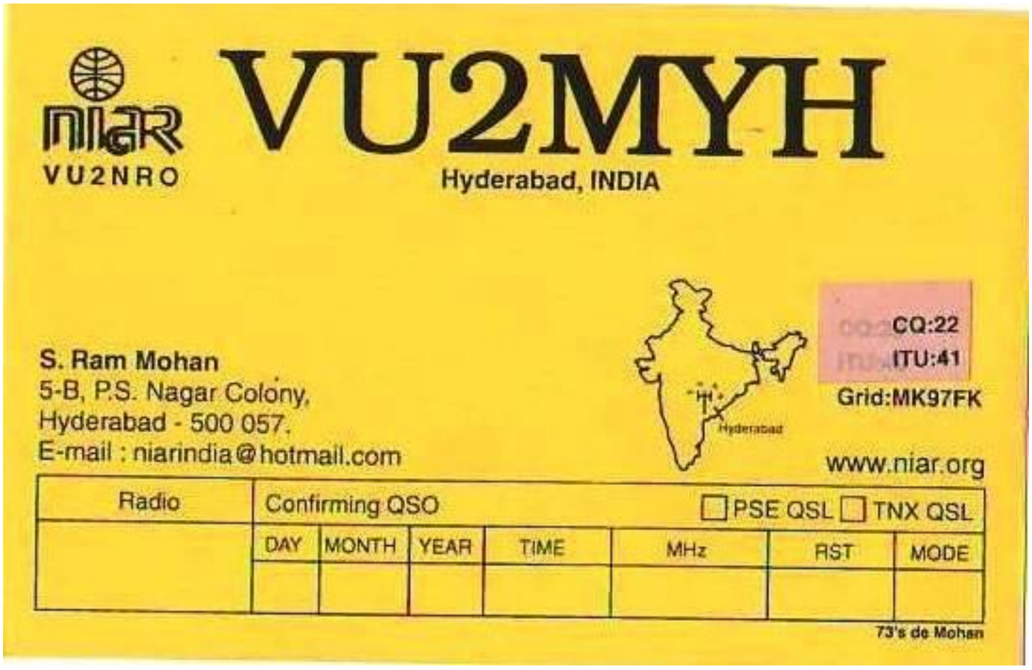
The General call shall Consist of the word CQ three times followed by the word DE in Morse Code and THIS IS in voice, followed by the stations callsign three times and the ending signals AR K.

Eg. Morse: CQ CQ CQ DE VU2JOS VU2JOS VU2JOS AR K

Voice: CQ CQ CQ THIS IS VU2BL VU2BL VU2BL CALLING CQ & STANDING BY

The call may be sent three times at intervals of two minutes and then it shall not be repeated for another ten minutes. The reply to a call shall consist the callsign of the calling station not more than three times, the words DE in Morse Code and the words THIS IS in voice and the callsign of the station called, not more than three times. Transmission of a message shall be terminated by the signal AR in Morse Code and by the word OVER in voice. The end of work between two stations shall be indicated by the signal VA in Morse code and the word OUT in voice.

33. QSL CARD



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 transmitter and antenna etc. Collecting these cards is also part of this hobby. For sending and receiving the cards economically, QSL Bureaus of radio clubs are used. One has to send the cards to the bureaus which will dispatch it to other foreign bureaus and vice versa.

34. LOG BOOK

A chronological record of all transmissions must be kept in a bound book (not loose sheet) showing the following:

a. Date and time of starting and ending of contact with each station, in Indian Standard Time using the 24 hour format.
b. Callsigns of stations contacted.
c. Frequency or Meter Band used.
d. Mode and power used.
e. In case of portable or mobile station, the temporary location.
f. Brief summery of communications

No gaps shall be left between the entries and they shall be initialed. We have to preserve the log for a period of one year from the date of last entry. If the station is operated by another amateur, he must sign in the log and indicate his name, callsign and licence number.

Specimen copy of log book:

Sl.No. of contact	Date	Time	Frequency & Type of emission & power input to final stage (PEP)	Station called by	Station heard or worked	Report sent /received RST	Time of terminating QSO	Time of record experiment & test / summery of communication	QSL card (sent / received)	Initials
1	16 Mar 2021	1530	14 MHz, CW 100 Watts	VU2NRO	VU2RBI	599 599	1545	Bharathi, New Delhi		
2	17 Jan 2021	0700	7 MHz, SSB, 100 Watts	VU2NRO	VU2MY	59 59	0715	Suri, Hyderabad		

35. EQUIPMENT REGISTER

A register giving details of equipment owned /used by the Amateur Radio operator is to be maintained in the following format:

