SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

AN AUTONOMOUS INSTITUTION

Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai

INTERNAL ASSESSMENT EXAMINATION – II ANSWER KEY

VI Semester

B.E – Electrical and Electronics Engineering

19EE605 – Protection and Switchgear

Regulations 2019

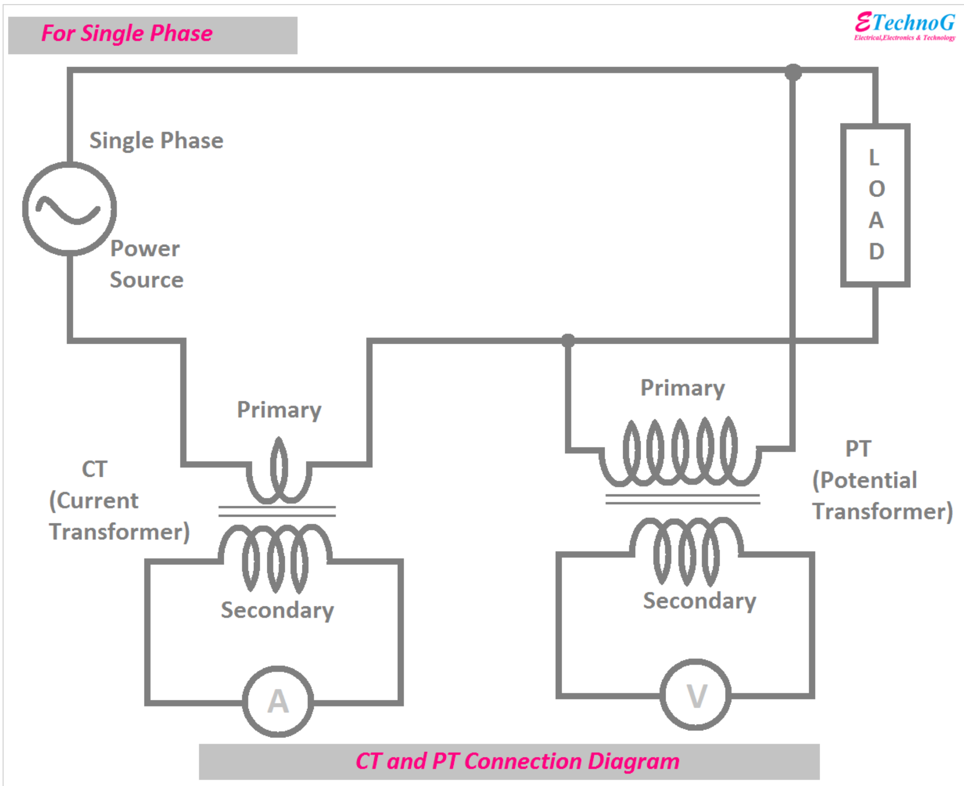
PART - A

Q.No	Question
1.	**Give the principle of negative sequence relay.** It protects generators from the unbalanced load by detecting negative sequence current. A negative sequence current may cause a dangerous situation for the machine. Phase to phase fault mainly occurs because of the negative sequence component
2.	**List the factors affecting the performance of differential relays.** Current Transformers (CTs) Circuit Configuration Fault Location Fault Impedance CT Saturation System Grounding Communication Delays Relay Settings Environmental Conditions Maintenance
3.	**Why secondary of transformer should not be opened?** If we keep secondary open, CT will face an open circuit voltage on secondary winding. This open circuit voltage can puncture an insulation of CT and cause burning of CT, as insulation of CT is not design to withstand with this voltage due to its cost and size limitation.
4.	**List the types of busbar protection.** Differential Protection Overcurrent Protection Impedance-Based Protection Voltage-Based Protection Distance Protection Transfer Trip Protection Backup Protection
5.	**In the event of faults in generator windings, field excitation is to be suppressed as early as possible. Why?** When a generator loses its excitation, other generators in the system increase the reactive power output. This may cause the overloading in some transmission lines or transformers and the over-current relay may consider this overloading as a fault and isolate the non-fault equipments.

PART - B

6.a	**Give a detailed explanation about CT's and PT's and its application to power system.**

CT and PT type of transformer used in AC power. CT and PT both are measuring devices used to measure currents and voltages. They are used where large quantities of currents and voltages are used. The role of CT and PT is to reduce high current and high voltage to a parameter.



