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Transformer less Hybrid Power Filter Based on a Six-Switch Two-Leg Inverter with Sliding Mode Control Technique for Improved Harmonic Compensation

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ABSTRACT:

Random series and / or parallel resonant, tuned passive filter and the line inductance, industrial power system can lead to serious harmonic distortion. In this paper, to suppress the harmonic resonance and reduce harmonic distortion based on the technique of controlling the sliding mode provides a hybrid active filter. The active filter inverter to improve the behavior of the current mode of operation of the line at the time of the Nass Passing's introduction of a new operating mode, which is described in detail. According to the proposed hybrid filter the voltage total harmonic distortion harmonic variable conductance operated; Therefore, the harmonic distortion of the power system can be reduced to an acceptable response to load change or variation of the parameter. With regard to the sliding mode control, sliding surface, the existence of the condition and its equally analyzed. The steady-state error, the current error and it has integrated its sliding surface, reduced by the implementation. Hybrid Filter seventh tuned passive filter and an active filter in series connection, DC voltage and KVA rating of the active filter is composed of two dramatically compared to pure shunt active filter are decreased. With the active power filter is too expensive power electronics completely from the real application, this feature is very attractive. Hybrid is a reasonable compromise between performance and cost of the filter is an active filter. Performed in consideration of the design, and the experimental results are provided to verify the effectiveness of the proposed method.

INTRODUCTION

The term refers to the quality of the balance of power in the world, is the ideal sinusoidal current waveform, it is in the form of a pure voltage, to understand how pure. Commercial and industrial power and the most important power quality practices. Ideally, without any kind of distortion of the power supply should be a perfect sinusoidal waveform. Current or voltage waveforms to be distorted from its ideal form, then it are termed as harmonic distortion. This is because of the many factors that could result in harmonic distortion. In today's world, the importance given by the engineers to derive a method to reduce harmonic distortion. When the models are very simple and conservative power systems harmonic distortion is very low in the past. But, the industry these days is the use of complex models aswell increased harmonic distortion.

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Harmonics' this project and steps to mitigate the effects of the power system, explains the scientist. This project is also one of the most important issues associated with power quality and power system harmonic distortion to create many disturbances explains. It has the power to improve the quality of harmonic reduction techniques, and it is also the same simulation.

CAUSE OF POWER QUALITY DETERIORATION

2.1 Introduction

As always, the main goal of the system power is the generation of electrical energy to the end user. The term is associated with power generation and power quality as well as the system. It was a lot of importance has been given to the quality of electric power engineering is considered as a separate region. There are many reasons for the importance of power quality. One of the main reason, customers as well as interruptions of power quality, switching transients sagging and is informed. Also, many power systems internally connected into a network. This is connected to the internal network, it is a failure of the entire energy system, resulting into negative consequences if there was no one. In addition to all this, with microprocessor-based controls, protective equipment, protective devices and power quality than the last generation to become more sensitive to diversity.

Some of the most common disturbances that may affect the power system.

1. Transients
2. Sagging
3. Variations in voltage
4. Harmonics

2.2 Transients:

In terms of the power system, power system transients and the nature of an act or not desirable variations can be defined as the condition of the power system. It is possible to have a common understanding of transient RLC network is considered to be an oscillatory transient. A person who is new to the transient power system to define the term "surge" is used. A surge protection is done using a surge arrester, which is derived from the aesthetic shock, analyzed as temporary. More groomed man in the field of electrical engineering, it is definitely the word "surge" indicates, unless it is specified as to what the term "surge" would avoid use. That is the short-term and sudden transient oscillatory transient divided into two groups. [1] [3]

2.2.1 Transient oscillatory:

To change the polarity of the voltage or whose values are part of the transient oscillatory current. Suddenly a steady state voltage and power frequency, or the positive and negative polarity values will not change, but when the power of the frequency change, such change in the current case, when the efficacy of the transient oscillatory. [2] [3]

2.2.2 Impulsive Transient:

Impulsive transients are mostly caused due to lightning. That is unidirectional in polarity voltages and currents in a steady state condition, but the power frequency oscillatory transient is a sudden change, but such a situation impulsive transient. Impulsive transients also an exciting natural frequency of the power system have the ability to generate the oscillatory transients. [2] [3]

2.3 Voltage Variations:

There are two types of the variations in voltages.

