RADIO AMATEUR EXAM
GENERAL CLASS

By **4S7VJ**

CHAPTER- 1 BASIC ELECTRICITY

1.1 ELECTRIC CHARGE

Everything physical is built up of atoms, or particles. They are so small that they cannot be seen even through the most powerful microscope. The atom in turn consists of several different kinds of still smaller particles. Electron and proton are the most important particles for electricity. They are having negative and positive electric charges respectively.

The important fact about these two opposite kinds of electricity is that they are strongly attracted to each other. Also there is a strong force of repulsion between the two charges of the same kind. Opposite charges attract each other with a strong force.

An ordinary atom consists of a central core called nucleus, carrying a number of protons. The positive charge on the nucleus is exactly balanced by the negative charges on the electrons, orbiting around the nucleus. However, it is possible for an atom to lose one of its electrons. When that happens the atom has a little less negative charge than it should. That is, it has a net positive charge. Such an atom is said to be ionized, and in this case the atom is a positive ion. If an atom picks up an extra electron, it is called a negative ion.

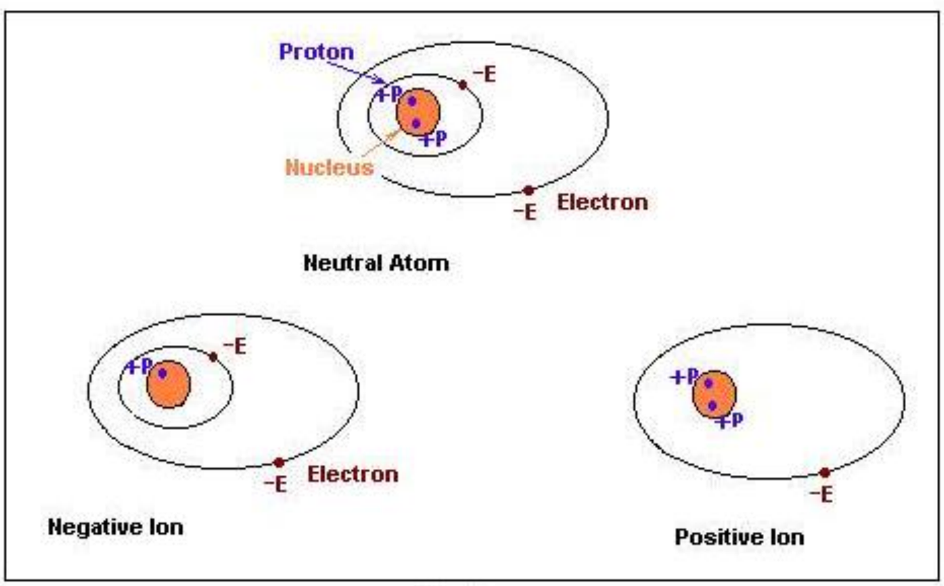

Fig 1.1

1.1.1 COULOMB (C)

The practical unit (SI-unit) of electric charge is "Coulomb". This is equivalent to the many billions of electrons.

1 Coulomb = 6.242*10^18 electrons

1.2 ELECTRIC CURRENT (AMPERE)

A positive ion will attract any stray electron in the vicinity, including the extra one that may be attached to a nearby negative ion. In this way it is possible for electrons to travel from atom to atom. The movement of ions or electrons constitutes the electric current. The flow of electric current is measured in Amperes. One "Ampere" is equivalent to the movement of one Coulomb passes a point in the circuit in one second. This is the practical unit (SI-unit) for the electric current, but for the sake of convenience we use smaller units as milliampere (mA) and microampere (µA).

1000 µA = 1 mA
1000 mA = 1 A

1.3 ELECTROMOTIVE FORCE (E.M.F.)

The electric current flows due to the electrical pressure or force generated by the source. This is called electromotive force.(e.m.f.) That causes current flow may be developed in several ways, the chemical reaction in a cell or the magnetic effect in a generator (alternator). The unit of e.m.f. is "Volt". Larger unit is kilovolt (kV) and smaller units are mV and µV.

1.3.1 POTENTIAL DIFFERENCE & VOLTAGE

The electrical pressure difference between two points of an electrical circuit is called potential difference. When it is measured by Volts it's called voltage. The units as same as e.m.f.

1.3.2 E.M.F. and VOLTAGE

E.M.F. of a cell is equal to the voltage between two terminals, while there is no current flow. When there is a current flow or energy consume by an external circuit, the voltage will be reduced. If the external circuit disconnected the voltage will increase up to the value of E.M.F.

The reducing amount is called the **voltage drop**. The voltage drop is depending on the internal resistance of the battery (or cell or source) and the resistance of the external circuit.

1.3.3 Capacity of a battery (Ah. or mAh.)

Normally large batteries have more capacity. The general idea is how much energy can take from the battery is the capacity. If 2Amp current can take 5 hours continually from a battery, the capacity is little more than 10 Ampere-hour (Ah.)

1.4 CONDUCTORS & INSULATORS

Materials in which electrons or ions can be moved with relatively easy are called conductors, while those that refused to permit such movement are called nonconductors or insulators.

Examples:-

Conductors:- Metals, Carbon, Acids, Salts, ionized gases

Insulators:- Glass, Mica, Rubber, Porcelain, Dry wood, Dry air

1.4.1 GOOD & POOR CONDUCTORS

Conductors are divide into two; good conductors and poor conductors.

