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Design and Implementation of Three Phase Solar PV Integrated UPQC Based on Artificial Neural Networks

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***Abstract:** Project deals with the design and performance analysis of a three-phase single stage solar photovoltaic integrated unified power quality conditioner (PV-UPQC). The PV-UPQC consists of a shunt and series connected voltage compensators connected back-to-back with common DC-link. The shunt compensator performs the dual function of extracting power from PV array apart from compensating for load current harmonics. An improved synchronous reference frame control based on moving average filter is used for extraction of load active current component for improved performance of the PVUPQC. The series compensator compensates for the grid side power quality problems suchas grid voltage sags/swells. Thecompensator injects voltage in-phase/out of phase with point of common coupling (PCC) voltage during sag and swells conditions respectively. The proposedsystem combines both the benefits of clean energy generation along with. The steady state and dynamic performance of the system are evaluated by simulating in Matlab-Simulink under a nonlinear load. The system performance is then verified using a scaled down laboratory prototype under a number of disturbances such as load unbalancing, PCC voltage sags/swells and irradiation variation.*

I. INTRODUCTION

With the advancement insemiconductor technology, there is an increased penetration of power electronic loads. These loads such as computer power supplies, adjustable speed drives, switched mode power supplies etc. have very good efficiency, and however, they draw nonlinear currents. These nonlinear currents cause voltage distortion at point of common coupling particularly in distribution systems. There is alsoincreasing emphasis on clean energygeneration through installation of rooftop PV systems in small apartments as well as in commercial buildings. However, due to the intermittent nature of the PV energy sources, an increased penetration of such systems, particularly in weak distribution systems leads to voltage quality problems like voltage sags and swells, which eventually instability in thegrid. These voltage quality problems also lead to frequent false tripping of power electronic systems, malfunctioningand false triggering of electronic systems and increased heating of capacitor banks etc. Power quality issues at both load sideand grid side are major problems faced by modern distribution systems. Due to the demand for clean energy as well as stringent power quality requirement of sophisticated electronic loads, there is need for multifunctional systems which can integrate clean energy generation along with power quality improvement. A three phase multi-functional solar energy conversion system, which compensates for load side power quality issues has been proposed in. A single phase solar pv inverter along with active power filtering capability has been proposed in. Major research work has been done in integrating clean energy generation along with shunt active filtering. Though shunt active filtering has capability for both load voltageregulation, it comes at the cause of injecting reactive power. Thus, shuntactive filtering cannot regulate PCC voltage as well as maintain grid current unity power factor at same time.Recently, due to the stringent voltage quality requirements for sophisticatedelectronics loads, the use of series active filters has been proposed for use in small apartments and commercial buildings. A solar photovoltaic system integratedalong with dynamic voltage restorer has been proposed in. Compared to shuntand series active power filters, a unified power quality conditioner (UPQC), which has both series and shunt compensators can perform both load voltage regulation and maintain grid current sinusoidal at unity power factor atsame time. Integrating PV array along with UPQC, gives the dual benefits ofclean energy generation along with universal active. The integration of PV array with UPQC has been reported in. Compared to conventional grid connectedinverters, the solar PV integrated UPQC has numerous benefits such as improving power quality of the grid, protecting critical loads from grid side disturbances apart from increasing the fault ride through capability of converter during transients.

With the increased emphasis on distributed generation and micro grids,there is a renewed interest in UPQC systems. Reference

signal generation is amajor task in control of PVUPQC. Reference signal generation techniques can be broadly divided into time domain and frequency domain techniques. Time domain techniques are commonly used because of lower computational requirements in real-time implementation. The commonly used techniques include instantaneous reactive power theory (p-q theory), synchronous reference frame theory (d-q theory) and instantaneous symmetrical component theory. The main issue in use of synchronous reference frame theory based method is that during load unbalanced condition; double harmonic component is present in the d-axis current. Due to this, low pass filters with very low cut off frequency is used to filter out double harmonic component. This results in poor dynamic performance[24]. In this work, a moving average filter (MAF) is used to filter the d-axis current to obtain fundamental load active current. This gives optimal attenuation and without reducing the bandwidth of the controller. Recently, MAF has been applied in improving performance of DC-link controllers as well as for grid synchronization using phase locked loop (PLL). [26], In this paper, the design and performance analysis of a three phase PV-UPQC are presented. An MAF based dq theory-based control is used to improve the dynamic performance duringload active current extraction. The main advantages of the proposed system are as follows, • Integration of clean energy generation and power quality improvement. • Simultaneous voltage andcurrent quality improvement. • Improved load current compensation due to use of MAF in d-q control of PV-UPQC. • Stable under various dynamic conditions of voltage sags/swells, load unbalance and irradiation variation. The performance of the proposed system is analyzed extensively under both dynamic and steady state conditions using MATLAB-Simulink software. The performance is then experimentally verified using a scaled down laboratory prototype under various conditions experienced in the distribution system such as voltage sags/swells, load unbalance and irradiation variation

