

TRANSFORMER

Subject Name: Electrical Fundamentals

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Approved By:

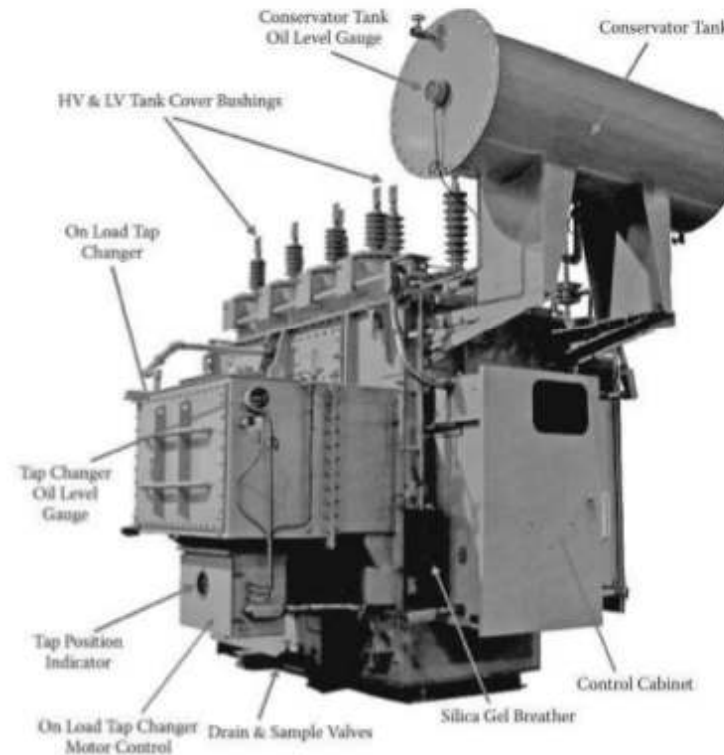
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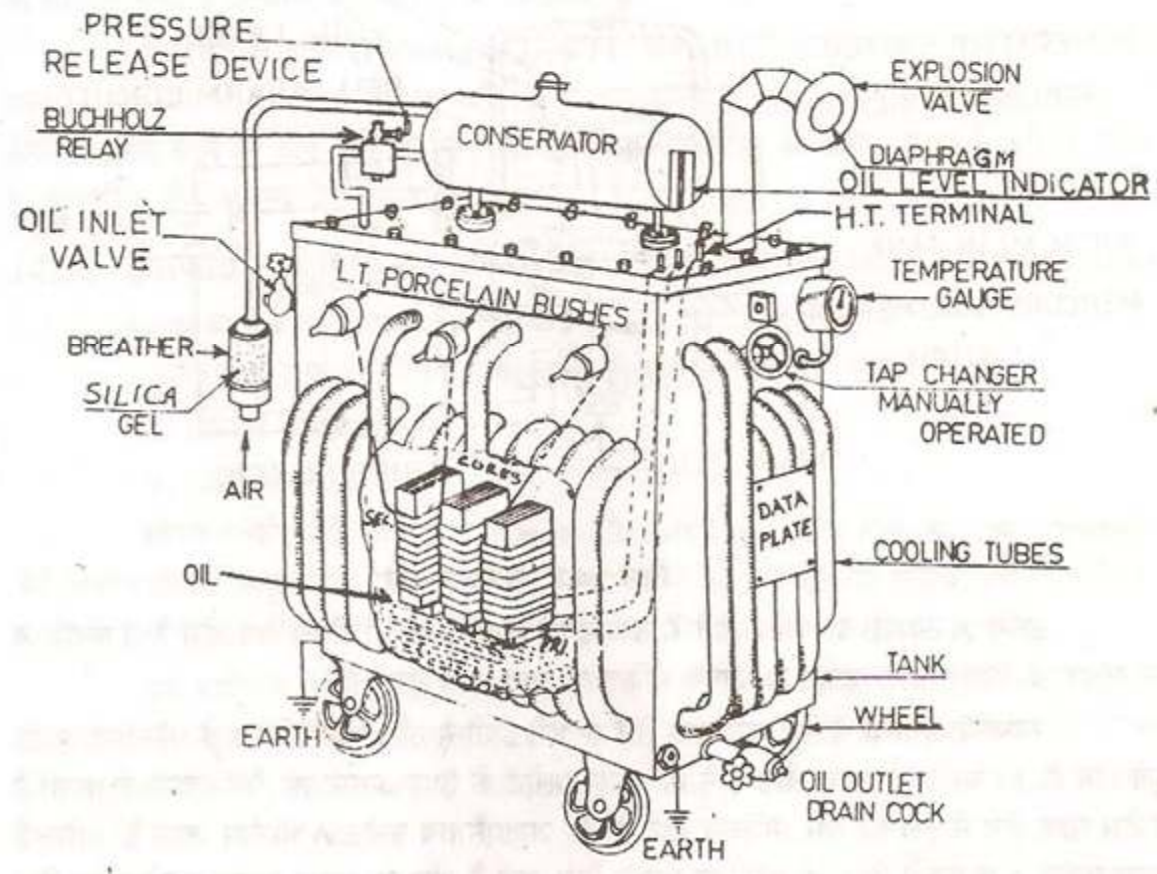
PARTS OF TRANSFORMER

