Design And Implementation Of Zone-1 Distance Protection For Long Transmission Line For Protection Against Phase Toneutral Fault Using IED-7SA522

Aishwarya B G, B R Lakshmi, Kavya Bhayya, Chandu M R, Prof. Kiran

Department of Electrical and Electronics Engineering, Dayananda Sagar Academy of Technology andManagement, Udayapura, Kanakapura main Road, opp. Art of Living,Bangalore-560082

ABSTRACT

This paper stimulates thought on Zone-1 transmission line protection. voltage and current indications from the transmission line's local terminal that is under protection. Within 10 milliseconds of the fault, zone-1 detection is accomplished with a 98.4% accuracy. The digital distance relay, which employs symmetrical components of three- phase currents and voltages, is used to safeguard transmission cables fed from one end. The system's power factor is improved by dividing the distance into zones 1, 2, and a transmission line. Based on the use of an artificial neural network, decide whether a defect exists in the given line length in almost real-time. Transmission line protection is provided by electromechanical distance relays. The operation of the distance protection relay during a malfunction ona transmission line with series compensation is examined. It describes how the relay created, together with shunt reactor correction, was used toa 645 km long, 1000 kV UHV transmission line. To further demonstrate howsuccessfully distance protection functions with the distribution system, this research incorporates information from real world event reports.

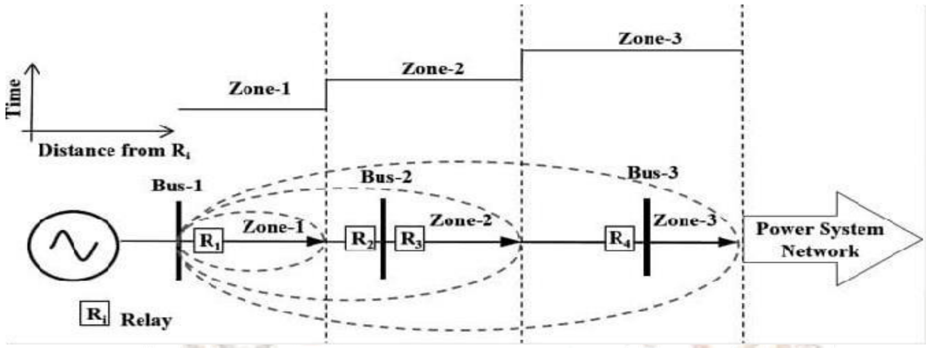
INTRODUCTION

Distance or impedance protection is the most fundamental and common protection used in high voltage power transmission systems. determine if the fault is within the zone to be protected. Different types of problem such as short circuit, noise effect and others are occurring in power system networks and due to this short circuit heavy current flow through the equipment working in the system causing damage of equipment's. In order to maintain the system stabilityand to improveits reliability, fault detection and rapid equipment mechanism present in the system.

The study investigated the feasibility of distance protection in extra voltage networks for relativity long EHV transmission lines a major problem in existing distance production is that the major independence of importance relay may not be proportional to the fault distance to study analysed this problem in details through theoretical analysis.

Variable filtering algorithm that improves operating speed without sacrificing security. Adaptive polarizing scheme that accommodates rapidly changing system conditions. This paper deals with distance protection elements based on quadrilateral operation characteristics. An alternative method to solve the optimization problem related to the determination of the reach settings of the quadrilateral distance protection element of mutually coupled transmission lines is proposed.

Electro mechanical distance relays used for production of transmission linear prone to effect of resistance each part condition improves the relay performance this paper present in new approach artificial neural network to overcome the effect of heart resistance on relay operation consequently the decision made by a relay will not be seriously affected by variation in system parameters.



It is frequently possible to boost the electrical transmission capacity of a transmission line by utilising series compensation. However, there is a limit to how much compensation may be appliedto a line since protection settings are frequently impacted when compensation surpasses 50% of theline impedance. co-ordination.

In order to increase distributed shunt capacitance and raise natural power while lowering corona losses on the conductor surfaces, line designs frequently minimise characteristic impedance. As a result, it is extremely likely that a distance relay system will need a more accurate model rather than a depiction of the UHV transmission line using lumped parameters. The apparent impedance is determined by a distance relay using locally recorded current and voltage. The impedance of a transmission line is normally spread uniformly over its length.

There is typically a primary trunk on a distribution feeder from which branch circuits sprout. Theselaterals are often connected to the main trunk via a fuse. The feeder protection for a fused lateral is designed to ensure that a permanent fault will only result in an outage for that lateral. For longer feeders with midline reclosers, the feeder protection is set up to prevent tripping of the source breaker for faults downstream of the recloser.

SYSTEM AND METHODS

A. Numerical Relays

A numerical relay is a computer-based system with software-based protection algorithms for the detection of electrical defects in utility and industrial electrical power transmission and distribution systems. These relays are also known as protective microprocessor relays. They can provide various protective functions in one unit, as well as metering, communication, and self-test features. They are a functional substitute for electro-mechanical relays. The physical depiction of numerical relays is

Fig 1: 7SA522 RELAY

Shown in Figure 1. Additionally known as intelligence electronic devices, numerical relays (IED).