- Short duration voltage variations
- Long duration voltage variations.

2.3.1 Short duration voltage variations:

Short duration voltage variations are usually caused by defects in the electrical system. Short duration voltage variations, power sags caused by faults in the system and are characterized by the occurrence of the conditions of the system. It's really the voltage drops, voltage increase and in some circumstances may also lead to the disruption caused by the energy system, under what condition will depend on what kind of

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wrong. When such errors occur, the protection devices used to clear the fault. However, the short duration of the effect of voltage variation of this is the wrong conditions. [3]

Interruptions:

When the voltage or current supply interruptions and breakdowns occur. Interruptions occur due to various reasons, equipment, etc., some of them being the power system faults, failures [3]

Sagging:

2.3.2 Long Duration Voltage Variations:

Voltages, over voltages, voltage variations, as well as in the long term can have. Under-voltage and over-voltage conditions, variations in the electrical system, and the system are not due to faults must emerge. RMS voltage of the power system for the long-term steady state voltage variations, refers to the situation. Voltage variations, more than long-time voltage and under voltage disturbances, which are divided into three different categories. [1] [3]

2.4 Harmonics:

Harmonics' is one of the major concerns of the energy system. Harmonics' result of the deterioration of the power system current and voltage waveforms cause distortion. The first step for harmonic analysis is the balance from non-linear loads. The results of such analysis difficult. For many years, a lot of importance is given to methods of analysis and balance control. Harmonics electricity system is currently non-integer multiples of the fundamental frequency of the wave and a periodic. Balance weights from two different types of energy produced by the system.

The first category is described by the linear loads in the load. The stability of linear time-sinusoidal voltage to the load current to a sinusoidal current results described in such application. Sinusoidal voltage is applied to a fixed-block will be displayed from the time of loading. Also present will result into an increase in the voltage and current as the voltage increases, are directly proportional to each other. An example of such a load is incandescent lighting. Rotating air gap flux wave machine, even if sinusoidal pretty much under normal loading conditions, transformers, and rotating machines that do not meet this definition. Also, a transformer current DC Including the odd and hold the balance.

2.4.1 Active Harmonic Filter:

As previously described, active harmonic filters required reactive power is used for the low-low voltages. The way this works filter through the filter of each half cycle of the voltage waveform, the weight of the product can be obtained by increasing the voltage. Therefore the rectifiers to favor the construction of the power supply voltage to the current. Duty cycle and therefore improves the power factor. Depending on the active harmonic filter, the output distortion is reduced. Also, due to the weight of the load current, which generates the linear part of the current harmonic filter to the exact shape of the watch and creates a single waveform? [3] [5]

2.4.2 Passive Harmonic Filter:

As shown before, passive harmonic filters are such that they can be used for different voltage levels. In the case of passive harmonic filters, the balance can be reduced by using the filters in series or parallel resonance. The way this works is loaded passive harmonic filters in parallel and connected in series with the filter inductance and current capacitance is accepted. Inductance and capacitance in parallel and in series with the load current accepted that there is a parallel filter.

FILTERS USED IN POWER SYSTEM

3.1 Introduction:

The presence of harmonics is the most since 1990 and has led to a decrease in quality of energy. Moreover, the non-residential areas where loads and loads of transmission and distribution systems, electrical systems, including the use of electronic loads has been an increase in the use of tools and equipment. Also,

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some non-sinusoid ally, drawing the short-term loads, and electronics equipment, instead of the current pulses are drawn in such a way that there are now creating balance. But some examples of burdens rectifiers, inverters, etc. Examples of electronic devices, computers, scanners, printers, etc. can be certain that

3.2 The roles of the filters in the power system:

There are two types of filters

- Passive filters
- Active Filters

Active and passive filters are often used for the reduction of the balance of the capacitors.

