Available online at: http://www.ijmtst.com/vol3issue11.html
International Journal for Modern Trends in Science and Technology
ISSN: 2455-3778 :: Volume: 03, Issue No: 11, November 2017

A Novel Fuzzy Based Fault Ride-Through Control of a DFIG Generator under unbalanced Voltage Swags and Swells

Erukulla Shashank[1] | J.Srineswari[2]

[1]PG Scholar, Department of EEE, MREC (A), Maissammaguda, Hyderabad, Telangana, India.
[2]Assistant Professor, Department of EEE, MREC (A), Maissammaguda, Hyderabad, Telangana, India.

To Cite this Article
Erukulla Shashank and J.Srineswari, "A Novel Fuzzy Based Fault Ride-Through Control of a DFIG Generator under unbalanced Voltage Swags and Swells", *International Journal for Modern Trends in Science and Technology*, Vol. 03, Issue 11, November, 2017, pp.-17-23.

ABSTRACT

This paper proposes an organized control of rotor side converters (RSCs) and grid side converters (GSCs) of variable speed doubly-fed induction generator (DFIG) based wind time systems under unequal voltage conditions. The control plot utilizes stator flux-oriented control for the rotor side converter and grid voltage vector control for the grid side converter. Framework practices and operations of the RSC and GSC under unequal voltage are shown. The coordinated control plans figure out how to reestablish the wind turbines typical operation after the leeway of blame. An entire reenactment display is created for the control of the dynamic and receptive forces of the doubly nourished generator under factor speed operation. A few investigations are performed to test its operation under various wind conditions. The paper describes the control of a double-fed induction generator (DFIG) for variable speed wind control era under grid blame condition. Point by point Models is utilized as a part of Electromagnetic Transients Programs and catch both quick elements because of the electromagnetic homeless people and ease back progression because of electromechanical drifters. Reproduction has been done for a detail demonstrate from Matlab and Simulink.

Keywords: *Double Fed Induction Generator (DFIG), Stator Flux Orientation (SFO), Rotor Side converter (RSC), Grid Side converter (GSC), Vector oriented control (VOC).*

I. INTRODUCTION

The worldwide electrical vitality utilization is rising and there is enduring increment of the request on control era. So notwithstanding traditional power era units a vast no. of sustainable power source units is being incorporated into the power framework. It has been accounted for that sustainable power source will give as much as 10% of the world's vitality supply by 2020, and will increment to as much as half by 2050. Among the other economical power sources, wind essentialness has wound up being a champion among the most reassuring advances since they are gotten forceful, environmental spotless and safe unlimited power sources, when appeared differently in relation to non-sustainable power source and nuclear power time. These days, the most broadly and widely utilized wind turbine in high power wind Energy Conversion System (WECS) depends on doubly nourished acceptance generator (DFIG) because of its recognizable focal points:

1) Various speed eras

2) Double yield Generator bolsters dynamic and receptive energy to the Grid through both stator and also rotor.
3) Generates control more than appraised without overheating.
4) Decoupled control of dynamic and responsive power
5) Improve control quality.
6) Mechanical anxiety diminishment of turbine and acoustic clamor decrease.

DFIG's capacity to control rotor streams takes into consideration responsive power control and variable speed operation, so it can work at most extreme proficiency over an extensive variety of wind speeds. In any case, wind turbines in view of the DFIG are extremely touchy to grid aggravation, particularly to voltage plunges, huge negative and zero arrangement segments will show up in the stator flux causing intemperate over current or voltage in rotor windings, which will harm the electronic gadgets in the converter. Electromagnetic torque and the dynamic and responsive power begin to waver with enormous amplitudes, which are unsafe to the mechanical arrangement of the wind turbine and the solidness of the associated control organize. So it is imperative to break down the transient conduct of DFIG and to apply certain control methodology which will enable DFIG to remain associated with the grid under defective conditions.

