Identification of Single Phase to Ground Faults in Power Distribution Systems with RG Technique

Ranjithkumar [1], Maruthupandi [2]

[1]P.G scholar, Department of Electrical and Electronics Engineering, Government College of Technology, Coimbatore, India.
[2]Assistant Professor, Department of Electrical and Electronics Engineering, Government College of Technology, Coimbatore, India.

E-mail: [1]ranj.65757@gct.ac.in, [2]pandi@gct.ac.in

Abstract

Fault in a power system is an irregular condition that interrupts the stability of the system and causes a high fault current to flow through the power systems and its devices. Single phase to ground fault is an unsymmetrical fault that takes place between any phase of the system and ground. It is the most frequently occurring fault (70%-80%) that happens in the power system. Resonant Grounding (RG) is the proposed approach that reduces a fault current of a single phase to ground fault to a minimum level that is often independent of fault impedance. In this case, the single phase to ground fault current is too small and the typical overcurrent relay does not respond in this circumstance. As a result, a new and improved approach for detecting single phase to ground fault failures in arc suppression coil grounding distribution system with very low fault currents, though the fault impedance is low, is required. The faults are initially detected based on the neutral voltage displacement by a regionalized fault detection technique. The statement is validated by simulating a single phase to ground fault on an IEEE thirteen node test system and the results are presented. Since it employs local voltage and current information to detect power system fault condition, the suggested technique does not require communication between circuit breaker, relays, transformer, transmission lines etc. This approach can be used to a variety of different forms of unsymmetrical faults.

Keywords: Fault detection, fault classification, unsymmetrical faults, single phase to ground fault, regionalized fault detection technique, generating station, resonant grounding

DOI: https://doi.org/10.36548/jeea.2022.1.002
Received: 09.03.2022, received in revised form: 09.04.2022, accepted: 16.04.2022, published: 26.04.2022

1. Introduction

There are no fault free conditions in power system due to various conditions such as climatic conditions, transient and switching surges. Thus, immediate identification of power system fault condition is very important. Fault categorization and fault isolation are also the related tasks. The fault diagnostic process entails determining the fault type and characteristics as well as providing as much information as possible about the issue, such as the time of discovery, location and clearing time [1-5]. So many possibilities are should be considered when choosing single phase ground fault identification. Important criteria include the type of equipment failures, the description of the process operation, the process dynamics, the measured process signals, the process complexity, the amount of process input-output data available and the process suitability for rule-based description. One reason for the difficulty is that traditional fault detection methods generally require extensive prior knowledge of system behaviour, which is not always easily obtained beforehand. Another technique employed is the Artificial Neural Network which owns a disadvantage of requiring a large number of samples to train the network which might be challenging [6-9]. Therefore, to overcome the disadvantages of the conventional fault detection methods, identification of single phase to ground fault for generation station along with arc suppression coil grounding using IEEE thirteen bus test feeder is described in this paper.

2. Modelling Of Distribution System

The IEEE thirteen bus feeder is a lesscomplexitysystems that is used to test distributio n systems. It operatesat 4.16kV, has one generatingsource, a circuitbreaker, many number of short unbalanced transmission lines, and shunt capacitors. Figure 1 shows a single line diagram of generating station along with the arc suppression coil grounding and single phase to ground fault impedance.

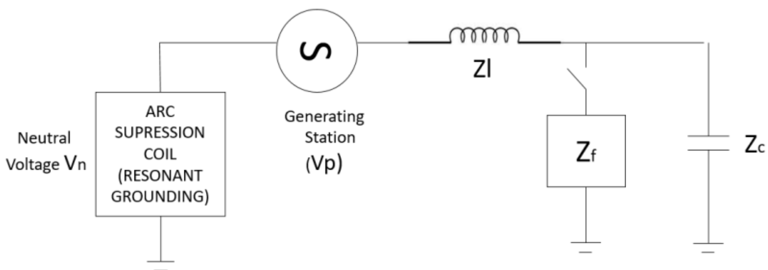

Figure 1. Schematic model of the proposed system

The figure 1 represents the model of the proposed system. It consists of arc suppression coil, generating station, line impedance and line capacitance. Where neutral voltage (Vn) and Fault impedances (Zi) are measuring parameters. Due to the neutral voltage displacement, the fault condition and type of the fault can be identified. A simplified circuit for the neutral to ground voltage during the single phase to ground fault can be expressed as:

$$Neutral\ voltage\ (Vn) = \frac{(Impedance\ of\ resonant\ grounding)\ (Generating\ voltage)}{Resonant\ grounding\ impedance + Line\ impedance + (Line\ capacitacne\ ||\ Fault\ impedance)}$$

