CheggSolutions - Thegdp

Electrical Engineering: Transformer and Generator Specifications

Part (a): Transformer Calculations

Given:

Primary Voltage (\(V_1\)) = 11000V

Secondary Voltage (\(V_2\)) = 400V

Transformer Rating (S) = 100 kVA

Secondary Turns (\(N_2\)) = 160 turns

Reactance (\(X\)) = 0.1 pu

Step 1: Calculate the primary and secondary currents you would expect to measure on full load (i)

Transformer rating formula:

$S = V1 \cdot I1 = V2 \cdot I2$

- **For primary current (\(I_1\)):**
- $I1 = S / V1 = 100000 / 11000 \sim 9.09$ Amps
- **For secondary current (\(I_2\)):**
- $I2 = S / V2 = 100000 / 400 = 250$ Amps

Step 2: Calculate the number of primary turns (ii)

Transformer turns ratio formula:

$N1 / N2 = V1 / V2$

$N1 = N2 \cdot (V1 / V2) = 160 \cdot (11000 / 400) = 4400$ turns

Step 3: Calculate the reactance in Ohms, referred to the secondary (iii)

Per Unit System:

$X_{pu} = 0.1$

Calculating base impedance (Z_{base}):

$Z_{base,secondary} = V2^2 / S = 400^2 / 100000 = 1.6$ Ohms

Actual reactance on secondary ($X_{secondary}$):

$X_{secondary} = X_{pu} \cdot Z_{base} = 0.1 \cdot 1.6 = 0.16$ Ohms

Part (b): Generator Characteristics for an Isolated Power System

Given:

Load = 330 kVA

Load Voltage (\(V_{load}\)) = 33 kV

Power Factor (pf) = 0.9 (lagging)

Transmission Line Impedance (z) = 0.4 + j0.6 Ω/km

Line Length = 20 km

Step 1: Calculate the generator current requirement, including the angle (i)

Complex Power (S) = Apparent Power:

$S = 330 \text{ kVA} = 330 \times 10^3$

Power Factor (pf) = 0.9 (lagging):

Real Power (P):

$P = S \cdot pf = 330000 \cdot 0.9 = 297$ kW

Reactive Power (Q):

$Q = S \cdot \sin(\cos^{-1}(0.9))$

$Q = 330000 \cdot \sin(\cos^{-1}(0.9)) \approx 330000 \cdot 0.4359 = 143847$ VAr

Current (I):

$$I = S / \sqrt{3} \cdot V_{load}$$

$I = 330000 / \sqrt{3} \cdot 33000 \approx 5.774$ Amps

Power Angle (φ):

$$\cos \varphi = 0.9$$

$\varphi = \cos^{-1}(0.9) \approx 25.84°$

Step 2: Calculate the generator voltage requirement, including the angle (ii)

Line Impedance (Z_{line}):

$$Z_{line} = Z_{total} = 20 \cdot (0.4 + j0.6) = 8 + j12 \text{ Ohms}$$

Voltage Drop (V_{drop}):

$$V_{drop} = I \cdot Z_{line}$$

$V_{drop} = 5.774 \cdot (8 + j12) \approx (46.19 + j69.29)$ Volts

$V_{drop} = \sqrt{(46.19^2 + 69.29^2)} \approx 83.3$ Volts

Generator Voltage (V_g):

$$V_g = V_{load} + V_{drop} = 33 \text{ kV} + 83.3 \text{ V} = 33.0833 \text{ kV}$$

Final Solution:

(a)

- (i) The primary and secondary currents are approximately 9.09 Amps and 250 Amps, respectively.
- (ii) The number of primary turns is 4400 turns.
- (iii) The reactance referred to the secondary is 0.16 Ohms.

(b)

- (i) The generator current requirement is approximately 5.774 Amps with a power angle of 25.84 degrees.
- (ii) The generator voltage requirement is approximately 33.0833 kV.