Improving and Smoothing Of Power Quality Problem Using Ultra Capacitor

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Abstract: Now a day’s power quality problems become a major concern which has to be decreased by mitigate the sag / swells & harmonic with DVR and Super Capacitor based on fuzzy logic controller. Harmonics affect the power system area which causes severe effect to the distribution grid. In order to reduce the intermittencies and improve the power quality of the distribution grid, an super capacitor integrated power conditioner with a custom power device based on fuzzy logic controller is used. By using fuzzy logic controller gives active power capability, which is useful in tackling the grid intermittencies and in improving the voltage sag and swell compensation. In this paper, Super capacitor is integrated into dc-link of the power conditioner through a bidirectional dc–dc converter that helps in providing a stiff dc-link voltage. There are so many types of fuzzy logic controllers like mamdani, Tsukamoto, Sugeno, Larsen. In this paper mamdani type has a ability to working well under a wide range of operating conditions. Hence fuzzy logic controller is used to reduce the total harmonic distortion. Design and control of both active power filter and dynamic voltage restorer is discussed. This simulation performed in matlab/simulink environment.

I. INTRODUCTION

1.1 Modern Electric Vehicles:
During the last few decades, the negative environmental impacts of petroleum based vehicles have ignited the interest toward Electric Vehicles with low or zero emissions. An Electric Vehicle uses one or more electric motors for propulsion. There are three types of EV’s as follows.

1. Continuously powered from an external electric power station.
2. Powered by the electricity stored originally from an external electric power source.
3. Powered by an on-board electrical generator, such as an internal combustion engine.

This vehicle category is called Hybrid Electric Vehicle. If the electric source of the HEV is also accessible from outside to recharge, the HEV is known as Plug-in- HEV(PHEV). HEV can have a parallel design, series design or a combination of both with series configuration at low speeds and parallel configuration for highways and accelerations:

- In a parallel design, the vehicle is powered by two independent mechanical drives, as shown in Figure.1.1 (a). The electric motor only assists the primary engine in the events of acceleration, hill climbing, braking etc.
- In a series design, the vehicle is powered only by one mechanical drive as shown in Figure1.1 (b) and the primary engine charger the battery, which drives the electric motor.
- In a parallel design, the highest power is delivered is 100 KW.
- In a series design, as there is one mechanical drive so the power is 10-50KW.
- The series and parallel design are started from 18th century.
EV’s can also be categorized based on their power rating, since their power rating can range from hundreds of watts in Light Electric Vehicles to several hundreds of kilowatts in heavy duty vehicles. The power rating of LEV’s such as e-bikes, scooters, seaways and lawnmowers are less than several kilowatts. The next power level includes racing motorcycles and sedan vehicles with a power rating in the range of 10-100 KW. The highest power EV category, with power rating over 100 KW, includes heavy duty vehicles, such as buses and tracks.

EV’s came into existence in the mid-19th century. Shortly after, they were driven to the side by the ICE based vehicles due to several reasons, such as level of comfort and the energy-density of their storage element. Electric power remained a common source for vehicles like trains that are directly power from the grid and do not require energy storage. During the last few decades, oil price forecasts and environmental impacts renewed the interest toward electric transportation infrastructure. The global oil price forecast shown a significant increase by 2035, according to the 2013 annual energy outlook published by the Energy Information Administration, as shown in figure. 1.2. EVs can have minimal environmental impact, since the energy consumed by the EVs can be generated from many sources, including clean renewable energy sources. Another key advantage to EVs is their ability to recover energy, that otherwise would be lost during braking, which is known as Regenerative Braking.

1.1.1 Challenges in ESS EVS:
One major challenge in the mass adoption of EVs and HEVs is their Energy Storage System. Classical electrochemical batteries have several limitations.
• Lower energy-density compared to petrol-based fuel, which effects the weight and the range of the vehicles. The specific-energy of petrol and Lithium-Ion batteries are 13KWh/Kg and 0.2 KWh/Kg respectively. Considering a typical energy efficiency of 20% for the ICEs and 90% for the electric drives, the effective specific-energy of petrol is 14 times higher than that of Lithium-ion batteries, resulting in a very limited range for EVs.
• The charge time is another prohibitive factor and charging time varies with the charging levels. The battery lifetime is another major concern and is usually not sufficient for traction applications.
• Numerous battery chemistries are available and the best choice of battery is application dependent. A List of available battery chemistries is provided below:
  1) Lead-Acid Batteries
  2) Nickel-Metal Hydride Batteries
  3) Lithium-Ion batteries.
  4) Nickel-Zinc Batteries.
  5) Nickel-Cadmium Batteries.

