Implementation of Efficient Autorecloser Scheme in 132 kV Transmission System

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Abstract : Whenever fault occurs on overhead transmission lines, immediate tripping of the circuit breakers isolates the fault. However, reclosing of protective relaying is essential in high voltage transmission system (above 132 kV voltage level), due to the fact that 70-80% of total faults occurring on transmission system are temporary in nature. When such temporary fault occurs, it is necessary to restore the system to its normal state to improve service continuity. Hence, it is necessary to analyze the effect of auto-reclosing scheme on overhead High Voltage (HV) transmission line. The remaining 20% – 30% of faults are permanent in nature which does not clear upon tripping and reclosing. In this situation, the auto-reclosure scheme should be blocked.

This project describes new algorithm for coordination of protective relay and auto-reclosing scheme used in HV transmission line. The simulation of 132 kV transmission system along with relay modeling has been carried out in MATLAB/SIMULINK software package. The proposed scheme recloses the transmission line during transient faults and blocks/lockout the scheme during permanent faults. The results of simulation show the effectiveness of the proposed scheme in terms of both speed and reliability.

1. Introduction

Protection of the power system is critical for safety, maintaining security and supply quality and avoiding damage to equipmen t. It also has a crucial role to play in the modernization of the smart grid. Protective relays are modified to be adaptive, changing s ettings constantly to secure the system as a whole.

After all, 70 to 90% of electrical transmission faults are temporary in nature. A transient fault is a fault that is cleared by the instantaneous tripping of one or even more circuit breakers to separate the damaged section of the network, such as an insulator flashover, bird or kite falling fault, but that should not work until the line is further triggered. Commonly, faults are only present for a few periods that are in the 80% limit. In comparison, the remaining faults are semi-permanent in type. The remaining 10 - 30% of faults are of a semi-permanent or permanent type.

It is apparent that with the proper use of relay and breaker, further fault proportions can be effectively cleared. This de-energizes the transmission system completely to gain access to the fault origin and to deenergize the fault arc, then recloses the network instantly to resume service. Consequently, because of faults, the auto recloser will massively reduce the time and give the consumer routine service continuity.

This project describes new algorithm for coordination of protective relay and auto-reclosing scheme used in HV transmission line. The simulation of 132 kV transmission system along with relay modeling has been carried out in MATLAB/SIMULINK software package. The proposed scheme recloses the transmission line during transient faults and blocks/lockout the scheme during permanent faults. The results of simulation show the effectiveness of the proposed scheme in terms of both speed and reliability.

To confirm the desired system, by modeling 132 kV transmission systems several simulations have been carried out. Different faults on power transmission systems, ranging from transient to permanent, are assessed for the assessment of the proposed algorithm scheme.

2. AUTORECLOSER

Autoreclosing is the method of re-energizing a power device soon after a mistake has occurred. It takes advantage of the fact that about 80 to 90 percent of faults are transient in nature on overhead transmission lines. A signal will be sent by the autoreclosing relay to a CB to reclose, re-energizing the defective portion of the device. At this time, as the faults continue, the safety system will operate again and travel the line further, and the autoreclose will often be disabled and the fault should be permanent. The autoreclose relay, known as multi-shot recloser, will be set to attempt to reclose the number of times in many versions, primarily on the delivery side. In the setting of autoreclosing relays, there are different parameters involved, the most important of which are dead time, reclaim time and number of shots. Dead time is a moment after the safety operates until the first reclosure attempts at the reclosing relay, and the recovery time is the time from the first reclosure signal in anticipation of the relay being prepared to take action on other forms of faults. The number of shots is how many reclose attempts before the deadlock are permitted, normally set between different shots at increasing time durations.

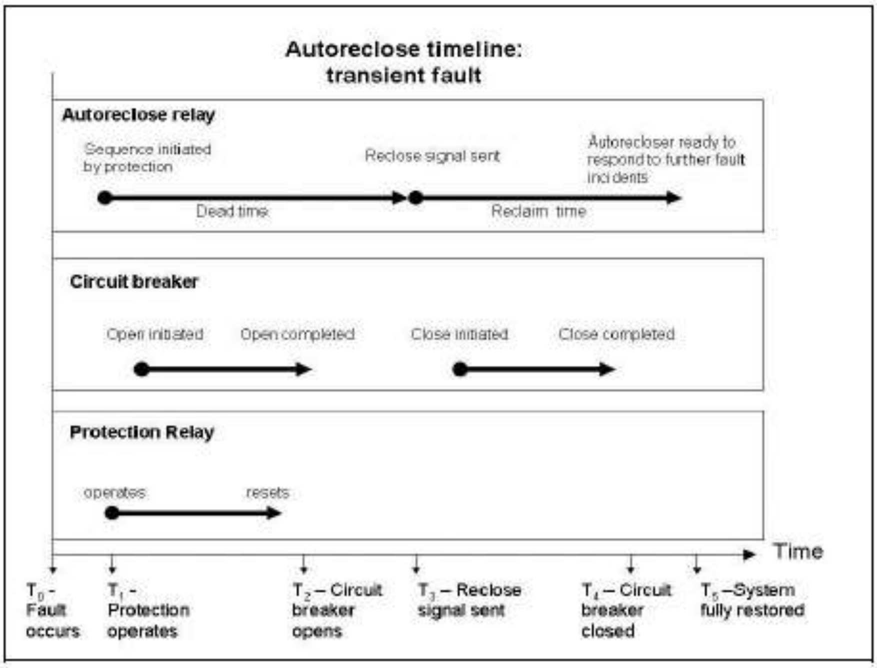


Figure 2.1 Autoreclose Timeline for Transient Fault

A series of behaviour relating to the operation of the CBs, the security relay and the autorecloser depends on the role of autoreclosing. On the timelines in figures 2.1 and 2.2, the process by which these fundamentals cooperate with each other can be visualized. Figure 2.1 describes how these components of the power system react to a temporary fault, and Figure 2.2 describes a permanent form of fault. For a single shot autoreclosing device, the principle shown here is that the autoreclosure is locked after the first failed attempt.