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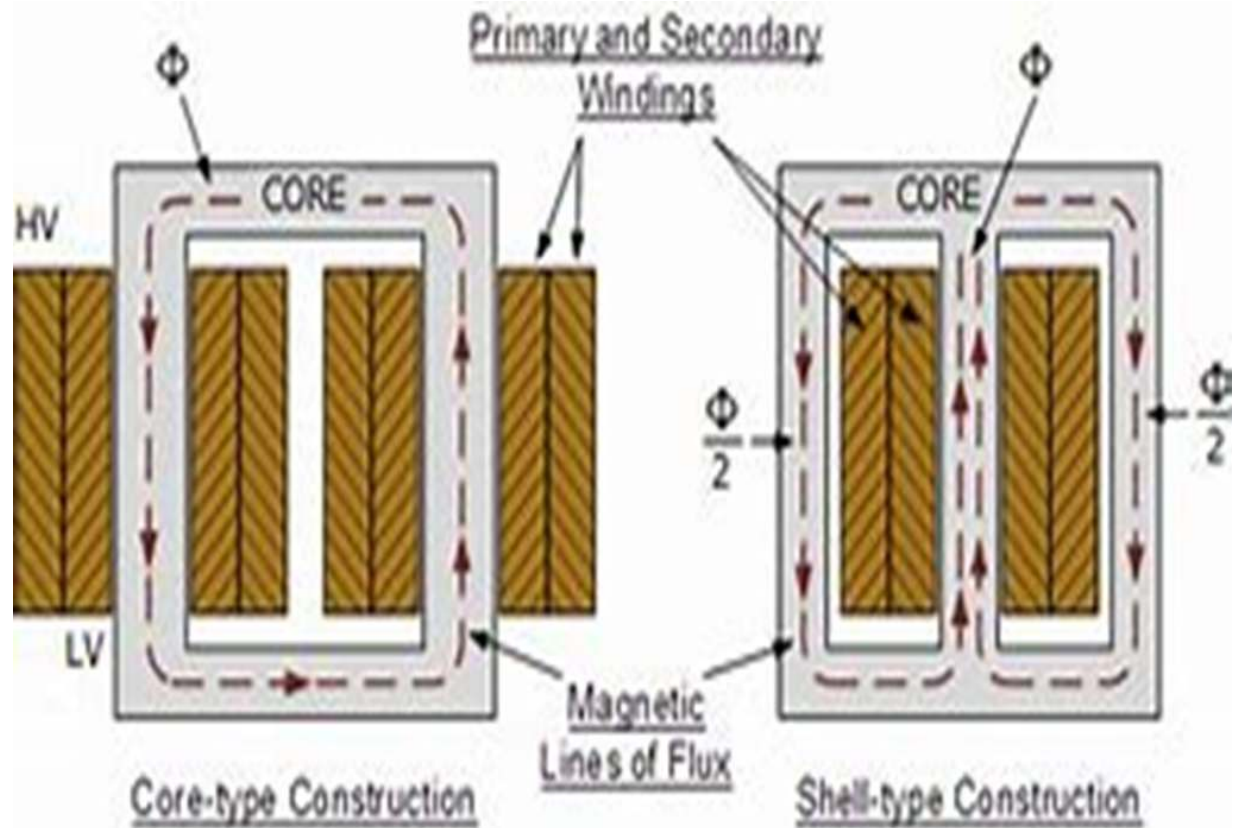
- Main tank
- Primary winding
- Secondary winding
- Buchholz relay
- Oil level indicator
- Breather
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- L T & HT bushes
- Tap changer
- Air release plug



