Journal of Theoretical and Applied Information Technology

www.jatit.org

EVALUATION OF FAULT ANALYSIS IN TRANSMISSION LINES USING RELAY SETTINGS

N.VIJAYSIMHA [1*], CH.CHENGAIAH[2]

[1*] M-TECH (PSOC), Department of Electrical and Electronics Engineering, Sri Venkateshwara University college of Engineering-Tirupati-517502-INDIA.

[2] Associate Professor, Department of Electrical and Electronics Engineering, Sri Venkateshwara University college of Engineering-Tirupati-517502-INDIA.

ABSTRACT

This paper reports on the analysis of EHT (Extra High Tension) transmission line protection using distance relay settings of TYPE: RAZOA and TYPE: REL-100 (MAKE: ABB COMPANY). The calculations of relay settings for the distance schemes have also been performed, using MATLAB program.

Keywords: *Power system; Relay setting; RAZOA; REL-100; Matlab.*

(1) INTRODUCTION*:*

There is a rapid development in the field of electrical power systems, in which large amount of interconnection involved for consuming continuity of supply good voltage regulation. Generation, Transmission and Distribution are three main stages in power system. Among these the performance and maintenance of transmission play an important role in the field of power system. Analysis of fault is very pivotal for the stable operation power system. The cause of the faults makes damage to power systems, due to not properly protected using relay settings. Faults on the power system can be analyzed using required relay settings. To meet this requirement a high speed protection system is required for 132 KV and above level which can be achieved by using RAZOA and REL-100 protection schemes. The RAZOA distance has been taken for line protection and REL-100 a non-switched distance schemes is taken for protecting line. The main focus of this paper is to calculate relay settings for these distance schemes.

(2) Operating Principle of Protecting Relays Schemes:

2.1 Operating principle of RAZOA Relay:

The operating principle of RAZOA relays is a voltage retained over current relay. It is basically switched scheme three-phase distance relay with three directional zones and contain microprocessor based three under impedance starter and one measuring unit as shown in Fig

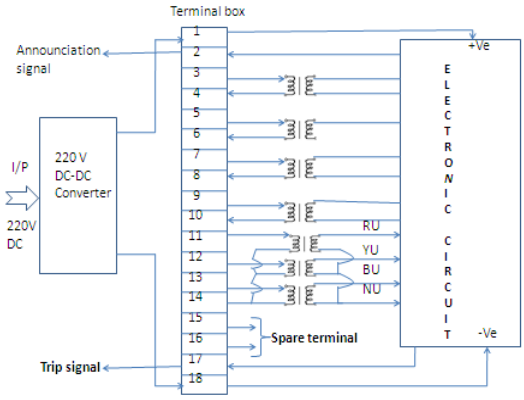

Fig 1 Block diagram of RAZOA Relay

This is a static type Electronic relay. An input supply of 220 V DC is being given to electronic relay as auxiliary supply. This 220 V DC will be stepped down to 12V, because all electronic cards present in this relay work for 12 V DC supply only. 18 terminals present in this relay for inputs and operation of relay shown in Fig 1 and terminals used in RAZOA relays are explained in APPENDIX-1.

The RAZOA relay is tested at 220 KV level substation by ZFB kit .From these test the performance of relays have been analyzed. The procedure of analyzing the performance of relay is at first theoretical values are calculated with help of replica impendence and then relay is tested with ZFB kit.

The values are taken for phase-neutral, phase-phase of three zones. The actual values should be ±10% to the theoretical values. The theoretical values and actual values are shown in APPENDIX-2

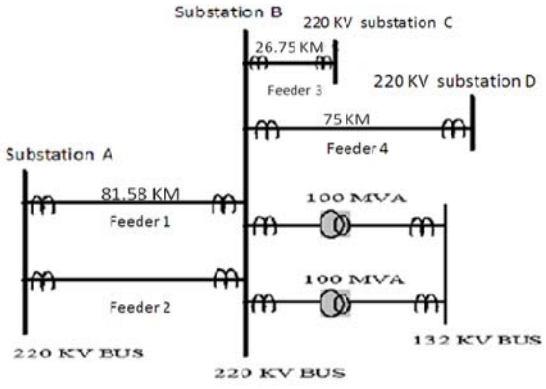

Fig 2 Line *diagram of 220 KVSubStationA-220 KVSubStationB*

Fig 2 shows the arrangement of RAZOA relay in the line diagram. The relays are placed at sending end and receiving end of the feeders. The sending end is at substation A and receiving end is at substation B.The relay setting are calculated for the RAZOA relay at 220 KV substation A and the relay available on this feeders are RAZOA (MAKE: ABB COMPANY). From the

