Inverter Control Designing to Optimize the Output Parameters in Solar PV System Driving Motor Load

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Abstract: *Solar power is the conversion of solar energy into thermal and electric electricity. Solar energy is the cleanest and most prolific renewable energy source, and the United States boasts some of the world's most important solar resources. This paper covers the fundamentals of solar power system modelling, as well as the model construction of conversion controllers in a two techniques. The work performed in this paper shows that a PV cell can be used to power a motor via a three-phase bidirectional converter. We can conclude that this research will contribute to the study of solar panels used to power a motor via a PWM inverter*.

Keywords: Solar Power, PWM inverter, PV cell, MLI

I. Introduction

Solar power is the conversion of solar energy into thermal and electric electricity. Solar energy is the cleanest and most prolific renewable energy source, and the United States boasts some of the world's most important solar resources. Solar technology can be used to generate power, provide lighting or a warm indoor atmosphere, and heat water for household, commercial, or industry usage, among other things. Solar energy can be harnessed in three ways: photo - voltaic, solar heating systems, and concentrated solar power Photovoltaics employ an electrical method to create electricity directly from sunshine which can be used to power everything from small gadgets like calculations and traffic signs to residences and major commercial organizations. Solar heating and cooling (SHC) [1] and concentrating solar power (CSP) utilise the excess energy to heat spaces or liquid in SHC systems, or to power typical electricity-generating turbines in CSP power stations.

Because the costs of Photovoltaic panels and systems that work have decreased by as much as 50% in the last 5 years, the use of solar photovoltaic (PV) devices has exploded. Advancements in electricity company network integrates directly and the use of PV arrays in stand-alone applications Photovoltaic systems are becoming more popular as a renewable/alternative energy source due to the local energy production and building automation with storage batteries and backups hybrid electric vehicles. In several nations, specific subsidies and tax credits, as well as feed-in tariffs and power purchase back legislative programmes, have been implemented to promote and encourage producers and consumers, as well as to raise capital spending in solar PV power use in various industries.

In the recent decade, the cost of producing solar panels has dropped drastically, making them not only accessible and often the cheapest form of energy. Solar panels have such a 30-year lifespan and available in a multitude of colors based on the type of materials in use in their production [2]. Solar rays are focused utilizing mirrors in concentrated solar power (CSP). These rays heat fluid, resulting in steam, which is used to power a turbine and generate energy. Large-scale power stations employ CSP to produce power. A field of mirrors is typically used in a CSP power station to redirect sunlight to a tall thin tower. One of the key advantages of a CSP power station over a solar PV power station is that it may be built with molten salts to store heat and create electricity after the sun has set.
The multilayer inverter (MLI) [3] is a variant of the two-level inverter concept. We do not even deal with two-level voltages in multilevel inverters; rather, many input voltages are blended to provide a smooth stepping output waveform. The waveform's smoothing is proportional to the electric levels; as the voltage level rises, the waveforms becomes smoother, but the complexity rises as well.

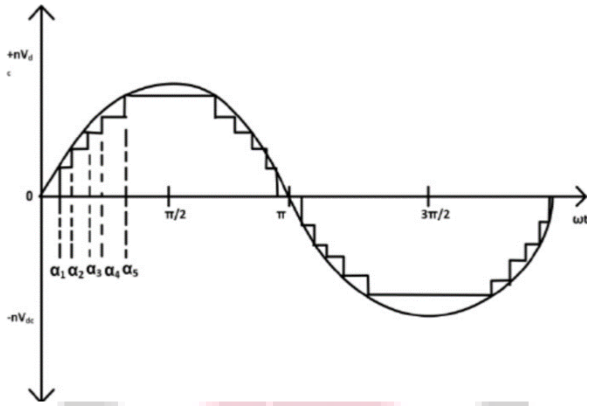

Figure 1 Output Waveform of Multilevel Inverter

Different Types of Multilevel Inverters

In general, a DC/AC converter (inverter) is a component of energy conversion equipment that converts DC input supplies into an output Ac power that may be used to power AC loads. Inverters offer a wide range of applications that meet the needs of the sectors listed above. The functioning of these integrators has been limited by the ratings of the electronic systems components and also the control methods.

In recent years, multilevel inverters have received increased interest for high-power applications because they can operate at very high frequency variation while emitting lower-order harmonic content. A multilayer inverter not only provides large power ratings, but it also allows renewable energy to be used [4]. Photovoltaic, windy, and hydrogen fuel sources of energy can all be simply connected to a multilayer inverter system for a show a high level. Neutral point clamping inverters, flying capacitors-based multilayer, cascaded H-bridge inverter topology, hybrid H-bridge multilayer inverter, and new hybrid H-bridge multilevel converters are some of the topologies available. The different inverter control designs are shown in Figure 2.

