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Optimal Co-ordination of Directional overcurrent Relay Co-Ordination

A Genetic Algorithm Approach

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Abstract —*Relay Coordination in main purpose is to make the network more stable and secure. The Function of (DOCRs) is to minimize the Damage in duration of the Service interruption When Faults occur in the System. The OCR time coordination in used ring fed distribution networks is a highly constrained optimization problem. The purpose is to find an optimum relay setting to minimize the time of operation of relays and at the same time, to avoid the mal-operation of relays.This paper presents continuous genetic algorithm (CGA) technique for optimum coordination of OCR in a ring fed distribution system. Constraints are incorporated in the fitness function making use of the penalty method.Computer programs(using MATLAB)have been developed for optimum coordination of OC relays using GA technique.*

Keywords *- DOCR- Directional Over-current Relay,GA- Genetic Algorithm, CGA-Continuous Genetic Algorithm, TDS-Time Dial Setting, TMS- Time Multiplier Setting*

I. INTRODUCTION

Power system Protection is the bough of the electrical power engineering. DOCRs are good technical and economic for the protection of interconnected sub-transmission system and secondary protection of the transmission systems.Relay co-ordination plays an important role in the protection of power system. “Relay co-ordination is characterised by the development of the techniques and programs that can coordinate the protective relays in a specific power system network” It is the art of co-ordinating relay for particular fault. Relay Co-ordination procedure is used for power system protection. Need of Relay coordination is the operation of the relay should be fast and selective. It should isolate the fault in the shortest possible time causing minimum disturbance to the system. Relay co-ordination can be done by selecting proper plug setting and time multiplication setting of the relay, considering maximum fault current at the relay location.[1,2,3]

The OCR coordination problem can be defined as the constrained optimization problem. In this paper Presented CGA techniques for the system. The objective is to minimize the operating time of relayand also depends on three sets of constraints, which are imposed due to bounds on relay operating time, coordination criteria and relay characteristics.GAs are defined as the Computerized search and optimization algorithm based on the mechanics of natural genetics and natural selection. Hence GA gives the global optimum solution. The CGA is inherently faster than the binary GA because the chromosomes do not have to be decoded. Also the CGA gives an advantage of requiring less storage than binary GA.

II. GENETIC PROBLEM FORMULATION

The coordination problem of DOCRs 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, is to be minimized.[2]

The objective function is:

$$\text{Min } z = \sum_{i=1}^{m} Wi.tik -----(1)$$

Where, m is the number of relays,
t_{ik} is the operating time of the relay Ri, for fault in zone k
W_i is weight assigned for operating time of the relay Ri.

In distribution system, the lines are short and approximately equal length, equal Weight (=1) assigned for the operating times of the relays.The objective of minimizing the total operating time of relays is to be achieved under three sets of constraints, as discussed in the below.

2.1.Constraint Set 1:Coordination Criteria

t_{ik} - t_{jk} $\geq$ Δt ---------- (2)

Where, t_{jk} is the operating time of the primary relay R_j , for fault at k;
t_{ik} is the operating time for the backup relay R_i, for the same fault (at k);
Δt is the coordination time interval (CTI).

2.2.Constraint Set 2:Bound on Relay Settings and Operating time

$ti, min \leq t_{ik} \leq$ ti,max$- - - - - - - -$ (3)

Where, ti, min is the minimum operating time of relay at i for fault at any point
ti, max is the maximum operating time of relay at i for fault at any point.

The bounds on time multiplier setting (TMS) of relays can be stated as

$TMSi, min \leq TMS_i \leq TMSi, max$-------------- (4)

Where, $TMSi, min$ is the minimum value of TMS of relay Ri
$TMSi, max$ is the maximum value of TMS of relay Ri;
$TMSi, min$ and $TMSi, max$ are taken as 0.025 and 1.2, respectively.
Since constraints (3) and (4) are correlated with each other, only one need to be considered.

