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Improvement Of Power Quality Using Hybrid Up-Pwm Scheme For Heric Inverter With Closed Loop Control

Anantapatnaikuni Giridhar[1], Dr. K.V.S. Ramachandra Murthy[2], K. Rambabu[3]

P.G. Scholar[1], Professor[2] , Associate Professor[3]

Department of Electrical and Electronics Engineering,

[1]Aditya Engineering College(A), Surampalem, Andhra Pradesh, India

ABSTRACT: When dealing with photovoltaic generating, an inverter that is both efficient and reliable is critical. Switching frequency is the most popular approach to raise the standard of the inverter output voltage. However, power losses will increase as a result of this strategy. As a result, this work proposes a hybrid unipolar pulse width modulation (UP-PWM) system. For generating positive power, the hybrid method uses traditional UP-PWM. A modulation system that only necessitates the operation of freewheeling switches is especially presented for the generation of negative power. Control of output voltage and current zero crossing points (ZCPs) is also introduced by means of a UP-PWM closed control with a changed dead time. A 3-kW HERIC inverter system with a 25-kHz frequency is used in simulations and experiments to verify the efficiency of the suggested mehod. Reactive power injection is better with the hybrid UP-PWM closed control method, and efficiency is better than with the traditional UP-PWM closed control method with dead time, according to the results. Better power quality is another benefit of the UP-PWM closed control system that has been offered.

Index Terms—HERIC inverter, hybrid unipolar PWM (UP-PWM).

I. INTRODUCTION

Low leakage currents and a moderately high efficiency characterise the cost-effective topology of the extremely effective and trustworthy inverter concept (HERIC) inverter. So, PV systems devoid of transformers are ideal. Maintaining the HERIC inverter's high efficiency, excellent power quality, and reactive power injection simultaneously is difficult when using the disclosed modulation approaches. [1], Low leakage currents and a respectably high efficiency are two characteristics of the cost-effective topology of the extremely effective and trustworthy inverter concept (HERIC) inverter. So, photovoltaic systems devoid of transformers are ideal. However, maintaining the HERIC inverter's high efficiency, excellent power quality, and reactive power injection simultaneously is difficult when using the disclosed modulation strategies. Simulations and testing are run on a 3-kW HERIC inverter system with a 25-kHz switching frequency to verify the efficacy of the suggested strategy. The findings demonstrate that the proposed hybrid UP-PWM strategy outperforms both the conventional UP-PWM system and UP-PWM with deadtime in terms of reactive power injection and efficiency. Moreover, the proposed UPPWM method enables a higher power quality.

The focus of Kjaer et al[2] .'s investigation on solar module single-phase grid-connected inverters is on the inverter technologies that are employed to connect solar panel modules to a 1-ϕ grid. The following criteria are used to group the four main types of inverters: The number of cascading power processing stages, the type of power decoupling between the PV module(s) and the 1-ϕ grid, the use of a transformer and the type of power stage connected to the grid are the four factors to consider. We show, compare, and assess various inverter topologies in terms of requirements, lifetime, component ratings, and price. The ideal topologies for applications utilising either a single PV module or numerous PV modules are highlighted in the last section.

Step-up transformerless configurations are compared for solar ac-module utilisation by Meneses et al [3]. To compare the most useful solutions among the configurations looked at, a benchmark is constructed. This assessment is based on an average ac-module application that takes grid and solar panel requirements into account. The chosen alternatives are built and simulated in line with the benchmark, receiving ratings for passive and semiconductor components, in order to conduct a size and cost comparison. In relation to the measured ratings and ground currents, the analysed topologies are addressed. The proposals offer configurations solutions that satisfy the application benchmark.

Thought to be unreliable substitutes for traditional energy sources like oil, natural gas, or coal, renewable energy sources include the wind, sun, and water. The United States, Germany, Denmark, Japan, and Japan are leading the way in developing distributed power generating systems (DPGSs) that employ renewable energy. According to Blaabjerg et al. [4], the increasing number of DPGSs connected to the utility network has led to the provision of new and more stringent criteria for power quality, safe operation, and islanding prevention. Distributed generating system control needs to be improved in order to meet the requirements for grid connectivity. The DPGS architectures based on fuel cell, solar, and wind turbine technology are briefly discussed in the study. It also covers the possibility of correcting for low-order harmonics and grid-side converter control techniques. The handling of control schemes when using grid faults is another important consideration. The study's conclusion includes a summary of synchronisation strategies and a discussion of their importance in the control.