The design of autoreclosing systems depends greatly on the topology of the system, various switchgears, local protective relays and different levels of voltage. It must remember how different customer loads can be exaggerated by autoreclosing on the delivery side. Reclosing definitely offers benefits in terms of supply stability and reliability. Power system reliability can also be improved on freely linked transmission lines. The downside is unwanted secondary shocks caused by failed attempts to reclose the system. This can occur when a permanent fault is reclosed or a temporary arcing fault is not given sufficient time to extinguish the arc and to deionize the air in the arc direction.

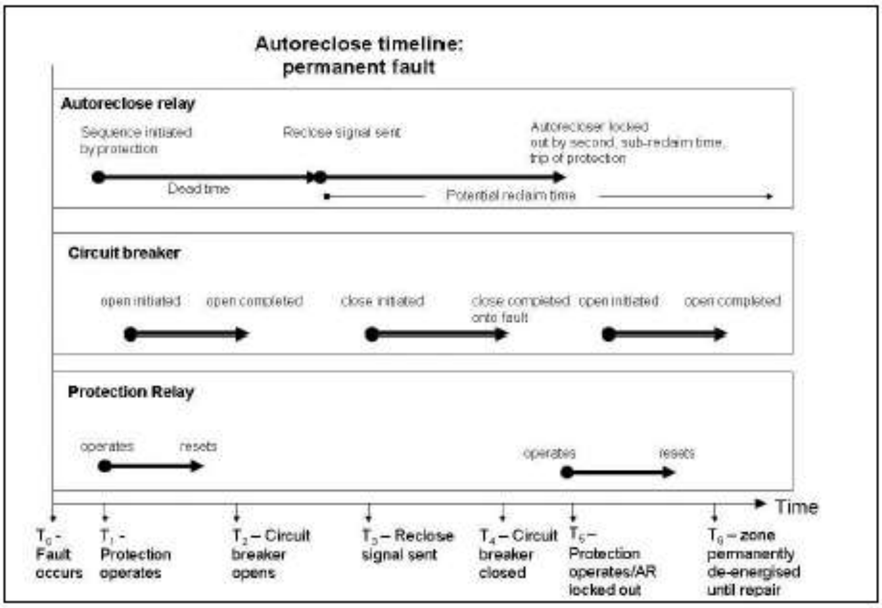


Figure 2.2 Autoreclose Timeline for Permanent Fault

3. AUTORECLOSER CONSIDERATION

Several variables must be included in the real system autoreclosure definition for power transmission lines. These all take into account whether it is helpful to allow specified autoreclosure close to the power system, and if so, what would be the formation of the model in the event of various faults.

Indispensable considerations in autoreclosure scheduling include, although they are not limited to:

Position of generating systems because unsuccessful reclosure attempts may cause damage through various torsional forces (especially in 3 phase autoreclosure),

The criticality of the power system-linked loads.

Coordination with other systems of defense, such as defects in other parts of the protected component (most faults on transformers, underground cables and switchgear are permanent and should have reclosure blocked)

CBs capacity-single pole feature, reaction time etc.

Coordination of the reclosing system with protective relay for power distribution lines when the power line has other sub-branches.

Besides, for particular operating scenarios, many time-varying parameters may read out whether autoreclosure should be blocked. Recent history of fault-this may suggest, for example, the existence of a recurrent transient fault because a tree limb is repeatedly blown onto the line. In this case, autoreclosure should be blocked for safety reasons when maintenance is done on live power lines.

Weather conditions, i.e. settings during a thunderstorm, can alter High-speed autoreclosing is usually the one that makes attempts to reclose as easily as possible. Typically this is pre-set at around 20 cycles or 400 ms, but varies depending on voltage levels and can be approximated with the following equation:

$$t = 10.5 + (V_{l-l}) / 34.5 \quad (3.1)$$

Where t is time expressed in cycles.

A synchronism check is not normally essential in rapid autoreclosing, so that the voltage phase and magnitude dissimilarity of buses at either end of the line are kept within permissible limits. This has common consequences for power supply reliability and stability in the scenario in which the original reclosure attempt is successful.

There are other older reclosure schemes where it is helpful to have an obstacle between the fault and the initial reclose shot. In addition, the environment for this DAR can be adaptive and managed by several variables. Whereas, for the purposes of this study, "adaptive autoreclosure" hereon applies to both: reclosure for temporary fault in the shortest possible period or blocking the reclosure for permanent fault in everything.

4. Operation of Autorecloser

A recloser can detect a fault at its most simple, and then open it before working automatically for a pre-programmed time. This automatic closure is known as an autoreclose, and it is possible to use multiple open and close sequences to minimize transient faults. The next autoreclose operation will reset the power supply if the line failure is transient and mitigated when the line is open. Ultimately, if the fault is permanent in nature, the recloser will open and not attempt to close unless directed by a private individual. This condition is referred to as the lockout of reclosers. Consumers have standardized until lockout on a limit of four safety trip operations. The first shot is always instant, while the next shots are programmed over time. (Fig. 4.1).

