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Procedure

a- Note down ratings and determine the rated currents for both the windings.

S(kVA)	V1(V)	V2(V)	I1(A)	I2(A)	f(Hz)
16.750	970	194	17.26804124	86.34020619	50

1 Short-Circuit Test:

- Connect the circuit such that the transformer secondary is short circuited, keep the primary voltage at rated value

V_1=V_{rated}	I_1	Psc
970	190.7	131045.5920444

- Adjust the output of the autotransformer such that rated current flows through the windings. Record the applied voltage, current and input power.

V_1	I_1	Psc
87	17.1	1054.186906575

- Calculate R_{eq} and X_{eq}. (compare with R_1, R_2, X_1 and X_2)

$$Z_{sc} = \frac{V_{sc}}{I_{sc}} = \frac{87}{17.1} = 5.0877\,\Omega$$

$$R_{eq} = R_{sc} = \frac{P_{sc}}{{I_{sc}}^2} = \frac{1054.1869}{17.1^2} = 3.60516\,\Omega$$

$$X_{eq} = X_{sc} = \sqrt{{Z_{sc}}^2 - {R_{sc}}^2} = \sqrt{5.0877^2 - 3.60516^2} = 3.589918\,\Omega$$

$$\cos(\varphi_{sc}) = \frac{P_{sc}}{I_{sc}\,V_{sc}} = \frac{1054.186906575}{87 * 17.1} = 0.70860$$

$\varphi_{sc} = 44.8787°$ $\quad R_1 = 1.4043283\,\Omega$ $\quad R_2 = 0.087771\,\Omega$

$\frac{V_1}{V_2} = \frac{970}{194} = 5$ $\quad \therefore\ {R_2}' = 0.087771 * 5^2 = 2.194275$

$$R_2' + R_1 = R_{eq} = 2.194275 + 1.4043283 = 3.5986\,\Omega$$

$$X_1 = j\omega L = j2\pi f L_1 = j2\pi * 50 * 0.004472 = 1.40492\ \Omega$$

$$X_2 = j\omega L = j2\pi f L_2 = j2\pi * 50 * 0.00028 = 0.08796\ \Omega$$

${X_2}' = 0.08796 * 25 = 2.199\Omega$ $\quad {X_2}' + X_1 = X_{eq} = 3.89918\Omega$

2 No-Load Test:

- **Connect the circuit such that the transformer secondary is short circuited**
- **Apply the rated voltage to the HV side and record primary current and power drawn from the source.**
  (Note: the test is usually performed in the LV side)

V_1	I_1	Poc
970	**0.4148**	**335.4931322603**

- **Calculate The parameters of the no load branch (compare with R_c and X_m)**

$$\cos(\emptyset_o) = \frac{P_o}{I_o V_1} = \frac{335.4931322603}{0.4148 * 970} = 0.8338216$$

