

Power Quality Improvement and Analysis Using Multi-pulse Converter



Renu Kumari, M. A. Ansari and Shubham Shukla

Abstract The paper displays the power quality improvement with the help of the multi-pulse converter. Proposed AC–DC converter structure, consists of phase-shifting zigzag transformer overcomes the harmonic problem in AC mains. As we know the very fact that power quality becomes a vital issue to electricity shoppers additionally to work out the ability of wattage offer devices, this work stresses on simulation to analyze the entire harmonic distortion and improve power quality during this work. Results are obtained by simulating and digital implementation of MATLAB/Simulink.

Keywords AC/DC converter · DC drives · DC motor
Multi-pulse converter · THD

1 Introduction

The power quality (PQ) issue is outlined as “any power downside demonstrates in voltage, current, and frequency deviations that lead to failure or disoperation of client instrumentation.” Nowadays, power quality could be a main issue for the assembly, distribution of the electricity provide the foremost common issues, are placed like harmonics, short-term voltage deviations (sags, swells, and interruptions), future voltage variations transients, unbalance, frequency variations will cause many issues to the people who need high levels of power quality for their industrial processes or home usages [1]. The earliest harmonic distortion problems were related to third harmonic currents made by saturated iron in machines and transformers, alleged magnetic attraction masses. By definition, harmonic (or nonlinear) masses are those

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devices that naturally manufacture a non-sinusoidal current once energized by a curved voltage supply [2]. The main target of research worker is to eliminate harmonics in shift converters. Several ways are there, and also the researchers have used the ways as per the wants and suitability. This analysis paper deals with the reduction of total harmonic distortion victimization multi-pulse AC-to-DC conversion theme. The three-phase multi-pulse AC-to-DC system applies a phase-shifting electrical device and a three-phase system [1].

2 Power Quality and Issues

The power quality is fairly a broad concept; it may be defined as supply of voltages and system so that consumers of electric power can use electric energy with help of the distribution successfully, without disturbances in power quality defined in the IEEE 100 Authoritative as the concept of powering and grounding electronic system in a way that is suitable for the operation that is apparent and compatible with the basis wiring system and other connected equipment [3]. The power quality is damaged by different factors of the electrical network. Power quality complication affects the performance of electrical service and shortens its lifetime [4].

• Voltage Fluctuations

- A. **Voltage Sag**—A voltage sag or voltage dip could also be a brief amount of reduction in RMS voltage which could be done by a brief circuit, overload, or starting of electrical motors. Voltage sag happens once the RMS voltage decreases between 10 and ninety p.c. of nominal voltage for simple fraction cycle to at least 1 min.
 - B. **Voltage Swell**—Voltage Swell is defined as a rapid short-term increase in voltage typically caused by the switching off bank of capacitors and large block of loads. Voltage Interruption is the disappearance of the supply voltage on one or more phases. When the interruption is longer than 1 min.
- **Interruptions**—Interruptions are either a short-span or long-span variation. However, the term “interruption” is usually used to consult with short-duration interruption, whereas the latter is preceded by the word “sustained” to point a long duration. They are measured and represented by their length since the voltage magnitude is often but 100% of nominal (Fig. 1).

Fig. 1 Representation of power quality issues

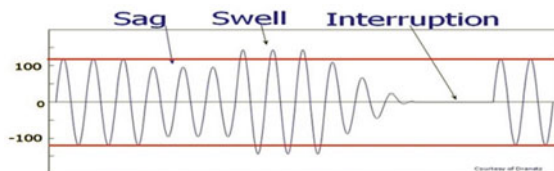
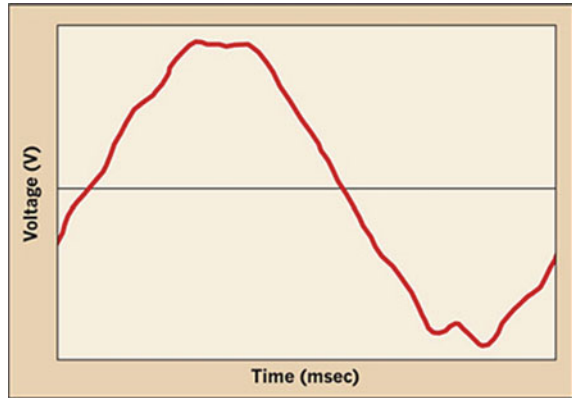