In order to create new topologies, Wang et al. [6] derived rules using current high-performance inverters with a H6-type arrangement. Therefore, it is essential for power electronics engineers to have a solid understanding of fuel cell operation. A theoretical and experimental analysis of how a fuel cell stack responds to current harmonics is proposed by Fontes et al. [7]. The main purpose of the internal two layer capacitor is shown. Another workable solution is to cap the maximum feed-in power of the existing PV systems at a certain level. By simultaneously boosting penetration and reducing the need for grid expansion, it might be possible. Therefore, Verband der Elektrotechnik recommended a Constant Power to achieving the demand for this new potential supplementary service offered by PV systems [8].

A innovative, high-efficiency transformer-less topology for grid-tied PV systems with reactive power regulation was put forth by Islam et al. [9]. Along with the new topological structure and comprehensive operating theory, reactive power flow is defined. The control of the suggested topology and the high frequency common-mode (CM) model are both examined. The recommended topology's inherent circuit structure precludes issues with reverse recovery even when reactive power is provided, allowing MOSFET switches to be employed to boost overall efficiency. Measures must be taken to lower harmonics at the inverter's output. Numerous attempts have been made to improve the power quality and lessen the harmonics produced by PV inverters. By altering the switching frequency settings of the semiconductor components that make up a PWM inverter, the output waveform can be made better. As the switching frequency is raised, the resulting waveform gradually becomes sinusoidal. The efficiency of the inverter diminishes when switching frequency rises as a result of higher power losses on the switch. The quality of the voltage output from the PV inverter can be enhanced by using both a multi-level topology and a topology that is naturally designed to produce voltage output with minimal harmonics. Multilevel inverter technology allows for high power operations while simultaneously enhancing voltage quality, lowering harmonics, and decreasing switching frequency. he power circuit topology of the HERIC inverter is altered by using a multilevel topology, and as a result, a novel PV-inverter topology is detailed in this paper. To exemplify what can be done, the outcomes of a software simulation are displayed.

II. SCHEMES FOR ADVANCED MODULATION

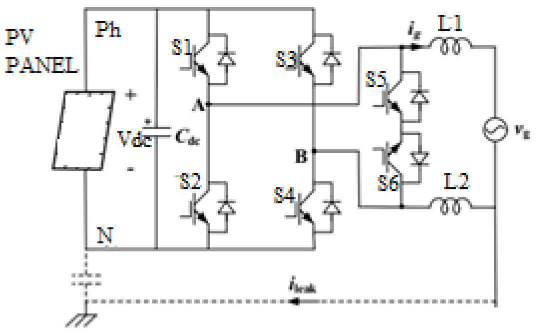

Fig. 1. The single-phase, single-stage grid-connected driveline hardware schematic

FIG. 1 depicts the HERIC inverter's schematic diagram. By utilising KVL, the dynamic equation for the grid current can be discovered (KVL).

$$v_L(t) = L\frac{di_g(t)}{dt} = v_{AB}(t) - v_g(t) \tag{1}$$

where L1 + L2 is the grid filter, and ig(t) is the grid-connected current, vg(t) is the grid voltage, and vAB(t) is the differential-mode voltage. The DC-link voltage Udc is assumed to be constant since only the modulation mechanism of the single-phase single-stage grid-connected HERIC inverter is described. It is also characterised as ig's forward direction in Figure 1.

II. i Typical Modulation Schemes

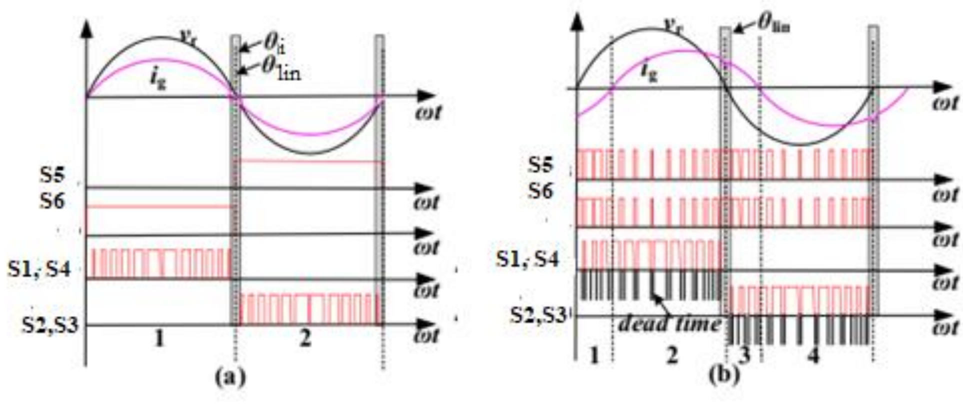

Fig. 2. HERIC inverter modulation techniques include (a) the traditional UP-PWM and (b) θlin and θi are ZCD zones close to the voltage ZCP and current ZCP, respectively, in the UP-PWM with dead time.

