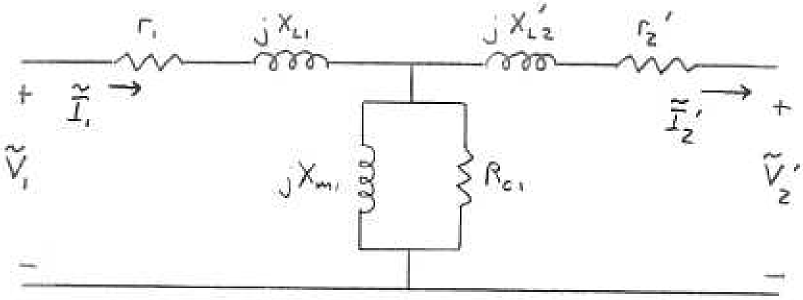
Spring 2007

EE228 CIRCUIT ANALYSIS II
Laboratory Exercise #12A
"Transformer T-Equivalent Circuit Parameter Determination"

Background: Today we will apply some standard measurement tests to determine the six circuit components of the transformer T-equivalent circuit.



We will be using the EMS8341 transformer that provides various interconnection possibilities. For our study, we will be treating the coil between terminals 1 and 2 as the *primary* and the coil between terminals 3 and 4 as the *secondary*. Record the rated voltage and current are for the primary and secondary.

$V_{1,rat}$ = ________ $I_{1,rat}$ = ________ $V_{2,rat}$ = ________ $I_{2,rat}$ = ________

Part 1. Coil Resistance Determination

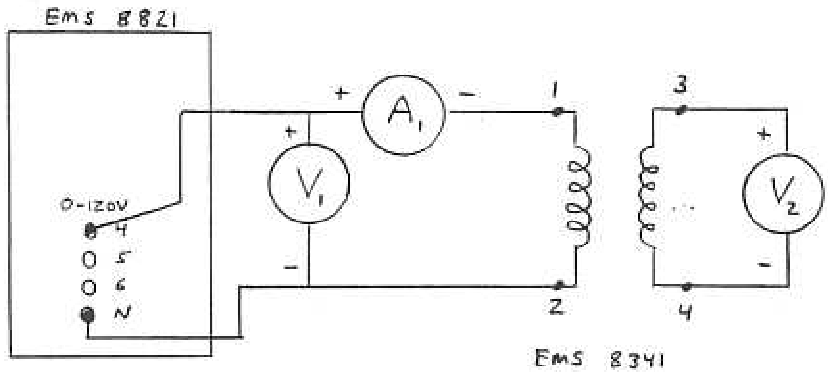
a. Using the handheld or desktop Digital Multi-Meter, measure the DC resistance of the primary and secondary windings (make sure to be on as low of scale as possible)

r_1 = ________ r_2 = ________

b. "Skin effect" is the phenomenon we associate with AC currents producing AC fluxes that tend to push the current flowing in the conductor to the outside of the conductor. This effect is rather small at 60Hz. However, since we know that resistance is given by $R = \frac{\rho L}{A}$, will the coil resistances at 60Hz be slightly higher or lower than those measured above?

Part 2. Open-Circuit Measurement Data

a. Build the following circuit using two phases of the power analyzer, the transformer, and the variable voltage terminals of the power supply. Ensure that the voltage control knob of the power supply is fully CCW (0V). Have the instructor verify your setup before continuing: ____________



b. Note, with only a voltmeter across the secondary winding, it is open circuited. Energize the power supply and increase the power supply voltage to 120Vrms (or maximum) using the voltage control knob.

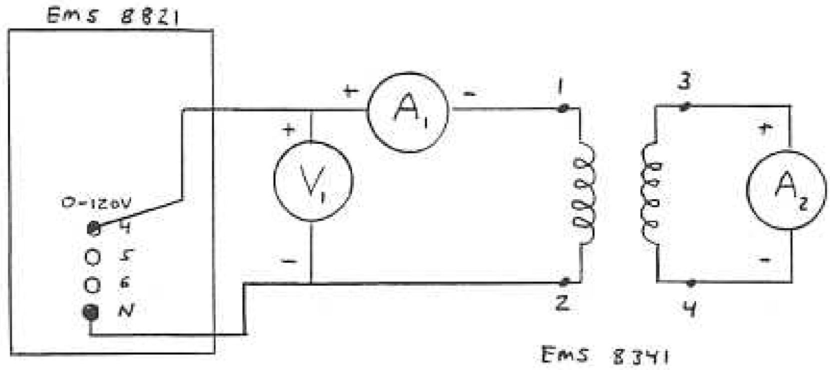
c. Record the primary voltage, primary current, primary real power, and secondary voltage below.

