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DISTRIBUTED POWER FLOW CONTROL(DPFC) IN PV SYSTEM TIED TO WEAK GRID

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ABSTRACT

Photovoltaic (PV) systems proposes attractive alternative source of generation because these can be placed near to the load centers when compared with other renewable source of generation. Most of renewable energy systems works in conjunction with the existing electrical grids. Also, inverter technology has an important role to have a safe and reliable grid interconnection operation of renewable energy systems. It is also necessary to generate a high quality power to the grid with reasonable cost. They also must be capable of provide high efficiency conversion with high power factor and low harmonic distortion. For this reason, the control policy must be considered. Therefore, The most important current control techniques are investigated in this paper. This paper proposes the Comparison of Constant Current and Hysteresis Controlling Techniques for on grid PV system. Keywords: PV system design, modeling, DC-DC Boost Converter, PWM inverter, PLL constant current control, Hysteresis Controlling Techniques.

Keywords: PWM Inverter, PV system, DC-DC Boost Converter, DC-DC Boost Converter

I. INTRODUCTION

In an effort to rid the earth of pollution and make it more eco-friendly, the global community is shifting toward renewable energy sources. The difficult part is making the most of these sources via grid integration. Since these sources provide such a great potential for production at the load terminal, they have been a key focus of grid integration research, and single-phase rooftop PV systems in particular. With the right hardware and control system in place, the extra energy produced by a rooftop application using single-phase Distribution Generation systems supplied by a photovoltaic source may be sent back into the grid, where it can be used by other residents. Large voltages may be produced by photovoltaic systems. In order to prevent injuries and the destruction of costly parts and machinery, safety is crucial. A metal matrix embedded in the ground underneath the solar array or more traditional earth rods are common methods of earthing a solar array to ensure its safety. If the mounting framework of the solar array is properly earthed, then protection against direct lightning strikes is usually unnecessary. Inverters and other electrical controllers that are wired into the array, however, need to be safeguarded. Solar arrays have blocking diodes fitted in them to stop energy from being lost and to protect the solar modules from being damaged by reverse current flows. The modules have bypass diodes built into them to protect the array from malfunctioning if certain cells or modules are covered by shadows.

If you want your photovoltaic system to function properly and last as long as possible, you need to get it serviced on a regular basis. Clearing the path in front of the modules, removing debris, dead branches, etc., are all essential maintenance activities. resulting in modules being cast in shadow, Battery electrolyte level should be checked and topped up, and if it continues extremely low, the system should be re-engineered. The remaining parts of PV systems are almost maintenance-free. A steady rise in clean, renewable electricity is essential for decentralised energy generation. Power reliability, security, and quality might all take a hit if the distribution infrastructure and power plant were to become overburdened by rising energy demand.

Solar, wind, and hydro power are all viable alternatives, but only if they are integrated into the utility grid. Connecting the renewable energy system to the grid depends on the accessibility of various renewable energy sources. Recently, solar power generating systems have gained popularity since they are more efficient and better for the environment than traditional power generation systems like fossil fuel, coal, or nuclear energy. Solar energy may be converted into electricity by using photovoltaic cells. Silicon, one of the most abundant materials on Earth, is used to make the overwhelming majority of solar cells. Pure silicon, which is used to make tetrahedral crystal lattices, is a terrible conductor of electricity. The four valence electrons on the outside of a silicon atom create these lattices.

Stress is applied to the crystalline sheets' electron clouds by including trace quantities of materials with three or five outer shell electrons. This results in the electrons having increased freedom of movement. The nuclei and the crystal lattice fit together well, but there aren't enough electrons in the outer shell to make up for the deficiency of protons, therefore positive holes persist in the electron cloud. The atom has an abnormally high number of electrons, with just five occupying the outermost shell. Doping refers to the intentional use of performance-enhancing drugs. To create "N-type" silicon, silicon is doped with a five-electron element, creating an excess of free electrons (the "n" stands for "negative"). If a three-electron element is added to silicon, the material changes from P-type to N-type. The lack of electrons in the operational states of a p-type electronic component is a defining characteristic of such devices (the holes). The presence of both N-type and P-type silicon at the junction creates an electrostatic field. The flow of electrons across the junction is slowed or stopped when electrons from the N side and P side combine at the junction to form a barrier. This might be a short-term or long-term situation. When the two sides are in a state of equilibrium, an electric field will form between them.

A solar cell generates an electron and a hole when exposed to photons from the sun. A free electron will travel to the N side of the atom and a hole will move to the P side when an electric field is applied. This further disrupts electrical neutrality, and if an external current channel is provided, the electrons will travel back down the route to the P side, where they may combine with holes produced by the electric field and do meaningful work. If an internal current channel is made available, the electrons will go back to their starting point (the N side) and recombine with the holes deposited there by the electric field. Voltage is generated when an electric field, caused by the motion of electrons within the cell, is applied to a conductor. Power, which is the product of an electric current and voltage, may be generated in this way. Monocrystalline solar cells, polycrystalline solar cells, and thin film solar cells are the three main types of commercially accessible solar cells right now. Materials, efficiency, and chemical make- up of solar cells all vary depending on the kind.

