WORKSHOP LECTURE ON WIRELESS COMMUNICATION

Topic: "THE OPERATIONAL FUNCTIONS OF RADIO EQUIPMENT COMPONENTS"

BY

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INTRODUCTION - RADIO FUNDAMENTALS.

Radio equipments are used for the transfer of information by electromagnetic means. A complete assembly of a radio circuit required to effect the desired transfer of information is known as a telecommunication system. Common telecommunication systems include telegraphy, telephony, telemetry, television, radio etc. In general, the building block of wireless systems or otherwise include the transmitter, the channel and the receiver. The transmitter converts the input signal (audio or video etc) into an electrical signal; the channel links the transmitter and the receiver and includes wires, waveguides, radiowaves in space etc; the receiver converts the electrical signal back into the audio or video form.

In the radio system, electromagnetic radiation of frequency within the radio frequency portion of the electromagnetic spectrum will be used for transmission and reception of electrical signal. The transmission channel is the radiowave in space and their frequency of operation range from about 100KHZ to 1000MHZ.

The transmitting station generates electro-magnetic waves which travel in space at the speed of light ($3x10^8$m/s) and is picked up by the receiving stations. They maybe switched on and off by means of a key in accordance with a signalling code (as in wireless telegraphy), or their characteristics maybe varied electrically in response to sound waves entering a microphone (as in radio telephony or sound Broadcasting); or they maybe varied in response to light waves entering an electronic camera (as in television). Other uses of these waves are for radar (the detection of distant objects by the use of waves which are reflected from the object back to the transmitter); and for telemetry (the transmission of scientific data from instruments fitted in rockets, balloons etc).

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In all these cases, the waves are set up in space when currents alternating at radio frequencies are pumped into the transmitter aerial. These currents alternate at high frequencies and can be modulated.

The possible frequency bands[I] for use include: Very low frequency (VLF, 3-30KHZ for long range navigation; sonar), Low frequency (LF, 30-300KHZ for navigational aids, radio beacons), Medium frequency (MF 300-3000KHz for maritime radio, directionfinding, distress and calling, Commercial AM radio, coast guard communication), High frequency (H.F 3-30MHZ search and rescue air craft communication with ships, telegraph, telephone), very high frequency (VHF, 30-300MHZ for VHF television channel, F.M. radio, taxi cab, police, navigational aids etc); Ultra High frequency (UHF, 0.3-3GHZ for UHF television channel, navigational aids, surveillance radar, satellite communication, radio altimeters etc), Super high frequency (SHF 3-30GHZ, for satellite communication, weatherradar, approach radar, airborne radar etc), Extremely high frequency (EHF, 30-300GHZ for rail road service, radar landing systems etc).

I.I RADIO COMPONENTS:

The radio transmitter and receiver are made up of three main component groups VIZ: inductors, capacitors and resistors. Others might include transistors, diodes etc.

As an example, a mains transformer can be classified as an inductor because it comprises a number of coils of wire wound on iron laminations, giving inductance as well as transformer action; an intermediate - frequency (I.F.) transformer is really a combination of two or more inductors which are tuned to specific frequencies and coupled to provide the transformer action.

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When inductors are used solely to give transformer action, however, the components are usually referred to as a transformer e.g. the mains transformer; I.F. transformer, audio frequency(A.F) transformer, as distinct from a main inductor, I.F inductor etc.

I.I.I TRANSFORMERS

Three basic types of transformers are found in Radio equipment. These include: power transformers (designed for the mains frequency): Loudspeaker and AF coupling transformers (designed for a specific range of low frequencies; Aerial coupling and I.F. transformers (designed to tune and couple R.F. circiuts).

Power transformers are made in various sizes to suit the current they are required to supply without overheating. They always use fairly massive sheet-iron laminations, depending upon their power ratings. The primary winding is connected across the supply and the other supply low voltage to the transistor and high voltage to the rectifier circiut is called the secondary. The primary winding usually has various taps to suit the number of mains voltage. The design on such components is concentrated on securing maximum efficiency at the power frequency (50or 60HZ).

