



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 6, June 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118



9940 572 462



6381 907 438



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Voltage Regulation of Critical Load by Using Advance Power Electronic Converter

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ABSTRACT: The main aim of this project is to explain the effects of Total harmonic distortion in the Power System and steps to reduce the effects of Harmonics. This project will also explain how Harmonic distortion is one of the most important problems associated with power quality and creates several disturbances to the Power System. It includes the Harmonic reduction techniques to improve the power quality and it also includes the simulation for the same. In this project, a 7-level Multilevel Inverter (MLI) with a resonant switched capacitor Converter based on sinusoidal PWM, is implemented to analyze the performance of load side under voltage variations at PCC. By the proposed MLI based voltage regulation of critical load as well as harmonics reduction due to voltage sag and swell conditions. Remarkable features of the proposed topology are maintaining voltage balance in input capacitors and reduction of power components. Simulations have been done in MATLAB Simulink on distribution system. Tested results are analyzed with THD% in critical load voltage.

KEYWORDS: Critical load, multilevel inverter, resonant switching capacitor converter

I. INTRODUCTION

The term harmonics referred to Power quality in ideal world would mean how pure the voltage is. How pure the current waveform is in its sinusoidal form. Power quality is very important to commercial and industrial power system designs. Ideally, the electrical supply should be a perfect sinusoidal waveform without any kind of distortion. If the current or voltage waveforms are distorted from its ideal form it will be termed as harmonic distortion. This harmonic distortion could result because of many reasons.

In today's world, prime importance is given by the engineers to derive a method to reduce the harmonic distortion. Harmonic distortion was very less in the past when the designs of power systems were very simple and conservative. But, nowadays with the use of complex designs in the industry harmonic distortion has increased as well. This project explains the effects of Harmonics in the Power System and steps to reduce the effects of Harmonics this project will also explain how Harmonic distortion is one of the most important problems associated with power quality and creates several disturbances to the Power System. It includes the Harmonic reduction techniques to improve the power quality and it will also include the simulation for the same. This project also explains different types of inverters that are used in the Power System. During the transformation from DC to AC, harmonics affect the the power quality a lot. How harmonic reduction will improve the power quality will be explained in detail as always, the main objective of the power system would be generation of electrical energy to the end user. Also, associated with power system generation is the term power quality. So much emphasis has been given to power quality that it is considered as a separate area of power engineering. There are many reasons for the importance given to the power quality. One of the main reason is, the consumers are well informed about the power quality issues like interruptions, sagging and switching transients. Also, many power systems are internally connected into a network. Due to this integration if a failure exists in any one of the internal network it would result into unfavorable consequences to the whole power system. In addition to all this, with the microprocessor based controls, protective devices become more sensitive towards power quality variation than were the past generation protective devices.

II. NEED OF PROJECT

Due to the high penetration of renewable sources of energy in distribution systems, voltage variations occur in the distribution system. In this scenario, it is a challenging task to maintain constant voltage to hospital and military loads,

known as critical loads as per their voltage sensitivity requirement. Energy sources also lead to the paradigm shift from centralized control to the distributed control in demand side management.

This leads to poor performance of the loads and premature failure of components in inverter. Solutions to these are modulation schemes, use of switched capacitor converters and switched capacitors with resonant operation. Apart from the general discussion in terms of THD analyses, other solution methods as mentioned earlier are deliberated only

The voltage fluctuations due to change in environmental condition. Hence if we able to compensate these voltage fluctuations then we required constant supply. It should overcome by using multilevel inverter. It effective in regulating the mains voltage despite the fluctuation caused by the intermittent nature of power. MLI with RCCC Circuit is nothing but a special type of reactive power compensator which improves the voltage profile of the power system. For stabilizing and supporting the power supply with the addition of multilevel inverter with low pass filter we not only reduced total harmonic distortion content and maintain constant voltages of line without any load distribution. DC to AC inverters are those devices which are used to produce inversion by converting a direct current into an alternating current. If the output of a circuit is AC then depending on the input i.e. either AC or DC, the devices are called as AC-AC cycloconverters or DC-AC inverters. DC to AC inverters are such devices whose AC output has magnitude and frequency which is either fixed or variable. In case of DC to AC inverters the output AC voltage can be either single phase or three phase. Also, the magnitude of the AC voltage is from the range of 110-380 VAC while the frequencies are either 50Hz, 60Hz or 400Hz.

