# Power Management & Control of a Grid Tied Hybrid AC/DC Microgrid with PV & Wind Power Sources

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***Abstract***— This paper suggests a hybrid alternating current/direct current microgrid to reduce grid conversions. Hybrid grid multi-bidirectional converters connect AC and DC networks. DC and AC networks connect sources and loads. Energy storage devices can operate on either DC or AC networks. Connect or use hybrid grids. Coordination control systems transmit alternating and direct current electricity and operate consistently under changing generation and load conditions. Wind, solar irradiation, temperature, and load all fluctuate dramatically. Basic hybrid grid simulation with MATLAB Simulink. The simulation demonstrates that coordination control can maintain grid stability as operating modes change.

***Keywords***—*Solar (PV); Wind Energy (WECS); Battery; Boost-Converter; Bidirectional AC/DC Converter; AC Microgrid; DC Microgrid; AC/DC Microgrid; Stability; DFIG - Doubly-Fed Induction Generator.*

## I. INTRODUCTION

Microgrids are connecting to larger power grids via the use of renewable energy sources in response to rising environmental and energy issues. Power is produced through AC/DC microgrids. [1, 2]. AC microgrids are used in power networks because of their ease of usage. Today's culture and alternative DC power sources, including solar, have led to a rise in the prevalence of DC microgrids. DC data centers, air conditioning systems, and energy conversion devices are all being linked to AC grids [3, 4]. In AC microgrids, DC equipment and renewable energy sources may perform better and be less expensive. AC and DC electric appliances will cohabit for some time, since both the main power supply and the AC microgrid use AC current. Power losses, control problems, and harmonic currents may all be mitigated in AC or DC microgrids by avoiding unnecessary conversions. Microgrids may use DC or AC power sources, depending on what is available [5]. As a result of their advantages over purely DC or AC microgrids [6, 7], hybrid AC/DC microgrids are gaining in popularity across the globe. Hybrid AC/DC microgrids employ AC/DC converters and microgrids to provide power in both directions [8, 9]. A bidirectional AC/DC converter controls the microgrid's power flow. Both are useful for hybrid AC/DC microgrids. It is possible that DC and AC electrical equipment connected to a hybrid AC/DC microgrid might receive power from a variety of sources without needing to undergo any transformations. Reduce wasted energy and boost the efficiency of the power conversion process. Connecting and disconnecting the hybrid AC/DC microgrid from the grid is made possible by static transfer switches. More regulation is needed for AC/DC microgrid hybrids [10, 11]. Microgrids that combine AC and DC power sources are called hybrid AC/DC microgrids. The AC microgrids connect the DC microgrids in a hybrid system. You may use it either off- or on-grid. Possibilities for AC microgrids that are tied into the larger grid are endless [12]. The bidirectional AC/DC converters and batteries might be used to adjust DC bus voltage and power balancing in AC and DC microgrids. U-Q and PQ govern energy flow in both directions of the AC/DC converter. When the main converter needs PQ control, continuous power supplements the AC microgrid with PV power. U-Q management maximizes DC PV use by sending excess PV energy to the AC microgrid. The AC/DC converter works in both directions, simplifying the transition between U-Q and PQ modes. In island mode, when no grid is present, Batteries and a two-way AC/DC converter are used to maintain equilibrium between supply and demand. The AC/DC converter regulates the voltage and frequency of the AC bus. Subgrids of alternating current and direct current may be balanced using battery nodes. Model and architecture for AC/DC microgrid simulations. In this article, we take a quick look at the submodule controllers used in a hybrid AC/DC microgrid. Coordination and control systems are put through their paces in a virtual environment.

## II. SYSTEM CONCEPTUALIZATION AND DEVELOPMENT

### A. Microgrid with an AC/DC hybrid power supply

Power flow and AC/DC systems are shown in Figure 1 for a simple hybrid AC/DC microgrid. This is a 45 kW DFIG wind turbine, which stands for "double fed induction generator" and three-phase alternating current (AC) loads are directly connected to the AC bus through a back-to-back AC/DC/AC converter [13]. DC sub-microgrid is a copy of DC electrical devices, consisting of 228 KW of PV arrays (15 parallel and 10 series), 400 Ah of battery storage, and direct-connected variable DC loads. Power in AC and DC sub-microgrids is controlled via bidirectional AC/DC converters. The PCC enables either grid-connected or island-based operation of the hybrid microgrid. An isolated hybrid microgrid is the result of an opened breaker. The hybrid microgrid is connected when the breaker is closed.