Fig 2, There are two 220 KV lines emanating from substation A (Feeder 1 & Feeder 2) to substation B. These feeders will feed 220 KV load to substation B. At the 220 KV substation B another two 220 KV feeders (Feeder 3 & Feeder 4) which feed 220 KV load to substation C and substation D.Another two 100 MVA 220/132 KV transformers are also connected to substation B.The following impedances are to be calculated for the RAZOA relay settings.

1. Impedance of the protected line i.e. 220 KV transmission lines of substation A and substation B (Feeder 1 & Feeder 2).
2. Impedance of Feeder 3
3. Impedance of Feeder 4
4. Impedance of Transformers

For calculating Relay setting for any distance scheme we need the following data.

1. Conductor used
2. Voltage levels
3. Current to be carried.
4. Line length
5. Shortest data line connected to the protected line
6.longest data line connected to the protected line
7.Transformer data which is connected to line

Operating Characteristic of the RAZOA relay:

The directional measuring unit have quadrilateral characteristic with independent settings in resistive and reactive directions. Which have resistance (R) and reactance (X)

can be set independently. R-X diagram is shown in Fig 3.The impedances can be made to operate with a circle or oval characteristic with a selectable switch present in RAZOA relay. The setting range is from 0.16 to 64 Ohms.

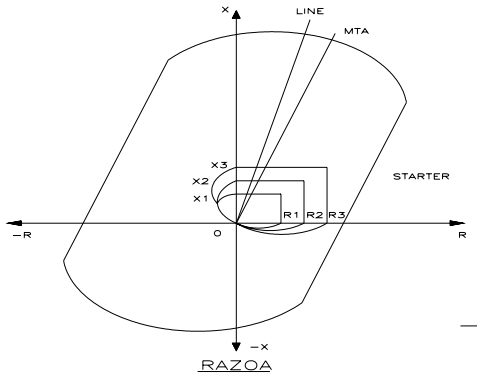

Fig 3 shows the operating characteristic of RAZOA relay

We use oval characteristics for long transmission lines and circular characteristics for short, medium transmission lines. If we set relay in the short transmission lines, the resistances values are kept more to avoid reactance effect .If we set relay in the long transmission lines, the reactance values are kept more to avoid power swing problems. So, there is possibility of changing the characteristic in RAZOA relays.

2.2 Operating principle of REL-100 Relay:

The different types of faults in impendence zones can be analyzed using protection terminal in REL-100 relay.The relay includes three forward and one reverse impedance zone, measuring technique used in REL-100 is based on signal processors which operate with numerical signal derived from the analogue to digital converter (A/D) shown in Fig 4.

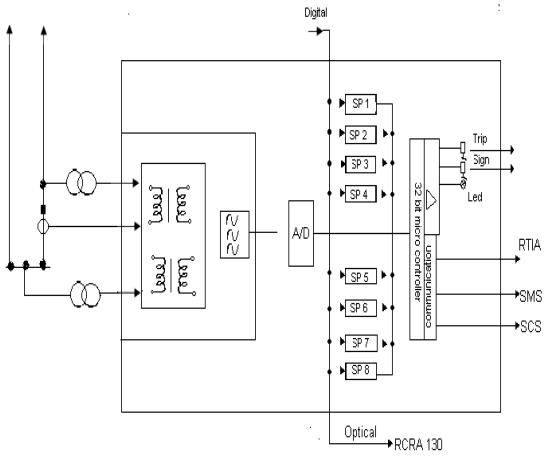

Fig 4 Block diagram of REL 100 Relay

Eight scheme communication logic is included in the basic version together with current reversal logic. These are selectable independently of one another during setting procedure. Four groups setting parameter are available in REL-100.They are completely independent of one another. The self supervision function is performed continuously and includes as fallows:

-normal microprocessor watch-dog function

-checking of digitized measuring signals

-checksum verification of PROM contents

-checksum verification on all signal communications

-Read-write –read write cycling of memory cells and internal registers.

