Journal of Engineering Research and Education
Volume 10, 2018 [125-132]

Voltage Relay Protection at Transmission Lines with Arcing Fault

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ABSTRACT

Utilities are responsible for the generation, transmission, and distribution of electricity to consumers. Protection schemes are generally divided into equipment protection and system protection. The main function of equipment protection is to selectively and rapidly detect and disconnect a fault on the protected circuit to ensure optimal power quality to customers and to minimize damage to the primary plant. Besides that, it also can prevent damage to healthy equipment that conducts fault voltage during faults and sustains the stability and integrity of the power system. So, it will limit the safety hazard to the power utility personnel and the public. High voltage conditions do not only cause serious damage to the connected load equipment and to the power generation equipment, if not removed, but can cause the loss of the entire electric power system. This paper presents a simulation modeling of voltage relay protection caused by arcing fault at transmission line simulation using MATLAB SimPowerSystem.

Keywords: Voltage Relay, Transmission Line, Arcing Fault.

1. INTRODUCTION

Due to the advancement of energy frameworks, the high-voltage direct current (HVDC) transmission line has assumed an undeniably noteworthy part in the late years. In contrast with high-voltage alternating current (HVAC) innovation, HVDC innovation is more aggressive for long-distance control transmission, asynchronous power grid interconnections, and sustainable power source reconciliation due to its adaptable power control and huge power transmission limits [1][2].

Conventionally, direct current (DC) transmission-line insurance utilizes the voltage differential rate to distinguish the line flaws [3], which is delicate to fault resistance and cannot effectively recognize a high-impedance fault. Reference [4] introduces high-speed traveling-wave protection to transmission-line protection, but its performance is easily affected by disturbance. In addition, it has low affectability in high impedance fault circumstances. Remove assurance is another way to recognize the line fault by fault separation estimation.

High voltage in an electrical power system can be classified into lightning surges and switching surges. The power system is required to be capable of withstanding these phenomena. Temporary overvoltage is generally due to the normal system operating conditions such as line energization, reclosing and transformer energization [5].

Traditionally, voltage relays were applied to protect power transformers. So, if a temporary high voltage occurred in the system, the affected power transformers were tripped together with their loads. The load loss exacerbates the high voltage, causing more transformers disconnection and possible cascading and blackout in some areas. In order to avoid these

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blackouts, it was necessary to implement a system with high voltage scheme that would not trip load unnecessarily. Such a scheme would meet a commitment to shed the lowest possible load and also prevent equipment damages [6].

Arcing fault is the flow of current in the air via the phase conductor that makes contact with the ground. Arcing fault at the transmission lines with high impedance can occur when current carrying conductor make an unwanted electrical contact or touch with the ground. Apart from that, arcing fault also can occur when the conductor making contact with the branches of the tree that is having a high impedance. In addition to bolted and linear short circuit faults, arcing faults are also a frequent occurrence in the transmission line. Almost 90% of the faults in power systems are followed by an arc. Arcing fault is a nonlinear phenomenon as the arc fault resistance is a nonlinear function of voltage and current [7].

The objective of this paper is to understand the concept of voltage relay protection at transmission lines in power system protection. Furthermore, the design and simulating on voltage relay protection on the transmission line need was done using Matlab/Simulink software. Thus, the comparison results of the voltage waveform between with and without voltage relay protection are made.

2. METHODOLOGY

This paper designs a voltage relay protection system that will disconnect and isolate the power system when a fault occurs. The flow of this paper can be divided into several stages where the first stage is the modeling of the basic 132kV power system in MATLAB SimPowerSystem. In this stage, the 132kV power system is simulated without the implementation of any protection scheme. The simulation result in this stage will be used as the initial condition where the system is not isolated when the fault occurs.

In order to overcome the initial condition, a protection system scheme needs to be implemented into the 132kV power system. Therefore, a voltage relay protection model is designed and attached to the power system during the second stage of the project. The next stage is to observe the dependability of the voltage relay when the fault occurs.

