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GROUND FAULT PROTECTION USING OPEN BREAK DELTA GROUNDING TRANSFORMER IN UNGROUNDED SYSTEM

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Abstract. One of the most common and difficult problems to solve in distribution power systems is the location and elimination of the ground fault. This paper presents a method for ground fault protection system scheme is used overvoltage relays and open break delta transformers, whereas for fault location detection using voltage transformers in star connections. An experimental for further understanding about the electrical distribution network, the ungrounded system will be operated at 20 kV on the primary and 380 V on the secondary. The model uses smaller nominal voltages consisting of 380 V on the primary and the secondary. The highest single line to ground fault value is used for consideration of ballast rating selection. The single line to lowest ground fault value is used for setting the threshold on the voltage relay (59N). The result of one phase fault protection mechanism works well at each point of interference, and voltage transformers are protected from overheating and damage. The lowest value of the single-phase to ground short circuit that occurs at the fault location at the farthest point of interference from the protection relay location is used for the threshold setting on the voltage relay. The one phase fault protection mechanism works well at each point of interference, and the voltage transformer is protected from overheating and damage..

Keywords :. ungrounding system, ground fault protection, open break delta transformers, overvoltage relay

1. INTRODUCTION

An ungrounding system is an earthing method that does not have a direct relationship between the star-point of a power transformer and the ground. Therefore, there is no circumference current of ground fault when the disturbance of the ground is occurring. The economic considerations and the maintained loading balance of the three-phases make this system selected.

Baldwin, T. shows a fault detection method in ungrounding and high impedance earthing systems using zero sequence current generator injections [1,2]. The technique developed is able to trace the disturbance to determine the location of the point of disturbance. Implementation of distribution network systems is using two methods. First, the installation of a zero-sequence signal generator was employed. When a ground disturbance is detected, the related relay initiates a signal generator to supply current through a system of looping back through the ground network after reaching the point of interference. The distance of electricity from the relay to the point of interference will be determined from the propagation of the signal generator. To avoid communication problems with other equipment, the frequency chosen for the signal generator is different from the frequency of the power line. The second, a remote ground-fault indicator (RGFI) was used. RGFI is connected to the zero sequence current of the transformer. When line-to-ground interference occurs, RGFI detects currents through a zero sequence and then provides a physical indication of where the interference occurs. The test results from both methods were tested on ungrounding delta-connected networks and high-resistance grounding networks.