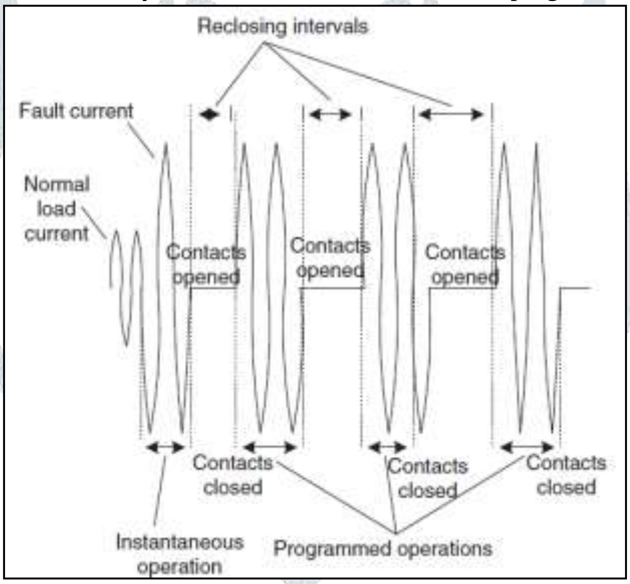


Figure 4 Sequence of Autoreclosure Operation

Early on, reclosers simply defined the current stage, de-energized for a preprogrammed number of times after a particular time period, energized and constant the chain. Multiple operations scored these devices; that is, downstream reclosers had less autoreclosure operations than upstream reclosers. All consumers on the affected feeder are subject to outages through this principle of grading, but only the first recloser upstream of the fault locks out and isolates downstream supply.

The next breakthrough was the implementation of current-dependent time for the power relay to work. IDMT curves are the terms usually used to describe the current-dependent operating rate. In the first reclosers, IDMT applications used electric and hydraulic mechanisms to provide a variable time from fault current detection to recloser opening. This time was inversely proportional to the fault current value and allows devices in series to be graded by using Cts with different turn ratios to be graded on current. These reclosers often incorporate mechanical means to provide the curve with a time multiplier, enabling serial equipment with different operating characteristics to be better organized. Current grading relies on downstream reclosers to open faster than upstream reclosers at a given fault level. Only the recloser works close to the fault; the upstream supply is not at all disrupted. A TCC controlled by the operating mechanism and the inaccuracy of the time to trip on any given fault current are limited to hydraulic operating mechanisms. This prohibits precise scoring, resulting in compromises that have to be made in lieu of fault conditions of all sorts. The preamble of electronic relays benefited from subsequent generations of reclosers to refine flexibility and time period precision for the trip of the circuit breaker. The development of control of microprocessors has led to the current generation of reclosers with increasingly primitive security capabilities

5. POWER TRANSMISSION NETWORK

Simulation of modelling of 132 kV power transmission network of test system is shown in following Figure. 2 synchronous generators are connected in this system which feed power to 132 kV power transmission network by step up it from 11 kV to 132 kV. At consumer side, a wind generator is connected which also feed surplus power to 132 kV transmission system through step up of transformers from 11 kV.

Test data for verifying the proposed adaptive scheme has generated by modelling the complete system using MATLAB/SIMULINK software package. The test data include different types of faults, such as L-G, L-L, L-L-G, L-L-L and L–L–L–G. Synchronous generator, wind generator, transformers, loads etc. components are designed according to the collected data and specifications.

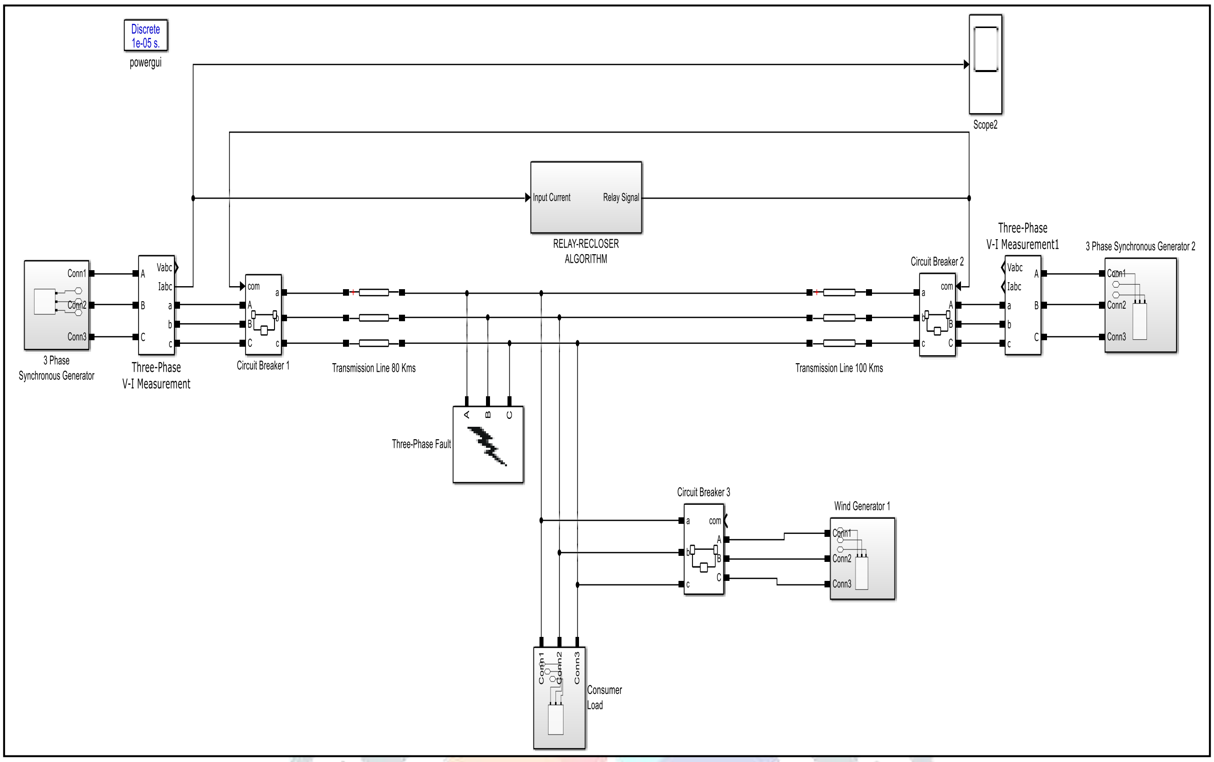


Figure 5 MATLAB Modelling of 132 kV Transmission System

6. RECLOSER MODELLING

The Recloser is normally equipped with inverse-time over current trip devices. The general characteristics of such devices can be described by the following equation.