Fig. 2 Harmonics



- Harmonics**—The presence of harmonics in electrical systems suggests that current and voltage are distorted and deviate from serpentine waveforms. Harmonic voltages and currents in wattage grid give results of nonlinear electrical hundreds. Harmonic frequencies within the facility are a frequent reason for power quality problem. Harmonics in power systems lead to enhanced heating within the instrumentality and conductors, flop in variable speed drives, and torsion pulsations in motors. Reduction of harmonics is taken into account fascinating (Fig. 2).

3 Total Harmonic Distortion

Total harmonic distortion or THD may be a common measure of the extent of harmonic distortion gift in power systems. THD is outlined because of the magnitude relation of total harmonics to the worth at harmonic.

$$\text{THD} = \frac{\sqrt{V_2^2 + \sqrt{V_3^2} + \sqrt{V_4^2} + \dots}}{V_1} \tag{1}$$

where V_n is the RMS voltage of n th harmonic and $n = 1$ is the frequency. Dominant sources of harmonic reproduction in power system are: controlling action of power electronic devices such as chopper, inverter causing inequality in power system leading to harmonic generation and on-linear loads like as UPS, SMPS, and battery charger [5].

4 Proposed Harmonic Analysis Methods FFT

The fast Fourier transform (FFT) may be used for analysis due to its process potency. FFT may be used to calculate the harmonic distortion and to separate even/odd/inter-harmonics. For analyzing harmonics, connected to power quality disturbances, STFTs engagement is done. FFT–FFT-quick Fourier rework analysis is utilized to convert time-domain modulation into their frequency counter parts and viceversa. Once the wave shape is periodical, the Fourier series may be helpful to calculate the magnitudes and phases of the elemental and its harmonic elements. The FFT utilizes some clever algorithms to identify identical factors. However DFT takes a lot less time to do so. The finiteor distinct is diffientiated by Fourier transform of advanced vector with n components [5].

5 Multi-pulse Method

Multi-pulse strategies involve multiple devices connected in order that the harmonics developed by one converter are off by harmonics made by alternative converters. Certain harmonics associated with some range of converters are eliminated from the power supply. In multi-pulse converters, reduction of AC input line current harmonics is incredibly vital as regards the impact the device has on the facility system. Multi-pulse strategy area unit is characterized by the utilization of multiple converters or multiple semiconductor devices with a typical load. Usually, diode is used with a better range of pulses for reducing harmonics in AC mains and drop price of ripple voltage within the DC output. These are developed in 6, 12, 18, 24, 30, 36, 48 pulses, etc. [6] (Fig. 3).

6 Phase Shifting and Harmonics

The best way to eliminate harmonics is to use a method referred to as “phase shifting.” The thought of part shifting involves separating the supply into many outputs, where every output being part shifted whereas the opposite outputs with an applicable angle are eliminated. The concept is to displace the harmonic currents so as to bring them to a 180° part shift, so they cancel one another out [7] (Fig. 4).

