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Role of Fault Current Limiter in Power System Network

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Abstract—**This paper presents an overview of fault current limiters Fault current limiters (FCL) in electrical power systems offer the opportunity to reduce short-circuit stresses to the system in the case of faults. But as electrical power systems are normally operated without faults most of the time, FCLs must not have negative effects during these periods of normal operation. Usage of renewable energy to meet demand without proper synchronization will result in power quality problems like voltage sag, swell etc. Fault Current Limiters offers a possible solution to the electrical network.**

Index Terms—**Power quality, Voltage sag, Fault current, FCL**

I. Introduction

The use of fault current limiters in electrical grids with a high short-circuit power is of high importance. The short circuit current is an essential indicator for the mechanical and thermal stress of a system. The most widely used solution for limitation of the fault currents is to use a transformer with a split secondary winding (or a three-windings transformer) and current limiting reactors.

However, the usage of fault current limiting reactors at facilities with powerful motor loads has a negative impact on the stability of motors, for example when short-term voltage sags occur. It would be worthwhile to directly control transients, resulting from faults, at primary circuits, thus
alleviating effects of the faults.

Various types of fault current limiters have been developed recently. Limiters utilizing high-temperature superconductors are usually cooled with relatively expensive liquid nitrogen and operating at 77 K [1].

Two varieties of such limiters are most widely used :parallel-type (or shunt-type) and series-type.

Series fault current limiters are limiting the fault current by disconnecting solid-state switch and increasing the impedance. However, such scheme has a disadvantage: the system should be operating in continuous mode, and malfunction of the static
switch could lead to interruption of power supply for the customer.

Parallel fault current limiters are activated only at the moment of fault and have the following functions:
- limit the peak fault current;
- decrease the motors' feeding into the fault;
- shunt the consumer switches while disconnecting.

The advantage of such scheme is the fact that it operates only when a fault occurs and for a short-term. It also could be used when older but still operational equipment gradually becomes underrated through system growth. The application of the fault current limiter provides a cost-effective solution for such problems [3].

The solid-state breakers are always embedded into two major useful categories in power system devices: i) solid-state transfer switch and ii)solid state fault current limiter (SSFCL) or Power electronic Fault current limiter (PEFCL).Moreover, the high level of short circuit current becomes the serious problem. It may be damage the electric devices or effect to machines operation. A fault current let through reactor and a ZnO surge arrestor. [t overcame the limitation of both [GBT FCL and SCR Bridge FCL.

Classical current limiters (fuses, electronic power components like SCR, [GBT, etc.,) are available only for low voltages and their response time is limited by the detection time «1 ms For a high temperature superconducting fault current limiter the limitation is effective in a sub millisecond time without detection or external command.

II .HOW CURRENT LIMITERS WORK

A current limiter is a parallel combination of a copper bar and anurrent limiting fuse.

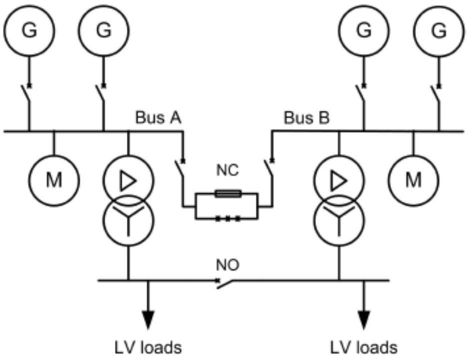

Fig-1:Use of current Limiters

During normal operation the load current flows through the copper bar which effectively shorts out the fuse. This is the reason why the current limiter has no effect on the distribution system in normal operation.

