Advantages of auto-transformer over two-winding transformer:

1. Saving of Copper

Saving of Cu:-

Volume and hence weight of Cu, is proportional to length and area of cross section of the conductors.

Length of conductor $\propto$ No of turns

Cross section depends on current.

$\therefore$ Weight is proportional to product of current and No of turns.

Weight of Cu in section AC $\propto (N_1 - N_2) I_1$

Weight of Cu in section BC $\propto N_2(I_2 - I_1)$

$\therefore$ Total weight of Cu in autotransformer

$$\propto (N_1 - N_2) I_1 + N_2(I_2 - I_1).$$

For a two winding transformer,

total weight of Cu $\propto (N_1 I_1 + N_2 I_2)$

$$\therefore \frac{\text{Weight of Cu in autotransformer}}{\text{weight of Cu in ordinary transformer}} = \frac{(N_1 - N_2)I_1 + N_2(I_2 - I_1)}{N_1 I_1 + N_2 I_2}$$

$$= \frac{N_1 I_1 + N_2 I_2 - 2 N_2 I_1}{N_1 I_1 + N_2 I_2} = 1 - \frac{2 N_2}{N_1 + N_2 \cdot \frac{I_2}{I_1}}$$

$$= 1 - \frac{2 \cdot \frac{N_2}{N_1}}{1 + \frac{N_2}{N_1} \cdot \frac{I_2}{I_1}} = 1 - \frac{2K}{2} = 1 - K.$$

So, there is a saving of Cu in auto-transformer. These are used for transformation ratios around unity and not for very wide ranges.

2. Owing to the reduction in conductor and core materials, the ohmic losses in conductor and the core loss are reduced. Therefore, an auto-transformer has higher efficiency than a two-winding transformer of the same output.

3. Reduction in the conductor material means lower value of ohmic resistance. A part of the winding being common, leakage flux and, therefore, leakage reactance is less. In other words, an auto-transformer has lower value of leakage impedance and has superior voltage regulation than a tw0-winding transformer of the same output.

Disadvantages:

1. If the ratio of transformation, k differ far from unity, the economic advantages of auto-transformer over two-winding transformer decrease.

2. The main disadvantage of an auto-transformer is due to the direct electrical connection between the low tension and high tension sides. If primary is supplied at high voltage, then an open circuit in the common winding BC would result in the appearance of dangerously high voltage on the lv side. This high voltage may be detrimental to the load and the persons working there. Thus, a suitable protection must be provided against such an occurrence.

Uses:

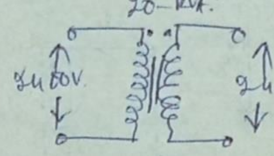
Single-phase and three-phase auto-transformers are mainly employed_

(i) for interconnecting power systems having voltage ratios, not differing far from unity.

(ii) for obtaining variable output voltages. When used as variable ratio auto-transformers, these are known by their trade names, such as, variac, dimmerstat, autostat etc.

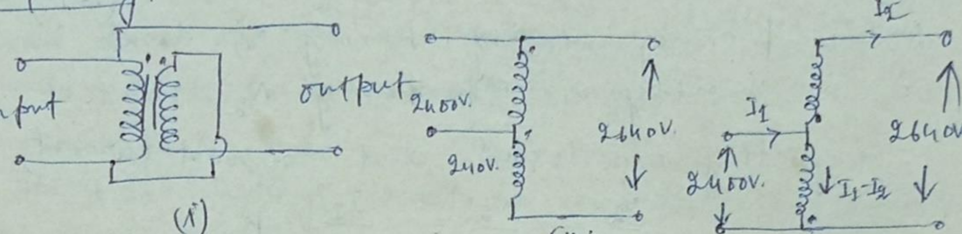
Conversion of 2-winding transformer in to Auto-transformer:-

Any two winding transformer can be converted in to an auto transformer either step down or step-up.



(a)

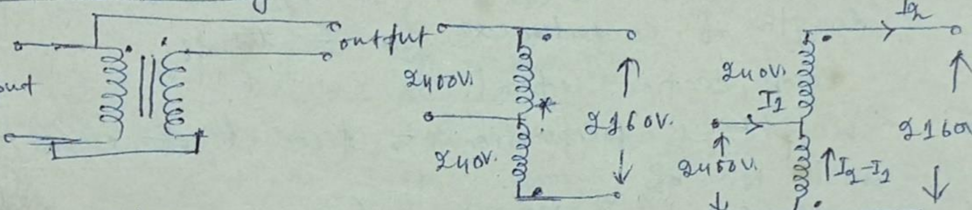
Additive polarity:-



(i) (ii) (iii)

Because of additive polarity $V_2 = 2400 + 240 = 2640V.$
and $V_1 = 2400V.$

Subtractive Polarity:-



(i) (ii) (iii)

In this case, transformer acts as step down transformer.