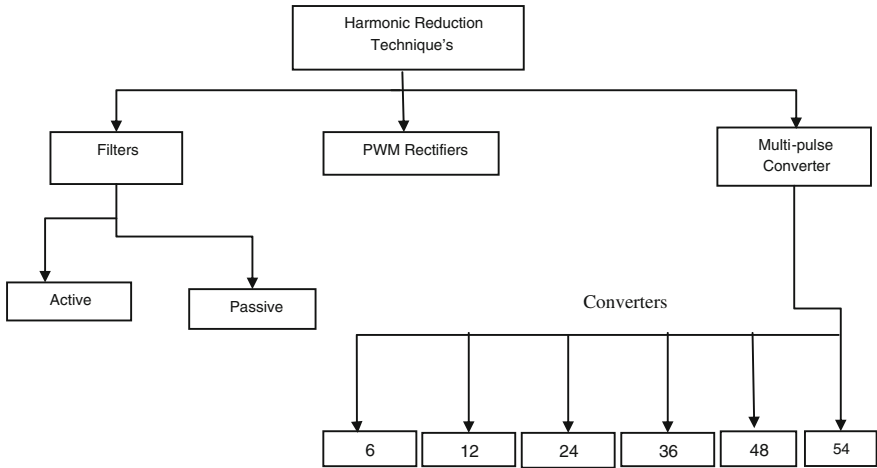
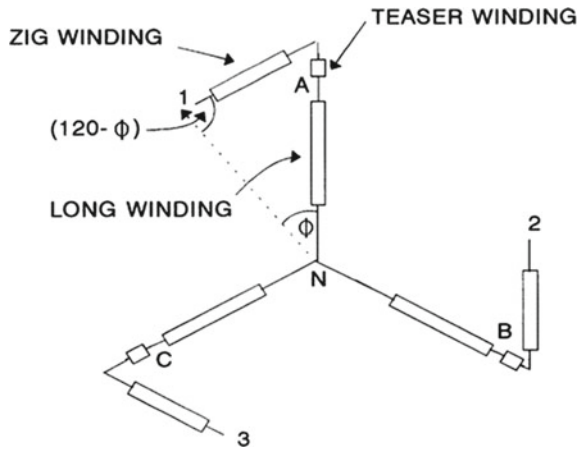


Fig. 3 Block diagram of harmonic reduction techniques

Fig. 4 Zigzag winding configuration



7 Simulation and Results

With the assistance of multi-pulse methodology, the harmonics contents in AC–DC converter is reduced due to multiple converters utilized in circuits so that harmonics made by one converter are off by harmonics made by another converter. There are two forms of pulse converter consistent with dominant techniques: First one is uncontrolled multi-pulse converter, and other is controlled multi-pulse converter. Moreover, an “Uncontrolled multi-pulse has mounted output and controlled converter has controlled output which can be controlled with the firing angle “ α ” know that just in case multi-pulse converter because the range of pulse increase the harmonics contents can

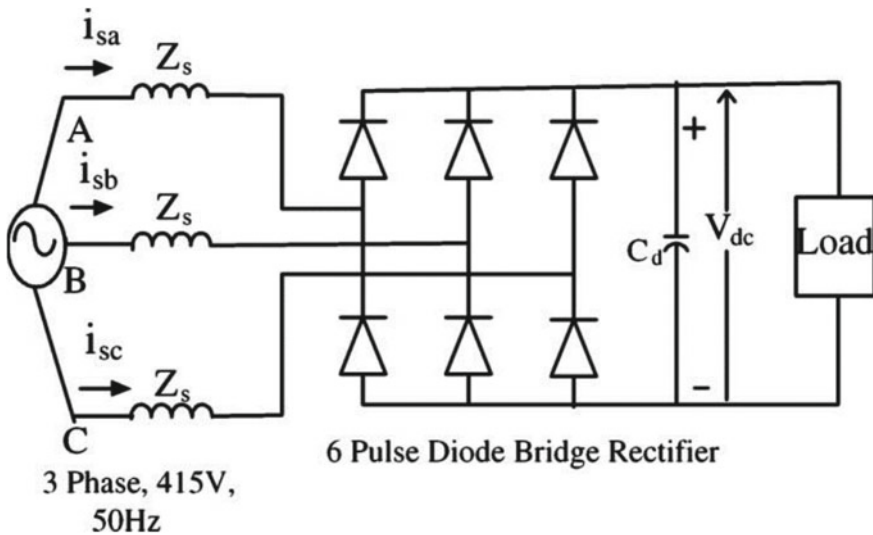


Fig. 5 Six-pulse diode bridge rectifier

be reduced and therefore the THD is relied upon part shift of the multi-pulse converter and it is given by equation. Phase shift = $60^\circ/\text{number of 6-pulse converter}$ (Fig. 5).

8 Simulation of Uncontrolled Multi-pulse Converters

1. Uncontrolled 6-Pulse Converter

Uncontrolled 6-pulse device is the elemental device unit of HVDC transmission issued for rectification wherever power flows from the AC aspect to the DC aspect and inversion wherever the power flow is from the DC aspect to the AC aspect. Thyristor valves operate as switches that activate and conduct current once dismissed on receiving a gate pulse and are forward-biased. The characteristic AC aspect current harmonics generated by 6-pulse converters are $6n \pm 1$. For uncontrolled model, we used diode (Figs. 6, 7 and 8).