Sl.No.	Particulars of the apparatus Make / Model / Chassis & Type No.	Name & address of the person from whom received (in case assembled by licencee write self made)	Date of receipt or assembly	In case of purchase give receipt no. and indicate the licence no. of the seller	Name & address of the person to whom sold or transferred	Date of sale or transfer	Particulars of the licence issued in the name of purchaser	Remarks
1	HF Transceiver	Self Made	10 Jan 2016	-	-	-	-	-
2	VHF Transceiver	ICOM, Box 700, Tokyo, Japan	15 Feb 2016	IC/VU/7204	-	-	-	-

36: TIMINGS OF OPERATIONS

HX : No specific working hours
H 24 : 24 hours
HJ: Sunrise to Sunset (Day frequency)
HN: Sunset to Sun rise (Night frequency)

Amateur Radio comes under HX: No specific times

37. STANDARD TIME AND FREQUENCY STATIONS

There are some stations that broadcast only time on some standard frequencies. They are called Standard Time and Frequency stations. These stations send time pips and time announcements usually on standard frequencies like 5.000, 10.000 and 15.000 MHz. We can know the time, frequency and propagation conditions by monitoring these stations.

The callsign of the Indian station is ATA located at New Delhi which is operated by National Physical Laboratory (N.P.L.).

38. IST/UTC

IST (Indian Standard Time) is 5.30 hrs ahead of UTC (Universal Coordinated Time). UTC is also known as GMT (Greenwich Mean Time). Thus when it is 5.30 am 1ST it is 0000 hrs UTC/GMT. When it is 1000 UTC, it is 3.30 pm 1ST.

39. AMATEUR RADIO BEACON

Amateur Radio Beacon means a station in the Amateur Service having transmitter(s) emitting carrier wave along with identification signals at regular intervals. Such beacons can be directional or non-directional.

40. DOCUMENTS TO BE DISPLAYED AT AN AMATEUR WIRELESS STATION

a. Original Licence with renewal cards if any.

b. Log Book for the period of one year from the date of last entry.

c. Copy of Indian Wireless (Amateur Service) rules.

d. Register for Wireless equipments.

41. LICENCE FEE

The licence is issued for 20 years (Rs.1000) / Life (Rs.2000) depending on the fees paid. If it is issued for 20 years, it can be renewed for 20 years / Life by paying the prescribed fees before the expiry of the licence. One must also send a declaration that the licensee has made at least 40 occasions per year. It can be also renewed on expiry of the licence by paying a surcharge of Rs.100 for every 6 months or part thereof.

All correspondence (except exam) must be with:

The Assistant Wireless Advisor to Government of India,
Ministry of Communications, (WPC Wing)
Department of Telecommunications, Amateur Section,
Sanchar Bhavan, 20 Ashoka Road,
New Delhi -110001.

42. FEES AT A GLANCE

Sl.No.	Details	Fee in Rs.
1.	Examination fee	Rs.100/-per Grade
2.	Licence fee for any Grade	Rs.1000/- for 20 years or Rs.2000/- for life time
3.	Renewal fee	Rs. 1000/- for 20 years, Rs.2000/- for life time
4.	Surcharge for late renewal	Rs.100/- for every 6 months or part there of
5.	Permanent change of location	Rs.200/-
6.	Duplicate licence	Rs.100/-
7.	Duplicate renewal	Rs.100/-

Exercise

1) What is the 40 Meter Band allocation for Amateur Radio License in India?
   a) 14.000 to 14.350 MHz
   b) 7.000 to 7.100 MHz
   c) 7.000 to 7.200 MHz.
   d) 7.100 to 7.200 MHz

2) How much power is permitted on HF for Restricted Grade Amateur Radio Licence in India?
   a) 50 watts
   b) 100 watts
   c) 400 watts
   d) 25 watts

3) By what name in general are the Amateur Radio Satellites known as:
   a) INSAT
   b) INTELSAT
   c) IRIDIUM
   d) OSCAR

4) What is the meaning of DE in Morse code?
   a) How are you?
   b) This is
   c) Who are you?
   d) Distant station

5) What type of emission is A1A?
   a) Morse Code b) SSB c) FM d) AM

6) What is emission for SSB, suppressed carrier :
   a) A1A b) F3E c) J3E d) A3E

7) When it is 10.30 pm IST, What will UTC time be?
   a) 1000 Hrs b) 1500 Hrs c) 0000 Hrs d) 1700 Hrs

8) The frequency band of 30 to 300 MHz is :
   a) HF b) UHF c) VHF d) SHF

9) How long must a log book be preserved?
   a) One year
   b) One year from date of last entry
   c) Two years
   d) Permanently

