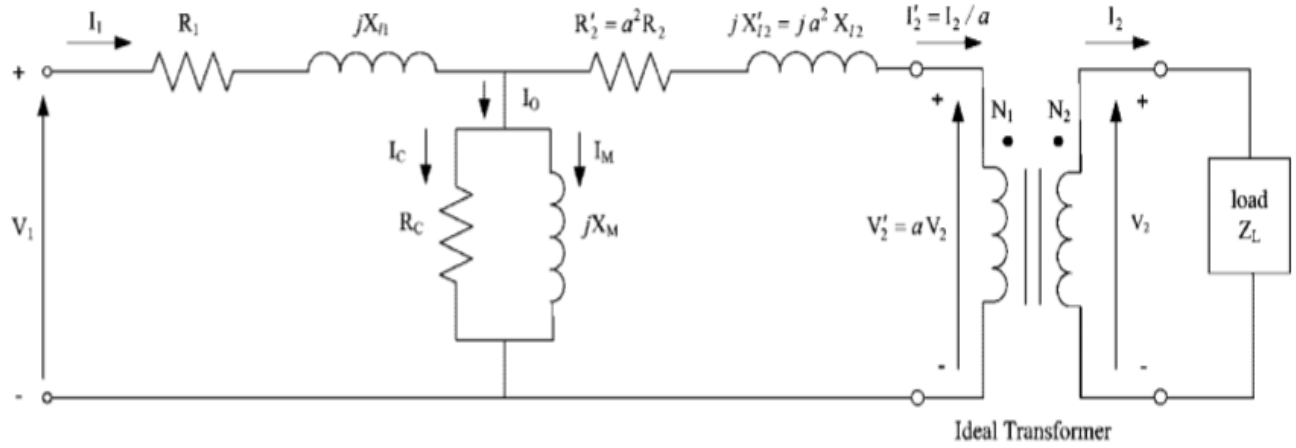
Title of the Exercise: Open and Short Circuit Test on Single Phase Transformer

Date: 25.10.2020

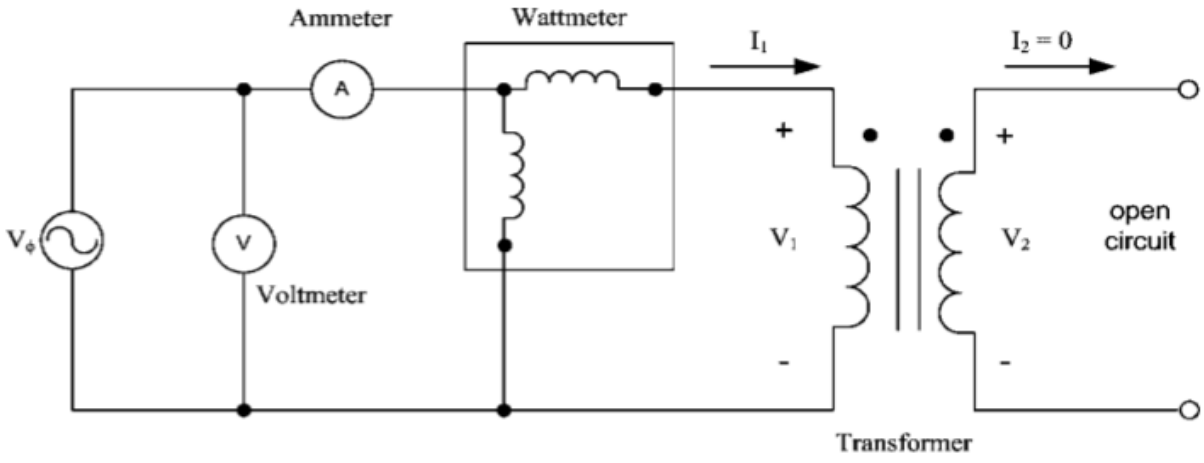
Aim: To perform open and short-circuited test on a two winding Transformer and find out equivalent circuit parameter as well as predetermination of efficiency under various loaded condition.

