COMPARATIVE STUDY OF PI AND FUZZY CONTROLLERS TO CONTROL POWER OF DFIG WIND CONNECTED SYSTEM

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***Abstract:-** From few years, the generation of power from renewable energy sources concern in the aspect to enhance the power which can produced by conventional sources. In all renewable energy sources, the most contributors to power generation is the wind energy generation system. Now a day's wind turbine with variable speed has more influence than fixed speed wind turbines because control of these turbines is easy and has efficient operation. For that reason Doubly Fed Induction Generator (DFIG) modeling is necessary for Wind Energy Conversion System (WECS). The considerable field in power control of renewable energy sources adds the grid connected DFIG based WECS. Generally these are having wind turbines associated with DFIG and turbine coupled DFIG is linked to grid with a power electronic converter.*

In this thesis grid side and rotor side controllers are constructed by using Proportional Integral (PI) controllers. To enhance the controllability PI controllers are replaced with Fuzzy controllers. This paper also shows the comparative study between PI and Fuzzy controller. Mamadani technique is used in fuzzy logic controller membership functions. In matlab-simulink that model is simulated and it shows that the behavior of the system. At the end of this paper results are conferred.

***Index Terms:** Doubly Fed Induction Generator (DFIG), Wind Energy Conversion System (WECS), Fuzzy Logic Control (FLC), Mamadani Technique.*

I.INTRODUCTION

The renewable energy resources are developed to meet the energy demand in our society. Generally the electricity is obtained by different renewable energy sources available in nature like hydropower, solar, wind and geothermal, tides, waves and biomass. DFIG is generally used for the production of electricity through wind energy. Because it has numerous advantages than all other resources.

Generally the manufacturers of wind turbines couples induction generators for power generating units. These may be function as a constant speed machines or a fluctuating speed machines. The constant speed machines are precisely coupled to grid, but the fluctuating speed machines ought to power electronic converters to link with the grid. The constant speed machines don't have that much of energy arrest when compared to fluctuating speed machines. There are disparate leverages for adopting fluctuating speed machine with less mechanical stress and noise of turbine. Fluctuating speed generators are obviously advantageous and have reasonable cost. This paper describes the Doubly Fed Induction Generator (DFIG) working for fluctuating speed wind power production.

The converter part of Doubly Fed Induction Generator (DFIG) is split into two parts one is Grid Side Converter (GSC) and other is named as Rotor Side Converter (RSC). These converters used Pulse Width Modulation (PWM) technique. Grid side converter(GSC) amend the potential at grid and rotor side converter(RSC) drives rotor circuit as well as oversight active and reactive power of stator side. Frequent regulation approaches to PI control of active and reactive powers and to enhance dynamic performance of wind turbine with the accommodation of PI controller specifications. By employing Fuzzy Logic Controllers (FLC) decisive controller outputs can be generated because the consequences of specifications like noise, online uncertain of control specification can be considered.

This paper exports the performance of fluctuating speed wind power generating system with Doubly Fed Induction Generator (DFIG) by adopting Fuzzy Logic based active and reactive power controllers in MATLAB/Simulink.

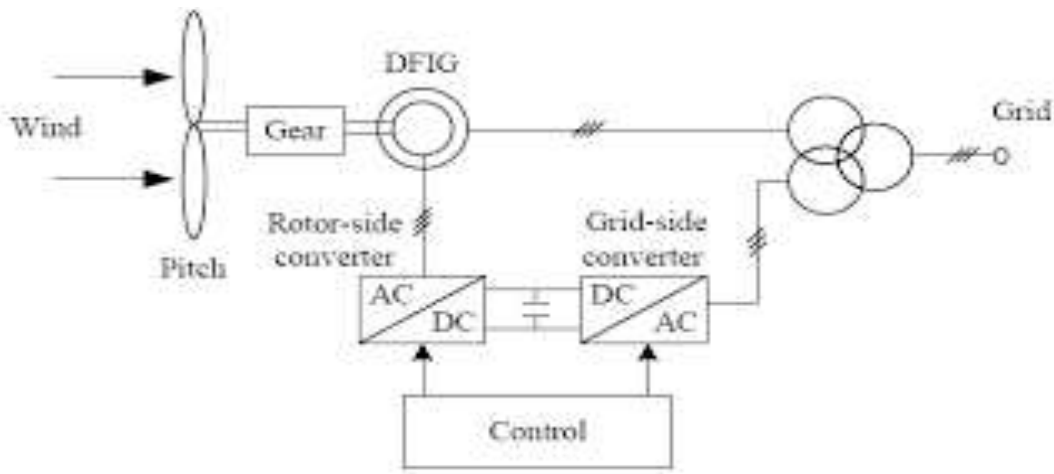


Fig1.1 schematic diagram of doubly fed induction generator (DFIG)