   The Time in the log book must be in : a) IST b) UTC c) GMT d) Local Time

Exercise

1. What does the first symbol indicate in emission: Type of modulation of main carrier
2.What is the meaning is QRM: I am being interfered with
3.What is the meaning of QSL? Can you acknowledge receipt?
4.What is the meaning of QRZ? Who is calling me?
5.How long can a Test signal be transmitted for ? 30 seconds
6. What does R stands for in RST Code? Readability
7.When is the suffix MO is used for? For Mobile operation
8.Which type of signal has the highest priority? Distress Signal
9.What is the Phonetics for 5? Panta Five
10.What is the meaning of Roger? Received fully
11. Signal Strength 9 means. Strong signals
12. Ultra High Frequency is : 300 to 3000 MHz
13.What is the standard shift between transmitting and receiving frequency for Amateur Radio VHF Repeater : 600 kHz
14.What is the minimum age for foreign nations to apply for reciprocal licence : 18 years
15.Who operates Standard Time & Frequency station in India : National Physical Laboratory
16.What is the Q code for sending test signal : QSV
17.Amateur Radio licence can be renewed for : 20 years or Life long
18.What is the International Distress Frequency in Radio telephony: 2182 kHz
19.What is the speed of Morse code if 200 letters are sent in one minute? 40 wpm
20..What is the Morse Code alphabet denoted by: .._. F
21.What is the space duration between letters in Morse Code? 3 dits
22.Mobile permission is issued for 90 days
23. Amateur Radio Messages must be in Plain language
24. Power permitted for Restricted grade on 144-146 MHz is : 10 watts
25. The fee for change of address is: Rs. 200

PART II

MORSE CODE

(Only for General Grade)

MORSE CODE

Morse Code is a method of transmitting text information as a series of on-off tones, lights, or clicks that can be directly understood by a skilled listener or observer without special equipment.

Each character (letter or numeral) is represented by a unique sequence of dots and dashes. The duration of a dash is three times the duration of a dot. Each dot or dash is followed by a short silence, equal to the dot duration. The letters of a word are separated by a space equal to three dots (one dash), and the words are separated by a space equal to seven dots. The dot duration is the basic unit of time measurement in code transmission.

Morse code is most popular among amateur radio operators, although it is no longer required for licensing in most countries.

Radiotelegraphy by Morse code is named after its inventor Samuel Finley Breese Morse, 1791-1872, an American artist and promoter of the telegraph.

LANGUAGE:

Radiotelegraphy by itself is a language. Not every amateur understands English, but through a recognised systems and combinations of dits and dashes every ham can converse in a common language, the Morse code. One of the Amateur logo is:

"ONE WORLD ONE LANGUAGE"

because of this Morse Code.

EFFICIENT:

Compared to voice, Morse code is less sensitive to poor signal conditions, yet still comprehensible to humans without a decoding device. Morse code is the most efficient means of radio communication. Nothing beats code for providing vital communication through noise and interference under marginal conditions.

ADVANTAGES:

Continuous Wave and Distant Station go hand in hand. With less crowded 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 of a phone signal. Many more CW stations can squeeze into 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.

Morse is a very effective mode of communication, which, depending on the skill of the operators, can facilitate communication when other modes fail due to low signal strengths. It thus enables low power, low cost equipment to be surprisingly effective - an important point to those working on a limited budget. Being a narrow band width, it uses the spectrum in a most effective way.

HINTS ON LEARNING MORSE CODE

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

Learn to listen to the sound 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 hut leave a blank space and concentrate on the next letter.

Avoid thinking back, you may lose more letters.

Practice Morse half 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.

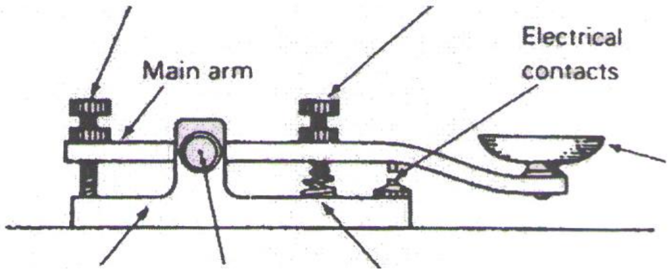
Set aside a definite time every day and stick to the schedule of daily practice.

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.

TRANSMITTING MORSE CODE

Contact space adjustment **Return spring adjustment** **Knob**



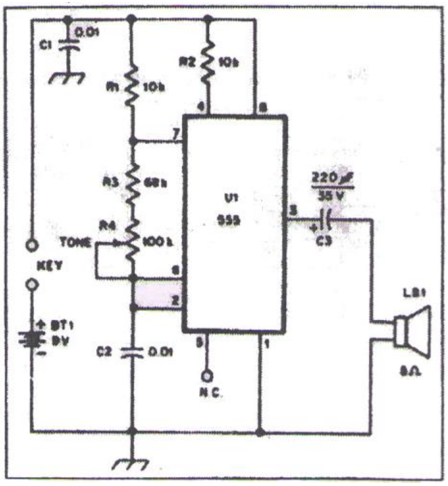
TELEGRAPH KEY

A key is a means of making and breaking a connection easily.

