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ANALYSIS OF HYBRID RES BASED AC AND DC MICRO GRID ON POSITIONING OF SFCL

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Abstract- *Nowadays, the main energy supplier of the worldwide economy is fossil fuel. However has led to many problems such as global warming and air pollution. Therefore, with regard to the worldwide trend of green energy, Fuel cell technology has become one of the most promising energy resources. Smart grid will integrate modern communication technologies and renewable energy resources into the future power grid, in order to supply more efficient, reliable, resilient and responsive electric power. In this paper, an application of superconducting fault current limiter (SFCL) is proposed to limit the fault current that occurs in power system, SFCL is a device that uses superconductors to instantaneously limit or reduce unanticipated electrical surges that may occur on utility distribution and transmission networks. Due to the difficulty in power network reinforcement and the interconnection of more distributed generations, fault current level has become a serious problem in transmission and distribution system operations. The utilization of fault current limiters (FCLs) in power system provides an effective way to suppress fault currents and result in considerable saving in the investment of high capacity circuit breakers is felt. In this work, a resistive type SFCL model was implemented by integrating Simulink and SimPowerSystem blocks in Matlab. The designed SFCL model could be easily utilized for determining an impedance level of SFCL according to the fault-current-limitation requirements of various kinds of the smart grid system. Three phase faults have been simulated at different locations in smart grid and the effect of the SFCL and its location on the wind farm fault current was evaluated. Fuel cell, PV Cell and Wind farm were considered and their performance is also evaluated.*

Keywords- *Fault current, micro grid, smart grid, superconducting fault current limiter, wind farm.*

I. INTRODUCTION

Smart grid is a term used for future power grid which integrates the modern communication technology and renewable energy resources for the 21st century power grid in order to supply electric power which is cleaner, reliable, effervescent and responsive than conventional power systems. Smart grid is based on the principle of decentralization of the power grid network into smaller grids (Microgrid) having distributed generation sources (DG) connected with them, One critical problem due to these integrations is excessive increase in fault current due to the presence of DG within a micro grid [1],Conventional protection devices installed for protection of excessive fault current in power systems, mostly at the high voltage substation level circuit breakers tripped by over-current protection relay which has a response-time delay resulting in power system to pass initial peaks of fault current [1].But, SFCL is a novel technology which has the capability to quench fault currents instantly as soon as fault current exceeds SFCL's current limiting threshold level [2]. SFCL achieves this function by losing its superconductivity and generating impedance in the circuit. SFCL does not only suppress the amplitudes of fault currents but also enhance the transient stability of power system [2][3].Up to now, there were some research activities discussing the fault current issues of smart grid

[5], [6].But the applicability of SFCLs into micro grids was not found yet. Hence, in order to solve the problem of increasing fault current in power systems having multiple micro grids by using SFCL technology is the main concern of this work. The utilization of SFCL in power system provide them most effective way to limit the fault current and results inconsiderable saving from not having to utilize high capacity circuit breakers. With Superconducting fault current limiters (SFCLs) utilize superconducting materials to limit the current directly or to supply a DC bias current that affects the level of magnetization of a saturable iron core. Being many SFCL design concepts are being evaluated for commercial expectations, improvements in superconducting materials over the last 20 years have driven the technology [4]. Case in point, the discovery of high-temperature superconductivity (HTS) in 1986drastically improved the potential for economic operation of many superconducting devices.

This growth is due to the capability of High temperate Sensitive materials to operate at temperatures around 70Kinstead of near 4K, which is required by conventional superconductors. The advantage is that refrigeration overhead associated with operating at the higher temperature is about 20 times less costly in terms of initial capital cost, operational cost and maintenance cost.

