

## Power Quality Improvement Use of Different Pulse Width Modulation Techniques

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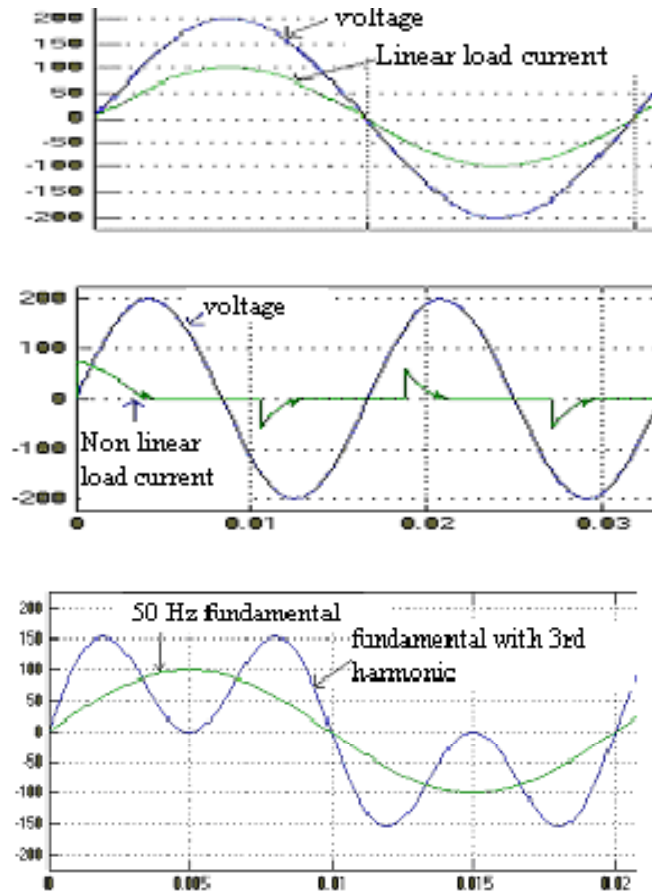
### Abstract

This paper has discussed the effect of harmonics on the power quality of the power supply. The paper also discussed the different configurations of PWM techniques for harmonic reduction and improvement of fundamental peak voltage. In addition, a comprehensive comparison of all configurations is made in terms of THD, FFT and dominating harmonics components. This paper describes the results on the basis of MATLAB simulation. It is shown how, with suitable modifications. The conventional Regular Sampled PWM technique can be simply extended to allow Harmonic Minimization and also Harmonic Elimination PWM to be closely reproduced using simple algebraic equations. This survey paper will provide the insight of trends and technology of "Power Quality Improvement using PWM Technique.

**Index Terms:** FET, Power Quality, PWM Techniques, THD.

### Introduction

**Power Quality:** There is a lot of confusion on the meaning of the term 'power quality', not in the least because 'power' is used as a synonym for 'electricity' in American English whereas it is also the energy transport per unit of time. Different authors use different definitions. A consistent set of definitions is given as follows: *Voltage quality* is concerned with deviations of the voltage from the ideal. The ideal voltage is a single frequency sine wave of constant amplitude and frequency. *Current quality* is the complementary term to voltage quality. It is concerned with the deviation of the current from the ideal. The ideal current is again a single frequency sine wave of constant amplitude and frequency, with the additional requirement that the current sine wave is in phase with the voltage sine wave.



**Figure 1:** Waveform shape. (a) Voltage and current waveform for linear loads. (b) Voltage and current waveform for non linear loads. (c) Waveform with symmetric harmonic component.

**Power quality [1]** is the combination of voltage quality and current quality. Quality of supply is a combination of voltage quality and the non-technical aspects of the interaction from the power network to its customers. Quality of consumption is the complementary term to Quality of supply.

### PWM Techniques

Because of advances in solid state power devices and microprocessors, switching power converters are used in more and more modern motor drives to convert and deliver the required energy to the motor. The energy that a switching power converter delivers to a motor is controlled by Pulse Width Modulated (PWM) signals applied to the gates of the power transistors. PWM signals are pulse trains with fixed frequency and magnitude and variable pulse width. There is one pulse of fixed magnitude in every PWM period. However, the width of the pulses changes from pulse to pulse according to a modulating signal. When a PWM signal is applied to the gate of a

power transistor, it causes the turn on and turn off intervals of the transistor to change from one PWM period to another PWM period according to the same modulating signal. The frequency of a PWM signal must be much higher than that of the modulating signal, the fundamental frequency, such that the energy delivered to the motor and its load depends mostly on the modulating signal [2].

