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# MULTIFUNCTION OF VSC CONTROLLED MICRO-GRID USING WIND ENERGY GENERATION AT DIFFERENT LOAD CONDITIONS

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**ABSTRACT**

*This paper proposes the multifunction of VSC controlled micro-grid, this µg VSC is used to analyses the as a bidirectional power sharing converter to control the power flow from the dc side to the ac side and vice versa, based on renewable power available at the dc link; 2) as a power quality compensator with the features of reactive power compensation, load balancing, and mitigation of current harmonics generated by nonlinear loads at the point of common coupling ,thus enabling the grid to supply only sinusoidal current at unity power factor; and 3) to damp out the oscillations in the G-VSC currents effectively using damping filter in the control algorithm. The multifunctional features of the proposed control algorithm are analyzed by the simulation studies.*

***Index terms***-micro-grid-STATCOM, wind energy Power quality

## I INTRODUCTION

Renewable energy resources are augmented by the energy sector due to the global energy crisis and due to its emergence as an alternative approach to the generation of clean energy. Recent advances using smart micro-grids to maximize operational efficiency and reliability have made this kind of system suitable for decentralizing the electricity generation. The government policies on renewable in developing countries further accelerated the renewable energy sector growth among various renewable energy resources, solar photovoltaic (PV) and wind are fast growing technologies. However, their intermittent nature has introduced many technical issues, including power quality, load management, stability and controls, reliability, and voltage regulation. With the advancement in power electronics and digital signal processors, the power electronic interfaces are effectively used to resolve some of the issues pointed above at the point of common coupling (PCC)wind energy has fastest growing technologies in the daily life wind energy uses the PMSG for the controlled output with higher efficiency The conventional boost converter has drawbacks such as reverse recovery problems at high duty ratios, highly sensitive to duty ratios at extreme ends ,and forcing the converter into an unstable region. Alternatively, the cascaded connection of conventional converters provides wider conversion ratios. One of the major advantages of these converters is a high-gain and low-current ripple. However, this configuration has a drawback that the total efficiency becomes low if the number of stages is high and thus leads to increased power losses in the switching devices [10]. Recently, a high-gain integrated cascaded boost converter topology is proposed for switched mode power conversion applications to get high voltage gains using single active switch only. The high-gain boost converter (HGBC) topology is used in this paper for the solar PV applications instead of the conventional boost converter topology, owing to the lower duty cycle operation of the converter On the micro-grid side, mostly current controlled voltage–source topologies and some of the current–source topologies are used asgridinteractiveconvertersinterfaceintermittentrene wables to the utility. Associated control algorithms are also reported in the literature [15]–[22] to address the power quality issues. However, use of the Clarke and its inverse transformations make them computationally intensive. Another drawback is the sluggish response of control due to the involvement of dc capacitor dynamics [23]. Compared to the control strategies mentioned earlier, the instantaneous symmetrical component theory is used in this paper due to the following advantages: it is simple in formulation, it is computationally less intensive for reference currents generation, thus ensuring fast dynamic response, and it avoids interpretation of various definitions of instantaneous reactive powers and complex transformations. Various concerns while connecting renewable energy sources to the utility grid are: power quality related problems, synchronization issues, voltage quality aspects, and bidirectional power flow with battery and dc loads. The bidirectional power transfer capability [24] and the improved damping features [25], [26] along with power quality enhanced operation are the important aspects to be addressed for the distributed generation applications. In this work, the authors have proposed a control algorithm for micro grid side voltage–source converter (VSC) with multifunctional features. Detailed simulation studies are carried out with solar PV as renewable energy source and HGBC topology is used to extract the maximum power from PV panels. The proposed control scheme with multifunctional features of the grid side VSC

## IIPROBLEM ANALYSIS

A Voltage Sag as defined by IEEE Standard 1159-1995, IEEE Recommended Practice for Monitoring Electric Power Quality, is a decrease in RMS voltage at the power frequency for durations from 0.5 cycles to 1 minute, reported as the remaining voltage. The measurement of a Voltage Sag is stated as a percentage of the nominal voltage, it is a measurement of the remaining voltage and is stated as a sag to a percentage value. Thus a Voltage Sag to 60% is equivalent to 60% of nominal voltage, or 288 Volts for a nominal 480 Volt system.