Following are some of the disturbances which are common in affecting the power system

Transients

Variations in voltage

Sagging

Transients:

In terms of power system, the transients can be defined as an action or a situation in power system with variations in power system and which is not desirable in nature. A general understanding of transient is considered to be an oscillatory transient which is damped due to the RLC network. A person who is new to the power system also uses the term “surge” to define transient. A surge may be analyzed as a transient which is resulting from the stroke of lightening where protection is done by using a surge arrester. A person who is more groomed in the field of power engineering would avoid using the term “surge” unless it is specified as to what exactly the term “surge” refers to. Transient can be divided into two categories i.e. the oscillatory transient and the impulsive transient.

Oscillatory Transient:

A voltage or a current whose values change polarity rapidly are part of oscillatory transient. In case of a steady state of voltage and current when there is a sudden non-power frequency change or when there is a non-power frequency change in positive and negative polarity values, such a change is termed as an oscillatory transient.

Impulsive Transient:

Impulsive transients are mostly caused due to lightning. Unlike the oscillatory transient, the impulsive transient is such a condition when there is sudden change of non-power frequency in a steady state condition of voltages and currents that is unidirectional in polarity.

Impulsive transients also have the ability to produce oscillatory transients by exciting the natural frequency of a power system.

Variations in Voltage:

There are two types of variations in the voltages.

Short duration voltage variations

Long duration voltage variations.

Short Duration Voltage Variations:

Short duration voltage variations are usually caused by faults in the power system. Short duration voltage variations consist of sags which are caused depending on the system conditions and faults that are caused in the power system. It really depends on what kind of fault is caused in the power system under what condition which may lead to voltage drops, voltage rise and even interruptions in certain conditions. When such faults takes place, protective devices are used in order to clear the fault. But, the impact of voltage during such faulty conditions is of short-duration variation.

Interruptions: When there are reductions in the voltage or current supply interruptions take place. Interruptions may occur due to various reasons, some of them being faults in the power system, failures in the equipment, etc.

Long Duration Voltage Variations:

Long duration voltage variations are comprised of over voltages as well as under voltages conditions. These under voltage and over voltage conditions are caused by variations in the power system and not necessarily due to the faults in the system. The long duration voltage variations refer to the steady state condition of the rms voltage of the power system. The long duration voltage variations are further divided into three different categories i.e. interruptions, over voltage and under voltage.

Under Voltage:

There are many reasons for the under voltage conditions in the power system. When there is a decrease in the rms ac voltage to less than 90% of a power system for some amount of time then under voltage condition exists. Load switching on or switching off of a capacitor bank can also cause under voltage condition. Also, when a power system is overloaded it may result into under voltage condition.

Over Voltage:

Compared to the under voltage condition, over voltage is an increase in the rms ac voltage to greater than 110% of the power system for some amount of time. Unlike under voltage condition, load switching off or capacitor bank getting energized are main reasons for the over voltage conditions

Sagging:-

A short duration voltage variation is often referred to as sagging. When there is a decrease between 0.1 to 0.9pu in rms voltage sagging takes place. There are many ways to obtain the magnitude of sagging from the rms voltages. Most of the times lowest value

Obtained during the event is considered. Sagging normally has constant rms value during the deep part of the sag. Thus, lowest value is an acceptable approximate value

Some of the basic applications of inverters would be an UPS (uninterruptible power supply). When the main power is not available UPS uses batteries and inverter to supply AC power. A rectifier is used to recharge the batteries used when the main power is back. Other applications of an inverter included Variable frequency drives. The variable frequency drives controls the frequency and voltage of power supplied to the motor, thus controlling the speed of AC motor. An inverter is used in the variable frequency drives to provide controller power. An inverter is also used in an induction motor to regulate the speed by changing the frequency of AC output.