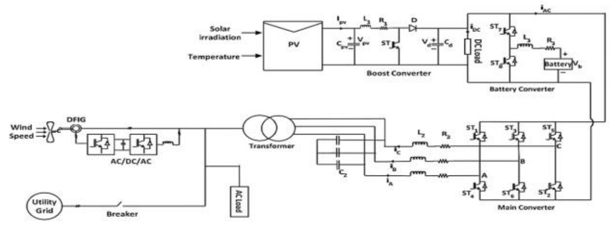


Figure 1: Representation of proposed hybrid grid

### B. *Grid-Connected Mode*

The utility grid balances electricity, eliminating the battery converter. The primary converter reduces the voltage drop across the dc bus and the amount of reactive power lost throughout the process. DC to AC conversion occurs when DC supply surpass DC loads. Pumping occurs when the converter's power output is less than the dc side's load. Hybrids feed the grid. Utility manages.

### C. *Isolated Mode*

Islanding disconnects the hybrid grid from the utility grid. Battery balances power and voltage. Battery or boost converter maintain DC bus voltage, depending on circumstances. The primary converter supplies continuous, high-quality alternating current bus voltage.

### D. *The PV panel's modeling*

PV systems are made up of modules connected by PV panels in series or parallel. PV panels are diode-powered current sources. (1) shows PV panel mathematics, whereas (2) shows a PV panel equivalent circuit model [13].

$$I_L = I_{ph} - I_s\,(e^{\frac{q(V+IR_S)}{AKT}} - 1) - \frac{V + IR_S}{R_{sh}} \qquad (1)$$

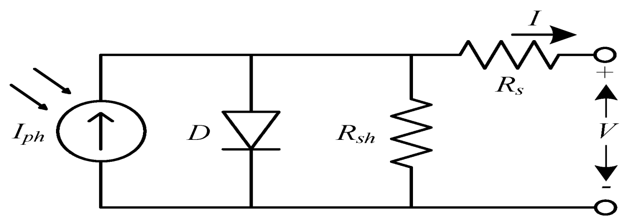


Figure 2: PV panel single-diode equivalent circuit

### E. *The battery's modeling*

The battery is essential to distributed generation as an energy storage device, but its internal characteristics interact non-linearly. Equations (2) and (3) reflect the battery model's voltage and SOC [14].

$$V_b = V_0 + R_b \cdot i_b - K \frac{Q}{\int i_b dt} + A \cdot exp\,(B \int i_b dt) \qquad (2)$$

$$SOC = 100(1 + \frac{\int i_b dt}{Q}) \qquad (3)$$

### F. *The WT generator's modeling*

The WT's mechanical power output is as follows:

$$P_m = 0.5\rho A C_p(\lambda, \beta) V_\omega^3 \qquad (4)$$

where $(\rho)$ is air density, $(A)$ is turbine swept area, $V_\omega$ is wind speed, and $C_p$ $(\lambda, \beta)$ is the power coefficient, which is the function of tip speed ratio $(\lambda)$ and blade pitch angle $(\beta)$.

## III. CONTROL APPROACHES

### A. *PV array control scheme*

Temperature and irradiance impact PV system power output. MPPT mode on the boost converter maximizes PV array performance. MPPT control algorithms maintain PV array efficiency regardless of irradiance and temperature. Simple MPPT methods like P&O [15] are popular. Figure 3 shows the P&O algorithm.

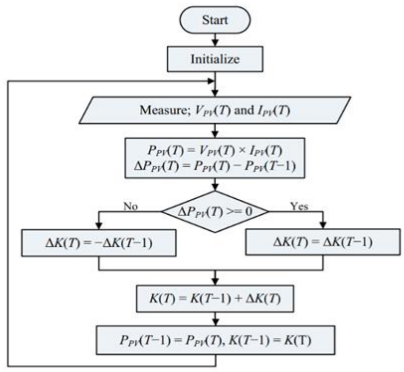


Figure 3: P&O Algorithm

Figure 4 shows how the P&O approach modulates the boost converter's duty cycle to monitor PV array MPP. MPPT improves solar generator energy supply. This process used boost converter control. The MPPT algorithm generates the ideal reference voltage Vm by detecting the PV array's current voltage Vpv, and the PI regulator reduces the error signal between Vpv and Vm. The PWM generator provides the switch pulse signal to activate MPPT [6].

