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Microgrid protection by using resistive type superconducting fault current limiter

Uma Maheswara Rao M.*, Mercy Rosalina K.

Department of Electrical and Electronics Engineering VFSTR, Vadlamudi, Guntur, Andhra Pradesh 522213, India

Corresponding Author Email: mumr_eeep@vignanauniversity.org

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ABSTRACT

Energy usage increases day to day. To overcome this usage, nonconventional energy sources are combined with conventional units here the loads, powers and frequency marched at load side and source side. In this work fuel cell, P-V power & wind energies are combined. The combination of these DGs increase fault current levels. Here we are using resistive type superconducting fault current limiters(R-SFCL) to limit the fault currents. SFCL gives a very fast response it limits fault current within the first cycle. It's having good characteristics, as compared to conventional protective devices SFCL gives good response and high efficiency. In this work resistive type superconducting fault current limiter improves the transient stability, voltage profile, power ratings and reduce harmonics at different fault conditions. This work is done by using MATLAB / Simulink.

1. INTRODUCTION

In general smart grid, protection is more complex, due to the integration of a number of DGs. Here the interconnection of distributed generations with the main grid is more complex and fault finds out process is also very difficult. Due to the process of interconnection of DGs short-circuit currents are increased more and more that currents are known as fault currents. In high voltage applications, fault currents range is more than the conventional protective devices range (circuit breakers), in that situation the system is completely damaged. Generally, existing protective devices had some intentional time delay so it allows two to three cycles of fault currents then our system is completely damaged. By considering above disadvantages we implemented Resistive type superconducting fault current limiter (R-SFCL).

In this work SFCL is used as a protective device it allows fault current for first half cycle so its response time is very high. Under normal operating conditions SFCL acts as a low impedance path, during abnormal conditions SFCL acted as high impedance path at that situation fault currents are minimized. T.Jamsb discussed superconducting fault current limiter (SFCL) is a good protective device to limit fault currents within one cycle [1]. C. Deng, F. Guo discussed the operation of superconducting fault current limiter [2]. The voltage and current attributes of superconducting fault current limiters are discussed at different fault locations.

This work introduces a superconducting fault current limiter (SFCL) into the power system model and discusses its advantages. This power system model is simulated with three distributed generations that are a Fuel cell, P-V power, and Wind power, these three DG's are connected with main grid. In this proposed system create fault at wind generator in MATLAB/Simulink. The following outputs are satisfactory.

2. RESISTIVE TYPE SFCL

Resistive type superconducting fault current limiter(R-SFCL) is effective in work compare to other superconducting fault current limiters. The aim of resistive type superconducting fault current limiter to limit the fault currents within the first half cycle. At normal operating conditions R-SFCL acts as a superconductor, during abnormal conditions (fault) it acts as a resistor with high resistance then fault currents are limited. After clear the fault again it comes automatically to the superconducting state.

Superconducting fault current limiter advantages are to improve system stability, reliability, power transfer capability and reduced localized disturbances. In olden days conventional protective devices like circuit brakes and relays are used to protect power system from abnormal conditions, these devices allow fault current two to three cycles at that time system is damaged. SFCL allows faulting current one cycle so its operating time is very fast as compare to conventional protective devices.

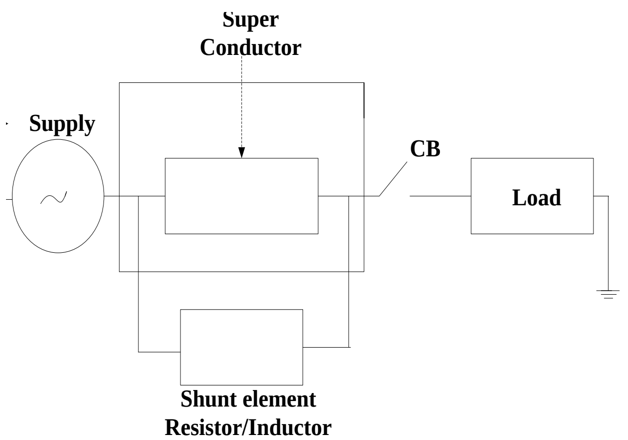

Figure 1. Resistive type superconducting fault current limiter

SFCL is used to reduce voltage dips, increased fault recovery time as compared to inductive type superconducting fault current limiter, R-SFCL is light in weight and small in size. Resistive type superconducting fault current limiter has one parallel branch (Resistive/Inductive) type, this branch is used to protect R-SFCL from high voltages and hot spots [8]. Figure 1 shows the resistive type superconducting fault current limiter.

