Of late, the electrical power utilities are undergoing rapid restructuring process worldwide. Indeed, with deregulation, advancement in technologies and concern about the environmental impact, competition is particularly fostered in the generation side thereby allowing increased interconnection of generating units to the utility networks. These generating sources are called distributed generators (DG) and are generally connected to the distribution networks. Various new types of distributed generator systems, such as microturbines and fuel cells, in addition to the more traditional solar and wind power, are creating significant opportunities for the integration of diverse DG systems to the utility. Inter-connection of these generators will offer a number of benefits such as improved reliability, power quality, efficiency, alleviation of system constraints along with the environmental benefits. Technology advancement in power electronics and energy storage devices have further accelerated the penetration of DG into electric power distribution system. With these benefits and due to the growing momentum towards sustainable energy developments, it is expected that a large number of DG systems will be interconnected to the power system in the coming years.

Unlike centralized power plants, the DG units are directly connected to the distribution system most often at the customer end. The existing distribution networks are designed and operated in radial configuration with unidirectional power flow from centralized generating station to customers. The increase in interconnection of DG to utility networks can lead to reverse power flow violating fundamental assumption in their design. This creates complexity in operation and control of existing distribution networks and offers many technical challenges for successful introduction of DG systems. Some of the technical issues are islanding of DG, voltage regulation, protection and stability of the network. In order to investigate these issues, accurate and efficient modeling of various DG systems by taking care of their diverse characteristics, design of standard interface control and performance study of developed models become very important.
The present trend in DG technology is towards smaller DG system, with capacity less than 500 kW. An excellent example is fuel cell based DG systems. These generation systems are more reliable, have higher operating efficiency and ultra low emission levels. They are proving to be a supplement to traditional forms of power generation whether it is stand alone, mobile, remote or interconnected with the utility applications. Among all fuel cells, solid oxide fuel cells (SOFC) are considered as promising type of fuel cell technology for DG and stationary applications.

In this thesis a dynamic model of SOFC based distributed generation system (DGs) has been developed. The model incorporates the electrochemical reaction dynamics and major voltage losses in SOFCs. A constant utilization mode has been adopted for the operation of fuel cell in which the control of constant utilization is implemented using current feedback to adjust the hydrogen input flow rate. Power electronic interface has been designed and employed for converting the power generated by the fuel cell into a usable form. A DC to DC boost converter has been adopted in order to step up the DC-link voltage, and a feedback PI controller has been designed to maintain a constant dc voltage for isolated mode operation as well as for grid connected operation. A three phase Sinusoidal PWM (SPWM) voltage source inverter (VSI) followed by RL series filter is considered to interface the SOFC fuel cell to a three phase isolated load. A control strategy under voltage controlled mode using PI controller has been developed for three phase PWM inverter that adjusts the modulation index to maintain the constant voltage across the load.

The performance of developed SOFC based DG system model has been analyzed under various operating conditions, through simulation in MATLAB. The dynamic behavior of SOFC, with step change in reference input is analyzed and it has been observed that the fuel cell responds slowly at sudden load changes and also during the starting period. The power output response from fuel cells is found to be faster than voltage and current response. The performance also has been analyzed when SOFC based DG system is interfaced to a three phase isolated load through DC-DC boost converter and three phase inverter topology. The simulation results obtained show that the control scheme designed and developed for the inverter functions accurately, even with sudden change in the load.
The Fuzzy logic control is a practical alternative for a variety of challenging control applications, since it is a convenient method for constructing non-linear controllers by the use of heuristic information. Thus, there is a possibility to use fuzzy logic control in place of conventional PI controller in fuel cell based DG system. The detailed design of fuzzy logic controller for boost converter and for load side inverter is presented. A triangle-shaped membership function has been used for fuzzy logic controller design. The numbers of rules set for DC/DC boost converter control are 49, which are based upon the seven membership functions of the input variables. Simulink model of voltage control scheme for three phase inverter has been designed wherein two fuzzy logic controllers have been employed. One for direct voltage component and another for quadrature voltage component control. The developed FLC controller performance has been studied for isolated operation of fuel cell. Simulation results are analyzed and compared with the results obtained using the conventional PI controller. From the simulated results it is shown that developed fuzzy logic controller can effectively track the reference voltage and is insensitive to the load conditions compared to PI controller.

The utility interconnected operation of SOFC based DG system is very important to supplement the conventional power supply. In this thesis an active power (P) and reactive power (Q) control scheme has been developed to operate SOFC based DG system in utility attractive mode. The developed control strategy makes use of decoupling method for control of active and reactive power independently. A three phase locked loop (PLL) available in MATLAB has been used to provide accurate phase angle reference for Park transformation within the control scheme. The performance of the developed control scheme has been studied under various cases. The simulation results reported in this work show that the developed control scheme is robust and works accurately. The performance of the developed model has also been studied under fault condition at point of common coupling. The total harmonic distortion (THD) of the voltage introduced by the SOFC based DG system is 3.5% which is well within the range of IEEE 1547–2003 standard.