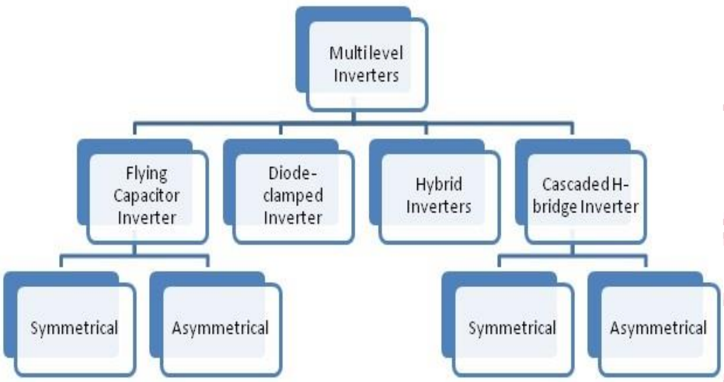

Figure 2 Different Topologies of Multilevel Inverter

II. LITERATURE REVIEW

(1) (Bharatiraja et al., 2014) offers a capacitors imbalancing control strategy for neutral point clamped multilevel inverters (NPC-MLI) built on a field programmable gate array (FPGA) for a freestanding autonomously photovoltaic (PV) system employing an innovative space vector PWM (SVPWM) scheme. By employing the selected three vector (STV) scheme, the recommended vector selection based PWM provides outstanding performance to NPC-MLI for capacitance balance management. The PV system provides inputs to the inverters, and maximum power point tracking (MPPT) is capable of harvesting maximum power from pv array connected to the DC-link. The real-time perturb and observe (P&O) algorithm is often used to monitor a photovoltaic (PV) generator's maximum power point (MPP). For the MPPT control scheme, a PIC 16F876 microcontroller is used. The full inverter control scheme is designed and constructed in VHDL and executed on a Xilinx SPARTAN-III 3AN-XC3S400- FPGA processor.

(2) (Susheela et al., 2018) For five and seven levels diodes clamping switching devices, a reverse mappings oriented space vector pulse width modulation (SVPWM) approach is presented. The transfer function is expressed in this technique as the sum of a candidate vector and an errors vectors. The particular sectors containing the tip of something like the references direction vector does not need to be determined here. The candidate vector is the one that is closest to the reference space vector. An errors vectors is determined by computing the vertical differential of a candidate vector from either the reference signal. An errors vectors is transferred to the origins of a state space diagrams that use the translation strategy. For an n-level inverters, the state space diagrams will have (n-1) steps. The 2-level space vector approach can be used since the error vector amplitude is smaller than one step of something like the state space diagrams. The pwm technique obtained can indeed be added to the candidate vectors to get a vectors that is extremely close to the reference signal. Any n-level inverter topology can benefit from this strategy.

(3) (Pongiannan&Yadaiah, 2021) provides a PV-tied Z-NPC-MLI energy systems with a novel hysteresis current control SVPWM (HSVM) method in the inverters input stage, as well as neutral point (NP) balanced control and direct current regulate. In addition, the suggested HSVM ensures grid connectivity by delivering superior currents and voltages. Simulations and FPGA-based experiment investigation have confirmed this CC-based SVPWM for Z-NPC MLI. The results show that the suggested HSVM for the PV tie grid connected Z- Source NPC-MLI is feasible and reliable.

(4) (Bharatiraja et al., 2016) PWM techniques for three-level diodes clamping multilevel inverters (DC-MLI) are proposed, whereby use a simple switching signals to identify the triangles for maximum throughput voltages and minimal CMV over the whole modulating region. There are two ways presented here: SVPWM portion elimination (PE-SVPWM) and full eradication (FE-SVPWM) (FE-SVPWM). The presented solutions involve exploiting the controlling level of freedom provided in SVPWM to select switches with impacting the inverter power output. As a result, CMV is reduced and eliminated while maintaining maximum voltage level and a lower THD. Any number of channels can be added to the suggested PWM techniques. The suggested technique outperformed existing SVPWM systems in a theoretical work, MATLAB/Simulink software based numerical simulations, and FPGA SPARTAN-III-3AN-XC3S400 processors assisted hardware confirmation.

(5) (Thomas et al., 2015) The goal is to find the best SVPWM approach for diode clamped MLI. The diode clamped MLI induction generator diesel generator is driven using both traditional SVPWM and the new SVPWM approaches. The usefulness of the proposed strategy is demonstrated by analyzing and comparing the performances of the both driving systems. The suggested technique has the added benefit of requiring fewer calculations and allowing for generalization.

(6) (Chamarthi et al., 2016) intends to make the SVM method for an n-level MLI easier to implement by introducing generalised equation which not only allow for direct market controlling pulses computations and eliminate the need for look up tables, but also results in efficient shifting. Despite this, the on-time calculations of the various MLI switching are still based on a simple this double Coordinate plane and a rudimentary two-level inverter implementations. The suggested technique employs a one-of-a-kind l-factor approach that directly determines the location of the several comment thread in the space vector hexagonal, allowing for direct on-line controlling pulses computing. Simulation and practical results for three and five levels diodes clamping multilevel inverters support the proposed approach.

