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A review on Autorecloser control methodology for improved distribution reliability

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Abstract- In electric power distribution, an Autorecloser is a circuit breaker equipped with a mechanism that can automatically close the breaker after it has been opened due to a fault. Autoreclosers are used on overhead distribution systems to detect and interrupt momentary faults. Since many short-circuits on overhead lines clear themselves, an Autorecloser improves service continuity by automatically restoring power to the line after a momentary fault.

The Autorecloser shall be designed for pole mounted or substation installation. All of the unit's protection, control and metering functions shall be electronically controlled within an integrated, modularized control unit. This paper gives a brief knowledge about the autoreclosers and its role in improving electrical power distribution reliability of the system.

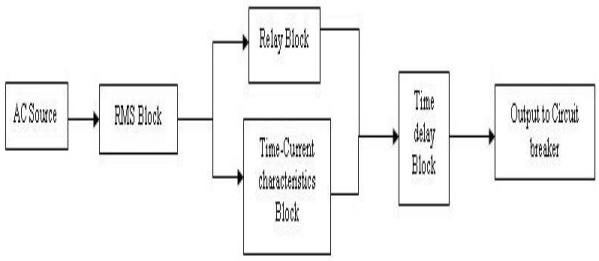
I. INTRODUCTION

Switchgear and control gear are necessary at every switching point in power systems. The switchgear and control gear industry in India is a fully developed industry, producing and supplying a wide variety of switchgear and control gear items needed by industrial and power sectors. Autorecloser is a circuit breaker equipped with a mechanism that can automatically close the breaker after it has been opened due to a fault. Automatic circuit reclosing is extensively applied to overhead line circuits where a high percentage of faults that occur are transient in nature. The Smart Grid is idea of a better electricity delivery infrastructure. Smart Grid implementations will certainly increase the quantity, quality, and use of information available from advanced sensing, and communications hardware and software. The Smart Grid is idea of a better electricity delivery infrastructure. Smart Grid implementations will certainly increase the quantity, quality, and use of information available from advanced sensing, computing, and communications hardware and software [1][3] .

II. AUTORECLOSERS IN PRESENT AND FUTURE SYSTEMS

Figure 2.1 shows the control circuit of autorecloser which is located inside the subsystem.

i.Sine wave: The sine wave block is the representation of AC source that is considered as supply source. For recloser AC (230V) or DC (110V) source can be considered as supply source.



Block diagram of Autoreclosers

ii.RMS (Root Mean Square): The RMS block is used to measure the root mean square value of the instantaneous current passing through the recloser.

iii.Gain: The gain block is used to obtain peak value of the instantaneous current passing through the recloser.

iv.Time-Current Characteristics: The peak value will pass to two blocks; the first is a Function Block parameter which contains the fast curve of the recloser. This fast curve is based upon the IEEE INVERSE TIME CHARACTERISTICS EQUATIONS.

v.Relay: The next block is a Relay Block which allows its output to switch between two specified values (0, 1). If the current is less than a specific value (reclosers setting) the relay output will stay at zero value, if the current value is greater than that specific value and more the output of the relay will be stick with 1.

vi.Variable time delay: Variable Time Delay block receives the output of the previous two blocks as an input. The output of that block will be either 0 or 1 after a delayed time. If a fault current is passed through the relay; its output signal is 0, and this signal will be delayed (by the variable time delay block) for a short time inversely proportional to the fault current value. The output of the last block is a signal that opens the breaker switch. If the fault is a temporary one, the relay output will be 1, so that the breaker switch closes.

vii.Scope: The signal in the recloser control circuit is monitored at various levels with the help of scope. Basically, there are 4 scopes used at different level in recloser control circuit [7][8].

