IJIREEICE

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

ISO 3297:2007 Certified
Vol. 6, Issue 4, April 2018

Design and ETAP Software of DOCR (Directional over current Relaying) for IEEE 9BUS Network

Snehal Rathava[1], Prerak Patel[2], Ronak Patel[3]

Student of Electrical Engineering, Grow More Faculty of Engineering, Himmatnagar, India[1]

Assistant Professor of Electrical Engineering, Grow More Faculty of Engineering, Himmatnagar, India[2,3]

Abstract: A significant factor for property designing the protection scheme of a smart grid is the fault current contribution from the converter interfaced distributed energy resources. The fault current direction and magnitude is difficult to be defined, since the currents injected by the converters affect it considerably. The fault situation is even more complicated considering. The case of islanded looped micro-grids with conventional protection devices. In such micro-grids, all protection devices are settled to the same rated current. In order to overcome these issues, this paper proposes a new method for detecting and clearing faults, without utilizing and communication means. The fault identification process is carried out by measuring indirectly the micro grid impedance, while each converter adapts the internal control method and injects a fault current proportional to the sensed impedance. Therefore, the sources being closer to the fault inject relatively larger currents enabling the relative coordination of conventional protection devices. In order to enhance even more the relative coordination of the protection devices, a time delay is also incorporated in the fault control, the proposed strategy is validated a looped micro grid, protected by simple over current relays.

Keywords: Directional Over current, ETAP, LINKNET, Relay coordination.

I. INTRODUCTION

Power System is a network which contains Generation, Transmission, and Distribution along with control devices. To study the operational features and electrical performance of a composite power system, analysis has been done. Modern Power System smart grid network extensively large area to meet the power demand more reliably and efficiently. It consist of very wide range of expensive equipments such as generators, transformers, circuit breakers, capacitors, reactors etc. A small abnormality occurred in system may result in interruption of supply and damage to the electrical equipment connected to the power system. Interruption is supply for small time may result in large revenue loss to industries such as process plants, telecom and to hospitals where electricity is the for-most necessity. Hence it becomes essential to readily identify the abnormality and remove it as rapidly as possible without disturbing working of rest of the system. This demands the requirement of reliable protective system in order to have correct fault identification and isolation to maintain system stability. Hence the objective of power system protection is to isolate a faulty section of electrical power system from rest of the live system so that the rest portion can function satisfactorily without any severer damage due to fault current.

[1] The main information obtained from the load flow study comprises of magnitudes and phase angles of the load bus voltages, reactive powers at voltage phase angles and generator buses, real and reactive power flow on transmission line together with power at the reference bus, other variables being specified. [1] This information is essential for the continuous monitoring of the current state of the system and analyzing the effectiveness of the alternative plants for the future, such as adding new generator sites, meeting increased load demand and locating new transmission sites. We are mainly interested in voltages at various buses and power injection into the transmission system. [1] The power system network of today is highly complicated consisting of hundreds of buses and transmission links. Thus, the load flow study involves extensive calculation. [1] Before the advent of digital computers, the AC calculating board was the only means of carrying out load flow studies. These studies were, therefore, tedious and time consuming. [1] With the availability of fast and large sized digital computers, all kind of power system studies including load flow study can now be carried out conveniently. [1] The abnormal system behavior under conditions of symmetrical short circuit (Symmetrical three-phase fault). Such conditions are caused in the system accidentally through insulation failure of equipment or flashover lines initiated by a lightning stroke or through accidental faulty operation. The system must be protected against flow of heavy short circuit current. (which can cause permanent damage to major equipment) by disconnecting the faulty part of the system by mains of circuit breakers operated by protective relaying. For proper

IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 4, April 2018

choice of circuit breakers and protective relaying, we must estimate the magnitude of current that would flow under short circuit conditions. [1] The majority of system faults are not three phase faults but faults involving one line to ground or occasionally two lines to ground. These are unsymmetrical faults requiring special tools like symmetrical components. Though the symmetrical faults are rare, the symmetrical fault analysis must be carried out, as this type of fault generally leads to most severe fault current flow against which the system must be protected. Symmetrical faults analysis is, of course, to simpler to carry out. [1] The paper presents design methodology of protection system for an industrial electrical network design to supply a process plant. The protection system is designed by keeping system constraints in mind. Directional over current protection is applied to the system. LINKNET structure algorithm is used for relay coordination. LINKNET programming is done using MATLAB software and relay settings are calculated and implemented using ETAP software.

II. SYSTEM DETAILS

The network consists of a IEEE standard 9BUS system with generation 247.5 MW, 108.8 MW and 163.2 MW. This power is being transferred by transmission lines having a capacity of 230 kv (50 km, 30 km, 20 km, 25 km, 15 km).

A. System Data

Table 1 Generator Details

ID	Rating				
	MW	KV	MVA	PF	FLA
Generator 1	247.5	16.5	247.5	100%	8660
Generator 2	163.2	18	192	85%	6158
Generator 3	108.8	13.8	128	85%	5355

Table 2 Transmission Line Data

ID	Rating (kV)	Length (km)	R1 (ohms/km)	X1 (ohms/km)
Line-1	230 kV	50 km	0.068	3.8
Line-2	230 kV	30 km	0.068	2.28
Line-3	230 kV	30 km	0.068	2.28
Line-4	230 kV	20 km	0.068	1.52
Line-5	230 kV	25 km	0.068	1.9
Line-6	230 kV	15 km	0.068	1.14

Table 3 Transformer Data

ID	Rating			
	kV	MVA	%Z	%Z p.u.
T-1	230/16.5 kV	100	4	3.328
T-2	18/230 kV	100	12.5	12.497
T-3	13.8/230 kV	25	10	9.988

B. Single Line Diagram

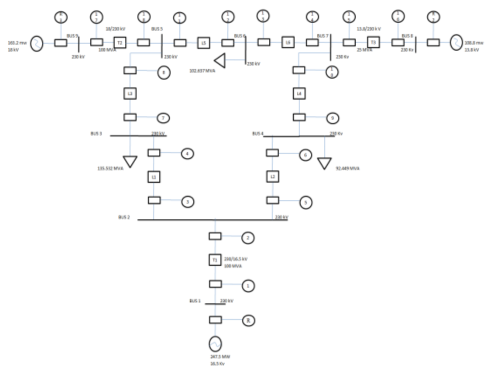

Fig 1 : Single Line Diagram

IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 4, April 2018

III. PROTECTION SYSTEM DETAILS

A. Detailed System Study
Detailed system study includes study of system configuration, different type and number of system equipments, equipment ratings, system operation, system loading etc.

B. Load Flow Analysis
The starting point of any analysis of power system will be the computation of complex voltages at all the busses. Once the complex voltages have been computed the power coming out of a bus and the power flowing in all the transmission lines can be calculated. Load flow analysis is a computational tool for this purpose. Load flow is normally used in planning studies when a power network is being laid or when a power network is undergoing expansion.[2]

C. Short Circuit Analysis
Before applying proper electrical protection system, it is necessary to have through knowledge of the conditions of electrical power system during faults. The knowledge of electrical fault condition is required to deploy proper different protective relays in different locations of electrical power system. Information regarding values of maximum and minimum fault currents, voltages under those faults in magnitude and phase relation with respect to the currents at different parts of power system, to be gathered for proper application of protection relay system in those different parts of the electrical power system. Collecting the information from different parameters of the system is generally known as short circuit analysis.

On large systems, short circuit analysis is required to determine both the switchgear ratings and the relay settings. No substation equipment can be installed without knowledge of the complete short circuit values for the entire power distribution system. The short circuit calculations must be maintained and periodically updated to protect the equipment and the lives. It is not safe to assume that new equipment is properly rated.[2]

D. Protective Device Selection
Protective device selection is very important task in protection scheme designing. Depending upon the severity of fault and protection requirement of particular equipment protective relays and protection schemes are chosen.

As system includes parallel lines and parallel transformer the non-directional relays used will not be able to discriminate the faulted zone. Directional feature is essential where fault current can flow in both direction from the bus. By introducing the directional feature in relays uninterrupted supply can be made possible at all load points connected in the parallel system. To ensure proper fault discrimination, directional overcurrent relays are used at the load end of parallel feeders.[3]

E. Protective Single Line Diagram

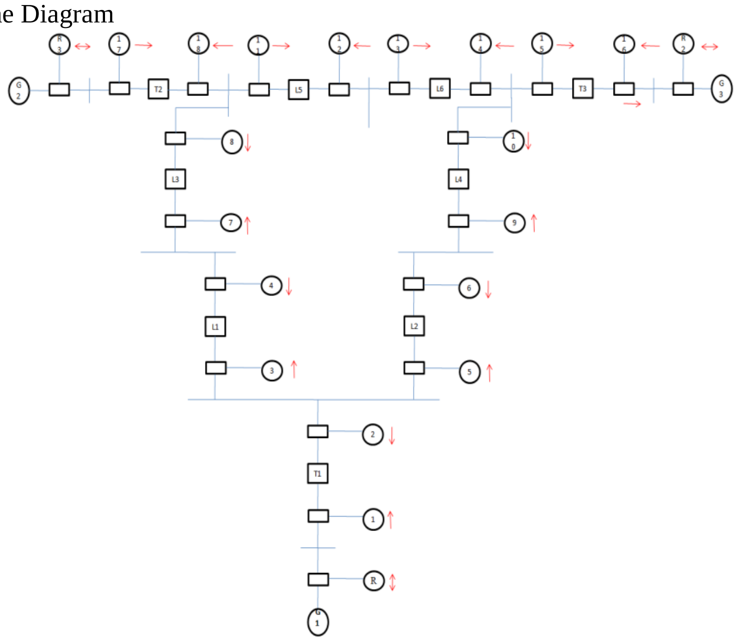

Fig 2 : Protection SLD

IJIREEICE

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

ISO 3297:2007 Certified

Vol. 6, Issue 4, April 2018

F. Relay Coordination

Over current relay coordination is necessary to achieve proper fault identification and fault clearance sequence. The relay must be able to distinguish between the normal operating currents including short time over currents and sustained over current due to fault conditions.

A relay operates as a primary relay for a fault in its zone of protection and the same relay operates as a backup to some other relays in the system. In the event of failure of primary relays meant for isolating the fault within its primary zone of protection, backup relays must operate after providing for sufficient time discrimination for the operation of primary relays. Hence, the operation of backup relays must be coordinated with those of the operation of the primary relays. The flexible settings of the relays (namely plug or tap setting, the time dial setting and possibly selection of suitable time-current operating characteristics), must be set to achieve the objectives stated in this section.

The procedure for relay coordination for single source system is easy but for parallel feeders, interconnected system such as networks of state electricity companies which have 10 to 15 or more buses, 40 to 50 transmission lines, the exercise of load-flow analysis fault level calculations and listing the primary backup pairs will be very tedious. The exercise is very difficult because one has to consider line contingencies and the relay settings are to be decided based on the worst case. Several iterations would be required to calculate the TMS of relays so that minimum discrimination margin as required is found between a relay and all its back up relays. This is done through computer programming.

G. LINKNET Structure

The LINKNET structure is a general purpose structure for representing networks in a computer. The LINKNET structure can be implemented at machine language level as a linked addressing scheme or it can be implemented in a high level language, in which case it works as a linked indexing scheme. For relay coordination programming is done using high level language.[3]

The power system network is represented using their branch and node property. The node and branch properties are stored in a standard fashion. For each node or branch property a one dimensional array is formed and each position in array is identified with the node or branch number.

The branch end numbers are derived from a branch number as:

END A = f (BRANCH) = (2*BRANCH) -1
END B =g (BRANCH) = (2*BRANCH)

Three one dimensional vectors which are used in LINKNET structure are described below:

- LIST (NODE): The first branch end on the list from node. For each branch a pointer is defined.
- NEXT (END): The next branch on the list after END. The last branch end on the list for each node is indicated when NEXT (END) = 0.
- FAR (END): The node at the far or opposite end of the branch. FAR (END) vector is used to link any relay with its remote bus. It points to the node at the far or opposite end of the branch.

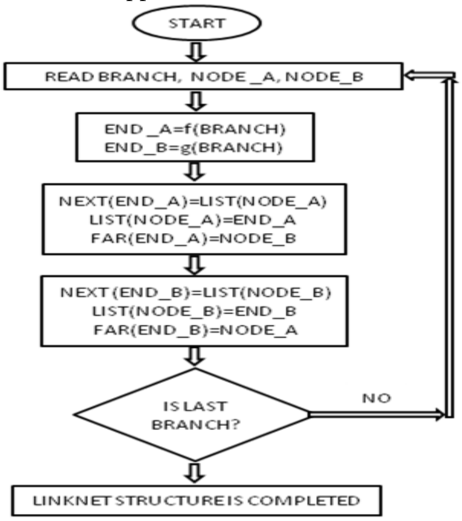

Fig: 3 Linknet Flowchart

IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 4, April 2018

H. Primary back-up Relay Pairs

Once the network topology is stored the next task is to identify primary and backup relay pairs for the protection. Primary- Backup pair identification can be done using following algorithm.

- The algorithm checks the directional and non-directional relay positions based upon the network information given by LINKNET structure, and stores relay locations in different variables.
- Once the relay locations are identified it checks for the nearest relay location to the relay whose back up pairs is to be found.
- The nearest relay to the considered relay is assigned as the first backup relay.
- After assigning first backup it again checks if there are another backup relays available in list, if the relays are present the process is repeated for second backup.
- Once all possible backups are assigned the algorithm checks whether all relays are provided backup or not, and it repeats until all relays in the network are considered.
- Following are the different variables used to locate relay positions.

IT = Relay at the other end
IFLT= Bus number near which the relay under consideration is located
IB = Directional relay looking towards IFLT bus
IS = Bus on which opposite end relay is placed
IF = Bus near which backup relay is placed
IN = Next directional relay incident at bus IFLT.[3]

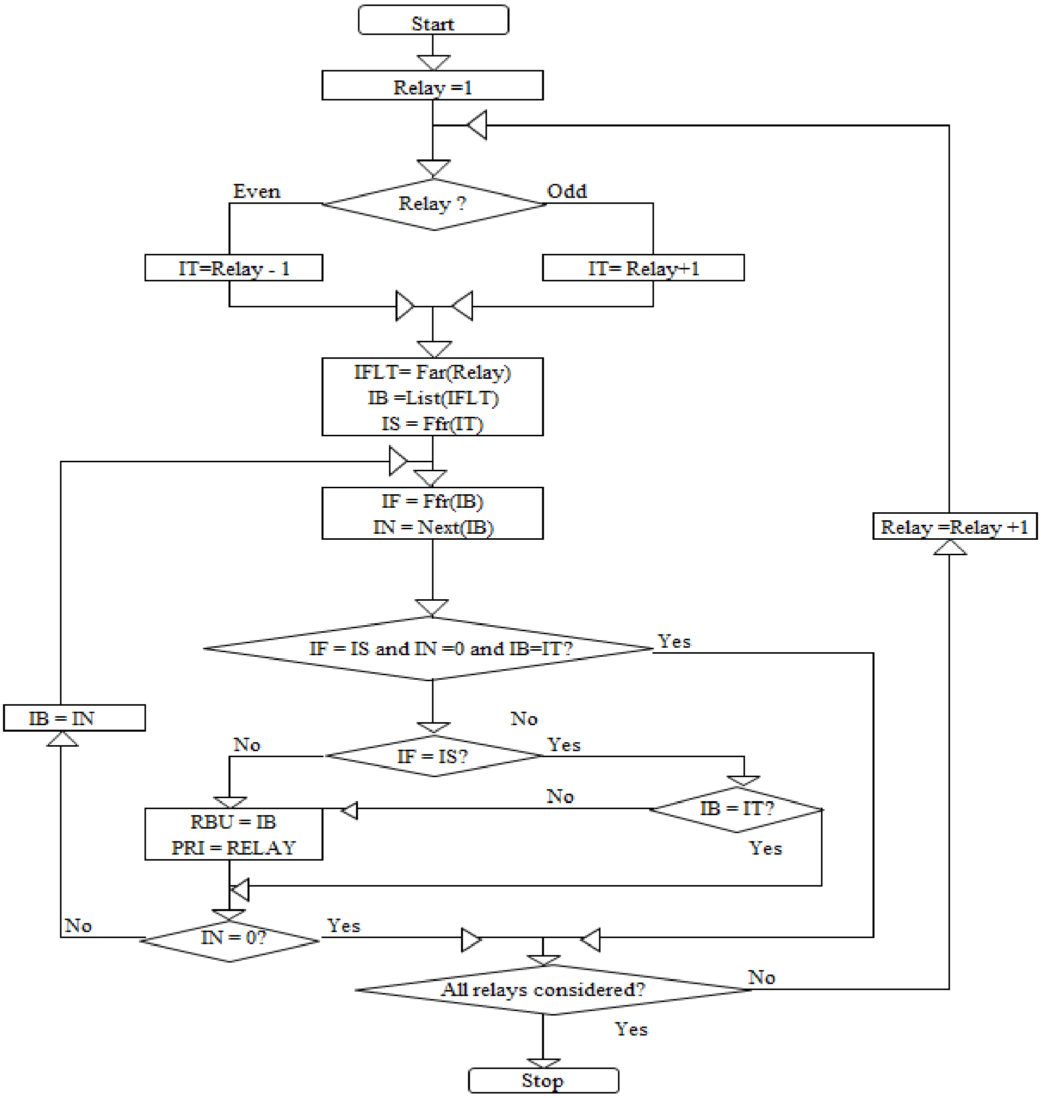

Fig: 4 Primary/Back-up Algorithm

DOI 10.17148/IJIREEICE.2018.649

IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 4, April 2018

Case 1 :

Table 4 Primary/ Back-up Pair

Relay	IT	IFLT= F(RE LAY)	IB= L(IF LT)	IS= F(IT)	IN= N(IB)	RBU	PRIM
1	2	2	2	1	0	RG1	1
2	1	1	1	2	0	RG1	2
3	4	3	4	2	0	6	3
4	3	2	3	3	2	4	4
5	6	4	6	2	0	4	5
6	5	2	5	4	3	6	6
7	8	5	8	3	0	10	7
8	7	3	7	5	4	8	8
9	10	7	10	4	0	8	9
10	9	4	9	7	6	10	10
11	12	6	12	5	0	RG3	11
12	11	5	11	6	8	12	12
13	14	7	14	6	0	13	13
14	13	6	13	7	12	14	14
15	16	9	16	7	0	RG2	15
16	15	7	15	9	14	16	16
17	18	8	18	5	0	RG3	17
18	17	6	17	8	11	18	18

I. Relay settings

Direction of relays are set as away from the bus. Plug Setting = % of rated current in terms of C.T secondary for back-up calculation.

Plug setting of relay will be, $\geq \frac{1.3}{1.05} \times PS\ of\ previous\ relay$

If there is a transformer between primary and backup relay then transformer ration needs to be incorporated in plug setting calculation.

Plug Setting Multiplier

$$\frac{fault\,current}{plug\ setting \times CT\ Ratio}$$

Time of Operation

$$\frac{3}{logPSM} * T.M.S$$

Time multiplier setting is usually selected as 0.1 sec for first relay and based on that further T.M.S are determined. The value 0.1 includes circuit breaker operation time/fuse operation timing as well as relay operation timing. If one wants to choose precise time multiplier settings then precise time delay can be determined from operating characteristics of fuse, circuit breaker and relay.[4]

IV. CONCLUSION

LINKNET Structure eases the complexity of primary backup relay pair identification. In the event of change in network topology user just need make minor changes in data fed to the program and program gives new primary backup pairs for the altered system.

REFERENCES

[1] [1] A Textbook on Power System Engineering by I J Nagrath, D P Kothari
[2] [2] Brijal mehta, T.V.Pavankumar (2014) "Design of system protection for 1/220/6.9 kV industrial network, Brijal mehta''
[3] [3] B.A.Oza, Bhavesh Bhalja, P.H.Shah (2002) "Coordination of over current relays for cascaded parallel feeder."
[4] [4] Vijay makwana, B.A.Oza, N.C.Nair, R. P. Mehta (2011) "Power system Protection and Switchgear."