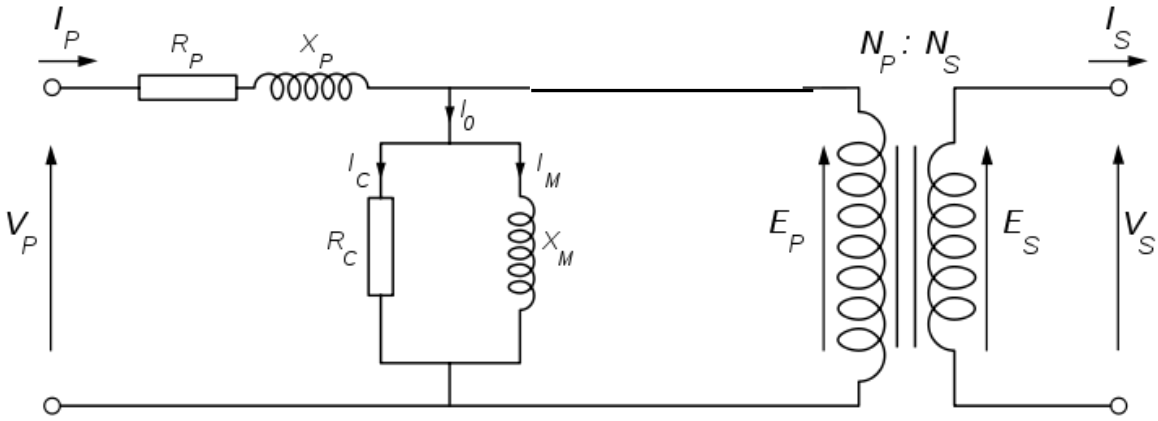
EE 340L
EXPERIMENT # 4

ELECTRIC POWER TRANSFORMERS

A practical power transformer can be represented by an ideal transformer, a series impedance, and a shunt impedance as shown below. In the series impedance, Rp represents the resistance of the copper windings, and Xp represents the reactance associated with the leakage flux. In the shunt impedance, Rc is associated with the losses in the core material (due to eddy currents), and Xm is associated with the flux flowing in the core material. Note that in a typical power transformer, the series impedance is very small when compared to the shunt impedance.



Ideal Transformer

A.Transformer Polarity and Turn Ratio:

1. Connect a 1-Φ transformer to a 120V power supply and leave the secondary side open as shown in Fig. (a). Record the primary and secondary voltages, V_p and V_s.
2. Connect the transformer as shown in Fig. (b) and measure V.

B. Open and Short Circuit Tests:

1. Connect a 1-Φ transformer to a 120V power supply and leave the secondary side open as shown in Fig. (a). Record the exciting current (i.e., the current flowing through the transformer under no load) and active power delivered to the transformer. Note that under no load, Vp ≈ Ep, since the voltage drop across the series impedance is very small, hence can be neglected.
2. 1. Connect the primary side of the transformer to a variable AC power supply which must initially be set to **zero** volts. Short circuit the secondary side (see

figure (c)) and **slowly** increase the variable supply voltage until the secondary current reaches 3 A.

C. Transformer Voltage Regulation and Efficiency

1. Connect the circuit shown in Fig 2(d) with V_p = 120V, L = 0.133 H, and R = 50 Ω.
2. Record the current, active power and voltage at the source side (i.e., primary side).
3. Repeat the measurements above on the load side (i.e., secondary side)

D. Transformer Hysteresis Loop

It is desired to view the transformer hysteresis loop with the aid of an oscilloscope. This requires the plot one signal that is proportional to the flux density versus another signal that is proportional the excitation current.

1. Design an appropriate circuit that is suitable of the above, and indicate the signals to be measured, and their corresponding proportionality constants.
2. Conduct and experiment using 120V supply and take snapshot of the scope display.
3. Repeat 2. By increasing the voltage supply to 140 V.

QUESTIONS

I. Transformer Polarity and Equivalent Circuit

1. Determine the turn ratio and polarity marking from the measurements in Part A of the experiment.
2. Determine the core resistance R_c and magnetizing reactance X_m of the transformer from the open circuit test.
3. Calculate the equivalent copper resistance Rp and leakage reactance Xp of the transformer (when referred to the primary side) from the short circuit test.