Figures 2(a) and (b) demonstrate common modulation techniques for the HERIC inverter, along with regular UP-PWM and UP-PWM with dead time, where vref is the output voltage reference. The power switches S1-4 operate at a higher frequency in the conventional UP-PWM (Fig. 2a), whereas the AC bypass power devices S5,6 are switched at the grid basic frequency. According to Fig. 2(b), the power devices S1-4 and the AC bypass switches S5,6 are operated in the UP-PWM with dead-time mode at a high frequency. Total power losses would rise as a result of unwanted switching states occurring during idle time. Additionally, the additional dead time will result in large ripple currents, which will impair power quality.

III. HYBRID UP-PWM TECHNIQUE PROPOSED

An UP-PWM approach for the HERIC inverter is presented in this part For maximum efficiency and high-quality power, and adequate reactive power capabilities. Fig. illustrates the operation principles. During an inverter's operation.

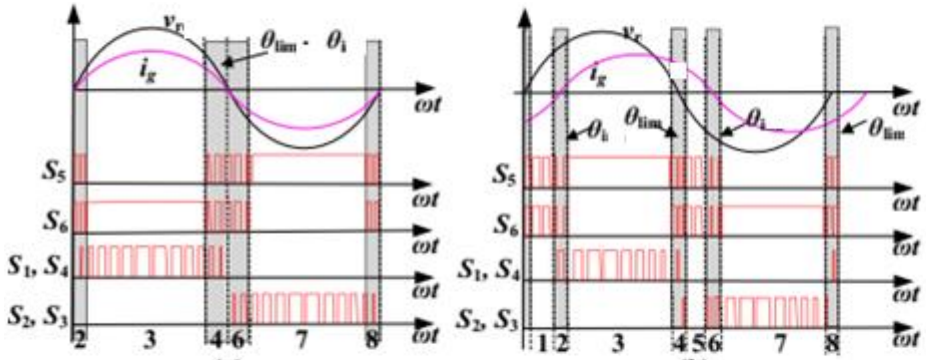

Fig 3.1. Hybrid UP-PWM is suggested for the HERIC inverter to increase power quality and efficiency both when operating at unity power factor and when operating at non-unity power factor.

Fig. 3.1 shows how the operation can be partitioned into eight parts if the power factor is not equal to unity (b). Consideration should be given to regions 2, 4, 6, and 8 in particular. Small output voltages or currents from inverters make it difficult to discern the polarity of power switches.

As a matter of fact, regions 1, 3, 5, and 7 pose the least amount of difficulty. Therefore, the hybrid UP-PWM method presented uses several modulation algorithms depending on the operating areas. It is possible to use one of three different modulation schemes:There are two types of conventional UP-PWM in Zones 3 and 7. There are minimal switching power losses and low ripple currents for standard UP-PWM.Dead time in regions 2, 4, 6, and 8 of UP-PWM. With the grid's polarity unknown, UP-PWM with dead time is used to assure reliable inverter system performance. Modifying the dead time can also help mitigate the negative effects of the minimum pulse width constraint. (3) UP-PWM in regions 1 and 5 for negative power production. The modulation, which just requires the operation of AC bypass switches like Fig. 3(a), is applied to the HERIC inverter to supply reactive power and decrease switching power losses.

To be clear, regions 1 and 5 aren't included in the operation with a unity power factor. In the suggested technique, there are only two modes of operation (i.e., standard UP-PWM and UP-PWM with dead time), as illustrated in Fig. 3.2. (a). The HERIC inverter's suggested hybrid UP-PWM scheme is explained in full in Fig. 3.2, including the following:All four-leg power switches are off in Region 1, as illustrated in Figs. 3.2(a) and (b). The high-frequency operation of the other two power switches is also depicted. A positive voltage vAB is generated by the grid-connected current ig flowing through diodes D1 and D4, whereas a zero voltage is generated by ig flowing through S5 and D6. There are three power switches in this region that run at a high frequency at the present ZCP: S1, S4, and S5. In this instance, there are currently two options open to you. In Fig. 3.2(c) and (d), the current ig runs through D1 and D4 to maintain a positive voltage vAB, and the current ig also flows via S5 and D6 to achieve a zero voltage.