(7) (Chokkalingam & Power, 2016) With the support of the New Space Vector PWM (SVPWM) scheme, a Z Source -T shape - Neurtal point Diode Clamped (NPC) - Multi Level Inverter (MLI) power conversion system (Z-T-NPC-MLI) is shown. The suggested current source inverters offers the features of DC to AC power boosting and converting. T-NPC- MLI achieves the desired power conversions with minimum switching and conduction loss, according to various research studies. Although the stated research on Z-NPC-MLI SVPWM addressed the decrease of Shoot through (ST) alternatives and their predominance augmentation, it didn't even address the DC-Link neutral point fluctuations issues. For Z-T-NPC- MLI with little ST state, this study provides an improved SVPWM technique. For both ST and regular switch, the technique takes advantage of the redundant switching vectors options, which provides self-control neutral point fluctuations.

(8) (Aly & Ramadan, 2019) proposes a concept and implementations for multilayer inverters of a generalised suitable for different Space Vector Pulse Width Modulation (SVPWM) algorithm (MLIs). SVPWM is regarded as a reliable and in-fluential tool for improving MLI performances. The proper choice of switch periods and states can help you achieve a variety of goals. MLIs can also be upgraded in terms of results. Until now, accomplishing numerous objectives in the SVPWM algorithms planning has been a difficult task. The weighting factor of the desirable performance characteristics has been used to define an optimal solution in this work. The suggested algorithm then selects the best switching signals from among valid switching sequences using the given optimal solution. The optimization problem can be weighed with this approach to achieve various performance value is also known; to outfit various applications and geographical and occupational. Different SVPWM design instances for improving the operation of MLIs can also be achieved. The proposed SVPWM was used to implement power balancing over the DC-link capacitor in MLIs as a case study.

(9) (Kale, 2017) For regulating multilevel inverters, numerous pulse-width modulation (PWM) algorithms have been devised, but SVM is the most popular because to its ease both in hardware and software. However, when the levels rise, the SVM gets increasingly hard to achieve. Several new strategies have been developed in many literatures to reduce the SVM at a high level. By modeling in MATLAB simulink software, an SPWM and SVPWM controlled cascaded H-bridge multilevel inverter for big motor outputs is constructed, examined, and contrasted to a standard inverters in this study.

(10) (Palanisamy et al., 2020) The implementation of Space Vector Pulse Width Modulation (SVPWM) for a 3-phase nested neutral point clamped multilevel inverter (NNPC-MLI) appropriate for grid connected (PV) systems. The adoption of a nested NPC topology aids in raising the inverter's output voltage. Because we have system design for each legs, the major purpose of the system is to balance the fly voltage level utilizing SVPWM. The voltage output of this suggested system is divided into four levels, with little voltage stress within every switching. The neutral point energy is balanced through redundancy inverter switching stages. The installation of the modulating approach for power balance control is detailed.

(11) (Hussain &Bazaz, 2016) A neural network constructed for motors speed and position estimates is demonstrated with a sensorless driven PMSM drive. For the creation of 5-level and 7-level voltages, a multi-level inverter (MLI) employs a modified space vector modulation (SVPWM) method. From computations based on observed current and voltage, the sensorless control determines the value of speed and torque. The problem with sensorless in condition monitoring originates from motor parameters change as well as current and voltage aberrations. The problem of motor parametric variations is addressed by using a neural net observers. The usage of MLI enhances estimate, and the suggested SVPWM further improves current distortions removal. In comparison to the standard technique, the suggested scheme uses fewer switching states, resulting in lower power outage. In order to check the physical performance of the PMSM drive, simulation is conducted in MATLAB.

(12) (Kumar, 2017) This work proposes a generalised hexagonal co-ordinate based space vector modulation technique for multilayer inverters with the goal of reducing complexities at elevated amounts. The focus of this study is on using a non-orthogonal coordinate system to determine and calculate the resident times of three neighboring power switches. Regardless of the inverter's output levels, the suggested algorithm maintains the same series of steps involved in detecting the three neighboring vector, related switch stages, and their residing time. After detecting switching signals, a reverse transformational strategy is used to map them to their former colonies. This approach is computationally effective and can be used with inverters with n levels. The performance of a five-level neutral position clamping inverters induction generator motor is verified using computer-aided simulations, and the findings are reported.

III. METHODOLOGY

Individual component efficiency is modelled using deterministic or stochastic methodologies. This section covers the fundamentals of solar power system modelling, as well as the model construction of conversion controllers in a two techniques.

