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Operation of Grid Connected PV-Battery-Wind Driven DFIG Based System

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Abstract: *The grid-connected system with an enhanced multi-functional control method for the grid-side converter (GSC) is presented in this study. It is powered by a PV-battery and a wind-driven doubly fed induction generator (DFIG). Both the DC-link voltage across the GSC and the reactive power into the grid are controlled by a three-stage improved reduced-order multiple integrator (ROMI) control. The grid side control raises the quality of the power under various abnormal circumstances. Additionally, it acts in a way that decreases the transients' rise time, maximum peak overshoot, and settling time. For the wind power generator (WPG), the rotor side converter (RSC) is employed to deliver the necessary amount of reactive power using field-oriented control. As a WPG, a DFIG is employed. A battery with a bidirectional converter and a single-stage PV array are connected to the GSC's common DC-link. In light load situations, the battery aids in maximizing wind power generation*

Keywords: Doubly-fed Induction Generator, PV-Battery, Wind Driven, Induction Generator

I. INTRODUCTION

Climate change, rising energy prices, and increasing energy demand are some of the world's issues in the twenty-first century. The addition of effective, dispersed, and renewable energy sources can help to alleviate this in part. But improving performance across the board in the production of renewable energy is frequently a significant problem. Regarding energy costs and generator durability, this has a direct or indirect effect on the sustainable development of the energy suppliers. In comparison to conventional systems, a generator's lifetime is substantially longer with higher performance and lower losses. Based on technical availability and control feasibility, the DFIG-derived wind energy generation device is a popular choice in the current worldwide setting, where practically all installed capacity will exceed 597 GW in 2019[1]. However, the effectiveness of the DFIG is still a question. Over the past two decades, related DFIG-based wind energy technologies have emerged.

Initially, sensor-less, grid connections were proposed for DFIG-centered wind energy conversion schemes [2]–[6]. [7] suggests a number of different schemes that will take into account an efficient optimization strategy to address micro-grid optimization problems with constraints. Power quality in the electric grid and the integration of wind energy using Stockwell's transform (ST) over various operational situations are discussed in [8]. Similar to the preceding phase, standalone DFIG off-grid systems have been recommended as described in [9]–[12] for the electrification of remote areas. It was discovered that the primary difficulties with these suggested techniques are generator performance and power supply intermission. Given efficiency and energy prices, these issues also need to be thoroughly explored for the development of sustainable wind power technology [13].Initiatives have been developed to control the device's effectiveness with regard to DFIG efficiency, as stated [14], [15]. However, a wide range of speeds cannot be used due to the low torque and magnetic saturation of both the high velocity and low velocity operational zones. [16] To get over the aforementioned speed restrictions, a double VSI-DFIG with a DC output and a rotor current-oriented stator frequency control method was proposed. The frequency of the stator is constant in this type of control with respect to efficiency. To improve the performance of DFIG dependent WEGS, efficient control models have been created in [17]–[19].

The DFIG-SPVS hybrid model's primary advantage is that it reduces the cost of traditional structures. The low-cost concept is extremely competitive in the renewable energy markets, especially in rural areas. A sensor-free maximum

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point tracking technique (MPPT) is suggested for both the PV source and the hybrid device in order to further reduce expenses. The main concept behind this method is to use output power to determine input power. The SPVS power can be calculated in operation using the grid side converter (GSC) and rotor side converter (RSC) power in accordance with the DC-link balance of the hybrid model.

II. STUDIED MODEL AND DESIGN COMPONENTS

This study examines the autonomous hybrid solar-wind system (AHSWS) model, which is illustrated in Figure 1 and uses a WES-DFIG and SPVS with a 3, 4-line battery energy storage supply grid. The output of the back-to-back DC-link converter is coupled with the DC-DC converter in this manner. The SPVS's inverter is then taken out. The overall cost of the equipment will be reduced as a result. The chopper converter used in this study is Buck-Boost (в-в), which operates with extreme stability, has a rapid response, and retains the maximum power generation from SPVS. The DC-link voltage receives the most power possible. RSC and GSC can then transform the DC electricity into AC power, which is subsequently given to the rotor or grid.

The simulation analysis looks at and goes into detail on the synchronization of these converters to control power flow. The hybrid model is given a sensor-less control system. By adopting this strategy, the cost of the hybrid model will be reduced by reducing the number of SPVS sensors.

