International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-2, December 2019

Enhancement of the Dynamic Behavior of Grid-Connected DFIG Based Wind Turbines by using Fuzzy Logic Controller under LVRT Conditions

K. Chandra Babu, K. Ramasekhara Reddy

***Abstract:** In recent years, due to the interconnection of large capacity wind turbines to the power grid lead, there are serious issues in the stability of Grid and generation of electrical power. Also, it is showing effect on the dynamic performance of the electrical power systems. To maintain stability during sudden changes in the grid, the LVRT (Low Voltage Ride Through) capability of the Wind Turbines is one of the prime requirements. Wind turbines attached to DFIG (Doubly Fed Induction Generators) are advantageous which have LVRT capability at limited extent. In this paper, the elaborated discussion of the LVRT of Wind turbines shafted to DFIG's in the Grid. It also presents the complete description of the sudden changes in the systems like transient characteristics and the Doubly Fed Induction Generators dynamic response at the time of grid voltage faults (Symmetrical and Asymmetrical). The latest rotor side control technology is displayed in this paper for DFIG and wind turbines with improved capacity of low voltage ride through at the time of severe grid voltage sags. A Fuzzy Logic controller-based control technology is introduced in this paper which performs the balancing the rotor-side voltage and short circuits during the disturbances in the Grid. The advantage in this proposed control scheme is that it reduces the additional cost and reliability issues. So, the DFIG is efficient and usability company norms are satisfied with the proposed Fuzzy logic controller compared to regular controller like PI controller. The performance of the proposed system is simulated and verified in the computer. The results are displayed and it conclude that the control strategy of LVRT capability for Grid connected DFIG based wind turbine systems with Fuzzy Logic Controller are more effective than the conventional control Methods*.

***Index Terms:** Wind energy, Induction generator with double fed, faults in Grid, Power electronic converters, Low-Voltage Ride-Through (LVRT).*

Revised Manuscript Received on December 30, 2019.

***** Correspondence Author

K. Chandra Babu*, Department of EEE, JNTUA university, Anantapuramu, India. Email: Chandra.

Dr. K.Ramasekhara Reddy, Department of EEE, JNTUA, Anantapuramu, India.

I. INTRODUCTION

Now and from past few years, there has been an enormous increment in worldwide demand for energy because of modern advancement, yet in addition populace development. Subsequently, the ascent in utilization of customary petroleum derivatives has prompted numerous significant issues, for example, vitality deficiencies, contamination, an unnatural weather change, the setback of conventional fossil vitality sources, and vitality uncertainty. These variables are driving the improvement of sustainable power source innovations. Generation of electrical power from wind is the most efficient way of producing the power and is increasing rapidly. As of year, 2016, 54 GW of intensity was produced from the Wind. With the extended closeness of wind essentialness in the power structure throughout the latest decade, an authentic stress over its impact on the dynamic direct of the electric power framework has developed. Thusly, it winds up major that Grid related breeze turbines act correspondingly to standard power stations and reinforce the power compose during normal and bizarre cross section conditions. Other than the enhancements made in the development of the network codes to utilize the breeze vitality accurately, The Induction Generator with doubly fed- based breeze turbine has ended up being one of the best decisions in wind control age. This is because of the unmistakable focal points that it has contrasted with the other vitality change frameworks that are right now accessible in the market. In any case, the DFIG's dynamic response to arrange voltage vagabonds is the most largest issue. Induction Generator with doubly fed -based breeze turbines is fragile to voltage hangs during system inadequacies. This is due to direct result of the back-back power electronic converters with partial scale. This converter interface with the generator of the rotor to the power arrange. Regardless of whether the issues are occurring long good ways from the turbine, will bring about decrease in the network voltage, which delivers a voltage flood in the DC transport interface and generator rotor current also increases. And also, it will lead to unsafe operation of the turbine because the turbine speed increases dangerously, and if there is no protection then it will lead to threat to the power electronic converters. So, during these all abnormal conditions we are going to find the solutions with some control mechanisms and check whether the DFIG connected Wind turbines are able to control low voltage ride through. So, the aim of this paper is to verify the induction generator with doubly fed connected for grid in Wind turbine dynamic performance and its LVRT capability.

Various abnormal conditions like, voltage sags, sudden transients and voltage recovery are analyzed in this paper. This paper likewise gives an itemized depiction of the most referred to and normally utilized solutions for LVRT by enhancing the Rotor-Side Converter (RSC) controlling techniques (dynamic methods) It portrays the essential activity.standard, points of interest and drawbacks of each proposed arrangement. the control procedure proposed, centers around moderating the rotor-side voltage and flow stun during unusual conditions on network, with no extra cost or unwavering quality issues. Therefore, the DFIG execution is improved and the service organization models are satisfied. Simulation studies are utilized to check the LVRT capacity of the novel procedure and its successful execution contrasted with the regular control plans.

II. WIND POWER GENERATION BY USING DFIG

At present there are new ideas with imaginative advances in Wind Turbines, generators and power hardware. We can structure a Wind turbine framework with various designs like mix of Synchronous generators with completely evaluated power converters or Induction generators with halfway appraised power converters or the other way around. The most widely recognized sort of Wind Configurations is completely evaluated power electronic converters based PMSG (Permanent Magnet Synchronous Generators) wind turbines and incompletely appraised power electronic converters based DFIG (Doubly Fed Induction Generator) Wind turbine. The two configurations are shown in Figure 1 and Figure 2. Out of the both configurations DFIG based wind turbines are suitably best for limited speed range and variable speeds i.e. variation of 30 percent difference with turbines speed. More over the device cost and losses during the operation is minimized since the electrical converters will handle some quantity of total generated power. In other configuration total generated power is to be handled by the power electronic converters.

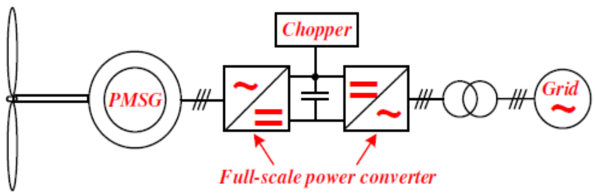


Fig.1. PMSG based wind turbines for power electronic converters with full scale.