II. Doubly Fed Induction Generator (DFIG)

Doubly Fed Induction Generator (DFIG) depends on an acceptance generator whose rotor windings are associated back to the grid through an air conditioner air conditioning voltage controller i.e. consecutive Voltage Source Converters. The stator is specifically associated with the AC mains, while the injury rotor is nourished from the Power Electronics Converter by means of slip rings to enable DFIG to work at an assortment of velocities in light of changing wind speed. In a DFIG, both the stator and the rotor can supply dynamic power, however the course of this power move through the rotor circuit is subject to the wind speed and as needs be the generator speed. Beneath the synchronous speed, dynamic power streams from the grid to the rotor side and rotor side converter (RSC) goes about as the voltage source inverter while the grid side converter (GSC) goes about as rectifier yet over the synchronous speed, RSC goes about as the rectifier, and GSC goes about as the inverter. So the machine can be controlled as a generator or an engine in both super and sub synchronous working modes acknowledging four working modes. The slip power can stream in both the headings from rotor to grid or grid to rotor contingent on the method of operation.

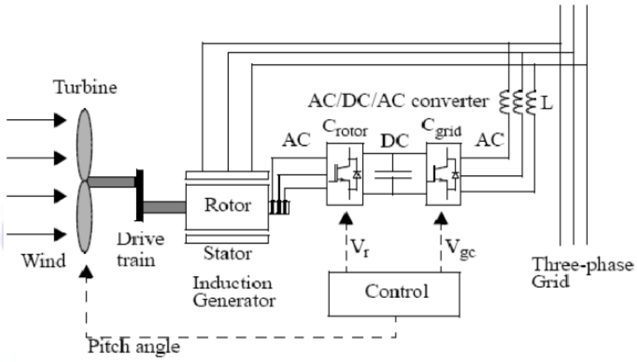


Fig 1: A typical wind energy system with Doubly Fed

Induction Generator In current DFIG outlines, the recurrence converter is worked independent from anyone else commutated PWM converters, a machine-side converter, with a middle of the road DC voltage interface.

AC/DC/AC converter comprises of an AC/DC converter associated with rotor twisting called as rotor side converter (RSC) and another DC/AC converter associated with grid called as grid side converter (GSVC).

RSC guarantees the decoupled control of dynamic and responsive power. GSC keeps the D.C. connect voltage steady paying little respect to the heading and greatness of rotor control. The DC capacitor connecting stator-and rotor-side converters permit the capacity of energy from acceptance generator for promote era.

III. Unbalance Grid Voltage

Reason: It might be voltage plunge i.e. a sudden decrease (in the vicinity of 10% and 90%) of the voltage at a point in the electrical framework, and sudden change of load (dynamic load) .There can be many reasons for a voltage plunge:
1) Short circuits some place in the grid
2) Switching operations related with a brief detachment of a supply
3) The stream of the substantial ebbs and flows that are caused by the begin of huge engine burdens, or expansive ebbs and flows drawn by circular segment heaters or by transformer immersion. Uneven grid voltage cause numerous issues for Induction Generator
1) Torque pulsations.
2) Reactive power pulsations.
3) Unbalanced currents.

A voltage dip can cause high induced voltages or streams in the rotor circuit. The high streams may wreck the converter, if nothing is done to secure it. Voltage plunges because of short out deficiencies cause the lion's share of gear outing and in this way of generally intrigue.

IV. Double Fed Induction Generator under Grid Fault Condition

Consider DFIG in which, instantly after a 3-phase fault happens, the stator voltage and flux lessens toward zero. The voltage drop depends, obviously, on the area of the blame. The rotor current at that point increments to endeavor to keep up the flux linkage inside the rotor windings consistent. DFIG under blame can be appeared in fig. 2. Be that as it may, for a DFIG the expansion in the rotor current promptly after a blame will be dictated by two components. The first is the adjustment in the stator flux and the second is the adjustment in the rotor infused voltage.

