ISSN 2350-1049

International Journal of Recent Research in Interdisciplinary Sciences (IJRRIS)
Vol. 3, Issue 2, pp: (11-16), Month: April 2016 - June 2016, Available at: www.paperpublications.org

A Review on Suppression of Secondary Arc Current Trough Single-Phase Auto-Reclosing

[1]Shalini Chandel, [2]A. K. Sharma

[1,2] Electrical Engineering Department, Jabalpur Engineering College, Jabalpur, India

Abstract: **When single-phase to ground fault occurs in high voltage transmission line, secondary arc current and recovery voltage must be suppressed in order to ensure that single-phase auto-reclosing operates reliably and successfully.**

This work adopts the suppression measure of secondary arc current using shunt reactor with neutral small reactor-which is applied widely in India, and then uses MATLAB Simulink software to simulate suppression effect about different fault point locations toward an example of 735kv double-ended sources high-voltage transmission line. According to the simulation results, suppression effects about different locations are distinct. Moreover, this measure can suppress secondary arc current effectively, ensure success of single phase auto-reclosing operation and finally achieve security and stability of power system

Keywords: **Fault point location, neutral reactor, secondary arc current, single phase auto reclosing.**

1. INTRODUCTION

Single-line-to-ground (S-L-G) transient arcing faults make up around 80% of faults on transmission lines [2]. In an effort to maintain high power quality levels and to provide continuous service to their customers, the power companies use fault locators and auto reclosure schemes. For the design of these fault mitigation techniques to be effective, it is important to possess accurate knowledge of the levels of prospective fault current on the line and the characteristics and behavior of electrical arcs.

The best way to gain the required understanding is to simulate fault conditions on model power systems using computer software. In order to accurately simulate the transient processes that a power system may be subjected to under fault conditions, it is important to realistically model the arcing fault so that all of its effects on the power system can be assessed.

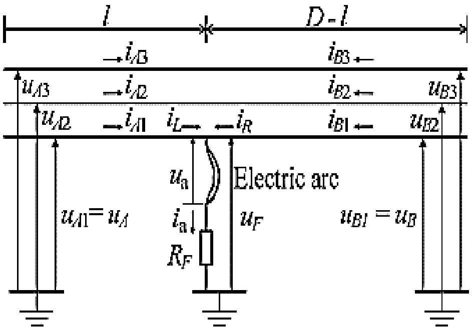

Fig.1: Equivalent circuit diagram of an S-L-G fault

ISSN 2350-1049

International Journal of Recent Research in Interdisciplinary Sciences (IJRRIS)
Vol. 3, Issue 2, pp: (11-16), Month: April 2016 - June 2016, Available at: www.paperpublications.org

Auto Reclosing:

Auto reclosing is the practice of reenergizing a circuit shortly after a fault has occurred. It takes advantage of the fact that on overhead lines, 80-90% of faults are transient in nature [4]. An auto reclosing relay will send a signal to a circuit breaker to reclose, re-energizing the faulted circuit. Should the fault persist after this time, the protection will operate again and re-trip the line, and usually the auto-reclose will be disabled and the fault assumed to be permanent. In some schemes, particularly at distribution level, the auto-reclose relay will be calibrated to attempt to reclose a number of times, known as multi-shot re-closure.

There are a number of parameters involved in configuring auto reclosing relays, of which the most important are dead time, reclaim time and number of shots. Dead time is the time after the protection operates before the reclosing relay attempts the first re-closure, and the reclaim time is the time from the first reclose signal until the relay is ready to respond to further faults. The number of shots is how many reclose attempts are allowed before lock out, usually set at increasing time intervals between shots.

This figure illustrates auto-reclose cycle for a circuit breaker fitted with single shot auto-reclose scheme.