B. ABOUT DIGSI SOFTWARE

Figure 2: Digsi-4 Software

In this fig 1.2 shows project Digsi-4 software is used to communicate with IED. The IED's aremicroprocessor and microcontroller-based protection relay hence it needs some programming/configuration to activate the protection function available in the IED. This configuration can be done with help of Digsi-4 software.

C. Secondary Injection Kit

It is a relay test kit that gives the relay's CT and PT inputs. Both current and voltage channels are present. A current knob included in the kit will be used to regulate the current inputs to the relay. Utilizing the voltage knob included in the kit, the voltage input to the relay will be managed. In order to know when the relay is operating, it also has one timer. The illustration shows an ordinary secondary injection kit.

Figure-3: Secondary Injection kit

D. Distance Protection

Distance Protection is a Non-unit System of Protection, which measures the Impedance between the Relay Location and the point, where the fault is incident and compares it with the Set Value. If the measured Impedance is less than the Set Value the Relay operates and Isolates the Faulty Section.

Distance protection is comparatively simple to apply and it can be fast in operation for faults located along most of a protected circuit. It can also provide both primary and remote back-up functions in a single scheme. It can easily be adapted to create a unit protection scheme when applied with a signalling channel.

E. Quadrilateral Characteristics

The quadrilateral properties as depicted in figure 5 are the foundation upon which the distance protection operates. The protection activates and sends the trip command to CB after a predetermined time delay if the measured impedance satisfies the quadrilateral specifications.

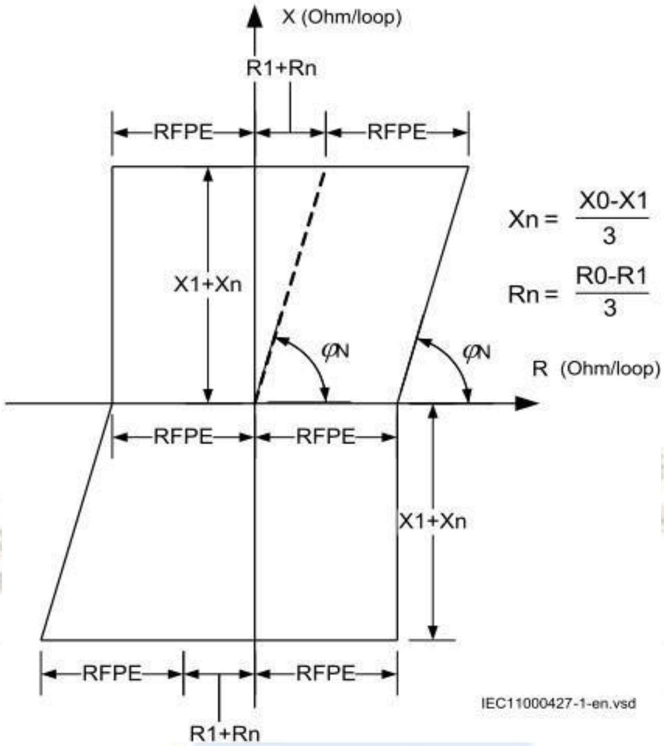


Fig 4: Quadrilateral Characteristics

F. Design and ImplementationSETTING CALCULATION INPUT DATA:

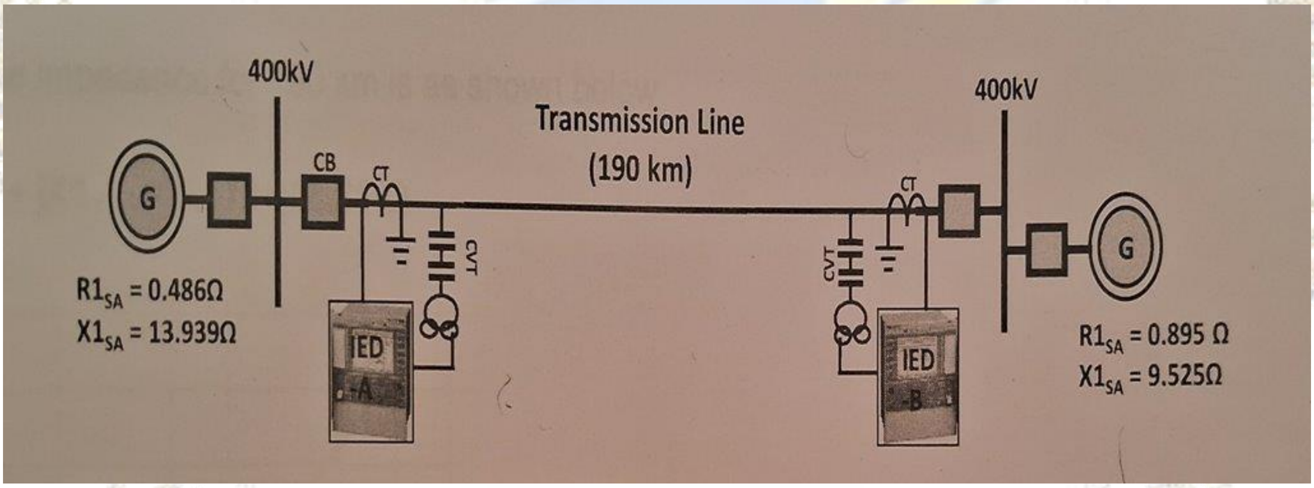


Fig 5: input data

Line: **Substation-A to Substation-B**

Frequency: 50Hz Line length: 190km CT ratio: 1000/1A

CVT ratio: 400/0.11kv

Line data:

R1+jX1: 0.0288+j0.307/km; R0+jX0: 0.2689+j1.072/km;

Total Impedance-

For 190km: $R1_T + jX1_T$ = 5.472 + j58.33 ohm

For 190km: $R0_T + jX0_T$ = 51.091 + j203.68 ohm

For Phase to Neutral Fault-

R_1+jX_1 = 0.0288 + j0.307/km

R_0+jX_0 = 0.2689 + j1.072/km.

For 190km, $R_{1T}+jX_{1T}$= 5.472+j58.33 ohm

For 190km, $R_{0T}+jX_{0T}$= 51.091+j203.68 ohm

Primary values:

R_1= 0.8×5.472 = 4.3776 ohm

X_1= 0.8×58.33 = 46.664 ohm

R_0 = 0.8×51.091 = 40.873 ohm

X_0 = 0.8×203.68 = 162.944 ohm

$R_n = (R_0 – R_1) / 3$

= 40.873-4.3776/3

= 12.17 ohm

$X_n = (X_0 – X_1) / 3$

= 162.944 – 46.664/3

= 38.76 ohm

Secondary calculations:

$R_{1(sec)} = (\frac{CT\ ratio}{VT\ ratio} * R1)$

= 0.275×4.377

= 1.204-ohm

CT ratio = I_1/I_2 = 1000/1 = 1000

VT ratio = V_2/V_1 = 400kv/110v= 3636.3

CT ratio/VT ratio= 1000/3636.3= 0.275

$X_{1(sec)} = CT\ ratio/\ VT\ ratio \times X_1$

= 0.275 × 46.664

= 12.8326 ohm

$R_{0(sec)} = CT\ ratio/VT\ ratio \times R_0$

= 0.275 × 40.873

= 11.24 ohm

$X_{0(sec)} = CT\ ratio/VT\ ratio \times X_0$

= 0.275 × 162.944

= 44.81 ohm

Secondary calculations:

$R_n = (R_0 - R_1)/3$

= 11.24 – 1.204 / 3

= 3.35 ohm

$X_n = (X_0 - X_1)/3$

= 44.81 – 12.8326 /3

= 10.66 ohm

$RFPE_{sec}$ = 13.75. (1000/3636.36) × 50

$X_1 + X_n$ = 12.8326 + 10.66

= 23.50

R1+Rn = 1.204 + 3.35

= 4.56

$\emptyset = tan^1 (X_1/R_1)$

= $\tan^{-1}$ (12.83/1.204)

