Analysis of Suitable Setting for Optimal Reclosing Time on 230kV Transmission Line using Alternative Transient Program (ATP)

San Thiri Aung

Department of Electrical Power Engineering, Yangon Technological University,
Yangon Technological University, Insein Township, Yangon, Myanmar
Email – santhi224210@gmail.com

Abstract: *This paper states that the analysis of suitable setting for optimal reclosing Time for 230kV Kamarnat-Myaungtagar line. The reclosing time is to reclose circuit breaker (CB) followed by a time delay after CB had tripped for restoring the system to normal as quickly as possible without regard to the system conditions. This time is made up of the circuit breaker time plus the system electrical dead time. Autoreclosure provides a means of improving power transmitting ability and system stability. Conventional auto-reclosing of circuit breakers adopts the fixed dead time interval which can affect the stability and power quality of the system. Circuit breaker should be reclosed at an optimal reclosing time to enhance the transient stability when the system disturbance has no effect after reclosing operation. Both transient and permanent fault in the power system model are considered. The optimal reclosing time is verified by simulation study using Alternative Transient Program/Electromagnetic Transient Program (ATP/EMTP).*

Key Words: *Auto-reclosing, Fault, Transient Stability, Alternative Transient Program/Electromagnetic Transient Program.*

1. INTRODUCTION:

Reclosures are means of increasing the dependability of a supply. Auto-reclosing is the important action, leading to an increasing of the reliability of the electrical power transmission. 80-90% of faults on any overhead line network are transient in nature. The remaining 10%-20% of faults are either semi-permanent or permanent. Transient faults are commonly caused by lightning and temporary contact with foreign objects. The immediate tripping of one or more circuit breakers clears the fault. Subsequent re-energization of the line is usually successful.

Unsuccessful reclosure in response to a permanent fault may threaten system stability and aggravate severe damage to the system and equipment. For this reason, it is very important in a reclosure sequence to distinguish a permanent fault from a transient fault. However, conventional autoreclosure techniques adopt fixed dead time interval techniques, where the breaker recloses as quickly as possible after a prescribed period following tripping operation regardless of whether the fault is permanent or transient. Although a permanent fault can be distinguished from a transient fault and the secondary arc extinction time can be estimated, the faster dead time proposed is not necessarily better for enhancing the transient stability because reclosing immediately following secondary arc extinction in the case of a transient fault can lower the chance of a successful reclosure. Optimal reclosure can also improve the transient stability. [1]

At present in power system, proper reclosing scheme is not still used and manual reclosing after fault. So, system blackout time can be longer and can be unsuccessful reclosing lead to system instability. The method of autoreclosure is an economical and effective technique for high capacity electric power system to improve reliability and stability. After fault clearing, adaptive auto reclosing scheme is used for system restoring without system blackout. Therefore, the proper reclosing time for power transmission system should be chosen for optimal condition.

The objectives of this paper are to determine proper setting of auto-reclosing, to optimize reclosure algorithm to minimize shock and damage to the power system when reclosure fails due to permanent faults, to determine optimal reclosing time for system stability and to determine suitable settings for Auto Reclosing Scheme of system after carrying out stability analysis without loss of synchronism.

2. AUTORECLOSING:

Auto-reclosing is an important technique for the speedy restoration of faults, improvement of system stability and the prevention of power system disturbances. The method of auto-reclosing is an economical and effective technique for high capacity electric power systems to improve reliability and stability. If auto-reclosing is successfully executed, it usually restores the stability of the system and maintains the continuity of electric power transmission. Sufficient time must be allowed after tripping for the fault arc to de-energize prior to reclosing otherwise the arc will re-strike. The purposes of auto-reclose scheme are to enhance continuity of supply for medium voltage and to maintain System Stability and Synchronism. [2]

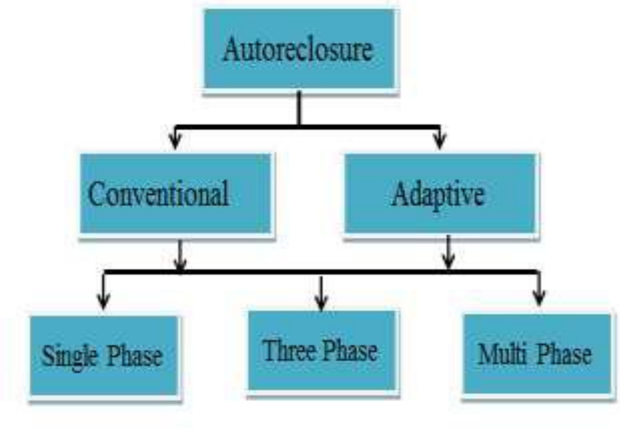

Fig.1 Type of Autoreclosure

A. Conventional Autoreclosure

Conventional Reclosure adopts the fixed time interval strategy to restore the system to normal as quickly as possible without regard to the system conditions (permanent of transient fault) after a prescribed period following tripping operation. It cannot guarantee that reclosing will be successful.