2. Uncontrolled 12-Pulse Simulink Model

Twelve-pulse converter could be a series association of two totally controlled 6-pulse converter bridges and needs two three-phase systems that are spaced excluding one another by thirty electrical degrees (Figs. 9, 10 and 11).

3. Uncontrolled 18-Pulse Simulink Model

Uncontrolled 18-pulse Simulink model during this 18-pulse topology is the circuit worked as same as the 6-pulse converter; thus, this topology is comparatively the

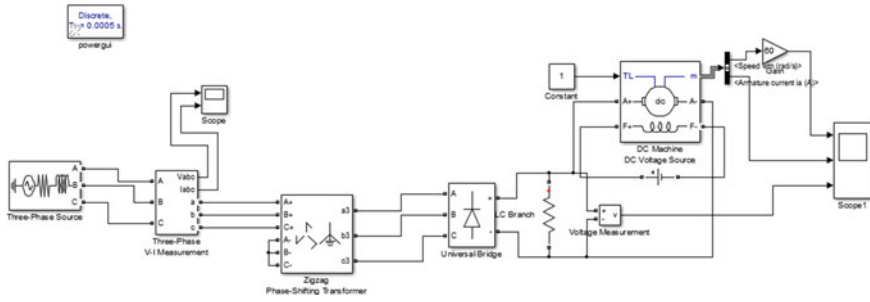


Fig. 6 Simulink/model of 6-pulse uncontrolled converter

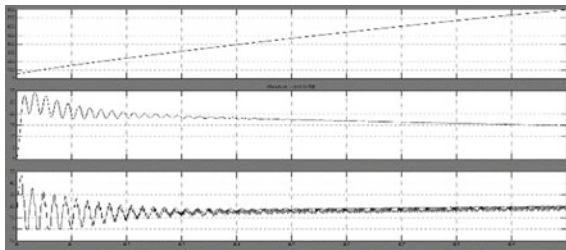


Fig. 7 Scope of 6-pulse uncontrolled converter

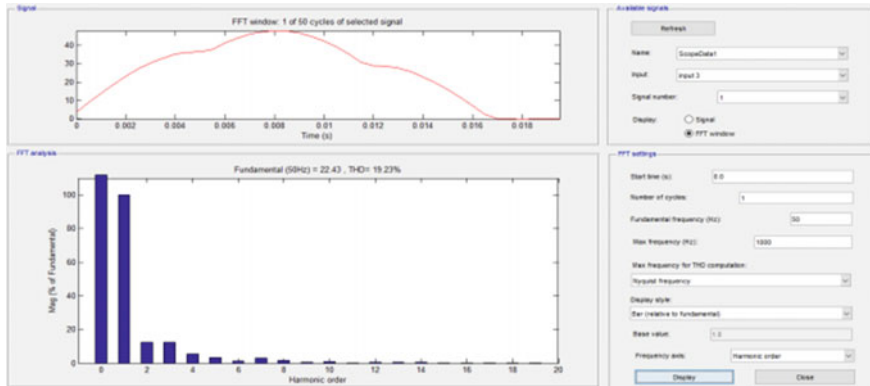


Fig. 8 THD of output voltage

hottest one. A part shift of two hundred has been provided between all three-phase shift transformers with star-connected secondary (Figs. 12, 13 and 14).

4. Controlled 6-Pulse Simulink Model

For the simulation of controlled converters in place of the diode bridge, we have a tendency to use the thyristor bridge and additionally the corresponding pulses are given (Figs. 15, 16 and 17).