As explained in earlier chapters, the harmonics can be present in any system. Similarly, the harmonics are present in a system where inverters are used as well. Ideally, the main aim of using an inverter is to produce an ac output from the dc source. Theoretically the output voltage waveform is expected to be sinusoidal, but in practical terms there is definitely going to be distortions due to harmonics present in the system which results into distorted output waveforms. As a result of this, inverters are used in a system in order to produce output waveforms which are purely sinusoidal and distortion free. If the output ac voltage is more distorted as compared to the reference ac voltage then filter circuits are used again to produce the desired clean sinusoidal AC voltage

III. OBJECTIVES OF PROJECT

- I. VOLTAGE REGULATION BY USING PWM TECHNIQUE
- II. REDUCTION IN TOTAL HARMONIC DISTORTION
- III. TO SIMULATE THE SYSTEM FOR VOLTAGE REGULATION

IV. SYSTEM DEVELOPMENT

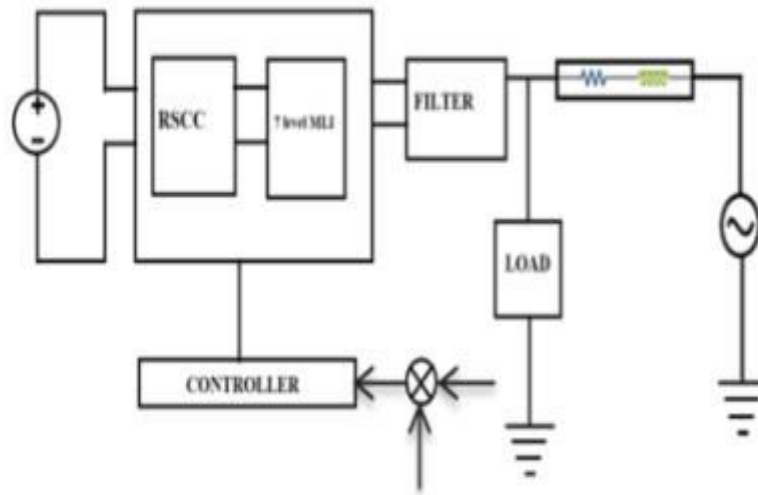


Figure 1:- Block diagram of overall test system

Supply

In this system we use 230 volt 50 Hz supply for the given load circuit and 400v DC giving to inverter circuit input

Controller

In this state, this controller will generate PWM signals to activate the MOSFETs of the inverter. Based on the change within the load, the response signal is provided to the PID controller so that it will produce error. These signals are generated based on the fault signal. In this state we can obtain changeable input & output through a similar inverter. As the steady-state accuracy improves, the stability also improves. Controllers also help in reducing the unwanted offsets produced by the system. Controllers can control the maximum overshoot of the system. Controllers can help in reducing the noise signals produced by the system. Controllers improve the steady-state accuracy by decreasing the steady state error.

PID Controller

A closed-loop system like a PID controller includes a feedback control system. This system evaluates the feedback variable using a fixed point to generate an error signal. Based on that, it alters the system output. This procedure will continue till the error reaches Zero otherwise the value of the feedback variable becomes equivalent to a fixed point. This controller provides good results as compared with the ON/OFF type controller. In the ON/OFF type controller, simply two conditions are obtainable to manage the system. Once the process value is lower than the fixed point, then it will turn ON. Similarly, it will turn OFF once the value is higher than a fixed value. The output is not stable in this kind of controller and it will swing frequently in the region of the fixed point. However, this controller is more steady & accurate as compared to the ON/OFF type controller.