II. POWER QUALITY

The contemporary container craneindustry, like many other industry segments, is often enamored by the bells and whistles, colorful diagnostic displays, high speed performance, and levels of automation that can be achieved. Although these features and them indirectly related computer-based enhancements are key issues to an efficient terminal operation, we must not forget the foundation upon which we are building. Power quality is the mortar which bonds the foundation blocks. Power quality also affects terminal operating economics, crane reliability, our environment, and initial investment in power distribution systems to support new crane installations. To quote the utility company newsletter which accompanied the last monthly issue of my home utility billing: „Using electricity wisely is a good environmental and business practice which saves youmoney, reduces emissions from generating plants, and conserves our natural resources. ‟ As we are all aware, container crane performance requirements continue to increase at an astounding rate.

III. NEURAL NETWORK LOGIC

As of late, the number and assortment of uses of Neural Network logic have expanded fundamentally. The applications range from buyer items, for example, cameras, camcorders, clothes washers, and microwave stoves to mechanical procedure control, therapeutic instrumentation, choice emotionally supportive networks, and portfolio choice. To comprehend why utilization of Neural Network logic has developed, you should first comprehend what is implied by fluffy rationale. Neural Network logic has two unique implications. In a tight sense, Neural Network logic is a coherent framework, which is an augmentation of multivalve rationale. In any case, in a more extensive sense Neural Network logic (FL) is verging on synonymous with the hypothesis of fluffy sets, a hypothesis which identifies with classes of items with un sharp limits in which enrollment involves degree. In this viewpoint, Neural Network logic in its slender sense is a branch of fl. Indeed, even in its more limited definition, Neural Network logic varies both in idea and substance from conventional multivalve consistent frameworks. In fluffy Logic Toolbox programming, Neural Network logic ought to be translated as FL, that is, Neural Network logic in its wide sense. The essential thoughts fundamental FL are clarified plainly and sagaciously in Foundations of Neural Network Logic. What may be included is that the essential idea hidden FL is that of a phonetic variable, that is, a variablewhose qualities are words as opposed to numbers. As a result, quite a bit of FL might be seen as a technique for processing with words instead of numbers. In spite of the fact that words are intrinsically less exact than numbers, their utilization is nearer to human instinct. Besides, registering with words misuses the resistance for imprecision and along these lines brings down the expense of arrangement. Another fundamental idea in FL, which assumes a focal part in a large portion of its applications, is that of a fluffy if-then administer or, just, fluffy tenet. Despite the fact that principle-based frameworks have a long history of utilization in Artificial Intelligence (AI), what is lost insuch frameworks is an instrument for managing fluffy consequents and fluffy forerunners. In fluffy rationale, this system is given by the math of fluffy standards.

The math of fluffy guidelines serves as a premise for what may be known as the Neural Network Dependency and Command Language (FDCL). Despite the fact that FDCL is not utilized expressly as a part of the tool kit, it is viably one of its chief constituents. In the vast majority of the uses of fluffy rationale, a Neural Network logic arrangement is, actually, an interpretation of a human arrangement into FDCL.

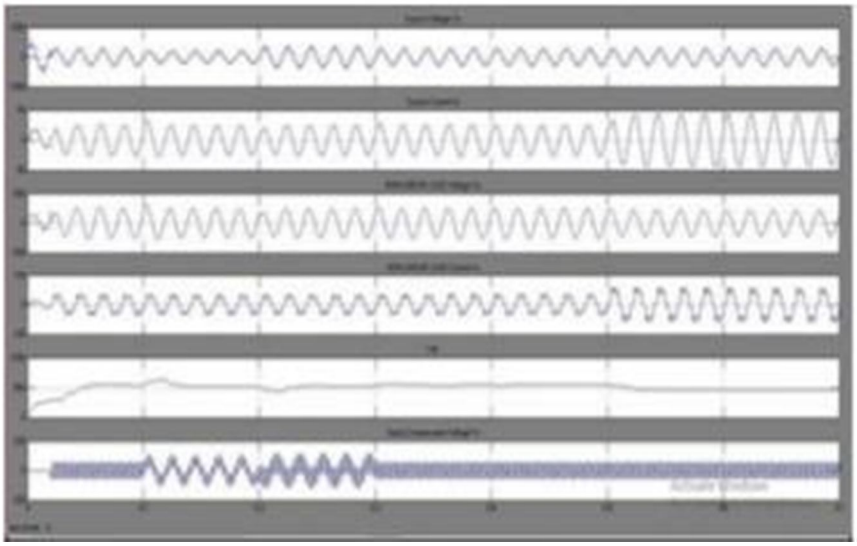


Fig 1 Performance of PV-UPQC under Voltage Sag and Swell Conditions.