If the voltage relay does not trip when a fault occurs, the designed voltage relay must be modified. However, if the voltage relay operates according to the desired setting and disconnects the power system when a fault occurs, the output result of this stage can be observed and analyzed. During the last stage, both results are compared and analyzed briefly in term of voltage relay dependability and voltage waveforms. Figure 1 shows the flowchart of the project.

Figure 2 shows the voltage relay protection operation flowchart. The voltage relay protection scheme starts by measuring the input voltage of the power system. The voltage for which the relay initiates its operations is called pick up the voltage of relay. The pickup voltage of the relay is basically adjustable. If the input voltage is smaller than pickup voltage, the voltage relay will send a trip signal to the circuit breaker which will interrupt the voltage flow and trip the system. However, if the input voltage is larger than pickup voltage, voltage relay will not operate and circuit breaker will remain in state condition. At the same time, the input voltage measurement will be repeated to continuously monitor the input current.

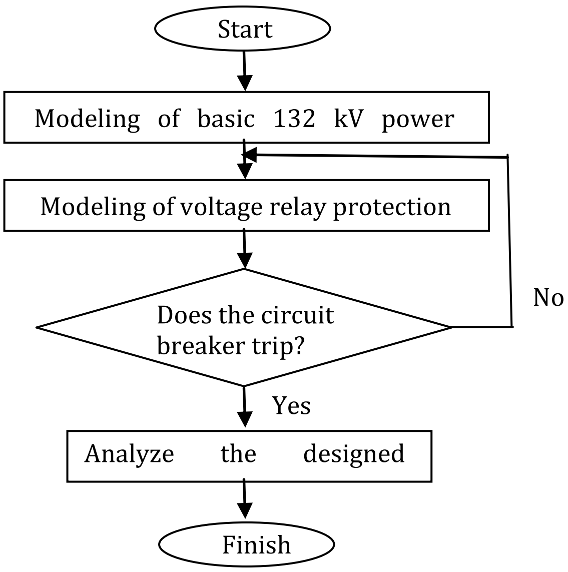

Figure 1. Flowchart of the project.

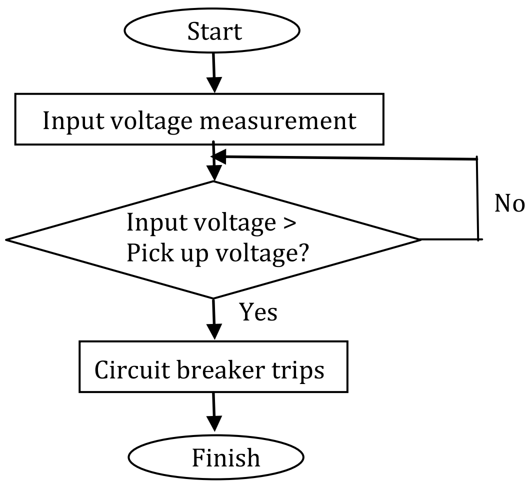

Figure 2. Flowchart of voltage relay protection operation.

Figure 3 shows the block diagram of the voltage relay. The system is based on the digital operating system. Figure 4 shows the basic 132kV power system with voltage relay protection scheme attached. The voltage relay is connected to the circuit breaker and the pickup voltage of the relay is set. The protection scheme will operate if the input voltage is more than pickup voltage.

Figure 5 shows the basic 132kV power system which does not have any protection scheme. Three phase fault with low resistance was injected into the power system. Low resistance and high voltage source will give a very high input voltage to the system. The designed system is simulated by using MATLAB SimPowerSystems. The results between the power system without protection scheme and with protection scheme are compared. Figure 6 shows a 132kV power system with and without protections system.

