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Optimizing Control of UPFC AI Based Dual Converter Technology for Grid Integrated PV System

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***Abstract*— Electricity suppliers and electricity end-users are increasingly concerned with meeting the growing energy needs. The work has been focused on obtaining the following key objectives Designing of a solar system with UPFC controlled by PI controller as well as integrating it wit the grid system in MATLAB /SIMULINK environment. Designing a compensating device and compare it with the UPFC compensator for active power output and reactive power output improvement in the system. The compensating device control has to be designed with an AI based linear crow optimizing algorithm to obtain a smooth voltage and current waveform. And this concludes that the solar system is made efficient for driving the loads having enhanced active power output at its terminal. The voltage available has been made less distorted and the THD level in current output has also come down.**

Keywords*— *UPFC, Solar System, PI Controller , Total Harmonic Distortion (THD) and Distributions Generation (DG).

I. INTRODUCTION

Electricity suppliers and electricity end users are increasingly concerned with meeting the growing energy needs. 75% of the world's energy needs are met by the combustion of fossil fuels. However, rising air pollution, concerns about global warming, fossil fuel depletion and rising costs have made it necessary to consider renewable as a future energy solution. Renewable energy has generated tremendous interest in power generation in many countries over the past decade. Market liberalization and government incentives have further accelerated the growth of the renewable energy sector. The renewable energy source (RES) integrated at the distribution level is called decentralized production (DG). The company is concerned about the high penetration of intermittent renewable energies into distribution grids, as this can pose a threat to the grid in terms of stability, voltage regulation and power quality (PQ) issues. Therefore, the DG's systems must comply with strict technical-regulatory framework conditions in order to ensure safe, reliable and efficient operation of the entire network. With advances in power electronics and digital control technology, DG systems can now be actively controlled to improve system operation through better PQ to the PCC. However, the widespread use of power electronics-based devices and nonlinear loads in PCCs creates harmonic currents that can degrade power quality. Typically, inverters with a current controlled voltage source are used to connect the intermittent RES in a distributed system. Some control strategies have recently been proposed for inverters connected to the grid with PQ solution. An inverter works as an active inductor at a certain frequency to absorb harmonic current. However, accurate real-time network inductance calculation is difficult and can affect control performance. A similar approach is proposed, in which an active shunt filter plays the role of active conductivity to dampen harmonics in the distribution network. A theory-based control strategy is proposed for inverters with a renewable interface. This strategy requires measuring the load current and the inverter to compensate for the harmonics of the load current. Harmonics of non-linear load current can lead to voltage harmonics and cause a serious PQ problem in the power grid.

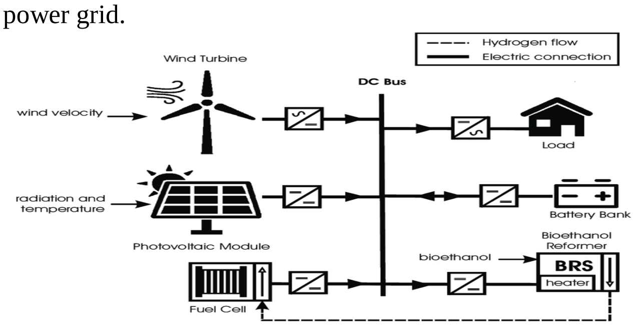

Fig.1: Schematic diagram of renewable energy distributed system

A. Need for Integration of Renewable Energy sources

Traditionally, the electricity grid is not designed to generate and store renewable energy at the distribution level. Electrical services use many types of architectures for power systems based on different designs and choices. The overall development of the network was not monolithic or based on a unified approach to create the most technically up-to-date integrated system. As a result, there are major problems and obstacles to a smooth transition to the use of renewable energy sources with the grid. Optimizing the overall performance of the power system is one of the most important aspects for the long-term economy of distributed renewable energy systems. To achieve some of these benefits, electronic power interfaces must be integrated into the existing power system. Electronic power interfaces offer unique functions compared to conventional connection technologies. As the prices of power electronics and associated control systems fall, these types of interconnect interfaces, along with their benefits, are becoming more common in all types of distributed renewable energy systems.