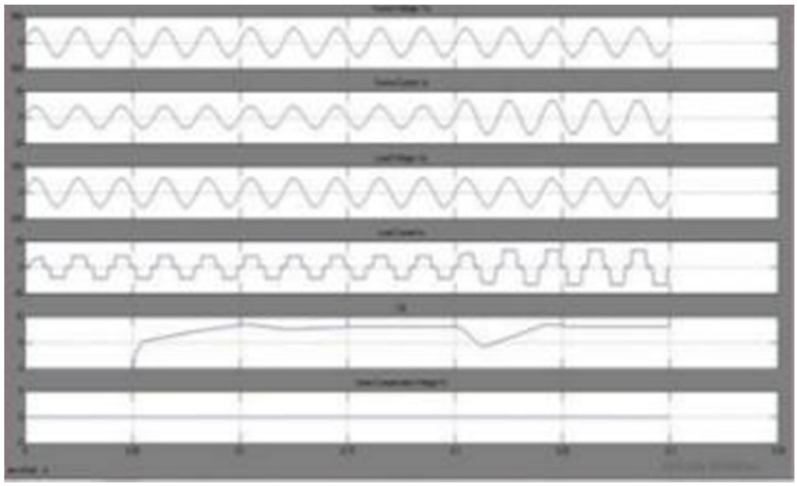


Fig 2 Artificial Neural Network based Performance of PV-UPQC under Voltage Sag and Swell Conditions.

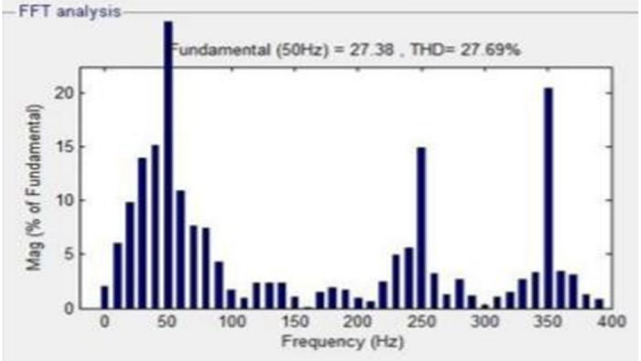


Fig 3 Harmonic Spectrum and THD of Load Current without Artificial Neural Network.

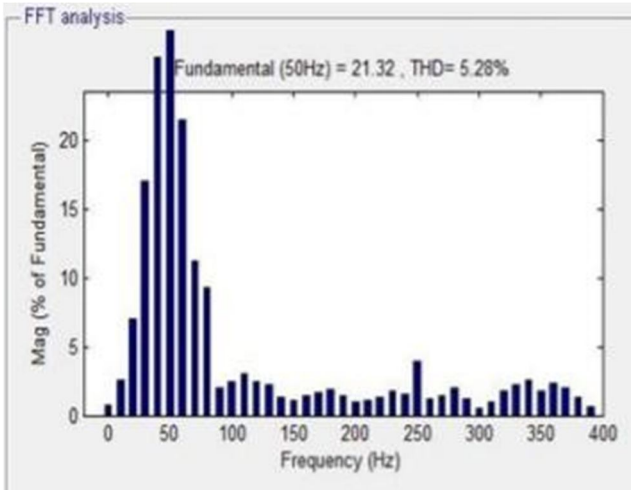


Fig 4 Harmonic Spectrum and THD of Grid Current without Artificial Neural Network

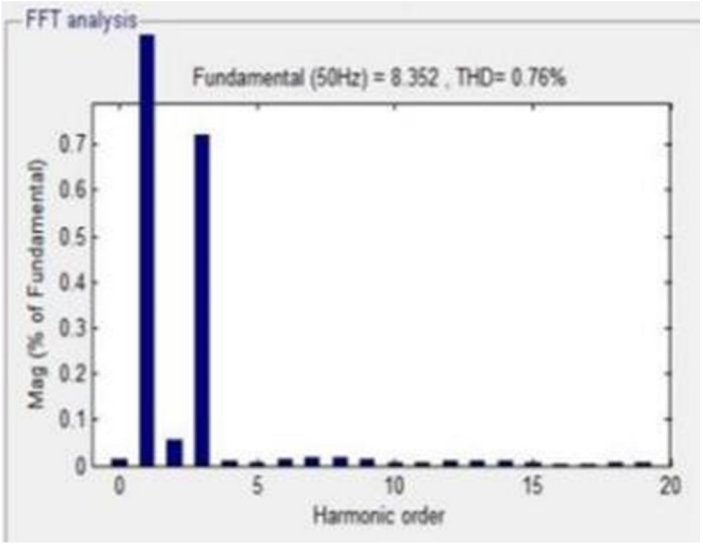


Fig 5 Artificial Neural Network Based Harmonic Spectrum and THD of Grid Current.

