MATLAB/SIMULINK based Wind Energy System with Three Phase Inverter Controlled by Artificial Neural Network

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Abstract In India, as a developing region, the introduction of sustainable energy presents an opportunity to provide a large number of people with a better source of energy resulting in a better quality of life while reducing the impact of global warming. Electricity is not available to many communities in India because the large capital investment required for the traditional electrical infrastructure has resulted in that a good reliable supply is only available in regions with strong economic and industrial activity and an existing grid infrastructure. The fact that renewable energy sources are also distributed sources offers an opportunity to save on the capital investment for the transportation and distribution of electricity. Though there are different renewable energy sources available such as photovoltaic and wind energy. Torque ripples and maximum power tracking form the most important problems facing Wind Energy Conversion System (WECS). This work presents modified toque ripple minimization algorithm for wind turbine using Artificial Neural Network (ANN) control. ANN which is designed to emulate the PI controller for closed loop operation under different wind speeds. Moreover inverter is used for connecting wind turbine generator to the grid in order to reduce Total Harmonic Distortion (THD).The MATLAB Simulink dynamic model developed wind turbine generator with ANN controller.

Index Terms— Wind Energy, Artificial Neural Network, Inverter, MATLAB , Simulation, Controller

INTRODUCTION

The use of wind power is one of the cheapest methods of reducing CO2 emissions in electricity production. Over the long haul, naturally vitality supply must be ensured by incorporation of inexhaustible assets. The overall capability of wind control implies that its commitment to power creation can be of critical extents. Wind turbines create power by utilizing the regular energy of the breeze. The wind is a spotless and supportable vitality source. It does not create pollution and it will never run out. Wind vitality is truly developing in light of ecological issues of conventional vitality sources and turbines innovative upgrades [1]. The piece of this sort of vitality is every day more imperative in breezy locales. In this manner, the wind turbine control quality effect on the power framework increments. In any case, wind vitality costs is still too high to contend with customary sources on less breezy locales. More watchful outline strategies must be acquainted into wind turbines control with enhance these issues. This control must be finished considering the entire wind turbine conduct. Annoyances from wind have additionally to be considered. This turbine is picked were as it speaks to a standout amongst the most well known breeze turbines introduced as of late. There is therefore a comparative large amount of data available in the public domain, compared with other available turbines. With a specific end goal to recreate this breeze turbine, a model was created and executed in a MATLAB/Simulink condition. The progressed numerical abilities incorporated with Simulink gave an incredible recreation motor to advancement of nonlinear wind turbine models. This model can be, and will be used to study in the future alternative control strategies.

OBJECTIVE & CONTRIBUTION

The main purpose of this work is the analysis of the switched reluctance generator for a wind turbine (WT) application during steady-state operation of SRG based wind energy conversion system emulator. In order to analyze the SRG during steady-state and transient operation both the modeling and the control of the system is important. Subsequently, the control and the demonstrating are additionally imperative parts of the postulation.. The main contribution of this thesis is dynamic and steady-state analysis of the SRG, with details being as follows:

- An in-depth literature survey has been carried and different aspects regarding SRG operation and control are analyzed. From all the strategies presented in the literature the focus is set on the ones that offered a good trade-off between complexity and performance.
- An energy efficiency comparison of electrical systems for wind turbines. The investigated systems are fixed-speed induction generator system and variable-speed systems.
- Artificial Neural Network (ANN) control of a SRG based wind turbine emulator has been effectively created, broke down.
- Furthermore, the results demonstrate validity of the closed-loop control with regards to the dynamic performance of the generator and stable control of the dc-link voltage, when they experienced torque disturbance from the exciter and the load machine.

MODELING OF WIND TURBINE AND WIND GENRATOR

Wind turbines convert aerodynamic power into electrical energy. In a wind turbine two change frames happen. The streamlined power (available in the breeze) is first changed over into mechanical power. Next, that mechanical power is changed over into electrical power. Wind turbines can be either steady speed or variable speed generator. In this hypothesis simply factor speed wind turbines will be considered.