II. DFIG CONTROL TECHNIQUES

We already knew that Doubly Fed Induction Generator (DFIG) has two types of converters. Independent control approach is matured to both Grid Side Converter (GSC) and Rotor Side Converter (RSC). In this contest explains the control strategies for these converters.

2.1Grid Side Converter Control (GSCC)

This type of control is also called as a Stator Side Converter Control. The potential at dc link capacitor can be govern by using a Grid Side Converter Control. For this type of controller the direct axis (d-axis) of the rotating reference frame is adopted for d-q transformation is adjust with the grid potential positive sequence values. The dc link potential between the converters can be adjusted by using this grid side converter shown in fig(2.1). The control of grid side controller (GSC) is achieved by d-q reference frame. The absolute potential at dc link is compared with its reference value Vdc-ref and whatever the difference between those two quantities is called error, that is reached a PI controller to resolve the reference signal for d-q axis current Idq_ref. This quantity is deducted from prevailing value Idqs and again this difference value is sent to one more PI controller to produce the reference voltage for the dq-axis current later it is mutate to abc reference frame.

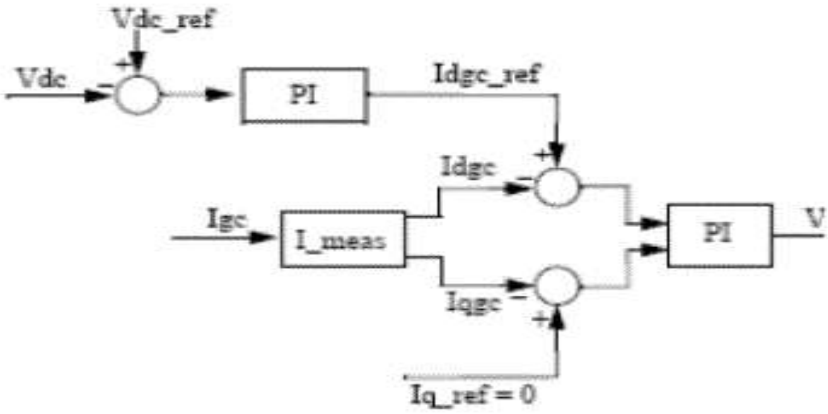


Fig 2.1 Grid Side Converter Control (GSCC)

2.2 Rotor Side Converter Control (RSCC)

The Rotor Side Converter (RSC) is used to regulate the stator voltage that is nothing but reactive power and active power produced by wind turbine as shown in fig(2.2). This controller is also achieved by converting Vabc to dq reference frame. In this contest whatever the rotor current that is dissolve into an active power (d-axis) and reactive power (q-axis) component. The absolute value of active power is compared with reference value and that is persistence by the speed of wind. Whatever the variation between these two quantities will be sent to PI controllers. This produces the appropriate values to d-axis rotor current. Then the PI controller which is placed on reactive power side is used to produce q-axis rotor currents. The outputs obtained from PI controllers are mutate from dq frame to abc frame.

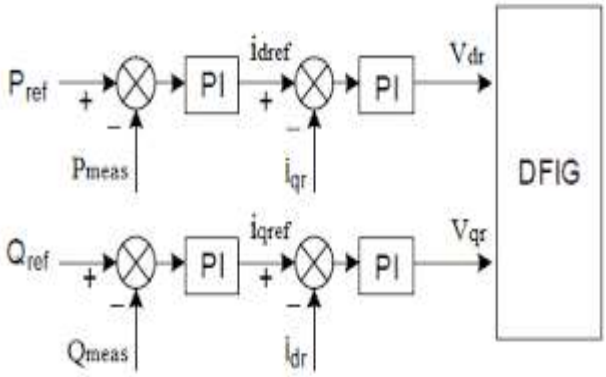


Fig 2.2 Rotor Side Converter Control (RSCC)

2.3 Fuzzy Control System

Frequently for the control purpose, we are using traditional PI controllers. But due to distinctions in numerous specifications erratic and fluctuating wind speeds tuning of PI controller specifications is very complicate in this control method. Perceptive approach with fuzzy control and this can be adequately used instead of PI controller to improve the controllability.

