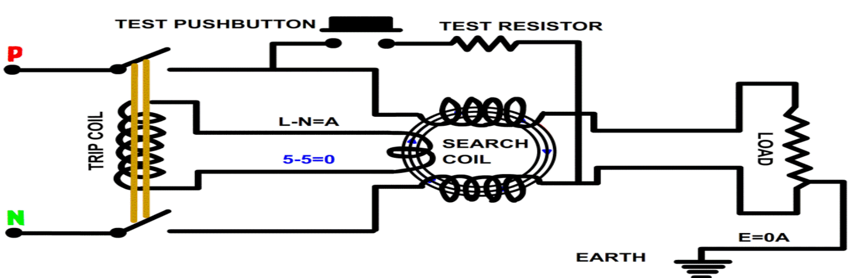
Scheme Of Evaluation

Internal Assessment Test III – Nov .2019

Sub:	Testing and Commissioning of Power System Apparatus							**Code:**	15EE752
Date:	18/11/2019	Duration:	90mins	Max Marks:	50	**Sem:**	VII	**Branch:**	EEE

Note: Answer Any Five Questions

Question #		Description	Marks Distribution		Max Marks
1	a)	**List out and explain the protective devices in residential electrical installation.** • List of all the protective devices used • Elaborate any 4 (each 2 marks) **RESIDUAL CURRENT CIRCUIT BREAKER** RCCB is provided mainly for the protection of human being from accidental electric shock that can occur due to faulty wiring or earth faults. In normal working conditions of the circuit the current flowing into it through the live wire is same as that of the current coming out the neutral wire.IN case of an earth fault the current finds path to earth. For example a person comes into accidental contacts with live wire then current flows to earth and the amount of current returning through the neutral is reduced and this reduced current is known as residual current.The RCCB continuously monitors the amount of current flowing and if there is any difference in current detected then it trip out.  A torroidal transformer is contained within the RCCB body this helps to detect the current imbalance within the system. There is current path for live and neutral wires connected to the transformer. A magnetic flux is generated proportional to the current drawn through the live and neutral wire. The construction of windings is such that they produce magnetic fields in the opposite direction. Net magnetic flux is zero in the case when there are no faults, since the magnetic fields cancel out each other. Even if there is a small residual current then the net magnetic flux will be greater than zero which will result in the tripping of circuit to avoid accidental shocks.	2 M 8M	10 M	10 M

There are two types of RCCB

TWO POLE RCCB

Two pole RCCB is used in case of a single phase supply. It has two points to which a live wire and neutral wire is connected.

FOUR POLE RCCB

Four pole RCCB is used in case of 3 phase supply. It has 2 ends to which 3 phase wires and one neutral wire is connected.

MINIATURE CIRCUIT BREAKER

There is a bi-metallic strip which becomes over heated when circuit is overloaded for long time. Overheating results in deformation of the strip and causes displacement of latch point. Even a slight movement of latch causes release of spring and makes the moving contact to move for opening the MCB. During short circuit the MMF of current coil causes its plunger to hit the latch point and displaces the latch, which results in the opening of the MCB. Arc generated by high currents will reach the arching chamber through the guide plate. The arc is separated into smaller arcs by the arc splitter and extinguished there.

CLASSIFICATION OF MCB BASED ON TRIPPING CHARACTERISTICS

TYPE B

These are mainly used for residential purpose. They trip between 3 and 5 times full load current.

TYPE C

This type of MCB is used where there can be chances of higher values of short circuit current in the circuit like commercial or industrial type of application. Loads connected are mainly inductive in nature. They trips between 5 and 10 times full load current.

TYPE D

This type of MCB is used for commercial purposes where there is high current in flow. They trip between 10 and 20 times full load current. RCCB, MCB, fuses, ELCB, are all devices used to protect users and equipment from fault conditions in an electrical circuit by isolating the electrical supply.

Fuses

Fuse is a protection device which melts and breaks the circuit when the current rating exceeds the rating of the fuse. Fuse must be replaced ones it has melted. Fuses are becoming rare as electrical installations are updated.

ISOLATORS

Electrical isolators isolates a part of the system from rest this is useful when circuit breaker trip the circuit but the open contacts are not visible from the outside so it’s not safe to touch the circuit just by switching of the circuit breaker. Therefore the isolator is opened only after the circuit breaker is opened and closed before the circuit breaker is closed. Electrical isolators must be operated only when there is no current flowing through the circuit. Isolator can be operated by hand as well as by motorized setup. But motorized set up costs more than hand operation.