Tool used: MATLAB/Simscape Power System

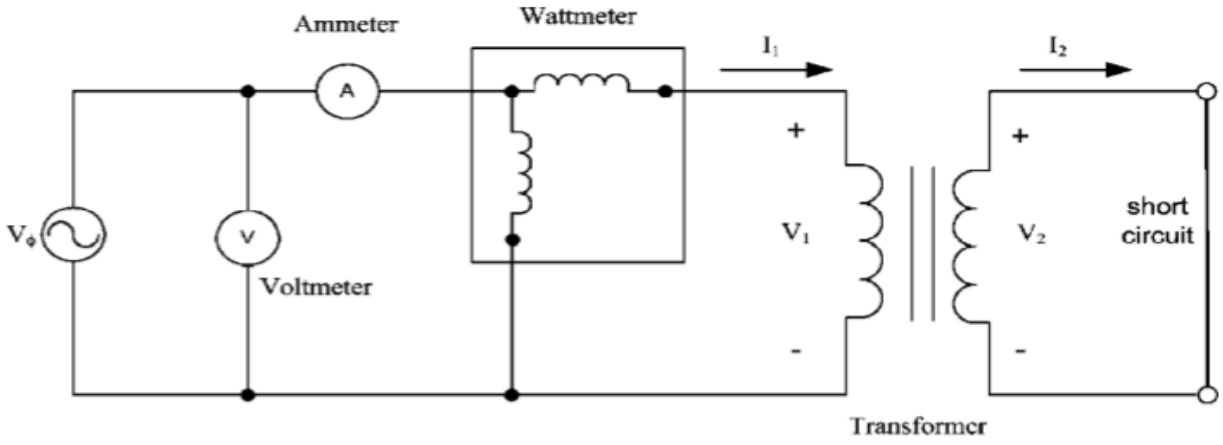
Electrical Circuit



Open Circuit Test



Short Circuit Test



Parameters used for the study

Transformer rating = 50KVA

V_1 = 2400 Volts	Primary Voltage in RMS
V_2 = 240 Volts	Secondary Voltage in RMS
f = 50Hz	Frequency
R_1 = 0.7488 Ohms	Primary winding resistance
R_2 = 0.007488 Ohms	Secondary winding resistance
X_{11} = 1.00224 Ohms	Primary winding reactance
X_{12} – 0.0100224 Ohms	Secondary winding reactance
X_M = 5008 Ohms	Magnetizing reactance
R_C = 33,391 Ohms	Resistance for core losses

Theoretical Analysis:

For Open Circuit

$$|Y_E| = G_c - jB_M = \frac{I_{oc}}{V_{oc}}$$

$$PF_{oc} = cos\theta = \frac{P_{oc}}{V_{oc}I_{oc}}$$

$$G_c = |Y_E|cos\theta,\ R_c = \frac{1}{G_c}$$

$$B_M = |Y_E|sin\theta,\ X_M = \frac{1}{B_M}$$

For Short Circuit

$$|Z_{eq}| = |Z_{sc}| = \frac{V_{sc}}{I_{sc}}$$

$$R_{eq} = R_{sc} = \frac{P_{sc}}{I_{sc}^2}$$

$$X_{eq} = X_{sc} = \sqrt{|Z_{eq}|^2 - {R_{eq}}^2}$$

$$R_{eq} = R_1 + a^2 R_2$$

$$X_{eq} = X_{11} + a^2 X_{12}$$

For predetermination of efficiency

Pc=Woc=Poc=Iron losses

Psc =full load copper losses

Wsc={(IL/If)^2 }*Psc = Pcu

Wsc= copper losses at different loaded conditions

W_T= Pc+ Pcu−Total power losses

I_L = Load current

I_F = Full load current

CosΦ = Power factor

Efficiency = (Po/Pi)*100

Calculations (Predetermination)

I_f = 207.4 A (From short circuit test) (Current at full load)

Woc = 174.3 W (From open circuit test) (Iron losses)

We calculate efficiency of transformer at different load current as 1,2……10 and power factor as 1

