GARVIT SHAH
F-24

Date

EXPERIMENT : No. 8

- Aim: Determination of single-phase transformer equivalent circuit parameters using open-circuit & short-circuit test.

- Theory: The open circuit & short circuit test on single phase transformer is to determine the efficiency & regulation of a transformer on any load condition & at any power factor. This method is also used to find the equivalent circuit parameters of transformer. This method of finding the parameters of a transformer is called as an indirect loading method.

1. Open Circuit Test:
The shunt branch equivalent circuit parameters (R_o, X_o) can be determined by performing this test. Since, the core loss & the magnetizing current depend on applied voltage, this test is performed by applying the rated voltage to LV winding & keeping the HV winding open. The circuit ~~dig~~ diagram to conduct this test is shown in fig.(a). The ammeter (A), Voltmeter (V) & Wattmeter (W) are connected in LV side of transformer as shown in fig.(a). Since, the secondary terminals are open (no load is connected across the secondary), current drawn from the source is called as "no load current". Through OC test find core loss of transformer.

Teacher's Sign. :

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2. Short Circuit Test :

The series equivalent circuit parameters (R_1, X_1, R_2, X_2) can be determined by performing this test. In this test, the secondary winding is short circuited with the help of thick wire. As high voltage side is low current side, it is convenient to connect high voltage side to supply & shorting the low voltage secondary side. Suppose the input voltage is reduced to a small fraction of rated value & secondary terminals are short-circuited. A current will circulate in the secondary winding. Since a small fraction of rated voltage is applied to the primary winding, the flux in the core and hence the core loss is very small. Now, the current flowing through the winding of transformer is rated current. Hence, total loss will be copper loss at full load. The Ammeter (A), Voltmeter (V) & Wattmeter (W) are connected in HV side of transform~~ation~~er as shown in fig (b).

• Procedure :

OPEN CIRCUIT TEST

1. Connect the circuit as shown in circuit digram.
2. Apply voltage equal to the rated voltage.
3. Note the reading of wattmeter, ammeter & voltmeter.

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4. Reduce the output voltage of the variac to zero & switch off supply.

SHORT CIRCUIT TEST

1. Connect the circuit as shown in diagram.
2. Increase the value gradually such that rated current current of the transformer is passing through the primary.
3. Note the reading of wattmeter, ammeter & Voltmeter
4. Reduce the output of the variac to zero & switch off the supply.

