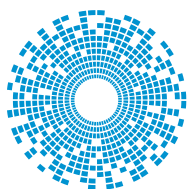


3-Phase Transformers

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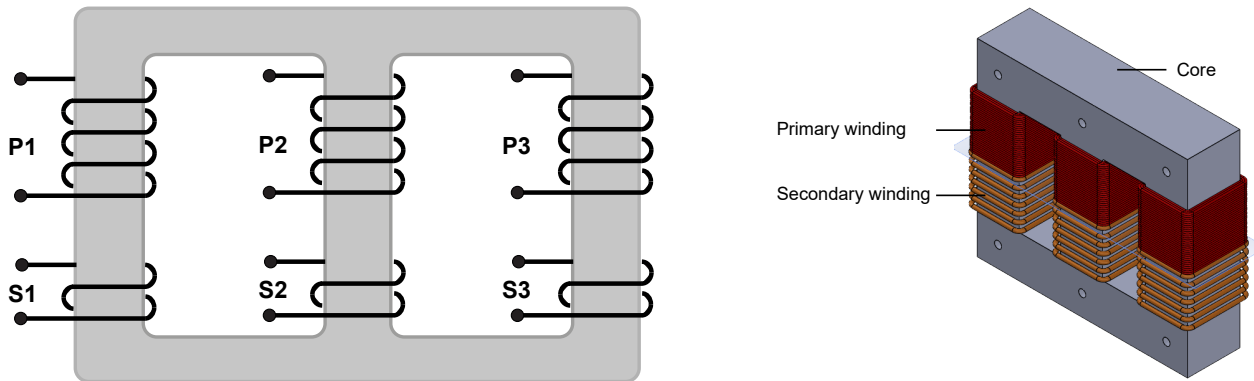
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A transformer is an electrical device which, by electromagnetic induction, transforms power between circuits at the same frequency, usually changing the values of voltage and current.

Since all source power is generated in 3-Phase format, 3-Phase transformers play a key role in long distance power distribution, regional grids, local grids, industrial and business facilities.

3-Phase power transformers are constructed by winding three single phase transformers on a single core. Because copper and the iron core are used more effectively, 3-Phase transformers for a given kVA rating will be smaller, more cost effective and lighter than three individual single-phase transformers.

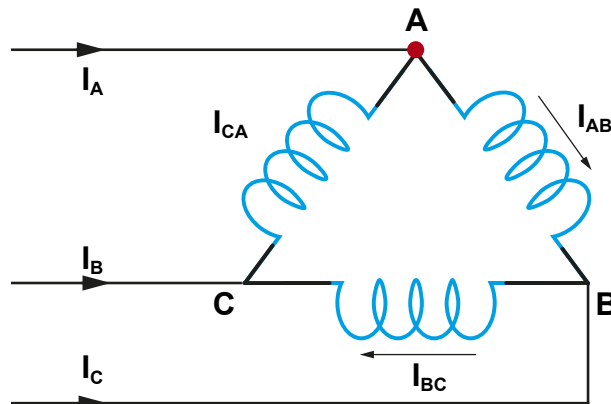
3-Phase transformers typically have at least 6 windings - 3 primary and 3 secondary.



The primary and secondary windings can be connected in the different configurations to meet many different requirements. In common applications, the windings are usually connected in one of two popular configurations: “Delta” or “Wye”.

“Delta” Connection:

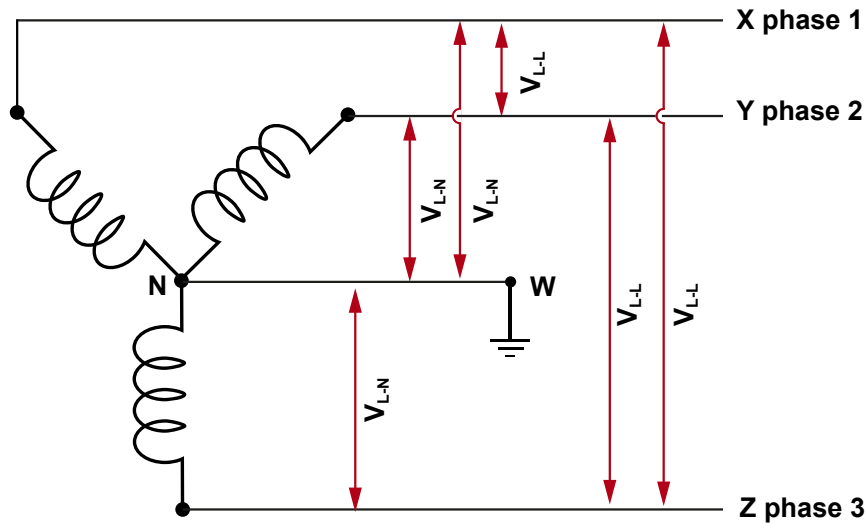
In a Delta connection, there are three phases and no Neutral. An output Delta connection can supply a 3-Phase load only. The line voltage (V_L) is equal to supply voltage. Phase current ($I_{AB} = I_{BC} = I_{CA}$) is equal to Line current ($I_A = I_B = I_C$) divided by 1.73. When a transformer’s secondary is connected to large unbalanced load, the Delta primary provides a better current balance for the input power source.



