OVER-CURRENT RELAY AND CIRCUIT BREAKER DESIGNING AND TESTING

Pritam V. Warbhe[1], Soniya K. Malode [2]

[1] *PG Scholar, Electrical Engineering Department, Shri Sai College of Engg & Tech, Bhadravati, Maharashtra, India*
[2] *Assistant Professor, Electrical Engineering Department, Shri Sai College of Engg & Tech, Bhadravati, Maharashtra, India*

ABSTRACT

Circuit breaker and relays are being utilized for secure, reliable and convenient operation of power system. The over current protection relay is widely used in the power system for protection of short circuit or wrong setting of system to the pre-specified value. Erroneous setting of over current relay in the power system it is difficult to send the trip signal. So it is connected carefully in the power system. Therefore it is important to accredit the setting of power protection equipment.

This paper represents the modeling of over current relay using available different techniques and simulation software's. The over current relay has the types of instantaneous, definite time, inverse time and inverse definite minimum time (IDMT) according to the time characteristics. This paper most important feature is the comparison of times between ideal & calculated results of over current relay. To make the protection system for transmission line by introducing different future techniques for the circuit breaker and over current relay designing, implementation and testing. To proper transmit the electric power from sending end to receiving end without suffering from any difficulty and dangerous condition. Implementation of over current relay and testing of circuit breaker & over current relay are present using different simulation software's and techniques.

Keyword: - *Overcurrent relay, circuit breaker.*

1. INTRODUCTION

With the growing demand of electric power, the distribution is increasing year by year and therefore maintenance of power system / power system equipment is very important for decreasing of cost and maintenance of power distribution for most reliable of the power system or power system equipment. Protection of power system is very important for different fault of over current, over voltage, and over load. We are used protection scheme for the protection of the short circuit and failure of equipment. It may be very dangerous condition for the operation of any power system equipment, electronic devices or circuits, generation, distribution and power transmission. So we are used the two main component or devices in power system protection, i.e. Circuit breaker and relays. These devices give safe operation or handling of any mechanical equipment like generator, motor, and transformer etc. for the short circuits. When the short circuit event occurs in a distribution feeder then the light loads such as computers and electronic equipment will be affected in few seconds. So power system protection of fault is very important [1-3].

All electrical machines, operation and other forms of electrical equipment's must satisfy two main requirements i.e. they must be able to operate continuously under normal condition and must be able to resist short- time over currents and over voltages. For operation of electrical machines and other apparatus with full reliability in normal operating condition, the two requirements should be fulfilled and they are [4]

(1) Rated current ≥ Actual load current

(2) Rated voltage ≥ operating voltage of the equipment.

Circuit breaker is a mechanical device which consists of two functions according to the normal and abnormal condition they are open contacts for the faulty or abnormal condition and closed contacts for the normal or healthy condition. Circuit breaker is automatically operating device by the relays, when the relay coil will energized then a

trip signal send to the circuit breaker. And circuit breaker contacts are open and safe the operating equipments such as motor, generator and transformer and also light loads electronics equipment or devices.
Circuit breaker carries the full load current continuously without overheating or damage, it opens and closes the circuit on no load, it makes and breaks the normal operating current and circuit breaker makes and breaks the short circuit currents of magnitude to the specified value [5].
Relay is a sensing device which sense of short circuit and faulty condition. When fault occurs in system then the high current flowing in the circuit and relay coil get energized and one trip signal is send to the circuit breaker which opens the circuit breaker contacts and protect the circuit by isolating the faulty section. Relay input current and voltage takes to the current transformer (CTs) and potential transformer (PTs) respectively. The amplitude and phase relation depends on the conditions of the system for a predefined value gives by the manufacturer or designer [6].

2. DIFFERENT TECHNIQUES FOR DESIGN AND TESING OF OVERCURRENT RELAY

A successive linear programming methodology is presented to treat more effectively those applications where a local structure change is performed to a system already in operation, and where the modification of the settings of already existent relays is not desirable. The dimension of the optimization problems to be solved is substantially reduced, and a sequence of small linear programming problems is stated and solved in terms of the time dial settings, until a feasible solution is reached. With the proposed technique, the number of relays of the original system to be reset is reduced substantially. It is found that there is a tradeoff between the number of relays to be reset and the optimality of the settings of the relays.