Filter circuit

Some of the major issues concerned with harmonics in nonlinear loads are overheating, temperature increase in generators, etc. These effects may result into permanent damage of the devices.

One of the way out to resolve the issue of harmonics would be using filters in the power system. Installing a filter for nonlinear loads connected in power system would help in reducing the harmonic effect. The filters are widely used for reduction of harmonics. With the increase of nonlinear loads in the power system, more and more filters are required.

The ripple in the signal denotes the presence of some AC component. This AC component has to be completely removed in order to get pure DC output. So, we need a circuit that smoothens the rectified output into a pure DC signal. A filter circuit is one which removes the AC component present in the rectified output and allows the DC component to reach the load.

Pulse Width Modulation

Pulse-width modulation (PWM), or pulse-duration modulation (PDM), It is a method of reducing the average power delivered by an electrical signal, by effectively chopping it up into discrete parts. The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast rate PWM is particularly suited for running inertial loads such as motors, which are not as easily affected by this discrete switching, because their inertia causes them to react slowly. The PWM switching frequency has to be high enough not to affect the load, which is to say that the resultant waveform perceived by the load must be as smooth as possible.

Critical load

Critical loads that directly affect the ability of an organization to operate and must either be kept running (without any break in power) when their mains supply fails or be powered down in an orderly manner to prevent system crashes, data corruption and life-shortening hardware damage.

PID Controller

As the name suggests, this article is going to give a precise idea about the structure and working of the PID controller. However going into details, let us get an introduction about PID controllers. PID controllers are found in a wide range of applications for industrial process control. Approximately 95% of the closed-loop operations of the industrial automation sector use PID controllers. PID stands for Proportional-Integral-Derivative. These three controllers are combined in such a way that it produces a control signal. As a feedback controller, it delivers the control output at desired levels. Before microprocessors were invented, PID control was implemented by the analog electronic components. But today all PID controllers are processed by the microprocessors. Programmable logic controllers also have the inbuilt PID controller instructions. Due to the flexibility and reliability of the PID controllers, these are traditionally used in process control applications.