$$\emptyset_o = 33.5066°$$

$$I_c = I_o \cos\emptyset_o = 0.4148 \cos 33.5066 = 0.345869\ A$$

$$I_m = I_o \sin\emptyset_o = 0.4148 \sin 33.5066 = 0.2289833\ A$$

$$R_o = \frac{V_1}{I_c} = \frac{970}{0.345869} = 2804.53\Omega$$

$$X_m = \frac{V_1}{I_m} = \frac{970}{0.2289833} = 4236.11678\Omega$$

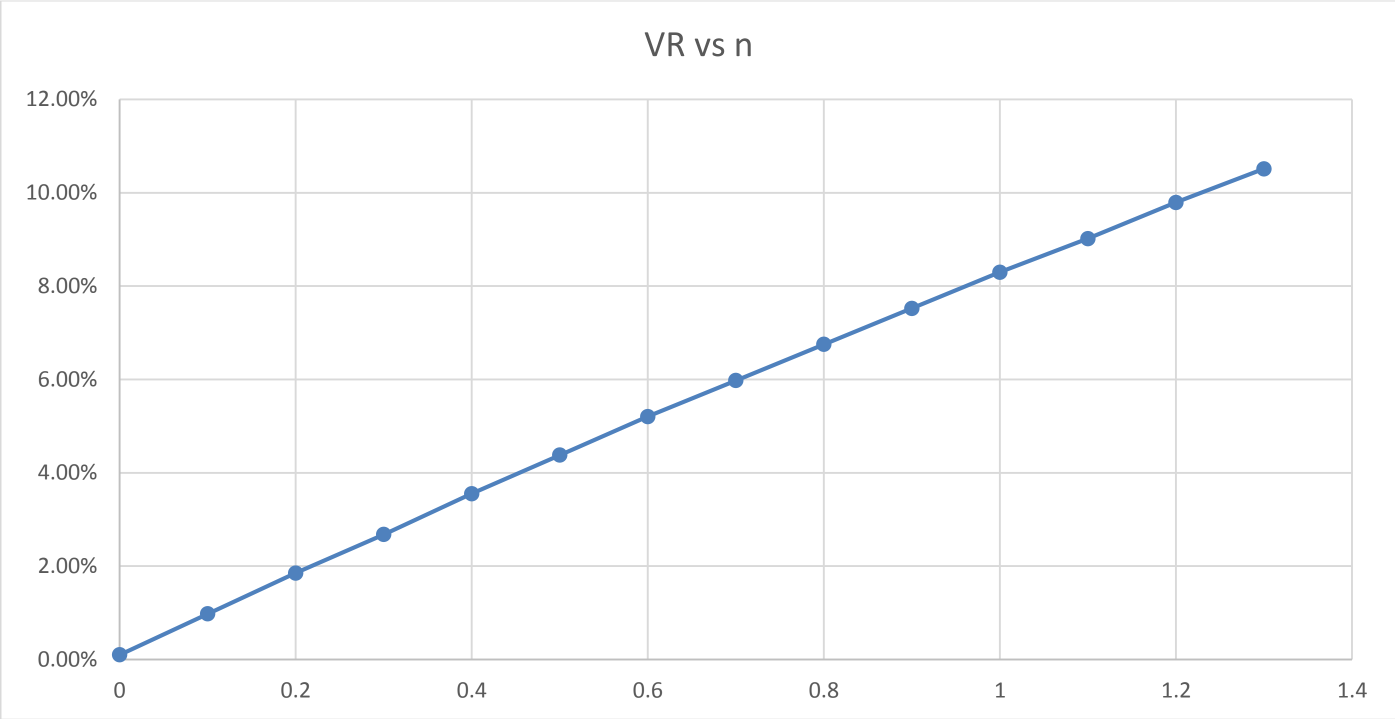
3 Loading Condition

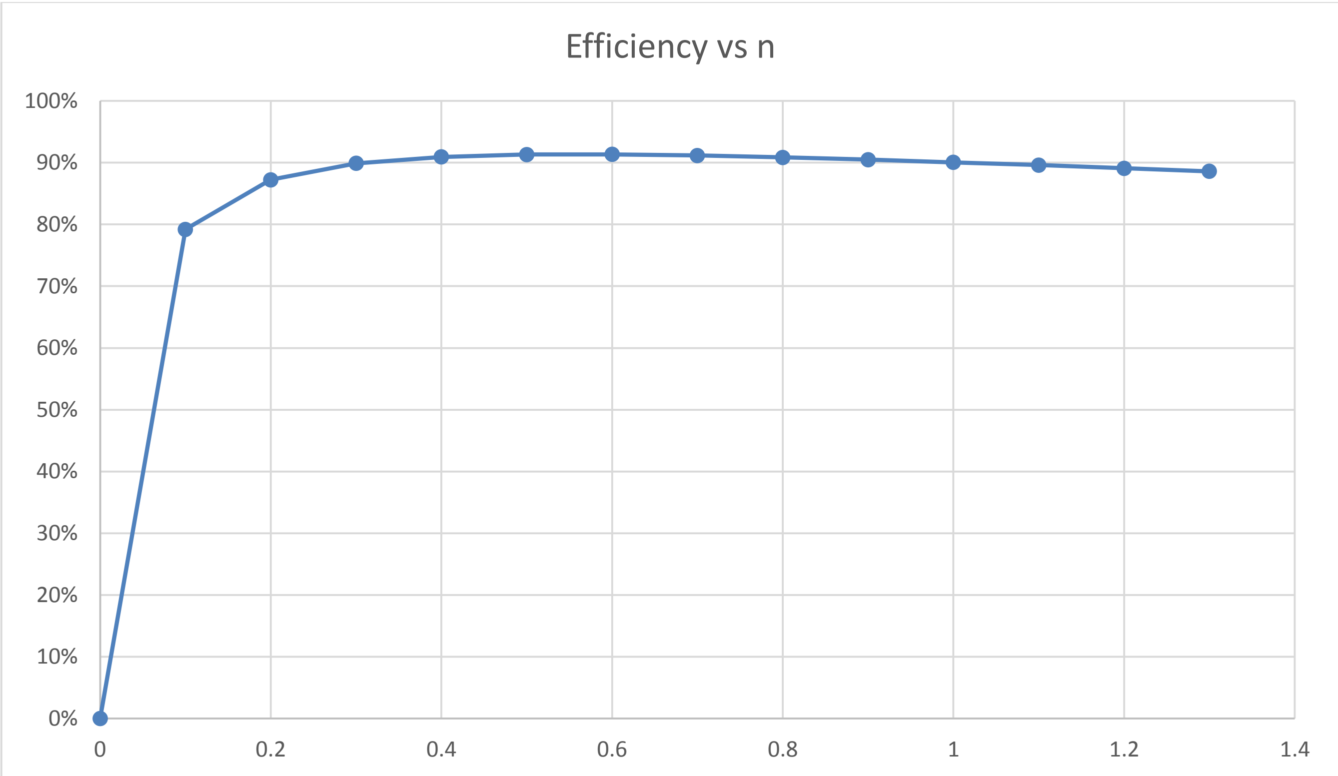
- Connect an RL load across the secondary side;

- Apply <u>the rated voltage</u> to the HV side and record primary current and power drawn from the source for different loading values. And record the secondary voltage, current and power.

n	LOAD $n*S_{rated}*(0.8+j0.6)$	V_1	I_1	P1	V2	I2	P2	%VR $=(V_{2nL}-V_2)/V_{2nL}*100$	Efficiency $=P_2/P_1*100$
0(no load)	0	970	0.4148	335.49	193.8	0	0	0.103%	0%
0.1	1340+j1005	970.1	2.124	1660.4	192.1	8.55	1314.98	0.979%	79.19%