B. Adaptive Autoreclosing

Adaptive autoreclosures avoid reclosing permanent faults and reclose to transient faults only after the secondary arc has extinguished. This is a fast-emerging technology for improving power system marginal stability during fault and it includes variable dead time, optimal recloser and phase by phase recloser in order to improve system stability. The advantages of autoreclosing are:

- Minimized unsuccessful reclosing,
- Improvements in transient stability margins,
- High-speed response to sympathy trips and
- Reduction in system and equipment shocks.

C. Application of Autoreclosing

The most important parameters of an auto-reclose scheme are: [3]

- Dead time
- Reclaim time
- Single or multi shot

Dead time is the time between the auto-reclose scheme being energized and the completion of the circuit breaker closing contactor.

Reclaim time is the time from the making of the closing contact on the auto-reclose scheme relay to the completion of another circuit within the auto-reclose scheme which will reset the scheme or lock out the scheme or circuit breaker as required.

Number of shots is the number of attempts at reclosing which an auto-reclose scheme will make before locking out on a permanent fault. The number of shots may be fixed or adjustable.

3. FAULT TYPE AND RECOVERY VOLTAGE:

A. Different Type of Faults

Faults on overhead lines fall into one of three categories. They are transient, semi-permanent and permanent. According to statistics, 80-90% of fault on any overhead line network are transient in nature. The remaining 10%-20% of faults are either semi-permanent or permanent. Transient faults are commonly caused by lighting and temporary contact with foreign objects. A small tree branch falling on the ling could cause a semi-permanent fault. Permanent faults are broken conductors and faults on underground cable sections.

B. Fault Type Depending upon Recovery Voltage

In a reclosure sequence, it is very important to distinguish clearly between a permanent fault and a transient fault. In this paper, the voltage waveforms are used to distinguish the fault types and estimate the secondary arc extinction time in the three-phase auto-reclosure as well as the single-pole auto-reclosure. Using these characteristics, the estimation of transient fault and the secondary arc extinction time is possible. [4]

4. CALCULATION OF DEAD TIME:

Based on relaying theory and application by ABB at 50 Hz, the equation of minimum dead time (T) is as following. [5]

T = 10.5 + kV / 34.5 cycles
For 230kV transmission lines, T = 10.5 + 220/34.5 = 16.87 cycles = 337.5 ms
For 132kV transmission lines, T = 10.5 + 132/34.5 = 14.32 cycles = 286.5 ms
For 33kV transmission lines, T = 10.5 + 33/34.5 = 11.45 cycles = 229 ms
For 11kV transmission lines, T = 10.5 + 11/34.5 = 10.82 cycles = 216.4 ms

5. CASE STUDY OF TRANSMISSION LINE FOR OPTIMAL RECLOSING TIME:

In this paper, the following case studies are analyzed and tested with Alternative Transient Program/Electromagnetic Transient Program (ATP/EMTP) depend upon calculation of circuit breaker arc extinguishing time.

- Case-1 Normal Conditions
- Case-2 Single Line to Ground Fault
- Case-3 Selection of Optimal Reclosing Time

A. Transmission System Model

Simulation tests were performed on the test model of a 230kV Kamarnat-Myaungtagar transmission system shown in Figure 2. This system is implemented through ATP/EMTP software.

Single line to ground fault transients on 230kV interconnection is investigated. At the sending end of the line shunt reactors are connected with neutral reactors to reduce the secondary arc current during the dead time of the single-phase reclosing. The fault has been initiated at the receiving end of the line.