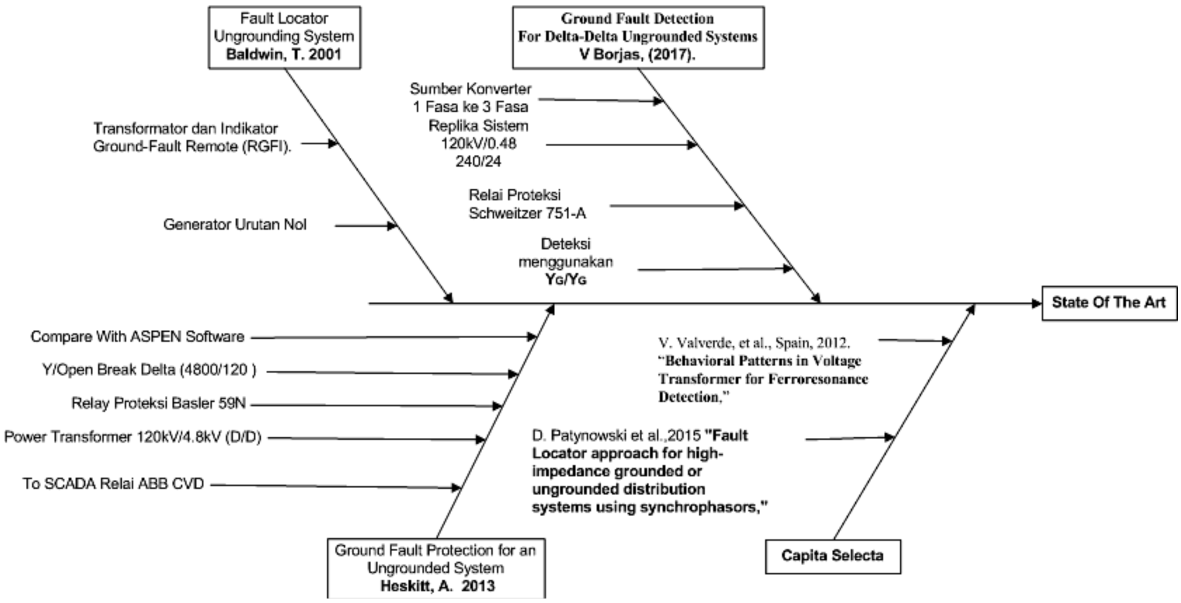

Figure 1. The state of the art of the simulator development

Further development is to study the effects of ferroresonance on ballast resistance which connected in parallel with overvoltage relays. For limiting the resonance between the VT inductance and the capacitance, the pattern system is developed referring to the technical experience. Most of the modern systems have a numerical relay in every phase, which can provide the necessary long-distance communication, but some utilities still use the solid state protection relay method.

Another method used is to determine the location of the fault by using a signal generator to zero sequence windings from the transformer. When a disturbance occurs, the relay starts generating a signal to send a current that will return through the soil network from the point of interference. This signal allows the relay to determine the distance between the points of interference from the relay so that the location of the fault can be specified in the system.

The ungrounding system has been studied extensively; A groundbreaking protection simulator design of an ungrounding system was developed by Heskitt [3] at the California Polytechnic State University in San Louis Obispo. On a network with a 120 kV/4.8 kV power transformer connected to Delta Delta, and a 4800 V/120 V voltage transformer, a 120 V secondary voltage connected by an open delta connected to the Basler-59N overvoltage protection relay. The two design simulators are replicas of the 12 kV electricity distribution system at the primary and 480 V at the secondary, which are reduced to 240 V at the primary and 24 V at the secondary. Current and voltage are connected to the Schweitzer 751-A protective relay which provides load monitoring and a ground fault detection scheme developed by V. Borjas [4] at Michigan Technology University USA.

In this study, we developed a design product for studying the soil disturbance protection in an ungrounding system of electric power distribution at a voltage of 20 kV on the primary and 380 V on a secondary, which was established at the Laboratory of Electric Power Distribution Systems, Bandung. In the simulator, the nominal voltage is simulated 380 V at primary and secondary. The ground disturbance protection system scheme uses an overvoltage relay (59N) and the voltage transformer on the primary with a star connection grounded, and the open secondary delta is grounded [5,6].

In this study, we will verify the consideration of choosing a ballast rating, and how to determine the overvoltage threshold setting, by the usage of four points of interference on the network. Therefore with the right selection, the protection against any location of interference along the network will be achieved, and the protection system elements are protected from damage. We will also look at the effect of short circuit interference in addition to a single phase to ground short circuit against the mechanism of the protection system.

