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A Fuzzy Based SFCL for Fault Current Limiter in Distribution System

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Abstract : *In the modern power system, as the utilization of electric power is very wide, and it is very easy for occurring any fault or disturbance, which causes a high short circuit current flows. More over the increase in the power generation results in an increase in the system fault current levels. The high current due to this fault large mechanical forces and these forces causes overheating of the equipment. If the large size equipment are used in power system then they need a large protection scheme from severe fault conditions. Generally, the maintaince of electrical power system reliability is more important. But the elimination of fault is not possible in power systems, so, the only alternate solution is to reduce the fault current levels. For this a fuzzy based Super Conducting Fault Current Limiter is the best electric equipment which is used for reducing the severe fault current levels. In this paper, we simulated the unsymmetrical faults with fuzzy based superconducting fault current limiter. In our analysis we had the following conclusions.*

Keywords – *Fuzzy, Current limiter, Distribution*

I. INTRODUCTION

Volts sag is one of the most regular energy top quality disruptions in power systems. It is necessary to examine voltage sag due to consumers' weeknesses. Mistakes are the primary cause of voltage sags in submission systems. Mistake in submission systems according to its requirements (its place, length and time) can cause an disruption or a voltage sag at the nodes of the system. By making unique faults, the voltage sag in such systems can be examined. The suggested framework stops voltage sag and phase-angle leap of the substation PCC after fault incident. This framework has a simple management technique. Using the semiconductor change (insulated-gate the illness transistor or checkpoint turnoff thyristor at dc present rout results in quick function of the suggested FCL and, consequently, dc reactor value is decreased. On the other hand, the suggested framework cuts down on complete harmonic distortions on fill voltage and it has low ac failures in regular function. Consequently, other birdfeeders, which are linked to the substation PCC, will have good energy top quality.

However, because of high tech and cost of superconductors, these products are not from the commercial perspective available. Therefore, by changing the superconducting coils with a non-superconducting one in the FCL, it is possible to make it easier and less expensive. It is worth noting that the main disadvantage of the non-superconductor is an electrical reduction which is minimal in contrast with the complete energy, offered by the submission bird birdfeeder. The other components which are presented have two figures of thyristor changes in the ac division of the diode link. When the mistake happens, after mistake recognition, the thyristor change changes off at first zero traversing and the mistake present is restricted to a good value. These components have changing energy reduction and a complex control routine because of thyristor changing in the regular function. In addition, we know that thyristor function wait (turn off at first zero crossing) causes disruptions on framework efficiency. So, to restrict the mistake present between the mistake incident immediate and thyristors convert off immediate, a huge reactor in the dc path is used. Due to volts fall, harmonic distortions, and energy failures, this huge value of dc reactor is undesirable.

II. FAULT CURRENT LIMITERS

Before technological innovation can be considered for the program of restricting a DG's fault current participation, the working circumstances and specifications of such a limiter must first be recognized. The current technological innovation can then be analyzed for their relevance for such a program by guaranteeing that any suggested system satisfies the specifications. The first need for the FCL is that it must function at the submission volts level. According to a software application study in [13] in which resources were required to explain their present submission systems and expected future program, resources reacted that the most frequent volts category is at 15kV. A common radial submission system

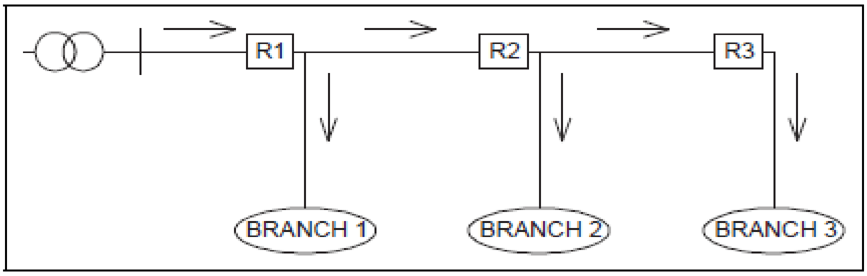

Fig 1: Typical radial distribution system with relay protection

III. STRUCTURE AND PRINCIPLE OF THE ACTIVE SFCL

As shown in Fig. 2, it signifies the circuit construction of the single-phase volts compensation type ASFCL, which is consists of an air-core superconducting transformer and a voltage-type PWM converter. Ls1, Ls2 are the self-inductance of two superconducting windings, and Ms is the common inductance. Z1 is the routine impedance and Z2 is the fill impedance. Ld and Cd are used for filtration great purchase harmonics due to the ripper. Since the voltage-type converter's ability to managing energy return is applied by managing the volts of AC part, the ripper can be looked as a managed volts resource Up.

