Department of Electrical and Electronic Engineering

Course Code: EEE301

Section no: 01

Group No. 07

Project on Transformer Construction

Submitted To: Khalid Imtiaz Saad

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Link of Activity Log:
https://docs.google.com/spreadsheets/d/18biV527VK4CiK0OTMuTgzOrph2W1t0Y0qTK-jzv3L2I/edit?usp=sharing

Activity Log

Serial	Date	Activity	Description	Participants
1	Nov 14, 2022	The group has been made		
2	Nov 15, 2022	Attending a meeting	We attend to a meeting and take decision about buying bobbin and core	Habiba, Tamim, Siam, Ramim
3	Nov 19, 2022	Going to Market	We supposed to go to the market and buy bobbin	Tamim, Siam, Ramim
4	Nov 22, 2022	Doing the calculation	We had a meeting on our campus and carried the calculation result	Habiba, Tamim, Siam, Ramim
5	Nov 30, 2022	Going to Market	We had bought wire, core, mask tap and other necessary equipment for transformer	Tamim, Siam, Ramim
6	Dec 2, 2022	Build the Transformer	Build our transformer with all the equipment	Habiba, Tamim, Siam, Ramim
7	Dec 14, 2022	Making Procedure & Datasheet	We had called a meeting and made the procedure and datasheet	Habiba, Tamim, Siam, Ramim
8	Dec 19, 2022	Completing the Report	We had called a meeting and made the report	Habiba, Tamim, Siam, Ramim

Calculation for Construction of a Transformer

1. Core Calculation:

Area of Core, A = 4.9 cm × 3.3 cm = 16.17 cm^2

= 0.001617 m^2

Operation Frequency, f = 50 Hz

Magnetic Flux Density, B = 1.2 Wbm^{-2}

Turns Per Voltage, T = $\frac{1}{4.44fBA} = \frac{1}{4.44 \times 50 \times 1.2 \times 0.001617}$ = 2.32 turns

2. Primary Winding Calculation:

Primary Voltage, $V_1 = 220$ V

Primary Current, $I_1 = \frac{S}{V_1} = \frac{10}{220} = 0.045$ A

Total Numbers of Turns, $N_1 = T \times V_1 = 2.32 \times 220 = 510.4 \approx 511$ Turns

3. Size of Conductor:

Current Density of Copper = 2.3 Amm^{-2}

Area = $\frac{\text{Current}}{\text{Current density}} = \frac{0.045}{2.3} = 0.0196\ mm^2 = 0.0000304\ inch^2$

From the standard American wire gauge table, we can find the conductor size = 34 gauge

4. Weight estimation of the Winding:

As our bobbin is rectangle, Length of One Turn = 2* (Height + Width)

$= 2 * (4.9 + 3.3) = 16.4$ cm $= 0.164$ m

Total Length of All Turns of Primary = Length of One Turn × Total Number of Turns of Primary

$= 0.164 \times 511 = 83.804$ m

Area of Conductor = 0.000031 inch^2 = $1.999 \times 10^{-8}\ m^2$

Volume of Copper Wire = Area of conductor × Length

$= 1.999 \times 10^{-8} \times 83.804 = 1.68 \times 10^{-6}\ m^3$

Density of Copper = 8960 kgm^{-3}

Weight of Primary Conductor = Density × Volume

$= 8960 \times 1.68 \times 10^{-6} = 0.015\ kg$

5. Secondary Winding Calculation:

Secondary Voltage, $V_2 = 80$ V

Secondary Current, $I_2 = \frac{S}{V_2} = \frac{10}{80} = 0.125$ A

Total Numbers of Turns, $N_2 = T \times V_2 = 2.32 \times 80 = 185.6 \approx 186$ Turns

6. Size of Conductor:

Current Density of Copper = 2.3 Amm^{-2}

Area = $\frac{\text{Current}}{\text{Current density}} = \frac{0.125}{2.3} = 0.054\ \text{mm}^2 = 0.0000837\ \text{inch}^2$

From the Standard American Wire Gauge Table, we can find the conductor size = 29 gauge

7. Weight estimation of the Winding:

Length of One Turn = 0.164 m

Total Length of All Turns of Secondary = Length of One Turn × Total Number of Turns of Secondary = 0.164 × 186

= 30.504 m

Area of Conductor = 0.0000837 inch^2 = 5.4×10^{-8} m^2

Volume of Copper Wire = Area of Conductor × Length

= $5.4\times10^{-8} \times 30.504 = 1.65\times10^{-6}$ m^3

Density of Copper = 8960 kgm^{-3}

Weight of Secondary Conductor = Density × Volume

= $8960 \times 1.65\times10^{-6} = 0.015$ kg

Calculation Table for Primary Side

Parameter	Formula	Value
Power ratting	Given	10VA
Voltage	Given	220V
Current	$I_1 = S/V_1$	0.045 A
Conductor size	Current density = Current Area	0.0000304 $inch^2$
Wire gauge	Check from the given Table	34 gauge
Number of turns	N_1= Turns per V × Primary Side Voltage	511 Turns
Total wire length	Total Length of All Turns in Primary = Length of One Turn × Total Number of Turns of Primary	83.804 m
Volume of conductor	Volume = Area × Length	1.68×10^{-6} m^3
Weight of conductor	Weight = Density × Volume	0.015 *kg*

