# Power Quality Improvement in Hybrid Wind-PV Farms Grid-Connected Using D-STATCOM (Static Dispensing Compensator)

**Ramavtar Dhakar**
**Depatment of Electrcal Engineering**
**Jabalpur Engineering College, Jabalpur,**

**Prof. Sudeep Mohaney**
**Depatment of Electrcal Engineering,**
**Jabalpur Engineering College, Jabalpur.**

***Abstract-*** The Static Compensator (STATCOM), the VSC (Voltage Source Converter), and the Flexible AC Transmitting System (FACTS) are a combination of renewable energy sources and voltage source converters that increase static & dynamic voltage control in the distribution & transmission systems. It's a power control system. In electronics & electrical industries, power quality is continually an important factor. The voltage flicker and harmonics are a system for measuring the power quality. In the distribution system, DSTATCOM is usually connected. The IGBT is used as a low switching loss power switch and is very simple to turn off. This paper analyses THD, voltage disturbances, and current waveforms with DSTATCOM are reduced. The simulation and validation of the distribution system using DSTATCOM in MATLAB/ SIMULINK, as well as the control scheme used to improve power efficiency.

***Keywords-*** *DSTATCOM, Inverter, Wind Enrgy, Solar Power System, MPPT, THD.*

## I. INTRODUCTION

The multi-part technological method of electric power generation and transmission is used by many strength system appliances to make full benefits of the output. Now, global plays a vital role. Agriculture, railways, manufacturing, education, and the growth of our financial system all benefit from this. It is therefore widely considered. Reactive power is the power that can drive active strength. In the transmission system, reactive and real power play a significant role. When a transmission or distribution line occurs any issues, such as skin impact, swell, sag, harmonics, noise, temperature effect, flickering, and so on, 'power loss' can be added at this point. To wear the power loss, the DSTATCOM can be linked to satisfactory electricity problems within the distribution system. A ‘static voltage compensator,' or DSTATCOM, is a device that is widely used in parallel distribution lines. In this paper, it is widely used to provide feeding with a single give up, i.e., just one clientfor example, in industries where one tapping is likely to be used due to very large amounts of current, the power loss may be extremelyhigh. Additionally, faults may occur in the transmission device to decreases STATCOM. D-static
compensator DSTATCOM, in comparison to STATCOM, may have more components. The main goal of the undertaking to fulfill the distribution mass of equipment in which no change can be created to the DSTATCOM

distribution loading aspect by the producing station. This paper's primary aim is to use a "distribution system" for the DSTATCOM, which is a lossless gadget. The "power quality," as well as "voltage flicker, sag, and in addition to harmonic ordinary and high-frequency clatter," contains issues. In an electricity network, alternate voltage, modern-day waveforms, and power electronic devices affecting the purchaser device & electricity offerings. The "Harmonic Voltages" motive means that the gadget measurement has been inaccurate and relays and system manipulation has been damaged. Electromagnetic noise, which is induced by the noise of high-frequency electromagnetic waves (Harmonics) generated through strength-digital circuits, distresses enterprise and business "electronic devices" & frequently stimulates interfering voltage with "communication strains."

The D-STATCOM distribution machine uses to reduce harmonics &high-frequency losses. STATCOM plays a key role in the distribution system when power first-class problem arises. It will only be supplied by the path if the supply is balanced, and only reactive power may be injected across the machine, which is called VAR compensation if the supply is unbalanced. To compensate for the strength Successful, the DSTATCOM connects to this task in a distribution system.

## II. POWER QUALITY

The word ‘PQ' usually refers to the significance of voltage supply. It provides reliable andadequate power for an application. This means that the consumer has adequate and uninterrupted power which no longer affects the equipment.The quality and tolerance of the current parameters and of the voltage for which the product has been artificially testedare used by the manufacturer.

***A. Why is PQ so essential:***

It is significant because

- For a good PQ, the user pays. It means that confidence is broken when power quality is damaged.
- Low quality damages the equipment of consumers and affects the life of the equipment.
- Bad eminence, like flickering, etc., reasons health threats & irrigation.
- Low voltage & high harmonic current lead to high heating and loss.
- Frequent faults, equipment botches & relay operations affect the reliability of the delivered energy.