Second, the grid-connected current polarity shifts from S1 and S4 to S6 and D5 in Fig. 3.2(e) and (f). This results in an increase in vAB when the current flows through S1 and S4, and a decrease in vAB when the current flows through S6 and D5. It's necessary to provide a pause between modes of operation. The third operating zone is depicted in Fig. 4(g) and (h), where S6 is always on, while S1 and S4 are turned on and off at a fast rate. S1 and S4 conduct the grid-connected current ig, whereas S6 and D5 conduct the negative voltage vAB. Transitioning options are available at voltage ZCP in Region 4. in order to create positive voltage vAB, as shown in Figure 3.2 (e) and (f), S1 and S4 are in the "on" state, which means that the current ig passes through them. Then, S5 and S6 are turned on to bring the voltage to zero, and the current ig flows through S6 and D5 to complete the circuit. In Fig. 3(i) and (j), S2 and S3 are both on, indicating that they are connected. VAB is set to a negative value. Zero-voltage current ig flows via the grid-connected conductors S6, D5, as S5 and S6 are in on-state. To avoid short-circuiting the DC side, the dead time must be applied during mode changes.According to Fig. 5, all four leg power devices have been turned off, but S5 and S6 continue to run at a high frequency in region 5. To create a negative voltage vAB, the grid-connected current ig flows via D2 and D3, while S6 and D5 provide zero voltage.

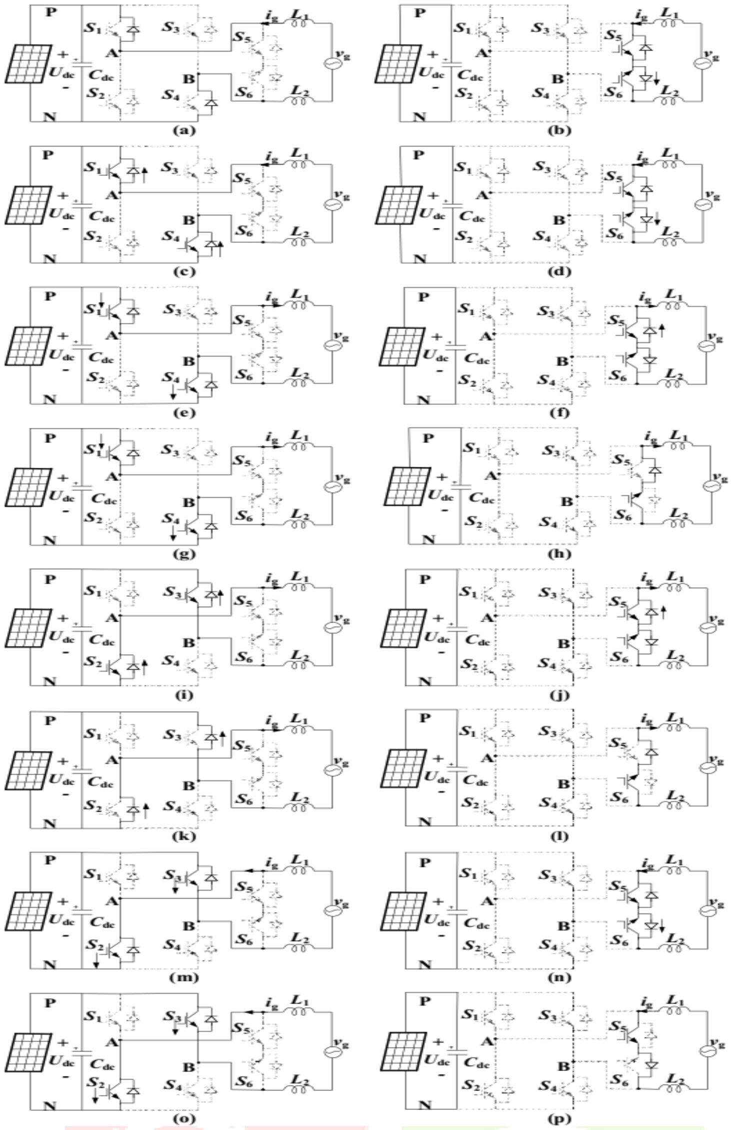

Fig: 3.2 modes of operation for the HERIC inverter's hybrid UP-PWM.

