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Research Article

Distribution Network Protection

A Relaying Coordination for Distribution Network Protection

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Fault identification is a significant task on a distribution line (DL) when a harsh disturbance occurs due to breakdown of insulation on a DL. The termination of fault diagnosis on DL should be done as soon as probable to avoid further economic and communal costs due to interruptions of load. This paper proposes the application of wavelet and Fourier analysis for mapping the connection between 3-Φ current signals at one terminal and fault information on the DL. The proposed relaying system allows automatic adaption of the feature extraction accountable for fault identification. Simulation results performed by MATLAB, verify the high precision of the proposed relaying system in shaping the fault identification. In these simulations, it is exposed that the relaying system is independent of the parameters of the DL and accordingly, it is better to the active schemes.

Keywords: Distribution Line Protection, Fault Identification, Fourier Analysis, Wavelet Analysis

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Introduction

Present in the power supply for purchasers and electrical power utilities. The disturbances should be identified prior to the protection accomplishment could be made to limit the disturbances in the distribution system. For this reason, researchers of [1], presented a relaying approach for STATCOM integrated transmission line fed through wind source. The scheme uses single-terminal measurements for its execution. The presented approach is developed using discrete wavelet transform (DWT) and artificial neural network (ANN). In [2], a fault diagnosis and fault location technique is developed using ANN-Stockwell transform in smart hybrid distribution generation systems. Authors in [3], discussed a protection system for high-impedance faults detection in power systems. The scheme is designed using synchrophasor measurements. In [4], a WABPS system based on Koopman analysis is introduced for faulted line identification in power system with capacitor compensation. In [5] a pilot relaying scheme (fault detection and classification) based on the differential admittance perception for fixed series capacitor (FSC)-compensated EHV TL is proposed. In [6], a fault classification scheme is designed for EHV TL connected with capacitive-compensation equipment using ensemble approach. The scheme is developed using wavelet and support vector machine. In [7], researchers focused on the diagnosis, classification, and location of faults in AC microgrid (grid and islanded). Authors proposed a spectral energy based differential protection system based on sparse Fourier kernel fast time-frequency transform and alteration detection filter. In [8], a system based on travelling wave (TW) and game theory (GT) for TLs is presented and hence the concept of fault diagnosis is introduced for TL protection. DWT and MMF were utilized. In [9], an intrusion (cyber-attack) recognition technique for phase current differential relays is proposed. In [10], a travelling wave-based protection scheme for TLs (SVC) using game theory, DWT, and MMF is presented.

This paper projected the combined Fourier analysis and wavelet analysis-based distribution network relaying system (DNRS) for fault identification in the distribution system. The Fourier technique is utilized for the feature extraction of the line signal. Wavelet technique includes the fault identification process.

The remaining sections of the paper are organized as follows. Section 2 includes test system of distribution network. Section 3 includes the proposed approach. Sections 4 and 5 include the result section and conclusions section.

Proposed Approach

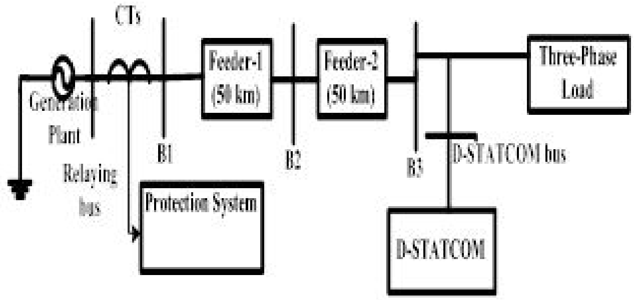

Fig.1. Distribution system with a relaying scheme and distribution-STATCOM: a single line diagram