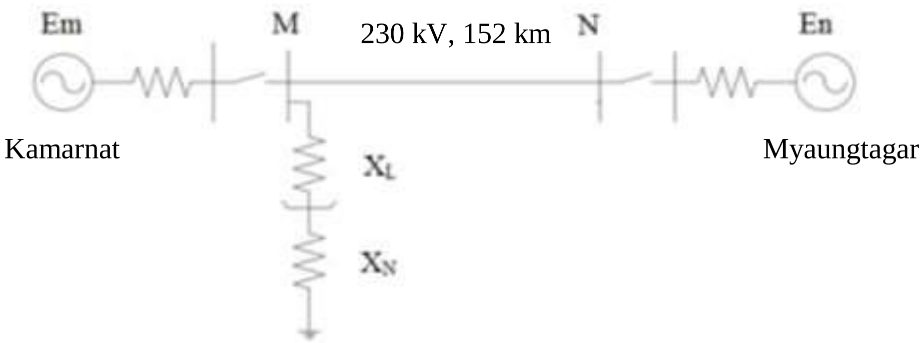

Fig.6 230kV ShweTaung-MyaungTaGar Transmission Line

B. Transmission System Model by ATP/EMTP

The one-line diagram of the completed ATP Draw circuit is shown in Fig. 3. There are two transpositions for 151.29 km length and each LCC object represents a line section between two transpositions with length 50.67 km respectively. The single-phase shunt reactors are represented by linear RLC components. The impedance of the fault arc is considered as 2-ohm constant resistance.

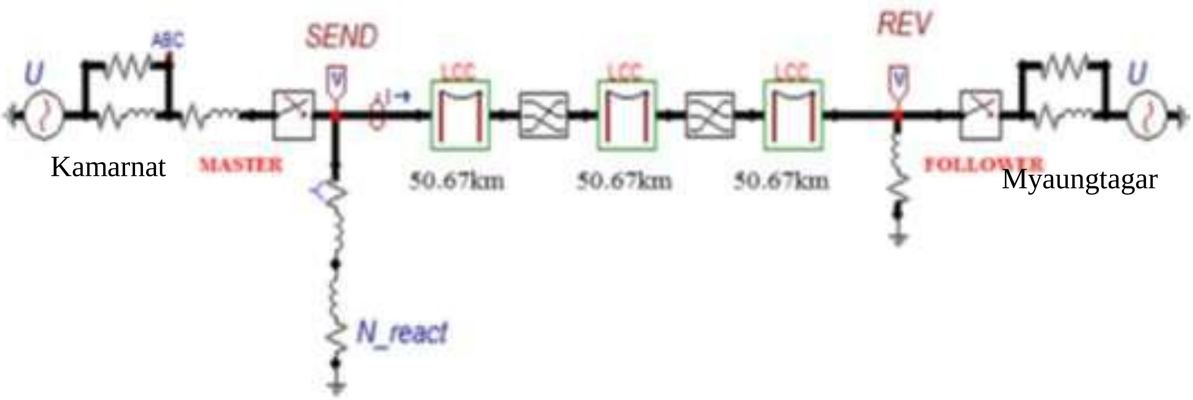

Fig.3 EMTP Simulation Model of 230kV Kamarnat-Myaungtagar Transmission Line

6. SIMULATION RESULTS:

A. Case Study 1: Normal Condition

Fig.4 shows normal condition of power transfer with 230 kV for Kamarnat-Myaungtagar line. System rated voltage (230kV) is taken as base voltage. The per unit of normal voltage is 1 p.u. Acceptable overvoltage and undervoltage rating of line circuit breaker is +/- 12% of 230kV.The relay setting of circuit breaker is 6 milliseconds for waiting 3 cycles.

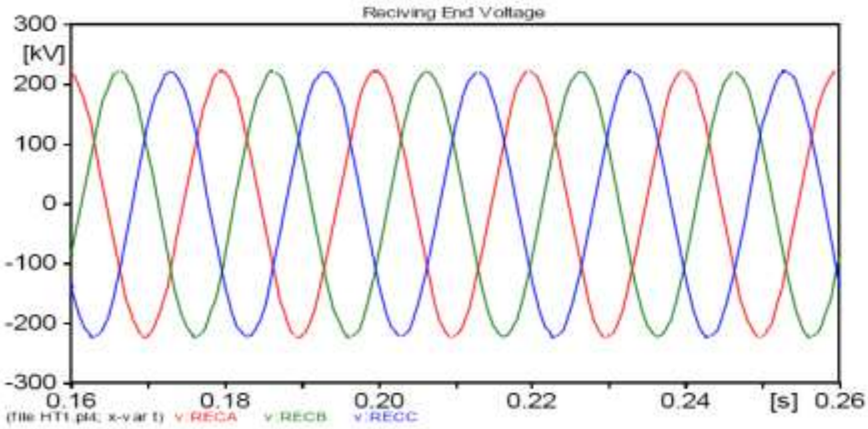

Fig.4 Normal Condition

B. Case Study 2: Single Line to Ground Fault

Figure 5 shows EMTP simulation model of 230kV Kamarnat-Myaungtagar transmission line with single line to ground fault.

