Solid State Circuit Breaker for Medium Voltage Feeder Protection

Shilpak S. Jogi[1] Umesh G. Bonde[2] Chandrakala R. Gowder[3]
[1]PG Scholar [2,3]Assistant Professor
[1,2,3]Shri Sai College of Engineering & Technology, Bhadrawati, India

Abstract— With the growing of demand of electrical power, the distribution system is increasing ceaselessly. This ends up in the high level of short-circuit currents. Therefore, the electrical cost like devices, installation, operation and maintenance will increase step by step. Moreover, the high level of short current becomes the intense downside. It's going to injury the electrical devices or impact on operation. Continuity of power offer systems is extremely low as a result of operations of protecting devices underneath faulted conditions. Mechanical circuit breakers in power distribution systems provides a safe handling of short-circuits underneath restricted short-circuit power of the grid. Victimization delayed turn-off times; the circuit breakers will be coordinated with another protecting instrumentation. Hence, a high availableness of the grid will be expected. However, once the short event happens in an exceedingly medium-voltage distribution feeder, voltages on the path area unit suddenly sagged. Sensitive hundreds like computers or electronic-control instrumentation can fail even though the voltage returns among a number of seconds. A solid-state fuse is in a position to modify at terribly high speed as quick as voltage or current sensing devices will response to the faulty signal. This methodology proposes detail of formulating solid-state breakers (SSB) in electrical power distribution systems by victimization GUI-based surroundings of MATLAB/SIMULINK. Utilization of MATLAB computer code simplifies downside resolution complexness and conjointly reduces operating time. During this methodology, a 22-kV power distribution feeder with a load having the SSB for defense is placed. A thyristor-based fuse is shapely. Detail of the facility circuit and its firing management half is incontestable in graphical diagrams victimization parts of the MATLAB's power System Blockset (PSB). Take a look at against a fault condition to verify its use is meted out. The results show that, with a moderate sensing technique to observe voltage and current of the protected feeder, the SSB will interrupt fault outright.

Key words: Solid State Circuit Breaker, Voltage Feeder Protection

I. INTRODUCTION

With the growing of demand of electrical power, the distribution system is increasing incessantly. These leads to the high level of short-circuit currents. Therefore, the electrical cost like devices, installation, operation and maintenance will increase bit by bit. Moreover, the high level of tangency current becomes the intense drawback. It's going to injury the electrical devices or impact on computer operation. Continuity of power offer systems is incredibly low as a result of operations of protecting devices below faulted conditions. Mechanical circuit breakers in power distribution systems provides a safe handling of short-circuits below restricted short-circuit power of the grid. Victimization delayed turn-off times, the circuit breakers is coordinated with another protecting instrumentation. Hence, a high handiness of the grid is expected. However, once the short-circuit event happens during a medium-voltage distribution feeder, voltages on the route are suddenly sagged. Sensitive masses like computers or electronic-control instrumentation can fail even though the voltage returns at intervals many seconds. A solid-state breaker [1-3] is in a position to change at terribly high speed as quick as voltage or current sensing devices will response to the faulty signal.

Figure 1 shows a feeder breaker of mechanical and solid-state varieties. Gift styles of distribution feeder protection consider expulsion fuses, that got to be reset manually. AN SBB is employed to guard sensitive masses by interrupting it if there exists a system fault on the availability feeder. This may be incorporated victimization thyristors [1].

The solid-state breaker is designed using thyristors because the switch requires a continuous current carrying and a short-time overcurrent rating equal to the feeder faults level. Thyristors have a short-time rating up to 16-kA and also have low conduction losses [1]. The thyristors in the feeder are normally energized by continuous and synchronized firing control signal. On detection of voltage sags, these firing pulses are stopped to break the current.

