Experiment #: 19

Experiment Title: Transformer

Objectives:

Theory:

To investigate the voltage and current ratios of a multi-tapped transformer and verify the ideal transformer ratio.

$$\frac{V_1}{V_2} = \frac{I_2}{I_1}$$

The windings of a standard single-phase transformer are called the primary winding and the secondary winding as shown in Fig.1. The primary winding is the power input winding which is connected to the ac power source. The secondary winding is connected to the load and is physically and electrically isolated from the primary winding.

Normally, transformers are designed to have fixed ratios between the primary and secondary windings. Transformers are widely used to step-up or step-down the voltages and currents; however a transformer can also be used as a mean of electrical isolation. The single-phase transformer that you will be using in this lab experiment has several taps both on the primary side and the secondary side. This makes the transformer versatile in terms of turns ratio and hence in output voltages and currents.

For an ideal transformer it can be proved that:

$$\frac{E_{prim}}{E_{sec}} = \frac{N_1}{N_2} \, and \, \frac{I_{prim}}{I_{sec}} = \frac{N_2}{N_1}$$

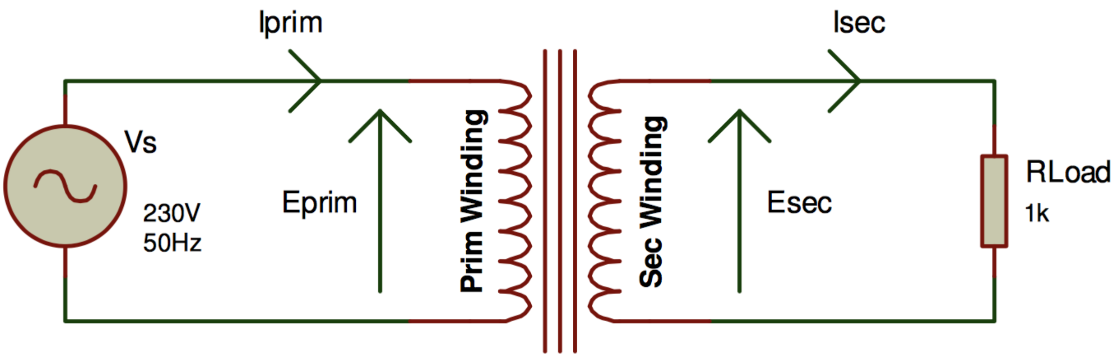

Figure 1

The voltage and current that flow in the secondary are related to the primary voltage and current by the transformer turns ratio . The ratio of primary voltage to

secondary voltage equals , while the ratio of primary to secondary current is equal

to the inverse of the turns ratio, . This can be written as

$$\frac{E_{prim}}{E_{sec}} = \frac{N_1}{N_2} \ , \quad \text{which gives:} \quad E_{sec} = \frac{E_{prim} \times N_2}{N_1} \quad \text{and}$$

$$\frac{I_{prim}}{I_{sec}} = \frac{N_2}{N_1} \ , \quad \text{which gives:} \quad I_{sec} = \frac{I_{prim} \times N_1}{N_2}$$

For a real transformer it can be proved that:

The transformer also experiences losses. A magnetising current is required to take the core through the alternating cycles of flux at a rate determined by system frequency. During this core magnetisation, energy is dissipated. This is known as the ***core loss, no-load loss or iron loss***. The core loss is present whenever the transformer is energised. On open-circuit the transformer acts as a single winding of high self-inductance. The flow of load current in the secondary of the transformer and the m.m.f. which this produces are balanced by an equivalent primary load current and its m.m.f., ***which explains why the iron loss is independent of the load***. The flow of a current in any electrical system, however, also generates loss dependent upon the magnitude of that current and the resistance of the system. Transformer windings are no exception and these give rise to the ***load loss or copper loss*** of the transformer. Load loss is present only when the transformer is loaded, since the magnitude of the no-load current is small as to produce negligible resistive loss in the windings. Load loss is proportional to the square of the load current. Fig. 2 illustrates the equivalent circuit of a real transformer

R_1 and R_2 represents the resistance of the primary and secondary windings X_1 and X_2 represents the reactance of the primary and secondary windings R represents the core loss due to hysteresis and eddy current losses X represents the no-load loss