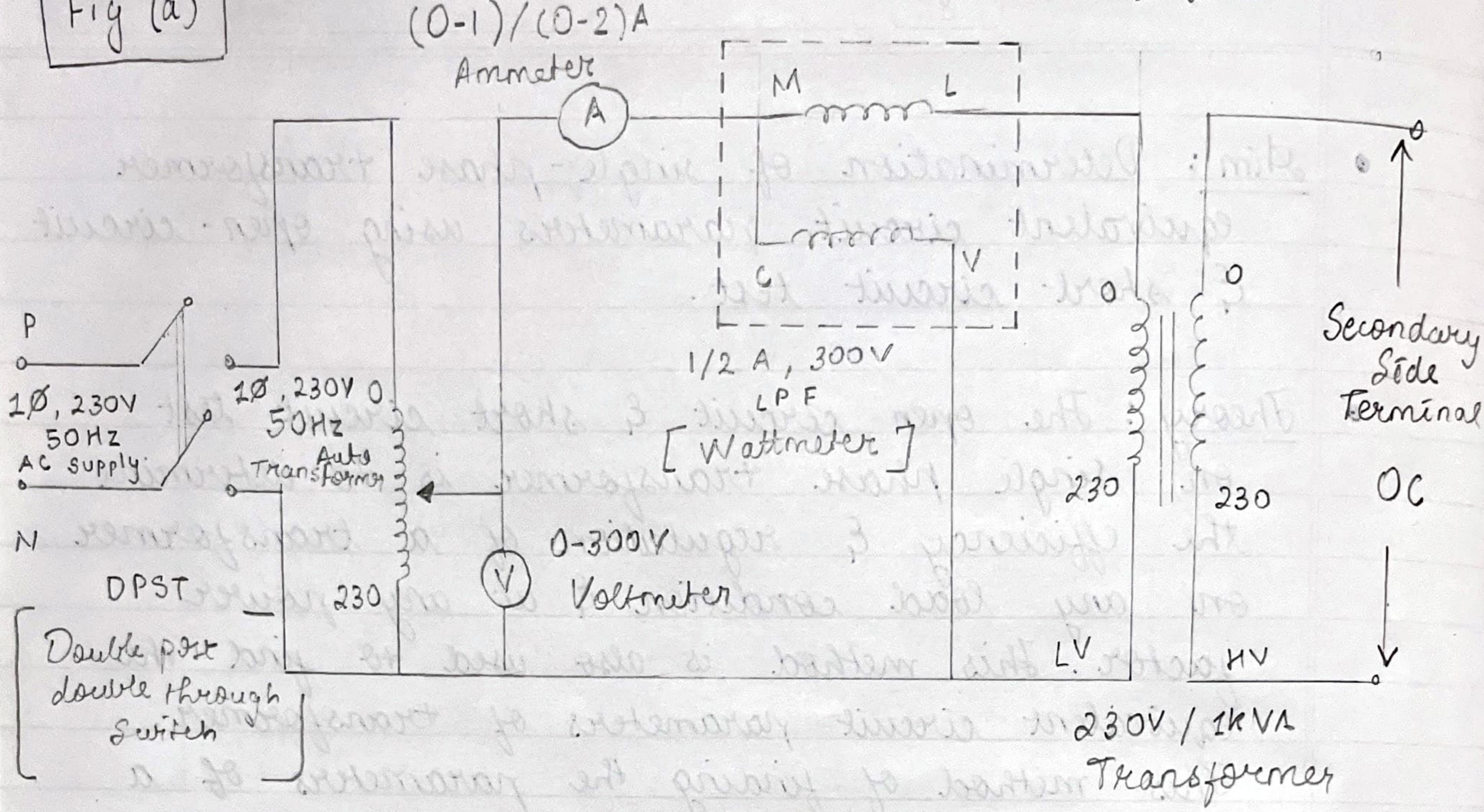
- Conclusion:

This test is used to find the efficiency ~~of~~ & voltage regulation of low rating transformer. This test is not available for high rating transformer, because of the non-availabity of large capacity load in laboratory & expensive power consumption for testing transformer.

APPARATUS REQUIRED :

Sr no.	Name	Type	Range	Qty.
1.	Voltmeter	Moving Iron (MI) type	0-300 V (OC)	1
			0 - 75 V (SC)	1
2.	Ammeter	Moving Iron (MI) type	(0-1)/(0-2) A (OC)	1
			(0-5)/(0-10) A (SC)	1
3.	Wattmeter	(Dynamometer) type wattmeter	1/2 A, 300V LPF (OC)	1
			5/10 A, 75V UPF (SC)	1
4.	Auto-transformer	Single Phase Variac (AC)	0-230 V	1
5.	Single Phase Transformer	(Core Type) AC	1KVA / 230V (turns ratio 1:1)	1
6.	Connecting Wires	-	-	-

Fig (a)


1: 1
(0-1)/(0-2)A
Ammeter
A
M
L
C
V
P
N
1Ø, 230V
50Hz
AC supply
1Ø, 230V
50Hz
Auto Transformer
0
230
DPST
Double post double through Switch
1/2 A, 300V
LPF
[Wattmeter]
0-300V
V
Voltmeter
0
230
LV
0
230
HV
Secondary Side Terminal
OC
230V / 1KVA
Transformer