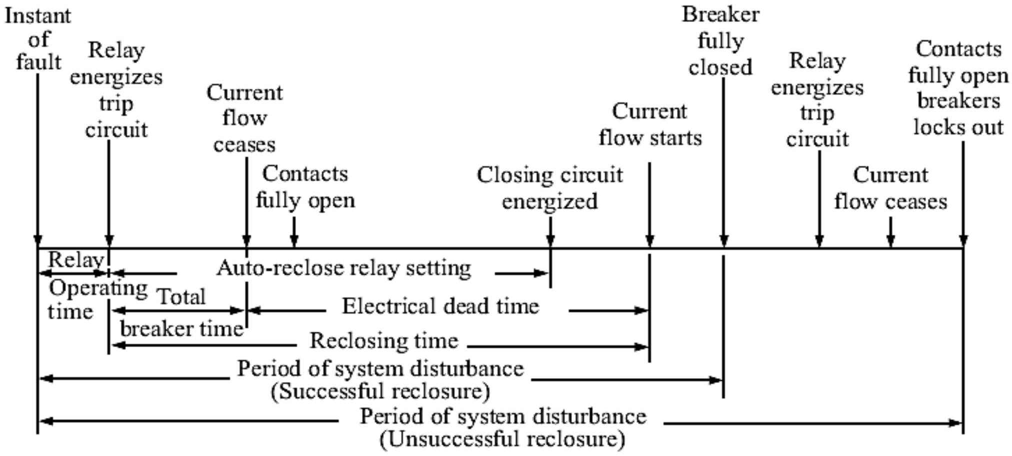

Fig.2: Auto-reclose cycle for a circuit breaker with a single shot auto-reclose scheme

High Voltage Auto-Reclose:

In the high voltage circuits where the fault levels associated are extremely high, it is essential that the system dead time be kept to a few cycles so that the generators do not drift apart. High speed protection such as pilot wire carrier or distance must be used to obtain operating times of one or two cycles. It is therefore desired that the re closure be of the single shot type. High speed re closure in high voltage circuits improves the stability to a considerable extent on single-circuit ties.

On double circuit ties subjected to single circuit faults the continuity through the healthy circuit prevents the generators from drifting apart so fast and increase in the stability limit is thus moderate. Nevertheless, it is sometimes important. However, when the faults occur simultaneously on both the circuits the stability limit increases again considerably.

The successful application of high speed auto-reclose to high voltage systems interlinking a number of sources depends on the following factors.

(i) The maximum time available for opening and closing the circuit breakers at each end of the faulty line, without loss of synchronism.

(ii) The time required to deionize the arc at the fault, so that it will not restrike when the breakers are reclosed.

(iii) The speed of operation on opening and closing of the circuit breakers.

(iv) The probability of transient faults, that will allow high speed reclosure of the faulty lines.

It will be seen that some of these conditions are conflicting, e.g., the faster the breakers are reclosed the greater the power that can be transmitted without loss of synchronism, provided that the arc does not restrike. But here the likelihood of arc restriking is greater. An unsuccessful reclosure is more detrimental to stability than no reclosure at all. For this reason the time allowed to deionize the line must not be less than the critical time for which the arc hardly ever restrikes.

ISSN 2350-1049

International Journal of Recent Research in Interdisciplinary Sciences (IJRRIS)
Vol. 3, Issue 2, pp: (11-16), Month: April 2016 - June 2016, Available at: www.paperpublications.org

The reduction of reclosing time obtained by high speed relaying is however preferred as it reduces the duration of arc. Indeed, the increase in power limit due to reclosing is muchgreater with very rapid fault clearing than with slower fault clearing. For best resultsthe circuit breakers at both ends of the faulty line must be opened simultaneously.

Any time during which one circuit breaker is open in advance of the other represents an effective reduction of the breaker electrical dead time and may well jeopardize the chances of a successful reclosure. To determine the electrical dead time for a circuit breaker used in a high speed auto-reclose scheme it is essential to know the time interval during which the line must be kept de-energized in order to allow for the complete deionization of the arc and ensure that it will not restrike when the line is reconnected to the system.