2. METHODS

Functional Testing Design

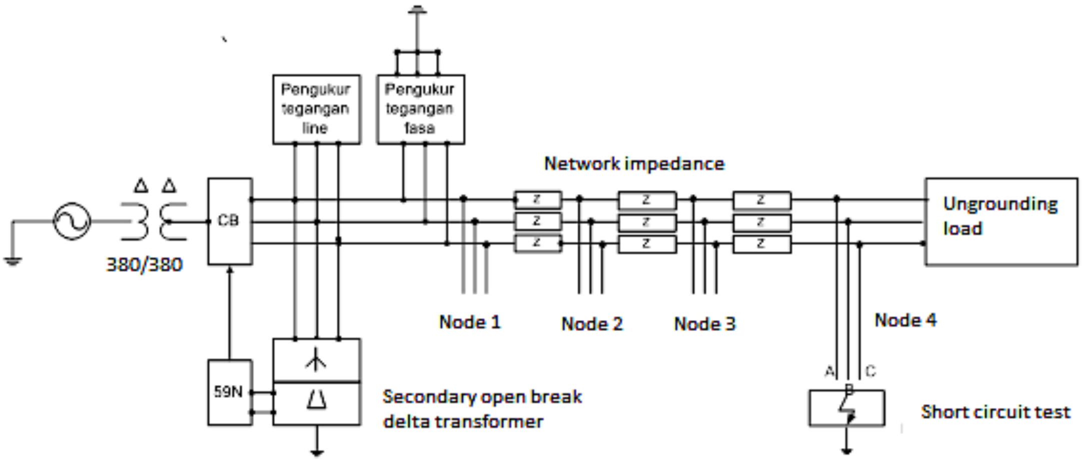

Figure 2. Functional testing design

The functional design that displays the relationship between function elements that become the framework in the simulator manufacturing process was shown in Figure 2. When one phase to ground interference occurs, the operating system will continue, in this condition cable insulation and equipment are under pressure. The effect that occurs during a zero voltage disturbance at the interrupted phase and the continuous phase voltage rises to √3 nominal voltage. The phase difference between the continuous stages drops from 120 degrees to 60 degrees. The testing process will run as follows:
1) Calculation and testing of one-phase to ground disturbances in the simulator will test for soil disturbances from four zones of disturbance point, 0% point of disturbance location as a representation of disturbance points at the substation, 25%, 50%, 75%, and 100% point location representation farthest interference.
2) The closest interference point (point 1) is used to determine the ballast capacity for the protection of a voltage transformer.
3) The farthest point of interference (point 4) is used to determine the overvoltage threshold set at a over voltage relay (59N).
4) Testing the mechanism of the one-phase to ground protection system of the four points of interference.
5) Examining the mechanism of the protection system against one phase to ground short circuit, phase to phase, two-phase to the ground, and three phase short circuit

Voltage During One Phase Disruption to the Ground

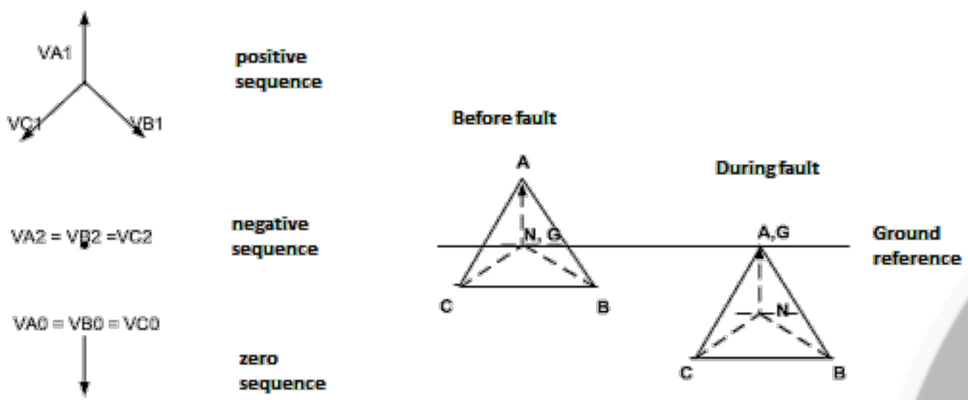

Figure 3. Ground Disturbance on Floating Grounding Systems

Protection for ground fault mechanism and voltage threshold settings

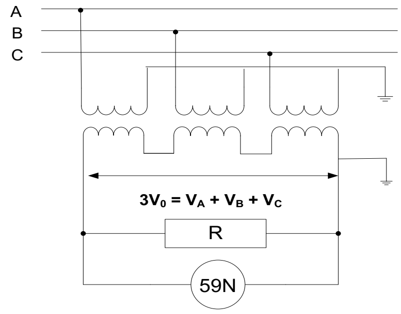

Figure 4. Open Break Delta Network and Overvoltage Relay (59N)

The concept of protection of zero sequence voltage characteristics in a not grounded system when a single phase fault occurs to the ground is shown in Figure 4. Voltage transformers in an open break delta relationship will give an increasing voltage signal in the event of a ground disturbance. The overvoltage protection relay ground disturbance will detect ground faults and give Circuit Breaker commands to break up [7,8].