Mount the key firmly to the operating table. Adjust the contacts until the handle moves about 1/16" when depressed. Fixing and adjustments are to he done to reduce side to side sway. Finally adjust the spring tension to a comfortable feel.

Now send from the wrist, not the fingers. Keeping the wrist off the table. a gentle grip around the knob and a smooth tip and down motion make for clean and effortless sending.

CODE PRACTICE OSCILLATOR



To send, you need a Morse key and a Code Practice Oscillator (CPO). For the do it yourself amateurs a common circuit is shown for guidance. This is a simple code practice oscillator and is capable of providing sufficient output power for classroom instruction. The tone is adjustable from a few hundred to several thousand Hertz. You may also choose any other circuit that provides any Tone which can be transmitted preferably from 800 to 1000 Hertz.

TIMING OF MORSE CODE ELEMENTS AND SPACES

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 clashes. 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.

The above relationships are indicated below for the guidance of learners.

• Dit (One Unit)	– Dah (Three Units)
Character to Character	One Dit (Unit)
Letter to Letter	Three Dits (Units);
Word to Word	Five Dits (Units)

MORSE CODE

Alphabet	Morse
A	• –
B	– • • •
C	– • – •
D	– • •
E	•
F	• • – •
G	– – •
H	• • • •
I	• •
J	• – – –
K	– • –
L	• – • •
M	– –
N	– •
O	– – –
P	• – – •
Q	– – • –
R	• – •
S	• • •
T	–
U	• • –
V	• • • –
W	• – –
X	– • • –
Y	– • – –
Z	– – • •

Number	Morse
1	• – – – –
2	• • – – –
3	• • • – –
4	• • • • –
5	• • • • •
6	– • • • •
7	– – • • •
8	– – – • •
9	– – – – •
0	– – – – –
Full Stop	• – • – • –
Comma	– – • • – –
Semi-colon	– • – • – •
Break sign	– • • • –
Hyphen	– • • • • –
Question mark	• • – – • •
Error Signal	• • • • • • • •

Error Signal: If the sending operator becomes aware of an error, he/she shall stop, send the error signal (••••••••) , repeat the last word correctly transmitted and continue the transmission.
It can be also learnt via the website : http://morsecat-beta.software.informer.com/

Sample question paper of the examination for award of Amateur Station Operator's Licence (General and Restricted Grade)

Government of India
Ministry of Communications &IT
Department of Telecommunications

Note:
1. All questions are of Multiple Choice type.
2. Maximum marks 100.
3. Restricted grade candidates have to answer the first 25 questions(each question carries Two marks) from each section and the time allotted for it is One hour.
4. General grade candidates have to answer all the 50 questions(each question carries One mark) from each section and the time allotted for it is Two hours.

SECTION-A
(Radio Theory and Practice)

1. The Transformer works on the principle of [ ]
   a) Self Inductance b) Mutual Inductance
   c) both a & b d) None
2. The Frequency of oscillation of a series RLC resonant circuit is [ ]
   a) f=1/2π√LC b) f=1/π√LC
   c) f=2π√LC d) None
3. The Capacitor is a [ ]
   a) Passive device b) Active device
   c) both a & b d) None
4. The frequency of a sinusoidal signal v(s)=10sin100t volts is [ ]
   a) 100/2π c/s b) 50 c/s c) 100 c/s d) 100t c/s
5. The resistance value of an Insulator is [ ]
   a) Zero b) Very High c) Less than unity d) None
6. The Conductance is proportional to [ ]
   a) Resistance b) Inverse of Resistance
   c) Reactance c) Inverse of Reactance
7. The power can be expressed as [ ]
   a) V=IR b) P=VI c) $P=I^2R$ d) both b & c
8. The Law behind electromagnetism is [ ]
   a) Newton's law b) Faradays law
   c) Kirchoffs law d) keplers law
9. As per Kirchoffs voltage law, in a closed circuit [ ]
   a) All the branch voltages meeting at a node should be zero
   b) All the branch currents meeting at a node should be zero
   c) The sum of all the voltage drops is equal to applied voltage
   d) None of the above

Contd: 2

10. The Impedance of a resonant circuit is [ ]
a) Zero b) Equal to resistance
c) Unity d) Equal to reactance

11. The Bridge rectifier is a [ ]
a) Full-wave type b) Half-wave type
c) both a & b d) None of the above

12. A Diode can be used as [ ]
a) Rectifier b) Detector c) Switch d) All the above

13. An Oscillator is based on [ ]
a) Positive feedback b) Negative feedback
c) No feedback d) both a & b

14. The output signal of an CE amplifier will be [ ]
a) 45 deg out of phase b) 90deg out of phase
c) 180 deg out of phase d) 270 deg out of phase