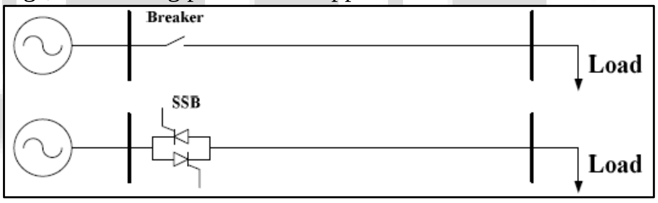

Fig. 1: Feeder circuit breakers

II. PROPOSED METHODOLOGY

A. *Main system*

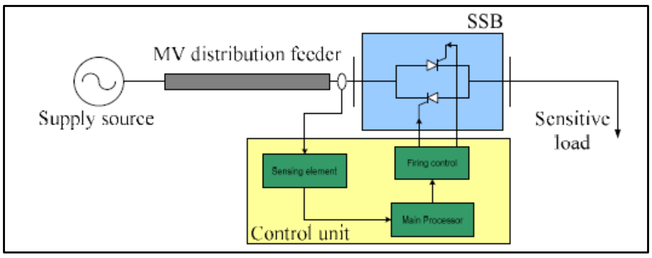

Fig. 2: Control structure of the SSB

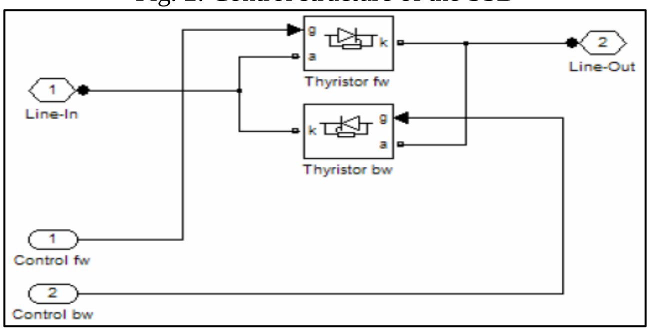

Fig. 3: SIMULINK model for an SSB (SSB_1ph)

B. Firing Control

To generate firing signals to show on the thyristors, a saw-tooth signal with a DC reference signal are compared. The result's the heart beat signal utilized in the SSB block. The firing management diagram created in SIMULINK is given in figure 4.

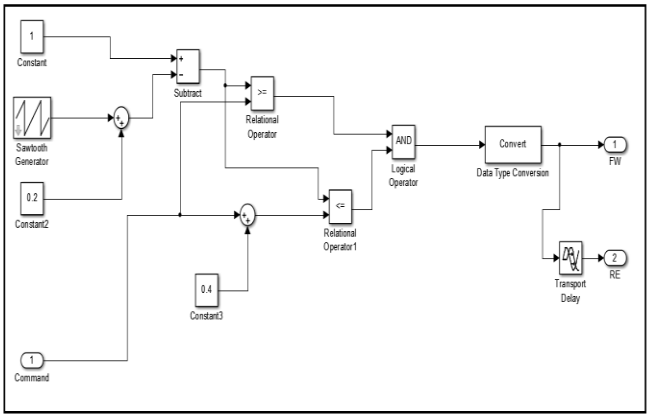

Fig. 4: SIMULINK model for a firing controller

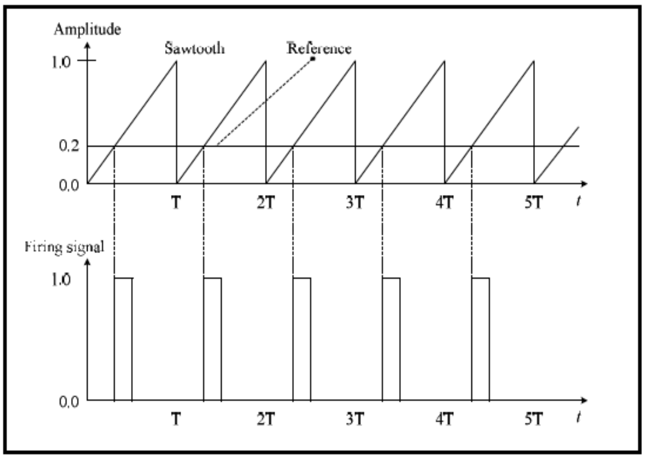

Fig. 5: Firing signal generated from the firing control

C. Voltage Detection Scheme

Firing strategy to the SSB has just one objective. It's to permit full current flowing to the load. The firing angle for this case is about to zero degree. Once a fault happens, the short-circuit current should be interrupted as quick as attainable. To change off the SSB, the firing angle is about to one hundred eighty degree. to alter the command to the firing management unit needs a voltage sensing device. During this work, rms voltage detection is employed to observe the voltage sag of the load. Figure 7 shows the diagram of rms voltage detection used for the SSB application.

III. SIMULATION RESULTS

A 22-kV distribution feeder serving the load of 200 kW, 150 kvar is created in SIMULINK as shown in figure 6. It assumes that a short-circuit event occurs at t = 0.16 s. The test case scenario performs with a time span of 0.2 s.