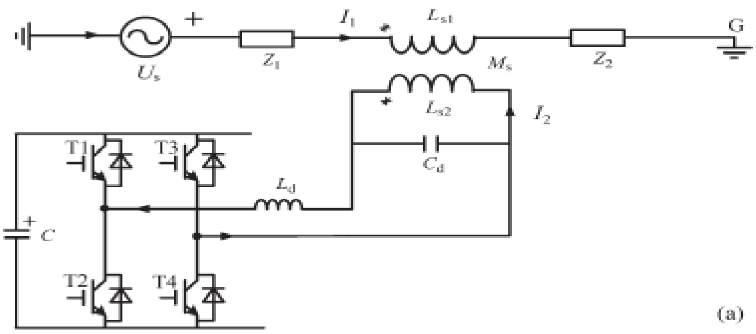

Fig 2: Single-phase voltage compensation type active SFCL

In ordinary (no fault) express, the infused current (I2) in the auxiliary twisting of the transformer will be controlled to keep a specific esteem, where the attractive field noticeable all around center can be repaid to zero, so the dynamic SFCL will have no impact on the principle circuit. At the point when the fault is recognized, the infused current will be opportune balanced in sufficiency or stage edge, in order to control the superconducting transformer's essential voltage which is in arrangement with the fundamental circuit, and further the fault current can be stifled to some degree.

IV. APPLYING THE SFCL IN TO A DISTRIBUTION NETWORK WITH DG

As appeared in Fig. 3, it shows the utilization of the dynamic SFCL in a dissemination connect with various DG units, and the transports B-E are the DG units' plausible establishment areas. At the point when a solitary stage grounded fault happens in the feeder line 1 (stage A, k1 point), the SFCL's mode 1 can be naturally activated, and the fault current's rising rate can be opportune controlled. Alongside the mode exchanging, its plentifulness can be constrained further. With regards to the SFCL's consequences for the initiated overvoltage, the subjective investigation is introduced. Keeping in mind the end goal to compute the over voltages initiated in the other two stages (stage B and stage C), the symmetrical segment technique and complex arrangement systems can be utilized, and the coefficient of establishing G under this condition can be communicated as G = −1.5m/(2 + m) ± j √ 3/2, where m = X0/X1, and X0 is the appropriation system's zero-succession reactance, X1 is the positive-grouping reactance [16]. Encourage, the amplitudes of the B-stage and C-stage over voltages can be depicted as:

$$U_{BO} = U_{CO} = \sqrt{3}\left|\frac{\sqrt{G^2+G+1}}{G+2}\right| U_{AN}$$

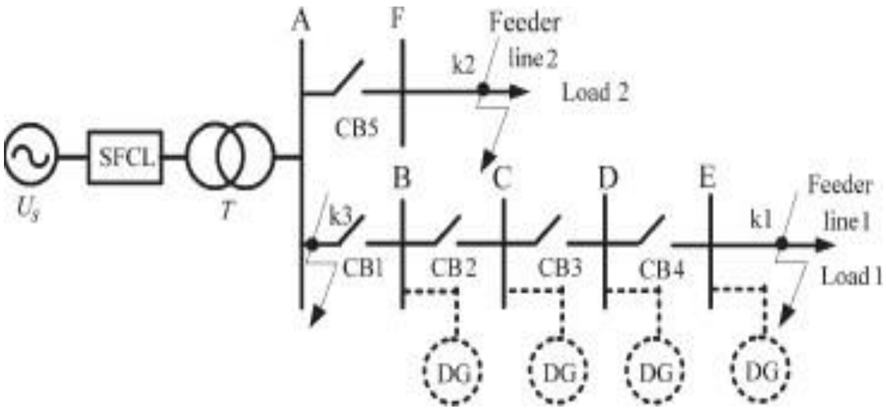

Fig. 3. Application of the active SFCL in a distribution system with DG units

PI Controller

A PI Controller (proportional-integral controller) is a combination of proportional and integral controller which is used for eliminating steady state error and peak overshoots [10-11]. The absence of derivative controller shows more stability under noise conditions. This is because the derivative controller is more sensitive under high frequency systems.