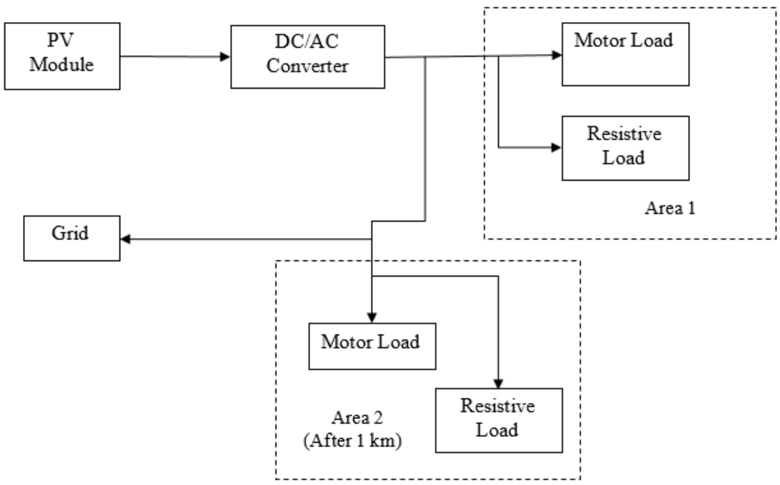

Figure 3 Proposed Hybrid energy system topology

PV systems classified as stand-alone and grid-connected Stand-alone and utility-interactive or grid-connected photovoltaic (pv) systems are the two types of systems available. PV systems are classified according to their operational and management needs, components configurations, and connections to other load demand and power generators. PV systems can either run independently or in combination with the power system. They can be linked to energy storage devices as well as other alternative energies, and they can provide AC and/or Dc electricity. Grid-connected PV systems, as already said, are developed to function in parallel and be linked to the electric power grid.

The main component of grid-connected PV systems is the power conditioning unit (PCU), also known as an alternator, which directly convert the DC power produced by the PV array into AC power that meets the utility grid's voltage and current performance standards for straightforward use on devices or for sending to the grid system to receive feed-in tariff compensatory damages. The PCU autonomously ceases sending power to the grid when the network is not powered.

IV. RESULT ANALYSIS

The project includes a solar panel arrays model with 900 Wb/m2 irradiation and a temperatures of 300°C for each modules. The research here is being done in order not only to increase the output power supplied by renewable energy resources, but also to tolerate variations in point loads whereas the software is geared to start the motor at two regions that are separated by a certain distance. The goal is to design an inverters controller that will generate increased and reliable output electricity to the system. This chapter will examine the output of a solar-based renewable sources that is also designed to be grid-connected. The comparison was done out in term of the program's output power.

The solar panel provides the inverters voltage level in this simulation study. The induced voltage towards the inverters will come from the voltage regulator. The work examines the following two systems:

System 1: Solar-powered two-area loading are regulated by an inverter with motor field-oriented control method.
System 2: Solar-powered two-area loads are managed by an inverter connected to the suggested load line, which drives adaptive multi-objective PWM control.

The suggested controller drives system 2, and a loaded analysis was performed to determine the effectiveness of the designed controller. The output in the following three situations depending on driving loads at two areas are discussed in this Section.

CASE 1: Solar system driving loads at area 1
CASE 2: Solar system driving loads at area 1and area 2
Case 3:Analysis of converter system during transient switching at area 2

The analysis was carried out by comparing all of the electrical characteristics at the respective point of discussion driving motor loading and analysing the output voltages at the merchant ships of region 1 and area 2, respectively.

CASE 1: Solar system driving loads at area 1

The inverter converts the solar program's output DC voltage to AC voltage. By using voltage and current regulator and generating pulses following their regulating, this inverter provides pulsing with a fundamental controlling technique. The direct method connects two locations that are driving 410 V motor load. After connecting to the transformer, the system is linked with both the grids. The figure below shows the graphics output voltage waveform of voltages, current, power factor, and reactive power. Evident from various also are driven in order to investigate the program's quality and effectiveness. During this study, the pressures at a certain distance from area 2 are not coupled.

