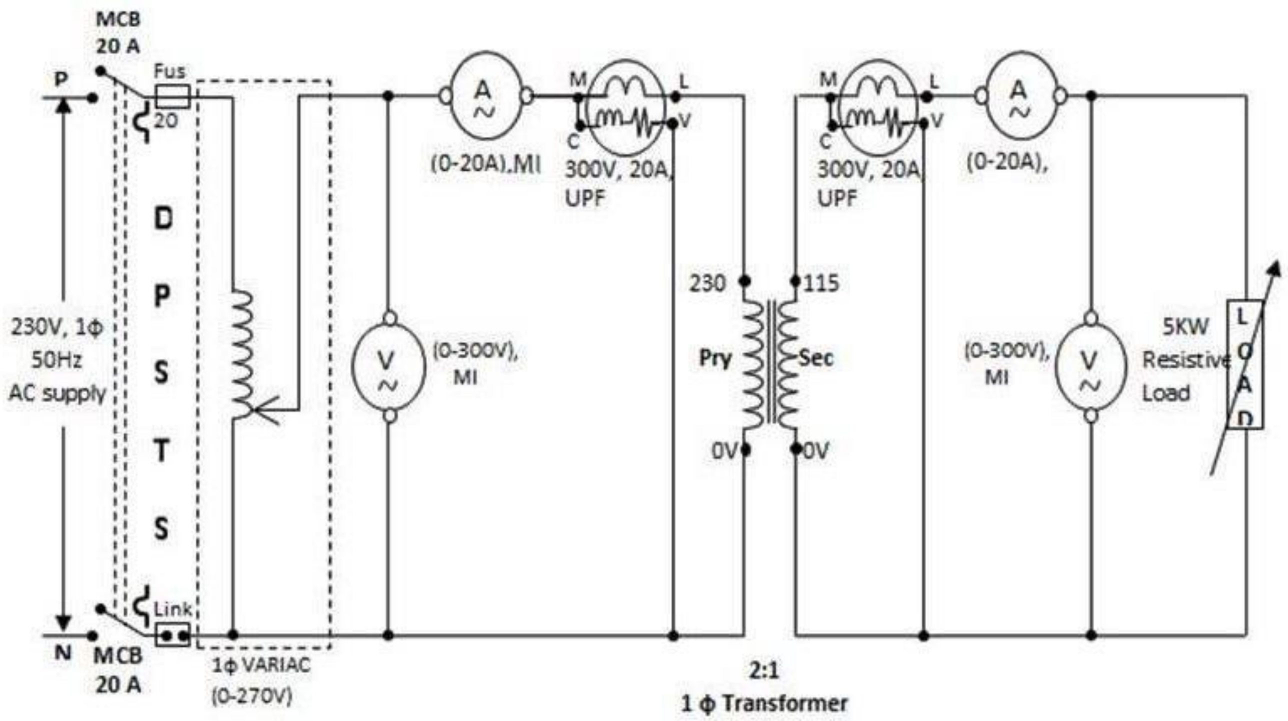
Title of the Exercise: Direct Loading Test on a Single Phase Transformer

Date: 27/10/2020

Aim: To perform direct loading 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:



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:

Transformer efficiency (**η**) = $\frac{ws}{wP}$ x 100

%Voltage Regulation = $\frac{vS0-vS}{v_{S0}} \times 100$

Where,

Wp - Input power in the primary (W)

Ws - Output power in the secondary (W)

Vso - No load secondary voltage (V)

Vs - Secondary voltage at load (V)

Calculations (Predetermination)

poc=172.7;

psc=644.9;

isc=207.4;

vsc=240;

po=v2*i2*pf=Ws;

wsc=(i2/isc).^2)*psc

wt=wsc+poc

pi=po+wt=Wp

eff=100*po./pi

vr=100*(vsc-v2)/vsc

at pf=1;