Transformer unit present in REL 100 consists of a total of ten analogue input quantities. All measuring currents enter the transformer unit via plugs and sockets. The line protection is automatically short circuited when the transformer unit withdrawn its input quantities.

In A/D converter unit all of the analogue signals are filtered in analogue

antailiasing low pass filters before entering the multiplexer and analogue to digital converter. A separate signal processor in the analogue to digital converter unit performs digital low pass filtering. The total bandwidth of the filtering signal is suitable for protection purpose; these information signals are converted parallel to serial mode and transmitted to measuring unit.

The measuring unit consists of 32-bit microcontroller and three signal processor which decode or change the encoded serial information into parallel information. The impendence measuring function performed by three basic signal processors which calculate the impendence for different fault zones. The 32-bit microcontroller collects all the information from the different signal processors, analogue to digital converters and the input signaling circuits as well as performing different logical functions, built into REL-100 line protection terminals. It also controls output unit as well as three communication ports. The communication ports are MMC unit (Man Machine Communication), SMS (Substation Monitoring System), SCS (Substation Control System).

The REL-100 relay is tested at 220KV level substation by TURH kit .From these testing the performance of relays have been analyzed. The reached values of reactive and resistive values have been taken from the testing of REL-100 relay. At first theoretical values are calculated with help of these values and then relay is tested with TURH kit. The actual values are taken for phase-neutral, phase-phase of three zones. The actual values should be ±10% to the theoretical values. The theoretical values and actual values of resistive and reactive reaches values are plotted in APPENDIX-3 and APPENDIX-4.

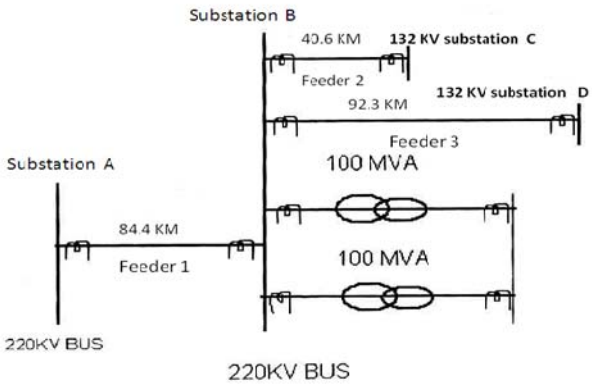

Fig 5 Line *diagram of 220 KVSubstation A-220 KV Substation B*

Fig 5 shows the arrangement of REL-100 relay in the line diagram. The relays are placed at starting and ending of the feeders. The sending end is at Substation A and receiving end is at Substation B.The relay settings calculated for the REL-100 relay at 220 KV substations A. The relay available on this feeders are REL - 100 (MAKE: ABB COMPANY).Only one 220 KV line is emanating from Substation A (Feeder 1) to Substation B.This feeder will feed 220KV load to substation B.At the Substation B there are two 220 KV feeders (i.e. feeder 2 and feeder 3) which feed 132 KV load to substation C and substation 3. Another two 100 MVA 220/132 KV transformers are also connected to substation B. The following impedance are to be calculated for the REL-100 relay settings.

1. Impendence of the protected line i.e. 220 KV transmission line of substation A and substation B (Feeder1).
2. Impendence of Feeder 2
3. Impendence of Feeder 3

4. Impendence of Transformers

Operating Characteristic of the REL 100 Relay:

It is a numerical relay with quadrilateral impedance units for phase and earth faults. Each measuring unit has individual and independent setting in resistive (R) and reactive(X) directions. Entire Zone-3 REACH i.e. zone 3R (in forward direction) which is available in reverse direction with a separate timer T 3R. R-X diagram is as indicated in Fig 6

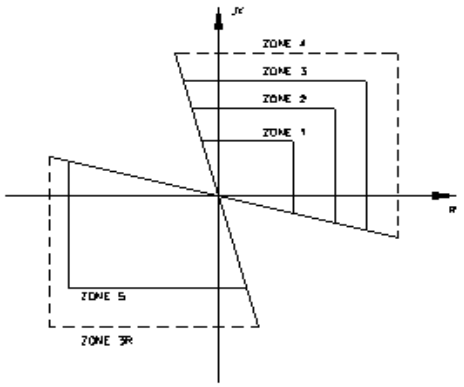

Fig 6 shows operating characteristics of REL-100 relay

Four groups of setting parameters are possible to suit different system conditions. Only one of the groups will be in service by choice. It is a continuous self monitoring of resistance and reactive values, self testing. Which indicate the same by using "Relay Available" LED (Light Emitting Device) on the relay. By using MMC (Man-Machine Communication), we can edit the relay settings, and read the values of line voltage, current, real, reactive power and frequency. The Setting ranges are from 0.1 upto 150 Ohms and the Timers are from 0 upto 10 Secs.

