# Parallel Operation of Transformer

# Introduction

- When the primaries of two or more transformers are connected to common supply bus bars and secondary are connected to common load bus bars, the transformers are said to connect in parallel.

# Why Parallel Operation?

The parallel operation of transformers becomes necessary in following conditions.

- When the load power is greater than the power handled by single transformer.
- When expansion of the plant or additional load necessary.

- It is better to connect second transformer of suitable rating is in parallel with first transformer rather than using single transformer of higher capacity in the future.
- However the cost of single transformer of same rating is less than the cost of two transformers which are connected in parallel.

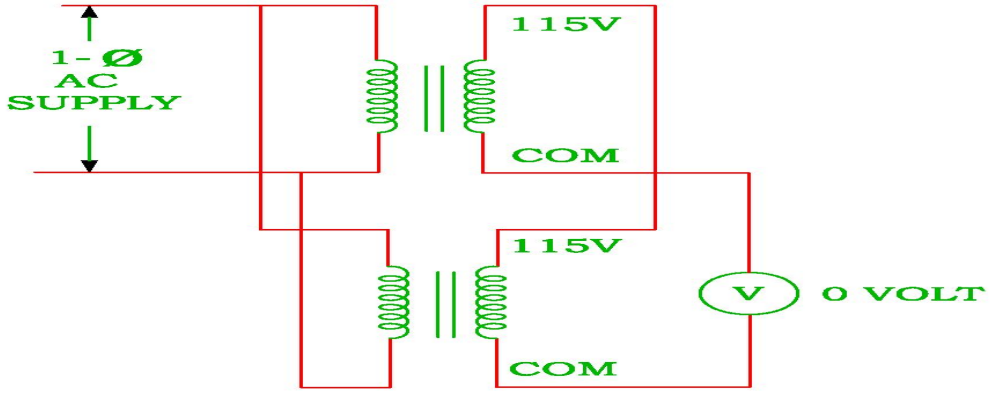
- Although the parallel operation is expansive but one transformer supply partly load when other transformer is in fault condition or take out of maintenance.
- The cost of stand by unit is reduced.

# Essential Conditions For Parallel Operation

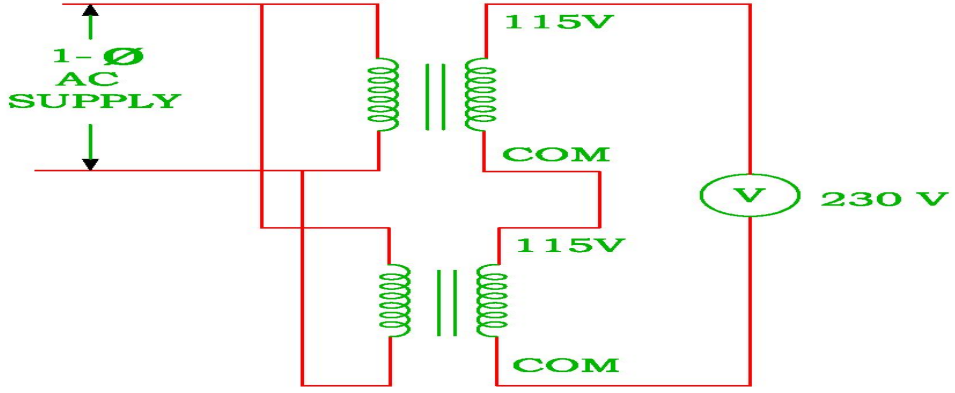
**The polarity of both transformers must be same**

- If the transformers are not connected in correct polarity, dead short circuit occurs.
- Let us know how to connect two transformers with correct polarity.

1. The primaries of both transformer are connected in parallel.
2. Connect the secondaries of transformers as shown in Figure A.
3. The rating of voltmeter must be double that of secondary rated voltage of the transformer. If the voltmeter indicates zero, it is "correct" polarity.




( a ) CORRECT POLARITY




( b ) INCORRECT POLARITY

FIG A : POLARITY CHECK OF THE TRANSFORMER

4. If the voltmeter indicates double voltage that of secondary rated voltage of a transformer, it is "incorrect" polarity. In that case anyone connection of the secondary winding is interchanged.

**The turns - ratio of both transformers are the same**

- If the voltage ratio of the both transformer is not identical the secondary emf will induce resulting circulating current flow in the secondary circuit.

- Therefore the primaries of the transformer will draw reflected secondary circulating current, in addition to the magnetizing current.
- This additional current cause copper losses on both windings of the transformers.

**Percentage impedance of the transformers is the same or X / R ratio should be the same for each transformer**

- If the percentage impedances of the transformers are not the same, a transformer with smaller percentage impedance will carry more load than its actual share load and other transformer carry only part of load.

- The impedance of the transformer is inversely proportional to its kVA rating.
- If the X/R ratios of the transformers are different, one transformer will be operating with a higher power factor and the other transformer with a lower power factor that of total load.
- It means that kW load is not proportionally shared by them.