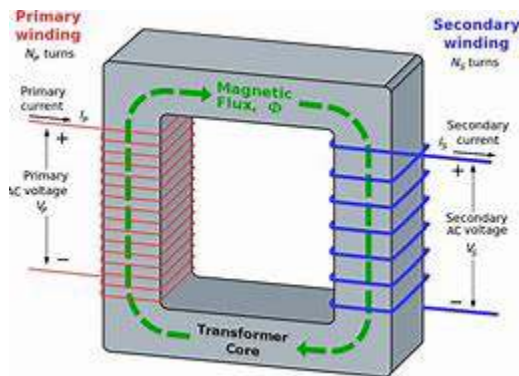
Conservator design 15/20 MVA 72kV-25kV



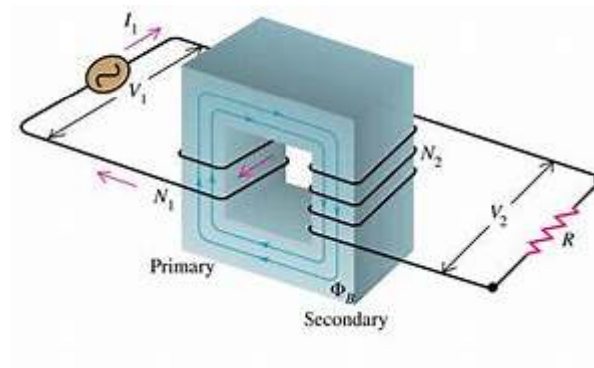
Core type & Shell type transformer



Primary & Secondary winding of Core type Transformer



Winding connection of Transformer



What is the operation of a transformer?

- The main principle of operation of a transformer is **mutual inductance** between two circuits which is linked by a common magnetic flux. A basic transformer consists of two coils that are electrically separate and inductive, but are magnetically linked through a path of reluctance.

Losses of Transformer

- **Types of Losses in a Transformer**
- **Iron Losses.** Iron losses are caused by the alternating flux in the core...
- **Copper Loss Or Ohmic Loss.** These losses occur due to ohmic resistance of the transformer windings.
- **Stray Loss.** The occurrence of these stray losses is due to the presence of leakage field.