Wind turbine basics - The mechanical power created by a breeze turbine is corresponding tothe solid shape of the wind speed. The rotational speed of the wind turbine for which maximum power is obtained is different for different wind speeds. Along these lines variable speed task is necessary to augment the vitality yield. Variable speed turbines are associated with the framework by means of a PEC that decouples the rotational speed of the breeze turbine from the lattice recurrence, empowering variable speed operation. Two basic concepts exist for variable speed turbines. The primary idea has an electric generator with a converter associated between the stator windings and the matrix organize appeared in Fig. 4.2(a). The converter has to be designed for the rated power of the turbine. The generator is mostly a (permanent magnet) synchronous machine. Some types do not have a gearbox: the direct-drive concept .An elective idea is a breeze turbine with a doubly-encouraged enlistment generator (DFIG), which has a converter associated with the rotor windings of the injury rotor induction machine, in Fig. 4.2(b). This converter can be designed for a fraction (~30%) of the rated power.To reenact a practical reaction of a DFIG wind turbine subjected to control framework issues, the principle electrical components as well as the mechanical parts and the controllers have to be considered in the simulation model. The connected DFIG wind turbine show is the same as depicted in [4], [5], and thusly just quickly portrayed here.) shows the square Chart of the fundamental segments of DFIG based breeze turbines:

- Drive prepare and optimal design
- Pitch point control framework

Drive train and aerodynamics: An improved streamlined model is adequate to show the impact of the speed and pitch point changes on the streamlined power amid framework shortcomings. This improved streamlined model is commonly in light of a two-dimensional streamlined torque coefficient-table [18], gave by a standard streamlined program.

In security investigation, when the framework reaction to overwhelming unsettling influences is examined, the drive prepare framework must be approximated by no less than a two mass spring and damper model [20]. The turbine and generator masses are associated through an adaptable shaft, which is characterized by a firmness k and a damping c. Using a two-mass mechanical model is to get a more precise reaction from the generator and the power converter amid framework blames and to have a more exact expectation of the effect on the power framework.

Pitch angle control system: The pitch point control is acknowledged by a PI controller. With a specific end goal to get a sensible answer in the pitch edge control framework, the servomechanism display represents a servo time constant and a constraint of both the pitch edge and its rate-of-progress, as showed in Fig.1. A pick up planning control of the contribute edge is executed request to adjust for the nonlinear streamlined attributes [18].

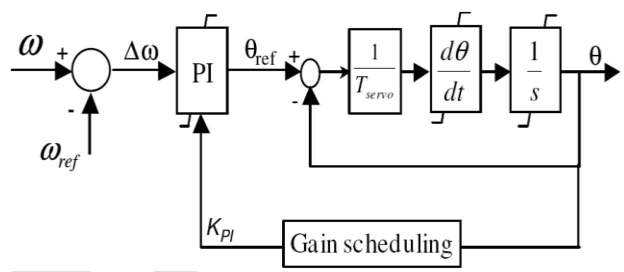

Fig.1 Pitch angle control

The rate-of-progress constraint is vital amid network deficiencies, since it chooses how quick the streamlined power can be lessened so as to anticipate over-speeding amid issues. In this work, the pitch rate restrain is set to a common estimation of 10 deg/s.Note that the pitch point control, represented in Fig. 1averts over-speeding both in ordinary activity and amid matrix flaws, because of the way that the pitch point controls specifically the generator speed. If there should be an occurrence of over-speeding, the streamlined power is consequently decreased while the speed is controlled to its evaluated esteem.

INTRODUCTION TO NEURAL NETWORK

A Neural Network (NN) is a data handling framework that has some execution qualities in the same way as organic neural systems. A Neural Network comprises of an arrangement of exceptionally interconnected straightforward nonlinear preparing components called neurons, units, cells or hubs. Every neuron is associated with alternate neurons by methods for coordinate correspondence joins where every hub has a related weight. The weight represents information being used by the network to solve the problem.

A neural system can accomplish wanted information yield mapping with a predetermined arrangement of weights put away in the associations amongst neurons, and can be prepared to complete a specific job by adjusting the weights on each connection.