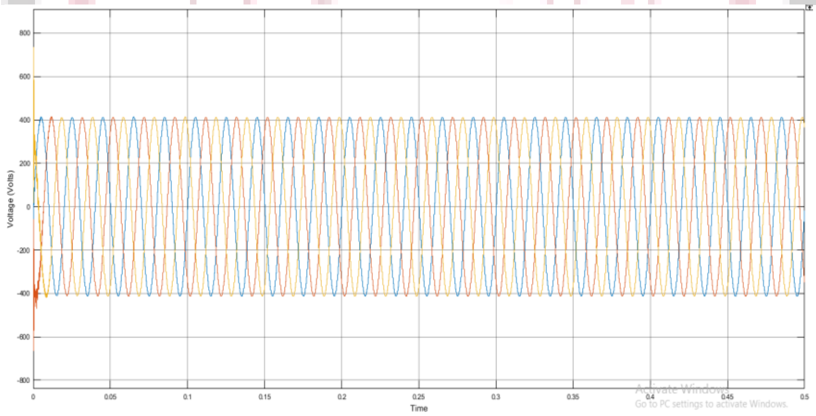

Figure 4 Voltage at the loading line in system 1 with loads from area-1

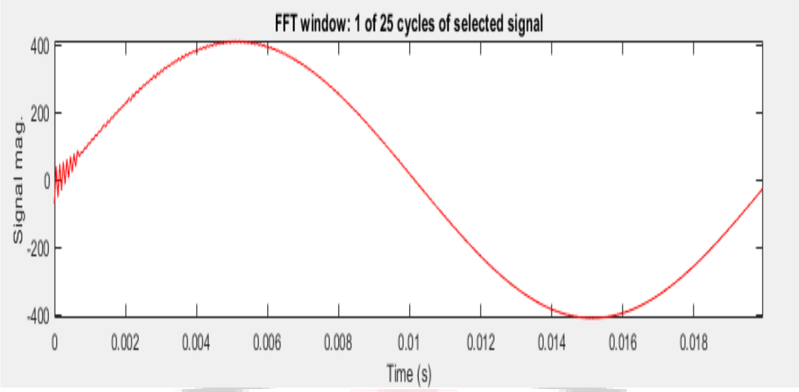

Figure 5 FFT analysis of voltage at loading line in system 1 with loads from area-1

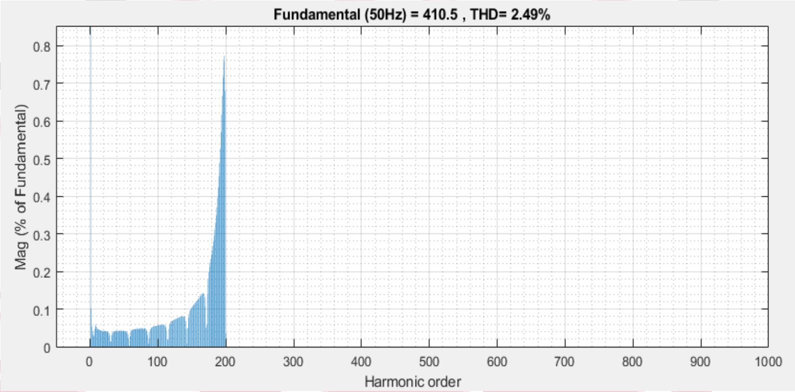

Figure 6 THD% in voltage at loading line in system 1 with loads from area-1

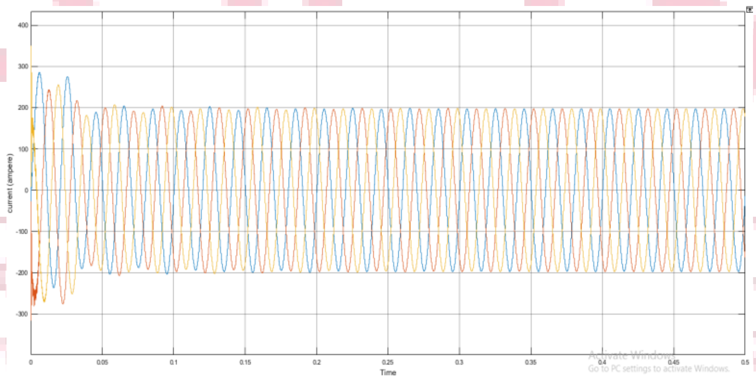

Figure 7 Current at the loading line in system 1 with loads from area-1

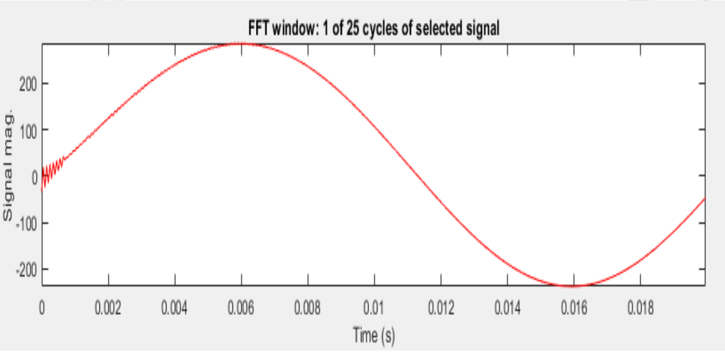

Figure 8 FFT analysis of Current at the loading line in system 1 with loads from area-1