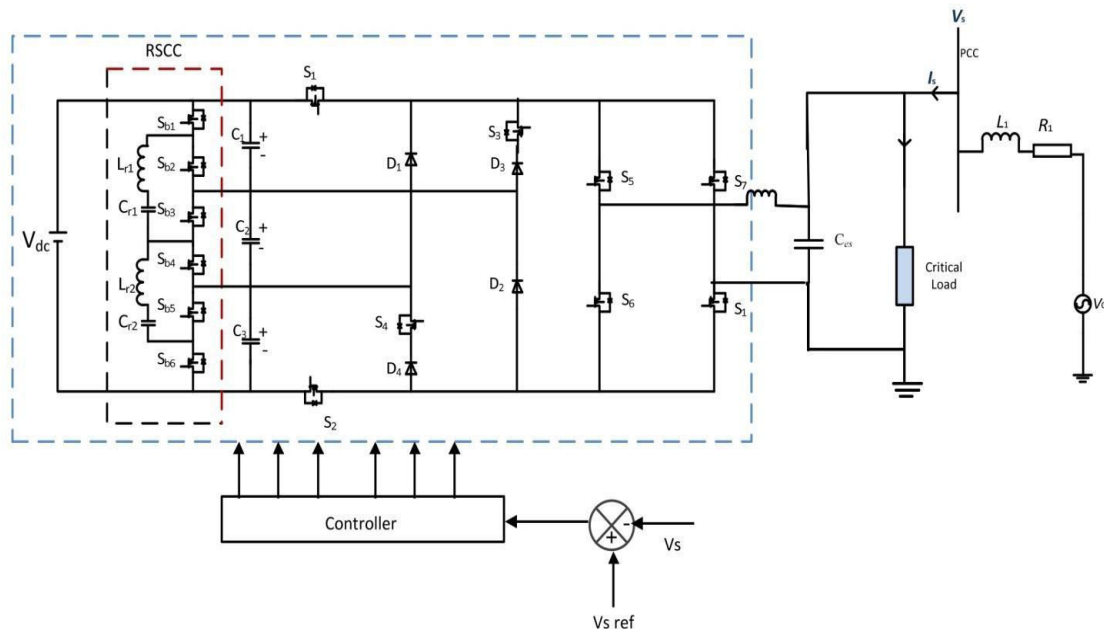


Figure 2:- Circuit diagram of test system

Parameter	Values
Line inductance (mH/km)	1.22
Line resistance(Ω /km)	0.1
Critical load Z (Ω)	53
Low pass filter	
Inductance (mH)	5

Capacitance (μF)	1.2
PI Controller K_p	2
(Initial values) K_i	1.5
MOSFET	
FET resistance R_{on} (ohms)	0.1
Internal diode resistance R_d (ohms)	0.01
Internal diode inductance L_{on} (H)	0
Internal diode forward voltage V_f (V)	0
Snubber resistance R_s (Ohms)	1e5
Snubber Capacitance	Inf
Diode	
Resistance R_{on} (ohms)	0.001
Inductance L_{on} (H)	0
Forward voltage V_f (V)	0.8
Snubber resistance R_s (Ohms)	500
Snubber Capacitance C_s (F)	250e-9
Series RLC Branch	
Inductance (H)	1e-3
Capacitance (F)	1e-6

