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Comparative Study of Fault Ride Through Capability For Convention And PV Fed UPQC With Improved Power Quality Features.

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ABSTRACT

The objective of the project is to minimize the power quality problems with the implementation of power quality enhancement device PV UPFC. This device has the capacity to improve the power quality at the point of installation. Without PV UPFC the system voltage and currents are unbalanced under fault condition with THD of 6.02%. When we applied PV UPFC with PI controller the vo output voltage is balanced and still some distortions observed in current waveforms under fault conditions the THD is reduced to 2.74%. By using the proposed Hybrid controller with PV UPFC the system output voltage and currents are balanced without any distortion and the THD is reduced finally to 0.08%. Hence the analysis proves that the proposed Hybrid controller with UPFC achieved better results when compared to the existing models.

INTRODUCTION

Electric systems and grids are complex dynamic systems. These systems suffer usually from unexpected or sudden changes of the currents and voltages. These changes are due mainly to the different types of linear and non-linear loads to which they are connected. In addition, to different types of accidents which can intervener into the grid. With the increasing use of power semiconductors in the most of industrial and domestic procedures, the electric grids are polluted with different harmonic currents and voltages. These harmonics affect the normal function of the most of the grid connected devices; in addition to considerable economic losses. Many classic and modern solutions have been proposed in the literary for the harmonic problems. In this chapter, the harmonic problem as one of the most common power quality problems will be presented. The different modern and traditional solutions will then be discussed.

Power quality is a term that means different things to different people. Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE1100 defines power quality as “The concept of powering and grounding sensitive electronic equipment in a manner suitable for the equipment.” As appropriate as this description might seem, the limitation of power quality to “sensitive electronic equipment” might be subject to disagreement. Electrical equipment susceptible to power quality or more appropriately to lack of power quality would fall within a seemingly boundless domain. 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 others 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 concern.

Power quality can also be defined as 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. Power distribution systems should provide their customers with an uninterrupted flow of energy at smooth sinusoidal voltage at the contracted magnitude level and frequency. However, in power systems, especially the distribution systems have many nonlinear loads, which significantly affect the quality of power supplies. As a result of the nonlinear loads, the pure sinusoidal waveform is lost. This ends up producing many power quality problems.

Electric Fault

An electric power system, a fault or fault current is any abnormal electric current. For example, a short circuit is a fault in which current bypasses the normal load. An open-circuit fault occurs if a circuit is interrupted by some failure. In three-phase systems, a fault may involve one or more phases and ground, or may occur only between phases. In a "ground fault" or "earth fault", current flows into the earth. The prospective short circuit current of a predictable fault can be calculated for most situations. In power systems, protective devices can detect fault conditions and operate circuit breakers and other devices to limit the loss of service due to a failure.

In a poly phase system, a fault may affect all phases equally which is a "symmetrical fault". If only some phases are affected, the resulting "asymmetrical fault" becomes more complicated to analyse. The analysis of these types of faults is often simplified by using methods such as symmetrical components.The design of systems to detect and interrupt power system faults is the main objective of power-system protection.

Causes of Electrical Faults

• Weather conditions: It includes lighting strikes, heavy rains, heavy winds, salt deposition on overhead lines and conductors, snow and ice accumulation on transmission lines, etc. These environmental conditions interrupt the power supply and also damage electrical installations.
• Equipment failures: Various electrical equipments like generators, motors, transformers, reactors, switching devices, etc causes short circuit faults due to malfunctioning, ageing, insulation failure of cables and winding. These failures result in high current to flow through the devices or equipment which further damages it.
• Human errors: Electrical faults are also caused due to human errors such as selecting improper rating of equipment or devices, forgetting metallic or electrical conducting parts after servicing or maintenance, switching the circuit while it is under servicing, etc.
• Smoke of fires: Ionization of air, due to smoke particles, surrounding the overhead lines results in spark between the lines or between conductors to insulator. This flashover causes insulators to lose their insulting capacity due to high voltages.