0.2	2680+j2010	970.1	3.802	2960.116	190.4	16.95	2582.62	1.855%	87.24%
0.3	4020+j3015	970.1	5.451	4234.436	188.8	25.21	3806.44	2.680%	89.89%
0.4	5360+j4020	970.1	7.072	5483.85	187.1	33.32	4987.16	3.556%	90.94%
0.5	6700+j5025	970	8.668	6714.27	185.5	41.3	6131.63	4.381%	91.32%
0.6	8040+j6030	970.1	10.23	7914.03	183.9	49.13	7228.99	5.206%	91.34%
0.7	9380+j7035	970	11.77	9101.75	182.4	56.84	8297.77	5.979%	91.16%
0.8	10720+j8040	970.1	13.28	10258.91	180.9	64.41	9321.32	6.752%	90.86%
0.9	12060+j9045	970	14.77	11400.19	179.4	71.86	10316.95	7.525%	90.49%
1.0	13400+j10050	970.1	16.24	12514.77	177.9	79.18	11270.68	8.298%	90.05%
1.1	14740+j11055	970	17.68	13615.86	176.5	86.4	12200.65	9.020%	89.60%
1.2	16080+j12060	970.1	19.09	14690.06	175	93.48	13089.62	9.793%	89.10%
1.3	17420+j13065	970.1	20.49	15753.05	173.6	100.5	13958.64	10.515%	88.60%

- <u>Plot</u> VR vs n and Efficiency vs n.