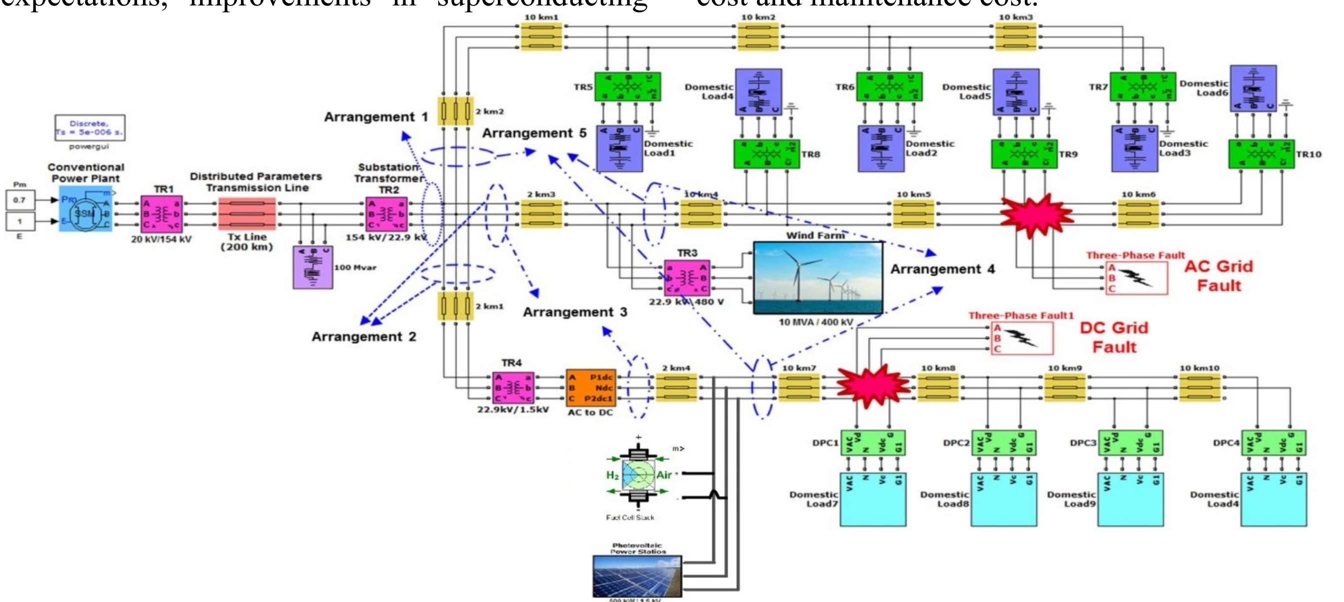

Fig.1. Power Power system model designed in Simulink/SimPowerSystem. Fault and SFCL arrangements are indicated in the diagram

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Based on the previous works, this paper presents feasibility analysis results of positioning of the SFCL and its effects on reducing fault current in smart grid having AC and DC micro grid together. The detailed power system was implemented with AC micro grid having wind farm and low voltage DC grid connected with photovoltaic farm. Transient analyses were performed for the worst case faults with the different SFCL arrangements. From the simulation results, it was possible to determine the strategic installation placement of SFCLs in power systems which limits all abnormal fault currents and has no negative effect on the distributed generation resources.

II. SIMULATION SET-UP

Matlab/Simulink/SimPowerSystem was selected to design and implement the SFCL model. A complete smart grid power network including generation, transmission, and distribution with an integrated wind farm model was also implemented in it. Simulink/SimPowerSystem has number of advantages over its contemporary simulation software (like EMTP, PSPICE) due to its open architecture, a powerful graphical user interface and versatile analysis and graphics tools. Control systems designed in Simulink can be directly integrated with SimPowerSystem models.

A. Power System Model

The microgrid has AC microgrid and DC microgrid together. Each microgrid is integrated with distributed generation sources. AC microgrid has the wind farm which is composed of five fixed speed induction type wind turbine.

Each wind turbine has a 2 MVA rating. The working voltage of AC microgrid is 22.9 kV which is typical distribution voltage in Korea. In case of DC microgrid, photovoltaic farm which is composed of 500 solar panels were connected to the grid. Each photovoltaic module has a 3 kW rating. The working voltage of DC microgrid is 1.5 kV and this voltage was chosen by considering the operating voltage of LVDC. The outstanding difference between AC and DC microgrid is the existence of voltage source convertor (VSC), pole mounted transformer (PMT) and domestic power convertor (DPC). As shown in Fig. 1, Arrangement 1 represents a single AC SFCL at the outgoing feeder of the substation transformer TR2. Arrangement 2 indicates two AC SFCLs at AC and DC microgrid. Arrangement 3 shows both AC SFCL and DC SFCL at AC and DC microgrid respectively. Arrangement 4 indicates AC SFCL and DC SFCL at the outgoing feeder of the integration points of distributed generations. Arrangement 5 Indicates combination of Arrangement 4 and a single AC SFCL at conventional power grid.

B. Resistive SFCL Model

The three phase resistive type SFCL was modeled considering four fundamental parameters of a resistive type SFCL [9]. These parameters and their selected values are: 1) transition or response time=2msec, 2) minimum impedance=0.01ohms and maximum impedance=20ohms, 3) triggering current=550A and 4) recovery time=10msec. Its working voltage is 22.9 kV.