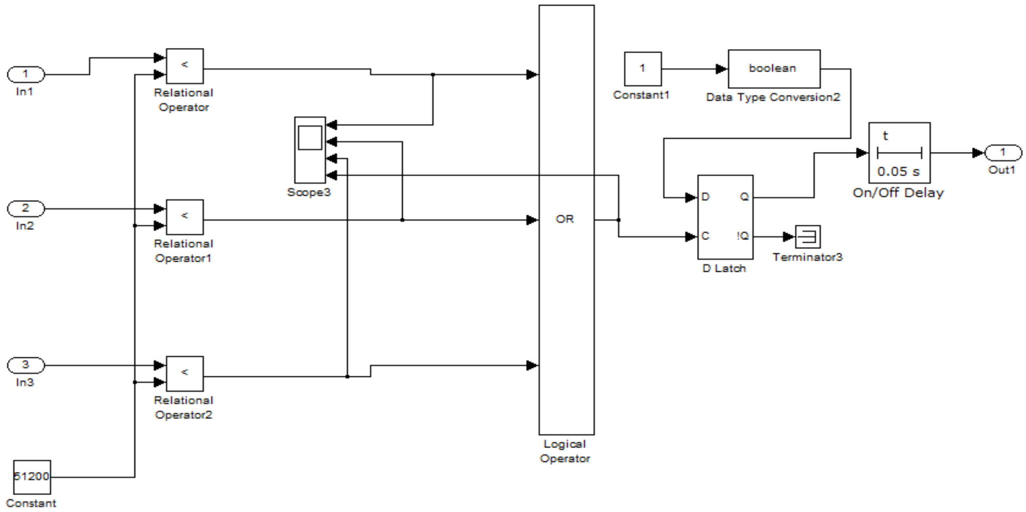

Figure 3. Voltage relay block diagram.

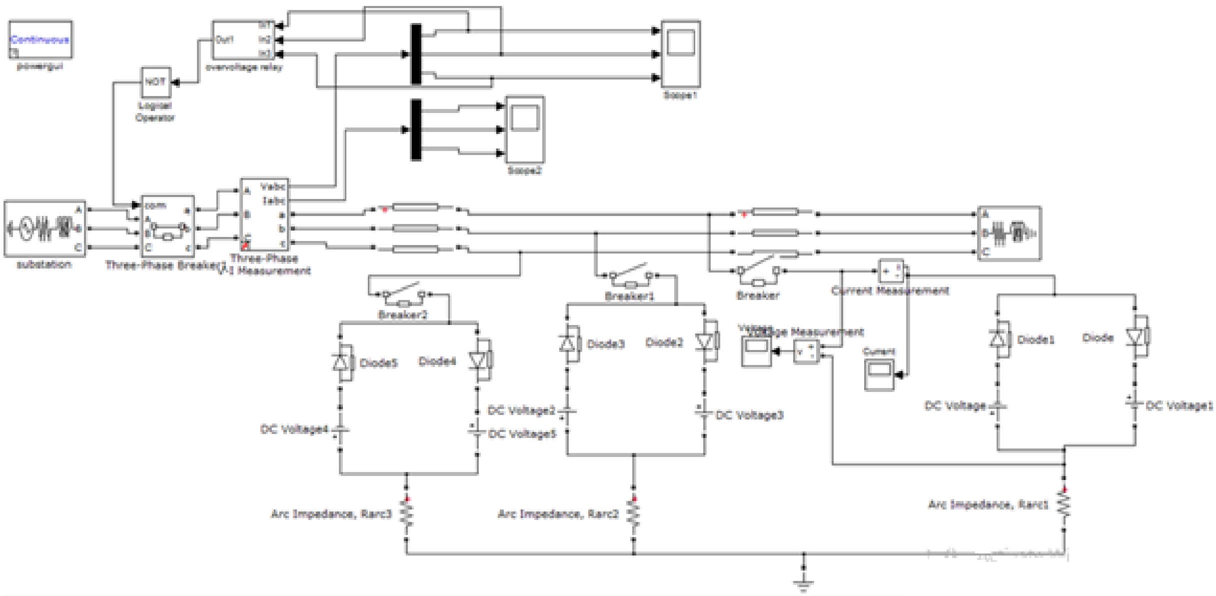

Figure 4. With voltage relay protection.