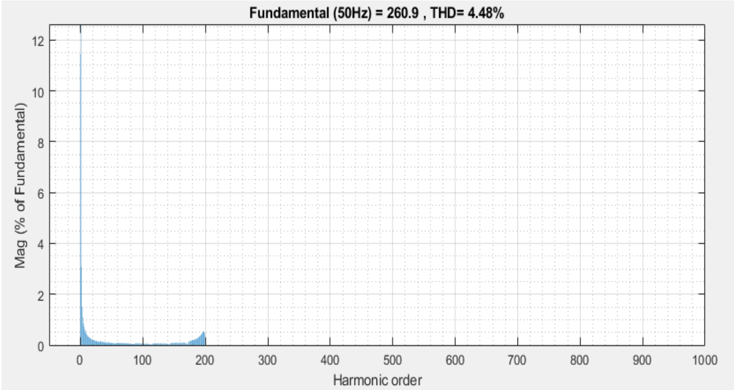

Figure 9 THD% Current at the loading line in system 1 with loads from area-1

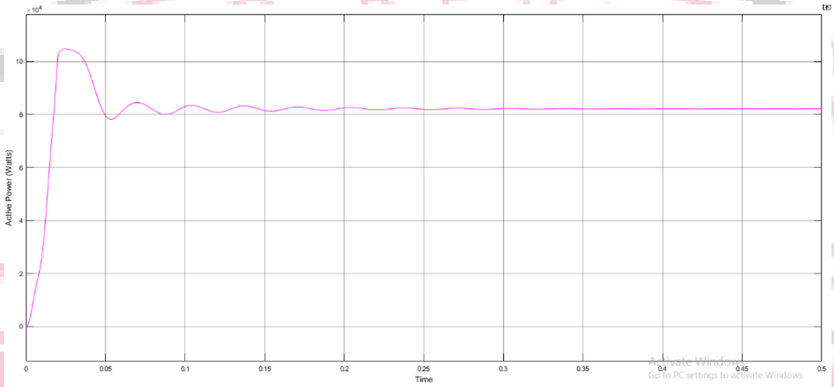

Figure 10 Active Power at the loading line in system 1 with loads from area-1

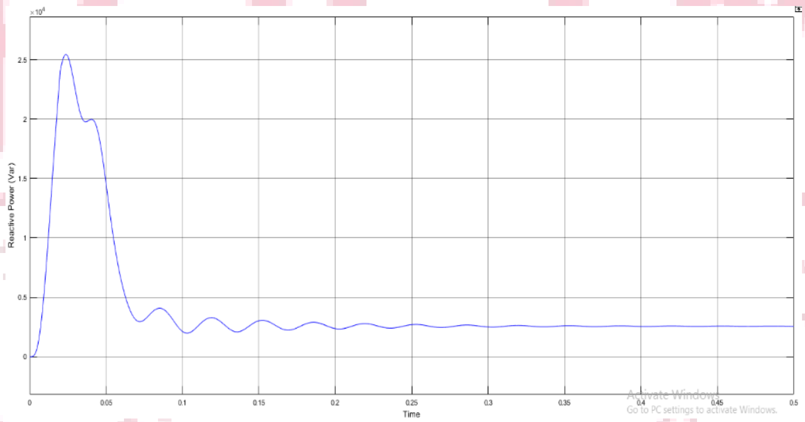

Figure 11 Reactive Power at the loading line in system 1 with loads from area-1

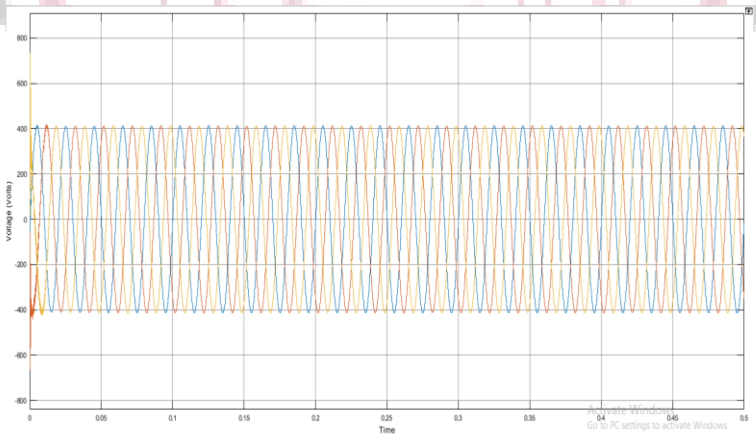

Figure 12 Voltage at the loading line in system 2 with loads from area-1

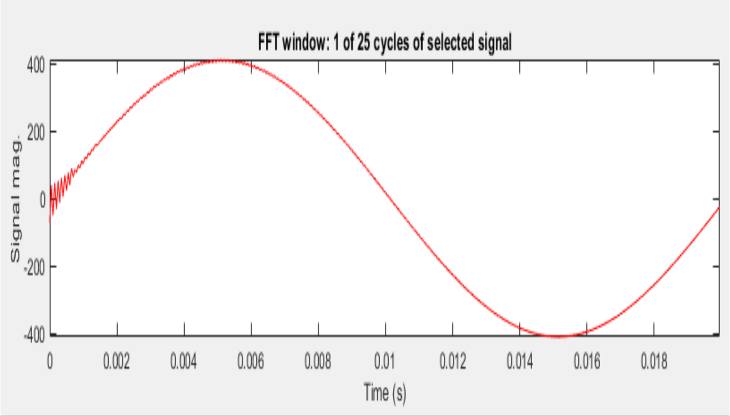

Figure 13 FFT analysis of Voltage at the loading line in system 2 with loads from area-1

