Parallel Operation of Transformers

11-Parallel Operation of Single-Phase Transformers

Two transformers are said to be connected in parallel if the primary windings are connected to supply bus bars and secondary windings are connected to load bus bars. Fig. (11-1) shows two transformers A and B in parallel. While connecting two or more than two transformers in parallel, it is essential that their terminals of similar polarities are joined to the same bus bars as shown in Fig. (11-1). The wrong connections may result in a dead short-circuit and primary transformers may be damaged unless protected by fuses or circuit breakers. There are three principal reasons for connecting transformers in parallel. Firstly, if one transformer fails, the continuity of supply can be maintained through other transformers. Secondly, when the load on the substation becomes more than the capacity of the existing transformers, another transformer can be added in parallel. Thirdly, any transformer can be taken out of the circuit for repair/routine maintenance without interrupting supply to the Consumers.

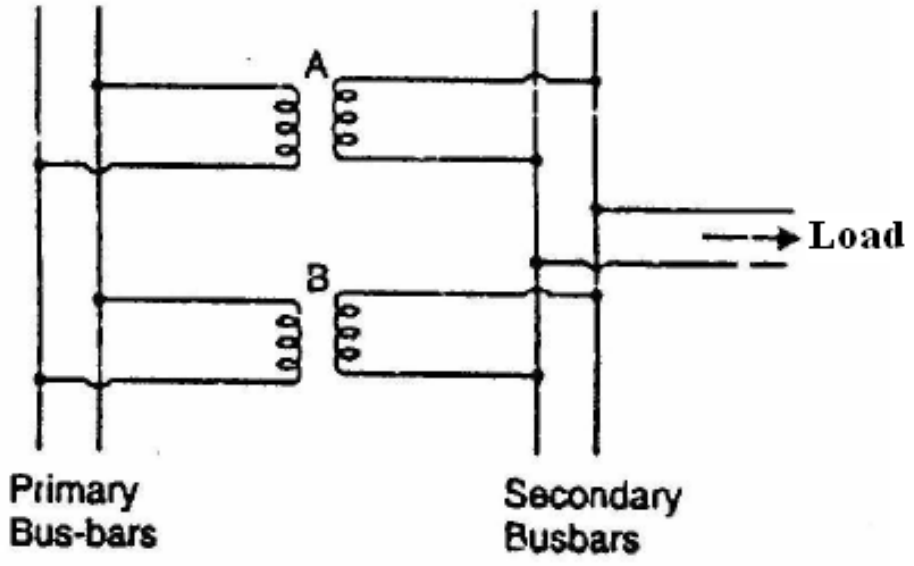

Fig.(11-1)

11-1 Conditions for satisfactory parallel operation

In order that the transformers work satisfactorily in parallel, the following conditions should be satisfied:

(i) Transformers should be properly connected with regard to their polarities.

This Condition is absolutely essential because wrong connections may result in dead short-circuit. Fig. (11-2 (i)) shows the correct method of connecting two single-phase transformers in parallel. It will be seen that round the loop formed by the secondaries, the two secondary e.m.f.s EA and EB oppose and there will be no circulating current.

Fig. (11-2 (ii)) shows the wrong method of connecting two single-phase transformers is parallel. Here the two secondaries are so connected that their e.m.f.s EA and EB are additive. This may lead to short-circuit conditions and a very large circulating current will flow in the loop formed by the two secondaries. Such a condition may damage the transformers unless they are

Protected by fuses and circuit breakers.