Current Transformers (CTs):

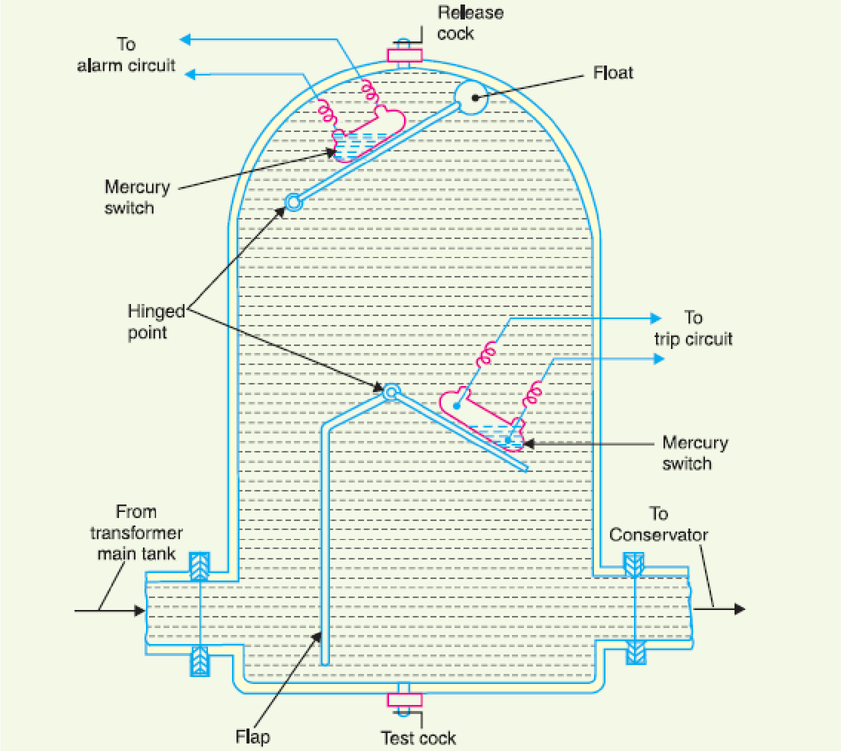
CTs are devices used to transform high currents in power systems to a standardized, lower current suitable for measurement and protection devices. Here's how they work and where they are applied:

1. **Functionality**: CTs work based on the principle of electromagnetic induction. When a high current flows through the primary winding (which is connected in series with the circuit), it induces a proportional current in the secondary winding (connected to measuring or protective devices), which is a fraction of the primary current. This secondary current is usually standardized to 5A or 1A for measurement and protection purposes.
2. **Ratio**: CTs have a ratio that defines the relationship between primary and secondary currents. For example, a 1000:5 CT will transform 1000A in the primary to 5A in the secondary winding.
3. **Applications**:
   - **Metering**: CTs are used to measure current flow in power systems for billing and monitoring purposes.
   - **Protection**: They are integral to protective relaying schemes. In case of a fault, CTs provide accurate information about the fault current to protective relays, enabling them to trip circuit breakers and isolate the faulty section of the system.
   - **Control**: CTs are also used in control circuits, where the magnitude of the current is used to regulate various parameters within the system.
4. **Accuracy and Calibration**: CTs need to be highly accurate to ensure proper operation of protection and metering systems. They are calibrated periodically to maintain accuracy.

Potential Transformers (PTs):

PTs, also known as voltage transformers, serve a similar purpose to CTs but for voltage measurements.

	They step down high voltage levels in power systems to a safe and standardized value suitable for metering, protection, and control purposes. Here's more detail: 1. **Functionality**: Like CTs, PTs work on the principle of electromagnetic induction. The primary winding of the PT is connected in parallel with the circuit, and the secondary winding is connected to the measuring or protective devices. When voltage is applied to the primary winding, a proportional voltage is induced in the secondary winding, which is usually standardized to 120V or 69V. 2. **Ratio**: PTs also have a ratio, defining the relationship between primary and secondary voltages. For example, a 10,000:120 PT will step down 10,000V in the primary to 120V in the secondary winding. 3. **Applications**: o **Metering**: PTs are used in conjunction with CTs to measure voltage in power systems accurately. o **Protection**: They provide voltage signals to protective relays, enabling them to detect abnormal voltage conditions and take appropriate actions. o **Control**: PTs are used in control circuits where voltage levels are monitored to maintain system stability and efficiency. 4. **Accuracy and Calibration**: Like CTs, PTs require calibration to maintain accuracy, especially in critical applications like protective relaying. **Importance in Power Systems:** CTs and PTs are indispensable components in power systems for several reasons: • They provide accurate measurements of current and voltage, which are essential for monitoring and controlling the system. • They enable protective relays to detect faults and abnormalities, helping to maintain system stability and protect equipment. • They ensure the safe operation of power systems by stepping down high currents and voltages to levels suitable for measurement and control devices.
6.b	**Describe the various methods of transformer protection.** **(i)** Buchholz devices providing protection against all kinds of incipient faults i.e. slow-developing faults such as insulation failure of windings, core heating, fall of oil level due to leaky joints etc. **(ii)** Earth-fault relays providing protection against earth-faults only. **(iii)** Overcurrent relays providing protection mainly against phase-to-phase faults and overloading. **(iv)** Differential system (or circulating-current system) providing protection against both earth and phase faults. **(i) Buchholz Realy** Buchholz relay is a gas-actuated relay installed in oil immersed transformers for protection against all kinds of faults. Named after its inventor, Buchholz, it is used to give an alarm in case of incipient (i.e. slow-developing) faults in the transformer and to disconnect the transformer from the supply in the event of severe internal faults. It is usually installed in the pipe connecting the conservator to the main tank as shown in Fig. It is a universal practice to use Buchholz relays on all such oil immersed transformers having ratings in excess of 750 kVA



Construction. Fig. shows the constructional details of a Buchholz relay. It takes the form of a domed vessel placed in the connecting pipe between the main tank and the conservator. The device has two elements. The upper element consists of a mercury type switch attached to a float. The lower element contains a mercury switch mounted on a hinged type flap located in the direct path of the flow of oil from the transformer to the conservator. The upper element closes an alarm circuit during incipient faults whereas the lower element is arranged to trip the circuit breaker in case of severe internal faults.

Operation.

In case of incipient faults within the transformer, the heat due to fault causes the decomposition of some transformer oil in the main tank. The products of decomposition contain more than 70% of hydrogen gas. The hydrogen gas being light tries to go into the conserva- tor and in the process gets entrapped in the upper part of relay chamber. When a predetermined amount of gas gets accumulated, it exerts sufficient pressure on the float to

cause it to tilt and close the contacts of mercury switch attached to it. This completes the alarm circuit to sound an alarm.

If a serious fault occurs in the transformer, an enormous amount of gas is generated in the main tank. The oil in the main tank rushes towards the conservator *via* the Buchholz relay and in doing so tilts the flap to close the contacts of mercury switch. This completes the trip circuit to open the circuit breaker controlling the transformer.

(ii) Earth fault relay

An earth-fault usually involves a partial breakdown of winding insulation to earth. The resulting leakage current is considerably less than the short-circuit current. The earth-fault may continue for a long time and cause considerable damage before it ultimately develops into a short-circuit and removed from the system. Under these circumstances, it is profitable to employ earth-fault relays in order to ensure the disconnection of earth-fault or leak in the early stage. An earth-fault relay is essentially an overcurrent relay of low setting and operates as soon as an earth-fault or leak develops. One method of protection against earth-faults in a transformer is the *core-balance leakage protection shown in Fig.

