

Earthing Transformer or Grounding Transformer

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The **Earthing transformer** is one of the the must to have equipments for those distribution stations, which deals with delta connected transmission lines. The power system transmission lines are generally made up with three phases, so three individual wires or conductors are used to transmit the three phase power from the generating station to the distribution substation. Three phase system is more economical and profitable than single phase or two phase system. The three phase power transmission system is termed as “three phase three wire system” of power transmission. The three wire system is most suitable for providing power in the industrial belts. Because, all the three wire systems consist of only phase wires, so it delivers the phase to phase voltage to the load, that is V_{Ph} . Suppose each phase carries 220 Volt. Then in distribution station, the phase to phase voltage will be very high, in order of 440 volt, which is generally used in industrial belts. But, for domestic purposes, the voltage level must be in order of 230 Volt.

This necessitates the three phase four wire system, where the additional wire is used as the system neutral. The phase to phase voltage (called as line voltage) is $\sqrt{3}$ times of phase to neutral voltage (called as phase voltage). Adding the neutral wire serves many purposes. A three phase four wire system is able to deliver both line voltage for industries and phase voltage for domestic uses. So, it increases the scope of power distribution conveniently. In star connected transmission lines, the neutral point is accessible for further using. Or in other words, a star connected transmission line is three phase four wire system. But, in Delta connected transmission lines, no neutral point is there. So, how to convert a delta connected three phase three wire system into a three phase four wire system? Here we use the **earthing transformer** or **grounding transformer** to create a artificial neutral point for the three phase system. This is the basic theory of earthing transformer, the operation and other features of an earthing transformer is described as follows.

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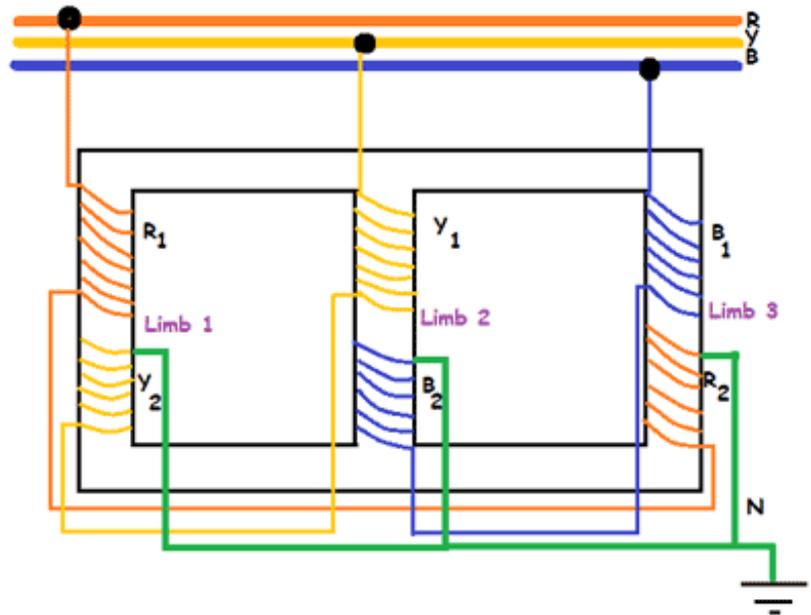
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Construction of Earthing Transformer or Grounding Transformer

Now you got the idea, that why a grounding transformer should be used in delta connected transmission lines. All **earthing transformers** are zigzag (or interstar) connected. We all know that, the resistance of the earthing path should be kept as small as possible, because fault current will always follow the lowest resistance path. Therefore, the impedance of a earthing transformer is made small intentionally. The copper loss is I^2R , and as the R is small, therefore the copper loss is also very small (almost negligible) in grounding transformer. When the fault occurs, very high level of current starts flowing through the lines, which is harmful for the earthing transformer. As the total impedance is low in grounding transformer, so an additional resistance is inserted into the neutral conductor to limit the fault current into a safe value.

