RPSC AEn-2024 Main Test Series | **ELECTRICAL ENGINEERING** | **Test 4**

Test Mode : • Offline • Online

Subjects : Power Systems

DETAILED EXPLANATIONS

PART-A

1. Solution:

- Copper conductor
- ACSR (Aluminium conductor steel reinforced).
- ACAR (Aluminium conductor alloy reinforced).
- AAAR (All Aluminium alloy reinforced).
- Expanded ACSR conductor: Normally used for EHV lines.

2. Solution:

The impedance of transmission line with losses, is known as characteristic impedance (Z_c) and the impedance of transmission line without losses is known as surge impedance (Z_s) or natural impedance (Z_n).

3. Solution:

The complete disruption in dielectric strength or insulation of insulating material (air) near the surface of the conductor at certain point is called as concept of corona. Corona occurs only when the electric field intensity is greater than dielectric strength of air.

4. Solution:

Balanced fault: A symmetrical fault, where all phase affected so that the system remains balanced.

Types: (L-L-L) and (L-L-L-G)

Unbalanced Fault: If the fault involves only one or two of the three possible phases, then fault is said to be unbalanced or asymmetrical fault.

Types: L-G, L-L, L-L-G

5. Solution:

- No charging current.
- No stability problem.
- Less corona loss and less radio interference.
- No reactive power compensation required.
- Low short circuit current.

6. Solution:

$$H = \frac{\text{stored energy in Mega joules}}{\text{rating in MVA}}$$

It gives us stored kinetic energy in machine at rated speed.

7. Solution:

A lightning arrester is a device used in electrical power system and telecommunication system to protect the insulation and conductors of the system from the damaging effects of lightning. The typical lightning arrester has a high-voltage terminal and a ground terminal.

8. Solution:

$$\text{Plant capacity factor} = \frac{\text{Peak load}}{\text{Plant capacity}} \times \text{load factor}$$

$$0.5 = \frac{30}{\text{Plant capacity}} \times 0.6$$

$\therefore$ Plant capacity = 36 W

$\therefore$ Reserve capacity = Plant capacity – Peak load

= 36 – 30 = 6 MW

9. Solution:

$$V_{RNL} = \frac{V_S}{A} = \frac{400}{0.8} = 500 \text{ kV}$$

10. Solution:

$$\text{String efficiency} = \frac{\text{Voltage across the string}}{n \times \text{voltage across the lowest unit}}$$

$$0.8428 = \frac{V}{3 \times 17.5}$$

$$V \approx 44.25 \text{ kV}$$

PART-B

11. Solution:

- Self distance (GMR) increased without change in mutual distance.
- Voltage gradient reduced so corona loss reduce.
- It reduces the interference with near by communication line.
- Inductance (L) of transmission line reduces and capacitance (C) increases.
- Surge impedance i.e. $Z_s = \sqrt{\frac{L}{C}}$ decreases.
- Power system stability increases.

12. Solution:

Power system stability can be defined as the ability of alternators maintaining synchronism after the disturbance, which are working parallel. Power system stability problem is appearing in power system due to large variation in inertia of electrical machine.

- Steady state stability limit is always more than transient stability limit.
- Transient stability limit can be improved maximum upto steady state stability limit.
- A system with high steady state stability limit is not guarantee for high transient stability limit, however a system with high transient stability limit is guarantee for high steady state stability limit.

13. Solution:

Relays are sensing device, which detect abnormal conditions in electric circuit like faults and send signal to operate circuit breaker to isolate faulty equipment from the system as quickly as possible.

(i) Electromagnetic attraction type:

(a) Balanced beam type.

(b) Moving plunger type.

(c) Attracted armature type.

(ii) Electromagnetic induction type:

(a) Shaded pole type.

(b) Induction cup type.

(c) Wattmeter type.

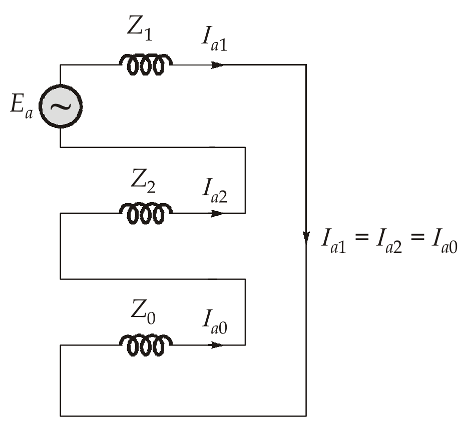
(iii) Gas operated relay: Buchholz relay.

(iv) Thermal relay: For over load protection.

(v) Static/microprocessor based relay.

14. Solution:

For single-line to ground fault,



Since, the generator is operating at no-load and rated voltage

$$E_a = 1\angle 0 \text{ p.u.}$$

$$Z_1 = jX_1 = j0.15 \text{ p.u.}$$

$$Z_2 = jX_2 = j0.15 \text{ p.u.}$$

and $$Z_0 = jX_0 = j0.05 \text{ p.u.}$$

Sequence currents, $$I_{a1} = I_{a2} = I_{a0} = \frac{E_a}{Z_1 + Z_2 + Z_0} = \frac{1\angle 0°}{j0.15 + j0.15 + j0.05}$$

$$= 2.857\angle 90° \text{ pu}$$

Fault current $= 3I_{a1} = 3 \times 2.857 = 8.57$ pu

15. Solution:

$$J = \text{moment of inertia} = 27.5 \times 10^3 \text{ kg-m}^2$$

Synchronous speed $= N_s$

$$= \frac{120\,f}{P} = \frac{120 \times 50}{2} = 3000 \text{ rpm}$$

Kinetic energy of the rotor $= \frac{1}{2} J\omega_s^2 = \frac{1}{2} \times 27.5 \times 10^3 \times (314.16)^2$

$$\text{K.E.} = 1357 \text{ MJ}$$

$$S = \text{Machine rating} = \frac{500}{\text{pf}} = \frac{500}{0.9} = 555.55 \text{ MVA}$$

$$\text{Inertial constant} = H = \frac{K.E.}{S} = \frac{1357}{555.55} = 2.44 \text{ MJ/MVA}$$

