# Simulation of Multifunctional VSC controlled Solar Photovoltaic System with Active Power Sharing and Power Quality Improvement

**Vamsi Krishna P[1], A. Mallikarjuna Prasad[2]**
[1]P.G. Scholar, 2Guide, Principal
[1,2] BRANCH : EEE(P&ID)
[1,2] Geethanjali college of engineering and technology
Email ID: [1]vamshikrishna044@gmail.com, [2]mallikarjunaprasad0307@gmail.com

**Abstract**
*This paper presents a multifunctional voltage sourced-converter (VSC) controlled solar photovoltaic (SPV) system with a generalized 'dq' and adaptive PLL-based approach to extract the dual features. These include enhanced active power sharing feature based on the availability of active power at DC-side collector bus while also serving as an active harmonic filter (AHF). The presented control is computationally less intensive and easy to formulate compared to its conventional counterpart like synchronous reference frame theory (SRFT). The objective of this work is to effectively extract the various ancillary services offered by multifunctional VSC in the power distribution system.*

*The primary function of any grid connected inverter (GCI) is to serve the active power demand of the load connected at the point of interconnection (PoI) in the power distribution network. However, the multifunctional VSC with presented control approach can also be utilized as AHF to attenuate the rich harmonic content present in source current, to mitigate the load reactive current demand, and to adequately supply the zero sequences harmonic component requirement of the unbalanced and nonlinear load by the fourth leg of the multifunctional VSC. Additionally, the proposed system typically ensures the unity power factor (UPF) operation. An incremental conductance (IC) based control technique is employed to optimize and continuously track the maximum power point (MPP) during solar intermittency. The usefulness of the proposed multifunctional VSC is demonstrated through transient test cases, conducted in the MATLAB/Simulink software environment. Additionally, its practicality is validated through a comprehensive set of experimental studies investigated on a laboratory developed prototype.*

**Keywords—Multifunctional VSC, grid-connected SPV system, unity power factor operation, power quality improvement, active harmonic filter, renewable energy sources.**

## INTRODUCTION

In a recent year, the growing electricity demand across the globe and increasing carbon emission generated by non-renewable sources have been gaining special attention from the science and engineering society. At the mean time, electric utilities are also concerned about serving the raising needs of energy. Thus, it has now become mandatory to look towards renewable energy source (RES) as a promising substitute to produce green and clean power. Besides this, the development of new/and rapid switching power electronics components, and the evolution in technological advancement in semiconductor technology have played a very crucial role in converting the energy generated by RES into a useful form. The classical converter technology employed in SPV typically systems suffers from poor efficiency ranging from 6 to 7 % and was very expensive in earlier days. However, with continuous evaluation in technological research has brought the efficiency of SPV module from 6-8% to 15-16%. Moreover, the prices of SPV array module along with converter technology used in it diminishing very moderately.

Today, the SPV system is taken into consideration as most optimistic substitutes to fossil fuel-based electricity generating systems, as there is no carbon emission, and no fuel cost involvement. But, it should be pointed out that the technology is still growing and many associated challenges are required to be addressed such as the intermittent nature of RES, high capital cost, and lower SPV module efficiency. Moreover, the application and usage of various nonlinear loads have been grown in the past couple of decades.

Consequently, power quality (PQ) problems are also emerging in the power distribution system mainly due to the harmonics introduced by these non-linear power electronics loads, which may pose to a shortfall in reactive current demand of load, power factor degradation, and varying voltage profile problems. Electronics ballast, laptops, battery chargers, adjustable frequency drives (ASD), and printers are considered as major sources of harmonic-rich current in the power distribution system. These current harmonics propagate across the PoI and deteriorate the voltage profile. Subsequently, these harmonics current influence the performance of linear loads adversely, which is not imperative for reliable and efficient power system network. The aforementioned problems can be well addressed by incorporating various functionalities offered by AHF into the control algorithm of the multifunctional VSC. Needless to say that, the control algorithm plays a very vital role in improving the operation and control of overall solar photovoltaic power conversion system (SPVPCS). The grid-connected SPV system proposed in this paper composed of double-stages including intermediate DC/DC boost converter stage, and DC/AC current controlled VSC stage. The primary function of employing boost converter on the SPV side is to harvest the maximal power from the solar array during the varying atmospheric condition. Moreover, the operational performance of VSC can be actively controlled by various algorithms reported in the literature. MPPT techniques and control algorithm have been illustrated in the following part of this section. There have been numerous MPPT methods elucidated in the literature like voltage control, fuzzy logic based control, and short-circuit current etc., although IC and perturb & observe (P&O) are amid the most preferred methods. In this paper, the IC-MPPT technique has been employed, because it offers decent dynamic performance during fluctuations in solar insolation condition.

Designing of boost converter along with topologies used in it are illustrated extensively in the scientific literature. The work demonstrated in this paper mainly emphasizes the operational performance and control of multifunctional VSC controlled SPVPCS. A simplified control technique is implemented in this paper to confirm and demonstrate the neutral current mitigation capability under unbalanced loading condition. The control algorithm presented in this paper ensures that not only active part of the load is supplied by respective phases of VSC but, harmonic, in addition to the reactive current requirement of nonlinear loads are also fulfilled by VSC. In particular, the control presented in this paper typically ensures UPF operation at PoI irrespective of load characteristic. The principal objective of this work is to diminish the total cost of the overall SPVPCS considerably by incorporating the various functionalities offered by conventional GCI and AHF together into the proposed multifunctional VSC. The various operating modes have been considered and elucidated to present all the aforementioned features of the multifunctional VSC based SPVPCS.

The major contribution of this work is outlined as below:

1. The implementation of generalized “dq” reference based approach to overcome the drawback of conventional SRFT, which further enables the fast transient response.

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 7
July 2021

2. Dual features: These includes PQ improvement features including source current harmonic suppression, load reactive current and zero sequences harmonic current compensation under nonlinear and unbalanced power electronics based loads. Additionally, it provides active power sharing feature based on the availability of active power at DC-bus terminal. Substantial simulation results and detailed hardware experimental investigations and validation are illustrated in Renewable generation affects power quality due to its nonlinearity, since solar generation plants and wind power generators must be connected to the grid through high-power static PWM converters. The non uniform nature of power generation directly affects voltage regulation and creates voltage distortion in power systems. This new scenario in power distribution systems will require more sophisticated compensation techniques.