TYPES OF ISOLATORS

DOUBLE- BREAK ISOLATOR

There are three post insulators. The central post insulator can be rotated. There is a flat male contact on central post insulator which rotates as central post insulator rotates. Female contacts are fixed up on the other two post insulators.

The rotating movement of male contact makes it in contact with the female contact and isolator becomes closed. And as the isolator rotates in opposite direction it loses the contact with female contact and isolator becomes open. Driving lever mechanism enables rotation of the central post insulator.

SINGLE- BREAK ISOLATOR

There are two post insulators which rotate. And due to their rotation the male and the female contacts fitted over them also rotates. Rotation of both post insulators stacks in opposite direction causes to close the isolator by closing the contact arm. Counter rotation of both post insulators stacks open the contact arm and isolator becomes in off condition.

Isolators are classified depending upon their position in power system.

1-Line side isolator is at the line side of any feeder.

2-Bus side isolator is directly connected with the main bus.

3-Transfer bus side isolator is directly connected with transfer bus.

RCBO (Residual Current Breaker with Overcurrent)

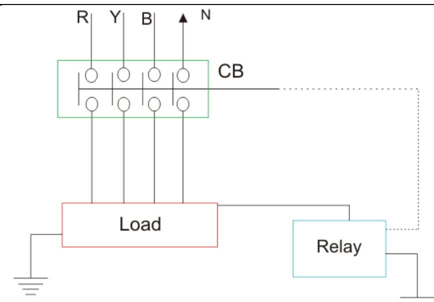
When there is need of combined protection against over current (over load and short circuit) and protection against earth leakage current RCBO is used.

It has wide range of breaking capacities and can be used for industrial and residential purposes.it has the combined effect of MCB and RCCB in one device. Every circuit has its own RCBO therefore if any device is tripped due to residual current, only the faulty circuit is disconnected.

The internal residual current detecting element will trip the circuit when there is a current leakage fault. The internal thermal/magnetic circuit breaker parts are able to trip the device when the circuit is over loaded. RCBO come in single pole and dual pole variations. The single pole is used as a direct replacement for MCB.

ELCB

An ELCB is a voltage sensing device which is used to prevent shock threats as well as protection of instruments. Earlier it was widely used but now a days RCCB's are in use for protection. An ELCB has a relay coil one of the terminals is connected to the equipment and other terminal is given to ground directly. In case of faulty conditions like if insulation of the equipment fails or live phase wires touches the metal part of the equipment, a voltage difference appears across the coil which is connected to device and earth. After this voltage reaches a limit, current developed in the relay trips the circuit breaker and the power supply to the device is stopped.

					
2	a)	**State and explain the various type tests and routine tests performed on High voltage ac circuit breaker.** • List out type and routine tests • Explain 4 type tests and 4 routine tests briefly (Each 1 Mark) ❑ **Routine tests on HV ac circuit breaker** • Ensure that the circuit breaker is made to meet the design specifications. • quality of the material used and manufacturing defects Tests include : ➢ Mechanical operation test , ➢ Timing test O,CO ➢ Milli volt drop test , ➢ Contact travel characteristics ➢ Voltage test on auxiliary circuits ➢ Power frequency voltage tests /Impulse voltage tests Measurement of resistance ❑ **Type tests on HV ac circuit breaker** ➢ Temperature rise test ➢ Mechanical operation test , ➢ Overload performance ➢ Short time withstand current test ➢ Short circuit making and breaking tests ➢ Power frequency voltage tests /Impulse voltage tests ➢ Measurement of resistance **Insulation Resistance Measurement** ➢ Measured using meggar. ➢ It consists of a built in hand driven dc generator. ➢ The two terminals of meggar are connected across the insulation i.e one to the conductor and other to the earthed body. ➢ For HV switchgear 1000V or 2500V meggar is preferred. ➢ HV circuit breaker has IR > 1000 Mega Ohms. ➢ IR of the control circuit, trip circuit, ,relay circuit etc. is measured using 500V meggar. **High Voltage Test at Site** ➢ Conducted after the erection of the circuit breaker. ➢ Defect in the insulation can be checked. ➢ The test voltage is applied for a duration of 1 minute. ➢ Isolated suitably during the test. ➢ The test voltage is applied 1. With breaker closed: (a) phase -earth b) Between Phases 2. With breaker open: - Between R, Y, B phases shorted together (on bus-bar side)and the frame of the CB. - Between 1 terminal of each pole & other terminal of same pole connected to the frame of CB	2 M 8 M	10 M	10 M