The process of Fuzzy Logic Controller (FLC) is mainly based on

- Fuzzification of entire excitation value into fuzzy membership functions.
- Execution of all suitable rules in rule base to figure out the fuzzy response functions
- Defuzzification of fuzzy response functions to obtain crisp response values.

In this paper, for the controlling purpose a mamadani type fuzzy logic is used. It is used in the place of PI controller which is in GSC, RSC controller. In this we have two input signals, one is error, other is derivative of error and response signal is command derivative. In the rule base we have if and then fuzzy logic conditional statements. These rules design is mainly depend on abstract knowledge and infer from huge simulation tests.

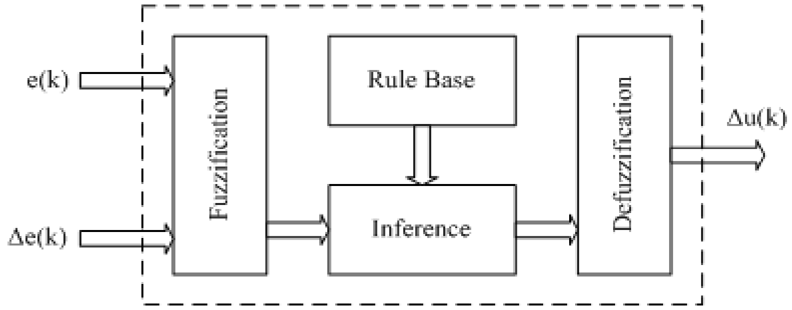


Fig2.3 Fuzzy Logic Controller

For controlling of active and reactive power, a mamadani type fuzzy logic is used. The PI controllers used in grid side and rotor side converter contollers are replaced with fuzzy logic controllers. The fuzzy membership functions and rule bases for each controller is shown below.

Fuzzy Logic Controller For Voltage Regulator:

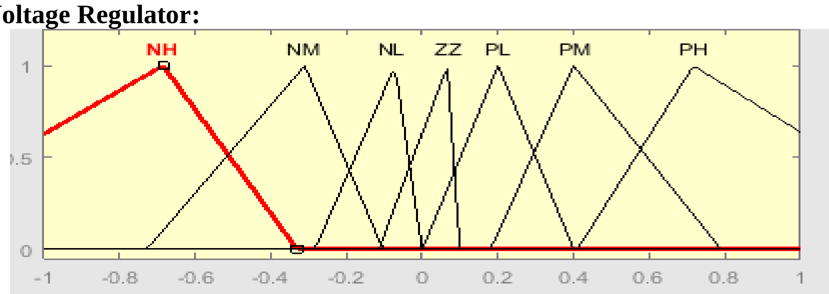


Fig2.4 Membership Functions For Input And Output Signals

Table-1 Rule Base For Fyzzy Logic Controller

e \ △e	NH	NM	NL	ZZ	PL	PM	PH
NH	NH	NH	NH	NH	NM	NL	NH
NM	NH	NH	NH	NM	NL	ZZ	NM
NL	NH	NH	NM	NL	ZZ	PL	NL
ZZ	NH	NM	NL	ZZ	PL	PM	ZZ
PL	NM	NL	ZZ	PL	PM	PH	PL
PM	NL	ZZ	PL	PM	PH	PH	PM
PH	ZZ	PL	PM	PH	PH	PH	PH

In this fuzzy control system we have seven membership functions. Those are ZZ=Zero, NH=NEGATIVE HIGH, NM=NEGATIVE MEDIUM, NL=NEGATIVE LOW, PL=POSITIVE LOW, PM=POSITIVE MEDIUM, PH=POSITIVE HIGH are the input and output signals. The rules are formed by using if and then conditional statements shown in Table-1.