Effects of electrical faults

• Over current flow: When fault occurs it creates a very low impedance path for the current flow. This results in a very high current being drawn from the supply, causing tripping of relays, damaging insulation and components of the equipments.
• Danger to operating personnel: Fault occurrence can also cause shocks to individuals. Severity of the shock depends on the current and voltage at fault location and even may lead to death.

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• Loss of equipment: Heavy current due to short circuit faults result in the components being burnt completely which leads to improper working of equipment or device. Sometimes heavy fire causes complete burnout of the equipments.

• Disturbs interconnected active circuits: Faults not only affect the location at which they occur but also disturbs the active interconnected circuits to the faulted line.

• Electrical fires: Short circuit causes flashovers and sparks due to the ionization of air between two conducting paths which further leads to fire as we often observe in news such as building and shopping complex fires.

Fault limiting devices

It is possible to minimize causes like human errors, but not environmental changes. Fault clearing is a crucial task in power system network. If we manage to disrupt or break the circuit when fault arises, it reduces the considerable damage to the equipments and also property.

Some of these fault limiting devices include fuses, circuit breakers, relays, etc. and are discussed below.

• Fuse: It is the primary protecting device. It is a thin wire enclosed in a casing or glass which connects two metal parts. This wire melts when excessive current flows in circuit. Type of fuse depends on the voltage at which it is to operate. Manual replacement of wire is necessary once it blowout.

• Circuit breaker: It makes the circuit at normal as well as breaks at abnormal conditions. It causes automatic tripping of the circuit when fault occurs. It can be electromechanical circuit breaker like vacuum / oil circuit breakers etc, or ultrafast electronic circuit breaker.

• Relay: It is condition based operating switch. It consists of magnetic coil and normally open and closed contacts. Fault occurrence raises the current which energizes relay coil, resulting in the contacts to operate so the circuit is interrupted from flowing of current. Protective relays are of different types like impedance relays, mho relays, etc.

• Lighting power protection devices: These include lighting arrestors and grounding devices to protect the system against lighting and surge voltages.

Application based three phase fault analysis

We can analyze three phase faults by using simple circuit as shown below. In this temporary and permanent faults are created by fault switches. If we press button once as a temporary fault, timer's arrangement trips the load and also restores the power supply back to the load. If we press ON this button for a particular time as a permanent fault, this system completely shutdowns the load by relay arrangement.

