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SUPER CONDUCTING FAULT CURRENT LIMITER USING FUZZY LOGIC TO LIMIT FAULTS IN POWER SYSTEMS

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Abstract

In the recent trends of power systems, with the wide utilization of electric power. It is quite an easy way for occurring of any fault or disturbance, which causes a high short circuit current to flow. Due to the increase in the power generation results in the increase in overall system fault current levels. Due to these faults, high currents are developed which enlarges the mechanical forces and causes overheating. For equipments of large rating in the power system then they require a more protection scheme against severe fault conditions. Generally, maintenance of equipment is oftenly done for the sake reliability. Faults can be avoided but cannot be eliminated, the only solution is to minimize the fault current levels. Therefore, a fuzzy based Super Conducting Fault Current Limiter is the best electric equipment which can be used to reduce the severe fault current levels. In our paper, we simulated the unsymmetrical faults with fuzzy based logic using superconducting fault current limiter.

Keywords:

Super Conducting Fault Current Limiter;
Sag Propagation;
Sag Magnitude;

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1. Introduction

Sag is one of the most common power quality disturbance that occurs in electric power system. It is necessary to find voltage sag depending on consumers'vulnerability [1-10]. The main cause of voltage sag in distribution networks is faults. A fault in a distribution network is an interruption or voltage sag occurs at the nodes of the network according to its specifications. By creating some random faults, the voltage sag in such networks can be observed.

The proposed scheme prevents voltage sag and phase-angle changes in the substation PCC in the event of fault occurrence. This control method has a simple structure. By IGBT or GTO thyristor by direct current leads to fast operation of the proposed fault current limiter and, consequently, reactor value gets decreased. The proposed structure will reduce the total harmonic distortion on load voltage which has low alternating current losses during normal operation. Hence the other feeders, connected to the substation PCC, will definitely have better power quality.

Today, in power systems the power quality problem is one of the important aspect. Voltage sag is one of the most significant issues regarding power quality. Voltage sags are incidents that reduce the voltage amplitude for a short time. Creating problems for a wide range of equipment is the main cause to study voltage sags. Voltage sags are hazardous for drives or computers and cause significant financial damages. To study the response of voltage sag the following points should be considered.

Firstly, voltage sags are caused by faults (short- circuit), energizing power transformers, starting electrical motors and sudden changes in loads. All these issues are classified as disturbances with low or moderate frequency. Secondly, variable loads with time are different.. Thirdly, faults are the main cause of voltage sag in distribution networks Therefore voltage sag effects depend on what occurs and the difference between the loads [18- 21].

Due to improved technology utilization and cost of superconductors, the availability of these devices are very rare. So, to make it simple easy and cheap. This can be made possible by placing the non superconducting one in the FCL by replacing superconducting coil. The disadvantage of non-superconductor is power loss which is negligible in comparison with the total power, provided by the feeder which is distributing. The circuit is simply implemented by using a full wave thyristor bridge. At the time of fault occurrence, fault is detected, the thyristor switch gets turned off at its first zero crossing and the fault current is limited to an acceptable value. This circuit has high switching power loss and the control circuit is complicated because of thyristor switches operates normal. Morever, we know that thyristor operation delay(turn off at initial zero crossing) interrupts structure performance. Therefore, to limit the fault current, a large reactor is used in the DC path.

2. VOLTAGE SAG IN A DISTRIBUTION SYSTEM

According to IEEE standard 1159- 1995, a voltage sag is defined as a decrease to between 0.1 and 0.9 p.u. in R.M.S voltage at the power frequency for durations of 0.5 cycle to 1 min [1]. Voltage sags usually occurs in power systems often, a lot of inconvience caused to customers. Faults occur in transmission level namely, EHV, HV, MV, and LV systems and the sags propagate throughout the power system. In this paper a standard power system area is modeled and voltage sag distribution calculations are done. The voltage sag distributions are calculated for both urban and rural power system areas for different types of faults.Voltage sag is characterized by sag magnitude, duration, and frequency[3]. Network impedances determine the sag magnitude.