At I_L = 1A

Wsc = Pcu = {(1/207.4)^2}*644.2 = 0.0149 Watts

Power output = I_L * 240 = 1 * 240 = 240 Watts

Total Power Loss = 174.3 + 0.0149 = 174.3149 Watts

Power Input = Power output + Total power loss

= 240 + 174.3149 = 414.3149

Efficiency = (240/414.3149)*100 % = 57.9269%

Therefore, efficiency of transformer at load current 1 is 57.92%

At I_L = 2A

Wsc = Pcu = {(2/207.4)^2}*644.2 = 0.0599 Watts

Power output = I_L * 240 = 2 * 240 = 480 Watts

Total Power Loss = 174.3 + 0.0599 = 174.3599 Watts

Power Input = Power output + Total power loss

= 480 + 174.3599 = 654.3599

Efficiency = (480/654.3599)*100 % = 73.33541%

Therefore, efficiency of transformer at load current 1 is 73.35%

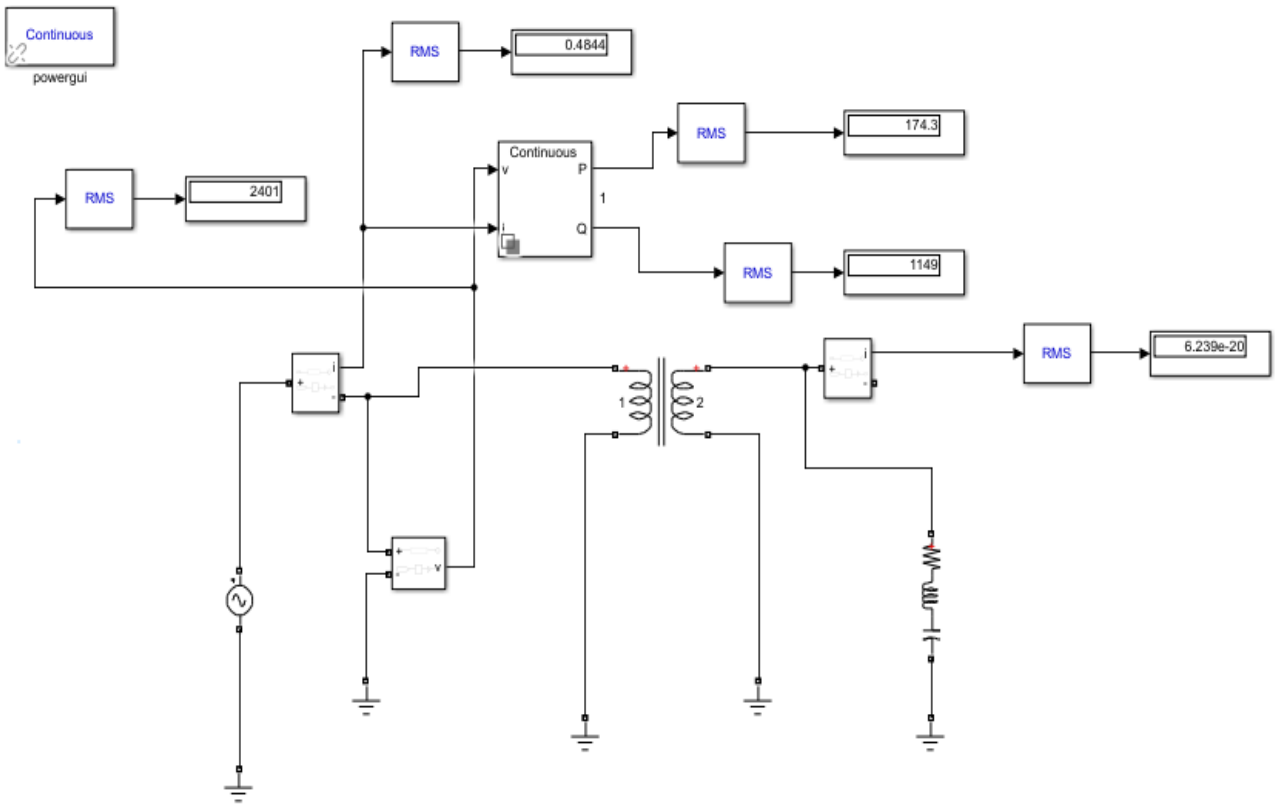
Now, similarly we can find efficiency for load current 3,4…10.