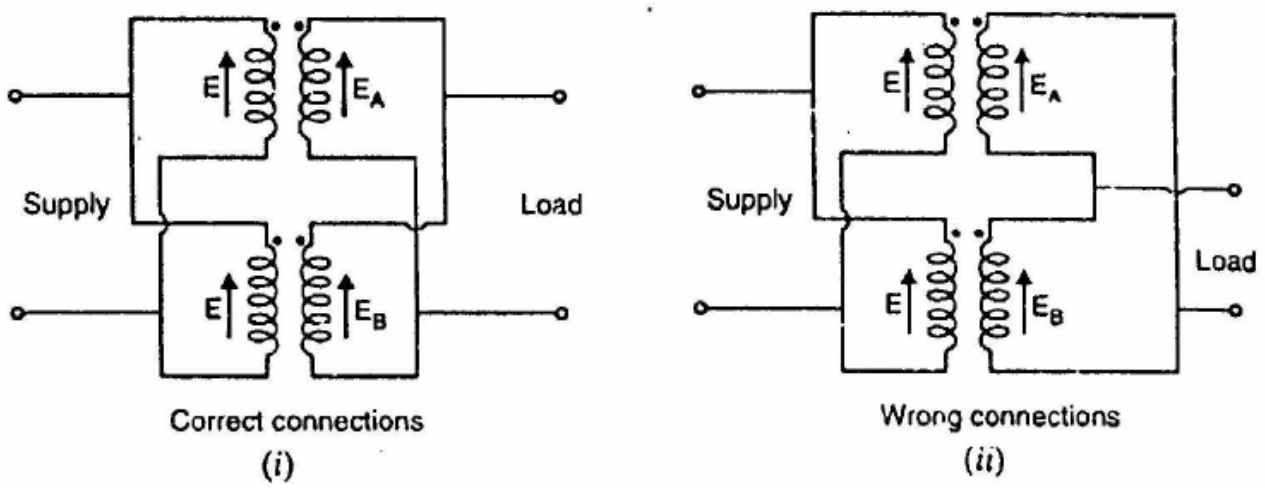

Fig.(11-2)

(ii) The voltage ratings and voltage ratios of the transformers should be the same.

This condition is desirable for the satisfactory parallel operation of transformers. If this condition is not met, the secondary e.m.f.s will not be equal and there will be circulating current in the loop formed by the secondaries. This will result in the unsatisfactory parallel operation of transformers. Let us illustrate this point. Consider two single-phase transformer A and B operating in parallel as shown in Fig. (11-3). Let EA and EB be their no-load secondary voltages and ZA and ZB be their impedances referred to the secondary. Then at no-load, the circulating current in the loop formed by the secondaries is

$$\text{Circulating current, } I_C = \frac{E_A - E_B}{Z_A + Z_B} \qquad \text{assuming } E_A > E_B$$

Even a small difference in the induced secondary voltages can cause a large circulating current in the secondary loop because impedances of the transformers This secondary circulating current will cause current to be drawn from the supply by the primary of each transformer. These currents will cause copper losses in both primary and secondary. This creates heating with no useful output.

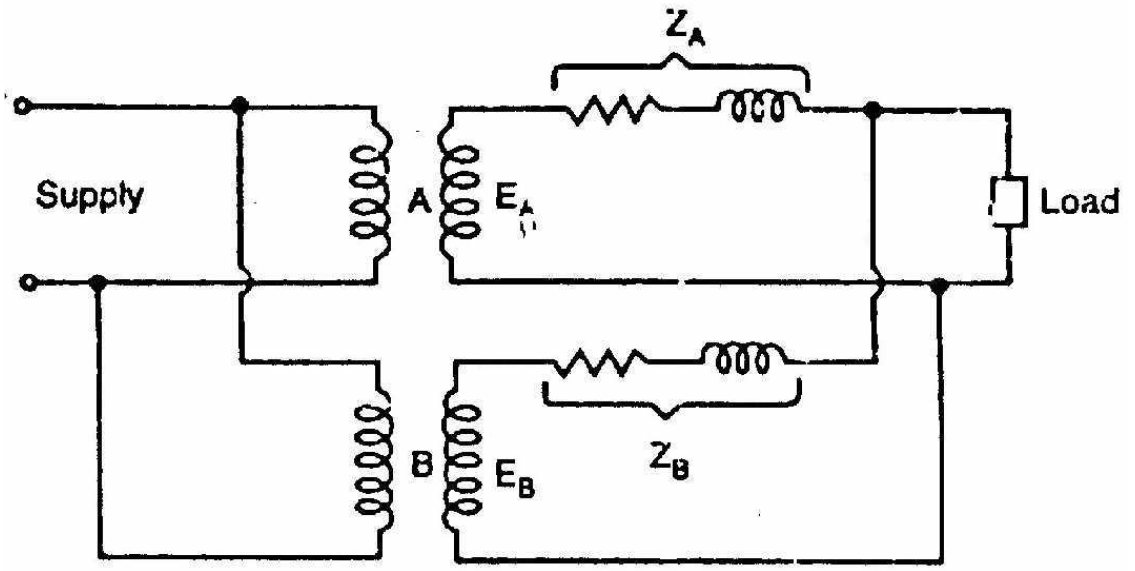

Fig.(11-3)

(iii) The per unit or percentage impedances of the transformers should be equal.

This condition is also desirable for proper parallel operation of transformers. If this condition is not met, the transformers will not share the load according to their kVA ratings. Sometimes this condition is not fulfilled by the design of the transformers. In that case, it can be corrected by inserting proper amount of resistance or reactance or both in series with either primary or secondary circuits of the transformers where the impedance is below the value required to fulfill condition (iii).

(iv)The reactance/resistance ratios of the transformers should be the same.

If the reactance/resistance ratios of the two transformers are not equal, the power factor of the load supplied by the transformers will not be equal. In other words, one transformer will be operating with a higher and the other with a lower power factor than that of the load. Considerable deviation from condition (iv) will result in only a small reduction in the satisfactory degree of operation. When desired, condition (iv) also may be improved by inserting external impedance of proper value.