Voltage sags can occur on Utility systems both at distribution voltages and transmission voltages. Voltage sags which occur at higher voltages will normally spread through a utility system and will be transmitted to lower voltage systems via transformers. The major causes of voltage sag are due to Operation of re closers and circuit breakers, Equipment failure, bad weather, pollution, construction activity, industrial plants, multi-phase sags and single phase sags. There are many technologies are introduced to overcome these problems.

Harmonics are common problems in power system in which they occur due to noise environment. Harmonics are defined as the integral multiples fundamental frequency at regular intervals more common harmonics produced in the power system are 3$^{rd}$ harmonic and 7$^{th}$ harmonic CSC based micro-grid reduces the current harmonics produced in the power system.

## VOLTAGE SAG AND SWELL IN LINEAR LOADS

In a linear circuit, the output response is directly proportional to the input. In an AC circuit, that means that the application of a sinusoidal voltage results in a sinusoidal current. As the instantaneous voltage changes over the period of the sine wave, the instantaneous current rises and falls in proportion to the voltage so that the waveform of the current. If a circuit is composed of ideal resistors, inductors and capacitors, it is a linear circuit because those components are linear. Real components can have some non-linearity because of non-linear characteristics such as the saturation of a magnetic circuit. There are degrees of linearity. AC motors are nearly linear. A motor's load current is a sine wave with only a little distortion.

In a purely resistive AC circuit, voltage and current waveforms are in step (or in phase), changing polarity at the same instant in each cycle. All the power entering the load is consumed (or dissipated). Where reactive loads are present, such as with capacitors or inductors, energy storage in the loads results in a time difference between the current and voltage waveforms. During each cycle of the AC voltage, extra energy, in addition to any energy consumed in the load, is temporarily stored in the load in electric or magnetic fields, and then returned to the power grid a fraction of a second later in the cycle. The "ebb and flow" of this nonproductive power increases the current in the line. Thus, a circuit with a low power factor will use higher currents to transfer a given quantity of real power than a circuit with a high power factor. Figure 3.5 and 3.6 represents the instantaneous and average power between power factors. A linear load does not change the shape of the waveform of the current, but may change the relative timing (phase) between voltage and current. Circuits containing purely resistive heating elements (filament lamps, cooking stoves, etc.) have a power factor of 1.0. Circuits containing inductive or capacitive elements such as electric motors, solenoid valves, lamp ballasts, and other soften have a power factor below 1.0

## Harmonics in non-linear loads

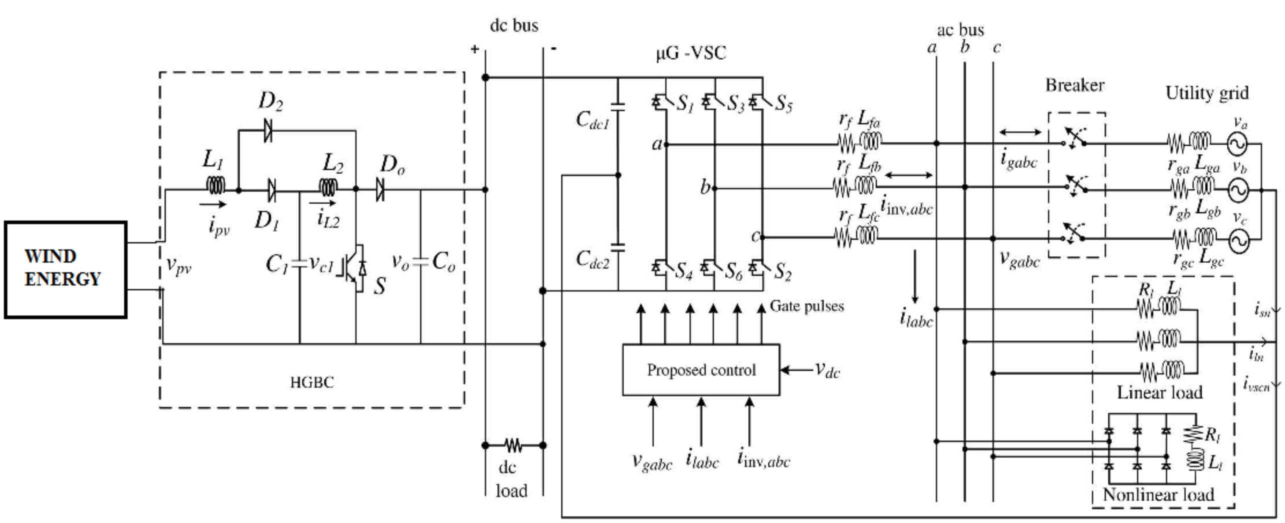
A load is considered non-linear if its impedance changes with the applied voltage. The changing impedance means that the current drawn by the non-linear load will not be sinusoidal even when it is connected to a sinusoidal voltage. These non-sinusoidal currents contain harmonic currents that interact with the impedance of the power distribution system to create voltage distortion that can affect both the distribution system equipment and the loads connected to it. In the past, non-linear loads were primarily found in heavy industrial applications such as arc furnaces, large variable frequency drives (VFD), heavy rectifiers for electrolytic refining, etc. The figure 3.3 shows the characteristics of linear and non-linear loads of induction motor. The harmonics they generated were typically localized and often addressed by knowledgeable experts.