Good conductors:- Through good conductors electricity can flow easily. It is found to vary with what is called the resistance of the material. Few examples for good conductors:- Silver, Copper, Aluminum.

Poor Conductors:- Through poor conductors electricity can flow, but not easily as earlier. Few examples are:- Nicrom, Tungsten, Iron.

1.5 RESISTANCE

Given two conductors of the same size and shape, but different materials the amount of current that will flow when a given EMF is applied will be found to vary with the resistance of the material. The lower the resistance, the greater the current for a given value of EMF.

Unit of resistance is "Ohm". Smaller units are micro Ohm (μΩ) and milli Ohm (mΩ) and larger units are kilo Ohm (kΩ) and Mega Ohm (MΩ).

1000 μΩ = 1 mΩ   1000 mΩ = 1 Ω
1000 Ω = 1 kΩ   1000 kΩ = 1 MΩ

1.5.1 RESISTIVITY

Regarding the earlier example, if both conductors having same size and same shape, there is a property vary with the type of material, it's called resistivity. The resistivity of a material is defined as **the resistance of a cube of the material measuring between two opposite faces**. But practically this is impossible to measure.

The resistance of a wire with uniform cross section is directly proportional to it's length and inversely proportional to it's cross sectional area.

A wire with a certain resistance for a given length will have twice as much resistance for a given length of the wire is doubled. If you consider two wires having same material and same length but the cross sectional area is twice, while doubling the cross sectional area will halve the resistance.

The formula related with above factors is :

$$R = \rho l / A$$

R = resistance of the wire
l = length of the wire
A = area of the cross section of the wire
ρ = specific resistance of the material of the wire
(ρ is a Greek letter "rho")

Units:- SI-unit is Ω-m. This is useful for calculations. But μΩ-m is more convenient.

If "R" is in Ohms, "l" is in meters and "A" is in square meters, then "ρ" is in Ohm-meter (Ω-m)

If "R" is in micro Ohms, "l" is in meters and "A" is in square meters, then "ρ" is in micro Ohm-meter (μΩ-m)

Other units are defined same as above:
micro Ohm centimeter (μΩ-cm)
and
Ohm centimeter (Ω-cm)

1.5.2 RELATIVE RESISTIVITY

One of the best conductors is copper. It is convenient to compare the resistance of the material under consideration with that of a copper conductor of the same size and shape. The ratio of these two is the relative resistivity of the material.

In other word the relative resistivity of a material is equals to the resistivity of that material divide by the resistivity of copper.

1.5.2.1 Relative Resistivity of Metals

Material	Relative resistivity	Resistivity (μΩ-cm)
Silver	0.94	1.59
Copper	1.0	1.7
Gold	1.4	2.4
Aluminum	1.6	2.7
Chromium	1.8	3.1
Tungsten	3.2	5.4
Zinc	3.4	5.8
Brass	3.7 - 4.9	6.3 – 8.3
Cadmium	4.4	7.5
Nickel	5.1	8.7
Iron	5.68	9.7
Steel	7.6 - 12.7	12.9 – 21.6
Lead	12.8	21.8
Manganin	25.6	43.5
Nicrome	58.1	98.8

1.6 D.C. AND A.C.

There are two main types of current and voltage called direct current (d.c.) and alternate current (a.c.).

1.6.1 DIRECT CURRENT (D.C.)

When we connect a battery to an electric circuit there will be a continuos current flow from positive terminal to negative terminal. If the current always flows in the same direction it is called "direct current" abbreviated d.c. It is the type of current furnished by batteries, d.c. generators and d.c. power supply units. The waveform of a current is a graph whose shape shows how the current varies with time. Those in fig.1.2 are for steady, pulsed and varying d.c.

