International journal of Inventive Research in Science and Technology ISSN: 2583-5637 (Online)

Volume 4 Issue 10 October 2025

ANALYSIS OF AI TECHNIQUE BASED DYNAMICS CONTROL IN RENEWABLE ENERGY INTERFACED GRID SYSTEMS

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ABSTRACT :- Energy incorporates a very important role for the development of a nation and it's to be preserved in a very most effective manner. Energy is that the ultimate issue accountable for each industrial and agricultural development. Power Quality issues are harmonics and voltage and frequency fluctuations. To study the system performance under the effect renewable energy based generating units the kundur's two area system has been taken as test system. The direct integration of these resources were studied for various instability issues like rotor angle stability, power stability at the generating points of machines and distortion level in the voltage and current waveforms of the grid system.The work has proposed a universal dynamic system optimizing control for system stability enhancement in all the aspects utilizing NN and AI-based differential evolutionary optimizing algorithm. The proposed differential evolutionary with NN learning-based control of the dynamic system optimizing control for system stability enhancement can be a better option for integrating any type of renewable energy resource-based generating system with the grid as it can mitigate most of the quality issues arising due to it.

Keywords: DFIG, STATCOM, Renewable energy, STATCOM control

1.Introduction

Energy incorporates a very important role for the development of a nation and it's to be preserved in a very most effective manner. Energy is that the ultimate issue accountable for each industrial and agricultural development. The new technologies that are developed to provide energy within the most environmental friendly manner and conservation of energy resources in most economical means has equal importance. The utilization of renewable energy technology to satisfy the energy demands has been steady increasing for the past few years. Import of petroleum products constitutes a serious drain on our foreign exchange reserve. Renewable energy sources are considered to be the higher choice to meet these challenges. The necessary drawbacks related to renewable energy systems are their inability to ensure reliability and their intermittent nature. A serious challenge of grid integration an increasing number of renewable-Energy-based distributed generators is featured whereas making certain stability, voltage regulation, and power quality [1].

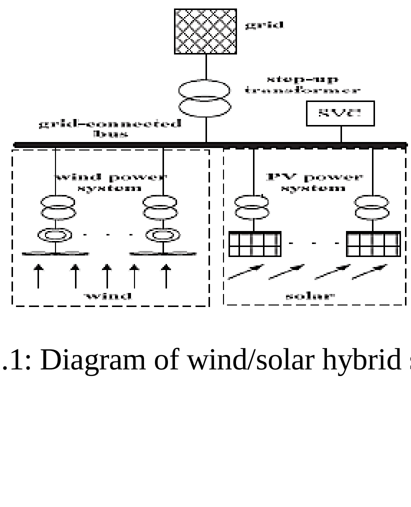

Figure 1.1: Diagram of wind/solar hybrid system

1.2 Hybrid energy system (HES)

It will be good to start with the Hybrid Energy System (HES). The hybrid power system is the technical design where the power components are hybrid or coupled. For example, organizing different energy resources to work in parallel (equivalent) is widely used in power supply. Hybridization is therefore defined as the formation of a cross between pairs of agents to work together to achieve a goal. Hybridization therefore consists in manually or automatically synchronizing two or more resources or components of the generating set in order to supply energy to the grid, thus forming a hybrid energy system. The hybrid energy system is an infrastructure project that integrates more or more energy converters into energy storage systems, energy conditioners and energy management systems. Overall, the Hybrid Renewable Energy System (HRES) is an extension of the HES that uses various resources such as hybrid or fully hybrid renewable energy resources to power the electricity grid.

1.3 Hybrid renewable energy power system (HREPS)

The Hybrid Power System for Renewable Energy (HREPS) is a cross or a mixture of an adequate (parallel) electrical grid infrastructure that provides reliable power. The hybrid renewable energy system (HREPS) has huge designs or models composed of five common subunits, namely (i) renewable energy source (RER) or energy recuperator, (ii) electrical system (air conditioner energy) and (iii) energy storage system (ESS), (iv) a common bus and (v) an electronic logic controller (ECS) are included for system management.

