

# DIPLOMA WALLAH

## JHARKHAND UNIVERSITY OF TECHNOLOGY (JUT)

### SAMPLE PAPER 1

*Practice the sample paper covered both important questions and exam patterns*

**Subject: Switchgear and Protection (EEE303)**

**Full Marks: 70**

**Time: 3 Hours**

**Instructions:**

- Question No. 1 is compulsory. (7 MCQs, 2 Marks each)
- Answer any FOUR questions from the remaining (Q.2 to Q.7).
- Q.2 to Q.6 carry 14 marks each (Divided into A and B, 7 Marks each).
- Q.7 consists of Short Notes (Answer any FOUR, 3.5 Marks each).

**Q.1 Choose the correct option (Compulsory - 7 x 2 = 14 Marks)**

**i)** Arc interruption in a vacuum circuit breaker occurs at:

- a. Current peak
- b. Current zero
- c. Voltage zero
- d. Any arbitrary time

**ii)** Which of the following relays is typically used for the protection of short transmission lines?

- a. Reactance relay
- b. Impedance relay
- c. Mho relay
- d. Buchholz relay

**iii)** The fusing factor of a fuse is always:

- a. Less than 1
- b. Equal to 1
- c. More than 1
- d. Zero

iv) Thermal overload relays are primarily used to protect the motor against:

- a. Short circuit
- b. Earth fault
- c. Overload
- d. Reverse power

v) The primary function of a Peterson coil is to:

- a. Reduce short circuit fault current
- b. Neutralize capacitive current during a single line to ground fault
- c. Increase the line voltage
- d. Provide solid grounding

vi) The operating speed of an electromechanical relay depends upon:

- a. Spring tension
- b. Rate of flux build-up
- c. Plug Setting Multiplier (PSM)
- d. All of the above

vii) In circuit breakers, MCCB stands for:

- a. Miniature Case Circuit Breaker
- b. Molded Case Circuit Breaker
- c. Motor Control Circuit Breaker
- d. Main Case Circuit Breaker

**Answer any FOUR questions from Q.2 to Q.7**

**Q.2 A)** Describe the construction, working principle, and applications of a Vacuum Circuit Breaker (VCB). (7 Marks)

**Q.2 B)** Explain the construction and working of an HRC (High Rupturing Capacity) fuse. What are its advantages and disadvantages? (7 Marks)

**Q.3 A)** Explain the Circulating Current (Merz-Price) Protection scheme for a 3-phase transformer. (7 Marks)

**Q.3 B)** What is Distance Protection? Explain how it is applied for the protection of transmission lines. (7 Marks)

**Q.4 A)** Discuss the principle of operation and construction of an Earth Leakage Circuit Breaker (ELCB) / RCCB. (7 Marks)

**Q.4 B)** Define and explain the terms: Restriking Voltage, Recovery Voltage, and Rate of Rise of Restriking Voltage (RRRV). (7 Marks)

**Q.5 A)** Explain the block diagram and working of a Microprocessor-based / Numerical relay. Mention its advantages over static relays. (7 Marks)

**Q.5 B)** Describe the different methods of Substation Earthing (Solid, Resistance, Reactance) and explain the function of a Peterson coil. (7 Marks)

**Q.6 A)** Explain the various protection schemes used for a large induction motor. (7 Marks)

**Q.6 B)** What is an AMF (Automatic Mains Failure) panel? Explain its working with a block diagram. (7 Marks)

**Q.7 Write short notes on any FOUR of the following (4 x 3.5 = 14 Marks)**

- A. MCCB (Molded Case Circuit Breaker)
- B. ZCT (Zero Sequence Current Transformer) and CBCT
- C. Buchholz Relay
- D. Pilot-Wire Protection
- E. RMU (Ring Main Unit)

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# SOLUTIONS FOR SAMPLE PAPER 1

## MCQ Answer Key

i) b, ii) a, iii) c, iv) c, v) b, vi) d, vii) b

## Model Answers for Long Questions

### Q.2 A) Vacuum Circuit Breaker (VCB):

- **Construction:** It consists of fixed and moving contacts enclosed in a permanently sealed vacuum interrupter. The vacuum acts as a highly effective dielectric medium.
- **Working:** When a fault occurs, the moving contact separates. The arc is struck in the metal vapor created by the sublimating contact material. As the AC current crosses zero, the vapor condenses almost instantly, restoring the dielectric strength and extinguishing the arc.
- **Applications:** Widely used in medium voltage switchgear (up to 33 kV) for rural distribution, industrial switchgear, and traction networks.

### Q.2 B) HRC Fuse:

- **Construction:** Consists of a heat-resisting ceramic body with metal end-caps. The fuse element (usually silver) is surrounded by a powder (like quartz sand) that acts as an arc-extinguishing medium.
- **Working:** Under heavy fault, the element melts and vaporizes. The vapor reacts with the sand to form a high-resistance substance (glass-like bead), successfully cutting off the fault current safely.
- **Advantages:** High breaking capacity, highly reliable, cheaper than circuit breakers, no maintenance needed.
- **Disadvantages:** Must be replaced after every operation, time-consuming to find and replace the blown fuse.