3. BASIC HYBRID SYSTEM MODEL

Figure 2 shows the power system model with a fuel cell, P-V array, and wind power. In this model, three DGs are interconnected and integrated with main grid here the capacities of DGs are Fuel cell-10 kW, P-V cell-250 kW, and Wind power-150 kW.

Three, three phase industrial loads are connected to this power system network and the ratings are load-1(150+j25) KVA, load-2 (450+j30) KVA, and load-3 (200+j20) KVA. Transmission line parameters are (0.27+j0.347) Ω/km. The frequency of power system model is designed to 50 HZ. Transmission line voltage levels are 10.5 kV this voltage level is step down to 415 volts by using a step-down transformer at the distribution level. That 415 volts three phase supply is given to the three industrial loads.

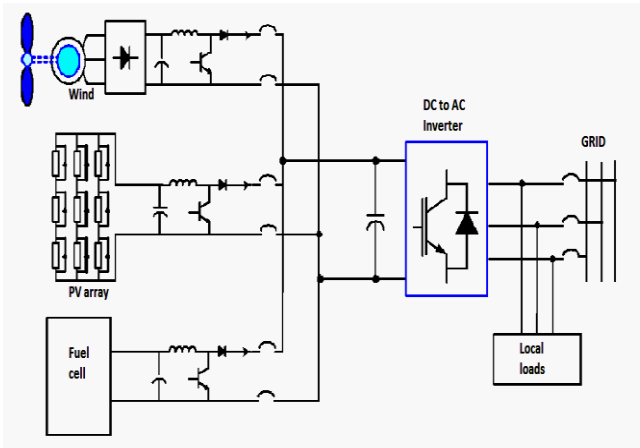

Figure 2. Basic power system model of hybrid network

4. SIMULINK MODEL

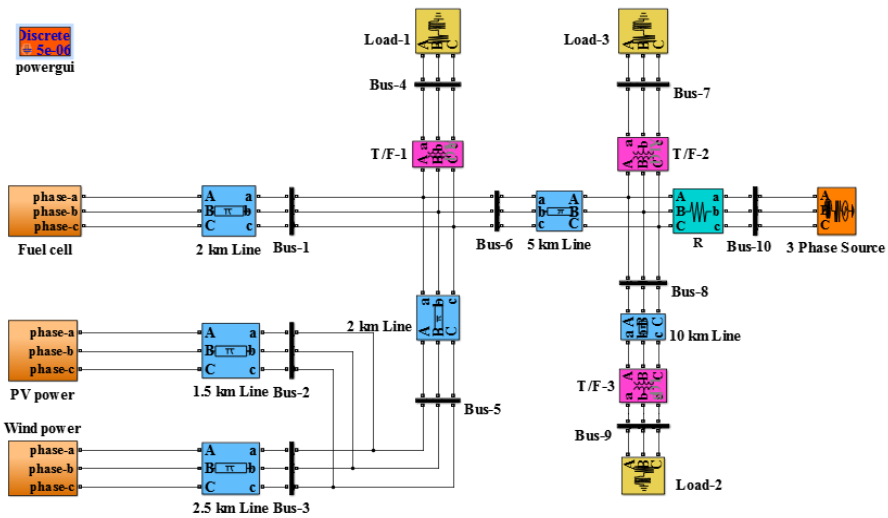

Figure 3. Schematic diagram of hybrid power system model without fault

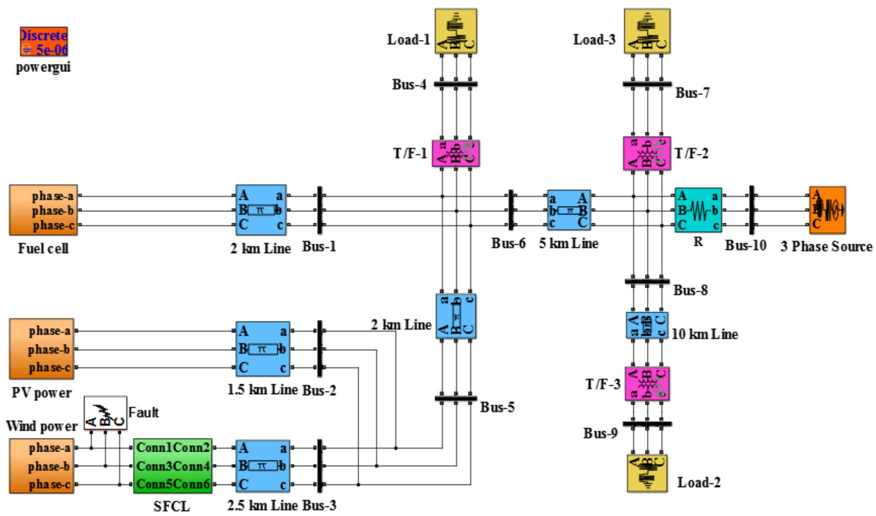

Figure 4. Schematic diagram of hybrid power system model with fault and SFCL

The hybrid power system network is developed by using MATLAB/Simulink, this software is advantage compare to EMTP and PSPICE. This hybrid power system without any fault, simulation diagram as shown in figure 3 and figure 4 shows the Schematic diagram of hybrid power system model with fault and SFCL.