***B. How does poor quality of power influence the economy:***

- The rotating machines are overheated on the generating side and are influenced by their existence in a state of high harmonics, which are created by electronic devices for load or power. Shutdown as a result of a device failure or the failure to supply a substantial amount of money.
- System industries such as "rolling mills," "fabric mills," and "paper mills," among others, are affected by the poor power supply, and manufacturing losses because of interruptions may be very high.
- Certain positively limiting voltages and harmonics are intended to be absorbed by systems. When unusual circumstances are taken into account, the costs enhance. This boosts both the project's price and affects the viability scheme.
- Generators have to supply maximum power to compensate for the losses due to poor power quality. An increased thermal generation affects the atmosphere by releasing greenhouse gases.
- Owing to the lack of power due to interruption force, the general public to use diesel or kerosene is much more costly.

***C. Benefits of PQ monitoring:***

- Ensures power system's stability.
- Explore the source of the 'disturbance.'
- The advantage in the maintenance of anticipation & prediction
- Traditional electrical supply calculations and disturbances affect.
- ‘Energy costs decrease, and risks are minimized.'

***D. Power system troubles:***

problem is a deviation from continuous steady-wave shape due to 'brief period' error or an unpredictable load change. The following are some of the problems with the power system:

- Dips in voltage (sag)
- Interruptions
- Increase in voltage (swell)
- Voltage impulses
- Transients

***E.Unbalanced system load effects:***

Phase voltage & phase current discrepancy are caused by unbalanced loads. An unbalance from single phase to ground fault is an extreme case. The average voltage of the phase is known as the phase voltage destabilizer as a maximum deviation of the phase voltage. Switching operation, non-linear loads, risky masses, reactive loads, arcing loads, atmospheric disorders, and a few of the bases for the smaller quantity of power factor.

## III. DSTATCOM

The FACTS controls were designed to discuss the reactive power in the distribution lines using phase-shifting techniques. Real power can be added into transmission lines if necessary, with support of the development of FACTS systems like "DSTATCOM" & "UPFC". requirement for a big capacitor bank & inductor bank is reduced, resulting in improved working efficiency.

DSTATCOM is a reactive power compensation system that uses an IGBT as a consistent high switching component as well as a 'Pulse-Width' modulation control principle to produce and/or fascinate reactive power. When fed from energy loading devices or DC energy source at their i/p terminals, it may generate and fascinate helplessly controllable reactive & real power at its output stations. Figure 1 shows a typical connection of DSTATCOM.

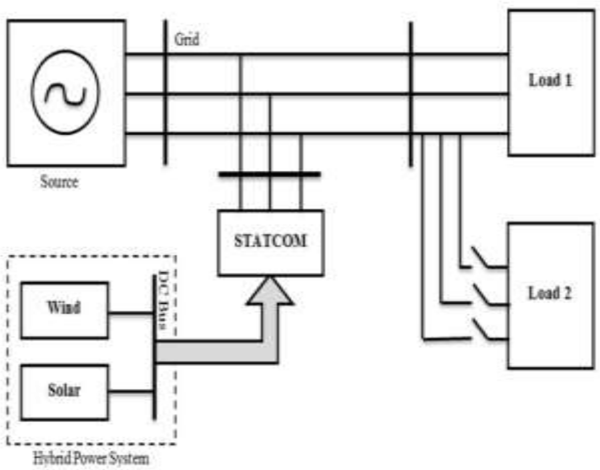


Fig.1.Schematic diagram of Interfacing the Hybrid Power System to Gridby Using STATCOM

Since the voltage drop is produced by both active & reactive power consumption, extra active power compensation is required in this case.

***A. Fundamental equations:***

The DSTATCOM' differential equation is

$$\frac{\mathrm{d}i_{fa}}{\mathrm{d}t} = \frac{1}{L_f}(-R_f.I_{fa} + V_{ia} - V_{ta})$$

$$\frac{di_{fb}}{dt} = \frac{1}{L_f}(-R_f.I_{fb} + V_{ib} - V_{tb})$$

$$\frac{di_{fc}}{dt} = \frac{1}{L_f}(-R_f.I_{fc} + V_{ic} - V_{tc})$$

Where Vta, Vtb, and Vtc are the PCC bus voltages with respect to neutral, and Via, Vib, and Vic are the converter output phase voltages with respect to neutral.