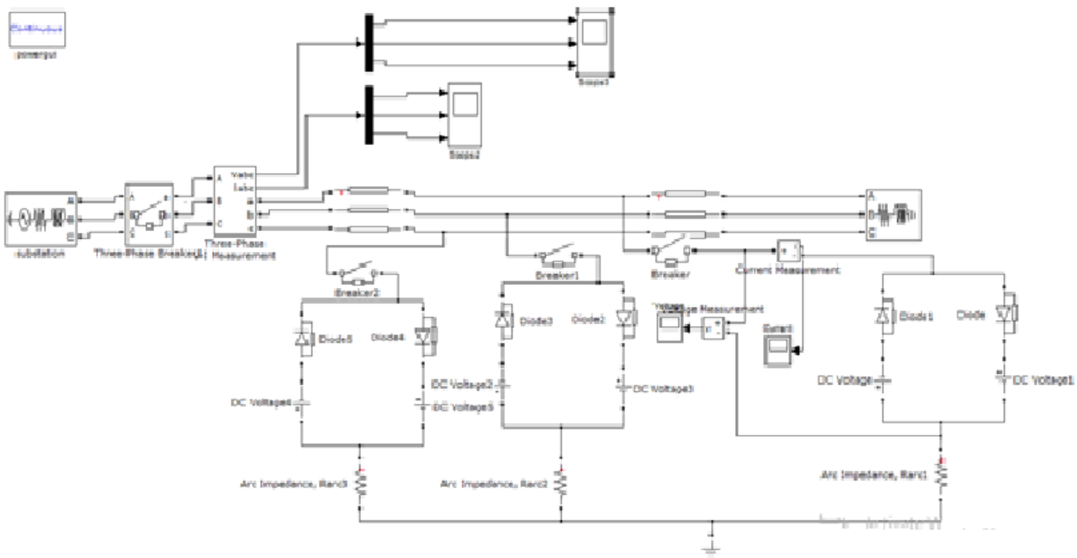

Figure 5. Without voltage relay protection.

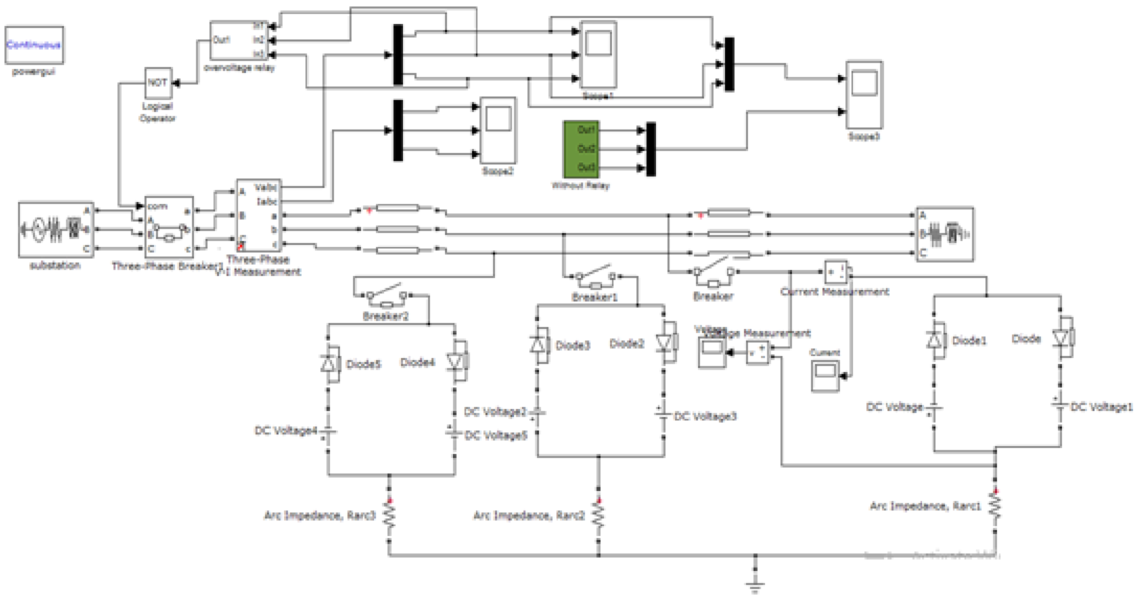

Figure 6. Comparison between with and without a relay.

