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Control Scheme for Wind Energy System with Fuzzy Controlled Statcom

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***Abstract*: -- When the wind farm is integrated into the power system, it has a stability problem. Fixed speed induction generators require reactive power to maintain air gap flux. Reactive power equipment like Static Synchronous Compensator (STATCOM) can be used to enable induction generators to recover from severe system disturbances and stabilize grid-connected wind generator. These devices have the ability to absorb or inject the reactive power. In this paper PI-based, Static Var Compensator is replaced, by the fuzzy controller in the AC voltage regulator and STATCOM has been Re-designed to make the comparative analysis between the PI-based controller and fuzzy controller. It will help to improve the overall performance of the grid and better control of reactive power with the help of the fuzzy controller.**

I. INTRODUCTION

In this wind model containing 9MW wind turbines in the form 3 pairs i.e. 1.5*2 in this type the three pairs are to be available. This wind turbines connected to 33kv distribution system that gives power to 120kv grid by a 25 km 33kv feeder. The simulation of 9MW wind farm is done by using 3 pairs of 1.5MW wind turbines. The stator winding is directly connected to a grid and the rotor is driven by a variable pitch wind turbine. The generator output power should be limited at its nominal value for wind exceeding the nominal speed (9m/s) that's why we need to control the pitch angle. For the generation of power the speed of the induction generator must be greater than the synchronous speed. Variation of speed between no load and full load is approximately 1pu and 1.005pu respectively. Protection system used by each wind turbine to monitor voltage, current and machine speed. For each wind turbines wind speed can controlled. Initially wind speed is set at 8m/s. For wind turbine 1 at t=2sec the wind speed is increased up to 11m/s. The same will happen to rest of the wind turbines.

STATCOM

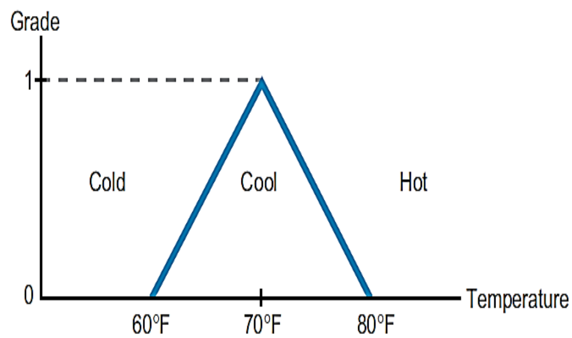
In a STATCOM from a DC input voltage source provided by the charged capacitor Cs. The converter produces a set of controllable three phase output voltage with the frequency of the ac power system. By changing the amplitude of the output voltage, the reactive power interchange between the converter and the alternating current system can be controlled in a manner as same as that of rotating machine. The main components of STATCOM are DC capacitor switching converter, leakage inductance and a coupling transformer .A dc capacitor provide DC input and also act as a energy storage device. A switching converter is used to convert DC to AC, generally a three phase voltage source converter are used in STATCOM. The output of a switching converter is a step wave. So the convert step wave into sine wave a inductor is connected between coupling transformer and switching converter. In actual transmission application number of elementary converter like 2-level, 6-pulse or 12-pulse with PWM skill are used. If only reactive power is to be controlled a size of dc capacitor is relatively small. If the converter is used to controlled both active as well as reactive power a dc capacitor with energy storage of significant capacity is required.

Design & Implementation

In this Paper PI based Static Var Compensator is replaced, by the fuzzy controller in the AC voltage regulator and STATCOM has been Re-designed. The PI based Static Var Compensator block is taken from the standard Simulink library. The PI controller of AC voltage controller is chosen for replacement with fuzzy controller because the output of the AC voltage regulator is the reference current Iqref for the current regulator (Iq = current in quadrature with voltage which controls reactive power flow). The expected outcome of the design is to have a fuzzy logic controlled STATCOM for the steady state and transient stability of grid connected WPGS.

