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ANN BASED SOLAR AND WIND CONNECTED GRID DRIVEN BY DFIG

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ABSTRACT:
This paper describes the architecture and control of an autonomous hybrid solar-wind system 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. Also, the stator-voltage oriented control scheme offers a stable function of DFIG to regulate the RSC on the stator edge for reactive and active power management in this approach. DC/DC converter is being used to maintain the maximum power from SPVS. A Perturb & Observe method is used for tracing maximum power in an SPVS. Simulated and test results show the performance of the developed system in different dynamic conditions, such as load unbalancing, changes in PV insolation and change in speed from the cut-in to cut-out speeds of the wind turbine. Moreover, these results show the battery behavior during different dynamic conditions.

Keywords: DFIG, GSC, RSC, SPVS, DC/DC, MPPT.

INTRODUCTION

A Hybrid Wind-PV system (HWPVS) is a large-scale integrated system that combines two or more renewable energy sources with energy storage devices such as a battery bank, flywheel, supercapacitors, or a fuel cell. HWPVS is becoming more and more popular for power generation applications with the advancement of renewable energy technologies. These systems are attractive because multiple sources can complement each other to provide more reliable electricity to the consumer than a single-source system. To ensure optimization of power supply conditions for local loads, WECS and PV systems must be compatible with auxiliary energy storage systems [1] [2]. Based on the foregoing, solar and wind energy are among the most reliable sources of renewable energy at present, as wind energy provides a lot of energy for most countries. The global wind

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energy market was expected to grow even more in 2019, and indeed this has been done with the total installed capacity reaching 597 GW [3] [4]. But due to their intermittent nature, systems based on wind and solar energy are unreliable without the use of energy storage technologies. Since wind and solar energy are complementary to each other, combining both improves the reliability of the energy source[5]. The literature on the wind-solar hybrid system has been widely discussed and varied. For wind turbines, this interpretation often depends on the options available number of blades, the direction of rotation, the rotor speed is variable or constant, direct generator or gearbox, induction or synchronous generator. Because wind speeds occasionally exceed the rated wind speed, the effective power is typically regulated by the standard stall concept: when the wind speed exceeds the rated wind speed, the power factor restrictions change, but the energy produced by the turbine remains constant.

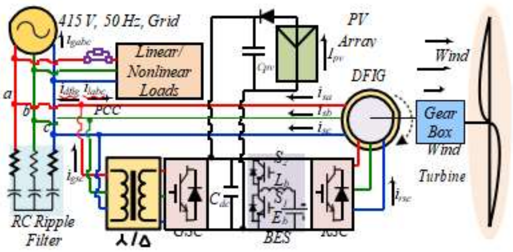

Fig.1. Proposed block diagram.

Two variants of this model, variable pole squirrel cage induction generators (SCIG) and a variable speed limited wound rotor induction generators design, have been used to overcome some of those problems. When wind speeds exceed the rated wind speeds, pitch modulation limits the power output of variable speed wind turbine (WT) with brushless generators, motors, and inverters to rated power. Regardless, fully-rated transformers have higher losses and are significantly more expensive than partial-rated transformers such as DFIG. However, in the case of PMSGs and SCIGs, numerous approaches are utilized controller parameters and increase efficiency, this system is available in a range of configurations for both PMSGs and SCIG [6] [7]. In [8] [9] described a novel self-configuring control technique for increasing the efficiency of grid-connected DFIG-based wind turbines while maintaining low computational complexity. As a result of this enhancement, he built an ideal control system based on the LinearQuadratic Controller, which consists of two similar and inexpensive frequency converters. Additionally, the author proposed a detailed approach that makes use of the innovative Grey Wolf Optimizer and Hybrid Cuckoo Search techniques. The objective was to determine the optimal variables for the PI controllers in the PMSG wind turbine. The technique of Least Mean Square Root Exponential which was naturally normalized using the negative absolute error exponent specified, is based on the negative square root of the absolute error function, this method is selfcontained. This strategy was employed in the research to maintain control and to obtain more consistent outcomes and performance.