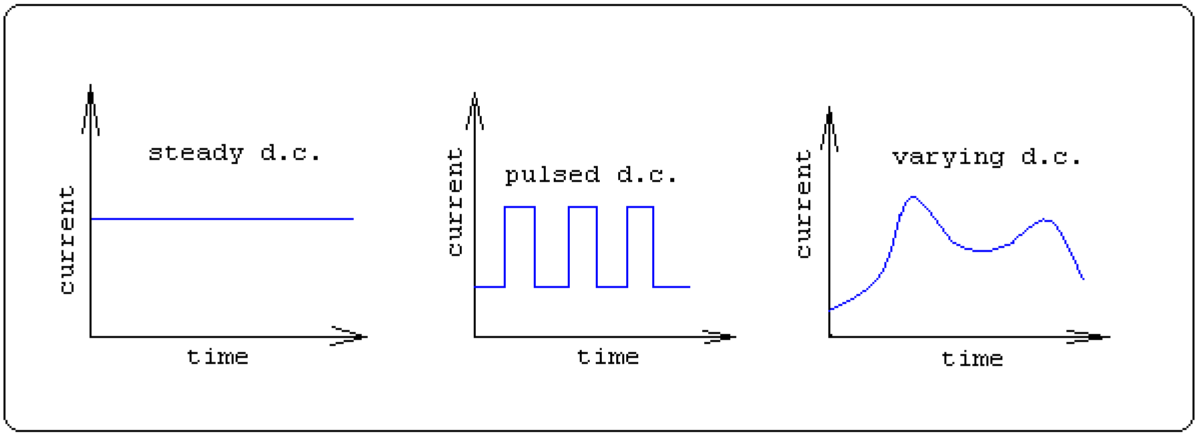

Fig 1.2

1.6.2 ALTERNATING CURRENT (A.C.)

It is also possible to have an e.m.f. that periodically reverses. With this kind of e.m.f., the current flows first in one direction and then in the other. Such an e.m.f. is called an alternating e.m.f. and the current is called an alternating current (a.c.). The reversals may occur at any rate from a few per second up to several billion per second. Two reversals make a cycle. The number of cycles in one second is called frequency of the a.c. supply. A motor car alternator and bicycle dynamo are gives a.c. supply, and the e.m.f. and frequency vary with the speed. Normally a car alternator generates an a.c. supply, then it is converted to a d.c. by using rectifiers. House hold mains power supply also a.c. 230 Volts and frequency is exactly 50 Hz(cycles per second). Some countries uses 60 Hz as standard.
Following instruments also gives an a.c. supply

1. Alternators:- (small and large scale power generators)

2. Inverter:- d.c. battery supply converts to an a.c. supply.

3. UPS:- Inverter and relay system keeps always an uninterrupted a.c.power supply. Normally it's output connected to a.c.mains input supply. When a.c.mains supply fails, momentarily it's connected to the inverter, which is operated with the battery, and output a.c.supply continue without interruption. Actually power interruption limits to few milliseconds.

4. Oscillator:- AF or RF oscillators generate an a.c.signal having with very low power.

5. Transmitter:- a.c. RF signal generate by an oscillator and amplify to a higher power level and transmits an electromagnetic wave.

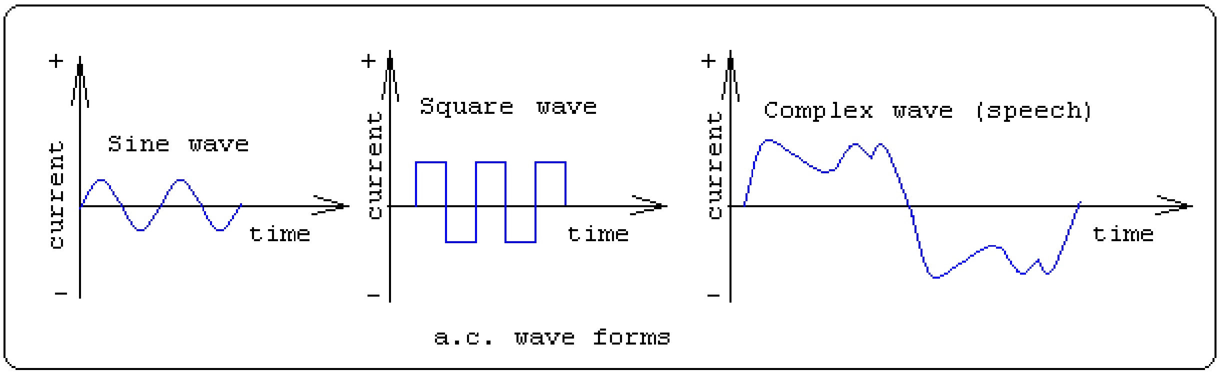

Fig.1.3

1.6.2.1 AC Waveform

If AC signal connected to the input of an Oscilloscope, we can see the shape of the wave, in other word how to vary the voltage or current with time.(X-axis is time and Y-axis is the voltage or current).
Most simple waveform is Sine-Wave, others are square-wave, saw tooth-wave, triangular-wave etc. Human voice is one of a most complicated wave. Any kind of wave is a combination of number of Sine waves, may be a few number or infinite number.

1.7 OHM'S LAW

If a current is flowing through a resistance, obviously there is an applied voltage. We can demonstrate this with using a simple circuit, like a battery and a resistor connected each other. With the use of a multimeter, we can measure the voltage, current and the resistance. (Fig. 1.4)

The relationship between them is known as "Ohm's Law".

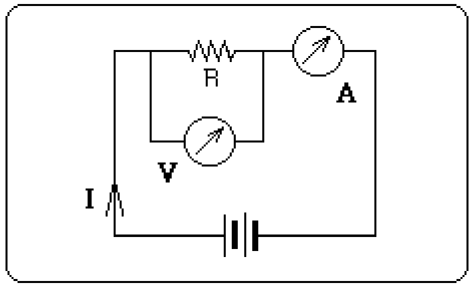

Fig 1.4

It can be stated as follows:
The current flowing through a resistance (Fig.1.4) is directly proportional to the applied e.m.f. and is inversely proportional to the resistance. This is Expressed in the following equations :

I = V/R or V = I x R or R = V/I

The units are Volt(V) , Ampere(A) and Ohm (Ω)

Example:-

When a bulb is connected to a 12 V battery, the current is 600 mA. What is the resistance of the bulb ?

V = 12volt, I = 600 mA or 0.6 A
According to the Ohm's Law V = I x R or R = V/I
therefore R = 12/0.6
= **20 Ohm**

1.8 RESISTORS

1.8.1 TYPES OF RESISTORS

1. Carbon resisters (solid carbon & carbon film)
2. Wire wound resistors
3. Variable resistors (preset & potentiometer)

1.8.2 TEMPERATURE EFFECTS

Consider the above example; when you apply 12 volts for the bulb (12v,8w bulb) the current is 600mA and the resistance of the bulb is 20 Ohms. But if you measure the resistance using an Ohmmeter it is very much less than 20. It is approximately 1.5 Ohms.

