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A New Topology for Hybrid Wind-Solar Generation System for Isolated Loads

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Abstract: ***Wind energy is going to be a significant part of electric energy generation in the very near future. However, in addition to its intermittent nature that could lead to major difficulties for power system reliability and stability, the conventional control applied to wind turbines and their generators, usually doubly-fed induction generators (DFIGs), does not allow them to participate in frequency regulation, whether short or long term. Moreover, the use of wind generators for autonomous frequency regulation is becoming an essential objective in power grids with reduced inertia and isolated micro grid operation. This system paves way for effective hybrid power systems.***

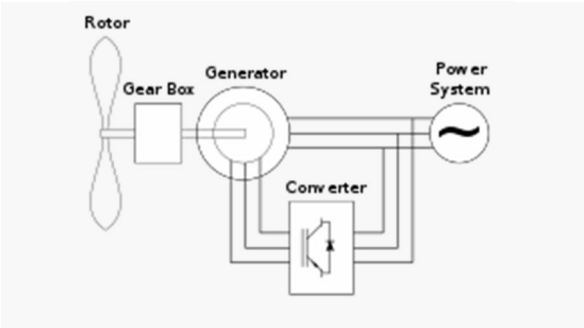
Keywords: Wind energy, reliability, wind turbines, doubly-fed, induction generators.

I. INTRODUCTION

The penetration of renewable energy sources has been increasing steadily in the power system. In particular, wind energy installations have grown rapidly with global installed capacity increasing .Amongst the many technologies that exist for wind energy conversion systems (WECS), doubly fed induction generators (DFIG) have been prevalent due to variable speed operation, high power density and lower cost . DFIG based WECS consist of an induction generator whose stator is directly connected to the grid while its rotor is connected via back to back converters known as the rotor side converter (RSC) and grid side converter (GSC), respectively. The generator is normally operated at a range and is connected to the transmission network (11– 33 kV) through a transformer that acts as an integral part of the WECS to interface the wind turbine and the grid.

Over the last decade, the penetration of renewable energy sources has been increasing steadily in the power system. In particular, photovoltaic installations have grown rapidly with global installed capacity increasing from 47.6 GW in 2004 to 369.6 GW. Amongst the many technologies that exist for photovoltaic systems (WECS), doubly fed induction generators (DFIG) have been prevalent due to variable speed operation, high power density and lower cost. DFIG based WECS consist of an induction generator whose stator is directly connected to the grid while its rotor is connected via back to back converters known as the rotor side converter (RSC) and grid side converter (GSC), The generator is normally operated at a range of

500 V-700V and is connected to the transmission network (11-33 kV) through a transformer that acts as an integral part of the WECS to interface the photovoltaic and the grid. DFIG for Double Fed Induction Generator, a generating principle widely used in wind turbines. It is based on an induction generator with a multiphase wound rotor and a multiphase slip ring assembly with brushes for access to the rotor windings. It is possible to avoid the multiphase slip ring assembly (see brushless doubly-fed electric machines), but there are problems with efficiency, cost and size. A better alternative is a brushless wound-rotor doubly-fed electric machine.



A. DFIG for wind Generation, Solar PV Generation System

This scheme uses Doubly fed induction generator for wind generation, which enables power generation at a constant frequency around + 30% of synchronous speed. Rotor power is being extracted, converted into DC and supplied to DC micro grid. When total power generated from solar and wind exceeds the power demand, it is stored in the super capacitor, which is used later in case of solar and wind success. Power converters are being used in slip power. In this scheme, super capacitor is comparatively efficient than existing battery but the main advantage is that the super capacitor is directly connected to the DC link, there is a proper control for its charging and discharging. The rest of the paper is organized as follows. Section II presents background and related works. In Section III, we motivate our system methodology and a description of our proposed block diagram is provided. Conclusion is summarized in Section VI.

B. Advantages

Super capacitors are ideal for providing active power support for events on the distribution grid which require active power support in the *seconds* to *minutes* time scale like voltage sags/swells, active/reactive power support, and renewable intermittency smoothing.

II. BACKGROUND AND RELATED WORKS

A doubly fed induction generator (DFIG) designed to be driven at variable speed from a wind turbine and supplying an isolated load is presented. Two back-to-back PWM voltage-fed inverters connected between the stator and the rotor allow sub- and super-synchronous operation with low distortion currents. The load voltage is maintained at constant frequency and its magnitude is regulated through control of the stator flux of the generator. An auxiliary load is connected in parallel with the main load, and the auxiliary power is controlled to allow the

DFIG to track the optimal wind turbine speed for maximum energy capture from the wind. An indirect stator-orientated vector control scheme is used to control the DFIG and this results in constant load voltage and frequency for variations in both load and wind speed. The techniques have been implemented and validated on a 7.5 kW experimental rig. The rapid diminishing rate of gas and oil is alarming us to think about alternative sources. Renewable energy is a better solution to this problem and technologies of extracting energy from renewable energy sources are being upgraded day by day. Our target was to find out the optimum renewable energy source giving best possible power generation. In our research we analyzed the feasibility of power generation using wind and solar energy. For wind property analysis we have used Window grapher and for cost analysis we have used Homer. The aim of the study was to analyze the solar and wind characteristics and selecting a suitable location where both solar and wind energy are strong enough for hybrid power generation and choosing suitable PV module and wind turbine for this purpose. We analyzed the beneficiary impact of this hybrid power extraction strategy on our environment and national economy and found that this new technique adaptation can really be useful in off shore islands and high rise buildings of our country.