Although active power filters implemented with three-phase four-leg voltage-source inverters (4L-VSI) have already been presented in the technical literature , the primary contribution of this paper is a predictive control algorithm designed and implemented specifically for this application.

**LITERATURE SURVEY**

Traditionally, active power filters have been controlled using pre tuned controllers, such as PI-type or adaptive, for the current as well as for the dc-voltage loops. PI controllers must be designed based on the equivalent linear model, while predictive controllers use the nonlinear model, which is closer to real operating conditions. An accurate model obtained using predictive controllers improves the performance of the active power filter, especially during transient operating conditions, because it can quickly follow the current-reference signal while maintaining a constant dc-voltage.

So far, implementations of predictive control in power converters have been used mainly in induction motor drives. In the case of motor drive applications, predictive control represents a very intuitive control scheme that handles multivariable characteristics, simplifies the treatment of dead-time compensations, and permits pulse-width modulator replacement. However, these kinds of applications present disadvantages related to oscillations and instability created from unknown load parameters. One advantage of the proposed algorithm is that it fits well in active power filter applications, since the power converter output parameters are well known. These output parameters are obtained from the converter output ripple filter and the power system equivalent impedance. The converter output ripple filter is part of the active power filter design and the power system impedance is obtained from well-known standard procedures. In the case of unknown system impedance parameters, an estimation method can be used to derive an accurate R–L equivalent impedance model of the system.

This project presents the mathematical model of the 4L-VSI and the principles of operation of the proposed predictive control scheme, including the design procedure. The complete description of the selected current reference generator implemented in the active power filter is also presented. Finally, the proposed active power filter and the effectiveness of the associated control scheme compensation are demonstrated through simulation.

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 7
July 2021

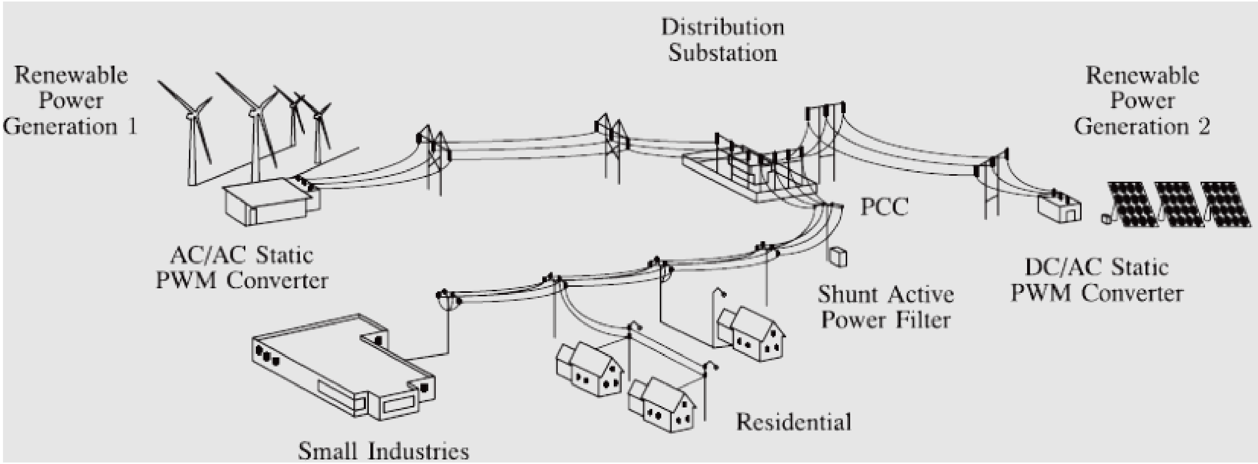

Fig. 1. Stand-alone hybrid power generation system with a shunt active power filter.

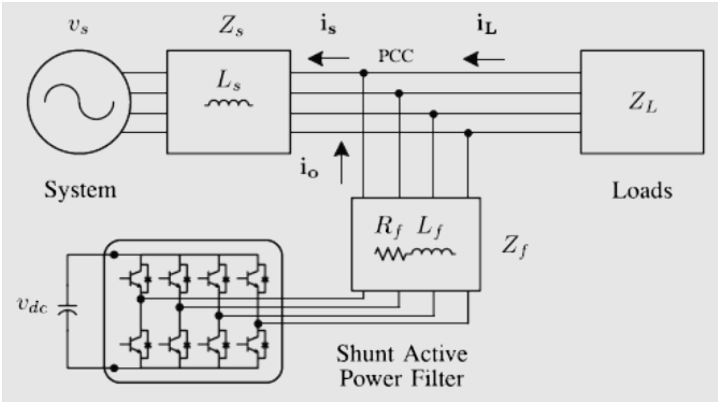

Fig.2. Three-phase equivalent circuit of the proposed shunt active power filter.

**Selective Harmonic Elimination in Three-Phase CSIs**

The SHE-based modulating techniques in VSIs define the gating signals such that a given number of harmonics are eliminated and the fundamental phase-voltage amplitude is

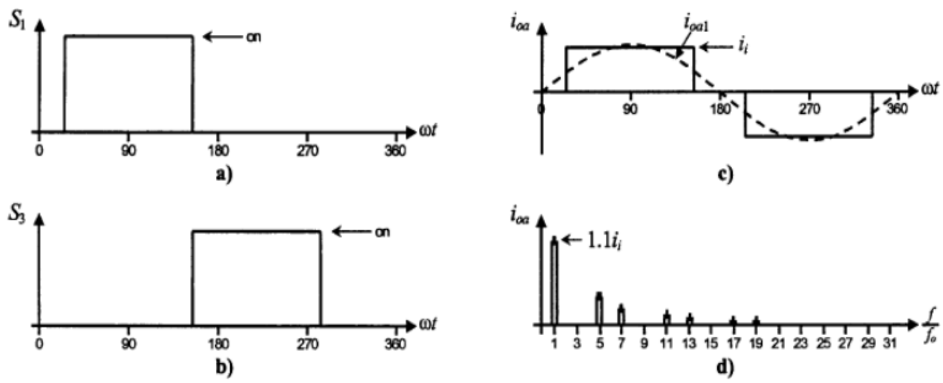

Fig: 3 The three-phase CSI. Square-wave operation: (a) switch S1 state; (b) switch S3 state; (c) ac output current; (d) ac output current spectrum.

