

# Co-Ordination of Multiple Power Generation Sources and Control in Hybrid Micro Grid with Smooth Power Transfer and Feature

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**ABSTRACT:**The paper proposes the hybrid micro grids with multiple no of generating sources like Solar and wind with combination of fuel cells and other power smooth transfer technologies for convenient utilities. As we know that up to now the AC power sources are connected with ac grid and dc loads are connected with dc grids. Now we can also observe that for AC and DC both are connected with large distance of transmission lines with all kinds of existing losses and other challenges. Coming to these kind of micro power grids can optimises the transmission length and losses, and also that the micro grid can be operated in the autonomous mode in Grid tide position. We can coordinate the power sources and converters by using the suitable algorithms .the coordination between the AC DC Grids varies under the loading generations and load conditions. Uncertainty and intermittent characteristics of wind speed and, solar irradiation level, temperatures and load also considered. The hybrid micro grids and a small grid has proposed and modelled the simulation results show that the system can maintain stable operation under the proposed when the grid is operated from one operation and other conditions .

**KEYWORDS:** Energy Generations, Micro grids, Power Control, PV System

## 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 peak saving 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 From the customer point of view, micro grids 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.

**II. SYSTEM CONFIGURATION AND MODELING**

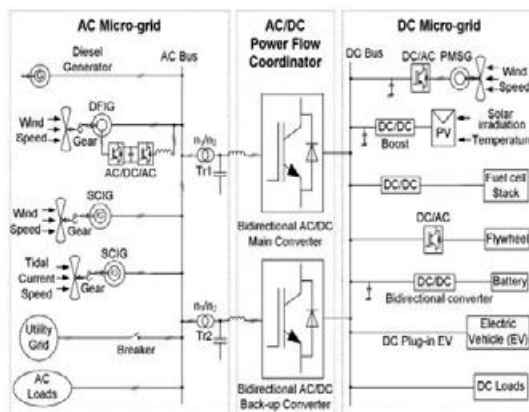


Fig. 1: A Hybrid AC/DC Microgrid System

The above figure shows the AC, DC Grid constructed with power converters and generation sources which as represented 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

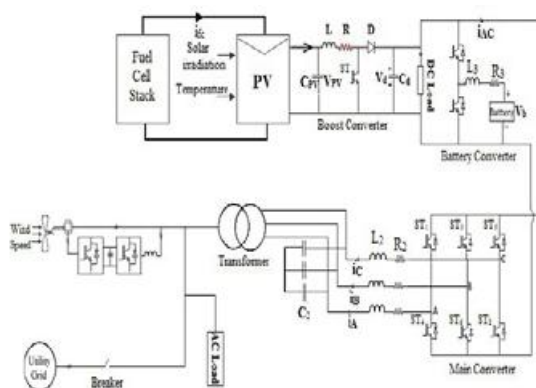


Fig. 2: Representation of the Proposed Hybrid Grid

40kW PV arrays are connected to dc bus through a dc/dc boost converter to simulate dc sources. A capacitor Cpv is to suppress high frequency ripples of the PV output voltage. A 50kW Wind Turbine Generator (WTG) with Doubly Fed Induction Generator (DFIG) is connected to an ac bus to simulate ac sources. A 65 Ah battery as energy storage is connected to dc bus through a bidirectional dc/dc converter. Variable dc load (20 kW–40 kW) and ac load (20 kW–40 kW) are connected to dc and ac buses respectively. The rated voltages for dc and ac buses are 400V and 400V rms 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. The hybrid grid can operate in two modes. In grid-tied mode, the main converter is to provide stable dc bus voltage and required reactive power and to exchange power between the ac and dc buses. When the output power of the dc sources is greater than the dc loads, the converter acts as an inverter and injects power from dc to ac side. When the total power generation is less than the total load at the dc side, the converter injects power from

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the ac to dc side. When the total power generation is greater than the total load in the hybrid grid, it will inject power to the utility grid.

