# Literature review on Relay coordination using software techniques

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***Abstract*— In this paper, I presented different techniques for relay coordination using software techniques. Now days, the demand of electricity is increasing. So, the network of electricity from generation to distribution is very large. The network of state electricity boards typically have 10 to 15 or more buses, 40 to 50 transmission lines and 80 to 100 overcurrent relays. The exercise of load flow analysis, fault level calculations and listing the primary backup pairs will be very tedious. The exercise is very difficult because one has to consider line contingencies and relay setting are to be decide based on the worst case. Also several iteration would be required to calculate TMS of relays so that minimum discrimination margin as required is found between relay and its backup relays. This is only by using some computer programming. In this paper, shows the some algorithm techniques and also discuss the advantages of latest software ETAP.**

## I. INTRODUCTION

In last few years, so many techniques are developed in field of relay coordination. The importance of coordination of different protective device is increasing now days. A power system consists of many number of equipment. So more number of circuit breakers and relays are required to protect the system. A relay must get sufficient chance to protect the zone under its primary protection. Only if the primary protection does not clear the fault, the back-up protection should initiate tripping, and therefore, overcurrent relay coordination in power distribution network is a major concern of protection engineer. The relay coordination in distribution network is highly constrained optimization problem.

The demand for electrical power generally increases at a faster rate in economically emerging countries. So it is necessary to install of transmission lines reaching out all the areas of country. Further, the efficiency of transmission should be high when a large bulk of power is to be transmitted over very long distance. It requires extra high voltage ac and HVDC transmission lines to be erected. The voltage of transmission nowadays has reached 765 KV ac and still higher voltages of transmission are planned. These transmission lines are required to be protected by comprehensive and quite involved protective schemes so that the power interruption are reduced to minimum with regard the times of interruption and the area are affected.

The protective scheme must operate fast and selectively before the power system become unstable. It is the usual practice to protect feeders of 11 KV and transmission lines of 66 KV by over current and earth fault relays as primary (main) protection. Transmission lines of 132 KV and 220 KV are protected by distance relay as primary protection, and earth fault relay as secondary or back up protection. Lines of 400 KV and beyond use complicated distance relay like quadrilateral relays. The role of over current and earth fault relays as back up still exists at 132 KV and higher transmission voltage levels [3].

So, we know, how much important of the correct relay coordination to avoid mal operation. In this paper, I have presented the different techniques for relay coordination of IEEE research papers in section 2. Also I include features of the latest software of ETAP and how easier to implement the relay coordination in this software in section 3. And at the last I have given conclusion of different techniques for relay coordination.

## II. DIFFERENT TECHNIQUES FOR RELAY CO-ORDINATION:

I have presented the different techniques for coordination of different protective device and also I mention the advantages and lacks of research papers. All the methods are based on the simulation program and algorithm.

### *A. A parallel processing algorithm for co-ordination of directional overcurrent relays in interconnected power systems:*

The problem of co-ordinating the setting of directional overcurrent relays in an interconnected power system is considered. The power system is decomposed into subsystems to give a constraint matrix of a diagonal structure with linking variables. Each subsystem is solved using the sparse dual revised simplex algorithm of linear programming. Benders algorithm for linear programming may be used to co-ordinate the solution from each subsystem and the master system. The authors propose a new parallel processing algorithm for this co-ordination procedure which depends on

the interaction balance principle of linear programming. This algorithm has been applied to various size systems and the results compared with those obtained using a conventional linear programming algorithm and Benders algorithm. It is shown that the proposed algorithm is more computationally efficient than previous methods.

Advance research in multiprocessors and the availability of high speed inter processor communications encourage the consideration of parallel processing algorithms for power system analysis. A parallel processing algorithm technique has also been applied for power system protection and introduce the new approach for adaptive transmission line protection and developed a fast techniques for computing relay setting in real time using either multiprocessing or supercomputing approaches. He defined the term 'adaptive protection' as the ability of the protection system to automatically alter its operating parameters in response to changing network conditions to maintain optimal performance. By optimal performance he means the best relay settings which result in the fastest relay operation, while satisfying established coordination criteria.

Advantages of this system: The application of such algorithms has a number of advantages which are particularly important in online applications.

- Low overall solution time
- Full utilisation of subsystem computers
- Low storage requirement
- Low inter processor data traffic
- A adaptive processing system

This work shows how the power system can be decomposed into subsystems giving a constraint matrix of diagonal structure with linking variables and describes the proposed mathematical model of overcurrent relays. A parallel processing algorithm for co-ordinating the directional overcurrent relays in interconnected power systems is suggested and the available multiprocessor organisation is described [2].