By providing a low impedance path to the passive filters, harmonic energy into the system and the current limit is used to protect the power system. Passive filters, resistors, inductors and capacitors are.
Most Active filters, using the energy of the voltage sagging filter the result into a good quality of current and voltage, etc., where the balance of the flickering, distribution networks are used.

3.3 Passive filters:

As previously described, passive filters, resistors, inductors and capacitors can have. They are not expensive and are often, but the effect of reducing the burdens on the balance of power in the system can be used to restrict the entry of the harmonic currents. Also, passive filters, harmonic generation, whereby the non burdens are placed close to the source. In doing so, provides good results in reducing the impact of passive harmonic filters. Figure 1 linear load and shunt passive filter shows a representation of the distribution system in a single step.

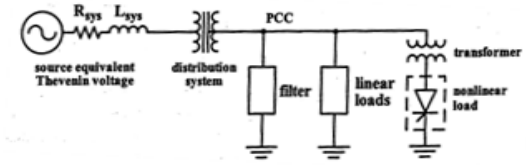

Figure 1 : Single Phase Representation of Non Linear load and Passive Shunt filter [3]

One of the most important aspect of the electrical system, installing passive filter, the filter is supposed to be installed, depending on the balance of the order. For example, to install a filter 3rd order harmonics, it is necessary to install the filter order harmonics 1.

3.3.1 Types of passive filters:

There are two types of passive filters:

- shunt passive filters and
- Series passive filters

These filters can be used for single-phase and three-phase electrical system. One important thing to note is that more than one shunt and series passive filters and a system that can be used without each other, that is.
Figure 2 and 3 shows the single phase passive filter with shunt and series configuration respectively.

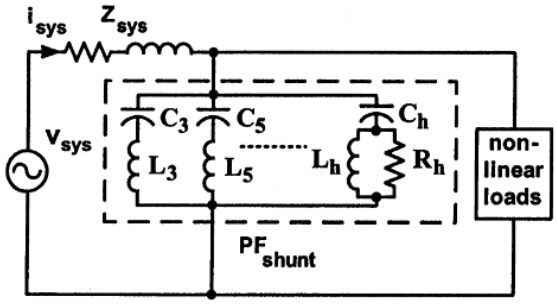

Figure 2 :Single Phase Passive filter with Shunt Configuration [3]

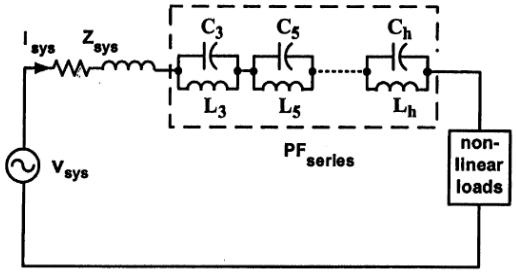

Figure 3 :Single Phase Passive Filter with Series Configuration [3]

Figure 4 and Figure 5 shows three phase three wire passive filter for shunt and series configuration respectively.

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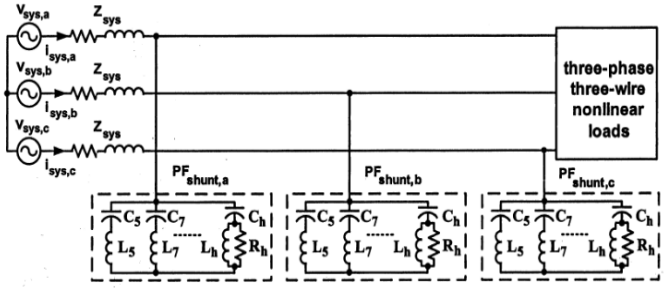

Figure 4 :Three Phase, Three Wire Passive Filter for Shunt Configuration. [3]

