Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 04, April -2018

OVERCURRENT RELAY COORDINATION USING FIREFLY ALGORITHM IN ELECTRICAL DISTRIBUTION NETWORK

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Abstract - *The planning, design, and operation of a power system network requires repetitive calculations and comprehensive analyses to evaluate system performance and to establish the effectiveness of alternative plans for system extension. The computational work provided the ability to determine electrical parameter during normal and fault conditions and to study the transient behaviour of the system resulting from abnormal conditions and switching operations. The analysis most likely to be needed is power flow analysis, short circuit analysis, and relay coordination. These analysis are needed to ensure that the system will operate economically, safely and efficiently for a network over the period of time. In the power system network in this paper, the analysis mentioned above will be done and abnormal behaviour of electrical parameter, if any are marked. In relay protection coordination, conventional calculations are completed at all bus voltage level and results are compared with various established algorithm such as firefly algorithm. Relay coordination results, thus obtained are compared and best results are furnished.*

Keywords - *Power system, Relay coordination, short circuit, load flow, Optimal relay coordination, Firefly Algorithm, electrical parameter, electrical planning and operation, power system security, , constrained optimization problem, Plug setting Multiplier, Time Multiplier Setting(TMS).*

I. INTRODUCTION

In any power system network, protection should be designed such that protective relays isolate the faulted portion of the network at the earliest, to prevent equipment damage, injury to operators and to ensure minimum system disruption enabling continuity of service to healthy portion of the network. When relays meant to protect specific equipments, transmission/distribution lines/feeders or primary zone protective relays, do not operate and clear the fault in their primary protection zone, backup relays located in the backup zone, must operate to isolate the fault, after providing sufficient time discrimination for the operation of the primary zone relays.The protective relays must also be able to discriminate between faulted conditions, normal operating conditions and abnormal operating conditions and function only for the specific protection for which they are designed, without operating for any normal and short term acceptable abnormal events for which they are not intended to act and provide protection.

The term or phase relay coordination therefore covers the discrimination, selectivity and backup protection as explained in the foregoing discussion. Further the coordination is not confined only to relays and equipment operating characteristics, but also includes other protective device characteristics such as Fuse, MCB's, Circuit Breakers as applicable.

Relay coordination calculation module must consider the operating characteristics of the relays, normal operating and thermal or mechanical withstand characteristics of the equipments and must determine the optimum relay settings to achieve the objectives stated to protect the equipments and to ensure continuity of power supply to healthy part of network.

Apart from the fault or short circuit conditions, protection system must also be designed to provide protection against thermal-withstand limits, motor stalling, negative sequence current with-stand limits, protection against abnormal frequencies, and protection against unbalance operating conditions as applicable to various equipments and operating situations.

The selected protection principle affects the operating speed of the protection, which has a significant impact on the harm caused by short circuits. The faster the protection operates, the smaller the resulting hazards, damage and the thermal stress will be. Further, the duration of the voltage dip caused by the short circuit fault will be shorter, the faster the protection operates. Thus, the disadvantage to other parts of the network due to undervoltage will be reduced to a minimum. The fast operation of the protection also reduces post-fault load peaks which, in combination with the voltage dip, increase the risk of the disturbance spreading into healthy parts of the network. In transmission networks, any increase of the operation speed of the protection will allow the loading of the lines to be increased without increasing the risk of losing the network stability. Good and reliable selectivity of the protection is essential in order to limit the supply interruption to the smallest area possible and to give a clear indication of the faulted part of the network. This makes it

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possible to direct the corrective action to the faulty part of the network and the supply to be restored as rapidly as possible. Thus, attention must be paid to the operating speed of the protection, which can be affected by a proper selection of the applied protection principle.

Selective short-circuit protection can be achieved in different ways, such as: • Time-graded protection • Time- and current-graded protection.

To enhance reliability of the system as well as to avoid excessive damage to the consumers the operating time of relay should be optimal. Hence relay coordination problem can be considered as one of the major problem of optimization in the field of power system protection. As this problem is governed by constraints so it is considered as constrained optimization problem. With the modern digital relaying technology it is possible to set any fractional value of time dial setting (TDS) to achieve optimal time of operation for coordination of relays.

II. ELEMENT OF STUDY

The main purpose of this difficulty is to obtain minimum operating time to avoid equipment damage or flashover or blackout. In general the coordination of over current relays of a network can be considered as a problem of prime focus, where the normal algebraic sum of total relay operation time 'S' of the considered network is to be minimized.IEC standards define four characteristic time-current curve sets for inverse time relays: • Normal inverse • Long-time inverse • Very inverse • Extremely inverse For inverse time relays the operating time (s) can be calculated from the equation:

$t = \beta / ((I / I>)^{\alpha} - 1)$

where

k is an adjustable time multiplier,

I is the measured phase current value

I > is the set start (pickup) current value

α, β are curve set-related parameters

According to the standards, the relay should start once the energizing current exceeds 1.3 times the set start current when the normal, very or extremely inverse time characteristic is used. When the long-time inverse characteristic is used the relay should start when the energizing current exceeds 1.1 times the set start current.