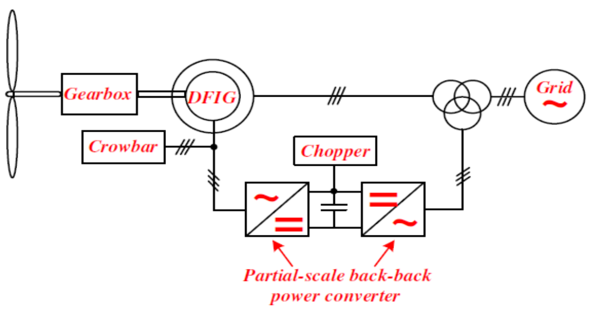


Fig.2.DFIG based wind turbines for power electronic converters with partial scale.

In this DFIG configuration, two converters are present that are connected serially. One converter is at rotor side and other one is at grid side. Between the both converters there is a DC link for the sake of storage of energy. This DC link will also reduce the fluctuations in the DC voltage. Speed - torque Active – reactive power at stator, DFIG are controlled by RSC. The reactive power control near grid side and DC link voltage regulation are managed by GCS.

The increase in voltage during grid faults and disconnection of loads suddenly will show bad result near DC link voltage. During these conditions the power stream heading is returned and the current streams to the DC connect. So, Dc interface voltage is fixed to a Nominal worth. We can confine the DC interface voltage with assistance of association of a chopper circuit with a resistor associated over the DC connect. This associated is known as Crowbar Circuit appeared in Figure 2. This circuit will build the scope of safe activity by constraining the DC transport voltage. This is the advantage of this configuration.

2.1. Dynamic Modeling for DFIG

The dynamic equivalent circuit of the DFIG is given in Figure 3, it is represented in dq reference frame and this operating principle is rotating magnetic field (RMF) theory. DFIG is represented as a regular Induction generator with some rotor voltage value.

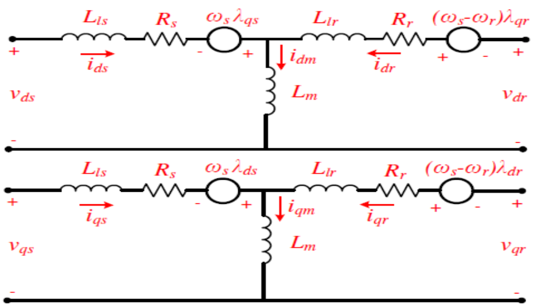


Fig.3. DFIGs Equivalent circuit for dq-synchronous reference frame

The below equations are representing the dynamic model for DFIG in the dq- axis.

$$\begin{cases} v_{ds} = r_s i_{ds} + \frac{d\lambda_{ds}}{dt} - \omega_s \lambda_{qs} \\ v_{qs} = r_s i_{qs} + \frac{d\lambda_{qs}}{dt} - \omega_s \lambda_{ds} \\ v_{dr} = r_r i_{dr} + \frac{d\lambda_{dr}}{dt} - (\omega_s - \omega_r)\lambda_{qs} \\ v_{qr} = r_r i_{qr} + \frac{d\lambda_{qr}}{dt} - (\omega_s - \omega_r)\lambda_{qs} \\ \lambda_{ds} = L_s i_{ds} + L_m i_{dr} \\ \lambda_{qs} = L_s i_{qs} + L_m i_{qr} \\ \lambda_{dr} = L_r i_{dr} + L_m i_{ds} \\ \lambda_{qr} = L_r i_{qr} + L_m i_{qs} \\ L_s = L_{ls} + L_m \\ L_r = L_{lr} + L_m \end{cases} \quad \text{---(1)}$$

r_s and r_r- stator and rotor windings resistances,
Lm- magnetizing inductance,
L_{ls} and L_{lr}- leakage inductances,
λ_s andλ_r- magnetic flux linkages for stator and rotor,
v_s and i_s- voltage and current for stator,
v_r and i_r- voltage and current for rotor,
ω_s and ω_r_angular synchronous speed for stator and rotor.

The aim now is to check the relation between the voltages, currents and the flux linkages of the stator and rotor. The goal of the DFIG is to inject the rotor currents considering rotor side converter as a current source by which it supplies the required power to the Grid. The q-axis is set to be stator flux for positive sequence.

Stator resistance is neglecting, the voltage equations on rotor can be expressed for:

$$v_{dr} = (r_r + \sigma L_r \frac{d}{dt}) i_{dr} - (\omega_s - \omega_r)\sigma L_r i_{qr} + \frac{L_m}{L_s}(v_{ds}) \quad \text{---(2)}$$

$$v_{qr} = (\omega_s - \omega_r)\sigma L_r i_{dr} + (r_r + \sigma L_r \frac{d}{dt}) i_{qr} + \frac{L_m}{L_s}(v_{qs} - \omega_r \lambda_{ds}) \quad \text{---(3)}$$

here $\sigma = 1 - \frac{L_m{}^2}{L_s L_r}$. The above equations can be given in the form of matrices as:

$$\begin{bmatrix} v_{dr} \\ v_{qr} \end{bmatrix} = \begin{bmatrix} r_r + \sigma L_r \frac{d}{dt} & -(\omega_s - \omega_r)\sigma L_r \\ (\omega_s - \omega_r)\sigma L_r & (r_r + \sigma L_r \frac{d}{dt}) \end{bmatrix} \begin{bmatrix} i_{dr} \\ i_{qr} \end{bmatrix} + \frac{L_m}{L_s} \begin{bmatrix} v_{ds} \\ v_{qs} - \omega_r \lambda_{ds} \end{bmatrix} \quad \text{---(4)}$$

Here (4) is given for steady and differing conditions close Wind turbines. It gives the quick estimations of the stator and rotor dq-voltages to the dq rotor flows and the straight connection between them. By incorporating the stator voltage, we can assess the stator motion. At steady conditions, not considering r_r and L_r and making $\frac{L_m}{L_s} \approx 1$, the yield voltage at rotor side converter is about sV_s, is the slip and, V_s is the consistent stator voltage. The slip is restricted between -0.3 to 0.3. A predefined security edge is typically required.

At the point when there is a voltage hang at stator side then the required voltage is given by (4) with the end goal that the rotor current won't be influenced and stays unaltered. Be that as it may, since the rating for RSC is restricted and can't create the fundamental voltage on rotor, a huge transient current on rotor will show up during network voltage droops.