2. METHODS OF SECONDARY ARC EXTINCTION

1. Single-Pole Tripping and Reclosing:

Single-pole switching (SPS) is the method by which only the faulted phase is taken out of service. SPS does not come without its challenges. From the point of view of a protection engineer, the complexity of the protection scheme is increased. From the point of view of a systems operator, questions need to be addressed, such as: “How long can the system tolerate a single-pole open condition (an unbalance on the system) before it affects generators and motors?”

SPS also leads to challenges on the power system, such as the extinction of the secondary arc resulting from the coupling between the faulted phase and healthy phase conductors.

Single-pole switching is a practical means to improve stability and reliability in extra high voltage networks where most circuit breakers have independent pole operation. Several methods are used to ensure secondary arc extinction. For short lines, no special methods are needed. For long lines, the four-reactor scheme is most commonly used. High-speed grounding switches may be used. A hybrid reclosing method used successfully by Bonneville Power Administration (BPA) on many lines over many years employs single-pole tripping, but with three-pole tripping on the back swing followed by rapid three-pole reclosure the three-pole tripping ensures secondary arc extinction .

Single-pole switching may necessitate positive sequence filtering in stability control input signals. For advanced stability control, signal processing and pattern recognition techniques may be developed to detect secondary arc extinction. Reclosing into a fault is avoided and single-pole reclosing success is improved.

High-speed reclosing or single-pole switching may not allow increased power transfers because deterministic reliability criteria generally specify permanent faults. Nevertheless, fast reclosing provides ‘‘defense-in-depth’’ for frequently occurring single-phase temporary faults and false operation of protective relays. The probability of power failures because of multiple line outages is greatly reduced.

2. Auto-Reclosing On EHV Transmission Lines:

The most important consideration in the application of auto-reclosing to EHV transmission lines is the maintenance of system stability and synchronism. The problems involved are dependent on whether the transmission system is weak or strong. With a weak system, loss of a transmission link may lead quickly to an excessive phase angle across the CB used for re-closure, thus preventing a successful re-closure. In a relatively strong system, the rate of change of phase angle will be slow, so that delayed auto-reclose can be successfully applied.

An illustration is the interconnector between two power systems as shown in Figure Under healthy conditions, the amount of synchronizing power transmitted, P, crosses the power/angle curve OAB at point X, showing that the phase displacement between the two systems is θo. Under fault conditions, the curve OCB is applicable, and the operating point changes to Y. Assuming constant power input to both ends of the line, there is now an accelerating power XY. As a result, the operating point moves to Z, with an increased phase displacement, θ_1, between the two systems. At this point the circuit breakers trip and break the connection.

The phase displacement continues to increase at a rate dependent on the inertia of the two power sources. To maintain synchronism, the circuit breaker must be reclosed in a time short enough to prevent the phase angle exceeding θ_2. This angle is such that the area (2) stays greater than the area (1), which is the condition for maintenance of synchronism.

International Journal of Recent Research in Interdisciplinary Sciences (IJRRIS)
Vol. 3, Issue 2, pp: (11-16), Month: April 2016 - June 2016, Available at: www.paperpublications.org

This example, for a weak system, shows that the successful application of auto-reclosing in such a case needs high-speed protection and circuit breakers, and a short dead time. On strong systems, synchronism is unlikely to be lost by the tripping out of a single line. For such systems, an alternative policy of delayed auto-reclosing may be adopted. This enables the power swings on the system resulting from the fault to decay before reclosure is attempted.

3. SECONDARY ARC EXTINCTION TIME

Based on the experience, some equations have been proposed in the past to estimate the arc extinction time. In the estimation of secondary arc extinction time only the stable extinction is taken in to consideration, because the instantaneous extinction could happen in less than 0.15 sec. According to the experiment the arc extinction time versus secondary arc currents about 20A and above, and voltage about 20 to30 kv is calculated from the equation

$$t_b = 0.02 \, . I_s$$

Further more the dead time of reclosure must be 0.25 more than extinction time which results in

$$t_d = 0.25 \, . (0.1 I_s + 1)$$

The exact value of arc extinction time depends on various factors and parameters of the system and could be batter estimated through performing transient studies.