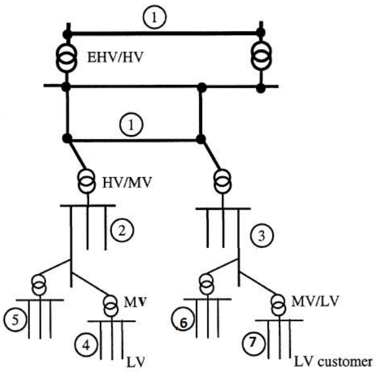

Fig. 1 Fault positions where voltage sag is observed

3. SAG DSITRIBUTION AND PROPAGATION

Sag Distribution

A sag distribution can be determined for every LV customer in the part of the network where is fault is occurred shown in Fig.2

EHV, HV, MV, and LV

1) EHV Transmission systems
2) HV distribution systems
3) MV distributionsystems
4) LV distribution systems

By a cumulative distribution function the sags experienced by an LV customer can be calculated as shown below.

$$F(u,t)_k = \sum_i^n \sum_{ft} (\lambda_{i,ft} \mid u_k \le u, \Delta t_{i,ft} > t) \tag{1}$$

where the fault frequency of fault type ft at fault position i,uk , the sagged voltage experienced by an LV customer at node k, and Δti,ft is the sag duration for the fault place and fault type in the equation.

For different faults, Voltage sags is observed with different characteristics, the fault frequencies of each type of fault is determined. Hence, the fault frequency l at a certain fault position includes the fault frequencies of all fault kinds.

$$\lambda_i = \sum_{ft} \lambda_{i,ft} = \sum_{ft,i} \frac{p_{i,ft}}{100} \lambda_i \tag{2}$$

The share of the different fault types will satisfy two properties

Sag Magnitude

The voltage calculations in meshed transmission systems are based on theorem of Thevenin's and the network impedance matrix [4]. To calculate the sag in the voltage at a particular bus caused by a fault (3) or (4) can be applied.

$$U_{sag,i} = U_{0,i} - \frac{Z_{ir}}{Z_{rr} + Z_{F_{ij}}} U_{0,r} \tag{3}$$

$$U_{sag,i} = U_{0,i} - \frac{Z_{ir}}{Z_{rr}} (U_{0,r} - U_{sag,r}) \tag{4}$$

Where $U_{sag,i}$ and $U_{sag,r}$ are the sagged voltages during the faults at nodes and , respectively. $U_{o,i}$ and $U_{o,r}$ are the pre-fault voltages. Z_{rr} is the element that corresponds to the diagonal element of the node impedance matrix, Z_{ir} the transfer element of the node impedance matrix which corresponds to nodes of i and r, and Z_F that is fault impedance.For distribution systems which are radial operated, the calculation is simplified and a voltage divider method is applied [5]. For instance, in the case of a symmetrical three-phase short circuit fault in a radial supplied MV distribution feeder, the sagged voltage on the substation busbar can be verified using the below equation

$$U_{sag,i} = \frac{Z_L + Z_{Ft}}{Z_S + Z_T + Z_L + Z_{Ft}} U_{0,i} \tag{5}$$

Where, Z_L is the impedance between the fault location and the substation it is related to, Z_T is the impedance of the primary transformer, and Z_S is the source impedance of the entire transmission system. While considering faults behind a neighboring HV/MV transformer, the PCC (= point of common coupling) will be on the High Voltage side of the transformer and (6) should be applied in the below equation:

$$U_{sag,i} = \frac{Z_{T2} + Z_{L2} + Z_{Ft}}{Z_S + Z_{T2} + Z_{L2} + Z_{Ft,i}} U_{0,i} \qquad (6)$$

Sag Propagation

Most of the customers are connected to LV networks and faults occur at all voltage levels. Therefore, the sag propagation should be modeled for the entire chosen network. In our paper, the Finland power system is chosen to find the voltage sag distributions experienced by LV customers:

i) 400kV and 220kV transmission systems, looped, neutrals impedance earthed, or solidly earthed;

ii) 110 kV sub-transmission system, looped, neutrals impedance earthed, or unearthed;

4. RESULTS

Results with respect to the proposed method are presented in this Section as shown in Fig.2 to Fig.4. The waveforms depicted in Fig.2 and Fig.3 are without and with SFCL while the Fig.4 refers to the waveform with Fuzzy application.