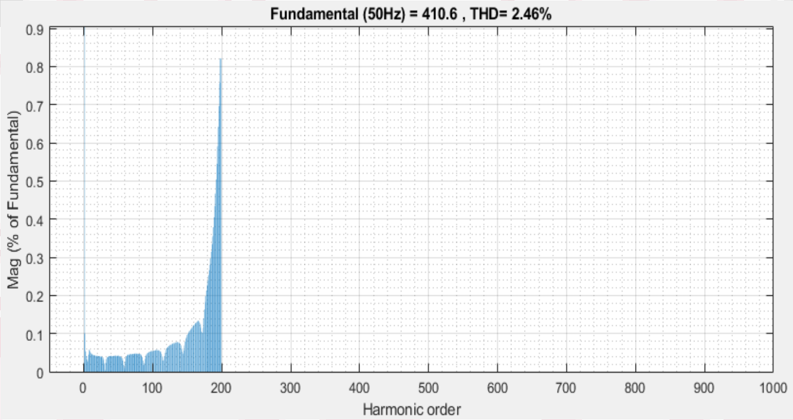

Figure 14 THD% in Voltage at the loading line in system 2 with loads from area-1

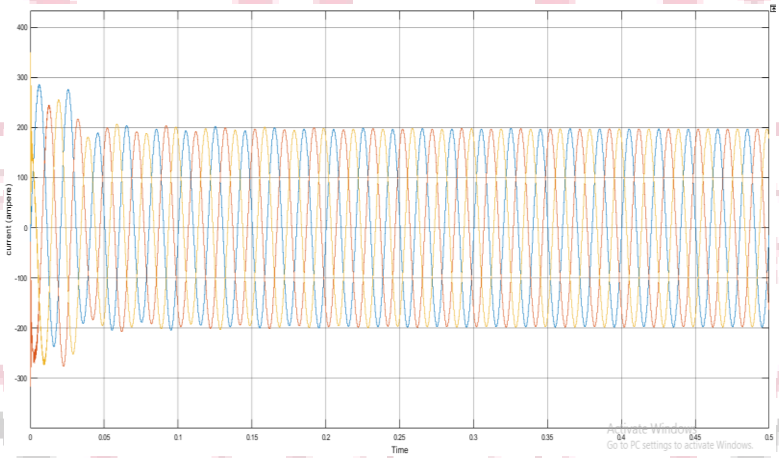

Figure 15 Current at the loading line in system 2 with loads from area-1

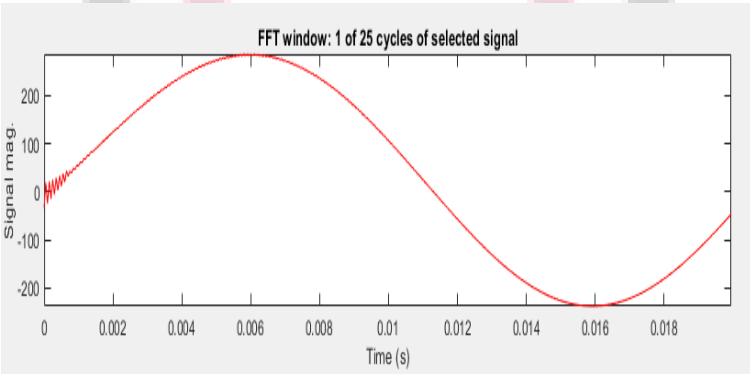

Figure 16 FFT analysis of Current at the loading line in system 2 with loads from area-1