The phase voltage at the output of the converter is

$$V_{ia} = V_{dc}.U_a$$

$$V_{ib} = V_{dc}.U_b$$

$$V_{ic} = V_{dc}.U_c$$

Hysteresis band control technique produces 'switching functions' that are $U_a$, $U_b$, and $U_c$.

***B. Power Reactive:***

The power that transfers in or reacts to the circuit itself is called the "reactive power." We distinguish between two power types: "active" &"reactive". The term 'apparent power' refers to acquire of active & reactive power.

As the energy flow between the source and the load is reversed from time to time in an AC circuit, energy is temporarily stored in inductive & capacitive elements, which affect. The power that is used or expended in an AC circuit is known as real power, & it is the real energy of the system that is used to perform work.This is the untapped power to transmit power that the device should appreciate. As energy accumulates as a "magnetic field," inductors (reactors) are supposed to store the reactive power. As a result of the voltage being mainly useful Via a coil, a magnetic field is created. As a consequence, the current is out of phase with the voltage.The capacitors should produce reactive power because they store energy as an 'electro static' field. As a result, a charge accumulates when the current is passing through the capacitor to produce a voltage change over some time. The capacitor is leaning to resistant this change, causing the voltages to lag current in phase. The instantaneous power in an inductive circuit is written as:

$$P = V_{max}.I_{max}.\cos\omega t.\cos(\omega t - \theta)$$

$$P = \frac{V_{max}.I_{max}}{2}\cos\theta\,(1+\cos 2\omega t) + \frac{V_{max}.I_{max}}{2}\sin\theta\sin 2\omega t$$
$$\frac{V_{max}.I_{max}}{2}\sin\theta\,(\sin 2\omega t)$$

Wherever:
P = instantaneously power

Imax = Peak rate of the current waveform

V max = Peak rate of the voltage waveform
ω = Angular frequency

t = Time period

At this time θ = The angle at that current-voltage lag in phase is such that the instant reactive power is pulsed at twice the frequency of device & its average charging rate is 0, & instant reactive power can be calculated as follows:

***C. Principle of operation:***

- The D-Static compensator is a controlled source of "reactive power." DSTATCOM produces anticipated reactive power preoccupation and generation entirety Via the electrical output of voltage & current waveforms' in the voltage-source transformer.
- In Fig.2, DSTATCOM single-line power system is shown, with a VSC connected Via a magnet connected to the utility bus.
- A DSTATCOM appears to be a 'modified voltage source' due to a reactance that indicates that shunt reactors & capacitor banks are not used in the captivation and reactive power generation thus providing the D-static compensator resulting in low magnetic effect, compact proposal, & low noise.
- The reactive power conversation b/w the AC system and converter is modified & altering the amplitude of the converter Es' 3-phase output voltage.
- In comparison to the efficacy bus, raising the output voltage amplitude causes current to flow from the converter to the AC system by the reactance, generating power of capacitive-reaction for the AC system. A current flows through the converter as the amplitude of the output voltage reduces concerning the utility bus, and the converter employs inductive reactive power.
- When the voltage of the AC device is equivalent to o/p voltage, there will be the reactive power exchange, which would be negligible; a non-consistent state-run condition would be established for the DSTATCOM.
- The phase shift among output voltage & output voltage of converter, & AC system voltage, are adjusted in some cases by controlling real power transmission that is, indicating that converter from their DC power needs real power to the AC system by charging yield voltage to operate the AC system voltage.
- If the "AC-system" voltage applied in the DC system lags behind AC-system voltage, DSTATCOM uses the real power of "AC-system" which is in use with the DC system. By fluctuating the immediate reactive power, it distributes reactive power among the AC system's phases.
- When the converter is used to provide reactive yield power real power supply from the DC source as an i/p must be 0.
- If operated with "capacitive" & "inductive," the voltage source converter has the same rating current aptitude.
- The voltage sources converter DSTATCOM uses a power electronic device to generate further reactive power.
- In a steady-state, the VSC uses basic frequency switches to reduce the losses of converters.
- To prevent the fault current from accessing the VSC during a transient state created by a fault, the VSC is

set to "pulse width modulation" (PWM) mode. As a result, the DSTATCOM can handle AC transients without being blocked.