$$t = \left[\frac{A}{(\mathrm{MP})^{c}-1} + B\right] \times \mathrm{TDS} \quad (6.1)$$

Where A, B, C are constants for particular characteristic, t is the operating time of device, TDS is the time dial setting, the value of TDS is set to be 0.5 is considered for the fast-mode Recloser whereas 1.0 for the slow-mode Recloser. MP is the multiple of pickup current. The flowchart of desired autorecloser algorithm is given in Figure (6.1)

$$MP = \frac{I_{F(CTS)}}{I_{pickup}} \quad (6.2)$$

Where $I_{f(CTS)}$ is the fault current referred to as CT secondary current, I_{pickup} is the Recloser current set point. The pickup current I_{pickup} for CB and Recloser can be computed by the nominal current $I_R$as shown by equation (6.3)

$$I_{pickup} = I_R \times OLF \quad (6.3)$$

Where, OLF is the overload factor that depends on the equipment being protected.

Flowchart of single shot autorecloser algorithm is shown in above Figure. 6.1 Which describes how autorecloser operates when different types of faults occurred in 132 kV transmission system.

Moreover, for other transient faults, such as L-L-G and L-L-L-G faults, output current waveforms are described in Figure 6.9 and Figure 6.10.

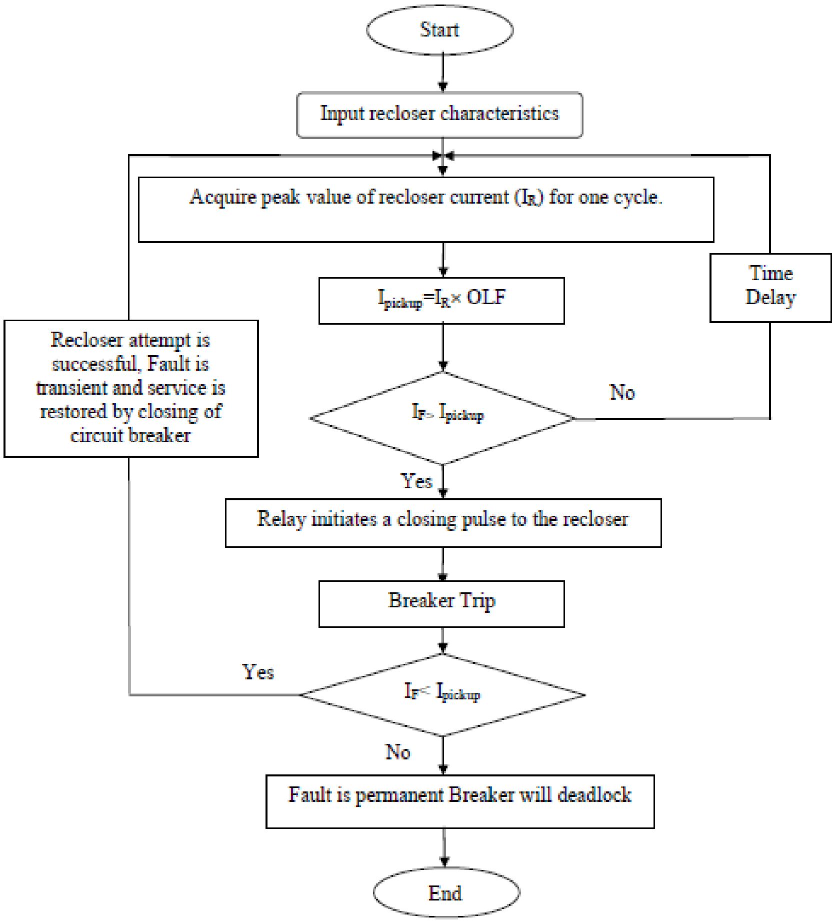


Figure 6.1 Flowchart of Single Shot Autorecloser Algorithm

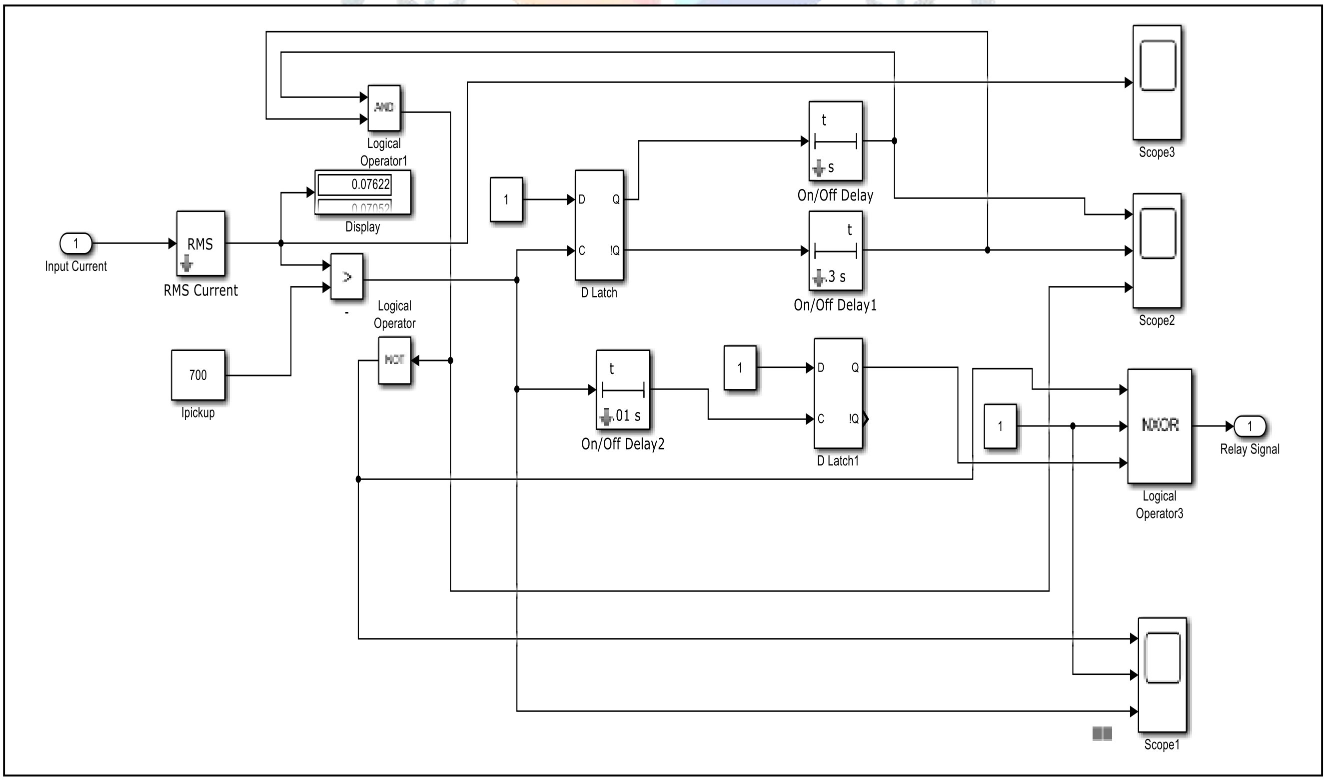
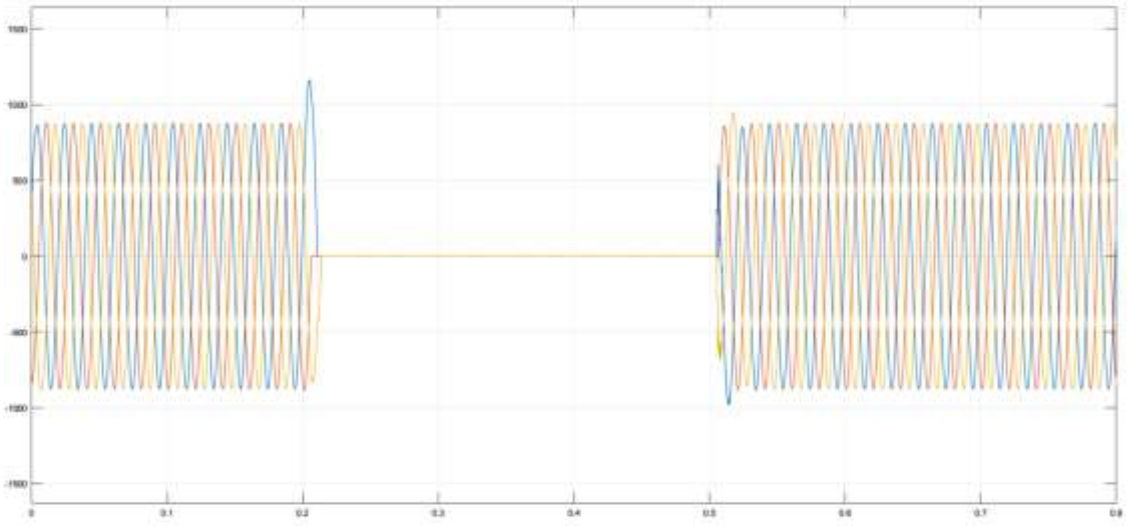


Figure 6.2 MATLAB Modelling of Relay and Single Shot Autoreclosure Algorithm with its Coordination

Table 6.1 Operating time of the proposed single shot autoreclosure scheme for different types of faults.

Sr. No.	Fault	Operating time of Recloser (s)	Value of Rated Current (Amp)	Value of Fault Current (Amp)
1	L-G	0.0104	600	784.15
2	L-L-G	0.0138	600	814.27
3	L-L-L-G	0.0151	600	783.35
4	L-L	0.0139	600	810.96
5	L-L-L	0.0115	600	785.25