III. MECHANISM OF AUTORECLOSER

Autorecloser is a protective device with the ability to detect phase and phase-to-earth overcurrent conditions, to interrupt the circuit if the overcurrent persists after a predetermined time, and then to automatically reclose to re-energise the line. If the fault that originated the operation still exists, then the recloser will stay open after preset number of operations, thus isolating the faulted section from the rest of the system. In an overhead distribution system between 80 to 95 per cent of the faults are of a temporary nature and last, at the most, for a few cycles or seconds [4]. Thus, the recloser, with its opening/closing characteristic, prevents a distribution circuit being left out of service for temporary faults. Typically, reclosers are designed to have up to three open-close operations and after these a final open operation to lock out the sequence. The counting mechanisms register operations of the phase or earthfault units which can also be initiated by externally controlled devices when appropriate communication means are available. The operating time/current characteristic curves of reclosers normally incorporate three-four curves based on the number of shots, one fast (Definite time, extreme inverse (EI) or very inverse curves (VI)) and further delayed curves (coordinated normal inverse (NI) or user defined IDMT curves). Most of the modern reclosers give flexibility for the programmers to either program IEC 60255, ANSI/IEEE C37.112 or any user defined time current characteristics. Curve settings, recloser settings and number of recloser shots can be set different for phase and earth faults. This allows reprogramming of the characteristics to tailor an arrangement to a customer's specific needs without the need to change components. Co-ordination with other protection devices is important in order to ensure that when a fault occurs, the smallest section of the circuit is disconnected to minimize disruption of supplies to customers. Generally, the time characteristic and the sequence of operation of the recloser are selected to co-ordinate with mechanisms upstream towards the source. After selecting the size and sequence of operation of the recloser, the devices downstream are adjusted in order to achieve correct co-ordination. Autoreclosers are used to apply fuse saving schemes in distribution lines under transient fault conditions with the help of fast curves. Further numerical autoreclosers are programmed to detect under voltage, under frequency, live line protections. Directional elements can be enabled for ring type feeders. Autoreclosers needs to be set with cold load pickup and inrush restraint settings for better sensitivity [8] [6].

Autorecloser instrument transformers continuously monitor all the phase currents, voltages, neutral current (using earth current sensitive CTs) and frequency. Whenever fault is identified, first shot is carried out in instantaneous mode to clear temporary faults before they cause damage to the lines. This can be achieved using definite time characteristics, EI or VI curves during high fault currents. Since it is known that most of the distribution feeder faults are transient in nature, the instantaneous mode of recloser operation helps in saving the downstream fuses during temporary faults. If the fault is cleared during the first recloser time delay (first dead time delay), after the reclosing, the fuse would observe normal load current thus saving the fuse blow. The later shots operate on time delayed curve which are set based on the coordination (discrimination time delay) of fuse/recloser whichever is present downstream and upstream of the autorecloser. If the fault is permanent, the time-delay operation allows other protection devices nearer to the fault to open (sectionalisers / fuses), limiting the amount of the network being disconnected. Earth faults are less severe and more in number than phase faults and, therefore, it is important that the recloser has an appropriate sensitivity to detect them. One method is to use CTs connected residually so that the resultant residual current under normal conditions is approximately zero under perfectly balanced loading condition; however the settings are set considering the probable unbalance condition in the feeder load. The other method of detection is using core balanced CTs to detect most sensitive earth faults [3].

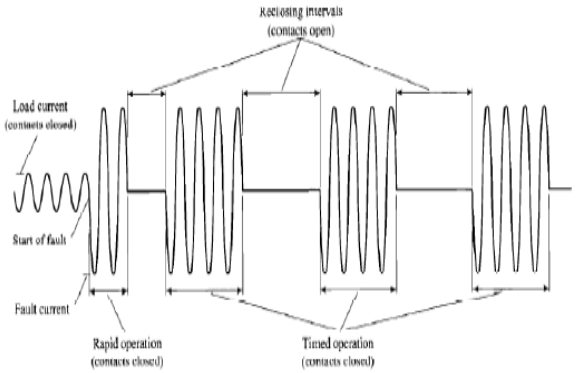


Figure 3. Sequence of Recloser operations.

IV. ADVANTAGES OF AUTORECLOSER

i. Since about 90% of faults are cleared by Autorecloser, it reduces the burden of fault detection and clearing time.
ii. Autorecloser provide good communication facility, For Ex: SMS service, event logging etc.
iii. Good metering ability of the Autorecloser helps in maintaining power quality to far end users.
iv. By the application of SCADA, many Autoreclosers can be monitored and operated simultaneously just by logging into the central computer.
v. In case of permanent faults, By the usage of in built protection algorithms in Autorecloser, it is possible to predict the approximate location of the fault.
vi. Autorecloser are provided with testing and troubleshooting kit, which reduces the maintenance work of Autorecloser.
vii. By the advanced features of Autorecloser, Reliability of the system can be increased [2] [3].

V. RESULTS AND DISCUSSIONS

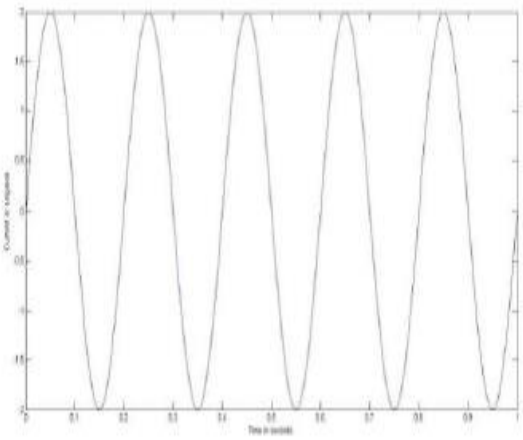


Figure 5.1 Input to Autorecloser control circuit

Figure 5.1 shows the sinusoidal AC instantaneous input fed to the autorecloser. Generally, the autorecloser is fed AC as input or DC in case of power failure. The sinusoidal input is resemblance of AC input fed to the recloser control circuit.