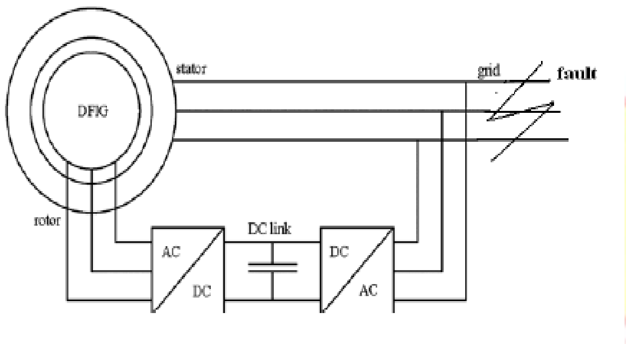


Fig 2: Block Diagram of DFIG with fault in Grid condition

A. Operation of DFIG under Unbalanced Condition: Behavior immediately after the fault: In the blame moment, the voltage at the DFIG generator terminal drops and it prompts a relating reduction of the stator and rotor flux in the generator. These outcomes in a diminishment of the electromagnetic torque and dynamic power. As the stator flux diminishes, the polarization that has been put away in the attractive field must be discharged. The generator begins in this manner its demagnetization once again the stator by the receptive power top at the time of blame. In the blame minute, as the stator voltage diminishes essentially, high current homeless people show up in the stator and rotor windings. So as to make up for the expanding rotor current, the rotor side converter builds the rotor voltage reference, which infers a "surge" of energy from the rotor terminals through the converter. On the opposite side, as the grid voltage has dropped instantly after the blame, the grid side converter is not ready to exchange the entire power from the rotor through the converter further.

B. Behavior at fault clearance: During the fault, the stator voltage and rotor flux have been diminished, the infused rotor voltage has been changed and the rotor speed has been expanded. Quickly after the blame is cleared the stator voltage is reestablished, and the demagnetized stator and rotor contradict this adjustment in flux in this way prompting an expansion in the rotor and stator currents.

V. Control of DFIG under Fault Condition

The DFIG enables the stator to be associated straightforwardly to a consistent recurrence, three-stage grid despite the fact that the wind turbine, to which it is coupled, has a variable speed. Variable speed operation is crucial for ideal wind control securing in light of the fact that the DFIG speed must track the changing ideal speed which is an element of the wind speed as the wind vacillates in time. Consequently the control of DFIG assumes a noteworthy part in accomplishing the variable speed operation. The DFIG is practical in light of the fact that when controlled by a Voltage-Source Converter associated with the rotor slip-ring terminals, its MVA rating is diminished by a factor of , the most extreme slip being = 0.3. The vector control conspire is connected to GSC and Instantaneous Reactive Power Theory is connected to the RSC considering the two converters inside a DFIG framework. The control plot utilizes stator flux-situated control for the rotor side converter and grid voltage vector control for the grid side converter. The power converters are normally controlled using vector control system, which permits decoupled control of both dynamic and responsive power. The co-composed control plans figure out how to reestablish the wind turbines ordinary operation after the leeway of blame. To give improved operation, the RSC is controlled to dispense with the torque motions at twofold supply recurrence under lopsided stator supply. The swaying of the stator yield dynamic power is then scratched off by the dynamic power yield from the GSC, to guarantee consistent dynamic power yield from the general DFIG era framework. There are diverse sorts of control technique for DFIG, which are as per the following:

A. Scalar control Scalar control is because of magnitude variety of the control factors just, and ignoring the coupling impact in the machine. For instance, the voltage of the machine can be controlled to control the flux, and the recurrence and slip can be controlled to control the torque. Scalar controlled drives are effectively implementable and thus generally utilized as a part of industry. However their significance has lessened as of late in light of the prevalent execution of vector controlled drives, which is requested in numerous applications. For Scalar control the innate coupling impact i.e. both torque and flux are elements of voltage or current and recurrence gives the lazy reaction and the framework is effectively inclined to unsteadiness in light of high request framework sounds. In the event that the torque is expanded by augmenting the slip, the flux tends to diminish. The flux variety is then repaid by the lazy flux control circle, nourishing extra voltage. This transitory plunging of flux diminishes the torque affectability with slip and protracts the framework reaction time. These previous issues can be comprehended by vector control or field arranged control where an enlistment generator can be controlled like an independently energized DC engine, got a renaissance the superior control of AC drives. Due to DC machine like execution, vector control is known as decoupling, orthogonal, or Trans vector control. Vector control is material to both acceptance and synchronous engine drives. Vector control and the comparing criticism flag handling, especially for current sensor less vector control, are perplexing and the utilization of capable microcomputer or DSP is obligatory. In view of the previously mentioned favorable circumstances over scalar control, vector control will be acknowledged as the business standard control for AC drives.

B. Decoupled Control of Active and receptive power It can be accomplished by d-q demonstrate. In the wake of changing over a-b-c tomahawks of 3 stage voltage to d-q hub and after that changing over it to remunerating terms and expansion of the repaying terms to the uncompensated voltage terms makes it conceivable to accomplish decoupled execution of the rotor side converter. A current directed PWM plot is utilized where q and d tomahawks streams are utilized to manage DC-connect voltage and related power separately.