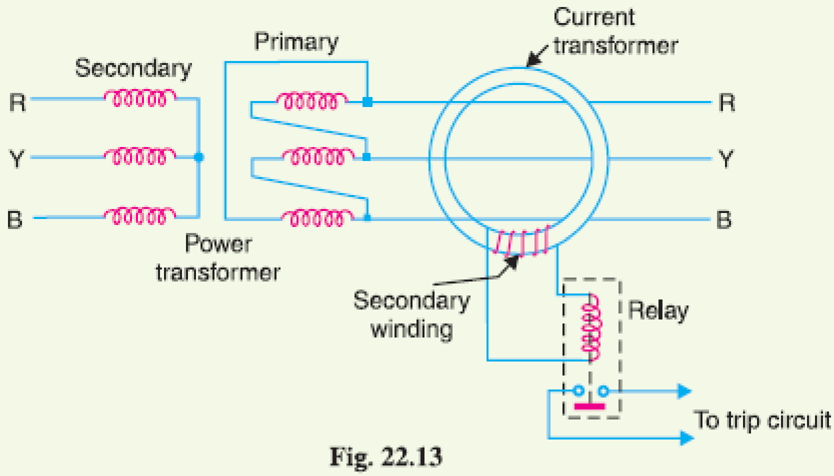


Fig. 22.13

The three leads of the primary winding of power transformer are taken through the core of a current transformer which carries a single secondary winding. The operating coil of a relay is connected to this secondary. Under normal conditions(i.e. no fault to earth), the vector sum of the three phase currents is zero and there is no resultant flux in the core of current transformer no matter how much the load is out of balance. Consequently, no current flows through the relay and it remains inoperative. However, on the occurrence of an earth-fault, the vector sum of three phase currents is no longer zero. The resultant current sets up flux in the core of the C.T. which induces e.m.f. in the secondary winding. This energises the relay to trip the circuit breaker and disconnect the faulty transformer from the system.

(iii) Circulating current scheme or Merz Price Protection

Fig. shows Merz-Price circulating-current scheme for the protection of a 3- phase delta/delta power transformer against phase-toground and phase-to-phase faults. Note that CTs on the two sides of the transformer are connected in star. This compensates for the phase difference between the power transformer primary and secondary. The CTs on the two sides are connected by pilot wires and one relay is used for each pair of CTs.

During normal operating conditions, the secondaries of CTs carry identical currents. Therefore, the currents entering and leaving the pilot wires at both ends are the same and no current flows through the relays. If a ground or phase-to-phase fault occurs, the currents in the secondaries of CTs will no longer be the same and the differential current flowing through the relay circuit will clear the breaker on both sides of the transformer. The-protected zone is limited to the region between CTs on the high-voltage side and the CTs on the low-voltage side of the power transformer. It is worthwhile to note that this scheme also provides protection for short-circuits between turns on the same phase winding. When a short-circuit occurs between the turns, the turn-ratio of the power transformer is altered and causes unbalance between current transformer pairs. If turn-ratio of power transformer is altered sufficiently, enough differential current may flow through the relay to cause its operation. However, such short-circuits are better taken care of by Buchholz relays.

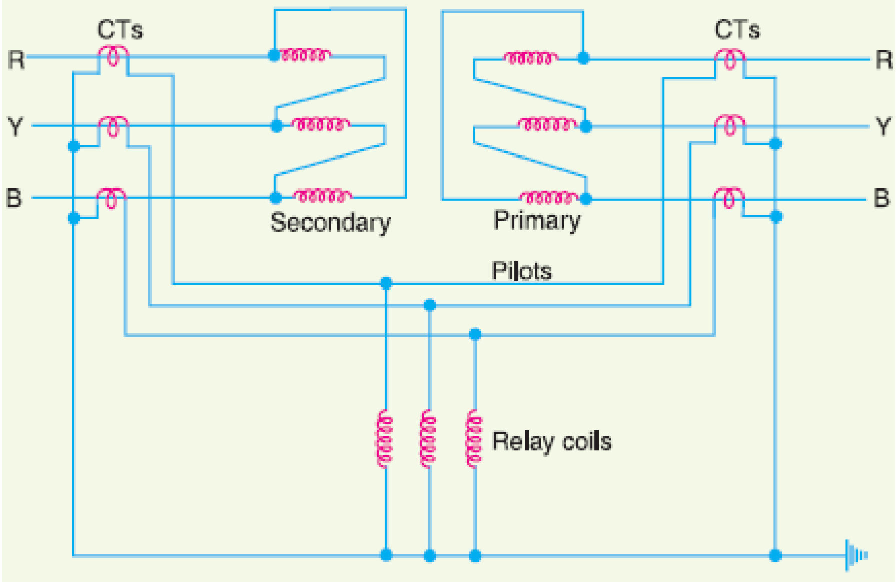
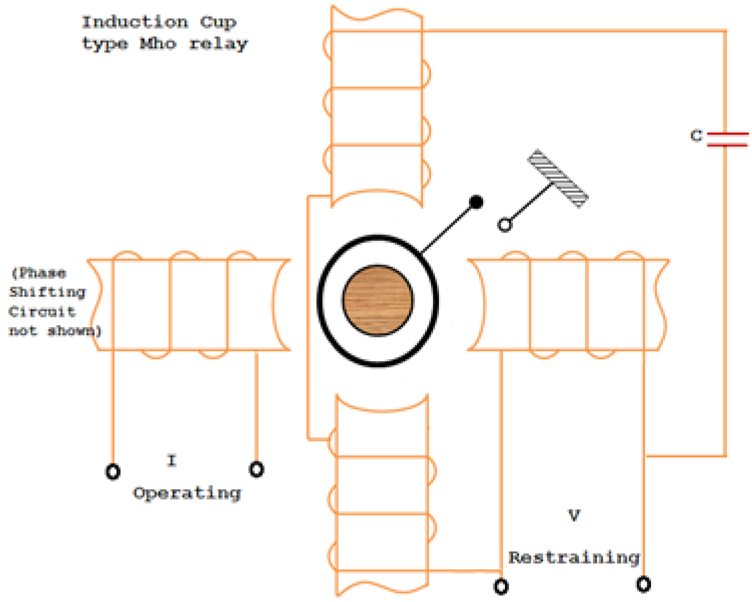