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SIMULATION RESULT ANALYSIS

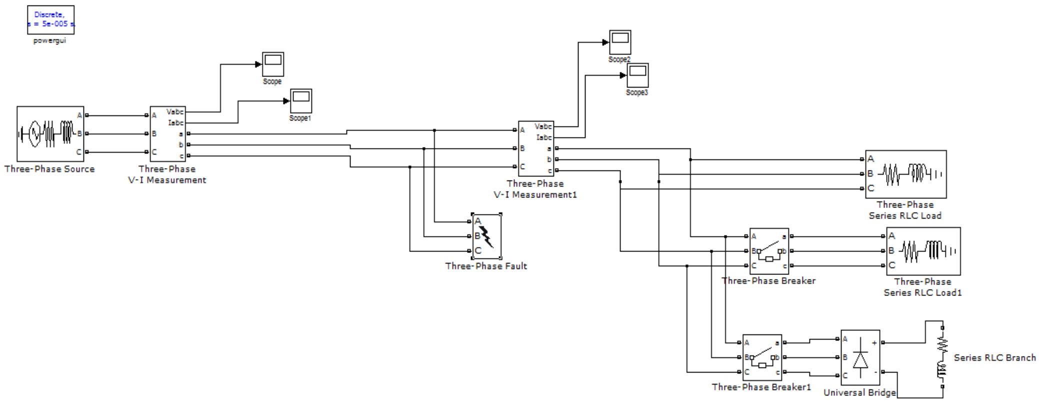

Fig 2 proposed circuit without UPFC

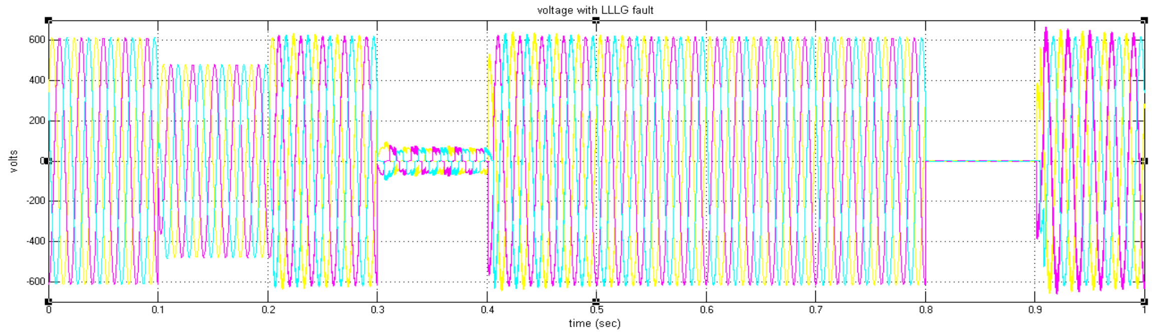

Fig 3 Output voltage without UPFC

The system without UPFC experiences a voltage disturbance when a LLLG fault occurred this effects the system power quality.

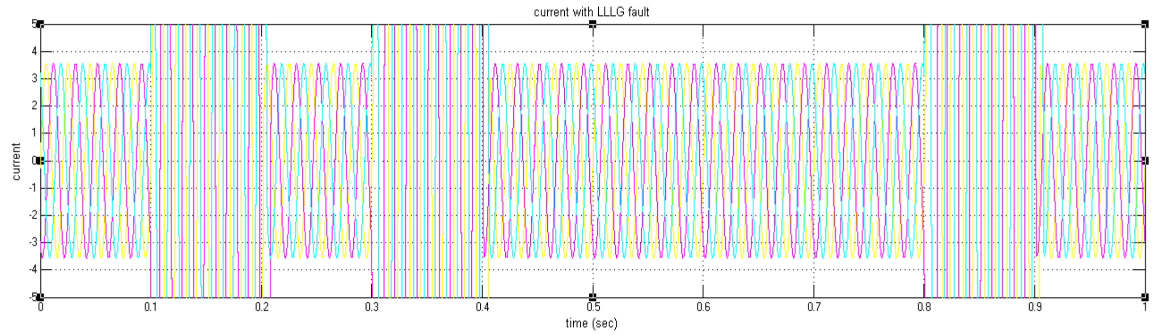

Fig 4 Output current waveform

A high current is observed under LLLG fault condition to the circuit with PI controller. This increases the system loses and effects the quality of power supply.

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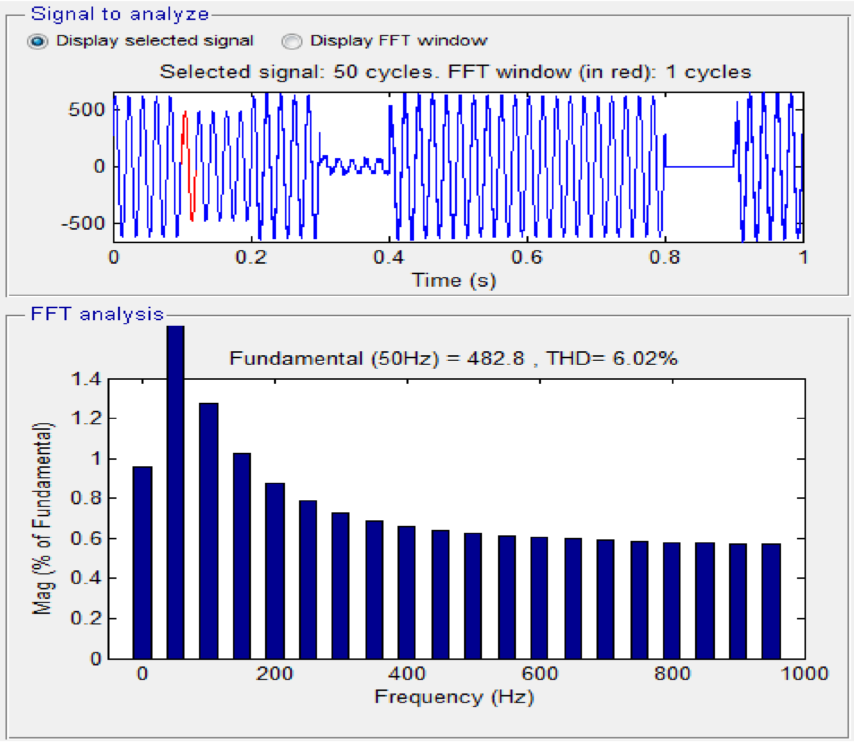