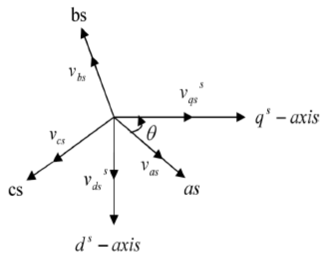


Fig 3: Stationary frame a-b-c to ds-qs axes transformation

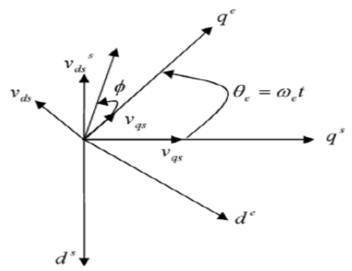


Fig 4: Stationary frame ds-qs to synchronous rotating frame de-qe

Rotor Side Converter Rotor side converter, guarantees decoupled control of dynamic and receptive power. The reference outline utilized here is likewise the synchronously turning outline i.e. SFO or SVO control conspire is utilized. The rotor side converter gives the activation and the control requires rotor and stator streams, stator voltage and rotor position. Examination of d-q streams and voltages traces the control plot for the converter.

Starter-side converter Keep the DC Link voltage consistent paying little respect to the course and size of rotor control. The 3-stage AC factors are alluded to synchronously turning outline utilizing Park's Transformation which changes over them into two DC factors at quadrature with each other, in particular the immediate segment and quadrature segment. The converter is present managed, with coordinate part used to direct DC Link voltage and quadrature segment to control responsive power.

Generator control of DFIG wind turbine Basically the speed control of a DFIG is accomplished by controlling the power. The rotor-side convertor is in charge of energy control which is a two-arrange controller including a genuine and receptive power controller. Stator-flux situated casing has been the most regularly used edge for the outline and investigation of DFIG. In this edge the q-hub and d-axis parts of the rotor streams are utilized for dynamic and receptive power control individually (Fig.6). To work converters at same steady recurrence, the present control procedure is executed through a voltage controlled PWM converter. The d-q control signals are produced by looking at the d-q current set esteems with the real d and q parts of the rotor current. The two-organize rotor side converter controller structure is appeared in the fig. beneath:

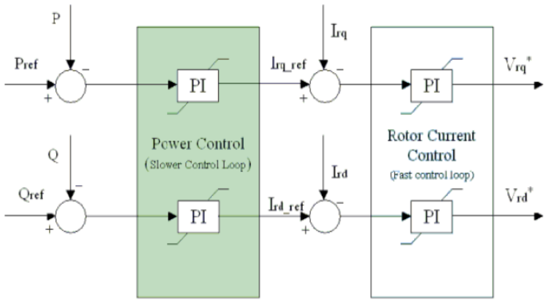


Fig 5

Simulation: A detail model of 9 MW wind cultivate associated with three transports B120, B25 and B575 has been reproduced to break down the outcomes. Nitty gritty Models are utilized as a part of Electromagnetic Transients Programs and catch both quick progression because of the electromagnetic drifters and ease back flow because of electromechanical homeless people. This model incorporates point by point portrayal of energy electronic IGBT converters. This model is appropriate for watching sounds and control framework dynamic execution over generally brief times of times (regularly many milliseconds to one moment).