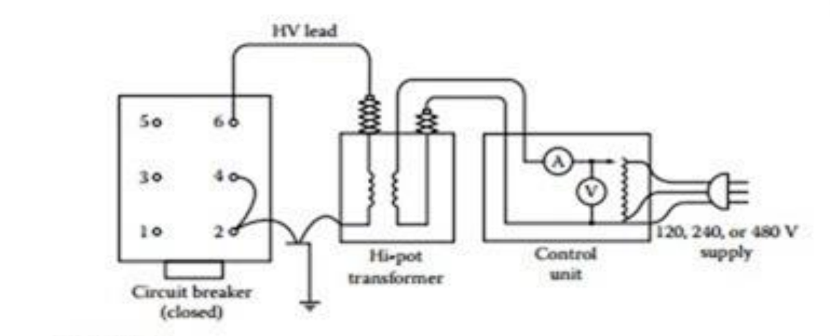


FIGURE 7.18
Typical connection for hi-pot test for circuit breaker in closed position.

Impulse voltage test/ Power frequency voltage withstand tests

- ➢ Impulse wave of specified amplitude is applied five times in succession(+&-ve polarity)
- ➢ Impulse generator
- ➢ Test voltage applied across each pole and earth for one minute.
- ➢ The peak value of the impulse wave and its shape is recorded using CRO with calibrated voltage divider

Impulse Voltage characterised by

- Polarity
- Peak value
- Virtual front
- Virtual half time/Wave Tail

Standard lightning impulse (1.2 /50 µsec)

Switching impulse(250/2500 µsec)

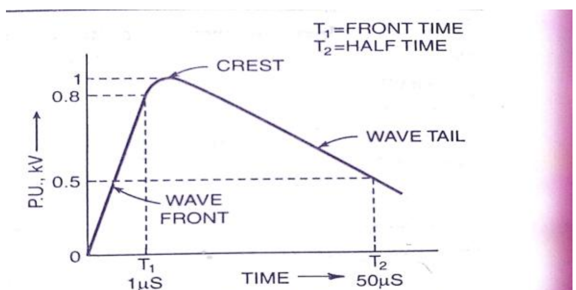


Fig. Q. 705. Standard Lightning Impulse wave 1/50 wave.

Temperature Rise Test

- ❑ Rated ac voltage at rated frequency passes continously
- ❑ keep the contacts in the closed position.
- ❑ Readings of various conducting, Insulating and structural parts are taken at an interval of one or half an hour.
- ❑ When steady temperature is reached the maximum temperature rise of each part should be less than the permitted values.

Mechanical Test (Endurance Test)

- ➢ The breaker should consistently open and close its contacts(nearly 1000 times).
- ➢ During the test, test is done without charging the main circuit.
- ➢ Adjustment or replacement of any part of the circuit breaker is not allowed.
- ➢ Lubricate as per the instructions of the manufacturer
- ➢ The tests are to be conducted after the improvement in the design and manufacture.

- After the **Mechanical Endurance** test,
- Contacts and other parts of circuit breaker must be in good position and there should not be any permanent deformation of any parts.
- Test proves the adequacy of design and also good quality of material used in manufacture.

Test for Contact Resistance of Circuit Breaker Pole

- Routine test - at ambient temperature.
- $R_{POLE} < m*20\ \mu\Omega$
- m is the number of joints, contacts in series per pole.
- This is measured by two methods.
  1. Micro ohmmeter:
  2. Millivolt drop method: The voltage drop across the circuit breaker pole is measured for different values of dc current.

The dc current should be sufficiently high but must be less than the rated current.

Time Versus Travel Characteristics
A travel trace is drawn showing the movement of the linkage

- Contact opening speed.
- Total distance of contact travel.
- See any type of binding to the linkage affecting travel or opening speed.