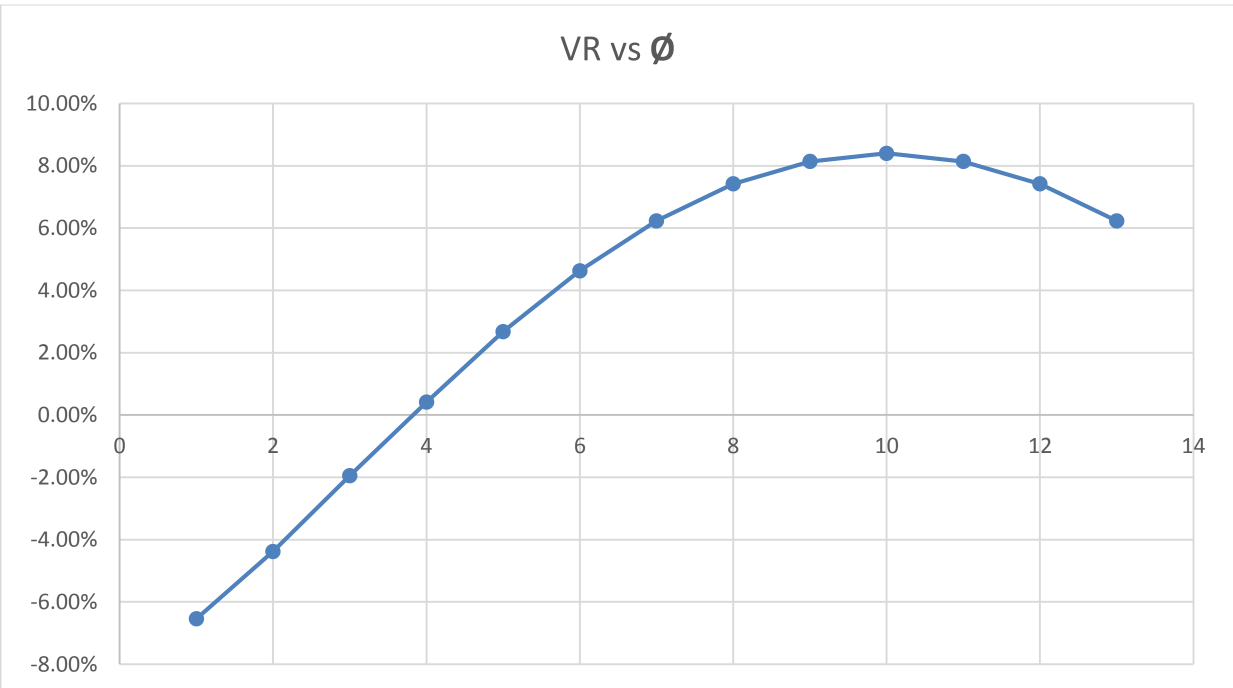

VR vs n
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
0
0.2
0.4
0.6
0.8
1
1.2
1.4

