EET 1150

1) LAB NUMBER: **9**

2) TITLE: **Power Transformers**

3) OBJECTIVES:

After completing this lab, the student will be able to:

1) determine the basic characteristics of a power transformer,
2) verify the usefulness of its equivalent circuit,
3) determine its efficiency.

4) EQUIPMENT:

METEX MS_9150 Generator
Oscilloscope
DMM
Experimenter board

5) COMPONENTS:

2- 5.1 Ω ½ watt 5% Resistor
1- Transformer (Mouser 41LK020)

6) TEXT REFERENCE:

Circuit Analysis: Theory and Practice (5th Edition):
A.H. Robbins and W.C. Miller

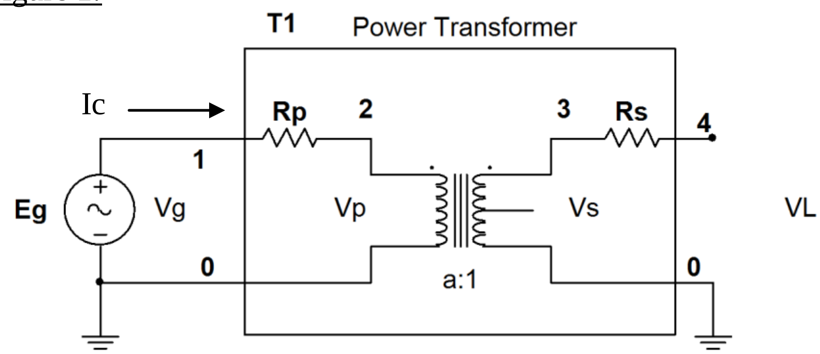
Section 23.2: Iron-Core Transformers: The Ideal Model
Section 23.3: Reflected Impedance
Section 23:5: Transformer Applications
Section 23.6: Practical Iron-Core Transformers

7) PRE-LAB ASSIGNMENT:

A – Open Secondary Study:

Study Fig.1 and do the followings:

Figure 1:



a) Rp is the primary coil resistance, Rs is the secondary coil resistance. When the secondary is open, the primary side has a small current Ic due to core loss. Since Ic is small and there is no secondary current:

$$Vp \sim Vg \qquad \text{and} \qquad VL = Vs$$

Thus the turn ratio "a" can be determined by the primary and secondary voltage ratio. Complete Table 1.

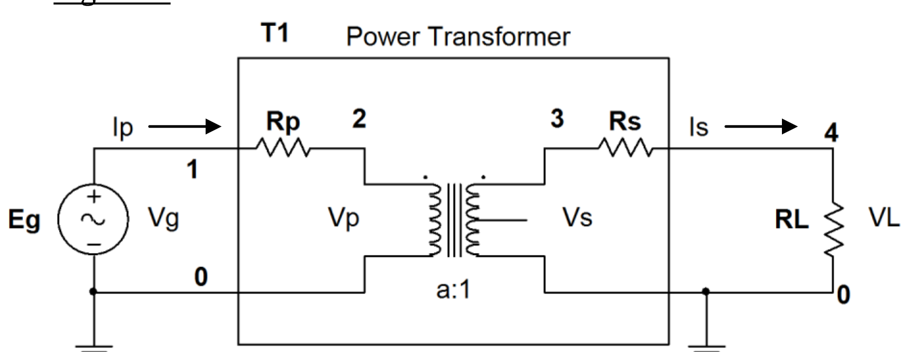
Table 1:

a = --------

B – Load Study:

b) In Fig.2, a load resistance RL is connected to the secondary side. Primary current Ip and secondary current Is flow.

Figure 2:



c) If we calculate the ratio of Is/Ip, will it give us the turn ration “a”?

d) If your answer is “No”, what correction should you make to the primary current Ip to get a result comparable to that of Table 1? (Hint: Think of the current components making up Ip)

Record your calculation in Table 2.

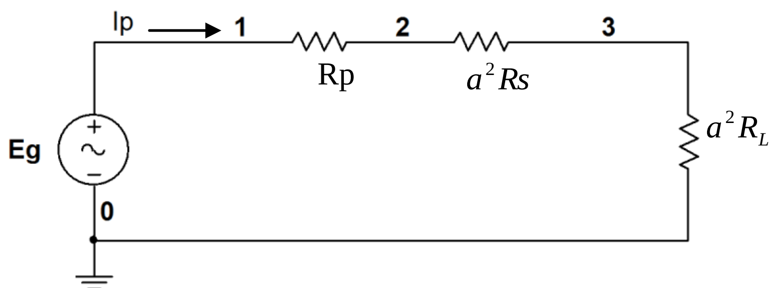
Table 2:

a = -----------------

C – Reflected Impedance Calculations:

e) Fig.3 shows a simplified equivalent circuit of the transformer with the secondary side reflected to the primary side:

Figure 3:



f) Calculate the primary current Ip from the given parameters. Record your results in Table 3:

Table 3:

Ip = ------------------------

g) If Pin is the power supplied by the source Eg, and Pout is the power delivered to the Load. Record the formula for the calculation of Efficiency:

Table 4:

η = -------------- x 100%

8) MEASUREMENTS:

A – Open Secondary Study:

a) Measure the resistance Rp of the primary coil and Rs of the secondary coil. Record your results in Table 5:

Table 5:

Rp (Ω)	
Rs (Ω)	

b) Set the METEX Generator to 60Hz and its output to zero. Connect the primary coil to this output using BNC – crocodile clip cable (Fig.1).

c) Set the DMM to measure AC voltage (RMS) and connect it to measure the primary voltage Vg. Increase the METEX output to maximum.

d) Use the DMM to measure Vg and Vs (ignore the center tap) then set the DMM to measure AC current and measure the primary core loss current Ic. Record your results in Table 6:

Table 6:

Vg (V)	
Vs (V)	
Ic (mA)	

e) Use these results and the formula in Table 1 to calculate the turn ratio. Record your result in Table 7.