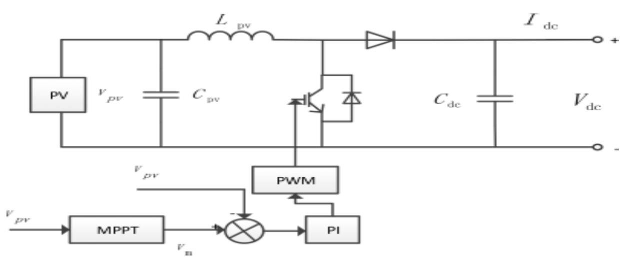


Figure 4: PV array strategy

### B. *Battery management approach*

Independent and grid-connected energy storage configurations are necessary for this research. The two-way DC/DC converter shown in Figure 5 is capable of maintaining a constant voltage on the DC bus while the battery is being charged or discharged. The voltage and current of the DC bus are both under the control of the bidirectional DC/DC converter higher than the DC bus's reference voltage [13]. Switching from S1 to S2 causes the converter to operate as a buck circuit, allowing the hybrid microgrid to charge the battery. The converter becomes a boost circuit and the battery is discharged to power the loads when the DC bus voltage VDC drops below the reference voltage VDC, activating IGBT S1 and deactivating S2.

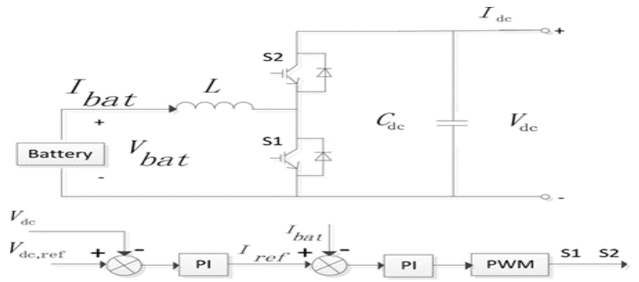


Figure 5: Battery charge and discharge control scheme

### C. *DFIG's control approach*

Control of wind power plants often include management of both the generator's WT and DFIG's back-to-back AC/DC/AC converters. Converting from one kind of AC current to another, in series. The DC link voltage is regulated by the grid-side converter, while active and reactive power on the rotor side is managed by the rotor-side converter. The rules for DFIG compliance are laid forth in [9].

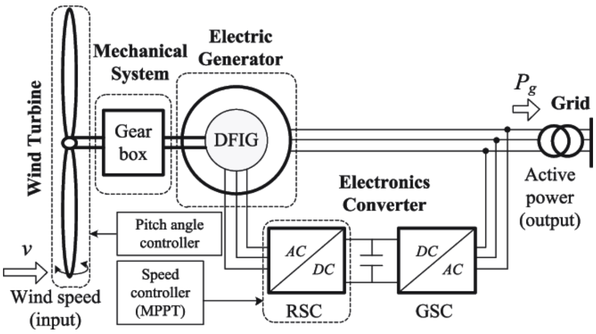


Figure 6: DFIG - Doubly-Fed Induction Generator

### D. *The bidirectional AC/DC converter's control scheme*

One of the most important parts of a hybrid microgrid is the main converter, often known as a bidirectional AC/DC converter. Maintaining consistent bus voltages and distributing electricity evenly across AC and DC microgrids both contribute to system reliability.