## IV. PWM TECHNIQUE IN DSTATCOM

In strength electronics circuits, the inverter's PWM is mostly used for realistic programs. PWM inverters can generate AC voltages of different magnitudes & frequencies. When used is best with a square wave inverter, the PWM inverter's output voltage recovers the fastest. PWM inverters are commonly used in variable-speed AC drives. The variation of the AC voltage frequency between the drives can be seen, and a linear relation should exist entre the voltage & the frequency. For single segments & three segment types, the PWM inverter is executed.

"There are various types"of PWM strategies available, depending on the implementation conditions. For my part, after filtering, the output voltage formed" acquires a very good great sinusoidal, voltage waveform having' chosen essential frequency and importance. "To change the voltage, the PWM inverter uses the output voltage to condense the harmonic data. Several techniques of modulation are:

1. Sinusoidal pulse width modulation (Sin-PWM)
2. Single PWM method (SPWM)
3. Modified sinusoidal PWM.
4. Multiple uniform PWM(UPMW)

*A. Modulation of the width of sinusoidal pulses:*

The industry generally uses this technique. In comparison, it is possible to produce a sinusoidal reference sign and the triangular wave of service. Each pulse's width is modified in proportion to the amplitude determined 'in the middle of identical pulse waves. It is far; in most cases, the popular management technique is used in inverter circuits of power electronics. It has the output has lower harmonics and is easy to implement, such as switching losses.

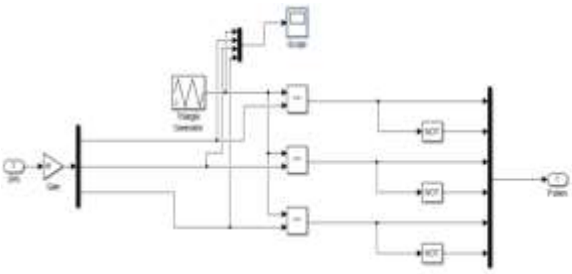

Fig.2. Inverter Switch PWM Firing

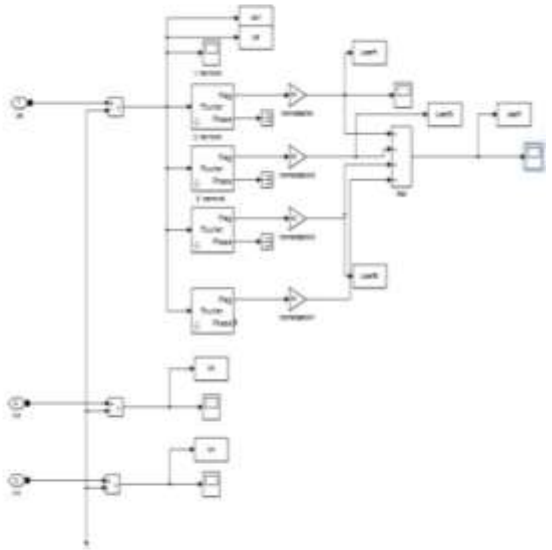

Fig.3.Mitigation Measurement circuit

## V. CONTROL SCHEME

The DSTATCOM's are predominantly implemented in the accompanying advances:

- Framework factor measurement and signal modeling
- Signals for reference compensation are extracted.
- Angles of firing for switching devices are produced.

The DSTATCOM control schematic diagram. DSTATCOM's primary aspect is the generation of proper pulse width modulation (PWM), which has a significant impact upon compensation destinations, homeless people, and state execution. Because DSTATCOM shares several concepts with STATCOM on the transmission stage, some of the control systems have been implemented in a DSTATCOM that uses PWM switching rather than FFS methods.