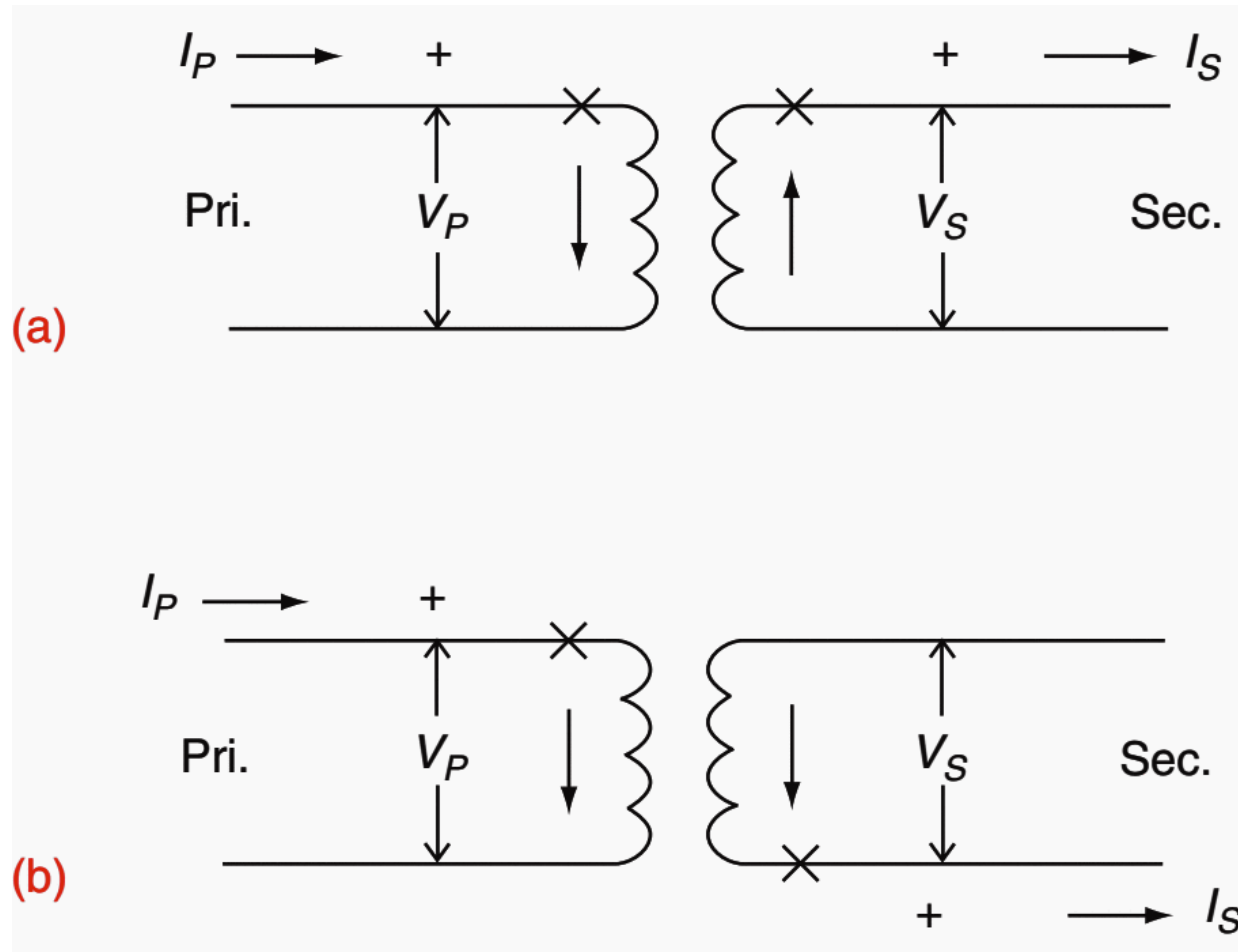
What is the efficiency of transformer?