Chopping angles for SHE and fundamental current control in three-phase CSIs: fifth and seventh harmonic elimination. synchronized with the signals .Sa.123 in order to symmetrically distribute the shorting pulse and thus generate symmetrical gating patterns. The circuit ensures line current waveforms as the line voltages in a VSI. Therefore, any arbitrary number of harmonics can be eliminated and the fundamental line current can be controlled in CSIs. Moreover, the same chopping angles obtained for VSIs can be used in CSIs. For instance, to eliminate the fifth and seventh harmonics, the chopping angles which are identical to that obtained for a VSI using the line current does not contain the fifth and the seventh harmonics as expected. Hence, any number of harmonics can be eliminated in three-phase CSIs by means of the circuit without the hassle of how to satisfy the gating signal constrains.

## APPLICATIONS

### DC power source utilization

An inverter converts the DC electricity from sources such as batteries, solar panels, or fuel cells to AC electricity. The electricity can be at any required voltage; in particular it can operate AC equipment designed for mains operation, or rectified to produce DC at any desired voltage.Grid tie inverters can feed energy back into the distribution network because they produce alternating current with the same wave shape and frequency as supplied by the distribution system. They can also switch off automatically in the event of a blackout.

### Uninterruptible power supplies

Inverters convert low frequency main AC power to a higher frequency for use in induction heating. To do this, AC power is first rectified to provide DC power. The inverter then changes the DC power to high frequency AC power'

### HVDC power transmission

With HVDC power transmission, AC power is rectified and high voltage DC power is transmitted to another location. At the receiving location, an inverter in a static inverter plant converts the power back to AC.

### Variable-frequency drives

A variable-frequency drive controls the operating speed of an AC motor by controlling the frequency and voltage of the power supplied to the motor. An inverter provides the controlled power. In most cases, the variable-frequency drive includes a rectifier so that DC power for the inverter can be provided from main AC power. Since an inverter is the key component, variable-frequency drives are sometimes called inverter drives or just inverters.

### Electric vehicle drives

Adjustable speed motor control inverters are currently used to power the traction motors in some electric and diesel-electric rail vehicles as well as some battery electric vehicles and hybrid electric highway vehicles such as the Toyota Prius. Various improvements in inverter technology are being developed specifically for electric vehicle applications. In vehicles with regenerative braking, the inverter also takes power from the motor (now acting as a generator) and stores it in the batteries.

### Air conditioning

A transformer allows AC power to be converted to any desired voltage, but at the same frequency. Inverters, plus rectifiers for DC, can be designed to convert from any voltage, AC or DC, to any other voltage, also AC or DC, at any desired frequency. The output power can never exceed the input power, but efficiencies can be high, with a small proportion of the power

## FOUR-LEG CONVERTER MODEL

Fig. 4.11 shows the configuration of a typical power distribution system with renewable power generation. It consists of various types of power generation units and different types of loads. Renewable sources, such as wind and sunlight, are typically used to generate electricity for residential users and small industries. Both types of power generation use ac/ac and dc/ac static

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 7
July 2021

PWM converters for voltage conversion and battery banks for long term energy storage. These converters perform maximum power point tracking to extract the maximum energy possible from wind and sun. The electrical energy consumption behavior is random and unpredictable, and therefore, it may be single- or three-phase, balanced or unbalanced, and linear or nonlinear. An active power filter is connected in parallel at the point of common coupling to compensate current harmonics, current unbalance, and reactive power. It is composed by an electrolytic capacitor, a four-leg PWM converter, and a first-order output ripple filter, as shown in Fig. 4.12. This circuit considers the power system equivalent impedance $Z_s$, the converter output ripple filter impedance $Z_f$ , and the load impedance $Z_L$ .

The four-leg PWM converter topology is shown in Fig. 4.11. This converter topology is similar to the conventional three-phase converter with the fourth leg connected to the neutral bus of the system. The fourth leg increases switching states from 8 ($2^3$) to 16 (24), improving control flexibility and output voltage quality and is suitable for current unbalanced compensation.

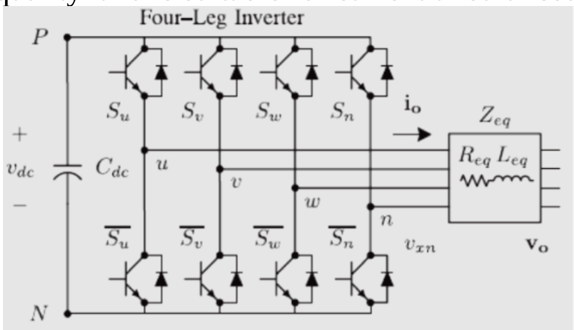


Fig. 4. Two-level four-leg PWM-VSI topology.

## DIGITAL PREDICTIVE CURRENT CONTROL

The block diagram of the proposed digital predictive current control scheme is shown in Fig. 5. This control scheme is basically an optimization algorithm and, therefore, it has to be implemented in a microprocessor. Consequently, the analysis has to be developed using discrete mathematics in order to consider additional restrictions such as time delays and approximations

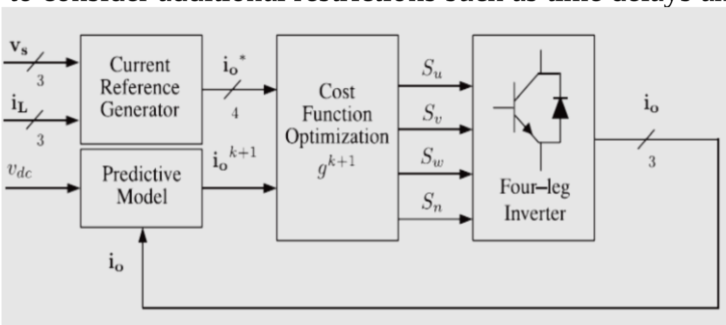


Fig. 5. Proposed predictive digital current control block diagram.