Calculation Table for Secondary Side

Parameter	Formula	Value
Power ratting	Given	10VA
Voltage	Given	80V
Current	$I_2 = S/V_2$	0.125 A
Conductor size	Current density = Current Area	0.0000837 $inch^2$
Wire gauge	Check from the given Table	29 gauge
Number of turns	N_1= Turns per V × Primary Side Voltage	186 Turns
Total wire length	Total Length of All Turns in Primary = Length of One Turn × Total Number of Turns of Primary	30.504 m
Volume of conductor	Volume = Area × Length	$1.65 \times 10^{-6}\ m^3$
Weight of conductor	Weight = Density × Volume	0.015 kg

Calculations of verification of the transformer

Verify the turns ratio and Apparent power of the transformer at various loads.

Objective: The objective of this project is to design and construct a transformer according to proper specification and verification of the design.

Theory: Transformers operate on the principles of Faraday's law of electromagnetic induction and mutual induction. A transformer core has two coils, a primary coil and a secondary coil. The primary core receives electrical energy from a power source and couples this energy to the secondary winding by means of a changing magnetic field. Turns ratio of transformer means the ratio of Primary turns to secondary turns.

To calculate turns ratio (**a**) we use the formula,

$$\boldsymbol{a = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{i_2}{i_1}}$$

And to verify Apparent Power (S) we use the formula, S = $\mathbf{V_1\, i_1 = V_2\, i_2}$.

Procedure:

1. Connect the transformer's primary side with a variable AC source and secondary side with resistive load of 600Ω and an AC voltmeter.

2. Supply 220V in primary side and measure the output voltage and current in secondary side. Tabulate the value of voltages in Table-01.

3. Follow the same process for 2400 Ω, 1600 Ω, 1200 Ω, 960 Ω, 685 Ω, 600 Ω, 480 Ω and 400 Ω resistive load and measure primary side voltage and secondary side voltage. Tabulate the value of voltages in Table-01.

4. Calculate Turns ratio and apparent power from Table-01 using primary and secondary side voltage.

5. Disconnect the transformer from resistive load and switch off the power supply.

6. Repeat the same process (Step 1 – Step 4) for inductive load, tabulate the voltages in Table-02 and measure turns ratio from the Table.

7. Repeat the same process (Step 1 – Step 4) for capacitive load, tabulate the voltages in Table-03 and measure turns ratio from the Table.

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Section	**01**
Group Number	**07**
Date	**19 December 2022**
Instructor's Signature	19/12/22

$i_0 = 0.25\,A$

Table-1: Recorded values for resistive load.

Load(Ω)	Primary Voltage (V_1)	Primary Current (i_1)	Secondary Voltage (V_2)	Secondary Current (i_2)	Turns Ratio (a)	Apparent Power (S)
∞						
400						
480						
600						
685	220	0.35	79	0.125	2.78	9.9
960	220	0.325	80	0.09	2.75	7.2
1200	220	0.36	80	0.07	2.75	5.6
1600	220	0.35	80	0.05	2.75	4
2400	220	0.30	79	0.04	2.78	3.16

Table-2: Recorded values for Inductive load.

Load(Ω)	Primary Voltage (V_1)	Primary Current (i_1)	Secondary Voltage (V_2)	Secondary Current (i_2)	Turns Ratio (a)	Apparent Power (S)
400						
480						
600						
685						
960	220	0.30	78	0.085	2.8	6.63
1200	220	0.30	79	0.07	2.78	5.53
1600	220	0.29	80	0.055	2.75	4.4
2400	220	0.30	80	0.03	2.75	2.4

Table-3: Recorded values for capacitive load.

Load(Ω)	Primary Voltage (V_1)	Primary Current (i_1)	Secondary Voltage (V_2)	Secondary Current (i_2)	Turns Ratio (a)	Apparent Power (S)
400						
480						
600						
685	220	0.26	80	0.13	2.75	10.04
960	220	0.25	81	0.095	2.72	7.695
1200	220	0.25	80	0.075	2.75	6
1600	220	0.25	81	0.055	2.72	4.45
2400	220	0.26	81	0.03	2.72	2.43

Discussion: In this experiment, we learned how to calculate and built a transformer under given requirements. From our testing, we found that we got our desired output voltage and turns ratio but we haven't got our desired current. At no load, our LT side current was also higher than our calculation. The loss of the flux in the core could be the reason for drawing a large exciting current. The higher resistance of the copper we used also could be a reason for the loss.