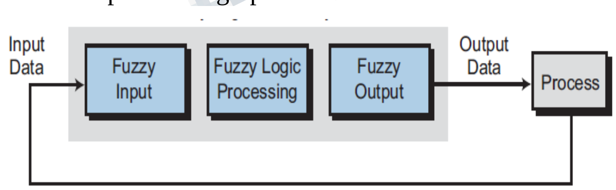
Basic Concept of Fuzzy

Fuzzy logic controller is that controller who deal with the artificial intelligence that deals with reasoning algorithms used to emulate human thinking and decision making in machines and systems. These algorithms are used in applications where process data cannot be represented in binary form. For example, the statements "the air feels cool" and "he is young" are not discrete statements. They do not provide concrete data about the air temperature or the person's age (i.e., the air is at 65°F or the boy is 12 years old). Fuzzy logic gives the statements like these so that they make logical sense. In the case of the cool air, a PLC with fuzzy logic capabilities would interpret both the level of coolness and its relationship to warmth to ascertain that "cool" means somewhere between hot and cold. In straight binary logic, hot would be one discrete value (example. logic 1) and cold would be the other (example logic 0), leaving no value to represent a cool temperature. In the binary logic, fuzzy logic can be thought of as gray logic, which creates a way to express in-between data values. Fuzzy logic associates a grade, or level, with a data range, giving it a value of 1 at its maximum and 0 at its minimum. For ex. Given Figure illustrates a representation of a cool air temperature range, where 70°F indicates perfectly cool air (i.e., a grade value of 1). Any temperature over 80°F is considered hot, and any temperature below 60°F is considered cold. Thus, temperatures above 80°F and below 60°F have a value of zero cool, meaning they are not cool at all.



Fuzzy Logic Operation

below Figure illustrates a fuzzy logic control system. The input to the fuzzy system is the output of the process, which is entered into the system through input interfaces. For example, in a temperature control application, the input data would be entered using an analog input module. This input information would then go through the fuzzy logic process, where the processor would analyze a database to obtain an output. Fuzzy processing involves the execution of IF...THEN rules, which are based on the input conditions. An input's grade specifies how well it fits into a particular graphic set.



Fuzzy Controller Design

In this work PI controller in AC Controller of STATCOM is replaced by FLC to modify the overall output. Fig 1 indicates the PI controller implemented in STATCOM.

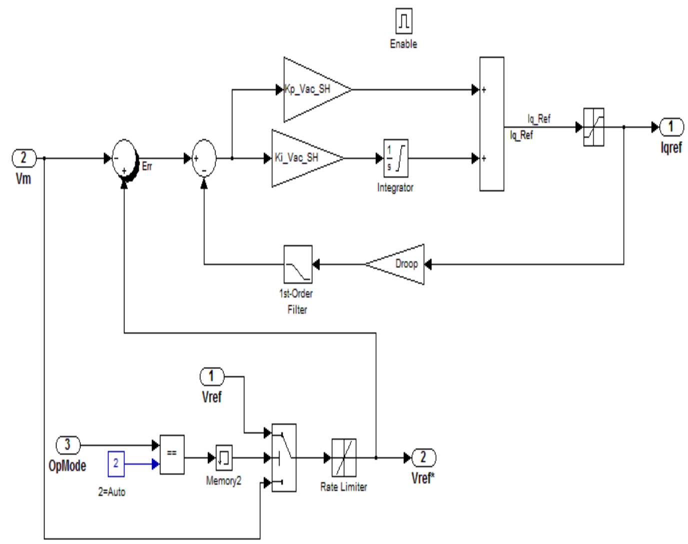


Fig.1 PI Controller connected in STATCOM

Fig 2 indicates the FLC connected in the STATCOM. Two inputs used FLC controller are the error signal & the change in the error signal of AC voltage regulator block inside the STATCOM.

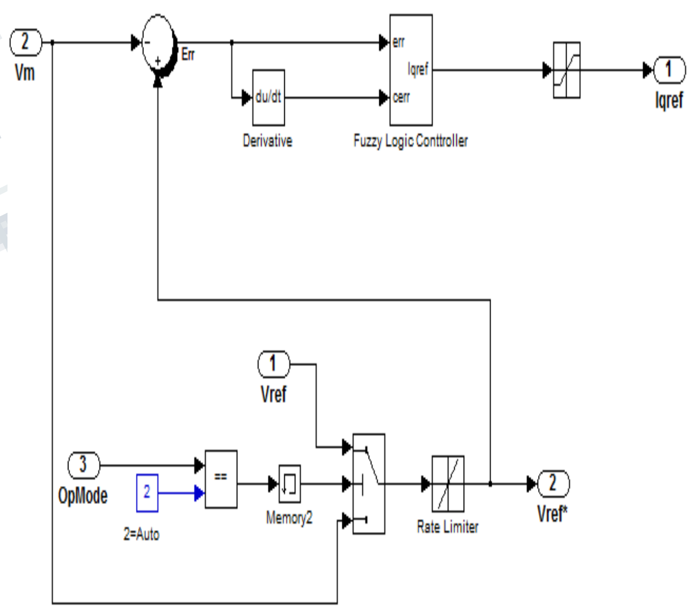


Fig. 2 Fuzzy Logic Controller connected in STATCOM

Fig 3 indicates the inside view of the FLC three gains are provided for inputs & output. For error signal gain provided is Ke. Gain provided for change in error signal is termed as Kce whereas the gain provided for the output signal i.e Iqref is termed as KIqref.