The main characteristic of predictive control is the use of the system model to predict the future behavior of the variables to be controlled. The controller uses this information to select the optimum switching state that will be applied to the power converter, according to predefined optimization criteria. The predictive control algorithm is easy to implement and to understand, and it can be implemented with three main blocks, as shown in Fig. 5.

1) Current Reference Generator: This unit is designed to generate the required current reference that is used to compensate the undesirable load current components. In this case, the system voltages, the load currents, and the dc-voltage converter are measured, while the neutral output current and neutral load current are generated directly from these signals (IV).

2) Prediction Model: The converter model is used to predict the output converter current. Since the controller operates in discrete time, both the controller and the system model must be

represented in a discrete time domain. The discrete time model consists of a recursive matrix equation that represents this prediction system. This means that for a given sampling time $T_s$, knowing the converter switching states and control variables at instant $kT_s$ , it is possible to predict the next states at any instant $[k + 1]T_s$ . a sufficiently accurate first-order approximation of the derivative is considered.

## CURRENT REFERENCE GENERATION

A dq-based current reference generator scheme is used to obtain the active power filter current reference signals. This scheme presents a fast and accurate signal tracking capability. This characteristic avoids voltage fluctuations that deteriorate the current reference signal affecting compensation performance. The current reference signals are obtained from the corresponding load currents as shown in Fig. 6. This module calculates the reference signal currents required by the converter to compensate reactive power, current harmonic, and current imbalance. The displacement power factor ($\sin\varphi_{(L)}$ ) and the maximum total harmonic distortion of the load ($THD_{(L)}$) defines the relationships between the apparent power required by the active power filter, with respect to the load, as shown in fig 6.The dq-based scheme operates in a rotating reference frame; therefore, the measured currents must be multiplied by the sin(wt) and cos(wt) signals. By using dq-transformation, the d current component is synchronized with the corresponding phase-to-neutral system voltage, and the q current component is phase-shifted by 90◦. The sin(wt) and cos(wt) synchronized reference signals are obtained from a synchronous reference frame (SRF) PLL [29]. The SRF-PLL generates a pure sinusoidal waveform even when the system voltage is severely distorted. Tracking errors are eliminated, since SRF-PLLs are designed to avoid phase voltage unbalancing, harmonics (i.e., less than 5% and 3% in fifth and seventh, respectively), and offset caused by the nonlinear load conditions and measurement errors [30]. Equation (8) shows the relationship between the real currents $i_{Lx}(t)$ (x = u, v,w) and the associated dq components ($i_d$ and $i_q$ ).

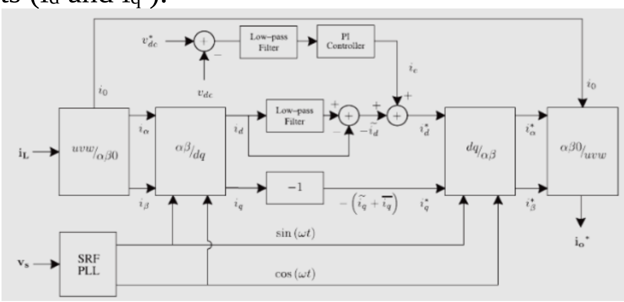


Fig. 6. *dq*-based current reference generator block diagram.

A low-pass filter (LFP) extracts the dc component of the phase currents $i_d$ to generate the harmonic reference components $-\tilde{i}_d$. The reactive reference components of the phase-currents are obtained by phase-shifting the corresponding ac and dc components of $i_q$ by 180◦. In order to keep the dc-voltage constant, the amplitude of the converter reference current must be modified by adding an active power reference signal $i_e$ with the d-component, as will be explained in Section IV-A. The resulting signals $i^*_d$ and $i^*_q$ are transformed back to a three-phase system by applying the inverse Park and Clark transformation, as shown in (9). The cutoff frequency of the LPF used.The current that flows through the neutral of the load is compensated by injecting the same instantaneous value obtained from the phase-currents, phase-shifted by 180◦, as shown next.

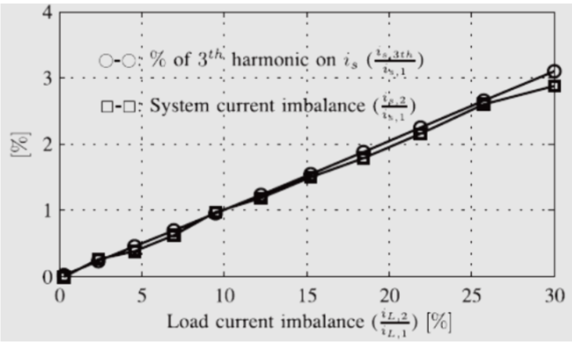


Fig. 7. Relationship between permissible unbalance load currents, the corresponding third-order harmonic content, and system current imbalance (with respect to positive sequence of the system current, $i_{s,1}$ ).

One of the major advantages of the dq-based current reference generator scheme is that it allows the implementation of a linear controller in the dc-voltage control loop. However, one important disadvantage of the dq-based current reference frame algorithm used to generate the current reference is that a secondorder harmonic component is generated in $i_d$ and $i_q$ under unbalanced operating conditions. The amplitude of this harmonic depends on the percent of unbalanced load current (expressed as the relationship between the negative sequence current $i_{L,2}$ and the positive sequence current $i_{L,1}$ ). The second-order harmonic cannot be removed from $i_d$ and $i_q$ , and therefore generates a third harmonic in the reference current when it is converted back to abc frame. Fig. 7 shows the percent of system current imbalance and the percent of third harmonic system current, in function of the percent of load current imbalance. Since the load current does not have a third harmonic, the one generated by the active power filter flows to the power system

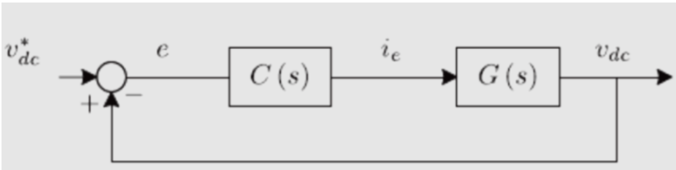


Fig. 8. DC-voltage control block diagram.

