Simulation of Multipulse Converter for Harmonic Reduction using Controlled Rectifier

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Abstract: ***This paper discusses the impact of using 3-phase and multipules converter circuit commonly found in unity power factor at input AC mains and regulates output voltage.3-phase thyristor rectifiers have been used in industries for obtaining a variable DC voltage, but they have a problem of including large lower-order harmonics in the input currents. For high-power applications, a 12-pulse, 18-pulse and 24-pulse configuration is useful for reducing the harmonics, but it still includes the (np±1) th (n: integer, p: pulse) harmonics. In this paper present the rectifiers are using the MATLAB/SIMULINK simulation model and several common conditions will be simulated to compare their harmonic levels.***

Keywords: Power factor, Harmonics, Multiples, Total Harmonic Distortion, Ripple Content, 6-pulse, 12-pulse, 18-pulse**.**

1. Introduction

Three-phase controlled rectifiers have a wide range of applications, from small rectifiers to large High Voltage Direct Current (HVDC) transmission systems. They are used for electro-chemical process, many kinds of motor drives, traction equipment, controlled power supplies, and many other applications. In modern power electronics converters, a three-phase controlled converter is commonly used especially as a rectifier in interfacing adjustable speed drives (ASD) [1]–[4] and renewable energy in electric utilities [5], [6]. We noticed earlier that a standard six pulse rectifier caused a predictable harmonic spectrum consisting of the 5th, 7th, 11th, 13th, 17, 19th…harmonics. For three phase power system rectifiers, the harmonics, which will normally be present in the input current harmonic spectrum, can be identified by the following equation:

$$h = k\,p \pm 1$$

Where, k is an integer (1, 2,3,…) and p is the number of rectifier pulses on the dc bus waveform for one cycle of ac input voltage. In this paper we deal with the reduction of Total Harmonic Distortion using Multi-pulse AC to DC Conversion scheme. The results are obtained for both uncontrolled and controlled converters for R, RL. They have the problems of poor power quality in terms of injected current harmonics, resultant voltage distortion and poor power factor at input ac mains and slowly varying rippled DC output at load end, low efficiency, and large size of AC and DC filters.

The performance improvement of multi-pulse converter is achieved for total harmonics distortion (THD) in supply current, DC voltage ripples and form factor. All the simulations have been done for similar ratings of RL Load, for all the multi-pulse converters configurations, so as to represent a fair comparison among controlled and uncontrolled continuations of multi-pulse converters. The presented simulation results show the reduced THD at supply side. These results agree with the IEEE Standards 519-1992. Effect of increase in number of pulses in converter circuits for uncontrolled and controlled multipulse converter on input supply current and DC side voltage and current has been presented in this work [7].

A lot of efforts have been performed to reduce harmonic contents in the utility line currents of controlled converters [8]. Passive filters have been used in many researches with different configurations [9], but this technique suffers from bulky, heavy filter elements and sometimes causes resonance problems. Active filters have been used in many researches and it seems to be an interesting option, but this technique suffers from complexity and high cost [10], [11]. Hybrid solutions using active filters and passive filters are used in high-power applications to improve passive filter performance [12]. An increasing number of pulses [13]–[16] reduce the harmonic contents in a line current. However, this technique is heavy, has high cost, complex construction, needs to be large in size, and it is not readily available from the manufacturer [15]. Early work in third harmonics injection techniques has been used in [6], [8], [16]. Some other literatures use switches in the main path of power flow, which increase the switching losses and reduce the system reliability. Injection of third harmonic current to line currents can be achieved by using LC branches tuned around the third harmonic frequency [16].

This paper is organized as follows: Section 2 describes the various multi pulse methods, in section 3 simulation of controlled multipulse converters. Section 4 discusses the simulations and the results and section 5 concludes the paper.

2. Various Multi-Pulse Methods

In this paper modeling & simulation of multiples converter is presented. In this dissertation two type of converter use one is uncontrolled converter (six pulse diode rectifier, 12 pulse and 18 pulse diode rectifier) and other is controlled converter (6 pulse thyristor rectifier, 12 and 18 pulse thyristor rectifier). Multipulse converter using for harmonic reduction from input current and reduction of ripple from dc current The effect of increasing the number of pulses on the performance of AC to DC converters has been analyzed. The rectifiers are modeled using the MATLAB/SIMULINK simulation model with R, RL Lode. Six-pulse rectifier distorts the input side current and voltage waveform, this distortion can be reduced by using multipulse converter such as twelve pulse, eighteen pulse.