2.3..Constraint Set 3:Relay Characteristics

Top= $\frac{\lambda(TMS)}{(PSM)^{\gamma}-1}$----------------- (5)

Where, top is relay operating time
PSM is plug setting multiplier
For Normal IDMT relay γ is 0.02 and λ is 0.14

As the pickup currents of the relays are predetermined from the system requirements, in Eq. (5) becomes

Top= a(TMS)---------------(6)

Where a= $\frac{\gamma}{(PSM)^{\gamma}-1}$------------------- (7)

Put (7) in (1) then Objective Function becomes

Min z=$\sum_{i=1}^{m} ai, k(TMS)i$------------(8)

Where, ai, k is constant of relay Ri for fault at k.

Therefore, the relay characteristic constraint are incorporated in the objective function itself and The values of ai, k for relay Ri for different fault locations (k) are predetermined for the Values of TMS for each relay is to be determined using continuous GA method.

III. CONTINUOUS GENETIC ALGORITHM

Genetic algorithm (GA) is a Search technique used in computing, to find the solutions to the optimization and search problems .Genetic algorithms are categorized as the global heuristics problems .Genetic algorithms are a particular class of Evolutionary algorithms (EA) that use techniques such as Reproduction, Mutation, Selection and crossover.Genetic Algorithm determines the optimal values of TMS and PS of relays and it is applied to minimize the operating time of relay.GA promises the global optimum point solutions to be reached.Genetic algorithm is becoming very much popular in engineering optimization problems for the wide range of search and capability of solving complex non-linear problems. In recent years, the heuristic optimization techniques have intense interest due to their flexibility, versatility and robustness in the global optimal solution .The GA method improves solution of the Converges and finding global optimal values problems. But the Results in reducing the operating time of the relay. In nature, the individual that has better survival traits will survive for a longer period of time.[7]