Fig 5 THD with PI controller

The above graph clearly describes the THD of the system with PI controller. It is observed a total harmonic distortion of 6.02%.

The continuous increase in the electrical energy with the clean environment needs the decentralized renewable energy production. The increasing energy consumption may overload the distribution grid as well as power station and may cause the negative impact on power availability, security and quality. The only solution to overcome this problem is integrating the utility grid with the renewable energy systems like solar, wind or hydro. The grid[1] can be connected to the renewable energy system as per the availability of renewable energy sources. Recently the solar power generation systems are getting more attention because solar energy is abundantly available, more efficient and more environment friendly as compared to the conventional power generation systems such as fossil fuel, coal or nuclear. The PV systems are still very expensive because of higher manufacturing cost of the PV panels, but the energy that drives them -the light from the sun- is free, available almost everywhere and will still be present for millions of years, even all non-renewable energy sources might be depleted. One of the major advantages of PV technology is that it has no moving parts. Therefore, the PV system is very robust, it has a long lifetime and low maintenance requirements. And, most importantly, it is one solution that offers environmentally friendly power generation.

Why Is Solar Energy

The most important issue of all is probably why solar energy is important to you, personally.

- Fossil fuels, like gas and oil, are not renewable energy. Once they are gone they can't be replenished. Someday these fuels will run out and then

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mankind will either need to come up with a new way to provide power or go back to life as it was prior to man's use of these things.

- Fossil fuels create massive pollution in the environment. This pollution affects waterways, the air you breathe, and even the meat and vegetables that you eat.
- These fuels are expensive to retrieve from the earth and they are expensive to use. Other, more Eco-friendly energy sources like wind and solar energies are relatively inexpensive and easy to produce.

The disadvantage of the PV system is that it can supply the load only in sunny days. Therefore, for improving the performance and supplying the power in all day, it is necessary to hybrid the PV system into another power generation systems or to integrate with the utility grid. The integration of the PV system with the utility grid requires the PWM voltage source converter for interfacing the utility grid and results some interface issues. A prototype current- controlled power conditioning system has been developed and tested. This prototype sources 20 kW of power from a photovoltaic array with a maximum power point tracking control. The disadvantage of this system is the need of high bandwidth current measurement transducers (dc to several times the switching frequency), and the need for relatively high precision in the reference signal generation. Hence, this increases the cost of the system. The inverters suitable for the PV system are central inverters, string inverters, Module integrated or module oriented inverters, multi string PV inverter with new trends has been described . If these solar inverters are connected with the grid, the control of these inverters can be provided using the phase locked loop . The need and benefits of the distribution technology has been presented . Single-phase Grid connected PV inverters with the control has been described with its advantages and disadvantages. The three-phase Photovoltaic power conditioning system with line connection has been proposed with the disturbance of the line voltage which is detected using a fast sensing technique. The control of the system is provided through the microcontroller. Power electronic systems can also be used for controlling the solar inverter for interfacing the Solar Power Generation system with the grid. The complete design and modeling of the grid connected PV system has been developed to supply the local loads