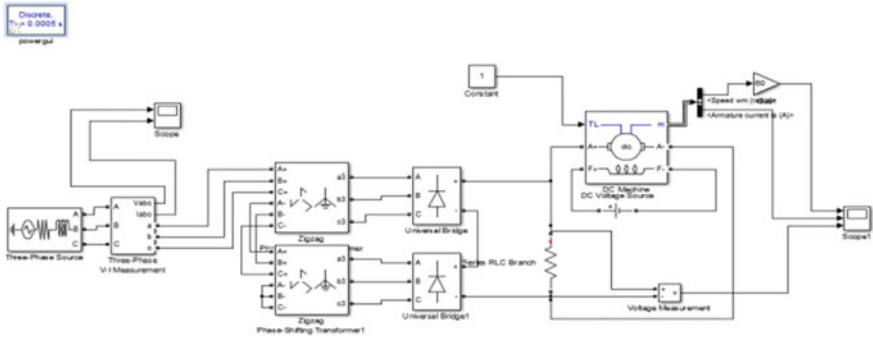


Fig. 9 MATLAB/Simulink model of 12-pulse uncontrolled converter

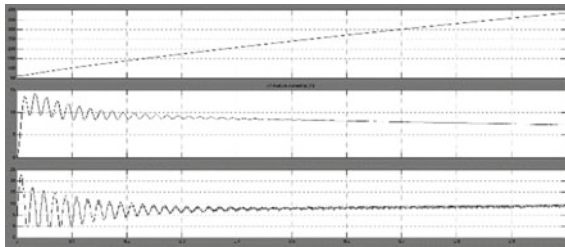


Fig. 10 Scope of 12-pulse uncontrolled converter

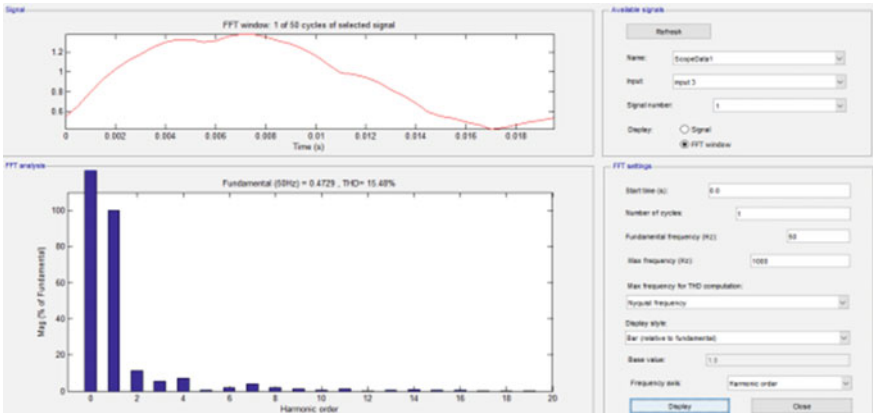


Fig. 11 V_{ab} (line voltage) and its THD

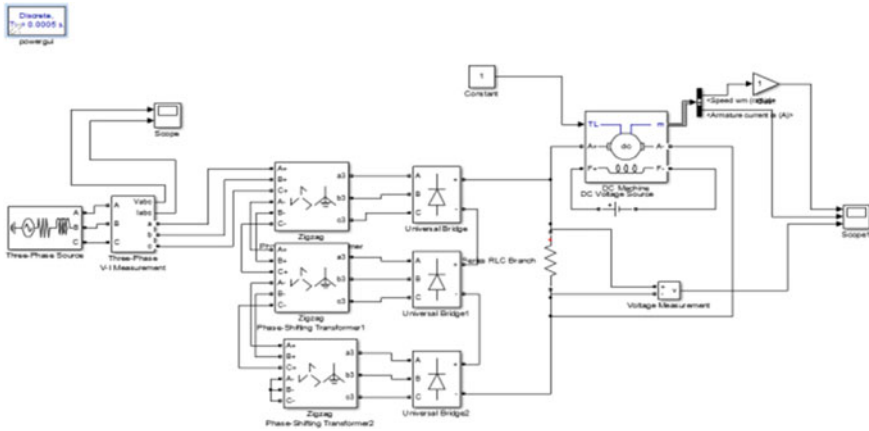


Fig. 12 Simulink/model of 18-pulse uncontrolled zigzag phase-shifting transformer