II. Voltage Regulation and Efficiency

4. Determine the transformer voltage regulation and efficiency under the specified load in figure 2(d) from the measured values. Transformer voltage regulation and efficiency are defined as follows:

$$VR(\%) = 100\frac{Vs(at\ no\ load) - Vs(under\ load)}{Vs(under\ load)}$$

$$Eff\ (\%) = 100\frac{P(out)}{P(in)}$$

5. Suppose that a variable Resistive load is connected across the secondary terminals of the transformer. Show that maximum efficiency is achieved when the power lost in Rp is equal to the power lost in Rc. Then calculate the maximum efficiency of this particular transformer.

II. Hysteresis Loop

1. Discuss the problems encountered (if any) and the results.

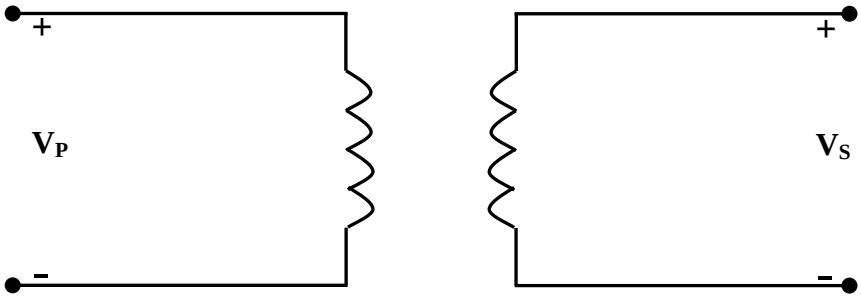


Fig. (a)

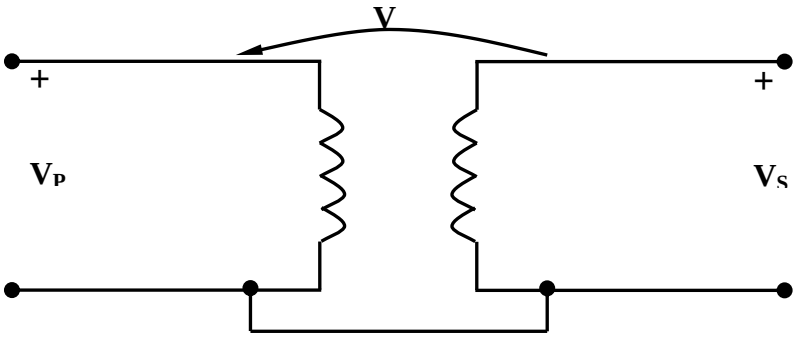


Fig. (b)

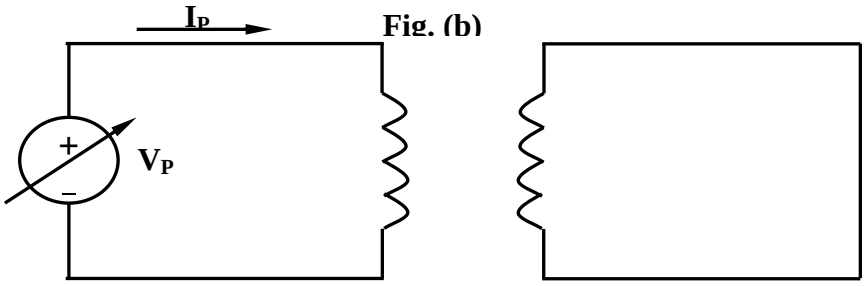


Fig. (c)

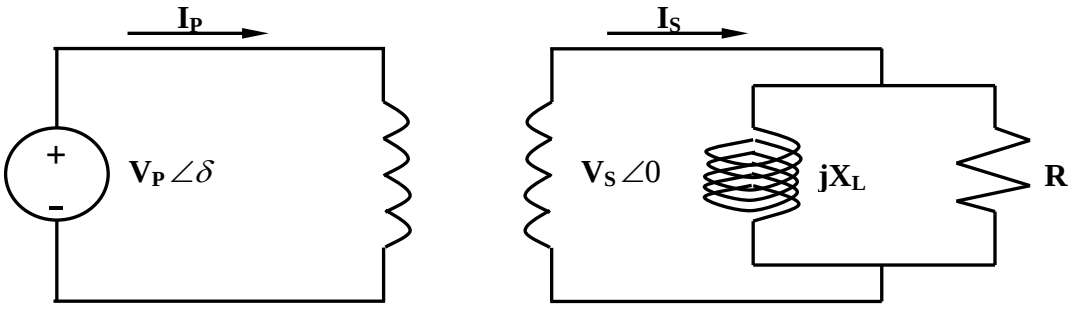


Fig. (d)