Fig. 2 shows the SFCL model developed in Simulink/Sim-PowerSystem. The SFCL model works as follows. First, SFCL model calculates the RMS value of the passing current and then compares it with the characteristic table. Second, if a passing current is larger than the triggering current level, SFCL's resistance increases to maximum impedance level in a pre-defined response time. Finally, when the current level falls below the triggering current level the system waits until the recovery time and then goes into normal state.

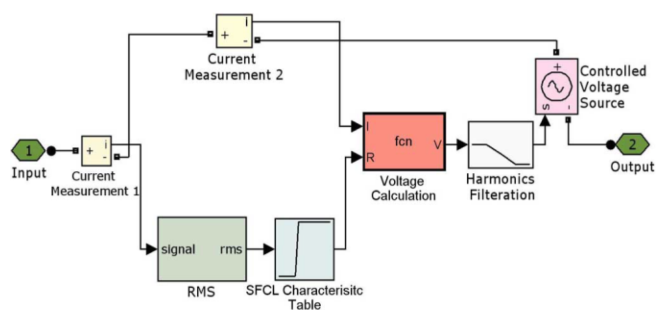

Fig.2. Single phase SFCL model developed in Simulink/SimPowerSystem

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Fig. 3 shows the result of verification test of SFCL model conducted on power network model depicted in Fig. 1. SFCL has been located at substation (Location 1) and for a distribution grid fault (Fault 1), various SFCL impedance values versus its fault current reduction operation has been plotted. Maximum fault current (No SFCL case) is 7500 A at 22.9 kV for this arrangement.

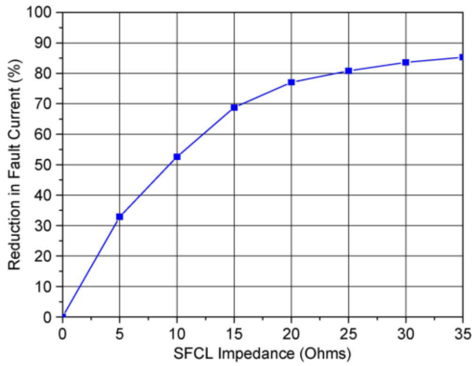

Fig.3.SFCL performance evaluation graph indicating the relationship between SFCL impedance and reduction in fault current

III. PHOTOVOLTAIC SYSTEM WITH GRID

A Photovoltaic (PV) system directly converts solar energy into electrical energy. The basic device of a PV system is the PV cell. Cells may be grouped to form arrays. The voltage and current available at the terminals of a PV device may directly feed small loads such as lighting systems and DC motors or connect to a grid by using proper energy conversion devices.

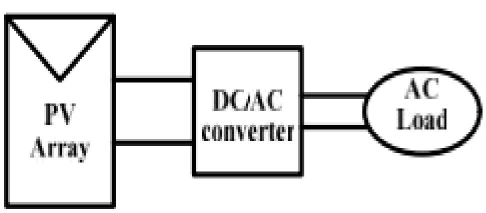

Fig.4. Block diagram representation of Photovoltaic system

This photovoltaic system consists of three main parts which are PV module, balance of system and load. The major balance of system components in this systems are charger, battery and inverter. The Block diagram of the PV system is shown in Fig.4. A photovoltaic cell is basically a semiconductor diode whose p–n junction is exposed to light. Photovoltaic cells are made of several types of semiconductors using different manufacturing processes. The incidence of light on the cell generates charge carriers that originate an electric current if the cell is short circuited1

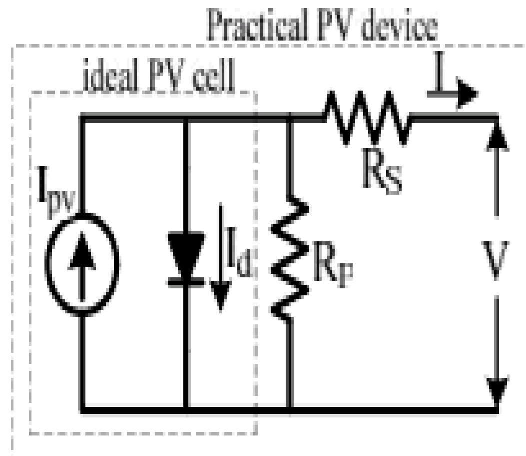

Fig.5. Practical PV device

The equivalent circuit of PV cell is shown in the fig.5. In the above figure the PV cell is represented by a current source in parallel with diode. Rs and Rp represent series and parallel resistance respectively. The output current and voltage form PV cell are represented by I and V