II. CUSTOM POWER DEVICES

2.1 Power Quality:
Power Quality is term that means different things to different people. Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE defines power quality as “the concept of powering and grounding sensitive electronic equipment in a manner suitable for the equipment” All electrical devices are prone to failure or malfunction when exposed to one or more power quality problems. The electrical device might be an electric motor, a transformer, a generator, a computer, a printer, communication equipment, or a household appliance. All of these devices and other react adversely to power quality issues, depending on the severity of problems.
A simpler and perhaps more concise definition might state:”Power Quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance or life expectancy.” This definition embraces two things that we demand from an electrical device: Performance and life expectancy. Any power related problem that compromises either attribute is a power quality. From the following figure 2.1 shows the power quality beginning of electricity i.e there is no disturbances, and figure 2.2 shows the power quality in Recent trends which shows that there are many power quality problems.

![Figure 2.1 Power Quality Beginning Of Electricity]

 SOURCE Without disturbances LOAD

![Figure 2.2 Power Quality In Recent Trends]

 SOURCE SAGS,SWELLS, HARMONICS LOAD

2.1.1 Power Quality Problems:
Any power problem that results in failure or misoperation of customer equipment, manifests itself as an economic burden to the user, or produces negative impacts on the environment. When applied to the container crane industry, the power issues which degrade power quality include:
The AC and DC variable speed drives utilized on board container cranes are significant contributors to total harmonic current and voltage distortion. Whereas SCR phase control creates the desirable average power factor, DC SCR drives operate at less than this. In addition, line notching occurs when SCR’s commutate, creating transient peak recovery voltages that can be 3 to 4 times the nominal line voltage depending upon the system impedance and the size of the drives. The frequency and severity of these power system disturbances varies with the speed of the drive. Harmonic current injection by AC and DC drives will be highest when the drives are operating at slow speeds. Power factor will be lowest when DC drives are operating at slow speeds or during initial acceleration and deceleration periods, increasing to its maximum value when the SCR’s are phased on to produce rated or base speed. Above base speed, the power factor essentially remains constant. Unfortunately, container cranes can spend considerable time at low speeds as the operator attempts to spot and land containers. Poor power factor places a greater kVA demand burden on the utility or engine-alternator power source.

Low power factor loads can also affect the voltage stability which can ultimately result in detrimental effects on the life of sensitive electronic equipment or even intermittent malfunction. Voltage transients created by DC drive SCR line notching, AC drive voltage chopping, and high frequency harmonic voltages and currents are all significant sources of noise and disturbance to sensitive electronic equipment. It has been our experience that end users often do not associate power quality problems with Container cranes, either because they are totally unaware of such issues or there was no economic consequence if power quality was not addressed. Before the advent of solid-state power supplies, Power factor was reasonable, and harmonic current injection was minimal. Not until the crane Population multiplied, power demands per crane increased, and static power conversion became the way of life, did power quality issues begin to emerge. Even as harmonic distortion and power Factor issues surfaced, no one was really prepared. Even today, crane builders and electrical drive System vendors avoid the issue during competitive bidding for new cranes. Rather than focus on Awareness and understanding of the potential issues, the power quality issue is intentionally or Unintentionally ignored. Power quality problem solutions are available. Although the solutions are not free, in most cases, they do represent a good return on investment.

However, if power quality is not specified, it most likely will not be delivered. Power quality can be improved through:
• Power factor correction,
• Harmonic filtering,
• Special line notch filtering,
• Transient voltage surge suppression,
• Proper earthing systems.