Table 7:

a =

f) The secondary coil has a center tab. Connect the Ground clips of both channels of the oscilloscope to this center tab, then connect CH1 to the upper secondary output tab and CH2 to the lower secondary output tab. Set the two Vertical channels to the same gain. Observe the amplitudes and phases of both outputs. Record your results in Table 8.

Table 8:

Magnitude	Equal / Not Equal
Phase	Same / Opposite

B – Load Study:

g) Connect CH1 (1) to measure Vg and **one 5.1Ω resistor** across the secondary as the Load (Fig.2). Connect CH2 (4-0) to measure VL. Set the DMM to measure AC current and break the circuit at a suitable point to measure the primary current. From VL calculate the secondary current Is. Record your results in Table 9.

Note: Vg will drop due to the loss in the Generator internal resistance. Since the Load is small, we use the scope to determine Is to reduce error due to the DMM internal resistance as it is connected in series with the Load.

Table 9:

Vg (V-RMS)	
VL (V-RMS)	
Ip (mA)	
Is (mA)	

h) Look back at Pre-Lab step (c) and (d) then use Table 2 to calculate the turn ratio "a". Record your result in table 10

Table 10:

a =

i) Compare Table 10 to Table 7.

C – Reflected Impedance Calculations:

j) Look at Fig.3 and use the measured values of Rp and Rs in Table 5 and RL (5.1Ω), calculate the total primary resistance (Rpt), and primary current (use "a" from table 10 and Eg = Vg). Record your results in Table 11.

Table 11:

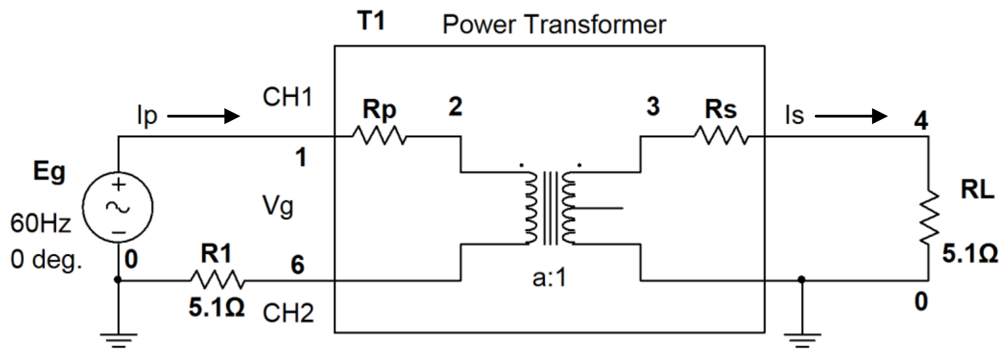
Rpt (Ω)	
Ip (mA)	

k) Compare the value of Ip in Table 11 and that in Table 9.

D – Efficiency Calculation:

l) Connect a **5.1Ω sense resistor** (R1) as in Fig 4 and connect CH2 to measure its phase (6) relative to CH1 which is connected across the primary (1) (both Ground clips are connected to the same low side of the supply).

Figure 4



m) Measure the phase shift (θ) and note its sign.
Record your results in Table 12.

Table 12:

θ (deg)	

n) The power Pin supplied by the source and the output power Po are calculated from. Use data in Tables 9 and 12 to determine these powers and record in Table 13.

$$Pin = Vg \times Ip \cos \theta$$
$$Po = (Is)^2 \times RL$$

Table 13:

Pin (mW)	
Po (mW)	
η (%)	

o) Use these results to calculate the Efficiency (η) of this transformer. Record all your results in Table 13.

9) LAB REPORT REQUIREMENT:

Your team's Lab Report should contain the followings:

A Cover Page with Lab Number, Lab Title, Team members' Names and Date.
An Introductory Page with list of Equipment and Components used.

Result Pages with:

A – Open Secondary Study:

Procedure:

(Summarize the main activities that your team did (past tense) in this section).

Results:

Show copy of Tables 5, 6, 7, 8.

Discussions:

1) What is the nature of the core loss current Ic?
2) Why do the two ends of the secondary coil have equal magnitudes and opposite phase?

B – Load Study:

Procedure:

(Summarize the main activities that your team did (past tense) in this section).

Results:

Show copy of Tables 9, 10.

Discussions:

1) Answer 8 (i).
2) What causes the differences?

C – Reflected Impedance Calculations:

Procedure:

(Summarize the main activities that your team did (past tense) in this section).

Results:

Show a copy of Table 11.

Discussions:

1) Answer 8 (k).
2) What causes the differences? According to the Text Reference, what else should be included in the equivalent circuit?

D – Efficiency Calculation:

Procedure:

(Summarize the main activities that your team did (past tense) in this section).

Results:

Show copy of Tables 12, 13.

Discussions:

1) What kind of efficiency does this transformer have?
2) Our testing was not done at rated voltage and current, if they were done at rated conditions would the efficiency be higher?

E – Conclusion:

1) Is the equivalent circuit useful? Explain your answer.

2) Can you now determine the basic characteristics of a power transformer? Explain your answer.

3) Are all the Lab objectives met? Explain if some are not.

Appendix:

Attach all Pre-Lab calculations.