IV. FUEL CELL

A **fuel cell** is a device that converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent. Hydrogen produced from the steam methane reforming of natural gas is the most common fuel, but for greater efficiency hydro carbon scan be used directly such as natural gas and alcohols like methanol. Fuel cells are different from batteries in that they require a continuous source of fuel and oxygen/air to sustain the chemical reaction whereas in a battery the chemicals present in the battery react with each other to generate an electromotive force (emf). Fuel cells can produce electricity continuously for as long as these inputs are supplied.

V.MATLAB/SIMULINK RESULTS

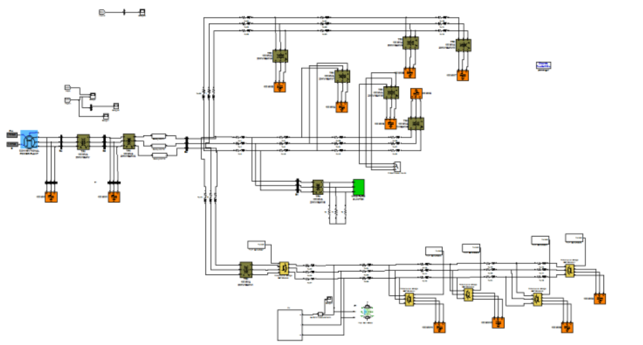

Fig. 6. Matlab/Simulink model of SFCL placed in arrangement 1.

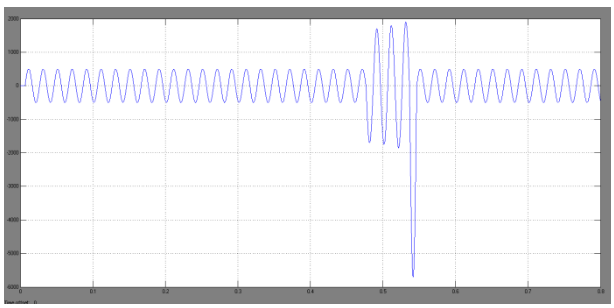

Fig. 7. Simulated output wave form of transmission line current at arrangement 1.

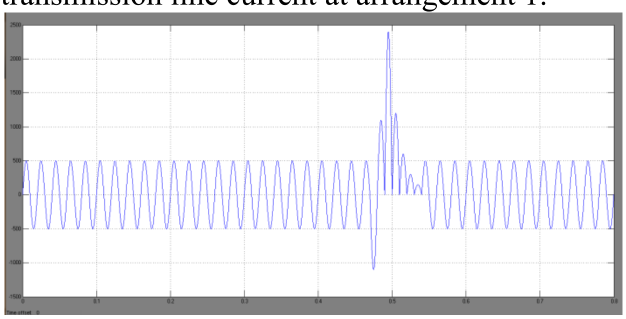

Fig. 8.Simulated output wave form of Wind Current arrangement 1 of SFCL.

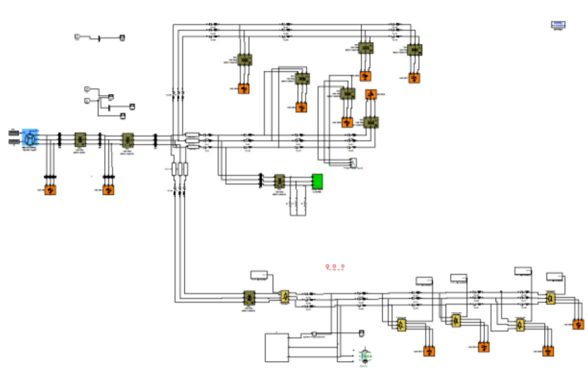

Fig. 9. Matlab/Simulink model of SFCL in arrangement 2.

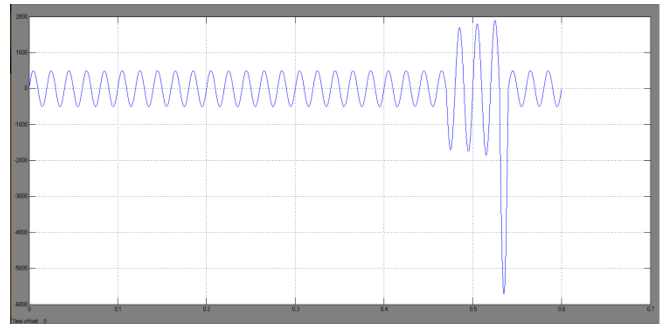

Fig. 10. Simulated output wave form of transmission line currents at arrangement 2.

