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POWER QUALITY IMPROVEMENT IN GRID CONNECTED RENEWABLE ENERGY SOURCES AT DISTRIBUTION LEVEL

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Abstract:

This paper presents a method to operate a grid connected hybrid system. The hybrid system composed of a Photovoltaic (PV) array and a Proton exchange membrane fuel cell (PEMFC) is considered. The PV array normally uses a maximum power point tracking (MPPT) technique to continuously deliver the highest power to the load when variations in irradiation and temperature occur, which make it become an uncontrollable source. In coordination with PEMFC, the hybrid system output power becomes controllable. Two operation modes, the unit-power control (UPC) mode and the feeder-flow control (FFC) mode, can be applied to the hybrid system. The coordination of two control modes, the coordination of the PV array and the PEMFC in the hybrid system, and the determination of reference parameters are presented. The proposed operating strategy with a flexible operation mode change always operates the PV array at maximum output power and the PEMFC in its high efficiency performance band, thus improving the performance of system operation, enhancing system stability, and decreasing the number of operating mode changes.

***Index Terms* - Grid, Distribution transformer ,Circuit breakers ,Nonlinear load ,linear load, renewable energy with inverter.**

I. INTRODUCTION

Due to continue using Fossil Fuel to generate Electrical energy increasing air pollution, global warming concerns, diminishing fossil fuels and their increasing cost have made it necessary to look towards Renewable Energy Sources (RES) as a future energy solution. Since the few past decade, to overcome this crisis many countries on renewable energy for power generation. The governments provide many incentives to accelerate the renewable energy sector growth. Renewable Energy Sources demand increasingly at the distribution level due to increase in load demand which utilize power electronic converters. Due to the large use of power electronic devices, disturbances occur on the electrical supply network. These disturbances are due to non-linear devices. These will produce harmonics in the power system thereby causing equipment overheating, damage devices, EMI related problems etc. Active Power Filters (APF) is used to compensate the current harmonics and load unbalance.

In this project present the new control strategy [1] to control the inverter in such a way that to maximum utilize Renewable energy with grid. Active power filter is used compensate harmonics load unbalance [2]. Current controlled voltage source inverter are used to interface the Renewable energy source in distributed system. This project presents a new method that consists of four leg VSI with new control strategy is capable to compensating problems like power factor, current imbalance and current harmonics, improve power quality and injecting renewable energy to grid with a low THD.

The proposed system consists of RES connected to the dc link of a grid-interfacing inverter as shown in Fig. 1. It is shows that both load are connected that is non-linear load as well as unbalance load at distribution. Grid is connected to step down transformer with reduce voltage level for distribution side as shown in fig. 1. For injecting Renewable energy to grid inverter that is power electronic devices is used. Power electronic devices produces the unwanted harmonics to reduce this shunt active power filter is used. Shunt active power filter is used to compensate load current harmonics by injecting equal but opposite compensating current. In this project three phase four wire voltage source current controlled inverter is used. Generally, three wire inverter is used but in this fourth terminal is used to compensate the neutral current. A voltage source inverter is converted renewable DC energy into Ac with required magnitude, phase angle and frequency. It also converts the DC voltage across storage devices into a set of three phase AC output voltages. It is also capable to generate or absorbs reactive power. If the output voltage of the VSC is greater than AC bus terminal voltages, is said to be in capacitive mode. So, it will compensate the reactive power through AC system. The type of power switch used is an IGBT in anti-parallel with a diode. The three phase four leg VSI is modeled in Simulink by using IGBT. The driving voltage across the inductance determine the maximum di/dt that can be achieved by the filter. A large valve of inductance is better for isolation from the power system and protection from transient distribution it also limits the ability of the active filter to cancel higher order harmonics.

