ADAPTIVE RELAYING IN ELECTRIC POWER SYSTEM PROTECTION

Behçet KOCAMAN
Bitlis Eren University Electrical and Electronic Engineering Bitlis Turkey
bkocaman@beu.edu.tr

Üzeyir AKCA
Kocaeli University Kocaeli Vocational School Kocaeli Turkey
uzeyir@kocaeli.edu.tr

Abstract: No matter how good the design and construction of electrical power systems, various faults and disturbances are encountered during their operation. Protection systems are used to minimize the effects of faults and disturbances on the network elements as well as to limit the danger of human life. Appropriate solutions can be produced to prevent faulty operation in electrical power systems. One of these solutions is the adaptive relaying. Adaptive relaying defines protection schemes that conform settings and logic of operations based on the prevailing conditions of the system. These adjustments can contribute to avoid repeating of miss-operation. Adjustments could include well changing relay parameters, the logging of data for post-mortem analysis and communication throughout the system. The electrical distribution system is considered one of the most complicated machines in existence in many countries. Electrical phenomena in such a complex system can inflict serious damages. This requires damage prevention from protection schemes. There was a safety problem between capacity to deliver power and the demand until last years. The protection schemes worked on dependability allowing the disconnection of lines and transformers with the purpose of isolating the damaged element. In this paper, adaptive protection schemes for electric power system protection will be discussed, one of which is communication.

Keywords: Adaptive relaying, Protection scheme, Power system protection

Introduction

The method of delivering energy in the form of electricity to businesses and homes was one of the most complicated systems in many countries all over the world. Later, power engineers are forced to push the limits on the capacity of what they can deliver with the current system. This has led to many changes in the approach of electricity distribution, specifically a sophisticated approach in the methods of protective relaying. It is only possible to manually change the settings of the conventional protection relays used in electrical power systems once they have been adjusted. This process cannot be performed automatically. Therefore, it is very difficult to use this type of protection when the load flow changes frequently. For situations where the load current frequently changes, a protection system must be used which can adapt to these changes. This protection system is called the adaptive protection system. The adaptive protection checks the current information in the network and the status of the breakers, calculates the load flow again if a change is detected, and changes the relay settings accordingly. For the application of this protection system, the relays have to communicate with a main center, otherwise the calculations cannot be transferred back to the relays after the changes. Furthermore, the communication should be very fast in case the fault can occur at any time(Özveren, 2015) A system is usually looked at in terms of its reliability when describing its protective relaying (Horowitz and Phadke, 2008). They noted that this reliability spectrum has two extremes, dependability and security. According to them, “a system is said to be dependable if it will react for any type of fault but may also operate inappropriately when not needed. A system is said to be secure if it will not react inappropriately or unnecessarily, but it may not react if there is indeed a fault”. They pointed out that many engineers preferred to select the dependability side of the spectrum to clear any possible problematic condition because for many positions there were alternative delivery paths. Also, they noted that constraints on the growth of the infrastructure have caused to increased system stress, which helps to possible operation of dependable protection schemes. The power system is divided into protection zones defined by the equipment and the available circuit breakers. Six categories of protection zones are possible in each power system: (1) generators and generator–transformer units, (2) transformers, (3) buses, (4) lines (transmission, subtransmission, and distribution), (5) utilization equipment (motors, static loads, or other), and (6) capacitor or reactor banks (when separately protected). Most of these zones are illustrated in Figure 1. Although the fundamentals of protection are quite similar, each of these six categories has protective relays, specifically designed for primary protection, that are based on the characteristics of the equipment being protected (Blackburn and Domin, 2006)

• This study is presented in International Science and Technology Conference (ISTEC), July 18-20, 2018 Paris, France