Fig. 22.15

7.a **Describe in detail about the construction and working of under frequency relays.**



These relays are designed to detect a decrease in frequency, which may be caused by an overload, a sudden loss of generation, or a fault in the power system. Underfrequency relays are typically used to initiate load shedding or generator tripping to restore the balance between supply and demand.

Construction:

Under frequency relays typically consist of the following components:

1. **Sensing Element**: This element detects the frequency of the electrical signal in the power system. It could be based on mechanical, electromagnetic, or electronic principles.
2. **Relay Circuit**: Once the frequency falls below a certain threshold, the relay circuit is triggered. This circuit is often electronic and may include amplifiers, comparators, and other components.
3. **Tripping Mechanism**: When the relay detects an under-frequency condition, it sends a signal to the tripping mechanism, typically a circuit breaker, to disconnect the affected part of the power system.

Working:

1. **Frequency Sensing**: The sensing element continuously monitors the frequency of the power system. Normal operating frequency is typically around 50 or 60 Hz, depending on the region.
2. **Threshold Setting**: The relay is set with a preset frequency threshold. If the frequency falls below this threshold, indicating a disturbance or imbalance in the system, the relay is activated.

3. **Relay Operation**: When the frequency drops below the preset threshold, the relay circuit triggers, initiating the protective action.
4. **Tripping**: The relay sends a signal to the tripping mechanism, usually a circuit breaker, to disconnect the affected part of the power system. This action helps prevent further damage to equipment and maintains system stability.
5. **Resetting**: After the under-frequency condition is resolved and the system frequency returns to normal, the relay is reset manually or automatically to prepare for potential future occurrences.

7.b **Illustrate the construction and operation of transley relay with neat diagram.**

