Effect of Circuit-Breaker Reclosure Time on the Performance of a Power System

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Abstract- *The magnitude and duration of restrikes upon the reclosure of the terminals of a circuit-breaker is important as failure to close at the right time may lead to detrimental effect to the power system in which the circuit breaker reside. For the purpose of demonstrating the operation of the circuit breaker to high voltage engineering students, this project is undertaken. A model of the power system in which the circuit breaker resides is designed based on the IEC standard. At the source side of the circuit breaker a circuit is present for reproducing a (2-parameter IEC) transient recovery voltage, while the RLC circuit at the line side represents a short transmission line that is short circuited. An single-shot pulse generator represents the source of surge. The simulation was conducted using MATLAB/Simulink (MLS). The performance of the power system is analysed in terms of the magnitude and duration of the restriking voltages. By comparing the switching time made at various points on the sinusoidal power source, the importance of correct switching time can be appreciated.*

Keywords: transmission line, circuit-breakers, pulse generator, MATLAB/Simulink (MLS)

1. INTRODUCTION

In addition to making and breaking load and overload currents of the circuit, a circuit-breaker must also capable of both making and breaking the full-rated short-circuit current of the system. Breaking refers to the separation of the terminals of the circuit breaker in the event of occurrence of a fault and the making the re-contact of the terminals, which is also known as reclosure. In order to break the full short-circuit current of the system, very sophisticated arc control mechanisms have been evolved over the years. The techniques of arc extinction were developed originally on a trial-and-error basis, and were considered to be more of an art than a science. However, with modern knowledge and experience, interrupter performance can more readily be predicted using advanced theory and computer techniques [1]. Circuit-breakers are also divided into two categories; namely, the low voltage and high voltage types. Low voltage breakers use synthetic resin mouldings to carry the metallic parts. For higher temperature ceramic parts are used. When the arc is likely to come into contacts with moulded parts, melanine or some special kind of alkyd resins are used because of their greater arc resistance [2].

2. PROBLEM STATEMENT

This project is realised because of the difficulty in explaining the importance of zero-crossing reclosure of a circuit break to electrical engineering students. The idea is that, if it can be made visually or graphically, students will be able to understand the concept better.

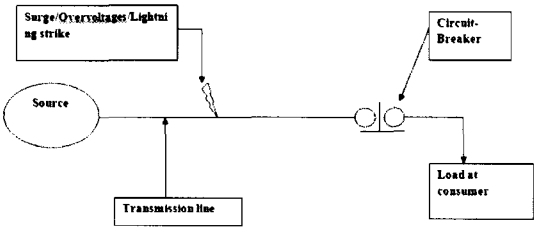


Figure 1: Typical setup of a power system

Figure 1 shows a typical setup of an alternating current power system having struck by a surge, which maybe lightning or switching overvoltage. Upon the strike, the circuit breaker is supposed to operate by separating its contact terminals, and after the arc is cleared, the terminals are supposed to again come into contact. The correct timing of the reclosure is important otherwise may cause restrikes.

3. OBJECTIVES

The objectives of this project are to determine and analyze the best of switching time for circuit-breaker to reclose upon the clearance of the fault or voltage surge that occurs in the power system. The analysis of the performance will be done using MATLAB/ Simulink (MLS).

1. The study on the effect of the circuit-breaker reclosures time on the performance of a power system when not done at correct timing.

2. To find out the best switching time for the circuit-breaker to operate and its effect on the performance of the power system.

4. METHODOLOGY

A few steps were taken to realize the objective and they are as mentioned in the followings. Most of these steps can only be taken after the preceding step has been performed. To simplify the explanation of the methodology, it is divided into a few steps of process.

Firstly, design the circuit to produce the voltage surge (lightning strike). The circuit represent as pulse generator. This circuit is controlled by the ideal switch. A dc supply is giving to the ideal switch. The signal from pulse generator will sent to gate signal to make the switch on/off. In on-state, the pulse is produce and this be assumed as the voltage surge.