15. In the process of modulation in communication system [ ]
a) Signal frequency is more than carrier frequency
b) Signal frequency is less than carrier frequency
c) Signal frequency will be directly transmitted
d) Signal frequency equals carrier frequency

16. The typical value of IF in a Superhetrodyne receiver is [ ]
a) 450KHz b) 455KHz c) 500KHz d) 405KHz

17. The output signal of a detector in a communication receiver is in [ ]
a) Audio Frequency range b) Radio Frequency range
c) Intermediate Frequency range d) None of the above

18. In a Radio receiver, the sensitivity will be governed by [ ]
a) RF b) Detector c) AF d) None of above

19. The noise in a Radio receiver can be expressed as [ ]
a) S/N ratio b) N/S ratio
c) Level of reference signal d) None of above

20. The following type of Oscillator will be more stable [ ]
a) RC Oscillator b) Hartley Oscillator
c) Colpitts Oscillator d) Crystal Oscillator

21. The length of a dipole for a signal frequency of 300MHz is [ ]
a) 10 mtrs b) 1 mtr c) 0.1 mtr d) 1 cm

22. The frequency 7100 KHz can be transmitted by [ ]
a) Tropospheric propagation b) Ionospheric propagation
c) Ground wave propagation d) Surface wave propagation

23. The most suitable antenna for receiving VHF range is [ ]
a) Dipole b) Log periodic c) Yaagi d) None of the above

24. The skip distance is the distance between [ ]
a) Transmitter and Receiver b) Transmitter and Ionospheric layer
c) Receiver and Ionospheric layer d) Between two Ionospheric layers

Contd.. 3

25. In A1A transmission [ ]
a) Amplitude of the carrier is modulated
b) Frequency of the carrier is modulated
c) Both a & b d) None of above

26. The colour bands of a 4.7KΩ±5% resistor are [ ]
a) Yellow, Violet, Orange and Gold
b) Yellow, Violet, Red and Gold
c) Yellow, Violet, Orange and Silver
d) Yellow, Violet, Red and Silver

27. A signal(f_m) is amplitude modulated with a carrier(f_c), the frequency value of Lower Side Band is [ ]
a) $f_m - f_c$ b) $f_m + f_c$ c) $f_c - f_m$ a) $f_c + f_m$

28. The doping concentrations of Emitter, Base and Collector in a NPN transistor is [ ]
a) Heavy, Moderate and Light b) Heavy, Light and Moderate
c) Moderate, Light and Heavy d) Moderate, Heavy and Light

29. The wavelength of a signal v(s)=5cos $6\pi 10^6 t$ is [ ]
a) 100m b) 50m c) 100cm d) 50cm

30. The Mutual Inductance(M) between two coils of Self Inductance L_1 and L_2 respectively can be expressed as [ ]
a) $M=\sqrt{L_1 L_2}$ b) $M=1/\sqrt{L_1 L_2}$
c) $M=k\sqrt{L_1 L_2}$ d) $M=k/\sqrt{L_1 L_2}$

31. For a Step-down Transformer, the relation between the number of turns in primary (N_p) and the number of turns in secondary (N_s) is [ ]
a) $N_s > N_p$ b) $N_s < N_p$ c) $N_s = N_p$ d) None of the above

32. The layer that reflects higher end frequencies in HF range during the day time is [ ]
a) F_1 layer b) F_2 layer c) E layer d) D layer

33. The power conversion efficiency of a Full-wave rectifier is [ ]
a) 40.6% b) 81.2% c) 100% d) Zero

34. The length of dipole, reflector and director of Yaagi Antenna in terms of wave length are [ ]
a) 0.55λ, 0.5λ and 0.45λ b) 0.45λ, 0.5λ and 0.55λ
c) 0.5λ, 0.55λ and 0.45λ d) 0.5λ, 0.45λ and 0.55λ

35. The side-band system adopted for Television transmission [ ]
a) Independent Sideband b) Vestigial Sideband
c) Suppressed Sideband d) All the above

36. One of the limitations of usage of BJT at Micro-wave frequencies is [ ]
a) Size b) Transit-time c) Power d) all the above

37. The oscillator that makes a communication receiver capable of receiving morse code is [ ]
a) Voltage Controlled Oscillator b) Local Oscillator
c) Beat Frequency Oscillator d) Phase Locked Loop

Contd. 4

38. The circuit that enables the radio receiver output to remains cutoff when carrier is absent [ ]
a) AGC b) Squelch c) Delayed AGC d) Noise Limiter

