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Optimal Study of Relay Coordination Techniques in Power System

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Abstract: - This paper shows a study of relay coordination technique used in power system. Relay coordination techniques provides a fast sensitivity and fault clearance time in transmission lines. In various studies optimal algorithm are used mostly to use control and stability in this technique. Relay coordination technique works efficiently in interconnected power system network. This new improved technique is very simple, optimal and efficient. There are many realistic techniques were used to provide efficient and fault proof network in transmission, & it is carried out due to this technique very effectively.
Keywords: - Relay Coordination, Over Current Relay, Power System, and Protection.

I. INTRODUCTION

Power system protection performs the function of fault detection and clearing as soon as possible, isolating whenever possible only the faulted component or a minimal set of components in any other case. Since the main protection system may fail (relay fault or breaker fault), protections should act as backup either in the same station or in the neighboring lines with time delay according to the selectivity requirement. The determination of the time delays of all backup relays is known as coordination of the protection system.

Coordination of protective relays is necessary to obtain selective tripping. The first rule of protective relaying is that the relay should trip for a fault in its zone. The second rule is that the relay should not trip for a fault outside its zone, except to back up a failed relay or circuit breaker. To coordinate this backup protection with the primary relay characteristic will ensure that the backup relay has sufficient time delay to allow the primary relay (and its breaker) to clear the fault. Directional over current relays are commonly used as an economical means for protecting power distribution and sub transmission power systems. They are also used as backup protection in transmission systems.

The selection of appropriate settings of these relays under various systems conditions plays an important role in timely disconnection of the faulty section of power systems. Over current (OC) relays normally have current setting multipliers ranging from 50 to 200% in steps of 25% which is referred to as plug setting (PS). PS for each relay is determined by two parameters: the minimum fault current and the maximum load current.

In the optimization method, some researchers used nonlinear programming for determining the optimal setting of pickup current and a linear programming for optimizing the time multiplier settings of the relays. Other researchers applied the linear programming technique only to minimize operating time while the pickup currents are selected based on experience.

Due to the complexity of nonlinear optimal programming techniques, the coordination of over current relays is commonly performed by linear programming techniques, including the simplex, two phase simplex and dual simplex methods. In these methods the current setting of the relays are assumed to be determined prior, and only find the time multiplier setting of the relays.

In this paper, an optimal coordination method for over current relays is proposed. The current setting and time multiplier setting of all relays are considered as optimization parameters and they are obtained simultaneously in an optimal manner. It is shown that lower protection operating time is achievable if the pickup current of the relays are determined in the optimization procedure.

Over current relays are the most widely used protection system relays to detect and isolate faults in power systems. There are two types of over current relays: 1) the instantaneous over current relays, operate instantaneously when the current reaches a predetermined value and 2) time delay relays which require that both the current and the time to exceed the setting values before the relay can operate. For time delay overcurrent relays, relay coordination involves setting the pickup current and time multiplier parameters. The most important parameter for the overcurrent relay coordination is the time multiplier which has a direct influence on the operating time of the relay.

II. RELAY COORDINATION TECHNIQUE

The power system considered in this research is the IEEE 24 Bus system. This system consists of two voltage levels, the 138 kV and

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the 230 kV. In this paper, the coordination of overcurrent relays is performed on the 230 kV voltage level. The 230 kV voltage level consists of 6 sets of machines, 14 buses and 20 lines. This algorithm applies the principles of survival of the fittest to search for optimal solutions. Solutions from one population are used to create a new population through genetic operators such as selection, crossover and mutation. Initially, the trial solutions are generated randomly. In every generation, a new set of trial solutions is created through the evolutionary process of selection, crossover and mutation. A new population is created by combining the information of the two parent solutions.

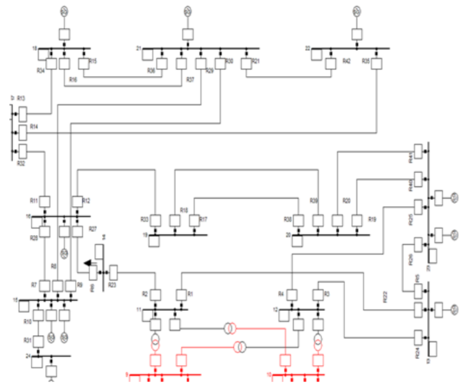

Fig. 1 – IEEE 24 Bus System

Over-current relay generally include an instantaneous unit and inverse time equipment. The inverse time operation characteristic can be provided in terms of a family of curves depending on a parameter usually referred as the time multiplier setting.