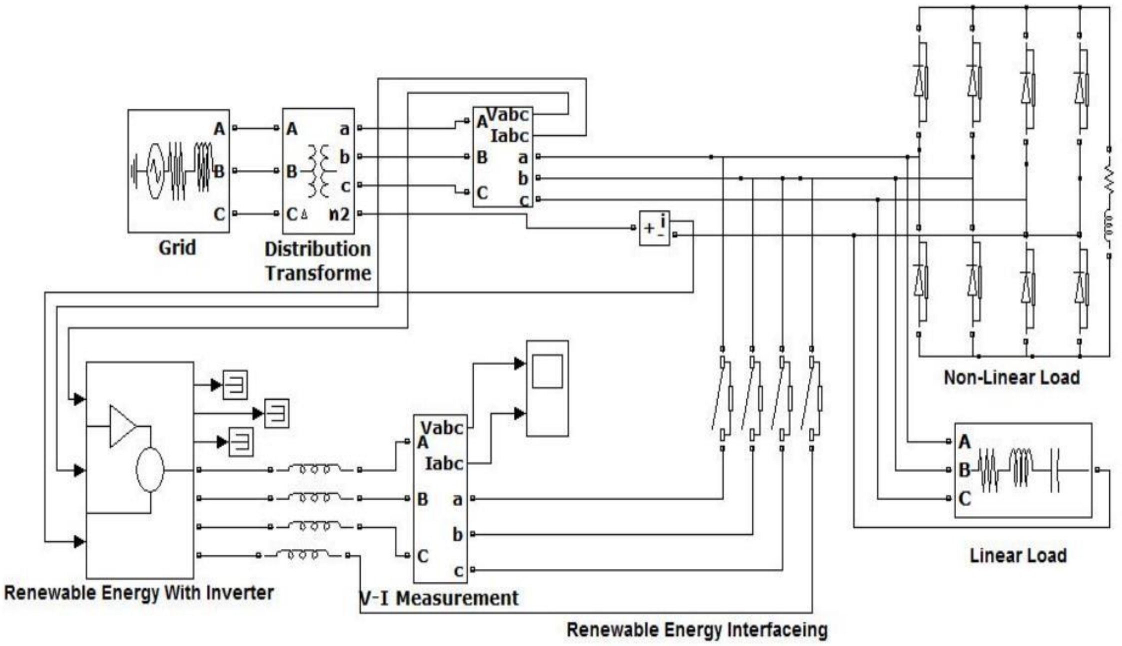


Fig.1. shows the grid connected renewable energy at distribution level.

Due to the intermittent nature of RES, the generated power is of variable nature. The dc-link plays an important role in transferring this variable power from renewable energy source to the grid. RES are represented as current sources connected to the dc-link of a grid interfacing inverter. Fig. 1 shows the systematic representation of power transfer from the renewable energy resources to the grid via the dc link. The dc-capacitor decoupled the RES from grid and allows the independent control of inverter on either side of dc link. P1 to P8 switching signal of inverter where P7 and P8 are multiplied with constant zero to compensate the neutral current.