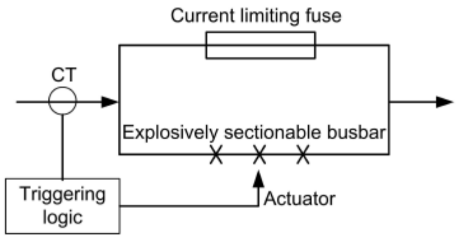

Fig-2:Current Limiting Device

When there is a short-circuit however, it is necessary to interrupt the flow of current through the copper bar and force the current through the current-limiting fuse. This must be done much before the peak short-circuit current value isreached if any limitation is to occur. A fast acting triggering device is therefore required. This, together with an explosive charge as shown in Fig-1 will cause the immediate destruction of the conducting path through the copper bar.

The fault current will then flow though the current limiting fuse until the first natural current zero is reached. After this current zero the fault current through the current limiter will be zero.This sequence is shown in figure-3.

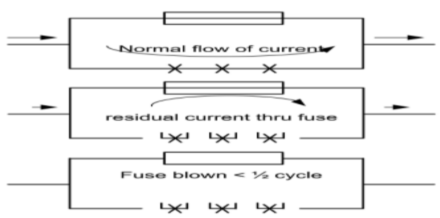

Fig:3 Operation Of Current Limiting Device

How the current limiter will reduce the short-circuit current can be seen when considering a fault on Bus A in Fig-1.Each generator in service will contribute to the fault current and thus a large percentage will flow though the bus-tie circuit-breaker. The current limiter will greatly reduce the magnitude of the fault current flowing through the bus-tie thus reducing the total current at the fault location. Fig. 8 shows the contributions to the fault current from the sources on Bus A and Bus B. For ease of understanding Fig-4 it is assumed that the contribution from Bus B is larger. As can be seen in Fig-4 the current through the bus-tie is limited to a value much lower than the prospective short-circuit current from the sources on Bus B. This current is limited much before the first peak of short-circuit current from Bus B occurs. The current limiter therefore reduces both the peak current and the interrupting current.

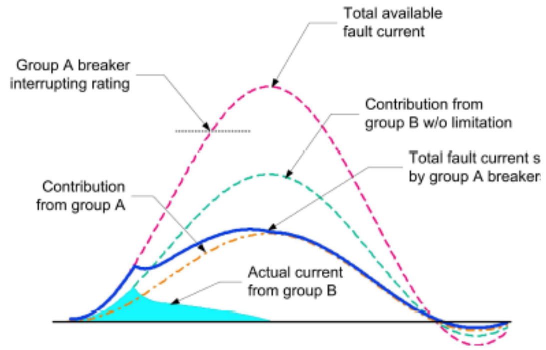

Fig-4 Short Circuit Current For Fault On Bus A

After operation of the current limiter the only fault current to be interrupted by the circuit-breakers on Bus A is that generated by the power sources on Bus A. Should a current limiter not have been installed in the bus tie the maximum short-circuit current would exceed the peak an interrupting capacity of the switchgear as shown in Fig-4.

III.TYPES OF FAULT CURRENT LIMITERS.

This section presents a brief review of the various kinds of FCL that has been implemented or proposed. FCL(s) can generally be categorized into three broad types:

I) Passive limiters
2) Power Electronic type limiters, and
3) Hybrid limiters

1)Passive limiters:

Fault limiters that do not require an external trigger for activation are called passive limiters.The current limiting task is achieved by the physics involved in the FCL itself. The simplest of all kinds of fault current limiter is the inductor. The current limiting strategy is achieved by inserting impedance.Since current cannot change instantaneously in an inductor, current is therefore limited at the moment of a fault.fig-5 shows the working of passive limiters.

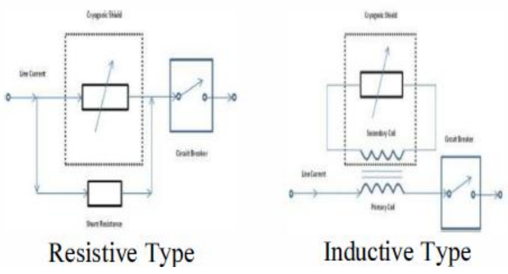

FIG-5 :Passive Limiters

2)Power Electronic Type Limiters:

Recent developments in power switching technology have made solid state limiters suitable for voltage and power levels necessary for distribution system applications. Figure 6 shows the power electronic type of limiters.