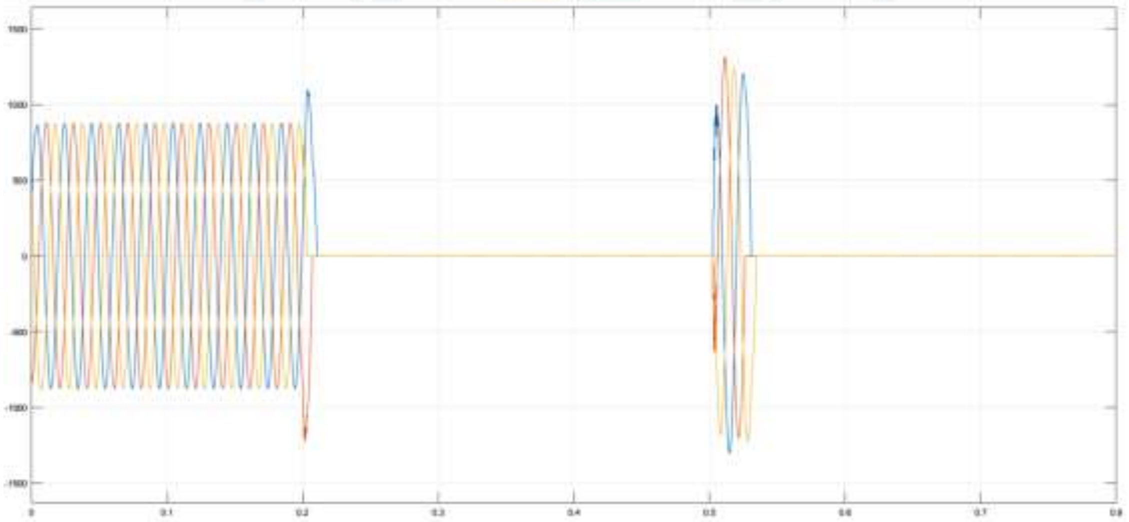
Current in Ampere



Time in Seconds

Figure 6.3 Output Current Waveform during Transient L-G Fault (For 0.3 Second Time Delay)

Current in Ampere



Time in Seconds

Figure 6.4 Output Current Waveform during Permanent L-G Fault (For 0.3 Second Time Delay)

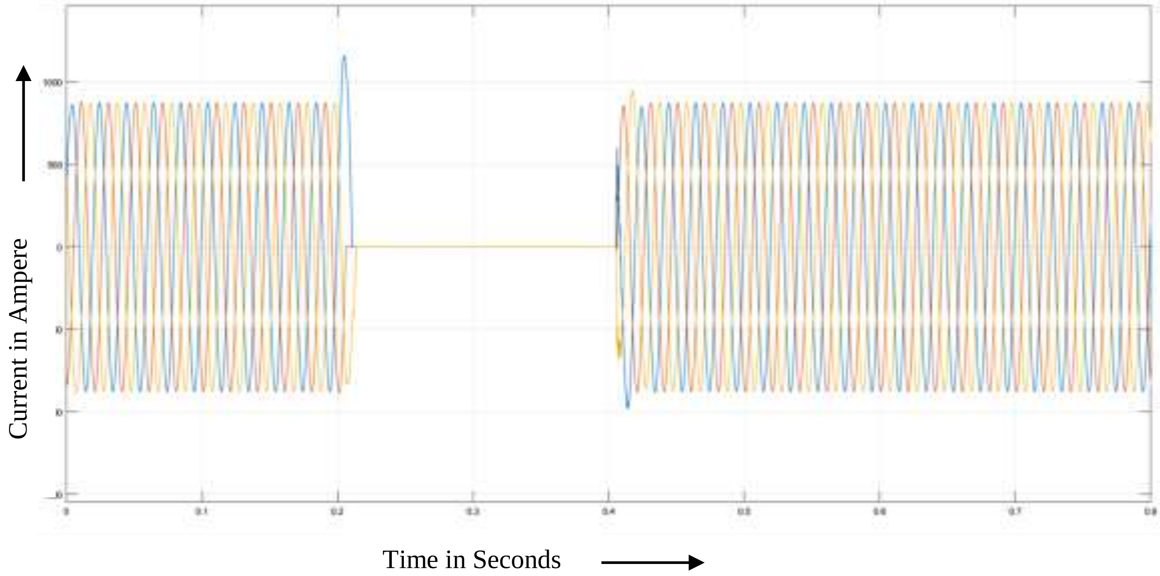


Figure 6.5 Output Current Waveform during Transient L-G Fault (For 0.2 Second Time Delay)

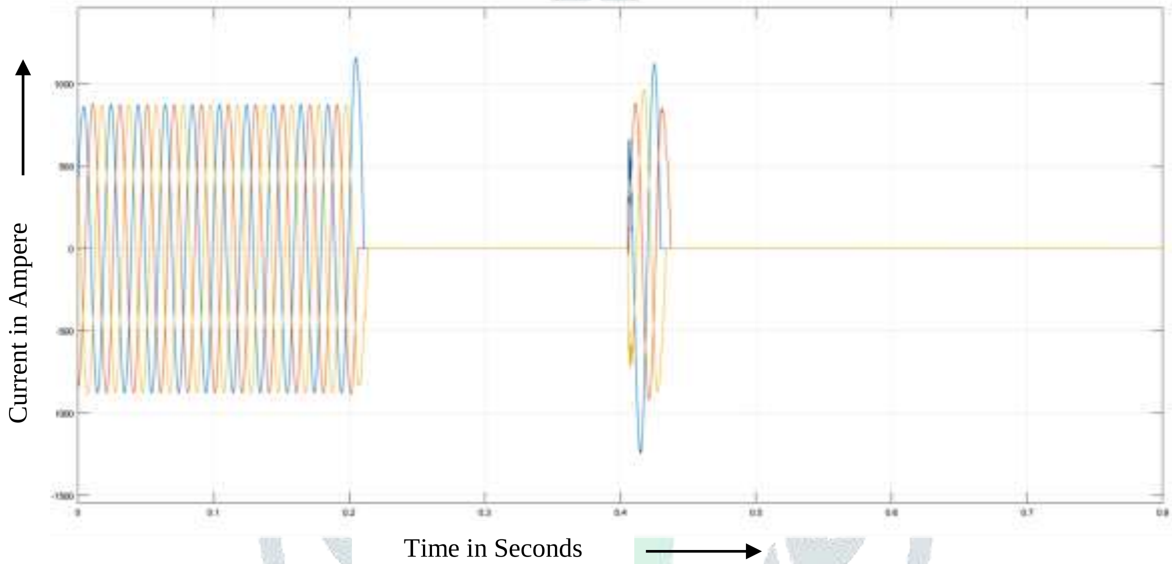


Figure 6.6 Output Current Waveform during Permanent L-G Fault (For 0.2 Second Time Delay)

Similarly, for other permanent faults, such as L-L-G and L-L-L-G faults, output current waveforms are described in Figure 6.7 and Figure 6.8.