IV SIMULATION RESULTS:

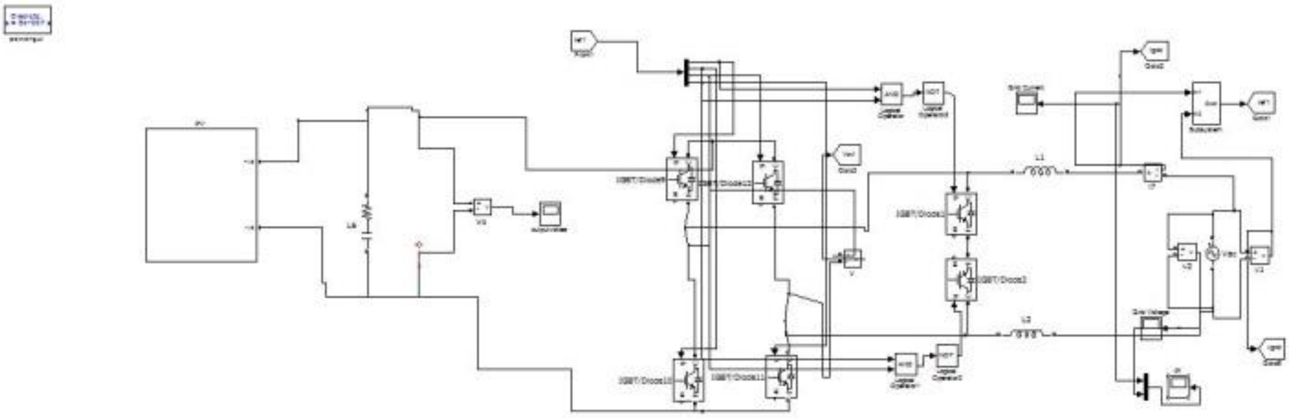

Fig 4.1 Simulink diagram of suggested system with lagging power factor

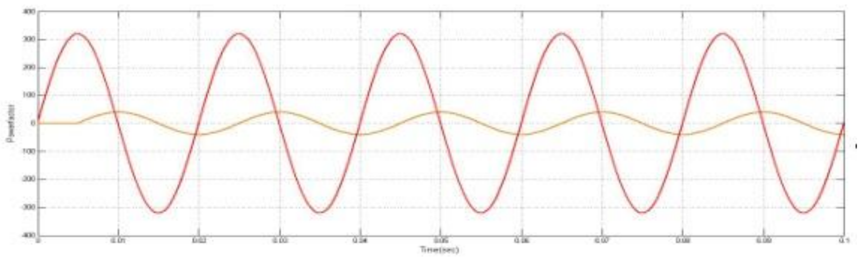

Fig 4.2 Simulation power factor wave form of suggested system with lagging power factor

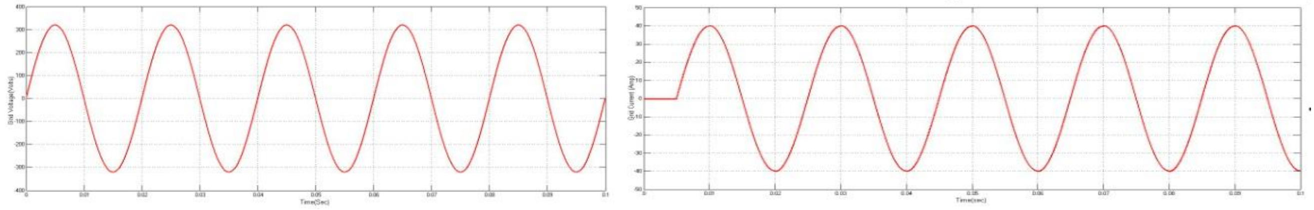

Fig 4.3 (a) Simulation Grid Voltage wave form of suggested system with lagging power factor (b) Simulation Grid Current wave form of suggested system with lagging power factor