Fuzzy Logic Controller For Power Regulator:

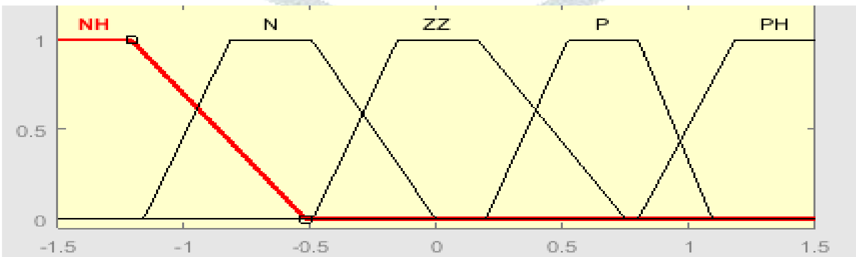


Fig 2.5 Membership Functions For Input Signals

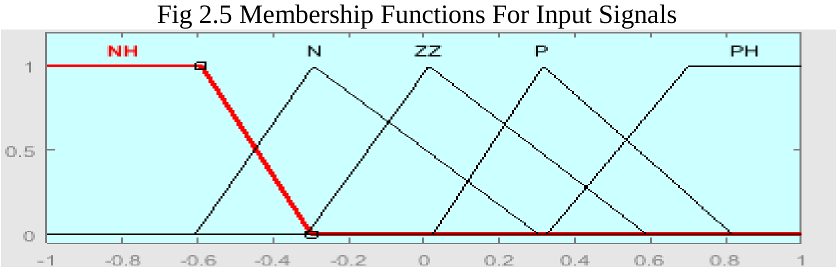


Fig 2.6 Membership Function For Output Signal

Table-2 rule base for fuzzy logic controller

△ e / e	NH	N	ZZ	P	PH
NH	NH	NH	N	N	ZZ
N	NH	N	N	ZZ	P
ZZ	N	N	ZZ	P	P
P	N	ZZ	P	P	PH
PH	ZZ	P	P	PH	PH

In this fuzzy logic controller we have only five membership functions. Those are ZZ=ZERO, NH=NEGATIVE HIGH, N=NEGATIVE, P=POSITIVE, PH=POSITIVE HIGH are taken as input and output signals. The corresponding if and then conditional statements are formed as rules shown in Table-2.

III. SIMULINK MODEL OF FUZZY LOGIC CONTROLLER ADOPTED IN GRID SIDE & ROTOR SIDE:

The simulink model of grid side and rotor side controllers developed with the help of fuzzy logic controllers is shown in fig3.1, fig3.2 and fig 3.3. The matlab model is designed for wind farm of 1.5MW along with wind turbine of 1.5MW linked with distribution system of 25KV voltage depot power to grid of 120KV over a feeder of length 30km & 25KV voltage.

