A Review on Application of Hybrid Smart Grid Network for Compensate the Power

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Abstract: This paper represents the active modeling and simulation results of a renewable energy based hybrid power system. The various energy sources such as wind, PV and FC are modeled individually and latterly integrated to form a hybrid system. The simulation model of stand-alone system is developed from mathematical models of solar photovoltaic system, wind turbines and fuel cell. The simulation includes all practical components of the system, in this thesis power delivered by the Combine system component is compared with each other and various conclusions are drawn. A comparative study of hybrid model of solar /wind and fuel cells system has been made. This paper describe of solar-wind hybrid system for supplying electricity to power grid. Work principle and specific working condition are presented in this paper.

Keywords: Introduction, Solar power, wind power, fuel cell, hybrid generation energy, grid.

I. INTRODUCTION

Nowadays many applications in rural and urban areas use hybrid systems. The power system in this study consists of a solar photovoltaic (PV) array; wind turbine and fuel cell. These components have very different characteristics. But when they are engineered properly, they can work together to generate power in a sustainable and reliable way. Reliable electricity supply cannot be ensured because of the intermittent nature of renewable energy sources. Therefore, wind, solar and FC hybrid systems, which combine conventional and renewable sources of energies, are a better choice for isolated loads.

Wind and solar hybrid model with proper storage system have been keen interest for the last few years. Fuel Cells (FC) in combination with electrolyzer (for hydrogen generation) and hydrogen storage tanks are being considered for energy storage. In this paper a hybrid model of solar / wind & fuel cell is developed and compared with the earlier model of solar/wind/battery system. The simulation circuit will include all realistic components of the system.

II. SYSTEM DESIGN AND MODELING

A. Grid Configuration

Fig. 1 shows a theoretical hybrid system configuration where various ac and dc sources and loads are connected to the corresponding dc and ac networks. The ac and dc links are connected 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.

A compact hybrid grid as shown in Fig. 2 is modeled using the Simulink in the MATLAB to simulate system operations and controls. PV arrays are connected to dc bus through a dc/dc boost converter to simulate dc sources. A capacitor is to suppress high frequency ripples of the PV output voltage. A wind turbine generator with doubly fed induction Generator is connected to an ac bus to simulate ac sources. Variable dc load and ac load are connected to dc and ac buses respectively. A three phase bidirectional dc/ac main converter with R-L-C filter connects the dc bus to the ac bus through an isolation transformer.

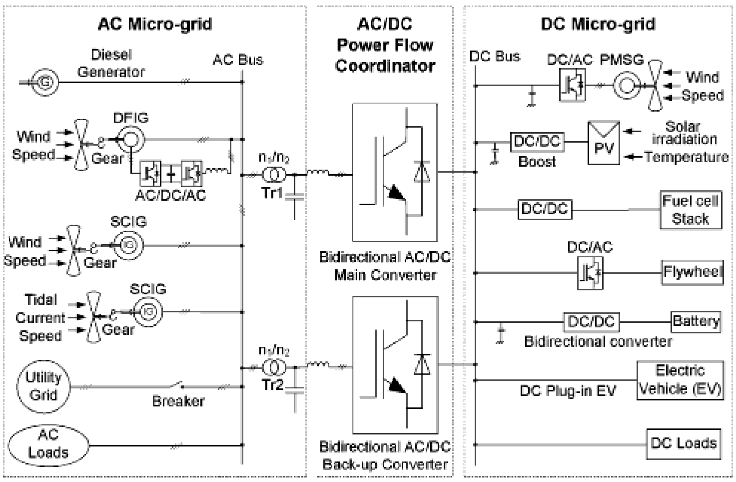


Fig. 1. A hybrid ac/dc microgrid system.

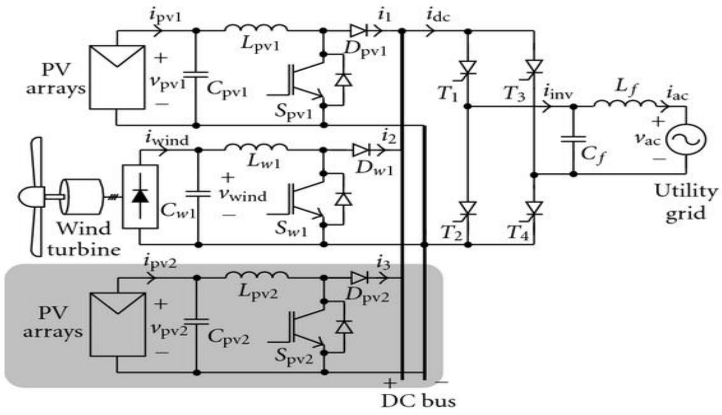


Fig (2) A compressed representation of the proposed hybrid grid

The characteristics and component of a hybrid micro grids system greatly depend on the application. The most important factor is to be considered whether the system is operated in islanded mode or grid tied mode.