2.1.2 The Benefits of Power Quality:
Power quality in the container terminal environment impacts the economics of the terminal operation, affects reliability of the terminal equipment, and affects other consumers served by the same utility service. Each of these concerns is explored in the following paragraphs.
2.1.3 Classification according to power circuit, configurations and connections:
The choice of power circuit chosen for the active filter greatly influences its efficiency and accuracy in providing true compensation. It is therefore important that the correct circuit configuration is chosen. Three major types of filter structures shown in figure 2.5 along with the relevant power circuit. There are

(i) Shunt active filters
(ii) Series active filters
(iii) Other filter configurations

![Figure 2.5 Subdivisions of Active Power Filter according To Power Circuit connections](image)

i. Shunt Active Filters
Shunt active filters are by far the most widely accept and dominant filter of choice in most industrial processes. The active filter is connected in parallel at the PCC and is fed from the main power circuit. The objective of the shunt active filter is to supply opposing harmonic current to the nonlinear load effectively resulting in a net harmonic current. This means that the supply signals remain purely fundamental. Shunt filters also have the additional benefit of contributing to reactive power compensation and balancing of three-phase currents. Since the active filter is connected in parallel to the PCC, only the compensation current plus a small amount of active fundamental current is carried in the unit as shown in figure 2.6. For an increased range of power ratings, several shunt active filters can be combined together to withstand higher currents. This configuration consists of four distinct categories of circuit, namely inverter configurations, switched-capacitor circuits, lattice-structured filters and voltage-regulator-type

![Figure 2.6 Shunt Active Filters Standing Alone](image)

![Figure 2.7 Shunt Active Filter Network Configurations](image)
ii. Series Active Filters

The objective of the series active filter is to maintain a pure sinusoidal voltage waveform across the load. This is achieved by producing a PWM voltage waveform which is added or subtracted against the supply voltage waveform. Series active filter stand alone is shown in figure 2.8. The active filter acts as a voltage source and thus it is often a preferred solution of harmonic producing loads such as large capacity diode rectifiers with capacitive loads. Series filters offer the main advantage over the shunt configuration of achieving ac voltage regulation by eliminating voltage-waveform harmonics. This means the load contains a pure sinusoidal waveform.

![Diagram of Series Active Filter Stand Alone](image)

*Figure: 2.8 Series Active Filter Stand Alone*

### 2.2 Dynamic Voltage Restorer:

The major objectives are to increase the capacity utilization of distribution feeders (by minimizing the rms values of the line currents for a specified power demand), reduce the losses and improve power quality at the load bus. The major assumption was to neglect the variations. In the source voltages. This essentially implies that the dynamics of the source voltage is much slower than the load dynamics.

When the fast variations in the source voltage cannot be ignored, these can affect the performance of critical loads such as (a) semiconductor fabrication plants (b) paper mills (c) food processing plants and (d) automotive assembly plants. The most common disturbances in the source voltages are the voltage sags or swells that can be due to (i) disturbances arising in the transmission system, (ii) adjacent feeder faults and (iii) fuse or breaker operation. Voltage sags of even 10% lasting for 5-10 cycles can result in costly damage in critical loads. The voltage sags can arise due to symmetrical or unsymmetrical faults. In the latter case, negative and zero sequence components are also present. Uncompensated nonlinear loads in the distribution system can cause harmonic components in the supply voltages. To mitigate the problems caused by poor quality of power supply, series connected compensators are used.
III. DC-DC CONVERTER

DC-DC Converters are electronic devices used whenever we want to change DC electrical power efficiently from one voltage level to another. They are needed because unlike AC, DC cannot simply be stepped up or down using a transformer. In many ways, a DC-DC converter is the equivalent of a transformer.

The DC-DC converter can be viewed as a dc transformer that delivers a dc voltage or current at a different level than the input source. Electronic switching performs this dc transformation as in conventional transformers and not by electromagnetic means. The DC-DC converters find wide applications in regulated switch mode dc power supplies and in dc motor drive applications.

DC-DC converters are non-linear in nature. The design of high performance control for them is a challenge for both the control engineering engineers and power electronics engineers. In general, a good control for dc-dc converter always ensures stability in arbitrary operating condition. Moreover, good response in terms of rejection of load variations, input voltage changes and even parameter uncertainties is also required for a typical control scheme.

After pioneer study of dc-dc converters, a great deal of efforts has been directed in developing the modeling and control techniques of various dc-dc converters. Classic linear approach relies on the state averaging techniques to obtain the state-space averaged equations. From the state-space averaged model. Possible perturbations are introduced into the state variables around the operating point. On the basis of the equations, transfer functions of the open-loop plant can be obtained. A linear controller is easy to be designed with these necessary transfer functions based on the transfer function.