Next, the model of the power system are been design base on the model from the MATLAB Simulink. The only part form source and load only be taken to put in this model. In this system, the differential voltage also will put together. The differential voltage will assumed as a surge arrestor. The circuit-breaker also put it together, along of the transmission line to protect the load at consumer.

Lastly, the circuit of pulse generator is connecting to the system and it will operate at different period. The signal come out from that circuit will be capture by the surge arrestor (differential voltage circuit). The circuit-breaker (ideal switch) will detect the signal, where that signal can make the ideal switch turn on/off.

5. SIMULATION WORK

First step the circuit will design to produce the pulse or surge. This component will be assumed as voltage surge (lightning). To produce this signal, the pulse generator are been used. The Pulse Generator block generates square wave pulses at regular intervals. The block's waveform parameters, Amplitude, Pulse Width, Period, and Phase Delay, determine the shape of the output waveform [2].

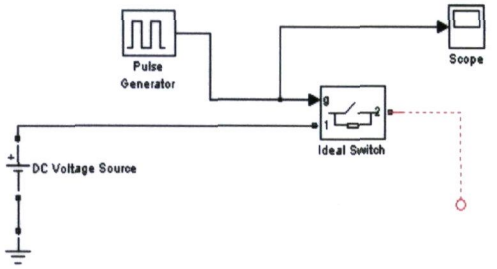


Figure 2: The circuit of the Pulse Generator

This circuit will produce the voltage surge where it be assumed as the fault at the transmission line. The ideal switch is use in this circuit as controlled. In on-state the switch mode has internal resistance (Ron). In off-state the internal resistance is infinite. The internal resistance must be greater than zero. The switch mode is on-state when the gate signal (g) is set to 1[2].

The next step, in order to capture and differentiate the surge, the circuit below will design by using subtract. This circuit represents as the differential voltage. The function is to differentiate the signal by using this formula y=u1-u2. This circuit is represented how to set the dv/dt. The dv/dt can represent the fast or slow rising voltage surge.

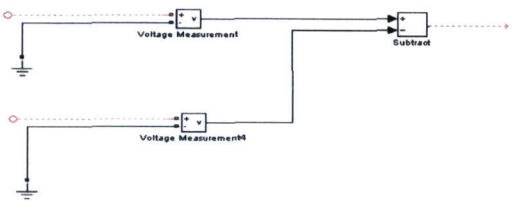


Figure 3: The circuit of the differential voltage

This circuit will working as the surge arrestor. At (+) or (u1) marked, the surge input represented and the (-) or (u2) marked represent by the supplies voltages or reference voltage. The output from subtract will sent to circuit-breaker. In order to make the circuit-breaker operate, the signal from the differential circuit are needed to make the circuit-breaker function as well. The ideal switch is used to represents the circuit breaker.

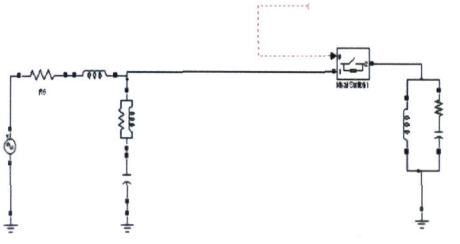


Figure 4: Schematic of the power system at normal condition

This schematic is in normal condition where no fault or voltage surge is disturbed in a system. The parameter at the source and the load are taken from SimPowerSystem Demos at MATLAB Simulink. The model will refer is the circuit-breaker-Cassie and Myar Arc Model. The ideal switch function if the signal from the differential voltage will be sent to the gate signal of the ideal switch.

The ideal switch block is fully controlled by the gate signal (g> 0 or g=0) It has the following characteristics:

- Blocks any forward or reverse applied voltage with 0 current flow when g = 0
- Conducts any bidirectional current with quasi-zero voltage drop when g > 0
- Switches instantaneously between on and off states when triggered.

The Ideal Switch block turns on when a positive signal is present at the gate input (g > 0). It turns off when the gate signal equals 0 (g = 0).The Ideal Switch block also contains a series Rs-Cs snubber circuit that can be connected in parallel with the ideal switch (between nodes 1 and 2) [2].