Times have changed. Harmonic problems are now common in not only industrial applications but in commercial buildings as well. This is due primarily to new power conversion technologies, such as the Switch-mode Power Supply (SMPS), which can be found in virtually every power electronic device (computers, servers, monitors, printers, photocopiers, telecom systems, broadcasting equipment, banking machines, etc.). The SMPS is an excellent power supply, but it is also a highly non-linear load. Their proliferation has made them a substantial portion of the total load in most commercial buildings.

## III PROPOSED SYSTEM

In this proposed system VSC based micro-grid is used to analyses the voltage sag and swell produced in the linear load condition and CSC based micro-grid are used to eliminate the current harmonics produced in the non-linear loads.in this wind energy generation is used as the input supply to the grid connected system. PSMG is used to obtain the controlled output from the wind turbine system.

1V SYSTEM DESCRIPTION AND CONTROL STRUCTURE



## HGBC model and control

To integrate the low-voltage PV panels to the distribution system, the output voltage of the intermediate dc–dc converter should be high enough to generate the dc-link voltage. Hence, a dc–dc converter with a high voltage gain is necessary. Theoretically, the conventional boost converter topology can be used to provide high voltage gain with high duty cycle. However, the voltage gain is limited by the effect of the power switches, diodes, and equivalent series resistance of the inductors and capacitors. Also, the high duty cycle operation results in reverse recovery and electromagnetic interference problems (due to high-current ripple at extreme duty cycle). In order to address these issues, an HGBC topology is chosen over the conventional boost converter topology.

## VSC BASED MICRO-GRID

The proposed control algorithm operates the grid side VSC as a multifunctional device. It provides the following features:

1) Bidirectional power sharing features: In this case, the proposed scheme has the ability to change the operation of VSC from inverter to rectifier mode based on the equivalent power available from renewable sources at the DC link. In the rectifier mode of operation, the power flow is from utility grid to the dc link to support the dc load along with the ac load at the PCC.

2) Power quality compensation with reactive power compensation, load balancing, and mitigation of current harmonics that are generated by the nonlinear and unbalanced loads at the PCC. Thus, it ensures the grid to supply only sinusoidal current at unity power factor (UPF).

3) The oscillations in the VSC currents under variable power operating conditions (at the dc link) are damped out by the damping filter in the current control loop. The proposed scheme mainly consists of generation of reference currents and the current control loop, Multiresonating proportional resonant (PR) controllers and damping filters are used in the current loop, to track the referencecurrents accurately with improved damping features. The loadcurrents, inverter currents, dc-link voltage, andthe voltages at the PCC are the sensed inputs given to the proposed control scheme.

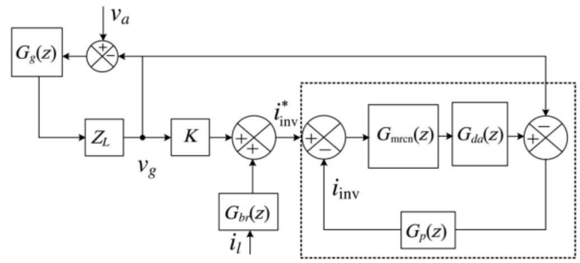



Fig 1Proposed inverter control

The proportional term of the PR controller play the same role as the PI controller in SRF. The selection of this design parameter is based on