While increasing system voltage by connecting solar cells in series is possible, increasing current requires connecting solar cells in parallel. A solar panel consists of solar cells that are electrically connected to one another. A solar array consists of many solar panels that have been mounted on a single frame. As an alternative to more cumbersome and bulky power sources, batteries provide convenience and portability. Energy storage batteries are like reservoirs that can be used and recharged many times over. The reservoir is charged and discharged with electrical currents, but the energy is stored chemically. Lead-acid batteries are by far the most prevalent kind of storage battery due to their widespread use in cars. Sixty percent of all batteries sold are rechargeable because of their lower prices and longer lifespans. There is a bad trade-off between the weight and amount of energy provided by lead-acid batteries, making them inappropriate for use in lightweight vehicles. Even though lead-acid batteries have many desirable properties, such as low cost, low danger, and a high possibility for recycling, scientists are always looking into new battery technologies in the hopes of enhancing the current state of the art. Many individuals now have high hopes for the nickel-metal hydride battery as the panacea for all of humanity's ills. The energy density of nickel-metal hydride batteries is about double that of standard lead-acid batteries, whereas the energy density of lead-acid batteries is around half that of nickel-metal hydride batteries. In addition, lithium ion batteries are another option with a high energy density.

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II. METHODOLOGY

PV SYSTEM

A photovoltaic (PV) system is composed of one or more solar panels combined with an inverter and other electrical and mechanical hardware that use energy from the Sun to generate electricity. PV systems can vary greatly in size from small rooftop or portable systems to massive utility-scale generation plants.

Solar Power

India is an excellent place for the establishment of a major solar energy sector because of the abundant solar radiation that is available for a bigger part of the year as a result of the country's tropical climate. In order to generate solar power for long-term use, solar photovoltaic (SPV) technology, which can generate 20 MW/km2, may be used. The use of technology is the key to achieving this goal. The second potential use of solar energy for human needs is the utilisation of solar thermal technology. Programs to use SPV via coupling to grid power systems are now being rolled out. Shanghai, China's financial hub, is reportedly preparing to roll out a solar photovoltaic (SPV) system that will be put on 100,000 roofs, as reported by the Xinhva news agency. It is estimated that 430,000,000 KWH of energy will be produced by this system, which is enough to power the whole city for two days.

Solar energy is also used in standalone applications such as street lighting, domestic illumination, and water pumps. However, despite widespread attempts, the cost of photo SPV modules in India, China, and others has not decreased to an acceptable level. These modules have a price tag of about $3.50 to $4.00 per watt. One dollar per watt is the target, which will be reached after demand has increased. Although initial efforts to use amorphous silicon-based technologies led to reduced prices, their continued use is problematic. Solar photovoltaic (SPV) technology might help those in rural areas if it were more cost-effective, since extending the grid would need a huge financial investment.

The aforementioned uses are only some of the many in which solar thermal appliances, such as water heaters, stoves, and dryers, find broad adoption throughout the country. Solar thermal applications are now being studied because of the vast potential they hold. It is estimated that 35 MW/km2 of solar thermal energy can be harvested.

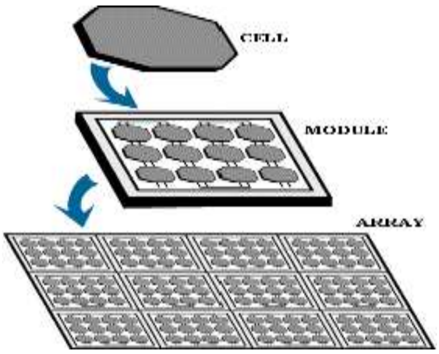

Figure 1: PV System

Fig 1 The circuit model developed for a PV cell is based on a current source and is depicted

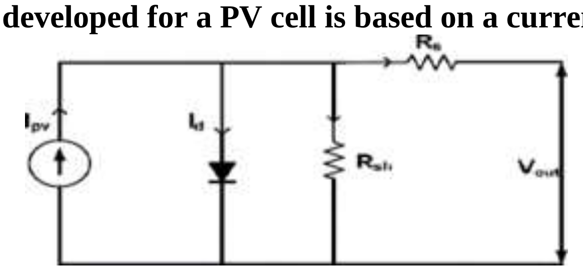

Figure 2: Equivalent Circuit Model of PV Cell

SYSTEM DESIGN

A system may either be standalone or linked to the larger power grid. As its name suggests, a stand-alone PV system relies on no other power source and provides power only to a fixed load or loads. A battery bank or other kind of energy storage might be used to keep the lights on when the sun isn't shining as brightly or when the sun isn't out. Since they do not need any other energy sources to function, standalone systems are also known as autonomous systems. However, the grid-connected PV system works in tandem with the existing electrical infrastructure. It may either be utilised to add to the grid's supply of energy or to power loads that draw power from the grid.

Alternate power sources (such as a diesel generator or wind turbine) may be integrated into the system to shoulder part of the load. The term hybrid is then used to describe such a system.

Although hybrid systems find employment in both grid-connected and off-grid contexts, they are more prevalent in the former because they reduce the storage need without increasing the loss of load likelihood if the power suppliers are set to be complimentary. The three primary kinds of systems are shown in the accompanying figures.

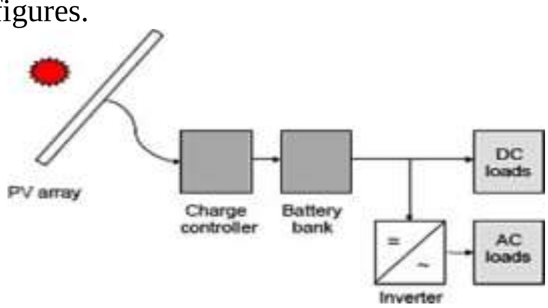

Figure 3: Schematic Diagram of a Stand-alone Photovoltaic System.

