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Implementation of grid interface for generation side power management

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Abstract

Increasing electrification of daily life causes growing electricity consumption and the rising number of sensitive or critical loads demand for high quality electricity. One of the main problems facing today is that related with the transmission and distribution of electricity. Due to the rapid increase in global energy consumption and the diminishing of fossil fuels, the customer demand for new generation capacities and efficient energy production, delivery and utilization keeps rising. Utilizing distributed generation, renewable energy and energy storage can potentially solve problems as energy shortage. A promising structure to interconnect these distributed energy resources(DER) is the microgrid paradigm. Since microgrid has the ability to generate, distribute and regulate the flow of electricity, this can be thought of as an effective solution to this problem. In this paper, considering the different cases of generation and demand, a Matlab/Simulink model of microgrid is developed, incorporating an energy storage system, such that when the demand is less, the charging of battery takes place and vice versa. Also, depending on the frequency variations, the ON and OFF of the non-critical loads were done automatically and the status of the battery and the different loads are decided by the control unit.

1. Introduction

When referring to the power industry, 'Grid' is the term used for an electricity network. In other words, electrical grid is an interconnected network for delivering electricity from suppliers to the consumers. The main functions of the Grid can be classified into Electricity generation, power transmission, distribution and control. Thus the grid is having a 'Hierarchal structure' with high voltage transmission network at the top level, then comes the medium voltage sub transmission network and finally the low voltage distribution network which deliver power to consumers. In the traditional method of electricity generation and distribution, one of the main limitations is that, with some minor exceptions that the electrical energy cannot be stored and electricity should be generated as and when required in order to meet the demand. So, some effective measures should be taken to ensure that the electricity generation closely matches the demand; otherwise the system will not be an efficient one. The centralised grid system is definitely the backbone of the electricity distribution system, but it has some drawbacks like less reliability, less energy utilization, pollution etc. Now a days the demand for energy has increased in such a way that the centralised grid system is insufficient to meet the demand and also the conventional power system uses the non renewable resources which are fast depleting. As such an effective measure that can be implemented is the Microgrid system in the power sector, which concentrates on the distributed generation technique.

A 'microgrid' can be defined as an electrical power distribution network that can operate in isolation (islanded mode) and in the grid connected mode. In Islanded mode, the microgrid continues to supply power to the consumers by its own, without having any connection with the central grid, with the help of various distributed energy resources (DER). DER's are the sources of electric energy in a microgrid, and are also known as 'micro sources'. The installed distributed energy sources include biomass, fuel cells, geothermal, solar panels, wind turbines, small steam turbines, micro turbines etc. In the grid connected mode, the microgrid itself will be having a connection with the central grid, and the power demand is met by the power generated by the central grid and the microgrid together. Thus by incorporating the microgrid technology into the centralised grid system, the impacts of the increasing energy stress can be reduced.

This paper investigates about the detailed structure of the microgrid and also focuses on the automatic controlling of the battery storage system as well as the various non critical loads associated with the microgrid. The entire simulation is done, considering the different cases of generation and demand of power, based on the frequency variations.

2. Structure of microgrid

The microgrid structure includes an aggregation of different loads and different micro sources, along with energy storage units, operating together as a single unit providing both power and heat. The micro sources (DER's) are the primary source of energy within the microgrid. The major issues related with the microgrid structure include the interface, control and protection requirements for each DER as well as the microgrid voltage control, power flow control etc during islanding, and overall protection. The installed DER's include biomass, fuel cells, geothermal, solar, wind, small steam turbines etc. The most important function of the microgrid is its ability to operate in the islanded mode as well as in the grid connected mode. The simple block diagram representation of a microgrid is shown in fig. 1.

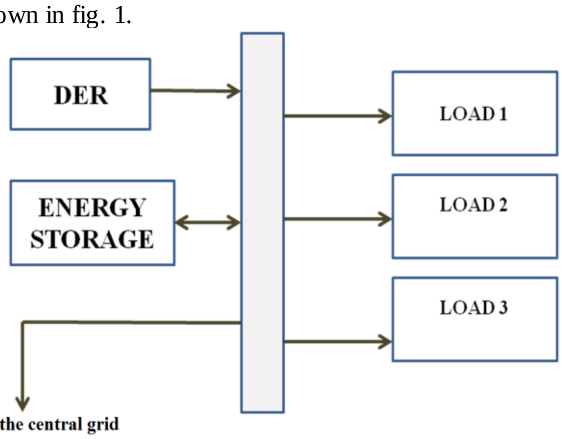

Fig. 1. Microgrid structure

Another important potential benefit of microgrids is its expanded opportunity to utilize the waste heat from the conversion of the primary fuel to electricity. This feature is very much significant, because in most cases, half to three- quarters of the primary energy consumed in power generation is ultimately released unutilized to the environment.