B. Grid Interface of Renewable Energy Sources

Fig.2 shows a general configuration of the network interface of a renewable energy source. Input power in various forms is converted into electricity via a power conversion unit, the configuration of which is closely related to the input power such as sun, wind, hydrogen, etc. The energy generated by these different sources can be delivered to local loads or to the public grid, depending on the need of the hour. The main purpose of the input power electronics interface function is to extract the maximum power from the input source, which contains the necessary circuitry to convert power from one form to another.

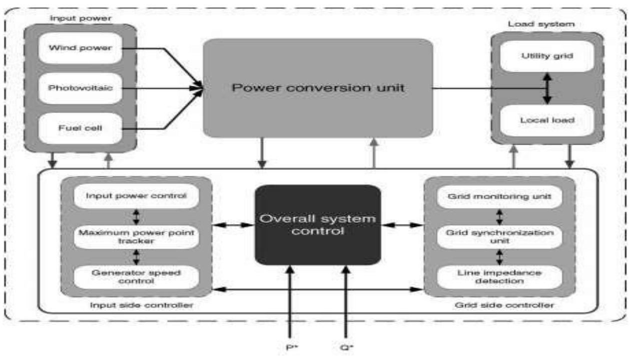

Fig. 2 General configuration of grid interface of renewable energy source with Power Electronics Interface and its Control Block Diagram

C. UPQC Interface for Renewable Energy System

UPQC is a combination of series active filters (DVR) and active shunt filters (DSTATCOM) which are connected in series on the DC side and share a common DC capacitor, as shown in Fig.1.3. The serial component of the UPQC is responsible for reducing supply-side disruptions. Voltage dips / surges, flickering, voltage imbalance and harmonics. Injects voltages to keep charge voltages at the desired level; balanced and distortion-free. The shunt component is responsible for alleviating the power quality problems caused by the consumer such as low power factor, harmonic load current, load imbalance, etc. The source currents become balanced sinusoids and in phase with the source voltages.

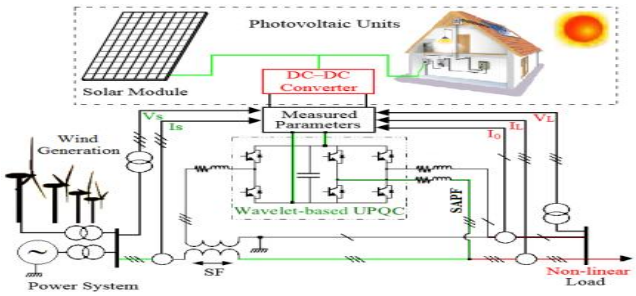

Fig. 3 UPQC Interface for Renewable Energy System

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II. LITERATURE REVIEW

Ritesh Dash et al. [1] This article discusses the rapid industrialization and energy demand that complicate the distribution system. To solve this problem, a robust control system is being developed for new concepts of micro-grids and smart grids. These control systems are a complex structure that links renewable sources to traditional sources of energy production. The power quality problems that arise from the interconnection of the number of variable generation systems make it more dynamic and fault-oriented. The dynamics of the system is based on the use of an air conditioning unit in the renewable system. Most of the power conditioners are of the power inverter type. However, if these inverters can consist of a single type of voltage source, reactive power compensation can be performed in addition to the active power fed into the grid by the inverter. The Dynamic Active Compensation System (DACS) is simulated through MATLAB to verify performance.

Priya M et al. [2] This paper proposes a multi-function inverter connected to the grid and MFGCI improves both voltage and current problems related to power quality. Using a Shunt Series MFGCI (SSS-MFGCI). The SSS-MFGCI is connected in series or parallel to the grid, which compensates for the grid voltage. The proposed system is implemented and the simulation result is validated. The proposed system is more efficient for multifunctional network connections.

