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INTEGRATION AND POWER CONTROL OF A HYBRID MICRO GRID WITH AND WITHOUT DSTATCOM

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Abstract

It is an important tool in modern electrical networks, particularly in addressing the challenges associated with increasing renewable energy integration and maintaining reliable power supply. Present work various results including FFT analysis with and without DSTATECOM has been proposed. In this work, it has been clearly seen that the input and output characteristics i.e., PV array voltage, PV array current PV array diode current PV array radiation current respectively increase of cell's working temperature, the current output of PV array increases and output voltage decrease, decreasing temperature voltage output increase and current decrease and become stable after 3 sec and reach MPP in PV array used perturbation and observation method for making voltage value at maximum point. Also, using DSTATCOM in the model 5.05% THD obtained and without DSTATCOM, 17.90% THD has been obtained. Total Harmonic Distortion (THD) is a measurement used to assess the quality of an electrical signal, typically in the context of AC (alternating current) power systems. It quantifies the presence of harmonic frequencies in relation to the fundamental frequency.

Keywords: DSTATCOM, MATLAB, Microgrid, Power Control.

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1. INTRODUCTION

The development of hybrid microgrids represents a significant advancement in energy system design, combining the strengths of renewable energy sources, energy storage systems, and conventional generators to create a reliable, flexible, and sustainable energy solution.

The idea of merging both AC Grid and DC microgrid systems is known as hybrid microgrid. Consequently, the hybrid microgrid benefits from both sources. A microgrid that is attached to both AC and DC sources is referred to as a hybrid microgrid. A hybrid microgrid's segment is further segmented into AC coupled and DC coupled hybrid microgrids. It depends on how the DC and AC buses at the source are set up, as well as how the DC and AC loads are linked. Different DG and energy storage devices are connected to the shared AC bus through the converters in the AC linked hybrid system. However, in a DC-coupled hybrid microgrid, a converter connects several DG and energy storage devices to a shared AC bus. Power will move from the AC Grid to the DC microgrid when the microgrid is overburdened.

The primary converter in this scenario will serve as a rectifier. the primary converter functions as an inverter, Whenever the DC microgrid generates more power than it needs, power is transferred from the DC microgrid to the AC grid. Delivering seamless electricity from the microgrid to the AC grid is the principal intertwined converter's job [19].

The DC-coupled hybrid microgrid provides a number of benefits, including a straightforward construction and the lack of synchronization. The voltage output synchronization of an IFC when power management calls for one is a significant difficulty. In a particular DC-coupled hybrid microgrid, the DG is linked directly to the DC bus without conversion.

The goal of the power management approach is to balance electricity between generation and demand by controlling the DC bus voltage. The two types of power management are islanding or standalone, grid-connected, with dispatched power from the grid, and dispatched power mode. Between the DC bus and the AC grid is where the IFC is attached. A bidirectional converter may be operated by the IFC in power control mode and DC bus voltage mode.

For internal coordination and reliable and secure exterior connections, the hybrid microgrid will require novel and creative control. As a result, utility companies must widely adopt hybrid microgrid technology, and customers must make comparable growth efforts. Important power management research will also be required. Without a revolution, managing the hybrid microgrid system's power and control will be torturous. Voltage regulation is the hybrid microgrid's main goal in order to provide reliable electrical energy distribution to loads. A microgrid bus is used to connect the various sources in parallel, which causes problems with power sharing and bus voltage management. The greatest answer to such issues is hierarchical control. There are several levels of control. It is more dependable to continue running the microgrid even if the centralized controller fails.

2. METHODOLOGY

A schematic of a variable speed wind system (WECS) is shown in Figure 1. Double feed induction generators (DFIG) have the stator phase windings connected directly to the grid, while the rotor phase windings are connected to a bidirectional power supply. converter via slip rings. The bidirectional power converter consists of two converters, ie a grid-side converter and a rotor-side converter, and a DC link capacitor placed between the two converters. The main purpose of the line side converter is to keep the intermediate circuit voltage variation low. Since grid-side converters and rotor-side converters can operate in bidirectional mode, the DFIG can operate in either sub-synchronous speed mode or super-synchronous speed mode. Here, the speed limit for DFIG is approximately ±30% of the synchronous speed [10]. In this work, the DFIG model with variable speed wind turbine was developed in Matlab/Simulink environment.

