5 Power System Protection

5.1 - Circuit Breakers

Multiple Choice Questions

Q.1 Match List-I (Equipments) with List-II (Applications) and select the correct answer using the codes given below the lists:

List-I

A. Metal oxide arrester
B. Isolator
C. Auto-reclosing C.B.
D. Differential relay

List-II

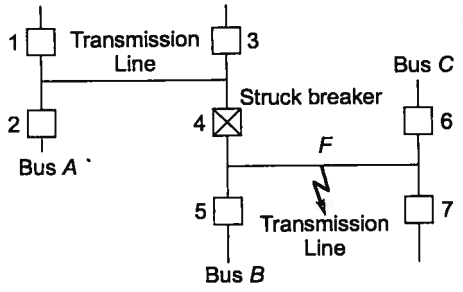
1. Protects generator against short circuit faults
2. Improves transient stability
3. Allows C.B. maintenance
4. Provides protection against surges

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	3	4	1	2
(c)	4	3	1	2
(d)	3	4	2	1

[ESE-2001]

Q.2 Consider the protection system shown in the figure below. The circuit breakers numbered from 1 to 7 are of identical type. A single line to ground fault with zero fault impedance occurs at the midpoint of the line (at point *F*), but circuit breaker 4 fails to operate ("Stuck breaker"). If the relays are coordinated correctly, a valid sequence of circuit breaker operation is



(a) 1, 2, 6, 7, 3, 5 (b) 1, 2, 5, 5, 7, 3
(c) 5, 6, 7, 3, 1, 2 (d) 5, 1, 2, 3, 6, 7

[GATE-2007]

Q.3 The making and breaking currents of 3 phase ac circuit breakers in power system are respectively in what form?

(a) r.m.s. value, r.m.s. value
(b) instantaneous value, r.m.s. value
(c) r.m.s. value, instantaneous value
(d) instantaneous value

[ESE-2009]

Q.4 A 50 Hz, 17.32 kV generator is connected to a power system. The system inductance and capacitance per phase are: 10 mH and 0.02 mF, respectively. What is the maximum voltage across the contacts of the circuit breaker at an instant when it passes through zero?

(a) 28.28 kV (b) 29.28 kV
(c) 30.28 kV (d) 31.28 kV

[ESE-2005]

Q.5 Which one of the following sequences of operations represents the rates operating duty cycle of a circuit breaker?
(*O* - open: *C* - close; $t = 3$ sec; $T = 3$ min.)

(a) $O-t-CO-T-CO$
(b) $O-CO-t-CO-T-C$
(c) $O-C-t-OC-T$
(d) $O-CO-T-CO-T-C$

[ESE-1999]

Numerical Data Type Questions

Q.6 A 50 Hz, 3-phase synchronous generator has inductance per phase of 15 mH. The capacitance of generator and circuit breaker is 0.002 μF. The natural frequency of oscillation is _____ kHz.

[ESE-2008]

Q.7 The inductance and capacitance of a line are respectively 1.0 H and 0.01 μF. If the instantaneous value of interrupted current is 10 A, the voltage across the breaker contacts will be _____ kV.

[IAS-1999]

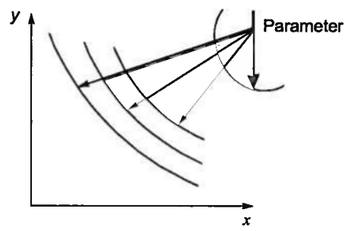
Q.8 In a 220 kV system, the inductance and capacitance up to the circuit breaker location are 25 mH and 0.025 μF respectively. The value of resistor required to be connected across the breaker contacts which will give no transient oscillations, is _____ Ω.

[ESE-2001]

5.2 - Relays

Multiple Choice Questions

Q.9 The inverse characteristics of an induction-disc relay are shown below



Match **List-I** with **(*x*, *y* co-ordinates and parameter) List-II (Variables)** and select the correct answer using the codes given below the lists:

List-I	List-II
A. *x*-co-ordinate	1. Plug settling voltage
B. *y*-co-ordinate	2. Current as multiplier of plug setting
C. Parameter	3. Operating time
	4. Time multiplier setting
	5. Power factor

Codes:

	A	B	C
(a)	5	4	1
(b)	2	3	4
(c)	5	3	4
(d)	2	4	1

[ESE-2002]

Q.10 For which of the following reasons is a differential relay biased to avoid maloperation when used for transformer protection?
1. Saturation of CTs.
2. Mismatch to CT ratios.
3. Difference in connection of both sides.
4. Current setting multiplier.