Beneath conditions are the dq stator flows in the wake of applying Laplace change, treating DFIG fifth order model and straight as in (1)

$$i_{ds} = \frac{1}{L_s} \frac{\omega_s}{s^2 + 2\frac{1}{\tau_s}s + \omega_s{}^2} v_{qs} - \frac{L_m}{L_s} i_{dr} \quad \text{---(5)}$$

$$i_{qs} = \frac{1}{L_s} \frac{s + \frac{1}{\tau_s}}{s^2 + 2\frac{1}{\tau_s}s + \omega_s{}^2} v_{ds} - \frac{L_m}{L_s} i_{qr} \quad \text{---(6)}$$

τ_s- time constant for stator.

Above equations (5) & (6) gives the direct relation between the voltage and current on stator .At voltage droop, when the current on rotor is kept consistent, current on stator begins to sway with stator recurrence (ω_s) and wavering damping relies upon the time constant for stator (τ_s). at the time of LG, LLG faults, a negative arrangement will show up and furthermore power motions yet with a frequency equivalent to $2\omega_s$.

It is likewise realized that the immediate connection between flux linkage on stator voltage on stator, current on rotor, utilizing the voltage on stator-arranged synchronous reference outline (v_{qs} = 0 and v_s = v_{ds}), can be obtained as:

$$\lambda_{ds} = \frac{s + \frac{1}{\tau_s}}{s^2 + 2\frac{1}{\tau_s}s + \omega_s{}^2} v_{ds} - \frac{L_m/\tau_s(s + \frac{1}{\tau_s})}{s^2 + 2\frac{1}{\tau_s}s + \omega_s{}^2} i_{dr} \quad \text{---(7)}$$

$$\lambda_{qs} = \frac{-\omega_s}{s^2 + 2\frac{1}{\tau_s}s + \omega_s{}^2} v_{ds} - \frac{L_m/\tau_s(s + \frac{1}{\tau_s})}{s^2 + 2\frac{1}{\tau_s}s + \omega_s{}^2} i_{qr} \quad \text{---(8)}$$

Equations (7) & (8) gives flux linkage on stator depends on stator voltage and rotor current, which explains that the flux on stator starts to oscillate with a frequency (ω_s). damping oscillations depends on the time constant for stator (τ_s). A -ve sequence will arrive during unbalanced faults and force of oscillations with a twice stator frequency $2\omega_s$.

2.2. Transient Analysis of Magnetic Flux of the DFIG during faults in grid

Symmetrical Faults

During steady state of operation, the speed of stator flux is synchronous speed with reference to stator. This stator flux is constant value which is directly proportional to grid voltage. The magnetizing current will excite the magnetic field and this inturn causes air gap flux between the stator and rotor and at the flow of active power between both mechanical and electrical stages.

In case of any sag of voltage at stator, it leads to the fluctuations the stator flux. this leads to transients in a rotor circuit. during voltage sag condition, these are two components in stator flux. one component is in synchronous and during fault condition grid voltage is proportional. the second component is a DC which usually decreases exponentially to zero additionally, the voltage at terminals of stator and this causes induction of a dc on the flux. the different in phase between the voltage sag and restoration indicates whether or not the present and the flux dc. Let the fault period of time chosen be one second. In 5-2 cycles the fault is almost cleared. In addition, the time constant of station is also adjusted by using the stator winding resistance is less preferred process.

Asymmetrical Faults

These faults are mostly occurring faults than the phase faults. So, there is a transient DC value at the time of grid faults and consists of positive component of stator flux and negative component of stator flux.

During $t = t_0$say there is an L-G fault takes place at the terminals of the DFIG on stator. Then the voltage of faulty phase, e.g. phase *a* to ground, +ve and -ve sequence networks have same impedance values (assume), and there is no change in the other phase voltages. So, when there is voltage sag the stator flux is expressed as

$$\vec{\lambda}_s(t) = \frac{\vec{V}_1}{j\omega_s} e^{j\omega_s t} + \frac{\vec{V}_2}{-j\omega_s} e^{-j\omega_s t} + \vec{\lambda}_{sno} e^{-\frac{t}{\tau_s}} \quad \text{---(11)}$$

The three terms in the above condition are the positive, negative, and DC (characteristic) stator motion segments.

As communicated previously, rather than the three-stage balanced voltage records, the fundamental estimation of the normal motion depends upon the minute when the shortcoming starts. For this circumstance, since the issue starts preciselyThe most dire outcome imaginable occurs during droop in voltage at time t =T/4, where T is the time period for grid. For this situation, the characteristic motion arrives at its most extreme incentive since the +ve and –ve sequence components will create fluxes that are totally inverse way and their aggregate is insignificant. Thus, the stator flux directions when the issue are distracting. Besides, the regular transition arrives at its most extreme worth, which augments the threat in the rotor circuit.

III. LVRT CONDITONS OF DFIG OPERATED WIND TURBINES

3.1. Definition

LVRT capability under grid fault conditions for wind turbines this is connected to the power grid. more over wind power generation will be exhibit a similarly to that of the ordinary power plant and then to support with voltage on grid under both symmetrical and asymmetrical voltage sags on grid this means to compensation for reactive power.

LVRT characteristics is appeared in Fig. 4. The specification for LVRT in wind based to remain associated with voltage on grid and supply reactive power. the blue area zone in fig-4 the PCC voltage will drop. More over the wind system will probably work continuously at V_f % of nominal line voltage of PCC (V_i) in fig 4.voltage sag level V_x and time clearance for fault (T_x) are decided by the what type of fault and protection system for turbine. The base estimation of $V_x$fluctuates among nations and may rise to zero contingent upon the LVRT trademark received in every nation. The slant of the recuperation relies upon the quality of the interconnection and responsive power support. More grounded frameworks can bear the cost of a lot more extreme increment and hence limit the ride-through prerequisites of the generators.This prompts bigger MVA limit during the plan procedure of the entire converter framework. Subsequently, fulfilling this interest is generally hard to accomplish by means of the wind turbine for DFIG idea, appeared in Fig. 2, with somewhat evaluated power electronic converters. One more power quality units like STATCOMs may conceivably be utilized to wind turbine framework in accomplishing this hard prerequisite. Fig. 5 demonstrates necessity for reactive current for wind energy.

