ZigZag Transformer Connection Overview

The zigzag connection of tranformer is also called the interconnected star connection. This connection has some of the features of the Y and the Δ connections, combining the advantages of both.

The zigzag transformer contains six coils on three cores. The first coil on each core is connected contrariwise to the second coil on the next core. The second coils are then all tied together to form the neutral and the phases are connected to the primary coils.

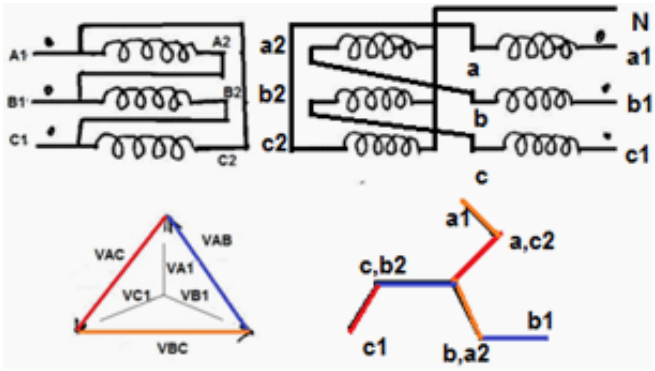
Each phase, therefore, couples with each other phase and the voltages cancel out. As such, there would be negligible current through the neutral pole and it can be connected to ground

Zigzag Grounding Transformer (Post Glover Resistors, Inc.)

One coil is the outer coil and the other is the inner coil. Each coil has the same number of windings turns (Turns ratio=1:1) but they are wound in opposite directions.

The transformer coils are connected as follows:

- The outer coil of phase **a1-a** is connected to the inner coil of phase **c2-N**
- The outer coil of phase **b1-b** is connected to the inner coil of phase **a2-N**
- The outer coil of phase **c1-c** is connected to the inner coil of phase **b2-N**
- The inner coils are connected together to form the **neutral** and our **tied to ground**
- The outer coils are connected to phases **a1**,**b1**,**c1** of the existing delta system.



ZigZag transformer coil connections

If three currents, equal in magnitude and phase, are applied to the three terminals, the ampere-turns of the **a2-N** winding cancel the ampere-turns of the **b1-b** winding, the ampere-turns of the **b2-N** winding cancel the ampere turns of the **c1-c** winding, and the ampere-turns of the **c2-N** winding cancel the ampere turns of the **a1-a** winding. Therefore, the transformer allows the three in-phase currents to easily flow to neutral.

If three currents, equal in magnitude but 120° out of phase with each other, are applied to the three terminals, the ampere-turns in the windings cannot cancel and the transformer restricts the current flow to the negligible level of magnetizing current. Therefore, the zigzag winding provides an easy path for in-phase currents but does not allow the flow of currents that are 120°out of phase with each other.

Under normal system operation the outer and inner coil winding's magnetic flux will cancel each other and only negligible current will flow in the in the neutral of the zigzag transformer.

During a phase to ground fault the zig-zag transformer's coils magnetic flux are no longer equal in the faulted line. This allows zero sequence.

If one phase, or more, faults to earth, the voltage applied to each phase of the transformer is no longer in balance; fluxes in the windings no longer oppose. (***Using symmetrical components, this is $I_{a0} = I_{b0} = I_{c0}$.***) Zero sequence (earth fault) current exists between the transformers' neutral to the faulting phase. Hence, the purpose of a zigzag transformer is to provide a return path for earth faults on delta connected systems. With negligible current in the neutral under normal conditions, engineers typically elect to under size the transformer; a short time rating is applied. Ensure the impedance is not too low for the desired fault limiting. Impedance can be added after the secondary's are summed (the $3I_o$ path)

The neutral formed by the zigzag connection is very stable. Therefore, this type of transformer, or in some cases an auto transformer, lends itself very well for establishing a neutral for an ungrounded 3 phase system.

Many times this type of transformer or auto transformer will carry a fairly large rating, yet physically be relatively small. This particularly applies in connection with grounding applications. The reason for this small size in relation to the nameplate KVA rating is due to the fact that many types of grounding auto transformers are rated for 2 seconds. This is based on the time to operate an over current protection device such as a breaker. Zigzag transformers used to be employed to enable size reductions in drive motor systems due to the stable wave form they present. Other means are now more common, such as 6 phase star.

Advantages of Zig-Zag Transformer

The ∆ -zigzag connection provides the same advantages as the ∆-Y connection.

Less Costly for grounding Purpose
It is typically the least costly than Y-D and Scott Transformer.

Third harmonic suppression
The zigzag connection in power systems to trap triple harmonic (3rd, 9th, 15th, etc.) currents. Here, We install zigzag units near loads that produce large triple harmonic currents. The windings trap the harmonic currents and prevent them from traveling upstream, where they can produce undesirable effects.

Ground current isolation
If we need a neutral for grounding or for supplying single-phase line to neutral loads when working with a 3-wire, ungrounded power system, a zigzag connection may be the better solution. Due to its composition, a zigzag transformer is more effective for grounding purposes because it has less internal winding impedance going to the ground than when using a Star type transformer.

No Phase Displacement
There is no phase angle displacement between the primary and the secondary circuits with this connection; therefore, the ∆-zigzag connection can be used in the same manner as Y-Y and ∆- ∆ transformers without introducing any phase shifts in the circuits.

Application

An Earthing Reference

Occasionally electrical engineers use a combination of **YD** and zigzag windings to achieve a vector phase shift. For example, an electrical network may have a transmission network of **220 kV/66 kV star/star** transformers, with **66 kV/11 kV delta/star** for the high voltage distribution network.

If a transformation is required directly between the 220 kV/11 kV network the most obvious option is to use 220 kV/11 kV star/delta. The problem is that the 11 kV delta no longer has an earth reference point.

Installing a zigzag transformer near the secondary side of the 220 kV/11 kV transformer provides the required earth reference point.

As a Grounding Transformer

The ability to provide a path for in-phase currents enables us to use the zigzag connection as a grounding bank, which is one of the main applications for this connection.

We rarely use zigzag configurations for typical industrial or commercial use, because they are more expensive to construct than conventional Star connected transformers. But zigzag connections are useful in special applications where conventional transformer connections aren't effective.

D or **Y** / **ZigZag** are used in unbalanced low voltage system – mostly with single phase appliances