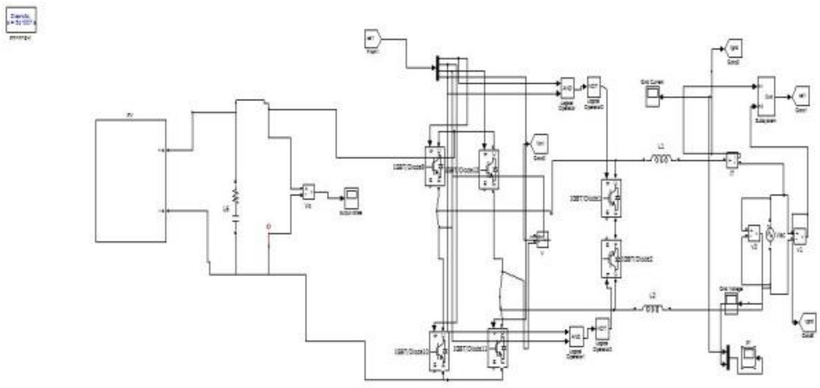

Fig 4.4 Simulink diagram of suggested system with leading power factor

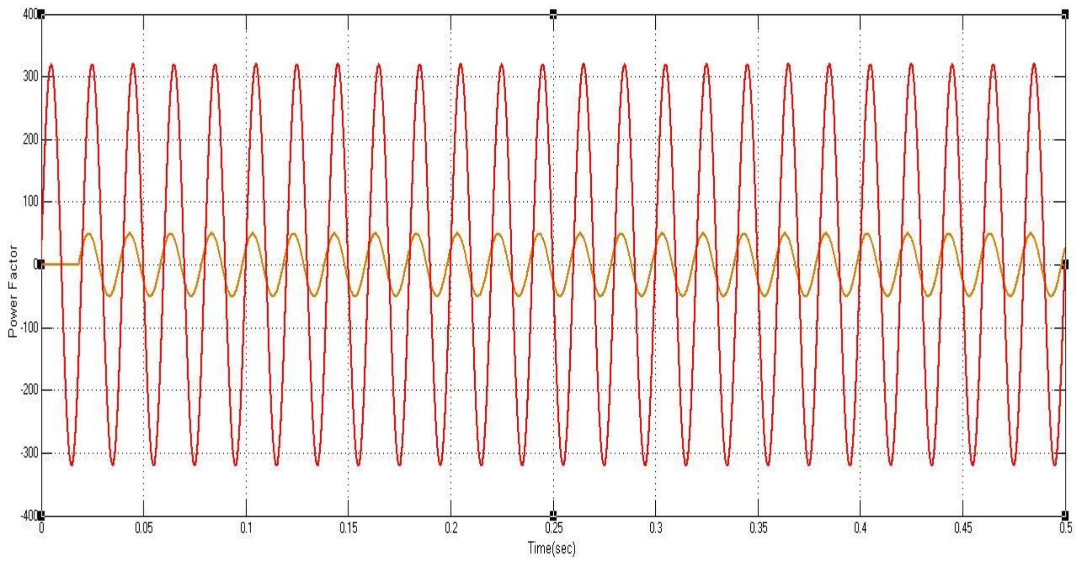

Fig 4.5 Simulation power factor wave form of suggested system with leading power factor

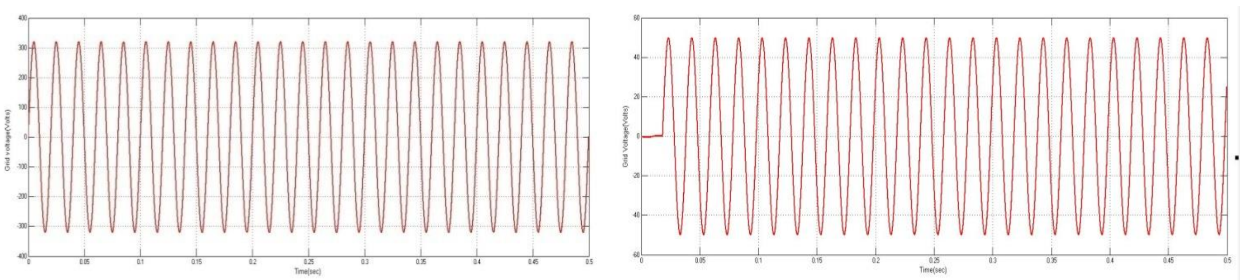

Fig 4.6(a) Simulation Grid Voltage wave form of suggested system with leading power factor (b) Simulation Grid Current wave form of suggested system with leading power factor