Generation	Demand	Switch(S1)	Switch(S2)
0	0	0	0
1	0	0	1
0	1	0	1
		1	0

3. Microgrid operation

The objectives of this project work were to implement a microgrid structure with a provision to operate it in the islanded mode, to have an interface with the central grid, and to use a storage system whenever the generation is more than the demand. The loads are classified as necessary (critical) loads and unnecessary (non- critical) loads. Necessary loads are that loads which needs a continuous supply of power and cannot be turned off frequently once it is started operating. Unnecessary loads are that which can be turned off as and when required.

The frequency is taken as the measure of demand of the system. Whenever the generation of power becomes more than the demand, the battery storage system is automatically connected for charging, so as to avoid the wastage. When the demand is more than the total power generated from the microgrid, a signal is send through wireless to the smart sensors placed at the load side. On receiving this signal, all the unnecessary loads are switched off. This takes a small time, during which the battery system can be used to feed back the stored energy. The microgrid also has a provision to get connected with the central grid permanently. The entire operation can be represented in the form of a block diagram as shown in fig. 2.

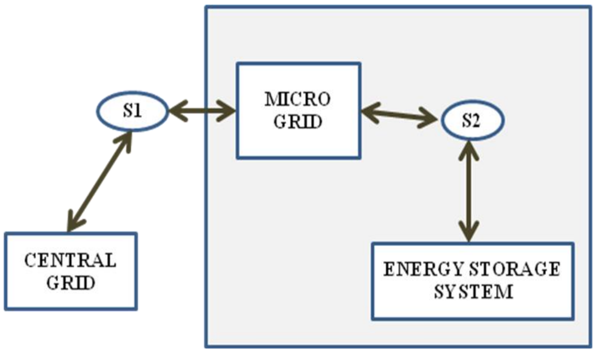

Fig. 2. Microgrid structure with interfacing switches.

S2 is the switch which connects the battery storage system with the microgrid and S1 is the switch which connects the microgrid itself to the central grid. Based on the demand generation status, the following switch positions can be selected.

Table 1. status of different switches.

The single line diagram of the microgrid structure considered in this project work including the control unit is shown in fig. 3.

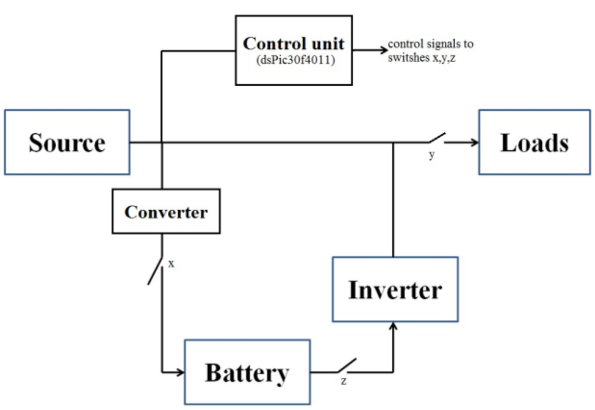

Fig. 3. Single line diagram of the microgrid structure.

The installed DER considered for simulation is a small steam turbine and the energy storage device is the inverter interfaced battery bank. They ensure the balance between the energy generation and consumption during sudden changes in the load or in the power generation. The loads are classified as critical and non- critical loads. The critical loads need reliable source of energy where as the non- critical loads may be shed during emergency situations.

4. Flowcharts

The status of the battery as well as the non- critical loads is decided taking frequency as a measure of demand. Every instant the frequency is measured by the processor in the control unit, and the measured frequency value is compared with the normal frequency value of 50Hz. Depending on the difference between these two values, a signal is generated, which acts as the control signals to the different switches in the circuit. Three cases of generation and demand are considered in this project work. i.e., the three cases are- when generation is greater than demand (G>D), when generation is equal to demand (G=D) and when generation is less than demand (G<D). Fig.4. shows the decision making, based on the three conditions of generation and demand. Fig.5. shows the decision making for turning ON and OFF of non-critical loads. Fig.6. shows the decision making on charging and discharging of the battery. One manual switch is also provided along with the non- critical loads so that these loads can be turned off even if the generation is more than demand.

