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To Enhance the Power Quality of Wind Turbines under Unbalanced Voltage Condition

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***Abstract*—**The article proposes a control strategy using a voltage control algorithm that uses a proportional-integral (PI) controller to regulate the voltage of the wind turbine, resulting in improved power quality. The Efficacyof the proposed elasticis validated throughemulation results, which show improved voltage regulation and reduced harmonic distortion in the output of the wind turbine.

***Keywords*—**Power Quality, Wind Turbines, Unbalanced Voltage Condition, Grid Faults, Unbalanced Loads, Control Strategy, Voltage Control Algorithm, Proportional-Integral (PI) Controller, Voltage Regulation, Harmonic Distortion

I. Introduction

Wind is a popular renewable energy resource of power that has lesser impact on environment compared to burning of fossil fuels. windmills are extensively used in pumping of water grinding of grains. Because of the absence of the steam engines in earlier days the sailing of ships is done with the help of wind energy. Invention of steam engine, the wind energy is no longer used in ships. In 19th century the electric power based on hydel and thermal technology is widely accepted rather than wind energy.

This helped in designing turbines with two or three blades. For better generation of electricity, turbines with high efficiency and high speed are needed. After second-world war, the deficiency of energy sources urged the development of wind energy, the turbine with less number of blades operate at high speeds to obtain wind power. The small wind turbines developed in olden days has a capacity of only 30 kW and later developed to a capacity of 1500 kW. With several advancements in technology large wind turbines up-to 4 Megawatt capacity are developed. With the advancements in power electronic technology the output power can be controlled smoothly.

Global wind power capacity = 282482 MW									
China	U.S	Germany	Spain	India	U.K	Italy	France	Canada	Other
75564	60007	31332	22796	19051	8445	8144	7196	6200	39852

Wind power capacity in India = 19051 MW									
T.N	Gujarat	Maharashtra	Karnataka	Rajasthan	M.P	A.P	Kerala	Odisha	Other
7154	3093	2976	2113	2355	386	435	35.1	2	3.2

The total installation capacity of wind energy in the world is around 280 Giga watt.Here table 1 and table 2 shows the wind power trends globally and in India respectively:

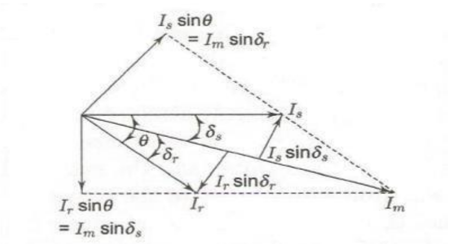
II. BRIEF DESCRIPTION OF PROPOSED METHODOLOGY

These machines became a large portion in wind energy generation. There are two types of three phase induction machines i.e, Squirrel cage type & slip ring (wound type).

In squirrel cage rotor has no fixed number of poles, but the equal poles as that of stator are induced in the rotor automatically by means of induction. In case of slip ring rotor the operation is not possible with unequal number of stator and rotor poles therefore number of rotor poles is made equal to number of stator poles.

When the balanced currents of rotor and stator flow through the distributed winding results in production of rotating magnetic field. The resultant space mmf vectors are represented as shown in figure in the terms of current space vectors.

The electromagnetic torque produced is given by the relation (2.1)



(2.1)

Where Im is the space vector of magnetizing current and it denotes the vector of air gap flux and the Irsinδ_r(Is sinδ_s) are the current vectors that produces torque. The two space vectors are always in perpendicular. The separate control of flux and torque is achieved by controlling Im and Irsinδ_r(Is sinδ_s) vectors respectively. Using this vector control the induction machine can be treated as dc machine with Im as field excitation and Irsinδ_r(Is sinδ_s) as armature current.

DFIGs are mainly employed in the variable speed wind turbine applications. DFIG based wind turbine(WT) connected to microgrid is represented diagrammatically as shown in fig2.2.Here RSC and GSC are connected with a coupling capacitor in between them. The control of RSC and GSC are done separatetly with different controllers each.