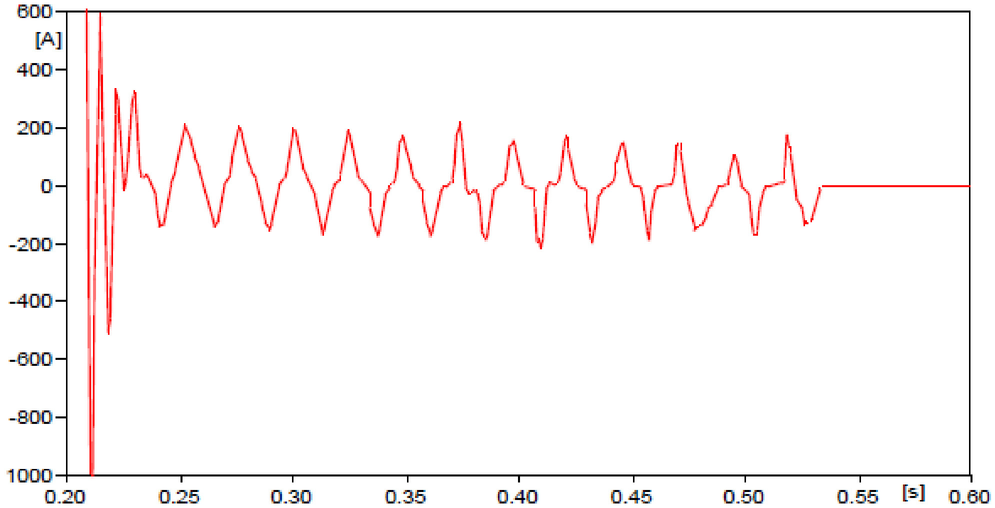

Fig.3: Secondary arc current transposed line with shunt compensation with fault location in 1km of line

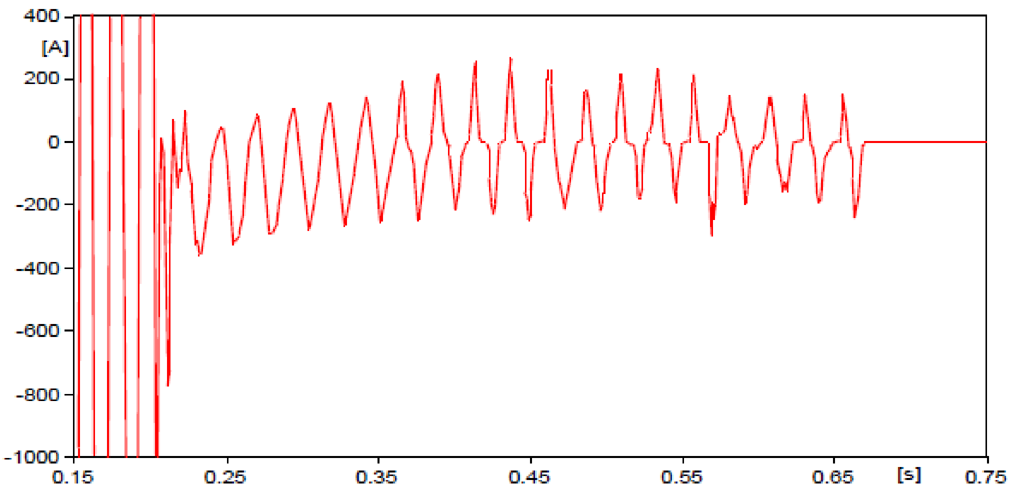

Fig.4: Secondary arc current un-transposed line with shunt compensation with fault location in 1km of line

International Journal of Recent Research in Interdisciplinary Sciences (IJRRIS)
Vol. 3, Issue 2, pp: (11-16), Month: April 2016 - June 2016, Available at: www.paperpublications.org

