Practice Problems

A single-phase 2-winding power transformer is rated at 5 KVA, 60 Hz, 480V/120V. Its series impedance is 0.05 +j0.1 p.u. It is also known that its excitation current is equal 0.03 pu and its core loss is equal to 50 W.

1. Calculate the Ohmic value of the series impedance when referred to the secondary side
   a) 0.05 + j0.1 Ω
   b) 0.144 + j0.288 Ω
   c) 2.3 + j4.6Ω
   d) 0.04 + j0.20 Ω

2. Calculate the Ohmic value of the shunt impedance when referred to the secondary side
   a) 288 Ω // j102 Ω
   b) 4.6 kΩ // j1.6 kΩ
   c) 96 Ω // j96 Ω
   d) 1,152 Ω // j408 Ω

3. Assume that the transformer is supplied by a fixed 480 V source, and serves a pure resistive load that has an equivalent resistance of 3 Ω. Determine the voltage across the load.
   a) 120 V
   b) 118 V
   c) 116 V
   d) 114 V

4. Calculate the transformer efficiency under the above condition.
   a) 93.2%
   b) 94.4%
   c) 95.6%
   d) 96.5%

5. Calculate the transformer voltage regulation under the above condition.
   a) 3.7%
   b) 4.5%
   c) 5.3%
   d) 6.7%

6. Determine the maximum efficiency of this particular transformer when supplying a purely resistive load?
   a) 93.2%
   b) 94.4%
   c) 95.6%
   d) 96.5%
Problem II: Consider a 10 KVA, 208 V, 60 Hz, Y-connected, 2-pole synchronous generator. Its internal impedance is 0.2 +j 0.5 Ω. The mechanical and core losses are known to be 200 W and 150 W, respectively. The machine is initially spinning at synchronous speed under no load, and its field current is adjusted so that the terminal phase voltage is at rated value (Eₐ = Vᵣ = 120 V).

1) When a Y-connected load with an equivalent impedance of 3 + j 4 Ω (per phase) is connected across the generator terminals, and after the rotor speed is brought back to 3,600 rpm, compute the value of the terminal phase voltage Vᵣ (hint: this is a simple voltage division problem).
   a) 120 V
   b) 109.7 V
   c) 106.2 V
   d) 103.4 V

2) Calculate the efficiency of the machine in 1) above.
   a) 90%
   b) 92.8%
   c) 81.3%
   d) None of the above

3) Calculate the power angle δ (i.e., the angle between the internal voltage Eₐ and terminal voltage Vᵣ).
   a) 5.32 deg
   b) 4.29 deg
   c) 3.91 deg
   d) 2.94 deg

4) Now adjustments are made in the field current under the same load above until the terminal phase voltage is restored to 120 V. Calculate the new power angle δ.

5) Under the condition in 4) above (with the terminal phase voltage at 120 V), the generator is loaded at
   a) 57.6% of full load
   b) 67.3% of full load
   c) 73.8% of full load
   d) 86.4% of full load

Problem III: A 3-phase, 12.5 kV, 100 MVA, 0.8 PF (lag), 60 Hz, 4-pole, Y-connected synchronous generator has a synchronous reactance of Xₛ = 0.2 pu and armature resistance of 0.1 pu. The machine is operating in parallel with a large power network at full load, at rated power factor, and at rated terminal voltage. Answer questions 5-10.

5) The magnitude of the internal impedance of the generator is nearly
   a) 1.56 Ω
   b) 0.35 Ω
   c) 0.312 Ω
   d) 0.156 Ω
6) The current supplied by the generator is
   a) 4,619 A  
   b) 3,695 A  
   c) 5,773 A  
   d) 8,000 A

7) The total copper loss in the generator is
   a) 1.24 MW  
   b) 3.33 MW  
   c) 1.11 MW  
   d) 7.46 MW

8) The phase angle of the internal voltage with respect to the terminal voltage is
   a) 2.25 deg  
   b) 4.75 deg  
   c) 7.24 deg  
   d) 10.85 deg

9) If the local load consumes a total of 70 MW and 40 MVAR, then the total active and reactive powers injected by the generator into the utility grid are
   a) 80 MW and 60 MVAR  
   b) 30 MW and 20 MVAR  
   c) 10 MW and 40 MVAR  
   d) 10 MW and 20 MVAR

10) To match the generated powers to the local load powers above, one should do the following:
    a) decrease the mechanical power and increase the field current of the generator  
    b) decrease both the mechanical power and the field current of the generator  
    c) increase the mechanical power and decrease the field current of the generator  
    d) increase both the mechanical power and the field current of the generator

Problem IV: Consider a 130 mi, 60 Hz, three-phase, power transmission line. Its total series impedance is \( Z = 25 \angle 53^\circ \, \Omega \) and total shunt admittance \( Y = j \, 0.004 \, S \). The phase voltage \( V_s \) at the sending end has a fixed value of 80 kV. Answer Questions 19-21.

11) If a short circuit occurs at the receiving end, the sending end current \( I_s \) is expected to be nearly
    a. 3.1 kA  
    b. 3.2 kA  
    c. 320 A  
    d. 160 A

20) Under some specific load condition, the sending and receiving end voltages are both equal in magnitude and in phase \( (V_s = V_r = 80 \angle 0^\circ \, kV) \). The magnitude of the receiving end current \( I_r \) under this condition is
    a. 1200 A
b. 333 A  
c. 109A  
d. 55 A  

21) The total load connected at the receiving end under the above condition is  
a) 38 MVA @ 0.8 PF (lag)  
b) 34 MVA @ 1 PF  
c) 30. MVA @ 0.8 PF (lead)  
d) 26 MVA @ 0.6 PF (lag)