Bhupendra Singh Niranjan et al. [3] In this article presented, power quality becomes a crucial factor due to the wide application of power electronics based devices. In industry and distribution, devices based on power electronics are widely used and pose greater power quality problems. Power quality is poor for a few reasons. This improvement in quality of service is for example B. Sagging, bulging, overvoltage, undervoltage and harmonics Conventional devices to improve power quality are not enough. Unified Power Quality Conditioner (UPQC) is a modern device that deals with voltage and current errors at the same time. Unified Power Quality Conditioner (UPQC), consisting of the Parallel Active Power Filter (PAPF) and the Series Active Power Filter (SAPF).

Abdulkerim Karabiber et al. [4] This article introduces renewable energy sources that can be connected to power grids using AC and DC integration methods. AC integration is a convenient and cost-effective method due to its simple structure. However, the power quality protection is weak. The DC integration method provides micro-grids with high power quality due to the additional AC / DC voltage conversion, but is less efficient than the AC integration method. This article presents a controllable AC / DC integration method that combines the advantages of AC and DC integration methods. In the proposed method, the integration of alternating current is activated in order to provide a high integration efficiency at times when the quality of the power supply network is appropriate.

Ashwani Kumar et al. [5] This document presents the pricing of stationary and dynamic reactive power compensation for a fixed capacitor (FC) and a STATCOM system. The main contributions of the article are: (1) evaluation of reactive power compensation using FC as static and STATCOM as dynamic compensator, (2) fast voltage response recovery using a genetic algorithm based on setting the controller gain constant STATCOM, (3) evaluation of reactive power compensation costs for stable and dynamic conditions due to changes in load and / or input demand, and (4) comparison of responses received for the optimized case with a reference compensation method already existing.

Digvijay B Kanase et al.[6] The three-phase system is subject to major PQ problems due to the various loads present in the system and also due to unexpected network expansions. Most AC loads use reactive power, resulting in poor quality power in the grid. The paper suggests a static distribution compensator to improve the quality of electricity using a photovoltaic cell. Dstatcom is used to reduce reactive power that results from various loads on distribution networks. The Dstatcom is used to compensate for harmonics and neutral current in the PCC.

V.Kamatchi Kannan et al. [7] This article is about a battery-powered DC / DC step-up converter or PV panel model, powered by a three-foot VSC (Voltage Source Converter) with a star-delta transformer to improve electricity quality. For the four-wire three-phase Distribution Static Compensator (DSTATCOM), a theory of the synchronous reference system is proposed which contains a voltage source converter and an intermediate circuit capacitor.

III. PROPOSED METHODOLOGY

This work comprises with an analytical and numerical description of proposed algorithm for sentiment analysis of UPFC which is simulated to obtain the performance of the proposed algorithm. In order to evaluate the performance of proposed algorithm scheme, the proposed algorithm is simulated in following configuration: Pentium Core I5-2430M CPU @ 2.40 GHz 4GB RAM 64-bit Operating System Matlab Platform The large-scale solar system is connected to grid via a converter and transformer. In order to improve the transient voltage stability of the large-scale solar system, reactive power compensation device UPFC is connected to grid. The compensator is being proposed for further enhancement in the output parameters like THD in voltage, THD in current and active power output.

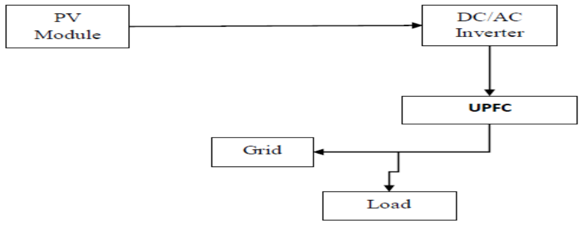

Fig 4 Hybrid energy system topology

As shown in Fig. 6, the wind power generation system consists of PV system and AC/DC inverter and UPFC connected with the grid system.

PV Module modeling: PV cells have single operating point where the values of the current (I) and voltage (V) of the cell result in a maximum power output. These values correspond to a particular resistance, which is equal to V/I. A simple equivalent circuit of PV cell is shown in Fig. 6.