3. Proposed Work

In the proposed method, the single phase to ground fault is detected the following steps. Initially all phase currents as well as neutral flow current of the system are noted. The ground leakage voltage is then corelated with the corresponding predetermined value getting from the too many times simulation results. The accuracy of fault estimation fully depends on the predetermined value. This technique has the ability to differentiate the type of the fault. (temporary fault//permanent fault). Regionalized fault detection technique able to detect fault with in 10ms. Figure 2 representing the flow chart of the proposed regionalized fault detection technique.

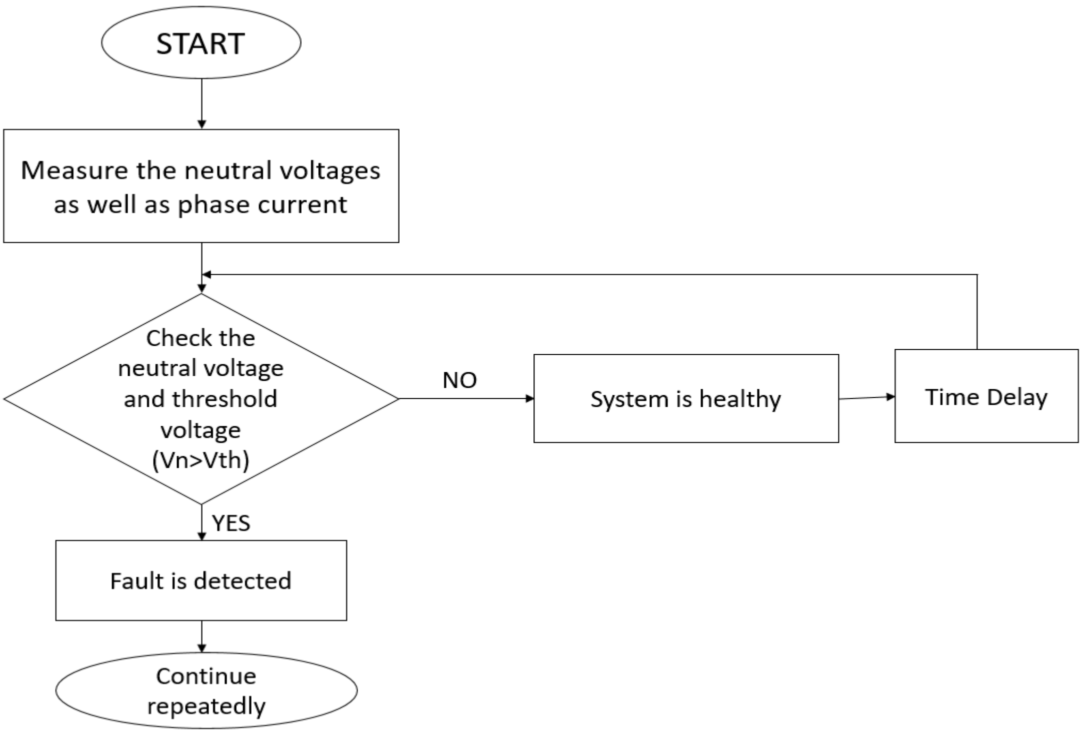

Figure 2. Flow chart of the proposed regionalized fault detection technique

Step 1	Consider all the input parameters such as line current, zero sequence current and neutral voltage.
Step 2	Let ‘t’ be the set time.
Step 3	Let t1 be the time of neutral voltage shift due to the fault occurrence.
Step 4	Ensure tolerance limit is within permissible range.
Step 5	Compare the neutral voltage and threshold voltage and check, if the ranges are violated or not.
Step 6	If neutral voltage is greater than the threshold limit then it signifies that the fault has occurred.
Step 7	If neutral voltage is less than the threshold limit then the system being healthy condition.
Step 8	For better accuracy again checking the neutral as well as threshold voltage for three cycles to five cycles so that the transient transient faults can be eliminated.
Step 9	Repeat the procedure again.