39. The category of pulse modulation that comes under digital systems is [ ]
a) Pulse Code Modulation b) Pulse Amplitude Modulation
c) Pulse Time Modulation d) All the above

40. The highest frequency that is reflected by an Ionosphere layer is [ ]
a) Maximum Usable Frequency b) Critical Frequency
c) Carrier Frequency d) All the above

41. The device that can be used as a Voltage Regulator is [ ]
a) Gun diode b) Zener Diode c) Pin Diode d) both a & c

42. The Reactance of a Capacitor increases when the frequency is [ ]
a) increased b) decreased c) zero d) remains constant

43. The elements in the tank circuit of a Colpitts Oscillator are [ ]
a) L and C b) R and C c) R and L d) R, L and C

44. The circuit that reduces ripples from the output of a Rectifier is [ ]
a) Limiter b) Discriminator c) Blanker d) Filter

45. Express the gain of an amplifier in dBm, when the output power of it is 100mW. [ ]
a) 10 dBm b) 20 dBm c) 40 dBm d) 0 dBm

46. The output of an Amplifier with 10 dB gain and an input of 1mW is [ ]
a) 10 mW b) 100 mW c) 1 mW d) 0 mW

47. The Transformers are rated in [ ]
a) Watts b) Volts c) Amperes d) Volt-Amperes

48. Batteries are connected in parallel to get more [ ]
a) Current capacity b) Voltage capacity
c) both a & b d) None of the above

49. A Superhetrodyne receiver with local oscillator frequency range 3.455 to 30.455 MHz is capable of receiving the input signal range is [ ]
a) 88-108 MHz b) 3-30 MHz c) 565-1600 KHz d) 2-17 MHz

50. The Capability of a receiver to receive weakest possible signal is its [ ]
a) Selectivity b) Sensitivity c) Fidelity d) All the above

* * *

SECTION-B
(Radio Regulations)

1. The value of bandwidth shown as 3K50 is [ ]
a) 3050 Hz b) 3500 Hz c) 3500 KHz d) 3050 KHz

2. The first character in class of Emission signifies about [ ]
a) Nature of signal(s) modulating the main carrier
b) Type of modulation of the main carrier
c) Type of Information to be transmitted
d) Details of multiplexing the signal(s)

3. In the Morse code, the Test signal contains the characters of [ ]
a) CQ CQ CQ b) V V V c) RT RT RT d) NON.

Contd.. 5

4. The range of VHF band is [ ]
a) 3 to 30 MHz b) 30 to 300 MHz c) 300 to 3000 MHz
d) 0.3 to 3 MHz

5. The time difference between IST and UTC is [ ]
a) 05.30 Hrs. b) 05.00 Hrs. c) 05.15 Hrs. d) 05.45 Hrs.

6. The characters in the RST system stands for [ ]
a) Readability, Signal and Test
b) Readability, Signal strength and Test
c) Readability, Signal strength and Tone
d) Readability, Signal loss and Tone

7. The VHF Frequency range that is authorised to Amateurs is [ ]
a) 140 – 146 MHz b) 144 – 146 MHz c) 140 – 144 MHz
d) 146 – 148 MHz

8. The ' Single Side Band with Suppressed Carrier ' is designated as [ ]
a) H3E b) R3E c) J3E d) A3E

9. The space between two words in Morse code is [ ]
a) a dot b) a dash c) a dot and a dash d) five dots

10. The Q Code for 'Are you busy?' is [ ]
a) QRM b) QRL c) QSA d) QRN

11. The distress frequency on Voice (Radio Telephony) is [ ]
a) 2128 KHz b) 2182 KHz c) 1282 KHz d) 1228 KHz

12. The characters that a Safety Signal contains in Morse code are [ ]
a) XXX b) MAY DAY c) PAN PAN d) SSS

13. The Phonetic used to represent digit '8' is [ ]
a) Octa Eight b) Okta Eight c) Okto Eight d) Octo Eight

14. The Answer or Advice for the Q-Code 'QTH' is [ ]
a) My exact location is .... b) What is your exact location?
c) My correct time is .... Hrs. d) None of the above

15. The written confirmation of a contact, exchanged between Amateurs is [ ]
a) QSA3 b) QSL NR53 c) QST? d) QRX 1100

16. The abbreviation used for 'All Before' is [ ]
a) AA b) AB c) AR d) AS

17. The calling Amateur's call sign in 'VU2DX DE VU2DJ' is [ ]
a) VU2DX b) VU2DJ c) DE d) VU2

18. The maximum characters that an Amateur Call Sign contains is [ ]
a) Four b) Five c) Six d) Three

19. The frequency range in 21 MHz band that is authorised to Amateurs is [ ]
a) 21000 – 21350 KHz b) 21000 – 21450 KHz
c) 21100 – 21150 KHz c) 21000 – 21400 KHz