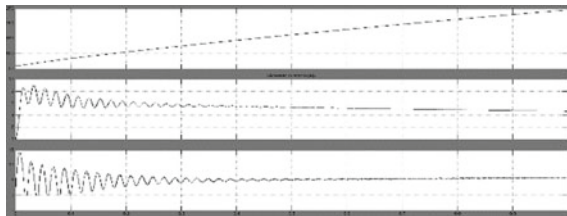


Fig. 13 Scope of 18-pulse uncontrolled converter

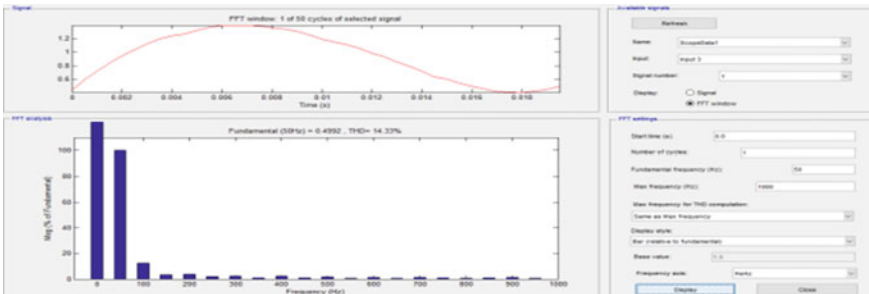


Fig. 14 Vab (line voltage) and its THD

5. Controlled 12-Pulse Simulink Model

Simulink model of 12-pulse device has two six-pulse converters connected serial or parallel in keeping with the appliance. The 3-section input of those two six-pulse converters has thirty section distinctions to every alternative. Due to this, 5th and 7th harmonics content are canceling to every alternative and 11th and 13th are assertive harmonics content (Figs. 18, 19 and 20).