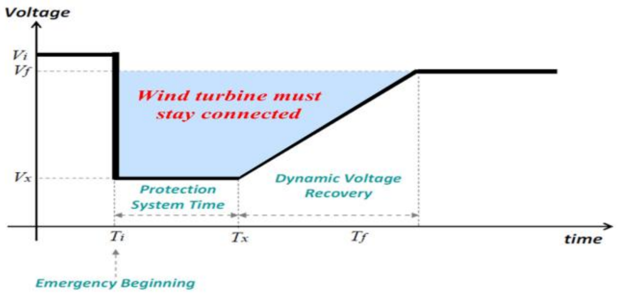


Fig.4.Characteristics of Low Voltage RT of a wind turbine.

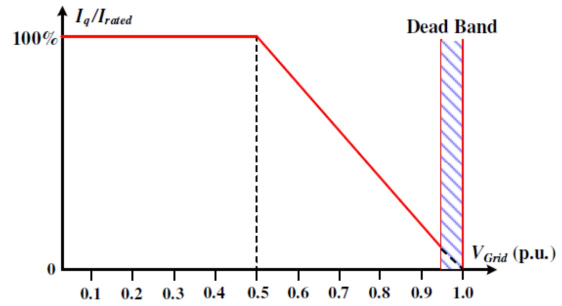


Fig.5. Reactive current necessity for a wind energy system at the time of grid sags

3.2. LVRT Solutions

Under grid fault conditions induction generator with doubly fed wind turbines are very sensitive. This is mainly due to back to back power electronic converter with partially scale. In power system network fault is occurred on the location of turbine can cause suddenly drop the voltage in grid. this leads to DC bus voltage is more severe and generator of the rotor circuit side is over current. so due these abnormalities without any protection power electronic converters get damaged at the same time to increase the turbine speed at above rated limits. These LVRT techniques can be isolated into two principle gatherings:

1) Arrangements of LVRT with equipment execution (in active strategies).

2) Arrangements of LVRT by enhancing the RSC control systems (dynamic techniques).

In this sub section gives enhancement of RSC control strategy (dynamic strategies), merits and demerits of LVRT solutions.

IV. CONTROL STRATEGIES FOR ENHANCING THE RSC BY LVRT SOLUTIONS

In vector strategy based on voltage on stator or flux on stator orientations. To achieve the control of independent of real and magnetizing powers of DFIG by using PI controllers with voltage on stator or flux on stator. This is to reduces designing of controller complexity and to get several actions.

The theme of the controller on RSC is to decoupled control between the real and magnetizing power on stator side to inject grid side .the first loop is inner current loop is direct and quadrature axis currents are regulated on rotor side and the second loop is outer loop is to regulate the both real and magnetizing power shown in fig 6. Stator flux linkage (λ_s) and reference frame are rotating synchronously, the direct axis aligned with stator flux is as shown in fig7. This is able to control the developed torque and magnetizing power on stator is independently. The use current on d-axis is to regulate magnetizing power and current on q-axis is to extract developed torque. RSC dc side output voltage of dq-axis components is cross coupled to dq-rotor currents.

Feed forward current regulators with PI controller are used to dq-rotor currents are decoupled. The cross-coupling terms $\omega_{slip}\sigma L_r i_{qr}$ and $\omega_{slip}\left(L_{mm} i_{ms} + \sigma L_r i_{qr}\right)$ are feed forward sign added to the yields of the PI current regulator. As appeared in Fig. 7. $v_{dr}^*$and $v_{qr}^*$is the reference estimations of the voltages on rotor in d-and q-axis. i_{dr}^* and i_{qr}^* are the reference estimations of the rotor flows in d-and q-axis.$v_{dr}^*$and P_s^* and $Q_s^*$are the reference estimations of the stator dynamic and responsive power; individually, $\omega_{slip}$is the slip precise recurrence; $\sigma = 1 - \frac{L_m{}^2}{L_s L_r}$;$L_{mm} = \frac{L_m{}^2}{L_s L_r}$; $i_{ms}$is the charging current; and every other image have a similar importance as recently characterized in the paper.

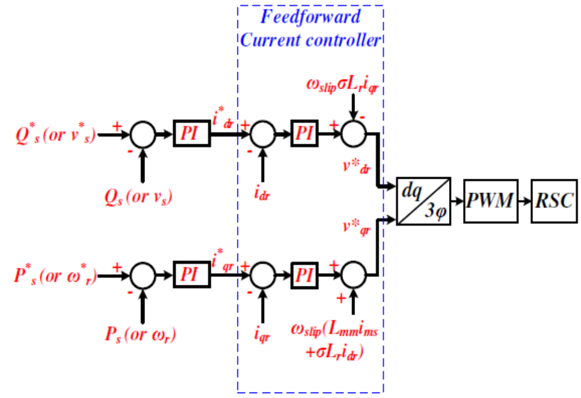


Fig. 6. vector control scheme for the DFIG on RSC side.

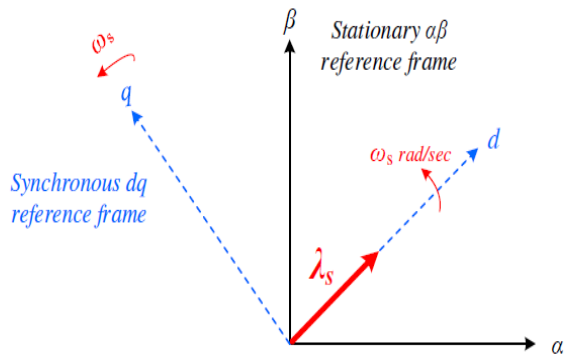


Fig.7. The flux-oriented on stator synchronous reference frame used for the vector control scheme for RSC.