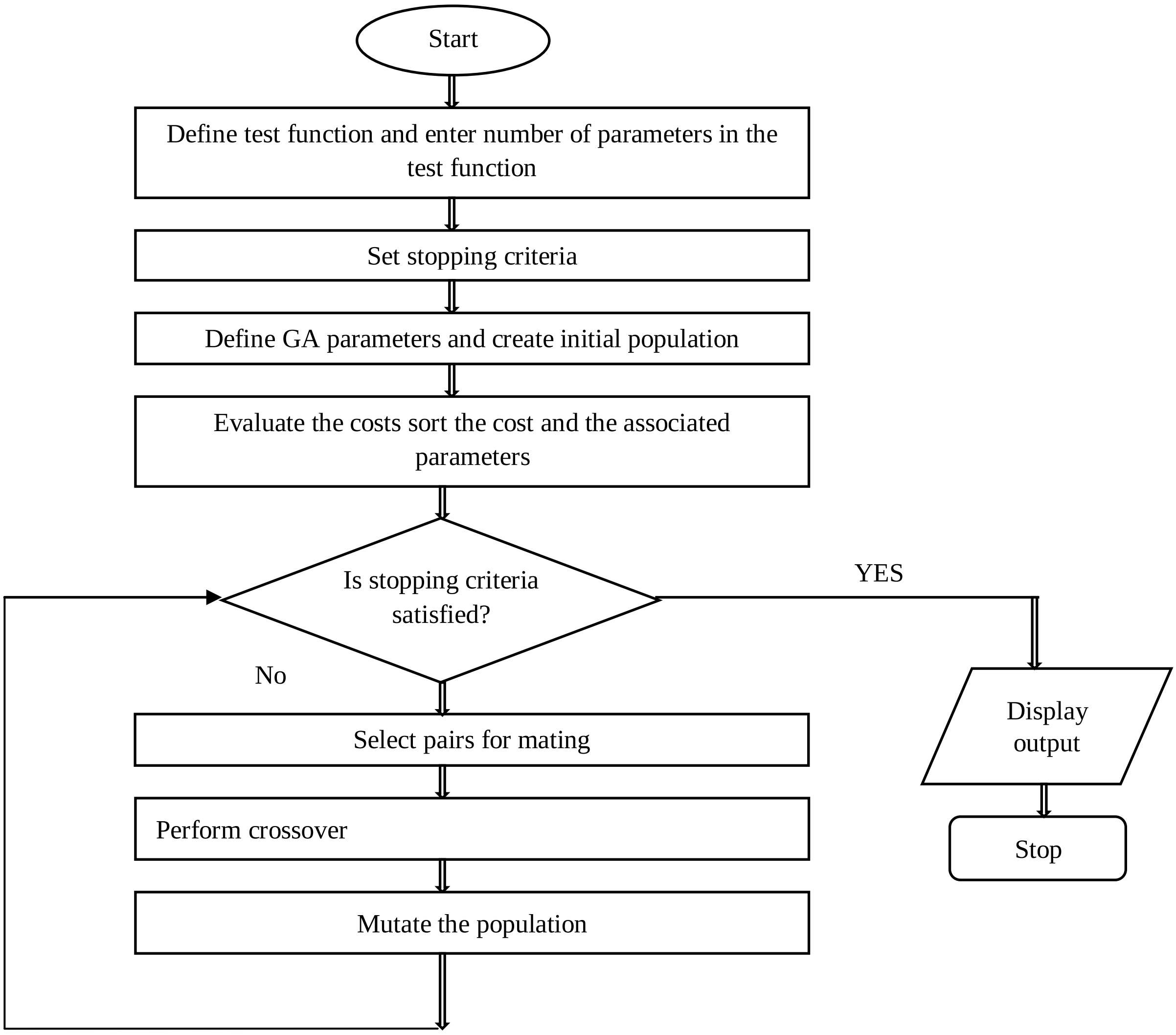

Fig1.FLOWCHART OF CONTINUOUS GENETIC ALGORITHM[2]

The basic genetic algorithm implemented in this work consists of the following steps:

Step-1 Define test function and enter number of parameters in test function.

Step-2 The initial population is generated randomly by keeping the value of each variable in the range specified by its lower and upper bounds andGenerate random binary chromosomes within their respective limits and convert the Binary to Decimal.

Step3 Evaluate Function and Find fitness of each chromosome $Fun_i = \frac{1}{1+k(\frac{Fi(x)}{Fmin}-1)}$.

Evaluate the costs and fitness of the chromosomes in descending order and rearrange them based on their fitness.

Step4 Is Stopping criteria not satisfied.

Step5 Pairs of parent chromosome made for mating.

Step6 Crossover and Mutation operation is done on parents chromosomes and children chromosomes are produced

Step7If stopping criterion is not violated then repeat steps 7 to 3.

Step8 For each new chromosome run and revaluates the function and Find fitness of each chromosome.

IV. IMPLIMENTATION OF PROPOSED METHOD

4.1. A Single-end-fed multi-loop distribution system

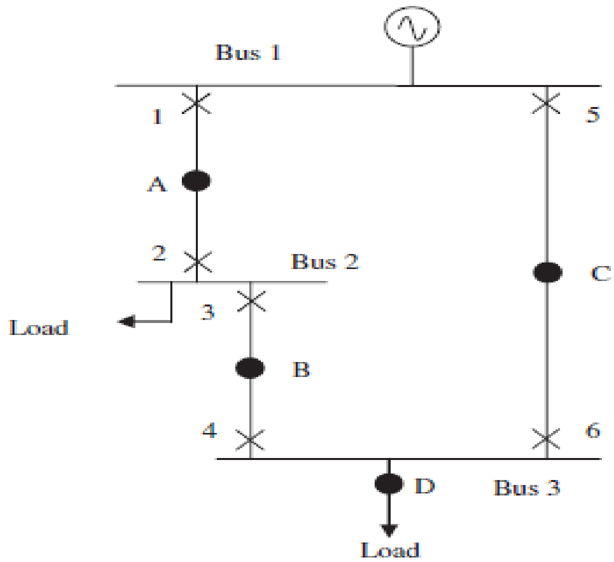

Fig2. Single-end-fed multi-loop distribution system

A single end fed, multi-loop distribution system, with six overcurrent relays in fig.2. was considered.The system is multi-loop system because depending on the fault point and different configurations (depending on the direction of current in various feeders) are formed.