1) The stability of the system,

2) The order of current harmonics that can be regulated without violating the stability limits,

3) The cross-over frequency and dynamic response, and

4) The reduction of the current harmonics at other frequencies. The integral constant determines the bandwidths centred at the concerned harmonic frequencies during which the characteristics are changed. The value of determines the gain at the resonant frequency. The optimum values of should be selected for each harmonic component to ensure zero steady-state tracking capability for sinusoidal current signals. Even though the resonating controlled theoretically provides zero steady-state error at the selected resonant frequency regardless of the controller gains, the controller gains must be designed carefully based on power stage parameters to ensure the system stability. Generation of Reference Currents for G-VSC The purpose of the proposed control scheme is to generate the three reference current waveforms in proportion to the generated power from the renewable sources and the compensation requirements. The reference currents are extracted using instantaneous symmetrical components theory. In order to meet the requirements of load compensation along with the renewable power support, the following three conditions are to be satisfied.The first condition is that the neutral current after compensationmust be zero. Therefore:

Condition 1: The objective of three phase four wire or threephasethree-wire system with ground is to provide balancedutility grid currents. Therefore,

$i_{ga}+i_{gb}+i_{gc}=0$

Condition 2: The second objective is that the reactive powerdelivered from the utility grid is controlled by the phase angle, between the positive sequence voltage and current. Hence,we can write the following: This implies thatsimplifying, where is a complex operator and is the zero sequence voltage of the utility grid.

Condition 3: The third condition is that the utility grid should supply or absorb the average power, which is the difference of load power and available renewable power. The objective of the G-VSC is to supply the oscillating component of the instantaneous load power and the real power proportional to the available renewable power at. Frequency response of current loop gain with different and values. The dc link. Therefore, the grid has to supply or absorb the net average power, to compensate the unbalanced and distorted voltage conditions, only the fundamental positive sequence PCC voltages and are extracted and are used for generating reference currents. Therefore, using , the µG-VSC reference currents in terms of active and reactive power components can be written G-VSC and load reactive powers, respectively.

**VSC CONTROL**

The VSC controls have been extensively studied in the literature, the most popular and mature control methodology is call nested loop dq current control there are some other control schemes including Direct Power Control and Sliding Mode Control. The various control algorithms will be described briefly as follows:

**Conventional dq Control**: The classical control algorithm for VSC is based on the nested loop d-q control scheme, which normally includes a outer control loop, either power control or dc voltage control, and an inner current control loop demonstrates the conventional d-q control algorithm. In which, the outer loop controls the active power and ac voltage while the inner loop controls the dq currents. The circuit diagram of conventional d-q control is shown in figure 4.4. A frame of reference transformation is required for this control. The ac voltages and currents are first transformed into d-q quantities via Park's transformation, and the outer control loop generates the respective d-q current references depending on the control objectives. The inner current control loop regulates the d-q currents and generate the appropriate switching pulses for converters.