“Delta” Connection Schematic

“Wye” Connection:

In a Wye connection, there are 3-phases and a Neutral (N) – four wires in total. An output of Wye connection enables the transformer to supply a 3-phase voltage (phase-to-phase), as well as a voltage for single phase loads, namely the voltage between any phase and Neutral. The Neutral point can also be grounded to provide additional safety when required. $V_{L-L} = 1.73 \times V_{L-N}$



“Wye” connection schematic

There are four common configurations in which 3-phase transformer’s windings are connected. They are:

A. Primary - “Delta” / Secondary – “Delta” (identification - D/d)

Advantages:

- If one out of three coils should become faulty or disabled, the two remaining undamaged coils will continue to deliver 3-Phase power with a capacity equal to approximately 2/3 of the original transformer’s output.
- If the transformer’s secondary is connected to large unbalanced load, the “Delta” primary provides a better current balance for the input power source.
- No phase shift between Pri. and Sec. windings.
- Often used for low voltage high current power transmission, or when continuity of service is to be maintained (should one of the phases develop a fault).

Disadvantages:

- Pri. + Sec. winding turns count is high, resulting in larger and more expensive coils.
- More inter winding and interlayer insulation is required.
- Thinner gauge magnet wire results in higher cost per pound.
- There is no “Neutral” connection.

B. Primary - “Delta” / Secondary – “Wye” (identification - D/y)

Advantages:

- The Primary windings provide a three-wire balanced load to the power generating utility.
- Ability to supply 3-phase and single-phase loads.
- Ability to create common output “Neutral”, when no such neutral exists in the line.
- Suppresses noise (harmonics) from the line to the secondary side.
- Commonly used for supplying power to commercial, industrial and high density residential end-users.

Disadvantages:

- If one out of three coils became faulty or disabled, the whole group might become disabled.
- 30-degree phase shift between Pri. and Sec. windings may result in greater ripple in D.C. circuits.

C. Primary – “Wye” / Secondary – “Delta” (identification – Y/d)

Advantages:

- With High Voltage input, the voltage across individual coils reduced by 1.73 results in reduced winding turns and less insulation. This configuration may be used as a step-down transformer at the end of the transmission line.
- Grounding wire (Neutral) on power source side.

Disadvantages:

- If one out of the three phase coils became faulty or disabled, the whole group may become disabled.
- 30-degree phase shift between Pri. and Sec. windings may result in greater ripple in D.C. circuits.

D. Primary – “Wye” / Secondary – “Wye” (identification – Y/y)

Advantages:

- The lowest cost of the four configurations.
- No phase shift between Pri. and Sec. windings.
- Neutral / Grounding wire is available on both Pri. and Sec. sides.
- Can provide power to both 3-phase and single-phase loads.

Disadvantages:

- The single-phase loads must be balanced as close as possible.
- More likely to pass noise (harmonics) between power source and load.

Depending on power and voltage levels, 3-phase transformers can be divided into two major categories:

1. Dry type transformers relying on air as cooling medium.
2. Liquid filled type transformers utilizing oil as a cooling medium.

Dry type transformers could be subdivided into two categories:

1. Open Frame, where resin impregnated core and coils are exposed, designed for enclosure installations.
 - Electrical Ratings: Voltage – up to 1000V; Power – up to 500 kVA.
2. Cast-Resin Coils, when each coil is solidly cast, typically in an epoxy mold.
 - Electrical Ratings: Voltage–up to 36.0 kV; Power–up to 40 MVA;

Liquid Filled type transformers are fully immersed into special mineral oil in vacuum sealed metal container.

- Electrical Ratings: Voltage – 6.0 kV to 1,500 kV; Power–up to 1000+ MVA



Open Frame Transformer



Cast-Resin Coils Transformer



Liquid filled Transformer

Conclusion:

For open frame transformers when circumstances permit, most industries prefer to use the Delta input and Wye output for connecting a 3-phase transformer in power distribution applications.

- The most common “**Delta**” input voltages are:
 - 600V, 480V, 415V, 400V, 230V, 208V.
- The most common “**Wye**” output voltages are:
 - 600V (L-L) / 347V (L-N) - Canada
 - 480V (L-L) / 277V (L-N) – US Large industrial loads
 - 208V (L-L) / 120V (L-N) – US Small industrial / Commercial / Residential loads

Signal Transformer Co. specializes in manufacturing dry-type open frame 3-phase transformers up to 1000V and 500 kVA power levels.