4. Simulation Parameters

The IEEE thirteen bus system is a less complexity test system that is used to simulate the fault in distribution generating systems with resonant grounding. The single line diagram of IEEE thirteen node test system block diagram is shown in figure 3.

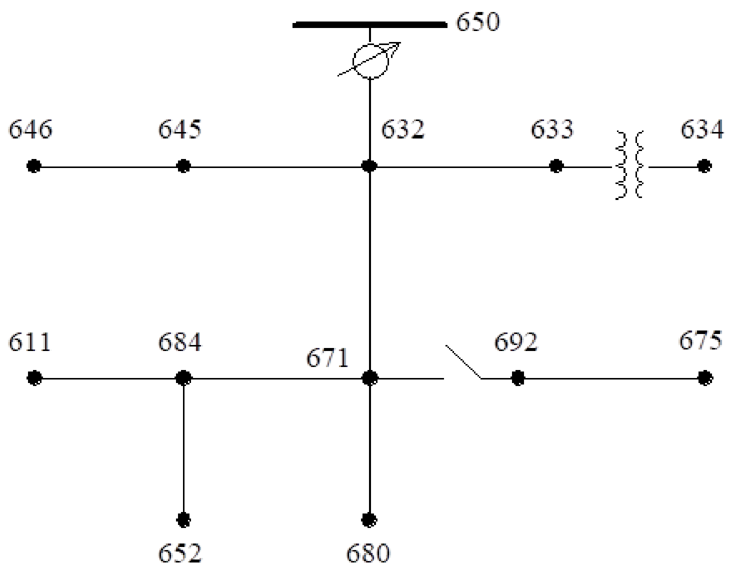

Figure 3. Test system – IEEE 13 nodes’ block diagram

ISSN: 2582-3051

The line data of IEEE 13-node test system specified in table 1.

Table 1. Line data – 13 node test system

S.no	Sending End	Receiving End	Resistance (per unit)	Impedance (per unit)	Length (feet)
1	632	645	0.207	0.459	500
2	632	633	0.753	1.181	500
3	633	634	XFM-1		0
4	645	646	0.207	0.459	300
5	650	632	0.347	1.018	2000
6	684	652	1.343	0.512	800
7	632	671	0.347	1.018	2000
8	671	684	1.324	1.357	300
9	671	680	0.347	1.018	1000
10	671	692	Switch		0
11	684	611	1.329	1.348	300
12	675	675	0.795	0.446	500

Table 2. shows the load data for the IEEE thirteen node test system [4].

Table 2. Load data – Thirteen node test system

Node	L Model	Phase-1 Kw	Phase-1 kVAr	Phase-2 kW	Phase-2 kVAr	Phase-3 kW	Phase-3 kVAr
634	Y-PQ	160	110	120	90	120	90
645	Y-PQ	0	0	170	125	0	0
646	D-Z	0	0	230	132	0	0
652	Y-Z	128	86	0	0	0	0
671	D-PQ	385	220	385	220	385	220
675	Y-PQ	485	190	68	60	290	212
692	D-I	0	0	0	0	170	151

611	Y-I	0	0	0	0	170	80
TOTAL		1158	606	973	627	1135	753
12	675		675	0.795		0.446	500

The transformer data of IEEE 13-node test system specified in table 3.

Table 3. Transformer data – 13 node test system

	kVA rating	**kV stepup**	**kV stepdown**	**Resistance %**	**Impedance %**
Substation:	5,000	115	4.16	1	8
XFM -1	500	4.16	0.48	1.1	2

5. Simulation Results

To validate the proposed technique, simulation studies are carried out on the IEEE thirteen node test bus system. The fault parameters are obtained through simulations in MATLAB/SIMULINK (version; 2021.a) and the fault parameters are validated using the proposed regionalized fault detection technique.