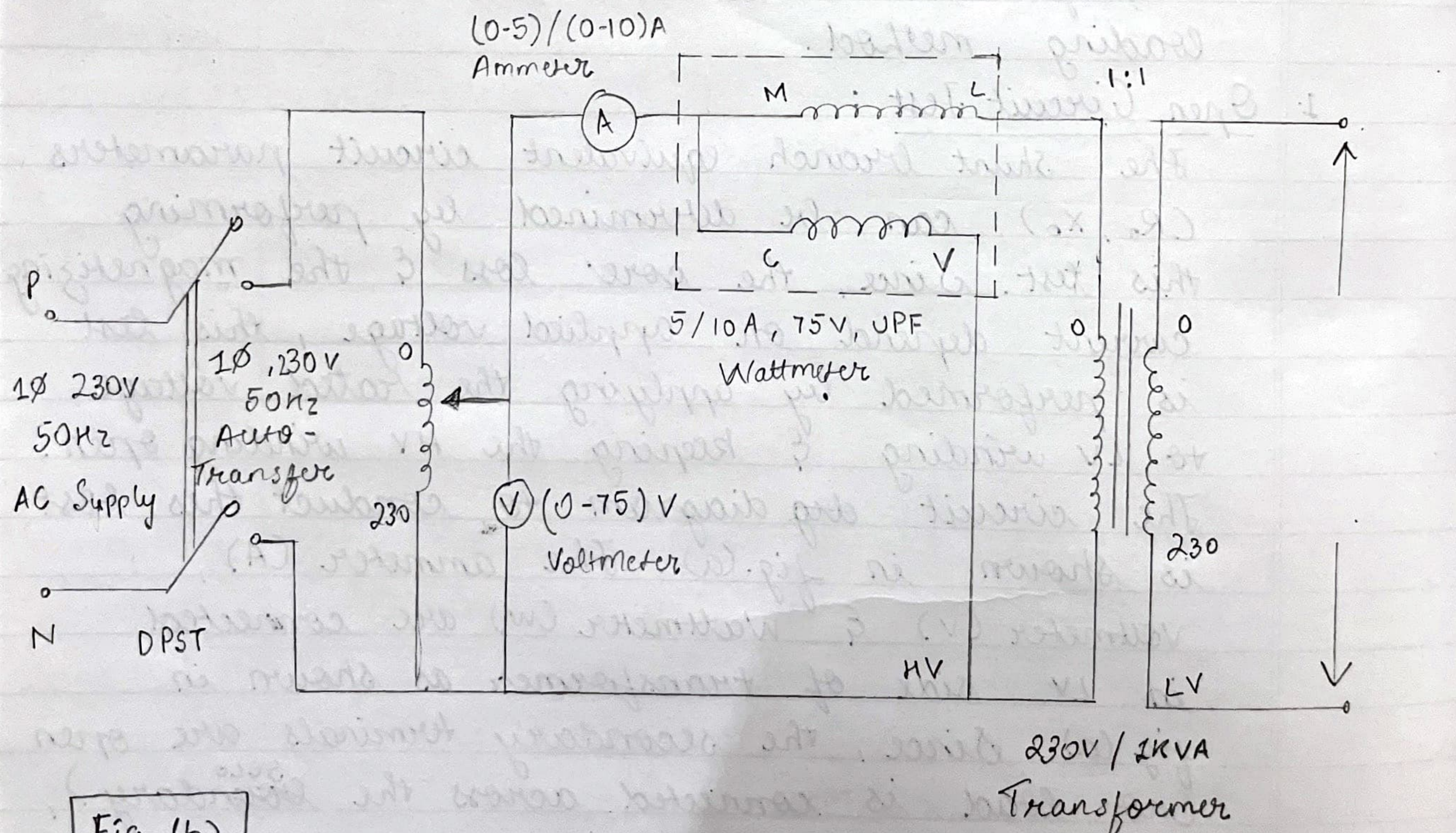

(0-5)/(0-10)A
Ammeter
A
M
L
C
V
1:1
5/10A, 75V, UPF
Wattmeter
P
N
1Ø 230V
50Hz
AC Supply
1Ø, 230V
50Hz
Auto-Transfer
0
230
DPST
V
(0-75) V
Voltmeter
0
HV
0
230
LV
230V / 1KVA
Transformer

Fig (b)

Observation Table :