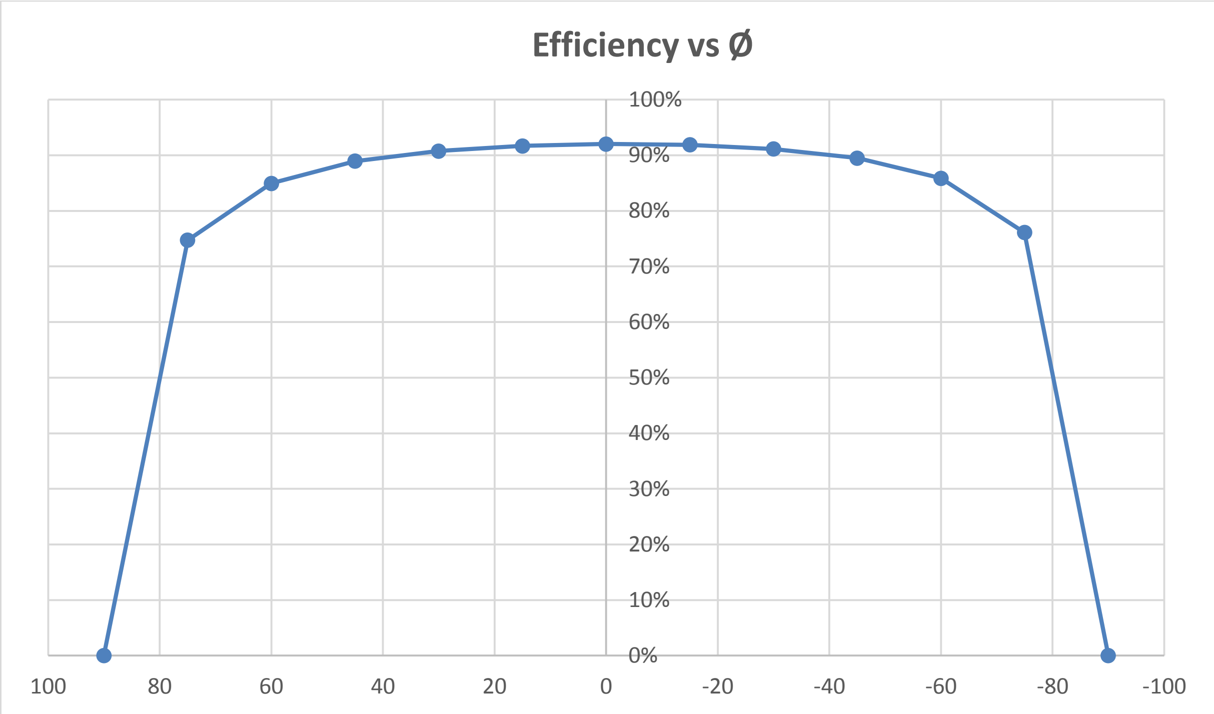

Efficiency vs n
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.2
0.4
0.6
0.8
1
1.2
1.4

➢ Apply <u>the rated voltage</u> to the HV side and record primary current and power drawn from the source for different loading values. And record the secondary voltage, current and power.

ϕ(deg.)	LOAD S_{rated}*(cos ϕ+jsin ϕ)	V_1	I_1	P1	V2	I2	P2	%VR =(V_{2nL}-V_2)/ V_{2nL}*100	Efficiency =P_2/P_1*100
-90	-j16750	970	18.21	1511.15	206.7	92.15	0	-6.54%	0%
-75	4335.21-j16179.25	970	17.93	6196.99	202.5	90.22	4717.54	-4.38%	76.12%
-60	8375-j14505.92	970	17.62	10137.03	197.8	88.09	8706.09	-1.95%	85.88%
-45	11844.03-j11844.03	970	17.31	13125.12	193.2	86	11748.94	0.412%	89.51%
-30	14505.92-j8375	970	17.01	15074.50	188.8	84.03	13740.34	2.68%	91.14%
-15	16179.25-j4335.21	970	16.75	16010.22	185	82.33	14711.00	4.63%	91.88%
0	16750	970	16.54	16001.33	181.9	80.96	14728.23	6.23%	92.04%
+15	16179.25+j4335.21	970	16.38	15131.36	179.6	79.96	13875.72	7.42%	91.70%
+30	14505.92+j8375	970	16.27	13487.23	178.2	79.32	12242.43	8.14%	90.77%
+45	11844.03+j11844.03	970	16.21	11172.92	177.7	79.07	9940.26	8.40%	88.96%
+60	8375+j14505.92	970	16.22	8323.77	178.2	79.3	7073.01	8.14%	84.94%
+75	4335.21+j16179.25	970	16.29	4994.78	179.6	79.88	3732.77	7.42%	74.73%
+90	j16750	970	16.41	1314.597	181.9	80.85	0	6.23%	0%

➢ <u>Plot</u> VR vs ϕ and Efficiency vs ϕ.




Efficiency vs Ø
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
100
80
60
40
20
0
-20
-40
-60
-80
-100