In existing system, DC bus is powered through both solar and wind power generation, which is conditioned through a power conditioner to feed the DC bus. The battery acts as an energy storage unit and it is charged when generation is more than the load requirement. In case generation is less battery supplies the excess load requirement. A dual active bridge is used here to control exchange of power between the DC link and the battery.

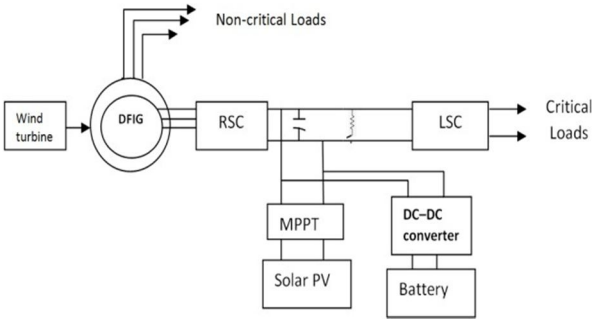


Fig :1 Problem Statement

A. Since we are supplying only critical loads from rotor side, which would be a comparatively small fraction of total load, therefore load demand (watts) is reduced.

B. Since critical load can be supplied from wind energy as well as solar energy, therefore runtime for battery backup will be lesser.

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III. SYSTEM METHODOLOGY

Here, presents a droop control method to incorporate wind generation in autonomous frequency/power regulation in isolated microgrids, and in weak power grids with reduced inertia. Droop control is implemented on both torque and power by some simple modifications in the conventional DFIG-based wind power controller. Small-signal modeling and eigen- values analyses are employed to distinguish the differences among both methods and gauge their impacts on frequency stability.

A. Rotor Side Converter (RSC)

The main objective of Rotor side converter is to supply Non-critical Loads on stator side at a desired constant frequency. RSC is controlled using vector control in a synchronously rotating reference frame oriented along stator flux. Stator flux orientation requires flux angle information, which cannot be derived by integrating stator voltages due to the presence of measurement noise and harmonics in a standalone system.

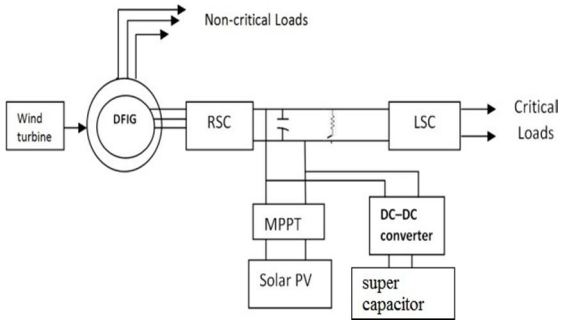

Fig: 2 Load Side Converter (LSC)

It is used only to convert constant DC voltage available at DC link to AC voltage at required frequency for critical loads. There will be no special control scheme for it resulting in reduced complexity of control circuitry.

B. MPPT Control of PV System

A PV array has non-linear i-v and p-v characteristics. From it can be seen that PV array generates the maximum power at a particular operating point which dynamically varies with environmental condition such as temperature, irradiance etc. So a dynamic tracking technique is important to ensure that maximum power is always obtained from the photovoltaic arrays and this technique of extracting maximum power at all operating condition is known as maximum power point tracking algorithm.

Bi-directional DC to DC converter Proposed topology requires an exchange of power from the super capacitor to the DC link and vice versa. DC bus is powered through both solar and wind power generation, which is conditioned through a power conditioner to feed the DC bus. The solar capacitor acts as an energy storage unit and it is charged when generation is more than the load requirement. In case generation is less supplies the excess load requirement. A dual active bridge is used here to control exchange of power between the DC link and the super capacitor.

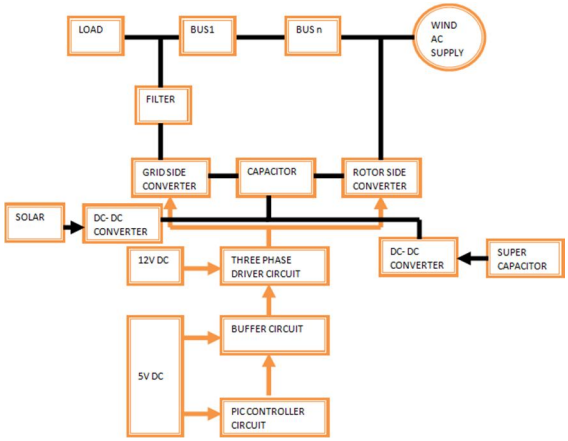

Fig :3

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C. OPTO Coupler

An opto-isolator (also called an optocoupler, photocoupler, or optical isolator) is an electronic component that transfers electrical signals between two isolated circuits by using light. Opto- isolators prevent high voltages from affecting the system receiving the signal. Commercially available opto- isolators withstand input-to-output voltages up to 10 kV and voltage transients with speeds up to 25 kV/μs.