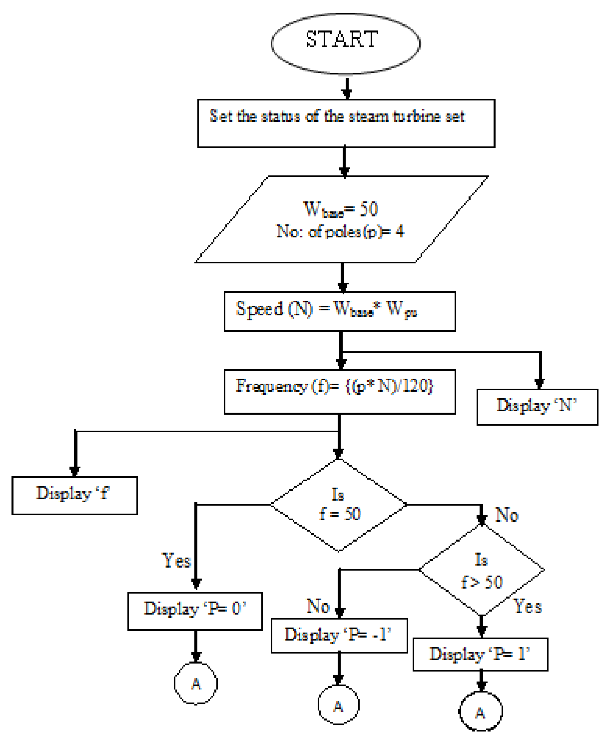

Fig. 4. Decision making, based on the three conditions on generation and

demand.

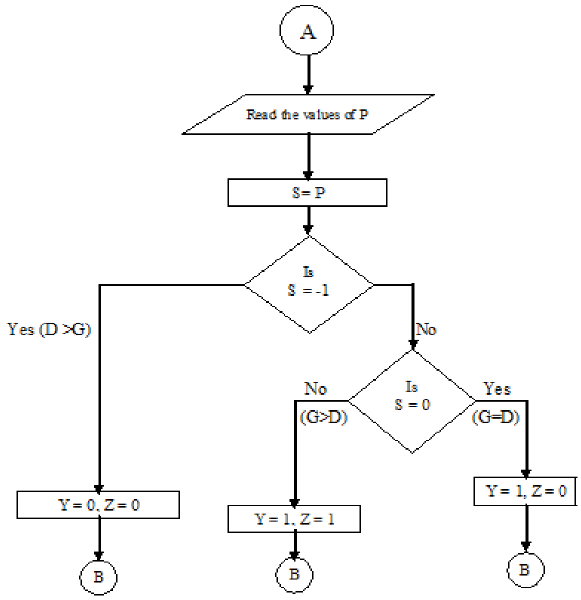

Fig. 4. Decision making for turning on and off of non-critical loads.

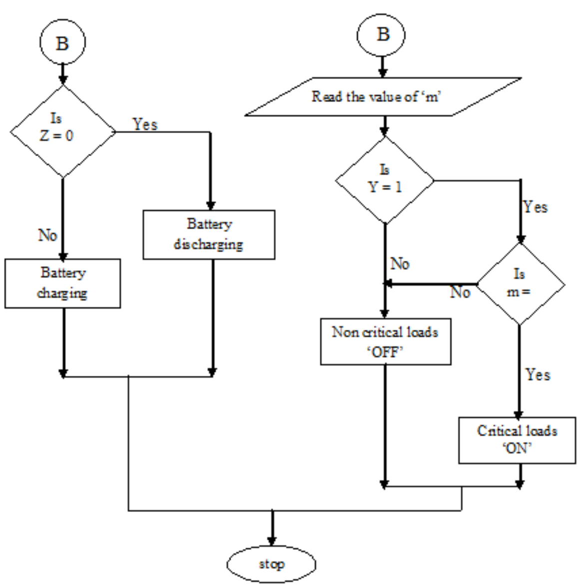

Fig. 6. Decision making on charging and discharging of the battery.