1.4 Controller For Solar and Wind Hybrid Power System

The main problems with wind and solar hybrid systems are energy quality and voltage stability. Since both sources are renewable, the performance of each source depends on the type. Wind speed is not always constant and sunlight also varies throughout the day. The solar system does not function during the rainy season. For this reason the voltage is not constant and the quality of the current suffers. Various regulators are used to maintain stability and improve power quality. UPFC D-STATCOM, IPFC, SVC, SSSC and Fuzzy Logic commands are used for power stability and to improve power quality

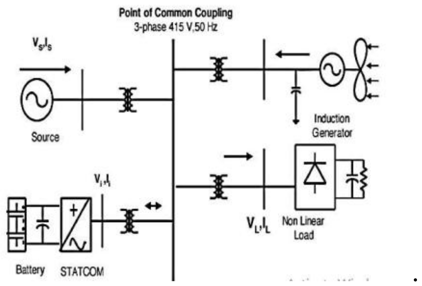

Figure 1.2: Grid connected FACT system for power quality improvement

2. LITERATURE REVIEW

Mohammad JavadMorshed et al. [1] This paper proposes a novel non-linear control approach for the coordination of DFIG and STATCOM (Static Synchronous Compensator) wind turbine controllers in multi-machine power systems. The main goal is to improve the transient and voltage stability of the interconnected multi-machine power supply system by simultaneously designin the DFIG rotor voltage and the STATCOM reference current. The non-linear approach is based on Zero Dynamic Range (ZD) Multi Input-Multi Output (MIMO) technology, which is complemented by Super Torsion Sliding Mode Control (STSMC) to reduce the effects of linearization error.

Konstantin Schaab et al. [2] On the other hand, a uniform synthesis scheme of regulators is proposed in this work, which together deals with the stability of the rotor angle and the stability of the voltage of networks containing synchronous generators and energy conversion systems. Wind turbine based on double power induction generators. . First, a method is proposed for describing production units using Linear Parameter Variant (LPV) systems in which network or windimposed fluctuations are mapped into time-varying model parameters. For adequate ranges of these parameters, decentralized and robust controls can be synthesized from the semi-finished programming so that the power grid is stabilized for the fluctuations and disturbances under consideration. The effectiveness of the approach is demonstrated for a multi-bus reference system where the network oscillations are well damped and the LPV controller stabilizes the network after permanent changes.

E. Sharifi et al. [3] this research focuses on the transient stability of multi-machine propulsion systems, fully taking into account the performance of the Takagi-Sugeno blur-based scroll mode control approach in combination with the conventional scroll mode, as well as the approaches. Final results in this area. As regards the robustness of the sliding mode control approach to parametric uncertainties and environmental disturbances, below, some different sliding mode control approaches are in fact designed for mutual comparison after a series of considerations of the prior art. In order to increase the control performance, the Takagi-Sugeno-Fuzzy based approach was developed to provide the appropriate coefficients.

A. Kanchanaharuthai et al. [4] This article examines the application of STATCOM and battery energy storage systems to improve transition stability of large multi-machine utility systems with synchronous and dual-feed induction generators (DFIG). For multi-machine power systems, a passivity-based control design method [passivity-based control for interconnection and attenuation assignment (IDA-PBC)] has been developed, including performance assessed on a two surface system consisting of two generators (SG) and two DFIG with STATCOM / battery energy storage system.

Godpromesse K et al. [7] An adaptive nonlinear controller for transient stability and voltage regulation of DFIG-based power systems in multi-machine configuration is presented using a standard third-order dynamic model of DFIG. Finite-time estimators are presented for the nonmeasurable time derivative of the quadrature component of the DFIG stator current, mechanical input, transient open-loop time constant of the unknown direct axis (function of rotor resistance). The main feature of the proposed control scheme is its robustness with respect to significant disturbances and parameter variations. Numerical results are presented to illustrate the performance of the proposed control scheme and its robustness properties.

Haotian K et al. [8] This article proposes a Switch Tissue Excitation Regulator (SSEC) to improve the transition stability of multi-machine feeding systems. SSEC switches from a bang-bang funnel excitation regulator (BFEC) to a conventional excitation regulator (CEC) based on a properly designed state-dependent switching strategy. Only the rotor angle following error is needed to implement BFEC with two control values in bang-bang mode. If the BFEC feasibility assumptions are met, the rotor angle following error can be adjusted within the predefined error funnels. The power system on which SSEC is installed can achieve faster convergence performance than one on which only CEC is implemented. Simulation studies are underway on the electrical network of 39 buses with 10 generators in New England. The control performance of the SSEC is evaluated in cases where a three-phase earth fault or a transmission line fault in the power grid occurs.