A. DC-Voltage Control

The dc-voltage converter is controlled with a traditional PI controller. This is an important issue in the evaluation, since the cost function is designed using only current references, in order to avoid the use of weighting factors. Generally, these weighting factors are obtained experimentally, and they are not well defined when different operating conditions are required. Additionally, the slow dynamic response of the voltage across the electrolytic capacitor does not affect the current transient response. For this reason, the PI controller represents a simple and effective alternative for the dc-voltage control.

The dc-voltage remains constant (with a minimum value of $\sqrt{6}v_{s(rms)}$ ) until the active power absorbed by the converter decreases to a level where it is unable to compensate for its losses. The active power absorbed by the converter is controlled by adjusting the amplitude of the active power reference signal $i_e$, which is in phase with each phase voltage.

**Matlab And Simulation Results**

An extensive transient simulation studies have been carried out to investigate the effectiveness of the presented control. It is shown that several functions can be acquired simultaneously for grid-connected DER interfaced to a 3P4W network. To demonstrate the system performance under different operating conditions, the notations used to represent grid voltage, grid current, load current, compensating current, DC-bus voltage, active power sharing, SPV array voltage, and SPV array current are $V_{sRYB}$, $I_{sRYB}$, $I_{LR}$, $I_{CR}$, $V_{DC}$, $P_S$ Vs. $P_{PV}$, $V_{PV}$, and $I_{PV}$, respectively. A simulation model for the three-phase four-leg PWM converter with the

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 7
July 2021

parameters shown in Table I has been developed using MATLAB-Simulink. The objective is to verify the current harmonic compensation effectiveness of the proposed control scheme under different operating conditions. A six-pulse rectifier was used as a nonlinear load. The proposed predictive control algorithm was programmed using an S-function block that allows simulation of a discrete model that can be easily implemented in a real-time interface (RTI) on the dSPACE DS1103 R&D control board. Simulations were performed considering a 20 μs of sample time.

**Block diagram of the proposed system and SIMULINK model**

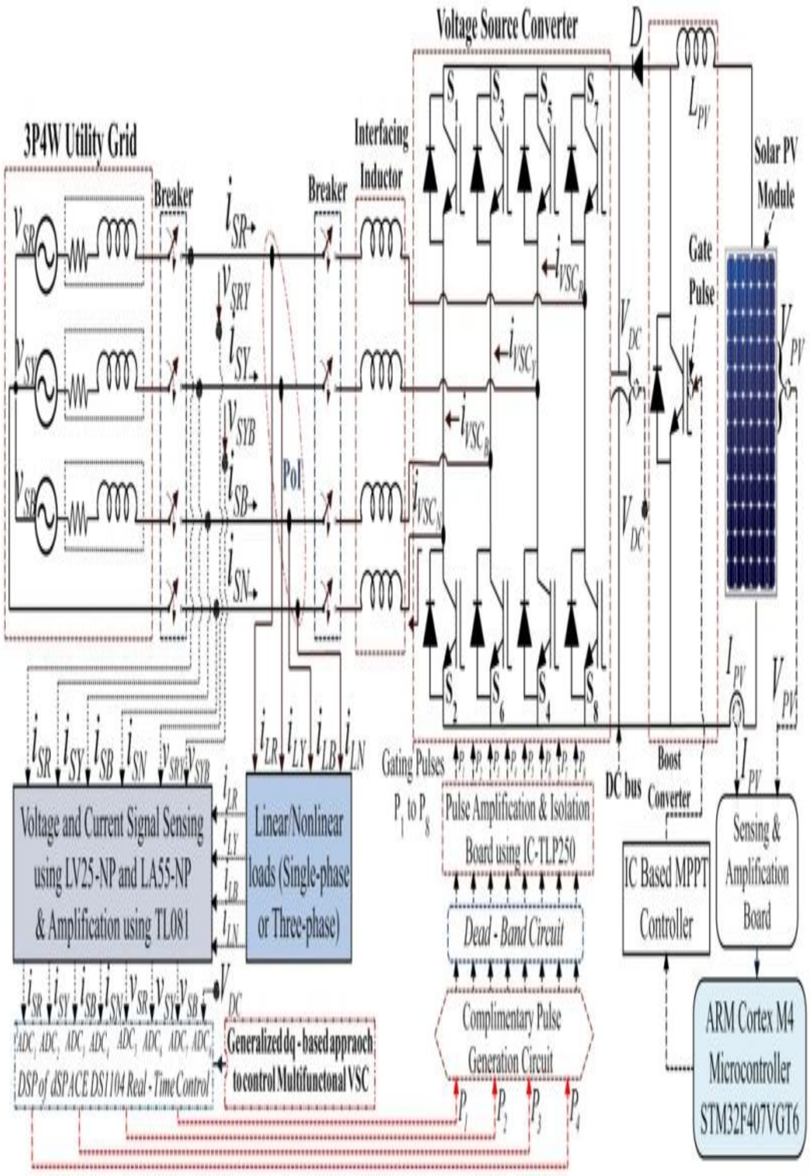


Fig.9. Block diagram of the proposed system

The block diagram of the proposed model is shown in fig.9 and the simulated results shown in Fig. 10, the active filter starts to compensate at t = $t_1$

