FUZZY BASED ENERGY MANAGEMENT SYSTEM FOR HYBRID MICROGRIDS

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ABSTRACT: - *Renewable energy based distributed generators (DGs) play a dominant role in electricity production, with the increase in the global warming. Distributed generation based on wind, solar energy, biomass, mini-hydro along with use of fuel cells and wind energy will give significant momentum in near future. Advantages like environmental friendliness, expandability and flexibility have made distributed generation, powered by various renewable and nonconventional sources, an attractive option for configuring modern electrical grids. A microgrid consists of cluster of loads and distributed generators that operate as a single controllable system. As an integrated energy delivery system microgrid can operate in parallel with or isolated from the main power grid. The microgrid concept introduces the reduction of multiple reverse conversions in an individual AC or DC grid and also facilitates connections to variable renewable AC and DC sources and loads to power systems. The interconnection of DGs to the utility/grid through power electronic converters has risen concerned about safe operation and protection of equipment's. To the customer the microgrid can be designed to meet their special requirements; such as, enhancement of local reliability, reduction of feeder losses, local voltages support, increased efficiency through use of waste heat, correction of voltage sag or uninterruptible power supply. In the present work the performance of hybrid AC/DC microgrid system is analyzed in the grid tied mode. Also control mechanisms are implemented for the converters to properly coordinate the AC sub-grid to DC sub-grid. The results are obtained from the MATLAB/ SIMULINK environment.*

Keywords: - Distributed Energy Resources, Renewable Energy Sources, Energy Storage System, Combined Heat and Power plant, Deep Of Discharge, Photo Voltaic system, Doubly Fed Induction Generator, Start Of Conversion, Voltage Of The Cell.

I. INTRODUCTION

As electric distribution technology steps into the next century, many trends are becoming noticeable that will change the requirements of energy delivery. These modifications are being driven from both the demand side where higher energy availability and efficiency are desired and from the supply side where the integration of distributed generation and peaks having technologies must be accommodated. Power systems currently undergo considerable change in operating requirements mainly as a result of deregulation and due to an increasing amount of distributed energy resources (DER). In many cases DERs include different technologies that allow generation in small scale (micro sources) and some of them take advantage of renewable energy resources (RES) such as solar, wind or hydro energy. Having micro sources close to the load has the advantage of reducing transmission losses as well as preventing network congestions. Moreover, the possibility of having a power supply interruption of end-customers connected to a low voltage (LV) distribution grid (in Europe 230 V and in the USA 110 V) is diminished since adjacent micro sources, controllable loads and energy storage systems can operate in the islanded mode in case of severe system disturbances. This is identified nowadays as a microgrid. Figure 1.1 depicts a typical microgrid. The distinctive microgrid has the similar size as a low voltage distribution feeder and will rare exceed a capacity of 1 MVA and a geographic span of 1 km. Generally more than 90% of low voltage domestic customers are supplied by underground cable when the rest is supplied by overhead lines. The microgrid often supplies both electricity and heat to the customers by

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means of combined heat and power plants (CHP), gas turbines, fuel cells, photovoltaic (PV) systems, wind turbines, etc. The energy storage systems usually include batteries and flywheels. The storing device in the microgrid is equivalent to the rotating reserve of large generators in the conventional grid which ensures the balance between energy generation and consumption especially during rapid changes in load or generation.

From the customer point of view, microgrids deliver both thermal and electricity requirements and in addition improve local reliability, reduce emissions, improve power excellence by supportive voltage and reducing voltage dips and potentially lower costs of energy supply. From the utility viewpoint, application of distributed energy sources can potentially reduce the demand for distribution and transmission facilities. Clearly, distributed generation located close to loads will reduce flows in transmission and distribution circuits with two important effects: loss reduction and ability to potentially substitute for network assets. In addition, the presence of generation close to demand could increase service quality seen by end customers. Microgrids can offer network support during the time of stress by relieving congestions and aiding restoration after faults. The development of microgrids can contribute to the reduction of emissions and the mitigation of climate changes. This is due to the availability and developing technologies for distributed generation units are based on renewable sources and micro sources that are characterized by very low emissions. There are various advantages offered by microgrids to end-consumers, utilities and society, such as: improved energy efficiency, minimized overall energy consumption, reduced greenhouse gases and pollutant emissions, improved service quality and reliability, cost efficient electricity infrastructure replacement. Technical challenges linked with the operation and controls of microgrids are immense. Ensuring stable operation during network disturbances, maintaining stability and power quality in the islanding mode of operation necessitates the improvement of sophisticated control strategies for microgrids inverters in order to provide stable frequency and voltage in the presence of arbitrarily varying loads. In light of these, the microgrid concept has stimulated many researchers and attracted the attention of governmental organizations in Europe, USA and Japan. Nevertheless, there are various technical issues associated with the integration and operation of microgrids. Protection system is one of the major challenges for microgrid which must react to both main grid and microgrid faults. The protection system should cut off the microgrid from the main grid as rapidly as necessary to protect the microgrid loads for the first case and for the second case the protection system should isolate the smallest part of the microgrid when clears the fault. A segmentation of microgrid, i.e. a design of multiple islands or sub microgrids must be supported by micro source and load controllers. In these conditions problems related to selectivity (false, unnecessary tripping) and sensitivity (undetected faults or delayed tripping) of protection system may arise. Mainly, there are two main issues concerning the protection of microgrids, first is related to a number of installed DER units in the microgrid and second is related to an availability of a sufficient level of short-circuit current in the islanded operating mode of microgrid since this level may substantially drop down after a disconnection from a stiff main grid. In the authors have made short-circuit current calculations for radial feeders with DER and studied that short-circuit currents which are used in over-current (OC) protection relays depend on a connection point of and a feed-in power from DER. The directions and amplitudes of short circuit currents will vary because of these conditions. In reality the operating conditions of microgrid are persistently varying because of the intermittent micro sources (wind and solar) and periodic load variation. Also the network topology can be changed frequently which aims to minimize loss or to achieve other economic or operational targets. In addition controllable islands of different size and content can be formed as a result of faults in the main grid or inside microgrid. In such 4 situations a loss of relay coordination may happen and generic OC protection with a single setting group may become insufficient, i.e. it will not guarantee a selective operation for all possible faults. Hence, it is vital to ensure that settings chosen for OC protection relays take into account a grid topology and changes in location, type and amount of generation. Otherwise, unwanted operation or failure may occur during necessary condition. To deal with bi-directional power flows and low short-circuit current levels in microgrids dominated by micro sources with power electronic interfaces a new protection philosophy is essential, where setting parameters of relays must be checked/updated periodically to make sure that they are still appropriate.

