International Journal of Advancement in Electronics and Computer Engineering (IJAECE)
Volume 12, Issue 7, July 2023, pp.310-315, ISSN 2278 -1412

Development of a Power Quality Situationing in power System By Using Fuzzy-PI Controllers

Seraz Ahmad[1], Prof. Ashish Bhargava[2]
[1]Mtech Scholar,BERI, Bhopal, India
[2] Prof. & HOD, BERI,ashi.sonali12@gmail.com, Bhopal, India

Abstract *– In power system there are so many different types of converters with different strategic controls which play an important role for converting, transmitting, and improving the performance of the high voltage system. There are different types of converters and their control strategies being used in the HVDC system, such as line commutated converter and voltage source converter. To improve the performance of the DC voltage control strategy, the AC active current is used to compensate for the DC voltage. However, now a days drive controllers still have some limitations in certain deficiencies in certain respects, such as in weak AC grid or in high voltage and power levels. The main objective is to simulate the different types of VSC BASED HVDC control strategy for improving the voltage profile of HVDC transmission system. In this project, the application of Fuzzy-PI control is proposed for the permanent magnet synchronous wind generator based on a voltage source converter to improve the Load stability of the VSC- HVDC system with the wind generator, including induction generators fixed speed which use PI- FUZZY controller to achieve good stability performance of controller system under normal and faulty situations. To evaluate the capabilities of the controller system, simulation and analyses are performed on a model system consisting of two wind generators connected to an infinite bus.*

Keywords: **Power Quality, Power System, Fuzzy Logic, Fuzzy-PI Controllers, Voltage**

I. INTRODUCTION

All Electrical power has three section which are: generation, transmission and distribution. In generation section, different kind of energies are converted into electrical energy. Transmission section is used for transporting electrical energy from one end to other station. In distribution section energy is transferred from utility grid to different consumers.

In developing years of electrical technologies, generation is made possible with the help of DC generators, therefore, direct current (DC) transmission system was using in earlier years. Ought to unavailability of technology, electric power is transmitted at low voltage levels. Transmission systems were having high voltage drop and losses because they were working at low voltage levels and it was the main drawback of previous systems. To overcome these problems, inventors went for the AC transmission through which power can be transferred for a long distance. After invention of alternating current, transformer came into picture through which power can be transferred for a long distance by increasing the value of voltage. Although in transmission, AC system has the biggest problem which is synchronization of systems, buses and grids etc. Voltage drop at the load end is also a bigger problem and it comes in the system due line impedance which reduces the load end voltage. Distance is the main problem in transmission system because impedance of the line increases with the increase in distance and it is more severe problem in AC transmission but not in DC transmission because AC transmission require minimum three wire to transmit power and DC require only two wire.

The main problem was to transmit the power over long distances. In Sweden, consumer centers is far away from hydro plant which is established in north to the centers. That transmission line was having a 400KV AC voltage level which was the highest voltage level in the world at that time. After few years later, in 1954, mercury-arc valves was developed which lead to the build of first direct current link between the island of Gotland with the mainland of Sweden .

With the advent of thyristors in 1967 mercury-arc rectifiers and thyratron tubes are replaced by thyristors because it has better capability than others. Thyristor word is taken from two words which are Thyratron and Transistors. Greek word “thy” is taken from thyratron which means ‘switch’ and suffix word “-istor” is taken from transistor which recognize that this device belongs to semiconductor devices . Like diode, it also provides output when it is in forward bias but with trigger pulse. It works only in one direction. It is also named as SCR (Silicon controlled rectifier) which differs it from other similar devices like GTO and TRIAC. It doesn’t turn-off until current flow in it goes below to level of holding current of

it. It commutated by natural or line-line commutation [30]. Properties of ideal SCRs are:

a) It doesn't have voltage drop across it.

b) During reverse bias, there is no reverse current.

c) Zero holding current.