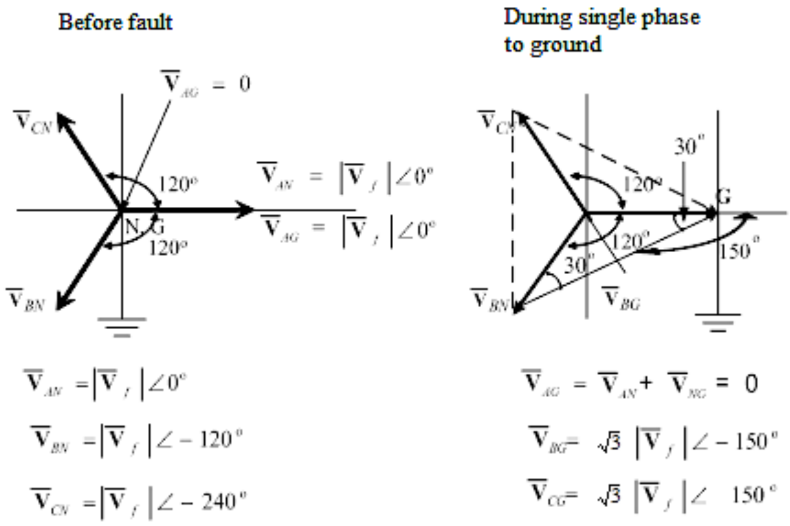

Figure 5 Vector Chart of The Open Break Delta Terminal Exit Voltage

When a ground fault occurs, the voltage will rise three times the phase voltage to nominal neutral. This voltage will be detected in the open break delta transformer terminal.

3. RESULTS AND DISCUSSION

Table 1. Results of Calculation of Interference Voltage One Phase to Ground Short Circuit

Type of fault	Voltage A V_A(Volt)	Voltage A V_B(Volt)	Voltage A V_C(Volt)	Voltage 59N V_0(Volt)
Before a fault in node 1	$220\angle 0^0$	$220\angle -120^0$	$220\angle 120^0$	0
Before a fault in node 2	$214\angle 0^0$	$214\angle -120^0$	$214\angle 120^0$	0
Before a fault in node 3	$208\angle 0^0$	$208\angle -120^0$	$208\angle 120^0$	0
Before a fault in node 4	$202\angle 0^0$	$202\angle -120^0$	$202\angle 120^0$	0
During ground fault in 1	0	$380\angle -150^0$	$380\angle 150^0$	$144\angle 180^0$
During ground fault in 2	0	$370\angle -150^0$	$370\angle 150^0$	$140\angle 180^0$
During ground fault in 3	0	$360\angle -150^0$	$360\angle 150^0$	$136\angle 180^0$
During ground fault in 4	0	$350\angle -150^0$	$350\angle 150^0$	$132\angle 180^0$

The purpose of the installation of detainees is to protect the transformer from working according to the rating of its capacity. From table 1 we get the highest relay voltage of 144 volts. The secondary rating of the ballast rating is determined by the capacity (VA) per phase of the voltage transformer divided by the secondary voltage transformer per phase rating. Therefore, for a 50 VA voltage transformer with a secondary voltage of 48 volts, the secondary current rating is 50/48 = 1 ampere. Ballast resistance is the voltage on the terminal relay 144 volts, the ballast resistance required is 144/1 = 144 ohms while the minimum resistor power is 144 x 1 = 144. In the simulator selected R = 200 ohms, and 150-watt ballast power.

Overvoltage settings 59N [5], from Table 1 shows that the value of the relay terminal voltage when a one-phase short circuit occurs at the lowest ground is 132 volts. The relay threshold voltage is set at 120 volts, and the disconnection time setting with inverse characteristics uses TDS = 40. The protection system is needed for short circuit ground fault until the breaker works clearing the interference and separating the part that is experiencing ground disturbance with a 10 second break time. IEEE Std 32-1972 [9,10,11].

Test Protection Performance in Various Short-circuit Interferences

When one phase to ground interference occurs, the operating system will continue, in this condition cable insulation and equipment are under pressure. The effect that occurs during a zero voltage disturbance at the interrupted phase and the continuous phase voltage rises to √3 nominal voltage. The phase difference between the undisturbed phases drops from 120 degrees to 60 degrees. When a ground fault occurs, the voltage will increase three times the phase voltage to nominal neutral. This voltage will be detected in the open break delta transformer terminal.