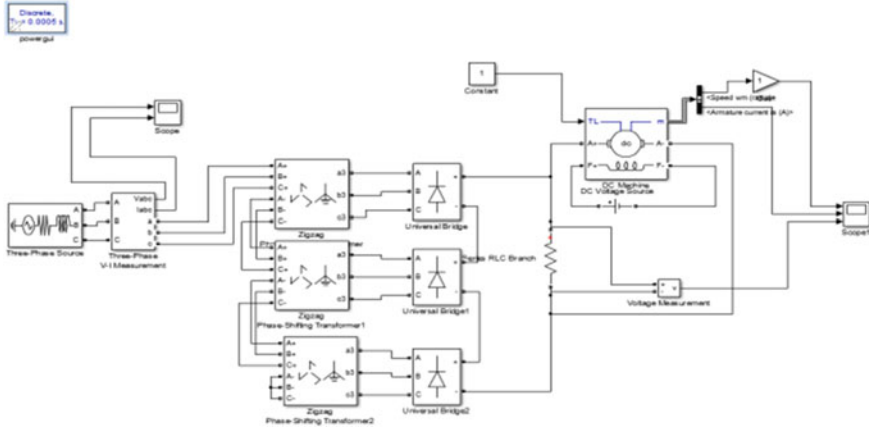


Fig. 15 Simulink/model of 6-pulse controlled converter

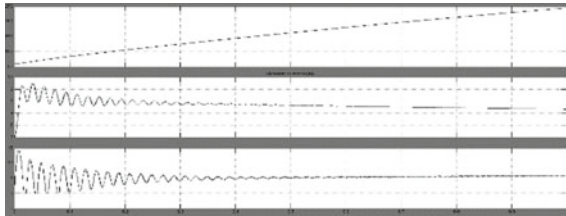


Fig. 16 Scope of 6-pulse controlled converter

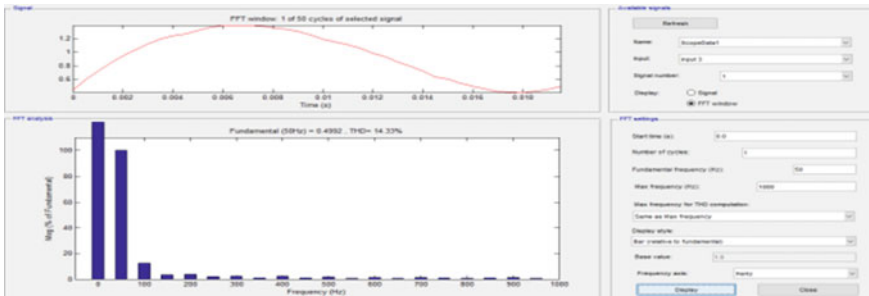


Fig. 17 Vab and its THD

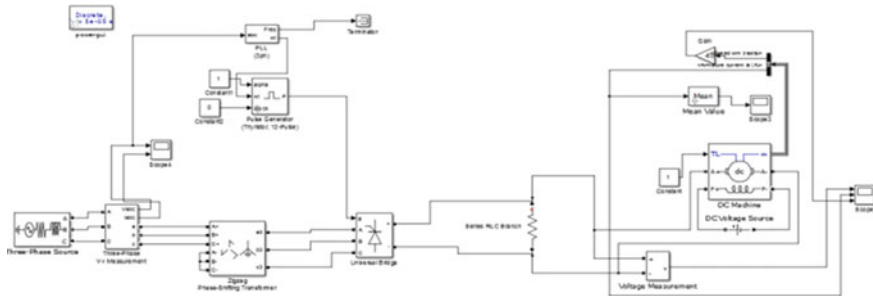


Fig. 18 Simulink/model of 12-pulse controlled converter

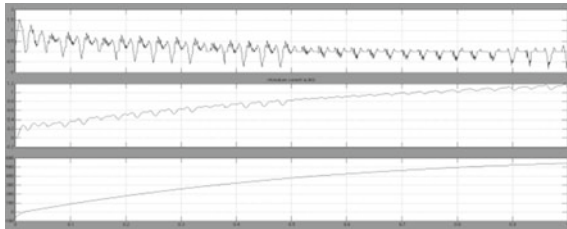


Fig. 19 Scope of 12-pulse controlled converter

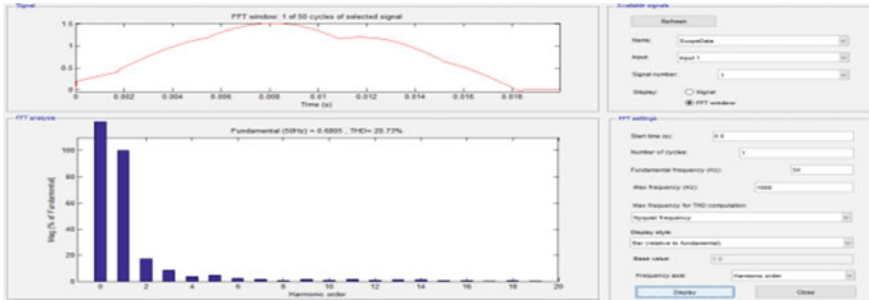


Fig. 20 Vab and its THD

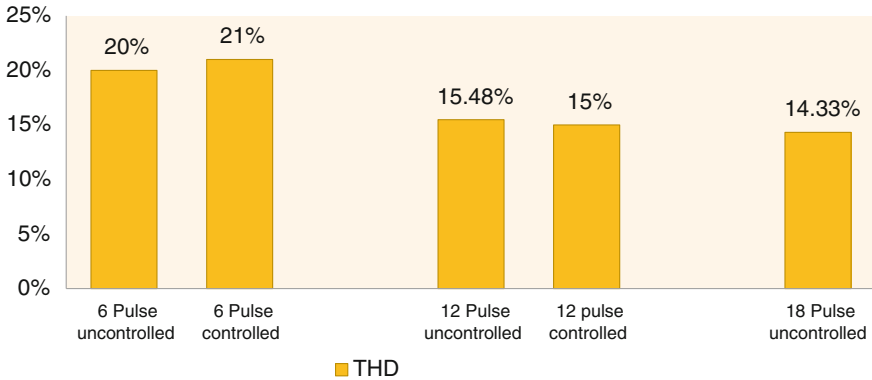


Fig. 21 Performance comparison of multi-pulse converters

9 Conclusion

In this paper, a performance comparison of multi-pulse converter has been administered. Six-pulse uncontrolled, 12-pulse uncontrolled, 18-pulse uncontrolled, and conjointly 6-pulse, twelve-pulse controlled AC/DC converters have been designed and simulated in MATLAB/Simulink. These converters are calculated in terms of harmonic spectrum of AC providing current, total harmonic distortion. Thus, commonly with the increases in varieties of pulses in multi-pulse case, the performance of the parameters of those converters is remarkably improved. The results obtained are analyzed with the no. of pulse; THD decreases with increasing no. of pulses (Fig. 21).

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