Multi-pulse methods involve multiple converters connected so that the harmonics generated by one converter are cancelled by harmonics produced by other converters. By this means, certain harmonics related to number of converters are eliminated from the power source. In multi-pulse converters, reduction of AC input line current harmonics is important as regards to the impact the converter has on the power system [17].

2.1 Multipulse Converter

Pulse number is defined as the number of pulses in the dc output voltage within one time period of the ac source voltage. In high-power applications, AC-DC converters based on the concept of multipulse, namely, 12, 18, 24, 30, 36, 48 pulses are used to reduce the harmonics in ac supply currents. These are named as multipulse converters. They use either a diode bridge or thyristor bridge, which is connected with special arrangement of zigzag transformer. This zigzag transformer also reduces second harmonics.

2.2 Advantages of Multipulse Converter

The Efficiency and unity input power factor at input mains. Harmonics reduction and regulated output voltage is obtained using twelve pulse PWM rectifier. As the number of pulses increases harmonic reduction will be better and hence a better DC link output voltage is achieved. Here we descried harmonic reduction technique in fig multi-pulse converter using uncontrolled and controlled rectifier figure 1 given below the various techniques used widely for the reduction of harmonics [19]-[20].

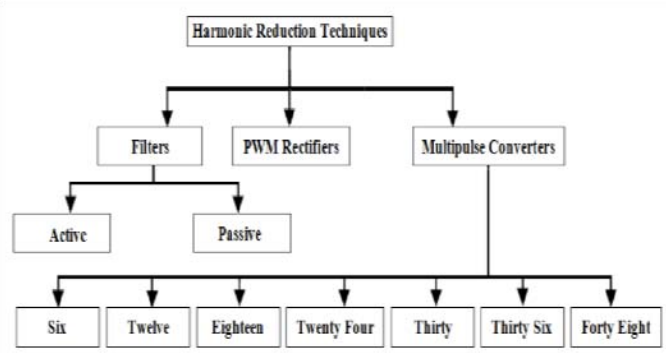

Figure 1. Various Harmonic Reduction Techniques

3. Simulation of Controlled Multipulse Converters

Three-phase six-pulse converter six thyristor are connected in a bridge manner. A three-phase supply is connected across the input terminal of the converter. The output of this converter is connected to the dc load. Because thyristor are unidirectional, dc current flows only in one direction. For generating 6 pulses per fundamental ac cycle synchronized 6-pulse generator is used. Figure.2 shows 6-pulse thyristor converter with resistive load.

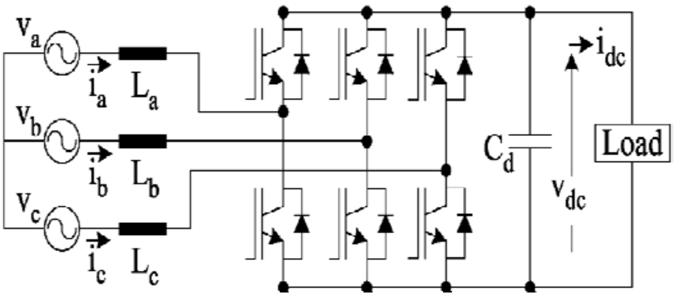

Figure 2. 6-Pulse thyristor converter

3.1 12-Pulse Converter

The 12-pulse method has been also used for reduced facility harmonics distortion. In these case two set of non linear load are fed by two phase shifted transformer winding with the using of twelve pulse converter 5th and 7th harmonics can be cancellation on primary side of transformer. From H= np±1 so that 11th and 13th harmonics are present. 12-pulse rectifier 5th, 7th 90% cancelled still has 11th, 13th, 17th, 19th etc.

