Parallel operation of two single phase transformers

Objectives: At the end of this lesson you shall be able to
- **state the necessity of parallel operation of transformers**
- **state the conditions to be full filled for the parallel operation of transformers**
- **explain how to determine the polarity terminals of transformer.**

Necessity of parallel operation of transformers

1 When the power demand of the load increases, two or more transformer may be operated in parallel.

2 When the power demand decreases, only required numbers of transformer may be operated with their full load capacity. Where as the remaining transformers may be switched "OFF" and taken for general maintenance/service.

3 Thus the efficiencies and life of the transformers increases and the losses are reduced.

4 It provides more reliability of power i.e., even one transformer fails or become out of service, other transformers will supply to the certain amount of load.

5 It is not economical to manufacture a single very large capacity transformer. Thus operationg two or more numbers of optimal capacity transformers in parallel is more economical.

6 It is easy to plan the maintenance schedule of the transforemers, hence the cost of maintenance and spares are reduced.

Conditions

1 the same voltage ratio

2 Input voltage must be same

3 the same per unit (or percentage) impedance

4 the same polarity

5 the same phase sequence and zero relative phase displacement, for 3 phase transformers.

Of these (4) and (5) are absolutely essential (1) and (2) must be satisfied to a close degree.

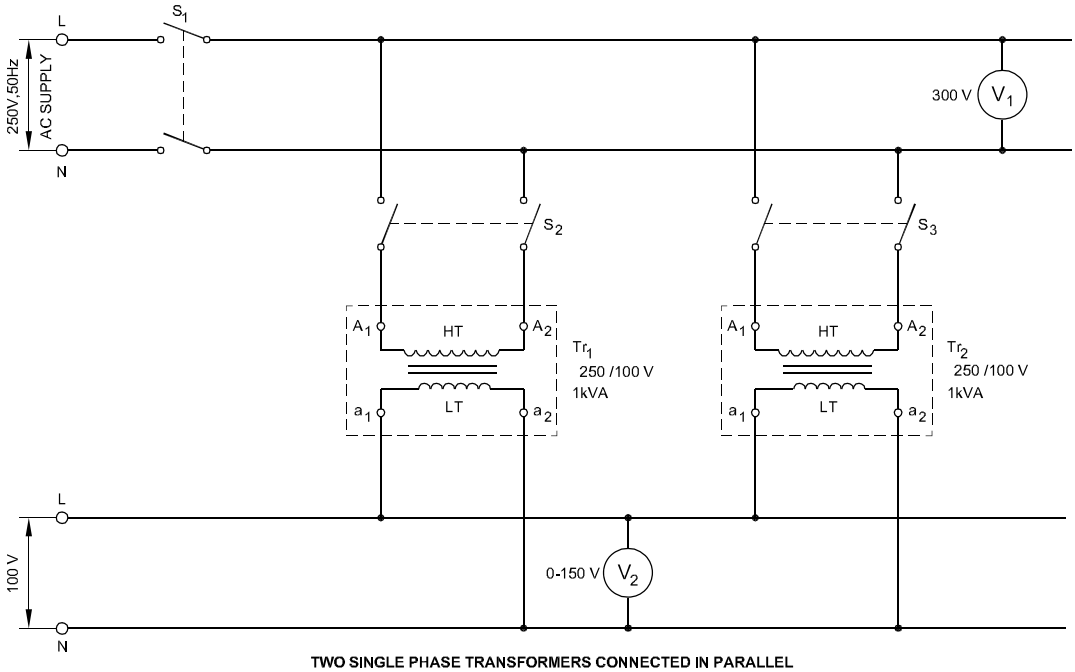
There is more allowance for a wide extent with (3), but the more nearly it is true, the better will be the load division between several transformers.

Parallel operation

Fig 1 shows two single phase transformers connected in parallel with their primary windings connected to the same supply and their secondary windings supplying a common load.

When operating two or more transformers in parallel, to have satisfactory performance the following conditions should be met

Fig 1



TWO SINGLE PHASE TRANSFORMERS CONNECTED IN PARALLEL

Voltage ratio: If voltage readings on the open secondaries of various transformers, to be run in parallel, do not show identical values, there will be circulating currents between the secondaries (and therefore between primaries also) when the secondary terminals are connected in parallel. The impedances of transformers is small, so that a small percentage voltage difference may be sufficient to circulate considerable current and cause additional I^2R loss.

When secondaries are loaded, the circulating current will tend to produce unequal loading conditions. Thus it may be impossible to take the full load output from the parallel connected group without one of the transformers becoming excessively heated.

Impedance: The currents carried by the two transformers are proportional to their ratings:

- if their numerical or ohmic impedances are inversely proportional to those ratings, and
- their per unit impedances are identical.

