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ANALYSIS AND MODULATION OF SINGLE PHASE VOLTAGE SOURCE INVERTERS

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ABSTRACT
In this paper are presented and analysed techniques for modulating a single phase VSI using new perspectives of the fundamental principles of PWM which are dependent of inverter topology and modulation strategy. For analyse are taken two cases which affect the harmonic performance of PWM systems. The modulation schemes aim to create trans of switched pulses which have the same fundamental volt second average as a target reference waveform at any instant. The major difficulty with these trans of switched pulses is that they also contain unwanted harmonic components which should be minimized. The simulations are done using the MATLab software.
Keywords: Voltage Source Inverter - VSI, Inverter topology, Pulse Width Modulation Strategy – PWM Strategy.

1. INTRODUCTION
In a PWM VSI circuit, adjusting the output signal is achieved with the help of the control signal acting on the switches component. Choosing the order of the sequences, the number of switching, the width of pulses, etc. directly affect the quality of output voltage and current in the inverter. Therefore, the choice of modulation strategy and require a special care in their design [1]. Besides, the algebraic analysis method simplifies the comparison of the modulator for different strategies, based on the results form the best selected and designed. VSI PWM circuit is a good demand for the trade, and has consistently attracted the attention of many researchers worldwide. Switching signals are determined in an additional block known as modulation block, which are generating the reference voltage and carrier signal. PWM strategy based on the carrier signal can operate with high switching frequency and they provide high quality waveform and implementation advantages. PWM strategy based on the wave carrying give the desired wave shapes for the output voltage [2]. The choice of PWM strategy directly affects the efficiency of the inverter, the quality of waveform, and linearity of the voltage. The principle of inverter work is based primarily on switching semiconductor power components, and therefore these circuits introduce harmonic components of current and voltage in the source system and output. These components cause the output voltage distortion, harmonic generation components in the supply system and interference with communication circuits [3]. The major difficulty with these trans of switched pulses is that they also contain unwanted harmonic components which should be minimized. Hence for any PWM scheme, a primary objective can be identified which is to calculate the converter switch ON times which create the desired target output voltage. The secondary objective for a PWM strategy is to determine the most effective way of arranging the switching processes to

minimize unwanted harmonic distortion (THD), switching losses, or any other specified performance criterion.

2. TOPOLOGY OF A SINGLE PHASE INVERTER

One of the most important performances of power electronic circuits considered their efficiency of conversation. However, an example of regulation can be achieved by taking a one-phase voltage source inverter as shown in Fig. 1. Typical waveforms for this circuit are shown in Figure 2. For determining the composition of the harmonic voltages and currents used decomposition in the Fourier Series.

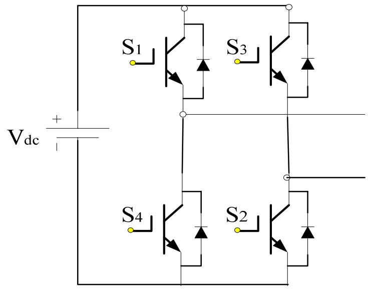

Figure 1. A single phase voltage source inverter using power transistors (IGBT)

The resulting waveform is often called sinusoidal modified so that the effective value of output voltage at the fundamental frequency not exceeding 230 V and more devices are able to work with it without any problem. Rectangular pulses containing many harmonic components. When inverter works with 50 Hz input frequency, the voltage waveforms at the output of circuit except basic harmonic will also contain higher harmonic component 3f, (150 Hz, 250 Hz) and so on then harmonic multiples of the fundamental frequency. These harmonics can disrupt work of some equipment.

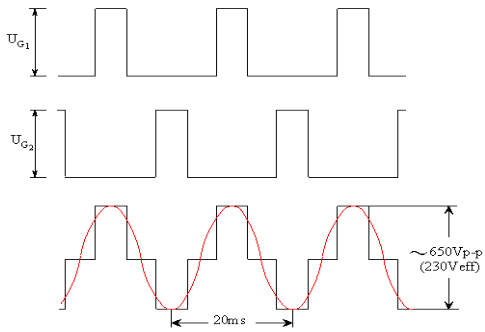

Figure 2. Waveforms of transistors signals S_1 and S_2: modified sinusoid (black appearance), and closer sinusoid (output red color).