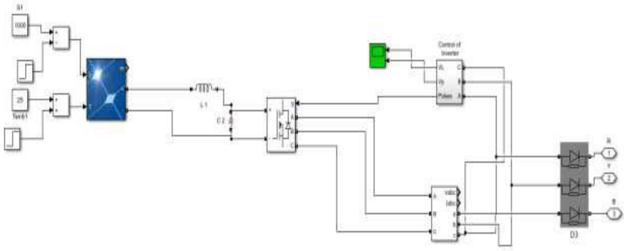

Fig 5 Modeled solar system

UPFC Working UPFC consists of two back to back GTO based voltage source converters (shunt and series) via a common DC link as shown in Fig. 1. The main objective of series converter is to produce an ac voltage Vc of controllable magnitude and phase angle and inject this voltage at the fundamental frequency in series with the transmission line, exchanging the real and reactive powers at its ac terminals through the series connected transformers.

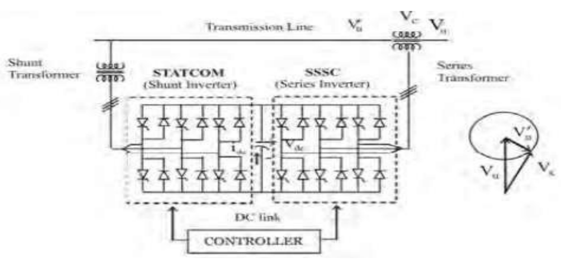

Fig 6 Basic Circuit Configuration of the Unified Power Flow Controller.

CCSA algorithm Conventional search methods have long been applied to solve engineering design problems. Although these methods find promising results in many real problems, they may fail in more complex design problems. In real design problems, the number of decision variables can be very large and their effect on the objective function can be very complicated.

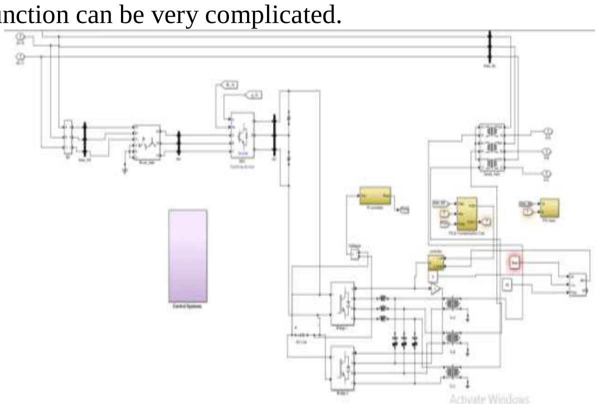

Fig. 7 Compensator with proposed constrained crow search algorithm

IV. SIMULATION RESULTS

Results In this world of depleting energy resources the use of renewable based source of energy is highly required to meet the demands of future. The use of solar and wind energy resources for the generation of electricity is the best choice for combating the use of the exhaustible resources. The best part is that it is also a clean source for generating electricity. This field is henceforth chosen for our work on these resources. The work focuses on analysis of a solar energy system by implementing it in MATLAB/SIMULINK software. The system is made to get integrated with the grid system also in order to enhance its efficiency. The distortion level has been calculated for both voltage and current waveforms neglecting the sudden transient at the starting of system. The chapter here discusses the solar/wind energy system in the following two cases.

Case 1: solar PV system with UPFC having PI controlled electronic converters

Case 2: solar PV system with UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters

The solar PV system is created with two inputs to the solar panel being temperature and irradiation. The DC output voltage form the solar energy system is fed to the inverter for its DC/AC conversion. The solar panel has been modelled with PV arrays having 10 cells connected in each series with 40 parallel branches that together give out the DC output from the system. The variable illumination of 1000 lux is provided along with varying temperature of 250 C .This output is and further sent to the inverter for its AC conversion. The DC output wave from have been illustrated in the fig. below.