Procedure for simulation study

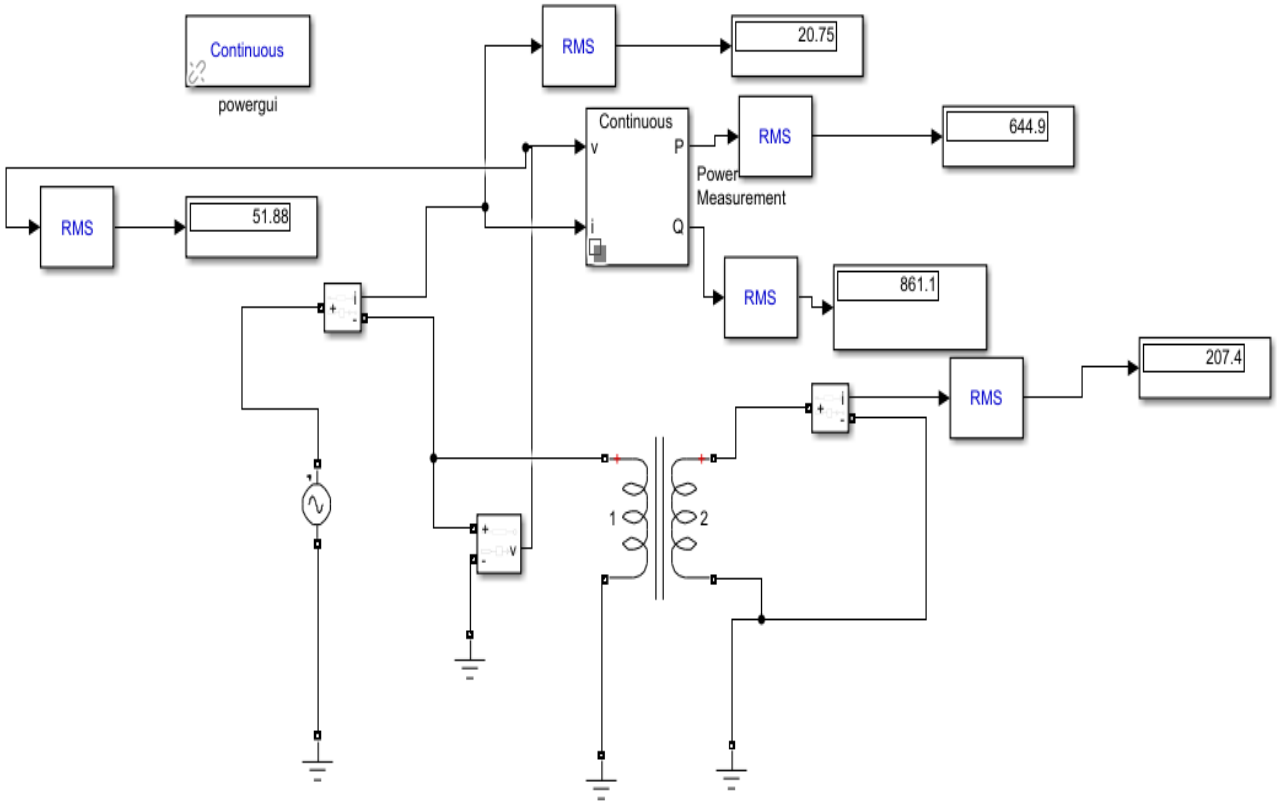
- Initialize the input parameters and write coding as per the requirement of plots in m file and save it.
- Open new Simulink and make mathematical modelling as per circuit diagram and save it.
- Run Simulink file and then run m file.
- Calculate the equivalent parameters and plot the necessary graphs.