The parameters α and β define the steepness of the time-current curves as follows:

Type of Characteristic	α	β
Normal Inverse	0.02	0.14
Very Inverse	1.0	13.5
Extremely Inverse	2.0	80
Long-Time Inverse	1.0	120

III. FIREFLY ALGORITHM

The primary purpose for a firefly's flash is to act as a signal system to attract other fireflies. Xin-She Yang formulated this firefly algorithm by assuming:

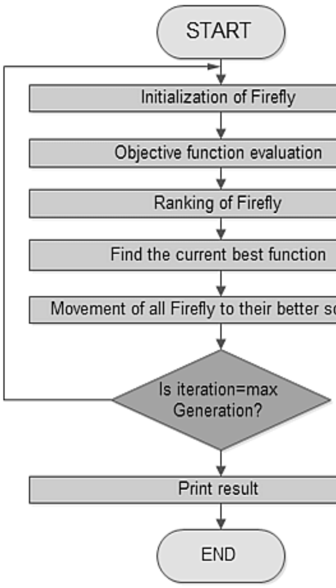
1. All fireflies are unisexual, so that any individual firefly will be attracted to all other fireflies;
2. Attractiveness is proportional to their brightness, and for any two fireflies, the less bright one will be attracted by (and thus move towards) the brighter one; however, the intensity (apparent brightness) decrease as their mutual distance increases;
3. If there are no fireflies brighter than a given firefly, it will move randomly.

The brightness should be associated with the objective function:

Firefly algorithm is nature inspired Meta heuristic algorithm developed by Xin She Yang in late 2007-2008 .This algorithm is same as particle swarm optimization and based on flashing behavior of fireflies. This is a kind of Swarm Intelligence algorithm and number of flies is mentioned in implementation part in an n-dimensional search space. This search space is governed by the number of relays connected in a network. This location of fireflies shows the possible solution to the optimization problem in a search space either local or global. The brightness is an index of fitness value of each firefly.

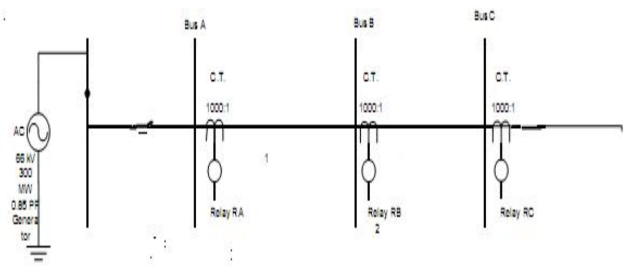
Each firefly attracts towards the relatively brighter one. And hence the idea of attraction is generated and it is a function of brightness. As brightness is also a dependent function on distance between two flies. Hence the attractiveness is a function of brightness as well as distance. The velocity of each firefly to move towards the brighter one depends on the attractiveness. As it is an iterative method the values of brightness and attractiveness is calculated and updated after every iteration. Depending on these updated values, the positions of the fireflies in a random space are going to be updated and at the predefined or sufficient number of iteration counts the fireflies

Note that the number of objective function evaluations per loop is one evaluation per firefly, even though the above pseudocode suggests it is n*n. (Based on Yang's matlab code.) Thus the total number of objective function evaluations is (number of generations) * (number of fireflies).



A firefly is specified by a vector in an n-dimensional space: $X_i = [X_{i1}, X_{i2} \ldots X_{in}]$
Where n denotes the dimension of search space The search space is bounded by constraints:
$Xk(min) \leq Xk \leq Xk(max)$
The initial population of fireflies is governed by the equation in which uniform distribution is observed:
$Xmk = Xk(min) + (Xk(max) - Xk(min))$* random
Where random is a random number between 0 and 1,taken from uniform distribution.
The attractiveness between the i^{th} and j^{th} firefly, þi,j, is given by
þ i,j = (þmax,i,j - þmin,i,j)exp($-7r^2_{i,j}$)+ þmin,i,j
Where $r_{i,j}$ is a Cartesian distance between i^{th} and j^{th} firefly.
If the light intensity of j^{th} firefly is more than the intensity of i^{th} firefly, then i^{th} firefly moves towards the brighter j^{th} firefly and its position at the k^{th} iteration is assured by the following equation:
$x_{i(k)} = x_{i(k-1)} + þ_i(x_{i(k-1)} - x_{j(k-1)}) + a(random-0.5)$
Where a is the random movement factor
Therefore the objective function can be written as:
$S = \min K^{i=1} \Sigma^n t_i$

$K = \frac{0.14}{(PSM)^{0.02} - 1}$



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3 Bus Radial System

Sl. No.	Fault Location	RA	RB	RC
1	Just Beyond A	1.451	-	-
2	Beyond B	1.537	1.537	-
3	Beyond C	1.560	1.560	1.560

Subject to coordination constraint,
1.560x2 -1.560 x3 > 0.3
1.560 x1 -1.560 x2 > 0.3
1.560 x1 -1.537 x2 > 0.3

And lower bound on the relay is decided by the minimum operating time of relay. (Considered 0.2s)
1.451 x1 > 0.2
1.537 x2 > 0.2
1.560 x3 > 0.2

The results obtained for the TMS is shown in Table I. The values are only for IDMT relay characteristics and for other relays we can find out using the same. The results for other characteristics are tabulated for the verification purpose that we can find out optimal setting for the same after references. The results are compared with conventional calculations.

IV. CONCLUSION

The Time of Operation for the relay coordination is found out using Firefly algorithm and the results are far better than the conventional one and near about optimal. The results using modified firefly Algorithm are better than normal firefly algorithm. We can further improve the result by modifying the constant or by changing constraint handling method. One can use this for further comparison with different techniques, for different constant values, for different constraint handling method and also for different relaying characteristics and configuration.

	Conventional Calculations			Firefly Algortihm			Modified Firefly Algortihm		
Relay characteristics	R_A	R_B	R_C	R_A	R_B	R_C	R_A	R_B	R_C
Normal Inverse	384 ms	980 ms	1.09 s	380 ms	975 ms	998 ms	381 ms	971 ms	996 ms
Very Inverse	381 ms	910 ms	985 ms	379 ms	890 ms	980 ms	375 ms	886 ms	979 ms
Extremely Inverse	376 ms	890ms	970 ms	375 ms	889 ms	960 ms	377 ms	884 ms	943 ms

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