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Stabilization of voltage in Wind Energy Conversion System using PWM Modulated Power Filter Compensator

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Abstract -The need to exploit ample renewable energy sources such as wind and solar is growing due to world energy shortage, financial and environmental pollution concerns. Wind energy has become one of the important alternatives because of its abundance and the strong thrust for its commercialization. However, the voltage stabilization problem of a wind energy system is dependent on changing wind conditions and varying electric load conditions. In this paper a PWM MPFC controller is designed .This PWM MPFC Controller is used to stabilize the varying wind energy output. The proposed controller is tested on system using Matlab Simulink Environment. The Results are compared with results obtained without controller PWM MPFC controller provides better stabilization of voltage as compared to results obtained without controller

Index Terms: **- Chaos based SVPWM, MPFC, PWM, Wind energy, Voltage stabilization,**

I. INTRODUCTION

Use of electricity generation from renewable energy sources increased rapidly in the last decade as industrial sector become more aware about fossil fuel shortages and their environmental impacts. Wind energy is important source of electricity as it directly converts kinetic energy of air mass into electricity [1]. Wind energy Conversion systems are environmental friendly systems and is best suitable option among renewable energy resources, power generated is dependent on the wind speed. The generator is important part of WECS [2]. Induction Generator has been most frequently used in wind energy conversion system. The advantages of using Induction Generator over synchronous generator or doubly fed induction generator are its low unit cost, ruggedness and less maintenance. Due to its constant speed operation and variable wind speed, the power fluctuations are main problem in standalone system or in hybrid system [3]. Voltage stability is a major problem for standalone wind energy conversion scheme employing induction generator, under severe wind variation and dynamic load variation. So a novel stabilization scheme is used to ensure the voltage stability, efficient power utilization and boosts power Quality for a stand-alone wind energy conversion scheme [4]. In order to improve the power quality issue in the distribution systems that are combined with distributed generation (DG), a switched modulated power filter compensator (MPFC) which is driven by a Tri-loop Error Controller is used. MPFC Controller consist of following elements: Tri- loop dynamic error driven controller, three phase diode bridge, switched capacitor, PWM controlled ideal switches ,resistance and inductance[5]. Fig.1 shows equivalent circuit diagram of MPFC Controller.

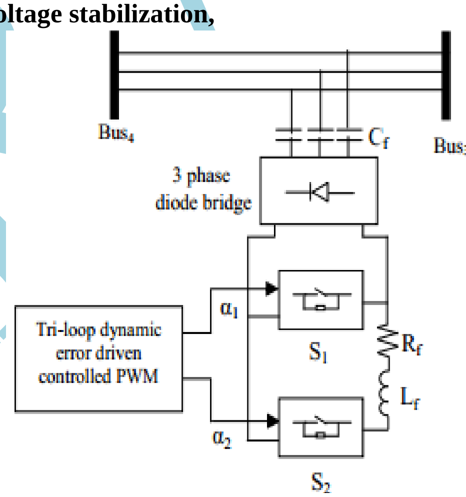

Fig.1. MPFC Controller [5].

With switch S_1 in open condition and switch S_2 closed, the resistor and inductor will form the part of the circuit and the capacitor forms a low-pass filter with the inductor through the diode bridge. If switch S1 is in closed position and switch S2 is opened, the resistor and inductor will not present in the circuit and the capacitor bank will form a capacitive admittance and provide reactive power to the utility grid [6].In order to control these IGBT switches a novel tri-loop driven PID controller is used. The tri-loop error driven controller consists of three basic loops. The main loop is a voltage stabilization loop, second loop consist of current stabilization loop and third loop consist of supplementary power loop to keep a near maximum energy utilization under varying wind and load condition The voltage loop keep the voltage of system at 1p.u and current loop keep the current at 1p.u.[1].

II. WIND INDUCTION GENERATOR TEST SYSTEM

Fig.2. shows sample study system of WECS. Sample study system consists of wind turbine which is mechanically coupled to asynchronous generator which produces electrical energy output, this electrical energy is stepped up using step up

transformer and is transmitted via transmission line to distribution end. Due to the presence of non linear load and varying wind conditions, voltage profile became poor so modulated power filter compensator is used to stabilize the wind energy output.

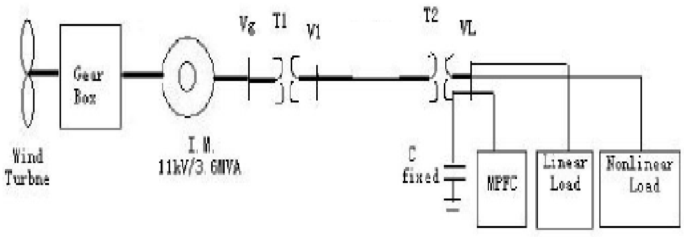

Fig. 2. Sample Wind Induction Generator Test System [1].

The sample study system is tested for serve electric load excursion. From Starting to 0.2 sec both linear and non linear load are present in the system. From 0.2 sec to 0.5 sec, only linear load is present.

