EXPERIMENT NO. lA

Objective

To conduct Sumpner's test on two identical transformers and calculate their efficiencies at 110%, 100%, 75% and 25% of full load at unity and 0.8 p.f. lagging.

Theory

Two identical transformers are used in this test. The primaries are connected to the supply. The secondaries are connected together such that the voltage in the loop formed by the secondaries is zero, i.e., the voltages are in phase opposition in the loop. Under this condition, the power taken from the mains equals the sum of the iron losses taking place in the two transformers. If an auxiliary voltage source is now introduced in the loop formed by the secondary windings, it essentially sees a short circuit in the primary winding circuit. As such, a small voltage of this source can be made to circulate short circuit currents through the primary and secondary windings of the two transformers equal to their full load currents. The power delivered by this auxiliary source is essentially equal to the copper losses in the windings of the transformers. The auxiliary voltage source is in the form of a booster transformer. See Fig. l.l for details. Since the transformers are identical, we can determine the iron and full load copper losses in each transformer from the readings of the total iron and copper losses. The main advantage of this test is that the power required for operation at any load is only equal to the losses. So, without much expenditure in energy, we can operate the transformers such that the iron and full load copper losses take place in them, and run them in this condition for a long enough time to determine the temperature rise under steady state condition. Such tests are called 'heat run' tests. They are extremely important since power ratings of transformers (for that matter, of any electrical power equipment), are decided by their temperature rise.

Laboratory Work

1. Study the circuit and mark the current paths in the primary and secondary of both the transformers under test.

2. Calculate the ranges of the meters required and get these approved. Make the connections as given in Fig. 1.1 and get them checked.

3. Connect the 4 amp variac (connected in primary of transformers) to single phase supply and increase the voltage from zero to the rated voltage of primary of transformers. If the voltmeter (connected in the circuit of the secondary windings of the test transformers), indicates double of secondary voltage i.e., if emfs are additive in the loop, switch off the supply and interchange any one of the secondary windings and again see the voltage. Now if the voltmeter indicates zero, the secondaries are connected back to back. Short circuit the voltmeter by closing the switch, as shown in Fig. 1.1.

4. Connect the supply to the 15 amps variac (connected in secondary side of transformers) as shown in Fig. 1.1 Increase the voltage (start from zero) of the secondary side of transformers through the variac gradually then the current in the secondaries of the test transformers will vary. Take the meter readings and record them in table for 60%, 80%, 100% and 110% of the rated current of the transformers under test.

Sl. No.	W_P	A_P	W_S	A_S

5. Calculate the efficiency of the transformer at unity and at 0.8 p.f. lagging for the various load currents given above and plot them. Also plot efficiency, copper loss and iron loss versus load current.

Precautions

1. Note carefully the rating of the transformers and connect accordingly the wattmeters, ammeters and voltmeters.

2. Do not exceed the currents in the secondaries of the transformers more than its rating except for 110% load. Keep the load on at 110% only for a short time.

3. Before connecting the variac (auto transformers) to the supply, check it should be at zero position.

4. Get your connections checked before connecting it to the mains.

5. The low power factor wattmeter required the additional single phase ac supply for working. The connection cord is provided for the purpose.