Ningqiang J et al. [10] To calculate the damping torque of a 3-machine drive system during the transition period, a numerical method based on Weierstrass is proposed and evaluated. Numerical studies were carried out to demonstrate the reciprocal effects of the generators on the damping torque when one of the generators is represented by a detailed model. The relationship between the mean self-damping coefficient of the detailed model and the damping coefficient of the classical model is examined numerically. An interesting observation from our studies is that at the end of the transient stability period, the damping torque coefficients tend to become zero when all generators are represented by the detailed model. This observation can be useful in determining the duration of the stability transition period. One application of the proposed Weierstrass-based method is the determination of adequate and precise damping terms for dynamic network simulation.

3. MODLEING TWO AREA SYSTEM

Rotor angular stability refers to the ability to maintain / regain synchronicity after suffering a disturbance in an interconnected network. In normal system operation, all synchronous machines rotate at the same electrical speed 2πf. The mechanical and electromagnetic couples acting on the rotating masses of each generator are counterbalanced and the differences in phase shift between the internal electromagnetic fields of the various machines are constant and remain synchronous. After a malfunction, a change in rotor speed occurs due to torque imbalance, which leads to loss of synchronism.

3.1 Development of test system

In general, a bus in an electrical power system is fed from the generating units which inject the active and reactive power into it and loads real and reactive power s from it. [n load flow studies, the generator and load (complex) powers are lumped into a net power. This net power is called bus injected power. The net power injected in the bus is given by:

$$S= P + jQ = PG + JQG - PD + JQD \quad ……(3.1)$$

The test system chosen comprises of two areas with four machines. The system is integrated with the highly variable feeding wind energy resource. The single line diagram of the sytem has been

depicted in figure.

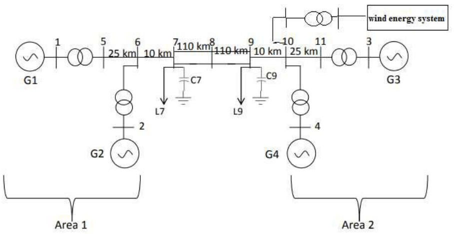

Figure 3.1 Single line diagram of two area system on wind integration

3.2.1 PV Module modeling: Photovoltaic energy is abundant in the environment and free of pollutants. The type of output power of the photovoltaic system depends on the geographical location. The photovoltaic system is a possible source of renewable energy with which it is possible to overcome the dependence on fossil fuels. Various combinations of hybrid photovoltaic / wind systems using battery storage and an additional DG unit are being considered in order to investigate the potential benefits and efficient use of photovoltaic wind systems to meet consumer load demand. Hybrid photovoltaic / wind systems have the following additional properties:

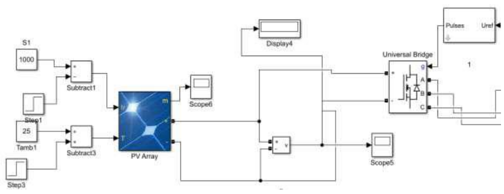

Figure 3.3 Modeled solar system

For each wind speed, there exists a specific point in the wind generator power characteristic, MPPT, where the output power is maximized. Thus, the control of the WECSload results in a variable-speed operation of the turbine rotor,so the maximum power is extracted continuously fromthe wind.

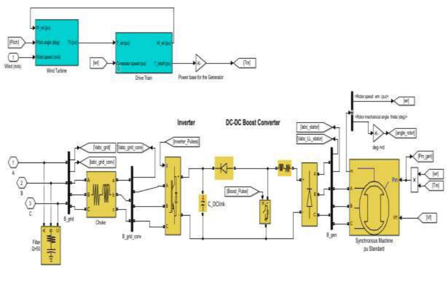

Figure 3.6 modeled Wind system

3.3 Solar/Wind/fuel cell system integration The PEMFC is an electrochemical device that allows the conversion of electrical energy from the chemical energy contained in a reaction between a fuel, hydrogen, and an oxidizing agent, oxygen. A bias voltage is applied to the electrochemical cell to induce electrochemical reactions on the two electrodes. Water is introduced to the anode and dissociated into oxygen, protons and electrons. Protons are driven by an electric field through the PEM to the cathode, where they combine with electrons from the outer circuit to form hydrogen gas.

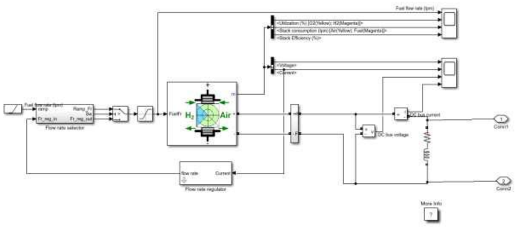

Figure 3.7 MATLAB/SIMULINK model of fuel system

Fuel cells are compact and quiet power generators that generate electricity from hydrogen and oxygen. The transport sector is the most important potential market for fuel cells and car manufacturers are investing heavily in research and development. However, power generation is seen as a market where fuel cells can be brought to market much faster. Compared to conventional technologies, fuel cells can achieve a high degree of efficiency (35% -60%). Figure 3.7 shows the approach taken to integrate the system into zone 1 of the two-zone system of Kundur.