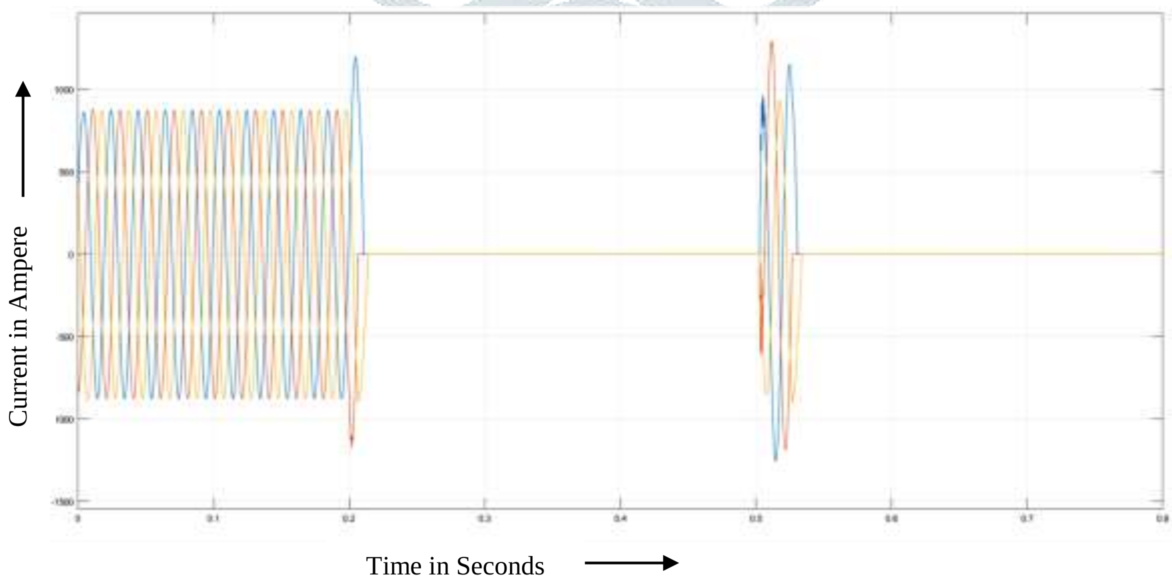
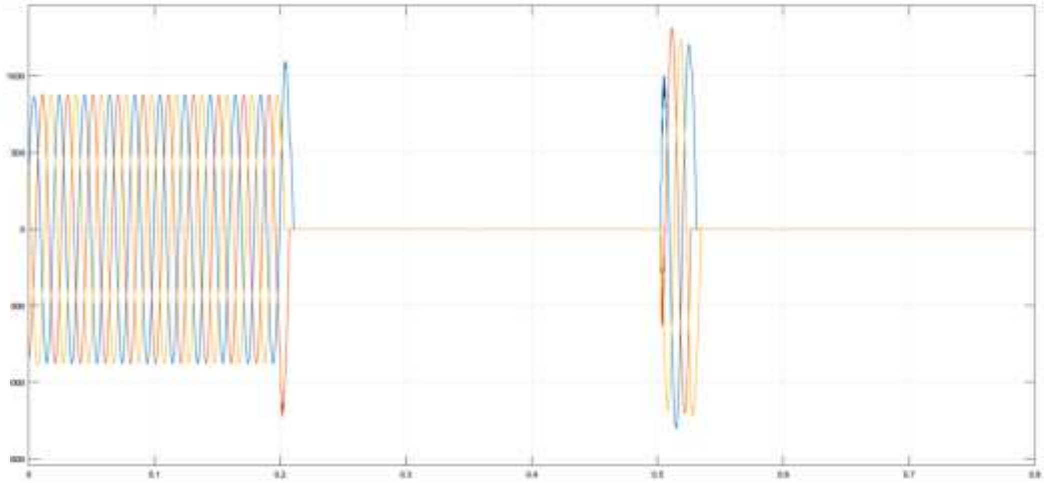


Figure 6.7 Output Current Waveform during Permanent L-L-G Fault (For 0.2 Second Time Delay)

