Synchronous generator based wind energy conversion system engineering essay

Abstract- Wind, a clean and immensely available energy beginning, stands as the most promising alternate to conventional strategies for electric power coevals. Direct driven Synchronous Generator (SG) based variable velocity air current turbine (VSWT) is one of the many options available for air current energy transition. With the rise of Multi-MW-turbine installing, construct of utilizing modular- convertor system alternatively of one full size convertor, in combination with direct driven Synchronous Generator (SG) based air current turbine, is deriving popularity. Benefits of modular convertor set up include higher efficiency, harmonics decrease and improved dependability. To day of the month, most of the work carried out on multi-modular convertor system maintains either a centralised control unit or utilizations master/slave control construction. These constellations badly limit system 's redundancy and expandability. To get the better of these defects, a modular convertor system with independent accountant, is desired. Objective of this work is the chase of such an independent accountant for L. V modular convertor system used in concurrence with direct driven SG based VSWT. Such a accountant will guarantee that both under steady province or dynamic conditions, the parallel runing units continue to portion active and reactive power every bit. Addition or remotion of a convertor faculty should non take to any malfunctioning of faculties already in operation. The interleaved operation of connected units is ensured at all times with units in operation seting the bearer stage displacement independently. The magnitude or stage leap of grid electromotive force should non upset the dynamic behavior and synchronism of the parallel affiliated faculties. Such an independent accountant will greatly better

system reliability/redundancy. To prove the developed independent accountant, simulation is carried out utilizing MATLAB.

Introduction

Wind, a widely available primary beginning of energy, presenting far less drastic environmental effects compared to fossil fuels, holds great possible to run into of all time increasing power demands of the universe. This work focuses on Direct driven Synchronous Generator (SG) based variable velocity air current turbine (VSWT) , a popular pick for air current energy systems. Typically a individual life-size frequence convertor is used for linking SG based VSWT to power grid. Connecting SG to the gird through a group of analogue connected, lower power evaluation, convertor faculties is an surrogate agreement which has proved its domination in footings of system dependability, efficiency and harmonic decrease over its full size convertor opposite number. Pictorial representation of this alternate strategy is shown in Fig. 1, where four analogue connected L. V convertor faculties are connected to a SG with multiple three stage weaving sets that are both electrically and magnetically independent.

Fig. 1: Multi-phase SG connected to the grid utilizing modular convertor design.

Concept of modular convertor system in non new, nevertheless, accountants used to day of the month, either hold centralized control construction or are in master/slave constellation. The major drawbacks faced by these control constellations include being of a individual point of failure and demand of extended control/ communicating interconnectednesss within the parallel

operating faculties. These defects limit expandability of the system and besides impact its dependability. To heighten redundancy of a modular convertor system it is of import to develop a control construction in which each faculty operates independently and manages to run into all the desired control aims. Purpose of this survey is development of control scheme for such an independent accountant for a modular convertor system. Effectiveness of proposed control strategy is verified through simulation utilizing MATLAB.

Analysis

In this subdivision, system of equation used for development of a multi-phase SG is presented. Control construction of each of the two sub-controllers, one being machine-side control unit and other being line-side accountant, are discussed. Controller for each and every convertor faculty contains these two sub-controllers.

Model of multi-phase SG

To develop dynamic theoretical account of multi-phase PMSG, rotor mention frame is chosen. Equation (1) , (2) , (3) and (4) are the vitamin D and q electromotive force and stator flux linkage equations that are relevant to each of the 3- stage weaving set of PMSG (for n # of 3-phase weaving sets, x= 1, 2.. n) . In the given equations variables I» sd, I» sq, Lsd and Lsq represent stator vitamin D and q axis flux linkages and self inductions severally. In instance of lasting magnet synchronal generator (PMSG) the field current beginning can be modelled as a practical, fixed magnitude current beginning (If) . Relation between magnetising induction (Lm) and PMSG 's rotor flux (I» rf) is given by equation (5) .