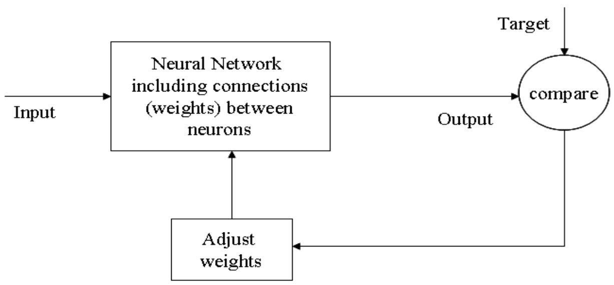

Fig.2. Working of neural network

Fig.3.1 demonstrates a circumstance where the system is balanced, in light of an examination of the yield and the objective, until the point that the system yield coordinates the objective [4]. Ordinarily numerous such information/target sets are expected to prepare a system. The change weights obstruct in the Fig.2 alters the weights as indicated by the blunder got from yield and target.Every neuron has an inner state, called its enactment or action level, which is a component of data sources it has gotten. Ordinarily a neuron sends its initiation as a flag to a few different neurons.

Fig.3 shows a straightforward neuron display in which x1, x2 and x3 are the sources of info and w1, w2 and w3 are comparing weights separately. The net info, y1 is the entirety of the weighted contributions from x1, x2, and x3 and predisposition i.e.

$$y1 = w1x1+w2x2+w3x3+b \quad (1)$$

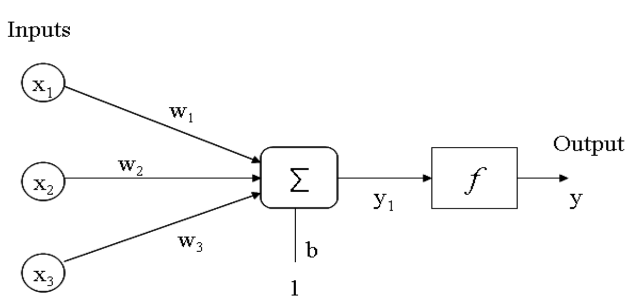

Fig.3. Simple Neuron Model

The net-input, y1 is passed to the actuation work f to get the yield y.

The conduct of an ANN (Artificial Neural Network) relies upon both the weights and the info yield work (exchange work) that is indicated for the units. This capacity normally can be categorized as one of three classes:

a) Linear (or slope)

(1) Positive Linear Transfer Function

(2) Linear Transfer Function

(3) Saturating Linear Transfer Function

(4) Symmetric immersing straight Transfer Function.

b) Sigmoid

(1) Logarithmic Sigmoid Transfer Function.

(2) Hyperbolic Tangent sigmoid Transfer Function.

c) Other Functions

(1) Symmetric Hard farthest point Transfer Function.

(2) Radial Bias Function

(3) Triangular Bias Function

SIMULINK MODEL OF ANN CONTROLLER BASED WIND TURBINE

In this thesis, we propose a modified control theme artificial neural controller for torque ripple control and maximum power extraction for wind system driven. The feedback signals, that is, torque and rotor speed are obtained from the dc link quantities. For the accuracy of those calculable quantities, the reconstructed ac line current waveforms should be correct. The exactness of remade waveforms relies on the Sampling rate. Higher the Sampling rate less is the blunder between the genuine and reconstructed waveforms. In an exceedingly hard-switching inverter, the switching frequency is limited to atypical value of 2 kHz. This confines the sampling rate of dc current and henceforth the refresh rate of torque and rotor speed utilizing dc interface amounts exclusively. Consequently, closing the loop directly on the instantaneous value of the estimated torque now becomes difficult as a result of estimation error throughout a PWM cycle may become significantly high. In fact, instantaneous error at the sampling instant may have a distinct polarity from the average error over one PWM cycle [19].In order to use the calculable torque during a lot of robust manner, a control strategy should use the averaged torque rather than the instant worth. During this system, ANN controllers are used to regulate the average worth of torque and speed severally. The yield of the ANN controller shapes the q-axis command current in a synchronously turning reference outline.