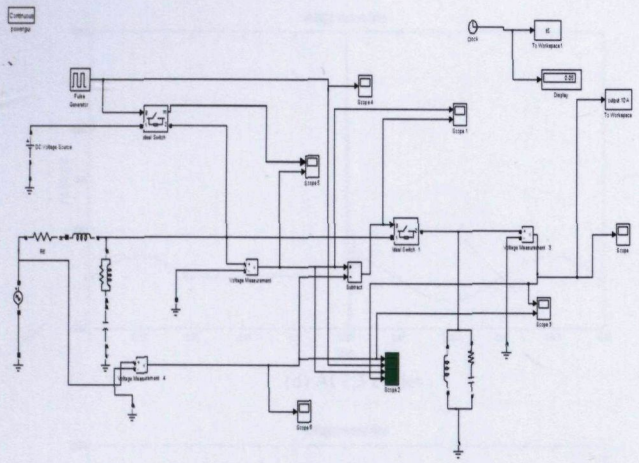


Figure 5: Schematic of the Circuit-Breaker at Power System

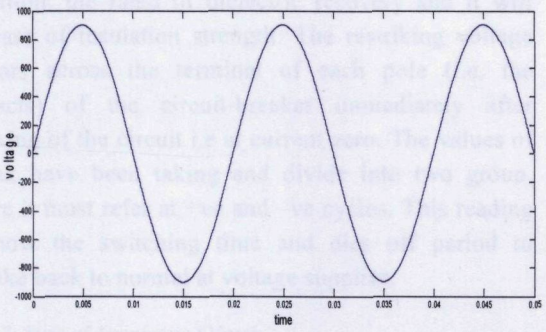
Lastly, all of circuits are combined to make this circuit become one system. This whole system are operated at same time by the each circuit has been setting. The pulse generator will produce the voltage surge, the differential voltage will detect or capture the fast or slow rising the voltage surge by differentiate it by using the subtract component and the ideal switch will be operate after detect all of the signal are disturb in the system of transmission line. The main point of this project is to operate or to make the circuit-breaker function where at the transmission line, the fault or voltage surge will be happen at some time. To protect the damage of equipment at the consumer load, this circuit-breaker must operate immediately [3].

6. RESULT AND DISCUSSION

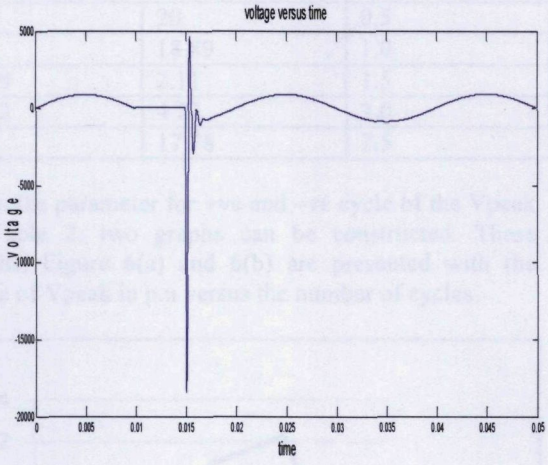
The simulation was employed using MLS. Simulation results are presented for MATLAB. Parameters used are as shown in Table 1.

Table 1: Parameter in MATLAB Simulation

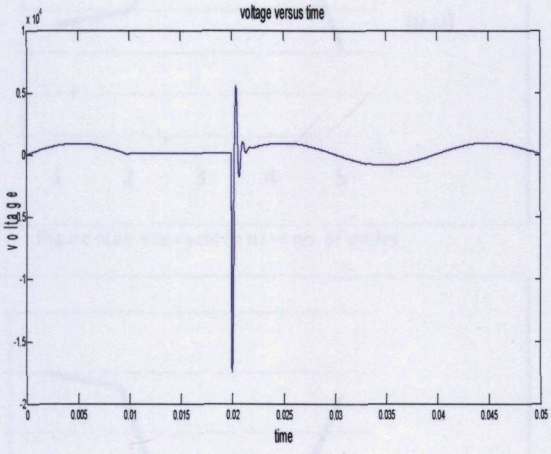
No. of cycle	Vpeak (p.u)		No. of oscillation	Settling time (sec)
	+ve cycle (p.u)	-ve cycle (p.u)		
0.5	5.33	20.00	3	2m
1.0	6.00	18.89	3	1.9m
1.5	10.89	2.11	3	1.74m
2.0	12.22	4.22	3	2.07m
2.5	4.22	17.78	3	2.45m