Low-frequency coupling and output transformers usually have two windings: the primary which connects the collector terminal of the transistor output and the secondary which connects to the loudspeaker or base terminal of the following stage. Both types are designed to operate efficiently over the whole of the audio spectrum, and with output transformers the tunns ratio is such that the low impendance of the speaker (usually of a few ohms, 3Ω say), reflected into the collector terminal of the output transistor as several thousands of ohms to match the optimum load impendance

of the transistor. The turnsratio required is equal to $(Z1/Z2)^{\frac{1}{2}}$. where Z_1 is the optimuim load impendance of the output transistor and Z2 is the impendance of the speaker. L.F. or audio coupling transformers may or maynot have a step-up (or step-down ratio, depending upon requirements, and since there is less power in a coupling circiut, such transformers are usually smaller than loudspeaker output transformers. High - quality audio output transformers have sufficient primary inductance to maintain a good low-frequency response, and a small winding capacitance to avoid attenuation at the high frequency end of the audiospectum. They are also much larger than loudspeaker transformers used in ordinary receivers.

Radio-frequency transformers, including I.F. transformers are really individually tuned and coupledwindings. For I.F. transformers each winding is tuned by parallel capacitance to the reguired intermediate frequency, which is usually 470KHZ for A.M. sets and 10.7MHZ for F.M. sets, a fixed capacitance is usually employed and tuning is accomplished by dust-iron cores. The coupling coefficient is usually fixed by the spacing of the two or more windings. Variable preset coupling possible, in this case two windings are wound on vertical formers and a third former simply carries an adjustable dustiron core, which has the effect of varying the coupling coefficient.

For miniature I.F. transformers, particularly those used in transistor receivers, potted cores are used.

In general transformers in radio equipments are used for the following purposes: transform current (or voltage) from a lower to a higher value and vice versa; isolate electrically one part of a circiut from another (two winding transformer), impedance matching etc.

I.I.2. CAPACITORS

Basically four types of capacitors exist namely;

(1) the electrolytic capacitor (which is polarized with one terminal positive with respect to the other and there must be used in circiuts with no voltage reversal; it has a large capacitance for a given size

(11) The fixed capacitor with paper, metallizedpaper; plastic film (polyster), mica or ceramic dielectric as used for coupling or decoupling

(111) The variable capacitor, used for tuning and

(1v) The trimmer or pre-set capacitor used instead of a dust-iron core to adjust the tuned frequency of L-C. circuits.

I.I.2(i) ELECTROLYTIC CAPACITORS

These are able to provide a large capacitance in a small space because the dielectric between the plates is microscopically thin. Apart from their capacitance, the working voltage and ripple current must be considered before choosing an electrolytic capacitor. They are used as by-pass and coupling capacitors

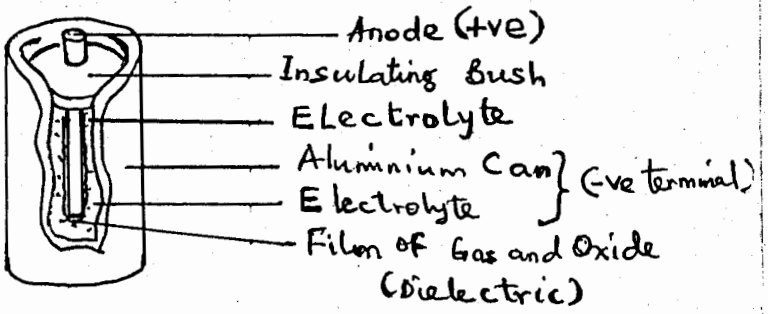


Fig 1.1. 2 (1) Section through an electrolytic capacitor.

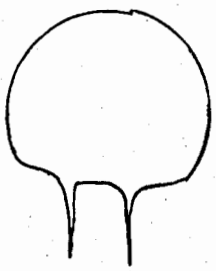
In high tension feed circuits, electrolytics are used as by- pass capacitor's, connected across emitter resistors. A high value is usually required for these applications and electrolytic capacitor is about the only component that can provide in a small volume. Sometimes a paper-type capacitor of rather low value is connected in parallel with an electrolytic used

as a by-pass or decoupler. This is due to the fact that an electrolytic capacitor has a fairly high inductance which can cause trouble in certain circuits, and the paper capacitor effectively by-pass only signal that may develop across the in inductive element.

Electrotytic capacitors are found also as couplers in transistor radio. These usually have a high value and very low working voltage and are physically small units. Beware of the connections!!!!