1. **Use of potentiometer**

- the two fixed terminals of potentiometer - 3 volts dc.
- The stem connected to the variable terminal of the potentiometer is connected to the lever of the circuit breaker.
- As the lever moves during opening and closing operation, generates a potential through the variable terminal changes proportional to the travel.
- Ultraviolet recorder

Short Circuit Test set up

- To prove the ratings and the behaviour of the CB
- Master CB
- Making switch
- Series resistors and reactors
- short circuit generators.
- three phase induction motors
- In addition, Measurement, record control, sequential operation, Auxiliaries, Transformers

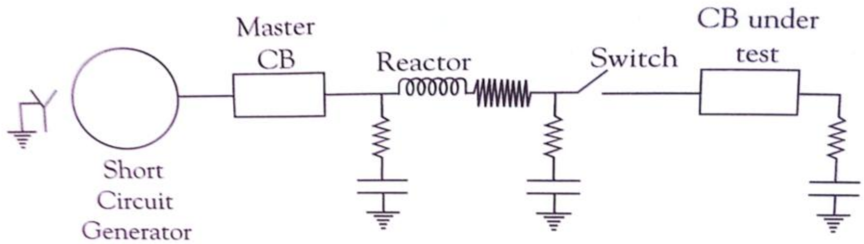


Figure 4.4: Layout of a simple short circuit test station

The circuit breaker should be capable of performing the opening and closing operations as per **rated operating sequence** for all values of short circuit currents upto its rated short circuit breaking current at specified test voltage and relevant conditions of transient recovery voltage for terminal short circuits.

❖ Synthetic testing

- Indirect method of SC testing.
- CURRENT SOURCE- SC current- short circuit generator
- VOLTAGE SOURCE- voltage source

➢ R , L & C are used to get desired test condition.
When switch S1 is closed SC current is supplied. At near final current zero, switch S_2 is closed (which is generally a spark gap).

➢ The voltage applied will have transient Thus the circuit breaker can be tested for TRV and RRRV. Both current voltage sources can be independently varied. International standards for synthetic testing are necessary. The types of synthetic test can be parallel current injection or series current injection methods

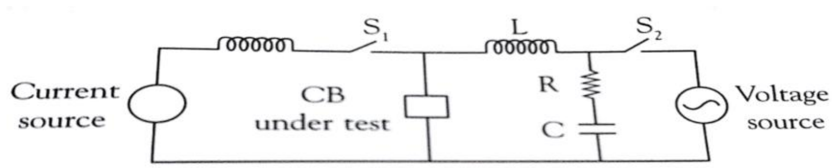


Figure 4.5: Synthetic Testing of Circuit Breaker

3 a) **Describe the various steps in maintenance of circuit breakers.** — 10 M | 10 M | 10 M

- Give all the steps (Each 1 mark)

Period of inspection

a. Under normal condition: 6-12 month for CB

1- 3 months for CB operating repeatedly

b. Overhead : 3 yrs/as recommended by manufacturer

c. Replacement: Life period expires

Checks includes

a. Check oil and oil condition.

b. Clean insulators. Trichloroethylene is used

c. Check contacts/operating system/indicating devices/ auxiliary switches

d. Tight nuts, bolts

e. IR test

When CB fails,

a. Check what caused the failure…

Sl. No	Trouble	Causes	Remedies
1	Low IR for insulators	Moisture, Dirty surface , oil, Copper/carbon sticking on surafce	Hot air/oil for 4-6 hrs
2	High Contact resistance between terminals of pole	Reduced contact pressure, loose screws/bolts, Damage/wear &tear in contacts,	Dismantle., reassemble/replace contacts
3	Unequal contact wipe & travel	Contact erosion due to repeated load operations and short circuit oprn.	Inspect contacts- replace(if badly eroded), adjust contact(if pole length is unequal)
4	Breaker operation slow	Excessive friction ,low battery voltage(so, higher trip coil pickup time)	Identify the cause
5.	Breaker does not operate on electrical command	Spring are defective, trip circuit open/ defective	Check closing and opening of CB visually, Identify cause