II. MICRO GRID COMPONENTS & EXISTING SYSTEM

A. INTRODUCTION

In 1839, a French physicist Edmund Becquerel proposed that few materials have the ability to produce electricity when exposed to sunlight. But Albert Einstein explained the photoelectric effect and the nature of light in 1905. Photoelectric effect state that when photons or sunlight strikes to a metal surface flow of electrons will take place. Later photoelectric effect became the basic principle for the technology of

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photovoltaic power generation. The first PV module was manufactured by Bell laboratories in 1954.

B. PV CELL

Photovoltaic cell is the building block of the PV system and semiconductor material such as silicon and germanium are the building block of PV cell. Silicon is used for photovoltaic cell due to its advantages over germanium. When photons hit the surface of solar cell, the electrons and holes are generated by breaking the covalent bond inside the atom of semiconductor material and in response electric field is generated by creating positive and negative terminals. When these terminals are connected by a conductor an electric current will start flowing. This electricity is used to power a load.

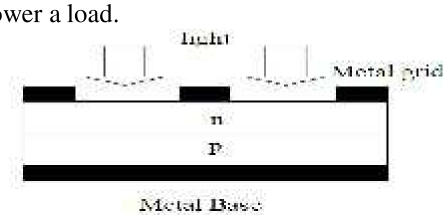

Fig.3.1 Structure of PV cell

B. PV MODULE

A single cell generate very low voltage (around 0.4), so more than one PV cells can be connected either in serial or in parallel or as a grid (both serial and parallel) to form a PV module as shown in fig.3.3. When we need higher voltage, we connect PV cell in series and if load demand is high current then we connect PV cell in parallel. Usually there are 36 or 76 cells in general PV modules. Module we are using having 54 cells. The front side of the module is transparent usually build up of low-iron and transparent glass material, and the PV cell is encapsulated. The efficiency of a module is not as good as PV cell, because the glass cover and frame reflects some amount of the incoming radiation.

D. PV ARRAY

A photovoltaic array is simply an interconnection of several PV modules in serial and/or parallel. The power generated by individual modules may not be sufficient to meet the requirement of trading applications, so the modules are secured in a grid form or as an array to gratify the load demand. In an array, the modules are connected like as that of cells connected in a module. While making a PV array, generally the modules are initially connected in serial manner to obtain the desired voltage, and then strings so obtained are connected in parallel in order to produce more current based on the requirement.

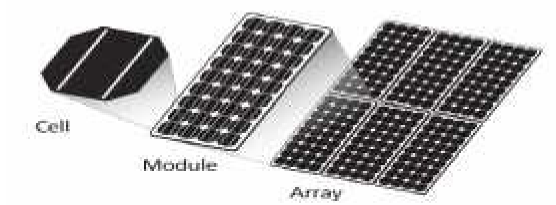

Fig.3.2 Photovoltaic system

E. WORKING OF PV CELL

The basic theory involved in working of an individual PV cell is the Photoelectric effect according to which, when a photon particle hits a PV cell, after receiving energy from sunbeam the electrons of the semiconductor get excited and hop to the conduction band from the valence band and become free to move. Movement of electrons create positive and negative terminal and also create potential difference across these two terminals. When an external circuit is connected between these terminals an electric current start flowing through the circuit.