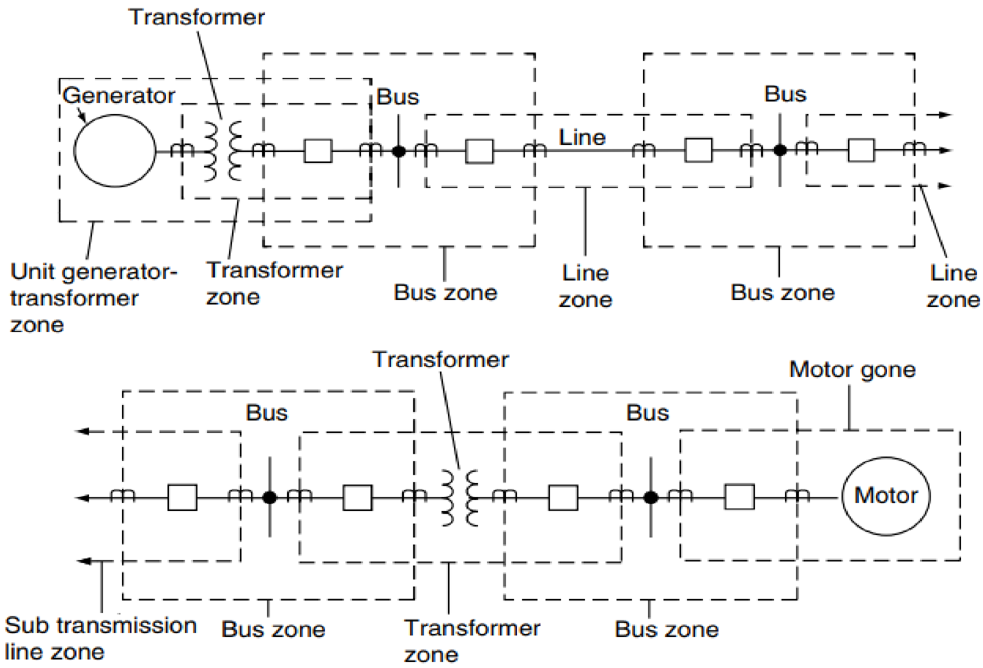

Figure 1. Typical relay primary protection zones in a power system(Blackburn and Domin, 2006)

Adaptive Protection Schemes

Adaptive protection systems, thanks to the multi-setting group, protection setting of parameters of changing are provided according to the state of protect region of the protection relay. Thus, the protection system adapts to different operating situations. In this way, the possibility of faulty of the protection system can be minimized. Due to their dynamic structure, adaptive protection systems offer more selective and reliable protection compared to conventional protection systems. Therefore, in today's electric power systems, adaptive protection systems are preferred instead of classical protection systems (Doğancı, 2014) There are four major factors that influence protective relaying. These are economics, ‘‘Personality’’ of the relay engineer and the characteristics of the electric power system, location and availability of disconnecting and isolating devices such as circuit breakers, switches and input devices and available fault indicators(Blackburn and Domin, 2006). Adaptive relaying means changing relay settings and relay pick up currents in online mode as operating conditions of the system changes. Adaptive relay is capable of very high speed operation, maintaining a good reach point accuracy in the presence of travelling wave noise and is immune to the presence of harmonics or variation in power system frequency. The principle diagram of the adaptive relay in figure 2.

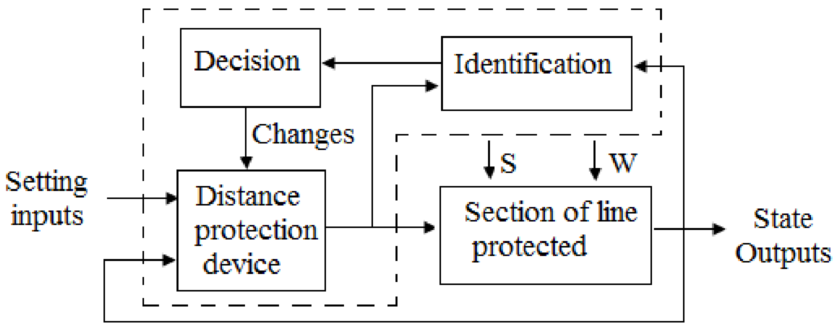

Figure 2. Principle of Adaptive relaying diagram

Adaptive distance protection control system, adaptive loop consists of identification, decision and changes. Shortfall in power system protection performance are applied at both transmission and distribution networks. Many factors are the reason of that including increased penetration of distributed generation, varied operational conditions and severe wide area disturbances (Horowitz at all., 2008 and Salman & Rida, 2001). Salman and Rida stressed that maintaining acceptable protection performance is vital for a functional smart grid as these schemes ensure the reliable and safe operation of the primary system protection. Adaptive protection using dvanced setting calculation techniques has been proposed as a solution to enhancing the performance of protection schemes in response to many of these factors (Tholomier at all., 2009). But, they added that a body of work tackling adaptive protection schemes for the verification and validation of such schemes is non-existent.

Differential Protection

Differential protection relay operation depends on the phase difference of two or more electrical quantities. It is used for the protection of the generator, transformer, feeder, large motor, bus-bars etc. The classification of the differential protection relays are current, voltage, biased/ percentage and voltage balance differential relay. The differential protection relay shown in figure 3.

Figure 3. Differential protection relay

Differential protection schemes are constructed simply to check for any difference between two quantities at a given instance (Zaremski, 2012). Limitations on time synchronization changed this implementation only reasonable for equipment protection and difficult for other applications. The burden of communication turned out the implementation of differential protection difficult or unattainable for signals collected from distant points into a system. Its application required the two measurements to be added very close to one another because of the constraints on communication in past, while the protection is useful in detecting a difference in current from one substation to the next one. This mean that the scheme was limited generally to transformer and generator protection.