Additionally, the battery voltage declines as its stored power is drained. Switched DC-DC converters offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing.

3.1 Types of DC-DC converters:

There are many different types of DC-DC converters, each of which tends to be more suitable for some type of applications than for others. For convenience they can be classified into various groups,
however for example some converters are only suitable for stepping down the voltage, while others are only suitable for stepping it up a third group can be used for either. Currently DC-DC converters can be divided into two types

- Non–isolated dc-dc converters.
- Isolated dc-dc converters.

IV. SUPER CAPACITOR

4.1 Definition:
CAPACITOR: It is a device to store the charge in an electric circuit.
SUPER CAPACITOR: It can be defined as a energy storage device that stores energy electrostatically by polarizing an electrolytic solution.

Basically a capacitor is made up of two conductors separated by an insulator called dielectric. The dielectric can be made of paper, plastic, mica, ceramic, glass a vacuum or nearly any other nonconductive material. Some capacitors are called Electrolytic in which the dielectric is aluminium foil conductor coated with oxide layer.
The electron storing capacity of capacitor is measured in units Farads. One Farad is approximately the charge with 6,280,000,000,000,000,000,000. Unlike batteries no chemical reaction takes place when energy is being stored or discharged and so super capacitors can go through hundreds of charging cycles with no degradation. Super capacitors are also known as double-layer capacitors or ultra capacitors

4.2 Principle of Super Capacitor:
Energy is stored in super capacitor by polarizing the electrolytic solution. The charges are separated via electrode-electrolyte interface as shown in figure 4.1.

![Figure 4.1 Principle Of Super capacitor](image)

4.3 Block Diagram of Super Capacitor:

![Figure 4.2 Block Diagram of Super Capacitor](image)
4.4 Construction of Super Capacitor:
Super capacitor consists of a porous electrode, electrolyte and a current collector (metal plates). There is a membrane, which separates, positive and negative plated is called separator. The following diagram 4.3 shows the super capacitor module by arranging the individual cell.

![Super Capacitor Stack](image)

**Figure 4.3 Construction of Super Capacitor**

V. MODEL OF POWER CONDITIONER WITH SUPERCAPACITOR

5.1 Introduction:
Power quality is major cause of concern in the industry, and it is important to maintain good power quality on the grid. Therefore, there is renewed interest in power quality products like the dynamic voltage restorer (DVR) and active power filter (APF). DVR prevents sensitive loads from experiencing voltage sags/ swells and APF prevents the grid from supplying non sinusoidal currents when the load is nonlinear. The concept of integrating the DVR and APF through a back–back inverter topology was first introduced in and the topology was named as unified power quality conditioner (UPQC). The design goal of the traditional UPQC was limited to improve the power quality of the distribution grid by being able to provide sag, swell, and harmonic current compensation. In this paper, energy storage integration into the power conditioner topology based on fuzzy logic controller is being proposed, which will allow the integrated system to provide additional functionality.

With the increase in penetration of the distribution energy resources (DERs) like wind, solar, and plug-in hybrid electric vehicles (PHEVs), there is a corresponding increase in the power quality problems and intermittencies on the distribution grid in the seconds to minutes time scale. Energy storage integration with DERs is a potential solution, which will increase the reliability of the DERs by reducing the intermittencies and also aid in tackling some of the power quality problems on the distribution grid. Applications where energy storage integration will improve the functionality are being identified, and efforts are being made to make energy storage integration commercially viable on a large scale. Smoothing of DERs is one application where energy storage integration and optimal control play an important role. In super capacitor and flow battery hybrid energy storage system are integrated into the wind turbine generator to provide wind power smoothing, and the system is tested using a real-time simulator. In super capacitor is used as auxiliary energy storage for photovoltaic (PV)/fuel cell, and a model-based controller is developed for providing optimal control. Voltage sag and swells are power quality problems on distribution grid that have to be mitigated. Sag/swell compensation needs active power support from the energy storage in the milliseconds to 1 min duration.