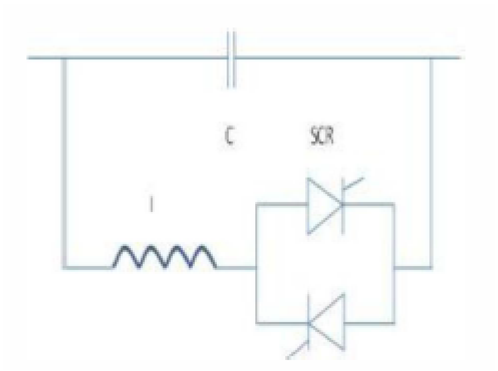

Fig-6:Power Electronic type limiters

Power Electronics limiters use a combination of inductors, capacitors and Thyristor or IGBT to achieve fault limiting functionality. An inductor and a pair of thyristor. In steady state, the thyristors are turned off and all current flows through the capacitor. The placement of the capacitor is also useful by nature because it provides series compensation for the inductive transmission line.

3)Hybrid Limiters:
As the name implies, hybrid limiters use a combination of mechanical switches, solid state FCL(s), superconducting and other technologies to create current mitigation. It is a well-known fact that circuit breakers and mechanical based switches suffer from delays in the few cycles range. Power electronic switches are fast in response and can open during a zero voltage crossing hence commutating the voltage across its contacts in a cycle. Fig. 4 shows the circuit arrangement of Hybrid limiter device.The reactance of the capacitor C 1 and reactor L isabout zero at nominal power frequencies. In steady state, the TVS (Triggered Vacuum Switch) and SW2 are in the off state. SW2 is a quick permanent magnetism vacuum contactor with a 3-lOms closure delay, which prevents TVS from long-time arc erosion. When a fault occurs, a trigger signal is sent to both TVS and the contactor turning on the bypass capacitor C I. This creates a situation where the reactor L will limit the fault current immediately. The ZnO arrestor is used for over voltage protection and capacitor C2 and switch SWI is set-up as conventional series compensation.Fig-6 shows the hybrid limiters.

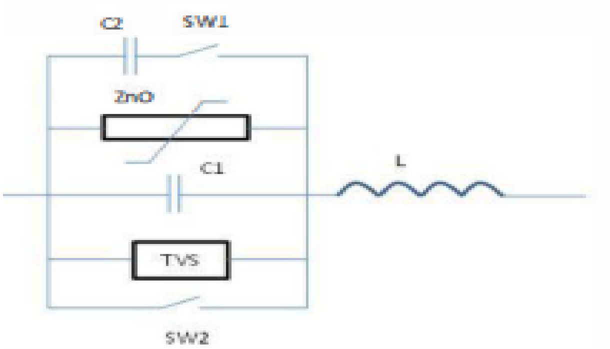

Fig-7 Hybrid limiters

IV. POWER QUALITY STANDARDS, ISSUES AND ITS CONSEQUENCES:

1) *INTERNATIONAL ELECTRO TECHNICAL COMMISSION GUIDELINES*:
The guidelines are provided for measurement of power quality of wind turbine. The International standards are developed by the working group of Technical Committee-88 of the International Electro-technical Commission (IEC), IEC standard 61400-21, describes the procedure for determining the power quality characteristics of the wind turbine.
The standard norms are specified.
1) IEC 61400-21: Wind turbine generating system, part-21. Measurement and Assessment of power
quality characteristic of grid connected wind turbine.
2) IEC 61400-13: Wind Turbine—measuring procedure in determining the power behaviour.
3) IEC 61400-3-7: Assessment of emission limits for fluctuating load IEC 61400-12: Wind Turbine performance.
The data sheet with electrical characteristic of wind turbine provides the base for the utility assessment regarding a grid connection.