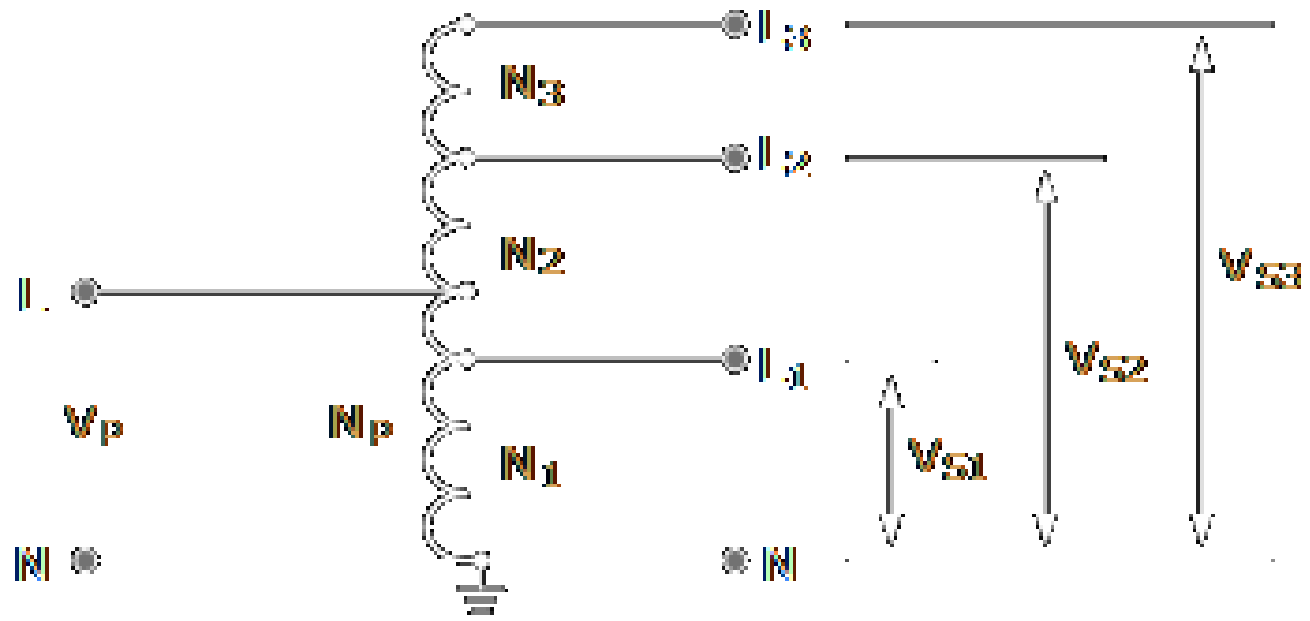
- Efficiency of Transformer. Transformer efficiency may be defined as the **ratio between Output and Input**. Transformer Efficiency = Output / Input. On specified power factor and load, the transformer efficiency can be found by dividing its output on Input (similar to other electrical machines i.e. motors, generators etc).

Autotransformer

1. An **Autotransformer** has only one single voltage winding which is common to both sides.
2. This single winding is “tapped” at various points along its length to provide a percentage of the primary voltage supply across its secondary load.
3. It has the usual magnetic core but only has one winding, which is common to both the primary and secondary circuits.
4. The main advantage is that it is a lot cheaper for the same VA rating.

Polarity Marking of Transformer



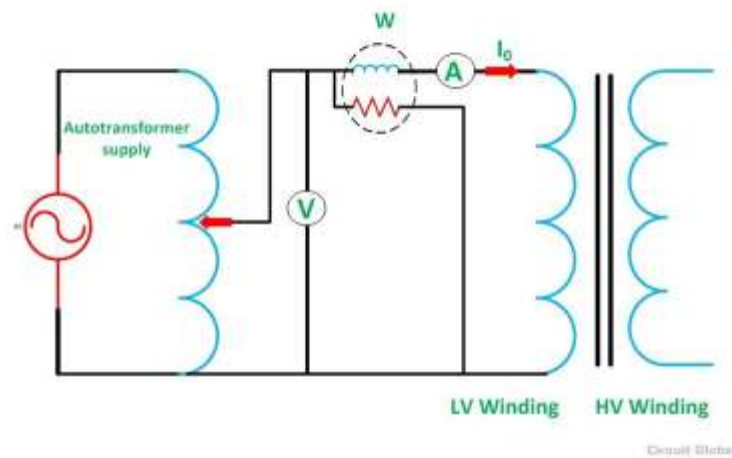


Open Circuit Test

- The purpose of the open circuit test is to determine the no-load current and losses of the transformer because of which their no-load parameter are determined. This test is performed on the primary winding of the transformer. The wattmeter, ammeter and the voltage are connected to their primary winding. The nominal rated voltage is supplied to their primary winding with the help of the ac source.