### III. TECHNICAL CHALLENGES IN MICRO GRID

Protection system is one of the major challenges for micro grid which must react to both main grid and micro grid faults. The protection system should cut off the micro grid from the main grid as rapidly as necessary to protect the micro grid loads for the first case and for the second case the protection system should isolate the smallest part of the micro grid when clears the fault, Otherwise, the hybrid grid will receive power from the utility grid. In the grid tied mode, the battery converter is not very important in system operation because power is balanced by the utility grid. In autonomous mode, the battery plays a very important role for both power balance and voltage stability. DC bus voltage is maintained stable by a battery converter or boost converter according to different operating conditions. The main converter is controlled to provide a stable and high quality ac bus voltage. Both PV and WTG can operate on maximum power point tracking (MPPT) or off-MPPT mode based on system operating requirements.

### IV. MODELING OF PV PANEL

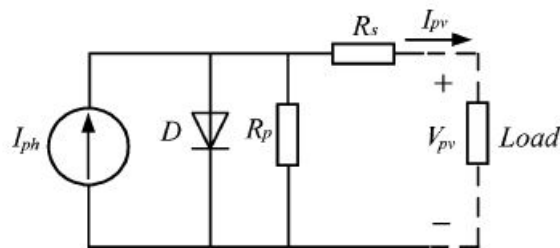


Fig. 3: Solar Cell Equivalent Circuit

The photovoltaic system can generate direct current electricity without environmental impact when is exposed to sunlight. The basic building block of PV arrays is the solar cell, which is basically a p-n junction that directly converts light energy into electricity. The output characteristic of PV module depends on the cell temperature, solar irradiation, and output voltage of the module. The figure shows the equivalent circuit of a PV array with a load. As an electronic system maximum power point tracker (MPPT) functions the photovoltaic (PV) modules in a way that allows the PV modules to produce all the power they are capable of. It is not a mechanical tracking system which moves physically the modules to make them point more directly at the sun.

$$I_{pv} = n_p I_{ph} - n_p I_{sat} * \left[ \exp \left( \left( \frac{q}{A k T} \right) \left( \frac{V_{pv}}{n_s} + I_{pv} R_s \right) \right) - 1 \right] \quad (1)$$

$$I_{ph} = (I_{sso} + k_i (T - T_r)) * S / 1000 \quad (2)$$

$$I_{sat} = I_{rr} \left( \frac{T}{T_r} \right)^3 \exp \left( \left( \frac{q E_{gap}}{k A} \right) \left( \frac{1}{T_r} - \frac{1}{T} \right) \right) \quad (3)$$

### V. MODELING OF BATTERY

Battery terminal voltage  $V_b$  and state of charge (SOC) as follows

$$V_b = V_O + R_b . i_b - K \frac{q}{Q + i_b dt} + A . \exp (B \int i_b dt) \quad (4)$$

$$SOC = 100 \left( 1 + \frac{\int i_b dt}{Q} \right) \quad (5)$$

$R_b$  is internal resistance of the battery,

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$V_0$  is the open circuit voltage of the battery charging current,

### VI. MODELING OF FUEL CELL

The equivalent circuit of a P E M Fuel cell is as shown in the fig. 4. The charge double layer capacitance  $C$  is a function of the electrode and individual stack properties .Whenever two different materials are in contact, there is a buildup of charge transfer from one to the other. The voltage formed due to this charge double layer will take some time to respond to sudden change in the current.

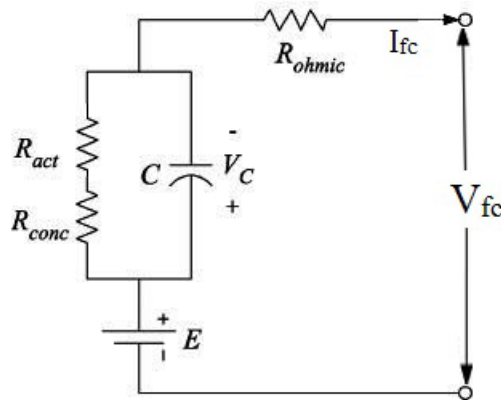


Fig. 4: Equivalent Circuit of a PEM Fuel cell

Here  $R_{ohmic}$ ,  $R_{act}$ ,  $R_{conc}$  are respectively the representation for the ohmic, the activation and the concentration resistance; with  $C$  corresponding to the membrane capacitance due to the double layer effect. This effect is incorporated in the output voltage of the PEM Fuel cell. The voltage across  $C$  is given by

