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Relay Coordination Using Different Methods-A Review

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Abstract *— Power system required protection against various types of fault. Different relays are used for different kind of protection. Directional relay are widely used for Generator protection and Transmission line protection. Relay co-ordination is very important and challenging aspect of power system protection. In this paper, Different methods are discussed for relay coordination. Among them artificial methods seems better.*

Keywords- *Constraints for relay coordination; Trial and error method; Two Phase Simplex Method; Non Linear Programming; Genetic algorithm.*

I. INTRODUCTION

A Relay nearest the fault point should operate first and if it fails to operate then backup relay must be operated in sequence to provide back-up protection is called Relay coordination. The relays in the power system are to be coordinated properly so as to provide primary as well as back up protection, and at the same time avoid mal function and hence avoid the unnecessary outage of healthy part of system. The system will be highly protected with back-up protection and proper co-ordination.Certain time interval must be maintain between the operating times of various protection devices to ensure correct sequential operation of devices.The time interval essential for maintaining selectivity between primary and back up protections.[4] (Known as CTI) Manual calculation of relays is possible but, if the network is very large and complicated then it is very tedious to be done coordination of relays .[1]

In modern power system, the directional over current relay causes difficulties in coordination but the main advantage is that the directional over current relaying is simple and economical.[5] In transmission systems it is widely used as a secondary protection and as a primary protection in distribution and sub-transmission systems.[5]

II. CONSTRAINTS FOR RELAY COORDINATION

Coordination criteria for each Back up/Primary relay pair

$t_{i,k} - t_{j,k} \geqslant \Delta t$ [2]

Where
tj,k = operating time of the primary relay Rj , for fault at k;
ti,k = operating time of the backup relay Ri , for the same fault (at k)
Δt = CTI.[2]

Bounds on relay settings for each relay

$$TMS_{i,min} \leq TMS_i \leq TMS_{i,i}$$[2]

Where
TMSi,min = minimum value of of relay ;
TMSi,max =maximum value of of relay ;

$$PS_{i,min} \leq PS_i \leq PS_{i,i}$$[2]

where
PSi,min = minimum value of of relay ;
Psi,max = maximum value of of relay .

Relay charactrestics[2]

$$t_{op} = \frac{(\lambda)(TMS)}{((PSM)^{\gamma} - 1))}$$

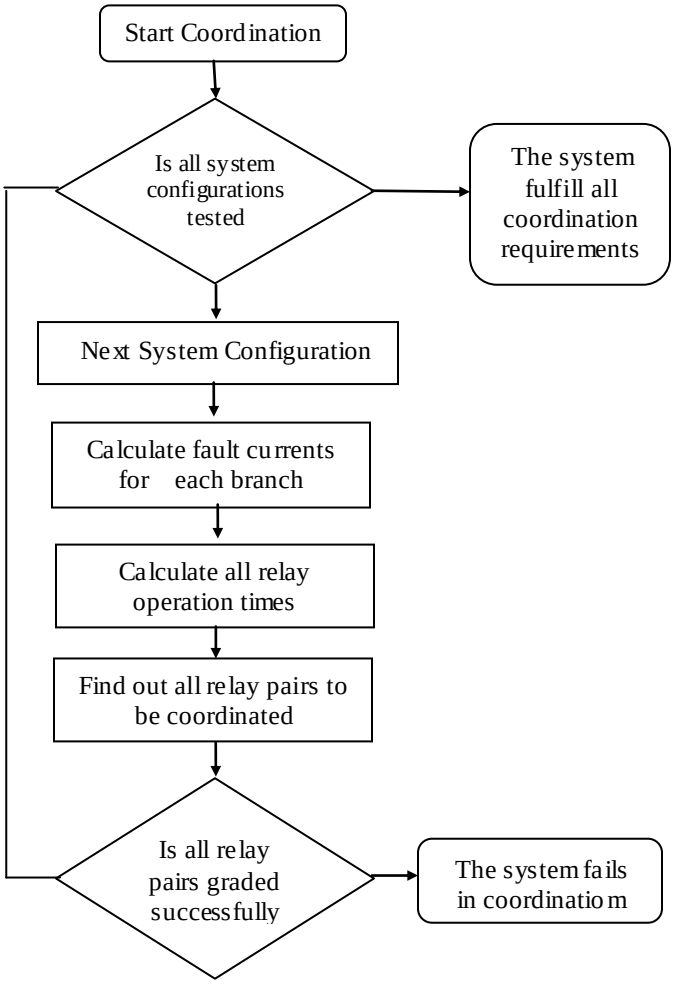

Fig.1 COORDINATION ALGORITHM BLOCK[1]