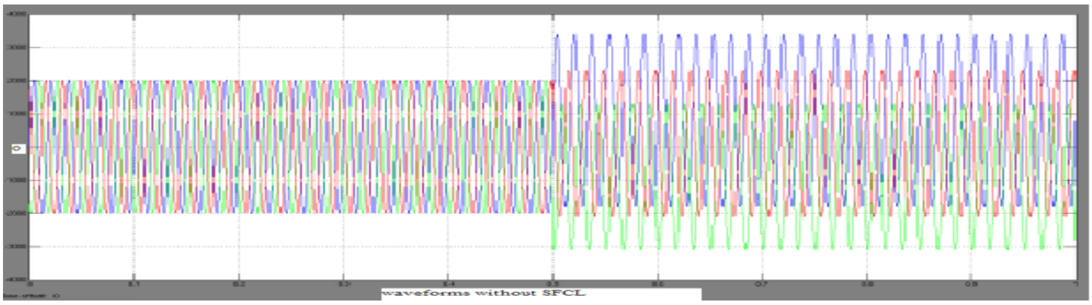

Fig.2: Without SFCL

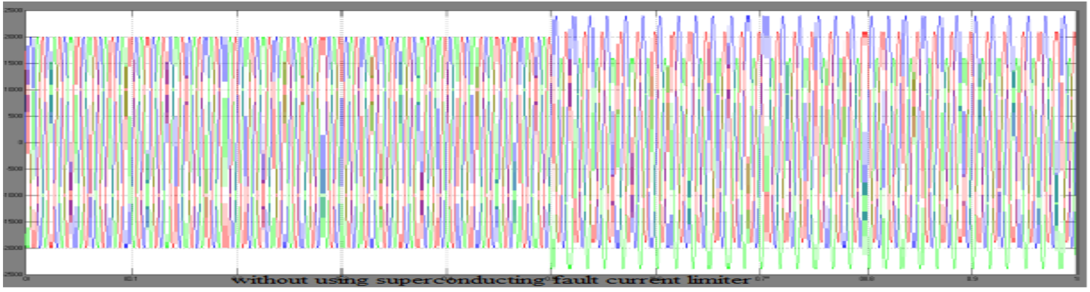

Fig.3:With SFCL

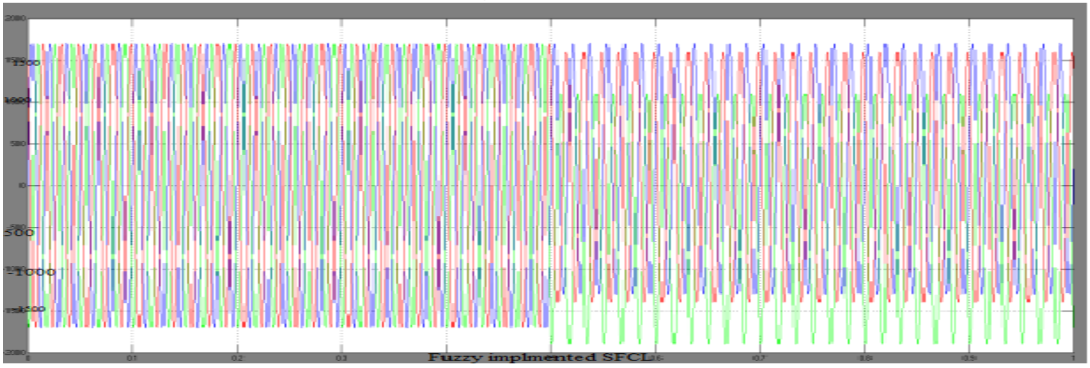

Fig.4: Waveforms using Fuzzy Logic

5. Conclusion

The voltage sag compensation, mitigating the changes in phase angle, and the fault current limiting operation using the proposed method is analyzed. The Fault Current Limiter is capable of mitigating the voltage sag and phase-angle within the tolerance limts. The proposed scheme is done with the help of a semiconductor switch in the dc current path instead of using two thyristors at the branches of bridge. SFCL limits the current at a higher speed. The dc reactor value is minimized to a lower value. It has observed that the control system structure used in this scheme is simpler when compared to the previous. Besides, the dc voltage source placed in the structure reduces THD and ac losses in normal operation. In general, this type of FCL, with the simple control circuit and low cost, is useful for the voltage-quality improvement because of voltage sag and phase-angle jump mitigating and low harmonic distortion in distribution systems. Power systems are developed with and without the FCL.

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