The reason is the temperature effect. When we measure the resistance, the filament of the bulb is cold. When it is connected to the battery the filament is very hot (about 1000°C)

Practically the resistance of any metallic conductor increases with increasing temperature. Carbon, however, acts in the opposite way; its resistance decreases when its temperature rises.

1.8.3 COMBINATIONS OF RESISTORS

Resistors are available in the market for various standard values, but not for all. (Eg:- 1k, 1.5k, 2.2k, 2.7k, 3.3k, 3.9k, 4.7k). If we need other values, it is possible to combine two or more resistors to get the required value. Most simple types of combinations are parallel and series combinations.

1.8.3.1 Series Combinations

If we connect a number of resistors like a chain (Fig 1.5) it is called a series combination. The equivalent value is the addition of all.

R = R1 + R2 +... ,where R is the equivalent value of R1, R2,...

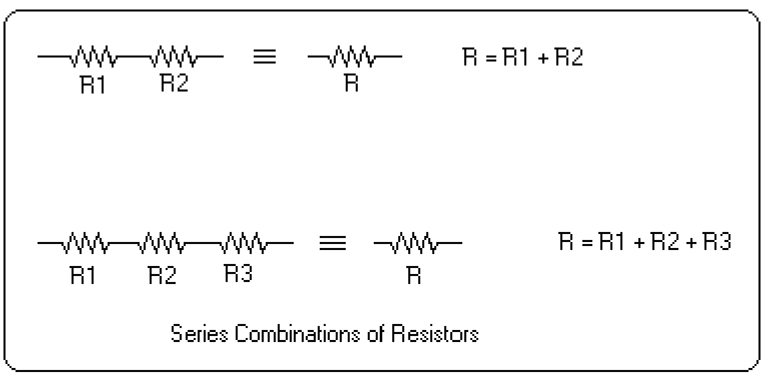

Fig 1.5

1.8.3.2 Parallel Combinations

If we connect one terminal from each resistor together and all the others together, it is called a parallel combination of resistors. Suppose the equivalent resistance of this combination is R and values of each resistor are R1, R2 and R3, then the relationship is:-

1/R = 1/R1 + 1/R2 + 1/R3

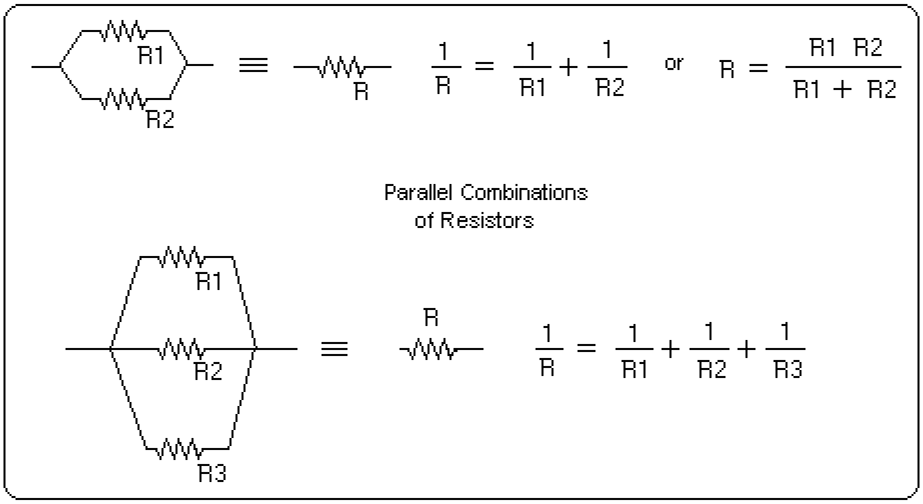

Fig.1.6

Equal parallel resistors

If number of resistors having the same value, are connected in parallel, the equivalent value is, the value of one of that divide by the number of resistors.

Two resistors in parallel

If R1 and R2 connected in parallel then the equivalent value is the multiplication of those divide by the addition of those.

$$R = \frac{R1*R2}{R1 + R2}$$

Example-1 :-

Calculate the equivalent resistance of the parallel combination having 2kΩ and 4kΩ

1st method:-

1/R = 1/2 + 1/4
= 0.5 + 0.25
= 0.75

R = 1/0.75
= **1.33 kΩ**

2nd method:-

R = (2*4)/(2+4)
= 8/6

= **1.33 kΩ**

Example-2 :-

Calculate the equivalent resistance of the parallel combination of 200 equal resistors of 2.2kΩ.

equivalent resistance = 2.2kΩ/200
= 2200/200
= **11 Ω**

Example-3 :-

Calculate the equivalent resistance of the parallel combination of 20 Ω, 10 Ω, 5 Ω.

1st method :-

1/R = 1/20 + 1/10 + 1/5
= 0.05 + 0.1 + 0.2
= 0.35

R = 1/0.35
= **2.85 Ohm**

2nd method:-

1/R = 1/20 + 1/10 + 1/5

$$= \frac{1 + 2 + 4}{20}$$

= 7/20
R = 20/7
= **2.85 Ω**

3rd method :-

First calculate the equivalent resistance of the parallel combination of 20Ω and 5Ω.

it is = (20*5)/(20+5)
= 100/25
= 4Ω

Then find the equivalent resistance of the parallel combination of the new 4Ω and 10Ω.

it is = (4*10)/(4+10)
= 40/14
= **2.85Ω**

1.8.4 RESISTOR COLOUR CODE

The value of a resistor is normally indicated by using color bands. Normally there are three color bands printed on the resistor, starting from one end.