The block diagram for coordination is shown in Fig.1. The coordination should take into account all the system configurations, fault conditions and relay settings .All conditions must be met for a successfully coordinated system. The relay grading coordination is a constraint optimization process and is affected by the following conditions. [1]

1. Possible system configurations
2. Over current relay operation time
3. Relay grading pairs
4. Fitness of relay coordination

III. DIFFERENT METHODS

To make a Relay coordination by using different methods. The methods, which are used, for performing this task (relay settings) can be classified into three classes: [6]

(1) Trial and error method
(2) Topological analysis method
(3) Optimization method

Trial And Error Method

Manual calculation of relays is possible but, if the network is very large and complicated then it is very tedious to be done coordination of relays, Trial and error methods were used before but accuracy was very less.[6] The computer aided coordination technique is used to solve relay Coordination problem in complex power system with Graphical user interface. The power system simulator Siemens Network Calculation Software is also used to carry out coordination studies [5].

The authors carryout Coordination studies by means of "Computer Aided Protection Engineering (CAPE)" [5]. Thereforring network, is easily implemented and different types of faults such as single line to ground fault, line to line fault and double line to ground fault are inserted on feeder.The effects of Superconducting Fault Current Limiter (SFCL) on the optimal sizing of the renewable energy resources and relay coordination are described in [5].
Various optimization methods used in several papers are:

i) Linear Programming
ii) Non Liner Programming
iii) Artificial intelligents methods

Different Linear programming methods are described following methods.

1 Simplex method
2. Two phase simplex method

Two Phase Simplex Method

The method is based on the simplex algorithm which is used to find optimum solution of LP. The method introduces artificial variables to get an initial basic feasible solution (IBFS). [7] Artificial variables are removed using iterative process of first phase which minimizes the auxiliary objective function. The second phase minimizes the original objective function and gives the optimum time coordination of OC relays.[7]

Problem Formulation for LP

The coordination problem of directional OC relays in a ring fed distribution systems, can be stated as an optimization problem, where the sum of the operating times of the relays of the system, for different fault points, is to be minimized.[7]

$$\min z = \sum_{i=1}^{m} w_i t_{i,k}$$

Where
m is the number of relays,
ti k , is the operating time of the relay *i R* , for fault at k,
Wi is weight assigned for operating time of the relay *i R* [7]

A nonlinear and popular OCRs characteristic function as per below equation has been considered. [7]

$$t_{op} = \frac{(\lambda)(TMS)}{((PSM)^{\gamma} - 1))}$$

Above equation becomes

$$t_{op} = a(TMS)$$

Where

$$a = \left(\frac{\lambda}{(PSM)^{\gamma} - 1)}\right)$$

Non Linear Programming

Non-linear programming method for the relay coordination in the system. And consideration of weight factor and far end and near end faults. It is also observed that if the objective function is changed to running sum of all violating constraints, all valid considered constraints are satisfied.[3] The problem of infeasibility of constraints does not arise with this approach. The quality of coordination achieved by performing DOCR coordination based on faults simulated at near ends only as compared to the faults on both ends, i.e., near-ends as well as far-ends.[3]

Different artificial intelligent methods are describe following methods

i) Genetic algorithm
ii) Artificial neural network
iii) Fuzzy logic
iv) Particle swarm optimization

Papers which I have studied recommend GA method for relay coordination.