The response time of a PWM-based conveyance static compensator is faster, & the harmonic end power is higher. For control factor adjustment and harmonic mitigation, DSTATCOM uses three techniques. The figure depicts his phase shift control schematic graph. In this technique, the compensation is achieved by estimating RMS voltage at the load points without the need for reactive power estimation. For a consistent switching frequency, a modulation system for sinusoidal pulse width is used. This error signal is sent using the comparison of the deliberate framework RMS voltage & reference voltage to a single (PI) controller that creates the composition for selecting the important stage transfer between VSC output voltage and AC terminal voltage. The synchronization signal used to operate the PWM in the phase angles of the equally spaced balanced supply voltages of 120 degrees is produced at this angle. Using a separate battery source, the DC voltage is maintained constant in this scheme. When the load varies linearly, the source voltage & source current must also be phased, correction of power factor system. However, the finish compensation must also not be done if the load is nonlinear. This method, on the other hand, is easy to implement, efficient, and capable of providing partial reactive power pay without the use of harmonic concealment.

## Disadvantages

- Since the controller requires its own DC transport, the capacitor must be pre-charged with a large DC source.
- The supply phase angle can only be measured over the fundamental with balanced sources & RMS voltages assumed.
- For non-linear loads, there is no harmonic suppression & only partial compensation.