World is moving towards the greener sources of energy to make the planet pollution free and environment friendly. The major utilization of these sources with grid integration is the challenging task. It is therefore Distribution Generation (DGs) particularly single phase rooftop PV system are major research area for grid integration, since these sources have huge opportunity of generation near load terminal. The rooftop application involving single phase DG’s fed with PV source can be not only utilized for household use but the excess energy can be transferred to the grid through proper control scheme and adequate hardware. Control scheme based on instantaneous PQ theory has been

presented in some literatures for single phase system.
Other control scheme such as synchronous reference frame (SRF) is mainly used with three phase system in which sinusoidal varying quantities are being transferred to dc quantities that provides better and precise control than PQ based control even under distorted condition of mains. But SRF based control scheme can be customized for single phase which can't be utilized to get the desired dc quantity to generate required reference command. PV sources are interfaced with the grid through voltage source converters (VSC's). VSC's can be controlled either in PWM based voltage control method or hysteresis based current controlled method (HCC). HCC based controller gives fast response and better regulation but its major drawback lies with Variable frequency. On the other hand the PWM based control gives fixed switching frequency that could be utilized easily for proper design of LC or LCL filters. With PV sources connected at the DC side of the inverter, it is utmost essential to fetch maximum power from the source to make the system efficient. Out of different algorithm to track maximum power point (MPP) such as perturb and observe (P&O), Incremental Conductance (IC) etc., IC based method provides fast dynamics and control over fast changing insolation condition. In this paper new control scheme based on SRF theory has been proposed for single phase rooftop PV grid connected system. The VSC controller is designed in taking the advantage of both current and voltage controller which is called current driven PWM based voltage controller. Through the VSC the maximum tracked power is pumped into the grid through proper control on DC link voltage. By maintaining the DC link voltage constant during operation, is ensured the total power being generated by PV transferred across the DC bus by the inverter to the grid. Apart from active power transfer the system could be well utilized for providing limited reactive power compensation based on available capacity of the VSC. The detailed system configuration and various control schemes are briefly discussed and explained. The rooftop PV system with proposed scheme is simulated under the MATLAB simulink environment for grid connection to push real power into the grid along with limited power conditioning. The contents are dealt in the following sections: (II) System Configuration (III) PV array modeling and IC MPPT techniques, (IV) Control, (V) MATLAB Simulation, (VI) Performance evaluation.

The photovoltaic effect was experimentally demonstrated first by French physicist Edmond Becquerel. In 1839, at age 19, he built the world's first photovoltaic cell in his father's laboratory. Willoughby Smith first described the "Effect of Light on Selenium during the passage of an Electric Current" in a 20 February 1873 issue of Nature. In 1883 Charles Fritts built the first solid state photovoltaic cell by coating the semiconductor selenium with a thin layer of gold to form the junctions; the device was only around 1% efficient. In 1888 Russian physicist Aleksandr Stoletov built the first cell based on the outer photoelectric effect discovered by Heinrich Hertz in 1887.

Albert Einstein explained the underlying mechanism of light instigated carrier excitation—the photoelectric effect—in 1905, for which he received the Nobel Prize in Physics in 1921. Russell Ohl patented the modern junction semiconductor solar cell in 1946 while working on the series of advances that would lead to the transistor.

The first practical photovoltaic cell was publicly demonstrated on 25 April

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1954 at Bell Laboratories. The inventors were Daryl Chapin, Calvin Souther Fuller and Gerald Pearson.

Solar cells gained prominence when they were proposed as an addition to the 1958 Vanguard I satellite. By adding cells to the outside of the body, the mission time could be extended with no major changes to the spacecraft or its power systems. In 1959 the United States launched Explorer 6, featuring large wing-shaped solar arrays, which became a common feature in satellites. These arrays consisted of 9600 Hoffman solar cells.

Improvements were gradual over the next two decades. The only significant use was in space applications where they offered the best power-to-weight ratio. However, this success was also the reason that costs remained high, because space users were willing to pay for the best possible cells, leaving no reason to invest in lower-cost, less-efficient solutions. The price was determined largely by the semiconductor industry; their move to integrated circuits in the 1960s led to the availability of larger boules at lower relative prices. As their price fell, the price of the resulting cells did as well. These effects lowered 1971 cell costs to some $100 per watt.