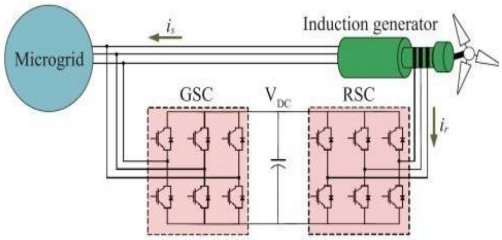


Fig. 1. DFIG based wind turbine schematic diagram

Fuzzy logic is based on the observation that people make decisions based on imprecise and non-numerical information. Fuzzy models or sets are mathematical means of representing vagueness and imprecise information. These models have the capability of recognizing, representing, manipulating, interpreting, and utilising data and information that are vague and lack certainty. The FLC mainly consists of three blocks:

- Fuzzification
- Inference
- Defuzzification

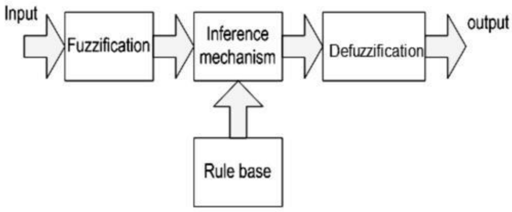


Fig. 2. Block diagram of fuzzy logic controller

III. IMPLEMENTATION OF PROPOSED METHODOLOGY

MATLAB is an elite language for exclusive registering. It organizes estimation, portrayal, and programming in an easy to-use environment where issues and plans are conveyed in common mathematical documentation.

The MATLAB is Application Program Interface (API). This is a library that licenses you to create C and FORTRAN programs that work together with MATLAB. It consolidates workplaces for calling plans from MATLAB (dynamic interfacing), calling MATLAB as a computational engine, and for examining and creating MAT-records.Simulink is an item add-on to MATLAB which is a mathematical gadget made by The Math works association arranged in Natick. MATLAB is energized by wide numerical assessment capacity.

Simulink is an instrument used to apparently program an incredible structure (those addressed by Differential conditions) and look at results.

Regardless of the way that it has down to earth insight in numerical enrolling, an optional instrument stash interfaces with the Maple delegate engine, allowing it to be significant for a full PC polynomial number related structure.

Some of the MATLAB applications listed are**:**

- Orthogonal frequency division multiplexing
- Speech recognition using VQ method
- Channel Estimation and Detection in DS-CDMA
- Investigation of iterative channel assessment and multi-client identification in multi way DS-CDMA channels
- Time-domain signal detection

IV. RESULT AND DISCUSSION

The voltage sag severity aggregates, this may call for the action of disconnecting WTs from grid for further protection. To test the performance the fuzzy based ITSMC controller in mitigating voltage sags so as to avoid disconnection of WTs from the grid, the tests are performed under worst case conditions. At time between t=0.5 sec and t=0.7 sec voltage sag of magnitude 80 percent was:

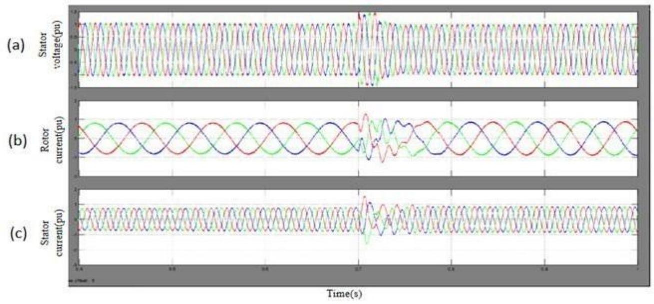


Fig. 3. DFIG (a)Stator voltage(pu),(b)rotor current(pu),(c)stator current(pu) in fuzzy based ITSMC approach

With the same previous test conditions of 80p voltage magnitude the SSMC behavioris tested. The variations in voltage and current of stator, rotor currents variations in this SSMC approach are shown in Figs. 3.2(a)-(b).The active power, voltage of DC-link and electromagnetic torque variations in this voltage sag under SSMC approach are shown in Fig.3.

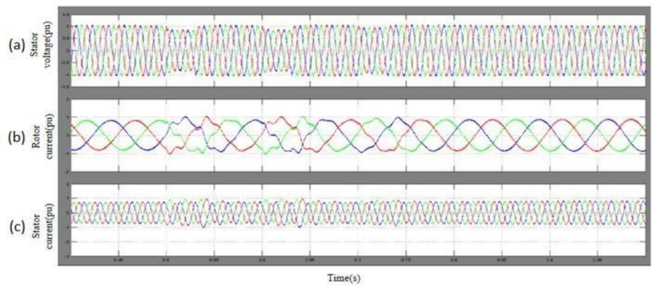


Fig. 4. DFIG (a)(pu),(b)(pu),(c)(pu) in SSMC approach

The rotor, stator inductance and resistance values of DFIG were allowed to a 20percent increase in their corresponding original values. The variations in DFIG's voltage of DC- link and real power due to parameter variationsare compared. In Figs. 3.4 comparisons are made among normal parameters, fuzzy based ITSMC due to parametric variation.