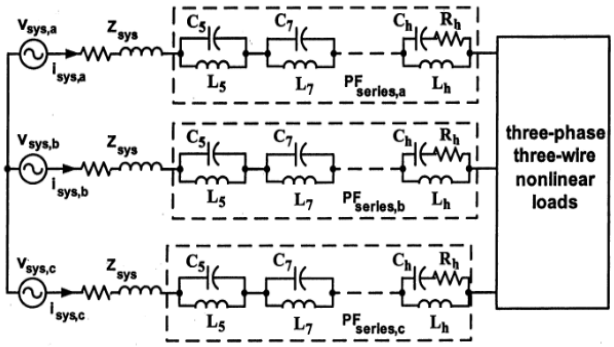

Figure 5: Three Phase, Three Wire Passive Filter for Series configuration. [3]

Is usually connected in a system with more than 3 filters to reduce the balance. The first two are used to filter high-pass filters, which are less effective, and then connect to minimize the impact of the balance.
Figure 6 and 7 shows shunt and series connected passive filters respectively.

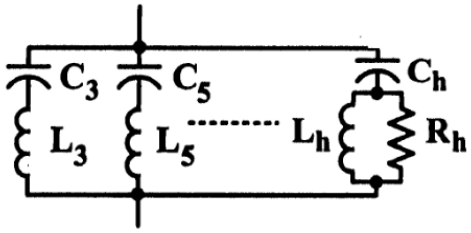

Figure 6: Shunt Passive Filter Block. [3]

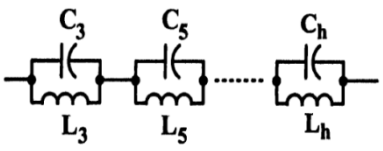

Figure 7: Series Passive Filter Block. [3]

3.4 Active Filters :

Active filters are a perfect alternative to passive filters. Active harmonic filters and phase angles in terms of quantity orders can be used to change the name of a situation. Dynamic compensation in such situations it is feasible to provide the use of active elements instead of the passive ones.

Active filters are based on the balance of the time is used for the linear load conditions. Just as passive filters, active filters, either in series or in parallel, depending on the type of energy sources can be connected to create a balance in the system.

The benefits of active filter over passive filter:

- One of the main advantage of using the passive filter, the filter is active on more than one is used to reduce the effects of the balance of the order.
- Active filters also are useful in the electrical system, the flickering caused problems.
- One disadvantage is that the active filter is a passive filter

Disadvantages of active filter over passive filter:

- Active filters cost more than passive filters
- Active Filters power system can not be used for small loads
- current and voltage harmonics in both the active filter will not be able to solve the problem in certain applications.

Figure 8 and 9 shows single phase active filters in shunt and series configuration respectively.

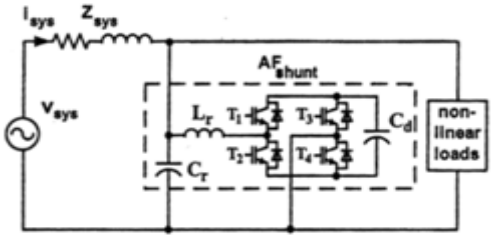

Figure 8 : Single Phase Active Filter, Shunt Configuration. [3]

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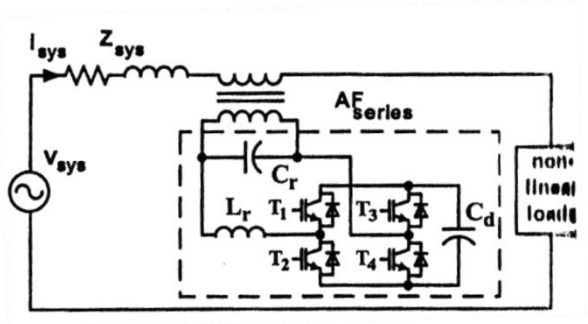

Figure 9 Single Phase Active Filter, Series Configuration. [3]

HARMONIC REDUCTION IN INVERTERS

4.1 DC-AC Inverter:

AC to DC inverters convert the direct current into an alternating current is used to produce devices that are inverted. AC and then, depending on either AC or DC input, which means that if one circuit output, devices called inverters, AC-AC and AC cycloconverters or DC-. The size of the AC output inverters, AC to DC and have either fixed or variable frequency tools like it. In the case of AC to DC to AC voltage single phase or three phase inverters can be output. Also, AC voltage, either the size of the frequencies of 50Hz, 60Hz or 400Hz from the range of 110-380 VAC.