The first and the second bands indicate the 1st and the 2nd significant figures for the value of the resistor in Ohms; and the third color band represents the multiplier. (Number of zeros)

Sometimes there are four color bands. The fourth band is reserved for the tolerance.

RESISTOR COLOR CODE :-

0	Black	5	Green
1	Brown	6	Blue
2	Red	7	Violet (purple)
3	Pink (Orange)	8	Gray
4	Yellow	9	White

There are two more colors for the third and fourth bands only.

Decimal multipliers for the third band:-

0.1	Gold
0.01	Silver

The colors of the fourth band for tolerance:-

5%	Gold
10%	Silver
20%	No color (three bands only)

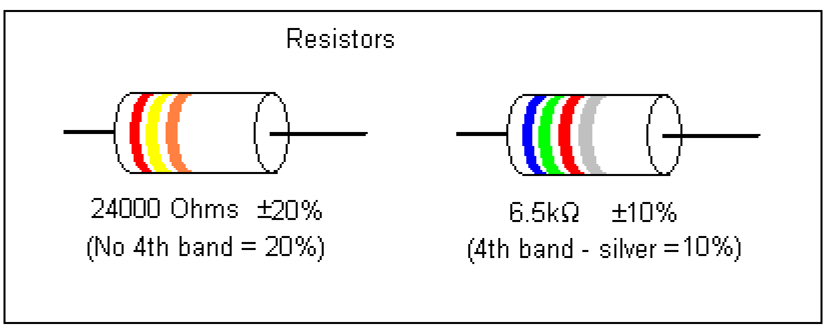

Fig 1.7

Examples:-

1. Brown, Black, brown ....100 Ω +or-20%
2. Yellow, Purple, Red, Gold ....4700 Ω +or-5%

or 4.7kΩ=or-5%
3. Blue, Gray, Yellow, Silver....680000Ω +or-10%
or 680kΩ +or-10%
4. Blue, White, Gold, Gold..... 6.9Ω +or-5%
5. Green, Pink, Silver.........0.53Ω +or-20%
6. Red, Red, Green.............2200000Ω +or-20%
or 2.2MΩ +or-20%
7. Brown, Green, Black ....15Ω +or-20%

1.9 ENERGY AND POWER

1.9.1 ENERGY

Energy is equal to the amount of work done. For an example, when you climb a staircase 10ft. high , you have to waste a certain amount of energy ; if you climb 20 ft. you waste double the earlier amount of energy. When you boil a kettle of water, you have to use a certain amount of electrical or heat energy; if you use half of the water, you have to use half of the energy.

1.9.2 POWER

The rate of doing work or the rate of consumption of energy is equal to the power. The electrical power is equal to product of the voltage and current. The unit is "watt". (mw., kw., Mw)

$$W = V \times I$$

W = power in watts, V = voltage in Volts, I = current in Ampere
Therefore

Watt = Volt x Ampere

With the help of Ohm's law above equation can be written as

$$W = I^2R \quad \text{or} \quad W = V^2/R$$

Eg:- The voltage drop of a 150Ω resistor in a circuit is 5V. What is the power dissipation of the resistor? What is the power rating of the resistor?

$$W = V^2/R$$
$$= (5 \times 5)/150$$
$$= 1/6$$
$$= 0.1667$$
$$= \mathbf{167\ mW.}$$

Therefore power dissipation is 167 mW.(0.167W) and power rating is **1/4 Watt.**

Eg:- If 100Ω 1/4 Watt resistor connected to a circuit what will be the maximum current consumption?

$$W = I^2R$$

therefore $I^2 = W/R$, $W = 0.25$, $R = 100\ \Omega$

$$I^2 = 0.25/100$$
$$= 1/400$$

$I = 1/20$ A , $(20 \times 20 = 400)$

$= 1000 \times (1/20)$ mA.

= **50 mA.**

1.10 IONOSPHERIC PROPAGATION

1.10.1 PROPERTIES OF THE IONOSPHERE

Regarding radio wave propagation through the atmosphere and the ionosphere, there are three main properties.