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 7
July 2021

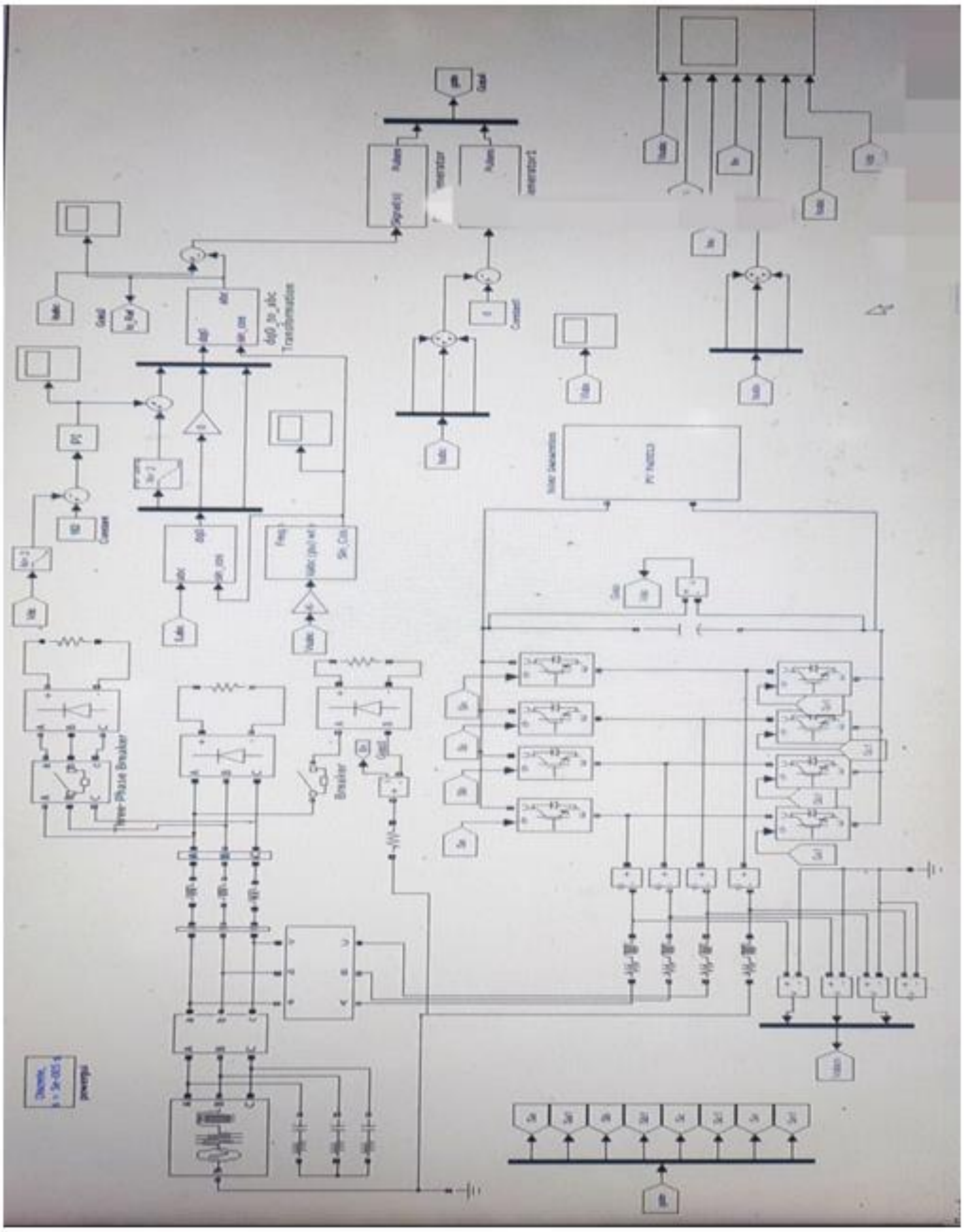

Fig 10 Simulation model of the photovoltaic system

At this time, the active power filter injects an output current $i_{ou}$ to compensate current harmonic components, current unbalanced, and neutral current simultaneously. During compensation, the system currents **is** show sinusoidal waveform, with low total harmonic distortion (THD = 3.93%). At t = $t_2$, a three-phase balanced load step change is generated from 0.6 to 1.0 p.u. The compensated system currents remain sinusoidal despite the change in the load current magnitude. Finally, at t = $t_3$, a single-phase load step change is introduced in phase u from 1.0 to 1.3 p.u., which is equivalent to an 11% current imbalance. As expected on the load side, a neutral current flows through the neutral conductor ($i_{Ln}$), but on the source side, no neutral current is observed ($i_{sn}$). Simulated results show that the proposed control scheme effectively eliminates unbalanced currents. Additionally the dc-voltage remains stable throughout the whole active power filter operation.

## 10. Transient Performance of the System under Unbalanced Loading

The PQ enhancement feature of the presented control is investigated against unbalanced loading condition. The performance effectiveness of the system is checked by connecting an unbalanced load, whose current unbalancing, harmonics, and reactive power requirements are to be mitigated as depicted in Fig. 11(a)-(j). In this case, the multifunctional VSC is injecting harmonic, as well as, reactive component requirement of the nonlinear load. Additionally, the zero sequences harmonic component requirement of unbalanced load is supplied by fourth leg of VSC along with active power injection into the electric grid. Despite load current unbalancing, the source current is maintained to be sinusoidal balanced due to compensation provided by multifunctional VSC at PoI as shown in Fig. 11(a). It is seen that the magnitude of the load currents are increased [refer to Fig. 11(b)] due to unbalancing in load. The magnitude of compensating current also increases to meet the load power requirement as depicted in Fig. 11(c). It is also observed from the system behavior that the system has a fast transient response to change in load currents. The sudden rise in load neutral current magnitude can be observed from the presented wave shape. Moreover, grid neutral current remains nearly zero because VSC supplies the load neutral current demand as shown in Fig. 11(i). Besides this, UPF operation is ensured by keeping the value of reactive power nearly zero.