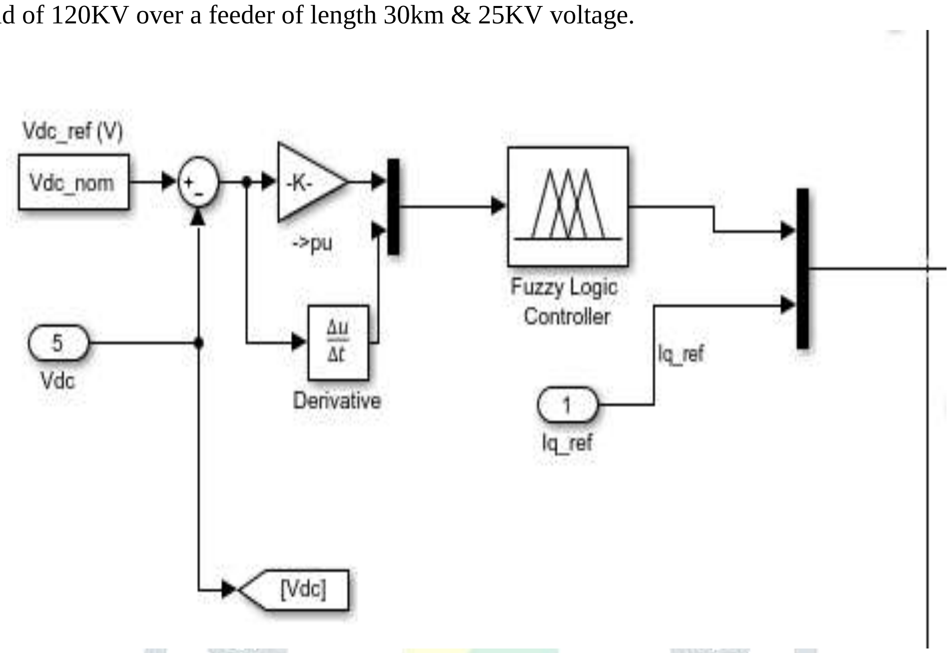


Fig 3.1 Simulink Diagram of GSCC For Voltage Regulation

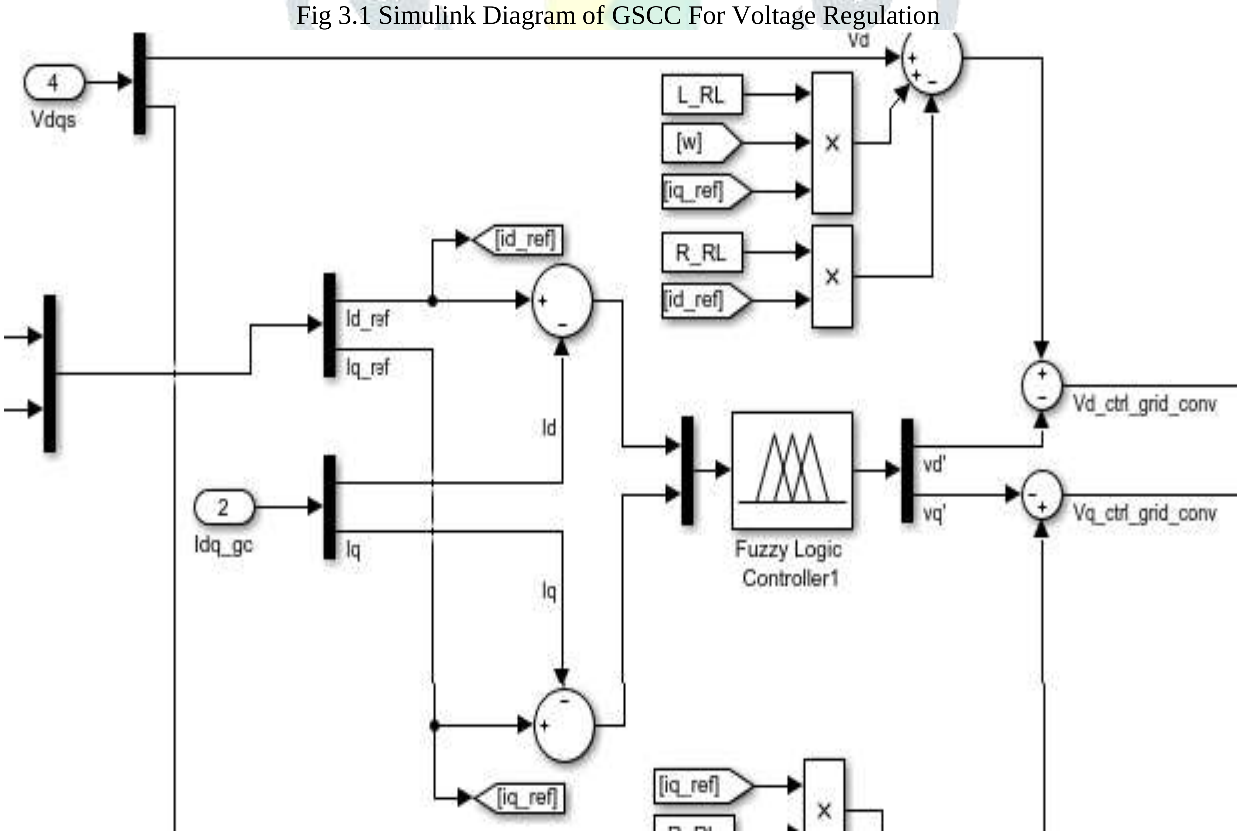


Fig3.2 Simulink Diagram of GSCC For Power Regulation

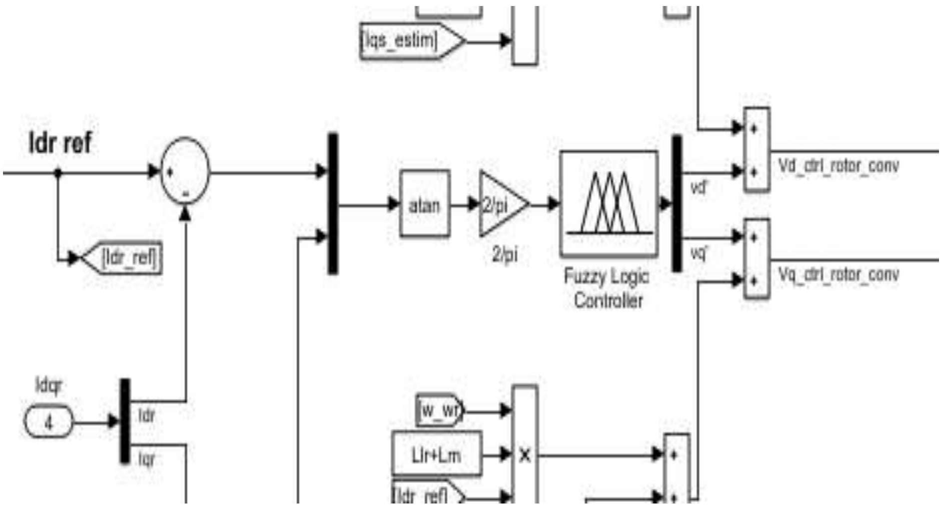
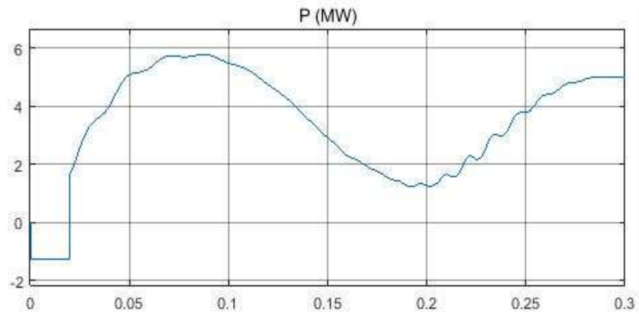


Fig 3.3 Simulink Diagram of RSCC For Power Regulation

IV.RESULTS:

The following simulation results are shows active and reactive powers of doubly fed induction generator.fig 4.1 and 4.2 shows active power by using PI and fuzzy logic controller under normal conditions. Whereas fig 4.3 and 4.4 shows reactive