1. Absorption
2. Refraction
3. Reflection

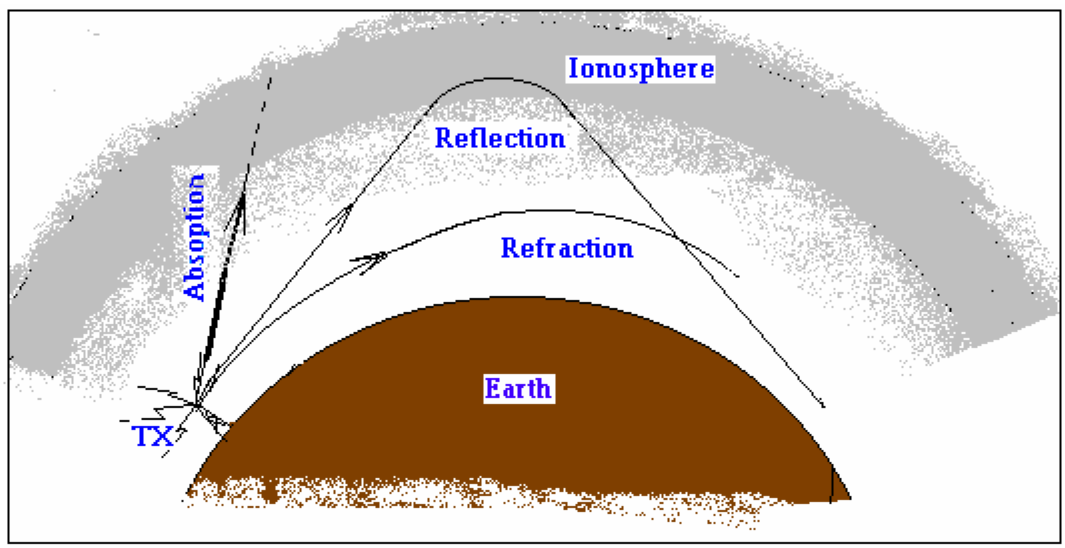

Fig 1.8

1.10.1.1 ABSORPTION

In traveling through the ionosphere the wave gives up some of its energy by setting the ionized particles into motion. That means some percentage of the energy belonging to the radio wave is lost or absorbed by the ionosphere. This absorption is greater at lower frequencies. It also increases with the intensity of ionization, and with the density of the atmosphere in the ionized region.

1.10.1.2 REFRACTION

When radio waves travel through the atmosphere, they are bent slightly, due to variation of the density of air layers and degree of ionization in the ionosphere. Thus low-frequency waves are more readily bent than those of high frequency. For this reason the lower frequencies, 3.5 and 7 MHz are more reliable than the higher frequencies. (14 to 28 MHz.) When the degree of ionization is low value, the waves of the higher frequencies are not bent enough to return to earth.

1.10.1.3 REFLECTION

When radio waves bend more and return to earth, it is call reflection. This reflection happens from upper layer of the ionosphere. These layers are named D, E, and F (F1, F2).(Fig1.6)

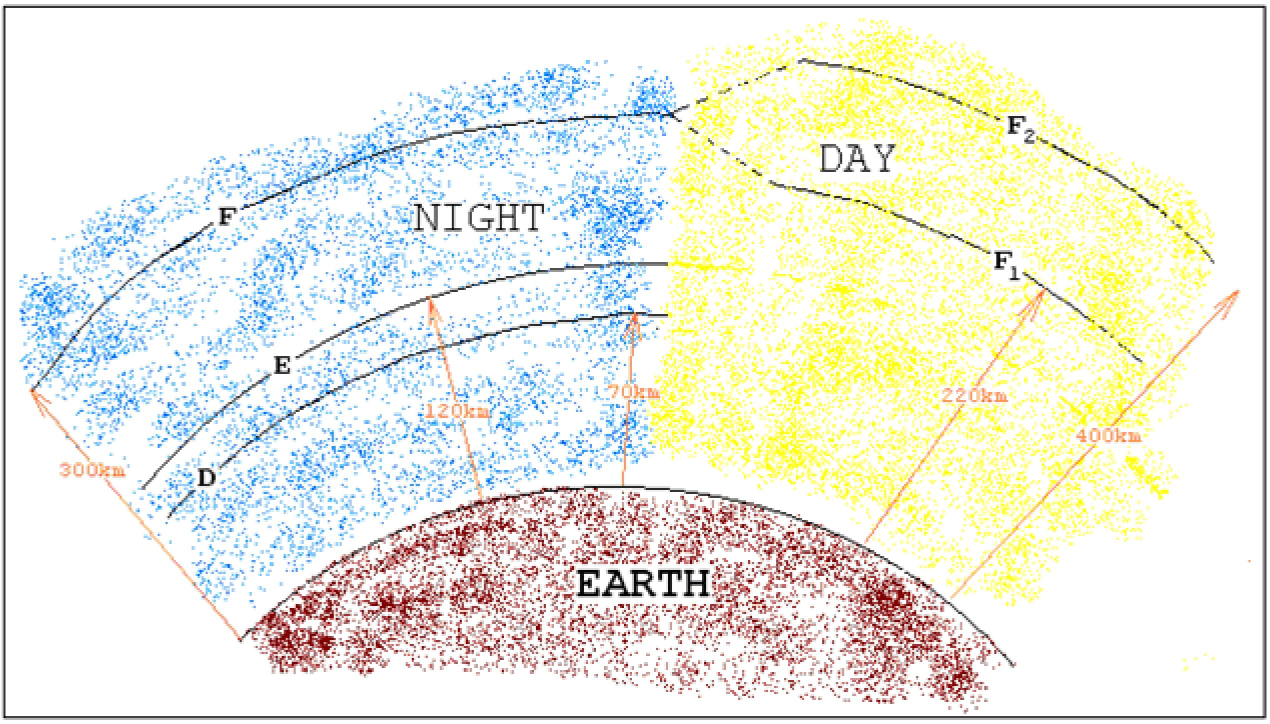

Fig. 1.9

1.10.2 Classification and Definitions of the Ionosphere

1.10.2.1 D-LAYER

In the daytime there is a still lower ionized area, the D region. D region ionization is proportional to the angle of elevation of the Sun and is greatest at noon. The lower frequencies (1.8 and 3.5 MHz) are almost completely absorbed by this layer, and only the high-angle radiation penetrates and is reflected by the E layer.