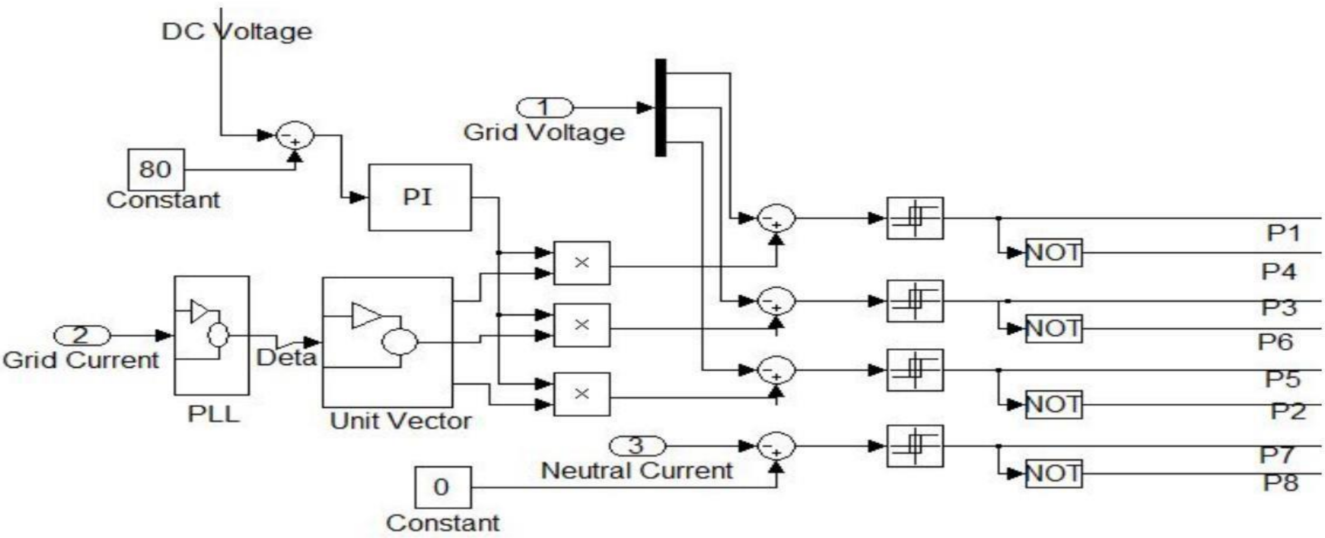


Fig. 2. Shows the control strategy of inverter

The control diagram of grid- interfacing inverter for a 3-phase 4-wire system is shown in Fig. 3. The fourth leg of inverter is used to compensate the neutral current of load. The main aim of proposed approach is to regulate the power at PCC during:
1) PRES=0 ; 2) PRES PL. While performing the power management operation, the inverter is actively controlled in such a way that it always draws/ supplies fundamental active power from/ to the grid. If the load connected to the PCC is non-linear or unbalanced or the combination of both, the given control approach also compensates the harmonics, unbalance, and neutral current. The duty ratio of inverter switches is varied in a power cycle such that the combination of load and inverter injected power appears as balanced resistive load to the grid. The regulation of dclink voltage carries the information regarding the exchange of active power in between renewable source and grid. Thus, the output of dc-link voltage regulator results in an active current (IM). The multiplication of active current component (IM) with unity grid voltage vector templates (UA, UB and UC) generates the reference grid currents (IA *, IB * and IC *).

Harmonics

Power systems are designed to operate at frequencies of 50 or 60 Hz. However, certain types of loads produce currents and voltages with frequencies that are integer multiples of the 50 or 60 Hz fundamental frequency. These frequencies components are a form of electrical pollution known as harmonic distortion. There are two types of harmonics that can be encountered in a power system.

- Synchronous harmonics.
- Asynchronous harmonics.

Synchronous harmonics are sinusoids with frequencies which are multiples of the fundamental frequency. The multiplication factor is often referred to as the harmonic number. The synchronous harmonics can be subdivided into two categories.

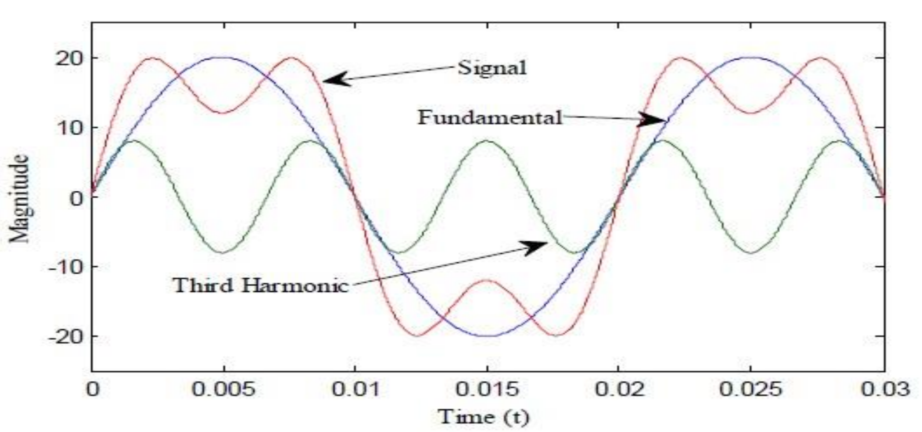
- Sub-harmonics: when the harmonic frequency is less than the fundamental frequency.
- Super harmonics: when the harmonic frequency is more than the fundamental frequency.

Harmonics are familiar to the musicians as the overtones from an instrument. They are the integer multiples of the instrument's fundamental or natural frequency that are produced by a series of standing waves of higher and higher order. Exactly the same thing happens in power circuits when non-linear loads create harmonic currents that are integer multiples of the supply fundamental frequency. The rapid growth of solid-state power electronics has greatly increased the number and size of these loads.

The concept of harmonics was introduced in the beginning of the 19th century by Joseph Fourier. Fourier has demonstrated that all periodic non-sinusoidal signals can be represented by infinitive sum or series of sinusoids with discontinuous frequencies as given by Equation (2.1).

$$i(t) = I_0 + \sum_{h=1}^{\infty} I_h \cos(h\omega t + \varphi_h) \quad \ldots\ldots \quad (2.1)$$

The component I_0 in the Fourier series is the direct component. The first term of the sum with the index h=1 is the fundamental of the signal. The rest of the series components are called the harmonics of the range h. Fig. 2.1 Shows the form of a wave containing the third harmonic (h=3). In the three phase electric grid, the principle harmonic components are the harmonics of ranges (6*h±1).