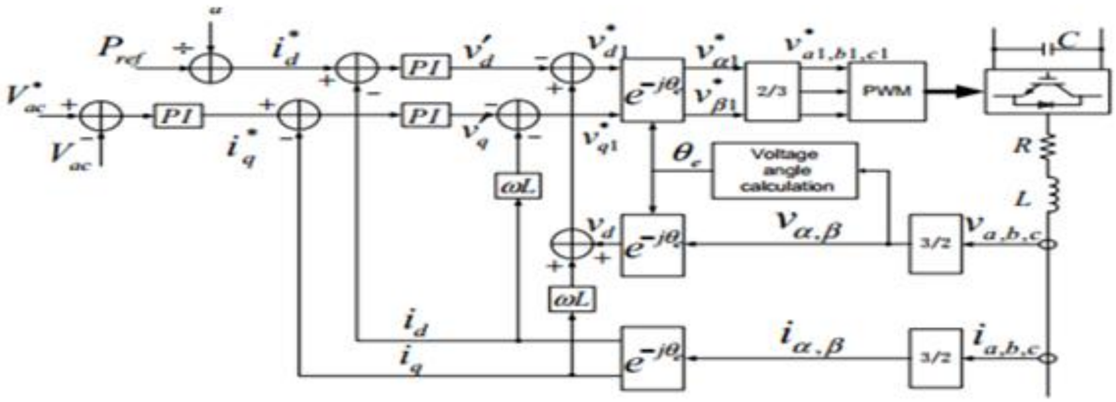



Fig 2 conventional d-q control

**Direct Power Control:** The Direct Power Control (DPC) eliminates the current control loop and regulates the active and reactive power directly. It depicts the configuration of a Direct Power Controller, where the active power command is provided by a dc-bus voltage control block and the reactive power command is directly given. The errors between commands and feedback powers are input to the hysteresis comparators and digitized to the signals Sp and Sq. The phase of the power source voltage is also digitized to the signal θn. Sp, Sq and θn are the input to a switching table and generate appropriate switching signals to converters. The advantage of DPC is its simple structure and direct control capability of powers. The controller is easy to be implement

**Sliding Mode Control**: Comparing to conventional P I control, the Sliding Mode Control(SMC) does not need an accurate mathematical model of the objective to be controlled, but offers better stability regardless the plant parameters and load variations demonstrates a Sliding Mode Controller for a boost inverter. The SMC first needs to select appropriate state variables, and the input current iL1 and output voltage V1 are selected. 1 and 2 are the state variable errors of iL1 and V1, which forms a sliding surface equation

$$S(iL1, V1) = K1\varepsilon 1 + K2\varepsilon 2 = 0 \quad (2.1)$$

The value is input to a hysteresis block H1 and generate the switching signals S1 and S2.

## Harmonics reduction using CSC

Harmonic currents due to power electronics switching have been widely investigated in the literature. Active filter is a mature solution to mitigate the harmonic currents. The current control strategies are discussed and compared in, which include linear current control, digital deadbeat control and hysteresis control. The linear current control utilizing d-q synchronous frame control has been proposed and tested. Another control method developed in is called Proportional-Resonant (PR) controller. With PR control theory, the complexity of harmonic current control system can be effectively reduced for both positive and negative sequences. . Uncontrolled power electronics devices with load can produce non-negligible low orders harmonic currents to micro grid. In, even small percentage of grid voltage unbalance would lead to additional high 3rd order harmonic currents from rectifiers. In order to eliminate the harmonic currents, a appropriate control strategy has to be developed.

**Proposed block diagram**

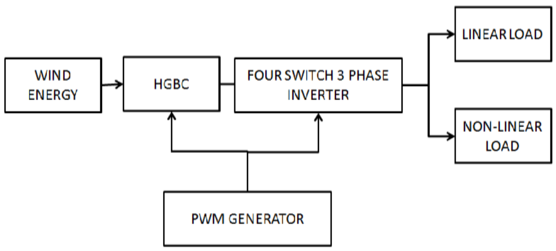



Fig 3 Block diagram of proposed system

In this system wind energy is use as the source for the voltage source converter in which PMSG is used for controlled output obtained from the wind turbine. High gain boost converter is used to for the boost up process of voltage from the PMSG. Four switch three phase inverter is used for the conversion purposes .PWM generator is used for giving pulse signal to the switches in which it is given directly from the PWM generator in which the manual operation is not required.

In a linear circuit, the output response is directly proportional to the input. In an AC circuit, that means that the application of a sinusoidal voltage results in a sinusoidal current. As the instantaneous voltage changes over the period of the sine wave, the instantaneous current rises and falls in proportion to the voltage so that the waveform of the current is also a sine wave. If a circuit is composed of ideal resistors, inductors and capacitors, it is a linear circuit because those components are linear. Real components can have some non-linearity because of non-linear characteristics such as the saturation of a magnetic circuit. There are degrees of linearity. AC motors are nearly linear. A motor's load current is a sine wave with only a little in linear there are many power quality problems mainly of voltage sag and swell, voltage distortions, harmonics, and this can be minimized by voltage source converter in grid line.

A load is considered non-linear if its impedance changes with the applied voltage. The changing impedance means that the current drawn by the non-linear load will not be sinusoidal even when it is connected to a sinusoidal voltage. These non-sinusoidal currents contain harmonic currents that interact with the impedance of the power distribution system to create voltage distortion that can affect both the distribution system equipment and the loads connected to it. By connecting current source converter we can reduce the current harmonics in the grid line

By using current source converter we can reduce the current harmonics in the grid line due to some disturbances in the system .and by using voltage source converter we can reduce the voltage sag and swell there by increasing the system performance of the power system and the stable operation of the system is done.