v1=2400,i1=26.11

v2=236,i2=260.3

Po=236*260.3=61430=Ws

Pi=61430+172.6+(260.3/208.3)^2*649.9=62618

Eff=100*Ws/Wp=98.10

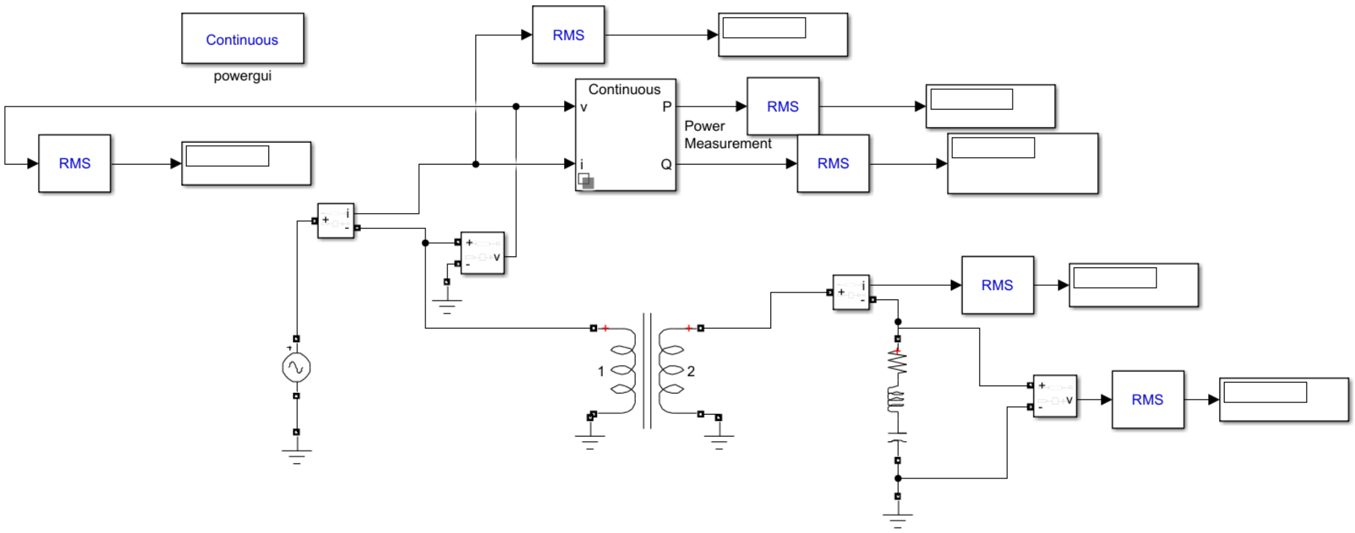
Voltage regulation=(240-236)/240=1.66

Similary, for all cases efficiency and voltage regulation can be calculated at different power factors.

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:



M file for PF = 1:

```
Isc = 207.4;

IL = [119,59.75, 39.89, 29.93, 23.95, 19.97,17.12];

ZL = [2,4,6,8,10,12,14];

vL= [238.1, 239, 239.3, 239.5, 239.5, 239.6, 239.7];

Po = 240*IL*1;

Psc=644.9;

Woc=172.7;

Voc = 240;

Wsc = ((IL/Isc).^2)*Psc;

Wt = Woc + Wsc;

Pi = Po + Wt;

eff = 100*(Po./Pi);

regulation= (Voc- vL)./Voc *100;

subplot(2,1,1)

plot(Po,eff);

legend("PF= 1");

xlabel('Output Power');

ylabel('Efficiency');

subplot(2,1,2)

plot(Po,regulation);

xlabel('Output Power');

ylabel('Regulation');

legend("PF= 1");

%pf = 1
```

M file for PF = 0.7 lagging:

```
Isc = 207.4;
IL = [166.4, 83.9, 33.74, 16.9, 8.45];
vL= [235.8, 237.8, 239.1, 239.5, 239.7];
Po = 240*IL*0.7;
Psc=644.9;
Woc=172.7;
Voc = 240;
Wsc = ((IL/Isc).^2)*Psc;
Wt = Woc + Wsc;
Pi = Po + Wt;
eff = 100*(Po./Pi);
regulation= (Voc- vL)./Voc *100;
subplot(2,1,1)
plot(Po,eff);
%ylim([0 150]);
legend("PF= 0.7");
xlabel('Output Power');
ylabel('Efficiency');
subplot(2,1,2)
plot(Po,regulation);
xlabel('Output Power');
ylabel('Regulation');
legend("PF= 0.7");
%pf = 0.7
```