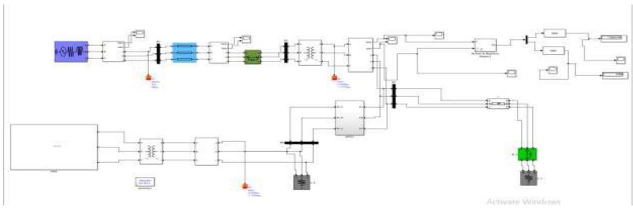

Fig. 8 Matlab/SIMULINK model of the grid connected PV system with UPFC

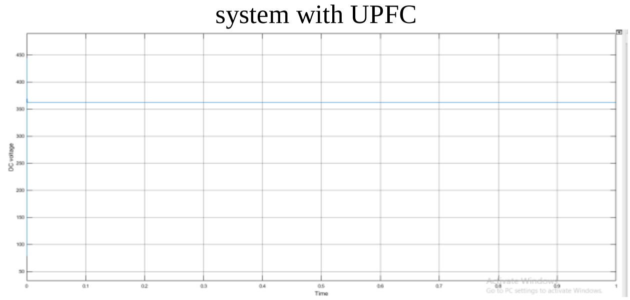

Fig. 9 DC output voltage from the grid connected solar PV system

Case 1: solar PV system with UPFC having PI controlled electronic converters The system in this case is modeled with solar energy with UPFC having converters driven by PI controller which is then further integrated with the grid. Further the voltage current, active power and reactive power waveforms have been analyzed.

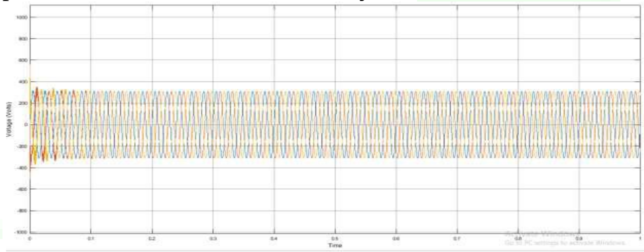

Fig. 10 Voltage in transmission line in the grid connected system with UPFC having PI controlled electronic converters

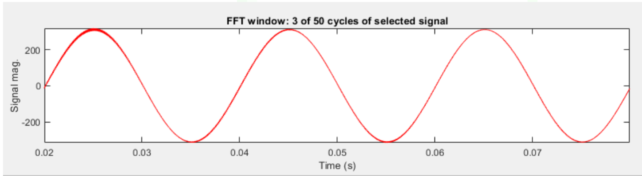

Fig. 11 FFT analysis of Voltage in transmission line in the grid connected system with UPFC having PI controlled electronic converters

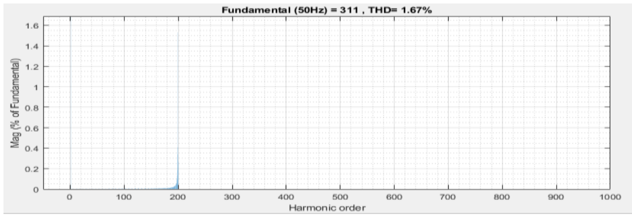

Fig. 12 THD% of Voltage in transmission line in the grid connected system with UPFC having PI controlled electronic converters

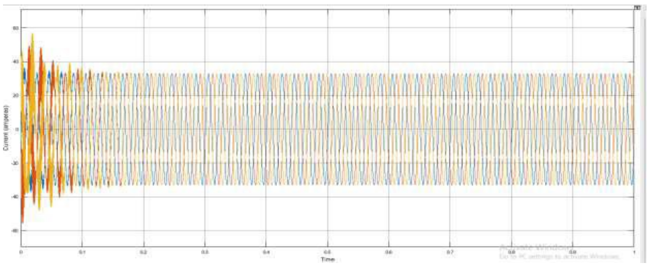
Fig. 13 Current in line in the grid connected system with UPFC having PI controlled electronic converters

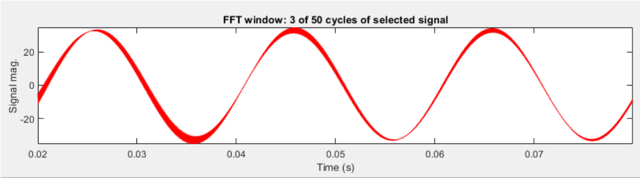

Fig. 14 FFT Analysis of Current in line in the grid connected system with UPFC having PI controlled electronic converters