2) *VOLTAGE VARIATION:* The voltage variation
issue results from the wind velocity and generator torque. [4]The voltage variation is directly related to real and reactive power variations. The voltage variation is commonly classified as under:
• Voltage Sag/Voltage Dips.
• Voltage Swells.
• Short and Long duration voltage variation.
The voltage flicker issue describes dynamic variations in the network caused by wind turbine or by varying loads. Thus the power fluctuation from wind turbine occurs during continuous operation. The amplitude of voltage fluctuation depends on grid strength, network impedance, and phase-angle and power factor of the wind turbines. It is defined as a fluctuation of voltage in a frequency 10–35 Hz. The IEC 61400-4-15 specifies a flicker meter that can be used to measure flicker directly.

3) *HARMONICS*: The harmonic results due to the
operation of power electronic converters. The harmonic voltage and current should be limited to the acceptable level at the point of wind turbine connection to the network. To ensure the harmonic voltage within limit, each source of harmonic current can allow only a limited contribution, as per the IEC-61400-36 guideline. The rapid switching gives a large reduction in lower order harmonic current compared to the line commutated converter, but the output current will have high frequency current and can be easily filter-out.

V.SIMULATION RESULTS:
In the simulation model renewable energy source is considered. Renewable energy systems will create power quality problems due to its variation in wind and solar radiation. Sometimes because of variation in source also creates some over voltage problems.

The main aim of of the proposed scheme is to mitigate the fault current and voltage sag in power system network. Here for single phase with FCL under line to ground fault condition compared with that of without FCL. They are compared in terms of percentage of Total Harmonic Distortion (THD), input and output voltage and current waveform. Simulink Models has been developed with FCL and that with respect to without FCL. Simulation work is carried in MATLAB 13.0/Simulink.