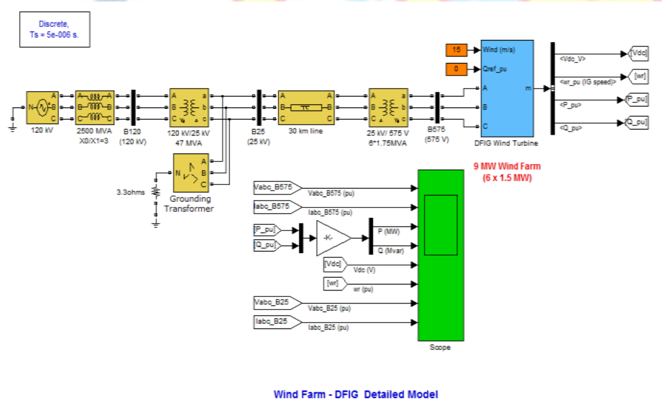


Fig 6: The Detailed Model of DFIG in WECS

Matlab Design of Case Study & Results

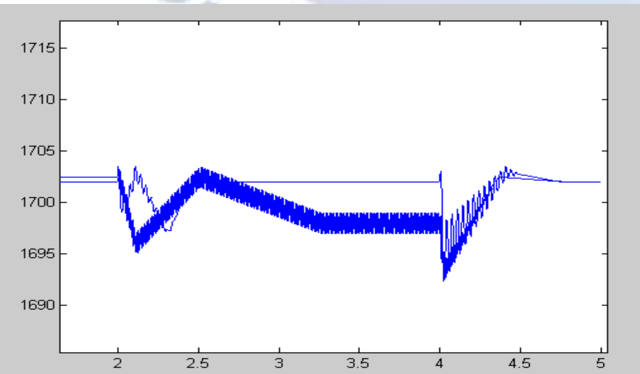
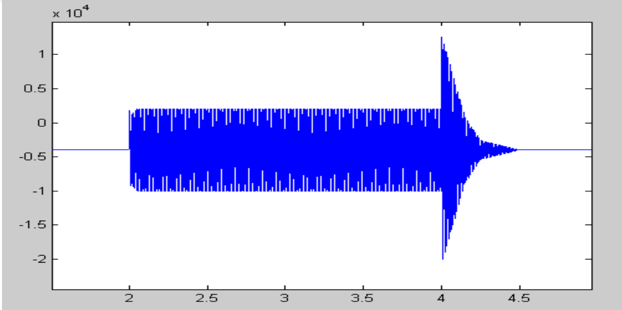
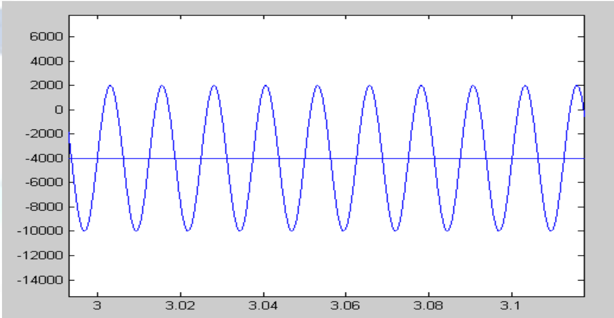


Fig.7.1 Rotor speed comparison of a two-phase voltage sag of 50% using the

Standard control technique T1 and the technique T3

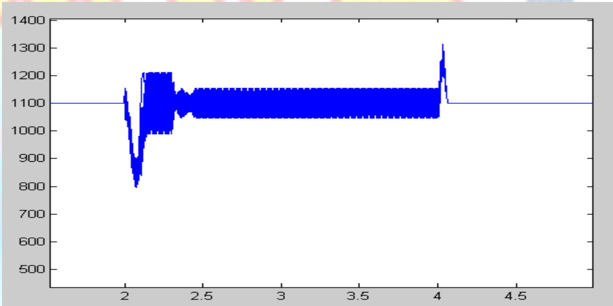


(a)

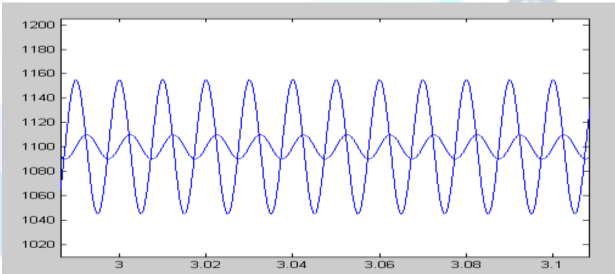


(b)

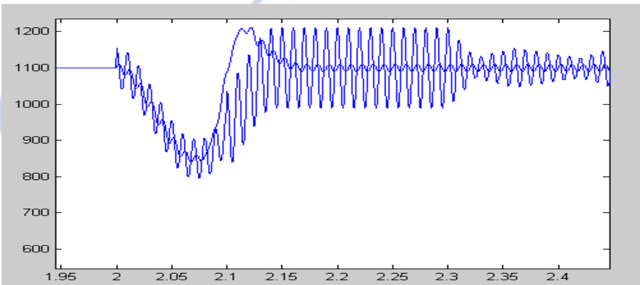
Fig.7.1 Torque response comparison of two-phase voltage sag of 50% using the standard control technique T1 and the technique T3 (a) Torque response for the whole voltage sag time. (b) Torque evolution in the center of the sag.



(a)



(b)



(c)

Fig. 7.2 Comparison of the dc voltage response to a 50% two-phase voltage-sag using T3 or T2. (a) DC voltage response for the whole voltage sag time. (b) DC voltage evolution in the center of the sag. (c) DC voltage response in the initial time of the sag.