### **Advantages of PWM**

The advantage of PWM based switching power converter over linear power amplifier is:

- Easy to implement and control,
- No temperature variation-and ageing-caused drifting or degradation in linearity,
- Compatible with today's digital microprocessors,
- Lower power dissipation, and
- It allows linear amplitude control of the output voltage/current from previously not present.

### **Disadvantage of PWM**

- Attenuation of the wanted fundamental component of the PWMed waveform, in this case from 1.1-0.866<sup>^</sup> p.u.
- Drastically increased switching frequencies (in this case from 1 pu to 21 pu)-this means greater stresses on associated switching devices and therefore derating of those devices, and
- Generation of high-frequency harmonic components.

### **The following are some major concerns then comparing different PWM techniques**

- Low switching losses.
- Good utilization of DC power supply that is to deliver a higher output voltage with the same DC supply.
- Good linearity in voltage and or current control.
- Low harmonics contents in the output voltage and or currents, especially in the low-frequency region.

### **The basic PWM techniques are**

- Single Pulse Width Modulation
- Multi Pulse Width Modulation
- Sinusoidal Pulse Width Modulation (SPWM)

But when the technology progresses some advanced modulation techniques [3] is also proposed by the different researcher like

- Trapezoidal Modulation
- Staircase Modulation
- Stepped Modulation
- Harmonic Injection Modulation

- Delta Modulation
- Space vector Modulation (SVPWM)
- Random PWM

The objectives of this paper are as follows

- To report the total harmonic distortion (THD) of the unfiltered inverter output line voltages generated by three well known multi carrier PWM techniques, namely the Alternative Phase Opposition Disposition (APOD), the in Phase Disposition (PD), and the Phase Opposition Disposition (POD).
- To evaluate the performance of each technique with respect to harmonic distortion and distortion factors.

### **Harmonic Limits**

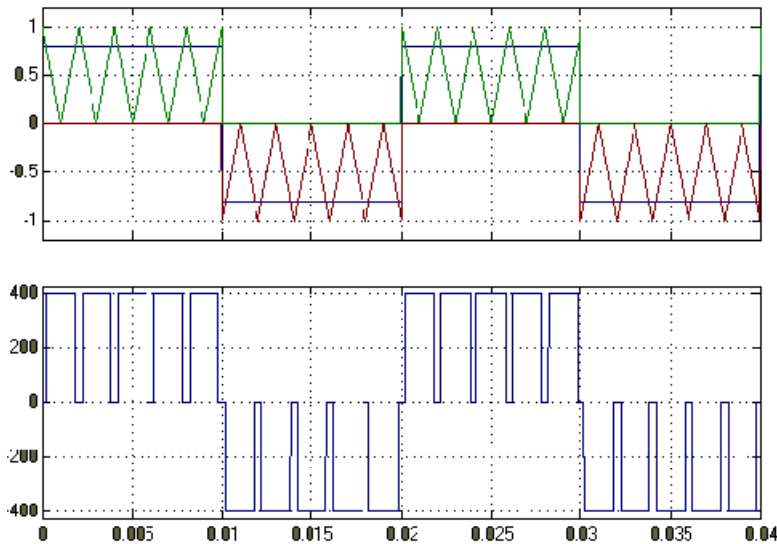
*Voltage and Current Harmonic Limits* According to IEEE 519, harmonic voltage distortion on power systems 69 kV and below is limited to 5.0% total harmonic distortion (THD) with each individual harmonic limited to 3%. The current harmonic limits vary based on the short circuit strength of the system they are being injected into. Essentially, the more the system is able to handle harmonic currents, the more the customer is allowed to inject. The harmonic current limits specify the maximum amount of harmonic current that the customer can inject into the utility system. The utility is responsible for providing a clean (low distortion) voltage to the customer. The utility can only be fairly judged, however, when the customer meets the harmonic current limits. Otherwise, the customer may be guilty of causing the voltage distortion himself. The intent of IEEE 519 is stated in its Forward: This recommended practice recognizes the responsibility that users have not to degrade the voltage of the utility serving other users by requiring nonlinear currents from the utility. It also recognizes the responsibility of the utilities to provide users with close to a sine wave of voltage [5]. Using PWM control per cycle reduces the load current distortion induced in phase controlled circuits. Synchronization with the supply mains is not required. The THD can be reduced employing specified controlled PWM pattern. At high switching frequency, the largest harmonic can be reduced using simple capacitive filtering.