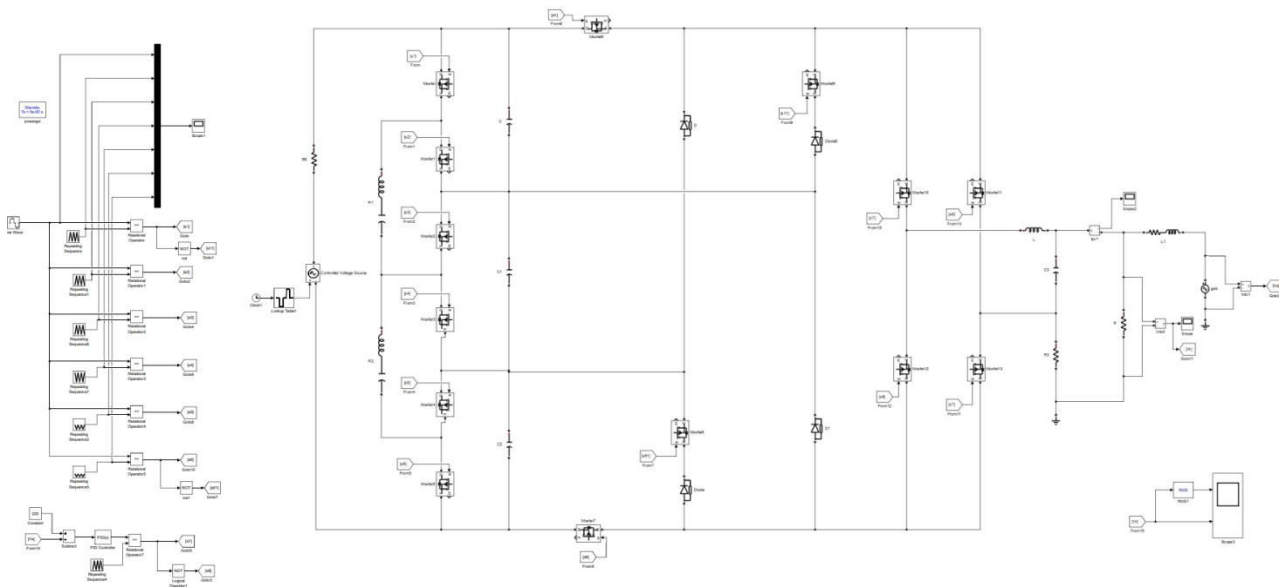


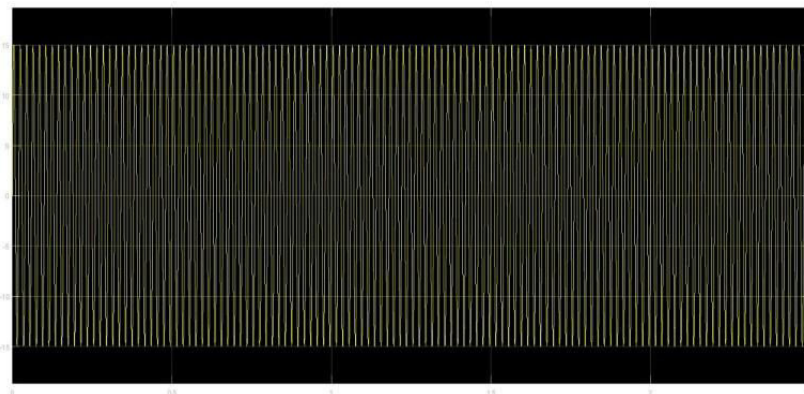
Figure 3 :- Simulation model of test system

V. RESULT



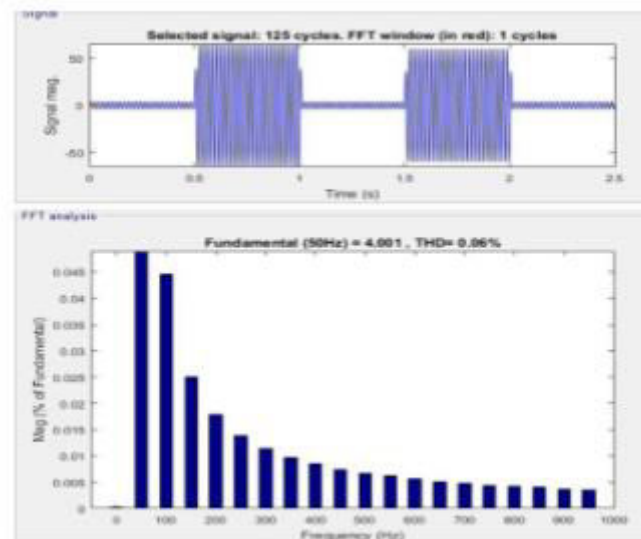
Graph 1:- representation of control input to the inverter

With the variations in the real power fed into the system by the DGs, voltage levels are affected. Results are shown for the simulation carried out for 1.5 seconds, in which due to real power fed by the DGs is changed from 1.8 KW to 1.1 KW at 0.5 sec and then back to 1.8 KW at 1 sec. This is traced with the RMS value of critical load voltage Critical load requires to be operated at 220 volts, but it falls to 185 volts



Graph 2:- Graphic representation of 7 level MLI output waveform

Hence this justifies that the voltage balancing is achieved in the multi-level inverter circuit by RSCC. Sinusoidal PWM technique is used to generate the pulses to the switches of MLI. The output voltage of the proposed inverter is compared with reference sinusoidal waveform and the error is given to the PID controller to generate the gating signals. The simulated circuit with PI controller is shown in figure 2 and the simulated output voltage of the open loop simulation obtained is shown in graph 2.



Graph 2:- Graphic representation of reduction in harmonic content present in voltage

V. CONCLUSION

This project presents a new model of Seven-level cascaded multilevel converter with PID controller. The simulation results show that voltage imperfection mitigation, and the enhancement of voltage stability has been achieved. The performance comparison of the proposed MLI with filter some previously reported MLI modules shows that it is more efficient in terms of power consumption and losses. It is also found that the absolute beneficial of voltage regulation can be achieved with connection of the distributed generation sources such as solar cells, wind generation system etc. The simulation results have demonstrated excellent suppression of voltage harmonic capabilities using the proposed new LC filter carrier based PWM technique. The MLI with filter is an attractive and efficient method for power quality improvement specifically to suppress voltage harmonics and also to mitigate voltage sag and combination both as a hybrid unit

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