Electrical Machines Laboratory

Department of Electrical Engineering, IIT Kharagpur

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Experiment #1

A. Study of Scott Connected Transformers

A Scott-connected transformer is fed from a 440 V, 50 Hz, two-phase AC network, and supplies a three-phase load (Y connected) with a rated power of 10 kVA, and rated line voltage of 220 V, as shown in Fig 1. The specifications of the transformers (linear) are given as

T1: $N : N_1 = 2 : \sqrt{3}$, 5 kVA, Winding Resistance = 200 $m\Omega$, Leakage Inductance = 2.5 mH, Core Loss Resistance = 1500 Ω, Magnetizing Inductance = 1500 mH (all parameters referred to the HV side).

T2: $N : N_2 : N_3 = 2 : 1 : 1$, 5 kVA, Winding Resistance = 250 $m\Omega$, Leakage Inductance = 6.5 mH, Core Loss Resistance = 1200 Ω, Magnetizing Inductance = 1000 mH (all parameters referred to the HV side).

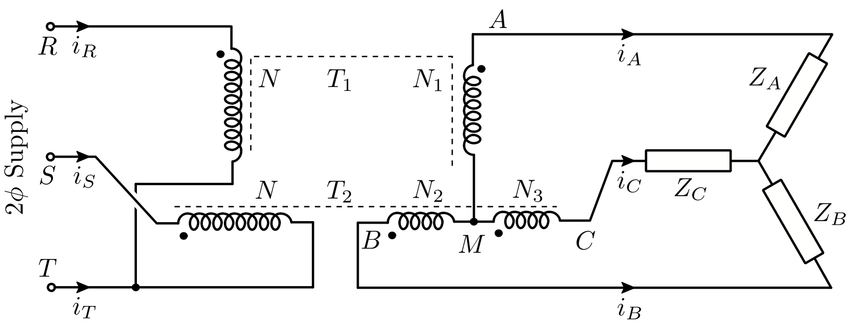

Figure 1. Schematic of the Scott connection of transformers.

1. Design the Scott-connected transformer in MATLAB/Simulink.

2. For a balanced three-phase load, observe the following

   - 2-phase voltages (v_{RT}, v_{ST})
   - 2-phase currents (i_R, i_S)
   - 3-phase voltages (v_{AB}, v_{BC}, v_{CA})

- 3-phase currents (i_A, i_B, i_C)

Plot these variables for two complete cycles.

3. Repeat the previous part for an unbalanced three-phase load.

4. Note the following readings for 5 different combinations of balanced and unbalanced loads.

$Z_A(\Omega)$	$Z_B(\Omega)$	$Z_C(\Omega)$	I_A(A)	I_B(A)	I_C(A)	V_{AB}(V)	V_{BC}(V)	V_{CA}(V)	I_R(A)	I_S(A)

B. Study of Vector Group of Transformers

Three identical single-phase 440/220 V, 3 kVA, 50 Hz transformers (linear) are connected to form a three-phase transformer, and is fed from a 440 V, 50 Hz AC supply. The parameters of each transformer is given as: Winding Resistance = 100 $m\Omega$, Leakage Inductance = 3.5 mH, Core Loss Resistance = 1500 Ω, Magnetizing Inductance = 1500 mH (all parameters referred to the HV side).

1. Connect the single-phase transformers in MATLAB/Simulink to obtain a three-phase transformer in the following configurations:
   I. $Yy0$ II. $Dd6$ III. $Yd1$ IV. $Dy11$ V. $Yz11$ VI. $Dz6$.
   Consider the neutral point for the star-connected side being isolated. Observe the voltage and current waveforms for the different connections. Calculate the ratio of the HV side line voltage to the LV side line voltage for all the connections.

2. Plot a line voltage of the HV side, and the corresponding line voltage on the LV side for any 3 configurations (for 1 complete cycle).

3. Consider a $Dy11$ connected three phase transformer, with the delta-connected side interfaced with a three-phase supply, and the star-connected side feeding a three-phase

load of 3 kW. The neutral point of the transformer is connected to the load neutral. Now, one phase of the load is disconnected from the transformer. Plot the phase and line currents on both sides of the transformer (for 1 complete cycle).

C. Discussion Questions

1. A delta-delta connected transformer operates from a three-phase supply and delivers power to a three-phase load. Now, if one of the transformer fails, calculate the percentage of the rated load that the transformer can supply without overloading the transformer.

2. A star-star connected transformer operates from a three-phase supply. Consider a practical transformer design, with the transformer core having a non-linear B-H characteristics. Now,

   - If the supply neutral is isolated from the neutral point of the transformer, comment on the phase voltage and magnetizing current drawn by the transformer.
   - If the supply neutral is connected to the neutral point of the transformer, comment on the phase voltage and magnetizing current drawn by the transformer.

3. What are the advantages of using a zig-zag connection of the transformer winding?

4. Terminal markings of a three-phase three limb transformer are missing. How could you identify all the terminals ($A_1 - A_2$, $B_1 - B_2$, $C_1 - C_2$, $a_1 - a_2$, $b_1 - b_2$, and $c_1 - c_2$) of the windings?