The general expression for PI controller is expressed as,

$$K_P \Delta + K_I \int \Delta dt$$

Fuzzy Logic Controller

In the previous section, control strategy based on PI controller is discussed. But in case of PI controller, it has high settling time and has large steady state error. In order to rectify this problem, this paper proposes the application of a fuzzy controller shown in Figure 4. Generally, the FLC [12] is one of the most important software based technique in adaptive methods.

As compared with previous controllers, the FLC has low settling time, low steady state errors. The operation of fuzzy controller can be explained in four steps.

1. Fuzzification
2. Membership function
3. Rule-base formation
4. Defuzzification.

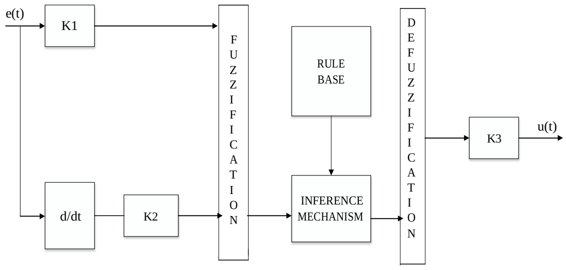

Figure 4: basic structure of fuzzy logic controller

In this paper, the membership function is considered as a type in triangular membership function and method for defuzzification is considered as centroid. The error which is obtained from the comparison of reference and actual values is given to fuzzy inference engine. The input variables such as error and error rate are expressed in terms of fuzzy set with the linguistic terms VN, N, Z, P, and Pin this type of mamdani fuzzy inference system the linguistic terms are expressed using triangular membership functions. In this paper, single input and single output fuzzy inference system is considered. The number of linguistic variables for input and output is assumed as 3.The numbers of rules are formed as 9.The input for the fuzzy system is represented as error of PI controller. The fuzzy rules are obtained with if-then statements. The given fuzzy inference system is a combination of single input and single output. This input is related with the logical operator AND/OR operators. AND logic gives the output as minimum value of the input and OR logic produces the output as maximum value of input.

V. SIMULATION STUDY

For reason for quantitatively assessing the current-limiting and overvoltage-compensation of the dynamic SFCL, the dissemination framework with DG units and the SFCL, as appeared in Fig. 3 is made in MATLAB. The SFCL is introduced in the behind of the power supply us, and two DG units are incorporated into the framework, and one of them is steadily introduced in the Bus B (named as DG1). For the other DG, it can be introduced in a discretionary position among the Busses C–E (named as DG2). The model's fundamental parameters are appeared in Table I. To diminish the converter's plan limit, doing the SFCL change to the mode 2 after the fault is recognized, and the discovery technique depends on measuring the principle current's diverse parts by Fast Fourier Transform (FFT) and symphonious investigation.

VI. SIMULATION RESULTS

Figures shown below, it indicates the line current waveforms with and without the active SFCL when the three-phase short circuit occurs at k3 point. After installing the active SFCL and Fuzzy based SFCL, the first peak value of the fault currents (iAf, iBf, iCf) can be limited to 2.51 kA, 2.69 kA, 1.88 kA, respectively, in contrast with 3.62 kA, 3.81 kA, 2.74 kA under the condition without SFCL.