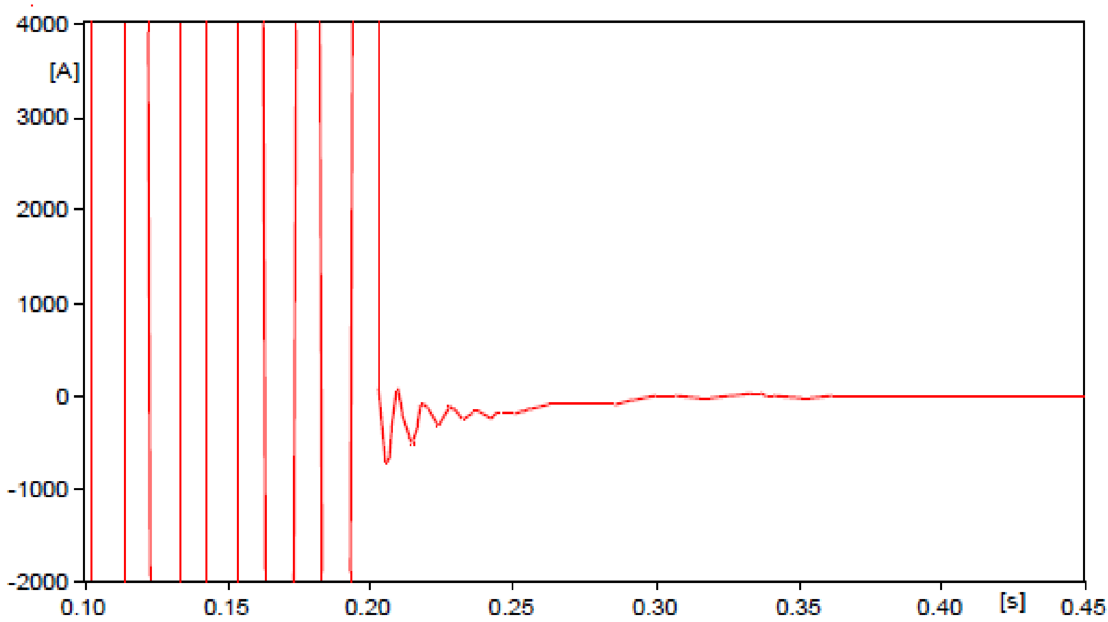

Fig.5: Secondary arc current transposed line with shunt compensation with fault location in 100km of line

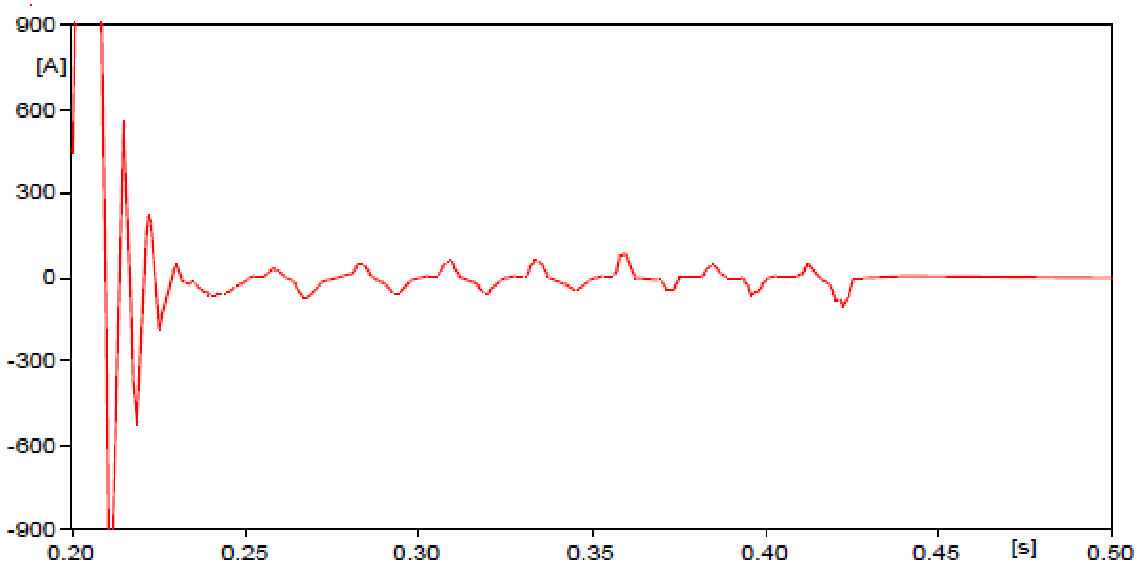

Fig.6: Secondary arc current un-transposed line with shunt compensation with fault location in 100km of line