The flowchart of the overall system performance is illustrated in Figure 2

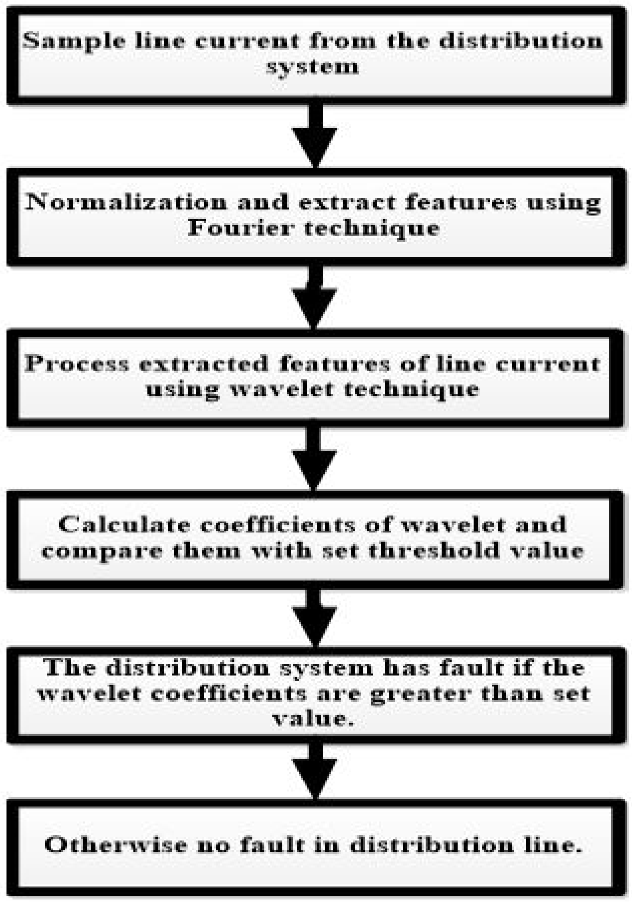

Fig.2. Flowchart of the general system performance using projected method

Test-System: The operation of the relaying system is illustrated through various case studies conducted on distribution system in MATLAB environment

As depicted in Fig. 1. The ratings of the load at Bus-3 are 1 MW, 5 MVAR. The length of the DL connecting B1 and B3 is 50 km per feeder. The performance has been carried out by assuming different faults inception connecting B1-B2 and B2-B3. Under such situations, the current signals obtained from CTs installed close to B1 are sampled with a sampling frequency of 1 kHz. The mother wavelet used for decaying the 3-Φ currents by DWT procedure is db1.

Case Studies

Functioning of the proposed DNRS has been validated in simulation platform in the subsequent sections.

A. Changing Fault Type: The change of fault type (FT) is investigated. To study the influence of change of FT, the category of fault is changed. Table 1 shows the functioning of the DNRS. In this table, fault identification is operated for different cases with inception time of fault 0.2 second and different fault types.

The simulation result of functioning of DNRS for AB-G fault is shown in Fig. 3. Hence, the DNRS has identified a fault and the identified fault is classified as AB-G since Φ-A>0.25 and Φ-B>0.25. Table 1 shows that fault identification has been accurately performed, which validate accuracy of the DNRS against changing the fault type.

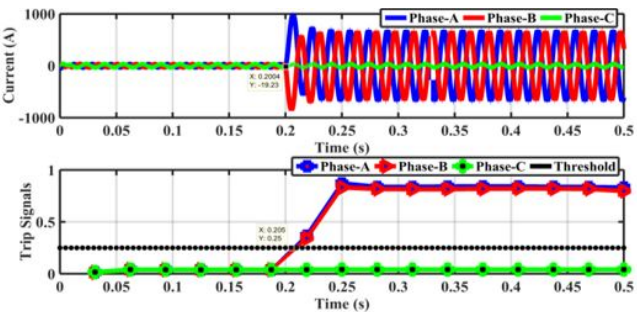

Fig.3. Functioning of DNRS for AB-G fault at 0.2 s at 50 km.

Table.1. Fault identification unit output for fault type variation

Applied Fault	Time (s)	Phase Comparison with THV			Fault Identification Time (ms)		
		Φ-A>0.25	Φ-B>0.25	Φ-C>0.25	Φ-A	Φ-B	Φ-C
ABG	0.2	YES	YES	NO	5	5	-
ACG	0.2	YES	NO	YES	10	-	10
AG	0.2	YES	NO	NO	15	-	-
BG	0.2	NO	YES	NO	-	15	-
ABCG	0.2	YES	YES	YES	5	5	5

B. Changing Fault Location: The change of fault location (FL) is investigated. To study the influence of change of FL, the category of location of fault is changed. Table 2 shows the functioning of the DNRS. In this table, fault identification is operated for different cases with inception time of fault 0.25 second and different FT and FL. The simulation result of functioning of DNRS for A-G fault at FL=20 km is shown in Fig. 4. Hence, the DNRS has identified a fault and the identified fault is classified as A-G since Φ-A>0.25.