A. Grid tied mode

If the hybrid system is connected to the utility grid as in Distributed generator application the system design will be simple with reduced no of components. Since the voltage and frequency are set by the utility system. In addition to this , the grid normally provides the reactive power . When the demand is more than the supplied power by the hybrid system, then the shortage is provided by the utility. Similarly, any excess power produced by the hybrid system can be absorbed by the utility system. In such cases, the grid does not act as an infinite bus. However, it is then said to be weak, additional components and control may need to be added. The grid connected mode hybrid system will then come to more closely resemble an isolated one

B. Islanded mode

Islanded grid connected hybrid system is differs in many ways from central grid connected system. Initially the system must be able to provide all the energy that is required at any time on the grid. They must be able to set the grid frequency and control the voltage. After that the system must be able to provide the reactive power required by the system. Under certain conditions, renewable generators may produce energy in excess of what is needed.

III. SYSTEM MODELLING

A. PV panel Modeling

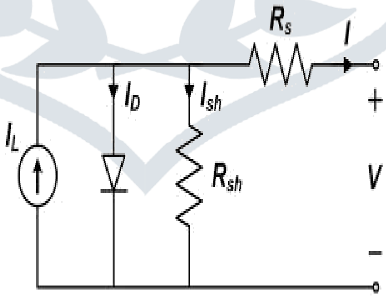
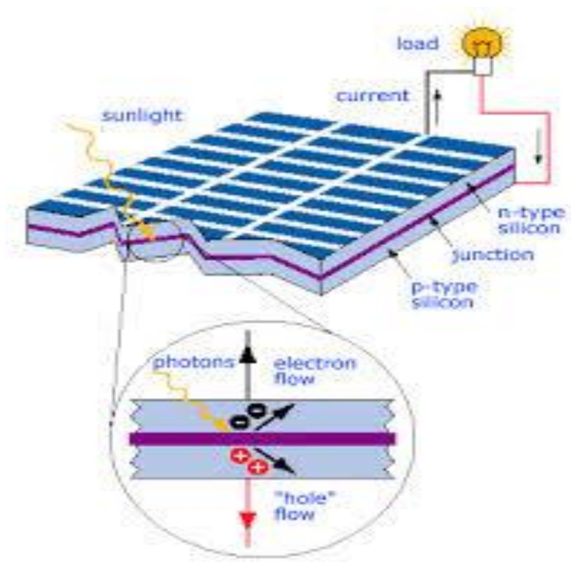


Fig: Equivalent circuit of a PV panel with a load.

A solar cell is the most fundamental component of a Photovoltaic system, which converts the solar energy into electrical energy. A solar cell essentially consists of a pn junction formed by semiconductor material. When sunlight falls on a solar cell an electron-hole pair is generated by the energy from the light (photons). The electric field created at the junction causes the electron-hole pair to separate with the electrons drifting towards the n-region and the holes towards the p-region. Hence electrical voltage is generated at the output. The photocurrent (Iph) will then flow through the load connected to the output terminals of the cell.

The ideal equivalent circuit of a solar cell consists of a current source in parallel with a diode. The output terminals of the circuit are connected to the load.



Ipv and Vpv are the terminal current and voltage of the pv panel, respectively.
The current output of the panel is modeled using theee following three equations.

$$I_{pv} = I_{ph} - I_s[\exp(q(V_{ph}+I_{ph} R_s)/kT_cA) - 1] - (V_{ph} + I_{ph} R_s)/R_p \quad \ldots\ldots\ldots\ (1)$$

The photocurrent mainly depends on the cell's working temperature and solar irradiation,

Which is explained as

$$I_{ph} = [I_{sc} + K_i(T_c - T_{ref})]\ \lambda /1000 \quad \ldots\ldots\ldots(2)$$

The saturation current of the cell varies with the cell temperature, which is represented as

$$I_s = I_{rs}(T_c/T_{ref})^3 \exp[qE_g(1/T_{ref} - 1/T_c)/kA] \quad \ldots\ldots(3)$$