Some of the basic applications of inverters and UPS (uninterruptible power supply) is. UPS AC power supply when the main power is used to carry out the batteries and inverter. A rectifier is used to recharge the batteries used when the main power back on. Other applications include variable frequency drives an inverter. AC variable frequency drives to control the speed of the motor, controls the frequency and voltage of the power supplied to the motor. An inverter to provide power to the controller is used with variable frequency drive. An inverter to control the speed by changing the frequency of the AC output is used as an induction motor. [6] [7]

4.1.1 The block diagram of the DC-AC option:

As described in earlier chapters, will present the balance of the system. Similarly, there is a system where the balance can be used as well as inverters. Ideally, the main objective of using an inverter, DC There is an AC output from the source. Theoretically, the product is expected to be sinusoidal voltage waveform, but in practice, there is sure to be distorted as a result of the system into the output waveforms of the current balance is going to be distortions.

Figure 10 to provide distortion free output of the AC signal is used to reduce the effect of the balance filters, DC-AC inverter, and shows a circuit showing. The front part of the circuit is the AC to DC converters. An AC to DC converters, AC line frequency of the switching frequency is, and it relies on the line of communication. The film is also used to reduce the balance of the system to produce clean sinusoidal AC voltage output shows a filter circuit.

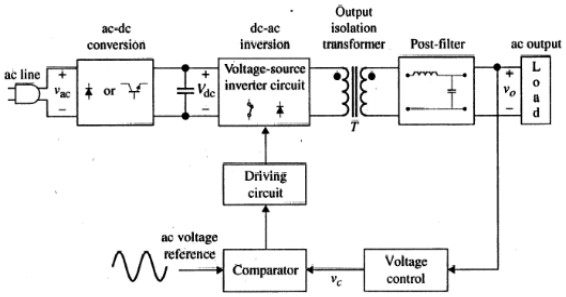

Figure 10: Power Electronic Circuit with DC-AC inverter. [6]

4.2 Types of Inverters:

There are three types of inverters

- Single Phase Inverters
- Three Phase Inverters
- Multilevel Inverters

4.2.1 Single Phase Inverters :

Inverter circuits may also be used in many different topologies. Is intended to be designed differently depending on the inverter to inverter circuits. Figure 11 shows a single phase inverter. Way switches and connected load, it is also known as an H bridge inverter. H-bridge load in both directions, which is used to apply voltage to a circuit known. The single phase inverter

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Four IGBT devices (also known as power control devices) connected in series with each other two IGBTs, where each will have. Each power control devices, diodes are connected in parallel with each other, but in the opposite direction. IGBT and diodes between the two devices connected to the network, there are loads. Two IGBT devices are turned off, if the load current flows through the diodes provide a path for a way to connect the diodes. Eg. IGBT2 If enabled, the negative side of the bus and the current through the diode will be connected in parallel. Now this IGBT2 is turned off and connected in parallel in the opposite direction of the current through the diode, which is to reach IGBT1 travel.

Single phase inverters, IGBT circuits right to the left and right of the modulation circuits IGBT IGBTIGBT circuits in the upper left is the IGBT inversion circuits is that, while the lower IGBT is a large duty cycle. A sainusoyidal often referred to as an inverter output by the following formula: [7]

$$V_{ac1}\ (t) = m_a \ . \ V_{dc} \ . \sin(w_1 .t)$$

m_a = modulation factor, where $0 \leq m_a \leq 1$

Vdc = input voltage

Vac1 = output voltage

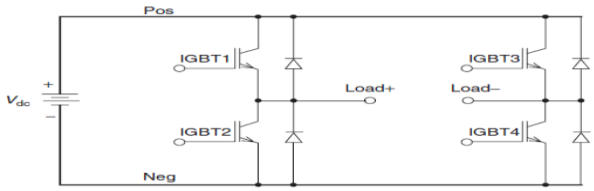

Figure 11:Single Phase Inverter. [7]