Then again, because of its constrained transfer speed and gain margin, the adequacy of PI controllers will be genuinely corrupted during grid voltage sags. Subsequently, the autonomous control of DFIG is totally lost and it is hard to come back to the powerful managed state. Under unbalanced network deficiencies and aggravations, second-request symphonious swells may show up in the stator current, electromagnetic torque, and stator dynamic and responsive power yields.

$$\begin{cases} 0 = r_s i_{ds\_dc} + \frac{d\lambda_{ds\_dc}}{dt} \\ 0 = r_s i_{qs\_dc} + \frac{d\lambda_{qs\_dc}}{dt} \\ v_{dr\_dc} = r_r i_{dr\_dc} + \frac{d\lambda_{dr\_dc}}{dt} + (\omega_r)\lambda_{qr\_dc} \\ v_{qr\_dc} = r_r i_{qr\_dc} + \frac{d\lambda_{qr\_dc}}{dt} - (\omega_r)\lambda_{dr\_dc} \\ \lambda_{ds\_dc} = L_s i_{ds\_dc} + L_m i_{dr\_dc} \\ \lambda_{qs\_dc} = L_r i_{qs\_dc} + L_m i_{qr\_dc} \\ \lambda_{dr\_dc} = L_r i_{dr\_dc} + L_m i_{ds\_dc} \\ \lambda_{qr\_dc} = L_r i_{qr\_dc} + L_m i_{qs\_dc} \end{cases} \quad --- \quad (12)$$

If the direct axis component on DC transient is towards DC flux direction on stator. The quadrature axis component $\lambda_{qs\ dc}$ is zero. Simplified for above equations:

$$\frac{d\lambda_{ds\_dc}}{dt} = -R_s i_{ds\_dc} \quad ---(13)$$

$$\lambda_{ds\ dc} = L_s i_{ds\ dc} + L_m i_{dr\ dc} \quad ---(14)$$

$$0 = L_s i_{qs\ dc} + L_m i_{qr\ dc} \quad ---(15)$$

$$i_{qs\_dc} = -\frac{L_m}{L_s} i_{qr\_dc} \quad --(16)$$

$$i_{dr\_dc} = \frac{\lambda_{ds\_dc}}{L_s} - \frac{L_s}{L_m} i_{ds\_dc} \quad ---\ (17)$$

equation (13) to equation (17) states that stator and rotor current component on DC transient. To split current on rotor and stator is controlled by the pre-fault moment. equation (15) can be modified to equation (16), showing the corresponding connection between the quadrature-axis DC current on the rotor and stator. Moreover, condition (13) states that to determine resistance on stator and DC current.

V. PROPOSED CONTROL STRATEGY DURING SYMMETRICAL GRID VOLTAGE SAGS

Under LVRT control DC magnetic field in the air gap is a major concern. if stray resistance is taken into account equation (13) can be written to equation (18).

$$\frac{d\lambda_{ds\_dc}}{dt} = -(R_s + R_{stray}) i_{ds\_dc} \quad ---(18)$$

The main theme of control strategy is decay of the DC component of the flux linkage on stator. equation (18) is a rate of change of dc flux linkage with respect to time is associated with resistance on stator and stray resistance of transmission line and the stator winding of DC component current
To control stator flux linkage in two ways
1) To change stator winding resistance.
2) Dynamic control application to the current of DC link on the stator winding.
In stator winding to change resistance is less supported methodology in light of the fact that the resistors utilized for current rot must deal with high vitality and control and are in this way cumbersome.

Besides, cut-in and cut-off resistors due to this resistor will bring extra transient into the framework. The fundamental goal of the control technique is to figure out how to quicken the rot of the stator DC Component as fast as could be expected under the circumstances.

Disregarding leakage inductances on the both stator and rotor, the flux linkage on stator lags induced voltage on rotor by 90degrees.RSC designing to control current on rotor side slip frequency. Other frequencies of voltages and currents are removed because PI regulator and DC link voltage both are not strong in stator DC flux induced current $(i_{r\ dc})$ lags to induced voltage ($v_{r\ dc}$) by certain degrees (circuit on rotor side and RSC is a inductive nature see in fig 8(a). $\lambda_{s\ dc}$ Is the DC flux linkage on stator under transient and,$i_{s\ dc}$ is a current excitation.

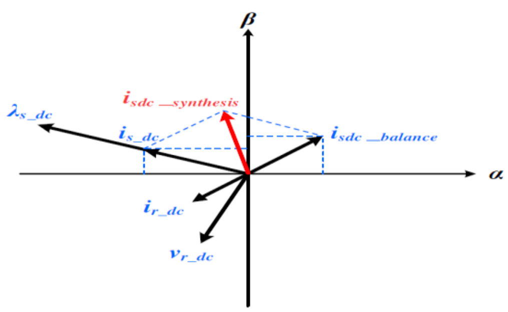
From sudden variations the current on rotor will affect the magnetic field and another current on DC component is $i_{sdc\ balance}$ on the side of stator to balance the magnetic field .so the DC flux stator current excitation$i_{s\ dc}$, and balanced current $i_{sdc\ balance}$ together the stator DC current,$i_{sdc\ synthesis}$ the final current is help to damp out passive flux on DC.

In the above explanation current is a natural decaying of the stator side DC flux but we cannot use active control by the RSC side .to apply the control methodology to change stator flux on DC trajectory.

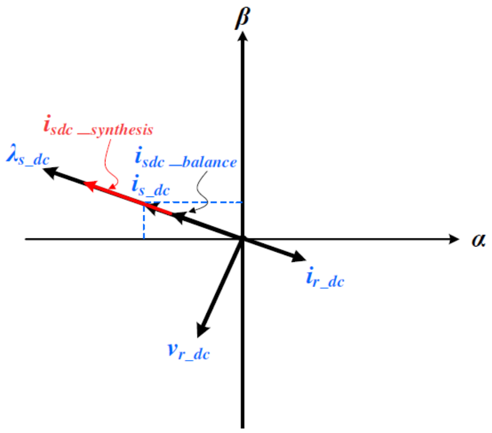
The control technique of proposed strategy we consider control action is needed for current in slip frequencies. The active control technique in speed frequency on rotor and stator flux decaying together. According to equation (18) to eliminate DC flux component on stator that means to maximize DC current on stator. the DC damping effect is maximize in rotors side but rotor side current frequency and DC flux on stator both are opposite direction .in this way the current on rotor side increases but current vector on stator moves from $i_{s\ dc}$ to $i_{sdc\ synthesis}$ and speed up the DC flux on stator is decay.

The RSC control strategy.$i^*_{dr\ dc}$and $i^*_{qr\_dc}$ are the DC flux linkage damping currents in direct and quadrature axis current.$\lambda_{s\ dc}$ is a DC flux linkage on stator under transient .$\lambda_{dqs\ P}$ and $\lambda_{dqs\ N}$ are the components of +ve and -ve sequences of a stator linkage on direct and quadratureaxis.Fig. 9 demonstrate the schematic view of the general RSC control framework, including the control technique for LVRT. All different images have a similar importance as recently characterized in the paper.