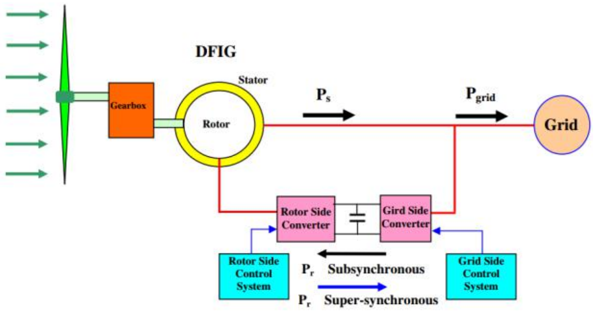

Figure 1. Schematic of the variable speed wind system (WECS)

The WRIM model expressed in a d-q reference frame rotating at synchronous speed is obtained by considering the position of the axis as shown in the figure. 4.3 is shown at an angle rotating synchronously to the D-axis. The rotor phase coil is σ ahead of the axis of the stator phase A coil. Let ωs be the synchronous speed with which d-q axis rotates.

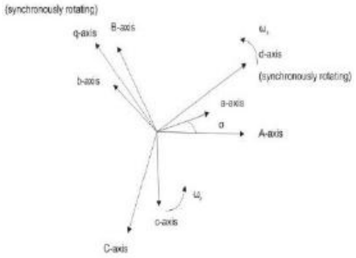

Figure 2. Schematic of axis transformation (ABC to dq)

The matrices are

$$Ms = \frac{2}{3}\begin{bmatrix} \cos(\sigma) & \cos(\sigma - 2\pi/3) & \cos(\sigma - 4\pi/3) \\ -\sin(\sigma) & -\sin(\sigma - 2\pi/3) & -\sin(\sigma - 4\pi/3) \\ 1/2 & 1/2 & 1/2 \end{bmatrix}$$

$$M_r = \frac{2}{3}\begin{bmatrix} \cos(\sigma_s - \sigma) & \cos((\sigma_s - \sigma) - 2\pi/3) & \cos((\sigma_s - \sigma) - 4\pi/3) \\ -\sin(\sigma_s - \sigma) & -\sin((\sigma_s - \sigma) - 2\pi/3) & -\sin((\sigma_s - \sigma) - 4\pi/3) \\ 1/2 & 1/2 & 1/2 \end{bmatrix}$$

Here the subscript ‘s’ denotes stator quantity and ‘r’ represents rotor quantity and all the rotor quantities are referred to the stator.

$$v_{ds} = r_s i_{ds} + \frac{d}{dt}\varphi_{ds} - \omega_s \varphi_{qs}$$

$$v_{qs} = r_s i_{qs} + \frac{d}{dt}\varphi_{qs} + \omega_s \varphi_{ds}$$

$$v_{dr} = r_r i_{dr} + \frac{d}{dt}\varphi_{dr} - (\omega_s - \omega_r)\varphi_{qr}$$

$$v_{qr} = r_r i_{qr} + \frac{d}{dt}\varphi_{qr} + (\omega_s - \omega_r)\varphi_{dr}$$

$$\varphi_{ds} = L_s i_{ds} + L_m i_{dr}$$

$$\varphi_{qs} = L_s i_{qs} + L_m i_{qr}$$

$$\varphi_{dr} = L_r i_{dr} + L_m i_{ds}$$

$$\varphi_{qr} = L_r i_{qr} + L_m i_{qs}$$

The dynamic model of induction machine in synchronous reference frame is shown in Figure 2.