### **Simulation**

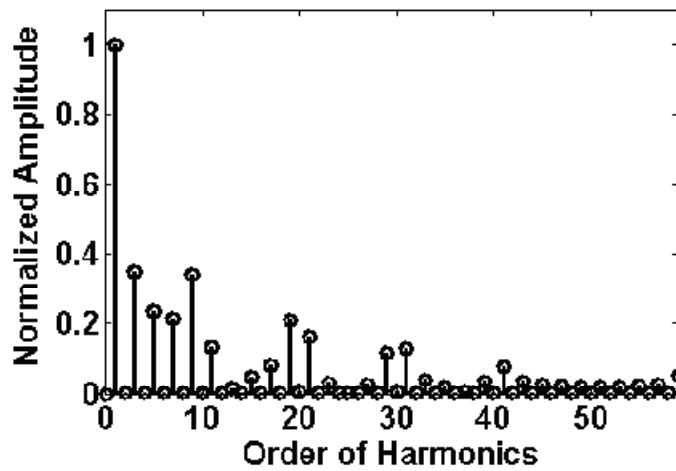
The Pulse Width Modulation techniques have been simulated in the MATLAB software and results of waveform and its FFT is shown in fig. 2 to 7. The different configuration of the Pulse Width Modulation technique like Multi pulse Width Modulation, Unipolar Pulse Width Modulation, Trapezoidal Pulse Width Modulation, Modified Pulse Width Modulation and Selective Harmonics Elimination Techniques. Best method out of these is found out and is modified Pulse Width Modulation techniques. The result is shown in table 1. The authors have suggested the different techniques of PWM for improving power quality.

**Table 1:** Comparison of PWM Techniques.

Parameter Peak	Fundamental	THD%	Dominating Harmonics
Square Wave	1.271V DC	48.3	3rd, 5th, 7th
Multi pulse PWM	1.23V DC	38.5	3rd, 5th, 7th
Uni polar PWM	0.866V DC	3.76	43rd and 45th
Trapezoidal PWM	1.05 V DC	38.5	3rd, 5th, 7th
Selective Harmonics	1.18 V DC	4.88	27th
Modified SPWM	0.866V DC	3.76	43rd and 45th
AC PWM	1.10V DC	22.35	19th and 21st



**Figure 2(a):** Multi pulse PWM i/p & o/p waveform.



**Figure 2 (b):** FFT of multi pulse PWM scheme.

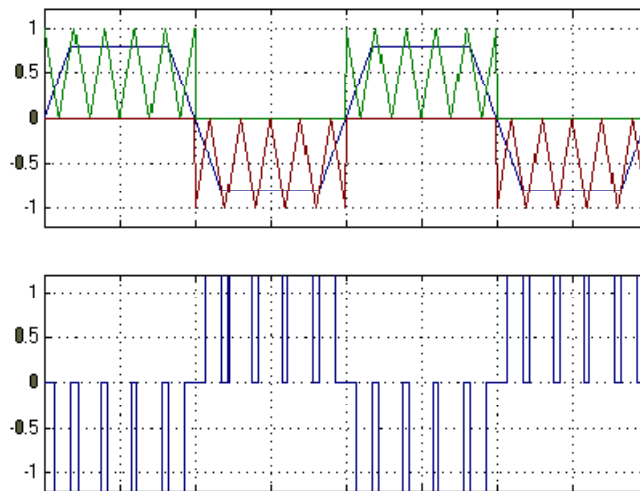


Figure 3 (a): Trapezoidal PWM i/p & o/p wave forms.

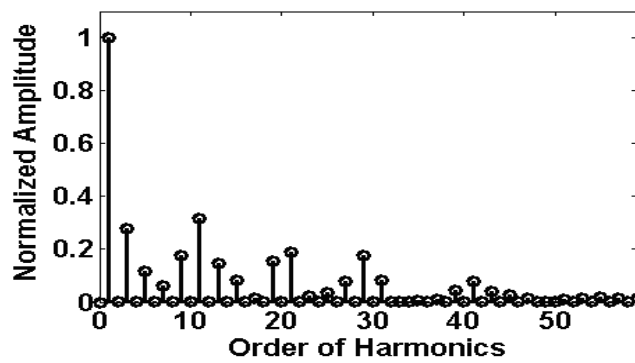


Figure 3 (b): FFT of Trapezoidal PWM scheme.