III. SIMULATION MODEL

Simulink Model of Wind Energy Conversion System is shown in appendix Fig.7. Here the induction machine equipped with wind turbine act as induction generator. The output of induction generator is fluctuating in nature due to variable wind speed and series of load excursion that are there on the system. Different types of loads that are present on the system are linear load of 100 KVA and non linear load of 100 KVA. Out of 100 KVA non linear load, 50KVA non linear load is present for .02sec and 50 KVA non linear load is present for 0.2sec and 100KVA linear load is present for 0.5sec. A PWM MPFC controller is used for voltage improvement and the result obtained through simulation without PWM MPFC controller. Given simulation model run under continuous mode.

IV. SIMULATION RESULTS

Simulation results are obtained by comparing results obtained without controller with PWM controller on the given system as shown in Fig. When PWM based MPFC controller is used: With Matlab/Simulink environment variation of load end voltage v/s time shown in Fig 5, load end current v/s time shown in Fig.6

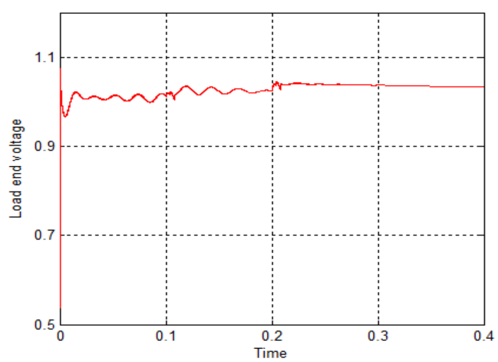

Fig.3.Shows variation of load end voltage without controller

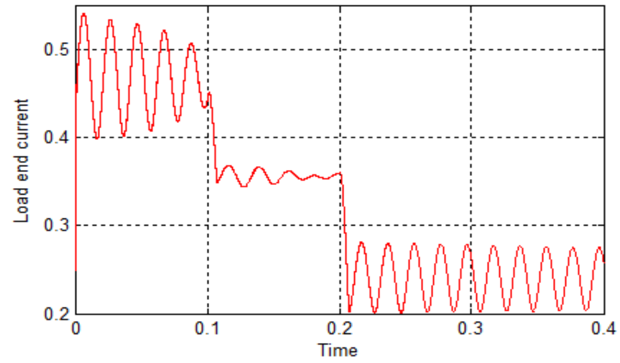

Fig.4.Shows variation of load end Current without controller

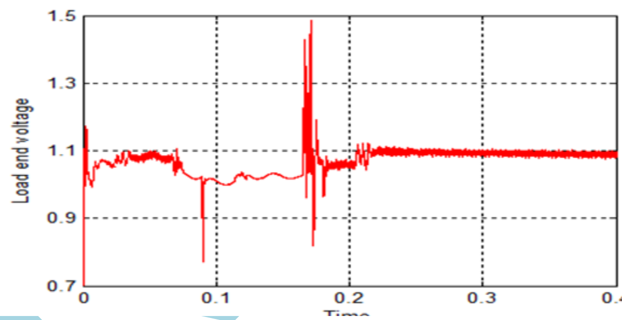

Fig.5.Shows variation of load end voltage with controller

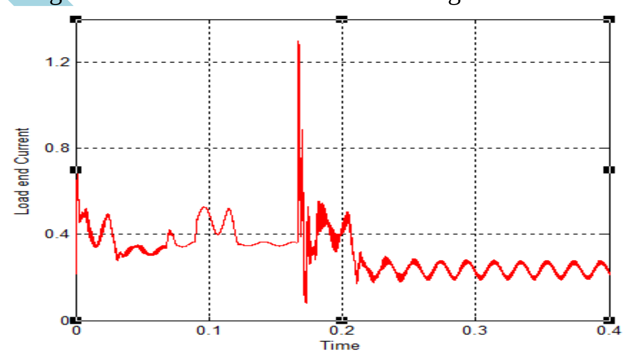

Fig.6.Shows variation of load end current with controller

Table1. Results with and without controller used

S.No.	Controller With Different PWM Techniques Used	Voltage on load end Side
1.	Without Controller	Small
2.	PWM based Controller	Increased

V. CONCLUSION

In This Paper PWM MPFC controller is successfully designed for providing dynamic voltage stabilization in wind energy conversion system. This control strategy is compared without MPFC controller for the system as shown in Fig.7 . Simulation results indicate that PWM MPFC controller provides better voltage stabilization as compared without controller.