power by using PI and fuzzy logic controller under voltage sag conditions. Here the voltage sag is 0.5v and duration is 0.05 sec.

Fig 4.1(a) & 4.2(a) gives the active power by using PI controller under normal conditions where as fig 4.3(a) &4.4(a) shows active and reactive power under voltage sag conditions.fig 4.1(b) &4.2(b) are the active and reactive with fuzzy logic controller under normal conditions where as fig 4.3(b) &4.4(b) are the active and reactive power under voltage sag condition.



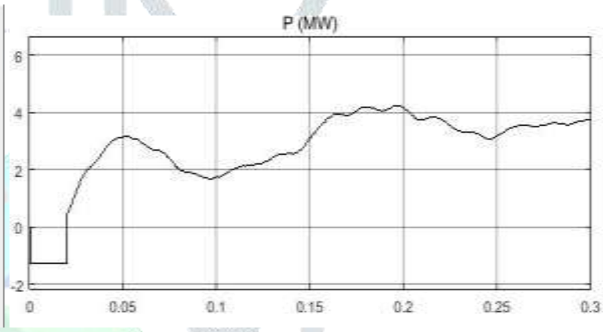
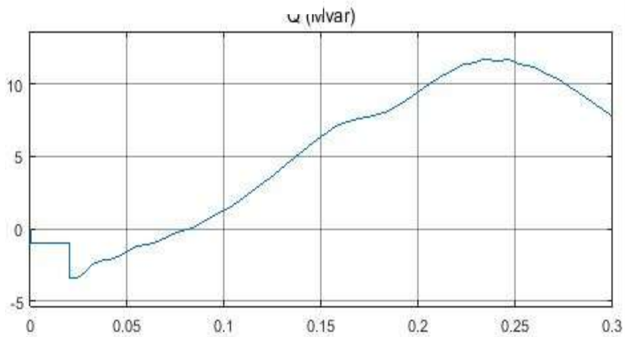