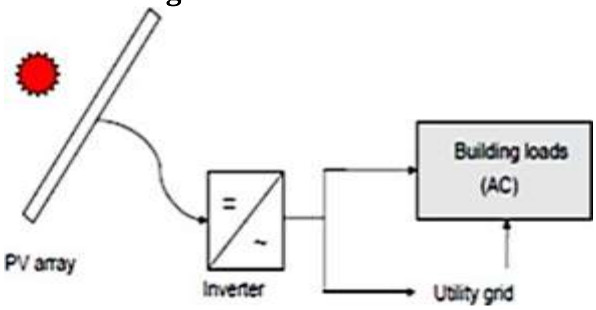

Figure 4: Schematic Diagram of a Grid Photovoltaic System

SOLAR CELL:

In common parlance, renewable energy is that which is generated by resources whose supply is regenerated by natural processes at a rate at least equal to that at which it is used. Renewable energy is a key component of sustainable power.

Significant progress has been achieved in India's generation of electrical power. Roughly 1300 MW of additional power generation capacity was installed around the time of independence, over 60 years ago. It includes electricity from a variety of sources, such as hydro, thermal, and nuclear. Money for America's power plants comes from the federal government, individual states, and private industry. There will be an 11 percent deficit in electrical supply. Experts estimate that if this deficit can be closed, it would allow for a 40% decrease in energy use with proper management. It has been shown that one watt saved at the point of use is worth more than two watts generated. An investment of Rs.40 million would get you one megawatt (MW) of new generation plant, while the same amount spent on energy efficiency might result in as much as three times as much unused producing capacity.

While the Tenth Plan included funding to connect 62,000 rural communities to the grid for electricity, many more remain unconnected. Because of the vital role that village-level organisations are anticipated to play in the rural electrification initiative, it is planned that their participation in power generation would be guaranteed. With regards to electrifying rural areas, this is of paramount importance.

Priority is being given to the renewable energy effort with a view toward commercialization. The management of this programme is under the purview of the Ministry of Alternative Energy. As a result, the private sector is boosting its investments in renewable energy sources to increase power generation. Coal, oil, and natural gas were formerly highly depended upon to provide the nation's energy demands, despite the fact that this was unsustainable in the long run due to the fuel's limited supply and harmful impact on the environment and ecology. It's no surprise that as fossil fuels become scarcer, nations are

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paying more attention to India's and other countries' rules on the usage of conventional and renewable energy sources.

Converters

The control system has only one degree of freedom in choosing when to turn on the thyristor since thyristors can only be switched on (not off) by control action and depend on the external AC system to execute the turn-off operation. This is due to the fact that thyristors need external control to activate. [11] A passive system cannot be powered by an HVDC converter because the commutating voltage in the AC system to which it is connected must be generated by synchronous machines.

Among these semiconductor devices is the insulated-gate bipolar transistor (IGBT), which may provide a second freedom of movement by separating the on/off switching of the device's control gates. Consequently, IGBTs may be included into self-commutated converters. In most DC-to- DC converters, the DC polarity is retained, and a massive capacitor is employed to smooth out the DC voltage so that it seems constant. This is why a voltage-source converter is a common name for an IGBT-based HVDC converter (or voltage-sourced converter[26]). IGBTs may be turned on and off several times each cycle with increased controllability, which improves harmonic performance. The requirement for synchronous machines in an AC system has also been eliminated because to the converter's newfound ability to self-commutate. In contrast to a low-cost converter (LCC) HVDC system, a voltage-sourced converter allows an AC network to be powered by just passive loads. When space is at a premium, as it is on offshore platforms, voltage-source converters are preferable over line-commutated converters (mostly because much less harmonic filtering is required).

Alternator with variable output voltage

The two-level converter had its first use in the Swedish Hellsjon experimental link in 1997. Since then, it has seen widespread application in VSC HVDC systems up to its retirement in 2012[7]. The two-level voltage source converter is the most basic kind of three-phase voltage source converter [29]. This converter is nothing more than a six-pulse bridge that uses IGBTs and inverse-parallel diodes instead of thyristors, DC smoothing reactors, and DC smoothing capacitors. The fact that these converters flip the positive DC potential at the AC output of each phase into a negative one gives rise to the "inverter" name that is often attached to them. When the valve in a phase that is more powerful than the other two in the phase is engaged, the AC output terminal that is coupled to the positive DC terminal will have a voltage of +1.2 Vd. In contrast, a negative output voltage of twelve volts (Ud) may be accomplished by connecting the alternating current (AC) output terminal to the direct current (DC) negative terminal when the phase's lower valve is open. This will result in a negative twelve volt (Ud) output voltage. Never turn on both valves for a single phase at the same time since this might cause the DC capacitor to discharge in an uncontrollable manner, which could result in the converter being completely destroyed.