For the analysis will be used to triangular waveform and a reference wave signal as the magnitude of 0 V to 1 V. To win the PWM signal will get different duty cycle from 0 to 100%. Taking the frequency of interruption of value and different duty cycle, waveforms are presented. This working method is very suitable for working at the limit cycle from 5% to 95%. Simulated results are presented in figure 3. However, if the reference signal exceeds 100% or cross fall 0%, then the result will be a PWM signal all the time ON or OFF. This condition is called over-modulation. This regime should be avoided by special conditions to control the signal.

$$D = 80\ \%,\ f_c = 1\ kHz,\ v_c(t) = \frac{a\cos\left(\cos\left(2\pi f_c t\right)\right)}{\pi}$$

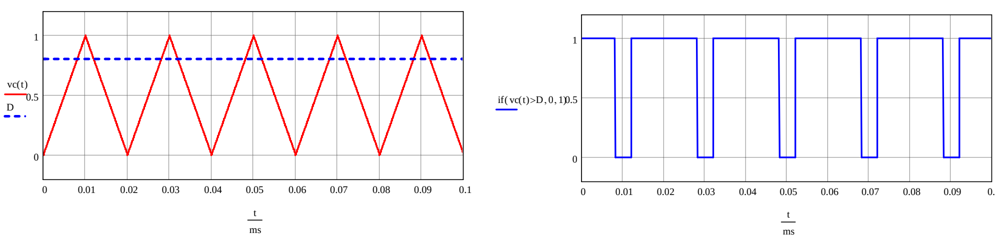

Figure 3. Triangle waveform and the PWM signal for 80% of duty cycle.

3. OPERATIONAL PRINCIPLE AND SIMULATION RESULTS

As an assistant circuit used to generate control signals to the gates g_1 and g_3 is the PWM modulator. The reference waveform V_{ref} produces pulses of signal in the frequency reference $f_{ref}=p*f_0$ which p is the number of pulses for half cycle, and f_0 is the frequency of the output voltage. Carrier waveform V_c is compared with the reference waveform V_{ref}, the ratio $m=V_{ref}/V_c$ is known as the modulation index. Note that controlling the modulation index therefore controls the amplitude of the applied output voltage. To be more clearly, we compare the cases when inverter is composed with 2 and 4 components (IGBT transistor).

First case: For analyses we use single phase inverter with PWM, which is composed of two switching components. Fundamental tension for inverter is $V_2=m/2*V_{dc}=0.8/2*400=160$ V. Inverter is controlled by the PWM generator. In input of inverter operating dc voltage V_{dc} = 400 V, carrier wave frequency is adjusted to be 1 kHz (2 kHz) and modulation index, m = 0.8.

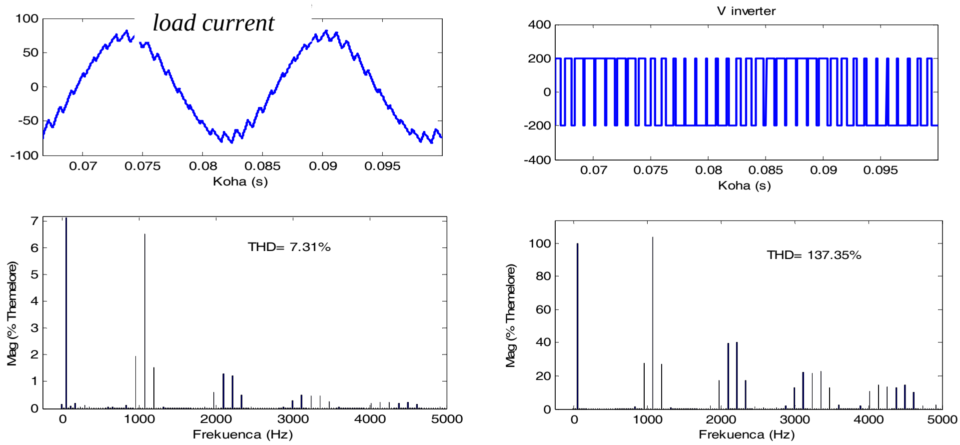

Figure 4. Waveform of the load current and voltage in the inverter in the carrier frequency 1 kHz.

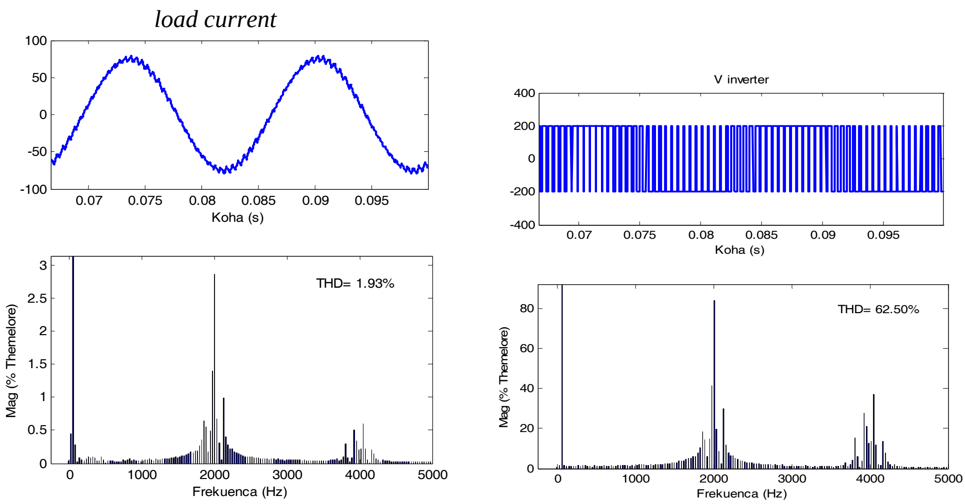

Figure 5. Waveforms of the load current and voltage in the inverter in the carrier frequency 2 kHz