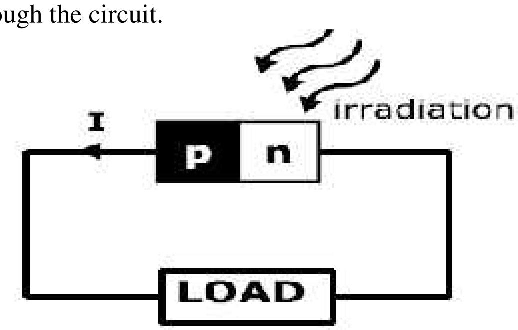

Fig 3.3 Working of PV cell

F. MODELING OF PV CELL

The photovoltaic system converts sunlight directly to electricity without having any disastrous effect on our environment. The basic segment of PV array is PV cell, which is just a simple p-n junction device. The fig.3.4 manifests the equivalent circuit of PV cell. Equivalent circuit has a current source (photocurrent), a diode parallel to it, a resistor in series describing an internal resistance to the flow of current and a shunt resistance which expresses a leakage current. The current supplied to the load can be given as.

$$I = I_{PV} - I_O\left[\exp\left(\frac{V - IR_S}{aV_T}\right) - 1\right] - \left(\frac{V + IR_S}{R_P}\right)$$

Where

I_{PV}–Photocurrent current,

I_O–diode's Reverse saturation current,
V–Voltage across the diode,
a– Ideality factor
VT –Thermal voltage
R_S– Series resistance
R_P–Shunt resistance

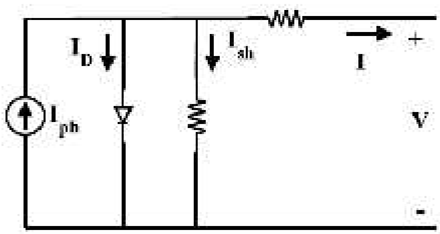

Fig 3.4 Equivalent circuit of Single diode modal of a solar cell

PV cell photocurrent, which depends on the radiation and temperature, can be expressed as.

$$I_{PV} = \left(I_{PV\_STC} + K_I \Delta T\right)\frac{G}{G_{STC}}$$

Where

KI – cell's short circuit current temperature coefficient
G –solar irradiation in W/m3
G_{STC} –nominal solar irradiation in W/m3
I_{PV_STC} – Light generated current under standard test condition

The reverse saturation current varies as a cubic function of temperature, which is represented as

$$I_O = I_{O\_STC}\left(\frac{T_{STC}}{T}\right)^3 \exp\left[\frac{qE_g}{aK}\left(\frac{1}{T_{STC}} - \frac{1}{T}\right)\right]$$

Where

I_{O_STC} – Nominal saturation current
E_g – Energy band gap of semiconductor
T_{STC} –temperature at standard test condition
q – Charge of electrons

The reverse saturation current can be further improved as a function of temperature as follows

$$I_O = \frac{\left(I_{SC\_STC} + K_I \Delta T\right)}{\exp\left[\frac{\left(V_{OC\_STC} + K_V \Delta T\right)}{aV_T}\right] - 1}$$

Where,

I_{SC_STC} – short circuit current at standard test condition
V_{OC_STC} - short circuit voltage at standard test condition
K_V – temperature coefficient of open circuit voltage

Many authors proposed more developed models for better accuracy and for different purposes. In some of the models, the effect of the recombination of carriers is represented by an extra diode. Some authors also used three diode models which included influences of some other effects that are not considered in previous models. But due to simplicity we use single diode model for our work.

Efficiency of a PV cell does not depend on the variation in the shunt resistance R_P of the cell but efficiency of a PV cell greatly depends on the variation in series resistance Rs. As R_P of the cell is inversely proportional to the shunt leakage current to ground so it can be assumed to be very large value for a very small leakage current to ground.

As the total power generated by a single PV cell is very low, we used a combination of PV cells to fulfil our desired requirement. This grid of PV cells is knows as PV array. The equations of the PV array can be represented as

$$I = I_{PV}N_P - I_O N_P\left[\exp\left(\frac{V + IR_S\left(\frac{N_S}{N_P}\right)}{aV_T N_S}\right) - 1\right] - \left(\frac{V + IR_S\left(\frac{N_S}{N_P}\right)}{R_P\left(\frac{N_S}{N_P}\right)}\right)$$

N_S – Number of series cells
N_P – Number of parallel cells

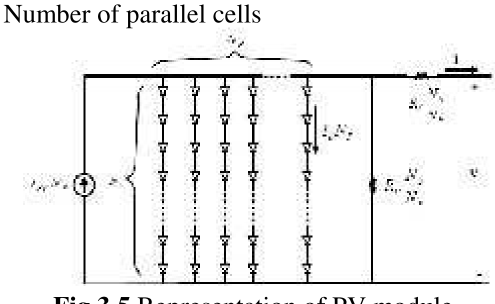

Fig.3.5 Representation of PV module

A small change in series resistance can affect more on the efficiency of a PV cells but variation in shunt resistance does not affect more. For very small

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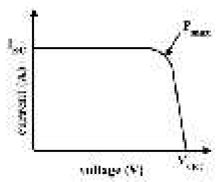
leakage current to ground, shunt resistance assumed to be infinity and can be treated as open.