All the above functionalities can be realized by integrating energy storage into the grid through a power conditioner topology. Of all the rechargeable energy storage technologies superconducting magnet energy storage (SMES), flywheel energy storage system (FESS), battery energy storage system (BESS), and super capacitors. The following below figure 6.1 shows the one line diagram of UCAP (super capacitor) with super capacitor.
5.2 Description of Block Diagram:

The theme of the block diagram is to maintain constant power output to the load as shown in the figure. But due to power quality issues the power to the load is not constant and it is disturbed by various problems like sags, swells and harmonics, So, in order to reduce those problems a 3-phase Dynamic Voltage Restorer is used which is in series with the distribution grid. The operation of the DVR is to inject voltage whenever there is a drop in the line.

To reduce the current harmonics which is produced in the model a 3-phase shunt active power filter is used which is connected in shunt to the grid. A Super Capacitor also known as UCAP is used in order to deliver the power to the dc link from dc/dc converter. A dc/dc converter is known as buck-boost converter.
5.3 Controller Implementation:
The series inverter controller implementation is based on the in-phase compensation method that requires PLL for estimating \( \theta \), and this has been implemented using the fictitious power method. Based on the estimated \( \theta \) and the line–line source, voltages \( V_{ab}, V_{bc}, V_{ca} \) are transformed in to the d–q domain and the line–neutral components of the source voltage \( V_{sa}, V_{sb}, \) and \( V_{sc} \) which are not available can then be estimated using

\[
\begin{pmatrix}
V_{sa} \\
V_{sb} \\
V_{sc}
\end{pmatrix} = \begin{pmatrix}
1 & 0 \\
-1/2\sqrt{3}/2 & 1 \\
-1/2 - \sqrt{3}/2 & 1
\end{pmatrix} \begin{pmatrix}
\cos \theta - \Pi/6 & \sin \theta - \Pi/6 \\
-\sin \theta - \Pi/6 & \cos \theta - \Pi/6
\end{pmatrix} \begin{pmatrix}
V_d/\sqrt{3} \\
V_q/\sqrt{3}
\end{pmatrix}
\]

---\ref{6.1}

\[
P_{dvr} = 3V_{inj2a(RMS)}I_{Lat(RMS)}\cos \phi
\]

---\ref{6.2}

\[
Q_{dvr} = 3V_{inj2a(RMS)}I_{Lat(RMS)}\sin \phi
\]

---\ref{6.3}

\[
P_{ref} = -3/2 V_{sq} i_{qref}
\]

---\ref{6.4}

\[
Q_{ref} = -3/2 V_{sq} i_{dref}
\]

---\ref{6.5}

The shunt inverter controller implementation is based on the id – iq method, which is modified to provide active and reactive power compensation, such that id controls the reactive power and iq controls the active power.

5.4 Fuzzy Controller Based Concept:

In this project a fuzzy logic is used in order to reduce the harmonic content. FLC determined by the set of linguistic rules. The mathematical modeling is not required in fuzzy controller due to the conversion of numerical variable into linguistic variables. FLC consists of three parts

a. Fuzzification  
  b. Interference engine  
  c. Defuzzification.

The fuzzy controller is characterized as; for each input and output there are seven fuzzy sets. For simplicity a membership functions is Triangular.
a) **Fuzzification:** - Fuzzification is using continuous universe of discourse. Implication is using Mamdani's "min" operator. Defuzzification is using the "height" method. Membership function values are assigned to the linguistic variables, using seven fuzzy subsets: NB (Negative Big), NM (Negative Medium), NS (Negative Small), ZE (Zero), PS (Positive Small), PM (Positive Medium) and PB (Positive Big). The partition of fuzzy subsets and the shape of membership function adapt the shape up to appropriate system. Input error E(k) and change in error CE(k) of values which is normalized by an input scaling factor.

In this system the input scaling factor is between -1 and +1 has design. The triangular shape of the membership function of this arrangement presumes that for any particular input there is only one dominant fuzzy subset.

b. **Inference Method:**
Several composition methods such as Max-Min and Max-Dot have been proposed and Min method is used. Minimum operator and Maximum operator of output membership function is of each rule.

c. **Defuzzification:**
As a plant usually requires a non-fuzzy value of control, a defuzzification stage is needed. To compute the output of the FLC, "height" method is used and the FLC output modifies the control output. Further, the output of FLC controls the switch in the inverter. In order to control these parameters, they are sensed and compared with the reference values. To achieve this, the membership functions of Fuzzy controller are: error, change in error and output.