4. CONCLUSION

The purpose of this paper is to illustrate some considerations in the design and implementation of single-pole-tripping relaying schemes. Single line to ground faults are the least damaging to the power system and that an open pole condition allows for the secondary arc to extinguish, while at the same time allowing power transfer. These conditions increase power system stability. SPT relaying scheme are implemented with SPT breakers and require individual control of the trip coils of each pole of the breakers. These breakers are more expensive than 3PT breakers at lower HV voltage levels, but breakers at EHV levels because of their phase clearance requirements, already have the ability to trip individual phases.

Ones a faulted phase has been selected and the SPT relaying system opens the proper pole a pole open condition is created in the power system. Ground directional units should be disabled during this condition and some considerations should be evaluated in adjacent lines to prevent miss operation of ground directional units.

ISSN 2350-1049

International Journal of Recent Research in Interdisciplinary Sciences (IJRRIS)
Vol. 3, Issue 2, pp: (11-16), Month: April 2016 - June 2016, Available at: www.paperpublications.org

REFERENCES

[1] IEEE Standard Common Format for Transient Data Exchange (COMTRADE) forPower Systems. IEEE Std C37.111-1999. DOI: 10.1109/IEEESTD.1999.90571

[2] V. Terzija, N. Elkalashy, G. Preston, V. Stanojevic, G. Strbac. "Detection of ArcingFaults: Modelling, Simulation, Testing and Algorithms Aspects". IEEE Power Tech.Conference Lausanne 2007, pp 1147 – 1152. DOI: 10.1109/PCT.2007.4538477

[3] M. Kizilcay, T. Pniok. "Digital Simulation of Fault Arcs in Power Systems". ETEPVol.1, No. 1, Jan/Feb 1991.

[4] V. Terzija, Z. Radojevic, M. Djuric. "A New Approach for Arcing Faults Detection andFault Distance Calculation in Spectral Domain". Transmission and DistributionConference Proceedings, 15-20 Sept. 1996. pp 573-578.

[5] Papoulis. 'Probability, Random Variables and Stochastic Processes'. 4th Ed.McGraw Hill. http://www.mhhe.com /engcs /electrical/papoulis ISBN: 0073660116

[6] EMTP Simulation of the Secondary ArcExtinction at Overhead Transmission Linesunder Single Phase Automatic Reclosing, 2005 IEEE St. Petersburg Power Tech Proceedings, June 27-30, 2005, Report №15.–ISBN 5-93208-034-0

[7] Research on Suppression of Secondary Arc Current under Different Fault Locations for 500kV Transmission Line , Cui Ruochen, Yin Zhongdong, Wang Miaomiao, Li Ke, 978-1-4244-4813-5/10/2010 IEEE

[8] Modelling of Secondary Arc Using EMTP-RV, Yun-Sik Oh. Sung-Bum Kang. Hun-ChulSeo. Chul-Hwan Kim, The Transactions of the Korean Institute of Electrical Engineers Vol. 61, No. 7, pp. 937～943, 2012

[9] Secondary arc extinction in extra high voltage systems using grounding switches, Qais M. Alias, Wafaa F. Tobia, Diyala Journal of Engineering Sciences, Vol. 07, No. 01, pp. 81-93, March 2014

[10] Analysis of Secondary Arc Extinction Effects according to the Application of Shunt Reactor and High Speed Grounding Switches in Transmission Systems, Seung-Hyun Sohn, Gyu-Jung Cho , Journal of International Council on Electrical Engineering Vol. 4, No. 4, pp.324~329, 2014