16. Solution:

$$M\frac{d^2\delta}{dt^2} = P_a$$

$$P_a = 15 - 10 = 5$$

So, $$M\alpha = P_a \Rightarrow \alpha = \frac{P_a}{M}$$

$$= \frac{HS}{180f} = \frac{15\times 20}{180\times 50} = \frac{1}{30}$$

So, $$\alpha = \frac{5}{1/30}$$

$$= 150 \text{ electrical degree/sec}^2$$

$$\alpha = 150\times\frac{2}{P} \text{ mech. degree/sec}^2$$

$$\alpha = 75 \text{ mechanical degree/sec}^2$$

17. Solution:

Rated MVA of circuit breaker = 2000 MVA

$\sqrt{3}\times|V(\text{line})|_{\text{rated}}$ × Symmetrical breaking current = Rated MVA of CB

$$\text{Symmetrical breaking current} = \frac{2000}{\sqrt{3}\times 33} = 35 \text{ kA}$$

18. Solution:

Size of the Jacobian matrix is,

$(2n - m - 1) \times (2n - m - 1)$

Given that 10 generator buses, we need to assume with in the 10 buses one bus as slack bus

then,

$(2 \times 100 - 10 - 1) \times (2 \times 100 - 10 - 1) = 189 \times 189$

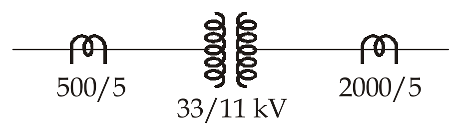
PART-C

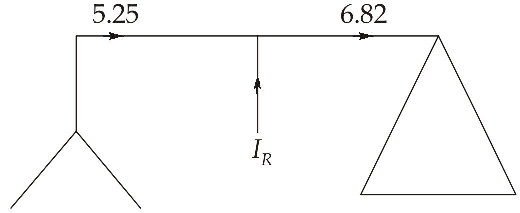
19. Solution:

The primary line current is,

$$I_P = \frac{30\times10^6}{\sqrt{3}\times(33\times10^3)} = 524.86 \text{ A}$$

Secondary line current is, $I_S = 3I_P = 1574.59$ A





The CT secondary current on primary side (star),

$$I_1 = 524.88\times\left(\frac{5}{500}\right) = 5.25 \text{ A}$$

and that on the secondary side (delta) is,

$$I_2 = 1574.64\times\left(\frac{5}{2000}\right)\times\sqrt{3} = 6.82 \text{ A}$$

The relay current at 200% of the rated current is then,

$$I_R = 2[I_2 - I_1] = 2\times(6.82 - 5.25)$$

$$I_R = 3.14 \text{ A}$$

20. Solution:

Let the base MVA of the system be 20 MVA, base kV of generator side 11 kV and for transmission circuit side 66 kV. Per unit reactance of different elements corresponding to this common base MVA are

For generator A and B,

$$X_{\text{p.u. g}} = j0.25 \text{ p.u.}$$

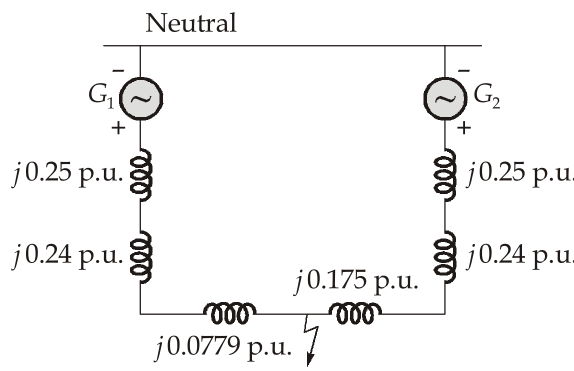
for transformers T_1 and T_2,

$$X_{\text{p.u.}} = j0.06\times\frac{20}{5} = j0.24 \text{ p.u.}$$

$$\text{Per unit reactance of 20 km line} = \frac{20 \times 0.848 \times 20}{66^2} = 0.0779 \text{ p.u.}$$

$$\text{Per unit reactance of 30 km line} = \frac{30 \times 0.848 \times 30}{66^2} = 0.175 \text{ p.u.}$$

Per unit reactance diagram is shown below,



$$X_{eq\ (p.u.)} = j(0.25 + 0.24 + 0.0779) \,||\, j(0.25 + 0.24 + 0.175)\text{p.u.}$$

$$= j0.5679 \,||\, j0.665 \text{ p.u.}$$

$$= \frac{j0.5679 \times j0.665}{j0.5679 + j0.665} = j0.3063 \text{ p.u.}$$

$$\text{Fault MVA} = \frac{\text{Base MVA}}{X_{eq(p.u.)}} = \frac{20}{0.3063} = 65.295 \text{ MVA}$$

$$\text{Fault current, } I_{SC} = \frac{65.295 \times 10^{-6}}{\sqrt{3} \times 66 \times 10^3} = 571.2 \text{ A}$$

❍❍❍❍