Select the correct answer using the codes given below:
(a) 1 and 4 (b) 1 and 2
(c) 2, 3 and 4 (d) 1, 2 and 3

[IAS-1995]

Q.11 Differential protection of a generator makes use of the principle that, under normal conditions, the current/currents
(a) at the neutral end of a phase winding is zero.
(b) in each of the phase winding is identical.
(c) at both ends of the phase winding are equal.
(d) at the two ends of the phase winding are unequal.

[IAS-1997]

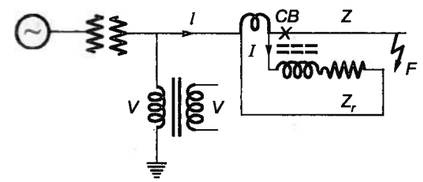
Q.12 In a 3-step distance protection, the reach of the three zones of the relay at the beginning of the first line typically extends upto:
(a) 100% of the first line, 50% of the second line and 20% of the third line
(b) 80% of the first line, 50% of the second line and 20% of the third line
(c) 80% of the first line, 20% of second line and 10% of the third line
(d) 50% of the first line, 50% of second line and 20% of the third line

[GATE-2000]

Q.13 Voltage phasors at the two terminals of a transmission line of length 70 km have a magnitude of 1.0 per unit but are 180 degrees out of phase. Assuming that the maximum load current in the line is 1/5th of minimum 3-phase fault current. Which one of the following transmission line protection schemes will NOT pick up for this condition?
(a) Distance protection using mho relays with zone -1 set to 80% of the line impedance.
(b) Directional overcurrent protection set to pick up at 1.25 times the maximum load current
(c) Pilot relaying system with directional comparison scheme
(d) Pilot relaying system with segregated phase comparison scheme.

[GATE-2008]

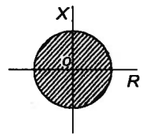
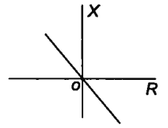
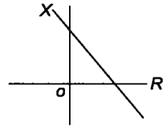
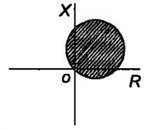
Q.14 The figure given below shows a schematic arrangement of a Distance Relay provided with a 'Replica Impedance' Z_r. The CT ratio = I/i and VT ratio = V/v.
When a fault occurs on the line being protected, when would the relay operate?



(a) $Z_r > Z$ (b) $Z_r < Z$
(c) $Z_r > Z.I/i$ (d) $Z_r > Z.V/v$

[ESE-2008]

Q.15 Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I	List-II
A. Mho relay	1. 
B. Plain impedance relay	2. 
C. Directional relay	3. 
D. Angle impedance relay	4. 

Codes:

	A	B	C	D
(a)	3	2	1	4
(b)	4	1	2	3
(c)	3	1	2	4
(d)	4	2	1	3

[ESE-2011]

Q.16 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I
A. Directional relay
B. Impedance relay
C. Differential
D. Pilot relay

List-II
1. Relay operates for fault within certain distance of its location
2. Relay will trip for fault in one location and block for all other locations
3. High speed protection for entire transmission line
4. The principal of current continuity is used to devise a simple and effective relaying system over a small physical space

Codes:

	A	B	C	D
(a)	1	2	4	3
(b)	2	1	3	4
(c)	2	1	4	3
(d)	1	2	3	4

[ESE-2004]

Q.17 Line trap at coupling capacitors are used for carrier current protection in which
(a) Line trap has high impedance to 50 Hz signal but low impedance to carrier current signal whereas a coupling capacitor has low impedance to 50 Hz signal but high impedance to carrier signal
(b) line trap has low impedance to 50 Hz signal but high impedance to carrier current signal, whereas a coupling capacitor has high impedance to 50 Hz signal but low impedance to carrier signal
(c) both line trap and coupling capacitor have low impedance to 50 Hz signal but high impedance to carrier current signal
(d) both line trap and coupling capacitor have high impedance to 50 Hz signal but low impedance to carrier current signal