Communication

Protection schemes did have ways of communicating between two distant points through technologies in the past like pilot wire, power line carriers, and microwave signals (Abdulhadi at all., 2010). They stayed that microprocessor-based relays easy access the internet to communicate with other relays. So, these connections allow new sources of communication to pass data between relays. Older forms of communication are based on direct links: microwave communication has transmitters and antennae transmitting data down the line wirelessly. This needs a direct line of sight. Power line carrier is based on the power line conductor as the communication media. RTU (Remote Terminal Unit) use for communication. Thanks to its modules, RTU can communicate with devices with different communication protocols without the need for additional software or hardware. They can also serve as a communication interface in the communication systems of their devices by using different communication protocols they have. The generating units and the loads of a power system are usually far apart and the transmission system inter-connects them. However, the control is centralized and many control decisions require system-wide knowledge. Each substation has complete information on its current status, but not on that of any other substation. data is gathered from major substations and is sent to a central control center for processing and further action. At any given time, only the control center has the up-to-date performance data profile of the system and the computing power to process the data. Pilot wire is a communication wire hung on the same poles as the transmission lines themselves. Each of these methods has their own advantages and disadvantages about the types of schemes that they use.

Data Mining

One of many advantages that microprocessors bring to protective relaying is that they give protection schemes a hard drive in which data can be stored (Tleis, 2008). So, the system conditions can be recorded with a great deal of precision and synchronization. He stayed that this small piece provides the ability to automatically scan data for preset limits. The recorded data can be used to detect incorrect relay settings. Tleis also pointed out that an obsolete relay setting could be described as a setting. This system was applied to protect a part of the system that has developed or changed significantly.

Conclusions

For situations where the load current frequently changes, a protection system must be used which can adapt to these changes. This protection system is also called adaptive protection system. The adaptive protection checks the current information in the network and the status of the breakers, calculates the load flow again if a change is detected, and changes the relay setting values accordingly. In the adaptive protection process, a RTU and SCADA (Supervisory Control and Data Acquisition) based system is preferred if both the number and the distance of the protection relays to communicate with each other are too high. By establishing the supervisory zone, which is a simple way to help a relay distinguish between a fault condition and a load encroachment, the relay can better react to stressed system state abnormalities. We believe that the stressed system conditions have proven to be more common and will continue to become more common as power system engineers are forced to do more with less. Also, when this concept is applied correctly it will not receive much notoriety. When the innovations made possible by the new tools given to protection engineers, prevention of blackouts and improvement of system stability are no matter.

References

Abdulhadi, I.F, Burt, G.M., Dysko, A. Zhang, R. and Fitch, J. (2010). The evaluation of distance protection performance in the presence of Quadrature Boosters in support of a coordinated control strategy. In Developments in Power System Protection. Managing the Change, 10th IET International Conference on, pp. 1-5.

Blackburn, J. L. , Domin, T. J. (2006). Protective Relaying: Principles and Applications, CRC Press, NW, USA.

Catterson, V.M., Davidson, E.M. and McArthur, S.D.J. (2011). Embedded Intelligence for Electrical Network Operation and Control. IEEE Intelligent Systems, vol. 26, no. 2, pp. 38-45.

Chapman, S.J. (2002). Electric machinery and power system fundamentals. Boston: McGraw-Hill.

Doğancı, A.Ç. (2014) Elektrik Dağıtım Sistemlerinde Adaptif Koruma, İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, İstanbul.

Grainger, J.J. and Stevenson, W.D. (1994). Power system analysis. New York: McGraw- Hill.

Horowitz, S., Novosel, D., Madani, V. and Adamiak, M. (2008). System-wide Protection. Power and Energy Magazine, IEEE, vol. 6, no. 5, pp. 34-42.

Horowitz, S.H. and Phadke, A.G. (2008). Power System Relaying (3rd Edition). John Wiley & Sons.

Özveren F. (2015), Mikroşebekelerin Aşırı Akım Rölesi İle Adaptif Ve Entegre Korunması, İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Salman, S.K and Rida, I.M (2001). Investigating the impact of embedded generation on relay settings of utilities electrical feeders. Power Delivery, IEEE Transactions on, vol. 16, no. 2, pp.246 -251.

Tholomier, D, Paraiso, D. and Apostolov, A. (2009). Adaptive protection of transmission lines. In Power Systems Conference, (PSC), pp. 1-14.

Tleis, N. (2008). Power Systems Modelling and Fault Analysis: Theory and Practice. Elsevier, USA.

Vassell, G.S. (1991). Northeast Blackout of 1965. Power Engineering Review, IEEE, 11(1): p. 42- 53.

Zaremski, B. Z. (2012). The Advancement of Adaptive Relaying in Power Systems Protection. Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of Master of Science In Electrical Engineering, USA.