$V_{1,OC}$ = ________ $I_{1,OC}$ = ________ $P_{1,OC}$ = ________ $V_{2,OC}$ = ________

d. De-energize the power supply and return the voltage control knob to zero. Given that the number of primary turns is given by $N_1 = 500$ and that the number of turns of the secondary is given by $N_2 = 865$, use these values to compute the "ideal" open-circuit secondary voltage given the measured primary voltage.

Part 3. Short-Circuit Measurement Data

a. Modify your previous circuit setup to the one shown below. Note, this entails replacing the voltmeter across the secondary with an ammeter, essentially imposing a short circuit. Have the instructor verify your setup: __________



b. Note, our goal is to SLOWLY increase the primary voltage until rated primary current flows! Be careful, this will require less than 15V to achieve! Energize the power supply. Slowing increase the primary voltage until rated primary current flows.

c. Record the primary voltage, primary current, primary real power, and the secondary current.

$V_{1,SC}$ = __________ $I_{1,SC}$ = __________ $P_{1,SC}$ = __________ $I_{2,SC}$ = __________

d. De-energize the power supply and return the voltage control knob to zero. Use the given winding turns to predict the "ideal" secondary current given the measured primary current.

Part 4. Calculations

a. Assuming that skin effect is negligible and that $X_{L1} = X'_{L2}$, identify the parameters of the transformer T-equivalent circuit.

b. Calculate the series equivalent of the parallel combination of the magnetizing reactance (jX_{m1}) and the core loss resistance (R_{c1}).

c. Compare the referred secondary resistance r'_2 found from the short-circuit test with the value calculated from the measured secondary resistance r_2 and the turns ratio.

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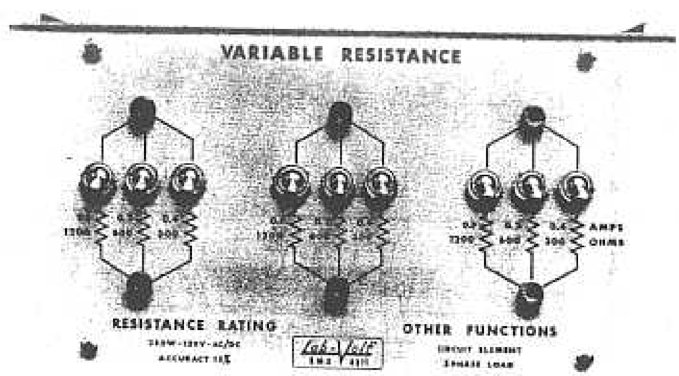
EE228 CIRCUIT ANALYSIS II
Laboratory Exercise #12B
"Transformer Performance Under Load"

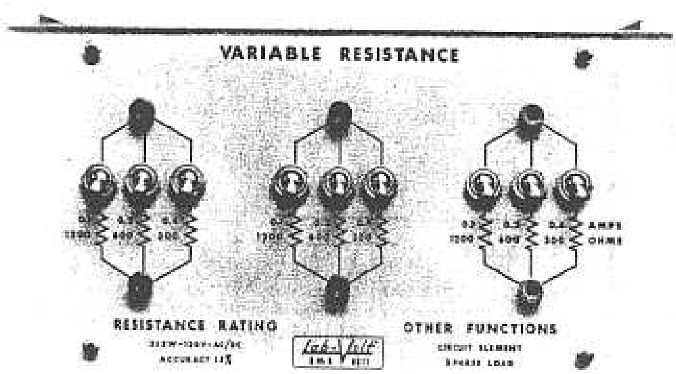
Background: Today we will investigate the behavior of our transformer with a load attached to the secondary. First, we will need to determine what load we can safely attach to the secondary without exceeding its current rating. Second, we will need to determine how to use the load resistance modules to safely achieve the desired resistance values. Again, terminals 1 and 2 constitute the primary; terminals 3 and 4 constitute the secondary. Determine the smallest resistance that can be safely connected to the secondary.

Next, if we wish to attach load resistances of 600Ω, 1200Ω, and 2400Ω, sketch below how we can achieve these values using the EMS 8311 Load Resistance Module

