ENG231 - Electrical Machines And Transformers - Assesment 2 Lab 4

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1.1 Name Plate

VA ratings	500
Primary voltage (V)	240
Secondary voltage (V)	115
Primary current (A)	2.1
Secondary current (A)	4.4
Turns ratio	2.1

1.2 DC Test

Primary resistance (R_{1dc}) (Ω)	1.5
Secondary resistance (R_{2dc}) (Ω)	0.4

The primary side has a higher resistance than the secondary side, this is because the primary side has more turns.

$$\begin{aligned} a &= 2.1 \\ R_{eqHV} &= a^2 R_2 + R_1 \\ R_{eqHV} &= 3.242\Omega \\ R_{eqLV} &= (1/a)^2 R_1 + R_2 \\ R_{eqLV} &= 1.12\Omega \end{aligned}$$

1.3 Open Circuit Test

	Primary				Secondary
	V1	I1	Poc	PF	V2
LV side open	110	0.563	10.3	0.165	220
HV side open	240	0.375	12.5	0.138	120

[Group] Calculate turns ratio for your transformer (a = N1 / N2) based on measured open-circuit voltages. Explain why there is a difference (if there is any difference) between your measurements and the nameplate voltages?

LV side open

$$a = \frac{V_2}{V_1}$$
$$a = 2$$

HV side open

$$a = \frac{V_2}{V_1}$$
$$a = 2$$

[Group] Calculate power factor from voltage, current and power measurements and verify that it matches your measured value (from power analyser)

LV side open

$$\begin{aligned} PF &= \frac{P_{oc}}{V_1 I_1} \\ &= 0.16631 \end{aligned}$$

HV side open

$$\begin{aligned} PF &= \frac{P_{oc}}{V_1 I_1} \\ &= 0.13889 \end{aligned}$$

The calculated power factor is very close to the measured power factor.

[Group] Calculate the core resistance Rc1 and the magnetizing reactance Xm1. (Do this now in the lab and check with the demonstrator that you have something reasonable before you continue)

LV side open

$$\begin{aligned} R_{c1} &= \frac{V_1^2}{P_{oc}} \\ &= 1174.76\Omega \\ X_{m1} &= \frac{V_1}{\sqrt{I_1^2 + \left(\frac{V_1}{R_{c1}}\right)^2}} \\ &= 192.73\Omega \end{aligned}$$

HV side open

$$\begin{aligned} R_{c1} &= \frac{V_1^2}{P_{oc}} \\ &= 4680\Omega \\ X_{m1} &= \frac{V_1}{\sqrt{I_1^2 + \left(\frac{V_1}{R_{c1}}\right)^2}} \\ &= 633.92\Omega \end{aligned}$$

[Individual] Comment on the differences, if any, between supplying power and measuring from the HV side or the LV side The LV side shows a higher power compared to the HV side.

This means that the LV side consumes more power. This can makes sense with the calculated resistances, the LV side has a higher resistance and hence a higher power draw.

[Individual] Calculate the % increase in current observed when voltage is increased by 20% above rated voltage? Comment on your observations and discuss? TODO: I dont think we did this

[Individual] On the Power Analyser (still while operating at 20% above rated voltage) observe transformer supply V and I waveforms. Include a sketch or image of a key waveform observed to help describe what you have observed and why? Does the waveform vary as supply voltage is varied?

1.4 Short Circus Test

	Primary				Secondary
	V1	I1	Psc	PF	I2
LV side Short circuited	7	1.76	10	0.863	3.5

[Group] Calculate R_{eq} & X_{eq}.

$$\begin{aligned} R_{eq} &= \frac{P_{sc}}{I_1^2} \\ &= 3.228\Omega \\ X_{eq} &= \sqrt{\left(\frac{V_1}{I_1}\right)^2 - R_{eq}^2} \\ &= 5.123\Omega \end{aligned}$$

[Group] Calculate power factor from these values and verify your measured value.

$$\begin{aligned} PF &= \frac{P_{sc}}{V_1 I_1} \\ &= 0.81169 \end{aligned}$$

The calculated power factor matches the measured one.