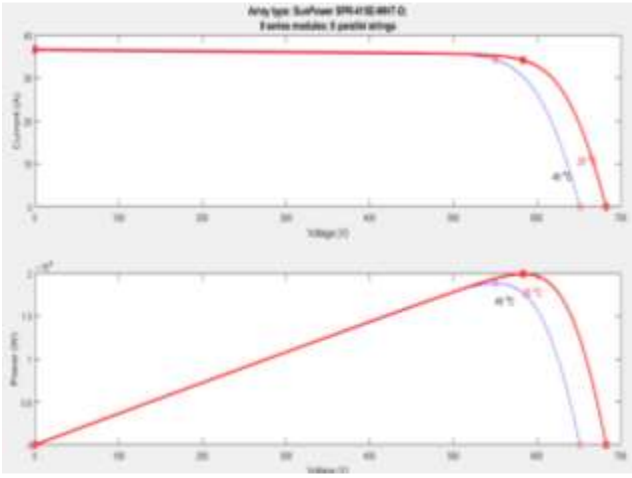

Fig.6. Solar Module PV Curves

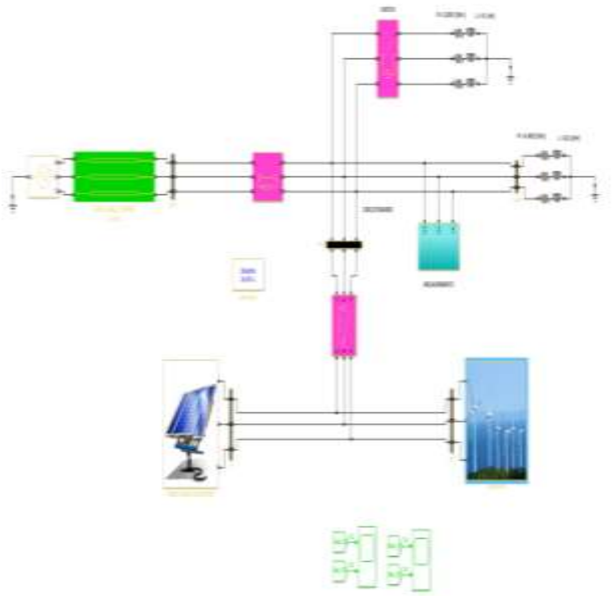

Fig.4.Matlab Simulated Hybrid Power System

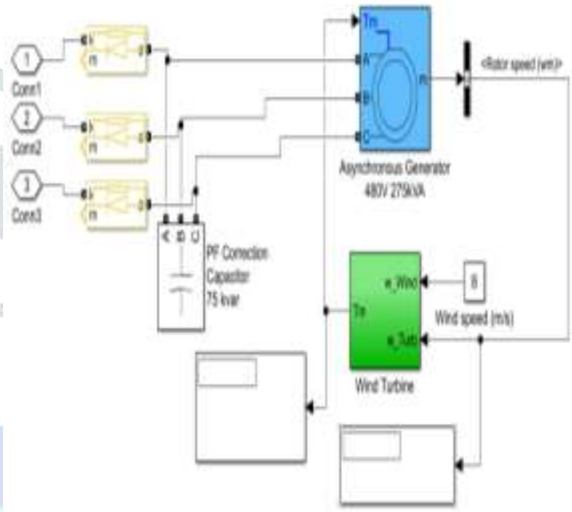


Fig.7. Simulation and connectivity of Wind Generator

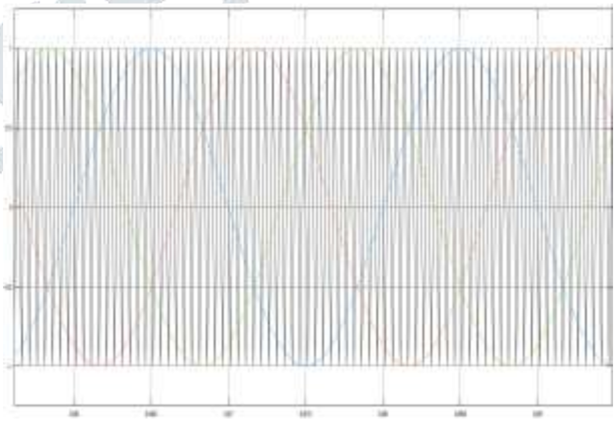

Fig.8. Inverter PWM Firing Results

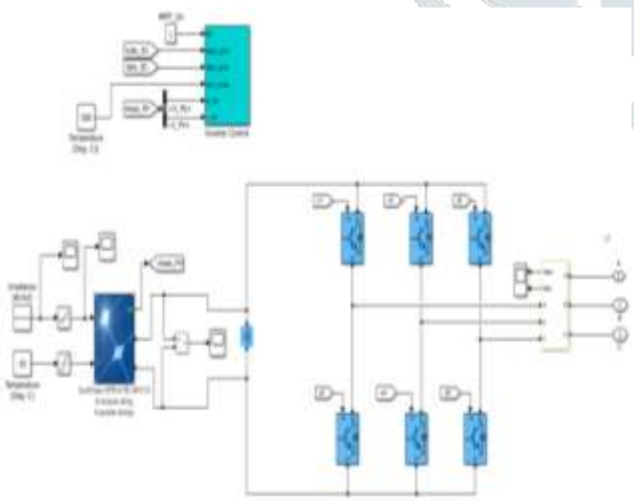

Fig.5. Simulation and connectivity of Solar System

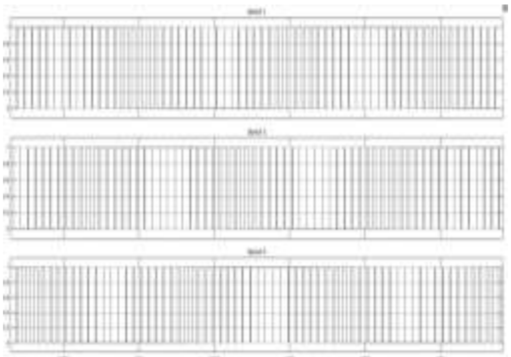

Fig.9.Inverter Gate Firing Pulses

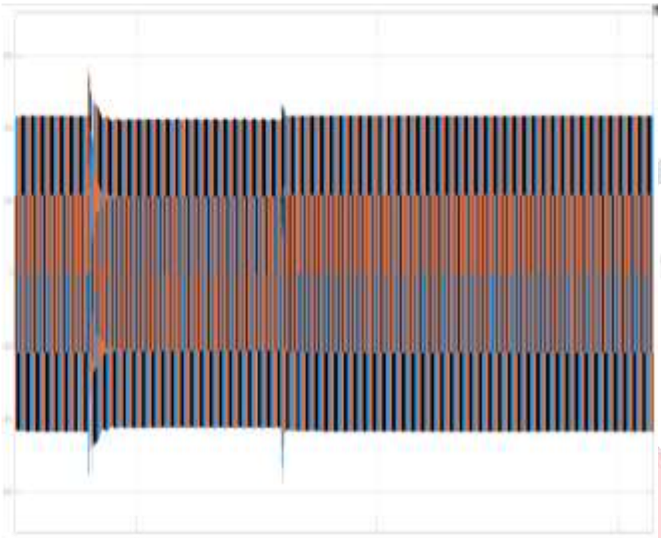

Fig.10. Voltage Wave at Load Side

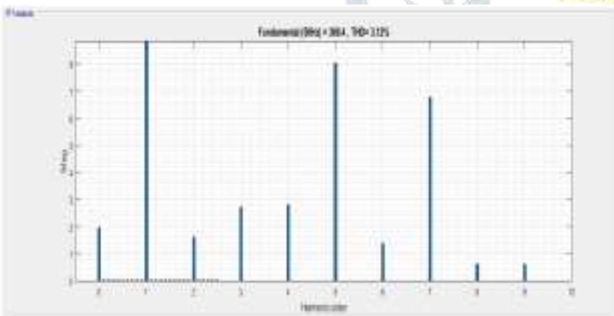

Fig.11. Total Harmonics Distortion of injected voltage by Hybrid Power System

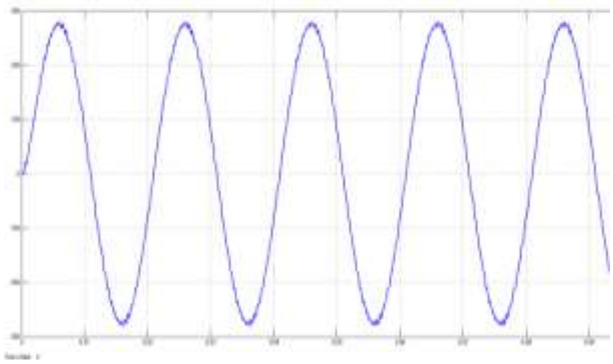

Fig.12.Invitercurrent wave form

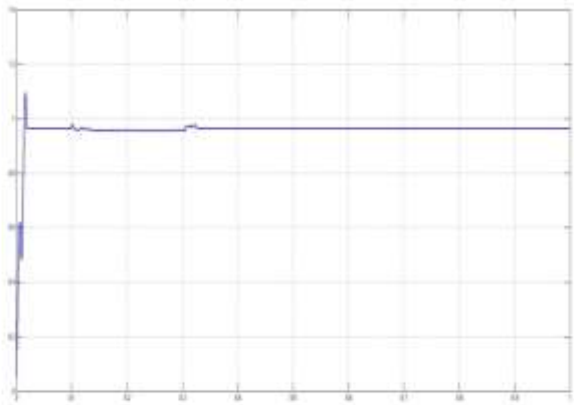

