LABORATORY EXPERIMENT NO. 41

TRANSFORMER REGULATION

OBJECT

1. To study the voltage regulation of the transformer with varying loads.
2. To study transformer regulation with inductive and capacitive loading.

DISCUSSION

The load on a large power transformer in a sub-station will vary from a very small value in the early hours of the morning to a very high value during the heavy peaks of maximum industrial and commercial activity. The transformer secondary voltage will vary somewhat with the load and, because motors and incandescent lamps and heating devices are all quite sensitive to voltage changes, transformer regulation is of considerable importance. The secondary voltage is also dependent upon whether the power factor of the load is leading, lagging or unity. Therefore, it should be known how the transformer will behave when it is loaded with a capacitive, an inductive or a resistive load.

If a transformer were perfect *(ideal)* its windings would have no resistance. Furthermore, it would require no reactive power *(vars)* to set up the magnetic field within it. Such a transformer would have perfect regulation under all load conditions and the secondary voltage would remain absolutely constant. But, practical transformers do have winding resistance and they do require reactive power to produce their magnetic fields. The primary and secondary windings possess, therefore, an overall resistance R and an overall reactance X. The equivalent circuit of a power transformer having a turns ratio of *1 to 1*, can be *approximated* by the circuit shown in *Fig. 41-1*. The actual transformer terminals are P_1 P_2 on the primary side and S_1 S_2 on the secondary.

In between these terminals we have shown the transformer as being composed of a perfect *(ideal)* transformer in series with an impedance consisting of R and X, which represents its imperfections. It is clear that if the primary voltage is held constant, then the secondary voltage will vary with loading because of R and X.

An interesting feature arises with a capacitive load, because partial resonance is set up between the capacitance and the reactance X so that the secondary voltage E_2 may actually tend to rise as the capacitive load value increases.

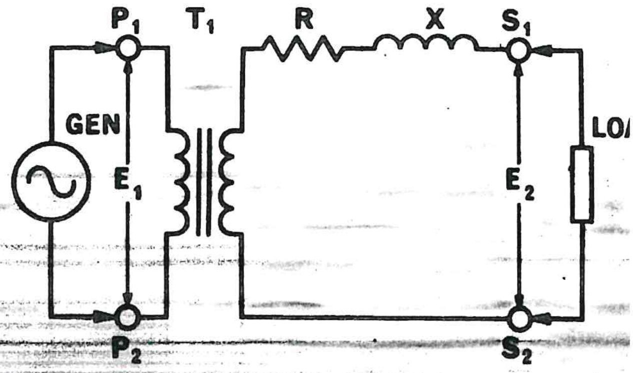

Fig. 41-1

INSTRUMENTS AND COMPONENTS

Transformer Module	*EMS 83*
Power Supply Module *(0-220 Vac)*	*EMS 88*
AC Metering Module *(250/250V)*	*EMS 84*
AC Metering Module *(0.25/0.25A)*	*EMS 84*
Resistance Module	*EMS 83*
Inductance Module	*EMS 83*
Capacitance Module	*EMS 83*
Connection Leads	*EMS 89*

PROCEDURE

Caution: High voltages are present in this Laboratory Experiment! Do not make any connectio with the power on! The power should be turn off after completing each individual measuremen

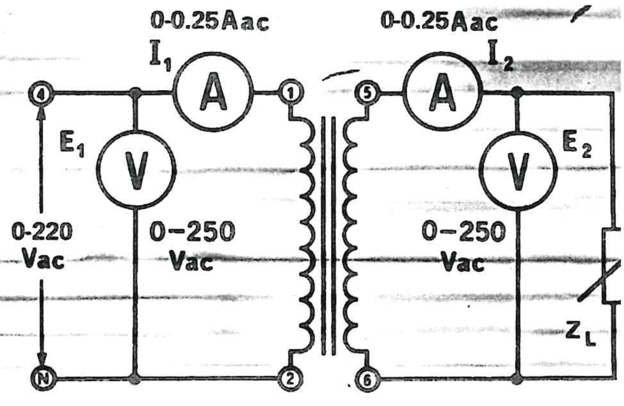

Fig. 41-2

☐ 1. Using your EMS Transformer, Power Supp Resistance and AC Metering Modules, connect t circuit shown in *Fig. 41-2*.