4.FEED FORWARD NEURAL LEARNING AND OPTIMIZATION

4.1 Feed forward Neural network based learning of system dynamics arriving at the integration ANNs are information processing systems that simulate human behavior. The ANNs obtain information about the characteristics considered and learn from the input data, even if our model contains noise. The structure of the ANN consists of essential information processing units, which are neurons. They are divided into several layers and linked together by defining weights. The synaptic weights show the interaction between each pair of neurons. These structures distribute information across neurons. The mapping of the input and the estimated responses of the output are calculated by combining several transfer functions. We can use the self-adaptive information shape recognition method to analyze the training algorithms of artificial neural networks.

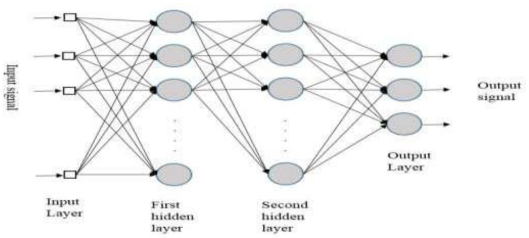

Figure 4.1 Architectural Graph of an MLP Network with Two Hidden Layers.

Neural networks can be divided into single-layer perception networks and multilayer perception networks (MLPs). The multilayer perceptual network comprises several layers of simple two-state sigmoid transfer functions with processing neurons interacting by applying weighted connections. A typical multilayer neural network consists of the input layer, the output layer, and the hidden layer. Multilayer perception (MLP) with the back propagation learning algorithm is used in this study because many previous researchers have used this type of ANN and it is also an approximation of general functions.

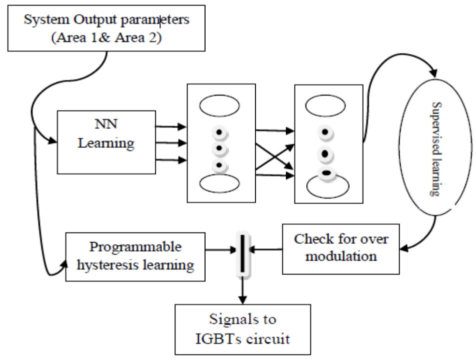

Figure 4.2: DE – NN controller Technique implemented in MATLAB/SIMULINK

4.2 Differential Evolutionary (DE)

This control is optimized through the use of a differential evolution technique. The technique uses the power on the load line as an optimization equation to balance its quality and adapt it to fluctuations. The flowchart of the optimization algorithm is shown in the following figure, implemented in MATLAB as equations and adjustment codes to generate an optimized PI output for the dynamic controller.

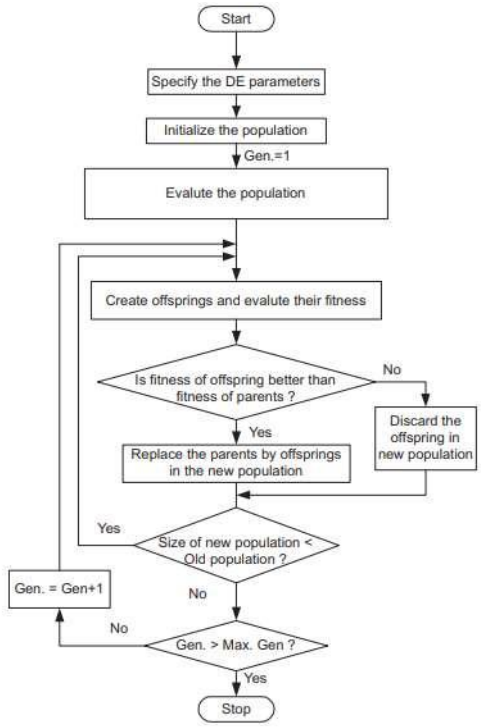

Figure 4.3 Flow chart of proposed Differential Evolutionary Algorithm

5. Result and Discussion

5.1 Results MATLAB stands for MATrix LA Boratory, which is a programming package exclusively designed for speedy and effortless logical calculations and Input/output. It has factually hundreds of inbuilt functions for a large form of computations and plenty of toolboxes designed for specific analysis disciplines, as well as statistics, optimization, solution of partial differential equations, information analysis. In this research work MATLAB platform is used to show the implementation or simulation of implemented algorithm performance. Measurement toolboxes are used and some inbuilt functions for generating graphs are used. Simulation results and comparison of the performance of implemented model with some existing ones are calculated by MATLAB functions.