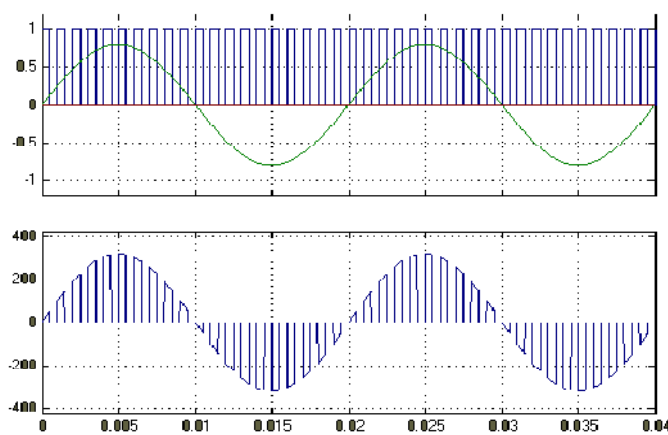


Figure 4 (a): AC voltage PWM i/p & o/p waveform.

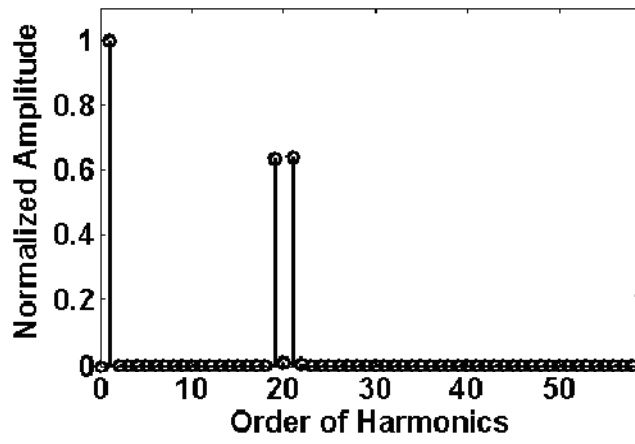


Figure 4 (b): FFT of AC voltage PWM scheme.

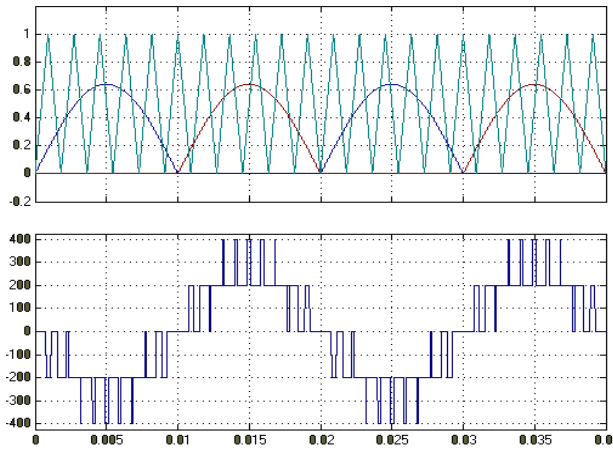


Figure 5 (a): Unipolar PWM i/p & o/p wave forms.

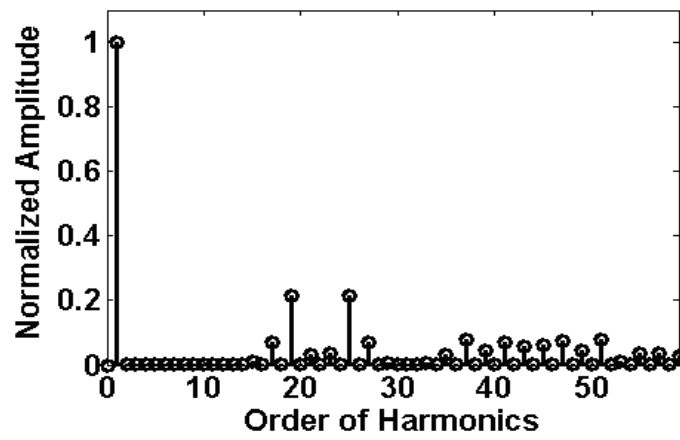


Figure 5 (b): FFT of Unipolar PWM scheme.

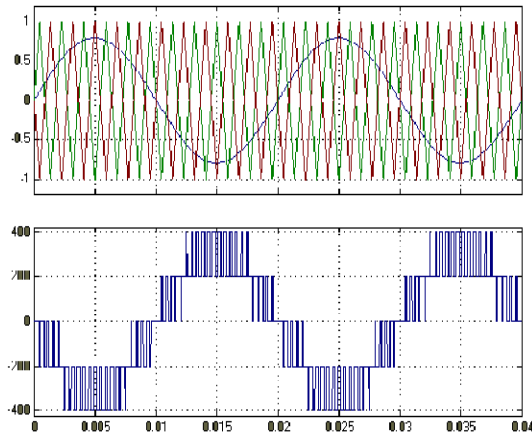


Figure 6 (a): Modified SPWM i/p & o/p wave forms.