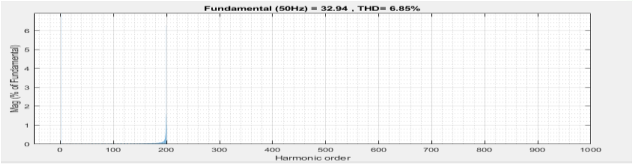

Fig. 15 THD% of Current in line in the grid connected system with UPFC having PI controlled electronic converters

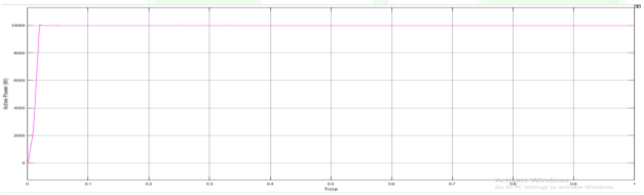
Fig. 16 Active power available in the grid connected system with UPFC having PI controlled electronic converters

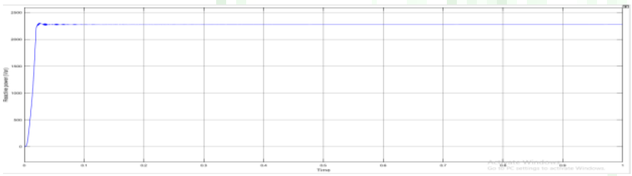
Fig. 17 Reactive power available in the grid connected system with UPFC having PI controlled electronic converters

The above waveforms shows the voltage output, current output, active power output, and reactive power in the system having UPFC in line, driven by PI controlled converters. It is concluded that the voltage output is coming to be approximately 310 volts. The current was found o be 36 approximately 33 Ampere with active power output as 9985W and reactive power output as 2283Var.

Case 2: solar PV system with UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters The system in this case is modeled with solar energy with UPFC having two converters driven by electrical power contrived CSA optimizing controlled which is then further integrated with the grid. Further the voltage current, active power and reactive power waveforms have been analyzed.

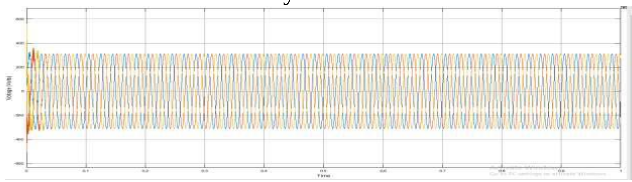
Fig.18 Voltage in the transmission line in system with UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters

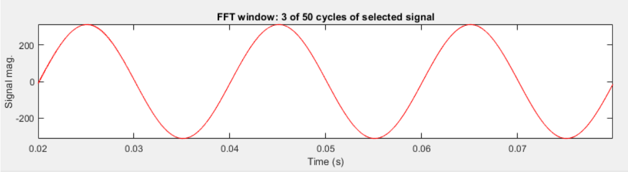

Fig.19 FFT analysis of Voltage in system with UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters

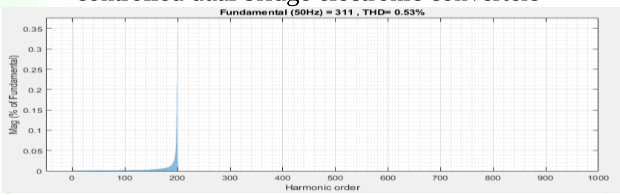

Fig. 20 THD% of Voltage in system with UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters

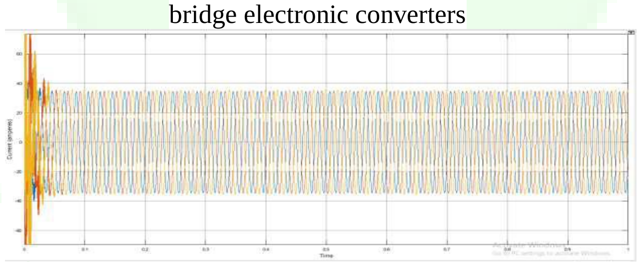
Fig.21 Current in system with UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters

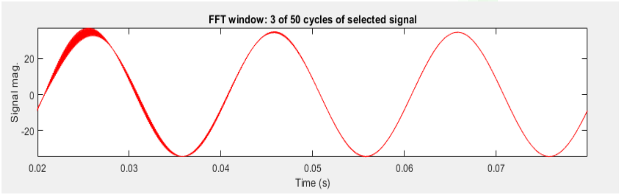

Fig.22 FFT analysis of Current in system with UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters

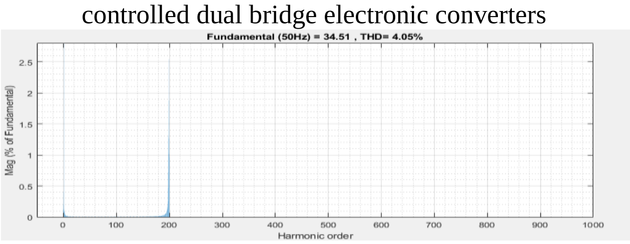

Fig.23 THD% of Current in system with UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters

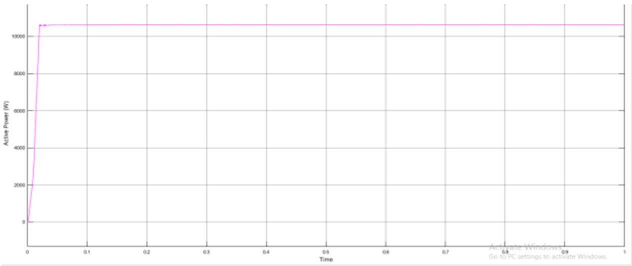

Fig.24 Active power available in system with UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters

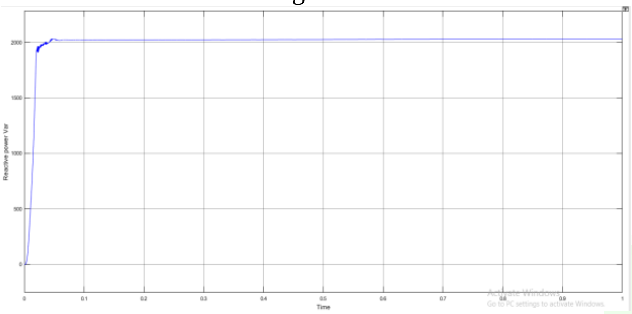

Fig.25 Reactive power available in system with UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters The above waveforms shows the voltage output, current output, active power output, and reactive power in the system having UPFC in line, having electrical power contrived CSA optimizing controlled dual bridge electronic converters. It is concluded that the voltage output is coming to 40 be approximately 310 volts. The current was found o be approximately 34.5 Ampere with active power output as 10620 W and reactive power output as 2029Var.

Validation: The UPFC modeled with contrived crow search based algorithm is expected to produce better results as compared to the UPFC with PI controlled converters

S.no	Parameters	system with UPFC having PI controlled electronic converters	UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters
1	Active power output	9985 W	10620 W
2	Voltage Output	310 V	310 V
3	THD% in voltage	1.67%	0.53 %
4	THD % in current	6.85 %	4.05 %
5	Reactive Power output	2283Var	2029Var

The above results show the comparative values of all the parameters. The active power output available has been enhanced from approximately 9985 W at the UPFC with PI controlled converters at the bus in the system having STATCOM to 10620 W in the system which is made UPFC having electrical power contrived CSA optimizing controlled dual bridge electronic converters. The reactive power output in the transmission line was studied to be reduced making it more stable from 2283 Var to 2029 Var.

V. CONCLUSION AND FUTURE WORK

The demand for electricity is increasing day by day, which cannot be fulfilled by non-renewable energy sources alone. Renewable energy sources such as solar and wind are omnipresent and environmental friendly. The renewable energy sources are emerging options to fulfill the energy demand, but unreliable due to the stochastic nature of their occurrence. The work here presents a solar based renewable energy system in MATLAB/SIMULINK environment for analysis. We have designed a controller for the UPFC contrived crow search optimizing algorithm for dual bridge converters which is a part of artificial intelligence. Following main conclusions were drawn:

The active power output from the system has enhanced to 1020 W in the system having UPFC regulated from the proposed controller that is constrained crow search algorithm from 9985 W in system having UPFC regulated from PI controllers.