[ESE-1999]

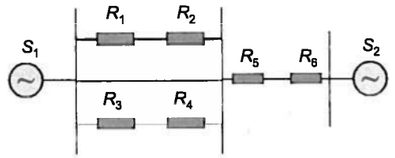
Q.18 Protection scheme used for detection of loss of excitation of a very large generating unit feeding power into a grid employs
(a) under voltage relay
(b) offset mho relay1
(c) under frequency relay
(d) percentage differential relay

[IAS-1995]

Q.19 Describe with suitable diagrams how the stator winding of a 3-phase alternator is protected from:
(a) Earth faults on the stator winding
(b) Unbalanced current in the stator winding
(c) Earth fault on the rotor winding
(d) Overloading of alternator

[ESE-2007]

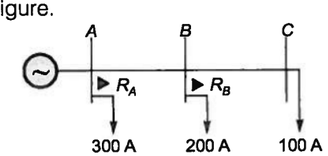
Q.20 A power system with two generators in shown in the figure below. The system (generators, buses and transmission lines) is protected by six overcurrent relays R_1 to R_6. Assuming a mix of directional and nondirectional relays at appropriate locations, the remote backup relays for R_4 are



(a) R_1, R_2 (b) R_2, R_6
(c) R_2, R_5 (d) R_1, R_6

Numerical Data Type Questions

Q.21 The over current relays for the line protection and loads connected at the buses are shown in the figure.



The relays are IDMT in nature having the characteristic

$$t_{op} = \frac{0.14 \times \text{Time Multiplier Setting}}{(\text{Plug Setting Multiplier})^{0.02} - 1}$$

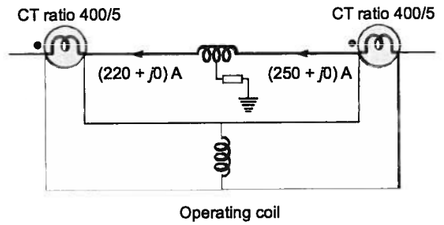
The maximum and minimum fault currents at bus *C* are 2000 *A* and 500 *A* respectively. Assuming the time multiplier setting and plug setting for relay R_B to be 0.1 and 5 A respectively, the operating time of R_B (in seconds) is _____ .

[GATE-2014]

Q.22 An over-current relay, having a current setting of 125% connected to a supply circuit through a current transformer of ratio 400/5 A. The pick-up value is _____ A.

[ESE-2000]

Q.23 Consider a stator winding of an alternator with an internal high-resistance ground fault. The currents under the fault condition are as shown in the figure. The winding is protected using a differential current scheme with current transformers of ratio 400/5 A as shown. The current through the operating coil is _____ A.



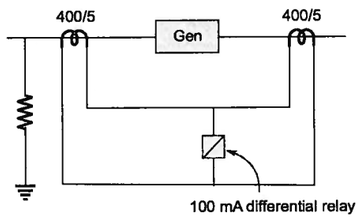
[GATE-2010]

Q.24 The neutral of 10 MVA, 11 KV alternator is earthed through a resistance of 5 ohms. The earth fault ready is set to operator at 0.75 A. The CT's have a ratio of 1000/5 A. The percentage of the alternator winding protected is _____ %.

[GATE-1998]

Conventional Questions

Q.25 (a) Discuss the general principle of operation of a generator differential protection scheme. Give the 3-phase connection of the biased scheme.



(b) The scheme shown below is used for protection of the generator winding by an ordinary differential relay, having a minimum pick up current of 100 mA. The C.T.s on the grounded neutral and the live ends have actual ratios of 79 and 81 respectively though their nominal ratios are same. Show that the differential relay will trip even when the generator is delivering, full load current of (400 + *j* 0.0)A, to the bus and there is no fault in the differential zone.