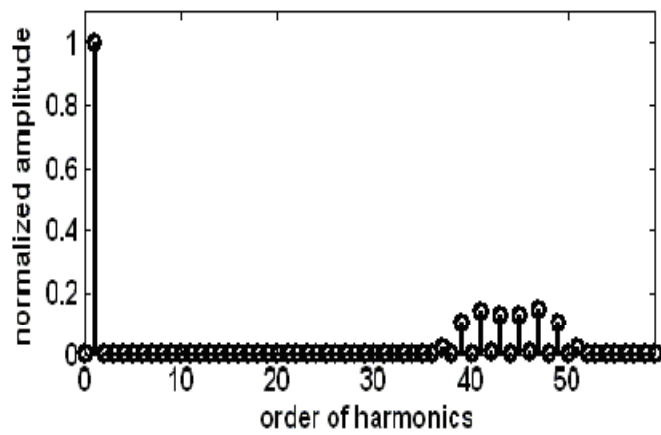


Figure 6 (b): FFT of modified SPWM scheme.

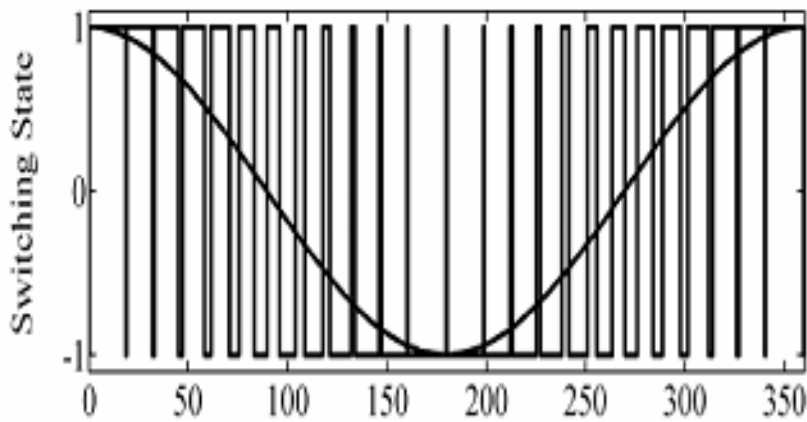
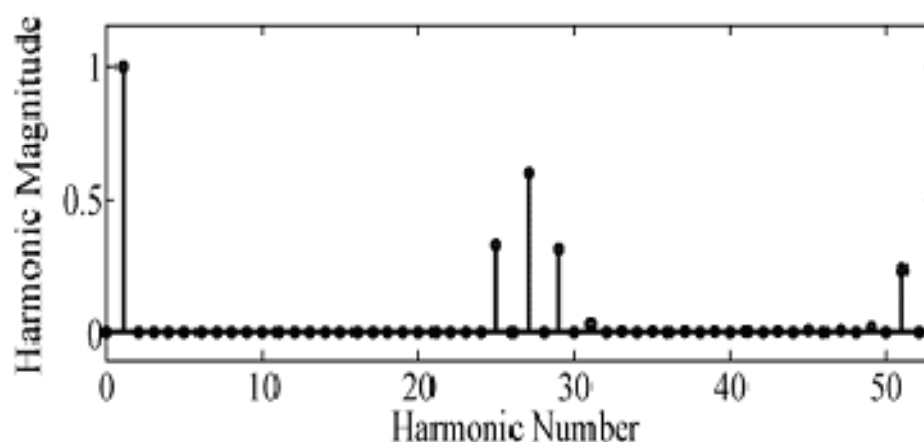


Figure 7(a): i/p & o/p waveforms for selective harmonics Elimination PWM method





**Figure 7 (b):** FFT of selective harmonics elimination PWM Scheme

## Conclusion

The authors have reviewed the different paper on the PWM and the simulated on the MATLAB. PWM technique is very useful in improving the power quality. The different PWM technique here is considered and the output is given in the form of waveforms. Out of all PWM technique the modified SPWM technique is best. The peak fundamental output of the techniques is 0.8 PU, the THD is well below the limit 3.76 % and Dominating Harmonic lies at 43rd and 45<sup>th</sup> order of the Harmonic.

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