20. The Emission that is used to sent Morse code by on/off keying the Unmodulated carrier in CW Transmission is [ ]
a) A1A b) A2A c) A3A d) A5C

21. The Q-code for 'The signal strength of your signals are Good' [ ]
a) QSA 5 b) QSA 4 c) QSA 1 d) QSA 3.

Contd: 6

22. The character that represents the Morse code '_ _ . _' is [ ]
a) Y b) Z c) C d) Q

23. The Amateur Licence will be issued in India by [ ]
a) Wireless Monitoring Organisation
b) Wireless Planning and Coordination Wing
c) Telecomm Regulatory Authority of India
d) Bharat Sanchar Nigam Limited

24. The Call sign blocks allotted to India are [ ]
a) ATA – AWZ b) VTA – VWZ c) 8TA – 8WZ
d) a & b e) a , b & c

25. The UTC stands for [ ]
a) Universal Time for Coordination
b) Universal Coordinated Time
c) United States Telecomm Community
d) Universal Telecommunication Centre

26. The Emission 'C3F' stands for [ ]
a) Double Side band Transmission
b) Single side band Transmission
c) Vestigial side band Transmission
d) Suppressed side band Transmission

27. The number of characters in a 8 wpm in 5 minutes passage should be [ ]
a) 240 b) 200 c) 160 d) 400

28. The standard shift between transmitting and receiving frequency for Amateur Radio in VHF band is [ ]
a) 500 KHz b) 600 KHz d) 1000 KHz d) 1200 KHz

29. The equivalent time in hours of 1730(IST) in UTC is [ ]
a) 1200Z b) 1230Z c) 0000Z d) 0530Z

30. The Q-code for 'I will call you again at 0400 hrs in the evening' is [ ]
a) QRX0400 b) QRX1600 c) QRX4 d) QRX0400Z

31. The Emission stands for an AM Broadcast with 3 KHz bandwidth is [ ]
a) A3E3000K b) A3E3K00 c) A3E0K300 d) A3E0H30

32. The distress frequency 156M800 Hz falls in the range of [ ]
a) HF band b) UHF band c) Microwave band d) VHF band

33. The character for Morse code '. . _ _ . .' is [ ]
a) Full stop b) Comma c) Question mark d) Hyphen

34. In a Morse code transmission what will be the duration of a dot, when the duration of a dash is 30mSec. [ ]
a) 90mSec b) 10mSec c) 1mSec d) 9mSec

35. The Abbreviation for 'I have nothing for you' is [ ]
a) QRU b) NIL c) NFU d) None of the above

36. Frequencies those are authorised to use during the 0800 to 2000 Hrs. of the day will be indicated as [ ]
a) H24 b) HN c) HJ d) HX

Contd.. 7

37. The Phonetic used for alphabet 'N' is [ ]
a) Norvey b) November c) Neighbor d) Night

38. The urgent messages in a Morse code are indicated by [ ]
a) PAN PAN b) XXX c) T T T d) V V V

39. The Emission that indicates a FM Broadcast station is [ ]
a) F1A b) F3A c) F3E d) F3C

40. What are the letters required to be sent for a third station to enter between two stations in a Morse code transmission are [ ]
a) BR b) BK c) BREAK d) BN

41. The word used in Voice which is equivalent to the word 'DE' transmitted in a Morse code transmission is [ ]
a) FROM b) THIS IS c) CALLING d) All of the above

42. The letters those are required to be sent in the time of Distress in Voice transmission are [ ]
a) SOS b) MAY DAY c) PAN PAN d) SECURTIE

43. The Q-code for Test Signal is [ ]
a) QRK b) QSU c) QSV d) QUM

44. In abbreviation 73, refers to [ ]
a) thanks b) welcome c) best regards d) none of these

45. The frequencies those are designated with 'HX' can be used [ ]
a) during the day time b) during the night time
c) intermittently d) 24 Hrs. of a day

46. The suffix that is required to be sent along with the call sign for a Mobile Amateur Station is [ ]
a) MOBILE b) MO c) MX d) None of the above

47. What will be the speed in wpm, when a message being transmitted contains 60 characters in a minute [ ]
a) 5 wpm b) 8 wpm c) 10 wpm d) 12 wpm

48. The ITU stands for [ ]
a) International Trade Union b) Indian Trade Unions
c) Indian Telecommunication Union
d) International Telecommunication Union

49. In RST system for Morse code transmission [ ]
a) R and S need to be reported
b) R and T need to be reported
c) T and S need to be reported
d) R, S and T are necessary