In late 1969, Elliot Berman was investigating organic solar cells, when he joined a team at Exxon SPC who were looking for projects 30 years in the future. The group had concluded that electrical power would be much more expensive by 2000, and felt that this increase in price would make alternative energy sources more attractive, finding solar the most interesting. He conducted a market study and concluded that a price per watt of about $20/watt would create significant demand.

The first improvement was the realization that the standard semiconductor manufacturing process was not ideal. The team eliminated the steps of polishing the wafers and coating them with an anti-reflective layer, relying on the rough-sawn wafer surface. The team also replaced the expensive materials and hand wiring used in space applications with a printed circuit board on the back, acrylic plastic on the front, and silicone glue between the two, "potting" the cells. Solar cells could be made using cast-off material from the electronics market.

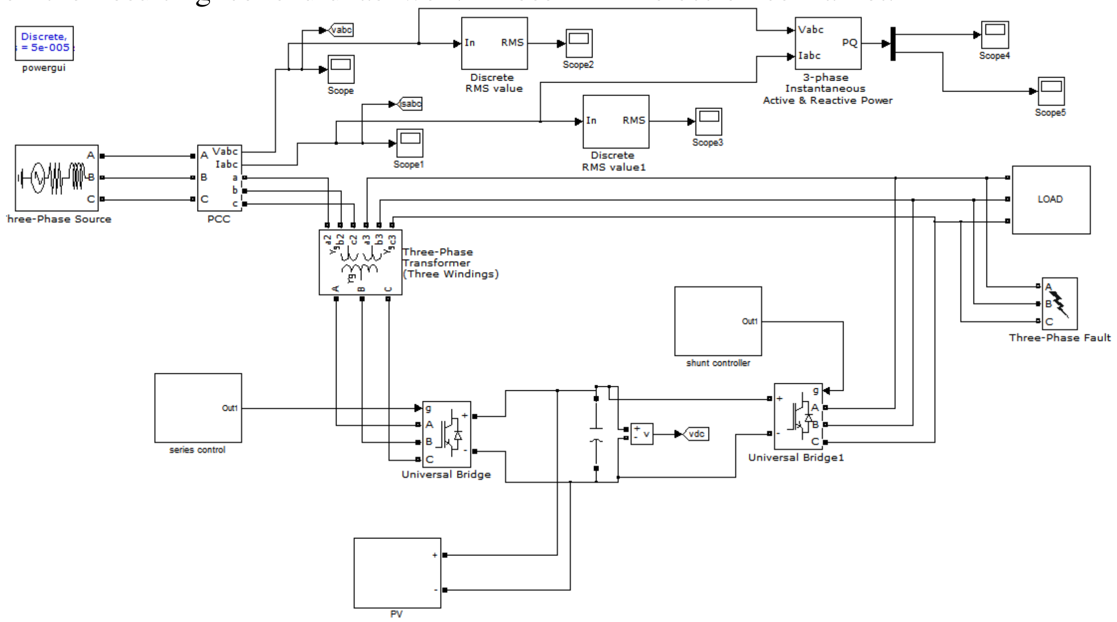

Fig 6 Simulation circuit with PV UPFC

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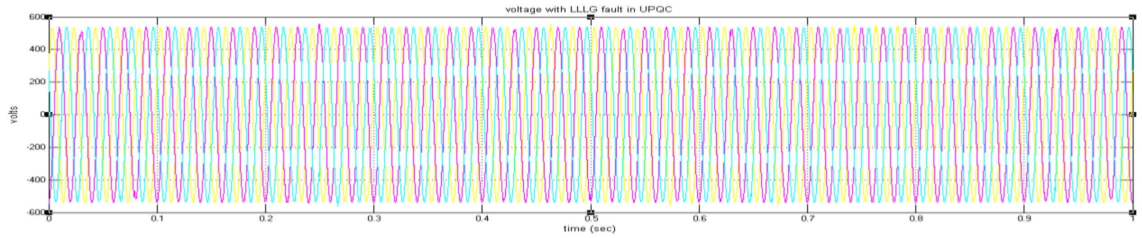

Fig 7 Output voltage waveform

The system with UPFC has generated a stabilized output voltage waveform without any distortions maintained during the LLLG fault condition.