I.1.2 (ii) CERAMIC CAPACITOR'S

These are often found in television equipment and some are unusual in having a negative coefficient of temperature (ie. their capacitance decrease slightly with increase in temperature). This feature can be useful for neutralizing frequency drift in Oscillator and I.F. circuits, and in most V.H.F/F.M. tuner units a selection of both types will be found. The capacitor used is rated at the appropriate a.c. working voltage.



(a) Disc type

(b) Tubular type

I.I. 2 (iii) VARIABLE CAPACITORS

Two types are in used, the tuning capacitor and the trimmer. As used in many radio receivers, the former has a set of fixed plates in parallel, called the stator, and an intermeshing set of plates on a shaft, called the rotor.

Air is employed as the dielectric, and these are normally two or three sections ganged to work together although operating as separate capacitors with each section of the same capacitance and any frequency difference in the tuned circuits served the component being allowed for by the use of padding and trimming capacitors or by coil design.

Some circuits may be found with two main sections and a third smaller section independently operated from a Separate spindle for band - spreading on the short waves. Two separate ganged sections may be found on some A.M./F.M receivers, the larger sections for A.M operations and the smaller for F.M. Variable capacitors in small transistor receivers are designed for use with printed circuit boards. They employ polythene as the dielectric to allow much smaller size for a given capacitance per section.

Trimming capacitors are-set to suit circuit conditions and then not touched in normal operation. They may take the form of a concentric arrangement where one set can be screwed between the air gaps of a second set, or there is the compression type where a screw is used to press down one plate(or several plates) on to another, with mica between. As the adjusting screw is turned clockwise for increased pressure, the capacitance is increased.

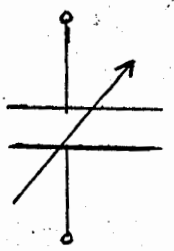


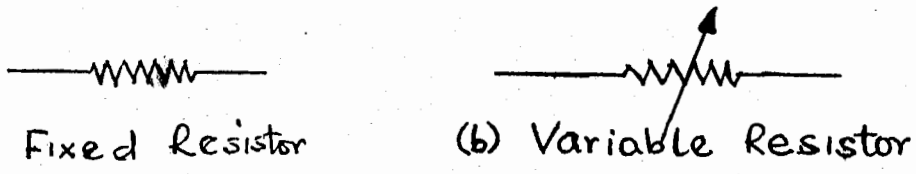
fig. 1.1.2 (111) variable capacitors symbol

I.I.3 RESISTORS

These have many applications, among which are: dropping voltage from the high tension line to the collector terminal of the transistor: acting as the collector

A.F. circuits); potential divider networks (either fixed or variable); and decoupling in collector and automatic gain control A.G.C.) circuits. The values of the resistance employed cover a wide range, from a few ohms (for biasing resistors) to many thousands (kilohms) or millions (megaohms) of ohms (for base leaks and decoupling purposes).

Resistors are mostly either of the composition type or wire wound. The first maybe of solid carbon composition or a film of carbon or similar materials on a glass or porcelain rod. The second are coils of resistance wire and are thus able to pass considerably more current than the composition resistors.



(a) Fixed Resistor (b) Variable Resistor

Fig 1.1.3 Resistors - Symbol

I.I.3(i) VARIABLE RESISTORS AND VOLUME CONTROL

The potentiometer or volume control resistor is used in radio and television set for the control of volume, tone, brightness, line and frame holds, height, inteference suppression etc. Most of these resistors are made of composition material or a layer of carbon or graphite, over which a slider rotates; or the resistive element may be wire-wound for carrying a greater current. (see Fig 1.1.3) As the slider moves back and forth it changes the effective resistance in the circuit in an upper or lower manner.

I.i 3(ii) THE THERMISTOR.

This is a negative temperature coefficient resistor whose resistance value decreases with increase in temperature. It is used for the suppresion of switch

on current surges in series-connected heater chains. In AC/DC receivers, the heater current is brought to the correct value by a mains dropper, the whole of the series circuit being connected across the mains supply. When the set is first switched on the series resistance of all the heaters and the mains dropper is relatively low, meaning a heavy surge current could flow through the circuit. To aviod a switch-on surge, a thermistor is connected in the heater chain, and since its value is relatively high when cold, it limits the chain current. The current however causes the thermistor to warm up, and as it does so, its resistance decreases, thereby progressively letting more voltage to reach the value heaters as their resistance increases during the warm-up period.