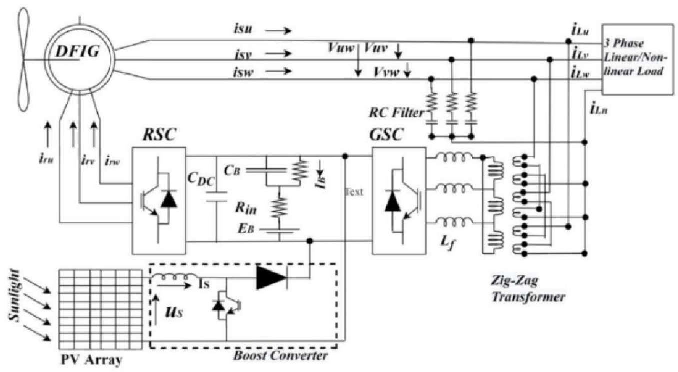


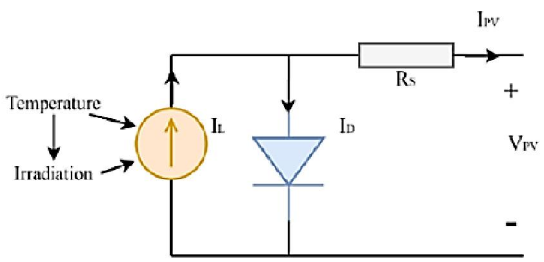
Figure1. Representation of the autonomous hybrid solar-wind system (AHSWS) with a battery energy system.

The AHSWS was created for a distributed generating system that required a maximum load of 4 KW and a mean load of 2 KW for a select number of houses. The solar and wind system blocks are considered to have a 19% capacity utilization factor. It is generally accepted that solar panels and wind turbines have a maximum rated capacity of 4KW. The RSC and the GSC, which are attached back-to-back at the DC end as depicted in Figure 1, are the two voltage converters that make up the whole system. The load ports and the rotor windings, respectively, are where the RSC and GSC AC ends are connected. To get the wind MPPT, RSC controls the speed of the wind turbine. The DC-DC boost converter, which provides the DC bus with solar power, is likewise set up using thesolar MPPT.

III. DFIG AND SPVS MODELING

This section deals with the mathematical equations DFIG and SPVS. These models are crucial for assessing the controlling tactics and DFIG and SPVS functionalities.

3.1 SPVS Model



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An identical SPV module circuit is presented in Figure 2. This module is involved in the diode and Current source connected to parallel. The output resistor and the diode primarily evaluate the SPV module Characteristics.

3.2 DFIG model

In several research studies, DFIG-WTs are suggested and established. The DFIG model and implementation are described in detail. This research article discusses only basic work-related equations. The relation between the stator flux and current the occurs in the stator-flux comparison framework is,

$$i_{ds} * L_s + i_{dr} * L_m = \psi_s \quad (2)$$

$$i_{qs} * L_s + i_{qr} * L_m = 0 \quad (3)$$

IV: CONTROL ALGORITHM

As shown in Figure 1, an oriented vector control strategy was used to manage the autonomous hybrid solar-wind system. This control strategy is dedicated to the back-to-back converter, which can be divided into an RSC and GSC. In order to maintain the steady-state voltage of the DC bus and to modify the reactive power on the grid side, the grid-voltage-oriented vector regulation must be used to control the GSC. A stable DFIG function is also provided by the stator-voltage-oriented control scheme to control the RSC at the stator edge for reactive and active power management [24], [25].