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II RELATED STUDY

In [1], an ideal scheme for fuzzy logic strategy has been presented and studied to reduce the overall integrated error. Maximum wind energy extraction is optimized and faults are minimized for grid-connected WT. At present, DFIG with adjustable speed WT and power ratings exceeding 1.5 MW is currently the most often utilized machine for commercialized wind power generation [2]. Additionally, to a low-cost DFIG standard and a partially rated converter feeding the rotor winding, DFIG is defined by a multi-stage drivetrain. Besides that, pitch adjustment maintains rated power output when wind speeds exceed rated speeds [3]. The characteristic of DFIG is that the converted power rate is approximately 25% to 30% of the rated power, this rate is sufficient to produce the rated active power as the speed ratio can be maintained at an appropriate level in most of the operating times [4]. When compared with the constant speed system, it is found that DFIG provides a more stable match with mechanical loads, the power quality is better; the audible noise is lower, improving the wind system's efficiency. In some literature, as will be explained, the PV system's output is connected to the DFIG to achieve a hybrid DFIG system for an autonomous application [5]. This hybrid technology is described by a few researchers, but it was not enough to explain the advantages of this system and whether the performance has been improved or not. The strategy defined in [6] is based on a relatively complex control method that makes use of machine parameters and a large number of PI controllers. In [8], an estimation system was proposed in RSC, and an efficient technique was used to track the maximum power of PV. In [10], the authors explained a hybrid autonomous wind-solar system, which is a four-wire distribution network consisting of WECS-DFIG and PV with battery energy storage technology. The control technique is to estimate the position of the rotor along with determining its speed and current, using indirect vector control algorithms. All of the previously investigated various control strategies based on DFIG with or without storage systems for a standalone system. The authors in [11] used PMSG and BESS which were connected to the DFIG rotor via a back-to-back converter. While PMSM is controlled and designed to maintain constant current link voltage under different mechanical speed conditions, battery power management technology was used to mitigate wind power fluctuations. To regulate the active power for the autonomous operation of a DFIG-based wind turbine, a hybrid storage system composed of a battery and a super capacitor is used. The super capacitor is connected to DFIG's back-to-back DC connection via a bidirectional buck converter, and the battery storage system is connected to the load side of the system to satisfy the constant component of the demand generation mismatch as well as to avoid deeper discharge. We proposed a method for compensating for the wind turbine's inertia weakness by coordinating control between the DFIG and the energy storage system, which can provide frequency support. In this context, a study was published to examine the feasibility of using a BESS to provide an inertial response in a system with significant wind energy penetration. To improve the frequency regulation capacity of a DFIG-and-energystorage system, a coordinated Fuzzy-based control method is used. The frequency fluctuation is determined by FLC, and the frequency support is coordinated with the storage system connected to the wind farms at the point of common coupling. A control of DFIG based on MPPT was explained under the usual conditions to keep improving the wind system's efficiency by adding a control loop to the RSC. A coordinated strategy for a DFIG integrated with BESS to provide frequency management was presented regarding the control of microgrids with a high wind energy penetration. A system based on DFIG with a PV system is created to overcome the drawback of individual PV and wind energy sources. MPPT technique, DC-link voltage control, active and reactive power, and grid voltage support control are all implemented using the integrated control for GSC and RSC. A microgrid based on DFIG and a PV array interfaced to the grid is presented, The (RSC) control is meant to achieve MPPT from the wind as well as unity power factor at the DFIG stator terminals. This improves MPPT from both wind and solar energy sources while maintaining grid power flow regulation. Despite some literature has achieved regulated power flow in the grid according to previous references. However, many of them rely on conventional control methods, which reduces efficiency and makes the response to changing wind speed slow compared with intelligent control. On the other hand, studies that depend on energy storage systems are charged at speeds higher than the specified speed only. The proposed system is characterized by the fact that the batteries are charged using PV rather than wind. As a result, the active power delivered to the grid is maximized at low wind speeds by the proposed PV-BESS system.