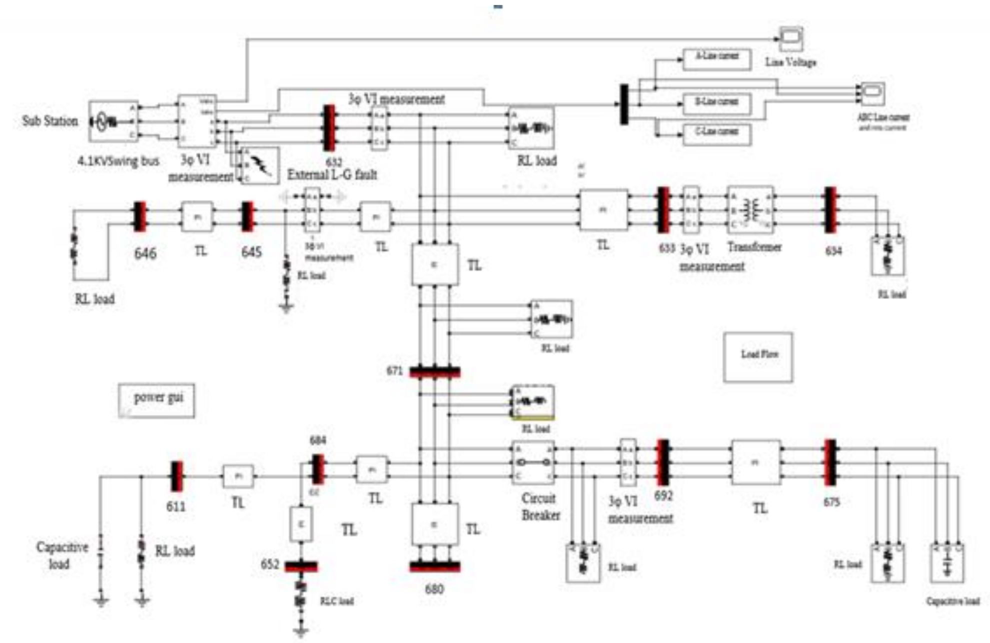

Figure 4. Simulation of the proposed model

Figure 4 depicts the Simulation model of the proposed IEEE thirteen node test bus system regionalised fault detection technique, as well as single phase to ground fault Simulink model.

Figure 5,6,7 show that once the fault occurs, the neutral current, line current and leakage current flow samples if it’s a single phase to ground fault. The neutral current of system under single phase to ground fault condition is shown in figure 5. The neutral current oscillations in the system are used to identify the fault condition. At the time of instant of fault, the neutral current varies with respect to the fault condition the peak value of neutral current varies of neutral current is compared with threshold value to evaluate the fault condition in the proposed system.

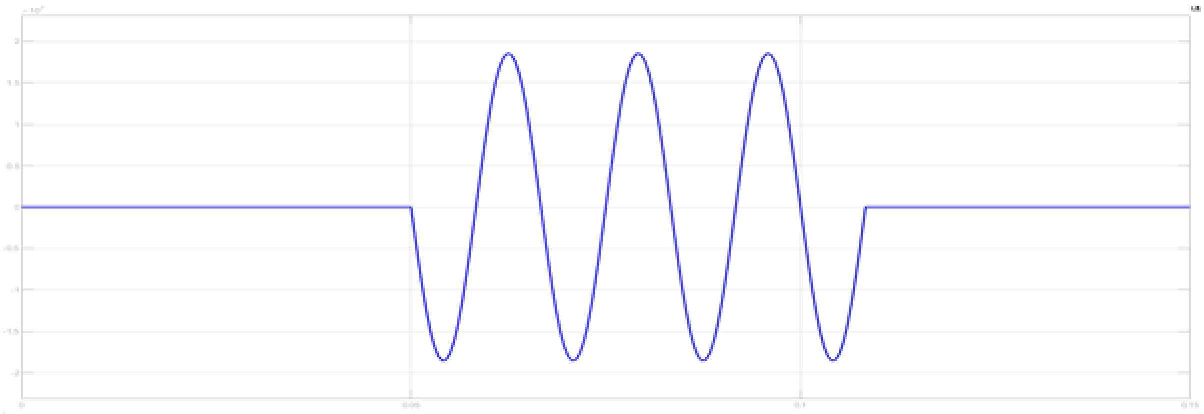

Figure 5. Neutral current under LG fault

The comparison is done for certain of time (i.e., Set time), where it classifies the faults as either permanent or transient faults. If fault condition presents after the set time, it is considered to be permanent fault. If fault cleared before the set time, it considered as transient fault and terminate.