A difference in the quality factor (i.e the ratio of reactance to resistance) of the per unit impedance results in a divergence of the phase angle of the currents, so that one transformer will be working with a higher and the other with a lower power factor than that of the combined output.

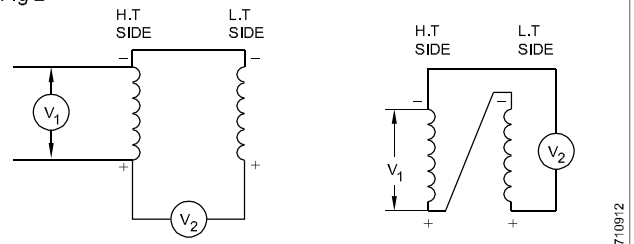
Verification of terminals or Polarity: Polarity in case of transformers means the relative marking to the terminals of the primary and secondary windings reaching the maximum value of emf at the same instant. When two or more transformers are to be connected in parallel on their primary and secondary sides, the terminals of the same polarity only can be connected together, otherwise a heavy circulating current will be produced between the windings.

Standard procedure to determine the polarity is explained below:-

- connect one end of the high voltage winding to one end of the low voltage winding as shown in Fig 2a.
- Connect a voltmeter between the two open ends.
- Apply a voltage not greater than the rated voltage of the winding to either high or low voltage winding.

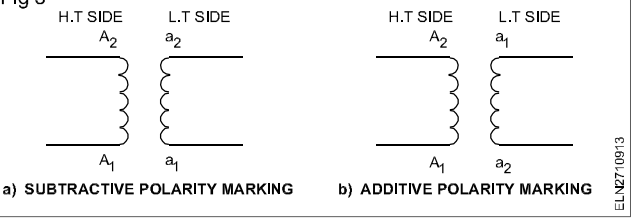
If V_2 reads less than V_1 (Fig 2a) the primary and secondary emfs are in opposition. The marking on primary will be A_1 for +ve side and A_2 for –ve side and a_1 for +ve side of secondary and a_2 for –ve side. If the connections are made (Fig 2b) the voltmeter V_2 will read more than V_1. Thereby it is ascertained opposite ends are connected.

Fig 2



If in transformer has similar ends in one side (Fig 3a) the polarity marking is said to be subtractive polarity marking on the other hand if the opposite ends are in one side (Fig 3b) the polarity marking is called as additive polarity marking.

Fig 3



Series (Secondary only) operation of transformers

Objectives: At the end of this lesson you shall be able to
- **state the necessity of series operations**
- **state the conditions to be fulfilled for series operation**

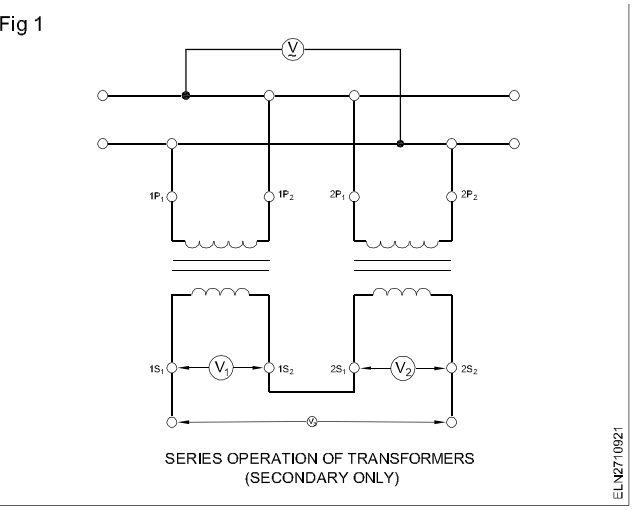
Series operation:

The connection diagram for series operation (secondary only) of two identical transformers is given below (Fig 1)

Necessity for series operations:

In general, the transformers are available with some standard input (primary) and output (secondary) voltages. In order to get some intermediate voltage for example , 36V, 48 V for special purpose, the series operation of transformers (secondary only) are necessary.

Fig 1



In series operation, individual secondary voltages of both transformers are added if they are connected with proper polarity, but the current ratings are remains same.

Condition for series operation:

Both transformers should be identical i.e,

a) Voltage ratio/turns ratio must be same

b) Polarities must be same

c) Type of core of both transformers (core or shell type) must be same.

d) Input voltages of both transformers must be same.

e) KVA ratings of both transformers must be same.

f) Percentage impedance or per unit impedance of both the transfers must be same.

Precautions:

- **The polarities of secondary of both transformers should be connected in proper way, same as series connection, to get the voltage added, otherwise the output voltage will be zero.**
- **As the output voltage is double that the individual secondary voltages, care to be given to ascertain the insulation level of the secondary windings.**