1.10.2.2 E-LAYER

This is the lowest useful ionized layer, and the average height is about 70 miles. The E- layer normally disappears after Sunset.

1.10.2.3 F-LAYER

This is the most important layer, which has a height of about 175 miles at night. In the daytime the F layer splits into two parts, the **F1 and F2 layers**,(Fig1.6) with average virtual heights of 140 and 200 miles respectively. These layers merge again at sunset into the F layer.

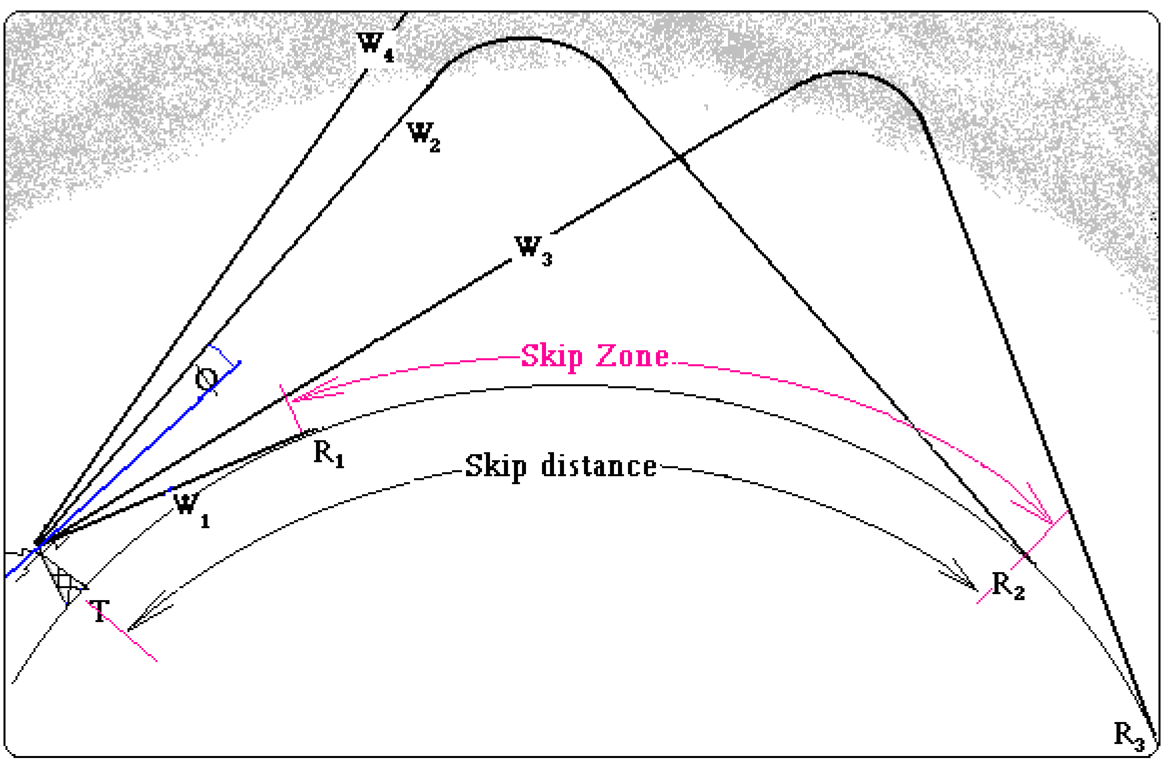

Fig.1.10

1.10.2.4 Angle of Radiation

The angle between the direction of the wave and the horizon or tangent of the earth is called the wave angle or angle of radiation. This is denoted by Ø in the diagram of Fig. 1.6

1.10.2.5 Ground Wave

The horizontal waves from the TX antenna (W_1 in the Fig 1.6)travels a line of sight distance or little more, parallel to the ground. This is called ground wave.

1.10.2.6 Critical Angle

The wave at a somewhat lower angle is just capable of being returned by the ionosphere. (W_2 in the Fig 1.6) This radiation angle is called the critical angle.(Ø in the Fig.1.6)

Radiation at angles more than the critical angle do not return to Earth, because it is only slightly bent in the ionosphere and to pass through it. **This is called sky wave.**

The radiation at angles smaller than the critical angle return to the Earth at a long distance. (W_3 in Fig 1.6)

1.10.2.7 SKIP DISTANCE and SKIP ZONE

When the wave angle is **equal to the critical angle** for a particular **frequency** and for a particular **time** for the day, it is reflect and return to the Earth at a certain distance. (at R_2 in Fig 1.7) For lower angle of radiation signals are reach beyond that point.(at R_3 in Fig 1.7)

This is illustrated in Fig-1.6, where Ø and smaller radiation angles give useful signals while waves sent at higher angles penetrate the layer and are not returned. The distance between T and R_2 is therefore the shortest possible distance at the particular frequency, and for a particular time for the day, over which communicate by ionospheric reflection can be accomplished. This distance is called **skip distance.**

The area between the end of the useful ground wave and the beginning of the ionospheric wave reception is called the **skip zone.**

The extent of the skip zone depends upon the frequency and the state of the ionosphere, and also upon the height of the layer in which the reflection takes place.