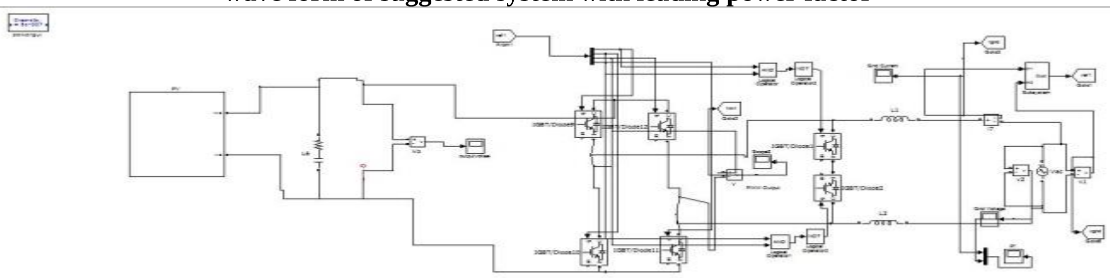

Fig 4.7 Simulink diagram of suggested system with Unity power factor

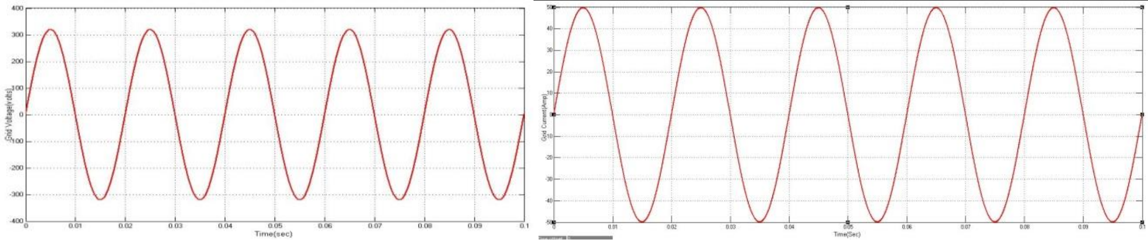

Fig 4.8 (a) Simulation Grid Voltage wave form of suggested system with Unity power factor (b) Simulation Grid Current wave form of suggested system with Unity power factor

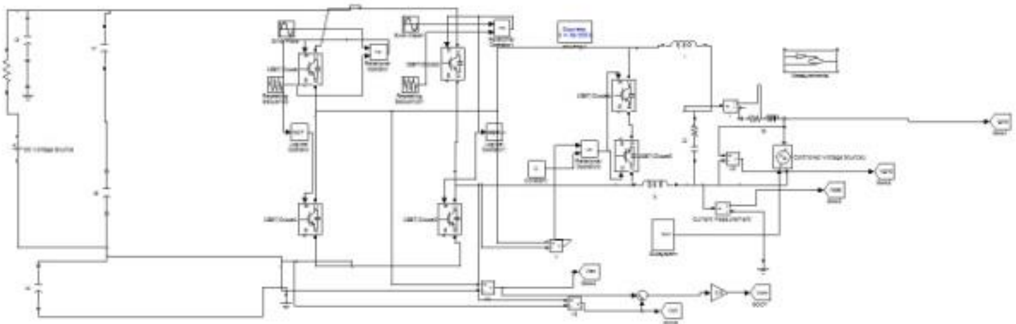

Fig 4.9 Simulink diagram of suggested system with lekage current condition

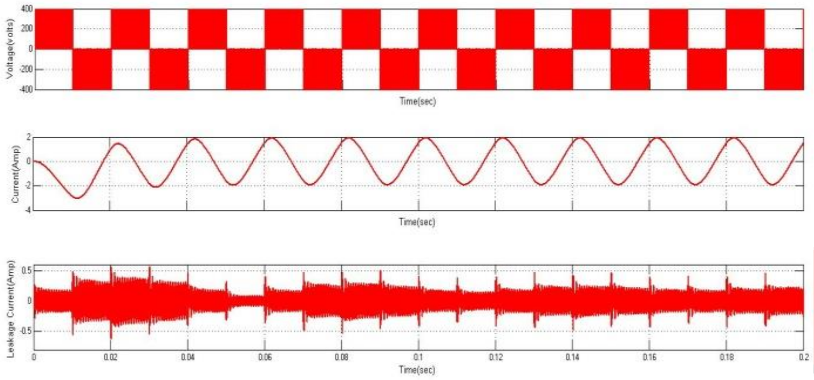

Fig 4.10 Simulation Grid Voltage, Grid current, and Leakage Current Wave form of proposed system with Closed loop Controller