4.2.2 Three Phase Inverters :

Similar to the Single Phase inverters, three phase inverters are also used in various topologies. Figure 12 shows a three-phase inverter circuit. Three single phase inverters, each of which is connected to one of the three terminals have a load, such as extension of that the H bridge circuit. In the case of single phase inverter, while there was a case of a three-phase inverter is the phase shift of 120 degrees, 180 degrees, a phase change between the different legs. Three-phase inverter inverter three legs 120 degrees from the phase change can help in removing the odd balance. Also, the output will be removed aswell pure AC waveform, then the balance. In order to modulate the output of a three-phase inverter, the output voltage is decreased by a factor related to the amplitude of the input voltage. This item is given by the equation: [7]

$$\frac{3}{2\pi} \ . \sqrt{3} \ = \ 82.7\ \%$$

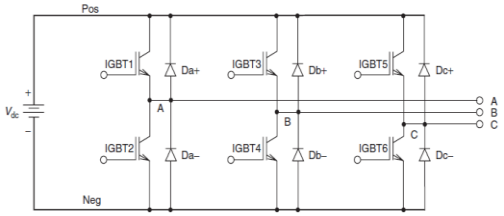

Figure 12:Three Phase Inverter. [7]

4.2.3 Multi Level Inverters :

Prior to the construction of multi-level inverters, which are a type of single-phase inverters and inverters is similar. Figure 13 Single and three-phase inverters and a multi-level inverter, which is an extension of the show. Here are three different legs of the circuits connected to the four IGBT and diodes connected in parallel in the opposite direction of each foot. Also, as shown in the picture loads are connected between each leg of the IGBT CIRCUITS.

Single and three phase inverters, multi-level inverters, instead of using the advantages are as follows: [7]

- Multi-level inverters can be used for high voltage levels
- As well, because of the multi-multi-level inverters, DC Are capable of reducing the high levels of balance.

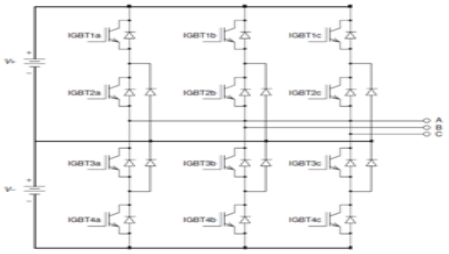

Figure 13:Multi Level Inverter. [7]

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4.3 Methods for Harmonic Reduction in Inverters:

As previously described, is one of the most important aspect of the system, the balance in the system have become. In the case of an inverter, it is, AC output from the balance is very important to remove.

C-DC inverter, a DC can be present in the balance The balance of the current compared to an AC converter can be seen very clearly. This is because the AC inverter, AC to DC's output. Therefore, AC inverter, DC to DC converters used in the filters of different designs compared to C filters is used. In the case of C-DC converters, the main goal is to improve the output voltage ripple. Therefore, passive filters easily, DC An AC converter can be used to improve the output.

4.3.1 Pulse Width Modulation Technique:

Figure 14 is used to remove the balance from the output waveform of a high frequency filter shows a block diagram of a single phase inverter. Here, however, the input DC voltage Vin, vo AC output.

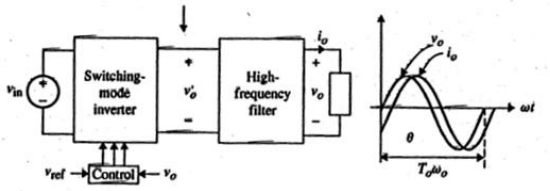

Figure 14 : Single Phase Inverter with Filter [6]

Figure 15 shows output waveforms that gets produced based on the Pulse width modulation technique when it is employed.