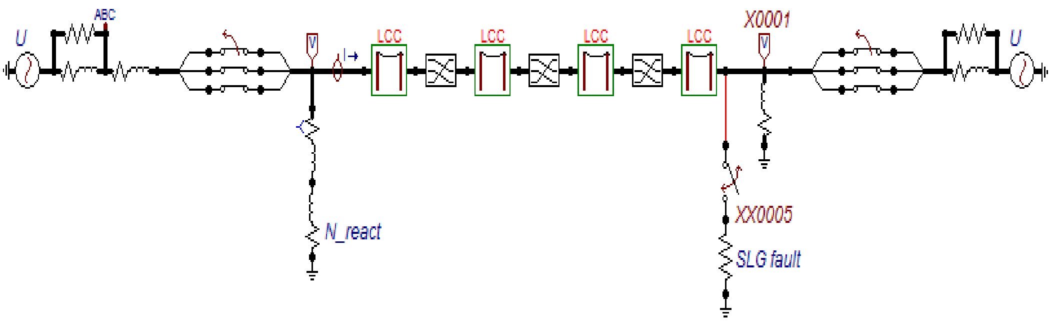

Fig.5 EMTP Simulation Model of 230kV HLawga-Tharyargone Transmission Line with Single Line to Ground Fault

- Single Line to Ground Fault at Phase A

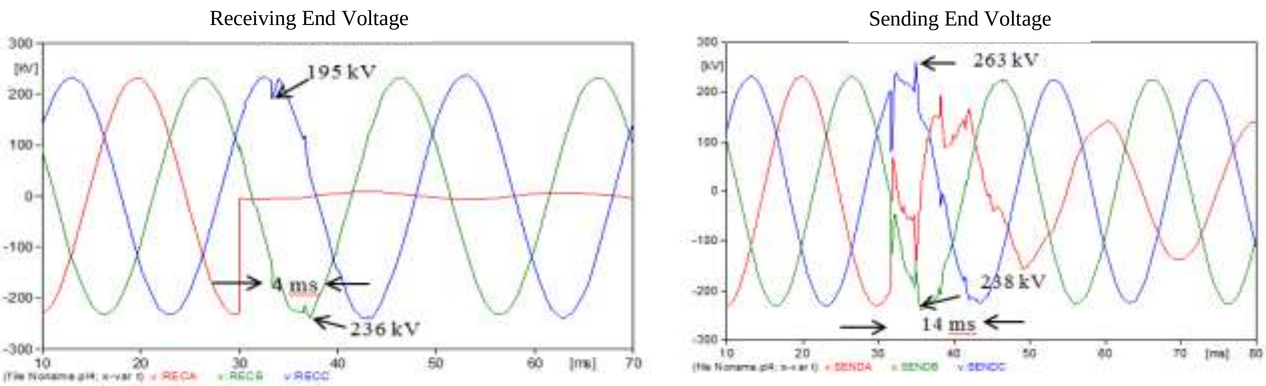

Fig.6 Receiving and Sending End Voltage when SLG fault Occurs

Both Sending and Receiving end overvoltage are within overvoltage acceptable level. Transient duration time 14 ms is not under CB's relay trip setting. (6 ms). CB will trip at both sides.