Case 1: Two area system with wind integration with STATCOM without any dynamics controller

Case 2: Two area system with wind-solar integration with neural network and differential evolutionary based forward learning mechanism for system stability enhancement

Case 3: Two area system with wind-solar and Fuel cell integration with neural network and differential evolutionary based forward learning mechanism for system stability enhancement

Changes in total harmonic distortion in voltage and current waveforms, rotor angle deviations, stability of power pu at generation points, and changes in rotor speed have been discussed in this chapter.

5.2 Case 1: Two area system with wind integration with STATCOM without any dynamic controller

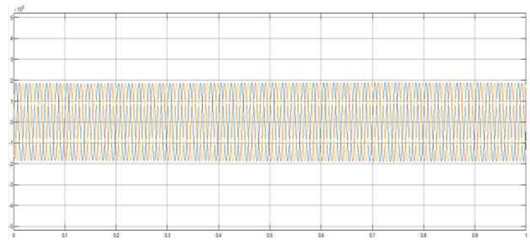

Figure 5.1 Two area system grid voltage without dynamics controller

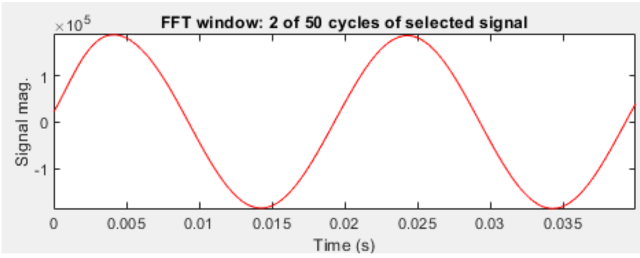

Figure 5.2 FFT analysis of two area system grid voltage without dynamics controller

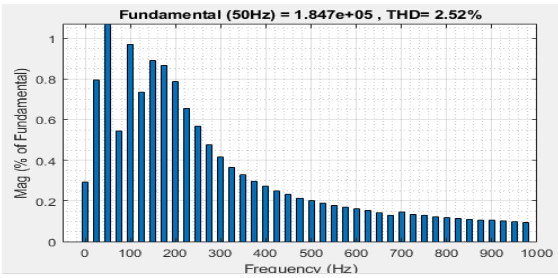

Figure 5.3 THD % in two area system grid voltage without dynamics controller

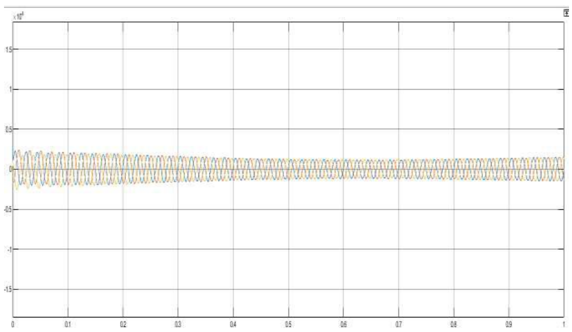

Figure 5.4 Two area system grid current without dynamics controller

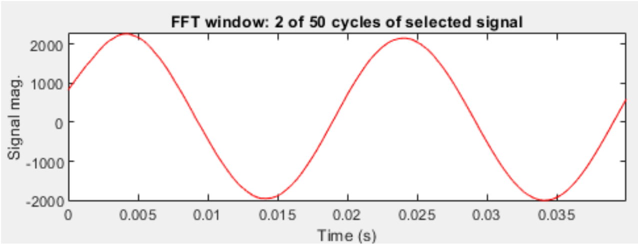

Figure 5.5 FFT analysis of two area system grid current without dynamics controller