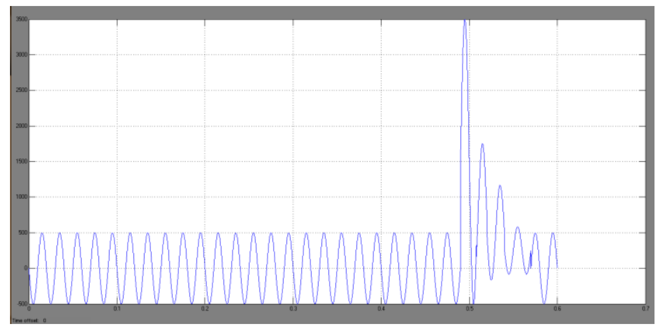

Fig. 11.Simulated output wave form of Wind current arrangement 2 of SFCL.

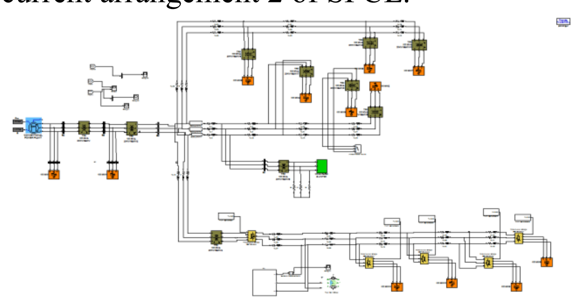

Fig 12. Matlab/Simulink model of SFCL in arrangement 3.

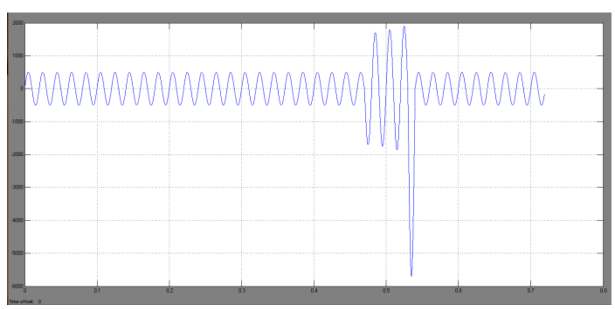

Fig 13. Simulated output wave form of transmission line currents at arrangement 3.

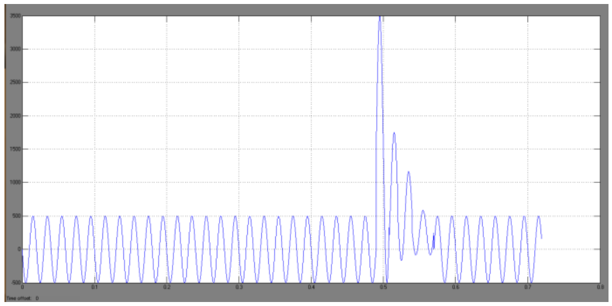

Fig 14. Simulated output wave form of Wind Current arrangement 3 of SFCL.

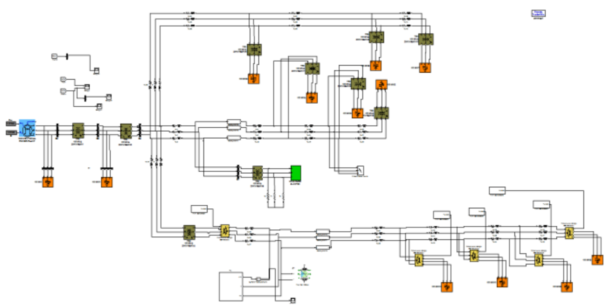

Fig 15. Matlab/Simulink model of SFCL arrangement 4.