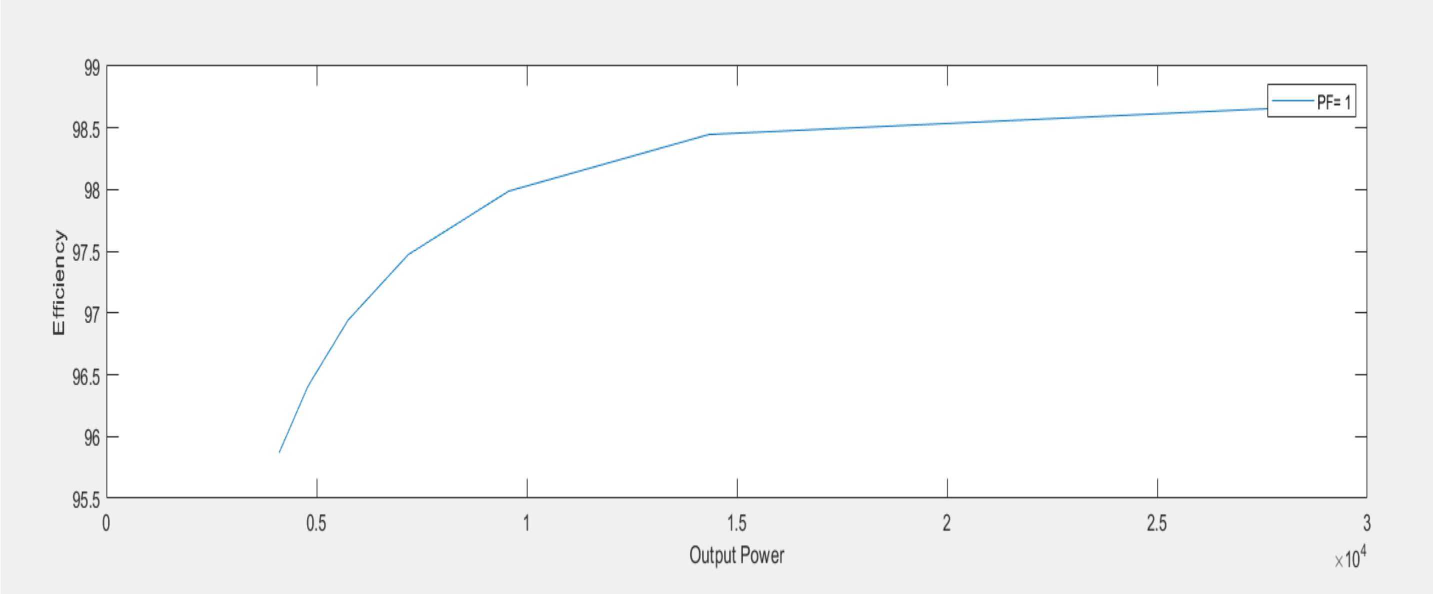
M file for PF = 0.7 leading:

```
Isc = 207.4;
IL = [8.225, 16.45, 27.43, 54.88, 82.35,109.9, 164.9];
vL= [240, 240, 240, 240.2, 240.3, 240.4, 240.6];
Po = 240*IL*0.7;
Psc=644.9;
Woc=172.7;
Voc = 240;
Wsc = ((IL/Isc).^2)*Psc;
Wt = Woc + Wsc;
Pi = Po + Wt;
eff = 100*(Po./Pi);
regulation= (Voc- vL)./Voc *100;
VR = -1*regulation;
subplot(2,1,1)
plot(Po,eff);
legend("PF= 0.7");
xlabel('Output Power');
ylabel('Efficiency');
subplot(2,1,2)
plot(Po,VR);
xlabel('Output Power');
ylabel('Regulation');
legend("PF= 0.7");
%pf = 0.7
```