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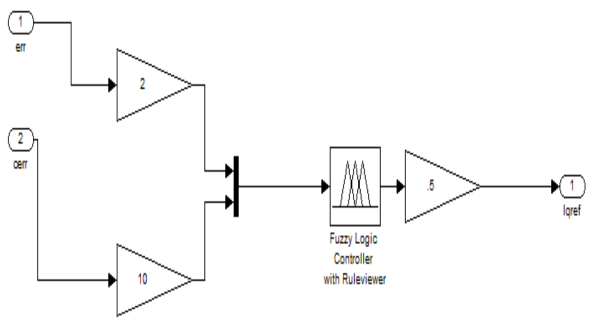

Fig.3 Fuzzy Logic Controller (Designed)

II. RESULTS & CONCLUSION

Active & Reactive Power Demand under steady state condition:-

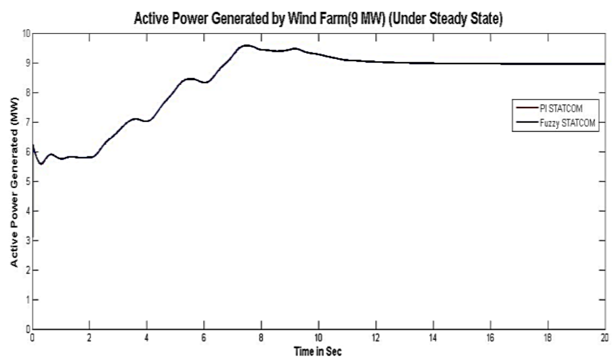

Fig. 4 Active Power Demand under steady state condition

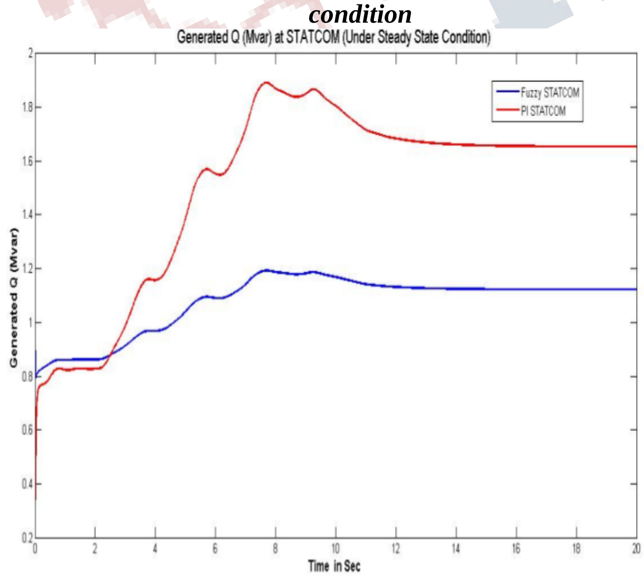

Fig. 5 Reactive Power Demand under steady state condition

The simulation is carried for two different conditions (i.e for STATCOM with PI, STATCOM with Fuzzy Controller) for the reactive power compensation of the wind farm. The measurement for reactive power demand at the B-25 bus is done. From the simulation result it can be seen that the STATCOM with fuzzy controller is matching the reactive power demand of the Interconnection bus exactly similar to that of the STATCOM with PI Controller.

Comparison of PI and Fuzzy STATCOM:

Type of Controller	Voltage level at B-25 Bus	Active Power Generated at B-25	Rotor Speed of Wind Turbine (in p.u)	Reactive Power Generated by STATCOM
PI	0.98	9	1.005	1.7
Fuzzy	0.979	9	1.005	1.15
	Approximately Same	Same	Same	Fuzzy Controlled STATCOM work effectively. STATCOM performance is optimized

III. CONCLUSION

In the above work for the wind power plant application, the considered model has been simulated for STATCOM with PI & STATCOM with fuzzy controller The simulation results are tabulated in the Table. It can be concluded that the settling time & overshoot in Mvar generated at STATCOM is less in case of Fuzzy compared to PI controller. Even for the same active power generation the reactive power generation is optimized in case of fuzzy controlled based STATCOM as compared to PI based STATCOM. So it is recommended to connect the STATCOM with fuzzy controller for wind power plants having Induction generators.

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