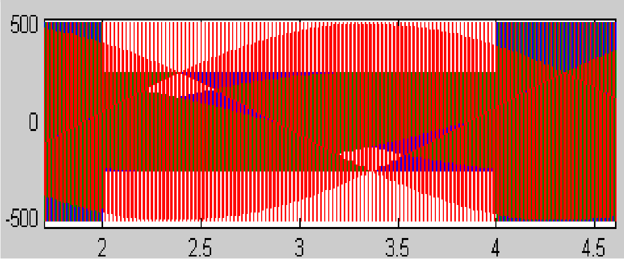


Fig.7.3 grid voltage

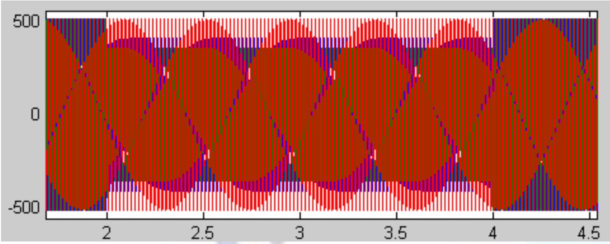


Fig.7.4 grid side converter voltage

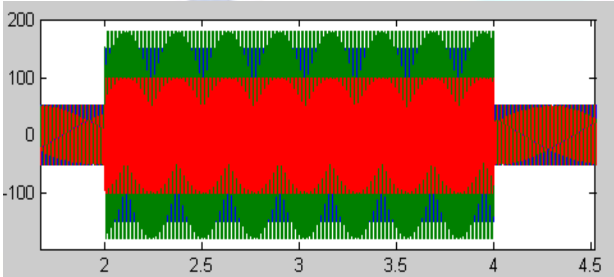


Fig.7.5 rotor side converter voltage

(a)

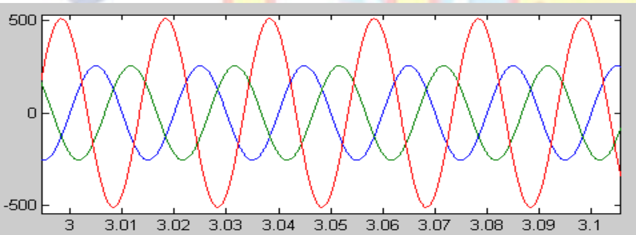


Fig.grid voltage

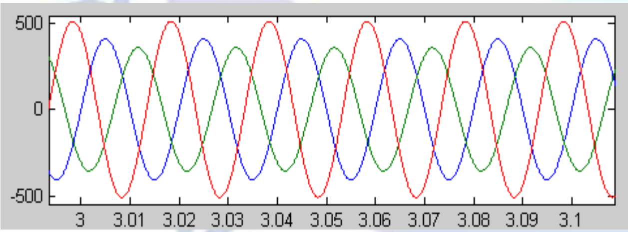


Fig. grid side converter voltage

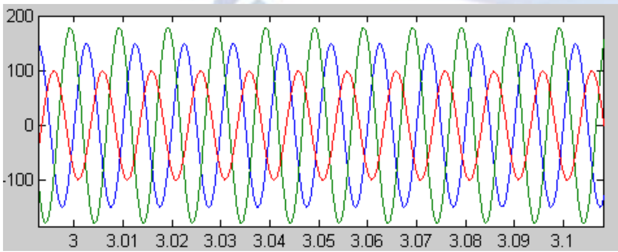


Fig. rotor side converter voltage (b)

Fig.7.6 Voltage response to a two-phase voltage sag of 50 %.
(a) Voltages evolution for the whole voltage sag time.
(b) Voltages evolution in the center of the sag.

VI. Conclusion

The DFIG considered in this examination is an injury rotor acceptance generator with slip rings. The stator is specifically associated with the grid and the rotor is interface by means of a consecutive incomplete scale control converter (VSC). Power converter are generally controlled using vector control systems which permit the decoupled control of both dynamic and responsive power stream to the grid. In the present examination, the transient reaction of DFIG is displayed for both typical and irregular grid conditions. The control execution of DFIG is attractive in typical grid conditions and it is discovered that, both dynamic and receptive power keeps up an examination design regardless of fluctuating wind speed and net electrical power provided to grid is looked after steady. Amid grid aggravation, significant torque throb of DFIG framework has been watched

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