4	a)	**Explain the various aspects to be considered in laying underground cables.** • Give all the factors to be considered (Each 1 mark) Purpose /type of cable • Control/ power cable • 1 core/3 core, • construction • Type of insulation Type of installation ▪ Outdoor /indoor installations ▪ Transmission / Distribution ▪ Buried/ in pipe/ Trench/tray Nature of soil : Sandy ,Hard, Rocky Soil Conditions: Wet, Muddy, Dry , Hazardous components Chemical action Operating conditions o Rated voltage / current o Earthing Conditions o Load Conditions o Permissible Temperature Conditions o : For conductor, insulation, sheath Drum length and mass cable jointing and terminations Economic considerations **Guidelines for cable laying** • **Selection of route BASED ON ROUTE SURVEY** When selecting route, Side of streets with least obstacle, trees and road crossings . If possible cables are laying along footpaths rather than carrier way. Max away from water pipes, parallel running gas and telephone communication cables, private property. Location for jointing and termination : Accessible • **Permissible gradient of route and permissible vertical height** PVC, XLPE, Paper insulated cables upto 11kV cables have no draining compound, gradients and vertical heights do not have any problem • **Minimum permissible bending radii** Bend Radius: the minimum **radius** one can **bend** a cable without kinking it, damaging it, or shortening its life. • **Permissible maximum tensile strength for cables** The cable is **very quickly damaged** by the use of too much force and must then be replaced Force of pulling < Maximum permissible pulling tension for power cables during installation • When pulled using cable socks • When pulled using pulling eye	10 M	10 M	10 M

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<td>a)</td>
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Describe the steps to be taken after occurrence of fault in underground high voltage cable.

- Give all the steps (Each 1 mark)

Check insulation resistance- L-L, L- G

Pre-location of fault

Pin pointing the fault

Analyse the fault

Take repair/replacement actions

Take preventive actions for the future

Methods of Cable Fault Location

1. Terminal methods - test at one end , compare values

✓ Murray loop method

✓ Capacitance bridge method

✓ Charging current method

✓ Radar method/ Pulse Echo

✓ Resonance method

2. Tracer Methods

✓ Tracing current method

✓ Radio frequency method

✓ Surge Thumber method

✓ Arc Reflection method

✓ Earth gradient method

✓ Meggar two end method

Capacitor Discharge Method/SurgeThumper Method

- DC Charged capacitor discharged to the faulted conductor
- Dielectric breakdown at the fault causes an explosion
- Noise of explosion reaches the atmosphere with a ‘THUMP”sound

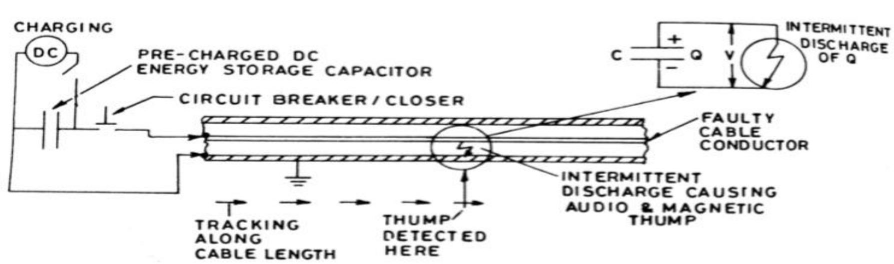

Fig. Q. 397. Capacitor Discharge Thump-Surge Tracking Method.

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Pulse Echo Method

- Helps to pin point the fault location accurately
- Test setup : Transmitter (LVHF Pulse), Time domain Oscilloscope
- Test pulse is transmitted
- Pulse Reflected back at fault
- Transmitted pulse and reflected pulse analysed in oscilograph

D= Vt/2

- D = Distance Btw Test location and fault location
- V =Velocity of propagation
- t = Transit Time