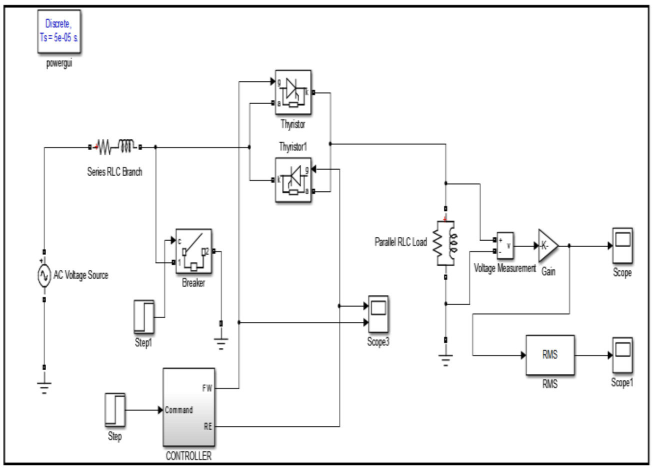

Fig. 6: SIMULNK model of the test feeder

It takes the first cycle for the rms value reaching its actual rms voltage. When the fault happens at t = 0.16 s, the load voltage drops to the value close to zero as shown in Figure 7. The rms value for the load voltage can be presented in figure 8.

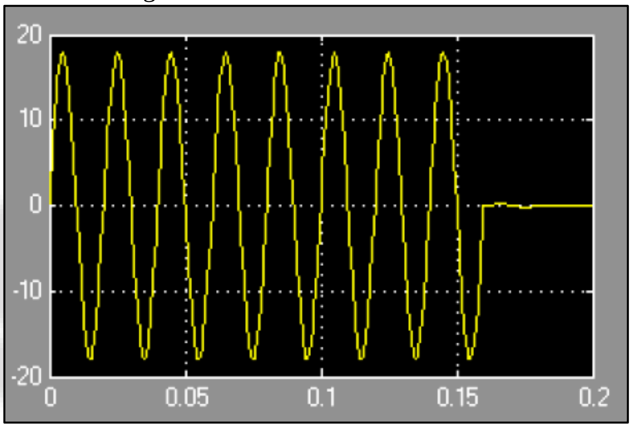

Fig. 7: Load voltage (kV)

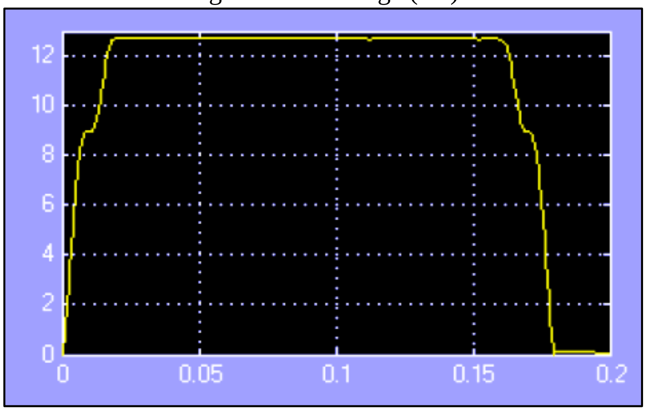

Fig. 8: RMS load voltage (kV)

To verify that the SSB can interrupt the fault current effectively, the currents supplied by the source and drawn by the load are recorded. Figure 9 gives information of the source current. This figure intentionally indicates the current during the fault event. Figure 10 explains the current drawn by the load at the normal loading condition.

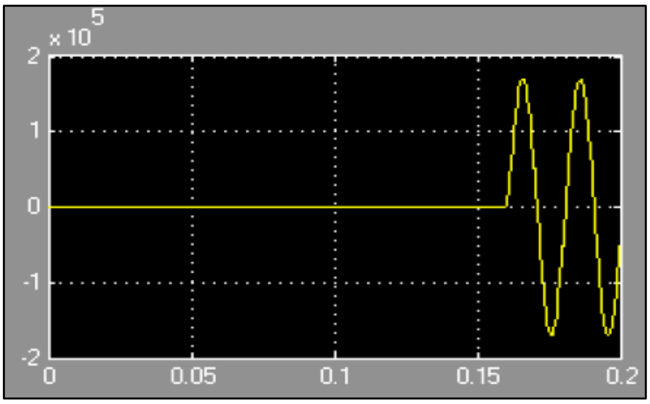

Fig. 9: Source current (A)

The load current responses can be shown in figure 5.10 from the figure; it can notice the DC component when operating at the normal load condition. The maximum positive peak current is just over 40 A. It can be seen that the SSB can successfully interrupt the fault current. Zeroing load current in the figure can support this reason. In addition, the firing command as shown in Figure 5.11 shows the transition of the SSB status from turn-on to completely turn-off for interrupting the fault current. During the fault the load current has no DC component.