= 84.64°

CREATING OPERATING CHARACTERISTICS

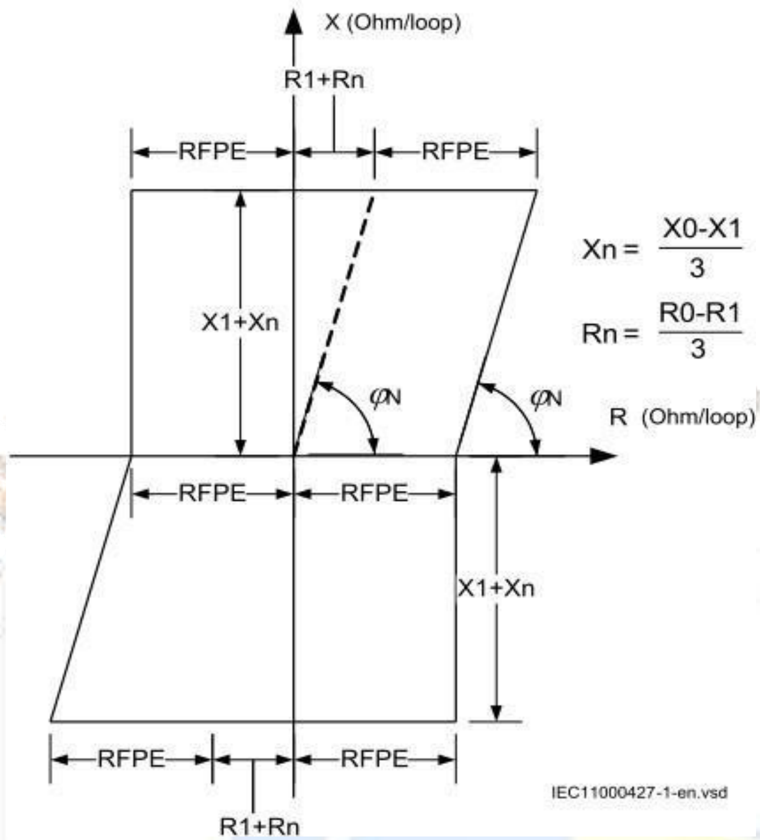


Fig 6: QUADRILATERAL CHARACTERISTICS

G. REVIEW

To stop the unintended effects of a fault, power transmission lines can use a network-based impedance protection. an algorithm to find faults and decide whether they are within a certain distance of the transmission line. The impedance for zone 1 is limited to under 25 ohms. Relay will communicate that a fault has occurred in zone 1 if it detects a fault impedance below 25 ohms. The outputs of networks' reactions when faults occurred at various fault parameters. When a single line to ground fault occurs, the time signals for voltage and current courses that were utilized as input forfault classification are used.

In-depth analysis was done on the issue of the measured impedance in long EHV transmission lines not being proportional to the fault distance. Due to CVT transients, the Zone 1 distance element does not overflow. Secure ways to shorten communications aided tripping schemes' total protection tripping times. This research discusses the use of an Ain and a categorized spectrum to enhance the performance of distance relays. They utilized Simulink while we use PCM 600 for simulation. While we are employing quadrilateral qualities, they had been using mho characteristics. When resistance is present, the relay's performance suffers.

Distance protection components with series compensation have exceptional line impedance, which could lead to relay failure. Subharmonic oscillations and non-linearity of the line impedance are twoissues caused by series compensationof transmission lines. The reported results are pertinent to how the distance relay behaves in fault conditions on a 400 kV series compensated line. The investigation is carried out in an industrial Dig silent Power setting.

To determine whether a problem is inside or outside the protection zone, the distance relay system integrates a distributed parameter line model based on steady-state transmission line equations. Experimental testing is carried out using an RTDS (real time dynamic system), which faithfully simulates a 645-km, 1000-kV UHV transmission line.

When integrating distributed generation (DG) or dispersed resources, an electrical power system owner or management faces technical obstacles. With the addition of relatively significant volumes of generation to the distribution system, the historical setup tenets and present design presumptions may be in peril.

The necessity for and complexity of additional safety and control systems increases when the total DG capacity inside a potential island approach or matches the load inside that island. It is also crucial to consider how DG availability and fault current capability evolve over time. Some of the key issues addressed and associated with DG on the distribution feeder include anti-islanding, transitory overvoltage's under fault conditions, and loss of sensitivity of feeder over current management for long feeders.

H. Components required

- 7SA522 Relay
- DIGSI software
- Omicron kit
- Omicron software
- Connecting wires

LITERATURE REVIEW

Ref No.	Title	Author	Year of Publication	Findings	Outcomes
[1]	"Advanced Transmission Protection"	G Benmouyal, N Fischer, A Guzman, J Mooney, and D Tziouvaras	2004	IEEE	In this paper, the authors provide the high-speed distance element performance, a series- compensated transmission line method to prevent Zone 1 element overrun, and a frequency estimation technique to ensure accurate frequency tracking under pole-open situations to avoid relay malfunctions.
[2]	"Fundamental of distance protection"	Bogdan Kasztenny, Dale Finney	2008	IEEE	The document explains electromechanical, static, and digital distance relay technologies as well as basic guidelines for implementing distance comparators (phase and amplitude comparators). The source impedance ratio, transient accuracy, and speed of operation are highlighted as elements affecting the performance of distance relays.

[3]	"A Distance Protection Relay for a 1000-kV UHV Transmission Line"	Z. Y. Xu, S. F. Huang, Li Ran	2008	IEEE	The method of accurately measuring fault impedance and configuring the relay, as well as a new line model for a distance relay, are presented in this work. It outlines the relay's intended use in connection with a 645-km, 1000-kV UHV transmission line, whichincludes shunt reactor compensation.
[4]	"Innovative solutions improve transmission line protection"	Daqing Hou, ArmandoGuzman, Jeff Roberts	2008	Research gate	For the CVT transients, the Zone 1 protective feature does not go too far.
[5]	"Distance Relay Element Design"	E. O. Schweitzer, III, and Jeff Roberts	2010	Research Gate	Basic distance and directional element design is presented in this work. Relationships between the more recent digital and numerical technologies and the traditional electromechanical and static-analog ways of developing relay components are stressed heavily.
[6]	"Distance Protection Scheme For Protection of Long TransmissionLine Consi dering the Effect of Fault Resistance"	A.P.Vaidya& Prasad A. Venikar	2012	IEEE	This research discusses the application of an ANN as a pattern classifier to enhance the performance of distance relay. If a pattern correlates to a fault or no fault state, the neural network can identify it. Additionally, the network is able to identify the operational zone in the event of a fault scenario.
[7]	"Distance Protection Based on Artificial Neural networks **Author:** Libor Straka,"	Libor Straka	2014	IEEE	This work discusses the usage of an ANN as apattern classifier to enhance distance relay performance. Whether a pattern relates to a fault or no fault situation can be determined by the constructed neural network. The network is also capable of determining the operating zone in the event of a fault scenario.
[8]	"Distance Protection in Distribution Systems: How It Assis ts With Integrating DistributedResources"	Amy Sinclair	2014	IEEE	This study examines how the distance protection relays on a transmission line with series compensation behave when there is a malfunction. Series compensation causes distance protection components to have unusual line impedance, which might cause the relays to malfunction. A issue