Fig 1.1.3(ii) : thermistor

I.I.3 (iii) VOLTAGE DEPENDENT RESISTORS: In this type the resistance decreases with increase in voltage. It is found in TV receivers where it is used for stabilizing the timebase against voltage variations and the effects of ageing component's. It belongs to the semi-conductor family.

Fig 1.13(iii): voltage dependent Resistor

I.I.3(iv) LIGHT DEPENDENT RESISTOR:

In this type the resistance decreases as the intensity of the light falling upon it increases. It is used in TV receivers to provide an automatic control of contrast or brightness to suit the room lighting conditions and is connected in the appropriate circuitry so that when the network resistance changes due to a change of illuminations, the brightness or contrast is automatically compensated for.

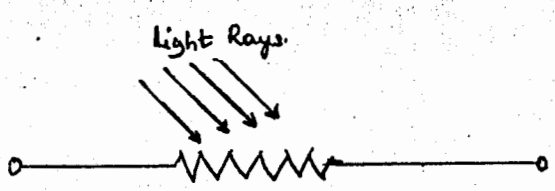


Fig 1.1. 3 (1v), light dependent Resistor

I.I. 4 INDUCTORS :

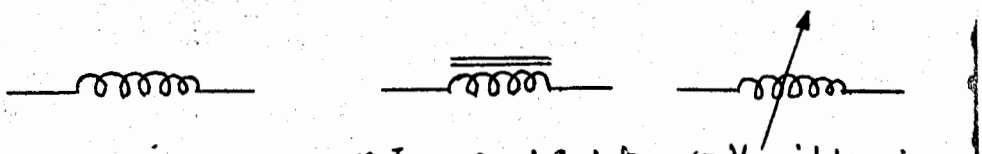
An ordinary untuned winding possess inductance and is known as an inductor or choke. A tune circuit is made up of both inductance and capacitance, and the frequency to which the combination tuned depends on the value of the two elements. Even a piece of wire has a small value of inductance which is a function of its length and configuration (whether wound as a coil or is merely looped).

At ordinary broadcast frequencies, the inductive effect of a short length of interconnecting wire inside a receiver is of little consequence but at very high frequencies as used for television and for V.H.F./F.M. radio, it may be sufficient to upset the normal characteristics of a tunned circuit. Types of inductors or chokes include the low frequency smoothening choke, the V.H.F tuning inductor.

A tuned circuit, comprising inductance, L and capacitance (C), has a tuned frequency (F) given as

$$F = \frac{1}{2\pi(LC)^{\frac{1}{2}}}$$

This frequency is increased or decreased by decreasing either L or C or decreased by increasing the value of one or both of these elements. In most broadcast receivers a variable capacitor is used for tuning, but in certain television and VHF/FM receivers the capacitance is fixed and the inductance is varied to cause a change in tuned frequency.



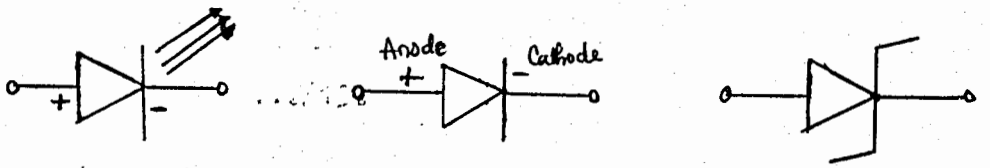
(a) Air-cored Inductor (b) Iron-Cored Inductor (c) Variable air-core Inductor.

Fig. 1.1.4 Schematic Representation of Inductors.

I.I.5 DIODES [3]

Diodes are the simplest solid state components. A diode has only two leads, an anode and a cathode. In amplifiers and communication equipment, diodes serve as temperature stabilizers, signal detector and regulators. Larger size diodes are used in electronic power supplies typically as rectifiers.

The diode family comprises: regular diodes, the zener diode (used primarily for voltage regulation), the tunnel diodes (used in Oscillators for its negative resistance characteristics), the light emitting diode(for illumination).



(a) Light Emitting Diode (LED) (b) Regular Diode (c) Zener Diode

Fig 1.1.5 : Some Diode Symbols

I.I.6 TRANSISTORS .

This is the most widely use semi conductor device they are widely used as amplifiers in communication circuits and as switches in digital circuits. They are available in discrete forms as well as in integrated circuit (IC) forms. Two basic types exist: the NPN and the PNP types.

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