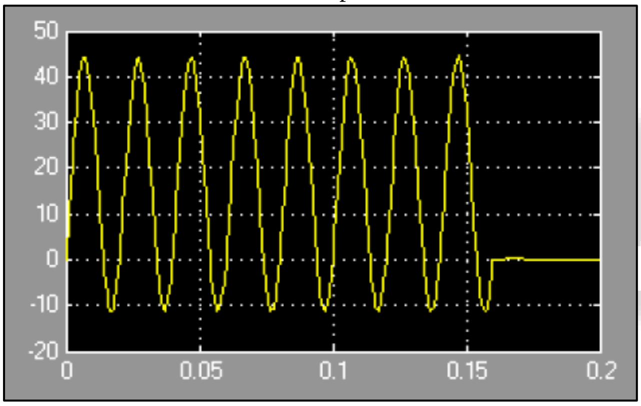

Fig. 10: Load current (A)

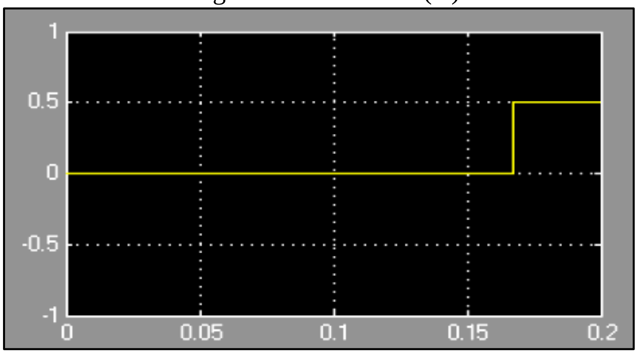

Fig. 11: Command signal for SSB control

This project presents a detail of formulating solid-state breakers (SSB) in electric power distribution systems by using GUI-based environment of MATLAB/SIMULINK. In this paper, a 22-kV power distribution feeder with a load having the SSB for protection is situated. Test against a fault condition to verify its use is carried out. As a result, with an appropriate sensing technique to monitor voltage and current of the protected feeder, the SSB can interrupt fault instantaneously.

IV. Conclusion

This paper proposes detail of formulating solid-state breakers (SSB) in power distribution systems by exploitation GUI-based setting of MATLAB/SIMULINK. During this report, a 22-kV power distribution feeder with a load having the SSB for defense is set. Check against a fault condition to verify its use is distributed. As a result, with associate acceptable sensing technique to observe voltage and current of the protected feeder, the SSB will interrupt fault outright.

The availability of high-voltage, solid-state switches change the transition of sea power distribution to MVDC power systems and also the vital advantages that they contribute. The flexibility of MVDC systems to interrupt full load currents in unit of time timescales delivers dramatic advances in fuse performance, yielding improved system irresponsibleness and safety. Identical technology additionally allows high frequency, high-voltage change power converters that square measure rugged, efficient, and compact.

New solid-state breaker exploitation IGCT wonderful turn-off capability and quick turn-off characteristic will isolate chop-chop the circuit fault and forestall the enlargement of the fault. However attributable to the solid state fuse is simply too quick, ought to stand up to over-voltage impact is incredibly high, the requirement to extend the resistance-capacitance freewheeling branch. Through the simulation check of ten kV voltage, the SSB while not the freewheeling branch's breaking over- voltage is up to 1.8 pu, and when increasing the free- wheeling branch, the breaking over-voltage is reduced to 1.2 pu, Therefore, the freewheeling branch support the energy cathartic channel, that not solely considerably suppress the breaking over-voltage, additionally clear the residual charge on the road, eliminating the hidden danger of over-voltage once the SSB closing.

The high-speed fuse mitigates voltage sag throughout fault conditions while not poignant the system stability. The high-speed solid-state fuse additionally provides fault current limiting features; thence facilitates interconnection of the distributed generations (DG). The event of the high-speed, solid-state DC fuse provides a viable answer for the protection of DC distribution systems. Combined with intelligent protection and reconfiguration theme, the high-speed solid-state DC fuse is prepared to be deployed during a DC distribution like sea power systems.

References

[1] L. Palav, and A.M. Cole, On using the solid state breaker in distribution systems, IEEE Canadian Conference on Electrical and Computer Engineering, Volume 2, 24-28 May 1998, pp. 693 – 696.
[2] Golland, F. Wakeman, I. McDonald, and T. Lakin, Integrated 30 kV solid-state switch for pulse power applications, Pulsed Power Plasma Science (PPPS-2001), Volume 2, 17-22 June 2001, pp. 1055 – 1058.
[3] G.F. Reed, M. Takeda, and I. Iyoda, Improved power quality solutions using advanced solid state switching and static compensation technologies, IEEE Power Engineering Society