After considering shunt resistance infinity, the mathematical equation of the model can be expressed as.

$$I = I_{PV} N_P - I_0 N_P \left[\exp\left(\frac{V + IR_S\left(\frac{N_S}{N_P}\right)}{aV_T N_S} \right) - 1 \right]$$

I-V and P-V characteristics of PV module are shown in figures 3.7 and 3.8 respectively.



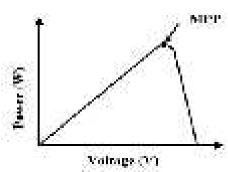


Fig. 3.6 V-I characteristic **Fig. 3.**7 P-V characteristics

The two key parameters which are used to relate the electrical performance are the open-circuit voltage of the cell VOC and short-circuit current of the cell I_{SC}. The maximum power can be stated as

$$P_{max} = V_{max} I_{max}$$

III. EXISTING SYSTEM

IV.

This project proposes a hybrid ac/dc micro grid to reduce the processes of multiple dc–ac–dc or ac–dc–ac conversions in an individual ac or dc grid. The hybrid grid consists of both ac and dc networks connected together by multi-bidirectional converters. AC sources and loads are connected to the ac network whereas dc sources and loads are tied to the dc network. Energy storage systems can be connected to dc or ac links. The proposed hybrid grid can operate in a grid-tied or autonomous mode. The coordination control algorithms are proposed for smooth power transfer between ac and dc links and for stable system operation under various generation and load conditions. Uncertainty and intermittent characteristics of wind speed, solar irradiation level, ambient temperature, and load are also considered in system control and operation. A small hybrid grid has been modelled and simulated using the Simulink in the MATLAB. The simulation results show that the system can maintain stable operation under the proposed coordination

Control schemes when the grid is switched from one operating condition to another.

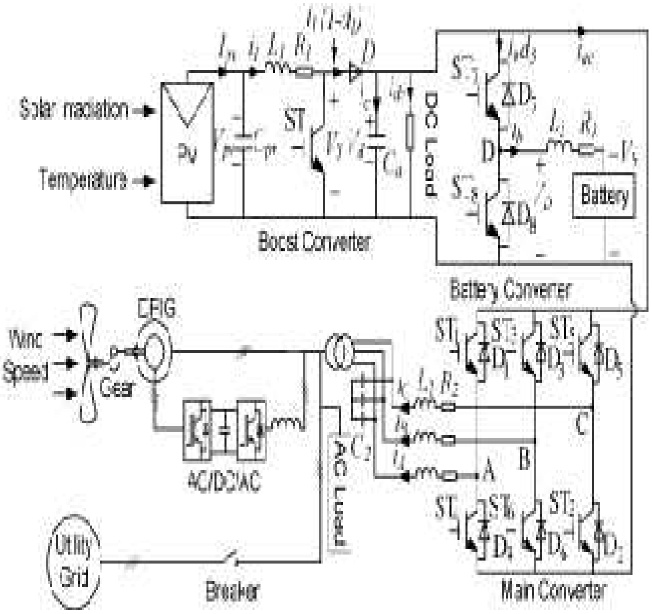


Fig 3.13 A hybrid ac/dc microgrid system.

A. RESULTS

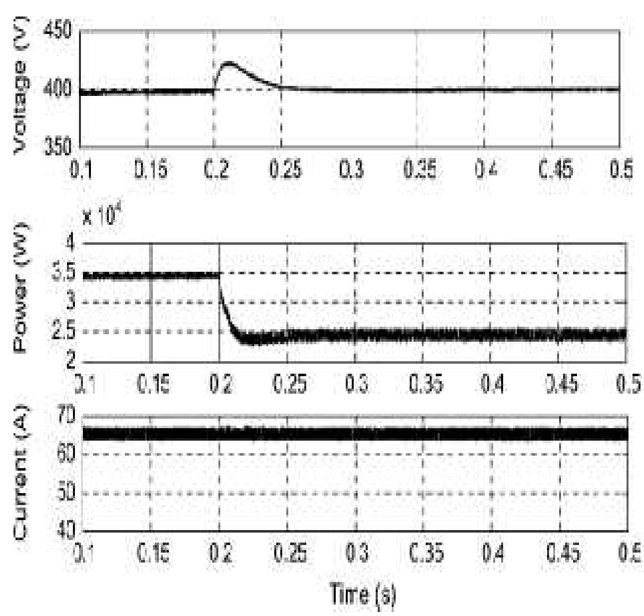


Fig 3.14 A hybrid ac/dc microgrid system outputs

V. PROPOSED SYSTEM

A. INTRODUCTION

The concept of microgrid is considered as a collection of loads and micro sources which functions as a single controllable system that provides both power and heat to its local area. This idea offers a new paradigm for the definition of the distributed generation operation. To the utility the microgrid can be thought of as a controlled cell of the power system. For example this cell could be measured as a single dispatch able load, which can reply in seconds to meet the requirements of the transmission system. To the customer the microgrid can be planned to meet their special requirements; such as, enhancement of local reliability, reduction of feeder losses, local voltages support, increased efficiency through use waste heat, voltage sag correction. The main purpose of this concept is to accelerate the recognition of the advantage offered by small scale distributed generators like ability to supply waste heat during the time of need. The microgrid or distribution network subsystem will create less trouble to the utility network than the conventional micro generation if there is proper and intelligent coordination of micro generation and loads. Microgrid considered as a 'grid friendly entity" and does not give undesirable influences to the connecting distribution network i.e. operation policy of distribution grid does not have to be modified.