50. The type of Infringement to be sent upon using incorrect emission is [ ]
a) Un Authorised Frequency b) Un Authorised Period
c) Un Authorised Emission d) Un Authorised Call Sign

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Model Questions & Answers for Amateur Radio examination

SECTION-B
(Radio Regulations)

1. The phonetic used for the digit '1' is: **Una One**

2. The Frequency range that is authorised to Amateurs in UHF band is: **434-438 MHz**

3. The third symbol in class of an Emission signifies about: **Type of Information to be transmitted**

4. The call sign of an amateur station must be sent: **At the beginning and end of each exchange of communications, and at least every 10 minutes, while in communications**

5. The Q Code for 'Are you busy?' is: **QRL?**

6. What is simplex operation? **Transmitting and receiving on the same frequency**

7. The message “PAN PAN PAN VU2NRO DE VU2JOS" is of type: **Urgency signal**

8. What will be the time in UTC when the time in 1ST is 1000 Hrs: **0430 Hrs**.

9. If you contact another station and your signal is strong and perfectly readable, you should: **Reduce your transmitter power output to the minimum needed to maintain contact**

10. The radiation in and reception from unnecessary directions can be minimized by using: **Directional antennas**

11. You are adjusting an antenna matching unit using an SWR bridge. You should adjust for**:** **Minimum reflected power**

12. The transmission of characters "VVV VVV VVV DE VU2NRO" denotes the following type of signal : **Test**

13. The Amateur Licence is issued in India by: **Wireless Planning & Coordination Wing**

14. The Q-code for 'I will call you again at 0400 hrs in the evening is: **QRX 1600**

15. Emissions shall be designated according to their: **Necessary bandwidth and Classification**

16. You must keep the following document at your amateur station: **Your Amateur Operator Licence**

17. The letters those are required to be sent in the time of Distress in Voice transmission are: **MAY DAY**

18. If you hear distress traffic and are unable to render assistance, you should: **Maintain watch until you are certain that assistance is forthcoming**

19. To make your call sign better understood when using voice transmissions, what should you do? **Use Standard International Phonetics for each letter of your callsign**

20. The first character in class of Emission signifies about: **Type of modulation of the main carrier**

21. The ITU stands for: **International Telecommunication Union**

22. The characters in the RST system stands for: **Readability, Signal Strength and Tone**

23. The international distress & calling frequency in Voice transmission is: **2182 KHz**

24. The Q-code for "Does my frequency vary”: **QRH?**

25. The frequencies those are designated with 'HX' can be used: **intermittently**

26. UTC stands for: **Universal Coordinated Time**

27. The letters that are generally used for the first letters in Indian Amateur Radio callsigns is : **VU**

28. The Abbreviation for 'I have nothing for you' is: **NIL**

29. The suffix that is required to be sent along with the call sign for a Mobile Amateur Station is: **MO**

30. Frequencies those are authorised to use during the 0800 to 2000 Hrs. of the day will be indicated as: **HJ**

31. The meaning of Roger is: **Received fully**

32. The type of Infringement to be sent upon using incorrect emission is: **Unauthorized Emission**

33. The Q Code for 'Are you ready? 'is: **QRV?**

34. The organization responsible for the International Radio Regulations is:
International Telecommunication Union

35. The distress frequency 156M800 Hz falls in the range of: **VHF band**

36. The Standard Time & frequency station in India is operated by: **National Physical Laboratory**

37. The Q-code for Test Signal is: **QSV**

38. The minimum age for a person to become a radio amateur in India is: **12 years**

39. In abbreviation 73 refers to: **Best regards**

40. Identification of a station primarily can be done by: **Callsign**

41. The time difference between IST and UTC is: **5.30 hrs**

42. The Phonetic used for alphabet 'N' is: **November**

43. The 20 Meter Amateur Radio frequencies allotted to India is: **14000 to 14350 kHz**

44**.** The range of VHF band is: **300 to 3000 MHz**

45. Can Radio Amateurs broadcast news: **No**

46. Test signals cannot be sent for more than**: 30 seconds**

47. What is QSL Card: **Written confirmation of a Contact**

48. The callsign blocks allotted for Amateurs in India is**: ATA-AWZ, VTA-VWZ & 8TA-8YZ**

49. The abbreviation for “Closing Down” is: **CL**

50. The meaning of CQ is: **General call for all stations**

References:

The following books have been referred, while compilation of study material for Radio Theory and Practice.

1. NIAR Study Manual (previous editions)
2. Amateur Radio Encyclopedia by Stan Gibilisco, W1GV
3. Basic Radio (Vol. I to VI) by Marvin Tepper
4. Amateur Single Side Band by Stuart Bonney, W5PAQ
5. Principles of Electronics by V.K.Mehta
6. ARRL Hand Book

Amateur Rules:

7. WPC official Website