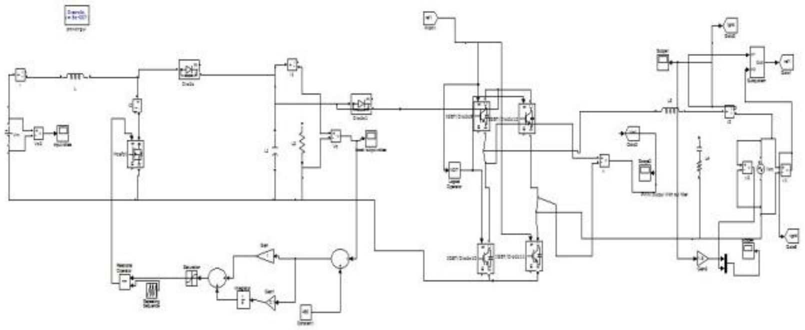

Fig 4.11 Simulink diagram of suggested system with Closed loop Controller

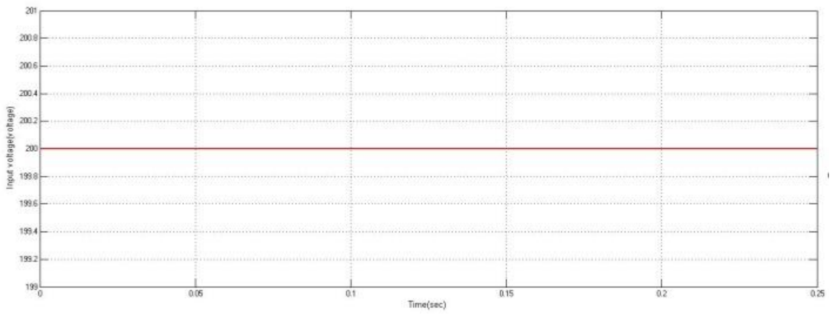

Fig 4.12 Simulation input voltage wave form of suggested system with Closed loop Controller

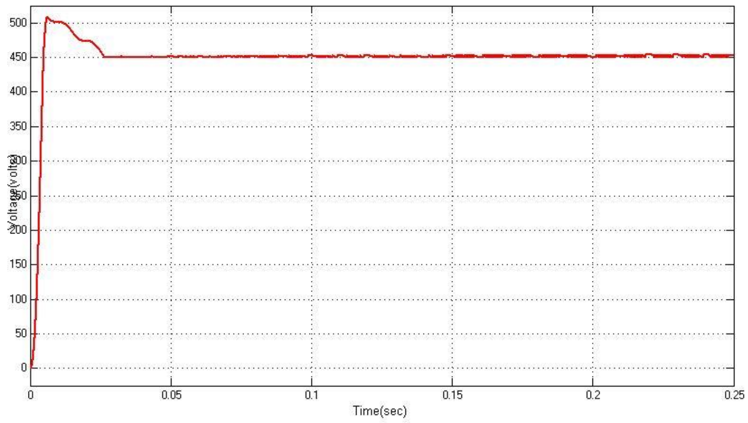

Fig 4.13 Simulation output voltage wave form of suggested system with Closed loop Controller

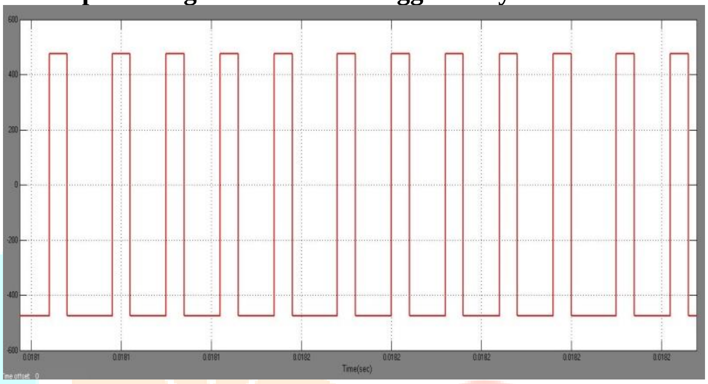

Fig 4.14 Simulation output voltage without filter wave form of suggested system with Closed loop Controller

V: CONCLUSION

The HERIC inverter might benefit from a hybrid UP-PWM technique, as shown in this study. The suggested technique takes use of the standard UP-PWM, the UP-PWM with dead time, and the reactive power capacity modulation strategy. Conventional UP-PWM is used to generate positive power in the operating mode of the proposed scheme. When negative power production is enabled, only two more high-frequency power switches are in use. Using the suggested PWM method, low switching power losses and tiny ripple currents may be achieved in this situation.

To further assure steady functioning of the inverter system, the UP-PWM with dead time is applied at the voltage and current ZCPs. The hybrid UP-PWM method adjusted for the impacts of the dead time and the minimum pulse width constraint to further enhance power quality. Hybrid UP-better PWM's power quality, increased efficiency, and, most crucially, its flexible reactive power controllability have all been demonstrated through simulation and experiment.

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