4. SIMULATION AND RESULTS

The RAZOA and REL -100 Relays have been simulated by using MATLAB program.

Case (i)

Input Data for calculating the relay settings of RAZOA:

Parameters	values
Enter primary voltage	220000
Enter secondary voltage	110
Enter primary current	800
Enter secondary current	1
Enter line length in KMS	81.58
Enter shortest line length in KMS	26.75
Enter longest line length in KMS	75
Enter transformer-I percentage impedance	8.44
Enter transformer-II percentage impedance	8.44
Enter Transformer-I MVA	100
Enter Transformer-II MVA	100
Enter frequency	50

Results of RAZOA relay for 220 KV:

Conductor to be used is zebra (ACSR)

Conductor size is 61/3.19

Operating characteristic is circular

Resistive Reach : 29.966160

a) Line Reactance : 0.305602

b) Distance Steps :

X1 : 10.431118

X2 : 15.176618

X3 : 18.169427

1. Adopted Voltage Ratio : 2000.000000

2. Adapted Current Ratio : 800.000000

3. Line Length : 81.580000

4. Line Constants per Phase per Circuit

a) Positive Sequence Parameters in Ohms

Rl : 6.256289,

Xl : 32.597244

Zl : 33.19219

b) Zero Sequence Parameters in Ohms

R0 : 22.737986

X0 : 109.200767

Z0 : 111.542922

c) Line Angle : 79.175652

d) Power Factor : 0.188487

5. Impendence Ratio : 2.500000

6. Secondary circuit data in Ohms

7. SETTINGS:

a) 1.starter unit characteristic C = Circular Characteristic

2. Neutral Current Starter ins = 0.2

b) Measuring Unit

1. Current Factor Settings

Inductive Reach a: 99.000000

Resistive Reach b: 29.966160

2. Voltage Factor Settings

p1= 30.370666

p2= 20.874216

p3= 17.435883

c) Zero Seq. Compensation kn: 0.783333

d) Time Settings in seconds

Zone-I Inst

Zone-II 0.3

Zone-III 0.6

Zone-IV 1.2

Case (ii)

Input Data for calculating the relay settings of REL-100:

Parameters	values
Enter primary voltage	220000
Enter secondary voltage	110
Enter primary current	800
Enter secondary current	1
Enter line length in KMS	84.4
Enter shortest line length in KMS	40.6
Enter longest line length in KMS	92.3
Enter transformer-I percentage impedance	8.44
Enter transformer-II percentage impedance	8.44
Enter Transformer-I MVA	100
Enter Transformer-II MVA	100
Enter frequency	50
Enter Fault Resistance at Earth Faults/loop	30
Enter Fault Resistance at two phase faults/phase	1

The MATLAB program is developed to calculate the relay setting of relays between one substation feeders to another substation feeder.

Results of REL-100 relay upto 220KV

Conductor to be used is zebra (ACSR)