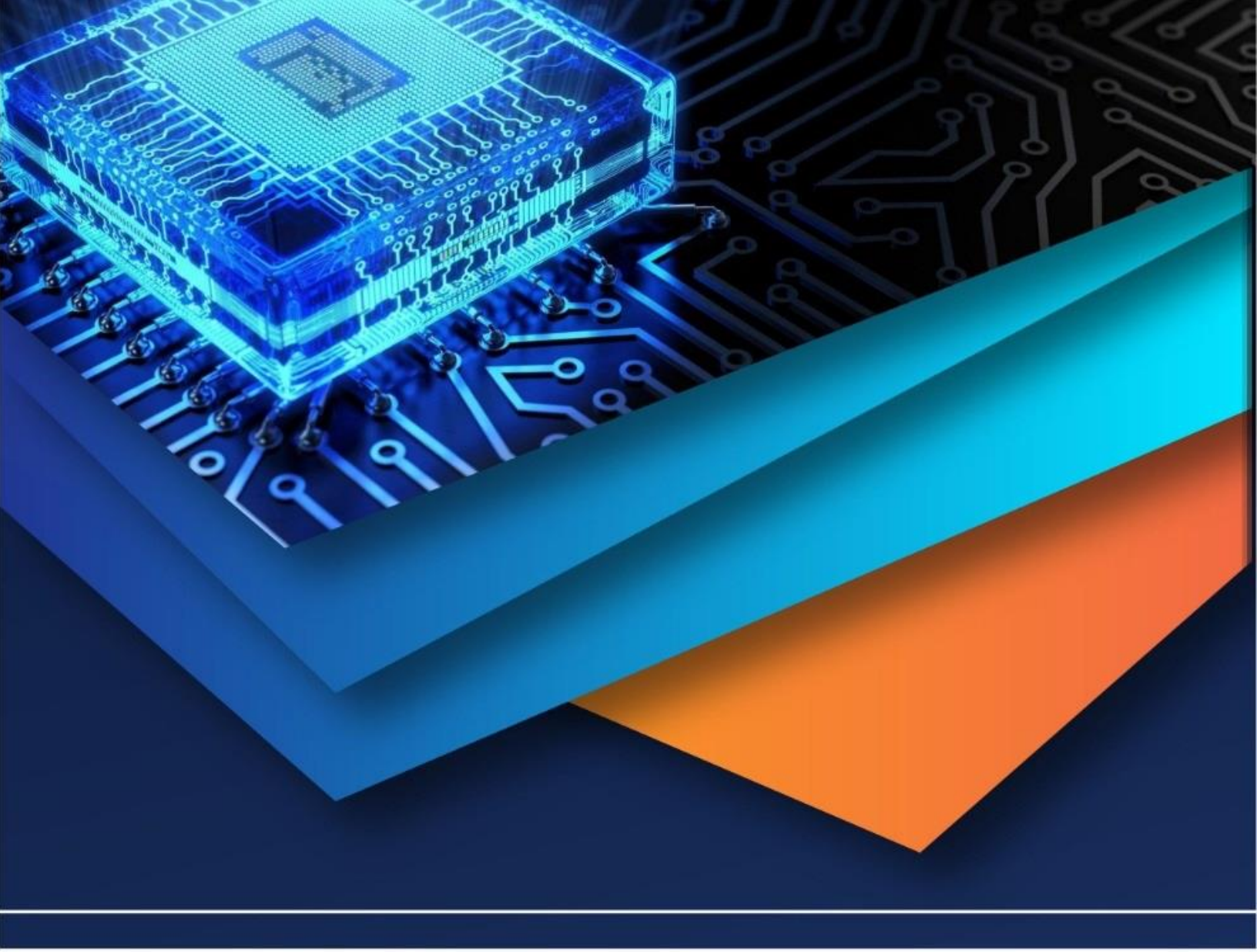
IV. CONCLUSION

The design and dynamic performance of three phase PVUPQC have been analyzed under conditions of variable irradiation and grid voltage sags/swells. The performance of the system has been validated through simulation. The systemis found to be stable under variation of irradiation, voltage sags/swell and loadunbalance. The performance of d-q control particularly in load unbalanced condition has been improved through the use of Neural Network controller. It canbe seen that PVUPQC with NeuralNetwork controller is a good solution for modern distribution system by integratingdistributed generation with power quality improvement.

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