Active Power Filters

The function of the active power filters (APF) is to generate either harmonic currents or voltages in a manner such that the grid current or voltage waves conserve the sinusoidal form. The APFs can be connected to the grid in series (Series APF), shunt (SAPF) to compensate voltage harmonics or current harmonics respectively. Or can be associated with passive filters to construct the hybrid filters (HAPF).

Active filters are relatively new types of devices for eliminating harmonics. This kind of filter is based on power electronic devices and is much more expensive than passive filters. They have the distinct advantage that they do not resonate with the power system and they work independently with respect to the system impedance characteristics. They are used in difficult circumstances where passive filters don't operate successfully because of resonance problems and they don't have any interference with other elements installed anywhere in the power system.

The active filters present many other advantages over the traditional methods for harmonic compensation such as:

- Adaptation with the variation of the loads.
- Possibility of selective harmonics compensation.
- Limitations in the compensation power.

- Possibility of reactive power compensation

Series Active Power Filter (Series APF)

The aim of the series APF is to locally modify the impedance of the grid. It is considered as harmonic voltage source which cancel the voltage perturbations which come from the grid or these created by the circulation of the harmonic currents into the grid impedance. However, series APFs can’t compensate the harmonic currents produced by the loads.

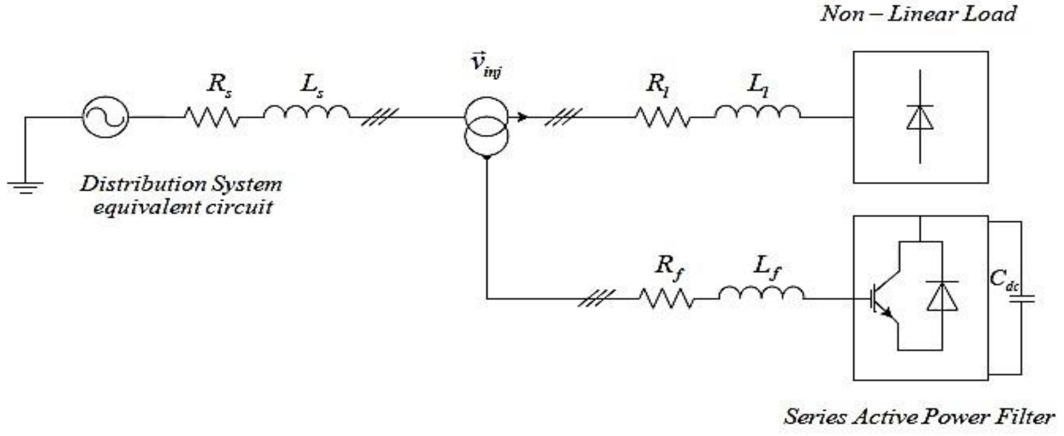


Fig. 2.5 Series Active Power Filter Connected to the Grid

Shunt Active Power Filter (SAPF)

The SAPFs are connected in parallel with the harmonic producing loads. They are expected to inject in real time the harmonic currents absorbed by the pollutant loads. Thus, the grid current will become sinusoidal.