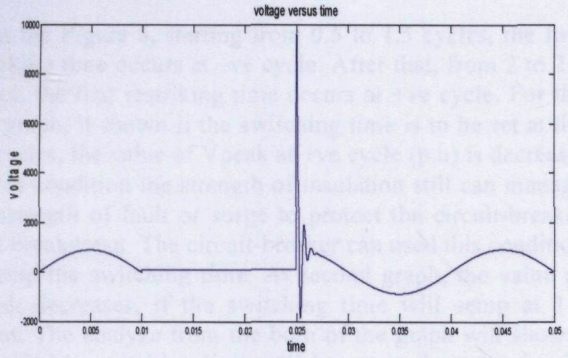
(a) The alternating voltage power source



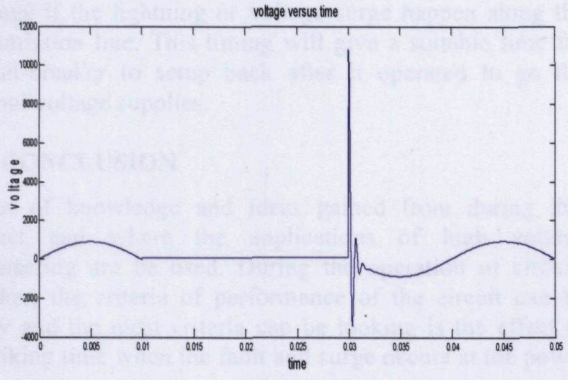
(b) At 0.5 cycle



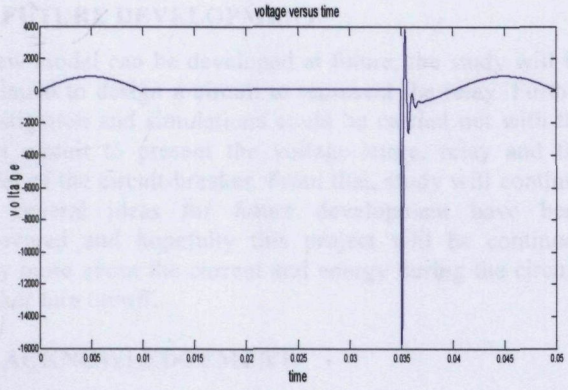
(c) At 1 cycle



(d) At 1.5 cycles



(e) At 2 cycles



(f) At 2.5 cycles

Figure 5: (a) Supplies Voltage, (b) At 0.5 cycles, (c) At 1 cycle, (d) At 1.5 cycles, (e) At 2 cycles, (f) At 2.5 cycles.

From the result above, it can be said that the output waveform have been get from the different value of pulse width from the pulse generator. The pulse width is represent the output waveform will be testing at different cycles. The table 1 are shown the parameter use to get the different output waveform for the figure 5: (b), (c), (d), (e), and (f). Figure (a) represent the supplies voltage, the value has been set is 900V. It is present the base value. At 1 cycle and 2 cycles, the restriking time start to restrike back at current zero. At this current zero across the origin, the arc diminishes and the arc will not re-establish [3]. This condition, the rated of dielectric recovery and it will increase of insulation strength. The restriking voltage appears across the terminal of each pole (i.e. the contacts) of the circuit-breaker immediately after breaking of the circuit i.e at current zero. The values of Vpeak have been taking and divide into two group, where it must refer at +ve and –ve cycles. This reading is show the switching time and dies off period to restrike back to normal at voltage supplies.