☐ 2. a) Place all of the Resistance Module switches in their open position for zero load current.
☐ b) Turn on the power supply and adjust for exactly 220 Vac as indicated by voltmeter E_1.
☐ c) Measure and record in *Table 41-1* the input current I_1, the output current I_2 and the output voltage E_2.
☐ d) Adjust the load resistance Z_L to 4400Ω. Make sure that the input voltage remains at exactly 220 Vac. Measure and record I_1, I_2 and E_2.
☐ e) Repeat (d) for each of the listed values in *Table 41-1*.
☐ f) Return the voltage to zero and turn off the power supply.

Z_L (ohms)	I_2 (mAac)	E_2 (Vac)	I_1 (mAac)
∞			
4400			
2200			
1467			
1100			
880			

Table 41-1

☐ 3. a) Calculate the transformer regulation using the no-load and full-load output voltages from *Table 41-1*.

____

____

____

_______________ = _______________ %

☐ b) Does the primary winding *VA* equal the secondary winding *VA* for every value of load resistance in the *Table*? __________ Explain.

____

____

____

____

☐ 4. a) Repeat Procedure 2 using the Inductance Module EMS 8328 in place of the resistance load.
☐ b) Record your measurements in *Table 41-2*.

Z_L (ohms)	I_2 (mAac)	E_2 (Vac)	I_1 (mAac)
∞			
4400			
2200			
1467			
1100			
880			

Table 41-2

☐ 5. a) Repeat Procedure 2 using the Capacitance Module EMS 8338 in place of the resistance load.
☐ b) Record your measurements in *Table 41-3*.

Z_L (ohms)	I_2 (mAac)	E_2 (Vac)	I_1 (mAac)
∞			
4400			
2200			
1467			
1100			
880			

Table 41-3

☐ 6. You will now construct an output voltage E_2 vs output current I_2 regulation curve for each type of transformer load.
☐ a) Plot your recorded values of E_2 (at each value of I_2 listed in *Table 41-1*) on the graph of *Fig. 41-3*.
☐ b) Draw a smooth curve through your plotted points. Label this curve "*resistive load*".
☐ c) Repeat (a) for the inductive (*Table 41-2*)

and capacitive *(Table 41-3)* loads. Label these curves *"inductive load"* and *"capacitive load"*.

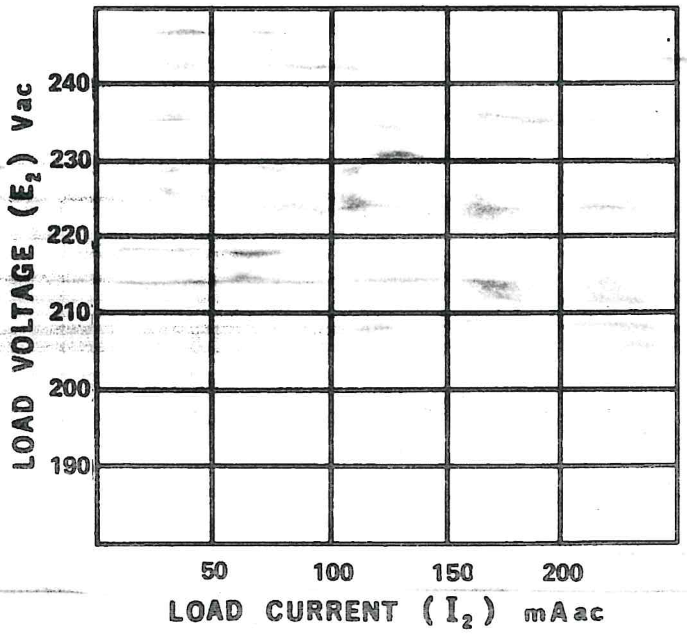

Fig. 41-3

TEST YOUR KNOWLEDGE

1. Explain why the output voltage increases when capacitance loading is used.

2. A transformer has a very low impedance *(small R and X)*:

a) What effect does this have on the regulation?

b) What effect does this have on short-circuit current?

3. Very large transformers are sometimes designed not to have optimum regulation properties in order for the associated circuit breakers to be within reasonable size. Explain.

4. Will transformer heating be approximately the same for resistive, inductive or capacitive loads of the same *VA* rating? __________ Explain.