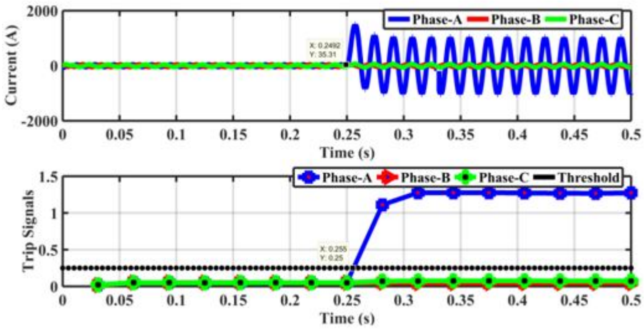

Fig.4. Functioning of DNRS for A-G fault at 20 km at 0.25 s.

Table 2 shows that fault identification has been accurately performed, which validate accuracy of the DNRS against changing the fault location.

Table.2. Fault identification unit output for location variation

Applied Fault	Time (s)	Phase Comparison with THV			Fault Identification Time (ms)		
		Φ-A>0.25	Φ-B>0.25	Φ-C>0.25	Φ-A	Φ-B	Φ-C
AG, 20 km	0.25	YES	NO	NO	5	-	-
BG, 37 km	0.25	NO	YES	NO	-	10	-
ACG, 49 km	0.25	YES	NO	YES	10	-	10
BC, 54 km	0.25	NO	YES	YES	-	10	10
ABC, 67 km	0.25	YES	YES	YES	10	10	10

C. Changing Fault Resistance: The change of fault resistance (FR) is investigated. To study the influence of change of FR, the category of fault resistance is changed. Table 3 shows the functioning of the DNRS. In this table, fault identification is operated for different cases with inception time of fault 0.2 second and different FT and FR. The simulation result of functioning of DNRS for AB-G fault is shown in Fig. 5. Hence, the DNRS has identified a fault and the identified fault is classified as AB-G since Φ-A>0.25 and Φ-B>0.25. Table 3 shows that fault identification has been accurately performed, which validate accuracy of the DNRS against changing the fault type.

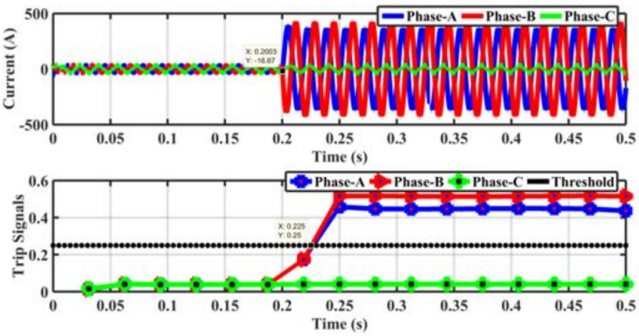

Fig.5. Functioning of DNRS for AB-G fault created at 60 km at 0.2 s and FR=15 Ω.

Table.3. Fault identification unit output for fault resistance variation

Applied Fault	Time (s)	Phase Comparison with THV			Fault Identification Time (ms)		
		Φ-A>0.25	Φ-B>0.25	Φ-C>0.25	Φ-A	Φ-B	Φ-C
ABG, 15 Ω	0.2	YES	YES	NO	25	25	-
AC, 20Ω	0.2	YES	NO	YES	35	-	35
AG, 25 Ω	0.2	YES	NO	NO	40	-	-
CG, 30 Ω	0.2	NO	NO	YES	-	-	45
ABC, 35 Ω	0.2	YES	YES	YES	45	45	45

D. Changing Location of Distribution STAT-COM: The change of location of distribution STAT-COM is investigated. To study the influence of this type of change, the distribution STAT-COM is installed at different locations on the test system. Table 4 shows the functioning of the DNRS. In this table, fault identification is operated for different cases with inception time of fault 0.05 second and different fault types. The simulation result of functioning of DNRS for BC-G fault is shown in Fig. 6. Hence, the DNRS has identified a fault and the identified fault is classified as BC-G since Φ-B>0.25 and Φ-C>0.25. Table 4 shows that fault identification has been accurately performed, which validate accuracy of the DNRS against changing the location of compensation device with FT.