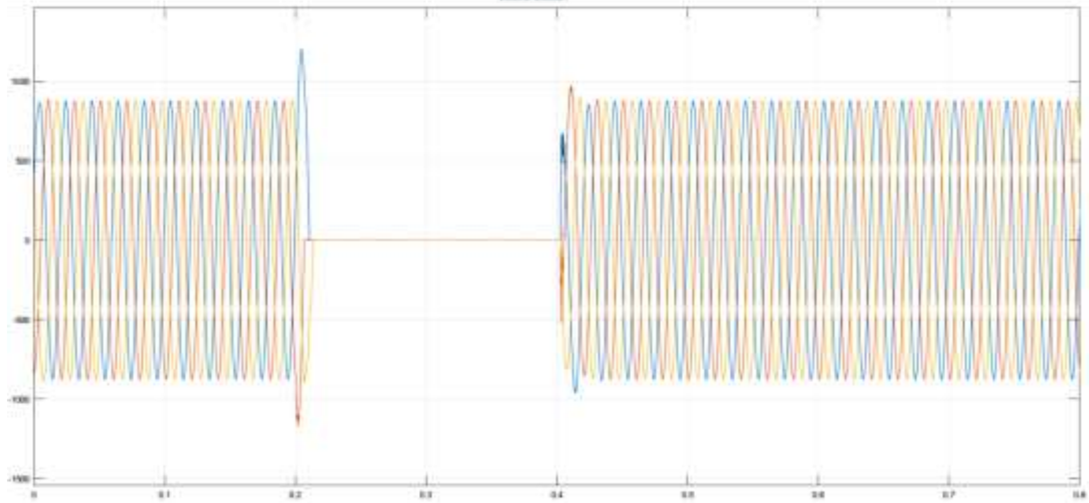
Current in Ampere



Time in Seconds

Figure 6.8 Output Current Waveform during Permanent L-L-L-G Fault (For 0.2 Second Time Delay)

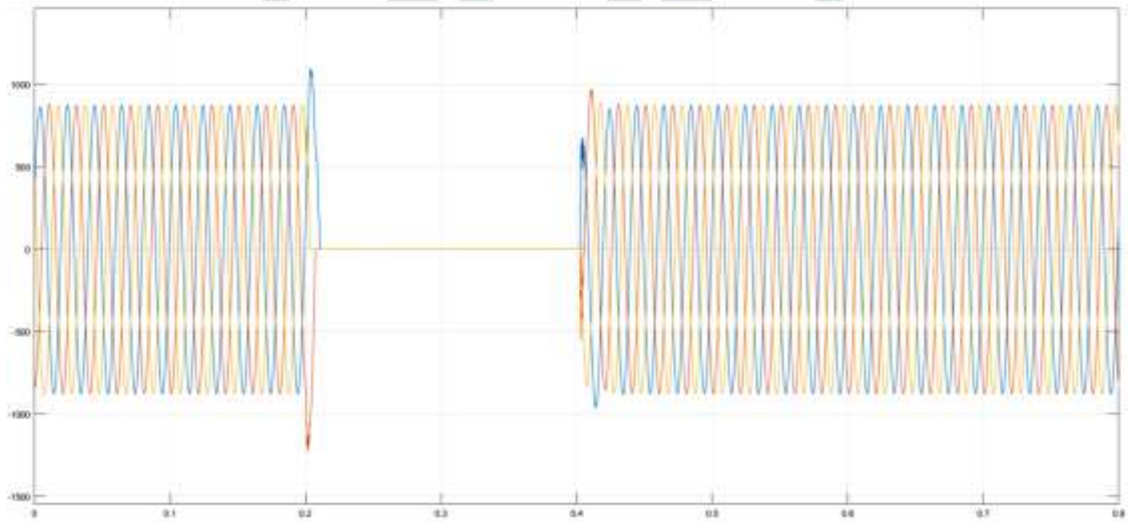
Current in Ampere



Time in Seconds

Figure 6.9 Output Current Waveform during Transient L-L-G Fault (For 0.2 Second Time Delay)

Current in Ampere



Time in Seconds

Figure 6.10 Output Current Waveform during Transient L-L-L-G Fault (For 0.2 Second Time Delay)

7. RELAY SIGNALS FOR CIRCUIT BREAKER

As per the condition of transmission system, relay-recloser system generates a signal to operate the circuit breaker during abnormal conditions which is produced by the proposed algorithm. The waveforms of signals have shown in Fig. 7.1.
It is clearly state that autoreclosure instantly penetrate when fault is occurred.

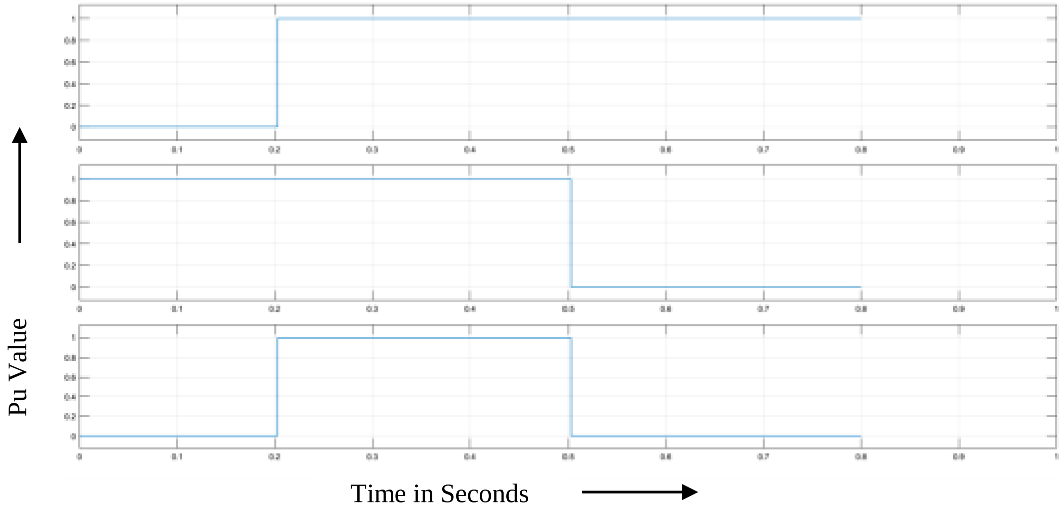


Figure 7.1 Relay Signals

8. CONCLUSION

This paper showcasing the application of Autoreclosure in 132 kV transmission system for different types of faults.

Implementation of single-shot Autorecloser scheme in 132 kV transmission system improves its continuity & reliability which is lucrative for power transmission and distribution.

9. REFERENCES

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