The vector control blocks, calculation for stator flux on stationary and also detection unit will be added. The control technique of RSC scheme to detect primarily$\lambda_{s\ dc}$, as shown in Fig. 10.



(a) Without extra rotor current control.



(b) With proposed method of rotor current control

Fig.8.vector relationship between DC components.

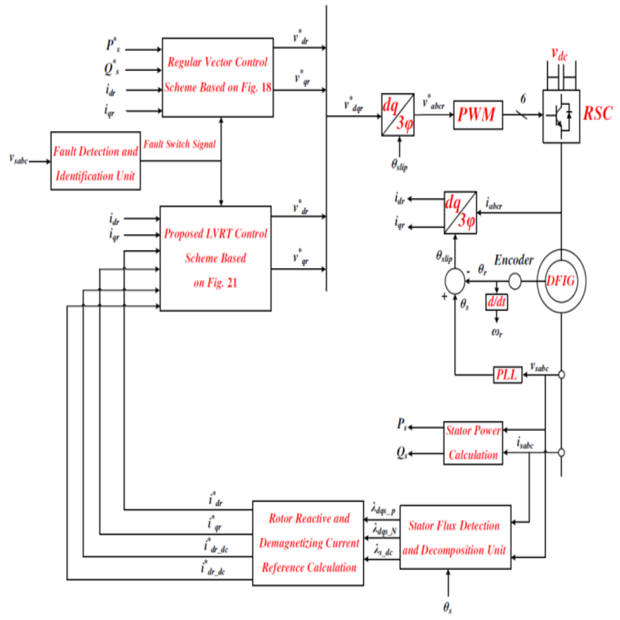


Fig.9. Block diagram for entire Rotor Side control, including the LVRT control scheme.

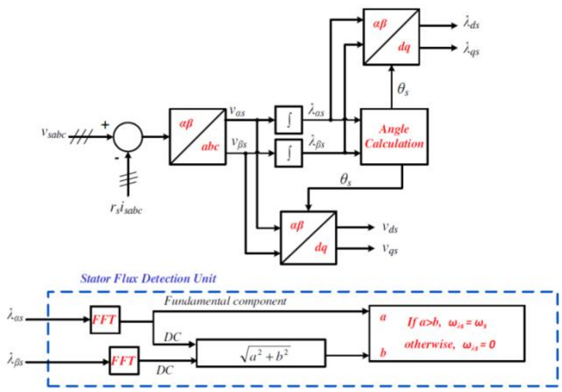


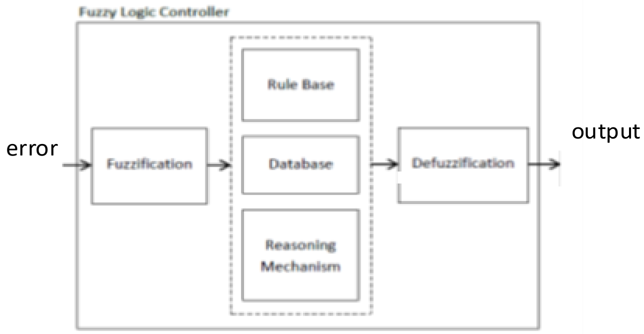
Fig.10. units to calculate and detect Stationary stator flux.

VI. DYNAMIC BEHAVIOR IMPROVEMENT USING FUZZY LOGIC CONTROLLER:

6.1 Fuzzy control system:

A fuzzy logic system is a nonlinear mapping of an input data vector into scalar output, aFLS maps crisp inputs into crisp outputs and it contains four components i.e. fuzzifier, fuzzy rules, inference engine and defuzzifier. Thus, we have seen that the designing of a Fuzzy Logic Controller (using the Mamdani Fuzzy Model) requires:

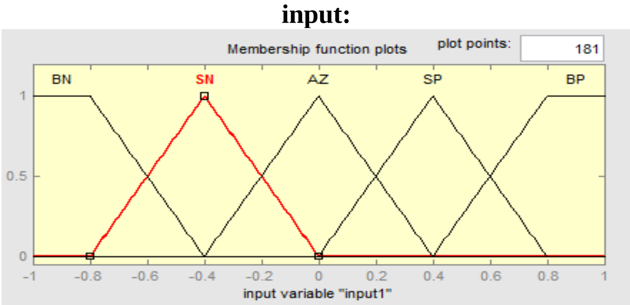
1. To select appropriate inputs and fuzzification.
2. To define input and output membership functions.
3. To define Fuzzy Rule Base.
4. The defuzzification of the output obtained after the processing of the linguistic variables with the help of a proper defuzzification technique.



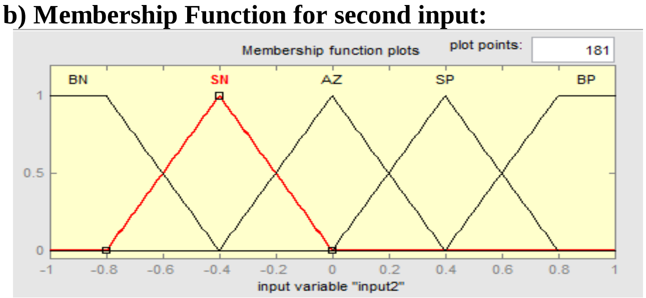
6.2 Fuzzy sets:

The FLS is a control system methodology. A fuzzifier maps crisp numbers into fuzzy sets. It is needed in order to activate rules which are in terms of linguistic variables, which are fuzzy sets associated with them. The designing of fuzzy logic controller is to choose appropriate inputs will be same.

a) Membership Function for first input:



b) Membership Function for second input:



c) Membership Function of Output parameter:

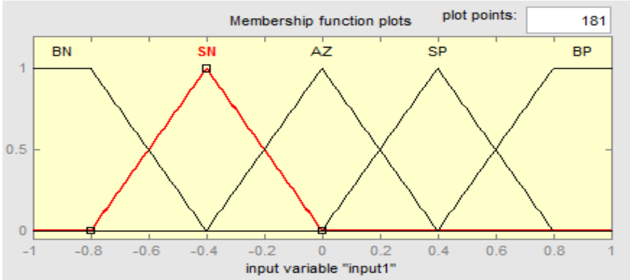
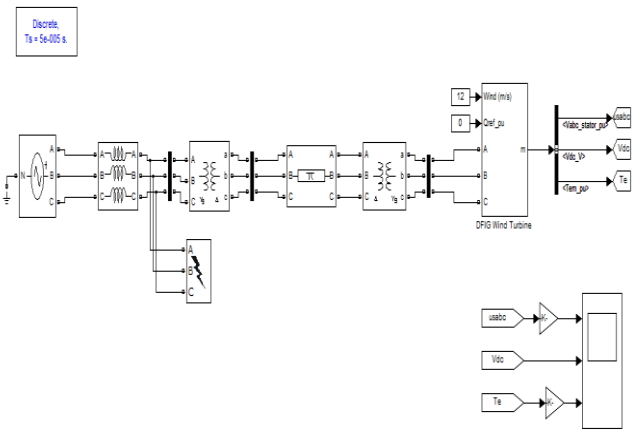


Fig 9 (a) Membership Function for first input (b) Membership Function for second input (c) Membership Function of output parameter

VII. SIMULATION DIAGRAM AND RESULTS:



Proposed System of MATLAB Simulation Diagram.