5. Simulation and results

The simulink model for the complete microgrid structure along with the battery storage unit and the control unit is shown in the fig. 7. The total generation capacity of the steam turbine generator set is 1.3MVA. the generated current and voltage waveforms are shown in fig. 8. Whenever the power generated becomes more than the power demand, battery charging takes place as shown in fig. 9. Whenever the power demand becomes more than the power generated, the extra power needed for meeting the demand is supplied by the battery storage system and the state of charge (SOC) of the battery will be as shown in fig. 10. The switch used in this project work is the SCR based switch which is a combination of two anti- parallel thyristors.

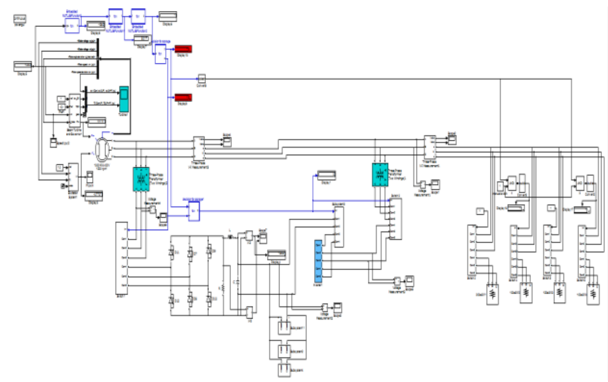

Fig. 7. Complete microgrid model in simulink.

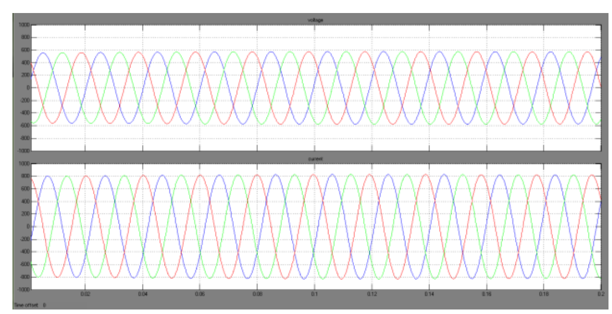

Fig. 8. Generated current and voltage waveforms

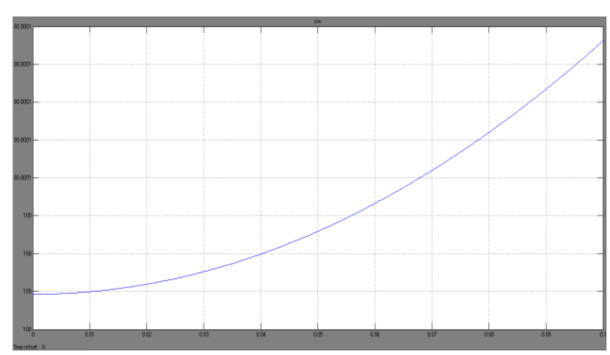

Fig. 9. Plot showing charging of the battery

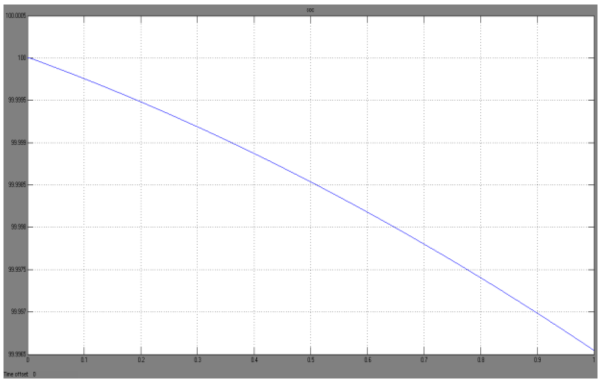

Fig. 10.Plot showing discharging of the battery

6. Conclusion

The microgrid technology using the distributed generation resources is now emerging as a new technology for economical and uninterrupted power supply, and is being used almost all over the world. Also, since they have lower carbon emissions, it is environmental friendly and is one of the main reasons why micrograms are preferred. It is obvious in speculating that by the onset of the year 2020, energy crunch would be the burning issue before us if not resorted to alternative methods of power generation and invisioned planning of energy management. In view of the lucid merits, the microgrid system can contribute a lot in the sustainity of mankind in the future.

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