3. RESULTS AND DISCUSSION

After the circuit was successfully designed, it needs to be tested and analyzed in term of voltage relay dependability. The output of the simulation is shown in Figure 7, 8 and 9.

Figure 7 shows the three-phase voltage waveform 132kV power system with protection system. When the fault is injected into the system at 0.05s, the voltage waveform decreases. At this time, the input voltage is lower than the relay pickup voltage. The relay will send a trip signal to the breaker so that the circuit breaker will disconnect the power system from the load. As shown in Figure 1, as the voltage flow of the system is interrupted during fault injection, therefore, there is no voltage flow after the fault occurred.

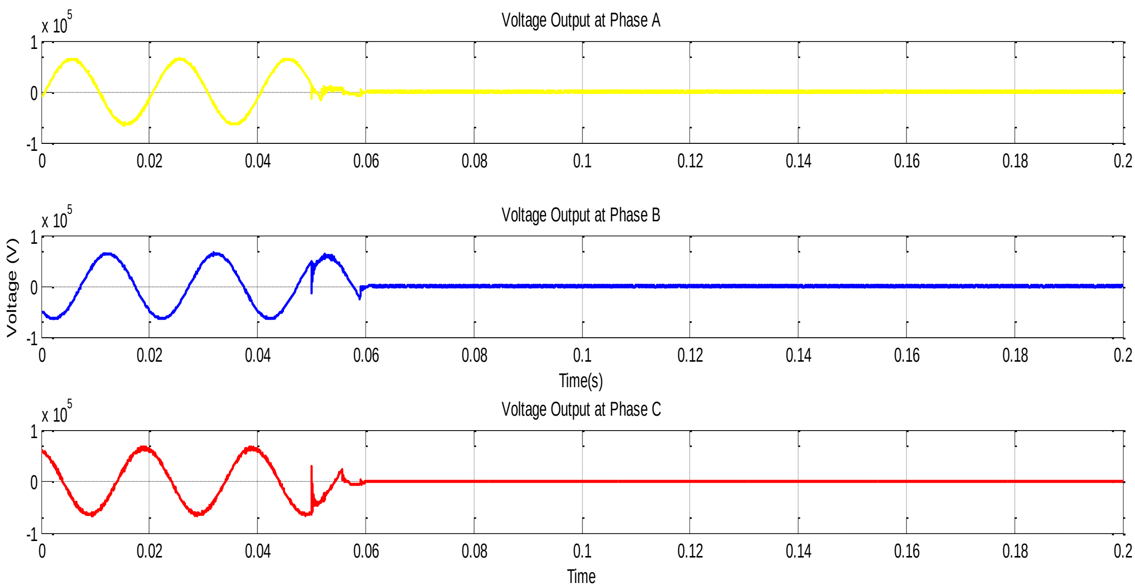

Figure 7. Power system with voltage relay protection.

Figure 8 shows the three-phase voltage waveform for 132kV power system without the protection system. As the fault is injected into the system at 0.05s, the voltage decreases. As there is no protection system implemented in the system, thus the fault is not isolated from the system. Based on the waveform in Figure 8, the fault voltage remains the same and continuously flow. However, the system performance is affected.