The mathematical modelization of this family of curves can be performed using multiple regression techniques in order to obtain an expression giving the operating time in function of time multiplier and the current flowing through the relay.

The aim of crossover function is to produce new solutions from two parent solutions in order for the algorithm to search through the solution space. In this paper, a combination of single point crossover and extrapolation was used. To prevent premature convergence, diversity is introduced into the population by using mutation operator.

There are various methods of implementing mutation; these include uniform mutation, non-uniform mutation, multi-non-uniform mutation, etc.

In general, overcurrent relays respond to a characteristic function of the type,

$T = f(TMS, I_p, I)$ (1)

where T is the operation time, TMS is time multiplier setting, I_p is the pickup current and I is the current flowing through the relay. Under simplistic assumption, the above equation can be approximated by the following equation:

$31\ (I / I)\ 2\ K\ T\ K\ TMS\ Kp$

Where: $K1$, $K2$ and $K3$, are constants that depend upon the specific device being considered. A more precise formula for approximating the relay characteristics is as follows:

$T = P(TMS)P(I_p)$ (3)

Where: $P(TMS) = K10 + K11TMS + K12TMS + K\ TMS$

M is the ratio of relay current (I) to the pickup current (I_p) and $K10$, $K11$, $K12$, $K13$, $A0$, $A1$, $A2$, $A3$, and $A4$ are scalar quantities which characterize the particular device being simulated.

The operating time of the backup relay must be greater than the sum of the operating time of its primary relay and the coordination margin. This can be expressed as:

$Tji \geq Tii$ + CTI

where *Tji* is the operating time of the backup relay *Rj* for the same near-end fault at *i*, and *CTI* is the coordination time interval. There are many pair of primary/backup relays for a given fault. The relation between the operation time *T* of the time overcurrent unit, and the
pickup current *Ip*, and time multiplier setting is a nonlinear function. As a consequence, in general this problem is a nonlinear optimization problem, but if the pickup current are determined prior and considering the relay characteristic, the objective function can be represented by a linear function of TMS and can be solved by linear programming methods.

The general relay coordination problem can be stated as a parametric optimization problem. The objective function of operating time of the primary relays is minimized subject to keeping the operation of the backup relays coordinated.

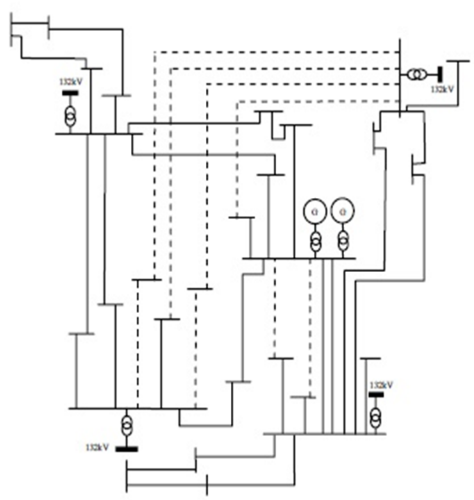

Fig. 2 – Single Line Diagram of Proposed network

III. SIMULATION RESULTS

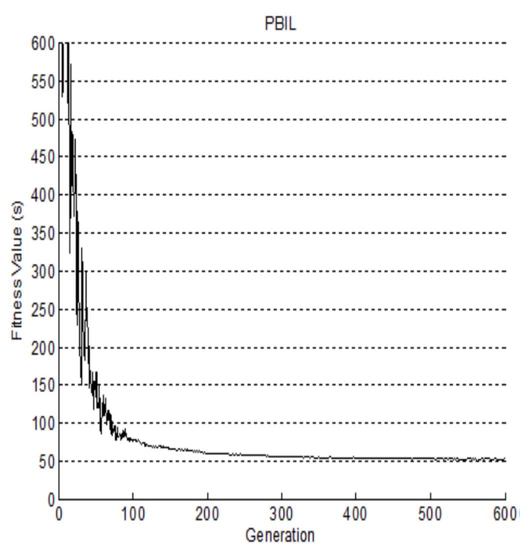

Fig. 3 – Result for initialize network

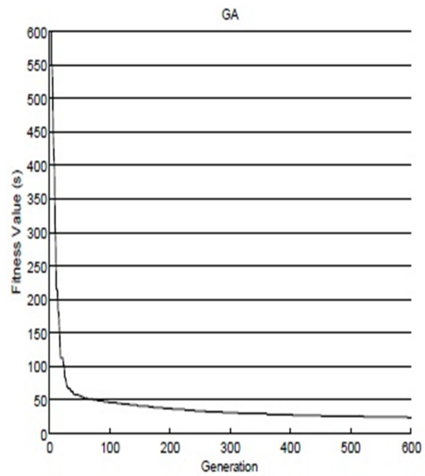

Fig. 4 – Result for finalized network

IV. CONCLUSION

In this paper, an optimization methodology is presented to solve the problem of coordinating directional overcurrent relays in an interconnected power system. Most of the previous algorithms, supposed that the current settings of relays are known prior and try to find the time multiplier setting of the relays. In this paper, the current setting and time multiplier setting of all relays were considered as optimization parameters and were obtained utilizing a non-linear optimization.