B. BLOCK DIAGRAM

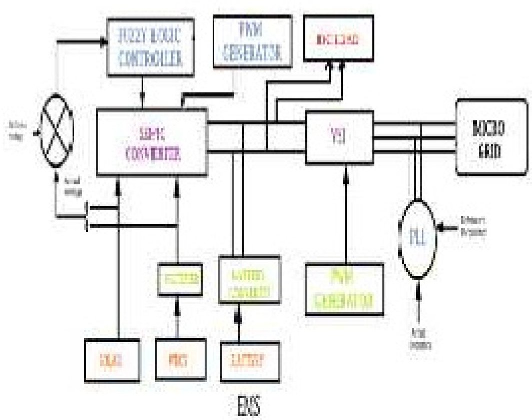


Fig4.1. A hybrid microgrid system

C. CIRCUIT DIAGRAM

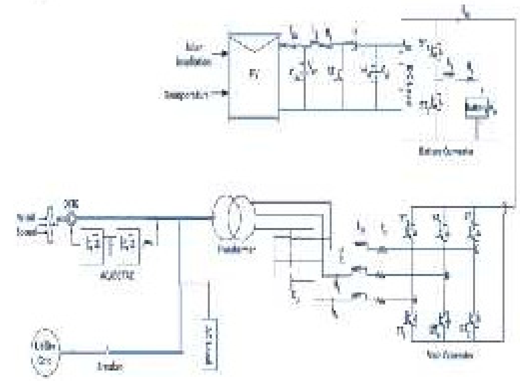


Fig 4.2. A Hybrid AC/DC microgrid system Circuit diagram

The configuration of the hybrid system is shown in Figure 4.1 where various AC and DC sources and loads are connected to the corresponding AC and DC networks. The AC and DC links are linked together through two transformers and two four quadrant operating three phase converters. The AC bus of the hybrid grid is tied to the utility grid. Figure 4.2 describes the hybrid system configuration which consists of AC and DC grid. The AC and DC grids have their corresponding sources, loads and energy storage elements, and are interconnected by a three phase converter. The AC bus is connected to the utility grid through a transformer and circuit breaker. In the proposed system, PV arrays are connected to the DC bus through boost converter to simulate DC sources. A DFIG wind generation system is connected to AC bus to simulate AC sources. A battery with bidirectional DC/DC converter is connected to DC bus as energy storage. A variable DC and AC load are connected to their DC and AC buses to simulate various loads. PV modules are connected in series and parallel. As solar radiation level and ambient temperature changes the output power of the solar panel alters. A capacitor C is added to the PV terminal in order to suppress high frequency ripples of the PV output voltage. The bidirectional DC/DC converter is designed to maintain the stable DC bus voltage through charging or discharging the battery when the system operates in the autonomous operation mode. The three converters (boost converter, main converter, and bidirectional converter) share a common DC bus. A wind generation system consists of doubly fed induction generator (DFIG) with back to back AC/DC/AC PWM converter connected between the rotor through slip rings and AC bus. The AC and DC buses are coupled through a three

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phase transformer and a main bidirectional power flow converter to exchange power between DC and AC sides. The transformer helps to step up the AC voltage of the main converter to utility voltage level and to isolate AC and DC grids.

D. OPERATION OF GRID

The hybrid grid performs its operation in two modes. GRID TIED MODE**:** In this mode the main converter is to provide stable DC bus voltage, and required reactive power to exchange power between AC and DC buses. Maximum power can be obtained by controlling the boost converter and wind turbine generators. When output power of DC sources is greater than DC loads the converter acts as inverter and in this situation power flows from DC to AC side. When generation of total power is less than the total load at DC side, the converter injects power from AC to DC side. The converter helps to inject power to the utility grid in case the total power generation is greater than the total load in the hybrid grid. Otherwise hybrid receives power from the utility grid. The role of battery converter is not important in system operation as power is balanced by utility grid. AUTONOMOUS MODE**:** The battery plays very important role for both power balance and voltage stability. DC bus voltage is maintained stable by battery converter or boost converter. The main converter is controlled to provide stable and high quality AC bus voltage.

E. MODELLING OF BOOST CONVERTER

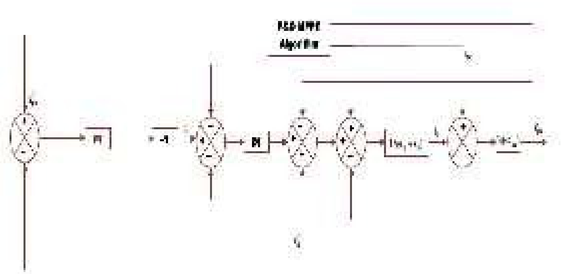


Fig 4.3. Control block diagram of SEPIC converter

With the implementation of Fuzzy logic algorithm a reference value is calculated which mainly depends upon solar irradiation and temperature of PV array. Here for the boost converter dual loop control is proposed. Here the control objective is to provide a high quality DC voltage with good dynamic response. The outer voltage loop helps in tracking of reference voltage with zero steady state error and inner current loop help in improvisation of dynamic response.