The second case: For analysis use single phase voltage source inverter with PWM, this is composed of four switching components. Fundamental tension inverter is $V_3 = m*V_{dc} = 0.8*400 = 320\,V$ Converter is controlled by the PWM generator. In input of inverter operating dc voltage Vdc = 400 V, carrier frequency is adjusted to be 1 kHz (2 kHz) and modulation index m = 0.8.

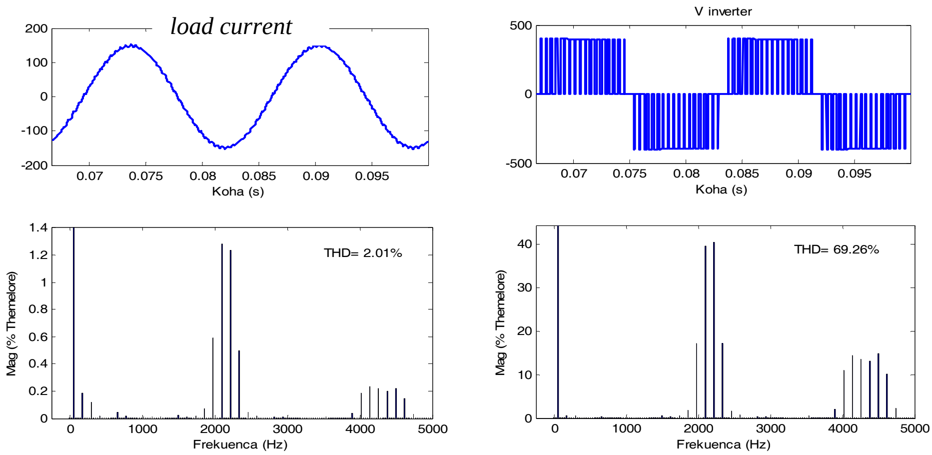

Figure 6. Waveform of the load current and voltage in the inverter in the carrier frequency 1kHz.

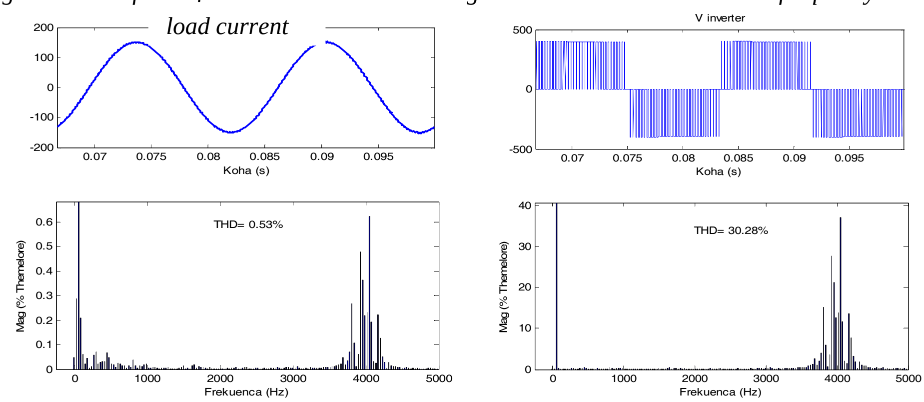

Figure 7. Waveform of the load current and voltage at the inverter for carrier frequency 2 kHz.

4. CONCLUSIONS

From analysis of model derived can conclude that: In the voltage waveform at the output, we see that the output unwanted harmonic components are present. Similarly, the load currents contain harmonic component of high level. As a result of the generation of these components also appear distortion harmonics output voltage and current in the load. As a result, the load currents and voltage in the inverter which contains four components, is "clean". For the PWM Inverter which contains 2 components for carrier frequency of 1 kHz (fig. 4), we see that distortion (THD) for load current is 7.3%, compared with only 2.01% for inverter which contains 4 (figure 6) components. For the PWM Inverter which contain 2 components for carrier frequency of 2 kHz. (fig. 5), we see that distortion (THD) for the load current is 1.93%, compared with only 0.53% for inverter which contains four components (Fig. 7).

5. REFERENCES

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