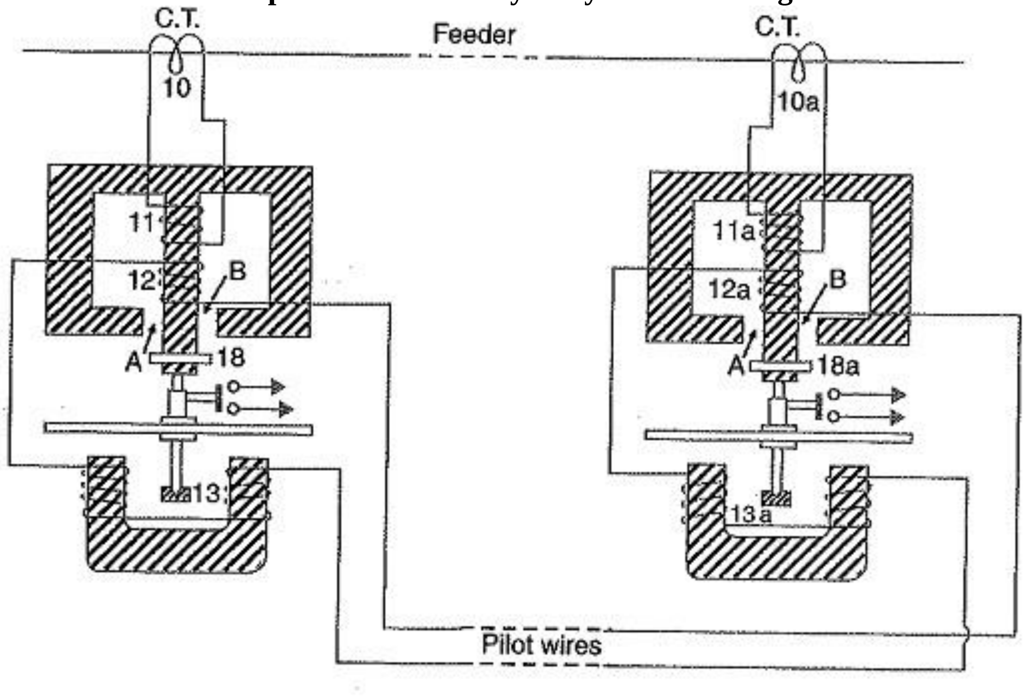


Fig. 21.28

The relays operate to open the circuit breakers at both ends of the line. When earth fault occur on Y phase, sections 2 and 3 of primary winding will be energized and cause the relay to operate. An earth fault on phase B will energize only section 3 of relay primary windings 11 and11a.
ChatGPT

Unfortunately, as a text-based AI, I can't create visual diagrams. However, I can certainly describe the construction and operation of a Transley relay in detail.

Construction:

The Transley relay consists of several key components:

1. **Coil**: The relay contains a coil, which serves as the primary sensing element. This coil is typically wound around a magnetic core.
2. **Contacts**: There are typically two sets of contacts: normally open (NO) and normally closed (NC). These contacts control the flow of current through the relay.
3. **Adjusting Mechanism**: The relay may have an adjusting mechanism to set the desired operating conditions, such as trip time or threshold levels.
4. **Spring Mechanism**: Springs are used to provide the necessary tension for the contacts to operate smoothly.

Operation:

1. **Normal Operation**: In the normal state, the coil is energized by a small control current. This current creates a magnetic field, but it's not strong enough to cause any movement of the relay contacts. Therefore, both the NO and NC contacts remain in their respective positions.

2. **Overcurrent Condition**: When an overcurrent condition occurs, the current flowing through the coil increases beyond a preset threshold. This increased current strengthens the magnetic field around the coil.
3. **Attractive Force**: As the magnetic field strength increases, it exerts an attractive force on an armature or plunger connected to the relay contacts. This force overcomes the tension of the springs, causing the contacts to move.
4. **Contact Operation**: Depending on the design of the relay, the movement of contacts can either close the normally open contacts (NO) or open the normally closed contacts (NC), or both. This action completes or interrupts the circuit connected to the relay.
5. **Trip Mechanism**: In the case of a protective relay like the Transley relay, the operation of the contacts may trip a circuit breaker or initiate some other protective action in the power system to isolate the fault and prevent damage to equipment

PART - C

8.a **Give a brief account on the protection of alternator using differential and biased differential protection scheme.**

Any internal fault inside the stator winding is cleared by mainly differential protection scheme of the generator or alternator. The differential protection is provided in the generator by using longitudinal differential relay.