					brought on by series compensation of transmission lines is the occurrence of sub-harmonic oscillations and non-linearity of the line impedance.
[9]	"Improved zone 1 top-line tilting scheme for the polygonal distance protection in the outgoing line of type-4 wind parks "	Hans Kristian Senior Member, IEEE	2015	IEEE	This work discusses the usage of an ANN as a pattern classifier to enhance distance relay performance. Whether a pattern relates to a fault or no fault situation can be determined by the constructed neural network. The network is also capable of determining the operating zone in the event of a fault scenario.
[10]	"Distance Protection: Why Have We Started With a Circle, Does It Matter, and What Else Is Out There?"	Edmund O. Schweitzer and Bogdan Kasztenny	2017	IEEE	The history of distance element design is reviewed, the operating principles are explained, implementation details are shared, and test results and real-world examples are presented. These show that distance element design has a significant operating time advantage over its more conventional competitors.
[11]	""Zone Protection System of Transmission Line by Distance Relay using Matlab/Simulink""	Farhana Ferdous	2018	IEEE	Because they can be taught using offline data, neural networks are advantageous for power system applications. Present are the network outputs for the 80 km single line to ground fault
[12]	"Machine Learning Based Settingfree Reach Element For Zone-1 Distance Protection" "	Neethu George, P. Suraj Nath	2019	IEEE	The input measurement is made using incremental voltage and current readings from the relay's local terminal. The neural network is trained using characteristics of the incremental voltage and current variables, such as the slope of the rising edge and the rise time of the initial peak.
[13]	"Distance protection of EHV long transmission lines "	Wang Jiang, Jiping Lu,Hongji Xiang, Xing Ma, Hui Fang	2019	State Grid Chongqing	The practical issues that came up when distance protection was applied to EHV long transmission lines were listed. In-depth analysis was doneon the issue of the observedimpedance in long EHVtransmission lines not beingproportional to the fault distance.

[14]	"Calculation of distance protection settings in mutually coupled transmission line: A comparative analysis."	Serna Jaramillo & JesusMaria Lopez Lezama	2019	Energies	In this paper, the authors are utilising single circuited lines as opposed to double circuited lines. The only difference in the application is the computation.
[15]	"The performance ofdistanc protection relay on series compensated line under fault conditions"	X.G. Magagula, D.V.Nicolae, A.A. Yusuff	2021	IEEE	This study examines how the distance protection relays on a transmission line with series compensation behave when there is a malfunction. Series compensation causes distance protection components to have unusual line impedance, which might cause the relays to malfunction.
[16]	"Settings Considerations for Distance Elements inLine Protection Applications"	Bogdan Kasztenny	2021	IEEE	This paper examines applications for zone 1, zone 2, and reversal zones.It also provides more thorough application of the zone 1, ground, and phase distance elements in weak systems and explains why distance protection application in such systems faces extra obstacles.

RESULT

Advanced Distance-test report-2

Test Object - Device Settings

Substation/Bay:

Substation: 7UT613 Substation address:

Bay: 20MVA TRAFO Bay address:

Device:

Name/description: 7UT613 /20MVA TRAFO Manufacturer: Device type: 7SA522 Device address:Serial/model number:

Additional info 1:

Additional info 2:

Nominal Values:

f nom:	50.00 Hz	Number of phases:	3
V nom (secondary):	110.0 V	V primary:	110.0 V
I nom (secondary):	1.000 A	I primary:	1.000 A

Residual Voltage/Current Factors:

VLN / VN:	1.732	IN / I nom:	1.000
VN (secondary):	36.67 V	IN (secondary):	1.000 A
Residual Direction:	Voltage3 * V0	Residual Current Direction:	-3 * I0

Limits:

V max:	120.0 V	I max:	10.00 A

Debounce/Deglitch Filters:

Debounce time:	5.000 ms	Deglitch time:	0.00 s

Overload Detection:

Suppression time: 50.00 ms

Other Device Properties:

Drop-out time: 20.00 ms

Test Object - Other RIO Functions

CB Configuration

Description	Name	Value
CB trip time	CB trip time	50.00 ms
CB close time	CB close time	100.00 ms
Times for 52a, 52b in percent of CB time	52a, 52b % of CB	20.00 %

Test Object - Distance Settings

System parameters:

Line length:	1.000 Ω	Line angle:	85.00 °
PT connection:	at line	CT starpoint:	Dir. line
Impedance correction1A/I nom:	no		
Impedances in primary values:	no		

Tolerances:

Tol. T rel.:	1.000 %		
Tol. T abs. +:	100.0 ms	Tol. T abs. -:	100.0 ms
Tol. Z rel.:	5.000 %	Tol. Z abs.:	100.0 mΩ

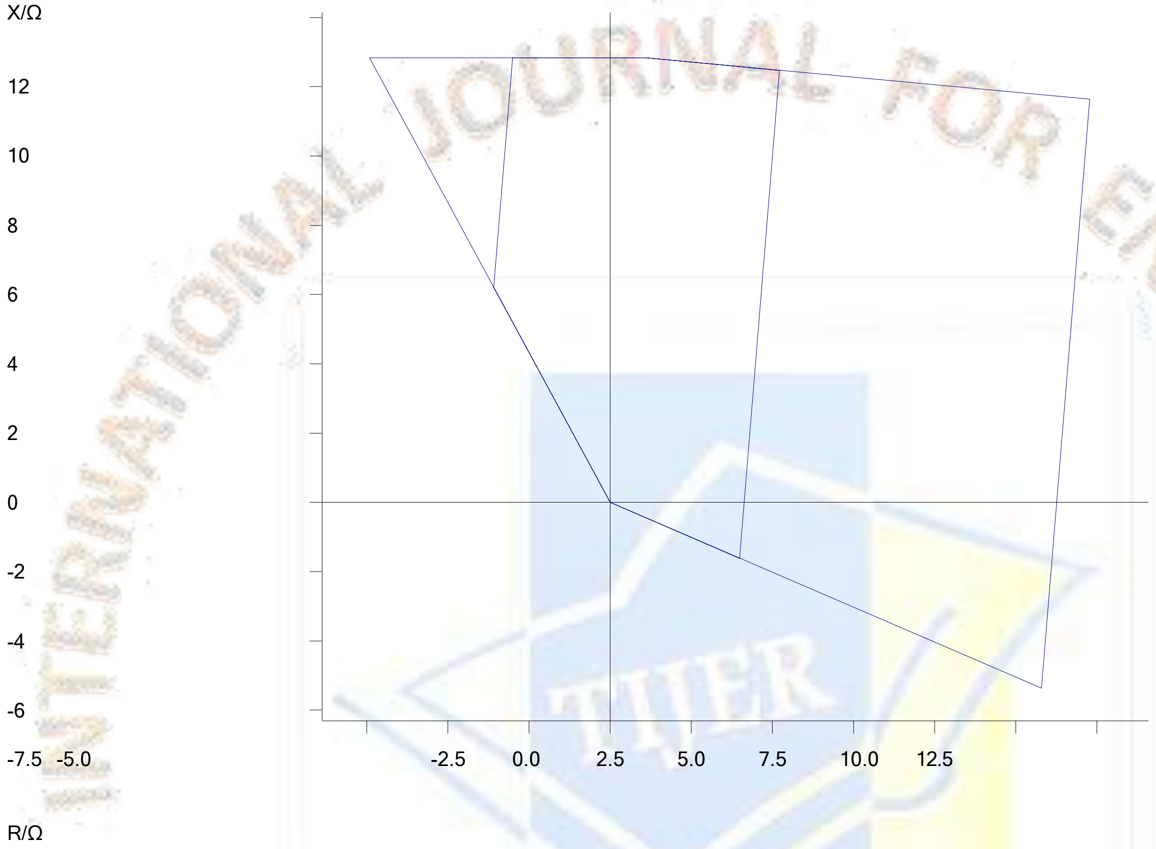
Grounding factor:

RE/RL: 2.000000 XE/XL: 0.830000

Separate arc resistance: no

Zone Settings:

Label	Type	Fault loop	Trip time	Tol. T rel	Tol. T abs+	Tol. T abs-	Tol. Z rel.	Tol. Z abs
Z1	Tripping	L-L	0.00 s	1.000 %	100.0 ms	100.0 ms	5.000 %	100.0 mΩ
Z1	Tripping	L-E	0.00 s	1.000 %	100.0 ms	100.0 ms	5.000 %	100.0 mΩ



Linked XRIO References

Reference Name	Unit	Value	XRIO Path
RIO.DEVICE.NOMINALVALUES.INOM	In	1.00 A	RIO/Device/Nominal Values/In
RIO.DEVICE.NOMINALVALUES.VNO M	V nom	110.00 V	RIO/Device/Nominal Values/V nom

Comment

Test Module

Name: OMICRON Advanced Distance Version: 4.31

Test Start: 27-Apr-2023 16:11:08 Test End: 27-Apr-2023 16:11:37

User Name: Manager:

Company:

Test Settings

Test model:

Test model:	Constant test voltage	VTest:	20.00 V
Allow reduction ofITest/VTest:	Yes	kS = kL:	No
ZS mag.:	0.00 Ω	ZS angle:	0.00 °
kS mag.:	1.000	kS angle:	0.00 °

Fault Inception:

Mode:	Random	Angle:	n/a
DC-offset:	No		

Times:

Prefault:	2.000 s	Max. fault:	6.000 s
Postfault:	500.0 ms	Time reference:	Fault inception

Other:

Extended zones:	Not active	Switch off at zero crossing:	Yes
Load current enabled:	No	Load current::	n/a

Search Settings:

Search res. rel.:	1.000 %	Search res. abs.:	50.00 mΩ
Ignore nominalcharacteristics:	No		
Search interval:	200.0 mΩ		

Binary Inputs:

Trigger Logic: OR

Name	Trigger State
Trip	1
Start	X

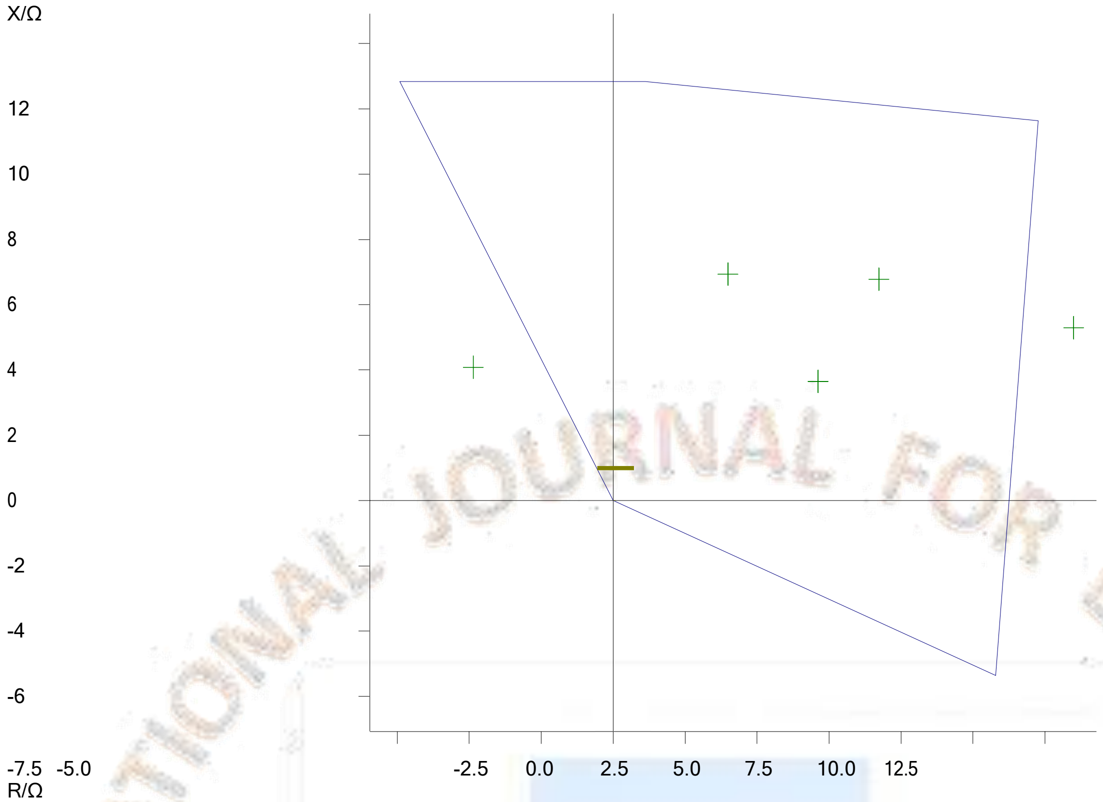
Binary Outputs:

Name	Fault inception Delay time	Slope	Trip Delay time	Slope
Ext. zones active	n/a	Open	n/a	Open

Test Results

Shot Test: Fault Type L1-E

| Z |	Phi	%	% of	t nom	t act.	Dev.	VTest	Result
8.000 Ω	60.00 °	n/a		0.00 s	15.90 ms	15.90 ms	20.00 V	Passed
11.45 Ω	36.28 °	n/a		0.00 s	16.30 ms	16.30 ms	20.00 V	Passed
8.000 Ω	27.05 °	n/a		0.00 s	16.20 ms	16.20 ms	20.00 V	Passed
6.337 Ω	140.00 °	n/a		no trip	no trip	n/a	20.00 V	Passed
16.85 Ω	18.27 °	n/a		no trip	no trip	n/a	20.00 V	Passed



Shot Details:

Parameters:

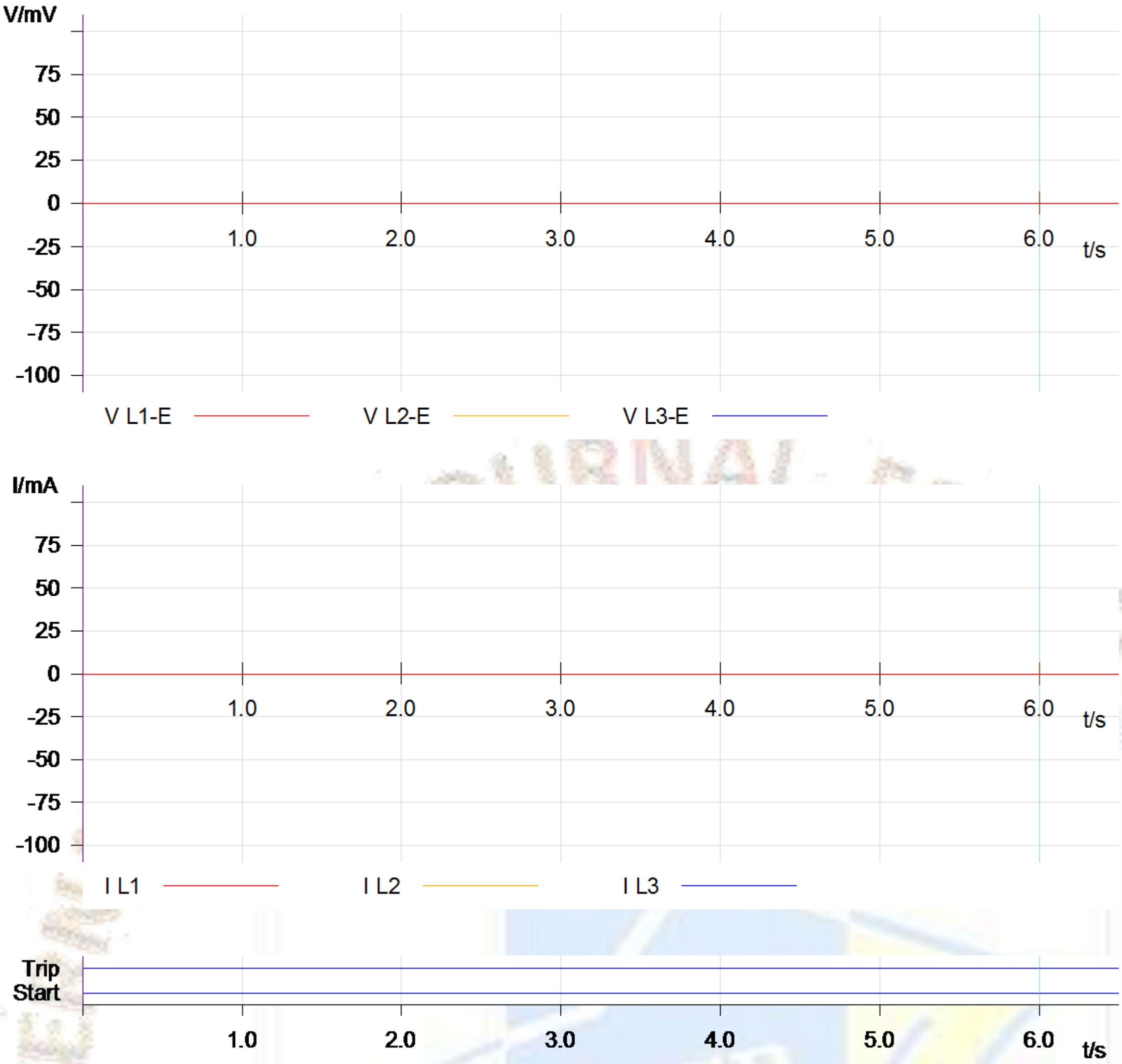
Fault Type: L1-E

| Z |:	16.85 Ω	Phi:	18.27 °
R:	16.00 Ω	X:	5.281 Ω
%:	n/a	% of:	
VTest:	20.00 V		

Results:

t act.:	n/a	Assessment:	Not tested
t nom:	no trip	Dev.:	n/a
t min:	no trip	t max:	no trip

Fault Quantities (natural):			Fault Quantities (symmetrical):		
VL1:	20.00 V	0.00 °	V0:	14.50 V	180.00 °
VL2:	63.51 V	-120.00 °	V1:	49.01 V	0.00 °
VL3:	63.51 V	120.00 °	V2:	14.50 V	180.00 °
IL1:	408.5 mA	-11.38 °	I0:	136.2 mA	-11.38 °
IL2:	0.00 A	n/a	I1:	136.2 mA	-11.38 °
IL3:	0.00 A	n/a	I2:	136.2 mA	-11.38 °
VFault:	20.00 V	0.00 °			
IFault:	408.5 mA	-11.38 °			



Cursor Data

	Time	Signal	Value
Cursor 1	0.00 s	<none>	n/a
Cursor 2	6.000 s	<none>	n/a
C2 - C1	6.000 s		n/a

CONCLUSION

Transmission line ZONE-1 distance protection. Incremental quantities of voltages and currents fromthe local terminal where the relay is located is used as the input measurement. The study of basic faults that generally occur in transmission line of a power system and their protection scheme using the distance relay. Here an 11kv transmission line is taken into consideration and a Simulink model is designed for the line by MATLAB/Simulink.

The practical problems encountered in the application of distance protection in EHV long transmission lines were specified. The developed neural network is able to detect whether the pattern corresponds to fault or no-fault condition. In addition to this, if there is a fault condition, network is also able to determine the zone of operation.

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