An **earthing transformer** consist of three separate limbs and generally, core type construction is used for this purpose. The core is made up with rolled electromagnetic steel sheets. The windings are made up with copper wires and generally the enamel or paper insulation is used. Each phases are equally divided into two halves with same number of turns inside the transformer. There are

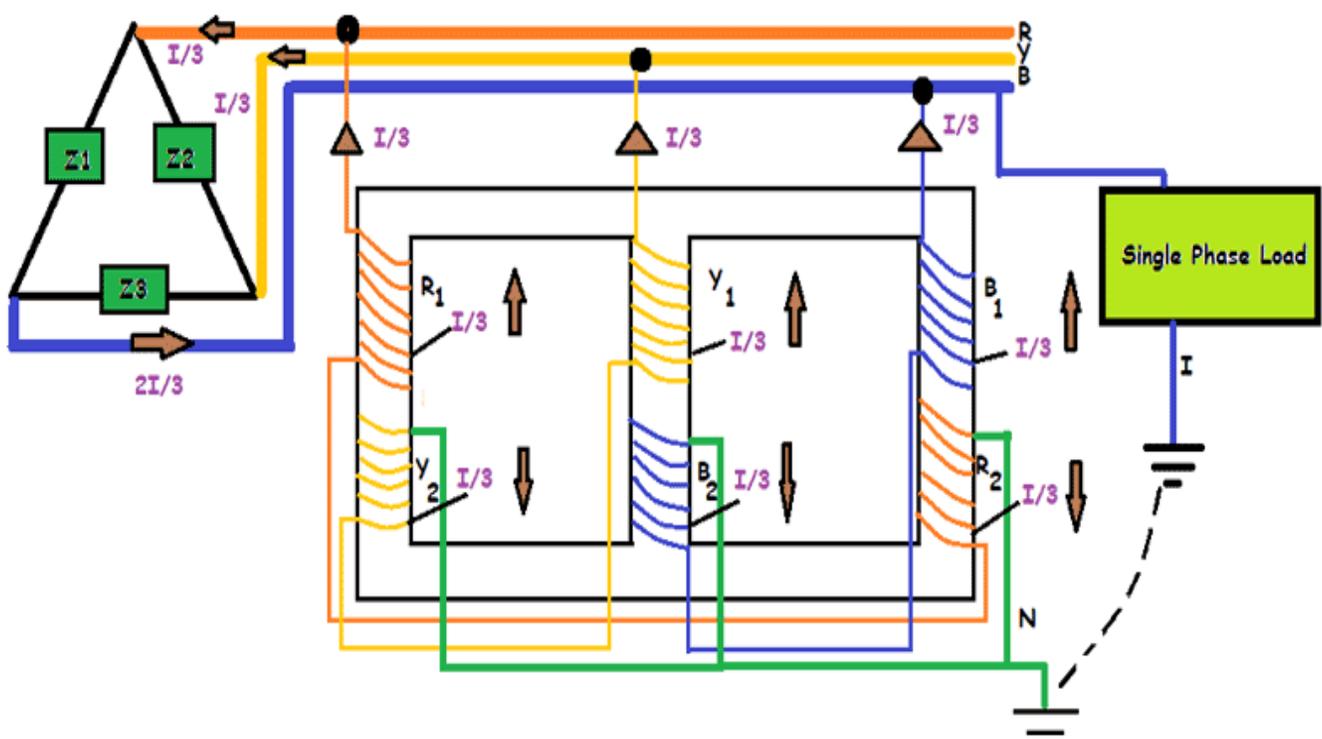
three phases Red, Yellow and Blue and three limbs in iron core also. But as the connection is zigzag so the phase segments will be arranged in an interstar connection. The first half of the red phase will be wound on the upper portion of the first limb of iron core. The another half of the red phase will be wound on the lower portion of the third limb. Similarly, the first half of the yellow phase will be wound on the upper portion of second limb. And rest portion of the yellow phase will be wound on the lower portion of the first limb of iron core. In this way, the



first half of the blue phase will be wound on the upper portion of third limb. The another half of blue phase will be wound on the lower portion of second limb of the iron core. In this way, each limb of earthing transformer consist of two different phase winding segments, which are connected differentially. After the winding is done, all phase terminals are connected by a single wire and in this way a common neutral junction is generated. In the diagram, the phase windings are shown along with the green neutral wire connection. This neutral point is grounded with the help on strong earthing electrode.