OPEN CIRCUIT TEST –

$\boxed{\cos\phi = 0.2}$

V_{oc}	I_{oc}	W_{oc} mf = 4
230V	0.48A	5.2

SHORT CIRCUIT TEST –

V_{sc}	I_{sc}	W_{sc} mf = 1
13V	4.34 A	40

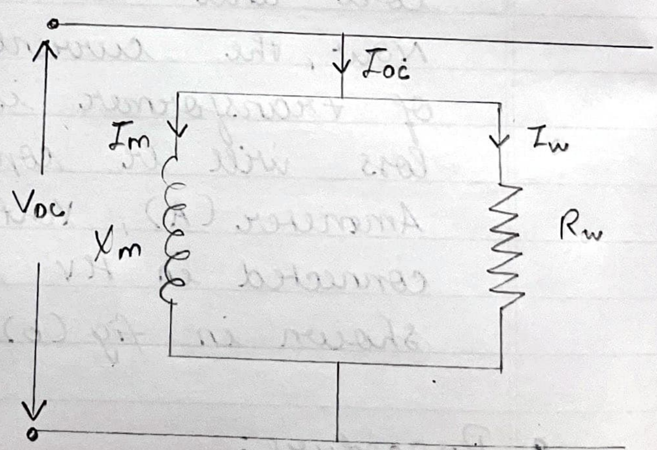
Calculations :

$$W_{oc} = V_{oc} I_{oc} \cos\phi_0$$

$$\Rightarrow \cos\phi = \frac{W_{oc}}{V_{oc} I_{oc}} = \frac{20.8}{(230)(0.48)}$$

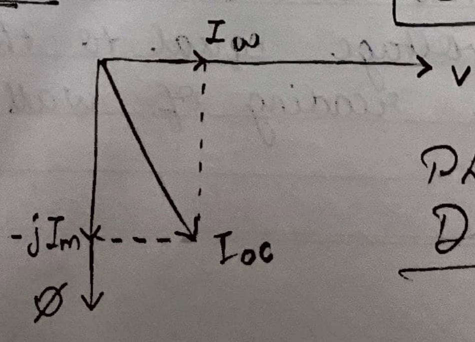
$$\boxed{\cos\phi = 0.188}$$

Equivalent Ckt



- $I_w = I_{oc}\cos\phi = (0.48)(0.188) = 0.09024A$
- $I_m = I_{oc}\sin\phi = (0.48)(0.96) = 0.463A$
- $R_w = \frac{V_{oc}}{I_w} = \frac{230}{0.0902} = 2549.889\,\Omega$
- $X_m = \frac{V_{oc}}{I_m} = \frac{230}{0.463} = 496.76\,\Omega$

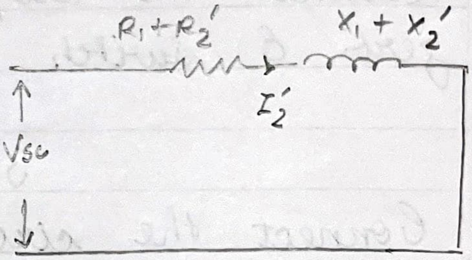
$\boxed{OC}$



Phasor Diagram

Calculations :

Equivalent ckt



$W_{sc} = V_{sc} I_{sc} \cos\phi_{sc}$

$\Rightarrow \cos\phi_{sc} = \dfrac{40}{(13)(4.34)} = \underline{0.7089}$

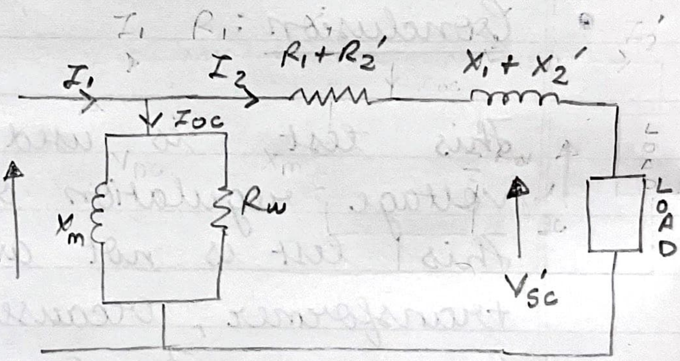
- $R_{sc} = \dfrac{W_{sc}}{I_{sc}^2} = \dfrac{40}{(4.34)^2} = 2.124\,\Omega$
- $Z_{sc} = \dfrac{V_{sc}}{I_{sc}} = \dfrac{13}{4.34} = 3$