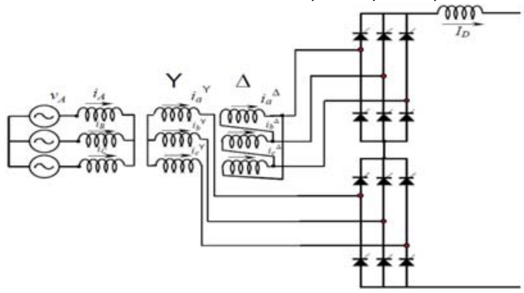

Figure 3. 12-Pulse controlled rectifier

3.2 18-Pulse Converter

When three individual six pulse bridge rectifiers are combined in a way such that each is fed from a separate transformer winding and each of these windings are phase shifted by 20 electrical degrees from each other, From H= np±1 then the 5th, 7th, 11th and 13th harmonics are theoretically cancelled. This eighteen pulse configuration will experience the harmonic stream containing the 17th, 19th, 35th, 37th, etc. harmonics. The total input harmonic current distortion for eighteen pulse rectifiers will typically vary between 5% to 8% THD-I for individual loads depending upon loading condition, pre-existing system voltage distortion, and percent of line voltage unbalance.

3.3 Simple 6-Pulse Thyristor Rectifier

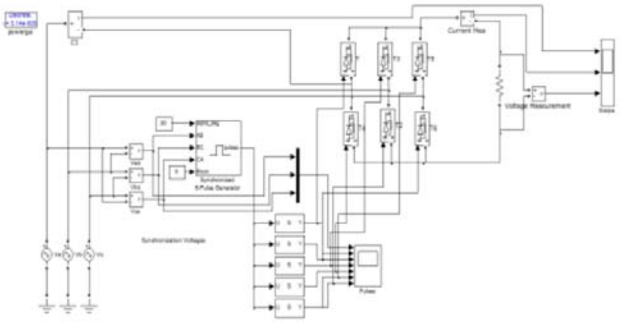

Figure 4. Controlled Six-Pulse Converter

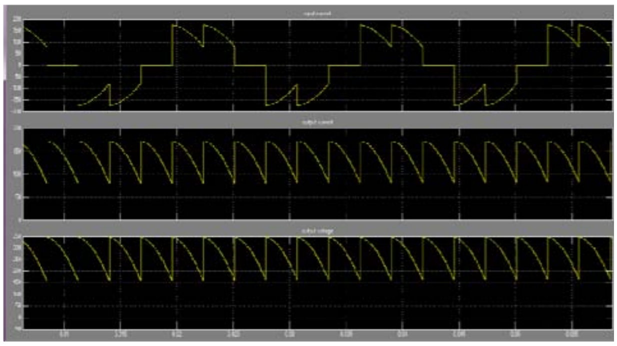

Figure 5. 6-Pulse thyristor rectifier waveform

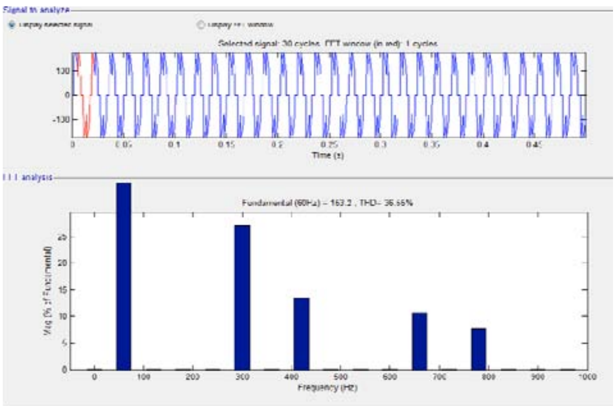

Figure 6. 6-Pulse THD