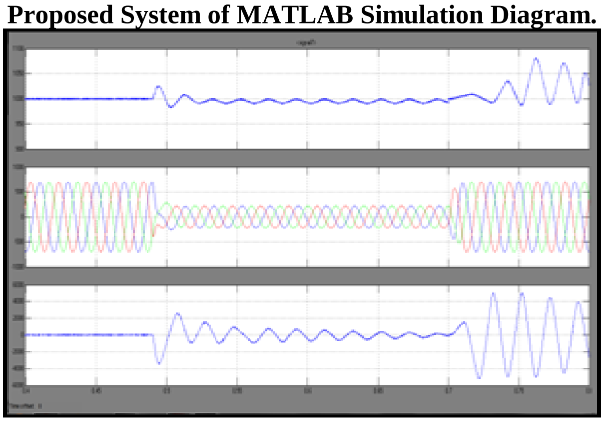
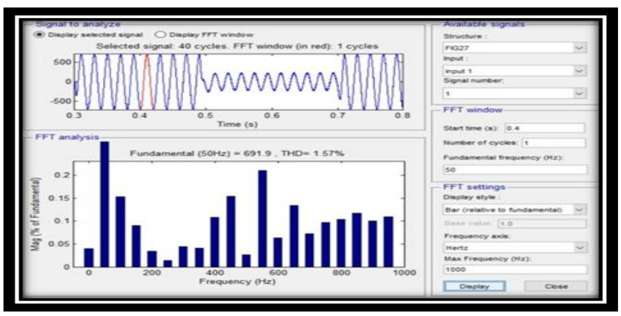


Fig.10. DC bus voltage and torque of DFIG at fault conditions with the control strategy proposed

THD



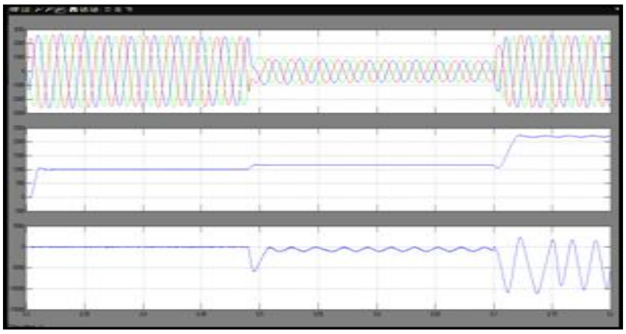


Fig.11. DC bus voltage and torque of DFIG at fault conditions with the vector control strategy

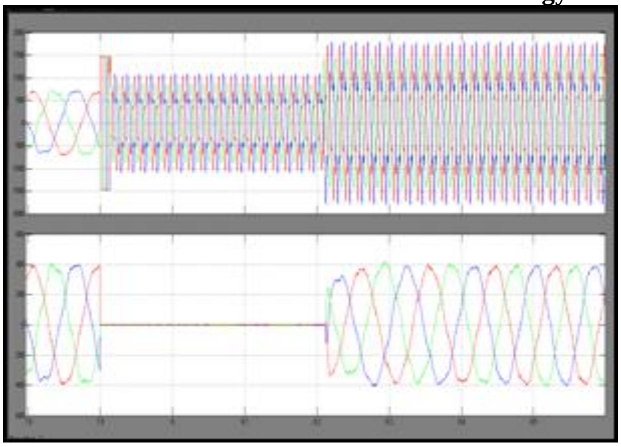


Fig.12. Transient nature of the 3-phvoltage on rotor and current at the instant of grid voltage

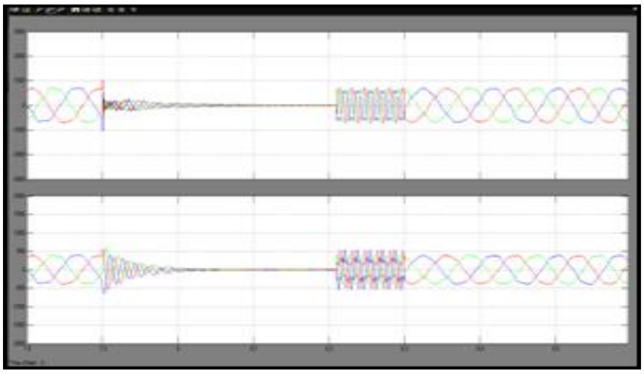
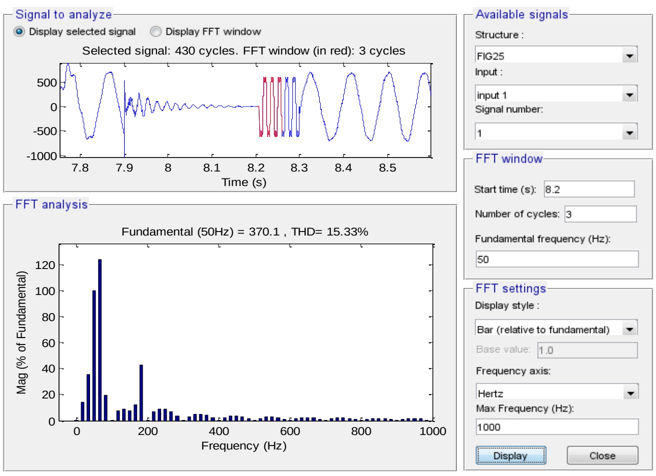


Fig.13. 3-Ph rotor voltage and currents Transient response 3-ph grid voltage dip using the control algorithm proposed