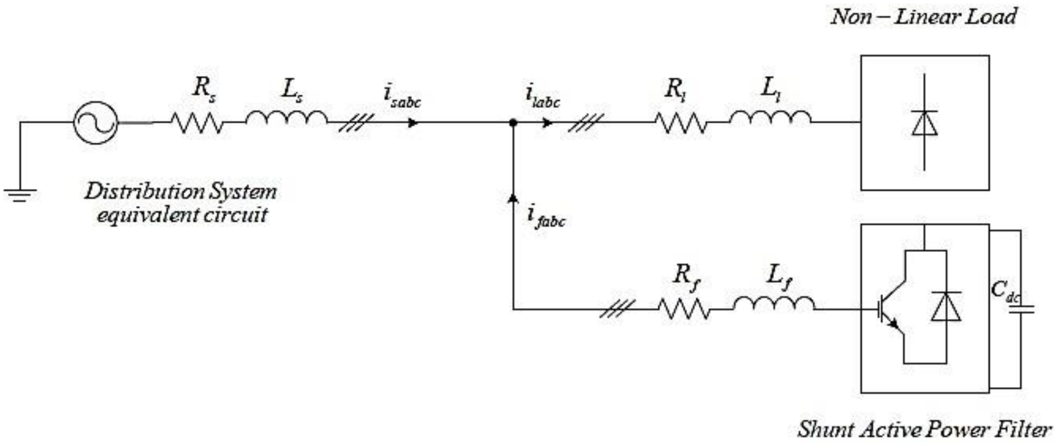
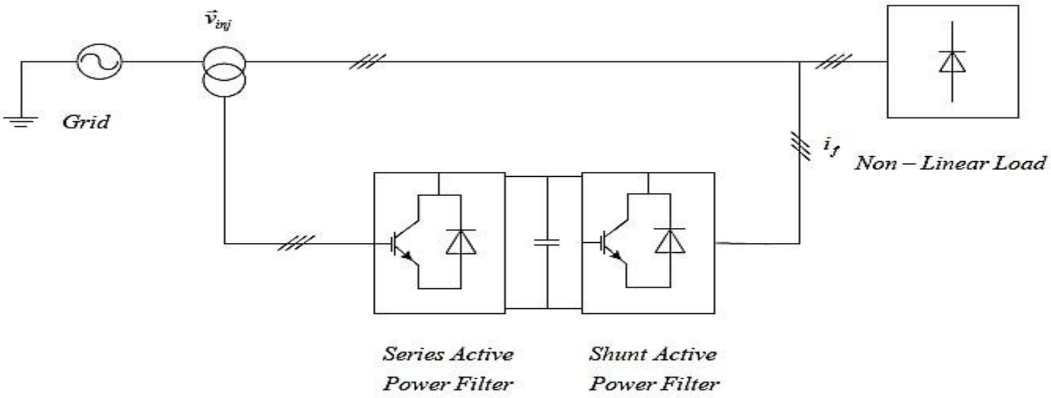
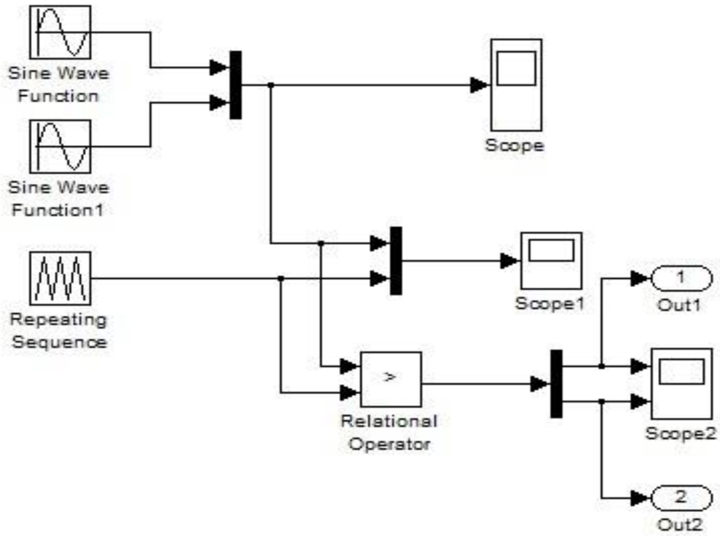


Fig. 2.6 Shunt APF Connected in Parallel with Non-Linear Load

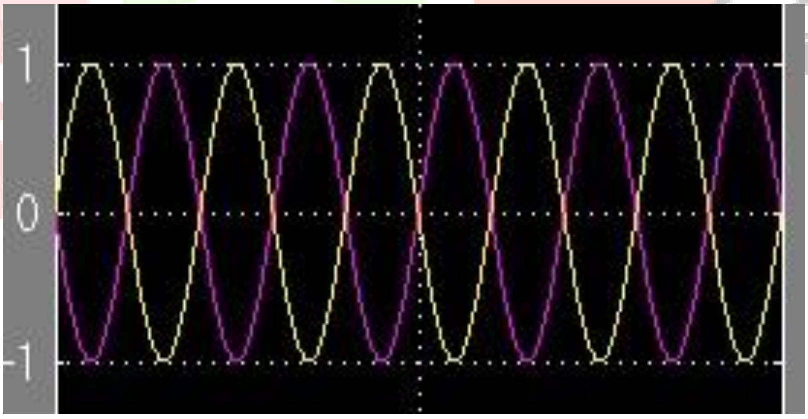
Combination of Parallel and Series APF (UPQC)

Fig. 2.7 explains the combination of two APFs parallel and series, called also (Unified Power Quality Conditioner). This structure combines the advantages of the two
APF type’s series and parallel. So it allows simultaneously achieving sinusoidal source current and voltage.

