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Review of methods for Voltage Control in AC Inverters

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ABSTRACT: *DC-AC inverters are electronic devices used to produce mains voltage AC power from low voltage DC energy (from a battery or solar panel). This makes them very suitable for when you need to use AC power tools or appliances but the usual AC mains power is not available. Examples include operating appliances in caravans and mobile homes, and also running audio, video and computing equipment in remote areas. Most inverters do their job by performing two main functions: first they convert the incoming DC into AC, and then they step up the resulting AC to mains voltage level using a transformer. And the goal of the designer is to have the inverter perform these functions as efficiently as possible. So that as much as possible of the energy drawn from the battery or solar panel is converted into mains voltage AC, and as little as possible is wasted as heat. One of the key factors pertaining to AC inverters is output regulation. We take for granted the fact that our mains power is very well regulated. So you can plug almost any appliance into a standard point outlet, and it will operate correctly. That's because the electricity supplier has enormous generating plants, with automatic regulation systems to keep the mains voltage and frequency very close to constant, despite load variations of many megawatts. Inevitably you can't get this kind of performance from a much smaller electronic inverter, connected to a modest battery or solar panel as the energy source. However most modern inverters can provide reasonably good regulation for loads of up to their rated capacity (given in watts) assuming of course that they are running from a well-charged battery.*

In this paper a brief review of most widely used methods for voltage regulation in AC inverters is explain and a mutual comparison is also drawn.

Keywords : *AC Inverters, PWM Inverters, Voltage Regulation*

I. INTRODUCTION

A power inverter, or inverter, is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).[1]The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source. A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

II . APPLICATIONS

- DC POWER SOURCE USAGE

Inverter designed to provide 115 V AC from the 12 V DC source provided in an automobile. The unit shown provides up to 1.2 amperes of alternating current, or enough to power two sixty watt light bulbs.

An inverter converts the DC electricity from sources such as batteries or fuel cells to AC electricity. The electricity can be at any required voltage; in particular it can operate AC equipment designed for mains operation, or rectified to produce DC at any desired voltage.

- UNINTERRUPTIBLE POWER SUPPLIES

An uninterruptible power supply (UPS) uses batteries and an inverter to supply AC power when mains power is not available. When mains power is restored, a rectifier supplies DC power to recharge the batteries.

- ELECTRIC MOTOR SPEED CONTROL

Inverter circuits designed to produce a variable output voltage range are often used within motor speed controllers. The DC power for the inverter section can be derived from a normal AC wall outlet or some other source. Control and feedback circuitry is used to adjust the final output of the inverter section which will ultimately determine the speed of the motor operating under its mechanical load. Motor speed control needs are numerous and include things like: industrial motor driven equipment, electric vehicles, rail transport systems, and power tools..The generated gate pulses are given to each switch in accordance with the developed pattern and thus the output is obtained.

- IN REFRIGERATION COMPRESSORS

An inverter can be used to control the speed of the compressor motor to drive variable refrigerant flow in a refrigeration or air conditioning system to regulate system performance. Such installations are known as inverter compressors. Traditional methods of refrigeration regulation use single-speed compressors switched on and off periodically; inverter-equipped systems have a variable-frequency drive that control the speed of the motor and thus the compressor and cooling output. The variable-frequency AC from the inverter drives a brushless or induction motor, the speed of which is proportional to the frequency of the AC it is fed, so the compressor can be run at variable speeds—eliminating compressor stop-start cycles increases efficiency. A microcontroller typically monitors the temperature in the space to be cooled, and adjusts the speed of the compressor to maintain the desired temperature. The additional electronics and system hardware add cost to the equipment, but can result in substantial savings in operating costs.

➢ POWER GRID

Grid-tied inverters are designed to feed into the electric power distribution system. They transfer synchronously with the line and have as little harmonic content as possible. They also need a means of detecting the presence of utility power for safety reasons, so as not to continue to dangerously feed power to the grid during a power outage.