A program was developed in MATLAB, for optimum coordination of OCR using CGA. The program was tested for various systems and was found to give satisfactory results in all the cases. In this system are presented here for the following CGA parameters were used:

Population size = 32
Crossover rate = 0.5 (50%)
Mutation rate = 0.1 (10%)
The minimum operating time of each relay is taken as 0.1 s.
The normal range of TMS is taken as 0.025 to 1.2.
The CTI is set to its typical value of 0.3 s.
TMS of the six relays are taken as x1–x6.
The lower limit of x1 was taken as 0.0274 and all other variables(x2 to x6) were taken as 0.025.
The upper limit of all variables was taken as 1.2.

Line	Impedance
1-2	0.08+j1
2-3	0.08+j1
1-3	0.16+j2

Table 4.1-Line data for system

Fault point	Primary relay	Back up relay
A	1	-
	2	4
B	3	1
	4	5
C	5	-
	6	3
D	3	1
	5	-

Table 4.2- Primary-backup relationship of relays

Relay	CT Ratio(A/A)	Plug setting
1	1000/1	1
2	300/1	1
3	1000/1	1
4	600/1	1
5	600/1	1
6	600/1	1

Table 4.3- CT Ratios and plug setting of relays

Fault point		Relay					
		1	2	3	4	5	6
A	I_{relay}	6.579	3.13	-	1.565	1.565	-
	a_i	3.6462	6.0651	-	15.5591	15.5591	-
B	I_{relay}	2.193	-	2.193	2.193	2.193	-
	a_i	8.8443	-	8.8443	8.8443	8.8443	-
C	I_{relay}	1.0965	-	1.0965	-	5.4825	1.8275
	a_i	75.9152	-	75.9152	-	4.0443	11.5397
D	I_{relay}	1.6447	-	1.6447	-	2.7412	-
	a_i	13.9988	-	13.9988	-	6.8720	

Table 4.4- Current seen the relays and the a_i constant

Min z = 102.4045x1 + 6.0651x2 + 98.7583x3 + 24.4034x4+ 35.3197x5 + 11.5397x6

The constraints due to minimum operating time of relays are

$3.6462x_1 \geq 0.1 \rightarrow x_1 \geq 0.0274$
$6.0551x_2 \geq 0.1 \rightarrow x_2 \geq 0.0165$
$8.8443x_3 \geq 0.1 \rightarrow x_3 \geq 0.0113$
$8.8443x_4 \geq 0.1 \rightarrow x_4 \geq 0.0113$
$4.0443x_5 \geq 0.1 \rightarrow x_5 \geq 0.0247$
$11.5397x_6 \geq 0.1 \rightarrow x_6 \geq 0.0087$

Minimum value of TMS

x1≥ 0.0274
$x_2 \geq 0.025$
$x_3 \geq 0.025$
$x_4 \geq 0.025$
$x_5 \geq 0.025$
$x_6 \geq 0.02$

The constraints due to coordination criteria are

15.5591x_4 - 6.0651x_2 ≥ 0.3
8.8443x_1 - 8.8443x_3 ≥ 0.3
8.8443x_5 - 8.8443x_4 ≥ 0.3
75.9152x_3 - 11.5397x_6 ≥ 0.3
13.9988x_1 - 13.9988x_3 ≥ 0.3