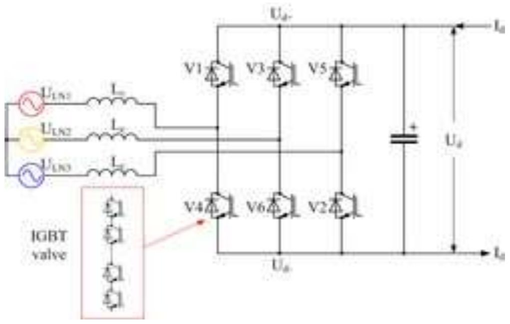

Figure 5: Three-phase, two-level voltage-source converter for HVDC

Modelling Procedure:

In order to develop a nonlinear model for power electronic circuits, Kirchhoff's circuit principles must be used. Electrical and semiconductor devices must be modelled as perfect components to prevent the need for sophisticated mathematics (zero ON voltages, zero OFF currents, zero switching times). As a result, the switch states may be determined by use of supplementary binary variables. All of the

allowable states caused by ON or OFF power semiconductor devices must be accounted for in the equations produced using Kirchhoff's principles.
here were being this same measures are necessary ing concept but instead replicate power electronics somewhere at full system.
1) you'll want to realize a attributes of a strength switch's state vector (such as that of the current but instead capacitive voltage) because then chances are you'll generate of one tried to switch state-space framework of both the cycle.
2) identify executables up to maximum jurisdictions for such semiconductor power (or to every shifting cell) to use decimal digits possible factors.
3) gain knowledge which one things influence where it nations electricity semiconductor materials or trying to switch cellular seem to be in.
4) make the assumption the first modalities for transformer (continuous and otherwise continuous conduction, and otherwise both), or perhaps the mechanisms considered necessary to elucidate only those fathomable formats sure circuit. then, utilising kirchhoff's precepts, integrates the all steps necessary through into favoured software trying to switch state-space framework.
5) reflect its decoder as both a nonlinear system set of numerical; and/ start writing that whole concept throughout integrated part document rather than reshape it so that perhaps the perfectly rational possibilities of something like the semiconducting have been part of the monitoring quaternion.
6) utilize Simulink slabs versus enact it and terms of dynamic (open circuit virtual environment was therefore crucial to test its gained model).
7) versus build be it regression rather than variational operators for said power conversion conclusion of the research swapping space-state design.
8) improve the feasibility of inverters along sealed computational modelling.
9) prior to initiating each and every framework, the strategy such as tackling a ordinary differential equation and indeed the scaling factor should have been chosen. the subsequent two stages are always to generate shuttered computer simulation [2].
10) Simulation Open-Loop Modelling of DC-DC Converters

III. RESULTS & DISCUSSION

The simulation result illustrates the notion of comparing hysteresis control with constant current control for photovoltaic systems that are integrated with grids. The wavy graphic is a Simulink model for a PV system that has been integrated with the grid and is controlled by a constant current controller. Figure 5 shows a representation of the simulink model for a photovoltaic system that has been integrated with the grid using a hysteresis controller. The simulink model of a hysteresis controller that can cut down on harmonics is shown in figure 6, which may be seen below. Simulink design for hysteresis controller design is shown here in figure 7, which may be seen below. The simulation of the suggested strategy is shown at the boost converter output in figure 8, which may be seen below. The simulation of the suggested strategy at with filter can be shown in figure 9, which can be seen below. The simulation of the proposed design may be seen in figure 10 below, which depicts the load as 2MW. The simulation of the proposed design may be seen in figure 11 below, which depicts the load as 30MW. The simulation of the suggested approach at without a filter can be seen in figure 12, which may be seen below. The results of running simulations with a hysteresis controller are shown in figure 13, which may be seen below.

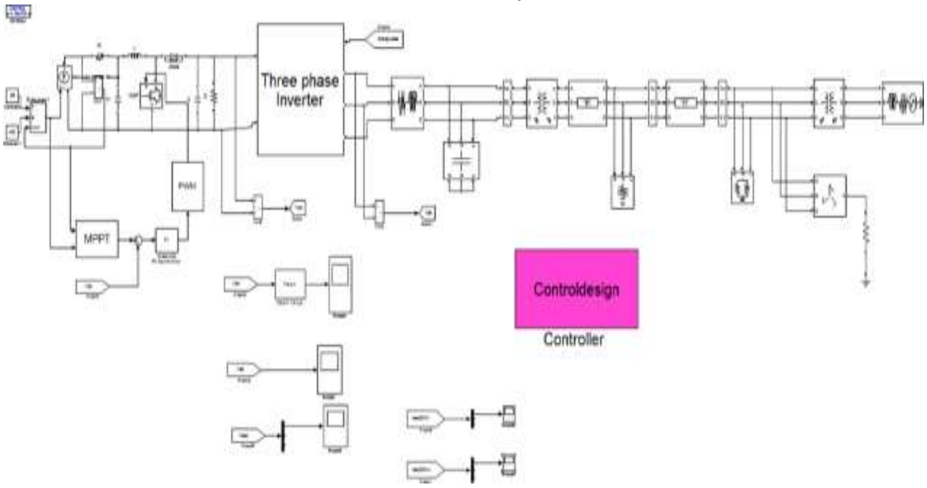

Figure 6: Model in Simulink for photovoltaic system that is integrated with the grid and uses a constant current controller