III VOLTAGE CONTROL METHODS

The various methods for the control of output voltage of inverters can be classified as:

(a) External control of ac output voltage
(b) External control of dc input voltage
(c) Internal control of the inverter.

The first two methods require the use of peripheral components whereas the third method requires no external components. Mostly the internal control of the inverters is dealt, and so the third method of control is discussed in great detail in the following section. Output voltage from an inverter can also be adjusted by exercising a control within the inverter itself[2]. The most efficient method of doing this is by pulse-width modulation control used within an inverter. This method is called the internal voltage control of the inverter

a) External Control of ac Output Voltage

In this type of control as shown in Figure 2.1 an ac voltage controller is used to control the output of inverter. Through the firing angle control of ac voltage controller the voltage input to the ac load is regulated.

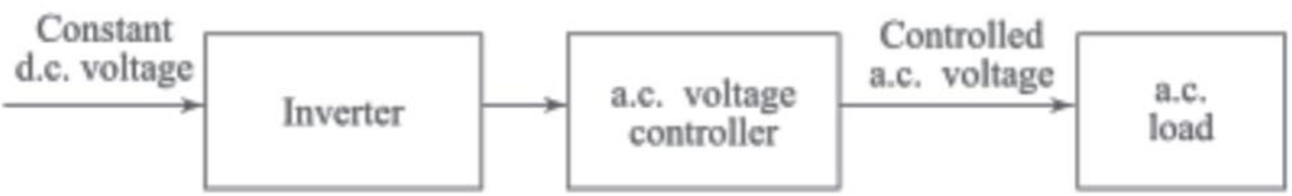

Figure 1: External control of ac output voltage

b) External Control of dc Input Voltage

When the available voltage souecr is ac then the dc voltage input to the inverter can be controlled through fully controlled rectifier, uncontrolled rectifier and chopper, ac voltage controller and uncontrolled rectifier as shown in Figure 2(a),(b) and (c).

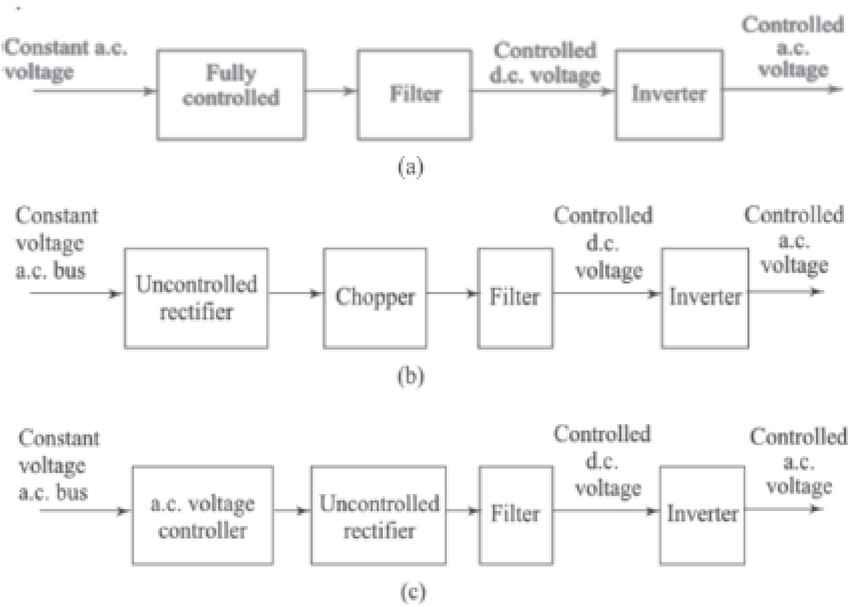

Figure 2: External control of DC input voltage

c) Internal Control of Inverter

Inverter output voltage can also be adjusted by exercising a control within the inverter itself. Pulse width modulation[3] is the most commonly used technique to control the output voltage of inverter, the various techniques are:

- Single-Pulse-Width-Modulation
- Sinusoidal Pulse Width Modulation (SPWM)
- Multiple Pulse Width Modulation
- Modified Sinusoidal PWM (MSPWM)

Single PWM:

In single pulse width modulation control, there is only one pulse per half cycle and the output rms voltage is changed by varying the width of the pulse. The gating signals of single pulse-width modulation are shown in Figure 3. The gating signals are generated by comparing the rectangular control signal of amplitude Vc with triangular carrier signal Vcar. The frequency of the control signal determines the fundamental frequency of ac output voltage. The amplitude modulation index is defined as:

$$m_a = \frac{V_c}{V_{car}}$$

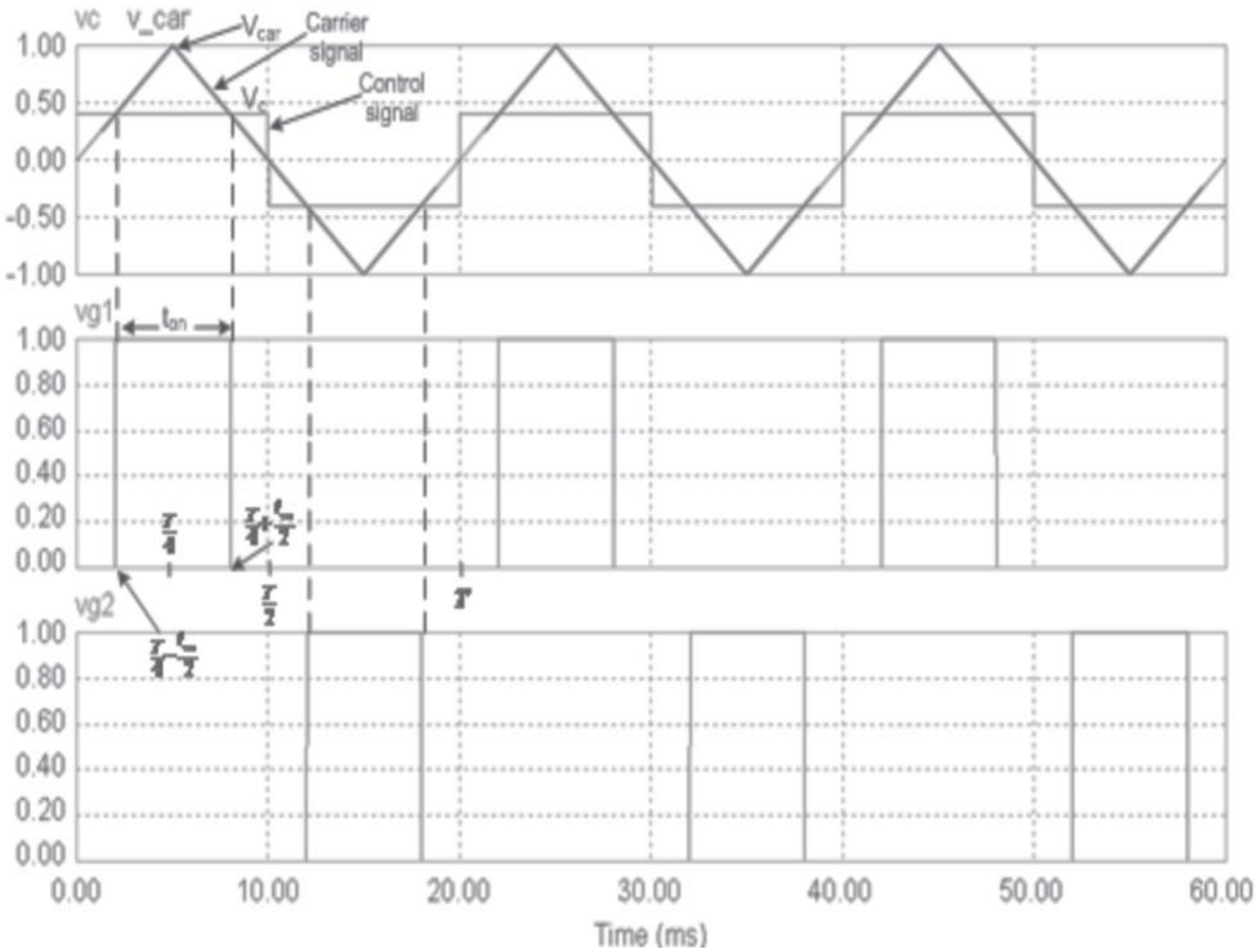

Figure 3: Gating signals of Single pulse-width modulated inverter

Sinusoidal Pulse Width Modulation (SPWM)