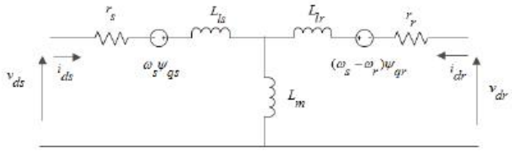

Figure 3. D-axis equivalent circuit of WRIM

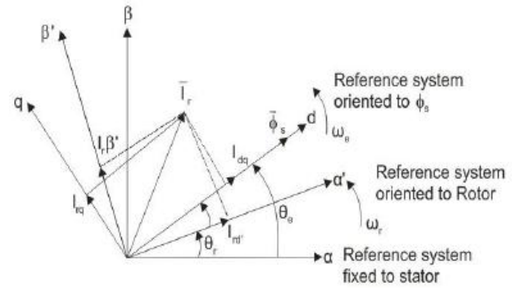

Figure 4. Reference system used in DFIG

From the above phasor diagram current relation can be written as:

$$\bar{I}_r = \bar{I}_{r\alpha} + \bar{I}_{r\beta}$$

$$\bar{I}_r = \bar{I}_{rq} + \bar{I}_{rd}$$

3. RESULTS AND DISCUSSION

A hybrid microgrid whose parameters are given in Table 4.1 is simulated using the MATLAB/SIMULINK environment. The operation is performed for network connected mode. The photovoltaic system performance of a double fed induction generator, with a hybrid microgrid, is analyzed. Solar radiation, cell temperature and wind speed are also taken into account for the study of hybrid microgrids.

The response to wind speed, three-phase stator voltage and three-phase rotor voltage are shown in Figures 5-6. Here, the value of wind speed varies between 1.0 and 1.05 pu, which is essential for the performance study of double-fed induction generator. The phase-to-phase stator voltage is set to 300 V, while the rotor voltage value is 150 V.

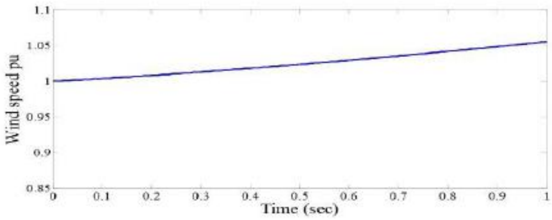

Figure 5. Response of wind speed

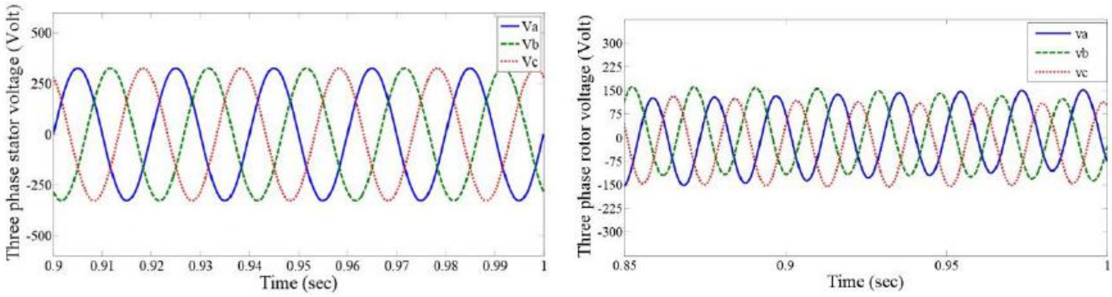

Figure 6. Three phase stator (left) and rotor voltage of DFIG (right)

The various characteristics of a hybrid microgrid are shown in Figure 7-8. Here the microgrid works in grid connected mode. In this mode, the mains converter operates in PQ mode and the power is balanced by the mains. Battery is fully charged. The mains maintain the AC bus voltage and the mains converter maintains the DC bus voltage.