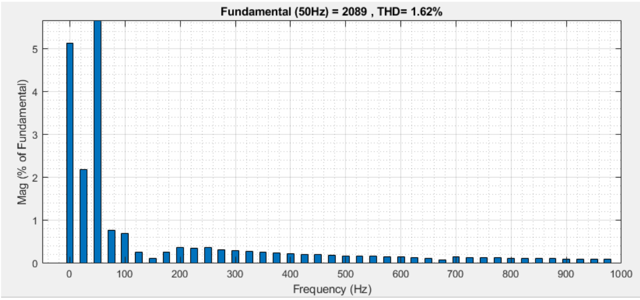

Figure 5.6 THD % in two area system grid current without dynamics controller

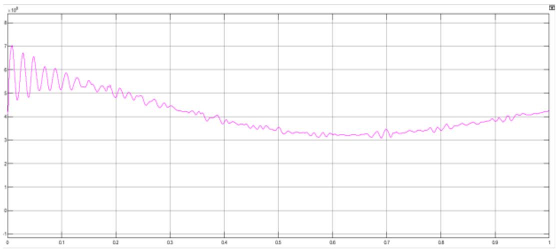

Figure 5.7 Active power that can be drawn in two area system grid current without dynamics controller Figure

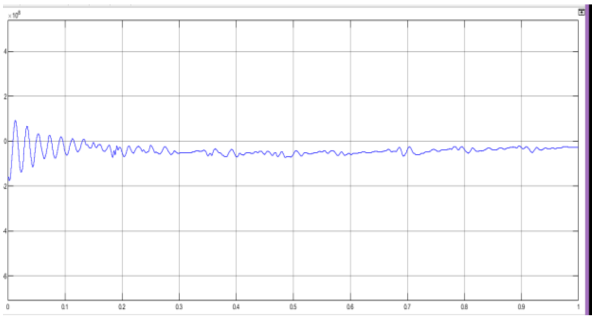

Figure 5.8 Reactive power in two area system grid current without dynamics controller

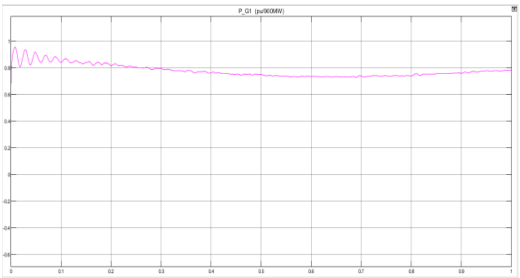

Figure 5.9 Power stability in p.u at the generating terminal of machines in case1without controller Figure

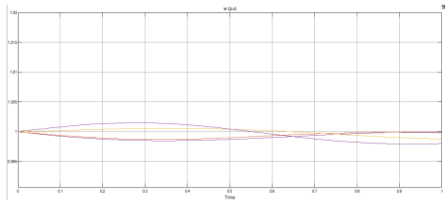

Figure 5.10 Rotor Speed variations on wind integration in case1 without controller

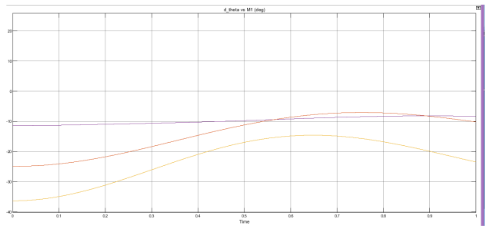

Figure 5.11 Rotor Angle Deviation at the machines on integration with wind energy resource in case1

5.3 Case 2: Two area systems with wind-solar integration with neural network and differential evolutionary based forward learning mechanism for system stability enhancement.

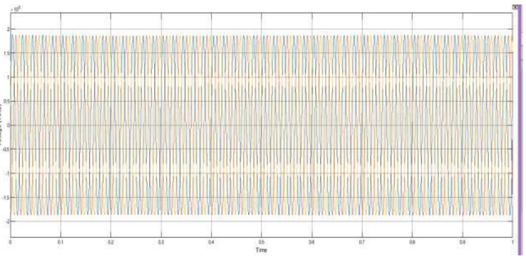

Figure 5.12 Voltage at the grid in two area wind-PV integrated system and nn-differential evolutionary control

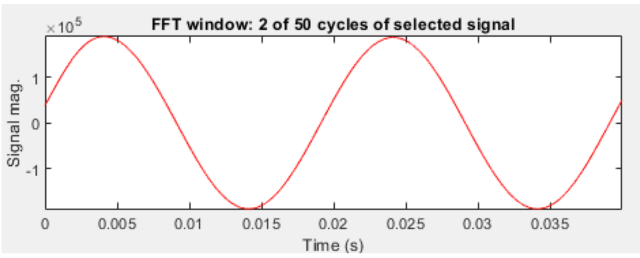

Figure 5.13 FFT Analysis of voltage at the grid in wind-PV integrated system and nn-differential evolutionary control