Problem:- ① Two single phase transformers rated for 25-KVA. and 50-KVA. respectively have their primaries connected in parallel across an 1100 V. supply and have a primary to secondary ~~turns~~ voltage ratio 5:1. Their secondaries are also connected in parallel and supply a common load of 300 Amps. at 0.8 p.f. lag. Referred to the secondary, the equivalent resistances are 0.044 and 0.011 ohms respectively and the equivalent reactances are 0.072 and 0.042 ohms respectively.

What current does each transformer supply to the load? Express each current as a fraction of the full-load current of the transformer.

Soln:- It is seen that the ratio of R/X is not equal but the transformation ratio is equal. Hence, both the secondary voltages are 220V.

Current supplied by transformer-I,

$$I_1 = \frac{I(R_2+jX_2)}{[(R_1+R_2)+j(X_1+X_2)]}$$

$$= \frac{300(0.011+j0.042)}{(0.055+j0.114)}$$

$$= \frac{300(0.011+j0.042)(0.055-j0.114)}{(0.055+j0.114)(0.055-j0.114)}$$

$$= 101+j21.6 = 103.3 \text{ Amps.}$$

Similarly, $I_2 = \dfrac{300(R_1+jX_1)}{[(R_1+R_2)+j(X_1+X_2)]}$

$$= \frac{300(0.044+j0.072)}{(0.055+j0.114)} = 199-j17.8$$

$$= 199.1 \text{ A.}$$

Full load current of transformer-I $= \dfrac{25,000}{220} = 113.6$ Amps

Full load current of transformer-II $= \dfrac{50,000}{220} = 227.2$ Amps

$\therefore$ Transformer-I supplies $= \dfrac{103.3}{113.6} = 90.9\%$ full-load current

Transformer-II supplies $= \dfrac{199.1}{227.2} = 87.6\%$ full load current.

(2) Two single phase transformers in parallel supply a load of 500 Amps. at 0.8 p.f. lagging and at 400V. Their equivalent impedances referred to secondary winding are $(2+j3)$ ohms. and $(2.5+j5)$ ohms respectively. Compute the current and KVA supplied by each transformer.

Soln:- Current supplied by transformer-I

$$= \frac{500(2.5+j5)}{4.5+j8} = 304.6 \text{ A.}$$

current by transformer–II $= \dfrac{500(2+j3)}{4.5+j8} = 1964$ A.

∴ KVA. supplied by transformer–I

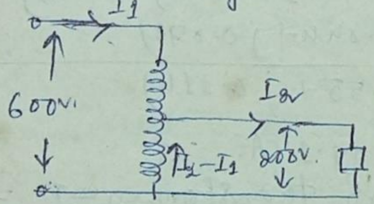
$$= \frac{304.6 \times 400}{1000} = 121.84 \text{ KVA.}$$

KVA. supplied by transformer–II.

$$= \frac{196.4 \times 400}{1000} = 78.56 \text{ KVA.}$$

(3) A 200/400V., 20-KVA., 50-Hz. transformer is connected as an auto-transformer to work of 600/200 V. supplies. Determine the KVA. rating of the auto-transformer. With a load of 20-KVA. 0.8 p.f. lagging connected to the 200V. terminals, find the currents in the load and in the two winding sections.

Soln.:– The two windings must be connected in series with the proper polarity so that 600V. can be applied across the total windings.



With 20-KVA. load, the load current,

$$I_2 = \frac{20 \times 1000}{200} = 100 \text{ A.}$$

$$I_1 = \frac{20 \times 1000}{600} = 33.33 \text{ A.}$$

∴ Current in 400V. section, $I_1 = 33.33$ A.

" " 200 V. " $\cancel{I_2} = I_2 - I_1$

$= 66.66$ A.

400 V. winding can carry a maximum current of 50A.

$\therefore I_1 = 50$ A.

200 V. winding can carry a maximum current of 100 A.

$\therefore I_2 - I_1 = 100$ A.

$\therefore I_2 = 150$ A.

∴ KVA. rating of the auto-transformer

$= V_1 I_1 = 600 \times 50 = 30$ KVA. $= V_2 I_2 = 200 \times 150 = 30$ KVA.