Table 2. The Measurement Results of Short-circuit Voltage Disturbance Furthest Point*

Type of fault	Voltage A V_A(Volt)	Voltage A V_B(Volt)	Voltage A V_C(Volt)	Voltage 59N V_0(Volt)
Before a fault	202	202	202	0
Single phase to ground faults	0	350	350	132
Phase to phase faults	202	101	101	0
Two phase to ground faults	303	0	0	66
Three phase faults	0	0	0	0

*) Determined at VT ratio 220/48, based on voltage measurement on the disturbance point

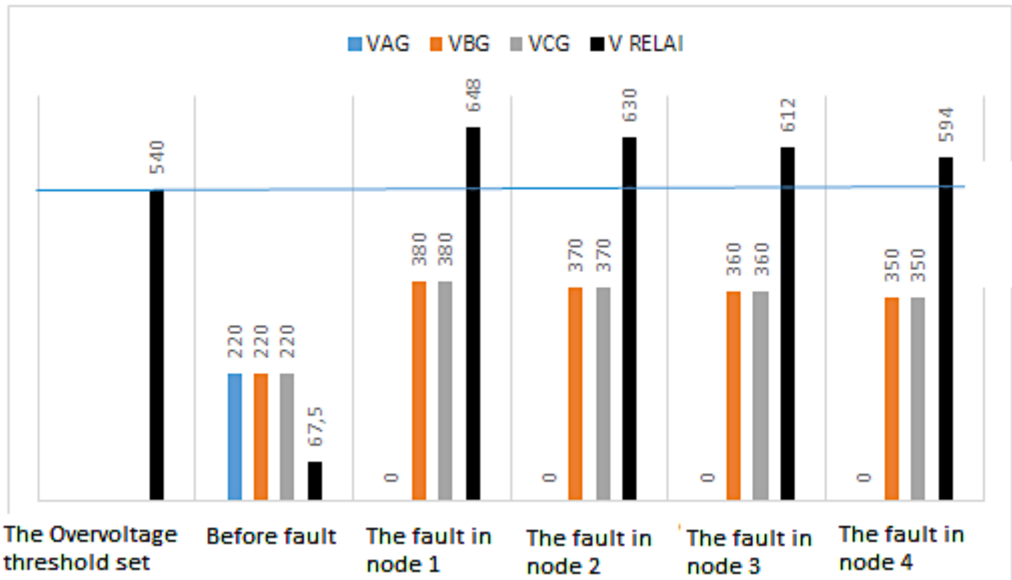

Figure 6 The Voltage at Single-Phase to Ground Fault in Function of Disturbance Location

From the graph in Figure 6 shows that the setting based on relay voltage at point 4 can protect all four points of interference. Using the characteristics of the inverse time function voltage with a 120-volt setting, and TDS = 40. In Figure 7 it is shown that in interruptions at point 4; 3; 2; 1 with a sequential termination time of 3.5 seconds; 3 seconds; 2 seconds, 1 second.