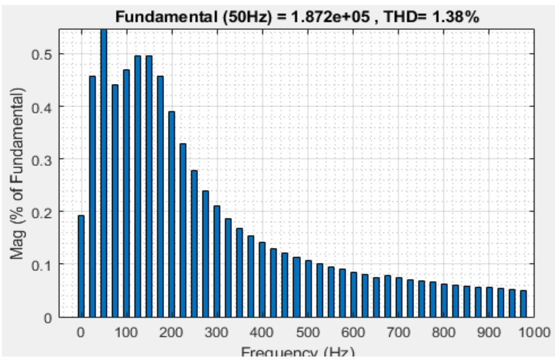

Figure 5.14 THD% in voltage at the grid in wind-PV integrated system and nn-differential evolutionary control

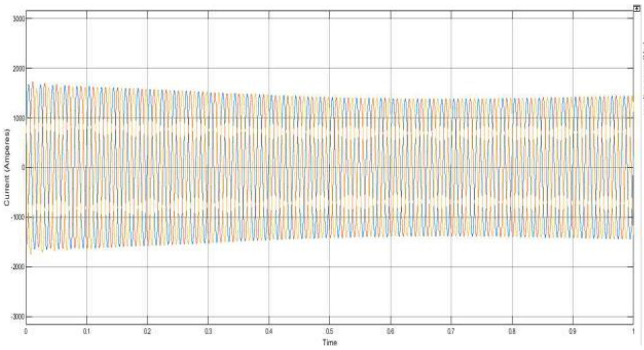

Figure 5.15 Current at the grid in two area wind-PV integrated system and nn-differential evolutionary control

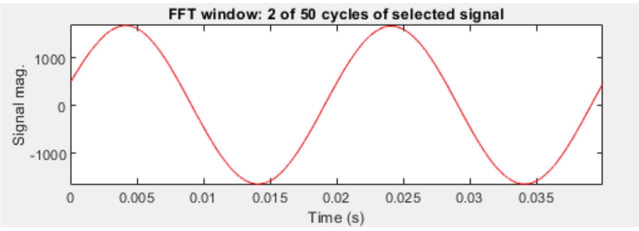

Figure 5.16 FFT Analysis of current at the grid in wind-PV integrated system and nn-differential evolutionary control

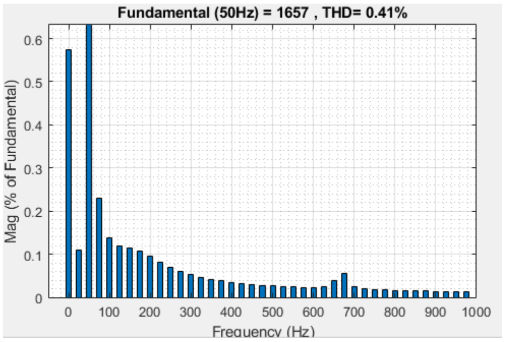

Figure 5.17 THD% in current at the grid in wind-PV integrated system and nn-differential evolutionary control

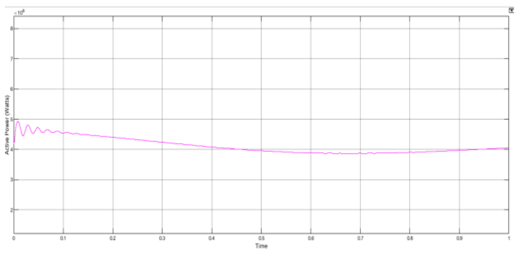

Figure 5.18 Active Power at the grid in two area wind-PV integrated system and nn-differential evolutionary control

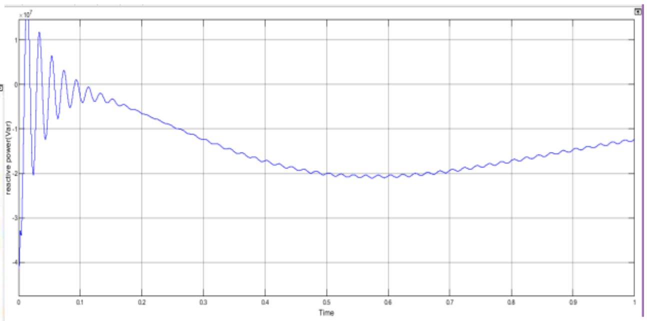

Figure 5.19 Reactive Power at the grid in two area wind-PV integrated system and nndifferential evolutionary control