3.4 Modified 6-Pulse Model with RL Load

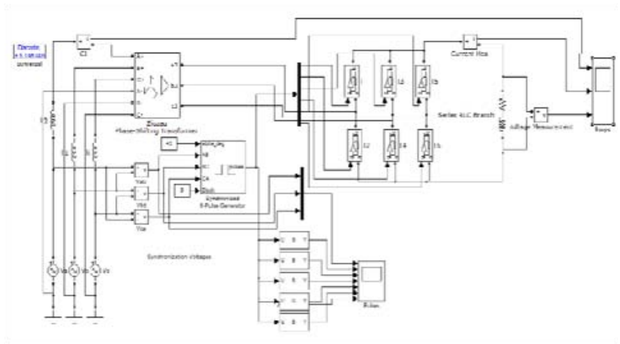

Figure 7. Controlled six-pulse Converter

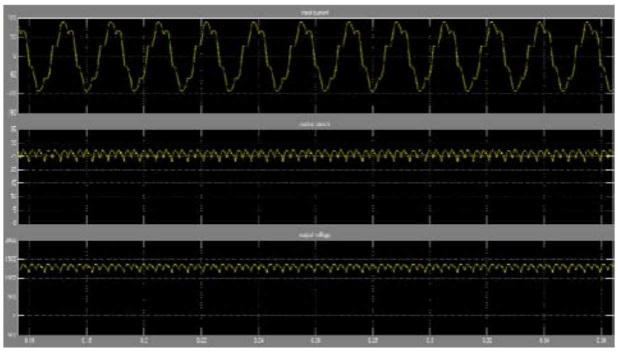

Figure 8. Controlled six-pulse Converter waveform

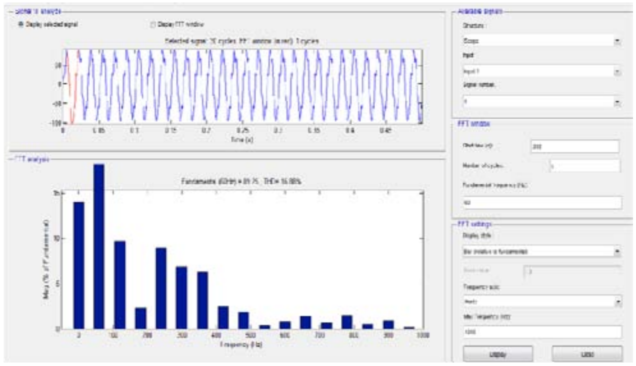

Figure 9. 6-Pulse THD

3.5 Simulation of 12-Pulse Thyristor Rectifier

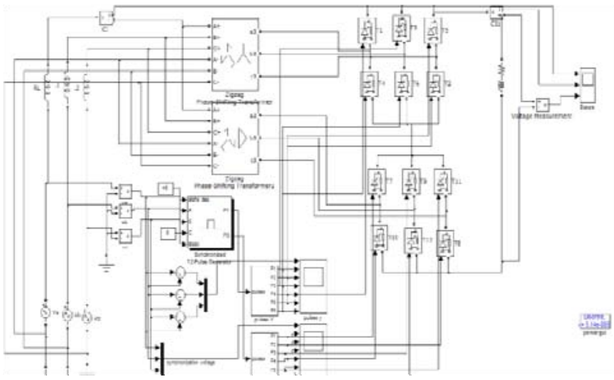

Figure 10. Simulation model of 12-Pulse thyristor rectifier

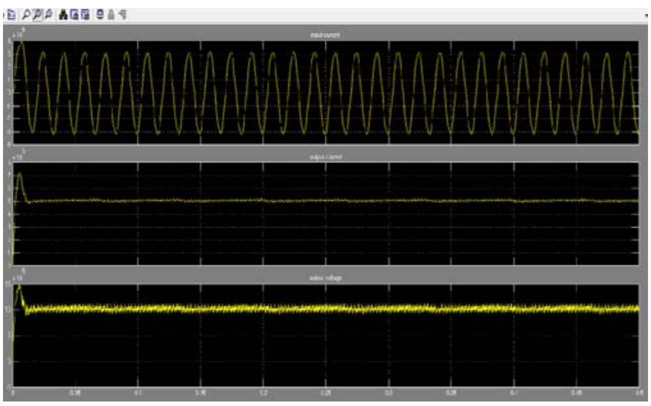

Figure 11. 12-Pulse waveform

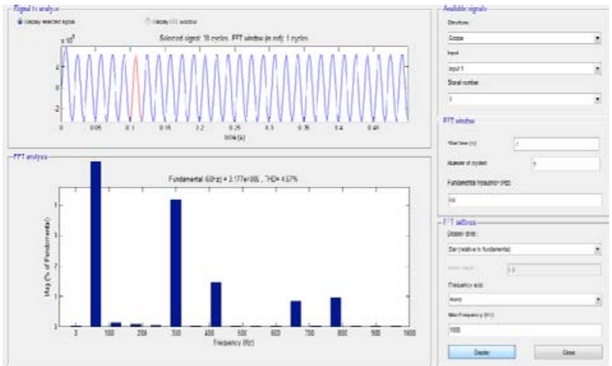

Figure 12. THD% of 12-Pulse for input current

3.6 Simulation of 18-Pulse Thyristor Rectifier

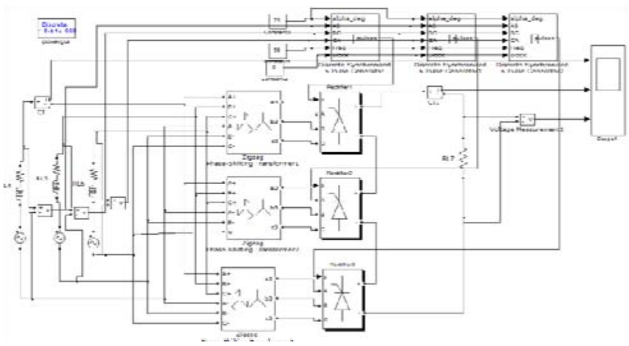

Figure 13. 18-Pulse thyristor rectifier model

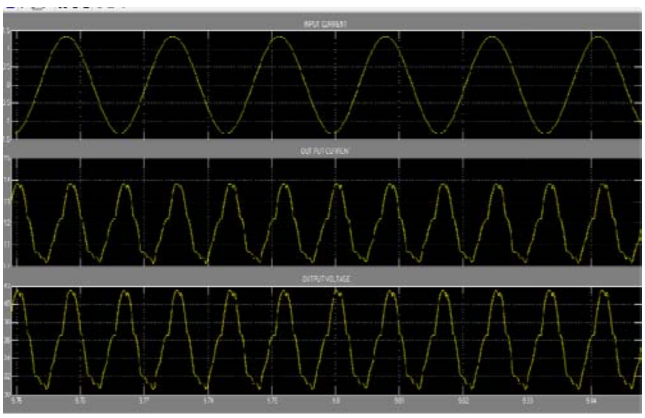

Figure 14. 18-Pulse waveform

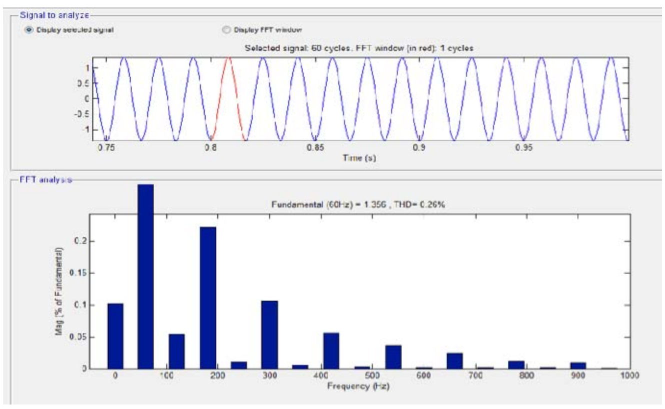

Figure 15. THD for input current

4. Simulations & Results

As a comparison, a 6-pulse rectifier will produce on the order of 25% current THD, whereas a 12-pulse rectifier will produce about 12% current THD. An 18-pulse rectifier will produce on the order of 5% current THD. Somewhat lower harmonics can be achieved using rectifiers with a pulse number greater than 12, however, the incremental benefit in harmonic reduction decreases while the complexity of the design increases.

Table 1: Comparison of Uncontrolled and Controlled Converters

No of Pulses	*THD % of Uncontrolled R-Load*		*THD % of Controlled R-Load*	
	Input Current	*Input Voltage*	*Input Current*	*Input Voltage*
6	30.82	26.48	36.09	25.82
12	9.90	7.25	15.08	16.07
18	8.24	6.18	13.34	18.07
24	1.87	0.36	7.34	7.88
36	0.26	0.16	4.30	3.36
48	0.21	0.14	3.21	2.57

5. Conclusion

This paper specifies the MATLAB/SIMULATION model. Comparison of performance for 6 pulse 12 pulse and 18 pulse is done. Best result of ripple factor, efficiency, and unity input power factor at input mains, harmonics reduction and regulated output voltage is obtained using multiples converter. As the number of pulses increases harmonic reduction will be better and hence a better DC link output voltage is achieved.

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