OPEN CIRCUIT TEST

OPEN CIRCUIT TEST (FOR FIND OUT CORE LOSS)



- The secondary winding of the transformer is kept open and the voltmeter is connected to their terminal. This voltmeter measures the secondary induced voltage. As the secondary of the transformer is open the no-load current flows through the primary winding.
- The value of no-load current is very small as compared to the full rated current. The copper loss occurs only on the primary winding of the transformer because the secondary winding is open. The reading of the wattmeter only represents the core and iron losses. The core loss of the transformer is same for all types of loads.

SHORT CIRCUIT TEST

- **Short Circuit Test**
- The short circuit test is performed for determining the below mention parameter of the transformer.
- It determines the copper loss occur on the full load. The copper loss is used for finding the efficiency of the transformer.
- The equivalent resistance, impedance, and leakage reactance are known by the short circuit test.
- The short circuit test is performed on the secondary or high voltage winding of the transformer. The measuring instrument like wattmeter, voltmeter and ammeter are connected to the High voltage winding of the transformer. Their primary winding is shortcircuited by the help of thick strip or ammeter which is connected to their terminal.
- The low voltage source is connected across the secondary winding because of which the full load current flows from both the secondary and the primary winding of the transformer. The full load current is measured by the ammeter connected across their secondary winding.

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Disadvantages of an Autotransformer

1. The main disadvantage is that it does not have the primary to secondary winding isolation of a conventional double wound transformer. Then an autotransformer can not safely be used for stepping down higher voltages to much lower voltages suitable for smaller loads.
2. If the secondary side winding becomes open-circuited, load current stops flowing through the primary winding stopping the transformer action resulting in the full primary voltage being applied to the secondary terminals.
3. If the secondary circuit suffers a short-circuit condition, the resulting primary current would be much larger than an equivalent double wound transformer due to the increased flux linkage damaging the autotransformer.
4. Since the neutral connection is common to both the primary and secondary windings, earthing of the secondary winding automatically Earth's the primary as there is no isolation between the two windings. Double wound transformers are sometimes used to isolate equipment from earth.

SHORT CIRCUIT TEST OF TRANSFORMER

- The low voltage source is applied across the secondary winding which is approximately 5 to 10% of the normal rated voltage. The flux is set up in the core of the transformer. The magnitude of the flux is small as compared to the normal flux.
- The iron loss of the transformer depends on the flux. It is less occur in the short circuit test because of the low value of flux. The reading of the wattmeter only determines the copper loss occur on their windings. The voltmeter measures the voltage applied to their high voltage winding. The secondary current induces in the transformer because of the applied voltage.

POWER IN 3 PHASE SYSTEM

Why Three Phase is Preferred Over Single Phase?

