An Overview Of Grounding System (Ungrounded)

Asif Eqbal

An Overview Of Grounding System (Ungrounded) (On photo: installed ground clamp. The 2" x 0.022" copper strip is treated with a copper based anti oxidation grease and then clamped to the clean copper plated 8' ground rod - by beevo.com)

Topics:

Underground Neutral Or Undergrounded System

Before 1950 power system were often without neutral grounding. Such system had ***repeated arcing grounds***, ***insulation failure*** and ***difficult earth fault protection***.

Every phase has inherent distributed capacitance with respect to earth. If earth fault occurs on phase B, the distributed capacitance discharges through the fault. The capacitance again gets charged and gets discharged. Because of this sever ***voltage oscillation*** is reached in healthy phases.

These voltage oscillation causes stress on insulation of connected equipment.

Ic2 = jCwv2
Ic3 = jCwv3
Ic = jCwv2 + jCwv3
Ic = jCw(v2 + v3) // Equation-01

Now by drawing the phaser diagram as shown below wecan write:

VN + V2 = **v2** // Equation-02
VN + V3 = **v3** // Equation-03

Substituting equation -02 and equation-03 in equation-01:

Ic = jCw(VN + V2 + VN + V3)
Ic = jCw(2VN + V2 + V3) // Equation-04

Voltage phasers V3 can be resolved in the direction of $\boldsymbol{V_N}$ and in direction perpendicular to V_N as ***V3Cosθ and V3Sinθ***.

Similarly ***voltage phaser V2*** can be resolved as ***V2Cosθand – V2Sinθ***

Hence:
V2 + V3 = V3Cosθ + V3Sinθ + V2Cosθ – V2Sinθ // Equation-05
V3 = V2
V3Cosθ + V2Cosθ = $\mathbf{V_N}$

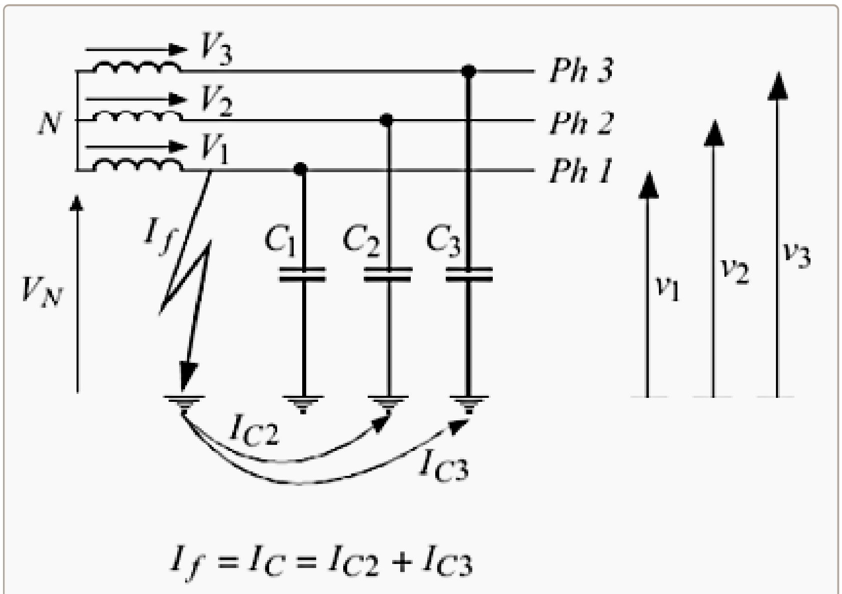

Figure 1 - Ungrounded neutral or ungrounded system

Substituting in equation-05 we get:

V2 + V3 = VN = V1 (Since V1 is shorted to ground soVN = V1) // Equation-06

Substituting equation-06 in equation- 04 we get:

Ic = jCw(2VN + VN)

Total capacitive charging and discharging current of healthy phase is:

Ic = j3CwV1

For ungrounded system:

If = IC2 + IC3 = IC = j3CwV1 // Equation-07

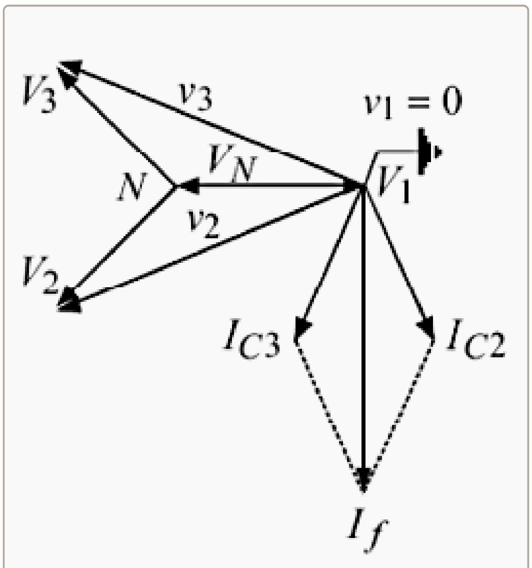

Figure 2 - Ungrounded neutral or ungrounded system

As seen from ***equation -07***, in unearthed system ground fault current is totally dependent on ***capacitive current*** returning via the network phase-earth capacitances. This is the reason for ***sever voltage stress*** in healthy phases of ungrounded system.

Since ***there is no return path available for fault current*** in ungrounded system so detection of earth fault current is difficult. This is other disadvantage of ungrounded system.

Advantages of Ungrounded System

There are some advantages of ungrounded system:

1. Ungrounded system has negligible earth fault current
2. Some continuous process or system and essential auxiliaries where single phase to ground fault should not trip the system.

Disadvantages of Ungrounded System

However below listed disadvantages of ungrounded system are more adverse than advantages:

1. Unearthed system experience repeated arcing grounds.
2. Insulation failure occurs during single phase to ground faults.
3. Earth fault protection for unearthed system is difficult.
4. Voltage due to lightning surges do not find path to earth.

In order to overcome the above mentioned technical and operation issues the concept of system grounding was introduced. System grounding is connecting the neutral of system to earth.

At every voltage level neutral of transformer is considered as ***neutral of system***.

System grounding is of two types:

1. ***Effective grounding:*** Effective grounding is also called solid grounding that is without resistance or reactance. In this case co-efficient of earthing ismore than 80%
2. ***Non effective grounding:*** When neutral to earth connection is made through resistance or reactance than the system is said to be non-effectively grounded. In this case coefficient of earthing is greater than 80%

Coefficient of earthing and earth fault factor

Coefficient of earthing is the ratio which is measured during single phase to ground fault:

Ce = Highest phase to ground voltage of healthy phase / Phase to phase voltage

In a system without neutral earth (***refer Figure 1***), phase to earth voltage phase-1 and phase-2 rises to 3times phase to phase voltage Vrms during single phase to earth fault on phase 3. In a neutral earthed system the voltage ofhealthy phase rises to Ce times Vrms.

Therefore value of Ce:

- For non-effectively earthed system ***Ce = 1***
- For effectively earthed system ***Ce < 0.8***. Hence surge arrester rated voltage is > 0.8 V rms

Surge voltage kV instantaneous is taken as 2.5 times of ***critical flashover voltage (CFOV)*** of line insulation. Thus discharge current is given as:

I = (2.5(CFOV) –Residual voltage of arrester) / Surge impedance of line

Earth fault factor is a ratio calculated at selected point of the power system for a given system. ***Earth fault factor = V1/V2***

- ***V1*** = Highest RMS phase to phase voltage of healthy phases (*phase 2 and 3 refer to Figure 1*) during earth faulton pahse-1
- ***V2*** = RMS value of phase to earth voltage at same location with fault on faulty phases removed

References:

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2. Switchgear protection & power system By Sunil S Rao, Khanna publications
3. EARTHING: Your questions answered By Geoff Cronshaw
4. IEEE Recommended Practice for Electric Power Distribution for Industrial Plants