(i) differential protection

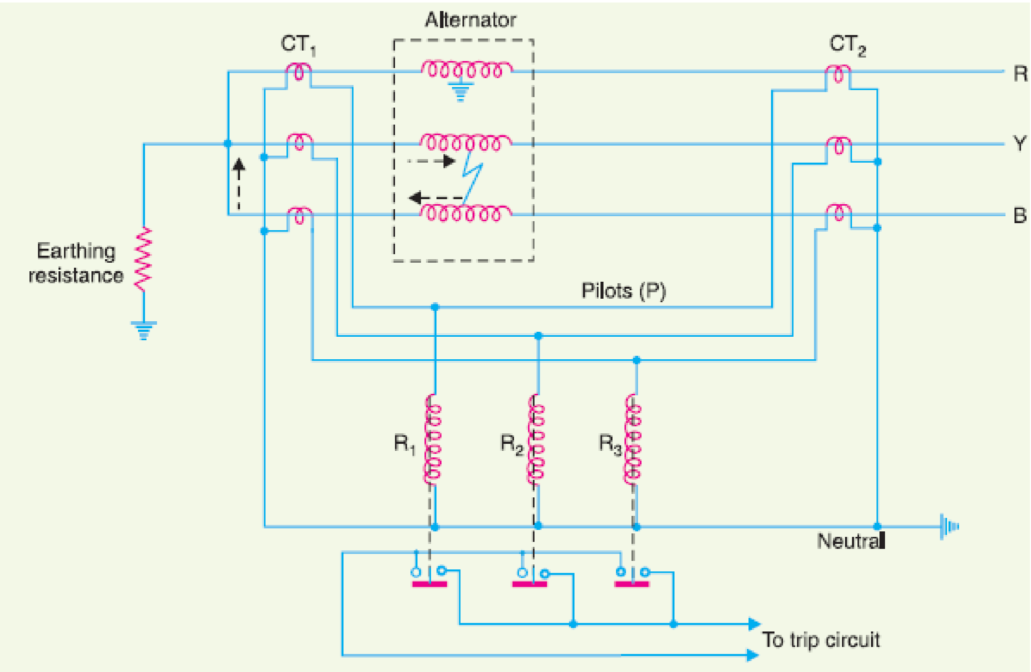


Fig. 22.2

Differential Protection:

1. **Principle**: Differential protection operates on the principle of comparing the currents entering and leaving the alternator winding. Under normal operating conditions, the sum of currents entering the winding should be equal to the sum of currents leaving the winding. Any imbalance indicates a fault within the protected zone.
2. **Construction**: Differential protection schemes typically employ current transformers (CTs) to measure the currents entering and leaving the alternator winding. The currents are then compared using a relay. If the difference between the two currents exceeds a predetermined threshold, the relay operates and initiates the trip circuit.
3. **Operation**: When a fault occurs within the protected zone, such as a short circuit or ground fault, the current entering the winding becomes unbalanced compared to the current leaving the winding. This imbalance triggers the differential relay, which trips the circuit breaker to isolate the faulty section of the alternator winding.

(ii) biased differential protection

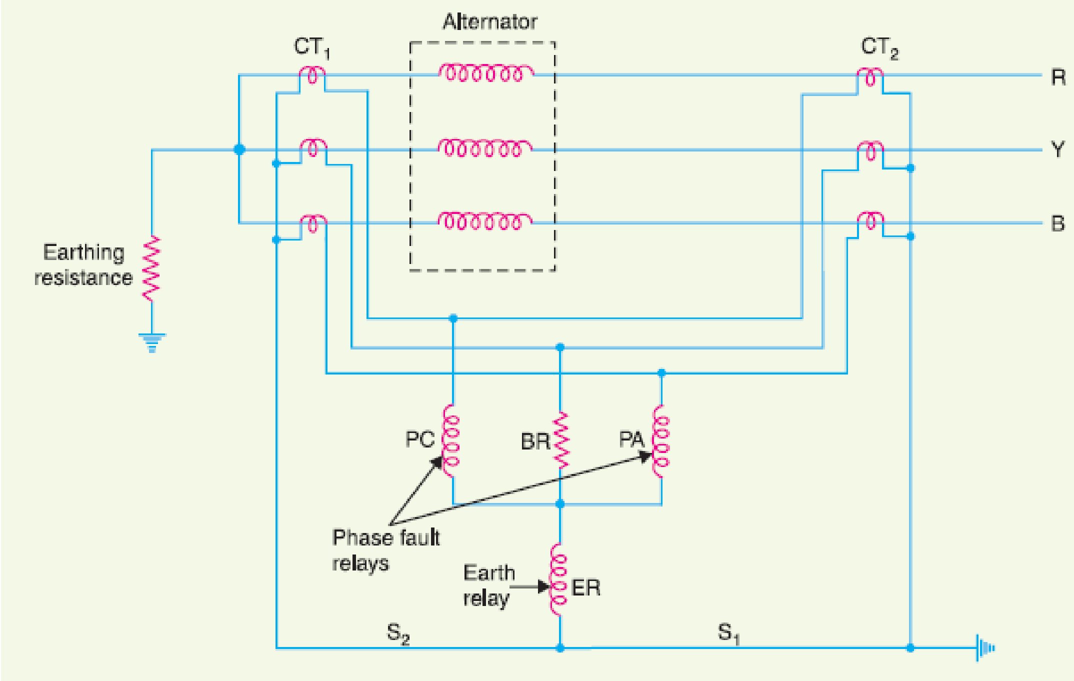


Fig. 22.5

Biased Differential Protection:

1. **Principle**: Biased differential protection is a variation of traditional differential protection that introduces a bias current component. This bias current compensates for normal operating conditions, such as load fluctuations, and enhances the sensitivity of the protection scheme to fault currents.
2. **Construction**: Similar to standard differential protection, biased differential protection schemes utilize CTs to measure currents entering and leaving the alternator winding. However, in biased schemes, a portion of the current entering the winding is deliberately added to the current leaving the winding as a bias component.
3. **Operation**: During normal operation, the bias current compensates for load imbalances and ensures that the differential current remains within acceptable limits. However, in the event of a fault, the fault current exceeds the bias current, causing a noticeable imbalance. This imbalance triggers the differential relay, initiating the trip circuit to isolate the fault.

Advantages and Applications:

- **Differential Protection**: Offers high sensitivity to faults within the protected zone and can quickly isolate faults to prevent damage to the alternator. Suitable for protecting large alternators and generators.
- **Biased Differential Protection**: Provides enhanced sensitivity to fault detection while maintaining stability during normal operating conditions. Particularly useful for protecting medium to large-sized alternators in systems with variable loads and operating conditions.

8.b **A star-connected, 3-phase, 10 MVA, 6.6kV alternator has a per phase reactance of 10%. It is protected by Merz-price circulating-current principle which is set to operate for fault currents not less than 175 A. Calculate the value of earthing resistance to be provided in order to ensure that only 10% of the alternator winding remains unprotected.**

Solution. Let r ohms be the earthing resistance required to leave 10% of the winding unprotected (portion NA). The whole arrangement is shown in the simplified diagram of Fig. 22.9.

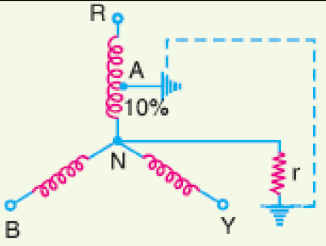


Fig. 22.9

$$\text{Voltage per phase, } V_{ph} = \frac{6 \cdot 6 \times 10^3}{\sqrt{3}} = 3810 \text{ V}$$

$$\text{Full-load current, } I = \frac{10 \times 10^6}{\sqrt{3} \times 6 \cdot 6 \times 10^3} = 875 \text{ A}$$

Let the reactance per phase be x ohms.

$$\therefore \quad 10 = \frac{\sqrt{3} \times x \times 875}{6600} \times 100$$

$$\text{or} \quad x = 0{\cdot}436 \ \Omega$$

$$\text{Reactance of 10\% winding} = 0{\cdot}436 \times 0{\cdot}1 = 0{\cdot}0436 \ \Omega$$

$$\text{E.M.F. induced in 10\% winding} = V_{ph} \times 0{\cdot}1 = 3810 \times 0{\cdot}1 = 381 \text{ V}$$

Impedance offered to fault by 10% winding is

$$Z_f = \sqrt{(0 \cdot 0436)^2 + r^2}$$

Earth-fault current due to 10% winding

$$= \frac{381}{Z_f} = \frac{381}{\sqrt{(0 \cdot 0436)^2 + r^2}}$$

When this fault current becomes 175 A, the relay will trip.

$$\therefore \quad 175 = \frac{381}{\sqrt{(0 \cdot 0436)^2 + r^2}}$$

$$\text{or} \quad (0{\cdot}0436)^2 + r^2 = \left(\frac{381}{175}\right)^2$$

$$\text{or} \quad (0{\cdot}0436)^2 + r^2 = 4{\cdot}715$$

$$\text{or} \quad r = \mathbf{2{\cdot}171 \ \Omega}$$