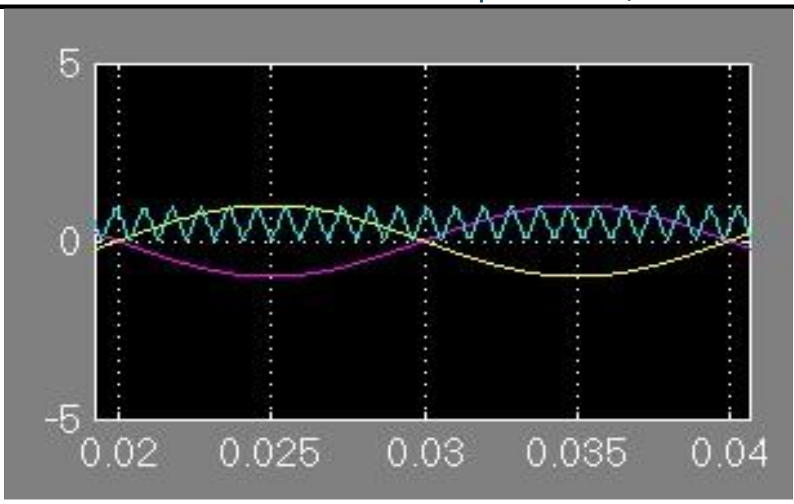




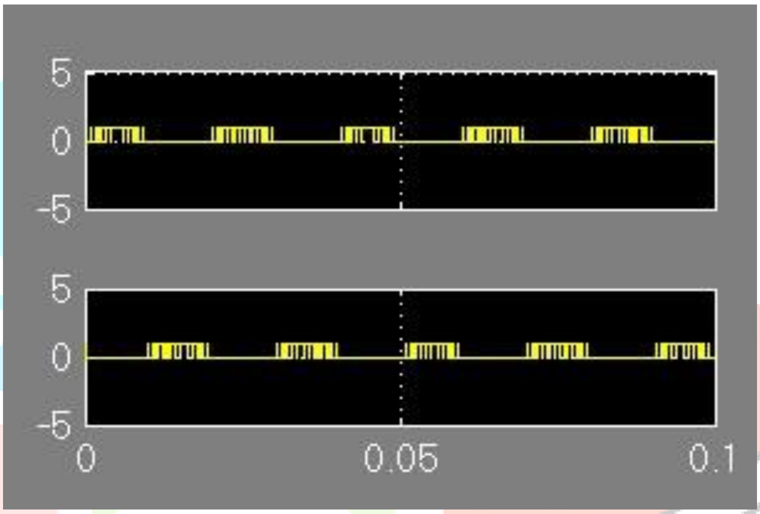
4.11 SPWM SIMULATION DIAGRAM



4.12 SCOPE view



4.13 SCOPE 1 view



4.14 SCOPE 2 view

the (ON time + OFF time) time of the pulse as constant. The (ON time + OFF time) of a pulse is called ‘Period’ of the pulse, and the ratio of the ON time or OFF time with the Period is called the ‘Duty Cycle’. Hence the PWM is a kind of modulation which keeps the Period of pulses constant but varying their duty cycle according to the amplitude of the modulating signal.

CONCLUSION

This project provide a power quality improvement in grid connected renewable energy at distribution by using three phase four wire inverter. The inverter is mainly is used to DC to AC at desired voltage level of the grid. Harmonics level of supply current is 28% without filtering, after implementing filter (inverter) the harmonic level is reduced to 2.94%. The grid interfacing inverter inject real power from RES and effectively utilized at lagging demand. The neutral current is prevented to flow to the grid this is done by fourth leg of inverter to compensate neutral current as nearly equal to Zero. The THD level of the grid current is reduced hence improve the power quality. It is future demonstration the Power quality under three different conditions. PRES=0, PRESPL. The current unbalance, harmonics at distribution level, and active power support due to unbalance load connected to the distribution system.

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