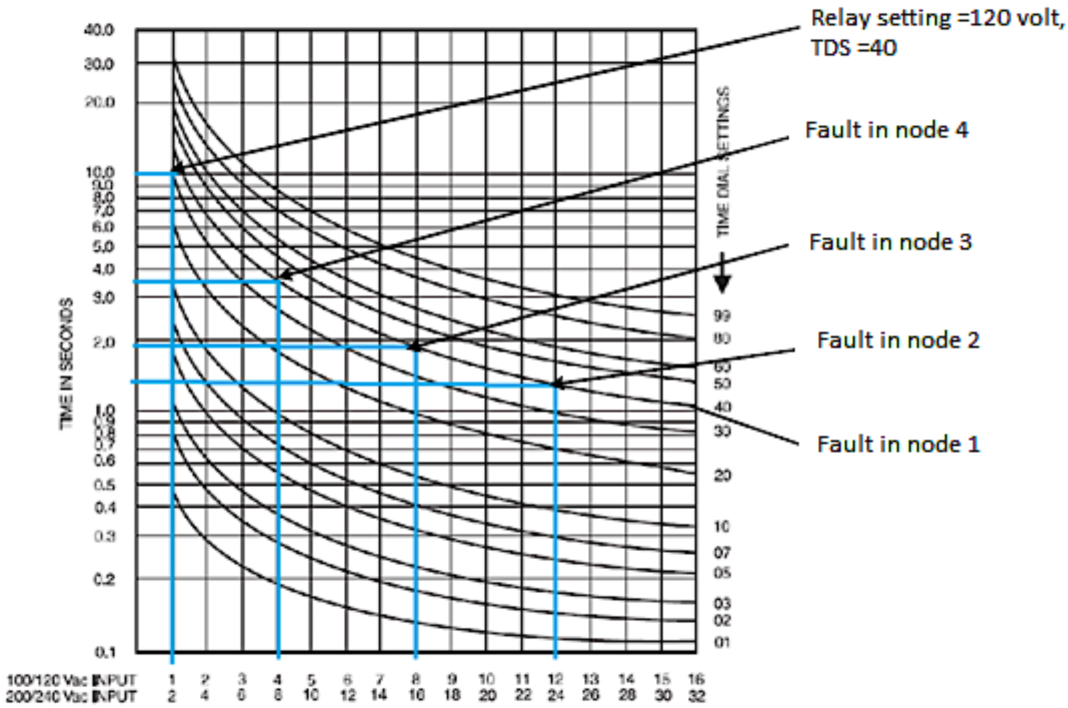

Figure 7 The Characteristic of The Overvoltage in Time of Inverse Termination

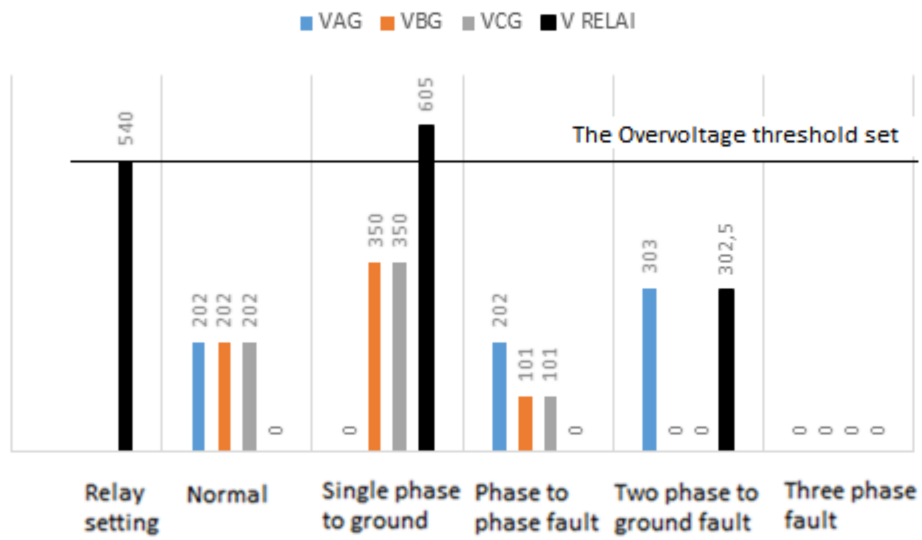

Figure 8 Voltage Function of Different Types of Disturbance

The results of testing with various types of short circuit interference indicate that this protection system only protects against one phase voltage to the ground. From this test, it can be seen that overcurrent protection of phase disturbances is still needed to provide phase disturbance protection.

4. CONCLUSION

The highest one-phase short-to-ground value is the location of the disturbance that occurs at the closest location to the installed relay used for consideration of ballast rating selection. The lowest value of the single-phase to ground short circuit that occurs at the fault location at the farthest point of interference from the protection relay location is used for the threshold setting on the voltage relay. Referring to the calculation results of the highest one-phase voltage at point 1 is 144∠180° volts, and the lowest is at point 4 of 132∠180° volts. 200-ohm ballast impedance with a power capacity of 150 watts, and an overvoltage threshold setting of 120 volts with a TDS of

40. The one phase fault protection mechanism works well at each point of interference, and the voltage transformer is protected from overheating and damage.

Testing with other short-circuit parameters in addition to the short circuit of one ground phase is not able to initiate the circuit breaker to operate, only in a single phase short circuit to the ground that the protection relay works to decide the network breaker. Therefore phase short circuit security is still needed to protect the network

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