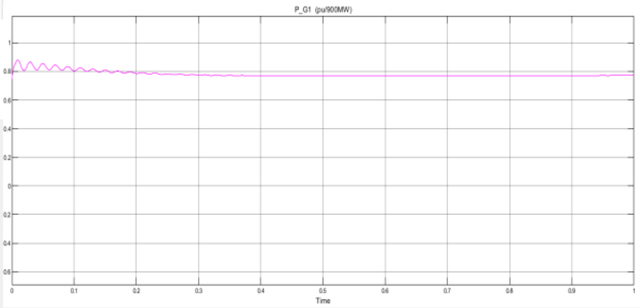

Figure 5.20 Power stability in p.u at the generating terminal of machines in case 2

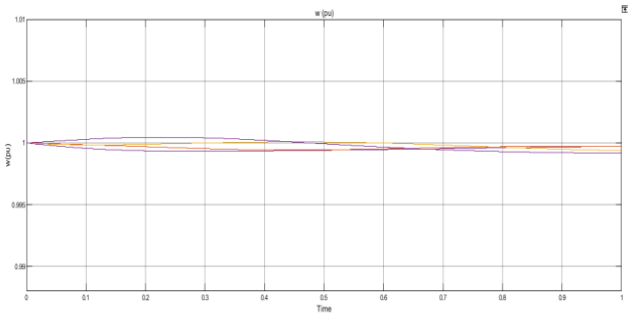

Figure 5.21 Rotor Speed variations on wind/Solar integration and nn-differential evolutionary control

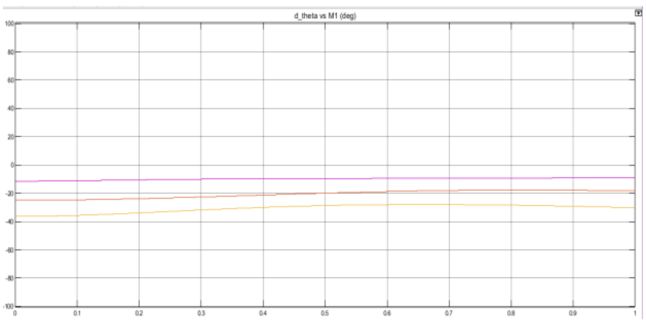

Figure 5.22 Rotor angle deviation in machines with wind/solar integration and nn-differential evolutionary control

The diagrams show the electrical power Pe and the voltage at the vt terminals of the machines in the two-range system when supplemented with wind and also solar and fuel cell resources. The graph of cases 2 and 3 shows a more stable performance of the machines in which the proposed neural network and the differential evolutionary advanced learning mechanism have been integrated to improve the stability of the system.

Table 5.1: Comparison of using Dynamic System Optimization control while integrating renewable resources in two area system		
Systems	THD% in voltage	THD% in current
Case 1:	2.52 %	1.6%
Case 2:	1.38%	0.41%
Case 3:	1.41%	0.43%

The table also summarizes the distortion levels created in the grid voltage and current waveforms following integration with renewable energy sources. The grid voltage and current in case 1 without system dynamic control were 2.52% and 1.6% at the time of wind energy integration. It was reduced to 1.38% and 0.41% in case 2, where the two-domain system with two variable energy resources was integrated into domain 2 thanks to the efficient control by the neural network and the learning mechanism advanced evolutionary differential to improve system stability.

6. CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

There are several technical problems related to grid-connected systems such as power quality problems, current and voltage fluctuations, storage, protection problems, isolation. Power quality problems are harmonics and voltage and frequency fluctuations. To examine system performance under the influence of renewable energy production units, the Kundur two-line system was used as a test system. Direct integration of these resources was investigated for various instability problems such as rotor angle stability, power stability at the machine generating points, and distortion levels in the grid system waveforms, voltage and current. The work proposed a universal dynamic system optimization control to improve system stability in all aspects, using a differential scalable optimization algorithm based on nn and KI. The MATLAB / SIMULINK environment is the platform for system design and implementation. The effects on the plant with two machines in zone four were studied by integrating a wind plant without dynamic optimization control in zone 1, then plants with sun and wind with a dynamic optimization controller based on differential evolution in zone 2 were developed for heavy loads. The study on the integration of the fuel cell system in zone 1 will also continue.

The THD% in voltage and THD% in current in final system having wind/solar/FC with proposed neural network and differential evolutionary based forward learning mechanism for system stability enhancement which is considerably reduced than in the system without controller at the time of integration

6.2 Future Work

In this project we have designed a universal grid optimization controller to consider maximum problems associated with the stability in machines for two area system each area consisting of two generators. The same can be extended to more area system or for a larger system. The work done in this project forms the base for larger power system networks.

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