Murray loop method - bridge method

Only for short circuit faults

Used only when one healthy conductor is available

$$\frac{R_1}{R_2} = \frac{R_g + R_y}{R_x}$$

Or $$\frac{R_1}{R_2} + 1 = \frac{R_g + R_y}{R_x} + 1$$

Or $$\frac{R_1 + R_2}{R_2} = \frac{R_g + R_y + R_x}{R_x}$$

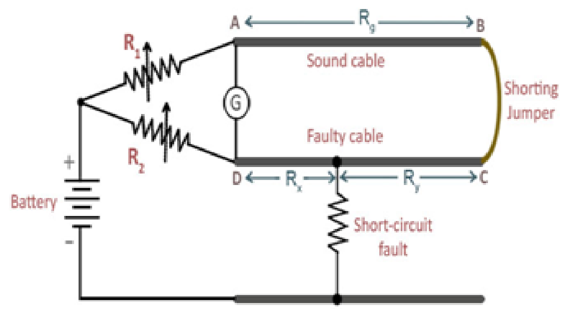


fig.(i) Murray loop test for short-circuit fault

$$\frac{R_1}{R_2} = \frac{R_g + R_y}{R_x}$$

Or $$\frac{R_1}{R_2} + 1 = \frac{R_g + R_y}{R_x} + 1$$

Or $$\frac{R_1 + R_2}{R_2} = \frac{R_g + R_y + R_x}{R_x}$$

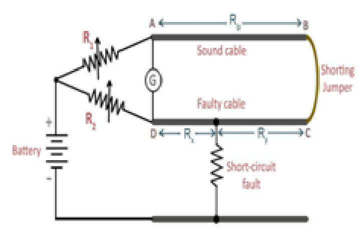


fig.(i) Murray loop test for short-circuit fault

Now, if r is the resistance of each cable,

then, $R_x + R_y + R_g = 2r$

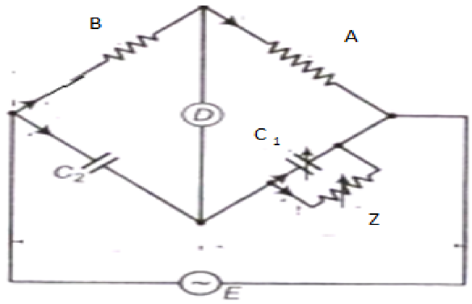
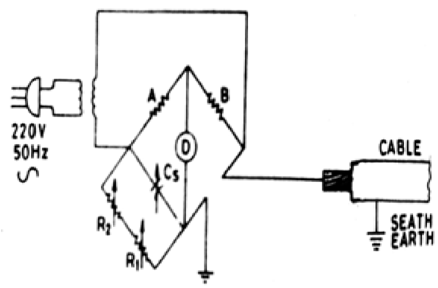
Putting this in the above equation,

$$\frac{R_1 + R_2}{R_2} = \frac{2r}{R_x}$$

$$R_x = \frac{R_2}{R_1 + R_2} \times 2r$$

Only for short circuit faults

$$L_x = \frac{R_2}{R_1 + R_2} \times 2L$$

		Capacitance Bridge Method To locate high impedance fault especially Open circuit > 200MOhm Measures the Capacitance of a faulted cable to ground Shering's bridge  • Known resistors- A & B • Variable Impedance $$\frac{C1}{C2} = \frac{X}{L}$$ C1= Fault cable capacitance C2= Unfaulted cable capacitance X= Length of cable till the fault L =Total cable length  Fig. Q. 389. Capacitance Bridge Method for locating cable fault.			
6	a)	**Identify the factors to be considered while selecting circuit breakers?** • Give all the factors to be considered (Each 1 mark) 1. Ratings 2. Break time 3. Ambient conditions 4. Type of design: indoor or outdoor 5. Control desired : direct/semi auto/auto 6. Type of operating mechanism 7. Type of breaker based on arc extinction medium 9. Frequency of operation 8. To be operated alone or in group	6 M	6 M	10 M
	b)	**Based on quenching medium categorize the types of circuit breaker?** • Classification of circuit breakers • Working of each circuit breakers with types of medium included in them – atleast 3 (each carries 1 mark)	1 M 3 M	4 M	

1. **Oil Circuit Breakers**

In oil type of circuit breakers, some insulating oil (in, transformer oil) is used as an arc quenching medium.

The contacts are opened under oil and an arc is struck between them. The heat of the arc evaporates the surrounding oil and dissociates it into a substantial volume of gaseous hydrogen at high pressure.

The hydrogen gas occupies a volume about one thousand times that of the oil decomposed. The oil is, therefore, pushed away from the arc and an expanding **hydrogen gas bubble** surrounds the arc region and adjacent portion of the contacts. The arc extinction is facilitated mainly by two processes.

Firstly, the **hydrogen gas** has high heat conductivity and cools the arc, thus aiding the de-ionization of the medium between the contacts. Secondly, the gas set up **turbulence** in the oil and forces it into the space between contacts, thus eliminating the arcing products from the arc path. The result is that arc is extinguished and circle current interrupted.

2. Air-Blast Circuit Breakers

These type of circuit breakers employ a **high-pressure air-blast** as a quenching medium. The contacts are opened in a flow of air-blast established by the opening of the blast valve. The air-blast cools the arc and sweeps away the arcing products to the atmosphere. This rapidly increases the dielectric strength of the medium between contacts and prevents from re-establishing the arc. Consequently, the arc is extinguished and the flow of current is interrupted.