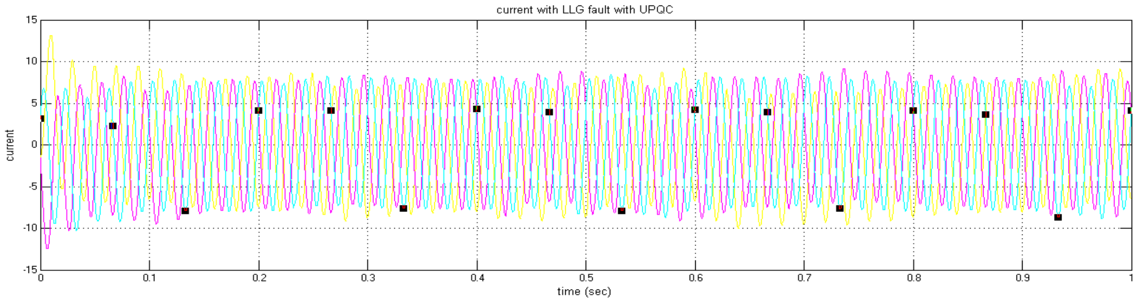

Fig 8 Output current waveform

The current waveform is still have some distortions under LLLG fault condition with UPFC Controller. This effects the system parameters.

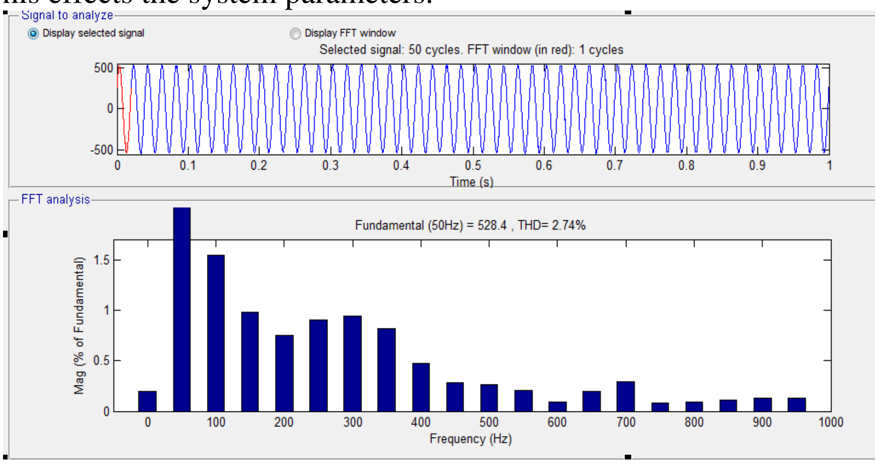

Fig 9 THD with UPFC

The THD of the system with UPFC controller has reduced the THD of 6.02% to 2.74%. this clearly shows that UPFC has achieved high efficiency when compared to the PI controller.

Conclusion

A noticeable trend in distribution systems is the emergence of distributed harmonic producing loads. These loads typically have comparable sizes and are distributed all over an electric network. There is a need to develop new techniques to assess harmonic distortions for systems with distributed harmonic sources. The objective of the project is to minimize the power quality problems with the implementation of power quality enhancement device PV UPFC. This device has the capacity to improve the power quality at the point of installation. Without PV UPFC the system voltage and currents are unbalanced under fault condition with THD of 6.02%. When we

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applied PV UPFC with PI controller the vo output voltage is balanced and still some distortions observed in current waveforms under fault conditions the THD is reduced to 2.74%. By using the proposed Hybrid controller with PV UPFC the system output voltage and currents are balanced without any distortion and the THD is reduced finally to 0.08%. Hence the analysis proves that the proposed Hybrid controller with UPFC achieved better results when compared to the existing models.

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