APPENDIX

A. Data

Data for various components used in matlab simulink model of Fig. 13 are as follows:

1. System per unit base: $S_B = 3.6$MVA
   $V_B = 11$KV/25KV/600V
   (Generation/Transmission/Load end)
2. Induction Generator Parameters: $S_G = 3.6$MVA
   $V_G = 11KV$
   Stator: $R_s = 0.016$ pu $LI_s = 0.06$ pu
   Rotor: $R'_r = 0.015$ pu $LI'_r = 0.06$ pu
3. Transformer Parameters:
   a) 11KV/25KV (L-L) Transformer (T1)
   Generation side: 11KV/3.6MVA,R=.002 pu L=.08 pu
   Load side: 25KV/3.6MVA, R=.002 pu L=.08 pu
   b) 25KV/600V(L-L) Transformer(T2)
   Generation side: 25KV/3.6MVA R=.002 pu L=.08 pu
   Load side: 600V/3.6MVA R=.002 pu L=.08 pu
4. Transmission Line/Feeder: Length: 10km
   Positive Sequence parameters: R_1 =0.01273ohms/km
   $L_1 = .93373e-3$ H/km, C_1 =12.74e-9 F/km
5. The Chaos based SVPWM switching power filter:
   Filter capacitor bank:C_f=1.7 mF/phase
   Filter inductance: L_f=30mH
   Filter resistance: $R_f = .25$ohms
6. Tri loop error driven PID Controller:$\gamma_v = \gamma_i = 1, \gamma_p = .5$,PID Controller Gains :$K_P = 0.5, K_i = .05, K_d = .01$
7. Load sequence excursions:
   From 0s to 0.2s: linear load 200KVA (50%)
   Non linear load 200KVA (50%)

From 0.2s to 0.5s: linear load 200 KVA (50%) on

B. Simulation diagram

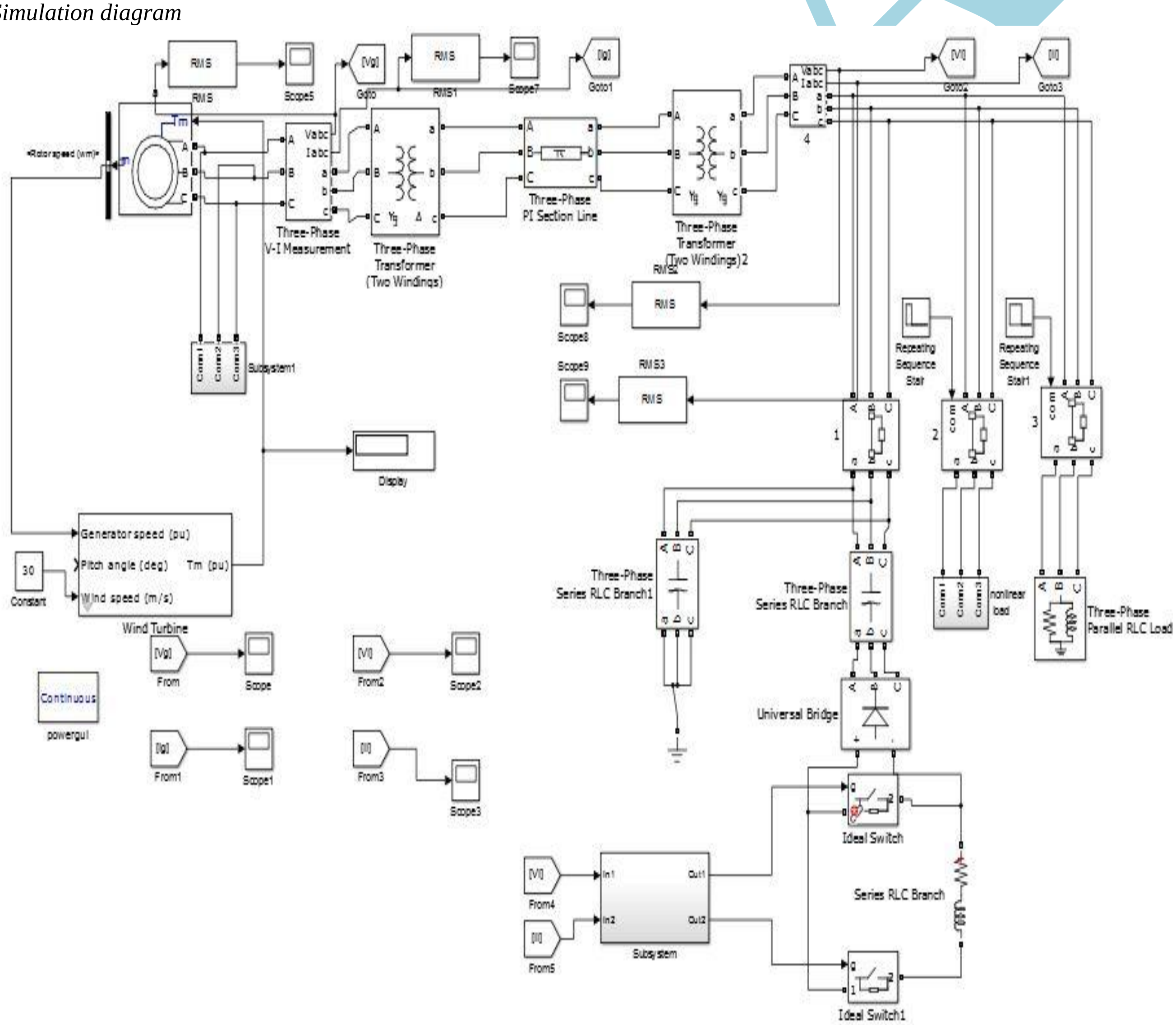

Fig.7 Simulation Diagram for Wind energy conversion system using chaos based SVPWM MPFC controller

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