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Title **SIMULATION AND ANALYSIS OF FAULT CURRENT LIMITER**

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Simulation and Analysis of Fault Current Limiter

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Abstract
In order to reduce the fault current to managerial level Fault current Limiter is used. This paper presents a MATLAB/Simulink model of Fault Current Limiter which can be used in power systems to reduce the fault current when different types of faults occur. Whenever fault occurs transformers and other protective equipment may overheat as a result of the huge mechanical stresses generated and there is a possibility of damage to protective equipment like circuit breakers by these fault currents, which jeopardize the mechanical stability of the power system hardware. Power network equipment needs to be protected from significant fault currents since it is very expensive. The most crucial element in the operation of power systems efficiently is their dependability. While it is not possible to totally prevent system faults, it is possible to lessen their negative consequences by reducing current during a breakdown. Fault Current Limiter is a current-edge piece which can lower fault current levels within the first cycle of fault current.

Keywords: Fault Current, Protective equipment, Circuit Breaker, Fault Current Limiter – MATLAB/Simulink Model.

Introduction

As electric power systems grow and come more connected at some points, the available fault currents may exceed the maximum short- circuit conditions of the switchgear equipment. As a result, the fault current problem tends to stability problems of the system and the operating range of standard switch gear equipment would be surpassed, necessitating high withstand range of the power networks. Conventional protection bias for protection of power equipment is over – current protection. relay along with the circuit breaker. The relay has a response time detention which allows more cycles of fault current before actuating. Some of the traditional ways to limit or to reduce the fault current are: increasing the rating of switchgear, introducing series reactors into the power system and many more. As mentioned earlier, these devices allow more cycles of fault current, but FCLs can reduce current in first cycle of fault current. The input signal for the FCL is real time current in a circuit and the model is controlled by controlled voltage source and additional resistance. Characteristics of FCL are,

1. Under normal operation, it offers veritably low resistance.
2. During short-circuit condition it offers maximum impedance.
3. The switching time from low impedance to high impedance should be low.

I. Simulation Model of a Fault Current Limiter

To analyze the Fault Current Limiter a simulation model is to be designed. The FCL works based on the magnitude of fault current. Under normal conditions the FCL offers negligible resistance. Based on the RMS value of current the minimum impedance or maximum impedance is determined as shown in Figure (1). The RMS value of current is measured using RMS block [1,2]. The minimum impedance or maximum impedance is determined using switch block.

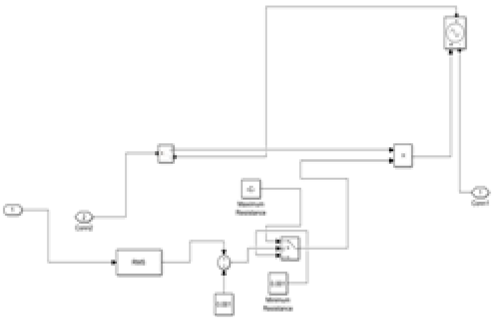

Fig.1: Simulink model of Fault Current Limiter

In switch block a threshold value of current is given. The switch block compares the RMS value of actual current in the circuit with the threshold value. If the actual current is greater than the threshold value, maximum impedance is added to the circuit, otherwise minimum impedance is added. The optimum value of shunt impedance can be determined using Direct Search method [9]. After the impedance is selected, it is multiplied with the actual current and given as input to the controlled voltage source. The controlled voltage source maintains the specified output voltage irrespective of current passing through it.

In order to observe the proper function of FCL a subsystem using Circuit Breaker is designed. The subsystem gives more clarity about Circuit breaker operation. As there is a fixed rating for circuit breaker, the designed subsystem tells us whether the circuit breaker with stand for the fault current or not.

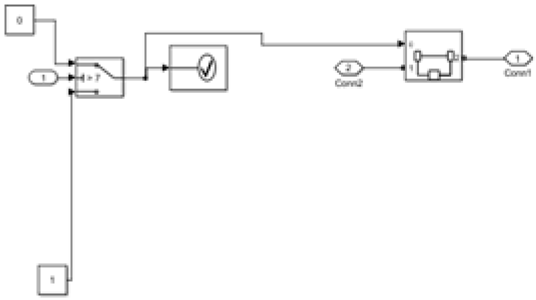

Fig.2: Circuit Breaker Subsystem

Under normal conditions the circuit breaker is closed and allows normal flow of current. Whenever fault occurs it compares the fault current with the rating of circuit breaker. For this comparison a switch block is used. If the fault current is breaker rating, it simply opens the circuit breaker makes the circuit open and if the magnitude of fault current is greater than the circuit breaker rating it display a message that conveys circuit breaker may damage. This can be done using assertion block. The assertion block is used to create warnings/errors explicitly.