II . HVDC SYSTEM

The HVDC transmission system was used because it has advantages compare to HVAC transmission as lower transmission losses, power controllability is better , stresses is reduced on cables, connection between asynchronous systems, , stability is better and so on .
In India there are five HVDC transmission LINE
1. Vindhyachal HVDC LINE
2. Rihand TO Delhi. HVDC LINE
3. Chandrapur TO Padghe. HVDC LINE
4. Vizag I&II. HVDC LINE
5. North-East TO Agra . HVDC LINE

Fig. 1.1- HVDC LINE in India

III. METHOD

The VSC BASED HVDC system

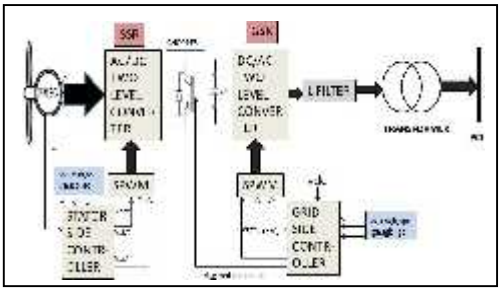

Fig. 2: Circuit diagram of VSC- HVDC system with wind generator

The wind generator is connected with wind turbine at fix speed . Due to simple mechanical construction & low cost induction generator are used . When required reactive power is not supplied induction generator goes in un stable situation. So it is disconnected from the power grid. System reactive power goes in unstable situation during under steady state situation. In this situation the voltage of wind generator creates fluctuation. So to improve the stability few methods like; FACT,STATCOM ,SVC,UPFC,SMES are used.

To get better output PMSG BASED WIND ENERGY CONVERSION SYSTEM and induction generator are used combine with some power electronics system. VSC convertor are linked between stator side convertor and grid side convertor. The grid side convertor delivers the Active &Reactive power to the system.

During the fault situation parameters of system will change so this will effect on controlling of convertor .For this we use PI controller to control the convertor of PMSG BASED WIND ENERGY CONVERSION SYSTEM.It is simple in construction & its performance is better in all situations.

PI controller is simple but they are not capable to control always in changing parameters. So to control Fuzzy controllers are used.

Fuzzy controllers are designed to control the PI controller parameter during variation in operating situation. So PI & Fuzzy controller better control performance during variation in operating situation.

Model of work power system

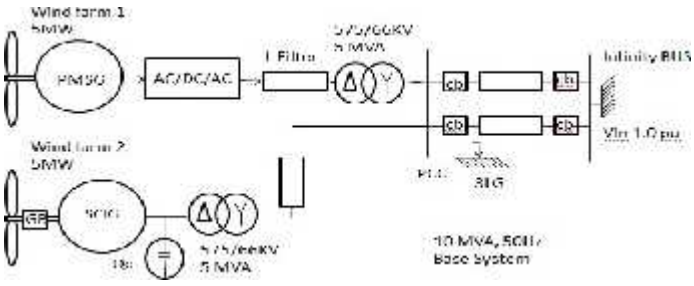

Fig. 3:Power system model of system

As present in fig. no. 3 , the wind generator 1&2 are PMSG BASED WIND ENERGY CONVERSION SYSTEM& Induction Generator .

With the help of turbine & wind generator power is generated. After that step up the voltage &transmitted to transmission line.

When Fault is go down e on transmission line of generator no. 2 , total load is shifted to generator no.1during the time of fault. During that duration the voltage is very low and current is very high .So with this situation the connected load device will damage. So this is required to maintain the stable situation as fast as possible.

In this situation at the fault duration , fault line is disconnected by circuit breaker and other generator try to adjust the speed to maintain the required power converted in to power.

PMSG BASED WIND ENERGY CONVERSION SYSTEM is a variable speed generator . So this generator adjust the speed during fault situation to maintain the required power.

Parameter used are given below

Table 1: Parameters of system

Parameters of System	**Used Ratings.**
Pmsg Based Wind Energy Conversion System(Permanent Magnet Synchronous Generator)WindTurbine.	575 Volt. 50 Hz
Wind Generator:Asynchrounus Generator.	480 Volt ,5 Mva,50 Hz
TRANSFORMER No. 1&2	5MVA, 575/66 Kv, 50 Hz
TRANSMISSION LINE No. 1&2	RL(Res. =0.1Ohm , Inductance=0.00127 H)
Grid(Three Phase Source)	66 Kv,50 Hz

Control strategies of VSC BASED HVDCwith wind generators system

There are so many control techniques are used in power system .For control of power system we used PI controller, FUZZY controller.

PI controller

A proportional–integral is a control loop mechanism mainly used in industrial control systems and other applications requiring continuously modulated control. A PI controller continuously calculates an error value as the difference between a desired set point and a measured process variable and applies a correction based on proportional, integral which give their name to the controller.