5. RESULTS AND DISCUSSION

From figure 4 Resistive type superconducting fault current limiter (R-SFCL) is placed near the wind generator and create one 3LG fault at a wind generator, that fault starting time is 0.08 sec and fault clearance time is 0.12 sec. At the time of the fault, the magnitude of fault currents increases up to 1250 amps shown in the figure-5 (without R-SFCL).

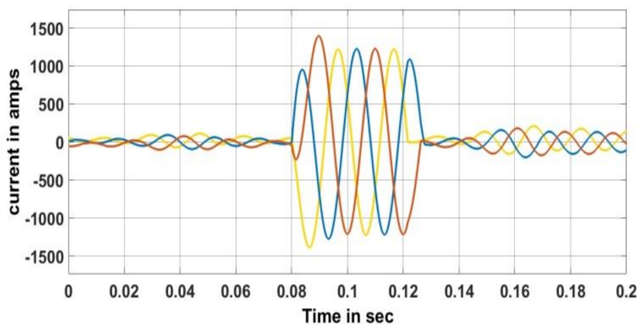

Figure 5. Current at fault location without R-SFCL

Figure 6 shows the current at fault location with the connection of Resistive type superconducting fault current limiter. At the time of fault R-SFCL acts as a high resistance, then fault current is limited up to 800 amps. The fault current is limited from 1250 amps to 800 amps.

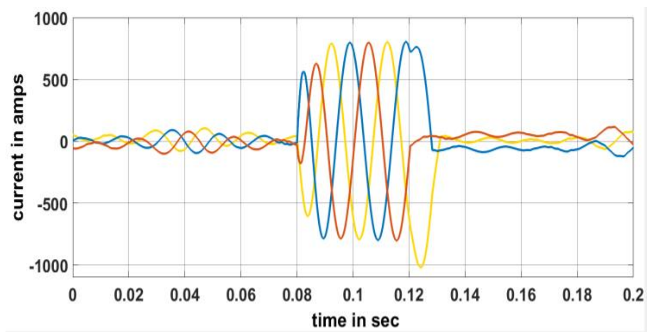

Figure 6. Current at fault location with R-SFCL

Figure 7 shows the three-phase voltage at fault location without connection of R-SFCL. Under normal operating conditions transmission line voltage is 10.5 kV, during abnormal conditions voltage levels in the transmission line is reduced. Fault time is 0.08 sec to 0.12 sec.

Figure 8 shows the three-phase voltage at wind generator. Whenever the R-SFCL placed in the circuit then voltage levels are compensated in the fault time, here pure sinusoidal waveform is not come due to presence of reactive power.

Figure 9 shows voltages (Vmax) per phase, that is 338.84 volts at load-1, load-2, load-3. Under normal operating conditions load voltages (Vrms) is 415 volts. During abnormal conditions voltages at fault, time is decreased (without R-SFCL).