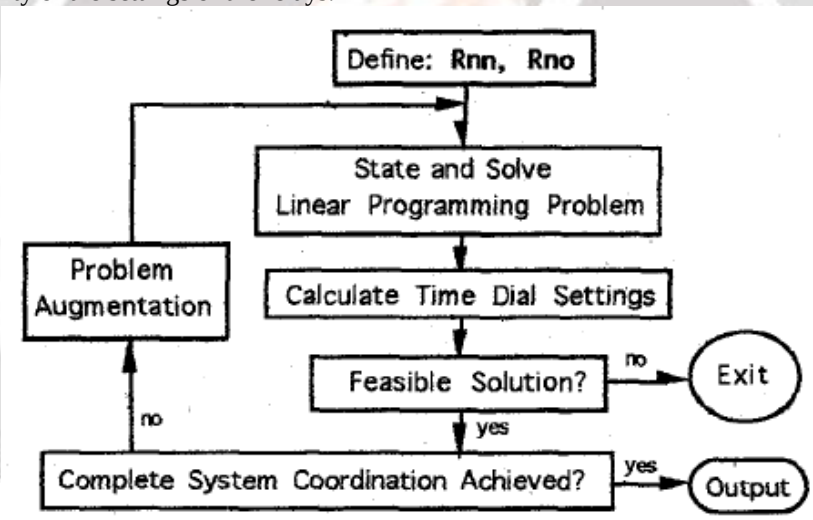

Fig.1:- Overcurrent relay using linear programming [1].

A methodology is presented for the consideration of definite time backup relays in the optimal coordination of directional overcurrent relays using linear programming. It is shown that the influence of considering second-zone distance relays and breaker failure relays impose important requirements for the determination of the time dial settings of directional overcurrent relays. Author introduces a revised formulation [2] of the optimization problem. Results are presented for the application of the methodology on a power system with 2 generators, 9 buses, 2 transformers and 7 transmission lines.

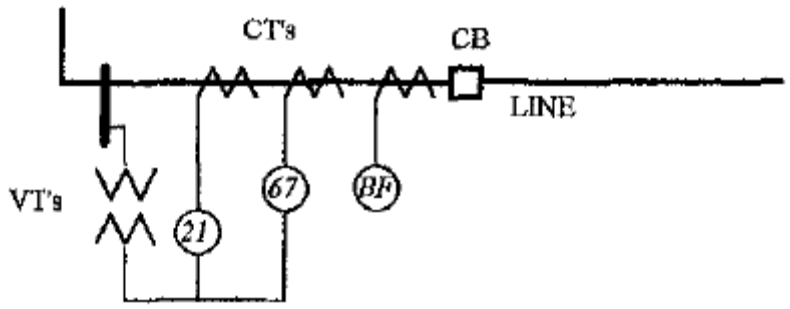

Fig.2:- Line protection scheme using distance relays (21), directional overcurrent relays (67) and breaker failure relays (BF) [2].

A multi-layer Feed-Forward Neural Network (FFNN) trained with the error back propagation algorithm has been developed to realize overcurrent relay [3]. The ANN based algorithm is off line tested using different simulation equations for overcurrent and voltage under fault conditions to evaluate the performance of the proposed method in terms of accuracy and speed. The proposed ANN based directional overcurrent relay shows promising dependability, security and speed of operation.

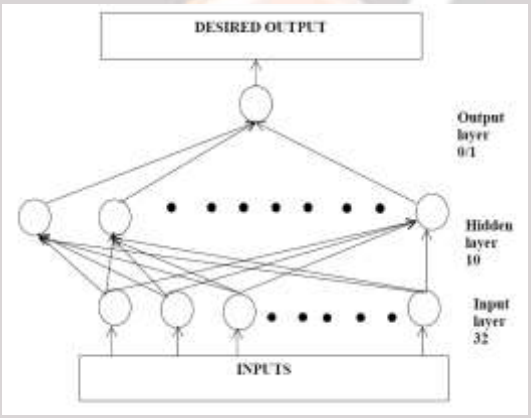

Fig.3:- ANN architecture for overcurrent relay implementation [3].