THD:



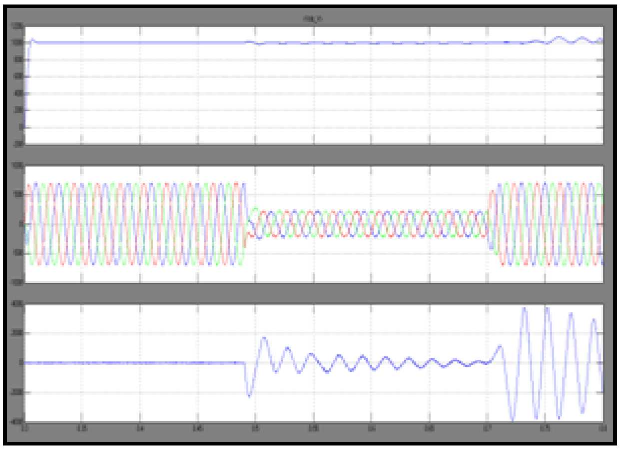
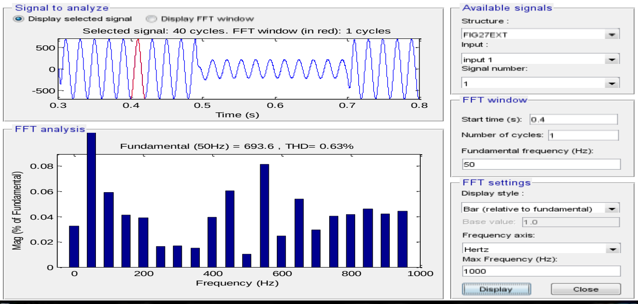


Fig.14. DC bus voltage and torque of DFIG at fault conditions with the Control strategy using Fuzzy Logic

THD:



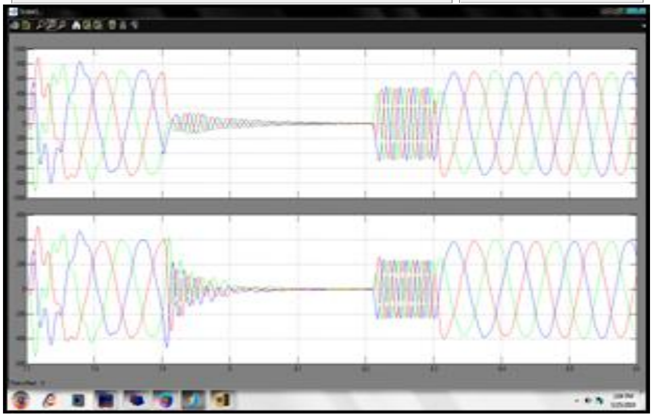
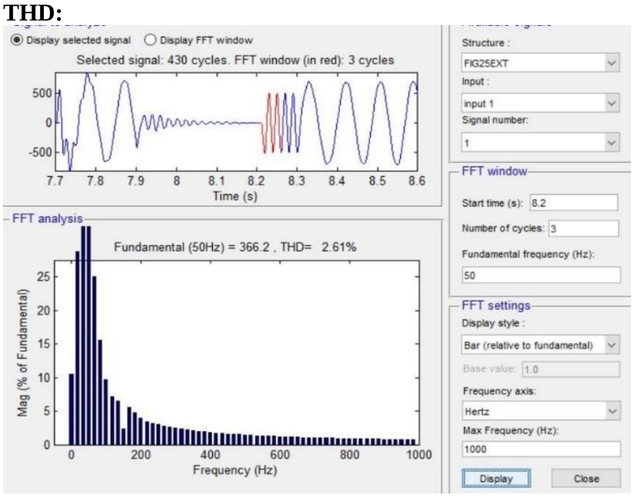


Fig.15. 3-ph rotor voltage and currents transient nature during a 3-ph grid voltage dip with the aid of control algorithm

THD:



Retrieval Number: B7809129219/2019©BEIESP
DOI: 10.35940/ijitee.B7809.129219
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

VIII. CONCLUSION

In this paper, justification of the LVRT of Wind turbines co-operated with DFIG's in the Grid. Simultaneously it exhibits the total portrayal of the transient qualities and the dynamic reaction of the DFIG's at the moment of grid side voltage sags. As an outcome, the FRT methodologies intended for single grid deficiencies don't give the best answer for the FRT of the DFIGs under repeating faults in grid. This paper likewise shows a nitty-gritty portrayal of the most referred to and ordinarily utilized LVRT answers-based wind turbines for DFIG based by improving the RSC control methodologies (dynamic techniques). It portrays the essential principle, just as points of interest and weaknesses of each proposed solution. The control plan comprising of a Fuzzy Logic Controller is more beneficial than the customary controllers like PI controller. At last, another control on rotor side plan to improvise the LVRT capability of wind turbines based on DFIGs during serious dips in grid voltage is proposed. The control methodology targets to moderate voltage and current on rotor side stun at strange grid conditions, with zero additional cost or dependability conditions.

REFERENCES

1. Wang A and Ortega A, Detailed review of the Dynamic response of grid associated Doubly fed Induction Generator Based Wind Turbines under LVRT Conditions, In Proc. 2015 IEEE Energy Conversion Congress.
2. Renewables 2016 global status report, November 2016 20% wind energy by 2030: increasing wind energy's contribution to U.S. electricity supply, U.S. Department of Energy, May 2008.
3. Harley and Qiao, Requirements and solutions for DFIG wind turbines connected to Grid, IEEE
4. Akh. V, Review of dynamic response of high wind power in power systems electric power, 2003.
5. Federal Energy Regulatory Commission - Wind Energy Inter-connection, Dec 2005.
6. Joosand Abbey, LVRT effect on voltage stability, IEEE Jun 2005.

AUTHORS PROFILE

Kaveti Chandra Babu has graduated his B. Tech from ALITS Engineering college, Ananthapuramu, A.P, India and currently he is pursuing M. Tech (EPS) from JNTUA college of engineering and technology, ananthapuramu-515003, A.P, India.

M.Ramasekhara Reddy has graduated his B.Tech from M.S.Bidve Engineering college, Latur in 1999,M.H,India and M.Tech from JNTUA college of engineering ,ananthapuramu in 2007,A.P.presently he is the assistant professor in electrical engineering from the JNTUA College of Engineering, ananthapuramu, A.P,India.