ELEC 302-81
Lab 3
Non-Ideal Transformer Properties

February 11, 2013

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1 Purpose of Experiment

In this experiment, the non-ideal properties of a transformer were examined. The performance of the transformer at the Lab-Volt station was first analyzed by measuring the primary and secondary: voltages, currents, and powers. Then the transformer was subjected to an open-circuit test and a short-circuit test in order to generate the equivalent circuit components. These results were then compared to the original performance specifications to show the transformer's non-ideal properties.

2 Procedure

2.1 EMS Workstation Set-up

At the Lab-Volt EMS workstation, a Fluke multi-meter was used to measure the DC resistance of the transformer windings. These values are recorded in Table 1. The DAI 24V supply was turned on, and the DAI USB connector was connected between the EMS workstation and the PC. On the LVDAM EMS application software, the metering windows for E_1, E_2, I_1, and I_2 were opened, set to continuous refresh.

2.2 Transformer Performance

With the main power switch set OFF and the voltage control knob fully CCW, the voltmeter selector switch was set to position 4–N. The circuit represented by Figure 1 was constructed with the secondary voltmeter E_2 open-circuited at first to simulate an infinite load. The main power supply was turned on, and the supply voltage was adjusted to 120V. The primary voltage E_1, primary current I_1, input power P_1, secondary voltage E_2, secondary current I_2, and output power P_2 were then measured for each of the four different loads listed in Table **??**. Prior to changing each load, the voltage supply knob was set fully CCW and the main power switch to OFF.

2.3 Open Circuit Test

The circuit shown in Figure 2 was then constructed. The main power switch was set ON and the voltage control knob was adjusted to 120V. The values of the primary voltage E_1, primary current I_1, and input power P_1 were measured. These values were recorded in Table 3. The main power switch was set OFF and the voltage control knob fully CCW.

2.4 Short Circuit Test

The circuit shown in Figure 3 was then constructed. It was noted that I_2 short circuited the secondary windings 5-6. Thus the voltage supply knob was slowly adjusted until a secondary current of 0.4A was obtained. The primary voltage, primary current, input power, and the secondary current were measured. These values were recorded in Table 4. The main power switch was set OFF and the voltage control knob fully CCW.

3 Results

3.1 Transformer Performance

Winding #	**Resistance** Ω
1–2	7.9
5–6	7.9

Table 1: Winding Resistances

Load	**Primary Voltage**	**Primary Current**	**Input Power**	**Secondary Voltage**	**Secondary Current**	**Output Power**
Z_L Ω	E_1 V	I_1 A	P_1 W	E_2 V	I_2 A	P_2 W
∞	119.9	0.027	2.453	119.0	0.003	0
300	119.3	0.388	46.01	112.4	0.368	41.35
300 + j300	119.5	0.270	23.63	112.4	0.244	20.20
300 - j300	119.5	0.281	27.30	120.0	0.276	23.52

Table 2: Primary and secondary voltages and currents

3.2 Open Circuit Test

Primary Voltage	**Primary Current**	**Input Power**
E_1 V	I_1 A	P_2 W
119.7	0.027	2.44

Table 3: Open Circuit

3.3 Short Circuit Test

Primary Voltage	**Primary Current**	**Input Power**	**Secondary Current**
E_1 V	I_1 A	P_1 W	I_2 A
11.7	0.403	2.607	0.398

Table 4: Data for Fig 3

4 Analysis

4.1 Transformer Equivalent Circuit Component Values

$\mathbf{R}_C$ Ω	$\mathbf{X}_M$ Ω	$\mathbf{R}_{eq}$ Ω	$\mathbf{X}_{eq}$ Ω
5.85k	6.80k	16.05	24.19

Table 5: Equivalent Transformer Components

4.2 Transformer Losses

	Losses	
Load Ω	$\mathbf{P_{Cu}}$ W	$\mathbf{P_{core}}$ W
∞	0.0014	2.453
300	2.162	2.433
300 + j300	0.956	2.441
300 - j300	1.223	2.437