MATLAB is used to implement programs [4] of digital distance relaying algorithms and to serve as main software environment. The technique is an interactive simulation environment for relaying algorithm design and evaluation. The basic principles of a digital distance relay and some related filtering techniques are also described in this paper. A 345 kV, 100 km transmission line and a MHO type distance relay are selected as examples for fault simulation and relay testing. Some simulation results are given.

The Real Time Digital Simulator (RTDS) is a tool for the design, development, and testing of power system protection and control schemes. RTDS can be used for the investigation, development, and integration of new and complex power system components. The user is able to study both the device itself and the response of the existing power system to its operation (or mis-operation).

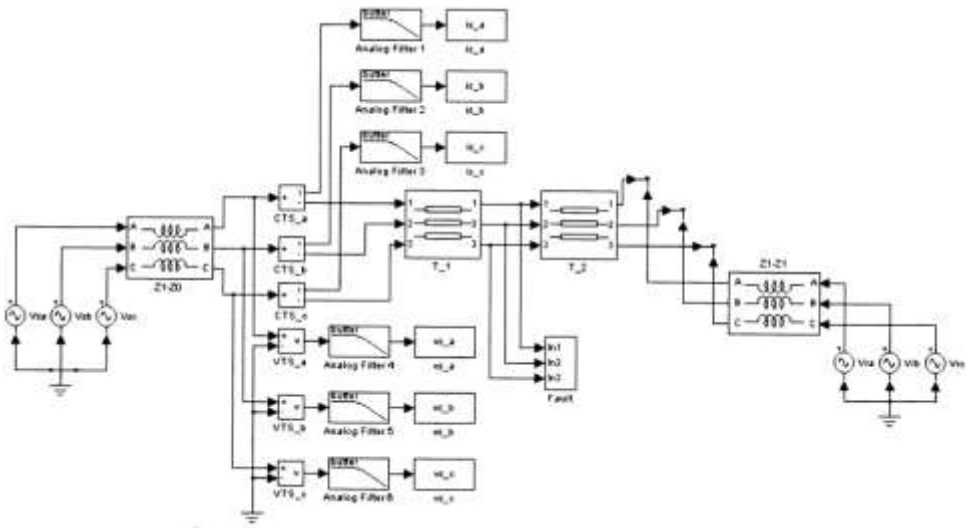

Fig.4:- MATLAB simulation model for MHO distance relay.

The Hardware in the Loop (HIL) test provides an opportunity for understanding the behavior and validating the model of physical device. In the HIL simulation, parts or components of the virtual power system are replaced with physical devices. In the Software in the Loop (SIL) simulation, the software model replaces the physical protective device. Author present modeling and testing of a Schweitzer Engineering Laboratories (SEL) 351S protective overcurrent relay [5] using RTDS. HIL tests conducted with the physical SEL 351S overcurrent relay for an eight-bus power system. Development of a software relay model in RSCAD and real time SIL simulation.

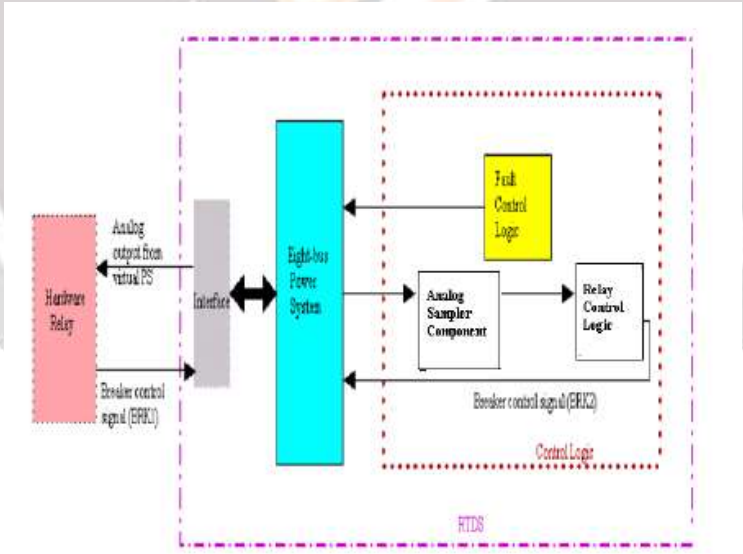

Fig.5:- HIL test block diagram [5].