(c) To over come the defect in the question (b) a percentage differential relay having the same minimum pick up current of 100 mA and 20% slope was used. Drawing the slope characteristic of the relay. Show that the undesired tripping has been avoided.

[ESE-2003]

Q.26 A 3-phase 66 kV/11 kV star/delta transformer is protected by Merz-price protection scheme. The CTs on the LT side have a ratio of 420/5 amp. Determine the CT ratio on the HT side. Also explain why biasing is provided in percentage differential scheme of protection.

[ESE-2008]

Q.27 A ring feeder with five sections and fed at one point is to be protected using directional over current (DOC) relays and over current (OC) relays with suitable time grading. Explain the working of the scheme. Show the location of DOC's and OC's and their time of operation. Assume a time grading of 5 ms between the relays. The fastest relays needs 5 ms for it to operate.

[ESE-2011]

Try Yourself

T1. A 3-ϕ transformer rated for 33 kV/6.6 kV is connected star/delta and the protecting current transformer on the low voltage side have a ratio of 400/5 A. The ratio of current transformer on the *HV* side is

(a) $80:\frac{5}{\sqrt{3}}$ (b) $70:\frac{5}{\sqrt{2}}$
(c) $60:\frac{4}{\sqrt{3}}$ (d) $74:\frac{6}{\sqrt{2}}$

[Ans: (a)]

T2. A relay at rating 8 A, 2.2 sec IDMT and having a relay setting of 130% TMS = 0.6. It is connected to a supply circuit through a C.T. $\frac{400}{5}$ A ratio. If the fault current is 5000 A, the plug setting multiplier of the relay is _____.

[Ans: 6]

T3. An alternator rated at 10 kV protected by the balanced circulating current system has its neutral grounded through a resistance of 10 ohms. The protective relay is set to operate when there is an out of balance current of 1.8 A in the pilot wires, which are connected to the secondary windings of 1000/5 A ratio current transformers. The winding which remains unprotected is _____%.

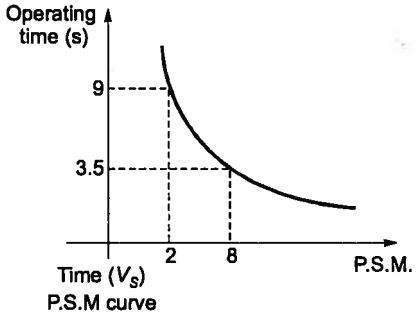
[Ans: 62.36]

T4. An air blast circuit breaker is designed to interrupt a transformer magnetising current of 11 A (rms) chops the current at an instantaneous value of 7 A. If the values of L and C in the circuit are 35.2 H and 0.0023 μF, then the value of voltage that appears across the contacts of the breaker is
(Assume that all the inductive energy is transferred to the capacitance)

(a) 345 kV (b) 512 kV
(c) 866 kV (d) 124 kV

[Ans: (c)]

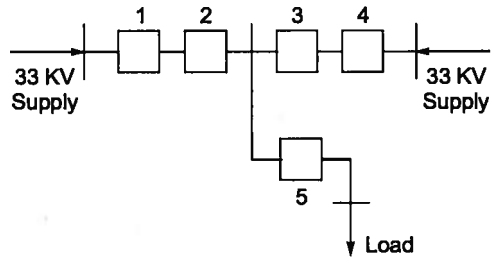
T5. The time of operation of a 5 A, 3 sec over current relay having a current setting of 125 % and a time setting multiplier of 0.6 connected to supply circuit through a 400/5 current transformer when the circuit carries a fault current of 4000 A



(a) 2.1 s (b) 2.8 s
(c) 3.1 s (d) 3.4 s

[Ans: (a)]

T6. The distribution system shown in the figure is to be protected by over current system of protection. For proper fault discrimination, directional over current relays will be required at locations



(a) 1 and 4 (b) 2 and 3
(c) 1, 4 and 5 (d) 2, 3 and 5

[Ans: (b)]

T7. In a 220 kV, 50 Hz system the reactance and suceptance upto location of circuit breaker is 12 Ω and 15×10^{-6} S respectively. A resistance of 500 Ω is connected across the contacts of the circuit breaker. The natural frequency of oscillation is _____ kHz.