The line current of system under single phase to ground fault condition is shown in figure 6. The line current of the system at the time of instant of fault, varies abruptly from extreme high to low. It is very essential to identify the faulty phase so that rest of the phases can be isolated from the fault conditions. At these extreme conditions of fault, if not isolated as soon as possible the power system equipment failure leads to extreme condition of blackout.

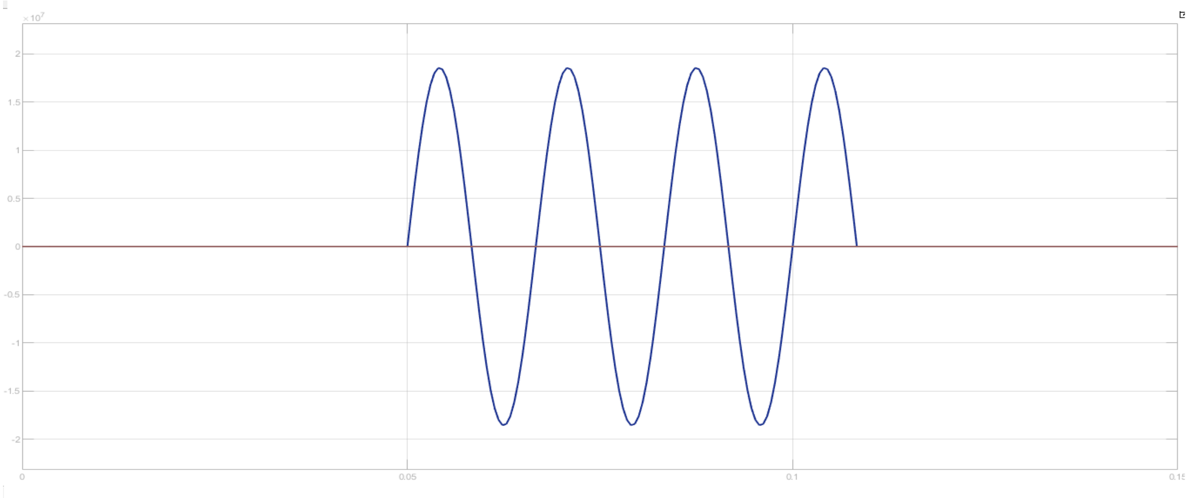

Figure 6. Line current under LG fault

The leakage current flow of system under single phase to ground fault condition is shown in figure 7.

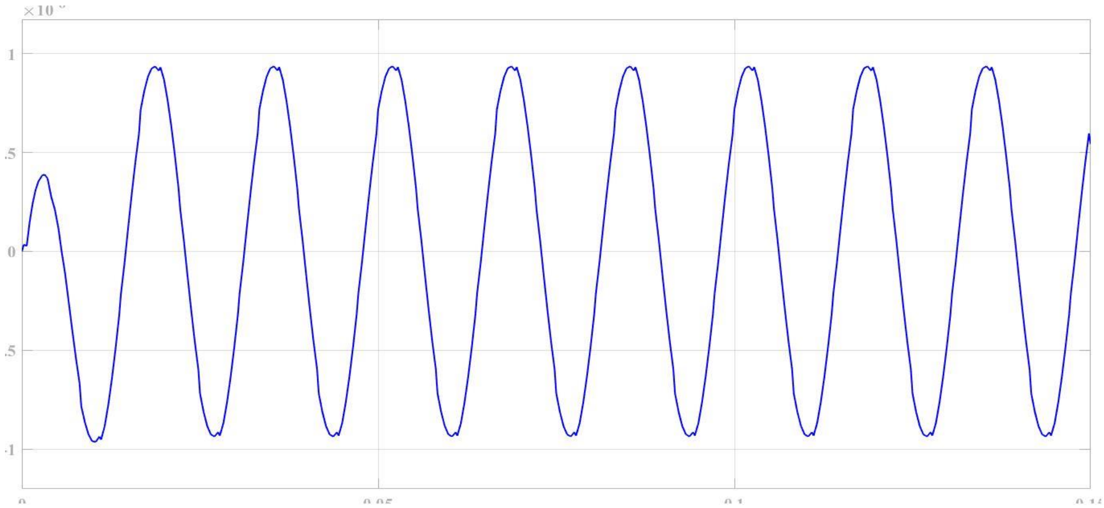

Figure 7. Leakage current flow under LG fault

For every time leakage current will be available in permissible limit. During fault conditions, varies abruptly. Thus, proper grounding is required to limit the leakage current .