Without SFCL:

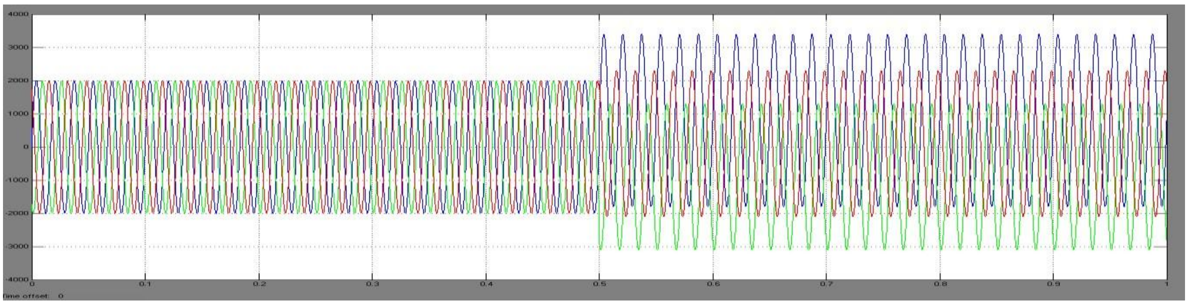

Fig 6: Simulation waveform for Fault Current without SFCL

With SFCL:

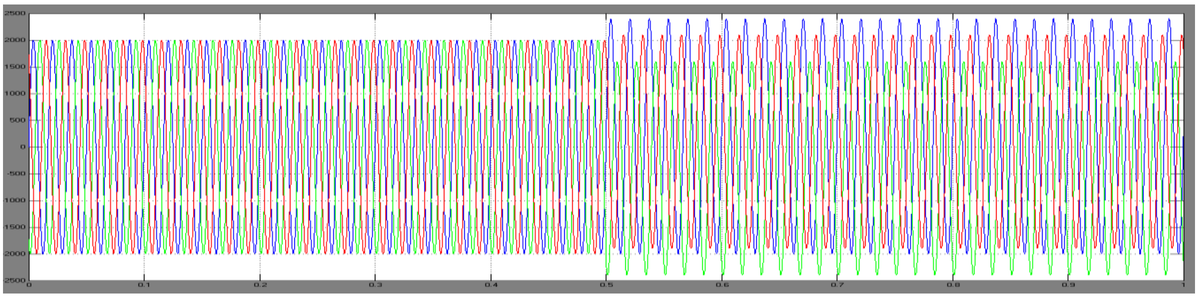

Fig 7: Simulation waveform for Fault Current with SFCL**With Fuzzy SFCL:**

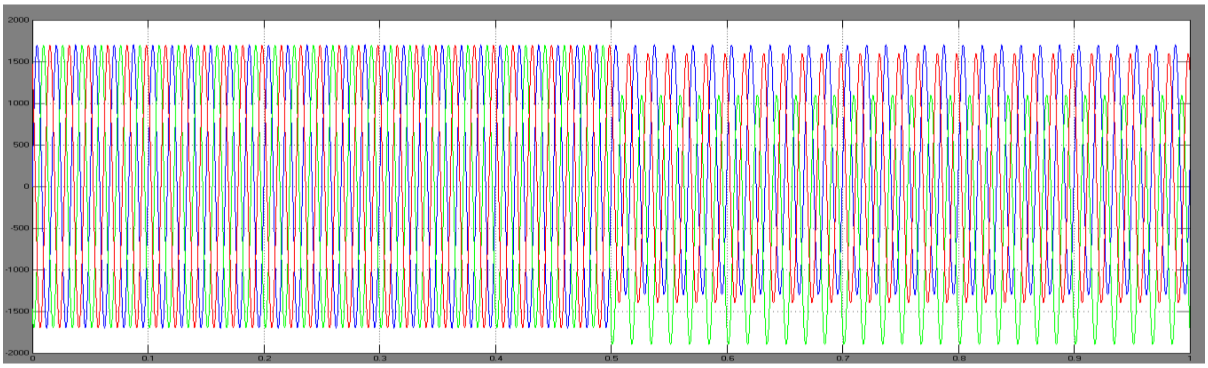

Fig 8: Simulation waveform for Fault Current with fuzzy based SFCL

VII. CONCLUSION

In this paper, the utilization of the Fuzzy rule for dynamic SFCL into in a power circulation connect with DG units is researched. For the power recurrence overvoltage brought about by a solitary stage grounded fault, the dynamic SFCL can diminish the overvoltage's abundancy and abstain from harming the important circulation gear. The dynamic SFCL can too smother the short out current prompted by a three-stage grounded fault viably, and the power framework's security and unwavering quality can be progressed. Besides, alongside the lessening of the separation between the fault area and the SFCL's establishment position, the current-constraining execution will increment.

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