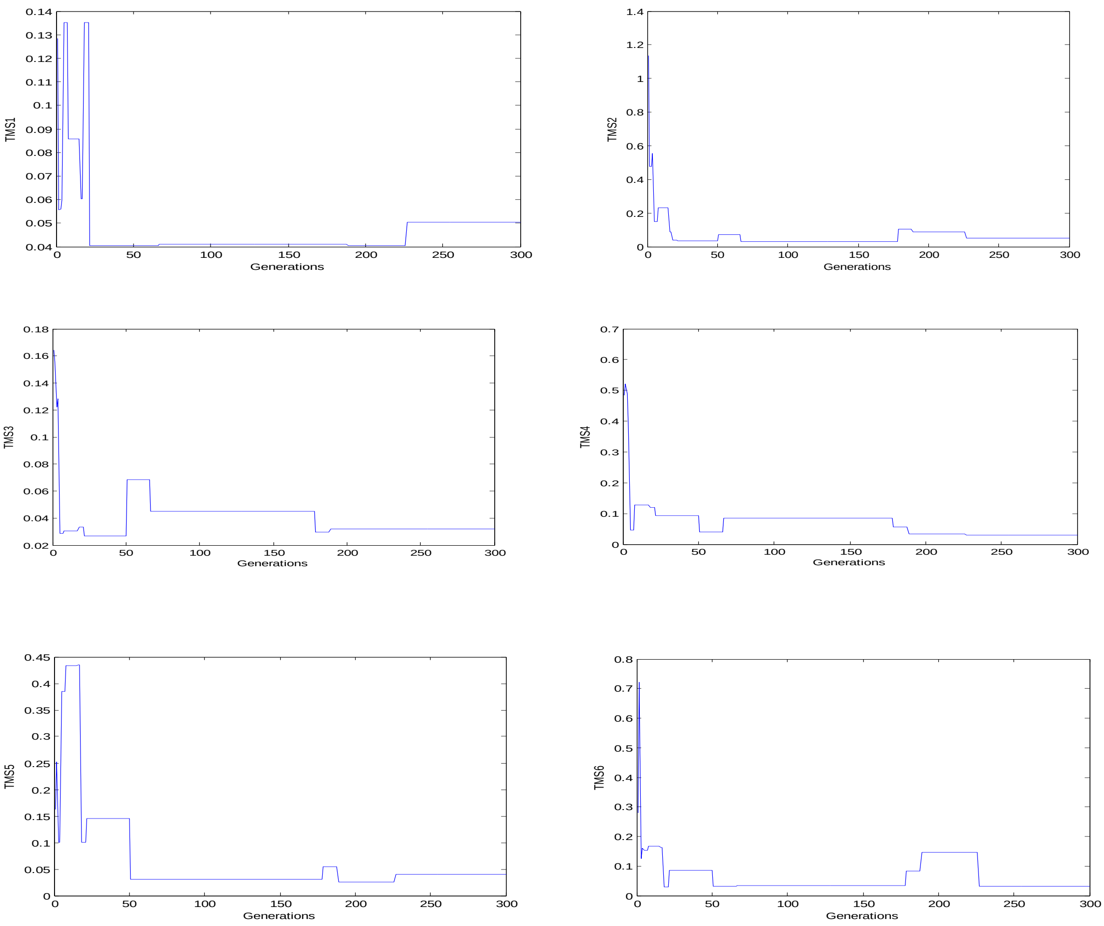

Fig3.Best values of TMS against generations of continuous GA

V. RESULT AND DISSCUSION

The relays will operate minimum possible time for fault at any point in the system and will also maintain the coordination.For applying CGA technique to this program, it was first converted into unconstrained optimization problem.The relay characteristic constraint was already incorporated in the objective function.

Using this Program, 300 iterations arePerformed. The optimum Values of TMS obtained are as under

TMS	Bhide et al	Proposed
TMS(1)	0.0765	0.0504
TMS(2)	0.034	0.0510
TMS(3)	0.0339	0.0318
TMS(4)	0.036	0.0288
TMS(5)	0.0711	0.0397
TMS(6)	0.0294	0.0321
Min(z)	15.11708	11.1583

VI. CONCLUSION

Continuous Genetic Algorithm (CGA) method for the optimal coordination of the overcurrent relays in the distribution system presented in this paper. In optimal relay co-ordination gives the constraints optimization problem and therefore, constraints optimization problems converted into the unconstraint optimization problems defining a new objective function (penalty method) and the bounds on TMS in which bounds on relay operating time as the limits of the variables.

The Programs has been developed in MATLAB for finding the optimal time coordination of the relays. The Continuous Genetic Algorithm (CGA) method has been tested for the various systems, including multi-loop systems and was found to give the satisfactory results in all the cases.

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