D. Buffer Circuit

A voltage buffer amplifier is used to transfer a voltage from a first circuit, having a high output impedance level, to a second circuit with a low input impedance level. The interposed buffer amplifier prevents the second circuit from loading the first circuit unacceptably and interfering with its desired operation.

IV. CONCLUSION

In this paper, a new topology has been suggested for wind-solar hybrid power generation for isolated loads, which uses DFIG as wind electric generator. Isolated loads are divided into two parts: Noncritical loads are supplied from stator of DFIG at constant frequency and critical loads are connected in the rotor circuit after back to back connected PWM converters, and can be supplied either from wind, solar or super capacitor. Availability of three alternative power supplies for critical load resulted in. To realize effective control of super capacitor charging and discharging, Dual active bridge has been used as DC-DC converter; this also helped in maintaining DC link voltage as constant. DFIG operation has been controlled using RSC in the rotor circuit. Vector control approach in a synchronously rotating reference frame, oriented along stator flux, has been applied to RSC.

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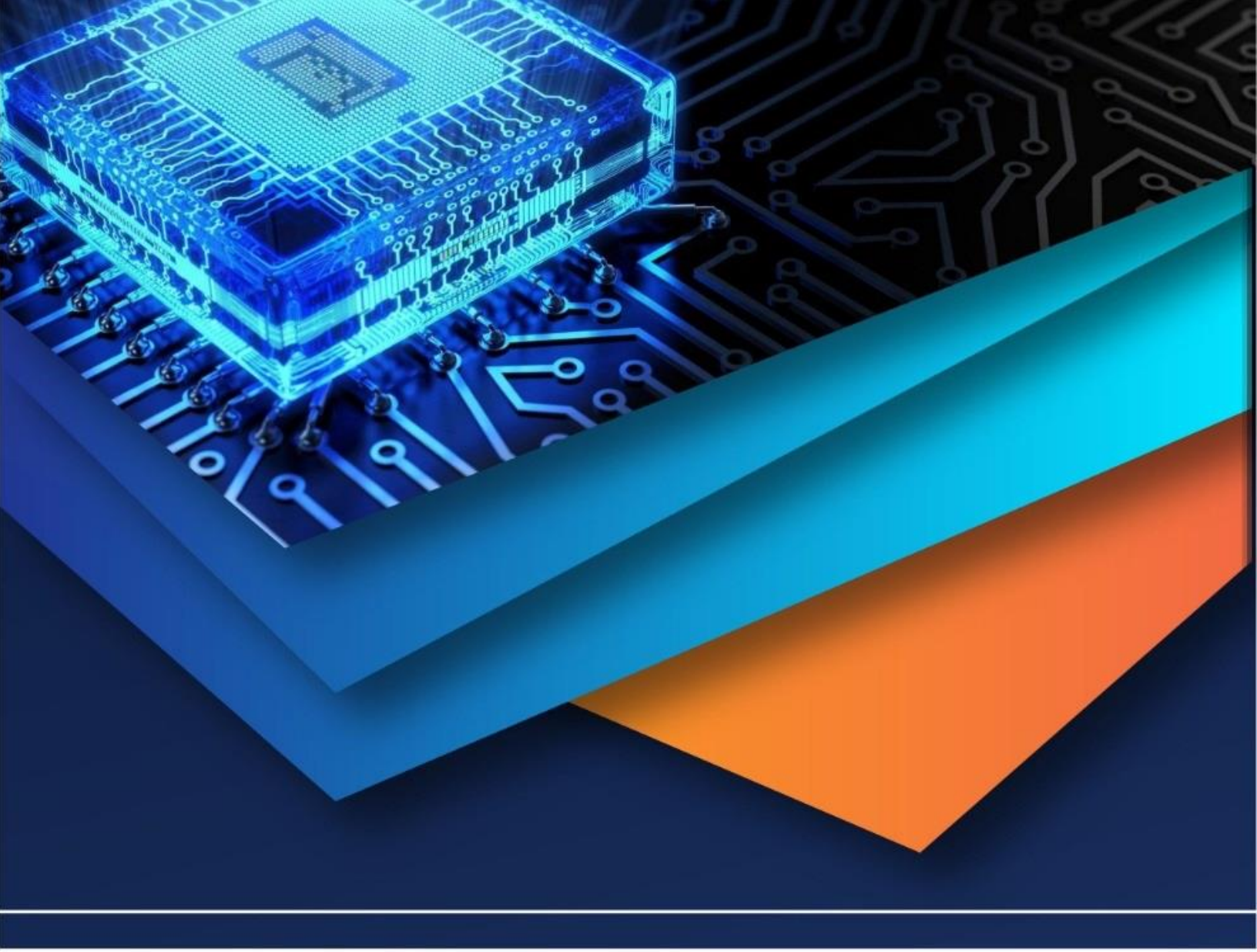

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