$$V_c = \left( I - \frac{dv_c}{dt} \right) (R_{act} + R_{conc}) \quad (6)$$

The output voltage of the Fuel cell  $V_{FC}$  is given by

$$V_{FC} = E - V_c - V_{act} - V_{ohmic} \quad (7)$$

#### F. Modeling of Wind Turbine Generator

A wind turbine extracts kinetic energy from the swept area of the blades. The power contained in the wind is given by the kinetic energy of the flowing air mass per unit time

Power output  $P_m$  from a WTG is determined by

$$P_m = 0.5 \rho A C_p(\lambda, \beta) V_\omega^3 \quad (8)$$

Where  $\rho$  is air density,

$A$  is rotor swept area,

$V_\omega$  is wind speed,

and  $C_p(\lambda, \beta)$  is the power coefficient,

which is the function of top speed ratio  $\lambda$  and pitch angle  $\beta$ .

The mathematical models of a DFIG are essential requirements for its control system. The voltage equations of an induction motor in a rotating d-q coordinate are as follows.

$$\begin{bmatrix} U_{ds} \\ U_{qs} \\ U_{dr} \\ U_{qr} \end{bmatrix} = \begin{bmatrix} -R_s & 0 & 0 & 0 \\ 0 & -R_s & 0 & 0 \\ 0 & 0 & R_r & 0 \\ 0 & 0 & 0 & R_r \end{bmatrix} \begin{bmatrix} i_{ds} \\ i_{qs} \\ i_{dr} \\ i_{qr} \end{bmatrix} + P \begin{bmatrix} \lambda_{ds} \\ \lambda_{qs} \\ \lambda_{dr} \\ \lambda_{qr} \end{bmatrix} + \begin{bmatrix} -w_1 \lambda_{qs} \\ w_1 \lambda_{ds} \\ -w_2 \lambda_{qr} \\ w_2 \lambda_{dr} \end{bmatrix} \quad (9)$$

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The dynamic equation of the DFIG

$$\begin{bmatrix} \lambda_{ds} \\ \lambda_{qs} \\ \lambda_{dr} \\ \lambda_{qr} \end{bmatrix} = \begin{bmatrix} -L_s & 0 & -L_m & 0 \\ 0 & -L_s & 0 & -L_m \\ -L_m & 0 & L_r & 0 \\ 0 & -L_m & 0 & L_r \end{bmatrix} \begin{bmatrix} i_{ds} \\ i_{qs} \\ i_{dr} \\ i_{qr} \end{bmatrix} \quad (10)$$

$$\frac{J}{np} \frac{d\omega_r}{dt} = T_m - T_{em} \quad (12)$$

$$T_{em} = n_p L_m (i_{qs} i_{dr} - i_{ds} i_{qr}) \quad (13)$$

where the subscripts d, q, s, and r denote d-axis, q-axis, stator and rotor respectively, L represents the inductance,  $\lambda$  is the flux linkage, and u and I represent voltage and current respectively, and  $\omega_1$  and  $\omega_2$  are the angular synchronous speed and slip speed respectively,  $\omega_2 = \omega_1 - \omega_r$ ,  $T_m$  is the mechanical torque,  $T_{em}$  is the electromagnetic torque.

### VII. COORDINATION CONTROL OF THE CONVERTERS

There are five types of converters in the hybrid grid. Those converters have to be coordinately controlled with the utility grid to supply an uninterrupted, high efficiency, and high quality power to variable dc and ac loads under variable solar irradiation and wind speed when the hybrid grid operates in both isolated and grid tied modes. The control algorithms for those converters are presented in this section.