In sinusoidal pulse width modulation there are multiple pulses per half-cycle and the width of the each pulse is varied with respect to the sine wave magnitude. Figure4 shows the gating signals and output voltage of SPWM with unipolar switching. In this scheme, the switches in the two legs of the full-bridge inverter are not switched simultaneously, as in the bi-polar scheme.

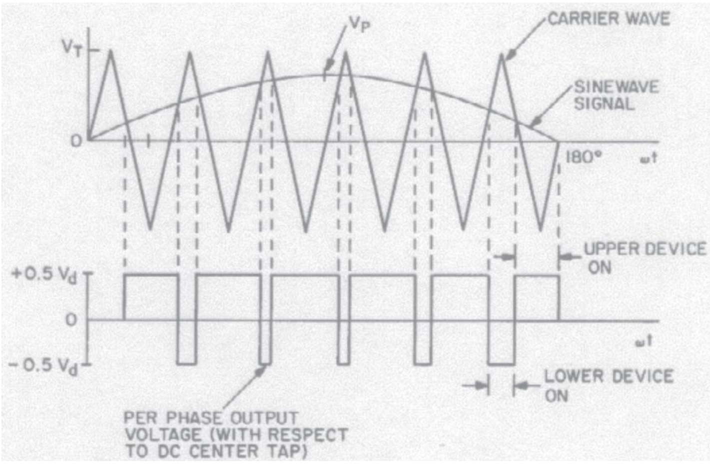

Figure 4: Sinusoidal Pulse Width Modulation

Multiple Pulse Width Modulation

Principle: Multiple pulses are used to reduced the harmonic contents and to control the output voltage. the width of all the pulses is same. In this modulation there are multiple number of output pulses per half cycle and all pulses are of equal width. The gating signals are generated by comparing a rectangular reference with a triangular reference. The frequency of the reference signal sets the output frequency (fo) and carrier frequency (fc). The number of pulses per half cycle is determined by p = fc/2f0