![Fuzzy Inference System In Simulink Software](image)

*Figure: 5.3 Fuzzy Inference System In Simulink Software*
VI. MATLAB/SIMULATION RESULTS

6.1 Simulink Diagrams:

6.1.1 Simulink Model Diagram of DVR and Super capacitor:

Figure 6.1 Proposed Simulink Model

As shown in the above figure 7.1 an DVR circuit is connected in series to the line and active power filter is connected in parallel to the line in order to reduce the current harmonics.
6.1.2 Control System For Proposed System

![Control System Diagram]

*Figure 6.2 Control system using fuzzy with PI controller*
As shown in the above figure 7.2 an PI controller as well as fuzzy logic controller is designed in order to improve the accuracy and to reduce the total harmonic distortion. The PWM Generator block generates pulses for carrier-based pulse width modulation (PWM) converters using two-level topology. The block can be used to fire the forced-commutated devices (FETs, GTOs, or IGBTs) of single-phase, two-phase, three-phase, two-level bridges or a combination of two three-phase bridges. The Fuzzy Logic Controller block implements a fuzzy inference system (FIS) in Simulink.

6.2 Simulink Results:

6.2.1 Source and Load RMS Voltages:

![Figure 6.3 Source and Load Rms Voltages during Sag Condition](image)

As shown in the above figure 7.3 yellow colour represents the load rms voltage. The reason for decreasing the load rms voltage is due to the sag occurs in the system. The above waveform is represented in per unit values.

6.2.2 Source Voltages during Sag Condition

![Figure 6.4 Source Voltage During Sag Condition](image)

The above figure 6.4 represents the three phase voltages during sag condition. This drop due to sag is recovered by dynamic voltage restorer.

6.2.3 Injected Voltages during Sag Condition

![Figure 6.5 Injected Voltage During Sag Condition](image)
The above figure 6.5 shows the voltages by dynamic voltage restorer which is injected to the line

6.2.4 Load Voltages During Sag Condition

![Figure 6.6 Load Voltages during Sag Condition](image)

The above figure 6.6 shows the final load voltages during sag condition. Although voltages dropped due to sag the dynamic voltage restorer recovered the voltage.

6.2.5 Currents and Voltages Of DC-DC Converter

![Figure 6.7 Voltages And Currents Of DC-DC Converter](image)

The above figure 6.7 represents the voltages and currents of dc-dc converter during the sag condition.

6.2.6 Active and Reactive Power Of Grid, Load And Inverter During Voltage Sag.

![Figure 6.8 Active and Reactive Power of Grid, Load during Sag Condition](image)

The above figure 6.8 represents $P_{load}$, $P_{dcin}$, $P_{grid}$, $P_{dvr}$ and $Q_{load}$, $Q_{dvr}$, $Q_{grid}$
6.2.7 Total Harmonic Distortion Using With Out Fuzzy Controller

![Figure 6.9 THD With Out Fuzzy Controller](image)

6.2.8 Total Harmonic Distortion Using With Fuzzy Controller

![Figure 6.10 THD with Fuzzy Controller](image)

VII. CONCLUSION

In this project, the concept of integrating super capacitor-based rechargeable energy storage to a power conditioner system to improve the power quality of the distribution grid along with implementing fuzzy logic controller is presented. With this integration, the DVR portion of the power conditioner will be able to independently compensate voltage sags and swells and the APF portion of the power conditioner will be able to provide active/reactive power support and renewable intermittency smoothing to the distribution grid. Super capacitor integration through a bidirectional dc–dc converter at the dc-link of the power conditioner is proposed. Similar UCAP based energy storages can be deployed in the future in a microgrid or a low-voltage distribution grid to respond to dynamic changes in the voltage profiles and power profiles on the distribution grid.

FUTURE SCOPE

1) An Multi Level Custom Power Devices Like DVR With Fuzzy Logic Controller Can Be Investigated
2) This Model Presented In This Paper Will Applicable To Power Electronic Loads Used In Modern Hi-Tech Industry.
3) This Fuzzy Logic Controller Based Model Is Implemented To Integrated Power Plants In Order To Reduce The Total Harmonic Distortion, There By Power Quality Is Increased.

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