The Crow search algorithm is contrived in a manner such that the output voltage and current distortion has also reduced. The voltage output distortion level from the solar energy system was found to be 0.53% which is less than 1.67 % of the system having UPFC regulated from PI controllers.

The crow search algorithm has collectively proved to be effective reducing the distortion level of current output also. The current distortion level has also come down to 4.05% using the proposed controller from the 6.85% in the solar system.

The system is also integrated with the grid energy system. The line voltage being maintained to 310 Volts. The reactive power output has also reduced. The algorithm has proven to be more effective in the compensating the reactive power as well.

The above description concludes that the solar system is made efficient for driving the loads having enhanced active power output at its terminal. The voltage available has been made less distorted and the THD level in current output has also came down.

References

[1] RiteshDash, Sarat ChandraSwain “Effective Power quality improvement using Dynamic Activate compensation system with Renewable grid interfaced sources” Ain Shams Engineering Journal, Volume 9, Issue 4, December 2018, Pages 2897-2905.

[2] Priya M, Vivekananda Sibal T “power quality improvement of multifunctional grid connected inverter with renewable system”, Volume 10, Issue 1, January – February 2019, pp. 46–51, Article ID: IJEET_10_01_007, International Journal of Electrical Engineering & Technology (IJEET).

[3] Bhupendra Singh Niranjan , Dashrath Kumar “Power Quality Improvement by Using UPQC in Wind Energy Conversion System”, International Journal of Advanced Research in Electrical, Electronics and

Instrumentation Engineering, Vol. 8, Issue 3, March 2019.

[4] Abdulkerim Karabiber, "Controllable AC/DC Integration for Power Quality Improvement in Microgrids" Advances in Electrical and Computer Engineering (Vol. 19, Issue 2), May 2019

[5] Ashwani Kumar, Nitin Kumar Saxena "Dynamic Reactive Power Compensation and Cost Analysis for Isolated Hybrid Power System"

[6] Digvijay B Kanase; A. R Thorat; H. T Jadhav, "Distribution Static Compensator for Power Quality Improvement Using PV Array" National Conference on Power Quality Resources on 2018.

[7] V.Kamatchi Kannan, N.Rengarajan "Photovoltaic based distribution static compensator for power quality improvement" International Journal of Electrical Power & Energy Systems, Volume 42, Issue 1, November 2012, Pages 685-692.

[8] Lavanya Viswanathan, Senthil Kumar "A Review: Control Strategies for Power Quality Improvement in Microgrid" International Journal of Renewable Energy Research-IJRER, Vol 8, No 1, 2018.

[9] Jaber Alshehri, Muhammad Khalid "Power Quality Improvement in Microgrids Under Critical Disturbances Using an Intelligent Decoupled Control Strategy Based on Battery Energy Storage System" IEEE, 08 October 2019.

[10] Sibtain ul Hassan; Zain ul Abideen; Tahir Izhar "Advanced control techniques for micro-grids power quality improvement" 2017 Asian Conference on Energy, Power and Transportation Electrification (ACEPT).

[11] N.S.Srivatchan, P.Rangarajan, S.Rajalakshmi "Control Scheme for Power Quality Improvement in Islanded Microgrid Operation" Procedia Technology, Volume 21, 2015, Pages 212-215.

[12] D. Masand, S. Jain, G. Agnihotri "Control Algorithms for Distribution Static Compensator" 2006 IEEE International Symposium on Industrial Electronics.

[13] T.sukanth, D.Srinivas, M. Lazarus, K.Pritam Satsangi "comparative study of different control strategies for dstatcom" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Energy, 2012.

[14] ByGaspard d'Hoop, Olivier Deblecker "Power Quality Improvement of a Microgrid with a Demand-Side-Based Energy Management System" DOI: 10.5772/intechopen.83604 February 1st 2019.

[15] Prajakta B. Borase; Sonali M. Akolkar "Energy management system for microgrid with power quality improvement" 2017 International conference on Microelectronic Devices, Circuits and Systems (ICMDCS).