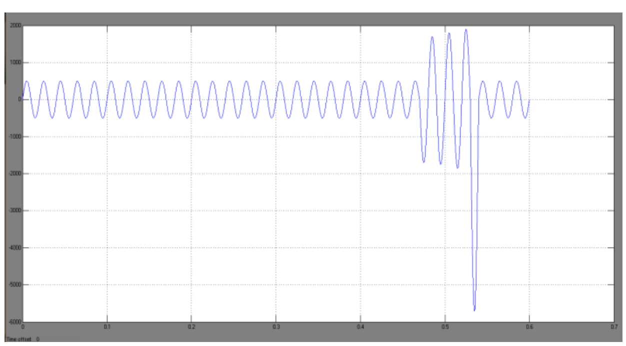

Fig 16. Simulated output wave form of transmission currents at SFCL arrangement 4.

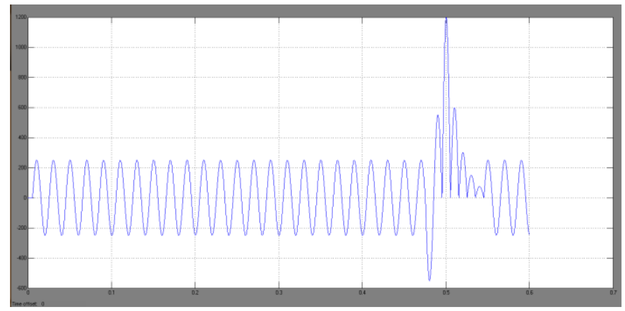

Fig 17. Simulated output wave form of Wind Current arrangement 4 of SFCL

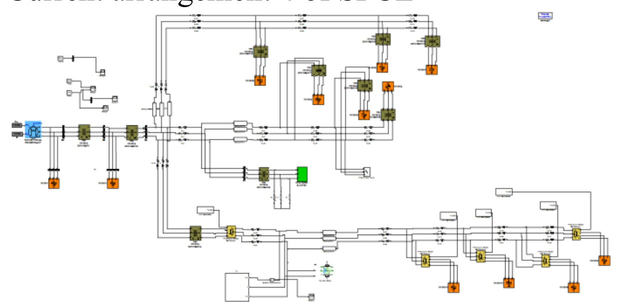

Fig 18. Matlab/Simulink model of SFCL arrangement 5.

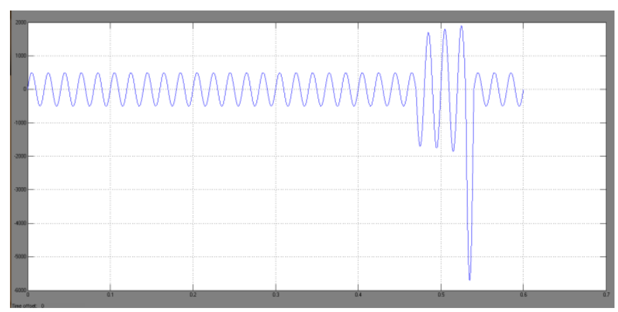

Fig 19. Simulated output wave form of transmission line currents at SFCL arrangement 5.

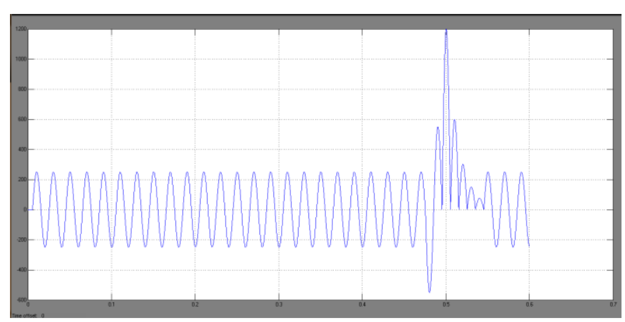

Fig 20. Simulated output wave form of Wind Current arrangement 5 of SFCL

VI. CONCLUSION

As a kind of clean energy technique, the Fuel cell, photovoltaic (PV) power generation offers the advantages of low emission, renewable energy source and independence of mechanical devices. However, the high cost and relatively low efficiency of the PV modules have limited the use of PV power generation in the past compared to other energy sources such as oil, gas, hydro and wind. This paper presented feasibility analysis results of positioning of the SFCL and its effects on reducing fault current in smart grid having AC and DC micro grid together. In order to determine the SFCL in neighboring AC and DC smart grid, AC and DC SFCL models were designed to perform for the worst case faults with the different SFCL arrangements. From the simulation results, the optimal strategic installation placement of SFCLs in power systems, which limits all abnormal fault currents and has no negative effect on the distributed generation resources, has been proposed. SFCLs installed in Arrangement 4 and 5 have shown the best fault current limiting performance because they are located in the direct path of the fault current occurred in AC and DC micro grid.

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