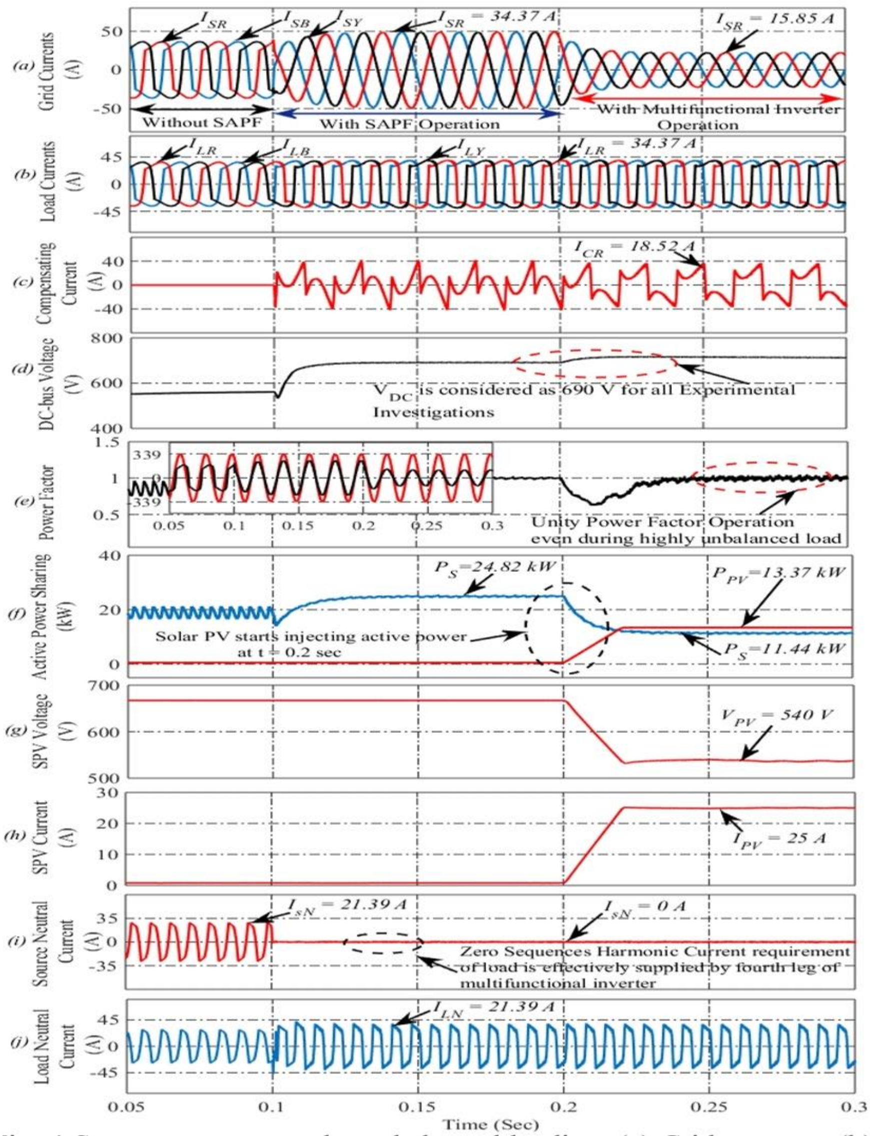


Fig 11. Source voltage, Load current, Filter output currents, load neutral current, system neutral current, system currents, dc link voltage

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 7
July 2021

**Transient Performance of System under Solar Intermittency**

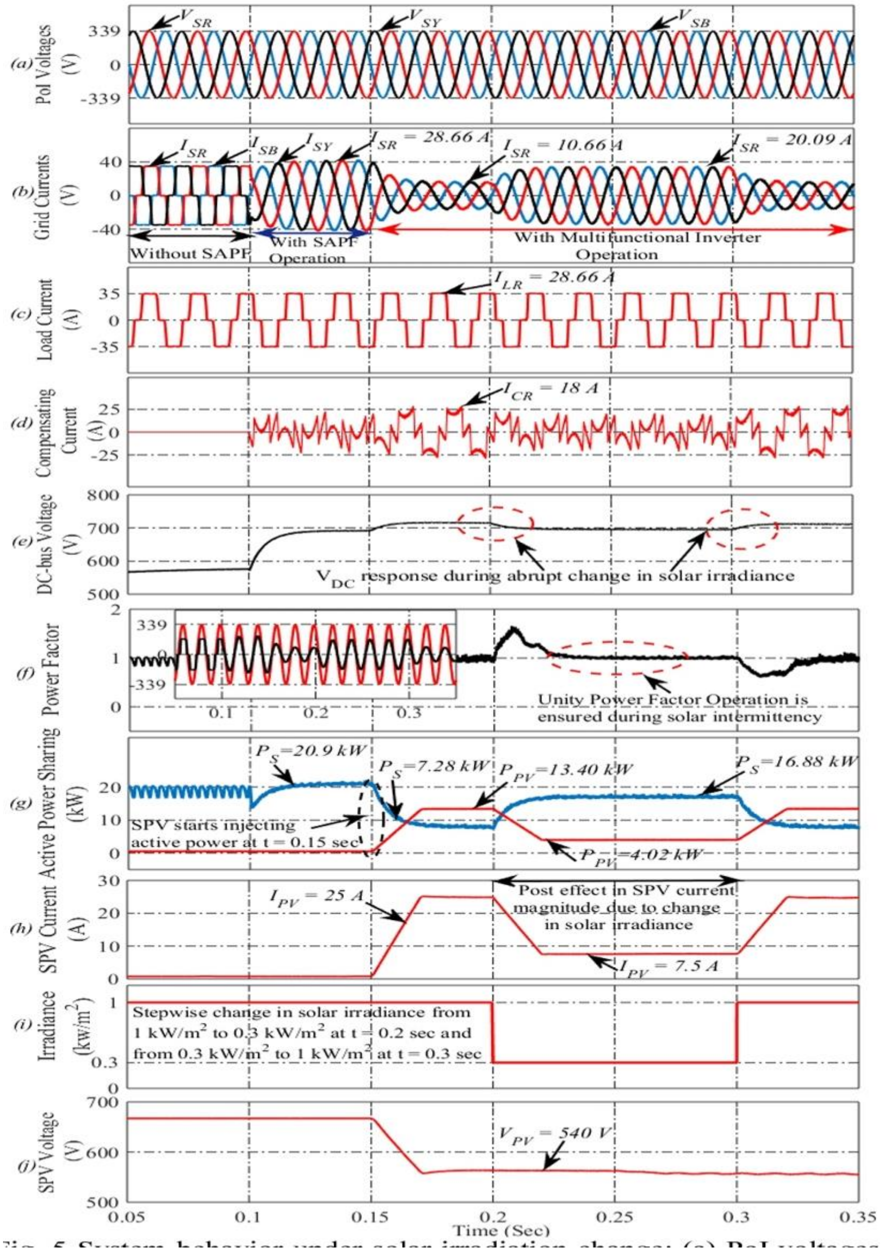

Fig. 5.4.System behavior under solar irradiation change: (a) PoI voltages, (b) Grid currents, (c) Load currents, (d) Compensating current, (e) DCbus voltage, (f) Power factor, (g) Active power sharing, (h) SPV current, (i) Solar irradiance, and (j) SPV voltage.