Where:
Iph = Photo current (A)
Is = Diode reverse saturation current (A)
q = Electron charge = 1.6X10-19 (C)
k = Boltzman constant = 1.38X10-23 (J/K)
T = Cell temperature (K)

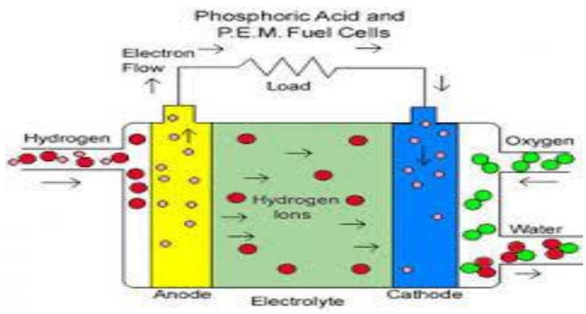
The power output of a solar cell is given by

$$P(pv) = V(pv) * I(pv)$$

Where:
I(pv) = Output current of solar cell (A).
V(pv) = Solar cell operating voltage (V).
P(pv) =Output power of solar cell (W)

Modeling of fuel cell:

A fuel cell consists of an electrolyte and two catalyst coated electrodes. The electrodes are a porous cathode and anode located on either side of the electrolytic layer. Gaseous fuel (usually hydrogen) is fed continuously to the anode and the oxidant (i.e. oxygen from air) is fed to the cathode).



Thus when hydrogen is fed to the anode, the catalyst in the electrode separate the negatively charged electrons of the hydrogen from the positively charged ions. The hydrogen ions pass through the electrolyte at the centre of the fuel cell and combine with the oxygen and electrons at the cathode with the help of catalyst to form water. The overall equation is given by:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

The electrons, which cannot pass through the electrolytic layer, flow from the anode to the cathode via the external circuit, giving rise to electric current.

Fig. shows the equivalent circuit of PEM fuel cell. The ohmic, activation and concentration resistances are represented with Rohmic ,Ract, Rconc respectively. C is the membrane capacitance. The membrane voltage equation is given by equation (4).

Vc=(1-dVc/dVt)(Ract+Rconc)……..(4)

The output voltage of the PEMFC is given by

Vfc = E – Vc – Vact – Vohmic

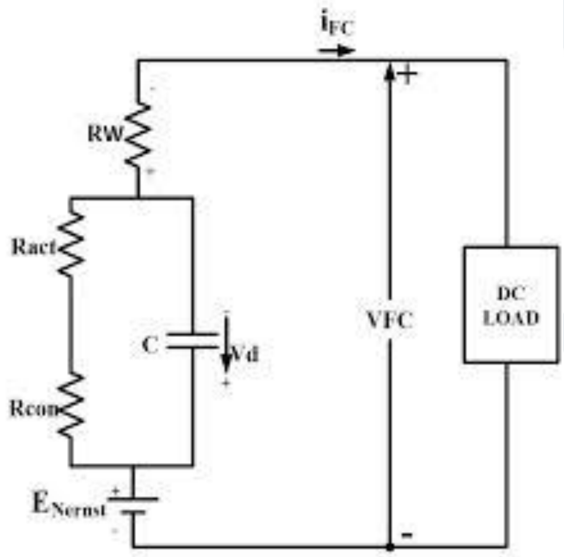
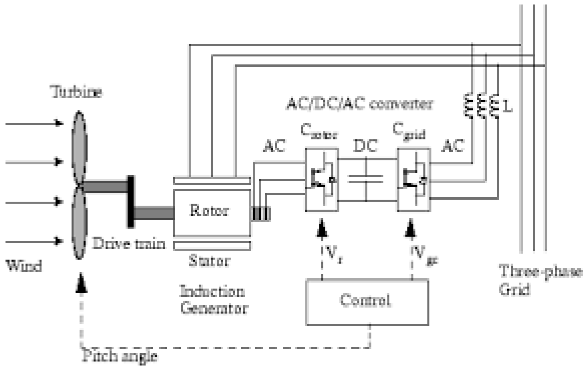


Fig: Equivalent circuit of PEM fuel cell

Modeling of wind turbine generator with DFIG :

This paper consists of DFIG as a wound rotor induction machine.