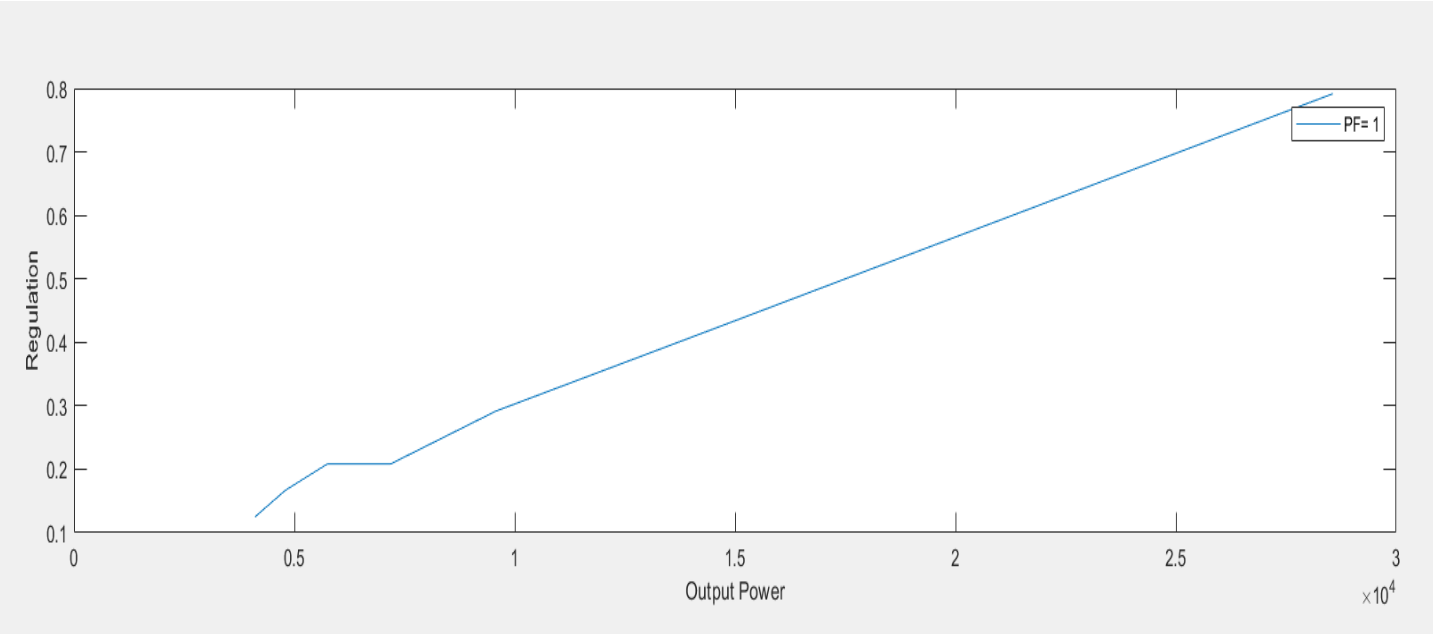
Results and discussions:

This section contains waveforms of different speed control characteristics.

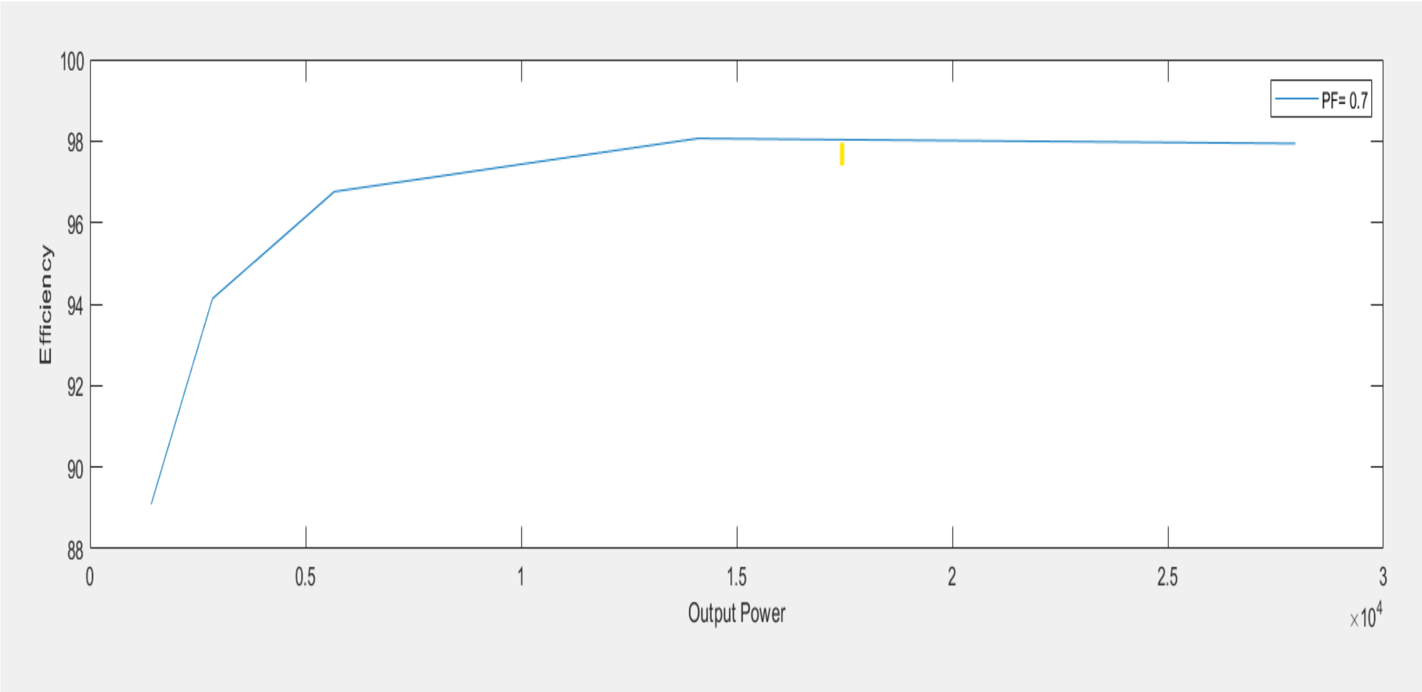
Efficiency vs output power plot for Pf = 1:



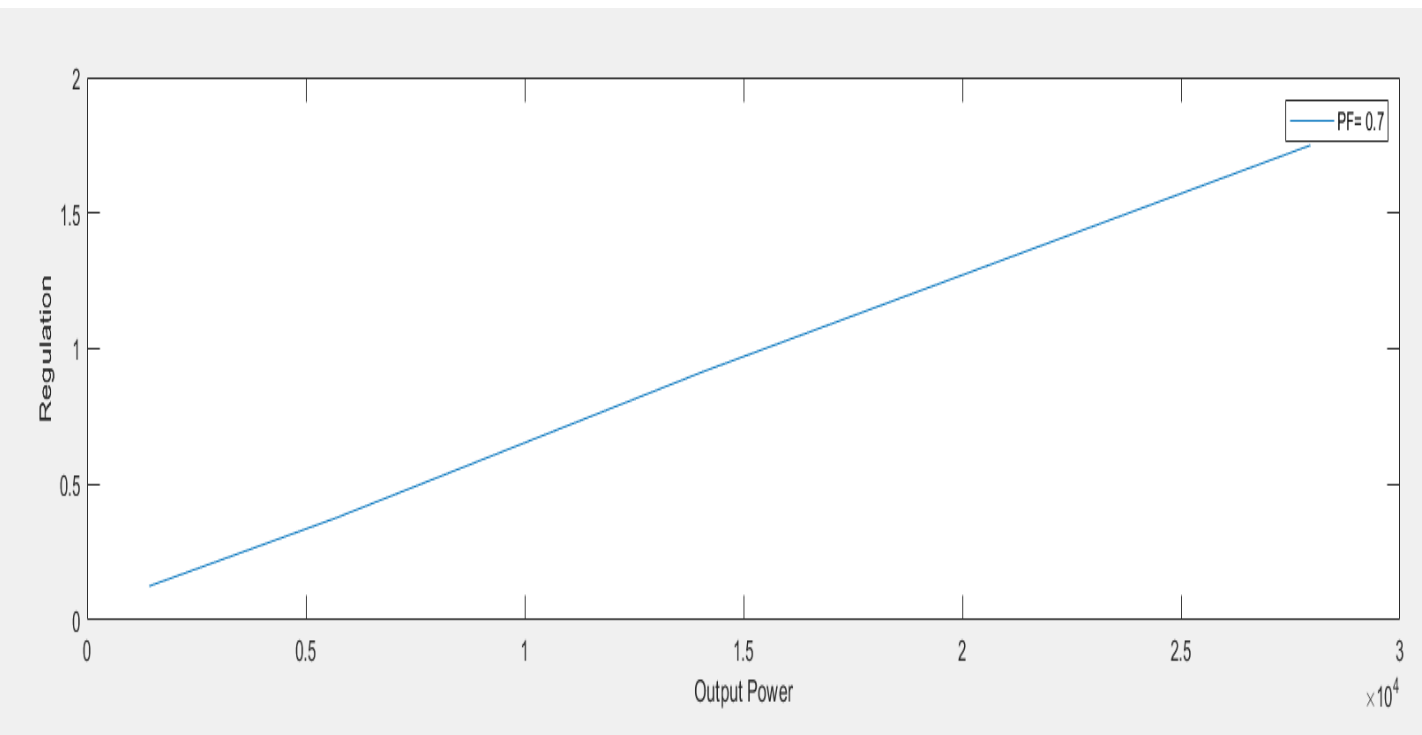
Voltage regulation vs output power plot for Pf = 1:



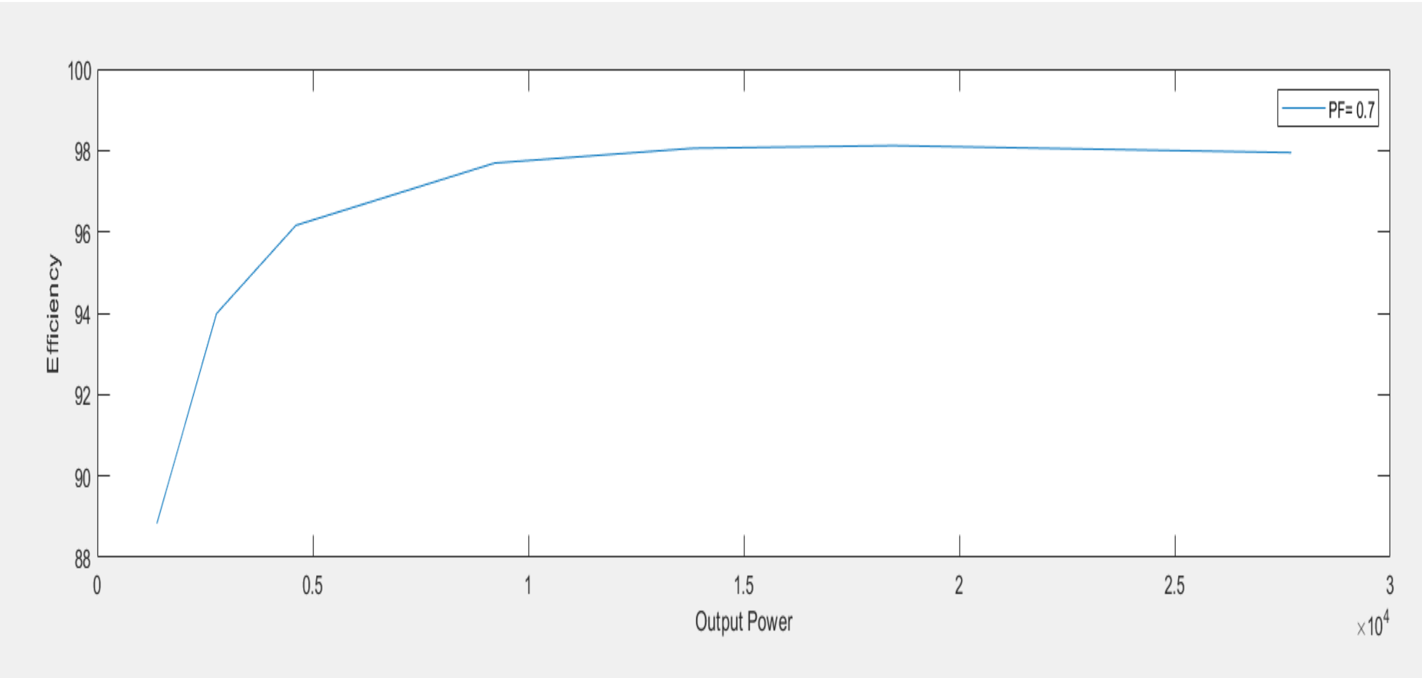
Efficiency vs output power plot for Pf = 0.7 lagging:



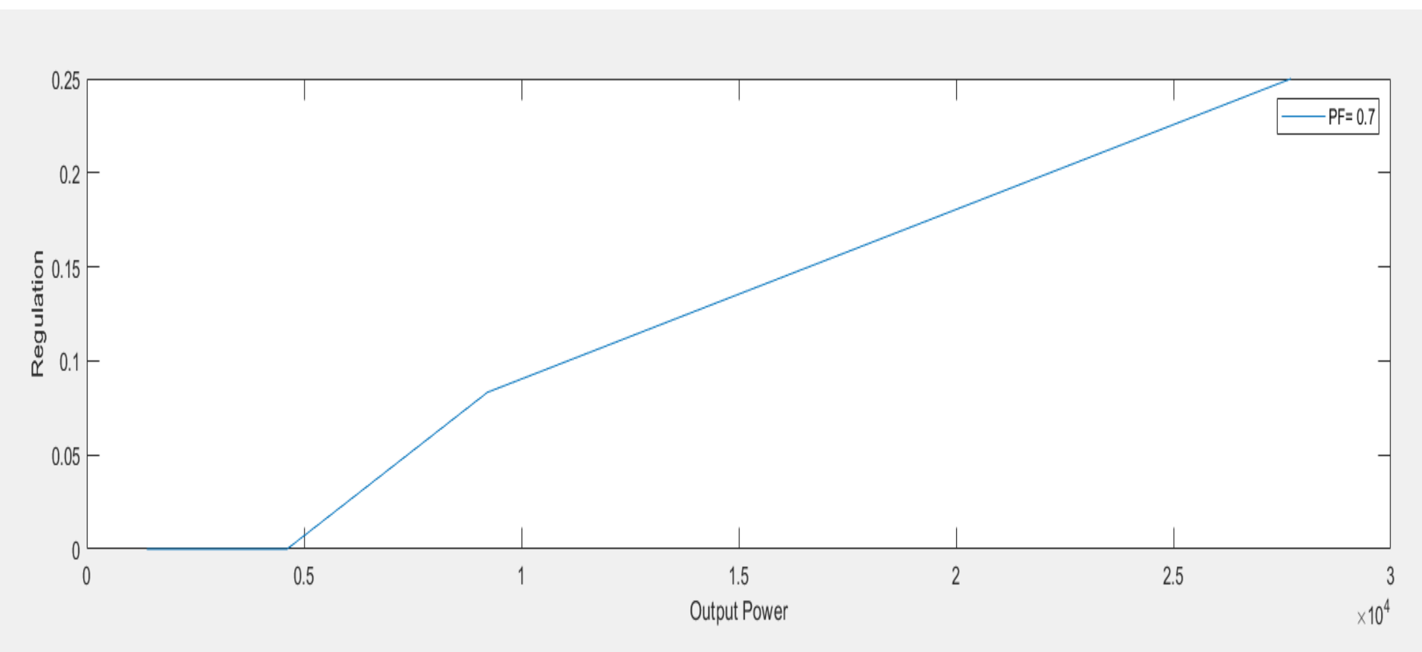
Voltage regulation vs output power plot for Pf = 0.7 lagging:



Efficiency vs output power plot for Pf = 0.7 leading:



Voltage regulation vs output power plot for Pf = 0.7 leading:



Observations:

PF =1

R (Ohm)	IL (A)	VL (V)	Efficiency %	Regulation %
2	119	238.1	98.669	0.7917
4	59.75	239	98.4469	0.4167
6	39.89	239.3	97.9882	0.2917
8	29.93	239.5	97.4743	0.2083
10	23.95	239.5	96.9423	0.2083
12	19.97	239.6	96.4059	0.1667
14	17.12	239.6	95.8680	0.1250

PF = 0.7 Lagging

R (ohm)	L (Henry)	I_L (A)	V_L (V)	Efficiency %	Regulation %
1	0.0032	166.4	235.8	97.9406	1.7500
2	0.0064	83.9	237.8	98.0642	0.9167
5	0.016	33.74	239.1	96.7606	0.3750
10	0.032	16.9	239.5	94.1323	0.2083
20	0.064	8.45	239.7	89.0942	0.1250

PF = 0.7 Leading

R (Ohm)	C (Farad)	IL (A)	VL (V)	Efficiency%	Regulation%
20	0.00015	8.225	240	88.83	0
10	0.0003	16.45	240	93.99	0
6	0.0005	27.43	240	96.16	0
3	0.001	54.88	240.2	97.69	0.0833
2	0.0015	82.35	240.3	98.06	0.125
1.5	0.002	109.9	240.4	98.12	0.1667
1	0.003	164.9	240.6	97.95	0.25

Conclusion:

Load test have been done and equivalent circuit parameter as well as percentage of efficiency and voltage regulation 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/**