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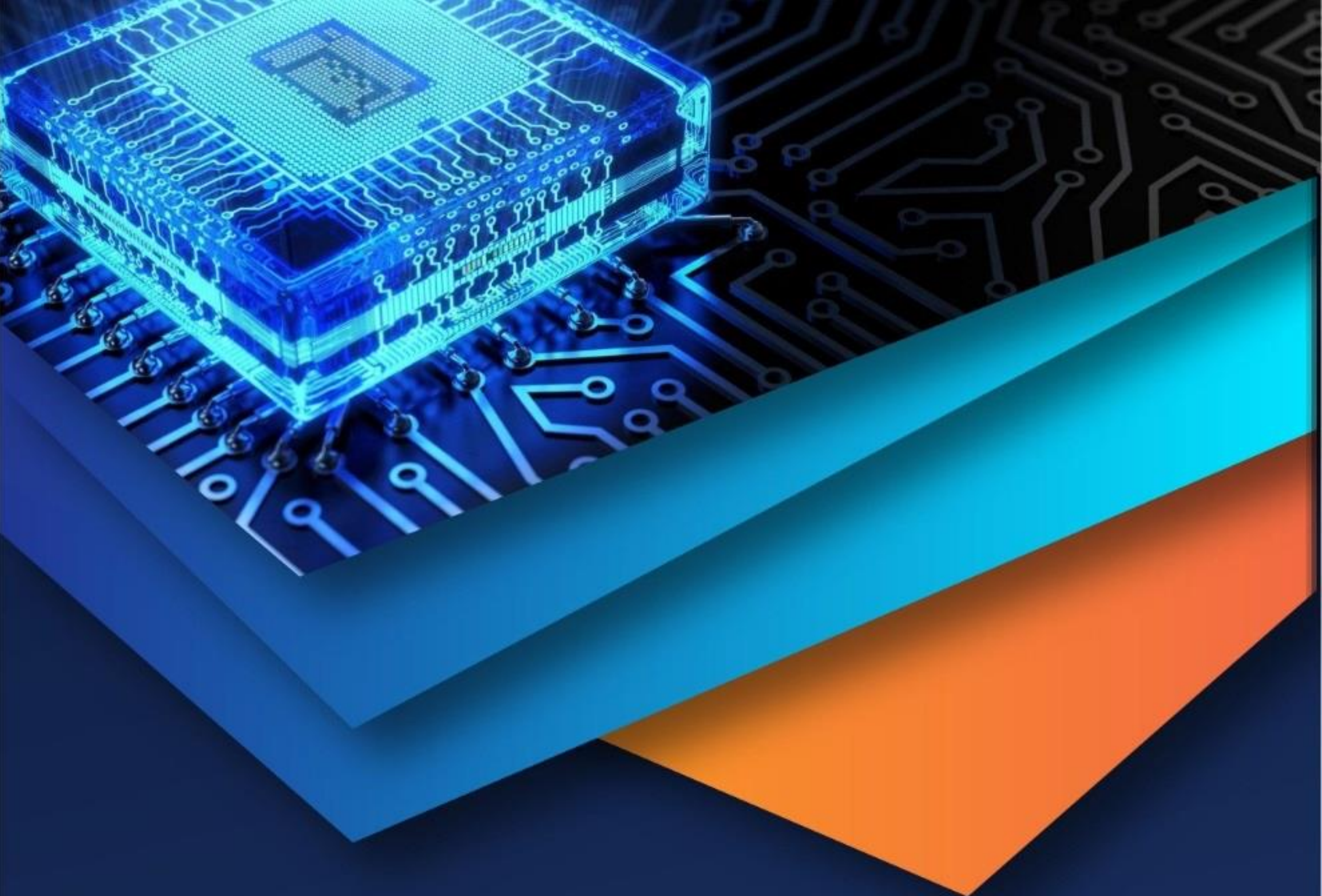

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