#### A. Grid-Connected Mode

When the hybrid grid operates in this mode, the control objective of the boost converter is to track the MPPT of the PV array by regulating its terminal voltage. The back-to-back ac/dc/ac converter of the DFIG is controlled to regulate rotor side current to achieve MPPT and to synchronize with ac grid. The energy surplus of the hybrid grid can be sent to the utility system. The role of the battery as the energy storage becomes less important because the power is balanced by the utility grid. In this case, the only function of the battery is to eliminate frequent power transfer between the dc and ac link. The main converter is designed to operate bi-directionally to incorporate complementary characteristic of wind and solar sources [6-7].

Power flow equations at the dc and ac links are as follows:

$$P_{pv} + P_{ac} = P_{dcL} + P_b \quad (13)$$

$$P_s = P_w - P_{acL} - P_{ac} \quad (14)$$

where real power  $P_{pv}$  and  $P_w$  are produced by PV and WTG respectively,  $P_{acL}$  and  $P_{dcL}$  are real power loads connected to ac and dc buses respectively,  $P_{ac}$  is the power exchange between ac and dc links,  $P_b$  is power injection to battery, and  $P_s$  is power injection from the hybrid grid to the utility. The reference value of the solar panel terminal voltage.

$$P_{pv} + P_w = P_{acL} + P_{loss} + P_b \quad (15)$$

Where  $P_{loss}$  is the total grid loss.

**VIII. SIMULATION RESULTS OF HYBRID GRID**

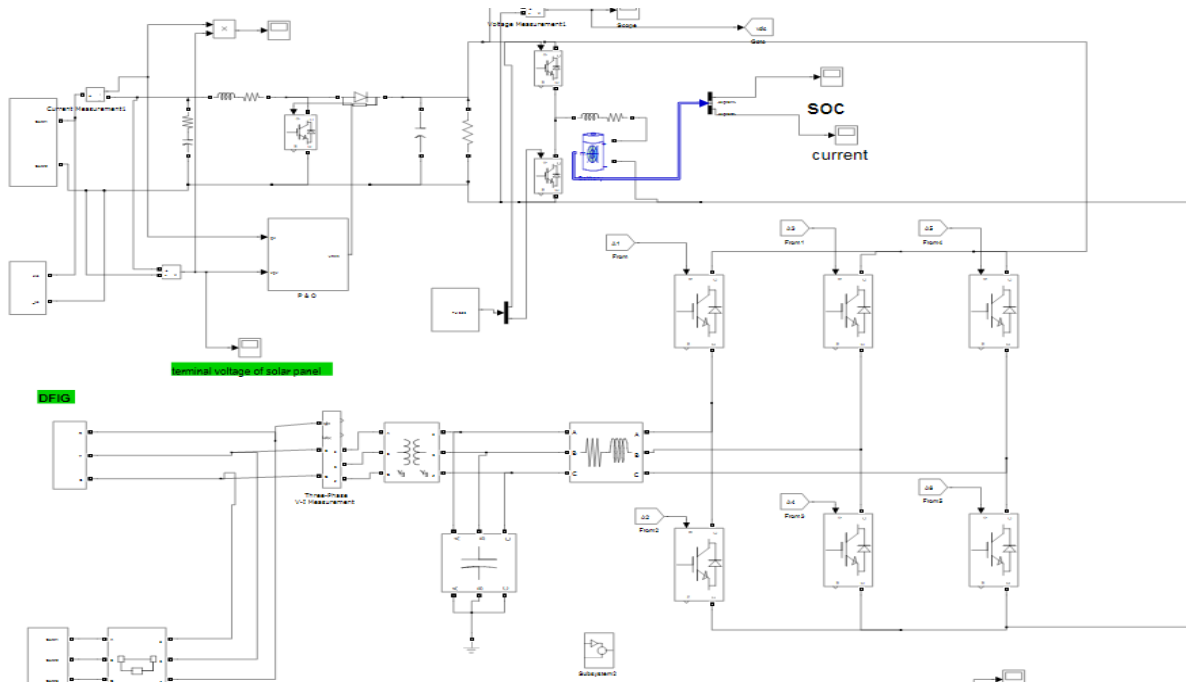


Fig 5 Proposed Circuit Design

The various characteristics of the hybrid micro grid are represented below.as we know that the micro grid operated with grid tied mode.in this mode the battery fully charged. Ac bus voltage is maintained by the utility grid.

