2 Auto-transformer

It is a transformer with one winding only, part of this being common to both primary and secondary. Obviously, in this transformer the primary and secondary are not electrically *isolated* from each other as is the case with a 2-winding transformer. But its theory and operation are similar to those of a two-winding transformer. Because of one winding, it uses less copper and hence is cheaper. It is used where transformation ratio differs little from unity. Fig. 5 shows both step down and step-up auto-transformers.

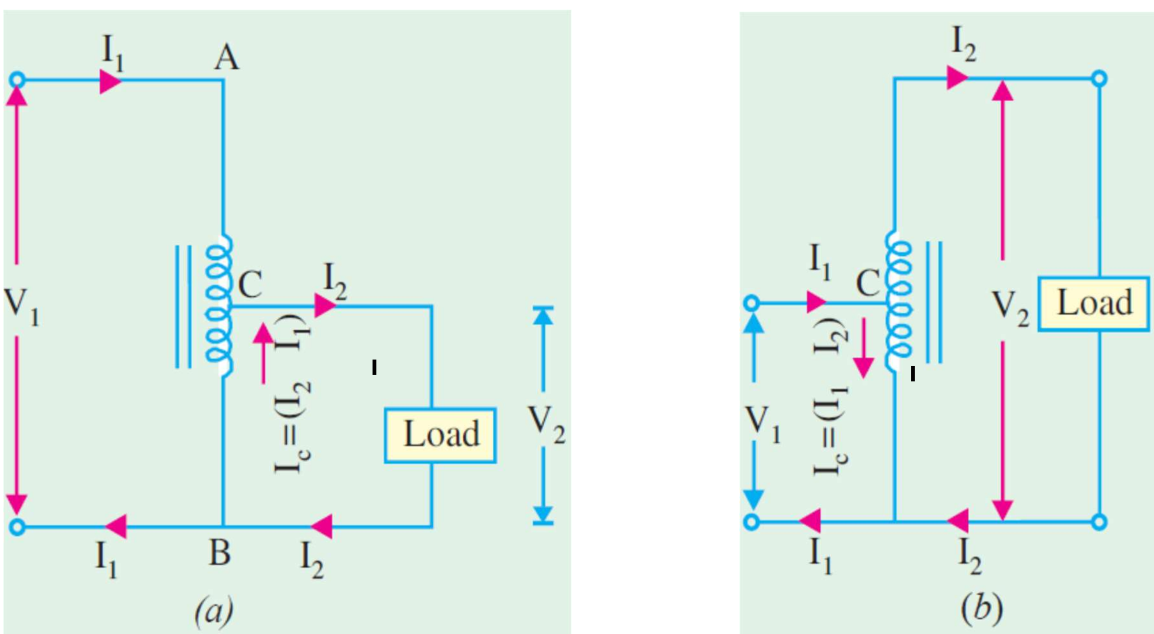

Fig 5. Auto-transformer

As shown in Fig. 5, *AB*, is primary winding having N_1 turns and *BC* is secondary winding having N_2 turns. Neglecting iron losses and no-load current.

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2} = K$$

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2.1 Saving of Cu

Volume and hence weight of Cu, is proportional to the length and area of the cross-section of the conductors. Now, length of conductors is proportional to the number of turns and cross-section depends on current. Hence, weight is proportional to the product of the current and number of turns.

Wt. of Cu in section AC is $\propto (N_1 - N_2) I_1$.

Wt. of Cu in section BC is $\propto N_2 (I_2 - I_1)$.

$\therefore$ Total Wt. of Cu in auto-transformer $\propto (N_1 - N_2) I_1 + N_2 (I_2 - I_1)$

If a two-winding transformer were to perform the same duty, then

Wt. of Cu on its primary $\propto N_1I_1$; Wt. of Cu on secondary $\propto N_2I_2$

Total Wt. of Cu $\propto N_1I_1 + N_2I_2$

$$\frac{\text{Wt. of Cu in auto} - \text{transformer}}{\text{Wt. of Cu in ordinary transformer}} = \frac{(N_1 - N_2)\, I_1 + N_2\, (I_2 - I_1)}{N_2\, I_1 + N_2\, I_2} = 1 - K$$

Wt. of Cu in auto-transformer

$(W_a) = (1 - K) \times$ (Wt. of Cu in ordinary transformer W_0)

$\therefore$ Saving $= W_0 - W_a = W_0 - (1 - K) W_0 = KW_0$

$\therefore$ Saving percent $= K \times 100$ %

Hence, saving will increase as K approaches

unity.

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2.2 Advantages of autotransformers

1- An autotransformer requires less Cu than a two-winding transformer of similar rating.

2- An autotransformer operates at a higher efficiency than a two-winding transformer of similar rating.

3- An autotransformer has better voltage regulation than a two-winding transformer of the same rating.

4- An autotransformer has smaller size than a two-winding transformer of the same rating.