II. Determination of optimum values for maximum Impedance

The impedance value can be determined by applying Direct search method [10]. The maximum impedance should lies between 0 p.u. and 1 p.u. According to this method it searches for varies values in the given range. By comparing various results optimum values can be determined. This is because values greater than 1 p.u. leads to inordinate fault current limitation. This undesirable limitation makes the protection relays unable to differentiate the fault current from steady state current.

III. Simulink model of three phase system with and without FCL

The steady state model of three phase system is shown in Figure (3).

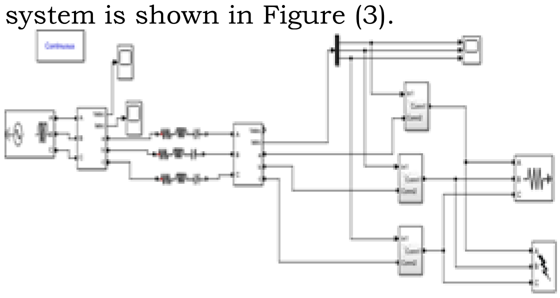

Fig.3: Steady-state Model of Three phase system

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The FCL model integrated into a three- phase system in Figure (4) is to pretend its performance in grid.

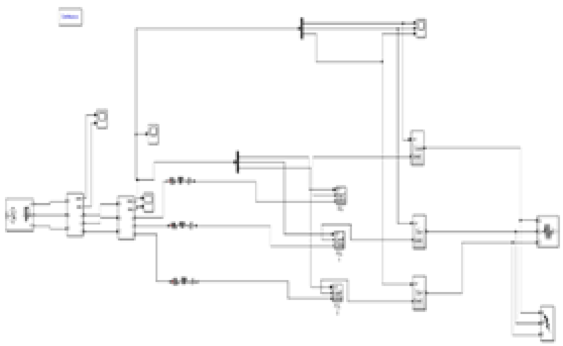

Fig.4: Three-phase system integrated with Fault Current Limiter

IV Results and Discussions

The FCL limits the fault current within the first half cycle and by employing the FCL in power system improves the reliability of the system. Fault occurs at 0.1s and continued to the end of simulation. Current waveforms for different types of faults with and without FCL are shown below are shown below:

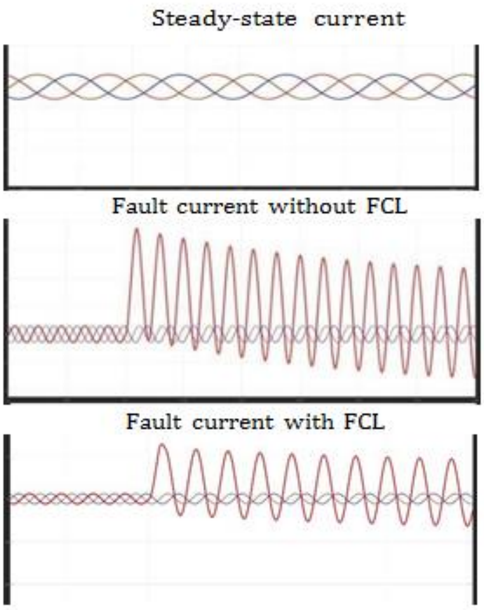

Fig. 5: For L-G Fault

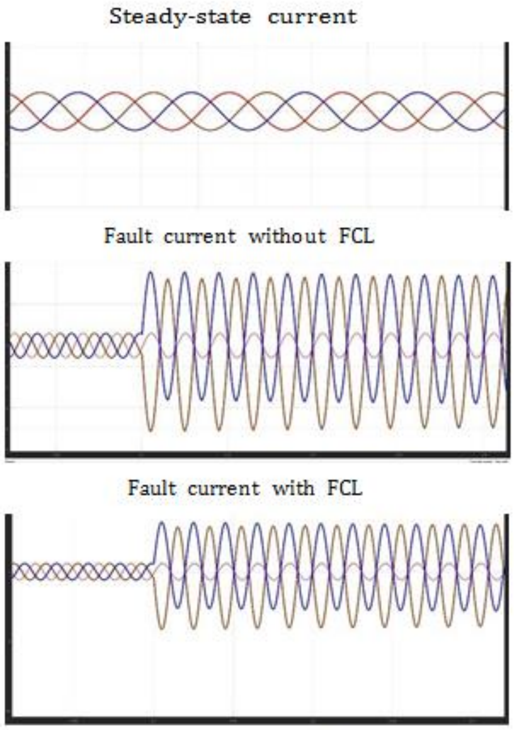

Fig 6: Line-to-Line Fault

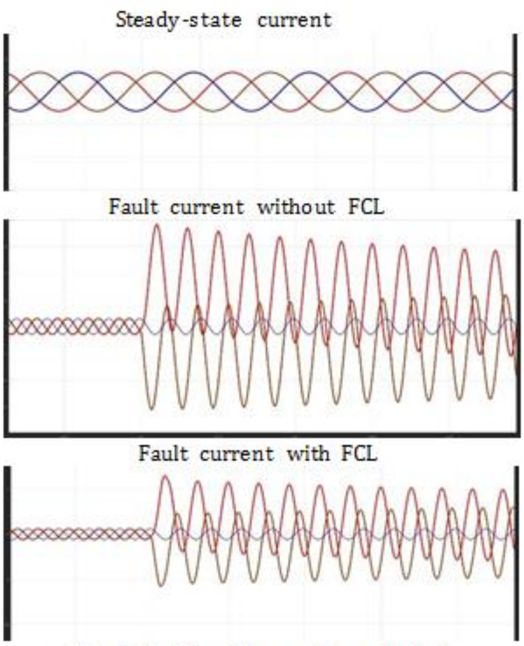

Fig 7: Double Line to Ground Fault

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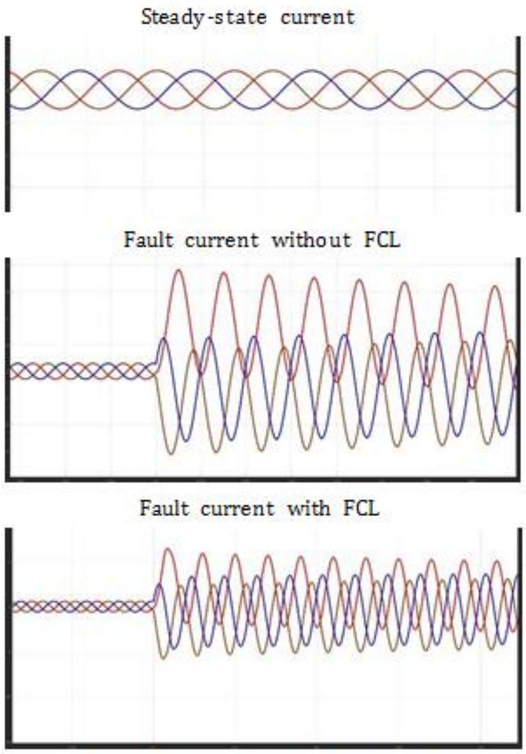

Fig 8: Three Line to Ground Fault

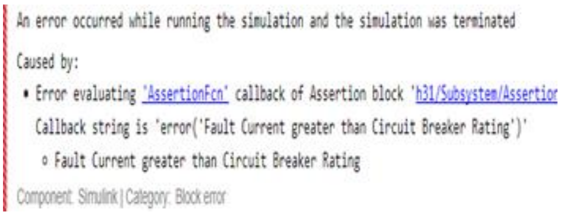

Fig 9: Error message of Circuit breaker subsystem

Figure (9) shows the error message that conveys fault current is greater than circuit breaker rating. If the fault current is greater than circuit breaker rating.

Type of Fault	**Magnitude of Fault Current**	
	Without FCL	**With FCL**
L-G	7.58 p.u	5.8 p.u
L-L	4.15 p.u	3.5 p.u
L-L-G	7.65 p.u	6.5 p.u
L-L-L-G	7.63 p.u	6.3 p.u

Table 1: Comparison of fault current values for different types of faults

VI. Conclusion

The performance of FCL is analyzed for different types of faults in power system i.e., for both symmetrical and unsymmetrical faults. The FCL able to reduce the fault current from the first reduce the fault current from the first able to compensate the voltage sag which arises due to fault condition of the system. The circuit breaker subsystem helps to know whether the fault current magnitude is greater than circuit breaker rating or not. And if fault current is more then it gives an error. From this we can able to know different optimum values like fault current that circuit breaker withstands, maximum impedance that reduce fault current to lower managerial levels etc.

VII. Future Scope:

The performance of the FCL can be improved by implementing additional features by using power electronic devices like SCR, GTO, IGBT and by considering different parameters like atmospheric conditions on which fault current depends. The normal switch can be replaced with diode or a thyristor switch which can be helpful to introduce a reactor. The reactance value and diode rating depend on the load current. The efficiency can be improved and it increase the stability of the power system.

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