III WORKING METHODOLOGY

The fundamental benefit of the DFIG-SPVS hybrid model is to minimize the price of conventional structures. The low-cost model in renewable energy markets, particularly in rural areas, is quite competitive. To further minimize costs, a sensor-less maximum point tracking technique (MPPT) for both the PV source and hybrid device is proposed. The key idea of this technique is to utilizing output power to calculate input power. The grid side converter (GSC) and rotor side converter (RSC) power can be used in operation to calculate the SPVS power according to the DC-link balance of the hybrid model. The following sections describe a detailed estimate algorithm. Such a sensor-less MPPT technique has been implemented and effectively implemented to an autonomous PV device in our previous work. This strategy will reduce the costs in comparison with the hybrid model using a conventional MPPT model. The price of the hybrid model is substantially cheaper with the use of less power electronic converters and less appropriate sensors. In the low voltage ride-through sources must be enhanced to compensate for the changing voltage within the grid during a fault. MATLAB/Simulink is used to develop and evaluate the complete system. This article introduces an autonomous hybrid solar-wind system (AHSWS) system utilizing a WES-DFIG and SPVS with 3ϕ, 4-line battery energy storage supply grid. The sensor-less MPPT hybrid model can execute well with changes in atmospheric circumstances and control conditions, as can be seen with simulation results. Three converters can work smoothly and in collaboration, while the DFIG mode of operation differs both in above and below rated synchronous speed. Also, the back-to-back converter manages the SPVS DC power and maintains the DC-link balanced even without an inverter. Finally, it is concluded that in all sorts of operating circumstances the complete module can provide rated voltage and frequency, maintaining DFIG current stable and the integrated sensor-less device can be an effective and reliable solution for different SPVS and DFIG setups. The key objective of this article is demonstrating

• To design an autonomous hybrid solar-wind system (AHSWS) system utilizing a WES-DFIG and SPVS with 3ϕ, 4-line battery energy storage supply grid

• To implementation of a sensor-less wind Speed control scheme dependent on Adaptive Backstepping.

• To achieve optimum efficiency under various mechanical, electrical circumstances.

OPERATION:

PV-battery with wind driven DFIG based 22 kW system is simulated in this work, where, the generated renewable power meets the load demand and extra power is fed to the grid. Moreover, the ROMI control takes care of the power quality issues and system stability. It also improves the overall system stability.

Performance of Wind Turbine at Various Wind Speeds

The dynamic behavior of the wind turbine along with the stator currents (isabc), rotor currents (irabc), grid voltages (vgabc), grid currents (igabc) and load currents (ilabc), where the wind speed is changed from 12 m/s to 7.5 m/s within the MPPT speed zone. Correspondingly, the rotor speed (ωr) is reduced from 204 rad/sec to 127.6 rad/s, additionally the power coefficient (Cp) and tip speed ratio (λ) are changed with the wind speed. The variation of the wind speed changes the stator currents (isabc), rotor currents (irabc) and grid currents (igabc).

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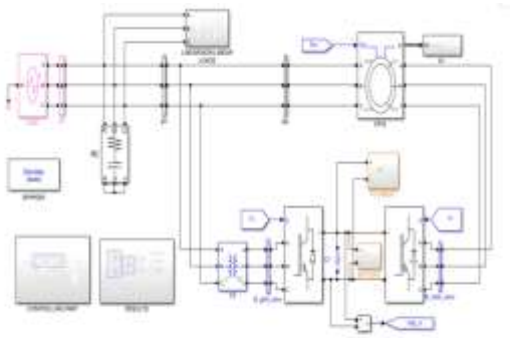
Simulation results without extension:



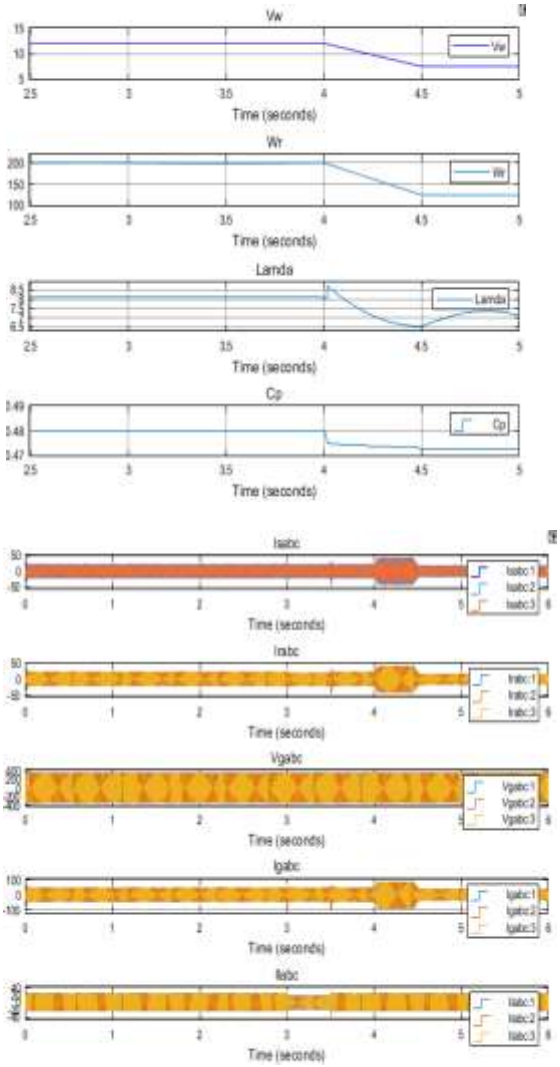


Fig.2. Simulated results of wind turbine at change in speed.

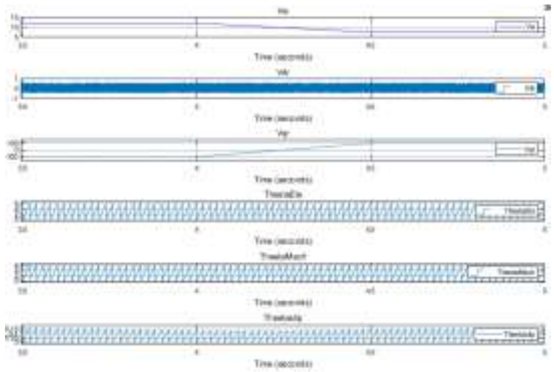


Fig.3. Internal signals of RSC control under change in speed.

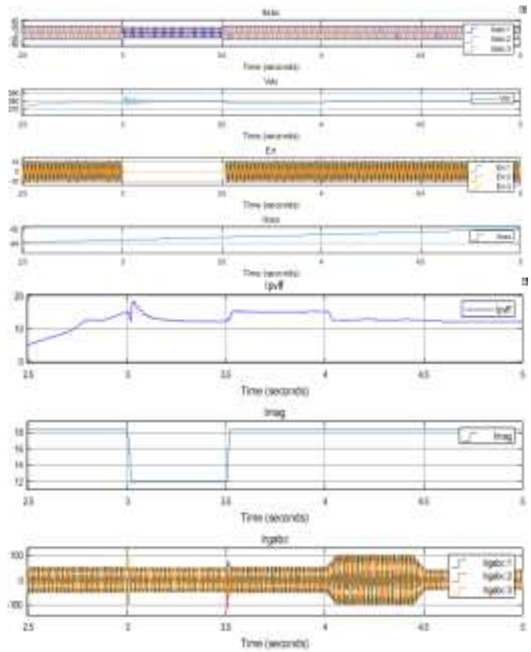
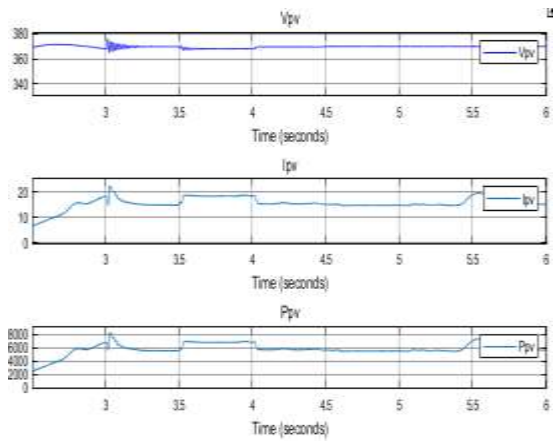


Fig.4. Internal signals of GSC control under speed change.



