An Overview Of Grounding System (Grounded)

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An Overview Of Grounded Grounding System (on photo: Grounded solar panel by J.E.M. Solar; jemsolar.com)

Topics covered

Solidly grounded system

Let us assume that ***R phase*** (***Phase-3 in figure-3***) is shorted to ground than:

- **If** = Current through shorted path (*Fault current*)
- **In** = Current through neutral to earth connection
- **Icy** = Capacitive current returning via the network Phase-2 (*Y phase*)-earth capacitances
- **IcB** = Capacitive current returning via the network Phase-1 (*B phase*)-earth capacitances

We can write:

If = In + IcY + IcB + Ir // Equation-08

Where ***Ir*** = Current returning via network insulation resistance which is always negligible

In case of LV, system voltage available between phase and earth is ***415/1.732 = 240V***. Resistance of earth plate, grounding connections etc… is of the order of ***1.5 Ohms*** so the earth current is limited to approximately ***240/1.5 =160 Amperes***. This is not very high magnitude hence any intentional impedance is not required in neutral to earth connection.

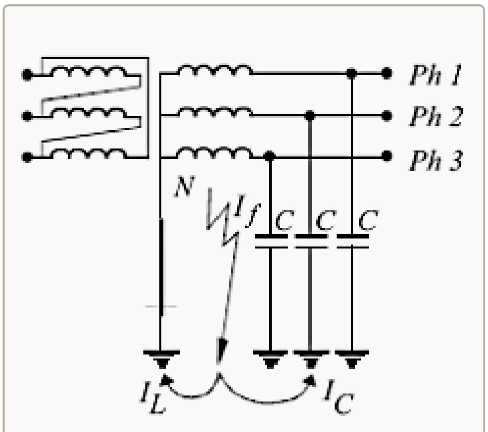

Figure 3 - Solidly grounded system

As per ***equation -08*** for If one can see that if ***IcY*** and ***IcB*** is negligible than ***If = In which is the case in LV system***. At ***415V*** level capacitive ground currents are not significant hence we can write:

If = **In** for solidly earthed LV system // Equation-09

Resistance grounded system

In case of ***MV system*** (*3.3kV onwards to 33kV*) voltage between phase and earth is high. Also ***capacitive charging current*** is not large enough to compensate the same, so earth fault current is likely to be excessive.

Hence resistance is connected between neutral to ground connection. Current through neutral is limited to ***100-400 Amperes***.

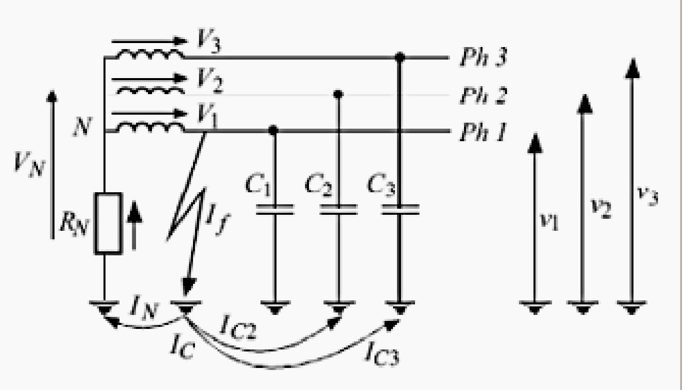

Figure 4 - Resistance grounded system

Restricting the earth fault current / current through neutral

Although all the component of power system at MV level are rated at ***full MV system fault level***, for instance:

- Winding of transformer,
- Cables,
- Bus ducts,
- Rotating machine winding, etc.

Than what is getting protected by restricting the earth fault current/current through neutral?

The neutral of transformer or generator are grounded through impedance, the principal element of which is resistance. This method is used when the earth fault current would be too large if not restricted (e.g.) MV Generators. Here, a resistor is connected intentionally between the neutral and earth. This is to limit the earth fault current.

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The reasons to limit the earth fault current

The reasons to limit the earth fault current are:

1. In rotating electrical machines like ***motors*** and ***generators***, if the earth fault current is high, as in the case of solid earthing, the core damage would be high. To limit the damage to the core, machine manufacturers allow only a limited ground fault current.

This is given in the form of a core damage curve.

2. A typical value would be ***25A-100A for 1 second***. This value is used as a guide in selecting NGR and setting stator earth fault relays in generator protection.

3. ***Winding damage in rotating electrical machines*** is not of serious concern (Though windings are rated for full fault level). The repairs to winding damages can be done by the local re-winder. But, in case of core damage, repairs cannot be carried out at site. The machine has to be sent back to the manufacturer's works for repairs thus resultingin prolonged periods of loss of production.

Since rotating electrical machines are not present in voltage levels from 22kV onwards, ***these systems are usually solidly grounded***.

4. ***X0/X1 ratio of the system*** also decides type of neutral earthing. If the corresponding X0/X1 ratio falls under that predefined range. It is a choice between to weather to deal with higher voltage or higher current while under short circuit. Effectively earthed lowers the over voltage limit of the healthy phases while another phase is short circuited to earth. But the ground fault current is very high.

That means system will need a high capacity breaker but insulation system has to be moderate BIL rating.

But as the neutral to earth impedance increases ground fault current reduces but doing so the over voltage factor will rise even up to 1.73 times! So requires a breaker with low current capacity but a HIGH BIL for all insulation system.

Let us assume that ***R phase*** (*Phase-1 in figure-4*) is shorted to ground than:

- **If** = Current through shorted path (*Fault current*)
- **In** = Current through neutral to earth connection
- **Icy** = Capacitive current returning via the network Phase-2 (*Y phase*)-earth capacitances
- **IcB** = Capacitive current returning via the network Phase-3 (*B phase*)-earth capacitances

Repeating equation-8 we can write:

If = In + IcY + IcB + Ir

Neglecting Ir and substituting the following:

In = -V1/Rn (*Negative sign indicates that capacitive charging & discharging current are in phase opposition to current through neutral*)

IcY + IcB = Total capacitive charging and discharging current of healthy phase ***= j3CwV1*** from ***equation-07***

Phasor diagram representation will be:

So finally after substitution of In and IcY + IcB expression for ground fault current in MV system would be:

If = -V1/Rn + j3CwV1 // Equation -10

Magnitude of ground fault current will be:

|If| = |V1|√(I/Rn)2+ 9C2w2

System earthing at EHV level

In case of ***HV system*** (*above 33kV*) Capacitive ground current is large enough ***to neutralize the earth fault currents*** hence no resistance is required in neutral to earth connection.

Solid grounding is universally adopted for following reasons:

1. As we already understood that it is a choice between weather to deal with higher voltage or higher current while under short circuit. At EHV level if we opt for higher voltage than due to higher costof insulation at EHV selection of higher voltage will not be a viable idea.

It is better to opt for higher current by selecting solid grounding.

2. Rotating machines are not present at EHV system so there is no use of limiting the ground fault current as we do in MV system. Even if rotating machines are present because of higher voltage capacitive ground current is also large enough to neutralize the earth fault current.

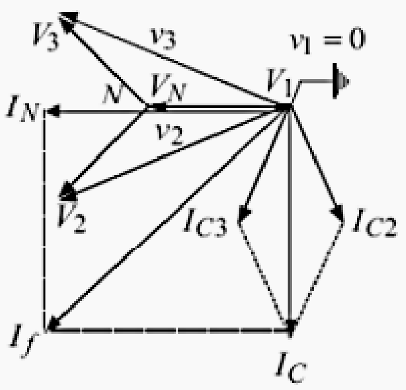

Figure 5 - Phasor Diagram

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3. EARTHING: Your questions answered By Geoff Cronshaw
4. IEEE Recommended Practice for Electric Power Distribution for Industrial Plants

Source:

http://electrical-engineering-portal.com/an-overview-of-grounding-system-grounded