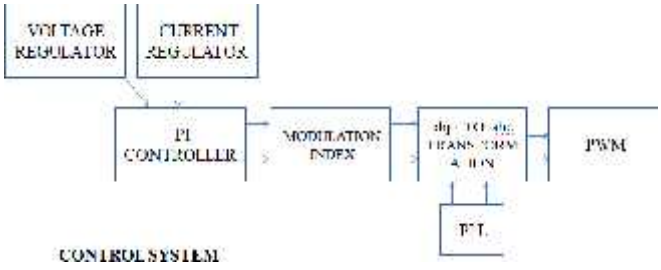

Fig. 4: Control system

PI controllers will eliminate forced oscillations and steady state error. However, introducing a integral mode has a negative effect on speed of the response and overall stability of the system. Thus PI controller will not increase the speed of response. It can be expected since PI controller does not have to perfect what will happen with error near future.This problem can be solved by introducing derivative mode which has the ability to predict what will happen with the error in near future and thus to decrease a response time of the controller. PI controllers are very often used in industry, especially when speed of the response is not an issue. A control without D mode is used when:

- Fast response of the system is not requiring.
- Large disturbances & noise are present during operation.
- There is only one method to find energy storage in this process (capacitive or inductive)
- There is large transport delay in the system.

The process controllers are placed a tremendous role in plant control system and offered an efficient control of process parameters during steady state and transient situation, But the tuning of procedure is necessary step of selecting proper P, PI, PID setting to control the process. Finally, it is concluding the TRIAL AND ERROR method is only the solution to find better parameters but in air this method; there are two methods which can reduce the no of trial s to find parameter.

FUZZY logic controller:

Fuzzy logic is a derivative from classical Boolean logic and implements soft linguistic variables on a continuous range of truth values to be defined between conventional binary i.e. [0, 1]. It can often be considered a subset of conventional set theory. The fuzzy logic is capable to handle approximate information in a systematic way and therefore it is suited for controlling nonlinear systems and for modeling complex systems where an inexact

model exists or systems where ambiguity or vagueness is common." The aim of fuzzy logic control is to model the human experience and the human decision-making behavior.

The importance of fuzzy logic derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature. In doing so, the fuzzy logic approach allows the designer to handle efficiently very complex closed-loop control problems. There are many artificial intelligence techniques that have been employed in modern power systems, but fuzzy logic has emerged as the powerful tool for solving challenging problems.

Advantages of Fuzzy logic Controller

- A simpler and faster methodology.
- It does not need any exact system mathematical model.
- It can handle nonlinearity of arbitrary complexity.
- It is based on the linguistic rules with an IF-THEN general structure, which is the basis of human logic.
- It is more robust than conventional nonlinear controllers.

Fuzzy logic is a superset of Boolean (conventional) logic that handles the concept of partial truth, which is a truth value between "completely true" and "completely false". Fuzzy logic is multivalued. It deals with degrees of membership and degrees of truth. Fuzzy logic uses the continuum of logical values between 0 (completely false) and 1 (completely true).Fuzzy logic controller is a popular computing frame work based on the concept of fuzzy set theory, fuzzy if- then rules, and fuzzy reasoning.

FUZZY –PI controller

In this study, the d-axis and the q-axis components are assumed identical, and hence the current loop control system can be analyzed by using one axis component only. Block diagram of Fuzzy-PI controller for d-axis current component is shown in Fig. 12. Here FLC adjust the PIparameters according to operating situations, e.g., the error (e) and change in error (de) of the input signals, which characterizes its first time derivative during process control. To determine control signal for proportional gain (Kp), inference engine with rule base having if-then rules in form of "If e and de, then Kp " is used. Figs. 13 and 14 show the membership function for input e/de and output Kp. The variables fuzzy subsets for input are Negative Big (NB), Negative Small (NS), Zero (Z), Positive Small (PS), and Positive Big (PB). Due to the variation of the d-axis or q-axis current between -1 to 1 pu, the range of input membership function is also set at this interval. Table II shows fuzzy control rule base for gain Kp. In this work, Mamdani's max-min method is used for inference mechanism. The center of gravity method is used for defuzzification