## IV RESULTS

Micro-grid is the system which encloses the activities of the entire network in the power system. In VSC-based micro-grids which employ the frequency/voltage droop control method, the power sharing controllers alter the frequency and magnitude of each VSC output voltage based on the output active and reactive power, The power quality problems are the major drawbacks in the power system which affects the system performance, stability and losses in the power system ,using voltage source converter in grid connected system we can minimize the voltage sag and swell in the power system and thereby increasing the system performances. And by the use of current source converter we can reduce the harmonics produced due to external disturbance in the grid line which increase the stable operation of the system

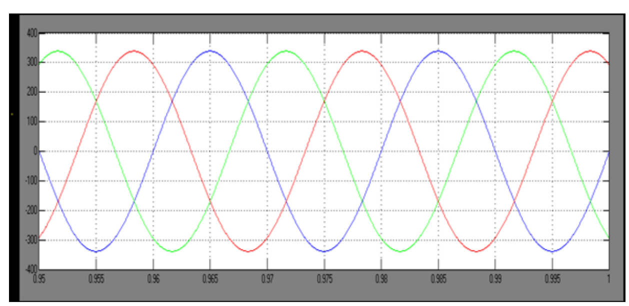


Fig 4 Terminal voltage obtained from PMSG

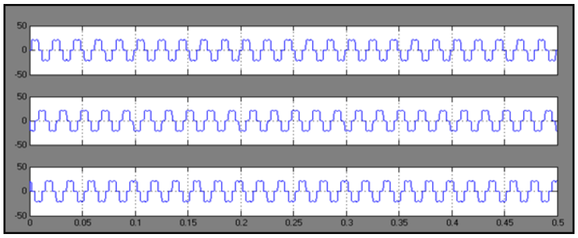


Fig 5 Harmonic elimination in grid line without CSC

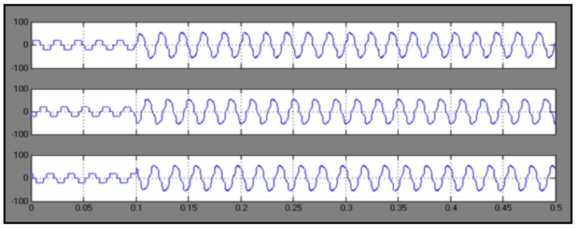


Fig 6 Harmonic elimination in grid line with CSC

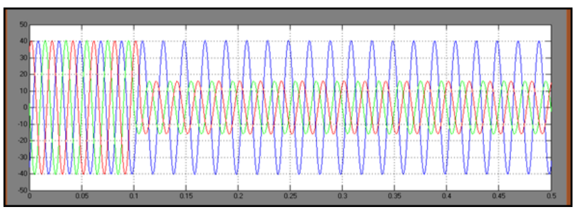


Fig 7 Voltage sag and swell minimization in grid line withoutusing VSC

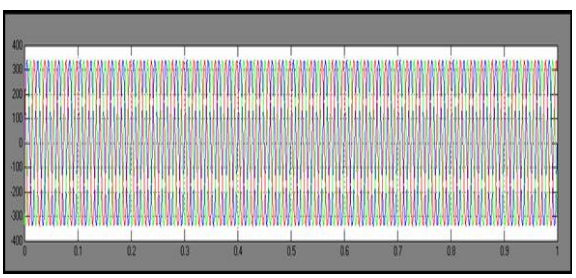


Fig 8Voltage sag and swell minimization in grid line using VSC

## V CONCLUSION

Improving of power quality problems in transmission system and distribution system we can obtain the stable operation of power system and we can also increase the system performance normally power quality problems arises due to the external and internal disturbances caused in the power system .The micro-grid-VSC can be effectively utilized for the power quality compensator without affecting its normal operation of real power transfer. The micro-grid VSC with the algorithm is used to operate as a power quality compensator with the features of reactive power compensation, load balancing, and mitigation of current harmonics generated by the nonlinear and unbalanced loads at the PCC. many solutions are given to the power quality problems using facts devices voltage sag and swell are reduced in grid line using voltage source converter and the system performance is increased Harmonics are eliminated in grid connected system using current source converter and the stable operation of system is done**.** The approach thus eliminates the need for an additional converter to improve the power quality aspects at the PCC.

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