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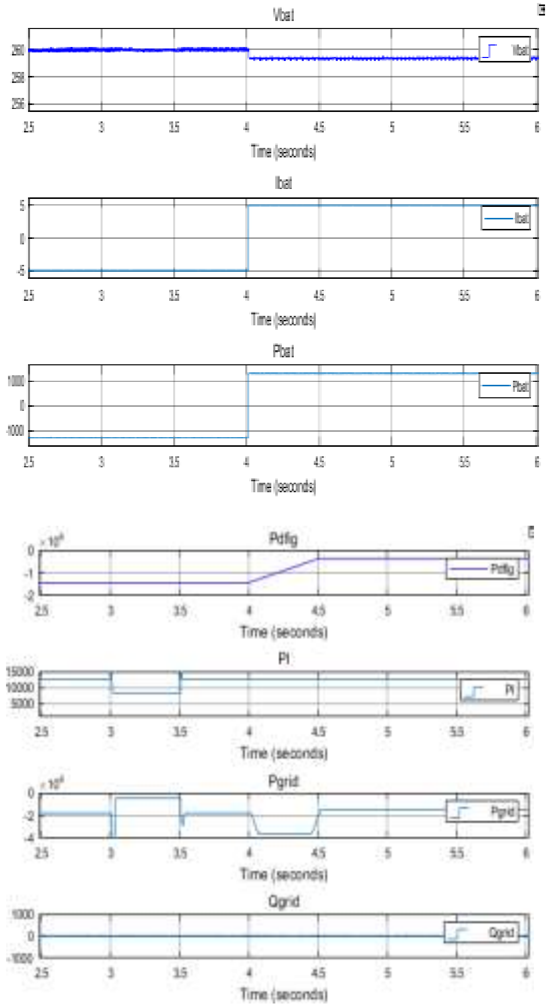

Fig.5. Discharging and charging battery cycle with PV, DFIG and grid power.

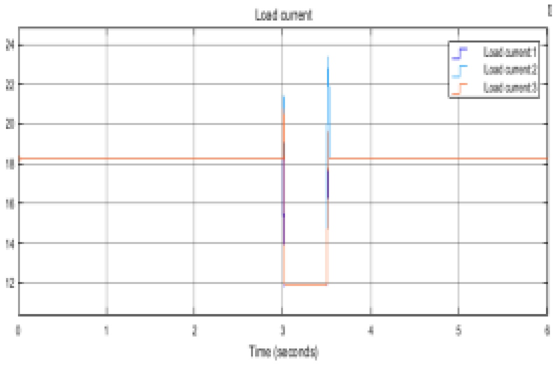

Fig.6. Comparison study of ROMI control with conventional and others advance controls.

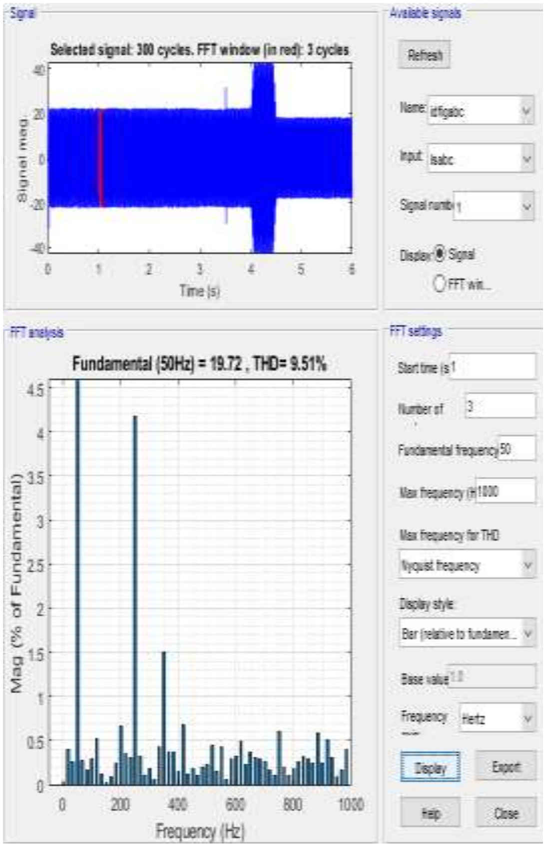

Fig.7. Harmonic spectrum of DFIG stator current (is).