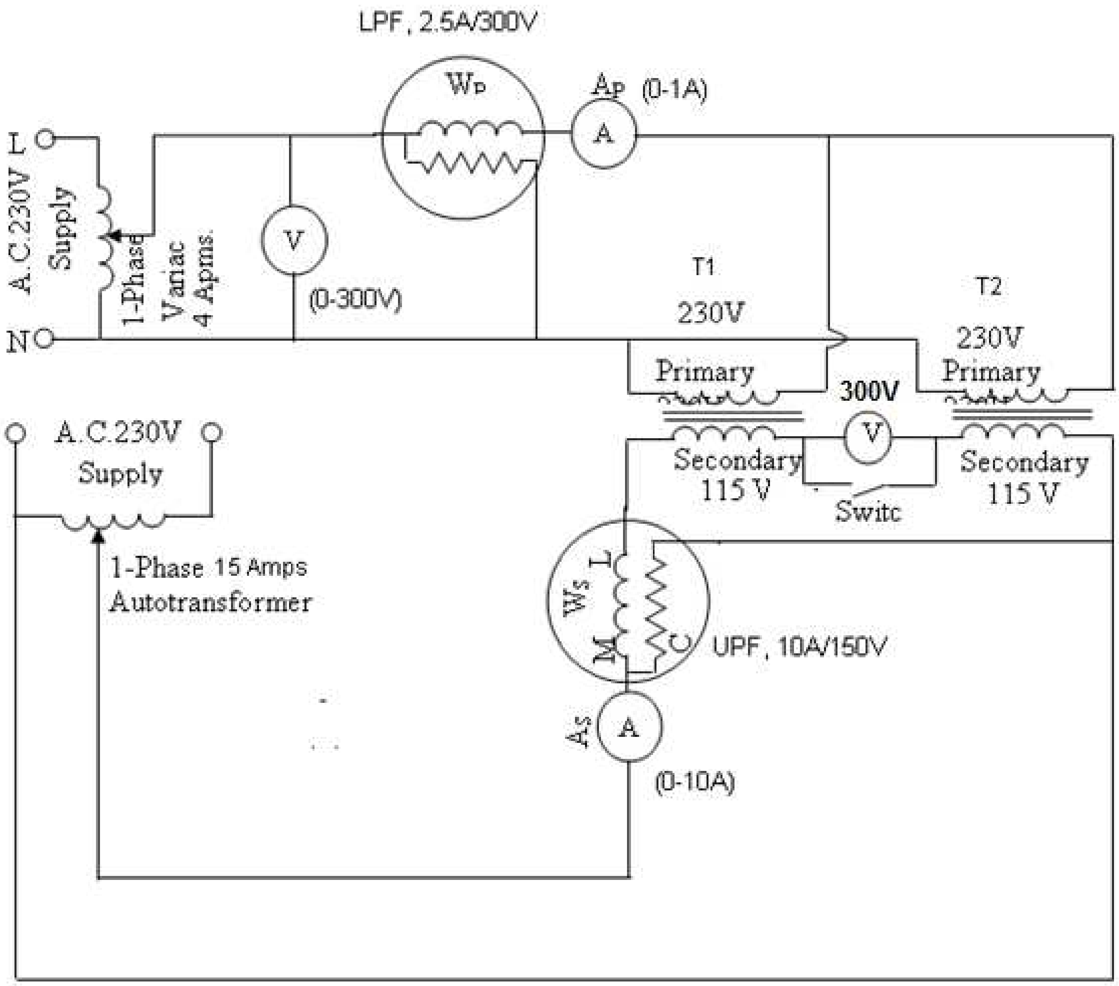

FIG 1.1 Circuit diagram for Sumpner's test.

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EXPERIMENT NO. 1B

Objective

To separate the hysteresis and eddy current losses combined in the core of a 1-phase transformer under the rated conditions.

Theory

At a given flux density, the hysteresis loss is proportional to the frequency, while the eddy current loss is proportional to the square of the frequency. Thus the total core loss P_c in the magnetic circuit of an electric machine can be written as

$$P_c = Hf + Pf^2 \qquad (1B.1)$$

Where f is the frequency, and H and P are functions of flux density B. The term Hf represents hysteresis loss and the term Pf^2 represents eddy current loss. If we keep flux density constant, H and P become constant. Dividing both sides of equation (1B.1) by f, we get,

$$\frac{P_c}{f} = H + Pf \qquad (1B.2)$$

This relationship is utilized in the separation of hysteresis loss from the eddy current loss. Let the value of total loss P_c be available at a certain flux density at two frequencies f1 and f2.

Writing equation (1B.2) at these two frequencies, we have

$$\frac{P_{c1}}{f_1} = H + Pf_1, \qquad (1B.3)$$

$$\frac{P_{c2}}{f_2} = H + Pf_2, \qquad (1B.4)$$

Solving the simultaneous equations, P and H can be determined. The individual losses P_h = Hf and $P_e = Pf^2$ can be computed at any frequency. The rated flux density can be obtained at any frequency by keeping the ratio V/f constant and equal to the value obtained at rated voltage and rated frequency. Here V represents the voltage applied to the transformer primary.

Laboratory Work

1. Draw the circuit diagram with the suitable ranges of the meters. Take the help of the circuit diagram shown in Fig 1.1B. Make the connections according to your circuit diagram, as shown by dotted lines. For separation of losses a variable frequency and variable voltage source is needed for which an alternator coupled with a D.C. shunt

motor is used. It can be assumed that the alternator gives a pure sinusoidal voltage waveform at its output.

2. Keep the D.C. motor field resistance to minimum and armature resistance to maximum position at the time of starting the motor.

3. Get your connections checked by the Lab Instructor. Start the D.C. motor by switching on the DC main switch and bring its speed to 1500 rpm by reducing the resistance of armature rheostat. If the rated speed is not attained by this, then slowly increase the resistance of field rheostat of the shunt motor so that you get 50 Hz supply from the alternator (which is a 4-pole machine in our case).

$$Frequency = \frac{RPM \times No.\,of\;\; poles}{120}$$

[Synchronous speed $= \dfrac{120 \;\; f}{P}$, where f is the frequency of alternator supply]

Core Loss Vs Frequency at Constant Flux Density

4. Keep the field rheostat of alternator to maximum position and then switch on the dc supply of field circuit of alternator.
5. Now switch on the output of alternator and set required voltage , starting from 115 volts and 50 cycles frequency (rated voltage and frequency of transformer), vary the voltage and frequency always in the same proportion, keeping V/f = 115/50 in order to separate eddy current and hysteresis losses under rated conditions. Observe wattage (core loss) and frequency at each point.