Fig4.1 u Fig4.1 (a) ıditions active power (a)by using PI c Fig4.1 (b) zy logic controller



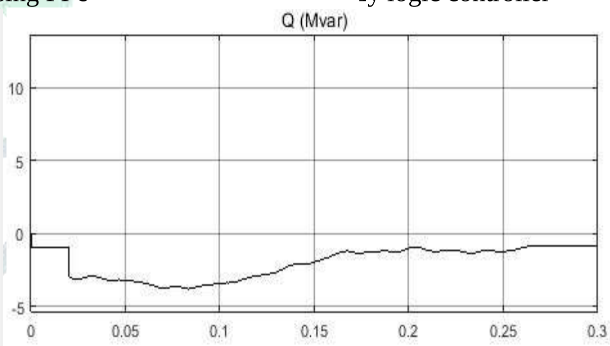
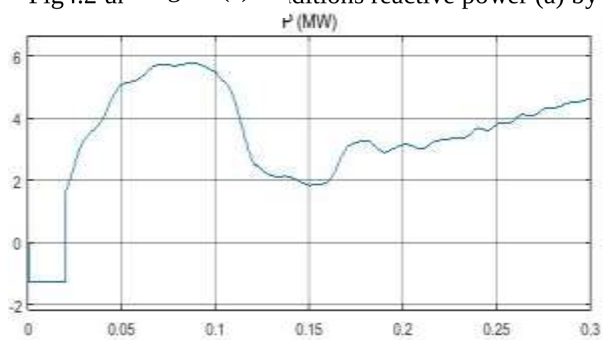


Fig4.2 ur Fig4.2 (a) ıditions reactive power (a) by using PI cc Fig4.2 (b) ng fuzzy logic controller



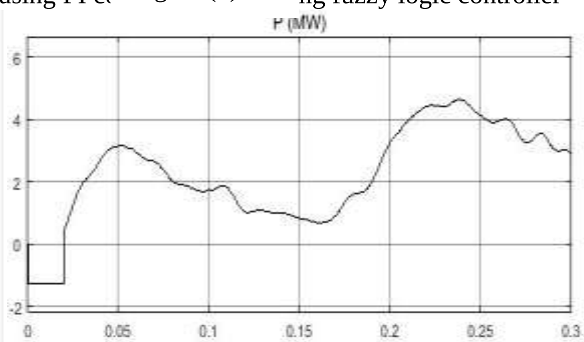


Fig 4.3 u Fig4.3 (a) condition active power (a) by using Fig4.3 (b) ng fuzzy logic controller

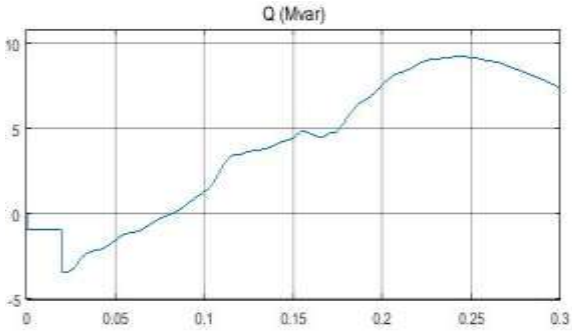


Fig4.4 (a)

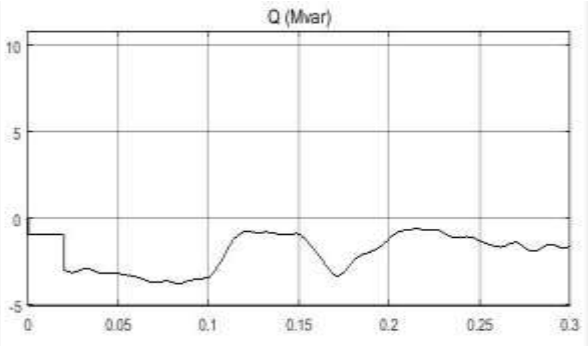


Fig4.4 (b)

Fig 4.4 ur ɔnditions reactive power (a) by ı by using fuzzy logic controller

V.CONCLUSION

The control of wind energy conversion system based on doubly fed induction generator achieved with the help of fuzzy logic controller and comparative study of PI controller and Fuzzy Logic Controller for active and rective power also attained.

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