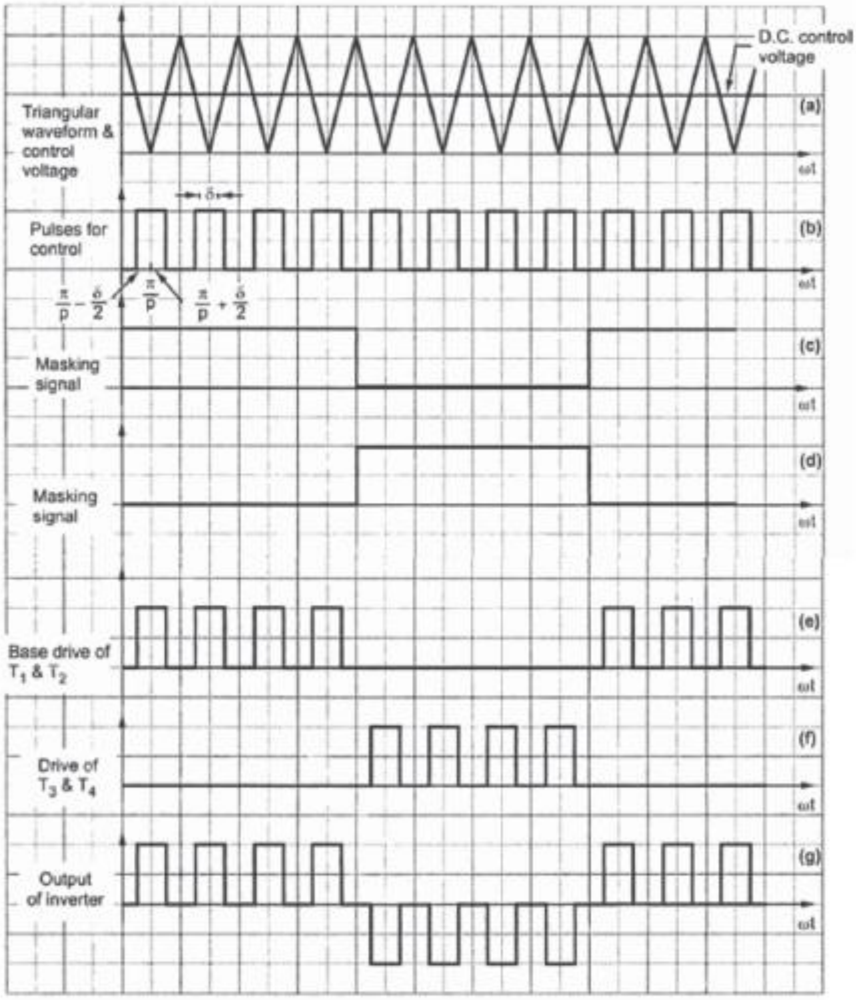

Figure 5: Waveforms of Multiple Pulse Width Modulation

Modified Sinusoidal PWM (MSPWM)

The widths of the pulses near peak of the sine wave do not change much when modulation index is changed. Hence carrier is suppressed at +30° and –30° in the neighborhood of peak of sine wave. Such scheme is shown in Figure 2.6.

Observe that the triangular wave is present for the period of first 60° and last 60° of the half cycle of sine wave. The middle 60° of the sine wave do not have the triangular wave. Hence the generated PWM has less number of pulses. The rms value is more for the same modulation index. The harmonic contents are also reduced. This control scheme also reduced switching losses. The implementation of this scheme is relatively complex then sine PWM.

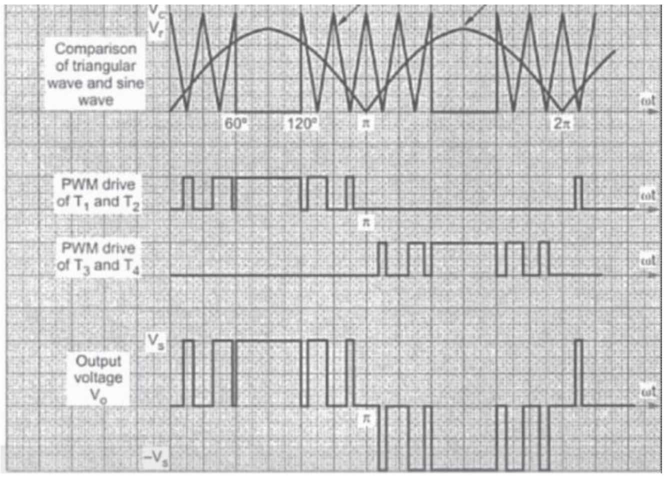

Figure 6: Waveforms of Modified Sinusoidal PWM

IV CONCLUSION

The paper presnts a review of various Voltage control Mechanisms in AC Inverters. Here the PWM control strategies were discussed in detail. Pulse width modulation is the most adaptable method which control the output voltage of the inverter by exercising the internal control of the inverter . the various PWM technique include:

1. Single pulse modulation.
2. Multiple pulse width modulation.
3. Sinusoidal pulse width modulation.
4. Modified sinusoidal pulse width modulation.

We also note that though there is various advantages of PWM techniques, it also poses some of the limitations the most important limitation is that by the implementation of these techniques the switching loss in the inverter Increases.

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