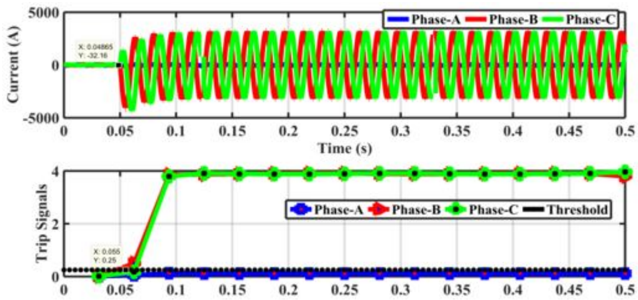

Fig.6. Functioning of DNRS for BC-G fault created at 0.05 s and DSTATCOM installed between F-1 and B1.

Table.4. Fault identification unit output for changing Distribution STAT-COM location

Applied Fault	Location	Time (s)	Phase Comparison with THV			Fault Identification Time (ms)		
			Φ-A>0.25	Φ-B>0.25	Φ-C>0.25	Φ-A	Φ-B	Φ-C
BCG	F-1 & B1	0.05	-	YES	YES	-	5	5
AB	F-2 & B3	0.05	YES	YES	NO	20	20	-
CG	B2 & F-2	0.05	NO	NO	YES	-	-	25
AG	F-1 & B2	0.05	YES	NO	NO	20	-	-
ABC	B1 & F-1	0.05	YES	YES	YES	20	20	20

Adding Load into The Distribution Stystem

The addition of extra load into the distribution system is investigated. To study the influence of addition of extra load into the distribution system, the category of ratings of load is changed. Table 5 shows the functioning of the DNRS. In this table, fault identification is operated for different cases with different types of loads connection with the test system. The simulation result of functioning of DNRS for load addition (75 MW, 45 MVAR) is shown in Fig. 7. Hence, the DNRS has not identified a fault and the unidentified fault is classified as load addition into the distribution system since Φ-A<0.25, Φ-B<0.25 and Φ-C<0.25. Table 5 shows that operation of fault addition has been accurately performed, which confirm accuracy of the DNRS against load addition into the test system.

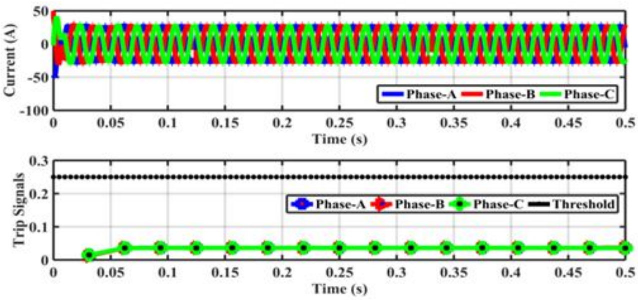

Fig.7. Functioning of DNRS for load addition (75 MW, 45 MVAR) done at 0.05 s.

Table.5. Fault identification unit output for addition of load

Active Power of Load (MW)	Reactive Power of Load (MVAr)	Time (s)	Phase Comparison with THV		
			Φ-A>0.25	Φ-B>0.25	Φ-C>0.25
75	45	0.05	NO	NO	NO
150	70	0.1	NO	NO	NO
250	95	0.15	NO	NO	NO
300	150	0.2	NO	NO	NO
350	175	0.25	NO	NO	NO

Conclusion

This paper proposed a fault identification relaying system for the DLs using combined wavelet and Fourier analysis. The relaying system identifies the fault using the phase comparison method with the THV (Threshold Value). The functioning of the relaying system has been illustrated using two-bus distribution system. Simulation results demonstrate that the relaying system has a high level of accuracy in the diverse conditions for instance different fault type, fault location, fault resistance.

As a future work, few cases of identification of multilocation faults and boundary faults on DL can be suggested.

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