1.10.2.8 CRITICAL FREQUENCY

If the frequency is low enough, a wave sent vertically to the ionosphere will be reflected back down to the transmitting point. (Eg: 80 m-band with horizontal Quad loop). If the frequency is then gradually increased, eventually a frequency will be reached where this vertical reflection just fails to occur. This is the **critical frequency for the layer** under consideration. When the operating frequency is **below the critical frequency, there is no SKIP ZONE.** The critical frequency is a useful index to the highest frequency that can be used to transmit over a specified distance.

1.10.2.9 MAXIMUM USABLE FREQUENCY (m.u.f.)

If a radio wave leaving the transmitting point 'T' and receive at the point 'R', for example, at a frequency 14 MHz., and if a higher frequency would skip over the receiving point, then 14 MHz. is the m.u.f. for the distance between T and R. The greatest possible distance is covered when the wave leaves along the tangent to the earth, that means horizontal. (Zero wave angle) Under average conditions, this distance is about 4000 km., for the F2 layer, and 2000 km., for the E layer. This distance varies depending on the height of the layer. **Frequencies above the m.u.f. do not return to earth at any distance.** The 4000km m.u.f. for the F2 layer is approximately three times the critical frequency for that layer. For the E layer the 2000 km m.u.f. is about 5 times the critical frequency.

1.10.2.10 SUNSPOT CYCLE

The propagation of the HF radio wave depends on the 11 year Sunspot cycle Activity. The maximum sunspot season is the best for HF Communication. (Eg:- 1980 & 1991, next 2002) The critical frequencies are highest During sunspot maximum period. During the period of minimum sunspot activity, the lower frequencies (40m & 80m) are the only usable bands at night.

1.10.3 PROPAGATION IN THE HF BANDS

1.10.3.1 160m-band (1.8-2.0 MHz)

160m band offers reliable working over range up to 25 miles during daytime. On winter nights ranges up to several thousand miles.

1.10.3.2 80m-band (3.5-3.8 MHz)

During the day time 80m-band covers upto about 200 miles. This band is more useful during the night because the range is several thousand miles. Transoceanic contacts are regularly made during the winter months. During the summer the static level is high.

1.10.3.3 40m-band (7.0-7.1 MHz)

40m-band has many of the characteristics as 80m-band except that the distance, that can be covered during the day and night hours are increased. Day-light distance upto about thousand miles and during winter nights it is possible to work stations as far as the other side of the world. The signals following the darkness path. Summer static is much less of a problem than on 80m.

1.10.3.4 20m-band (14.0-14.35 MHz)

This is the best amateur band for DX work. During the high portion of the sunspot cycle it is open to some part of the world practically throughout the 24 hours, while during a sunspot minimum it is generally useful only during twilight hours and the dawn and dusk periods. There is practically always a skip zone on the band.

1.10.3.5. 15m-band (21.0-21.45 MHz)

15m-band shows highly variable characteristics depending on the sunspot cycle. During sunspot maximum it is useful for long distance work during a large part of the 24 hours, but in years of low sunspot activity it is almost wholly a daytime band, and sometimes unusable even in daytime. However, it is often possible to use it for distances up to 1500 miles or more.

1.10.3.6 10m-band (28.0-29.7 MHz)

10m-band is generally considered to be a DX-band during the daylight hours (except in summer) and good for local work during the hours of darkness, for about half the sunspot cycle. At the sunspot minimum the band is usually dead.

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EXERCISES

1.1 A 12V battery connected to heater. The current flowing in the heating element is 3A. Calculate the resistance of the heater.

(ans:- 4 Ω)

1.2 When a soldering iron connected to the mains power supply the current is 200mA. If the resistance of the soldering iron element is 1.2 kΩ , what is the voltage of the power supply?

(ans:- 240 V)

1.3 If an electric bulb having a resistance of 1.1 kΩ connected to a power supply of 110V. What is the current flow through the bulb?

(ans:- 100 mA)

1.4 When you connect 2.2kê and 500ê resistors in series what is the equivalent resistance ?

(ans:-2700Ω or 2.7kΩ)

1.5 If you connect 100 resistors in series, which all are equal and each value is 1.5kê, what is the equivalent resistance ?

(ans:- 150 kΩ)

1.6 Soldering iron connected to a 12 V supply. If the current consumption is 2.5A what is the power of the iron element?

(ans:-30 W)

1.7 The resistance of a hotplate element is 22Ω. If it is connected to a 220 V supply what is the power output?

(ans:- 2.2kW)

1.8 If a resistor having a value of 5kΩ 1/2W, what is the maximum current can handle?

(ans:- 10 mA)

1.9 Find the resistance and the tolerance for the resistors having following color bands.

1. Brown, Red, Pink, Silver
2. Green, Gray, Black
3. Red, Purple, Gold, Gold
4. Brown, Green, Silver,Silver
5. Yellow, Violet, Yellow, Gold
6. Brown, Green, Green

(ans :- 12k 10%, 58Ω 20%, 2.7Ω 5%, 0.15Ω 10%, 470k 5%, 1.5M 20%)

1.10 Find the color bands for the resistors having following values

1. 690Ω, 20%	2. 0.25Ω, 10%	3. 8.7kΩ, 5%
4. 3.3kΩ, 10%	5. 4.7 MΩ, 20%	6. 1Ω, 5%

(ans:- 1. Blue, White, Black
2. Red, Green, Silver, Silver
3. Gray, Violet, Red, Gold
4. Pink, Pink, Red, Silver
5. Yellow, Purple, Green
6. Brown, Black, Gold, Gold)

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