6. Completing the experiment switch off supply of dc motor.

Record the readings as shown below:

Sl. No.	Motor RPM	Frequency (Hz)	Input Voltage (V)	Wattage (core loss) (W)	Remarks

7. Plot core loss against frequency at rated flux density. Separate eddy current and hysteresis losses and plot them against frequency.

Precautions

1. Keep the rotary switch of alternator rotor field in ‘off’ position at the time of starting the D.C. shunt motor, and then turn the rotary switch to the position 'D.C. for rotor

field' for excitation to the field winding of the alternator.

2. The voltage limitation to the winding of the transformer is 115 volts. It should not be exceeded.

3. Remember that H.T. (H.V. side) terminals of the transformer are alive the moment A.C. voltage is applied to the L.T. (L.V. side) terminals.

4. Keep the field resistance of D.C. motor to minimum and armature resistance to maximum position at the time of starting the motor.

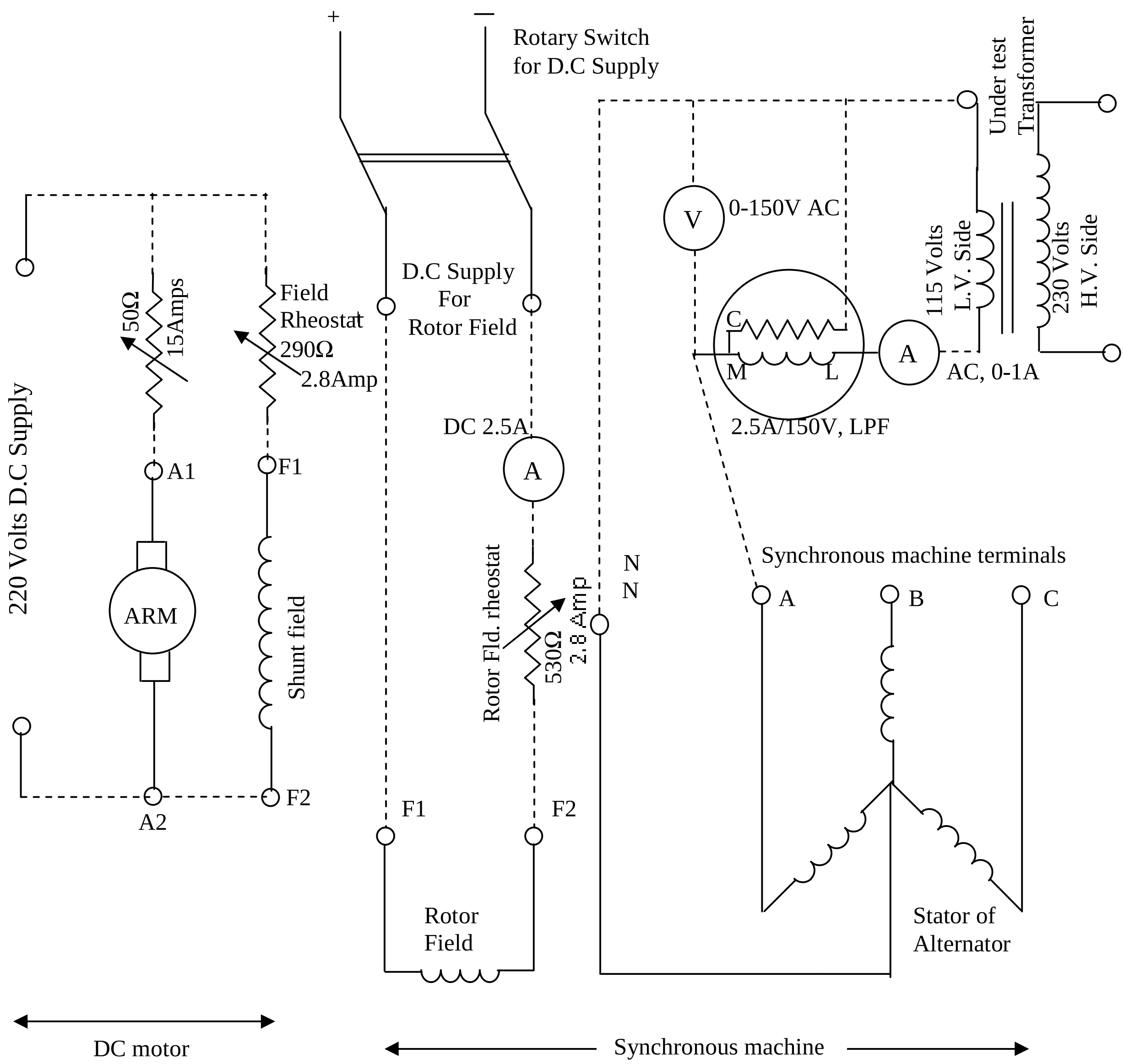

FIG 1.1B Circuit diagram for separation of losses.