GENETIC ALGORITHM

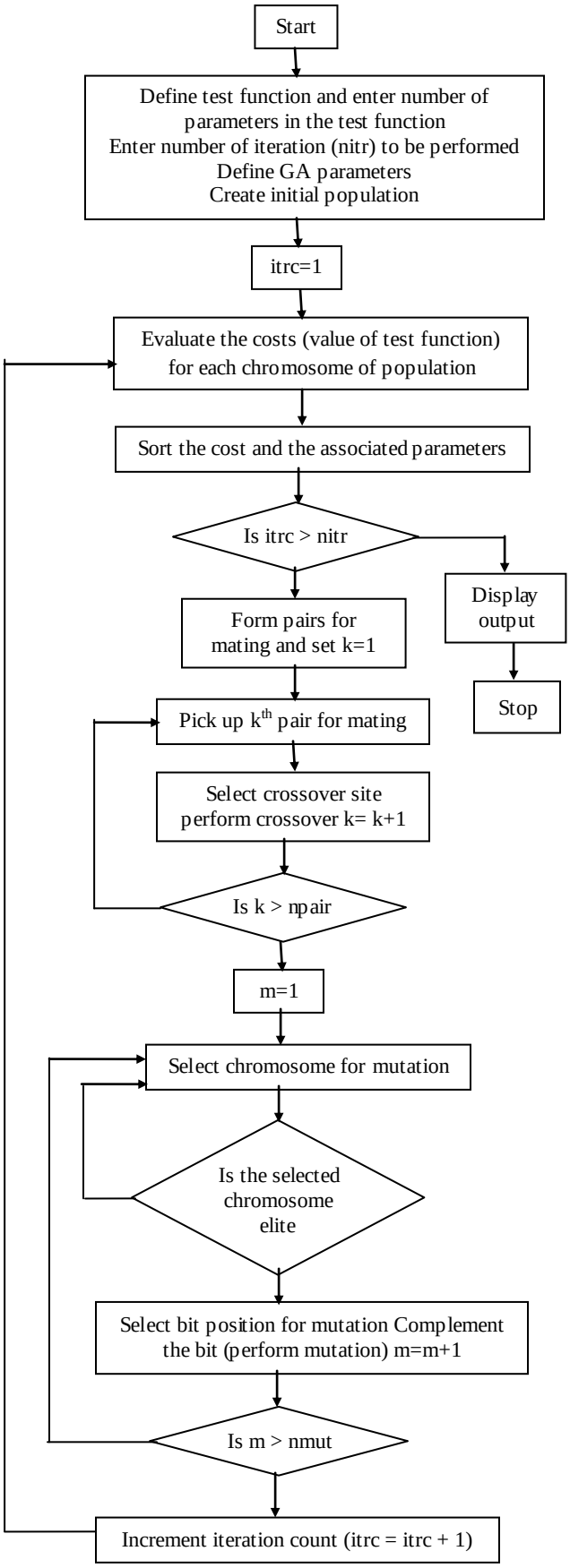

Fig.2.Flowchart of Genetic algorithm. [2]

Genetic Algorithm

Genetic algorithm is based on Darwin's theory of "survival of the fittest." GA is an optimization technique inspired by the principles of natural evolution and natural selection.[2]GA allows a population composed of many solutions to evolve under specified selection rules to a state that maximizes the "fitness".[2] GA begins, like any other optimization algorithm, by defining the optimization variables, and the fitness function (objective function). It ends like other optimization algorithms too, by testing for convergence. In between, however, this algorithm is quite different.[2] A path through the GA is shown as a flowchart in Fig. 2. In the flowchart itrc, nitr, npair, and nmut indicate iteration count, number of iterations to be performed, number of pairs for mating, and number of mutations to be performed, respectively.

The specified number of iterations have been considered as the stopping criteria.[2] In GA, the design variables are represented as strings of binary numbers, 0 and 1. If each design variable is coded in a string of length, a design vector is represented using a string of total length. This is achieved by placing the strings of all the variables side-by-side. This string (string of total length) is called a "chromosome". A starts with a group of chromosomes known as "population". [2]

IV. CONCLUSIONS

A comprehensive review of relay coordination techniques is presented in this paper. In literature many methods and techniques are proposed and implemented to solve relay coordination problem. It has been observed that the proper selection of primary and back up protection and maintaining a small time delay between primary and backup relays operation of relays. It is also observe that the all other optimization techniques especially GA with multipoint cross over yields the best fit results

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