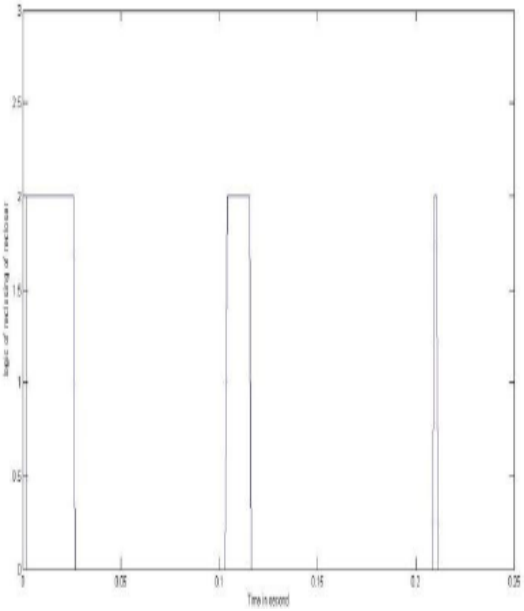


Figure 5.2 Reclosing attempts carried out by recloser

Figure 5.2 shows the reclosing attempt carried out by autorecloser when fault is still persistent even after first reclosing attempt. The frequency of reclosing depends upon system design, its capacity to withstand the continuous making and breaking of the breaker. Ideally, for distribution system the reclosing process is limited to 3 to 4 attempts to avoid major damage to the circuits. When a temporary fault occurs in the system, the breaker contacts get separated and reclosing is initiated. As the fault is temporary, the recloser generally resumes supply in first attempt itself. However, sometimes it may take 2 or 3 attempts. When persistent fault occurs in the system, as breakers keeps on tripping due to presence of fault and which results into failure in reclosing of breaker. Hence, system goes into lockout mode.

Various fault conditions in the present power system

The power system block diagram is constructed in SIMULINK environment and is simulated under various fault conditions.

Figures 5.3 and 5.4 clearly states that when phase to phase fault occurs in the system as no recloser is present in the system, the power system is needed to be checked for any existence of fault. This leads to increase in the outage time. In present power system, engineers has to go and manually check whether the fault is existing or not and after confirmation can resume the supply. But, the other parts of the system which are not affected by fault, faces outage.

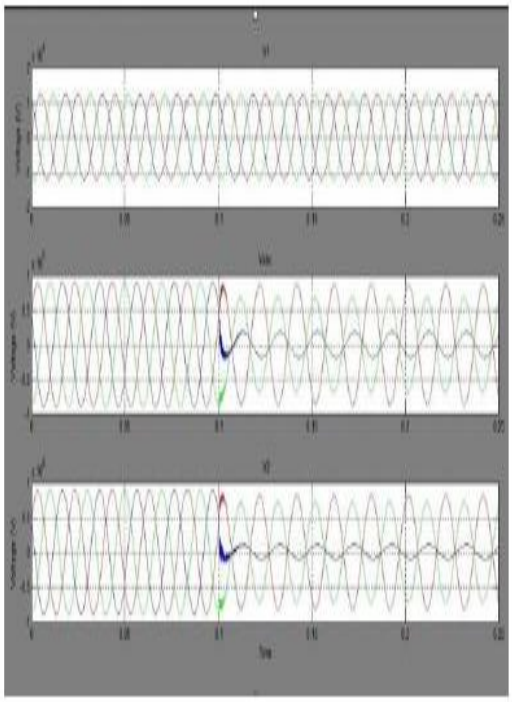


Figure 5.3 Voltage output near phase to phase fault generation.

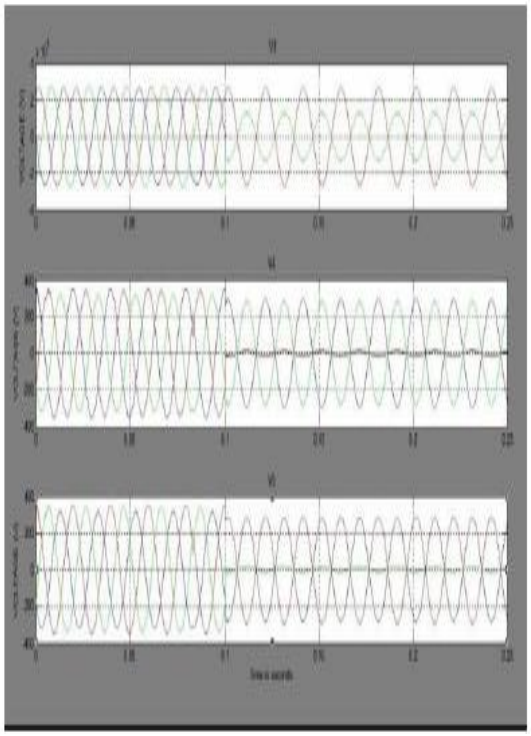


Figure 5.4 Voltage output near load during phase to phase fault.