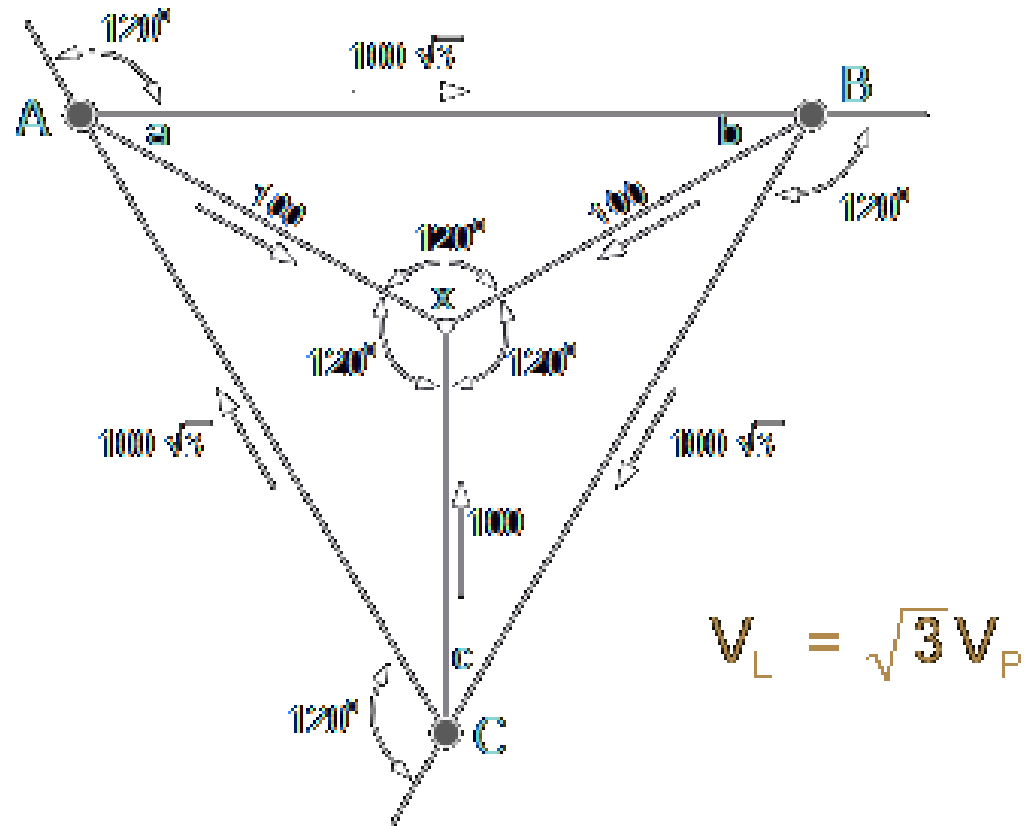
Advantages over single phase circuit.

1. The three phase system can be used as three single phase line so it can act as three single phase system. The three phase generation and single phase generation is same in the generator except the arrangement of coil in the generator to get 120° phase difference.
2. The conductor needed in three phase circuit is 75% that of conductor needed in single phase circuit.
3. The instantaneous power in single phase system falls down to zero but in three phase system the net power from all the phases gives a continuous power to the load.

Star Connection

- In **star connection**, there is four wire, three wires are phase wire and fourth is neutral which is taken from the star point.
- Star connection is preferred for long distance power transmission because it is having the neutral point. Unbalanced current affects transformer and it may also cause damage to the transformer and for this star connection is preferred for long distance transmission.

Three Phase Voltages and Currents



Concept of balanced and unbalanced current in power system

Balanced Power system

When equal current will flow through all the three phases, then it is called as balanced current.