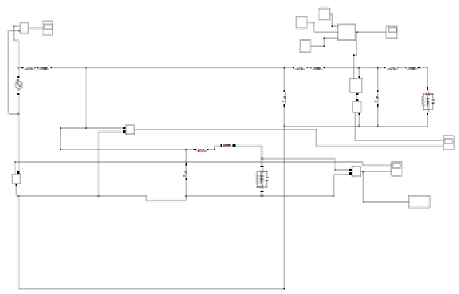

Fig:8

Block diagram without FCL

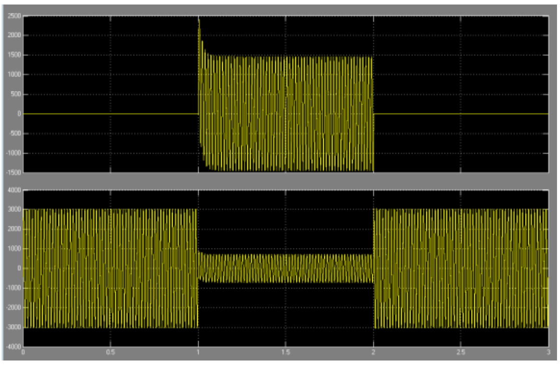

Fig:8a Fault Current And Output Voltage without FCL

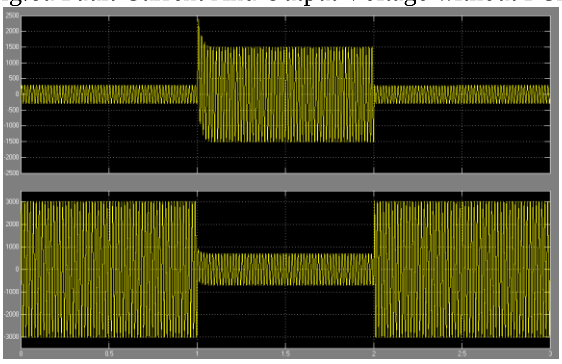

Fig:8b output current and voltage without FCL

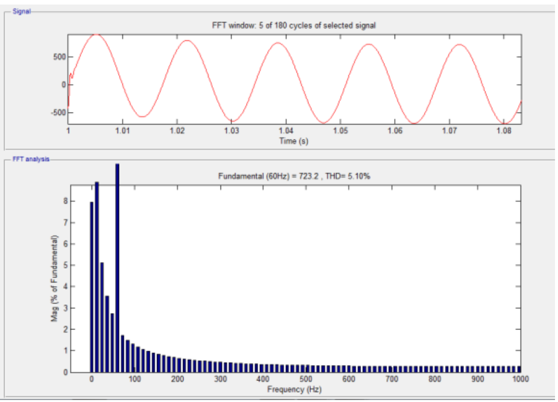

Fig:8c Response of THD without FCL

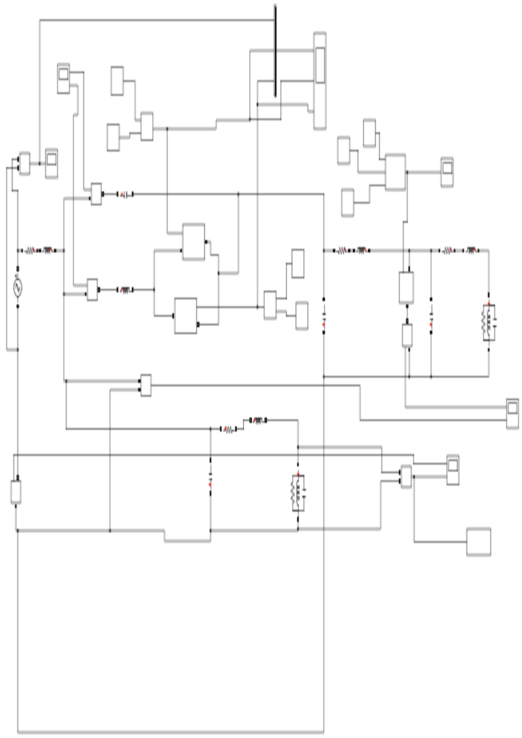

Fig:9 Block diagram with PEFCL

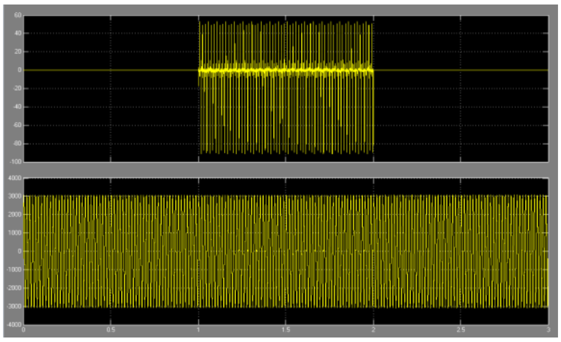

Fig:9a Fault Current And Output Voltage with PEFCL

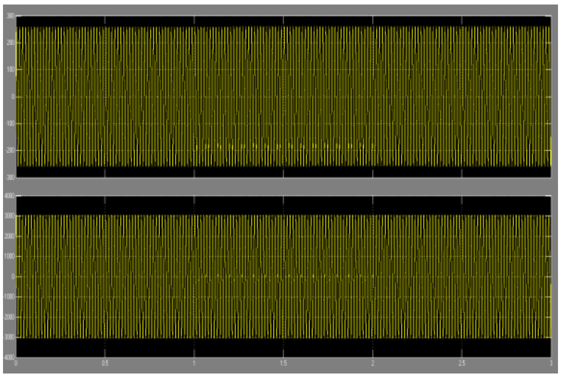

Fig:9b output current and voltage with PEFCL

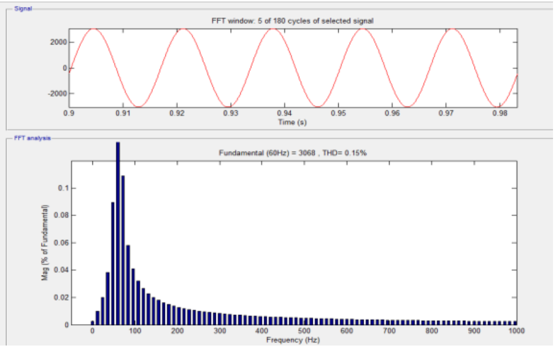

Fig-9c:Response of THD without FCL

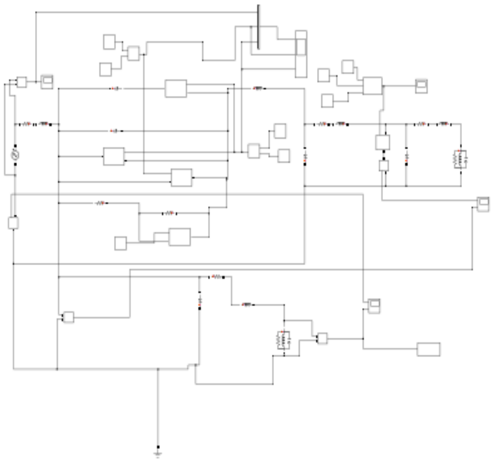

Fig-10:Block Diagram With Hybrid FCL

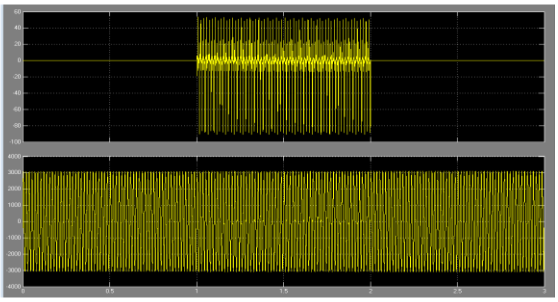

Fig-10a: Fault Current And Output Voltage with Hybrid FCL

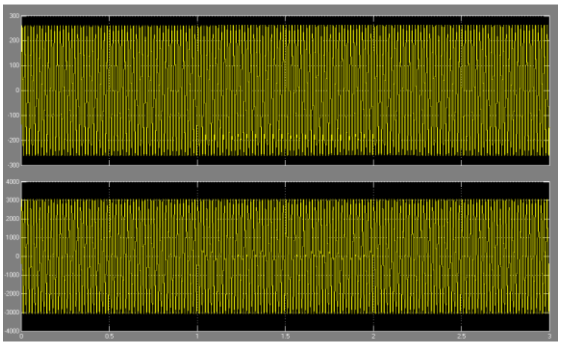