$\boxed{S.C}$

- $X_{sc} = \sqrt{Z_{sc}^2 - R_{sc}^2} = \sqrt{3^2 - (2.124)^2} = \underline{4.4886\,\Omega}$

$\therefore R_1 = R_2' = \dfrac{R_{sc}}{2} = 1.062\,\Omega$ | $X_1 = X_2' = \dfrac{X_{sc}}{2} = 2.2443\,\Omega$

Final Eq. Circuit



$\boxed{\text{EFFICIENCY}}$

$\eta = \dfrac{\text{output power}}{\text{input power}} = \dfrac{x \cdot S \cdot \cos\phi}{x \cdot S \cdot \cos\phi + W_{oc} + W_{sc} x^2}$

S - rated VA (1000 VA)

x - fraction of full load of the transformer

ϕ - load power factor angle

W_{sc} - Copper losses

I at $\cos\phi = 1$

→ $x_1 = 0.25$

$$\eta_1 = \frac{(0.25)(1000)(1)}{(0.25)(1000) + 20.8 + 40(0.025)} = \underline{91.97\%}$$

→ $x_2 = 0.5$

$$\eta_2 = \frac{(0.5)(1000)(1)}{(0.5)(1000) + 20.8 + 40(0.25)} = \underline{94.197\%}$$

→ $x_3 = 0.75$

$$\eta_3 = \frac{(0.75)(1000)(1)}{(0.75)(1000) + 20.8 + 40(0.4225)} = \underline{95.21\%}$$

→ $x_4 = 1$

$$\eta_4 = \frac{(1)(1000)(1)}{1000 + 20.8 + 1(40)} = \underline{94.26\%}$$

II at $\cos\phi = 0.8$

→ $x_1 = 0.25$ $$\eta_1 = \frac{(0.25)(1000)(0.8)}{(0.25)(1000)(0.8) + 20.8 + 40(0.25)^2} = \underline{\underline{89.56\%}}$$

→ $x_2 = 0.5$ $$\eta_2 = \frac{(0.5)(1000)(0.8)}{(0.5)(1000)(0.8) + 20.8 + 40(0.25)} = \underline{\underline{92.85\%}}$$

→ $x_3 = 0.75$ $$\eta_3 = \frac{(0.75)(1000)(0.8)}{(0.75)(1000)(0.8) + 20.8 + 40(0.75)^2} = \underline{\underline{93.27\%}}$$

→ $x_4 = 1$ $$\eta_4 = \frac{(1)(1000)(0.8)}{1(1000)(0.8) + 20.8 + 40} = \underline{\underline{92.93\%}}$$

Voltage Regulation

$$\% \text{ Regulation} = \left[\frac{I_{sc} \times R_{sc} \times \cos\phi + I_{sc} \times X_{sc} \sin\phi}{V_{rated}\ (230V)}\right] \times 100$$