(1)

(2)

(3)

(4)

(5)

By replacing equation (3) , (4) and (5) in equation (1) and (2) the resulting electromotive force equations are (6) and (7) . Rotor mechanical velocity (wm) and electromagnetic torsion (Te) of multiphase PMSG are given by equations (8) and (9) with parametric quantity like minute of inactiveness, mechanical input torsion, clash factor and figure of pole braces represented by variables J, Tm, F and Np severally.

(6)

(7)

(8)

(9)

Based on the last four equations theoretical account of multi-phase PMSG machine is developed in MATLAB.

Fig. 2: Block diagram of (I) machine-side sub-controller (two) grid side sub-controller

Controller for generator side convertor unit

Control of PMSG is done using Field Oriented Control (FOC) . Torque angle set to 90A° and d-axis current mention maintained to zero Amps, enables q-axis current to entirely maneuver machine torsion. Switch overing signals for the six IGBT 's are produced utilizing Carrier stage shifted PWM. As seen in Fig. 2 (I) , 500 & A ; q axis current constituents are generated utilizing two PI regulators which in bend produce electromotive force vector for the machine side sub-controller. To let independent control over d/q axis current, compensation footings are added at end products of PI current regulators.

Controller for line side convertor unit

Line side accountant aims at reassigning active power generated by the turbine to the grid. With unity power factor operation, reactive power flow is limited to zero. Keeping a really stable DC nexus electromotive force allows successful power transportation from turbine to the grid. Line side convertor contains cascaded cringles with PI regulators. Direct d-axis current controls DC link electromotive force and reactive power transportation to grid is governed by q-axis current constituent. Voltage feed-forward and transverse yoke footings are added to current accountants end product in order to bring forth electromotive force mention signal for Carrier stage shifted PWM generator.

Consequence

MATLAB Simulation is carried out for a WECS connected to stiff grid through two parallel L. V convertor faculties and a six stage PMSG. Detailed parametric quantities of the trial system are listed in appendix subdivision

under Table. 1. As seen in Fig. 5, consequences correspond to unity power factor operation. Carrier signals for two convertor faculties are interleaved with 180A° stage displacement. Using MPPT, mention active power signal for each convertor faculty is determined (mention to Fig. 7) which is closely followed by both convertor faculties (mention to Fig. 8) . From PMSG the current flow towards each analogue faculty is illustrated in Fig. 6 whereas the entire electromagnetic torsion (Te) is plotted under Fig. 4. Notice that Te equal to 1. 69 M N. m, when wm is set to 2. 365 rad/sec, corresponds rather accurately to the entire mention power of 4MW.

Fig. 3: DC link electromotive force for each channel

Fig. 4: Entire electromagnetic torsion (Te)

Fig. 5: Reactive power delivered per channel to the grid

Fig. 6: Current flow towards each faculty from PMSG

Fig. 7: Active power mention for each faculty

Fig. 8: Active power delivered per channel to the grid

Decision

With Multi-MW air current turbine installing on the rise, thought of using modular convertor units is deriving popularity. Objective of this survey is to develop control scheme for independent operation of accountants used for modular convertor system. Controller will guarantee that both under steady province or dynamic conditions, parallel runing units continue to portion active and reactive power every bit. Addition or remotion of a convertor

faculty should non take to misfunctioning of faculties already in operation. Interleaved operation of connected units is ensured at all. The magnitude or stage leap of grid electromotive force should non upset the dynamic behavior and synchronism of the parallel connected. Simulation carried out in Matlab for the base instance utilizing devised control scheme, revealed desirable operation of direct driven PMSG based modular convertor system.

Appendix

Table 1: Parameters of WECS utilizing multi-phase, outstanding pole PMSG

Rated Shaft power

4 MW

Rated rotor flux linkage (I» rf)

6. 77 Wb (extremum)

Rated Stator current

3346. 9 A

d-axis Syn. Inductance (Ld)

0. 30 mH

Rated phase electromotive force

398 V (rms)

q-axis Syn. Inductance (Lq)

0. 50 mH

Rated stator frequence

11. 30 Hz

Stator Resistance (Rs)

7. 3mI©

Rated Torque

1. 69 M N. m

Line side Filter induction

0. 126 mH

DC -link electromotive force

975 V

Number of poles

60