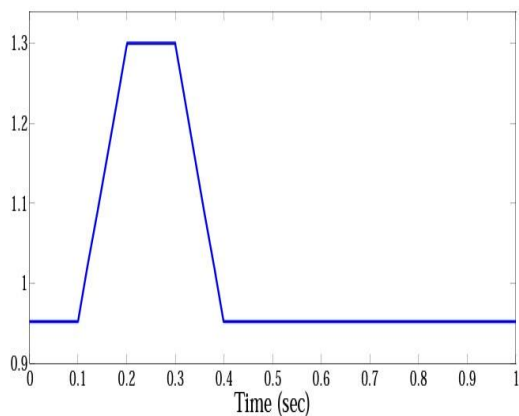


Fig 6 PV Irradiation

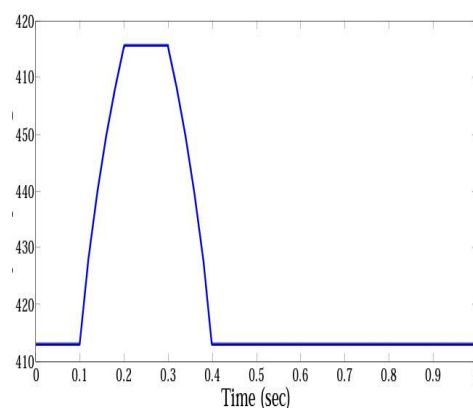


Figure 7 PV Out put voltage

The above PV radiation and PV output voltage are taken in the grid connected mode which as shown above



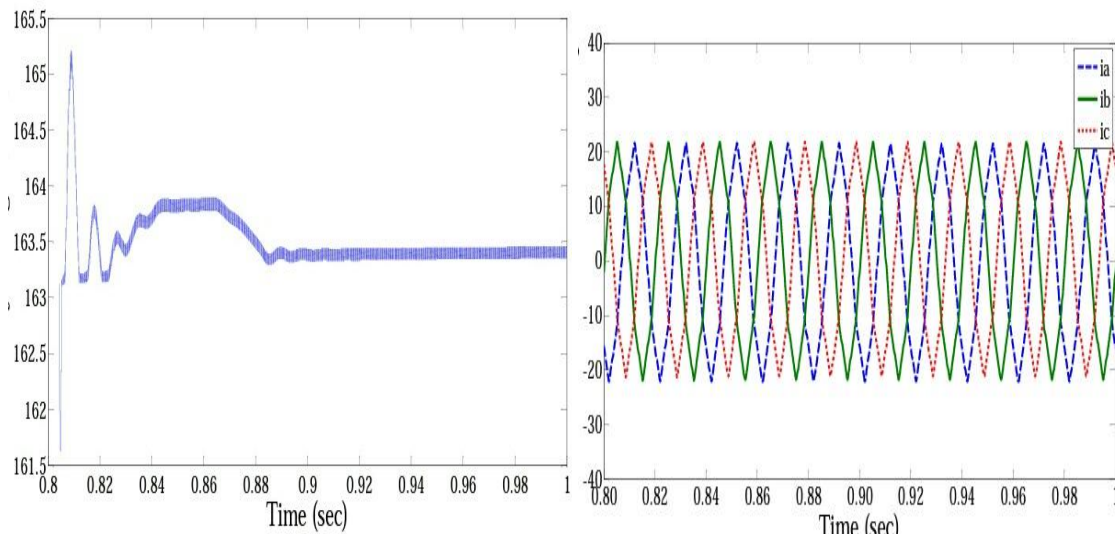


Fig 8 Battery Voltage

Fig 9 Ac Outputvoltage

### IX. CONCLUSION

The modeling of hybrid micro grid 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 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.

### X. SCOPE OF FUTURE WORKA AND REFERENCES

- a. The modeling and control can be done for the islanded mode of operation.
- b. The control mechanism can be developed for a micro grid containing unbalanced and nonlinear loads.

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