Grid side converter control

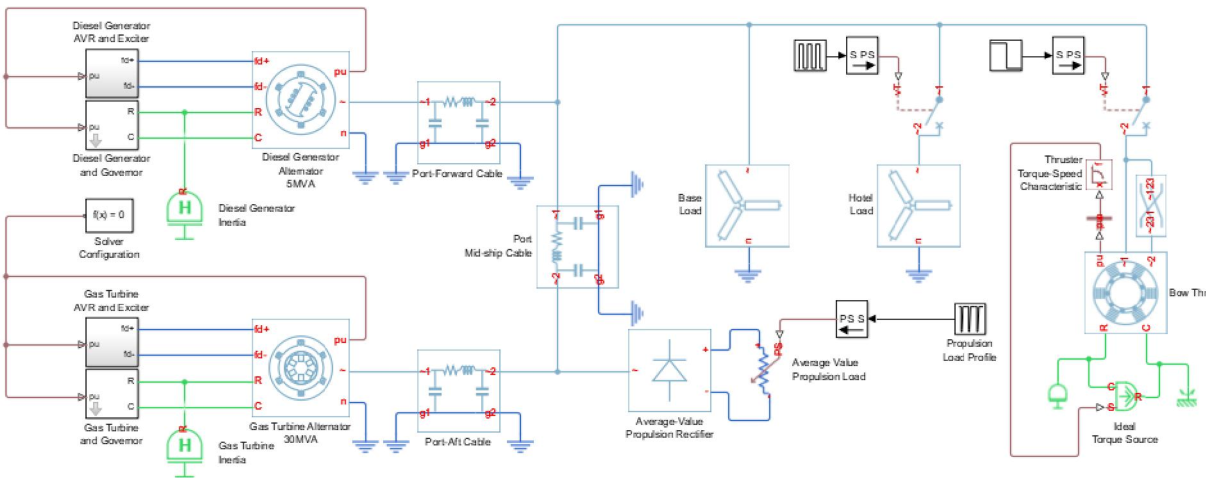
The two main goals of the GSC are satisfied by the vector control strategy used. Manage the DC bus voltage first, then the reactive power that is switched back and forth between the rotor and grid side. As a result, by connecting the grid voltage vector to the synchronous direct axis frame, its indirect axis element becomes zero.

Rotor side converter control

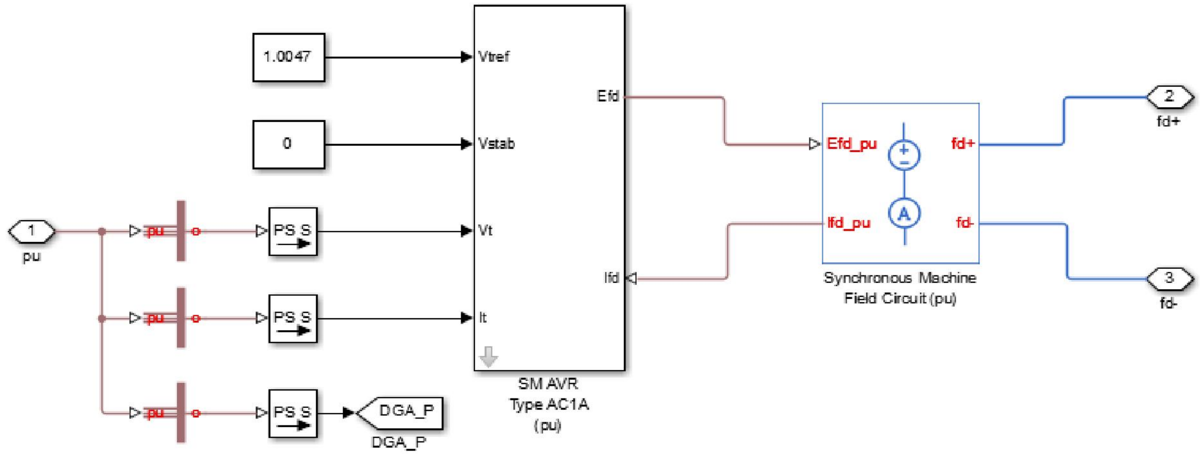
In grid-connected, DFIG-centered WECS, the RSC is crucial for controlling the DFIG in order to gather the wind turbine's best available and nominal mechanical power and maintain the stator's unit power factor. The magnetic flux of the stator is considered to be constant and is enforced by the grid by disregarding the stator's resistance and taking into account a balanced grid voltage. The stator voltage vector is perpendicular to the direct axis.