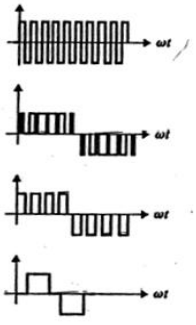

Figure 15: Output waveforms Produced Based on PWM Technique [6]

Single phase inverter, the output pulse width of the output voltage is used to control a variety of. Therefore, to control the output voltage of the inverter to reduce the balance of this process is known as pulse width modulation. Pulse width modulation is divided into two methods. [6]

- Non sinusoidal pulse width modulation
- sinusoidal pulse width modulation

4.3.2 Non-sinusoidal pulse width modulation:

In the case of non-sinusoidal pulse width modulation, the pulse width of the pulses is modulated together. Pulse widths of pulses in order to remove from the system, the balance can be adjusted with the same ratio. A typical representation of the non-sinusoidal pulse width modulation 16 is shown in the figure shown below. [6]

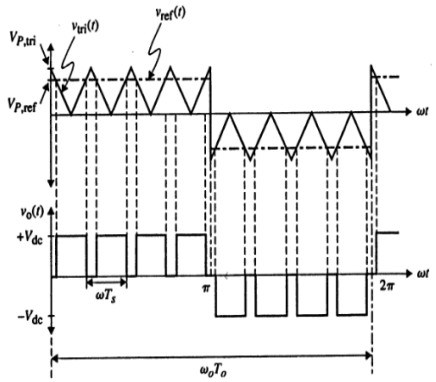

Figure 16 :Representation of Non Sinusoidal Pulse Width Modulation [6]

4.3.3 Sinusoidal Pulse Width Modulation

Sinusoidal pulse width modulation is a bit different compared to the sinusoidal pulse width modulation. In the case of sinusoidal pulse width modulation, the pulses are modulated individually. They are then compared to a reference sinusoidal pulse of each pulse of the reference sinusoidal wave is a wave which is equal to the product are modulated accordingly. Therefore, sinusoidal pulse width modulation, pulse-width controlled sinusoidally. [6]

Figure 17 shows a representation of Sinusoidal Pulse Width Modulation.

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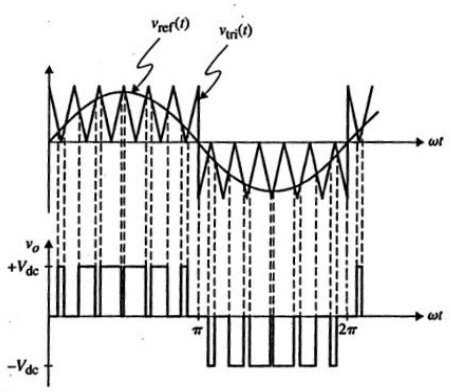
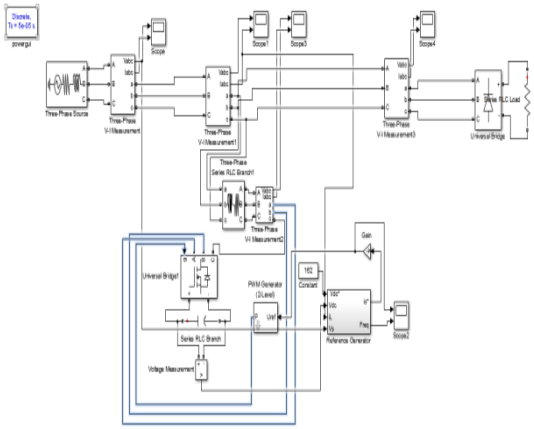


Figure 17 : Representation of Sinusoidal Pulse Width Modulation [6]