# Vector Diagram

Let

$V_2$ = Common terminal voltage

$Z_A$ = Impedance of transformer A

$Z_B$ = Impedance of transformer B

$Z_{AB}$ = Combined impedance of both transformers

$E_2$ = Induced emf

$I_A$ = Load current shared by transformer A

$I_B$ = Load current shared by transformer B

- Let us consider that both transformers have equal voltage ratio. Both the transformers are operate at lagging power factor ( from the vector diagram )

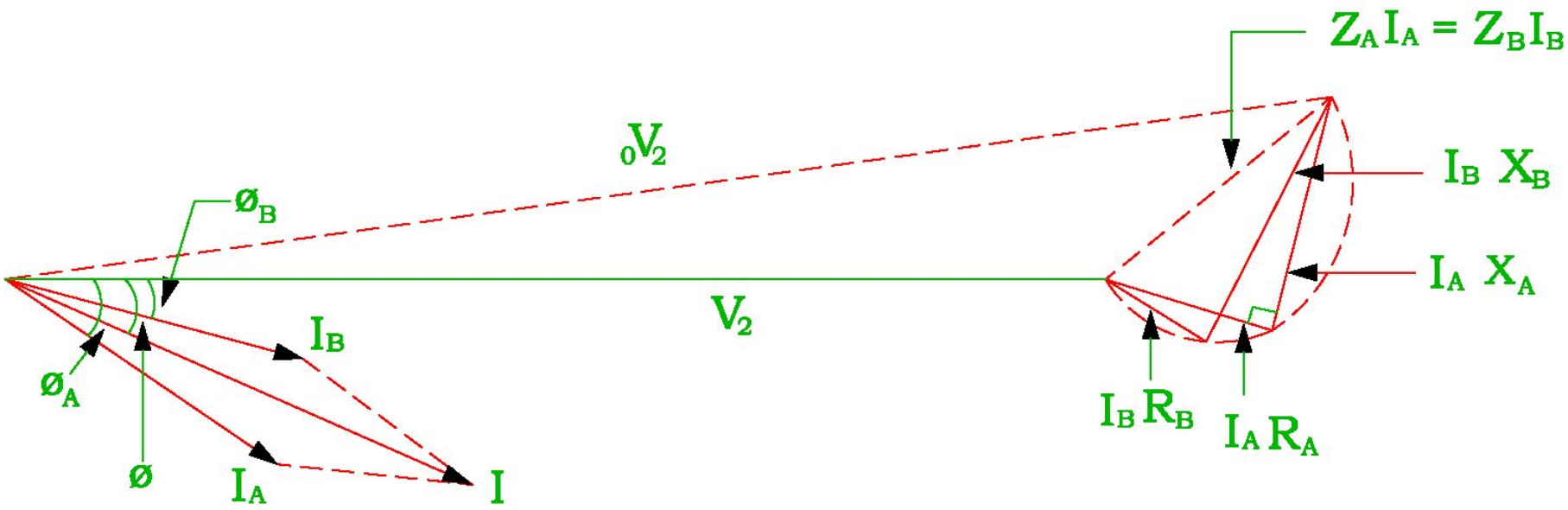



FIG B : VECTOR DIAGRAM FOR PARALLEL OPERATION OF THE SINGLE PHASE TRANSFORMER

Total impedance $Z_{AB} = Z_A \parallel Z_B$

$$Z_{AB} = ( Z_A Z_B ) / ( Z_A + Z_B )$$

From Figure B

$$I_A Z_A = I_B Z_B = I Z_{AB}$$

Therefore $I_A = ( Z_A Z_B ) / ( Z_A + Z_B ) [( I / Z_A )]$

$$I_A = I Z_B / ( Z_A + Z_B ). \ldots\ldots\ldots\ldots ( 1 )$$

Similarly

$$I_B = ( Z_A Z_B ) / ( Z_A + Z_B ) [( I / Z_B )]$$

$$I_B = IZ_A / ( Z_A + Z_B ) \ldots\ldots\ldots\ldots\ldots ( 2 )$$

Multiplying both side with $V_2$ in the equation ( 1 ) and ( 2 )

$$V_2 I_A = V_2 I [ Z_B / ( Z_A + Z_B ) ]$$

$$Q_A = Q [ Z_B / ( Z_A + Z_B ) ]$$

And

$$V_2 I_B = V_2 I \left[ Z_A / ( Z_A + Z_B ) \right]$$

$$Q_B = Q \left[ Z_A / ( Z_A + Z_B ) \right]$$

Where Q = Load kVA

$Q_A$ = kVA load share by transformer A

$Q_B$ = kVA load share by transformer B

# Questions

- Explain the term : Parallel operation
- Why the parallel operation of transformer is necessary?
- Draw the vector diagram of transformer operated in parallel ( Percentage impedance is same )
- Comment : The percentage impedance of the parallel operated transformer should be same.

# Questions

- Give reason : The polarity of the two transformers connected in parallel must be same.