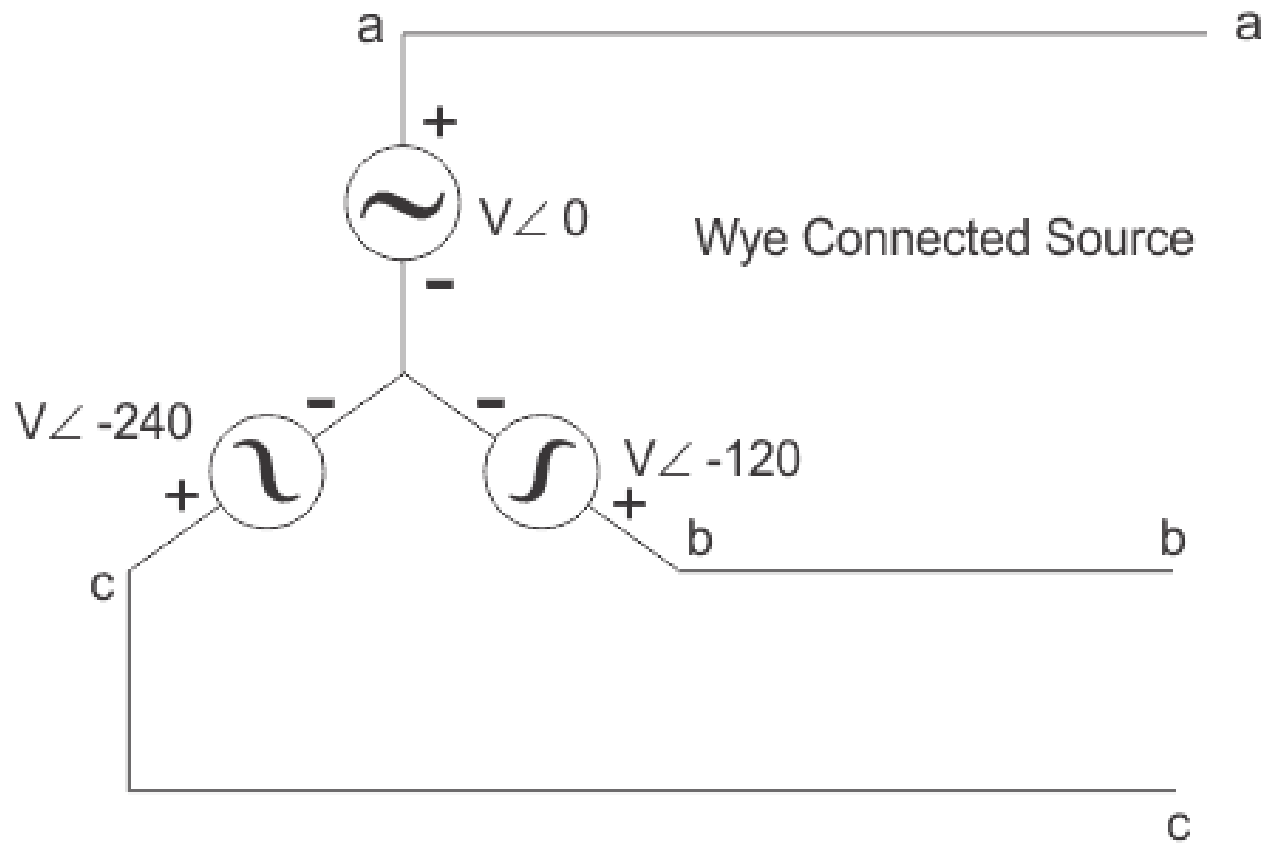
During balanced condition there will be no current flowing through the neutral line and hence there is no use of the neutral terminal.

Unbalanced Power system

And when the current through all the three phases will not be equal, in any of the phase, then it is unbalanced current.

But when there will be unbalanced current flowing in the three phase circuit, neutral is having a vital role. It will take the unbalanced current through to the ground and protect the transformer.

The star connection is shown below



In star connection,

1. The line voltage is $\sqrt{3}$ times of phase voltage.
2. Line voltage is the voltage between two phases in three phase circuit
3. Phase voltage is the voltage between one phase to the neutral line.
4. The current is same for both line and phase.
5. It is shown as expression below

$$E_{Line} = \sqrt{3}E_{Phase} \text{ and } I_{Line} = I_{Phase}$$

Delta Connection

1. In **delta connection**, there is three wires alone and no neutral terminal is taken.
2. Delta connection is preferred for short distance due to the problem of unbalanced current in the circuit.
3. In the load station, ground can be used as neutral path if required.
4. The line voltage is same with that of phase voltage.
5. The line current is $\sqrt{3}$ times of phase current.
6. It is shown as expression below

$$V_{Line} = V_{Phase} \text{ and } I_{Line} = \sqrt{3} I_{Phase}$$