3. Sulphur Hexafluoride SF6 Circuit Breaker

In such type of circuit breakers, **sulphur hexafluoride (SF6) gas** is used as the arc quenching medium.

The SF6 is an electronegative gas and has a strong tendency to absorb free electrons. The contacts of the breaker are opened in a high-pressure flow of SF6 gas and an arc is struck between them. The conducting free electrons in the arc are rapidly captured by the gas to form relatively immobile negative ions. This loss of conducting electrons in the are quickly builds enough insulation strength to extinguish the arc. The SF6 circuit breakers have been found to be very effective for high power and high voltage service.

4. Vacuum Circuit Breakers (VCB)

In such type of circuit breakers, vacuum (**degree of vacuum being in the range from 10 to 10 torr**) is used as the are quenching medium. Since vacuum offers the **highest insulating strength**, it has far superior are quenching properties than any other medium. For example, when contacts of a breaker are opened in vacuum the **interruption occurs at first current zero** with dielectric strength between the contacts building up at a rate thousands of times higher than that obtained with other circuit breakers.

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<td>Principle of VCB

The arc formation in a vacuum circuit breaker and its extinction can be explained as follows:

When the contacts of the breaker are opened in a vacuum (10 to 10 tor), an arc is produced between the contacts by the ionization of metal vapors of contacts.However, the arc is quickly extinguished because the metallic vapours, electrons, and ions produced during arc rapidly condense on the surfaces of the circuit breaker contacts, resulting in quick recovery dielectric strength.</td>
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<td>a)</td>
<td>Explain the radar method of locating cable fault.
• Circuit diagram
• Working

Pulse Echo Method

The pulse echo technique is performed with a time domain reflectometer (TDR), which combines a transmitter and a receiver. The transmitter sends out a low voltage high frequency pulse of a short duration onto a cable. This pulse of energy travels along the surface of the cable until it encounters some type of disruption manifested in a change within the characteristic impedance of the cable; these mismatches in the characteristic impedance of the cable may be caused by the start of the cable, splices in the cable, transformers, faults, etc. Depending upon the magnitude of the impedance change, either part or all of the transmitted energy reflects and travels back to the time domain reflectometer. In essence, this technique creates an electronic or a graphical roadmap of the underground cable showing different events along that path.
• Helps to pin point the fault location accurately
• Test setup : Transmitter (LVHF Pulse), Time domain Oscilloscope / reflectometer.
• Test pulse is transmitted
• Pulse Reflected back at fault
• Transmitted pulse and reflected pulse analysed in oscilograph
$D = Vt/2$
o D = Distance Btw Test location and fault location
o V =Velocity of propagation
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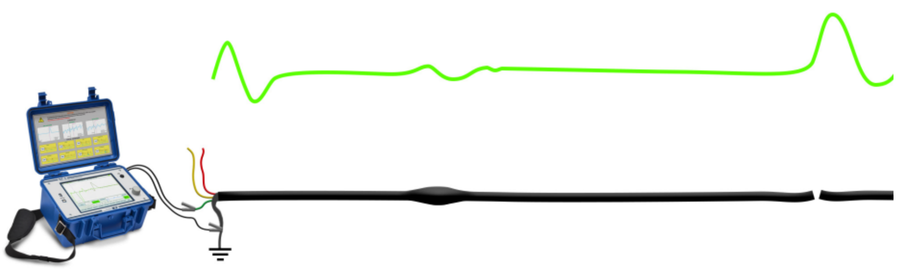</td>
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Amplitude of Reflected wave,

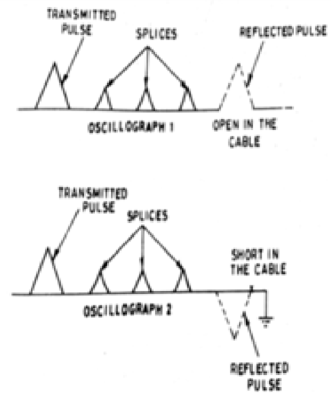
$$I_r = i_t * \frac{(R - Z)}{(R + Z)}$$

Z= Impedance of cable upto fault

R = Resistance of cable upto fault

Open Circuit = Inf. Resistance ($I_r = i_t$)

Short circuit = Zero Resistance ($I_r = -i_t$)



Q. 392. Typical waveforms on oscilloscope in Radar method
(a) Open circuit fault (b) Short circuit fault.