Fig.13.Mitigation behavior of the circuit

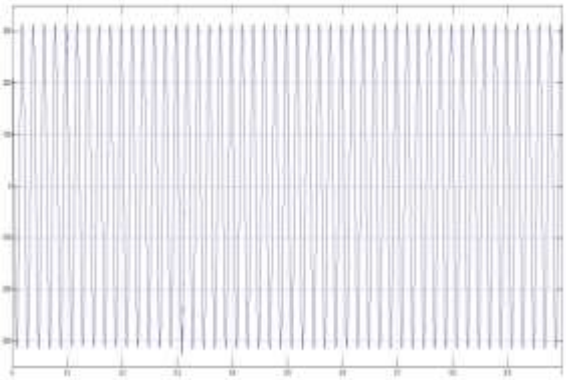

Fig.14.Load behavior of the circuit

## VI. CONCLUSION

This paper examined a summarize analysis of power systems installed in power distribution networks to avoid several fluctuations in power quality, dip, flickering, current harmonics, voltage sag/swells & power factor reduction. In the distribution system, these power electronics devices are used for the protection of plants, loading & feeders.The DSTATCOM, when linked to a shunt, provides high power quality for both distribution & transmission. In the meantime, the UPQC(Unified Power Quality Compensator) is important to energy gadgets, as it can direct both current and voltage-related issues. This system was fully integrated to create a custom power region.

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