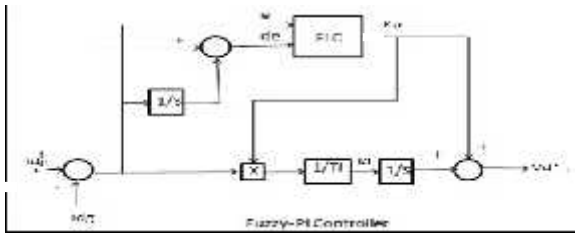

Fig. 5: fuzzy-PI controller

IV. RESULT

The voltage VSC BASED HVDC simulation with wind generator by pi-fuzzy controller

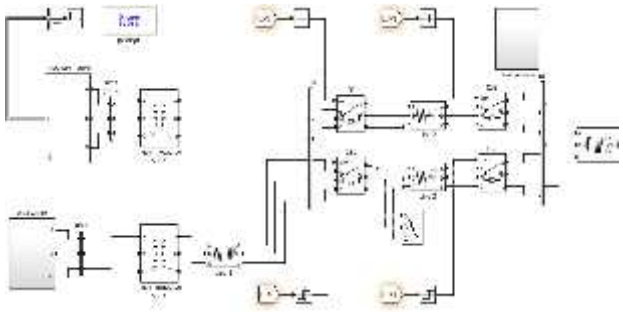
Fig. 6: VSC BASED HVDC simulation with wind generator using PI-FUZZY controller

The VSC BASED HVDC simulation with wind generator generation with fuzzy-PI controller is presented in fig no.6. In which wind generator 1 and wind generator 2(5MW) is connected to the infinite bus through power converters, filters with grid .

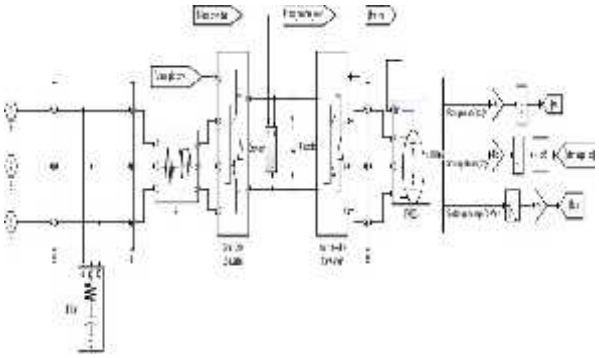
Fig. 7:Control circuit using FUZZY logic controller

The control circuit diagram for VSC BASED HVDC simulation of with wind generator generation with fuzzy-PI controller is presented in fig no.7 .

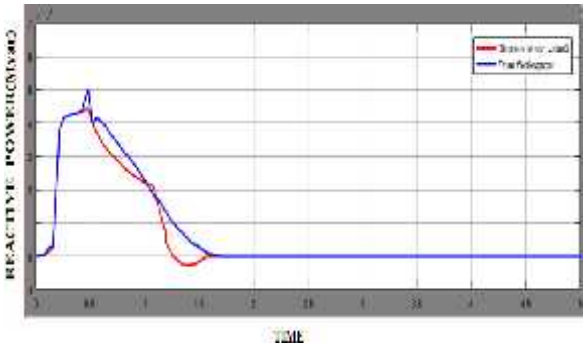

Fig. 8: Reactive power signal pattern at wind generator 1

The signal pattern of reactive power at wind generator 1 of VSC BASED HVDC with wind generator generation with fuzzy-PI controller is presented in fig no.8. In which of PI controller result line are red and fuzzy controller result line are blue .when we compare them fuzzy logic controller result is more improved than the result of PI controller.

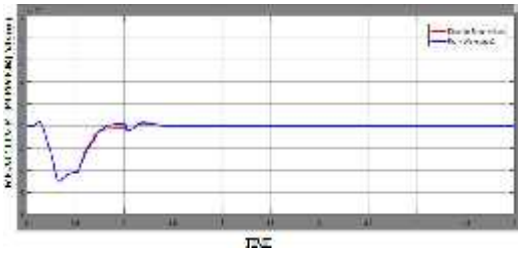

Fig. 9: Reactive power signal pattern at wind generator 2

The signal pattern of reactive power at wind generator 2 of VSC BASED HVDC with wind generator generation with fuzzy-PI controller is presented in fig no.9.

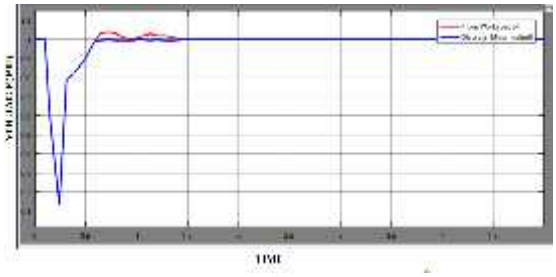

Fig. 10: Terminal voltage signal pattern
The terminal voltage of VSC BASED HVDC with wind generator generation with fuzzy-PI controller is presented in fig no.10.