The transient performance of presented control is verified under varying solar irradiance as depicted in Fig. 5.4(a)-(j). During time interval t = 0.2 to 0.3-sec, the solar irradiation is varied in step 11a shown from 1 to 0.3 kW/m$^2$ to evaluate the adaptability of the presented control during intermittent power generation from SPV as depicted in Fig. 5.4(i). The corresponding change in $I_{SRYB}$, $I_{CR}$, $P_S$, $I_{PV}$, and $P_{PV}$ are observed from the presented wave shapes. However, no substantial change has been observed in SPV array output voltage VPV, knowing the fact that SPV is a current source. The power output from the SPV array has also been decreased from 13.40 kW to 4.02 kW as seen in Fig. 5.4.(g).

At instant t = 0.3-sec, the solar insolation is again changed from 0.3 to 1 kW/m2 to evaluate the system behaviors and a corresponding change in grid currents and inverter current can be seen from Fig. 11(b) and (d), respectively. During t = 0.2 to t = 0.3-sec, the grid current magnitude is increased because the load power requirement is met by grid currents due to a decrease in solar insolation. A four-legged VSC is efficiently controlled to achieve UPF operation [refer to Fig. 11(f)] and well balanced sinusoidal grid current without being affected by varying solar insolation condition. It is to be noted that the grid-connected multifunctional VSC also delivers the load reactive current requirement locally. Therefore, once the multifunctional VSC starts functioning, the electric grid only exchanges fundamental active power. It is evident from the presented simulation results that the proposed multifunctional VSC can be efficiently employed to mitigate the source current harmonics, reactive power requirement, and load neutral current demand, in addition to active power injection from prime RES to the electric grid. This permits the utility grid to exchange balanced and sinusoidal active power while ensuring UPF operation.

## CONCLUSION

A generalized "dq" based control approach has been presented in this paper for generating a reference current for 3P4W multifunctional VSC controlled SPVPCS. It has been experimentally demonstrated that the proposed system not only injects the active power into the electric grid but also provides a various PQ solutions in the electric distribution network. The aforementioned multifunctional VSC can be employed to fulfill the following approaches: 1) to suppress the source current harmonics generated by the nonlinear load, 2) to provide the load neutral current demand by the fourth leg of the multifunctional VSC, and 3) to share the active power requirement of load based on the availability of active power at DC-bus terminal. It is evident from the results presented in this paper that this approach actively eliminates the need for supplementary power filtering equipment to enhance the PQ at PoI. The practicality of the proposed approach is verified through both substantial MATLAB/Simulink simulation. It is also demonstrated that the traditional GCI can be effectively utilized as a multifunctional VSC with suitable control technique. Improved dynamic current harmonics and a reactive power compensation scheme for power distribution systems with generation from renewable sources has been proposed to improve the current quality of the distribution system. Advantages of the proposed scheme are related to its simplicity, modeling, and implementation. The use of a predictive control algorithm for the converter current loop proved to be an effective solution for active power filter applications, improving current tracking capability, and transient response. Simulated and experimental results have proved that the proposed predictive control algorithm is a good alternative to classical linear control methods. The predictive current control algorithm is a stable and robust solution. Simulated and experimental results have shown the compensation effectiveness of the proposed active power filter.

## FUTURE SCOPE

It is evident from the presented simulation results that the proposed multifunctional VSC can be efficiently employed to mitigate the source current harmonics, reactive power requirement, and load neutral current demand, in addition to active power injection from prime RES to the electric grid. This permits the utility grid to exchange balanced and sinusoidal active power while ensuring UPF operation. It is further noted that the PQ enhancement and active power transfer into the utility grid have been demonstrated extensively under various operating conditions to confirm the performance and control of multifunctional VSC based grid-connected SPVPCS. Besides this, it is shown that the grid currents are maintained to be balanced and sinusoidal at UPF despite varying insolation, current unbalancing, and harmonics. Moreover, the fourth leg of the VSC is adequately employed to mitigate load neutral current locally so that its flow in grid side can be blocked.

## REFERENCES

[1] J. Rocabert, A. Luna, F. Blaabjerg, and P. Rodriguez, "Control of power converters in AC microgrids," IEEE Trans. Power Electron., vol. 27,no. 11, pp. 4734–4749, Nov. 2012.
[2] R. de Araujo Ribeiro, C. de Azevedo, and R. de Sousa, "A robust adaptive control strategy of active power filters for power-factor correction, harmonic compensation, and balancing of nonlinear loads," IEEE Trans. Power Electron., vol. 27, no. 2, pp. 718–730, Feb. 2012.
[3] M. Rivera, J. Rodriguez, B. Wu, J. Espinoza, and C. Rojas, "Current control for an indirect matrix converter with filter resonance mitigation," IEEE Trans. Ind. Electron., vol. 59, no. 1, pp. 71–79, Jan. 2012.
[4] R. de Araujo Ribeiro, C. de Azevedo, and R. de Sousa, "A robust adaptive control strategy of active power filters for power-factor correction, harmonic compensation, and balancing of nonlinear loads," IEEE Trans. Power Electron., vol. 27, no. 2, pp. 718–730, Feb. 2012.
[5] S. Kouro, P. Cortes, R. Vargas, U. Ammann, and J. Rodriguez, "Model predictive control—A simple and powerful method to control power converters," IEEE Trans. Ind. Electron., vol. 56, no. 6, pp. 1826–1838, Jun. 2009.
[6] D. Quevedo, R. Aguilera, M. Perez, P. Cortes, and R. Lizana, "Model predictive control of an AFE rectifier with dynamic references," IEEE Trans. Power Electron., vol. 27, no. 7, pp. 3128–3136, Jul. 2012.
[7] Z. Shen, X. Chang, W. Wang, X. Tan, N. Yan, and H. Min, "Predictive digital current control of single-inductor multiple-output converters in CCM with low cross regulation," IEEE Trans. Power Electron., vol. 27, no. 4, pp. 1917–1925, Apr. 2012.
[8] M. Preindl and S. Bolognani, "Model predictive direct speed control with finite control set of PMSM drive systems," IEEE Trans. Power Electron., 2012.
[9] T. Geyer, "Computationally efficient model predictive direct torque control," IEEE Trans. Power Electron., vol. 26, no. 10, pp. 2804–2816, Oct. 2011.
[10] M. Karimi-Ghartemani, S. Khajehoddin, P. Jain, A. Bakhshai, and M. Mojiri, "Addressing DC component in PLL and notch filter algorithms," IEEE Trans. Power Electron., vol. 27, no. 1, pp. 78–86, Jan. 2012.