I_1 is the total input current I_0 is the no-load current

the transformer's primary terminals (B_1 – B_4) to the mains supply as illustrated

With reference to Fig.2,

Figure 2

secondary terminals in open circuit measure and record the no load current on

□□With the
the primary terminals (A1) – _____

- Connect a rheostat (Variable resistor) to the secondary terminals (b_1 – b_3), (b_1 – b_5) and (b_1 – b_7). ***Before connecting the rheostat please be sure that it is on its highest resistance otherwise the transformer could be damaged.***
- Vary the rheostat in order to set the primary current for all connections stated in point 3.
- Tabulate your results in Table 1

I_1 is the total input current I_0 is the no-load current

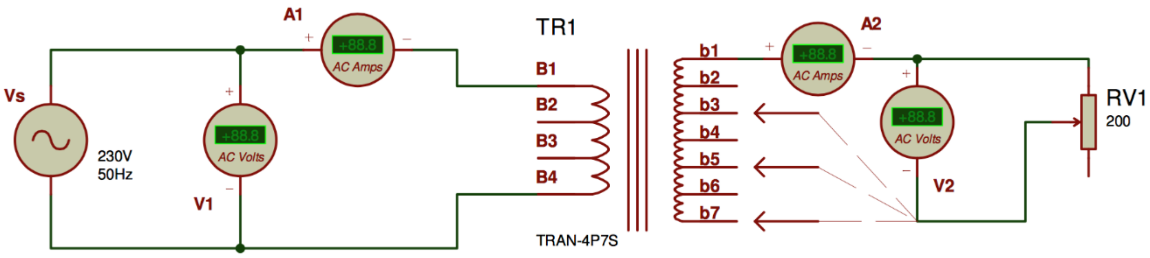

Figure 3

Table 1

Turns ($B_1 - B_4$)	V_1	A_1	V_2	A_2	Secondary Terminals	Turns
	230V	600mA			($b_1 - b_3$)	
	230V	1A			($b_1 - b_5$)	
	230V	1.5A			($b_1 - b_7$)	

Verify the ideal transformer ratio using both the voltage and current equations.

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Procedure 2: -

- Connect the transformer's secondary terminals ($b_1 - b_7$) to the mains supply.
- With the primary terminals in open circuit measure and record the no load current on

  the secondary terminals (A2) - ______

- Connect a rheostat to the primary terminals ($B_1 - B_2$), ($B_1 - B_3$) and ($B_1 - B_4$). ***Before***

  connecting the rheostat please be sure that it is on its highest resistance otherwise the

  transformer could be damaged.

- Vary the rheostat in order to set the primary current for all connections stated in point 3.

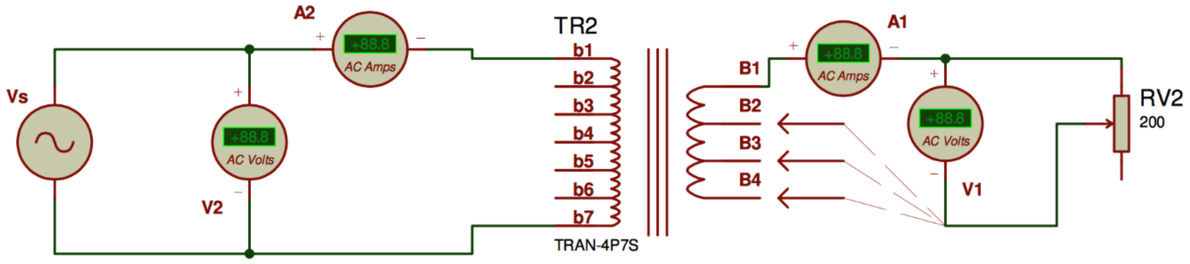

Figure 4

- Tabulate your results in Table 2

Table 2

Turns ($b_1 - b_7$)	**V_2**	**A_2**	**V_1**	**A_1**	**Secondary Terminals**	**Turns**
	230V	500mA			($B_1 - B_2$)	
	230V	650mA			($B_1 - B_3$)	
	230V	1.3A			($B_1 - B_4$)	

Verify the ideal transformer ratio using both the voltage and current equations.

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List of Equipment:

Apparatus

2 – Voltmeters

2 – Ammeters Rheostat (~200Ω)

Circuit Diagram:

Procedure:

Data Collection:

Calculation:

Result: