Optimum Coordination of Directional Over current Relays By Implementing Genetic Algorithm In The Presence of Distributed Generation

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Abstract- *Distributed generation is generally utilized to supply neighborhood loads.An entrance of DG prompts damaging transfer coordination in appropriation organizes. Interconnection of DG influences miss coordination of dispersion framework security, on account of the generator capacity to contribute extensive blame streams to2the blame point. Effect of DG on hand-off coordination influence working time of hand-off.CTI related with essential & reinforcement hand-off sets is getting disregarded because of changes in blame current level. Along these lines, coordination amongst essential and reinforcement transfers flops within the sight of DG. Henceforth, interconnection of DG in conveyance framework causes a unfriendly effect on assurance coordination. Transfer coordination issue had numerous limitations because of coordination criteria. Heuristic based enhancement procedure is utilized to take care of the streamlining issues. These methods have a downside of merging to the qualities that may not be ideal because of the extensive variety of plan factors and trouble in getting an underlying plausible arrangement with a short scope of outline factors. This paper introduces another algorithm to conquer the issue of the underlying attainable arrangement in deciding the ideal settings of OCRs. In this unique circumstance, streamlining issue is planned as obliged non-direct advancement issue and is deciding utilizing GA. This algorithm is tried on distinct systems which discovered reasonable to provide agreeable outcomes.*

Keywords- Distributed Generation, plug setting multiplier,

I. INTRODUCTION

An electric supply system consists of three principal components viz., the power station, the transmission lines and the distribution system. Electric power is produced at the power stations which are located at favorable places, generally quite away from the consumers. It is then transmitted over large distances to load centers with the help of conductors known as transmission lines. Finally, it is distributed to a large number of small and big consumers through a distribution network. DG is not a new phenomenon. Prior to the advent of alternating current and large-scalesteam turbines - during the initial phase of the electric power industry in the early 20thcentury - all energy requirements, including heating, cooling, lighting, and motive power, were supplied at or near their point of use. Technical advances, economies of scale in power production and delivery, the expanding role of electricity in American life, and its concomitant regulation as a public utility, all gradually converged to enable the network of giga watt-scale thermal power plants located far from urban centers that we know today, with high-voltage transmission and lower voltage distribution lines carrying electricity to virtually every business, facility, and home in the country. In recent years, due to the increased consumption demand of electrical energy, use of distributed generation resources to feed electrical loads has increased. The use of these sources in the distribution system networks has many benefits. However, installing DG causes to some problems in the distribution network protection. The fault current injected from DG leads to changes in the short circuit current levels in the various points of network. So the coordination of over current protective devices may disturb because of changes in value and direction of fault currents. The magnitude of fault current injected from DG to the network and the impact of DG on the network protection depends on the technology type of DG. Three Main types of DGs are synchronous generators, induction generators and inverter based generators. The synchronous based DGs commonly have the lowest fault current level. This study concentrates on the synchronous generators which have a significant impact on the protection coordination of distribution network. Presence of distributed generation in distribution networks violets the existing protective relay coordination as well as it changes the configuration of distribution network. Generally the distribution networks are radial in nature. Directional over current relays are commonly used for the protection of distribution networks. In distribution feeders, they play a more prominent role as there it may be the only protection provided. The distribution networks lose their radial nature due to presence of DG. DG changes the magnitude as well as direction of fault current which to miss coordination of directional over current relays. Different techniques are presented by the researchers to mitigate the relay coordination issues due to the fault current injected by DGs. An adaptive protection scheme is used to update the relay setting as per fault current injected by DG. The fault current injected by DG depends on its types as well as its mode of operation. Adaptive protection scheme require the replacement of all existing relays with the digital relays to set the adaptive settings.

II.PROBLEM STATEMENT

To achieve relay coordination, the sum of all primary relay operating times should be Minimized using the optimal relay settings [time multiple setting (TMS) and plugSetting (PS)].This is represented in equation 1

$$\text{Min } Z = \sum_{i=1}^{N} t_i \qquad (1)$$

Where,

Z-The objective function in zone k,
i- Index,
ti-Operating time of the ithprimary relay for its near-end fault in k,
N- A total number of directional over-current relays,
Depending upon relay characteristics the above optimization problem has following
Constraints,

A. Relay Setting

Each relay has time multiple setting (TMS) and plug setting (PS). PS limit has chosen based on the maximum load current and the minimum fault current seen by the relay, and the available relay setting. The TMS limits are based on the available relay characteristics.

$$PSimin \leq PSi \leq PSimax (2)$$
$$TMSimin \leq TMSi \leq TMSimax (3)$$

Where

PSi,-minimum value of PS of relay Ri
PSi,-maximum value of PS of relay Ri
$TMSi$,-minimum value of TMS of relay Ri
$TMSi$,-maximum value of TMS of relay Ri
$TMSi$,And $TMSi,max$taken as 0.025 and 1.2 respectively

B. Bounds on Relay Operating Time:

The relay needs a certain minimum amount of time to operate. Also, a relay should not be allowed to take too long time for its operation.Hasbeen mathematicallystated as.

$$timin \leq ti \leq timax (4)$$

Where,

$timin$-Minimum operating time of the relay for the fault at any point in the zone k,
$timax$-Maximum operating time of the relay for the fault at any point in the zone k,

C. Backup- Primary Relay Coordination Time Interval

The fault sensed by the both primary as well as secondary relay simultaneously. The backup relay should take over the tripping action only after primary relay fails to operate, to avoid maloperation. If $Ri$is the primary relay for fault at k, and $Rj$is the backup relay for the same fault, then the coordination constraint can be stated as.

$$tj, - ti, \geq \Delta t \ (5)$$

Where,

ti,-Operating time of the primary relay , for the fault at k,
tj,-Operating time of the backup relayRj, for the same fault at k,
Δt - Coordination time interval (CTI).

III. RELATED WORK

"Optimal Coordination of Directional Relays in Interconnected Power System " by Urdaneta, A. J., Ramon, N., and Jimenez, L. G. P. This paper presents a new methodology based upon the principles of optimization theory, to treat the problem of optimal coordination of directional over-current relays in interconnected power systems[1].

"Optimization Coordination of Over-current Relays in Distribution System Using Genetic Algorithm" by P. P. Bedekar, and S. R. Bhide presents genetic algorithm (GA) method for coordination of over-current relays[2]. The over-current relays are the major protection devices in a distribution system. Over-current relay is usually employed as backup protection. But in some situations it may be the only protection provided.

"Optimum Coordination of Over-current Relays in Distribution System UsingDual Simplex Method" by P. P. Bedekar, and S. R. Bhide, V S Kale presents dual simplex method for coordination of over-current relays[3]. The over-current relays are the major protection devices in a distribution system. Overcurrent relay is usually employed as backup protection.

"A Novel Problem Formulation for Directional Over-current Relay Coordination" by H. Zeienldin, El-Saadany and M.A. Salama. In general, directional over-current relays allow for continuous time dial settings but discrete pickup current settings[4]. All previous work formulates the coordination problem either as a linear programming problem or as a nonlinear programming problem. In this paper, the protective relay coordination problem is reformulated to take into account the discrete pickup current values.

"An Online Relay Coordination Algorithm for Adaptive Protection Using Linear Programming Technique" byB. Chattopadhyay, M.S. Sachdev, and T.S. Sidhu. An adaptive system for protecting a distribution network should determine and implement relay settings that are most appropriate for the prevailing state of the power system[5]. This paper presents a technique for determining coordinated relay settings.

"Optimum Time Coordination of Directional Over-current Relays Using GA-NPL Method" by P.P. Bedekar, S.R. Bhide presents the time of operation of over-current relays (OCRs)can be reduced, and at the same time, the coordination can be maintained, by selecting the optimum values of time multiplier setting(TMS) and plug setting (PS) of over-current relays[6]."Advanced Coordination Method for Over-current Protection Relays Using Nonstandard Tripping Characteristics," by Keil, T., and Jager, J. This paper describes an advanced coordination method for an optimized protection time grading based on a new nonstandard tripping characteristic for over-current protection relays[7]. The intention is the highest possible reduction of tripping times for a selective fault clearing in distribution networks protected by over-current relays without communication links.

IV. EXISTING SYSTEM

Coordination of over-current relays in a meshed distribution system is a challenge task for the protection engineers. Initially it was done manually. Linear and non-linear programming optimizing techniques are very frequently used for coordination of overcurrent relays. Presently artificial intelligence is applied for optimal coordination of over-current relays. This project discusses application of genetic algorithm for optimal coordination of over-current relays in a loops distribution system. Combination of primary and backup relays is chosen by using graph theory, to avoid miss operation of relays. This project presents the implementation of artificial bees colony (ABC) algorithm in solving directional relays coordination problem for near-end faults occurring in fixed network topology. The coordination optimization of directional over-current relays is formulated as linear programming (LP) problem. The objective function is introduced to minimize the operating time of the associated relay which depends on the time multiplier settings. The proposed technique is to taken as technique for comparison purpose in order to highlight its superiority. The proposed algorithms have been tested successfully on 8 bus test system. The simulation results demonstrated that the artificial bees colony algorithm which has been proved to have good search ability is capable in dealing with constraint optimization problems. This magnitude of fault current can be utilized for the indication of fault existence. The distribution system is radial in nature, and over-current based protection scheme are set unidirectional flow of current. But the injection of DG power uses meshed configuration of the distribution system and on few branch current flows in both directional. The impact depends on some DGs, size, type and location.

IV. THE PROPOSED SCHEME

The project provides a simulation model of IEEE 14 bus system for short circuit studies and analysis of symmetrical fault using mi-power software. AT the event of a fault occurrence, short circuit studies are performed to obtain current flow magnitude at different time intervals for a power system until steady state condition is achieved. The project gives simulation results of the current which flows in different parts of the power system immediately after occurrence of a fault. The data obtained is further used to decide switch gear ratings and circuit breakers and also aids in setting andcoordination of protective relays. Further simulation result provides data regarding the contribution of different power system apparatus to the fault located at the different buses in the power system and it gives an efficient, accurate and easy way to analyze symmetrical faults in a given power system. The optimum setting for TMS and PS are obtained using different algorithms proposed by the researchers. In some cases, pickup currents are determined based on experience and only the value of TMS is optimized. To achieve relay coordination, the sum of all primary relay operating times should be minimized using the optimal relay setting [time multiple setting (TMS) and plug setting [PS]. The primary relay should operate. So it is necessary to set operating time of primary relays less than that of the backup relay.

FLOW DIAGRAM:

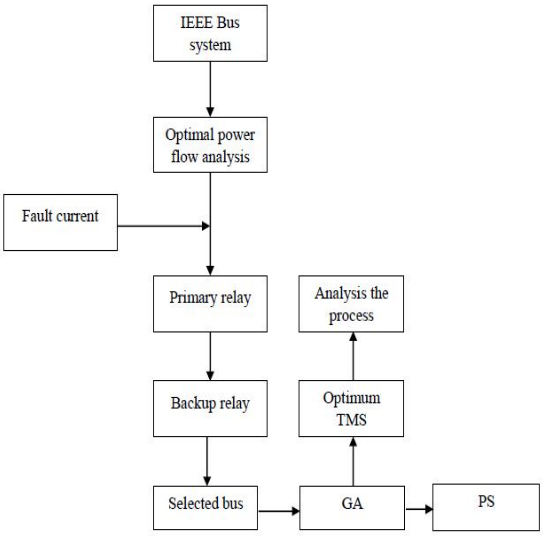


Fig a.Flow diagram

GENETIC ALGORITHM:

Genetic algorithm is a search method that mimics the biological process of naturalevolution and the idea of the "survival of the fittest".Starting with a population of randomly created solutions, the solutions with better fitness are more likely to be chosen as a parent to produce new solutions (offspring) for the next generation. The classical optimization methods have limitations in searching for global optimum point and sometimes trapped in local optimum point. In recent years, heuristic optimization techniques have aroused intense interest due to their flexibility, versatility and robustness in seeking global optimal solution.

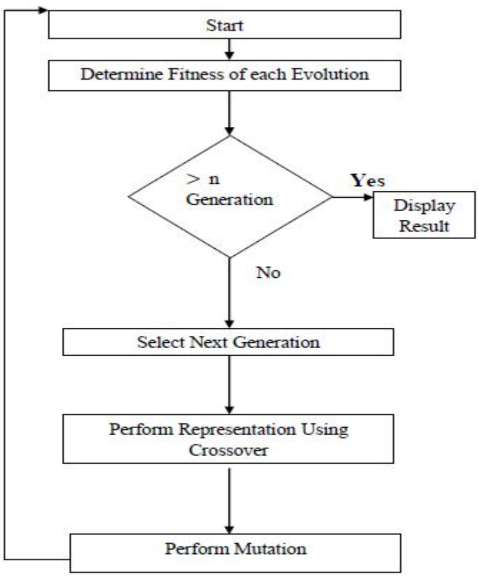


Fig. b Flow Chart of Genetic Algorithm

BLOCK DIAGRAM OF DIRECTIONAL OVER-CURRENT RELAY

Current transformer (CTs) and voltage transform (VTs) measures current and voltage, respectively. If the current is higher than the instantaneous pickup current (I) for $Tins$seconds, then the instantaneous over-current settings gives trip signal. If the current is lower than the $Iins$but higher than the pickup current (Ip), a trip signal is proposed according to the time over-current characteristics. Any of these trip signals can activate relay pickup (denoted by OR operation). However, the trip signal is not activated until the direction detects that the current is in forward direction (denoted by AND operation).

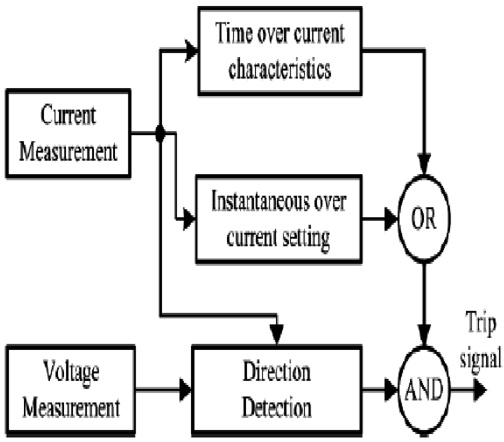


Fig c block diagram of directional over-current relay

4.3 ADAPTIVE RELAYING

Conventional relays have fixed setting parameters and therefore it becomes difficult to compare with the protection requirements in variable operation conditions in a power system. A solution to this problem is the adaptive protection, which can vary its setting parameters or its operating characteristics in response to changes in the power system. Adaptive protection is defined by Horowitz, Phadke and Thorp as "a protection philosophy which permits and seeks to make adjustments to various protection functions in order to make them more attuned to prevailing power system conditions." This implies updating of the relay settings, which represent a change in the powersystem topology. The concept of adaptive relaying is that many relay settings are dependent upon assumed conditions on the power system. In order to cover all possible scenarios that the protection system may have to face, the actual protection settings in use are often not optimal for any particular system state. If an optimal setting is desired for an existing condition on the power network, then it becomes necessary for the setting to adapt itself to the real-time system states as the system conditions change. When the power system is in a normal (healthy) state, there is sufficient generation and spinning reserve to meet the connected load, and transmission facilities are robust enough to provide strong alternative paths for power flow in the event of contingencies. In such a state, the greatest danger to the power system is instability resulting from faults that are not cleared quickly.

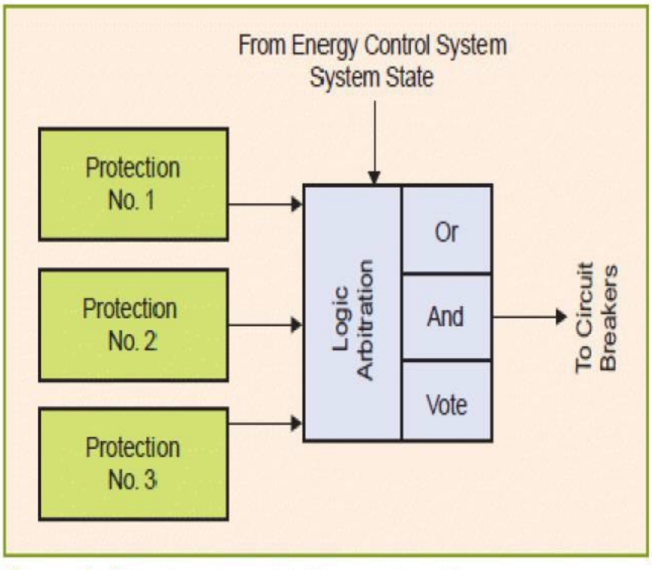


Fig d. Adaptive dependability and security

ADAPTIVE OVER-CURRENT PROTECTION ALGORITHM

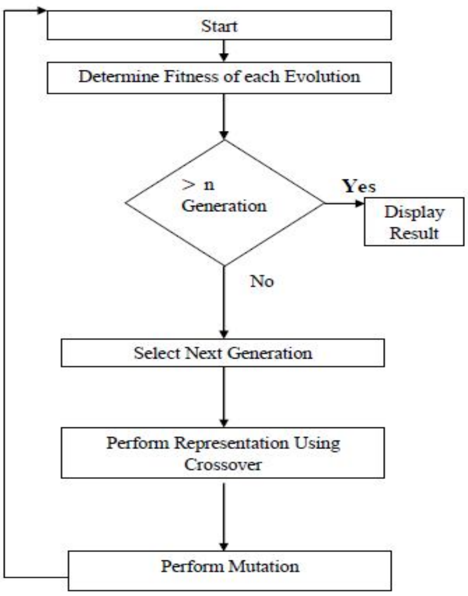


Fig e. Adaptive over-current protection algorithm

BLOCK DIAGRAM OF ADAPTIVE PROTECTION

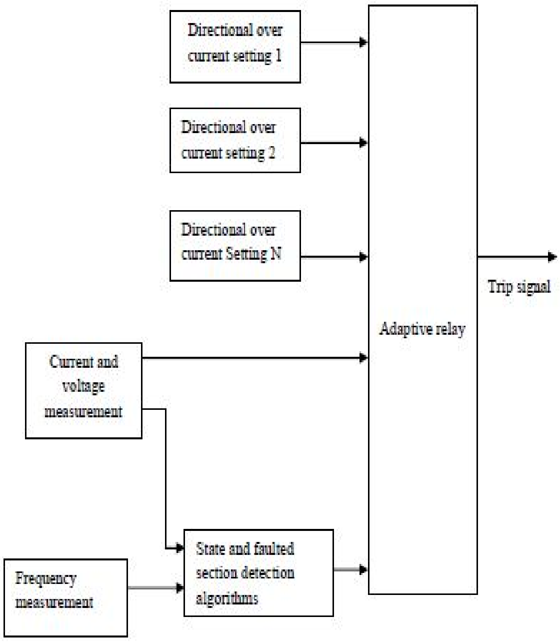
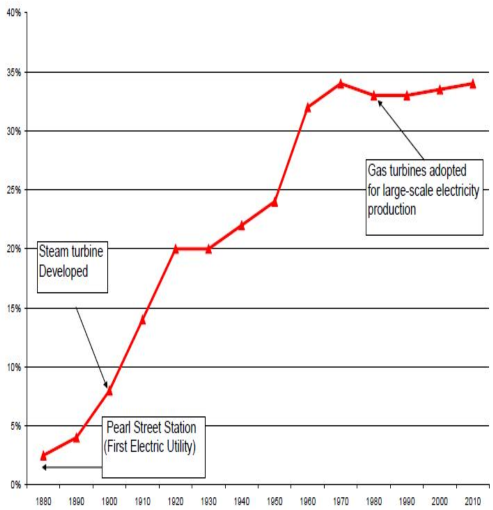


Fig f.Block diagram of adaptive protection

DISTRIBUTED GENERATION

Distributed generation (DG) systems are not new phenomena. Prior to the advent of alternating current and large-scale steam turbines, all energy requirements—heating, cooling, lighting, motive power—were supplied at or near their point of use.Technical advances, environmental issues, inexpensive fuel, the expanding role of electricity in American life, and its concomitant regulation as a public utility, all gradually converged around gig watt-scale thermal power plants located far from urban centres, with high-voltage transmission and lower voltage distribution lines carrying electricity to every business, facility, and home in the country.



Source: Energy Information Administration 2004.

V. RESULT AND DISCUSSION

Due to the presence of DG in distribution system, the original relay coordination islost. The original relay coordination is restored by disconnecting all DGs during the fault conditions. This will lead to the loss of DG power as well as it will create resynchronization problems for connecting DGs after clearing the fault.

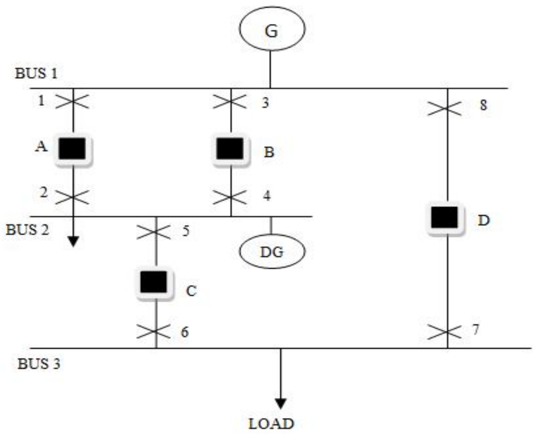


Fig g. Bus system with 8 directional over-current relays with single DG.

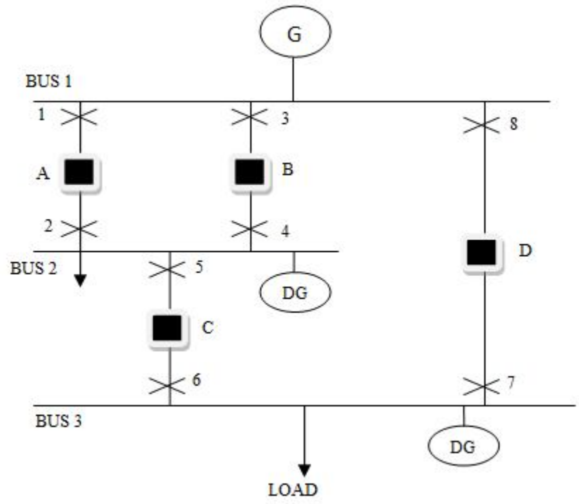


Fig h. Bus system with 8 directional over-current relays with two DG.

The 3-bus distribution system shown in Fig g is considered for the illustration. This system consists of 3 buses, 3 lines and one generator. A two, 1 MVA synchronous DG is connected at bus 2 and 3, to supply the local loads and both loads consider as 10 MW. The system data is given in Table 1. All lines are protected by directional over-current relays with normal inverse characteristic. Four different fault points (A to D at the middle of each line) are considered. Relay primary backup relationship and fault current data without considering DG and with DG is given in table 2. The minimum operating time as well as critical time interval is considered as 0.2 sec. The genetic algorithm method is used to find optimum relay settings with considering single and two DG. The optimum relay settings are presented in table3.

TABLE 1

Sl No.	Particulars	Ratings
1	Generator	25MVA, 11KV, Xd' =0.25 p.u
2	Line	0+j0.25 p.u
3	DG	1 MVA, 11KV, Xd'=0.30 p.u

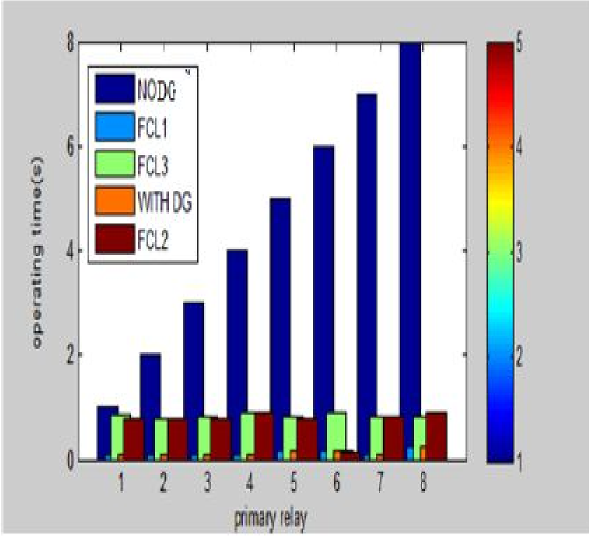
TABLE 2

Fault point	Relay		Fault current(Amp)			
			With single DG		With two DG	
	Primary	Backup	Primary	Backup	Primary	Backup
A	1	0	0	0	0	0
	2	6	4677	4769	6445.27	6428.46
B	3	0	0	0	0	0
	4	6	4677	4769	6428.46	6445.27
C	5	1	6174	875	6878.63	1242.86
	5	3	6174	875	6878.63	1242.86
	6	8	2613	6191	6878.63	6106.68
D	8	0	0	0	0	0
	7	5	6191	2613	6106.68	6878.63

OUTPUT

Relay Number	TMS and PS obtained using with single DG		TMS and PS obtained using with two DG	
	TMS	PS	TMS	PS
1	0.1039	0.8493	0.0982	0.8000
2	0.0817	0.8007	0.0816	0.8013
3	0.1056	0.8319	0.0981	0.8007
4	0.0783	0.8916	0.0777	0.914
5	0.1910	0.8170	0.1672	0.8000
6	0.1604	0.8980	0.1664	0.8141
7	0.0789	0.8320	0.0799	0.8044
8	0.2535	0.8350	0.2338	0.8851
Total operating Time(sec)	2.2388		1.8012	

OPERATING TIME RELAY:



VI. CONCLUSION

Distributed generations can bring many benefits in economic, technological, and environmental aspects but, at the same time, result in many challenges, of which one of the most important is the coordination of protective relays. When DGs are connected in a distribution system, both the direction and the distribution of the power flow and fault current in the distribution system could change significantly, such that the traditional protection scheme can no longer work properly. Hence, there is a demand for new protection schemes. In this project a genetic algorithm is used to find optimum settings of over current relays with and without considering the distributed generation. The impact of distributed generation is observed on protection coordination and fault current limiter (FCL) is used to restore the original relay settings. The resistive type of fault current limiter is used in series with distributed generation to mitigate the impact of DG. Due to additional resistance the fault current is reduced which is offered by DG. The results show the effectiveness of the proposed approach in restoring the original relay coordination for both with DG and without DG. This approach has the privilege of restoring the relay coordination without altering the existing relay settings or disconnecting DGs from the looped power delivery system.

Therefore,

- It makes use of the existing relay devices and protective scheme.
- It avoids the synchronization problems associated with reconnectingdistributed generation into the power delivery system.
- It is valid under the current practice of disconnecting DG and in the emergingtrend of maintaining DG in the power delivery system during fault.

- Implementation of fault current limiter adds an economic opportunity to limitthe buses short-circuit currents without the need for the buses equipmentupgrading.

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