Fig-10b: Output Current And Voltage With Hybrid FCL

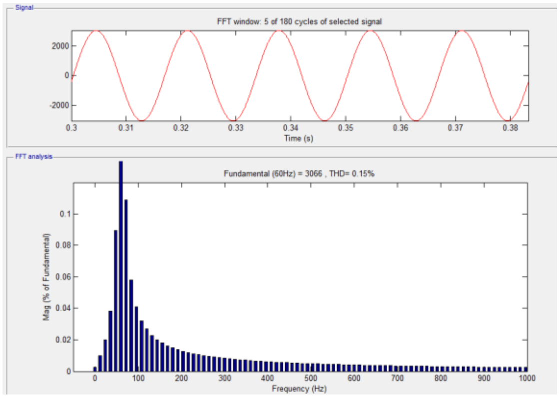

Fig:10c Response of THD with Hybrid FCL

VI CONCLUSION

In this paper simple single phase without and with Fault Current Limiter (Hybrid FCL), Power Electronic Fault Current Limiter (PEFCL) and creating fault has been simulated using Matlab simulink. Output results of the simulation is analysed and the results shows that with Hybrid FCL optimizes only the fault current, but voltage sag mitigation cannot be done because there is no power electronics devices present in the circuit. And the simulated PEFCL output results also been analysed and it shows that it is capable of optimizing fault current as well as voltage sag mitigation. Total Harmonic Distortion (THD) is analysed for single phase network.

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