### *B. Coordination of Overcurrent Relays in Distribution System using Linear Programming Technique:*

The overcurrent relay coordination in ring fed distribution networks is a highly constrained optimization problem. The purpose is to find an optimum relay setting to minimize the time of interruption of the power supply and to avoid the mal-operation of relays. This paper discusses linear programming technique for optimum coordination of overcurrent relays in a ring fed distribution system.

In a system where there is a source at more than one of the line terminals, fault and load current can flow in either direction. Relays protecting the lines are, therefore, subject to fault currents flowing in both the directions. If non directional OC relays were used in such system, they would have to be coordinated with, not only the relays at the remote end of the line, but also with relays behind them. Since directional relays operate only when the fault current flows in the specified tripping direction, they avoid coordination with the relays behind them. The directional OC relay coordination problem in distribution system can be defined as linear programming problem with constraints and can be solved using one of the linear programming techniques, namely, simplex, dual simplex or two phase simplex technique. The overcurrent relay coordination in ring fed distribution networks is a highly constrained optimization problem. As the pickup currents of the relays are pre-determined from the system requirements, the optimization can be treated as linear program problem.

In this paper simplex method is presented to solve the optimization problem. Two sample systems are considered for illustration. It is shown that simplex method provides an efficient tool to solve the coordination problem of directional overcurrent relays in ring fed distribution system [1].

### *C. NEW APPROACH TO COORDINATION OF DISTANCE RELAY ZONE - 2 WITH OVER CURRENT PROTECTION USING LINEAR PROGRAMMING METHODS:*

This method presents a new approach for the coordination of distance zone-2 and overcurrent relays by using linear programming methods. For this purpose, a topologic analysis is first carried out to identify the set of primary and back-up relays. The coordination constraints are then used in the linear programming methods, where for the zone-2 operating time is set independently for each distance relay and the results are compared with the case where all the zone-2 time settings are the same. Three linear programming methods are studied for solving the problem. The methods are tested for a typical interconnected network and the results are presented and compared.

Back-up operation is necessary since the main protection may fail. Back-up protection is provided in either the same substation or an upstream substation with a time delay according to the selectivity requirement of protection system. The time delays determination of all back-up relays is known as coordination of protection system. In transmission networks, it is a usual practice to use overcurrent relays as back-up for distance protection. Knowing that the distance relay zone-2 itself could act as primary protection for its line and as back-up for the following line, its coordination with overcurrent protection could be an optimization problem with the objective of minimizing the total protection time.

Traditionally, the protection engineer used to spend most of his time on performing calculations and manipulating graphics in order to coordinate a set of relays according to some technical constraints. The problem was arrived in large interconnected transmission networks

In recent years, new methods have been proposed for protective relays coordination using optimization techniques. Some work has been reported in the literature using linear programming methods for this purpose.

This paper proposes a new approach for the time setting coordination of distance relays zone-2 and overcurrent relays,

In the proposed method, distance and overcurrent relays setting are coordinated and optimized. In this context, the coordination problem is solved for two cases. In the first case, the time setting of zone-2 for all distance relays is considered the same, whereas in the second case this could be different for each relay.

If the overcurrent relay characteristic model is linear with respect to TMS, as this is the case in modern numerical relays, then linear programming for optimal coordination of distance relays zone-2 and overcurrent relays is applicable. Three linear programming methods have been studied in this technique for finding the optimum time setting of distance relays zone-2, while maintaining the overall overcurrent protection time settings as low as possible. Two cases of fixed time settings and different time settings for zone-2 of distance relays are considered in this study. According to the test results of the linear programming solving methods, the "path following method' is the best solution in both cases.

Independent settings of distance relay zone-2 reduces overall overcurrent relays time settings appropriately. Distance relay zone-2 setting of 0.4 seconds is not a good setting, especially in independent zone-2 settings [4].

### *D. Directional relay co-ordination in ungrounded MV radial distribution networks using a RTDS:*

In this research method, the result of relay co-ordination study of an existing ungrounded medium voltage (MV) network is presented. For this study, Real Time Digital Simulator (RTDS) which is part of closed loop relay test system is used. The relay is Siemens electronic directional over current relay with ground- fault element. Amplifiers are applied in order to supply the relay with its nominal secondary current and voltages. Furthermore, sequence-component have been used for the calculation of the protection building zone inside the feeder cable during single phase to ground faults. As a result, a maximum allowable network capacitance to ground is calculated, for which all ground faults can be detected and interrupted.

RTDS technology originated in the mid 19996's as there was a fast growing need for fast power system simulation studies. RTDS is extensively used now days in closed loop protective relay testing and system studies for which for which real time operation is required.