Operation of Earthing Transformer or Grounding Transformer

The operation of this type of transformer is quite easy to understand. Suppose, a three phase three wire delta connected system is converted into a three phase four phase system with the help of an earthing transformer, as shown in the given diagram. And a single phase load is connected with the blue phase and neutral point. Consider, the load current is I , which is flowing through the load circuit. After that, load current I is divided into three equal parts and they starts flowing through each winding of the earthing transformer. As the branch currents are all equal, so the neutral point is constant with respect to time. In this way, the phase to neutral voltage remains in balanced condition in three phase four wire system. Under the normal operation, the total induced flux in each limb of the transformer core is very small, so it draws negligible magnetising current from the source.



When any single phase to ground fault is occurred, zero sequence component of earth fault current starts flowing through the neutral wire. In earth fault, the current flowing in the faulty phase goes to the source via the grounding terminal. And, this fault current is divided equally in each phases of the earthing transformer. But, each limb of the iron core consist of two different phase winding segments. Therefore, equal but opposite currents are flowing through each winding. In this way, each winding segment will develop equal but opposite magnetic flux, which will neutralize each other. So, the net flux does not increase, even in the faulty condition. Therefore, the rated voltage and current flow will be continued through the load circuit in the faulty condition also. One third of the total load current will be fed to the main busbar by each phase winding of the earthing transformer. An series resistance will limit the fault current into a safe value, because the impedance of the transformer is quite low. In this way, the grounding transformer provides an artificial grounding point for all single phase loads as well as neutralize the fault current with the help of the interstar connection.

Why Zigzag connection is used for Earthing Transformers?

The zigzag connection is actually a inter connected star connection. In Earthing transformers, three pairs of concentric coils are arranged in zigzag pattern. This type of arrgement is used because, this connection has some special features. They are:

- Neutral shift is negligible for this arrangement, that is steady neutral point is generated by this connection.
- This type of connection provides very small impedance for the zero sequence currents, so in the time of earth fault, this winding gives the low resistance path for grounding the fault current.
- Winding insulations are subjected to negligible electric stress.
- This type of connection is free from any type of harmonic residuals.
- Due to the grounding, fault current does not affect the secondary side.

Difference between Earthing Transformer and Power Transformer

Although the operation is quite similar, but there are several differences in between the Earthing transformer and power transformer. They are discussed as

follows:

- The direction of power flow is unidirectional for earthing transformers, whereas for power transformer the power flows in both direction.
- The Earthing transformer KVA is designed for short time overload, but the power transformer KVA ratings are designed for continuous operation.
- Grounding transformers are used to derive a neutral point for ungrounded three phase system, whereas power transformers are used for transferring the power from one circuit to another, and changing the voltage levels.
- The fault current of earthing transformer is depended upon the system, sometimes it turns into few thousand amperes, but in power transformers the fault current is upto 25 times of normal rated current.
- The leakage reactances is comparatively lesser in earthing transformers as compared to the power transformers.
- Harmonic residual components are present in power transformer, but they are not seen in earthing transformers.
- The efficiency is more in earthing transformers, and the cost is comparatively lesser than power transformers, that is why it is very economical for use in wide variety of operations.

Applications of Earthing Transformer

Earthing transformers are widely used in three phase power system networks. Proper grounding in the power source is preferred in several applications, as this provides additional safety for the equipments connected with the network and for the operator also. These transformers are effectively provide an easy low resistance path for the fault current, during the period of earth fault. Additionally they are used to hold the neutral shift within an proper limiting range. Grounding transformers are used to generate an artificial neutral point for ungrounded three phase system, like three phase delta connected system. The zigzag connection of the transformer helps to derive a common



neutral point which is further grounded via series current limiting reactor. In this way, the three phase system is able to provide both single phase (line to ground) and three phase (line to line) power easily. This ensures the profitable operation of power system networks.