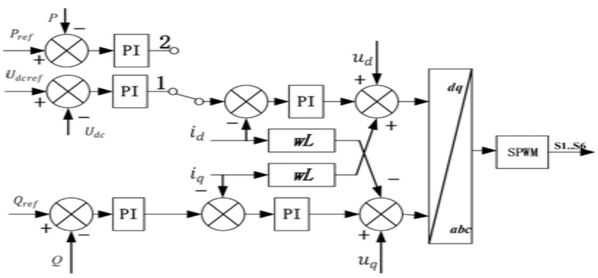


Figure 7: Control method for grid-connected bidirectional AC/DC converters

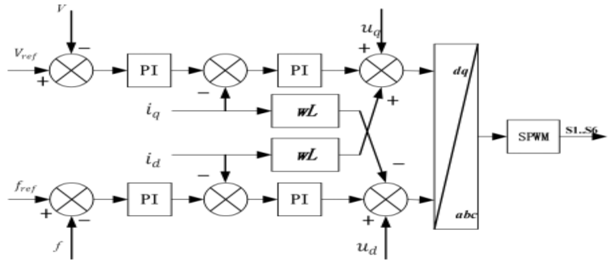


Figure 8: Control method for an islanded mode bidirectional AC/DC converter

## IV. SIMULATION RESULTS AND ANALYSIS

MATLAB/SIMULINK models hybrid microgrids. The method joins the grid. The hybrid microgrid, doubly fed induction generator, and solar system are being tested. Hybrid microgrid studies involve solar irradiance, cell temperature, and wind speed. Performance analysis using MATLAB simulations.

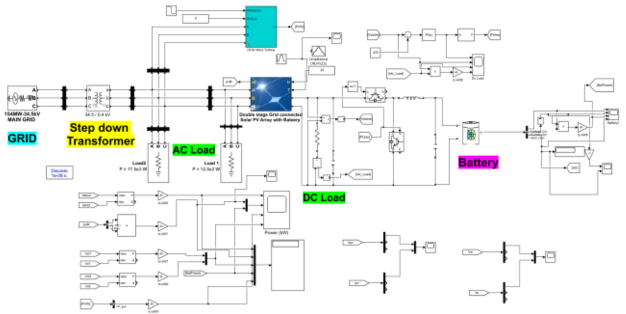


Figure 9: Simulink Model of Hybrid AC/DC Microgrid

### A. *PV array simulation Figures (10) and (11) show P-V characteristics with sun irradiation. The figures show that the PV cell's output power depends on its terminal operating voltage, temperature, and solar irradiation, demonstrating its nonlinearity.*

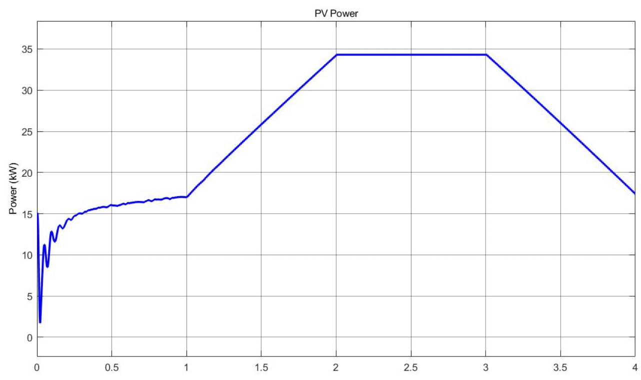


Figure 10: Photovoltaic (PV) Power Vs Time In (S)

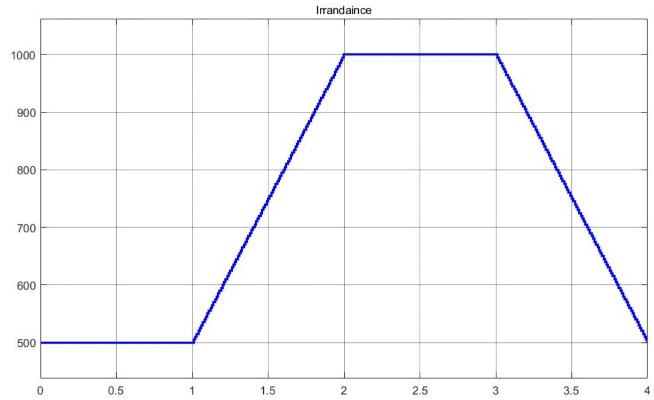


Figure 11: Irradiance Vs Time In (S)

*B. Results of a Doubly Fed Induction Generator (DFIG) Simulation with Grid Power, Solar PV, and Battery in Relation to AC Loads*