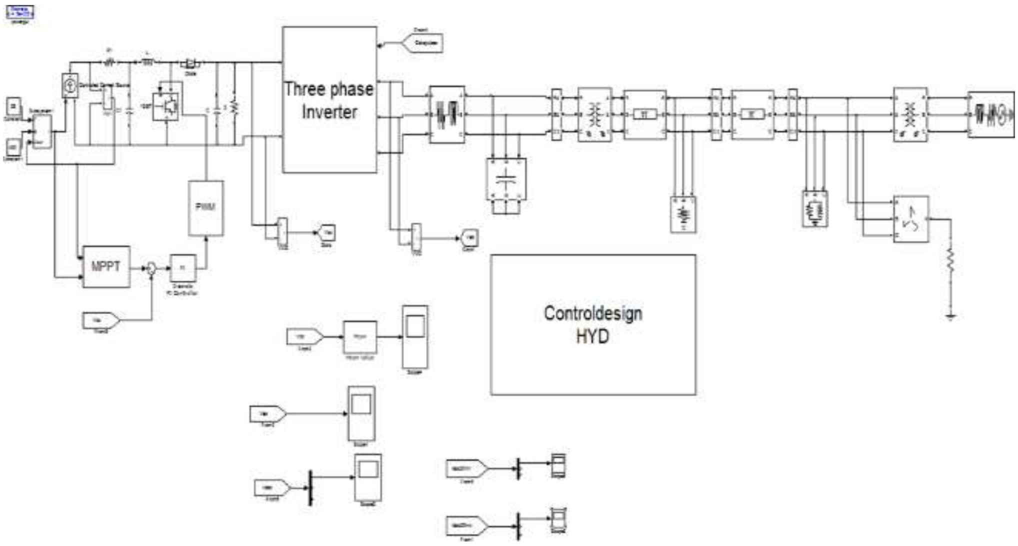

Figure 7: Hysteresis controller integrated solar photovoltaic system Simulink model

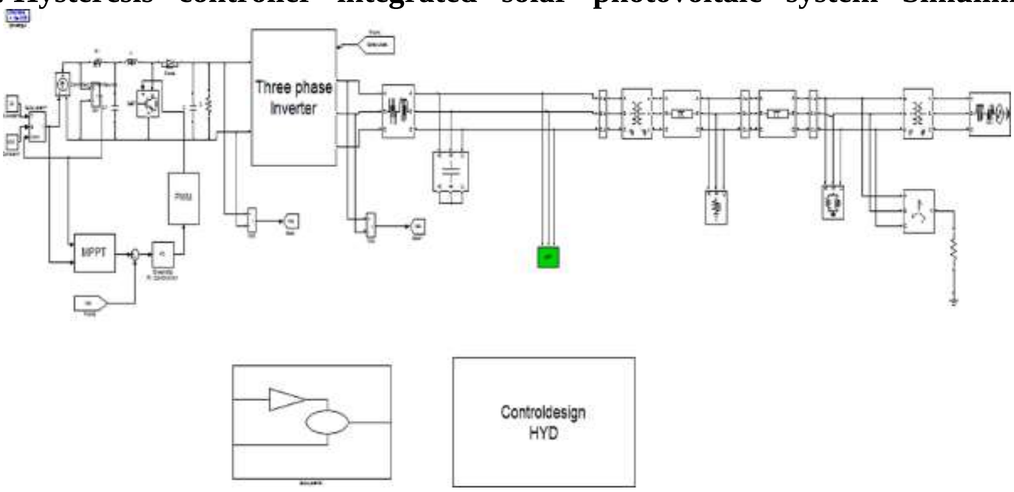

Figure 8: proposed circuit with hybrid power filter

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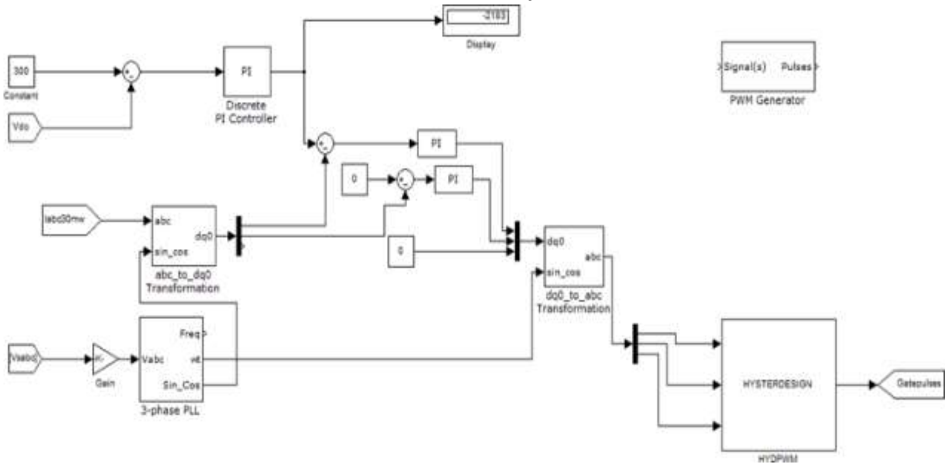