5- An autotransformer requires smaller exciting current than a two-winding transformer of the same rating.

2.3 Applications of Auto transformer

The various applications of an auto-transformer are,

1- For safely starting the machines like induction motors, synchronous motors i.e. as a starter.

2- To give a small boost to a distribution cable to compensate for a voltage drop i.e. as a booster.

3- As a furnace transformer to supply power to the furnaces at the required supply voltage.

4- For interconnecting the systems which are operating roughly at same voltage level.

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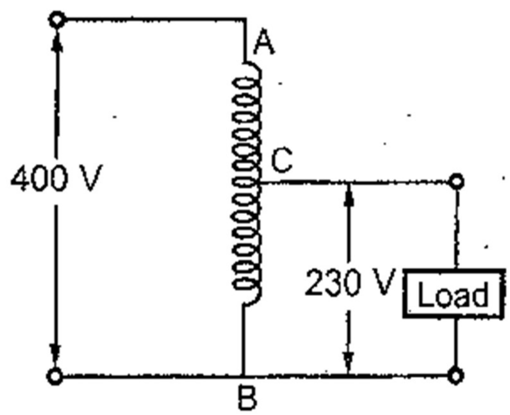
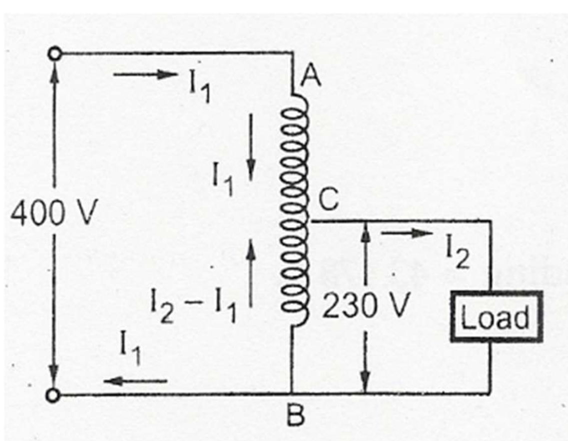
Example 5: In Figure shown an auto transformer used to supply a load of 2 kW at 230 V from a 400 V a.c. supply. Find the currents in parts AC and BC, neglecting losses and no load current . Also find the copper saving percent due to the use of autotransformer instead of using two winding transformer: Assume purely resistive load.



As the load is resistive, $\cos\phi_L = 1$

$$P_{out} = V_2 I_2 \cos\phi_2 = 230 \times I_2 \times 1 = 2 \times 10^3 \Longrightarrow I_2 = \mathbf{8.6956\ A}$$

$$\frac{V_2}{V_1} = K = \frac{230}{400} = \mathbf{0.575}$$



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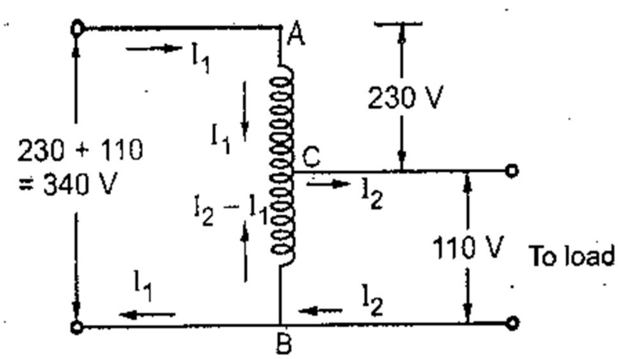
$\frac{I_1}{I_2} = K \Rightarrow I_1 = \mathbf{5\ A}$ which is the current in AC part

Current in BC = $I_2 - I_1 = \mathbf{3.6956\ A}$

Copper saving = $K \times 100\% = \mathbf{57.5\%}$

Example 6: A 10 kVA, 230/110 V transformer is to be used as an autotransformer. What will be the voltage ratio and output rating of an autotransformer.



Solution

$V_1 = 230\ V\ , V_2 = 110\ V\ , kVA = 10\ kVA$

Current through 230 V = $\frac{VA}{230} = \frac{10\times10^3}{230} = \mathbf{43.478\ A}$

Current through 110 V $= \frac{VA}{110} = \frac{10\times10^3}{110} = \mathbf{90.909\ A}$

Now as secondary voltage of two winding transformer is 110 V, let us assume. that autotransformer output voltage required is 110 V. So it can be connected as an autotransformer as shown in the Figure The part AC is primary of two winding while BC is secondary of two winding transformer.

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$V_1 = 230 + 110 = \mathbf{340\ V}, \quad V_2 = \mathbf{110\ V}$

$$K = \frac{V_2}{V_1} = \frac{110}{340} = \mathbf{0.3235}$$

$$K = \frac{I_1}{I_2} \Longrightarrow I_2 = \frac{43.478}{0.3235} = \mathbf{134.386\ A}$$

Output rating = $V_2 \times I_2$ = 110 x 134.386 = **14.782 kVA**