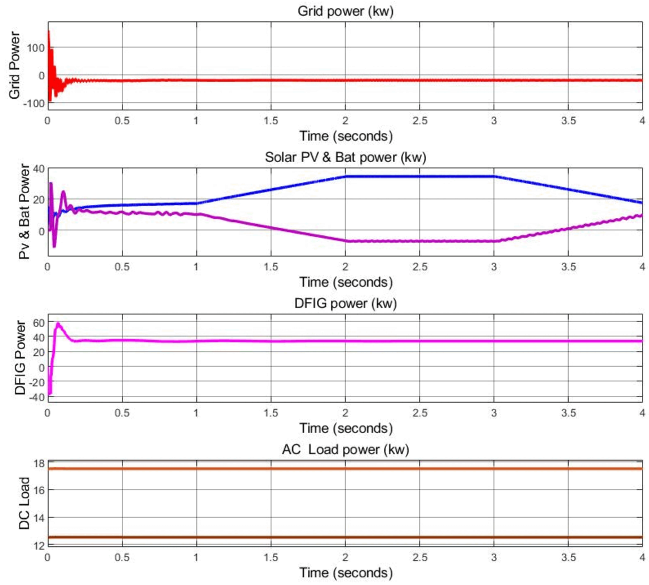


Figure 12: Grid Power (Kw), Solar PV & Battery Power (Kw), DFIG Power (Kw) & Ac Load Power (Kw) Vs Time In (S)

*C. Battery Charging and Discharging Simulation Results with SOC%*

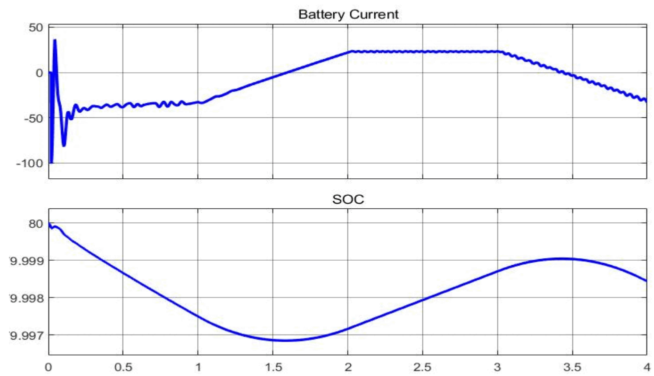


Figure 13: Battery Current & Soc Vs Time In (S)

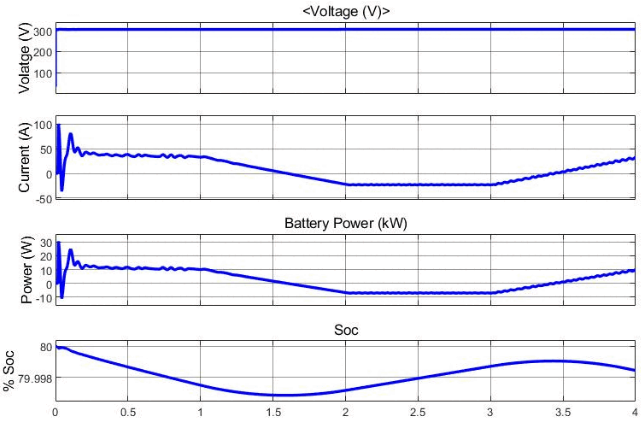


Figure 14: Battery - Current, Voltage, Power (Kw) & Soc % Vs Time In (S)

*D. Simulation Results Correspond to DC Load*

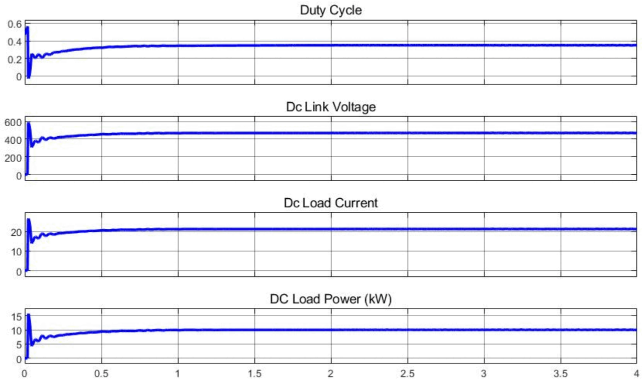


Figure 15: Duty Cycle, Dc Link Voltage, Dc Load Current & Dc Load Power (Kw) Vs Time In (S)

## CONCLUSION

This research suggests an AC/DC hybrid microgrid. The system functions steadily under fluctuating resource and load conditions, thanks to models and coordination control mechanisms for all converters. The coordinated control methods are validated with MATLAB/Simulink. Several control strategies have been developed to optimize power from direct current (DC) and alternating current (AC) sources while also regulating power exchange between grids. Exploring resource situations and load capacity validates control methods. According to modeling, the hybrid grid can work as either grid-connected or isolated. When operating conditions or load capacity change, the alternating current and direct current bus voltages may remain constant. When the load changes, the power remains smooth.

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