

Title of the Exercise: Sumpner's Test on Single Phase Transformer

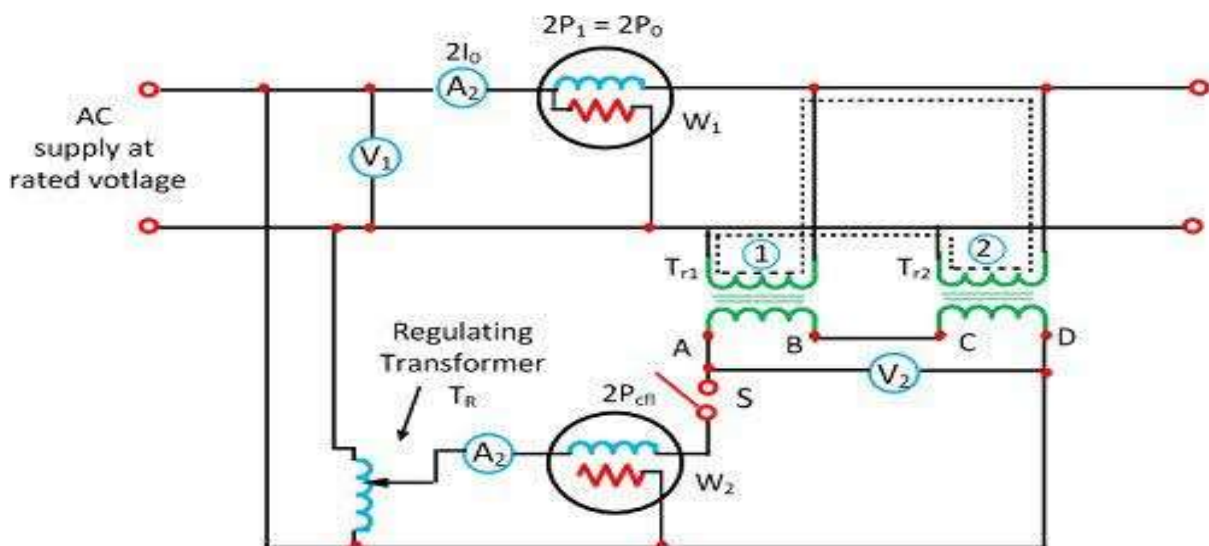
Date:6/11/20

Aim : To conduct Sumpner's test on a pair of identical Transformer using MATLAB/Simscape power system and find out equivalent circuit parameter.

Tool used :

- Matlab
- Simulink

Electrical Circuit : -



Back-to-back test on two identical single-phase transformers

Parameters used for the study :

Input :

Transformer rating = 50KVA

| | |
|--------------------------|--------------------------|
| $V_1 = 2400\text{Volts}$ | Primary Voltage in RMS |
| $V_2 = 240\text{Volts}$ | Secondary Voltage in RMS |
| $f = 50\text{Hz}$ | Frequency |

1st Transformer Parameters:

| | |
|---------------------------------|------------------------------|
| $R_1 = 0.7488\text{ Ohms}$ | Primary winding resistance |
| $R_2 = 0.007488\text{ Ohms}$ | Secondary winding resistance |
| $X_{11} = 1.00224\text{Ohms}$ | Primary winding reactance |
| $X_{12} = 0.0100224\text{Ohms}$ | Secondary winding reactance |
| $X_M = 5008\text{Ohms}$ | Magnetizing reactance |
| $R_C = 33,391\text{Ohms}$ | Resistance for core losses |

2nd Transformer Parameters:

| | |
|---------------------------------|------------------------------|
| $R_1 = 0.7488\text{ Ohms}$ | Primary winding resistance |
| $R_2 = 0.007488\text{ Ohms}$ | Secondary winding resistance |
| $X_{11} = 1.00224\text{Ohms}$ | Primary winding reactance |
| $X_{12} = 0.0100224\text{Ohms}$ | Secondary winding reactance |
| $X_M = 5008\text{Ohms}$ | Magnetizing reactance |
| $R_C = 33,391\text{Ohms}$ | Resistance for core losses |

Output :

Calculate and Tabulate the values and check Poc and Psc from no load and full load tests.

Theoretical Analysis :

This test provides data for finding the regulation, efficiency and heating under load conditions and is employed only when two similar transformers are available. One transformer is loaded on the other and both are connected to supply. The power taken from the supply is that necessary for supplying the losses of both transformers and the negligibly small loss in the control circuit.

Voltage = V_1 , Current = $I_0 / 2$, Core losses = $P_0 / 2$

Voltage = $V_{sc} / 2$, Current = I_{sc} , Copper losses = $P_{sc} / 2$

$$P_0 = P_i \text{ (iron-loss)}$$

$$P_0 = V_1 I_0 \cos \phi_0$$

$$\cos \phi_0 = P_0 / V_1 I_0$$

$$I_w = I_0 \cos \phi_0, I_\mu = I_0 \sin \phi_0$$

$$R_0 = V_1 / I_w, X_0 = V_1 / I_\mu$$

V_{sc} = Voltage, I_{sc} = Current , P_{sc} = Power (Copper loss)

$$Z_{01} = \frac{V_{\frac{sc}{2}}}{I_{SC}} = \sqrt{R_{01}^2 + X_{01}^2}$$

$$\text{Equivalent resistance, } R_{01} = \frac{P_{\frac{sc}{2}}}{(I_{SC})^2}$$

$$\text{Equivalent reactance, } X_{01} = \sqrt{Z_{01}^2 - R_{01}^2}$$

Calculations (Predetermination) :

From previously conducted no load and full load test we have the values of P_{oc} (core loss) and P_{sc} (copper loss) for this specific transformer:

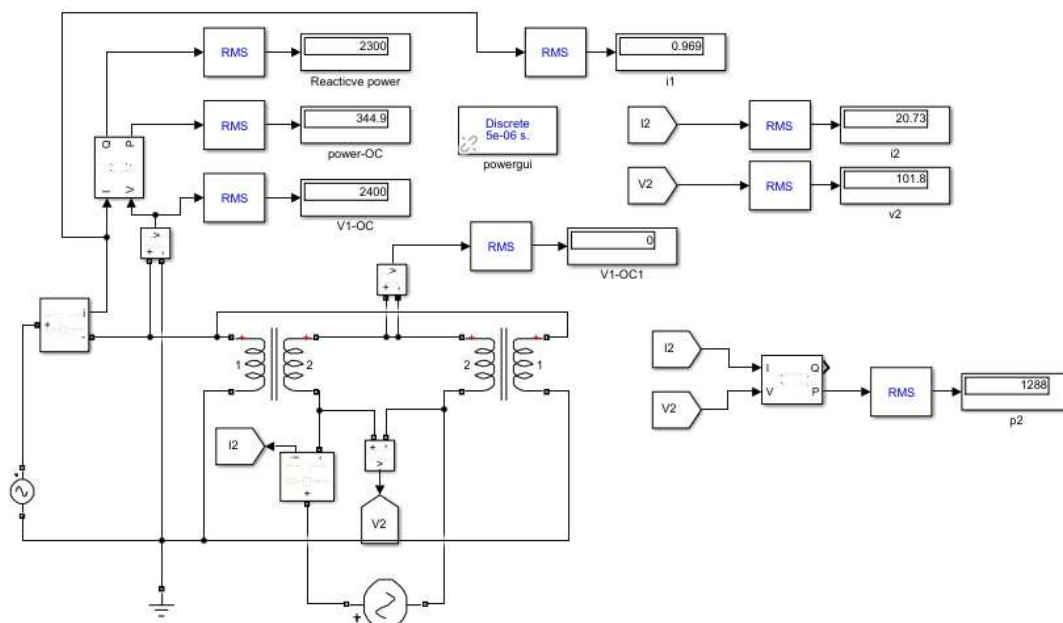
| Voc(V) | Ioc(A) | Poc(w) |
|---------------|---------------|---------------|
| 2400 | 0.4844 | 172.5 |
| Vsc(V) | Isc(A) | Psc(w) |
| 51.9 | 20.7 | 642.1 |

Transformer losses = $(W_1 + W_2) / 2$

Should match with the value of $P_{oc}(w) + P_{sc}(w) = 814.6 \text{ W}$

Procedure for simulation study :

- Initialize the input parameters and write coding as per the requirement of plots in m file and save it.
- Open new Simulink and make mathematical modeling as per circuit diagram and save it.
- Run Simulink file and then run mfile.
- Calculate the equivalent parameters and tabulate the values.

Simulation Diagram :**Results and Discussions :**

- In Sumpner's test the core and copper losses of a transformer are found at simultaneously
- The two transformers used should be of same rating and the values obtained are for losses are double since they are for 2 transformers that are connected .

Comparison (Observations) :

| V_p (v) | I_p (A) | P_{oc} (W) | V_s (V) | I_s (A) | P_{sc} (W) |
|-----------|-----------|--------------|-----------|-----------|--------------|
| 2400 | 0.0969 | 344.9 | 101.8 | 20.73 | 1288 |

| |
|---|
| Losses in each transformer = $\frac{P_{oc} + P_{sc}}{2} = (344.9 + 1288)/2 = 816.45W$ |
| Conclusion : <ul style="list-style-type: none">• The theoretical values obtained through calculations matches with the simulated values.• Hence the Sumpners test can be used for simultaneous calculation of the losses in a transformer |
| Inference : <ul style="list-style-type: none">• Hence the use of Sumpners test over conducting 2 separate tests is observed. |
| References : <ul style="list-style-type: none">• MATLAB Documentation• Simulink Documentation |