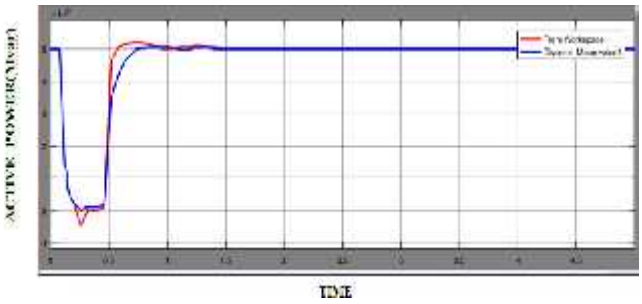

Fig. 11: Active power signal patternat wind generator 1

The signal pattern of active power at wind generator 1 VSC BASED HVDC with wind generator generation with fuzzy-PI controller is presented in fig no.11.

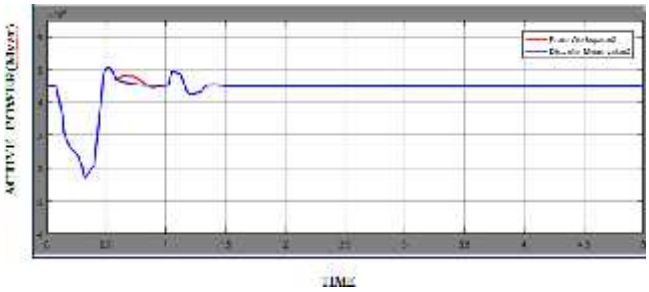

Fig. 12: Active power signal pattern of at wind generator 2
The signal pattern of active power at wind generator 2 VSC BASED HVDC with wind generator generation with fuzzy-PI controller is presented in fig no.12.network.

V. CONCLUSION

As We controlled the active power and reactive power, so the system voltage is stabilized and performance improved. When active power is +ve and reactive power is -ve , the current value will come near to zero, so the system voltage is stabilized. When the active and reactive power changes , voltage and current will also change , this will help in HVDC voltage stabilization.

Fuzzy-PI controller is used in the grid side converter controllers of wind generator to improve its Load stability as well as the performance of the connected other wind generator with Fixed Speed Wind Generators.

During fault situations Fuzzy-PI controller is very effective in improvement of the Load stability of overall system. During under voltage situation the applied voltage drop is approx 90 % of rated voltage at 2.5 sec and at that time the behavior of active and reactive

power changes as per the situation. And the voltage is stabilized.

References

[1] M. Imhof, A. Fuchs, G. Andersson, And M. Morari, “Load Stabilitycontrol Using Vsc Based Hvdclinks And Model Predictive Control,” Ieee-2014

[2] J. Khazaei, P. Idowu, A. Asrari, A. Shafaye, And L. Piyasinghe, “Review Of Hvdc Control In Weak Ac Grids,” Electric Power Systems Research, Sep. 2018

[3] O. J. Eyenubo And P. Oshevire, “Improvement Of Power System Quality Using Vsc-Based Hvdc Transmission,” Nigerian Journal Of Technology,

[4] H. F. Latorre And M. Ghandhari, “Improvement Of Load Stabilityby Using Vsc-Hvdc,” South Korea, 2009

[5] M. A. Hannan Et Al., “Advanced Control Strategies Of Vsc Based Hvdc Transmission System: Issues And Potential Recommendations,” Ieee Access, Vol. 6, Pp. 78352–78369, 2018

[6] Y. Zhang, W. Zhuang, M. Sun, L. Huang, J. Liu, And P. Xu, “A Study On Monitoring Technology For Multi-Terminal ±500kv Vsc Based Hvdcpower Transmission System,” In 2017 Ieee 2nd Advanced Information Technology, Electronic And Automation Control Conference (Iaeac)2017

[7] S.M. Muyeen, Member, Ieee, R. Takahashi, Member, Ieee, T.Murata, And J. Tamura, Senior Member, Ieee“Low Voltage Ride Through Capability Enhancement Of Fixed Speed Wind Generator”,Ieee-2017

[8] Marwan Rosyadi, Rion Takahashi, Junji Tamura Japan S. M. Muyeen. “Fuzzy-Pi Controller Design For Pm Wind Generator To Improve Fault Ride Through Of Wind Generator”Ieee-2018

[9] R. Doherty, E. Denny, M. O’malley, "System Operation With A Significant Wind Power Penetration", Ieee 2017

[10] K.S. Salman, A.L.J. Teo, "Windmill Modeling Consideration And Factors Influencing The Stability Of A Grid-Connected Wind Power-Based Embedded Generator", Ieee Trans,May 2003

[11] Z. Litipu, K. Nagasaka," Improve The Reliability And Environment Of Power System Based On Optimal Allocation Of Wpg", Ieee. Power Systems Conf.. 2004.