

GUIDE LINES FOR PARALLEL OPERATION OF TRACTION TRANSFORMERS ON INDIAN RAILWAYS

The satisfactory parallel operation of transformers is dependent upon five principle characteristics; that, any two transformers which it is desired to operate in parallel should possess:

1. Identical turn ratios and voltage ratings.
2. Equal percentage impedances.
3. Equal ratios of resistance to reactance
4. Same polarity.
5. Same phase angle shift.
6. Same phase rotation

For single phase transformers, only the first four conditions apply, as there is no phase rotation or phase angle shift due to voltage transformation.

1.0 Turn Ratio

The turn ratio of the transformer should be identical on each taps.

If the turn ratios are not same a circulating current will flow even at no load. A circulating current in the transformer windings of the order of, say 5 % of the full load current of the lowest rating of transformer may generally be allowed in the case of modern transformers without any fear of serious overheating occurring.

Transformers designed with RDSO specifications have tolerance of $\pm 0.5\%$ variation in turn ratio. This will result into total 1% variation in voltage between two LT windings which corresponds to 270 volts.

The circulating current will be approx. $270/(4+4) = 33.75$ Amps which is less than 40Amps i.e. 5% of rated current of 21.6 MVA transformer.

Similarly, for 13.5 MVA rating transformers the circulating current is $(270/(6.75+6.75)) = 22$ Amps, which is less than 25A, the 5% of the rated current.

Hence, same rating transformers procured as per RDSO specifications may be paralleled. For paralleling of dissimilar transformers, above guideline may be followed.

2.0 Percentage impedance:

If the percent impedance or the ratios of resistance to reactance are different there will be no circulating current at no load, but the division of load between the transformers when applied will no longer be proportional to their KVA

ratings. In the simplest case viz. of two transformers of the same output operating in parallel, the % impedance must also be identical if the transformers are to share the total load equally. However, good paralleling is considered attainable when the % impedance of two winding transformers is within 7.5% of each other.

RDSO specification specifies tolerance in percentage impedance ± 0.5 which amount to total variation of 8 %, hence paralleling can be done.

3.0 R/X ratio:

In power transformers of normal design the ratio of resistance to reactance (R/X) is generally sufficiently small to make the requirement of equal ratios of negligible importance in paralleling. When it is desired to parallel transformers having widely different impedances, reactors in series is placed with the transformer whose impedance is lower. It should have a value sufficient to bring the total effective %impedance of the transformer plus the reactor upto the value of the % impedance of the second transformer.

4.0 Polarity of the transformers needs to be checked before connecting them in parallel.

5.0 ***Conclusion: Transformers with same rating and built to the RDSO specifications are suitable for parallel operations.***

5.1 Precautions:

1. Ratings of the transformer should be identical and for dissimilar ratings circulating current should be less than prescribed limits.
2. It is preferable to parallel transformers with closest turn ratio and percentage impedance.
3. Connecting two transformers in parallel will result in a combined impedance which is less than either of the components (paralleling two identical transformers result in a combination which has an impedance of half that of each, individually), the primary result of this is to increase the fault level of the LV bus bar. Care must therefore be taken to ensure that the fault capability of the LV switchgear is not exceeded and suitable protection scheme is implemented.

References

1. The J&P Transformer book, twelfth edition, A Practical Technology of power transformer by Martin J.Heathcote.
2. M/s ABB instruction leaflet on Parallel Operation of Transformers, Technical Data 1LUS010001-LFE Rev 5, October 15 ,2003.