### Q.3 A) Circulating Current (Merz-Price) Protection for Transformer:

This differential protection scheme compares the currents entering and leaving the transformer. Current Transformers (CTs) are placed on both the primary and secondary sides. To compensate for the phase shift in star-delta transformers, the CTs are connected in delta on the star side and star on the delta side. Under normal conditions, secondary currents of the CTs circulate in a closed loop, and zero current flows through the operating relay coil. During an internal fault, this balance is disturbed, and the differential current flows through the relay, tripping the breaker.

### Q.3 B) Distance Protection of Transmission Lines:

Distance protection operates based on the ratio of voltage to current ( $V/I = Z$ ). The relay measures the impedance of the line up to the fault point.

If the measured impedance is less than the set impedance (which represents the length of the protected zone), the relay interprets it as a fault within its zone and trips. It is highly preferred for long transmission lines because it provides high-speed protection and is not easily affected by changes in generating capacity or system configurations.

### Q.4 A) ELCB / RCCB:

**RCCB (Residual Current Circuit Breaker):** It operates on the principle of Kirchhoff's Current Law. It uses a Core Balance Current Transformer (CBCT). Under normal conditions, the vector sum of currents in phase and neutral is zero, so no flux is induced in the CBCT. When an earth leakage occurs, a residual current creates an imbalance, inducing flux and a secondary voltage that operates the trip relay to isolate the supply, preventing fatal electric shocks.

### Q.4 B) Restriking Voltage & RRRV:

- **Restriking Voltage:** The high-frequency transient voltage that appears across the circuit breaker contacts immediately after the arc is extinguished at current zero.
- **Recovery Voltage:** The normal frequency (50 Hz) RMS voltage that appears across the contacts after the transient restriking voltage has died out.
- **RRRV (Rate of Rise of Restriking Voltage):** It is the slope of the steepest tangent to the restriking voltage curve. High RRRV makes arc interruption more difficult.

### Q.5 A) Microprocessor/Numerical Relay:

It converts analog signals from CTs/PTs into digital data via an A/D converter. A microprocessor analyzes this digital data using protective algorithms. If a fault condition is detected based on programmed logic, it sends a trip signal.

**Advantages over Static Relays:** Highly programmable, self-diagnostic features, capable of storing fault event data, takes up less panel space, and communication capability via SCADA.

### Q.5 B) Substation Earthing & Peterson Coil:

- **Solid Earthing:** Neutral is directly connected to earth. Used for voltages  $< 33\text{kV}$ .
- **Resistance Earthing:** A resistor is inserted between neutral and earth to limit fault current.
- **Reactance Earthing:** A reactor is used.
- **Peterson Coil:** An adjustable reactor connected between the neutral of a system and earth. It is tuned so that the inductive current drawn by the coil exactly matches and cancels the capacitive earth fault current during a single line-to-ground fault, suppressing the arcing ground phenomenon.

### Q.6 A) Motor Protection Schemes:

Large induction motors require protection against:

1. **Overload:** Using thermal overload relays (bimetallic strips).
2. **Short Circuit:** Using HRC fuses or instantaneous overcurrent magnetic relays.
3. **Earth Fault:** Using an earth fault relay with CBCT.
4. **Unbalanced Phase/Single Phasing:** Using negative sequence current relays.

### Q.6 B) AMF Panel (Automatic Mains Failure):

The AMF panel automatically switches the load to a standby generator when the main grid power fails.

**Working:** It constantly monitors the incoming mains voltage. If the voltage drops or fails, it sends a start signal to the Diesel Generator (DG) set. Once the generator reaches proper voltage and frequency, contactors automatically switch the load to the generator. When grid power is restored, it switches the load back and safely shuts down the generator.

### Short Answer Solutions (Q.7)

**A) MCCB:** Molded Case Circuit Breaker. Used for higher current ratings (up to 2500A) than MCBs. Features adjustable trip settings for both thermal (overload) and magnetic (short circuit) protection. Widely used in LV distribution panels.

**B) ZCT & CBCT:** Zero Sequence Current Transformer or Core Balance CT. All three phase conductors (and neutral) pass through its window. It only detects zero-sequence (unbalanced earth fault) currents to trigger an earth leakage relay.

**C) Buchholz Relay:** A gas-actuated relay installed in the pipe connecting the transformer tank and conservator. It protects against internal incipient faults by detecting gas generated from oil decomposition during minor faults or severe oil surges during major faults.

**D) Pilot-Wire Protection:** A differential protection scheme for short transmission lines. It uses pilot wires to compare the magnitude and phase of currents at both ends of the line. High cost of pilot wires limits its use to short distances.

**E) RMU (Ring Main Unit):** A compact, sealed switchgear unit used in medium-voltage distribution networks. It integrates load break switches and circuit breakers (often SF6 insulated) to allow uninterrupted power supply by forming a ring network.