Winter Meeting 1999, Volume 2, 31 Jan-4 Feb 1999, pp. 1132 – 1137.
[4] The MATHWORKS Inc., Power system blockset for use with SIMULINK, User Guider Version 1.0, 1999.
[5] G. A. Putrus, M. M. R. Ahmed, L. Ran, K. R. Chu, and T. Funabashi, “Integration of fault current limiters in power distribution networks,” presented at the DPSP Conf. Amsterdam, The Netherlands, Apr. 2004.
[6] R. K. Smith, P. G. Slade, M. Sarkosi, E. J. Stacey, J. J. Bonk, and H. Mehta, “Solid-state distribution current limiter and circuit-breaker application requirements and control strategies,” IEEE Trans. Power Del., vol. 8, no. 3, pp. 1155–1164, Jul. 1993.
[7] T. Ueda, M. Morita, H. Arita, Y. Kida, Y. Kurosawa, and T. Yamagiwa, “Solid-state current limiter for power distribution system,” IEEE Trans. Power Del., vol. 8, no. 4, pp. 1796–1801, Oct. 1993.
[8] L. Salasoo, A. F. Imece, R. W. Delmerico, and R. D. Wyatt, “Comparison of superconducting fault limiter concepts in electric utility applications,” IEEE Trans. Appl. Superconduct., vol. 5, no. 2, pt. 1, pp. 1079–1082, Jun. 1995.
[9] P. Bennich, M. De Oliveira, and A. Wikstrom, “Design and control of a current-controlled current limiting device,” in Proc. European Power Electronics Conf., Leoben, Austria, 2001.
[10] N.Woodley, M. Sarkozi, F. Lopez, V. Tahiliani, and P. Malkin, “Solidstate 13 kV distribution class circuit breaker: Planning, development and demonstration,” in Proc. Inst. Elect. Eng., Int. Conf. Trends in Distribution Switchgear, London, U.K., 1994, pp. 163–167.
[11] M. Steurer, K. Frohlich, W. Holaus, and K. Kaltenegger, “A novel hybrid current limiter breaker for medium voltage: Principle and test results,” IEEE Trans. Power Syst., vol. 18, no. 2, pp. 460–467, May 2003.
[12] J. Power, “An overview of transmission fault current limiter,” (in 1995/026) Inst. Elect. Eng. Colloq. Fault Current Limiter-A Look at Tomorrow, Jun. 1995.
[13] E. M. Leung, “Superconducting fault current limiters,” Inst. Elect. Eng. Power Eng. Rev., vol. 20, no. 8, pp. 15–18, 2000.
[14] M. M. R. Ahmed and G. Putrus, “Investigation into custom power technology,” in Proc. UPEC, 1999, pp. 519–522.
[15] M. M. R. Ahmed, G. A. Putrus, L. Ran, and R. Penlington, “Measuring the energy handling capability of the metal oxide varistor,” presented at the Proc. 16th Int. Conf. on Electricity Distribution, Amsterdam, The Netherlands, 2001.
[16] M. M. R. Ahmed, G.A. Putrus, L. Ran, and L. Xiao, “Harmonic analysis and improvement of a new solid-state fault current limited,” IEEE Trans. Ind. Appl., vol. 40, no. 4, pp. 1012–1019, Jul./Aug. 2004.
[17] Meyer, S. Schroder, and R. W. De Doncker, “Solid-state circuit breakers and current limiters for medium-voltage systems having distributed power systems,” IEEE Trans. Power Electron., vol. 19, no. 5, pp. 1333–1340, Sep. 2004.
[18] [18] “A hybrid fault current limiting and interrupting device,” Transl.: G. A. Putrus, M. M. R. Ahmed, L. Ran, L. Xiao, R. Penlington and S. May GB2375902, Nov. 2004.
[19] Birtwhistle and A. Kirvda, “Failure modes of LV overhead insulated mains,” IEE Power Eng. J., vol. 13, no. 6, pp. 309–319, 1999.
[20] SEMIKRON Application Manual, [Online]. Available: http://www. semikron.com/internet/index.jsp?sekId=13.
[21] “Transient Voltage Suppression Products,” Harris Corp., 1999, Harris Tech. Inform., Appl. Manual.
[22] K. Sheng, B. W. Williams, X. He, Z. Qian, and S. Finney, “Measurement of IGBT switching limits,” in Proc. IEEE Power Electronics Specialist Conf., Charleston, NC, 1999, vol. 1, pp. 376–380.
[23] H. Soonwook, C. Venkatesh, and D. A. Torrey, “Series connection of IGBT’s with active voltage balancing,” IEEE Trans. Ind. Appl., vol. 35, no. 4, pp. 917–923, Jul./Aug. 1999.