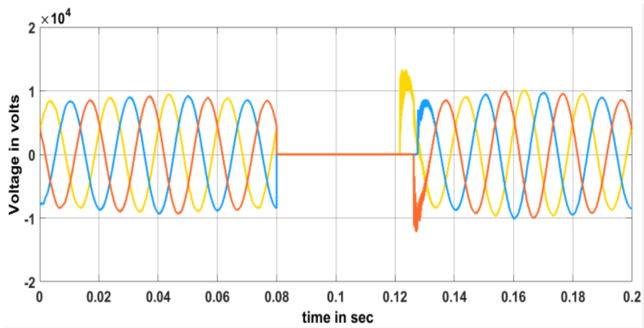

Figure 7. Without R-SFCL DG Voltage

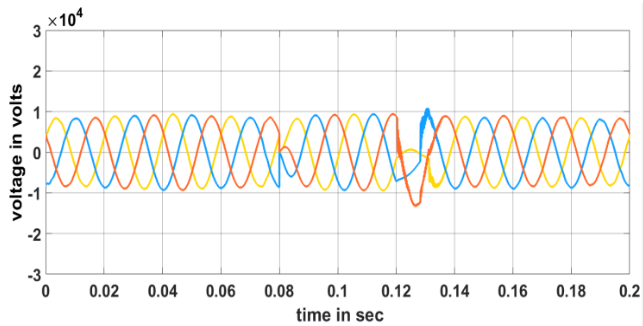

Figure 8. With R-SFCL DG Voltage

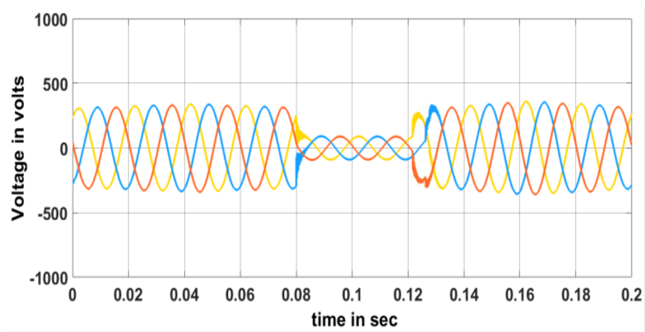

Figure 9. Voltages at load 1,2,3 without R-SFCL

Figure 10 shows the voltages (Vmax) per phase at load-1, load-2, load-3. Whenever R-SFCL is placed in the power system network fault currents are limited at the same time voltage levels are compensated.

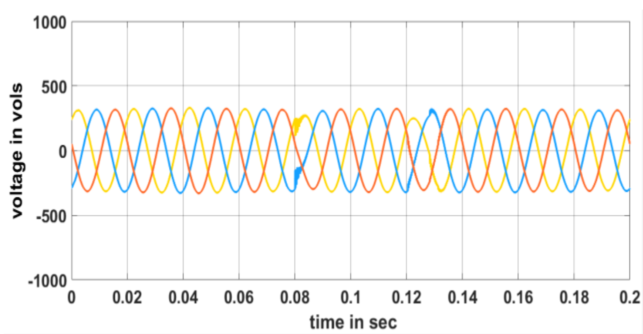

Figure 10. Load 1, 2 and 3 voltages with R-SFCL

Figure 11 shows the three-phase powers (active, reactive) without connecting R-SFCL. Under normal operating conditions powers at load-1 are (150+j25) KVA, during abnormal conditions power levels are reduced in the fault duration (0.08 to 0.12) sec. why because fault current is increases and voltage levels are reduced.

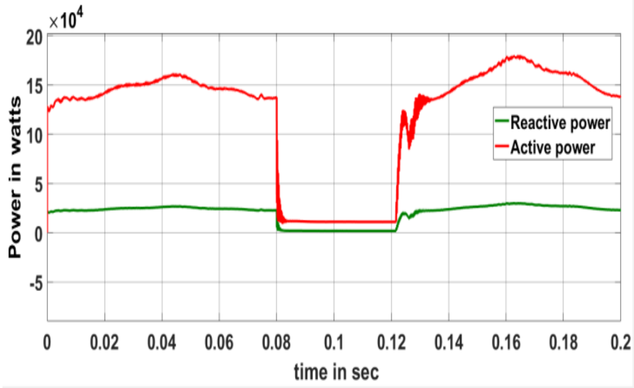

Figure 11. Power at load-1with out R-SFCL

Figure 12 shows three phase power at load-1 with R-SFCL. Whenever R-SFCL is placed in the power system network, it limit's the fault current and compensate the voltage profile. At that situation active, reactive powers are compensated to that original levels.

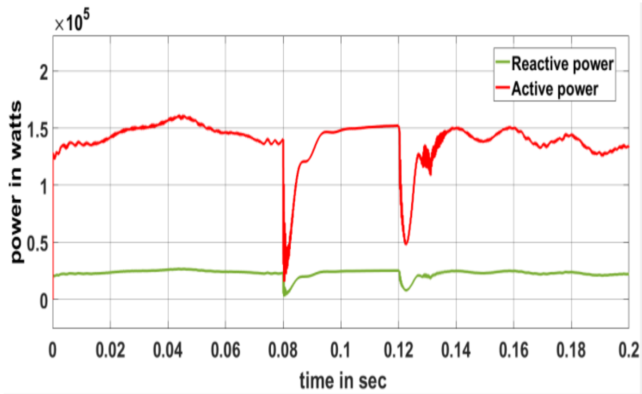

Figure 12. Power at load-1 with R-SFCL

Figure 13 shows the three-phase powers (active, reactive) without connecting R-SFCL. Under normal operating conditions powers at load-2 are (450+j30) KVA, during abnormal conditions power levels are reduced in the fault duration (0.08 to 0.12)sec, why because fault current is increases and voltage levels are reduced.