Differential evolution is a novel evolutionary approach capable of handling non-differentiable, nonlinear and multimodal objective functions. It has been consistently ranked as one of the best search algorithm for solving global optimization problems in several case studies. Author propose five new mutation schemes for the basic DE algorithm [6]. The corresponding versions are termed as MDE1, MDE2, MDE3, MDE4 and MDE5. These new schemes make use of the absolute weighted difference between the two points and instead of using a fixed scaling factor F, use a scaling factor following the Laplace distribution. The performance of the proposed schemes is validated empirically on a suit of ten benchmark problems having box constraints. Numerical analysis of results shows that the proposed schemes improves the convergence rate of the DE algorithm and also maintains the quality of solution. Efficiency of the proposed schemes is further validated by applying it to a real life electrical engineering

problem dealing with the optimization of directional over-current relay settings. It is a highly constrained nonlinear optimization problem. A constraint handling mechanism based on repair methods is used for handling the constraints.

Digital microprocessor based relays are currently being utilized for safe, reliable and efficient operation of power systems. The overcurrent protection relay is the most extensively used component to safeguard power systems from the detrimental effects of faults. Wrong settings in overcurrent relay parameters can lead to false tripping or even bypassing fault conditions which can lead to a catastrophe. Therefore it is important to validate the settings of power protection equipment and to confirm its performance when subject to different fault conditions. Author presents the modeling of an overcurrent relay in Sim Power Systems (MATLAB/Simulink) [7]. The overcurrent relay has the features of instantaneous, time definite and inverse definite minimum time (IDMT) characteristics. A power system is modeled in Sim Power Systems and this overcurrent relay model is incorporated in the test case. The overall model is then simulated in real-time using Opal-RT's eMEGAsim real-time simulator to analyze the relay's performance when subjected to faults and with different characteristic settings in the relay model. Finally Hardware-in-the-Loop validation of the model is done by using the overcurrent protection feature in Schweitzer Engineering Laboratories Relay SEL-487E. The event reports generated by the SEL relays during Hardware-inthe- Loop testing are compared with the results obtained from the standalone testing and software model to validate the model.

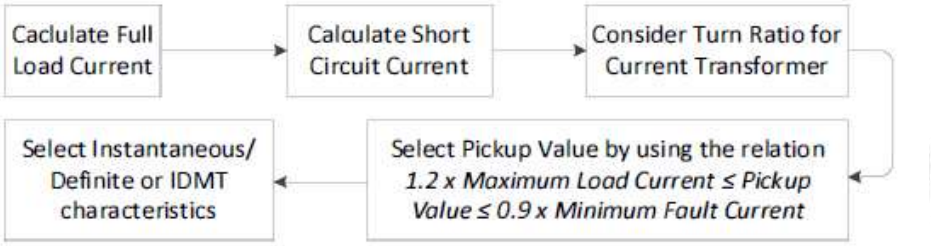

Fig.7:- Steps Involved in Selecting Pickup Values for Overcurrent Relays.

3. DIFFERENT TECHNIQUES FOR DESIGN AND TESING OF CIRCUIT BREAKER

In order to assess the feasibility of vibration analysis for diagnostic testing of high-voltage circuit-breakers [8] a comprehensive field test program has been carried out. Vibration patterns from 31 breakers (93 identical single-phase units) have been acquired, compared and analyzed. The breakers were assumed to be in good condition with no known irregularities at the time of testing. However, several serious faults, including an incipient rupture of the contact plug shaft, an incorrectly assembled crank, and major lubrication problems were disclosed. Thus, this "blind test" performed under realistic conditions on circuit breakers in normal service demonstrates that vibration analysis can be a reliable and suitable tool for non-invasive diagnostic testing.

The automated circuit breaker diagnostic system described by author [9] is an extension of the widely used portable circuit breaker testing device concept. The testing devices can be connected to the circuit breaker's control circuit to record analog and digital signals. The automated system consists of a signal processing module and an expert system module. The two modules process the voltage and current signals recorded by the testing device, diagnose and report any abnormalities that are discovered.