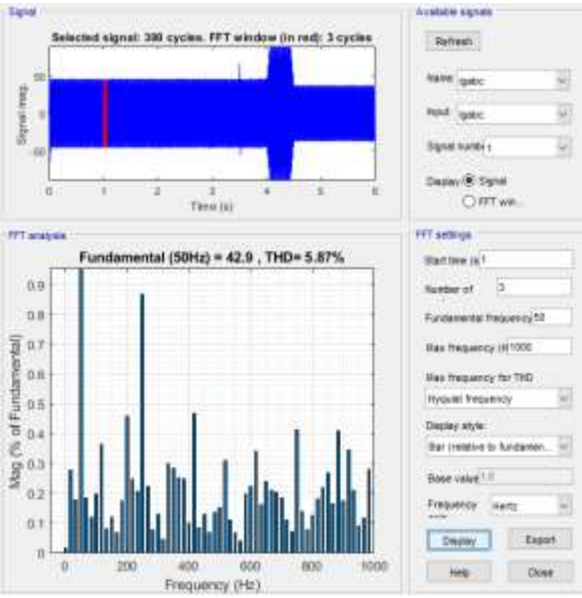

Fig.8. Harmonic spectrum of grid current (iga).

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Simulation results with Ann controller extension:

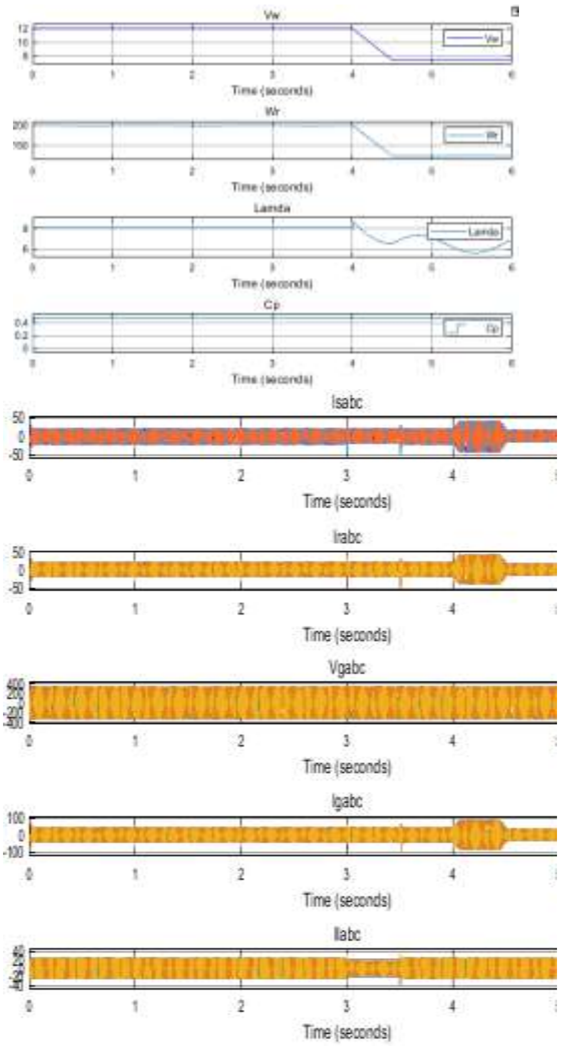


Fig. 8. Simulated results of wind turbine at change in speed.

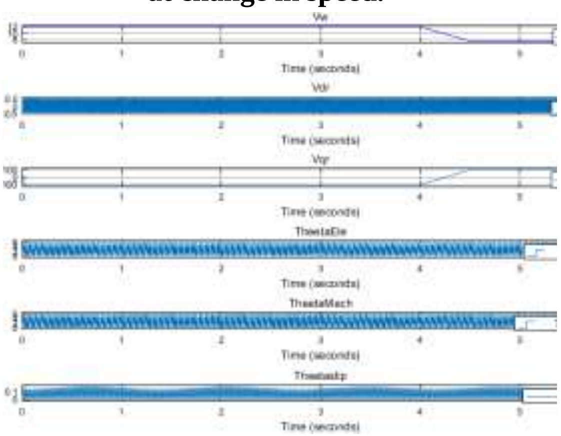


Fig.9. Internal signals of RSC control under change in speed.