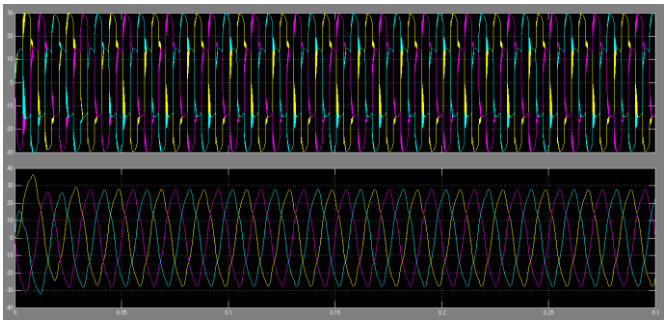
Note:
For figures 16 and 17,

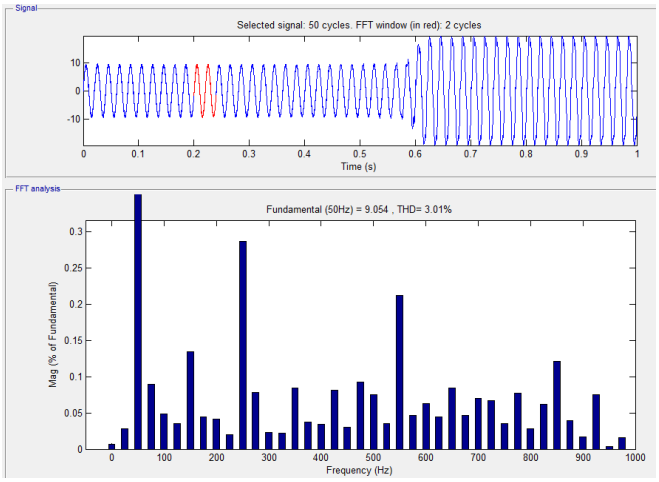
- ts = Time of the triangular waveform
- fs = frequency of the triangular waveform
- Vref = Reference voltage of the square or sinusoidal waveform
- Vp,ref = Peak value of the reference voltage
- to = Time of the output waveform of the Inverter which is desired
- fo = Frequency of the output waveform of the Inverter which is desired
- ma = Amplitude modulation index of Inverter
- mf = Frequency modulation index of Inverter
- k = Number of pulses per half cycle

SIMULATION AND CALCULATIONS

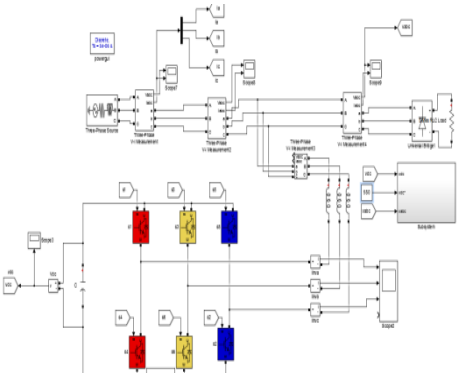


Base Paper Simulation Circuit

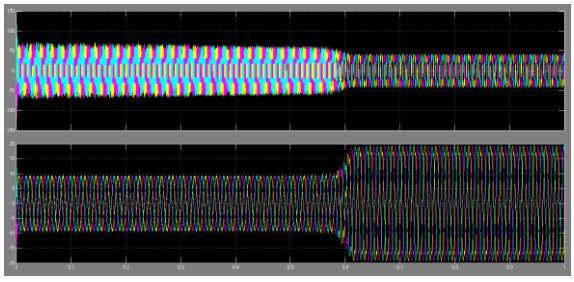




Base Paper Results



Extension Simulation Circuit



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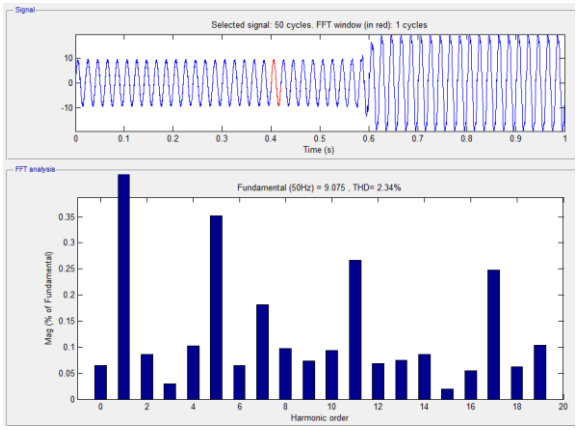

Extension Results

CONCLUSION

Sliding mode control technique based Hybrid Power Filter Proposed in this paper. The performance proposed topology is better than the conventional configuration. It is found that Total Harmonic Distortion in the source currents is less with the proposed control technique and it is meeting

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