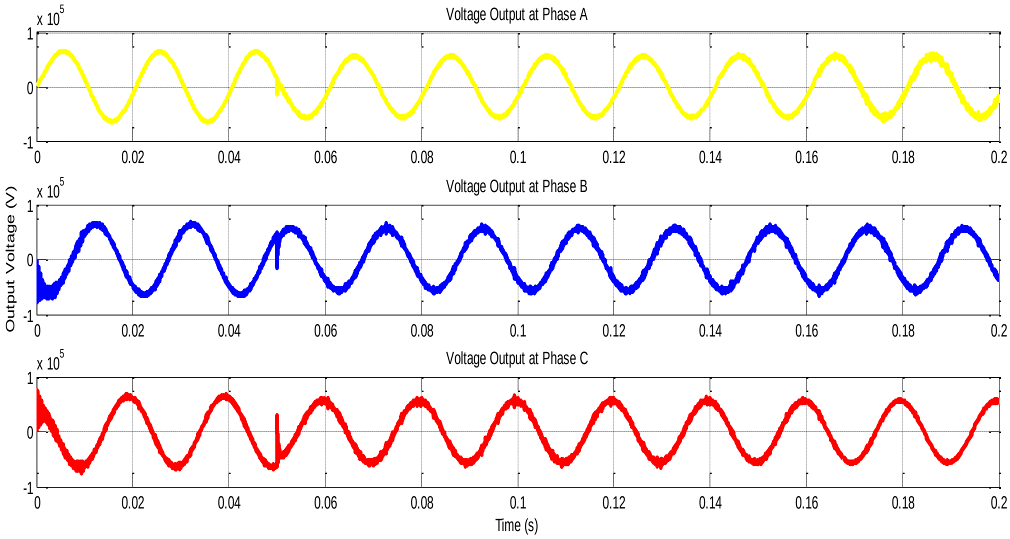

Figure 8. Power system without voltage relay protection.

Figure 9 shows the comparison of the power system between with relay protection and without relay protection. Based on the simulation, the fault voltage at the system with voltage relay is interrupted when the fault is injected and there is no voltage flow after the fault. However, for the system without any relay protection, the voltage fault is not interrupted and it continuously flows even after the fault is injected at 0.05s.

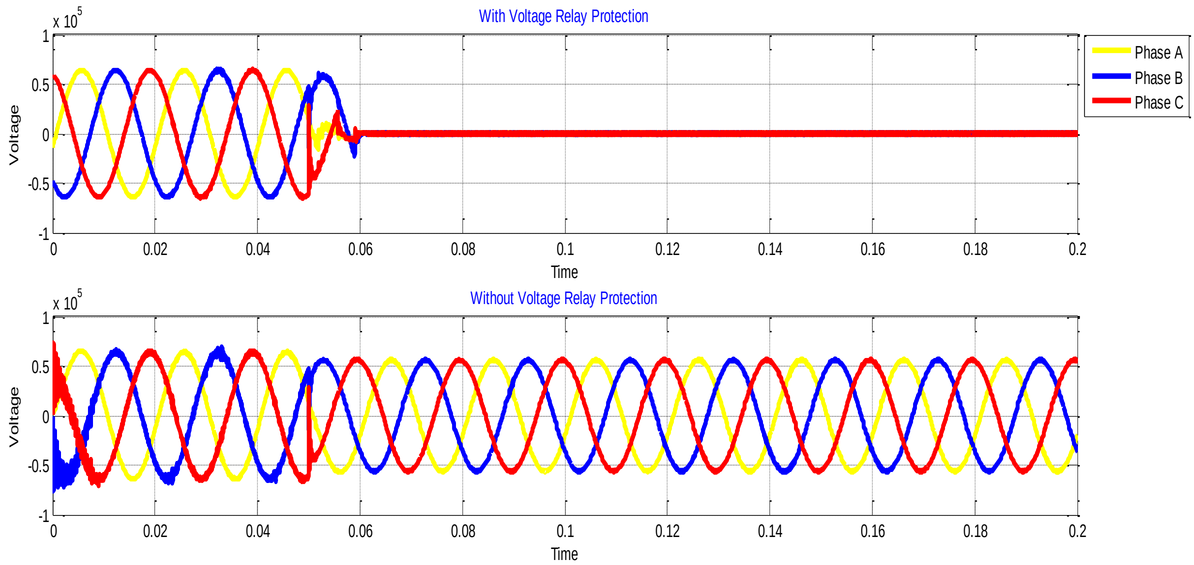

Figure 9. The comparison between without and with voltage relay protection.

4. CONCLUSION

In this paper, a voltage relay protection was designed using Matlab/Simulink software and the power system of 132kV is protected from arcing fault at the transmission line using a voltage relay protection scheme. This relay is designed to send the trip signal towards the circuit breaker when the input signal is higher than the pickup voltage. The received signal will trip the system and the equipment in order to protect them. The results from the simulation obtained in the form of the voltage waveform are being observed. The result of the phases is compared between the system with protection and without protection. Based on the comparison, the system without protection scheme is unreliable compared to the system with the protection system.

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