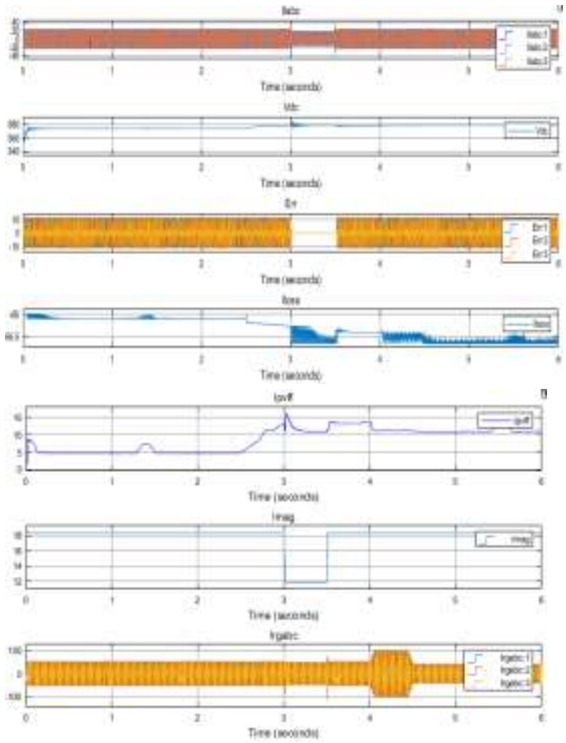
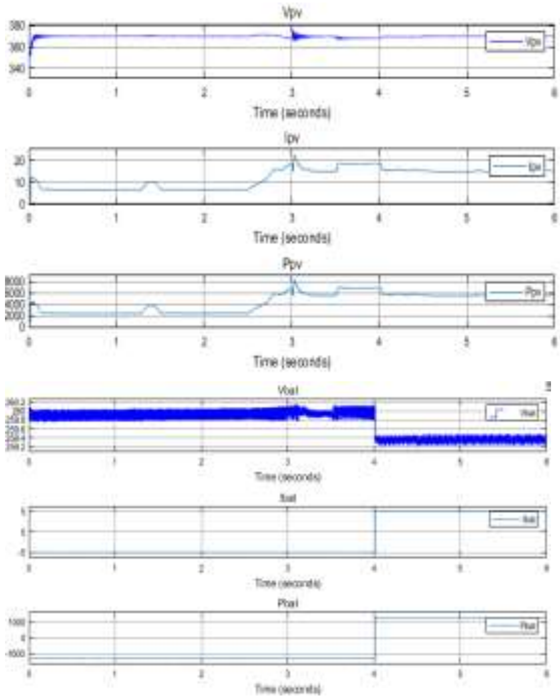


Fig.10. Internal signals of GSC control under speed change.



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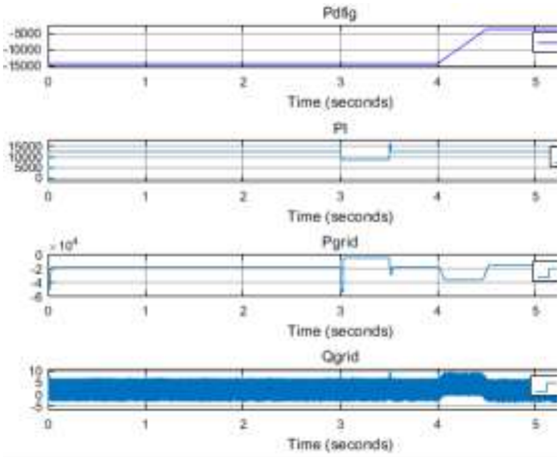

Fig.11. Discharging and charging battery cycle with PV, DFIG and grid power.

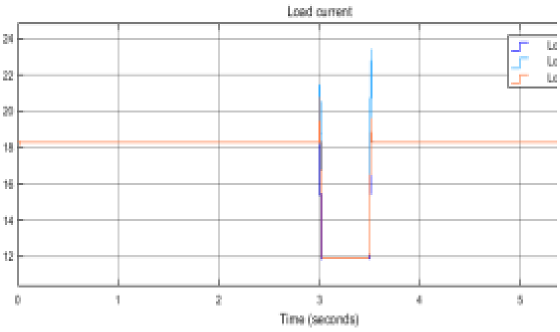

Fig.12. Comparison study of ROMI control with conventional and others advance controls.