V: MATLAB SIMULATION & RESULTS

5.1 MODEL AND SIMULATION RESULTS FOR WIND DRIVEN BASED ON DFIG:



5.2 MODEL AND SIMLATION RESULTS FOR PV BATTERY OR GENERATOR



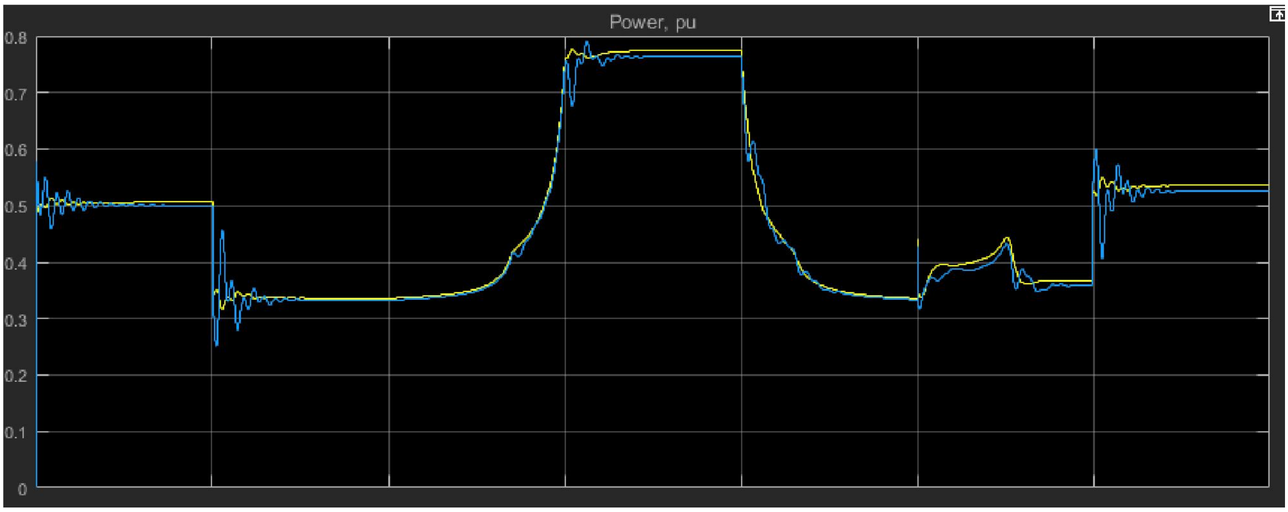


Figure 3: Grid Connected Power Supply

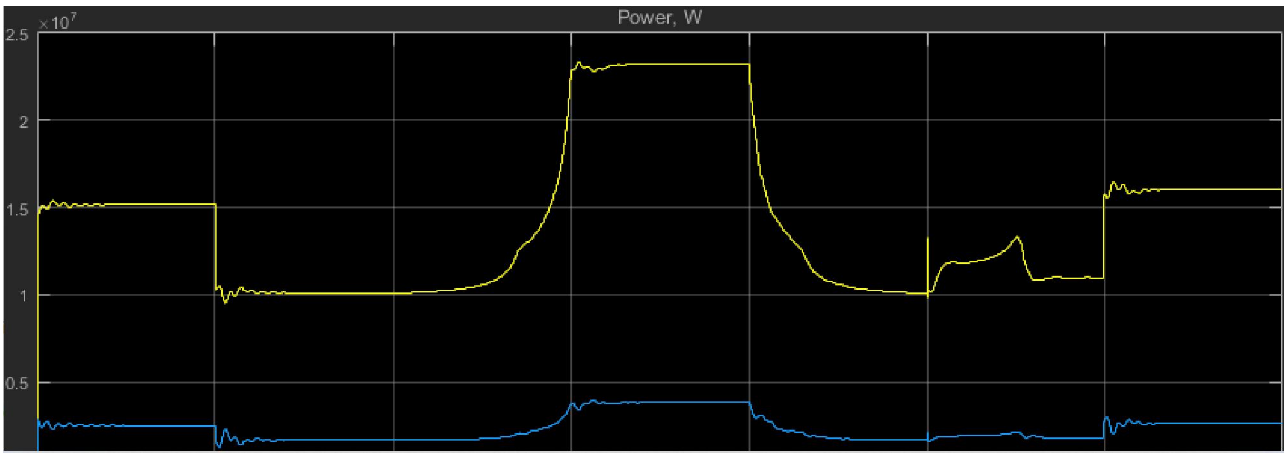


Figure 4. Wind Driven

VI: CONCLUSION

This paper describes the architecture and control of an autonomous hybrid solar-wind system (AHSWS) powered distributed generation system supplying to a 3ϕ-4 wire system. It includes a nonlinear controlling technique for maximum power point tracking (MPPT) used in doubly fed induction generator dependent wind energy translation scheme and solar photovoltaic system (SPVS). In the hybrid model, the DC/DC converter output from the PV system is explicitly coupled with the DC-link of DFIG's back-to-back converter. An arithmetical model of the device is developed, derived using a suitable d-q reference frame. The grid-voltage-oriented vector regulation is required to manage the GSC to keep the steady-state voltage of the DC bus and to adjust reactive power on the grid side.

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BIOGRAPHY

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