→ $\sin\phi = 0 \quad \cos\phi = 1$

$\boxed{VR = 4\%}$

→ $\cos\phi = 0.8 \quad \sin\phi = 0.6$

$\boxed{VR = 5.59\%}$

→ $\cos\phi = 0.8 \quad \sin\phi = -0.6$

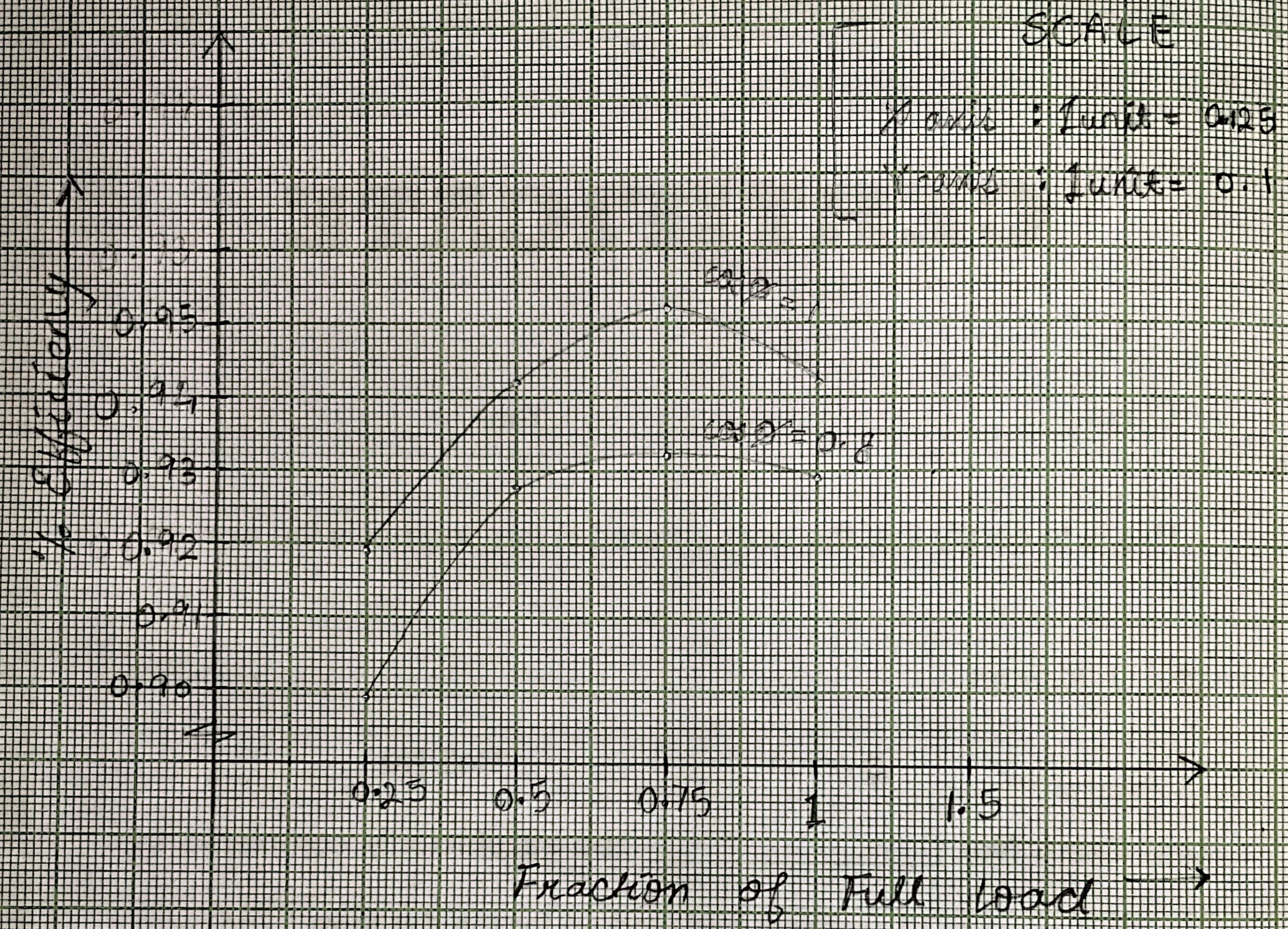
$\boxed{VR = 8.04\%}$

→ $\cos\phi = 0.6 \quad \sin\phi = 0.8$

$\boxed{VR = 5.59\%}$

→ $\cos\phi = 0.6 \quad \sin\phi = -0.8$

$\boxed{VR = -0.79\%}$


SCALE
X axis : 1 unit = 0.125
Y axis : 1 unit = 0.1
cos φ = 1
cos φ = 0.8
% Efficiency
0.95
0.94
0.93
0.92
0.91
0.90
0.25
0.5
0.75
1
1.5
Fraction of Full load