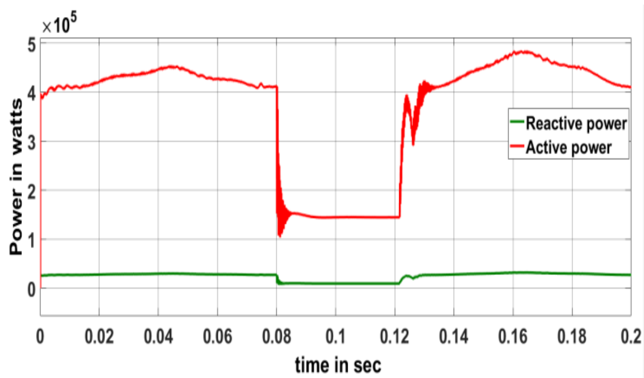

Figure 13. Power at load-2with out R-SFCL

Figure 14 shows three phase power at load-2 with R-SFCL. Whenever R-SFCL is placed in the power system network, it limit's the fault current and compensate the voltage profile. At that situation active, reactive powers are compensated to that original levels.

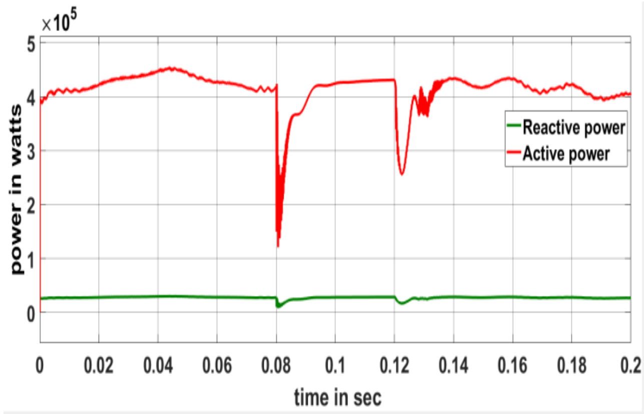

Figure 14. Power at load-2 with R-SFCL

Figure 15 shows the three-phase powers (active, reactive) without connecting R-SFCL. Under normal operating conditions powers at load-3 are (200+j20) KVA, during abnormal conditions power levels are reduced in the fault duration (0.08 to 0.12) sec, why because fault current is increases and voltage levels are reduced.

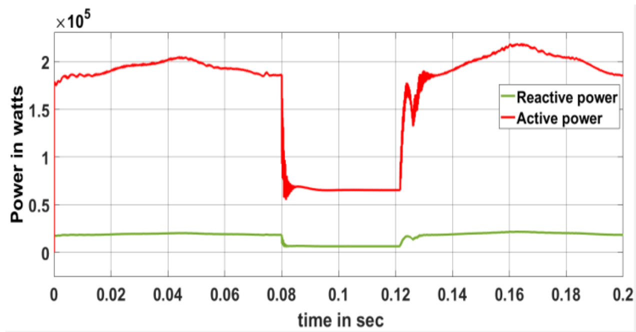

Figure 15. Power at load-3 without R-SFCL

Figure 16 shows three phase power at load-3 with R-SFCL. Whenever R-SFCL is placed in the power system network, it limit's the fault current and compensate the voltage profile. At that situation active, reactive powers are compensated to that original levels.

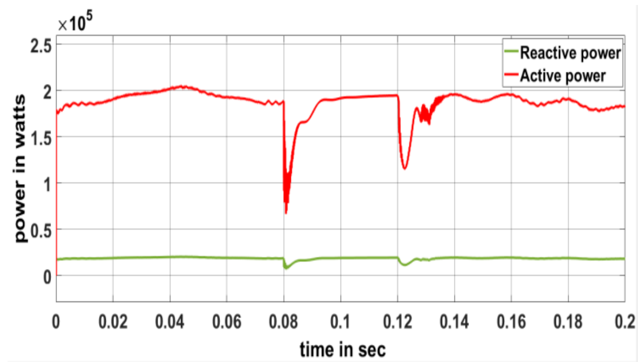

Figure 16. Power at load-3 with R-SFCL

6. CONCLUSIONS

This work represents hybrid electrical power system model. Due to the integration of fuel cell, P-V power and wind power with main grid large amount of fault currents will come. That fault current creates a major disturbance to power system so introduce Resistive type superconducting fault current limiter (R-SFCL) into the power system network. Here R-SFCL works very effective manner, under normal operating conditions R-SFCL works as superconductor during abnormal conditions it acts as resistor then fault currents are limited. R-SFCL is a very effective device to reduce harmonics, fault currents and compensate the voltage levels.

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