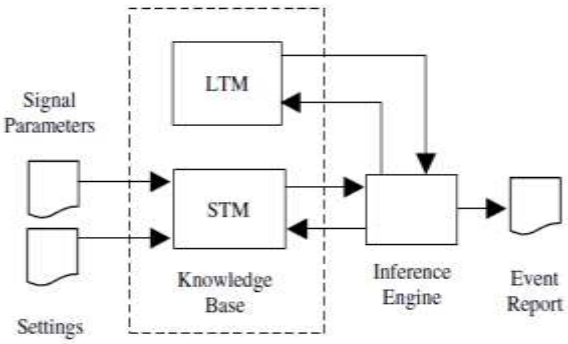

Fig.8:- Expert system analysis process.

Although many attempts have been made to design a fault-current limiting (FCL) circuit breaker (FCLCB) for medium voltage electric power systems, no economically attractive solution has been achieved so far. A novel concept for a FCLCB [10] is introduced based on a hybrid arrangement of semiconductors, temperature-dependent resistors, and a newly developed fast-opening mechanical switch. The latter utilizes one part of an electrodynamics repulsion drive, which is concurrent with the moving double-contact system. Laboratory tests as well as computer simulations of the complete FCLCB verify, as an example, the feasibility for the goal ratings 12 kV and 2/20 kA (single phase). A cost analysis shows the FCLCB to be more expensive than a conventional generator CB, but to be in the price range of the Is-limiter and below the costs of superconducting FCL principles. It is concluded that the presented method provides the basis for further commercial product development.

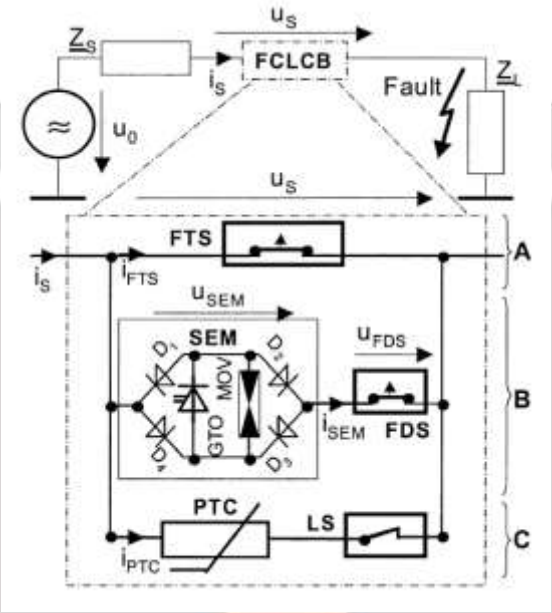

Fig.9:- Single-phase diagram of a hybrid fault-current limiting CB (FCLCB), consisting of a fast-opening transfer switch (FTS), a semiconductor unit (SEM), a fast-opening disconnecting switch (FDS), a limiting impedance (PTC-resistor), and a load switch (LS). The FCLCB is integrated into the equivalent circuit of a typical power network with source voltage u respectively [10].

The analysis is based on a record of waveforms taken from the circuit breaker control circuit [11] by using a portable recorder and manually forcing an operation of the breaker. This solution was driven by a need to perform the analysis in a more timely and consistent manner than what is available with existing technology. The solution is implemented using advanced wavelet transforms for waveform feature extraction and an expert system for decision making. A web-based database solution for storing and retrieving both the field-recorded and processed data is also implemented. The software is developed in two versions: for field (substation) as well as off-line (office) applications.

A new 27.5kV rated vacuum circuit breaker with bi-stable permanent magnetic actuator is designed and developed on the basis of electromagnetic field analysis coupled motion [12]. Firstly, the static characteristics of the permanent magnetic actuator are obtained using the finite element model with use of software package. Next, the electrical circuit and mechanical models which describe the behavior of the circuit breaker are constructed using Matlab package. The dynamic characteristics are simulated on the basis of over static simulation. And results for the time variations of the coil current, the displacement of the contact system, move velocity and electromagnetic force are obtained.