Figure 9: Simulink model of hysteresis controller to reduce the harmonics

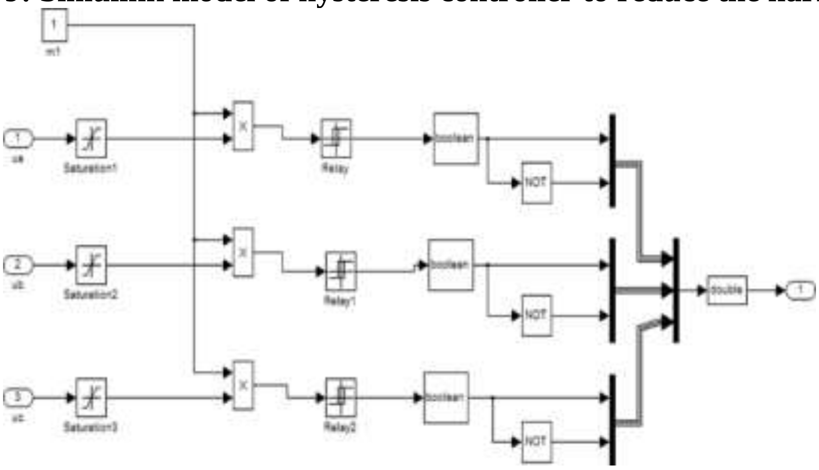

Figure 10: Simulink design for hysteresis controller design

Simulink is a software programme that may be used to model, simulate, and analyse a dynamical system. It can work with both linear and nonlinear systems, and it may use either continuous time or sampled time representations, or a hybrid of the two, to show how the systems evolve over time. The GUI in Simulink facilitates the building of models in the form of block diagrams via the use of simple point-and-click or drag-and-drop actions. Due to the hierarchical nature of models, they may be built in two separate ways from the top down or the bottom up. To get a better look at the model, we may start with a bird's-eye view of the system and then drill down into its components by double-clicking on individual blocks. This method clarifies the relationships between a model's parts and the way they interact with one another. Once a model has been created, simulation may begin by choosing an appropriate integration approach from a menu in Simulink or by entering commands into MATLAB's command window. Scopes and other display blocks let us to observe the results of the simulation even while it is still running. More than that, we can play with with the parameters and see the results in real time, enabling us to do what if studies.