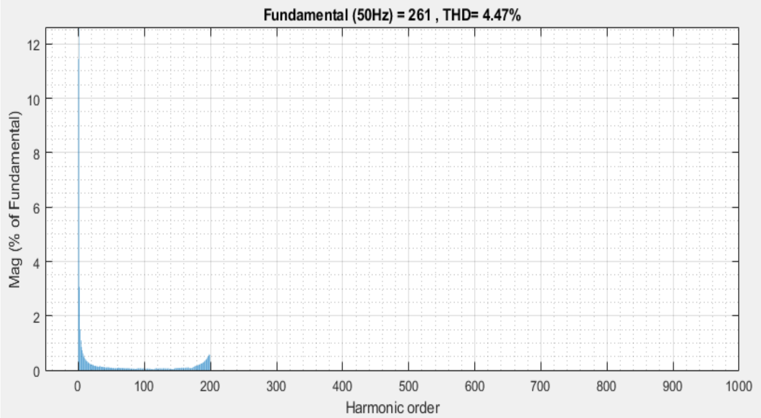

Figure 17 THD% in Current at the loading line in system 2 with loads from area-1

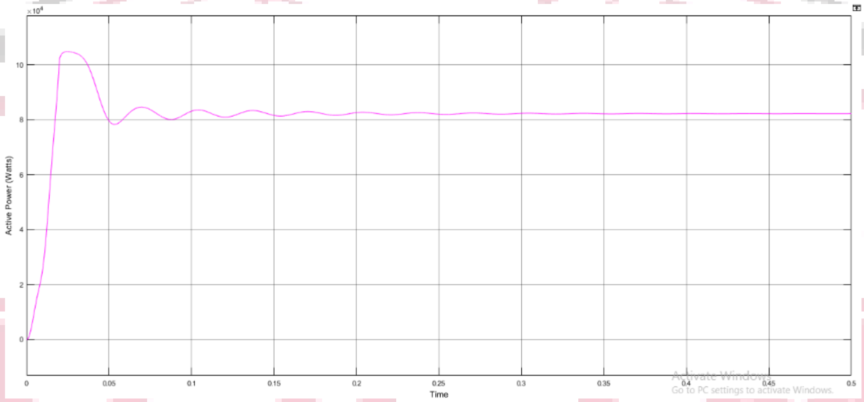

Figure 18 Active Power at the loading line in system 2 with loads from area-1

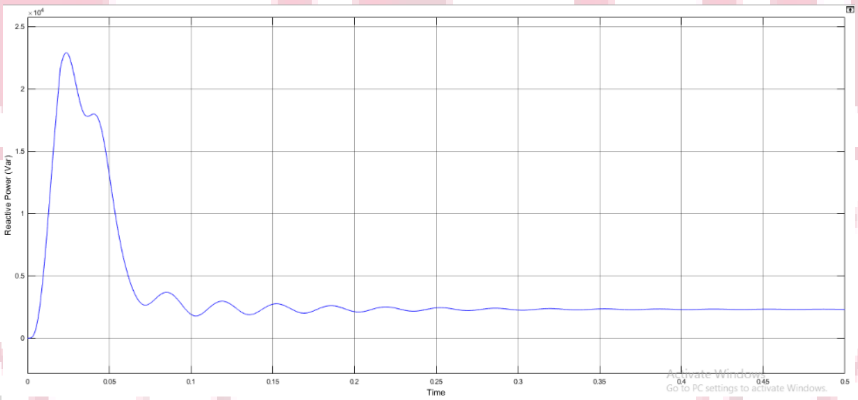

Figure 19 Reactive Power at the loading line in system 2 with loads from area-1

Comparative analysis of system 1 and system 2 driving area 1 in CASE 1		
Parameters	**System 1**	**System 2**
Active Power	82.18 KW	82.21 KW
Reactive Power	2563 Var	2308 var
THD% in voltage	2.49 %	2.46 %
THD% in current	4.48 %	4.47 %

Similarly we have tested the system in case 2 : Solar system driving loads at area 1and area 2 and CASE 3 Analysis of converter system during transient switching at area 2, the results we have discussed in the tabular format below

Comparative analysis of system 1 and system 2 driving both the areas in CASE 2		
Parameters	**System 1**	**System 2**
Active Power	124.5 KW	124.9 KW
Reactive Power	20.46 KVar	20.19 Kvar
THD% in voltage	3.29%	2.95%
THD% in current	10.21%	9.65%

CASE 3 : THD% in current in load line loading in case of system 1 and system 2		
Parameters	**System 1**	**System 2**
During loading at 0.1 sec	4.60%	4.52 %
During off-loading at 0.2 sec	4.45%	4.15%

V. CONCLUSION

The work performed in this paper shows that a PV cell can be used to power a motor via a three-phase bidirectional converter. We can conclude that this research will contribute to the study of solar panels used to power a motor via a PWM inverter. The goal of the project is to analyze an energy from the sun systems that also moves loads away from of the generation point. The conversion control is examined at the point loads during the processes, as well as the transitory load capacity. The proposed controller was designed to create pulses using the PWM technique, with a reference signal produced in consideration of the system's loading conditions, which adapts to change in motors point loads.

As a result of efficiency and reduced loses at distinct positions of drive loads in area 1 and area 2, the effective power production from the system has increased in the system with suggested direct method drive suitable for different PWM controls. The load switching analysis was used to compare the two systems' performances at two intervals. The efficacy of the proposed controllers in driving diverse loading with their sudden switch on the line was analyzed and the results.

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