F.

MODELLING OF MAIN CONVERTER

The role of the main converter is to exchange power between AC and DC bus. The key purpose of main converter is to maintain a stable DC-link voltage in grid tied mode. When the converter operates in grid tied mode, it has to supply a given active and reactive power. Here PQ control scheme is used for the control of main converter. The PQ control is achieved using a current controlled voltage source. Two PI controllers are used for real and reactive power control. When resource conditions or load capacities change, the DC bus voltage is settled to constant through PI regulation. The PI controller is set as the instantaneous active current iT- reference and the instantaneous reactive current in- reference is determined by reactive power compensation command.

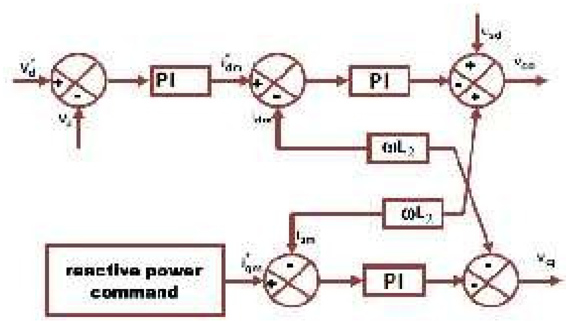


Fig 4.4. Control block diagram of main converter

In case of sudden DC load drop, there is power surplus at DC side and the main converter is controlled to transfer power from DC to AC side. The active power absorbed by the capacitor CT leads to rising of DC-link voltage VT. The negative error caused by the increase of VT produces a higher active current reference iT through PI control. A higher positive reference iT will force active current reference iT- to increase through the inner current control loop. Therefore the power surplus of the DC grid can be transferred to the AC side. Also a sudden increase of DC load causes the power shortage and VT drop at the DC grid. The main converter is controlled to supply power from the AC to DC side. The positive voltage error caused by VT drop makes the magnitude of iT- increase through the PI control. Since iT- and iT are both negative, the magnitude of iT- is increased through the inner current control loop. Hence power is transferred from AC grid to the DC side.

G. FUZZY LOGIC**:**

Fuzzy theory was first proposed in 1965 by Lotfi.A.Zadeh, an American scholar of automatic control, as a tool of quantitative expression for concepts that could not be clearly defined. A fuzzy control system is based on fuzzy-logic thinking in the design of how a controller works. The so-called fuzzy logic is to establish a buffer zone between the traditional zero and one, with logic segments of none-zero and none-one possible. It allows a wider and more flexible space in logic deduction for the expression of conceptual ideas and experience. A fuzzy controller differs from a traditional controller in that it employs a set of qualitative rules defined by semantic descriptions.

The design criterion requires that both the photovoltaic device and the wind turbine are supplied by a maximum power point tracker to maintain the maximum operating point. The difference between actual load and total generated power is taken into account for Li-ion battery in charge and discharge modes. The life cycle and SOC of the battery are in direct proportion. To improve the life of the Li-ion battery, we can control and maintain the SOC of battery with fuzzy control. The fuzzy controller is applied in the proposed hybrid power supply system, as shown in Figure-4.5.

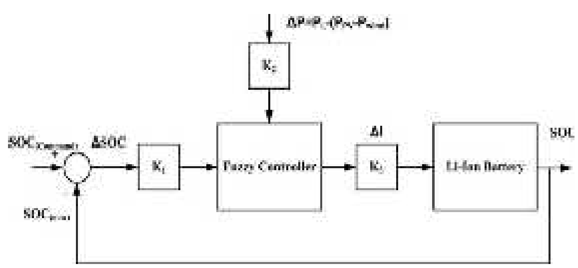


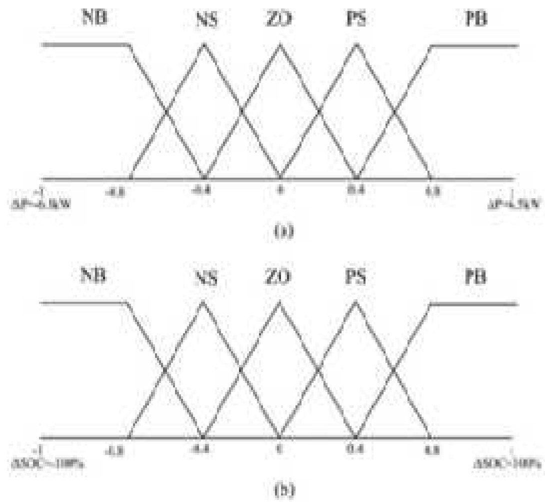
Fig-4.5. Block diagram of fuzzy control to maintain the desired SOC of the battery.

To obtain the desired SOC value, the fuzzy controller is designed to be in charging mode or discharging mode for the proposed hybrid system. The input variables of the fuzzy control are SOC and *P* and output variable is *I*.