6. Results and Discussion

The results obtained from the decentralized fault detection algorithm for both IEEE 13-node test system and compared to IEEE 34-node test system. The comparison of without SPG fault and with SPG fault for the both test systems is shown in table 4.

Table 4. Comparison of with and without SPG fault.

S.No	Standard Test system	Without fault condition	With fault condition
		IL(A)	**IL(A)**
1.	IEEE thirty-four NODE TEST SYSTEM	1350 A	1890.5 A
2.	IEEE thirteen NODE TEST SYSTEM	760.8 A	1071 A

7. Conclusion

This work discussed the regionalized fault detection algorithm for arc suppression coil grounding systems to detect the single phase to ground faults. The proposed algorithm simulated for IEEE thirteen bus system and compared the complex bus system (i.e., IEEE thirty-four test bus system. The comparative analysis is given in table 4. Based on the analysis and simulation results following conclusions are made.

i. Proposed algorithm predicts the nature of fault as either transient fault or permanent fault.
ii. This algorithm analysis the symmetrical and unsymmetrical fault.
iii. This algorithm gives better performance for the unsymmetrical fault in single phase to ground fault with unbalanced condition.
iv. This algorithm further implemented with ANN for symmetrical fault and double line to ground fault for both balanced and unbalanced loaded network.

References

[1] M.A. Barik A. M.A.Mahmud.,M.E.Haque.,Hassan Al-Khalidi “A Decentralized Fault Detection Technique for Detecting Single Phase to Ground Faults in Power” Distribution Systems with Resonant Grounding Transactions on Power Delivery, vol.33, no. 5, pp. 2462-2473, Jul.2018

[2] M. R. Bishal, S. Ahmed, N. M. Molla, K. M. Mamun, A. Rahman and M. A. A. Hysam, "ANN Based Fault Detection & Classification in Power System Transmission line," 2021 International Conference on Science & Contemporary Technologies (ICSCT), 2021, pp. 1-4,

[3] M. A. Barik et al., "Mathematical morphology-based fault detection technique for power distribution systems subjected to resonant grounding," in IEEE PES General Meeting, Chicago, USA, Jul. 2017.

[4] S. Gautam and S. Brahma, "Detection of high impedance fault in power distribution systems using mathematical morphology," IEEE Trans. Power Syst., vol. 28, no. 2, pp. 1226–1234, May 2013.

[5] W. H. Kersting, "Radial distribution test feeders," 2001 IEEE Power Engineering Society Winter Meeting. Conference Proceedings (Cat. No.01CH37194), 2001, pp. 908-912 vol.2, doi: 10.1109/PESW.2001.916993.

[6] Y. Wang et al., "Faulty feeder detection of single phase-earth faulT using grey relation degree in resonant grounding system," IEEE Trans. Power Del.,vol. 32, no. 1, pp. 55–61, Feb. 2017.

[7] A. Khelifi, N. M. Ben Lakhal, H. Gharsallaoui and O. Nasri, "Artificial Neural Network-based Fault Detection," 2018 5th International Conference on Control, Decision Information Technologies (CoDIT), 2018, pp. 1017-1022

[8] J. Ma et al., "A novel line protection scheme for a single phase-to ground fault based on voltage phase comparison," *IEEE Trans. Power Del.*, vol. 31, no. 5, pp. 2018–2027, Oct. 2016.

[9] E. C. Piesciorovsky and N. N. Schulz, "Fuse relay adaptive overcurrentprotection scheme for microgrid with distributed generators," *IET Generation,Transmission Distribution*, vol. 11, no. 2, pp. 540–549, 2017.