Conductor size is 61/3.19

1. Adopted Voltage Ratio : 2000.00

2. Adopted Current Ratio : 800.000

3. Line Length : 84.400000

4. Line Constants per Phase per Circuit

a) Positive Sequence Parameters in Ohms

Rl : 2.589021

Xl : 13.489617

Zl : 13.73582

b) Zero Sequence Parameters in Ohms

R0 : 9.409591

X0 : 45.190217

Z0 : 46.159464

c) Line Angle : 79.175652

d) Power Factor : 0.188487

5. Impedance Ratio : 2.500000

6. Secondary circuit data in Ohms

7. SETTINGS:

Resistive reaches for Phase faults

R1 : 3.671217

R2 : 5.186595

R3 : 6.583198

Reactive reaches for Phase faults

X1 : 10.791694

X2 : 18.687293

X3 : 25.964039

Resistive reaches for Earth faults

RN1 : 15.898175

RN2 : 18.750223

RN3 : 21.378729

Reactive reaches for Earth faults

X1 : 10.791694

X2 : 18.687293

X3 : 25.964039

Zero sequence compensation

KN1 : 0.786839

KN2 : 0.786839

KN3 : 0.786839

Phase sector for Earth faults : 13.119746

Phase sector for Earth faults : 38.566039

Phase sector for Phase faults : 13.119746

Phase sector for Phase faults : 38.566039

e) Time Settings in seconds

Zone-I Inst

Zone-II 0.3

Zone-III 0.6

Zone-IV 1.2

The results of these two relays i.e. RAZOA and REL-100,it was observed that RAZOA relays are based on transmission line characteristic i.e.short, medium, long transmission lines but the REL-100 are numerical relays, which provides back-up protection for 220 KV EHT transmission lines and above voltage levels with advanced relays setting.

4. CONCLUSION:

It could be concluded that the protection of EHT transmission lines and calculations of the corresponding relay settings have been presented. Both relays have been tested at 220 KV level substation .With the help of the line diagrams of the substations relays setting are calculated with required parameter. The relays setting for both have been successively calculated using the MATLAB program for 220 KV level .With help of this MATLAB program we can calculate relays setting for 220 KV and above voltage levels. By analysis and calculation on both relays i.e. RAZOA and REL-100, it is noticed REL- 100 was the most successful relay for the EHT transmission line protection in power system.

REFERENCES :

[1]. *Power System Analysis* – John Grainger and William Stevenson, Mc Graw Hill publications

[2]. *Power System Analysis* – Hadi Saadet, TMH Edition

[3]. *Power System Protection and Switchgear* – B.Ravindranath and M.Chander, New Age International (P) limited

[4]. *Art and Science of Protective Relaying* – C.R.Mason, Wiley Eastern limited

[5]. *Switchgear and Protection* – Sunil S Rao

[6]. *Electrical Power Systems* – C.L.Wadhawa

[7]. *Protective Relays* – Application Guide

[8]. *Technical Reference Book* – AP TRANSCO

[9]. *Company manual for Distance Protection Scheme (RAZOA)* – ABB, Bangalore

[10]. *Company manual for Distance Protection Scheme (REL 100)* – ABB, Bangalore

APPENDIX-1

Terminal No	Purpose
1	220V DC supply (+ve)
2	Used for Annunciation purpose
3	R-ph current input terminal
4	R-ph current return path terminal
5	Y-ph current input terminal
6	Y-ph current return path terminal
7	B-ph current input terminal
8	B-ph current return path terminal
9	N-ph current input terminal
10	N-ph current return path terminal
11	R-ph PT supply terminal
12	Y-ph PT supply terminal
13	B-ph PT supply terminal
14	N-ph PT supply terminal
15	Spare terminal
16	Spare terminal
17	To Energize Tripping Relay
18	220V DC supply(-ve)

APPENDIX-2

Phase Selected	**Z – I**		**Z – II**		**Z– III**	
	T	**A**	**T**	**A**	**T**	**A**
RN	35	34	51	50	61	60
YN	35	33	51	51	61	61
BN	35	34	51	51	61	60
RY	39	39	56	56	68	68
YB	39	39	56	56	68	66
BR	39	39	56	56	68	67

APPENDIX-3

Phase	**Z- 1**		**Z – 2**		**Z-3**	
	T	**A**	**T**	**A**	**T**	**A**
RN	3.179	2.986	3.566	3.5	3.966	3.872
YN	3.179	2.95	3.566	3.49	3.966	3.932
BN	3.179	2.985	3.566	3.472	3.966	3.699
RY	1.468	1.397	1.876	1.793	2.164	2.089
YB	1.468	1.41	1.876	1.765	2.164	2.132
BR	1.468	1.42	1.876	1.8	2.164	2.15
RYB	0.734	0.82	0.938	1.02	1.082	1.32

APPENDIX-4

Phase	Z-1		Z – 2		Z- 3	
	T	A	T	A	T	A
RN	3.854	3.795	5.76	5.73	7.09	6.92
YN	3.854	3.841	5.76	5.75	7.09	6.89
BN	3.854	3.85	5.76	5.75	7.09	6.92
RY	4.313	4.296	6.48	6.39	7.94	7.94
YB	4.313	4.296	6.45	6.38	7.94	7.92
BR	4.313	4.123	6.46	6.39	7.94	7.92
RYB	2.156	2.23	3.22	3.12	3.97	3.87

Note: Z=Zone T=Theoretical

A=Actual