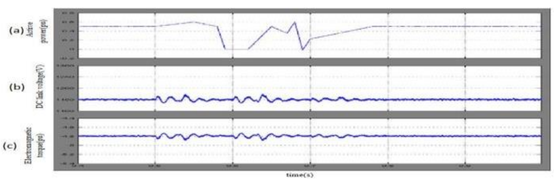


Fig. 5. Comparison between the normal and parametric variations of Electromagnetic torque using fuzzy based ITSMC

In Fig 6 the variations are occurred in the Electromagnetic Torque due to 20percent parametric variations in the DFIG when we compare this two cases in SSMC the variations between the NORMAL and SSMC controller in parametric variations the limits of Electromagnetic Torque are not within the acceptable limits so it is not suitable to continuously connecting the DFIG to the grid, so we need to disconnect from the grid while we are using the SSMC controller.

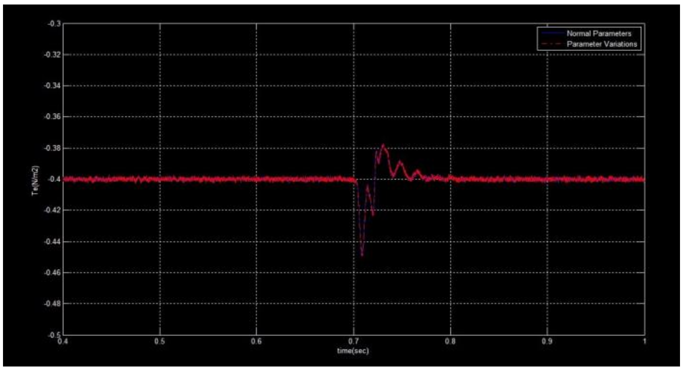


Fig. 6. Comparison between the normal and parameter variations of Electro Magnetic Torque while using SSMC controller.

Similarly In fig 7 the variations are occurred in the DC link voltage due to 20percent parametric variations in the DFIGwhen we compare this two cases in SSMC the variations between the NORMAL and SSMC controller in parametric variations the limits of DC link voltage are not within the acceptable limits so it is not suitable to continuously connecting the DFIG to the grid, so we need to disconnect from the grid while we are using the SSMC controller.

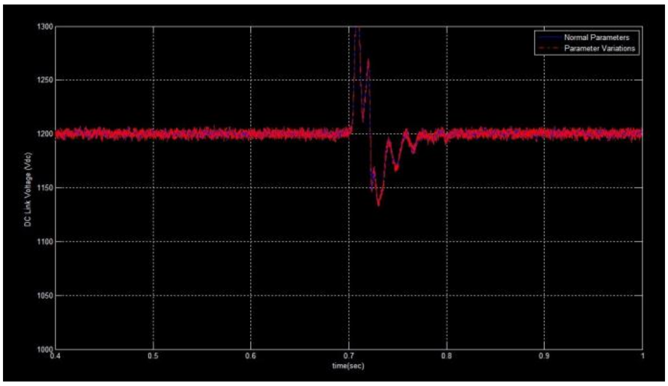


FIG. 7. COMPARISON BETWEEN THE NORMAL AND PARAMETER VARIATIONS OF DC LINK VOLTAGE WHILE USING SSMC CONTROLLER.

When we compare this two cases in SSMC the variations between the NORMAL and SSMC controller in parametric variations the limits of DC link voltage are not within the acceptable limits so it is not suitable to continuously connecting the DFIG to the grid, so we need to disconnect from the grid while we are using the SSMC controller.

V. OVERALL CONCLUSION AND FUTURE WORKS

This improve the power of wind turbines in asymmetrical voltage conditions, an integral terminal sliding mode control design was as shown. The design combines the estimated ability of disturbance observers with the dependability, fast reflexes, and high quality fleeting characteristics of integral terminal sliding mode control. It was successfully added to a wind turbine with DFIG rotor-side (RSC) and grid-side (GSC) converters. Using fuzzy logic, the controller gains were achieved. Deep voltage sags and the parameter scenarios was used to assess it. Also, its dynamic response was examined with that of the standard SMC.

The performance study and simulation results explains the approach seems to be enough for maintaining the currents, electromagnetic torque, active power and DC-link voltage within acceptable bounds even under the high voltage conditions.

In order to control the RSC and GSC of DFIG based wind turbine during unbalanced voltage conditions, as a future extension ITSMC approach based on advanced controllers such adaptive neuro fuzzy inference system controllers can used.

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