RESULTS ANALYSIS

An entire MATLAB recreation demonstrate for Artificial neural controller for torque swell control and most extreme power extraction for wind framework driven. Neural network controller is designed by adjusting the weights which is trained by a Levenberg –Marquardt (LM) learning algorithm derived from neural network theory in order to get simulated results. The performance of the ANN controller

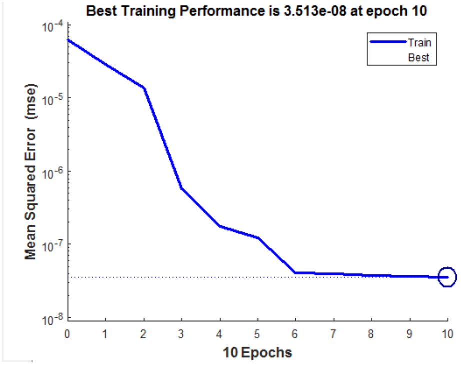

Fig. 5 ANN controller performance analysis

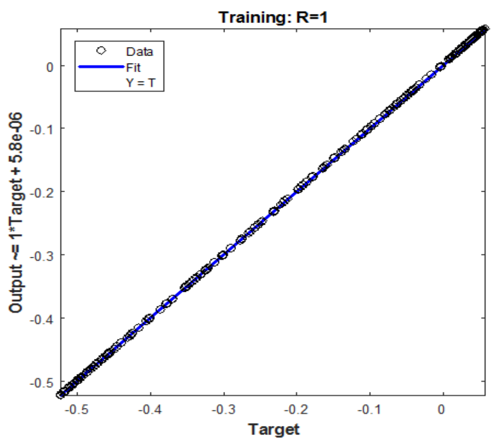

Fig. 6 ANN controller training and target analysis

Fig.4 Simulink model of Artificial neural controller for torque ripple control and maximum power extraction for wind system driven.