H. Design of fuzzy controller

The definition of input and output variables are listed as follows:

The power difference *P* is between required power and the total generated power of the hybrid system. The generated power comes from solar power P_{pv}, wind turbine P_{Wind} and power load PL for the proposed system. The input and output membership functions of fuzzy control contain five grades: NB (negative big), NS (negative small), ZO (zero), PS (positive small), and PB (positive big), as shown in Fig 4.6. By input scaling factors K1 and K2 , we can determine the membership grade and substitute it into the fuzzy control rules to obtain the output current for charge and discharge variance *I* of the Li-ion battery. If the *P* is negative, it means that the renewable energy does not provide enough energy to the load. Thus, the battery must operate in charging mode; if the SOC is negative, it means that the SOC of the battery is greater than the demand SOC. Thus, the battery must operate in discharge mode.



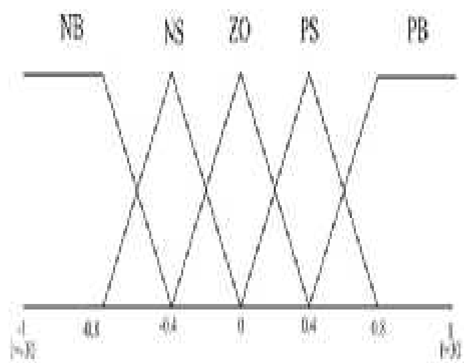


Fig.4.6. Output membership function of variable

There are several methods to design a fuzzy controller. The design of fuzzy controller involves formation of membership function and rule base [8, 9]. Here, we have taken the rule base proposed by Mamdani for the simulation of the Fuzzy controller. These rules are shown in Table-1.

ΔI		ΔP				
		NB	NS	ZO	PS	PB
ΔSOC	NB	PB	PB	PB	PB	PB
	NS	PB	PB	PS	PS	PB
	ZO	ZO	ZO	ZO	PS	PB
	PS	NS	NS	NS	NS	PB
	PB	NB	NB	NB	NB	PB

Table-1. Fuzzy control rules.

I. Fuzzy controller

This example verifies the accuracy of the proposed system with fuzzy controller that can maintain the SOC of the battery at a certain level whether initial value of the SOC is low or high. The Simulink model of Fuzzy Controller is shown in Figure-4.7.

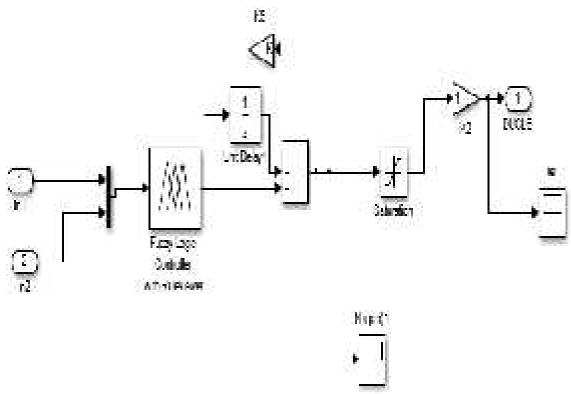


Fig 4.7. Simulink model of Fuzzy Controller

V. ENERGY MANAGEMENT SYSTEM

Microgrids are energy systems that aggregate distributed energy resources, loads and power electronics devices in a stable and balanced way. They rely on energy management systems to schedule optimally the distributed energy resources. For an interactive is required to co-ordinate their operation within the Microgrid. Renewable Energy Sources (RESs) just as non-dispatchable sources (Input Data) and accordingly, Energy Storage Systems (ESSs) are scheduled for balancing generation and demand.

The use of ESSs in MGs demands additional technical requirements within the EMS. Especially, those based on batteries need a proper management of the State of Charge (SoC) in order to prevent fast degradation. Therefore, the ESS should be accompanied by a battery charge control which avoids overcharge and deep discharge of the battery. Meanwhile, the EMS is responsible of scheduling properly the DERs, seeking for a proper window of stored energy, and a reduction in the stress caused by repeated cycles of charge. Besides, in previous works the authors do not consider the fact of that the ESS can get fully charged during the time horizon. In an energy management strategy is proposed for operating photovoltaic (PV) power plants with ESS in order to endow them with a constant production that can be controlled. In that work, the optimization aims to keep the SoC level of the battery as close as possible to a reference value at all times. Nevertheless, keeping the SoC of batteries in a fixed level is not the best practice since battery manufacturers recommend to charge completely the batteries between discharges cycles in order to improve the performance and considering the periods of full charge of the battery as well as reduced stress in discharge cycles of the battery by limiting the Deep of Discharge (DoD) to 30%. The main disadvantage of this approach is that the ESS is fully charged from the main grid at the beginning of the operation day instead of using the surplus of power from the renewable energy generators.