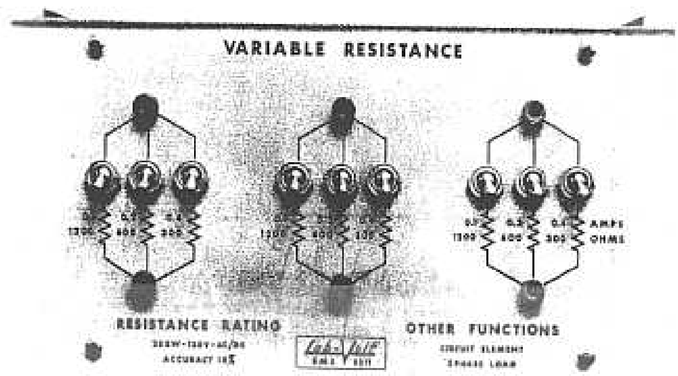
$R_L = 600\Omega$



$R_L = 1200\Omega$

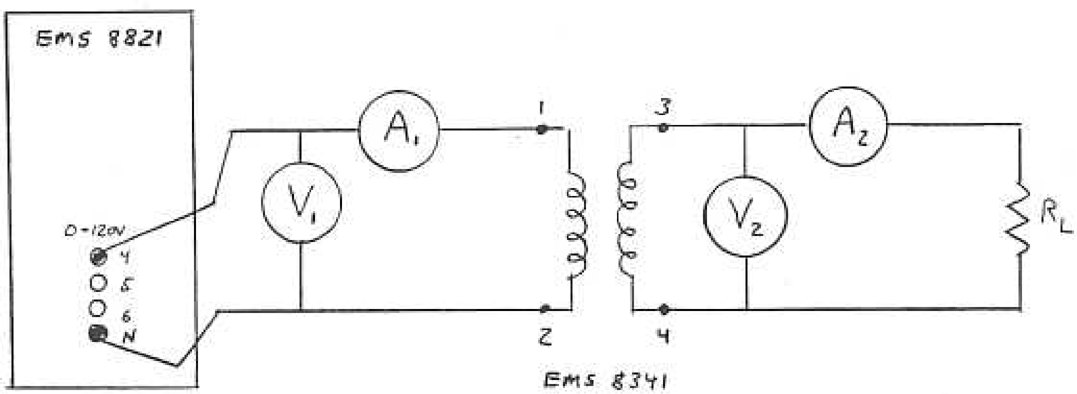


$R_L = 2400\Omega$



Part 1. Experimental Operation Under Load

a. Ensure that the power supply is de-energized and that the variable voltage control knob is fully CCW (zero volts). Build the following circuit using the variable voltage terminals of the power supply, two channels of the power analyzer, and the load resistance module. Set the load resistance for 600Ω. Have the instructor verify your setup: __________



b. Energize the power supply and increase the primary voltage to 120Vrms (or maximum). Record the primary voltage, current and real power. Record the secondary voltage, current and real power.

V_1 = __________ I_1 = __________ P_1 = __________

V_2 = __________ I_2 = __________ P_2 = __________

c. De-energize the power supply. Modify the load resistance bank to achieve a load resistance of 1200Ω. Energize the power supply. Record the primary and secondary voltage, current, and real power.

V_1 = __________ I_1 = __________ P_1 = __________

V_2 = __________ I_2 = __________ P_2 = __________

d. De-energize the power supply. Modify the load resistance bank to achieve a load resistance of 2400Ω. Energize the power supply. Record the primary and secondary voltage, current, and real power.

V_1 = __________ I_1 = __________ P_1 = __________

V_2 = __________ I_2 = __________ P_2 = __________

Part 2. Calculations

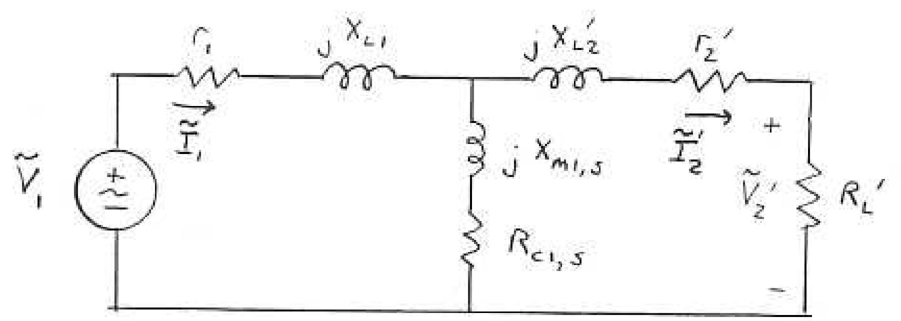
a. Determine the transformer efficiency for the three measured conditions

b. If the voltage regulation (VR) for a transformer is given by

$$VR = \frac{V_{2,NL} - V_{2,FL}}{V_{2,FL}} 100$$

where NL denotes no load (this is data collected in Lab 8A) and FL denotes full load (or closest to rated data collected today), determine VR.

c. Return to Ri-24. From Lab 8A, we determined the parameters of the "real" transformer model with a series equivalent impedance for the T-branch.



Next, given the source voltage and the REFERRED load resistance, write two mesh equations needed to solve for the primary and REFERRED secondary currents.

d. Write a Matlab script file that given the parameters of the transformer (including the turns ratio) and the load resistance, it calculates the actual secondary voltage, secondary current, and transformer efficiency. Compare these results for the three experimental data points. (Note, the mesh equations may be placed in the form Ax = B. This may be solved in Matlab using the matrix inverse function which would have the syntax x = inv(A)*B).