- Breaker Tripping Action

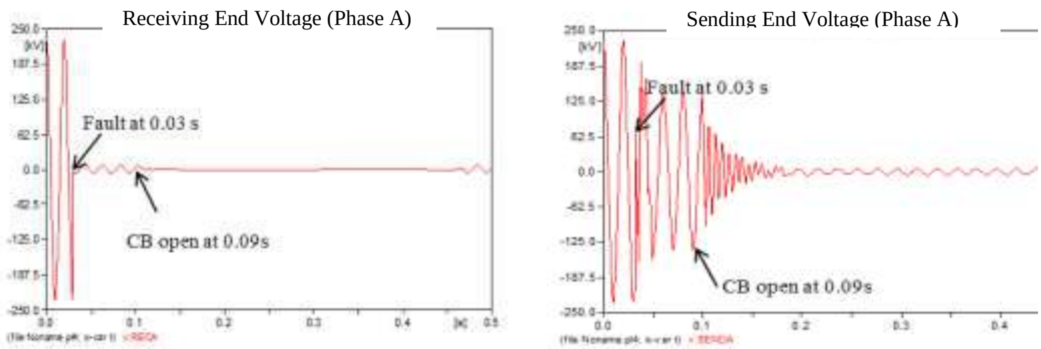

Fig.7 Receiving and Sending End Voltage when Breaker A opens

Figure 7 and 8 show breaker tripping action. Fault occurs at 0.03s and circuit breaker is waiting 3 cycles (0.06 s) to clear fault from the system. Therefore, breaker A opens at 0.09s.

- SLG fault and Fault Clearing

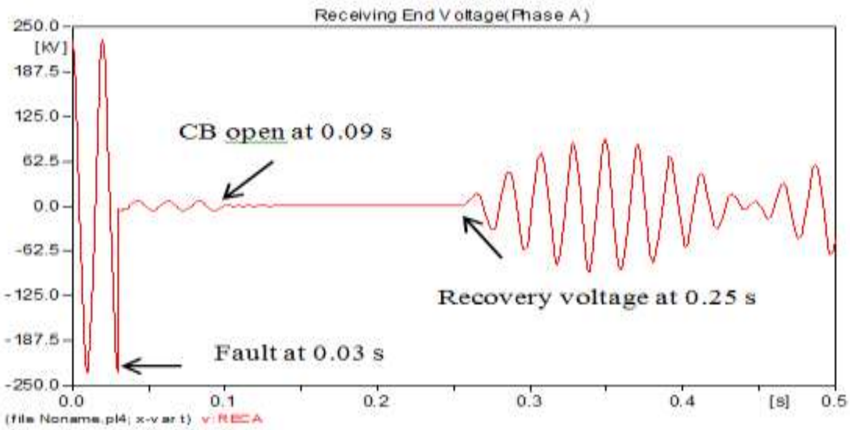

Fig.8 Receiving End Voltage after Fault Clearing

Figure 15 shows receiving end voltage after fault clearing. There is a fault at 0.03s at receiving end. Fault clear at 0.23s. Circuit Breaker (A) opens at 0.09s and recovery voltage appears after fault clearing. This type of fault is transient. So, CB should attempt to reclose.

C. Case Study-3: Selection of Optimal Reclosing Time
For ***230kV*** transmission lines,
T= 10.5 + 220/34.5 = 16.87 cycles= 337.5 ms=0.3375 sec

- Single Phase Auto Reclosing at 0.4275 sec

Master Relay reclose at 0.4275 s
Follower Relay reclose at 0.4675 s

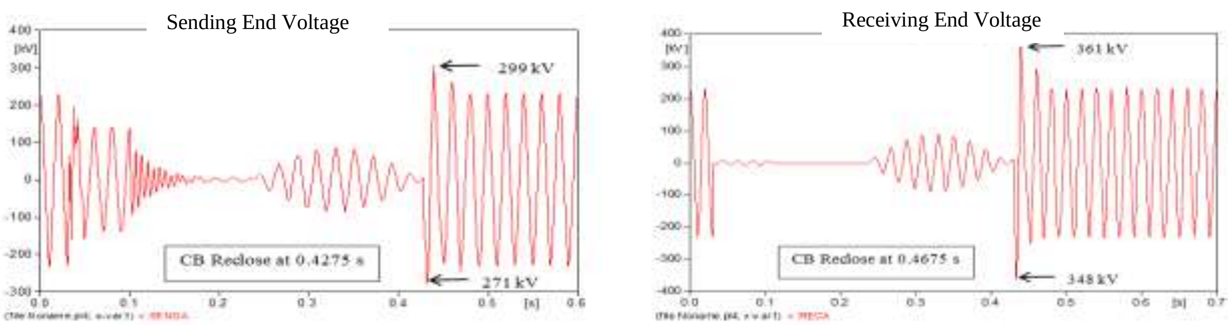

Fig.9 Sending and Receiving End Voltage after CB Reclose at 0.4275 s

Therefore, circuit breaker should be reclosed by the combination of trip time (0.09s) and arcing time (0.3375s). CB should reclose at 0.4275 s.