The amount of mechanical power captured from wind by a wind turbine can be formulated as:

$P_m = \frac{1}{2} \rho A C_p V^3$

Where:
ρ = Air density (Kg/m3)
A = Swept area (m2)
Cp = Power coefficient of the wind turbine
V = Wind speed (m/s)

Therefore, if the air density, swept area and wind speed are constant the output power of the turbine will be a function of power coefficient of the turbine. In addition, the wind turbine is normally characterized by its CP-λ curve; where the tip speed ratio, λ, is given by:

$\lambda = \omega R/V$

where, ω, R and v are the turbine rotor speed in "rad /s", radius of the turbine blade in "m", and wind speed in "m/s" respectively.

IV. POWER ELECTRONICS AND CONTROL

The hybrid micro grid contains six types of converters. All the converters have to be coordinately controlled with the utility grid to supply reliable, high efficiency, high quality power for variable DC and Ac loads. The controllers are presented in this section are coordinated successfully in both grid-tied.

Boost converter

The basic structure and control topology of the dc-dc boost converter is shown in Fig. The converter divides the input dc-link voltage into two levels: variable dc-link voltage at the output terminals of the energy source and fixed dc-link voltage at the input terminals of the voltage source inverter.
In this section, the operation of the boost chopper is theoretically analyzed. The energy sources are replaced by a variable dc voltage source in order to facilitate the analysis. The inverter circuit is simulated as a resistive load connected to a fixed dc-link, since it can be controlled to behave as a current source at the high power factor. The inductance and capacitance of the system are assumed to be sufficiently large, such that the switching device current and the dc output voltage are filtered by the inductor and capacitor respectively. The energy is stored in L, when Switch is "1", and the energy is transferred to load, when Switch equals "0".

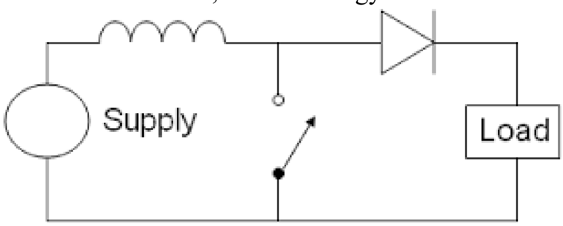


Fig: Boost converter

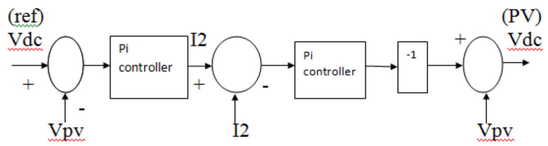
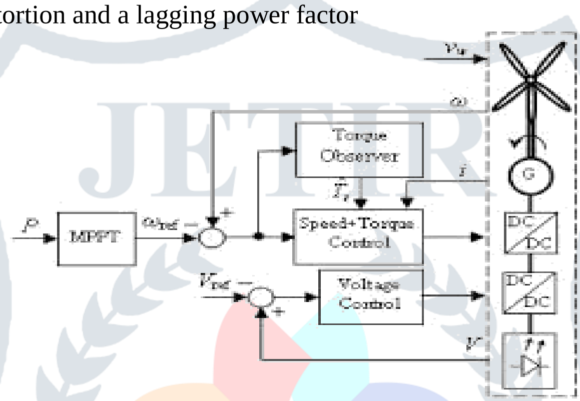


Fig : Control scheme for pv cell/ PEM cell

In wind turbine and photovoltaic array, the inductor current is controlled based on the error signal. For the wind turbine the error signal is the difference between the reference turbine speed obtained from MPPT and the actual speed. Similarly for the photovoltaic array this error is the difference between the reference voltage set by the MPPT algorithm and the actual measured voltage. The error is fed into a proportional integrator (PI) type controller, which controls the duty cycle of the dc-dc converters. For the fuel cell system, the inductor reference current is calculated using a look-up table. The input of the look-up table is difference between required power and summation of the power generated by the turbine and photovoltaic array. The difference between this reference current and the measured inductor current is fed to the PI controller to minimize the error. Since this system does not allow reverse power flow, because of step-up boost chopper, many generating units can be connected in parallel one smoothing unit and inverter. However, this gives rise to current distortion and a lagging power factor



V. CONCLUSION:

This paper represent the multi-objective optimization of hybrid systems has been applied to the renewable electrical energy generation. the hybrid production unit offers the best
Opportunity to use locally available renewable energies.

VI. FUTUTE WORK:

Modeling and control of different modes of hybrid connect with the grid and simulate it through the MATLAB/ simulink. With proper control strategy to compensate the reactive power and improving the power factor so that the efficiency of total power system can be increase.

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