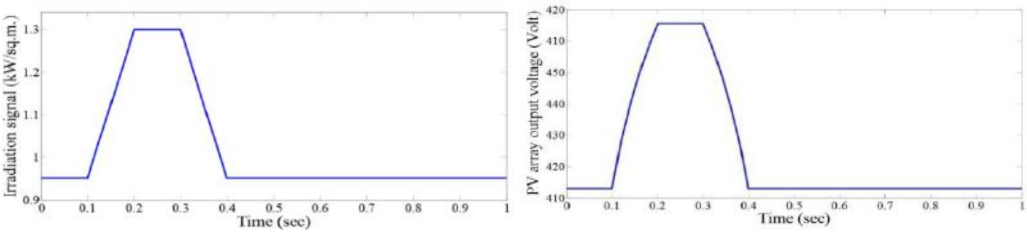

Figure 7. Irradiation signal of the PV (left) array and Output voltage of PV array (right)

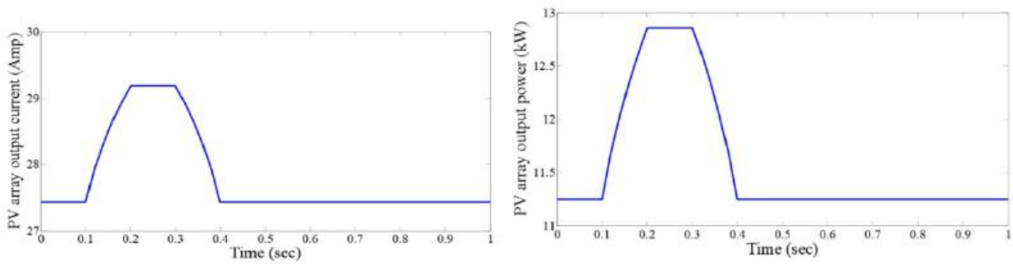

Figure 8. Output current (left) and power of PV array (right)

Figure 7 shows the solar irradiance level curve that is established at 950 W/m2 from 0.0 s to 0.1 s, linearly increases at 1300 W/m2 from 0.1 s to 0.2 s, remains constant at 0.3 s to 0.4 s decreases to 950 W/m2 and maintains that value for 1 s. Figures 9 and 10 mean the output voltage, current and power with respect to the solar radiation signal. The output power of the photovoltaic panels varies from 11.25 kW to 13 kW, which closely follows solar irradiance when the ambient temperature is constant.

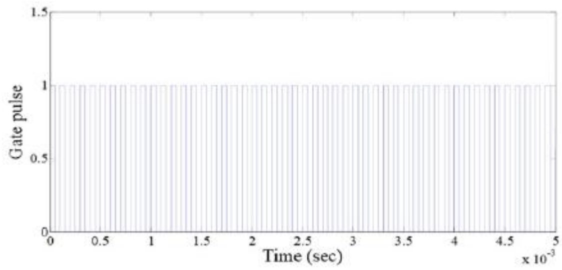

Figure 9. Generated PWM signal for the boost converter

4. CONCLUSION

Modeling of hybrid microgrid is done in MATLAB/SIMULINK environment for power system configuration. The present work mainly covers the network operation mode of hybrid network. Models have been developed for all converters to maintain a stable system under various load and source conditions, and the control mechanism has also been studied. MPPT algorithms are used to optimize power utilization from DC sources and to coordinate power exchange between DC and AC grids. Although hybrid networks can reduce the DC/AC and AC/DC conversion processes to a single AC or DC network, there are many practical problems for the implementation of hybrid networks based on current AC-dominated infrastructure. The efficiency of the overall system depends on the reduction of conversion losses and the addition of an additional intermediate circuit. Hybrid grids can supply consumers with reliable, high-quality and more efficient electricity. Hybrid networks may be viable for small isolated industrial installations with photovoltaic systems and wind turbines as the main source of energy. Additional simulation and monitoring is possible in transition mode based on the analysis performed in the job. The suggested hybrid microgrid can be scaled from multiple sources and energy storage devices such as supercapacitors and batteries can be used. Unit values can be used in place of actual values.

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