Various fault conditions in the future power system:

Future power system basically consists of autorecloser and DG systems as parts of distribution system.

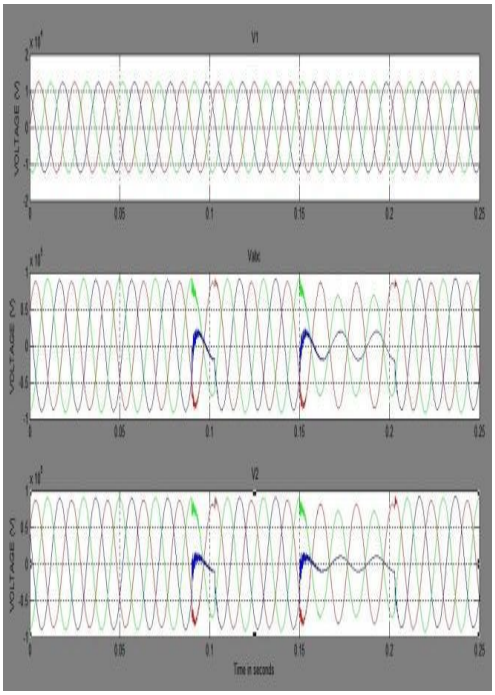


Figure 5.5 Voltage output near generation during phase to phase fault in presence of autorecloser.

Figure 5.5 and 5.6 shows the effect of having Aurorecloser in distribution system during phase to phase fault in the system. Due to the presence of autorecloser in the distribution system after two attempt the recloser resumes the supply to the affected system. This is possible only if the fault is temporary in nature.

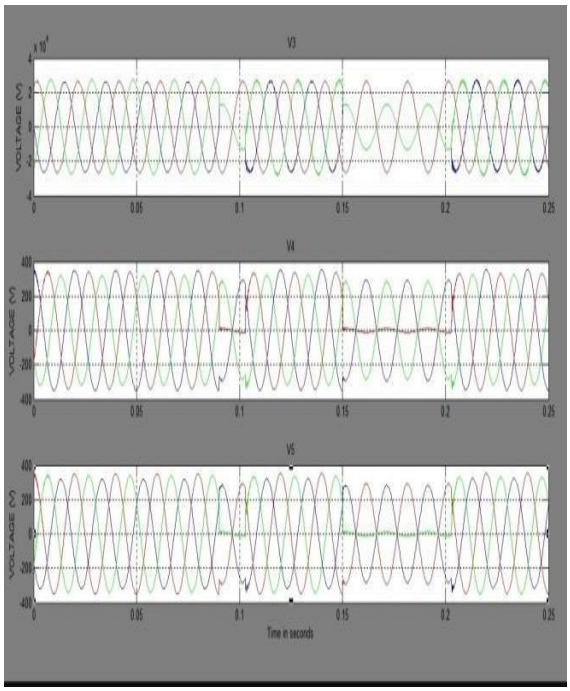


Figure 5.6: Voltage output near load during phase to phase fault in presence of autorecloser

Comparison of the results

Table 5.5: Theoretical and simulation values of reclosing time for given values of current.

Current (A)	Theoritical data (Reclosing time in seconds)	Simulation data (Reclosing time in seconds)
290	0.5	0.4
320	0.3	0.3
400	0.2	0.2
490	0.15	0.1
550	0.1	0.09
650	0.09	0.07
810	0.05	0.04
1150	0.04	0.03
2000	0.0333	0.02
3000	0.025	0.01
4000	0.015	0.09

Table 5.5 illustrates the theoretical and simulated data for given values of the current flowing through the recloser [7].

VI. CONCLUSION

By the usage of Autorecloser control methodology, Protection system for distribution network can be made Automated which is capable enough to operate and isolate only the faulted system elements at the earliest possible time without affecting the remaining system to maintain reliable power to the load [7].

The results obtained clearly states that the use of autorecloser with some modification will be beneficial if implemented in Indian power system. The use of decentralized generation in the distribution system will help the power system in reducing the outage time by diverting load to unaffected part. However, the decentralized generation system affects the recloser and fuse co-ordination. This problem is solved by selecting a DG system which does not affect recloser fuse co-ordination [6].

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