Table 6: Copper and Core Losses

4.3 Voltage Regulation and Efficiency Comparison

Load Ω	**VR** Part 1	**VR** $\mathrm{R_{eq}}$	**Percent Difference**
∞	0.00	0.00	0.00
300	5.97	6.39	7.0
300 + j300	6.16	6.69	8.6
300 - j300	-0.92	-1.25	35.9

Table 7: Transformer Voltage Regulation (VR)

Load Ω	η Part 1	η $\mathrm{R_{eq}}$	**Percent Difference**
∞	0.00	0.00	0.00
300	89.72	87.41	2.6
300 + j300	85.57	86.02	0.5
300 - j300	86.11	86.93	0.9

Table 8: Transformer Efficiencies (η)

5 Conclusions

By measuring the resistance of each transformer winding and not getting any extremely high resistance readings similar to an open circuit, it was determined that the transformer windings had no faults and the integrity of the windings were intact.

In Table 5 the circuit components of the transformer equivalent circuit are listed. These values were computed by using the voltage, current, and power values obtained from both the open-circuit test and short-circuit test.

In Table 6 the copper and core losses for each load are listed. The copper loss equation used was $\mathrm{P}_{C}u = \mathrm{I}_{S}$

Circuits Tested

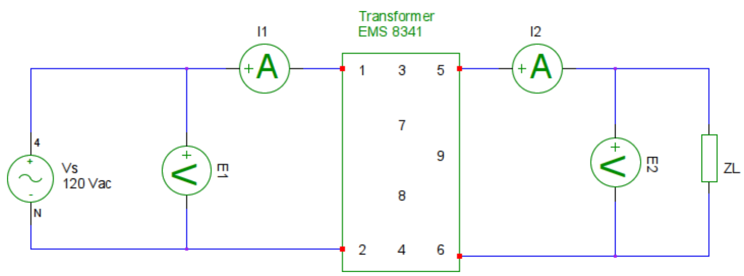

Figure 1: Single Phase Transformer Circuit for part one

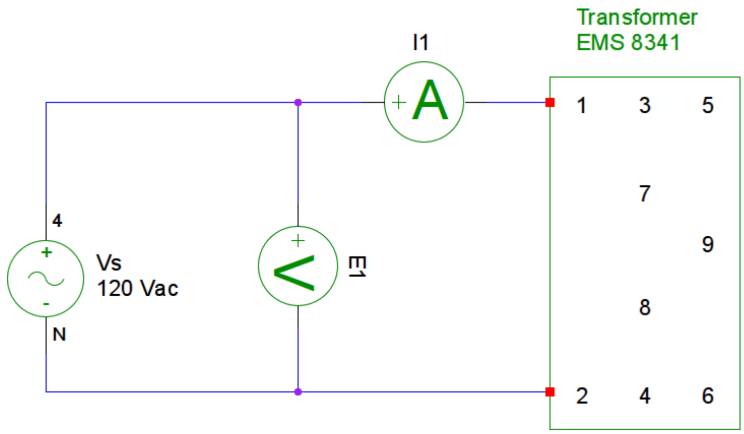

Figure 2: Single Phase Transformer Circuit for part two (open circuit test)

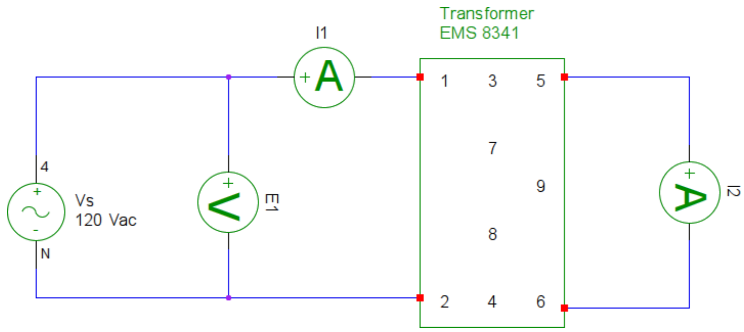

Figure 3: Single Phase Transformer Circuit for part two (short circuit test)