[Individual] Compare R_{eq} (equivalent winding AC resistance) to the DC resistance values measured earlier (you will need to refer them both to the same side). Why do you think there is a difference (if there is any)?

$$R_{dcTotal} = 3.1\Omega$$

The AC resistance is slightly larger than the DC resistance

[Individual] Draw the full equivalent circuit for your transformer, labelling impedances with your determined transformer parameters

TODO

1.5 Performance Test / Full Load Test

```
clear
clc
close
V2=[ 120, 119, 118, 118, 117, 116, 115];
P1=[ 80, 102, 147, 191, 277, 409, 537];
P2=[ 67, 90, 133, 177, 262, 386, 509];
I2=[ 0.56, 0.753, 1.12, 1.5, 2.2, 3.3, 4.4];
Eff=P2./P1*100;
```

```
subplot(2, 1, 1);
plot(I2, V2, 'o', 'LineWidth', 2);
xlabel('Secondary Current (A)');
ylabel('Measured Secondary Voltage (V)');
title('Measured Secondary Voltage vs. Secondary Current');
grid on;

subplot(2, 1, 2);
plot(I2, Eff, 'o', 'LineWidth', 2);
xlabel('Secondary Current (A)');
ylabel('Efficiency');
title('Efficiency vs. Secondary Current');
grid on;

title('Voltage and Efficiency vs. Secondary Current');
```

```
clear
clc
close
% Transformer Parameters
V1_rated = 240; % Primary rated voltage (V)
V2_rated = 115; % Secondary rated voltage (V)
R1 = 1.5;       % Primary resistance (Ω)
R2 = 0.4;       % Secondary resistance (Ω)
X1 = 192.73;       % Primary reactance (Ω)
X2 = 633.92;       % Secondary reactance (Ω)
S_rated = 10^3; % Rated power (VA)

% Load Conditions (Ohms)
load_resistances = [200, 150, 100, 75, 50, 33, 25]; % Load values (Ω)

% Initialize results
results = zeros(length(load_resistances), 8); % Columns for V1, I1, P1, PF, V2, I2, P2,
↪  Efficiency

for i = 1:length(load_resistances)
    R_load = load_resistances(i);

    % Calculate secondary current (I2)
    I2 = V2_rated / R_load; % Assuming full load voltage

    % Calculate secondary voltage (V2)
    V2 = V2_rated - (I2 * R2) - (I2 * 1j * X2); % Complex voltage

    % Calculate primary current (I1)
    I1 = (I2 * V2_rated) / V1_rated; % Assuming ideal transformer

    % Calculate power (assuming PF = 1 for simplicity)
    P2 = V2 * I2; % Output power
    P1 = V1_rated * I1; % Input power (ideal case)

    % Calculate efficiency
    efficiency = (abs(P2) / abs(P1)) * 100; % Efficiency in percentage

    % Store results
    results(i, :) = [V1_rated, I1, abs(P1), 1, abs(V2), I2, abs(P2), efficiency];
end
```

```
% Display results
disp('Results (V1, I1, P1, PF, V2, I2, P2, Efficiency):');
disp(results);

% Plotting
figure;
subplot(2, 1, 1);
plot(load_resistances, results(:, 5), '-o'); % Secondary Voltage
xlabel('Load Resistance (Ω)');
ylabel('Secondary Voltage (V)');
title('Secondary Voltage vs Load Resistance');

subplot(2, 1, 2);
plot(load_resistances, results(:, 8), '-o'); % Efficiency
xlabel('Load Resistance (Ω)');
ylabel('Efficiency (%)');
title('Efficiency vs Load Resistance');
```

```
clear
clc
close

% Transformer Parameters
V1_rated = 240; % Primary rated voltage (V)
V2_rated = 115; % Secondary rated voltage (V)
R1 = 1.5;       % Primary resistance (Ω)
R2 = 0.4;       % Secondary resistance (Ω)
X1 = 5.123;    % Primary reactance (Ω)
S_rated = 500;  % Rated power (VA)
```

1.6 Three-phase Transformer Configurations

1.6.1 Y-Y Connected Transformer

	Primary Side				Secondary Side	
Quantity	Expected	Observed		Quantity	Expected	Observed
VRN	139	139		Vrn	139	139
VWN	139	141		Vwn	139	142
VBN	139	139		Vbn	139	139
VRW	240	243		Vrw	240	243
VWB	240	243		Vwb	240	243
VBR	240	240		Vbr	240	240

1.6.2 Δ-Y Connected Transformer

	Primary Side				Secondary Side	
Quantity	Expected	Observed		Quantity	Expected	Observed
VRW	181	183		Vrn	181	180

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	Primary Side				Secondary Side	
VWB	181	181		Vwn	181	183
VBR	181	181		Vbn	181	181
				Vrw	315	315
				Vwb	315	315
				Vbr	315	320

1.6.3 Y-Δ Connected Transformer

	Primary Side				Secondary Side	
Quantity	Expected	Observed		Quantity	Expected	Observed
VRN	139	141		Vrw	139	141
VWN	139	142		Vwb	139	140
VBN	139	140		Vbr	139	140
VRW	240	245				
VWB	240	243				
VBR	240	242				

1.6.4 Δ-Δ Connected Transformer

	Primary Side				Secondary Side	
Quantity	Expected	Observed		Quantity	Expected	Observed
VRW	240	243		Vrw	240	243
VWB	240	243		Vwb	240	243
VBR	240	240		Vbr	240	240