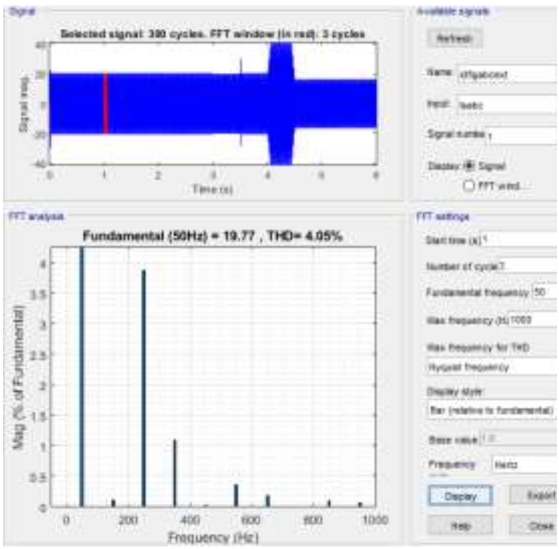

Fig.13. Harmonic spectrum of DFIG stator current (is).

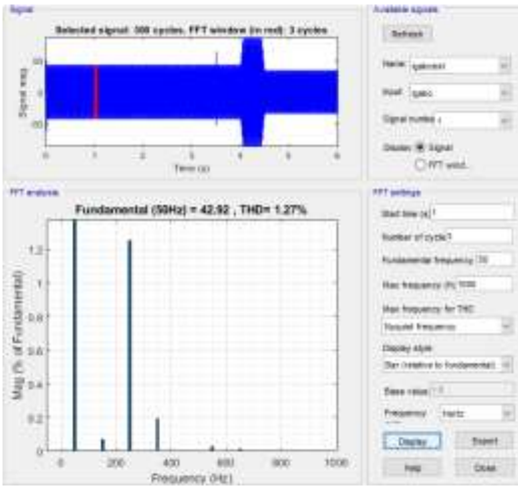

Fig.14. Harmonic spectrum of grid current (iga).

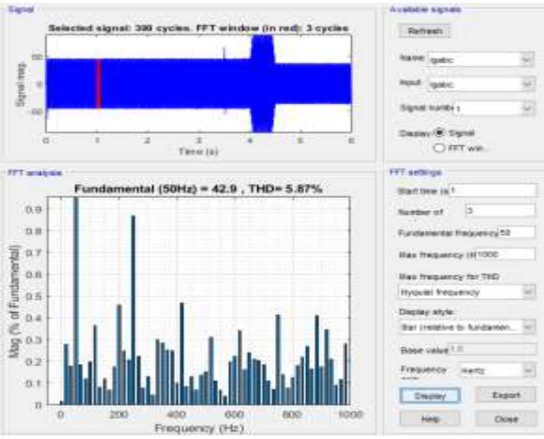

Fig.15. Harmonic spectrum of grid current (iga).

Results in table:

Tabular column: STATOR AND GRID CURRENT THD(Threshold Harmonic Distortion)

Control	Rating	Stator current (isa) A	Stator current THD (%)	Grid current (iga) A	Grid current THD (%)
Without NN controller	5.5kw	2.40	9.51	2.75	5.87
With NN controller	5.5kw	2.26	4.05	2.59	1.27

CONCLUSION

In this work, a PV-battery with wind driven DFIG based grid connected system with three-stage reduced-order multiple GSC control algorithm has been implemented. The maximum wind power has been extracted by TSR algorithm. The maximum PV power has been extracted by INC algorithm. The RSC has been used for meeting the reactive power demand by the DFIG. Moreover, it has been used for maximum wind power extraction. In light load condition, the battery has been used for maximum wind power extraction, which increases battery charging current. Moreover, the charging and discharging of the battery have been determined by the wind power generation. Simulated results have shown the performance of the turbine at different wind speeds. It also shows internal signals of GSC, RSC and power delivered to the grid and at different solar insolation as well as in different wind speeds. Moreover, the comparison among ROMI control with others advanced and conventional controls has been shown. The ROMI control has given better performance in dynamic conditions.

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