This method shows the relay co-ordination for the protection against single phase to ground faults of parallel feeder cables in a MV ungrounded distribution network. The protection method relies on over current and directional protection by making use of zero sequence quantities of the voltages and currents. Boundary limits are presented by generalizing the fault current calculation for several values of the MV network and cables capacitances. In this method, describe a simplified network model simulated in both MATLAB and RTDS. Further, present the basic operation of unidirectional and directional relays as it is used in practice in closed loop operation. Minimum relay settings are calculated and introduce the current margin factor. Simulate result for both, RTDS and MATLAB are presented. The presence of death zone (DZ) is calculated [5].

Advantages:

- RTDS can be used with full success for protection studies because relays can be interact with the circuit.
- This method gives guaranty to success coordination in radial cable network.
- It can be applied for parallel feeder protection against single phase to ground fault.

Limitation:

- This method can be applied only for two parallel cables.
- All phase to ground fault in the MV network should be switched off selectively.
- For limited range of network capacitance is assumed equal to 0.86.
- It is question of DZ situation occurs in practice.
- Amplifiers are needed for correct amplification of voltage and current signal.

## III. Simulation of power system in latest software ''ETAP'' & features of ETAP

Power System study and analyses are important parts of power system engineering. For the last few years electrical engineers have been focusing on the power system studies using software tools. Recent advances in engineering sciences have brought a revolution in the field of electrical engineering after the development of powerful computer based software. This research work highlights the effective use of Electrical Transient analyzer Program (ETAP) software for analyses and monitoring of large electrical power system which comprises of large power distribution network.

For many years electrical engineers have relied on the power (but not necessarily the convenience) of mainframe computers to analysed and design power systems. Recent advances in microcomputers have brought the power of mainframe computing to the desktop, paving the way for straight-forward, easy to use Engineering applications which are designed especially for the personal computer. System studies are an integral part of power system engineering and design. A structured computer program that uses technically correct models, employs a user-friendly interface, uses a common data base, and traps user errors is a powerful tool which greatly enhances the engineer's efficiency and productivity. ETAP is an engineering design and analysis program which satisfies these criteria. In addition, ETAP performs numerical calculations with tremendous speed, automatically applies industry accepted standards, and provides easy to follow output reports [6, 7].

ETAP includes the following programs:

- One Line Diagram
- Load Flow

- Short Circuit
- Dynamic Stability
- Motor Acceleration
- Motor Starting
- Cable Derating
- Cable Pulling
- Ground Grid Design
- Induction Machine Parameter Estimation
- Induction Machine Torque/Slip Curve
- Load Schedule

Features of ETAP:

▸ ETAP is a map interface applied software, it can be used for designing power plant, substations, there are generators, Transformers, cable lines and motors model libraries in it, the IEC standard is used to make off-line simulation, besides, ETAP software can also operate on line to achieve high-level Monitoring, on-line simulation, optimization, energy Management system and high-speed intelligent throwing loads and so on.

▸ ETAP capable of handling 1000 buses contains a load schedule program which tracks up to 10,000,000 load items, and reports the voltage and short-circuits current at the terminals of each load item. This capability makes ETAP suitable for large industrial facilities, as well as utility systems.

▸ System studies are an integral part of power System engineering and design. A structured Computer program that uses technically correct Models, employs a user-friendly interface, uses a common data base, and traps user errors is a powerful tool which greatly enhances the engineer's efficiency and productivity. ETAP is an engineering design and analysis program which satisfies these criteria. In addition, ETAP performs numerical calculations with tremendous speed, automatically applies industry accepted standards, and provides easy to follow output reports.

▸ A complete system analysis includes load flow, short circuit, and transient stability studies. Because of the unique data sharing capability of ETAP's programs, the data for an entire system needs to be entered only once with three user-friendly editors (Bus, Branch, and Machine). By not having to continually enter data, the user is free to concentrate his attention on analytical tasks, rather than bookkeeping. Errors in data input are thus reduced and more meaningful study results are obtained.

## IV. Conclusion

In this paper, the different methods are presented for relay coordination. The RTDS method is limited and useful only for two parallel feeders. Many other limitations are involved in this method. In parallel processing algorithm, algorithms have been developed for relay coordination with accurate parameters. In the linear programming method, simplex and duplex algorithms have been developed and also this method not gives surety for accurate result.

ETAP has many advance features than the others method. ETAP performs numerical calculations with tremendous speed, automatically applies industry accepted standards. ETAP capable of handling 1000 buses contains a load schedule program which tracks up to 10,000,000 load items.

Engineers depend on continual development of software to keep in step with fast-paced technological advancement. ETAP's designers are professional electrical engineers who are dedicated to researching and implementing new methods as well as developing new applications which will enhance the productivity and capability of ETAP users. Today's electrical engineer is limited only by the software available to him. ETAP is a technically accurate, user-friendly software package designed with the working engineer in mind. From the common data base input editors, to the clearly structured output reports, ETAP has pushed forward the frontier of desktop power system analysis software.

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