Table 2: Time of damping and Vpeak

Vpeak (p.u)		No. of cycle
+ve cycle (p.u)	-ve cycle (p.u)	
5.33	20	0.5
6.00	18.89	1.0
10.89	2.11	1.5
12.22	4.22	2.0
4.22	17.78	2.5

From the parameter for +ve and –ve cycle of the Vpeak in Table 2, two graphs can be constructed. These graphs, Figure 6(a) and 6(b) are presented with the value of Vpeak in p.u versus the number of cycles.

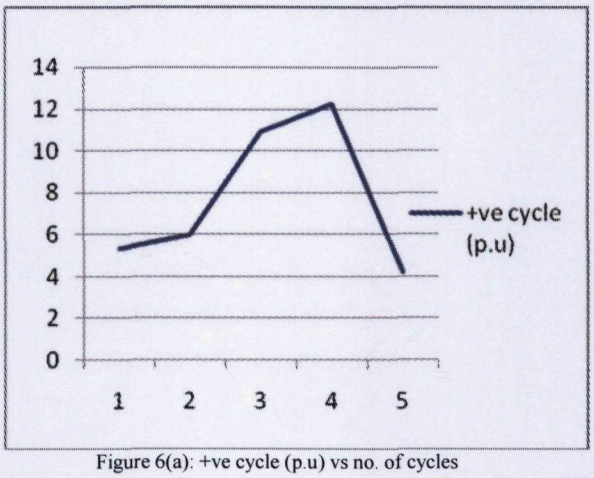


Figure 6(a): +ve cycle (p.u) vs no. of cycles

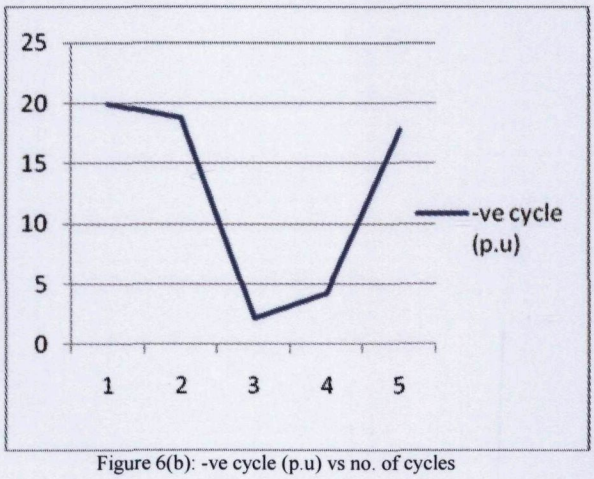


Figure 6(b): -ve cycle (p.u) vs no. of cycles

From the Figure 5, starting from 0.5 to 1.5 cycles, the first restriking time occurs at –ve cycle. After that, from 2 to 2.5 cycles, the first restriking time occurs at +ve cycle. For the first graph, it shown if the switching time is to be set at the 2.5 cycles, the value of Vpeak at +ve cycle (p.u) is decrease. At this condition the strength of insulation still can manage the strength of fault or surge to protect the circuit-breaker from breakdown. The circuit-breaker can used this condition to setup the switching time. At second graph, the value of Vpeak decreases, if the switching time will setup at 1.5 cycles. The analyze from the both of the graph will shown, if a suitable switching time will be set at timer to circuit-breaker, it will be protect the load at consumer from some damage if the lightning or voltage surge happen along the transmission line. This timing will give a suitable time for circuit-breaker to setup back after it operated to go the normal voltage supplies.

7. CONCLUSION

A lot of knowledge and ideas gained from during this project and where the applications of high voltage engineering are be used. During the operation of circuit-breaker, the criteria of performance of the circuit can be study and the most criteria can be looking is the effect of restriking time when the fault and surge occurs at the power system.

8. FUTURE DEVELOPMENT

A new model can be developed at future, the study will be continued to design a circuit to represent the relay. Further investigation and simulations could be carried out with the exact circuit to present the voltage surge, relay and the model of the circuit-breaker. From that, study will continue and several ideas for future development have been discovered and hopefully this project will be continued study more about the current and energy during the circuit-breaker turn on/off.

9. ACKNOWLEDGEMENT

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