In the case of small-scale microgrids, the current trend is oriented to promote local consumption of the energy generated by RESs rather than exporting the surplus of electricity to the main grid. This is especially important because under periods of high generation and low local consumption, the surplus of power generated from RESs and fed-in to the main grid may cause significant variations in the voltage at the common coupling point. In order to ensure voltage quality in the grid-connected microgrid, the surplus in RES generation should be limited when there is not enough storage capacity in the ESSs. In this sense, the term connected islanded mode in which the MG is connected to the grid but the management is performed to avoid power exchange with the utility. One strategy to deal with this issue is by means of power curtailment of the RES generation, this alternative is used to limit the power injected to the main grid.

In a power control strategy by limiting the maximum power injected by PV systems, ensuring a smooth transition between maximum power point tracking (MPPT) mode and Constant Power Generation. In this paper, a flexible structure of EMS for battery-based hybrid microgrids is designed and experimentally tested to provide optimal power references for DERs by considering their operation modes. The EMS includes the modelling of an optimization problem that aims to minimize operating costs, taking into account a two-stage charge procedure for ESSs based on batteries. In this way, the power delivered to the grid is limited while safe operation ranges of ESSs are ensured, which in turn, avoids their fast degradation. The mathematical formulation is straightforward, reproducible and can be used and enhanced to other microgrids. The MG is complemented with the design of a fuzzy-based supervisory control level that reacts to the deviation of the utility power by adjusting the references of the DERs. This supervisory control level can also work without the EMS to provide power references in a reactive mode.

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VI. SIMULATION RESULTS

A hybrid microgrid is simulated using MATLAB/SIMULINK environment. The operation is carried out for the grid connected mode. Along with the hybrid microgrid, the performance of the doubly fed induction generator, photovoltaic system is analyzed. The solar irradiation, cell temperature and wind speed are also taken into consideration for the study of hybrid microgrid. The performance analysis is done using simulated results which are found using MATLAB.

A. MATLAB SIMULINK

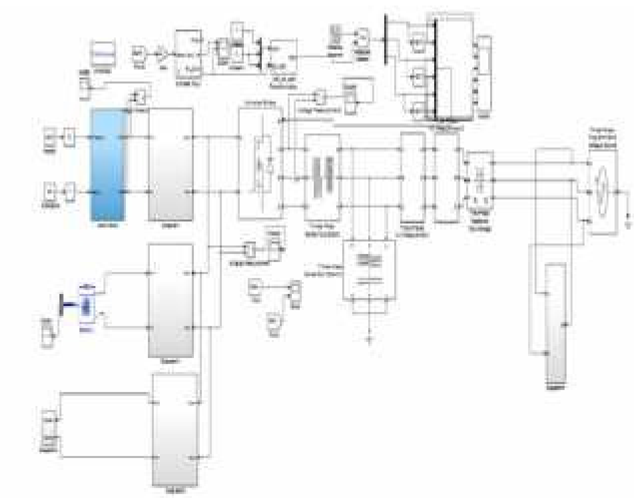


Fig 5.1 Proposed system Matlab simulation

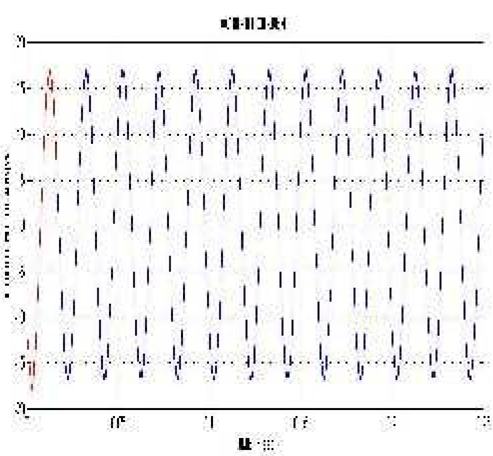
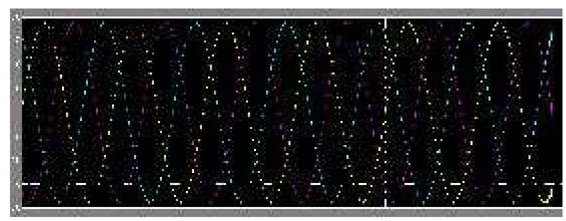


Fig 5.2 AC Output Voltage From The Main Converter

B. AC OUTPUT VOLTAGE FROM THE GENERATOR

C. THREE PHASE AC OUTPUT FROM THE GRID:



VII. CONCLUSION

The modelling of hybrid microgrid for power system configuration is done in MATLAB/SIMULINK environment. The present work mainly includes the grid tied mode of operation of hybrid grid. The models are developed for all the converters to maintain stable system under various loads and resource conditions and also the control mechanism are studied. MPPT fuzzy algorithm is used to harness maximum power from DC sources and to coordinate the power exchange between DC and AC grid. Although the hybrid grid can diminish the processes of DC/AC and AC/DC conversions in an individual AC or DC grid, there are many practical problems for the implementation of the hybrid grid based on the current AC dominated infrastructure. The efficiency of the total system depends on the diminution of conversion losses and the increase for an extra DC link. The hybrid grid can provide a reliable, high quality and more efficient power to consumer. The hybrid grid may be feasible for small isolated industrial plants with both PV systems and wind turbine generator as the major power supply.

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