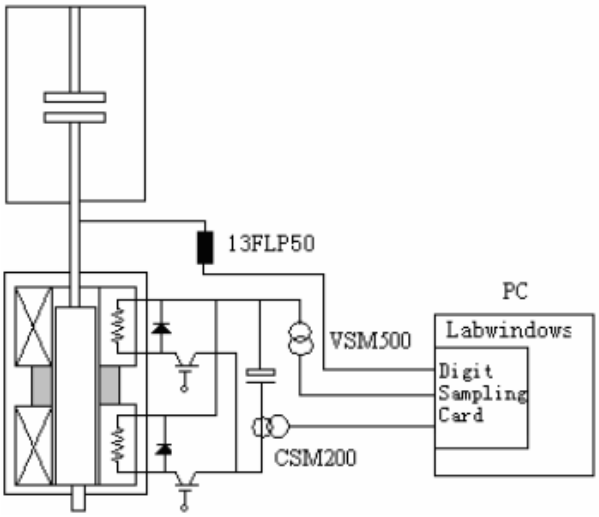

Fig.10:- Schematic of dynamic testing system [12].

4. CONCLUSION

This paper presents the study of circuit breaker and over current relay and how to protect the power system. Circuit breaker and over current relay is interconnection relation between each other. Testing of circuit breaker and over current relay is done by using different techniques and simulation software's.

5. REFERENCES

[1] Urdaneta, A. J., Restrepo, H., Marquez, S., & Sanchez, J. (1996). Coordination of directional overcurrent relay timing using linear programming. IEEE Transactions on Power Delivery, 11(1), 122-129

[2] Perez, L. G., & Urdaneta, A. J. (1999). Optimal coordination of directional overcurrent relays considering definite time backup relaying. IEEE Transactions on Power Delivery, 14(4), 1276-1284.

[3] Vishwakarma, D. N., & Moravej, Z. (2001). ANN based directional overcurrent relay. In Transmission and Distribution Conference and Exposition, 2001 IEEE/PES (Vol. 1, pp. 59-64). IEEE.

[4] Li-Cheng, W., & Chih, W. L. Modeling and Testing of a Digital Distance Relay Using MATLAB/SIMULINK.

[5] Saran, A., Kankanala, P., Srivastava, A. K., & Schulz, N. N. (2008, June). Designing and testing protective overcurrent relay using real time digital simulation. In Edinburgh, Scotland: Grand Challenges in Modeling and Simulation, Summer Simulation Conference.

[6] Thangaraj, R., Pant, M., & Abraham, A. (2010). New mutation schemes for differential evolution algorithm and their application to the optimization of directional over-current relay settings. Applied Mathematics and Computation, 216(2), 532-544.

[7] Almas, M. S., Leelaruji, R., & Vanfretti, L. (2012, October). Over-current relay model implementation for real time simulation & Hardware-in-the-Loop (HIL) validation. In IECON 2012-38th Annual Conference on IEEE Industrial Electronics Society (pp. 4789-4796). IEEE.

[8] Runde, M., Ottesen, G. E., Skyberg, B., & Ohlen, M. (1996). Vibration analysis for diagnostic testing of circuit-breakers. IEEE Transactions on power Delivery, 11(4), 1816-1823.

[9] Kezunovic, M., Nail, C., Ren, Z., Sevcik, D. R., Lucey, J., Cook, W., & Koch, E. (2002, July). Automated circuit breaker monitoring and analysis. In Power Engineering Society Summer Meeting, 2002 IEEE (Vol. 1, pp. 559-564). IEEE.

[10] Steurer, M., Frohlich, K., Holaus, W., & Kaltenegger, K. (2003). A novel hybrid current-limiting circuit breaker for medium voltage: principle and test results. IEEE transactions on power delivery, 18(2), 460-467.

[11] Kezunovic, M., Ren, Z., Latisko, G., Sevcik, D. R., Lucey, J. S., Cook, W. E., & Koch, E. A. (2005). Automated monitoring and analysis of circuit breaker operation. IEEE Transactions on Power Delivery, 20(3), 1910-1918.

[12] Wei, L., Fang, C. E., Zhou, L., & Jun, W. (2008, September). Simulation and testing of operating characteristic of 27.5 kV vacuum circuit breaker with permanent magnetic actuator. In Discharges and Electrical Insulation in Vacuum, 2008. ISDEIV 2008. 23rd International Symposium on (Vol. 1, pp. 125-128). IEEE.