Simulation Diagram and m. file coding

For Open Circuit



For Short Circuit



M file coding –

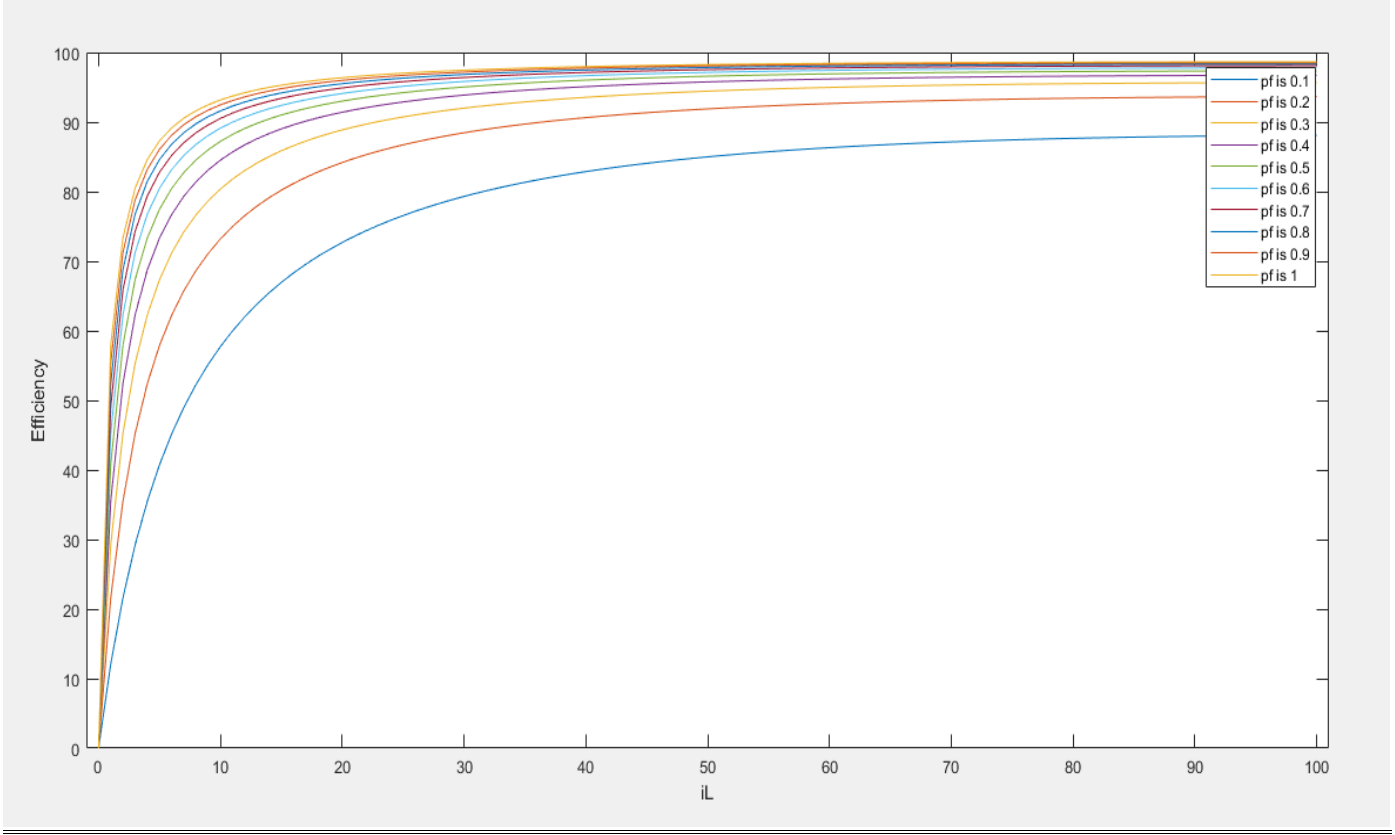
```
%Open Circuit
Poc = 174.3;
Voc = 2400;
Ioc = 0.4844;
PFoc=Poc/(Voc*Ioc);

%Short Circuit
Isc = 207.4;
Vsc = 51.9;
Psc = 644.2;
iL = (0:1:10);

pfi = (0.1:0.1:1);
for i = 1:10
    pf = pfi(i);
    Po = (240*iL)*pf;
    Wsc = ((iL/Isc).^2)*Psc;
    Wt = Wsc + Poc;
    Pi = Po + Wt;
    Eff = 100*(Po./Pi);
    plot(iL, eff);
    hold on
end
hold off
xlim([-1 101])
legend("pf is "+string((0.1:0.1:1)))
xlabel('iL');
ylabel('Efficiency');
```

Results and Discussions-

This section contains waveforms of different speed control characteristics.



Comparison (Observations)

S.No	Load Current(I_L)	Constant Losses(W_{oc})	Copper Losses(W_{sc})	Total Losses(W_T)	O/P Power(w)	I/P Power(w)	%η
1	1	174.3	0.0150	174.3150	240	414.3	57.9269
2	2	174.3	0.0599	174.3599	480	654.4	73.3541
3	3	174.3	0.1348	174.4348	720	894.4	80.4978
4	4	174.3	0.2396	174.5396	960	1134.5	84.6158
5	5	174.3	0.3744	174.6744	1200	1374.7	87.2934
6	6	174.3	0.5391	174.8391	1440	1614.8	89.1730
7	7	174.3	0.7338	175.0388	1680	1855.0	90.5644
8	8	174.3	0.9585	175.2585	1920	2095.3	91.6355
9	9	174.3	1.2131	175.5131	2160	2335.5	92.4850
10	10	174.3	1.4976	175.7976	2400	2575.8	93.1750

Conclusion:

Open circuit and short circuit test have been done and equivalent circuit parameter as well as predetermination of efficiency under various loaded condition has also been obtained.

Inference:

Our predetermined values match with the simulation value which are tabulated in above table.

References:

- https://in.mathworks.com/