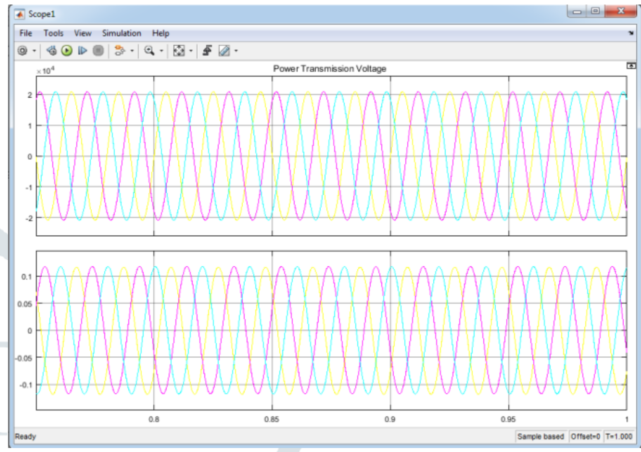

Fig. 7 Three phase grid connected system current and voltage

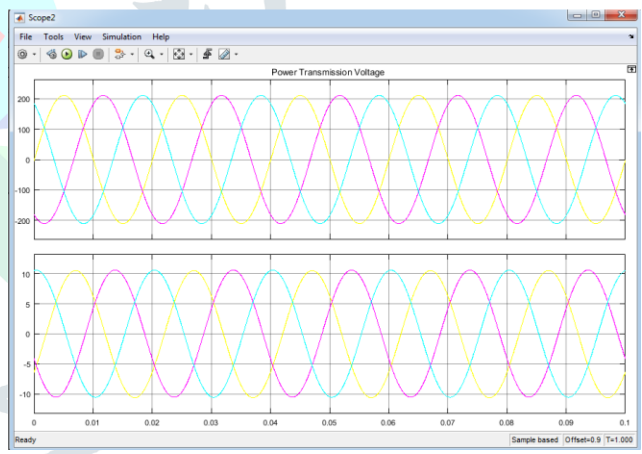

Fig. 8 Three phase load current and load voltage

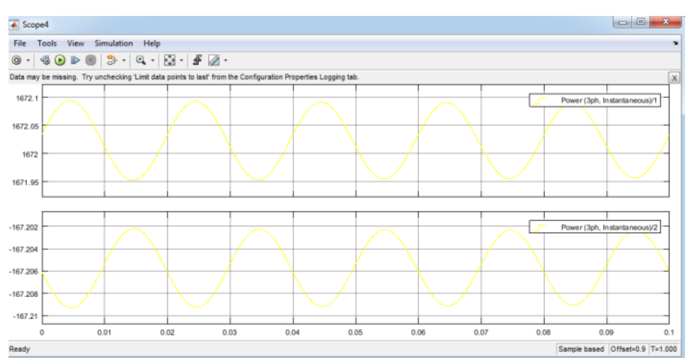

Fig. 9Active and reactive power waveforms

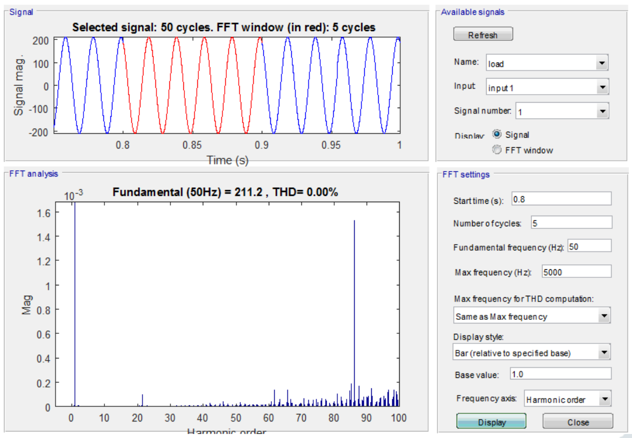

Fig. 10 THD analysis of load voltage

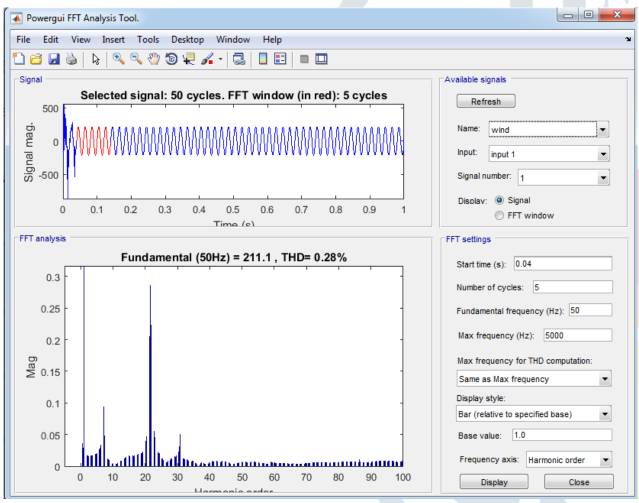

Fig. 11 THD analysis of wind output voltage

CONCLUSION

This thesis displays an investigation of the dynamic execution of variable speed SRG combined with either wind turbine or a dc engine and the power framework is subjected to unsettling influences, for example, voltage droop, lopsided activity or short out flaws. The dynamic conduct of SRG under power system disturbance was simulated MATLAB/SIMULINK stage utilizing framework/vector space control idea. Precise transient reproductions are required to explore the impact of the breeze control on the power framework solidness. Another technique for MPPT of SRG is presented in this paper. This strategy depends on changing the traditional HCL procedure utilizing ANN. The ANN controller is intended to copy the PI controller for shut circle task under various breeze speeds. The outcomes show the effectively tracks of the proposed controller for the MPP under extensive variety of wind speeds variety .The torque swell minimization strategy depends on controlling the stage current amid compensation and ideal profiling of the generator stage streams. This technique is accomplished by ANN controller that is appropriately balanced the stage torques to limit the torque swell in the aggregate stage. This inverter infuses unadulterated sine wave current to the network. The inverter lessens the THD of the infused current and furthermore decreases the measure of the utilized channel. The outcomes acquired from the general framework demonstrate the viability and usefulness of the proposed controllers for enhancing the execution qualities of the SRG under various working conditions.

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