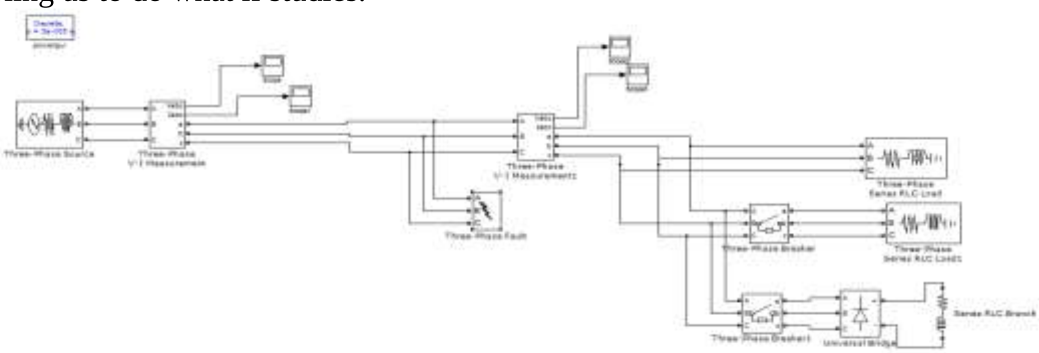

Fig 11 proposed circuit with out upqc

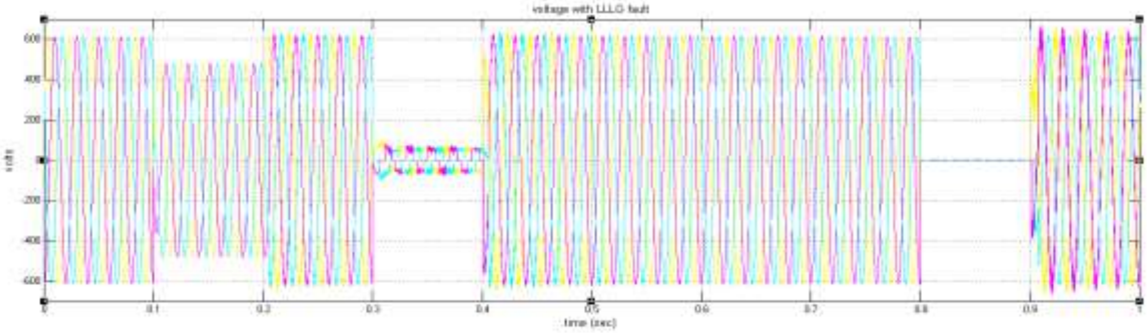

Fig 12 Output voltage without UPQC

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

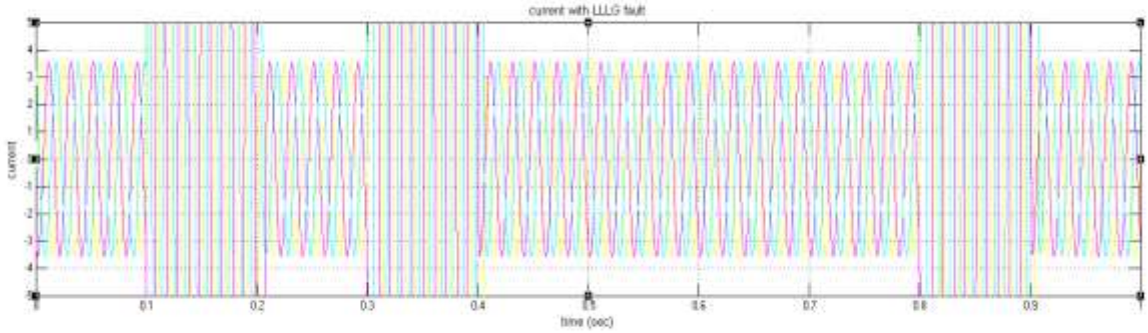

Fig 13 Output current waveform

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

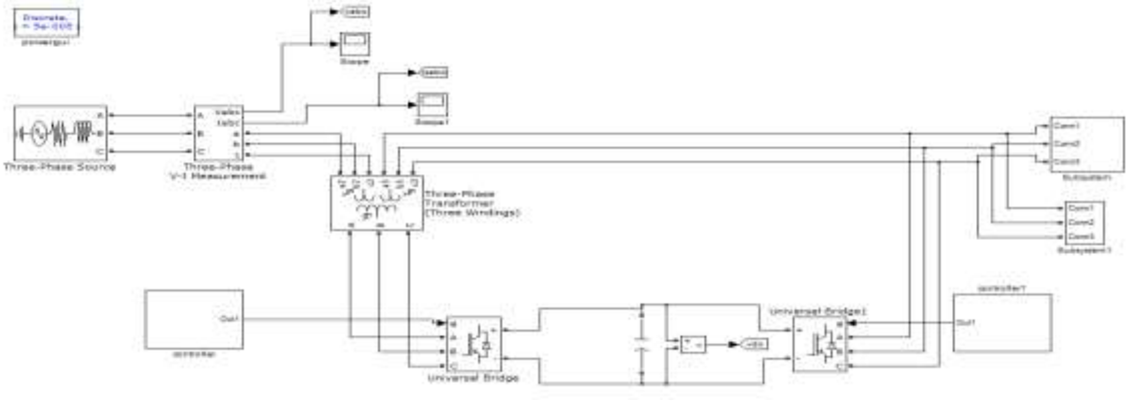

Fig 14 Simulation circuit with UPQC

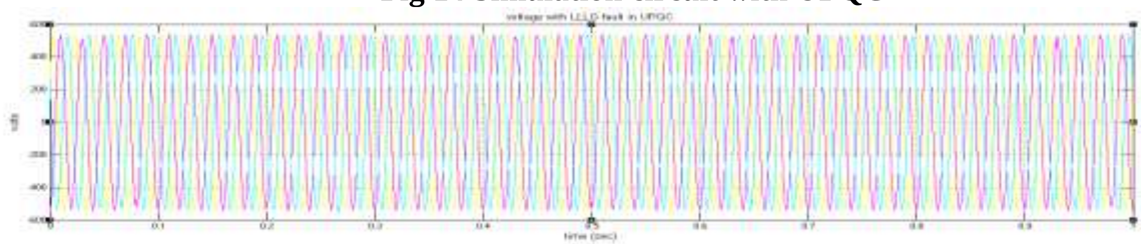

Fig 15 Output voltage waveform

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

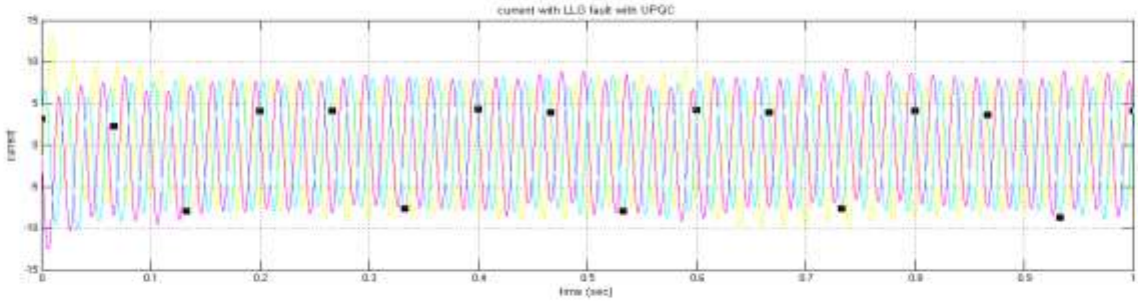

Fig 16 Output current waveform

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

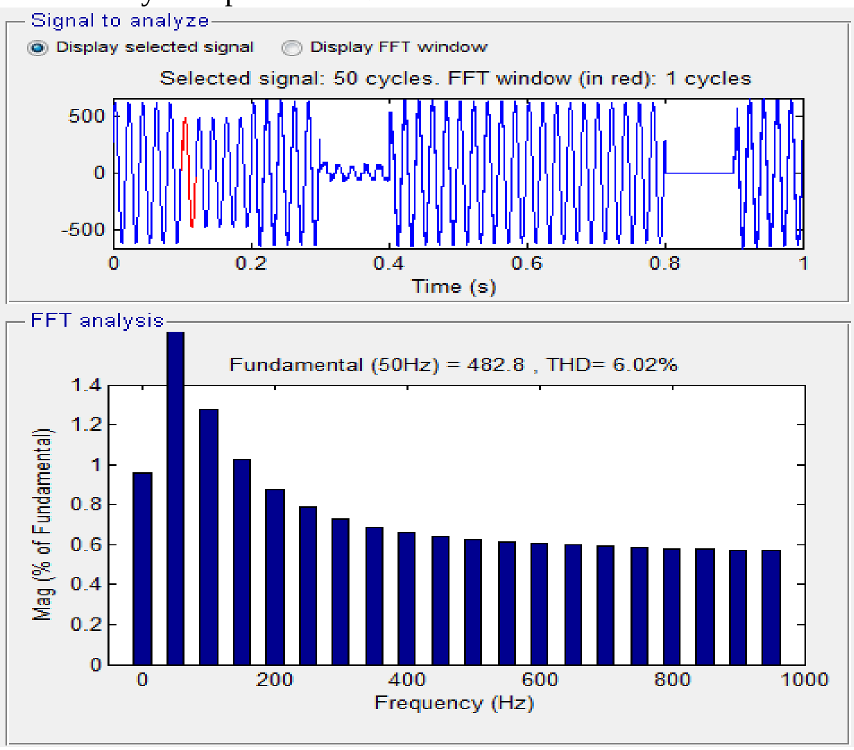

Fig 17 THD with PI controller

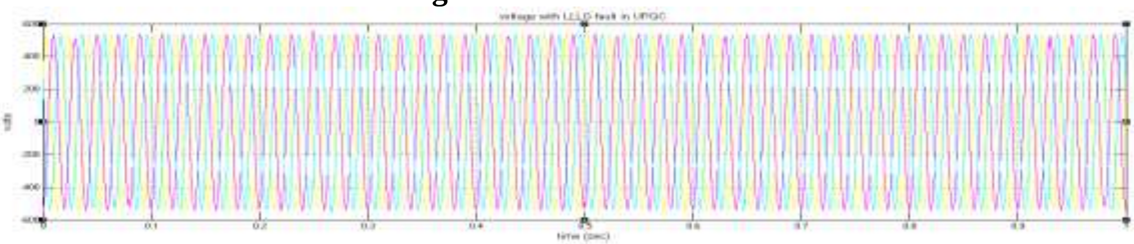

Fig 18 Output voltage waveform

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

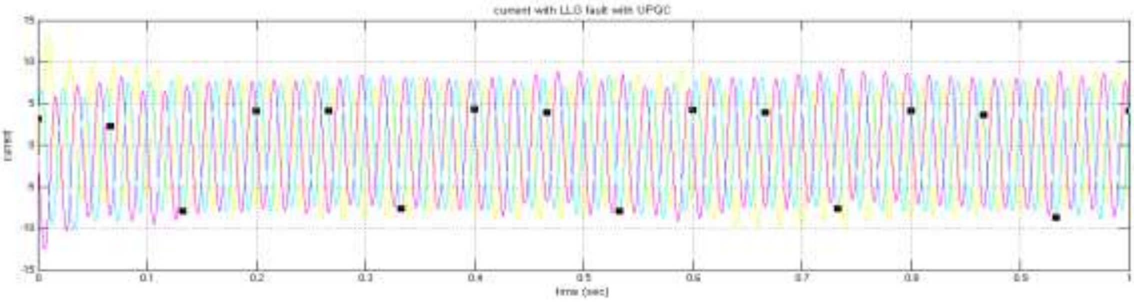

Fig 19 Output current waveform

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

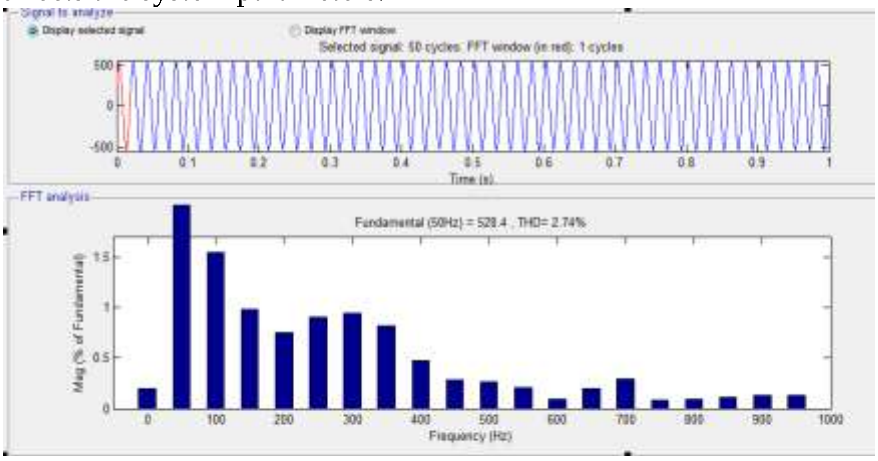

Fig 20 THD with DPFC

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

The results of the simulation may be imported into the workspace in MATLAB so that they can be post-processed and visualised. Exploring the behaviour of a broad variety of real-world dynamic systems, such as electrical circuits, shock absorbers, brake systems, and a great many more electrical, mechanical, and thermodynamic systems, may be done with the help of Simulink.

Using Simulink, one must go through a two-step procedure in order to simulate a dynamic system. To begin, we use the model editor in Simulink to develop a graphical representation of the system that is going to be simulated. The model illustrates the time-dependent mathematical connections that exist between the system's inputs, states, and outputs by representing these interactions mathematically. The next step is to mimic the operation of the system using Simulink for a predetermined amount of time. In order to carry out the simulation, Simulink will make use of the data that you have placed into the model.

IV. CONCLUSION

This investigation will compare and contrast the two primary approaches to grid-connected photovoltaic (PV) system regulation, which are known as constant current and hysteresis, respectively. In this article, we will discuss the benefits and drawbacks of connecting your photovoltaic (PV) system to the power grid using either a hysteresis controller or a constant current controller. In the absence of a filter, the results that the hysteresis controller and the constant current controller produce will be equivalent to one another. Alternately, a hysteresis controller may be used in place of a constant current controller to accomplish the same goals of high conversion efficiency, high power factor, and low harmonic distortion. Hence In conclusion, a photovoltaic (PV) system may be connected to the grid by using either a hysteresis controller or a constant current controller. However, the latter has the benefit of lowering the amount of harmonic content in the system.

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