- Single Phase Auto Reclosing at 0.44 sec

Master Relay reclose at 0.44 s
Follower Relay reclose at 0.48 s

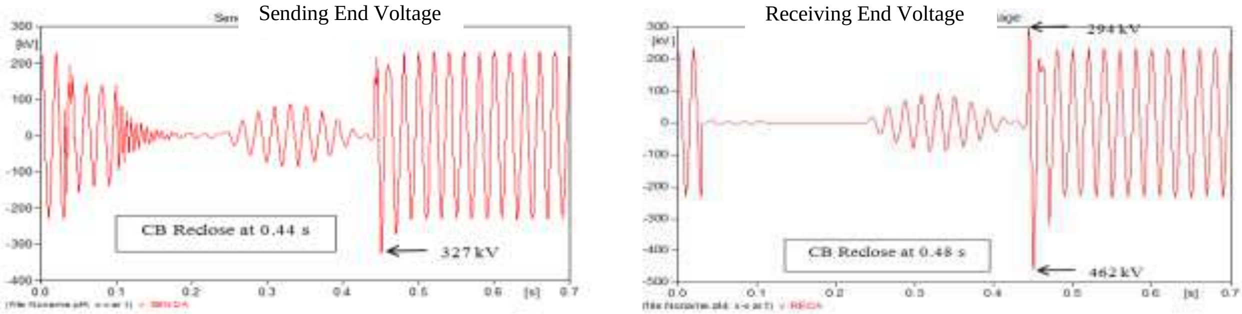

Fig.10 Sending and Receiving End Voltage after CB Reclose at 0.44 s

- Single Phase Auto Reclosing at 0.525 sec

Master Relay reclose at 0.525 s
Follower Relay reclose at 0.545 s

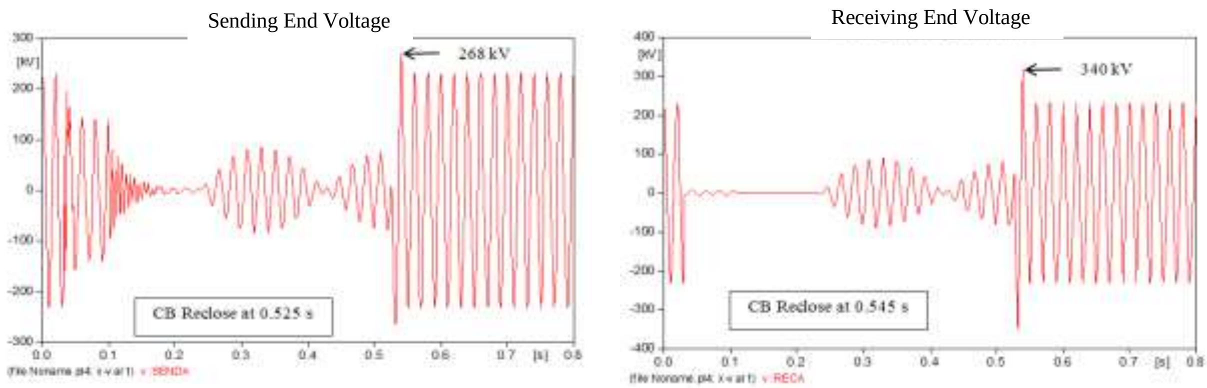

Fig.11 Sending and Receiving End Voltage after CB Reclose at 0.525 s

E. Comparison of Different Auto-reclosing Time

Table 1 shows the comparison of different auto-reclosing time based on conventional reclosing time. The time between master and follower relay is considered for 1 cycle (0.02 sec) and 2 cycles (0.04 sec). From the above comparison table by ATP/EMTP simulation results, Optimal Reclosing time should be chosen at 0.525 sec. Therefore, Master relay at Kamarnat should reclose at 0.525 sec and Follower relay at Myaungtagar should reclose at 0.545 sec for 1 cycle.

Table 1 Comparison of Different Auto-reclosing Time

Master Relay (sec)	Follower Relay (sec)	Sending End Peak Voltage (kV)	Receiving End Peak Voltage (kV)
0.4275	0.4675	299	361
0.44	0.48	327	462
0.35	0.37	343	482
0.525	0.545	268	340

7. CONCLUSION:

The results were analyzed using simulations created in ATP/EMTP software. The simulation results show that the fault types are classified by depending on recovery voltage waveform for optimal auto-reclosing. After distinguishing the transient and permanent fault, successful autoreclosing can be performed for system restoring without delay time and predict optimal reclosure times by comparing calculation and simulation.

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