СИМУЛИРАНЕ НА ТРИФАЗЕН ИНВЕРТОР ЗА КВАЗИ-СИНУСОИДАЛНО НАПРЕЖЕНИЕ

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Резюме: *Разглежда се инвертор, който синтезира трифазно квази-синусоидално напрежение към активен товар чрез метод на контролирани импулси с широчинно-импулсна модулация. Постига се линейна зависимост на активната мощност на товара, амплитудата на първата хармонична на напрежението и ъгъла на регулиране. Извършени са симулации на инвертора за постигане на квази-синусоидно напрежение на изхода на преобразувателя. Съставен е SIMULINK модел на трифазен инвертор за промишлени нужди с ограничени изкривявания. Полученото трифазно квази-синусоидално напрежение не е идеално, но води до значително намаляване на хармониците в товара на инвертора. Това осигурява по-ниско ниво на електромагнитните излъчвания и усъвършенства електромагнитната съвместимост.*
Ключови думи: *симулиране, трифазен инвертор, PWM, SIMULINK модел, редуцирани изкривявания, електромагнитна съвместимост.*

SIMULATION OF THREE-PHASE INVERTOR FOR QUASI-SINUSOIDAL VOLTAGE

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Abstract*: A inverter that synthesizes three-phase quasi-sinusoidal voltage supply to the active load through method of controlled pulses with pulse-width modulation is investigated. The linear dependence of active power in load and regulation angle, the first harmonic amplitude of load voltage and regulation angle, respectively is achieved. Simulations of the converter to achieve a quasi-sinusoidal voltage in the converter output are carried out. SIMULINK model of the three-phase converter for industrial purpose with reduced distortion is composed. The obtained quasi-sinusoidal voltage is not ideal one, but leads to a significant reduction of harmonics in the load of the converter. This ensures lower level of electromagnetic interference and improves electromagnetic compatibility.*
Keywords: *simulation, three-phase inverter, PWM, SIMULINK model, reduced distortion, electromagnetic compatibility.*

1. INTRODUCTION

PWM power control systems are easily realizable with semiconductor switches [4]. Almost no power is dissipated by the switch in either on or off state. Pulse width

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modulation PWM is used in a variety of applications including sophisticated control circuitry [1, 2]. PWM is used in many industrial appliances for controlling the voltage of the DC-AC inverters using the full bridge mode PWM feature. Modern semiconductor switches such as MOSFETs or insulated-gate bipolar transistors (IGBTs) are well suited components for high-efficiency controllers [3, 6]. By switching voltage to the load with the appropriate duty cycle, the output will approximate a voltage at the desired level. There are more sophisticated methods to decrease harmonics. The switching noise is usually filtered with an inductor and a capacitor or both.

2. DESCRIPTION OF THE MODEL

The Simulink model of the studied quasi-sine voltage inverter is shown in Fig.1.
The model of three-phase inverter consists of commutator, filter, load and control block.
The commutator contains model of three-phase bridge inverter. The filter contains the elements: inductance and filtering capacitor and resistor.
SPWM techniques are applied to inverters in order to obtain a sinusoidal output voltage with minimal unwanted harmonics. PWM inverter is considered as a voltage source inverter (VSI). Semiconductor switching devices (SW1–SW6) of the inverter are controlled by PWM signals to obtain three-phase quasi sinusoidal AC voltages of the desired magnitude and frequency at the inverter output. In most cases, control design for a three-phase PWM converter involves choice of modulation strategy, which corresponds to an open-loop converter control. The instantaneous voltage control scheme is applied to the proposed circuit.

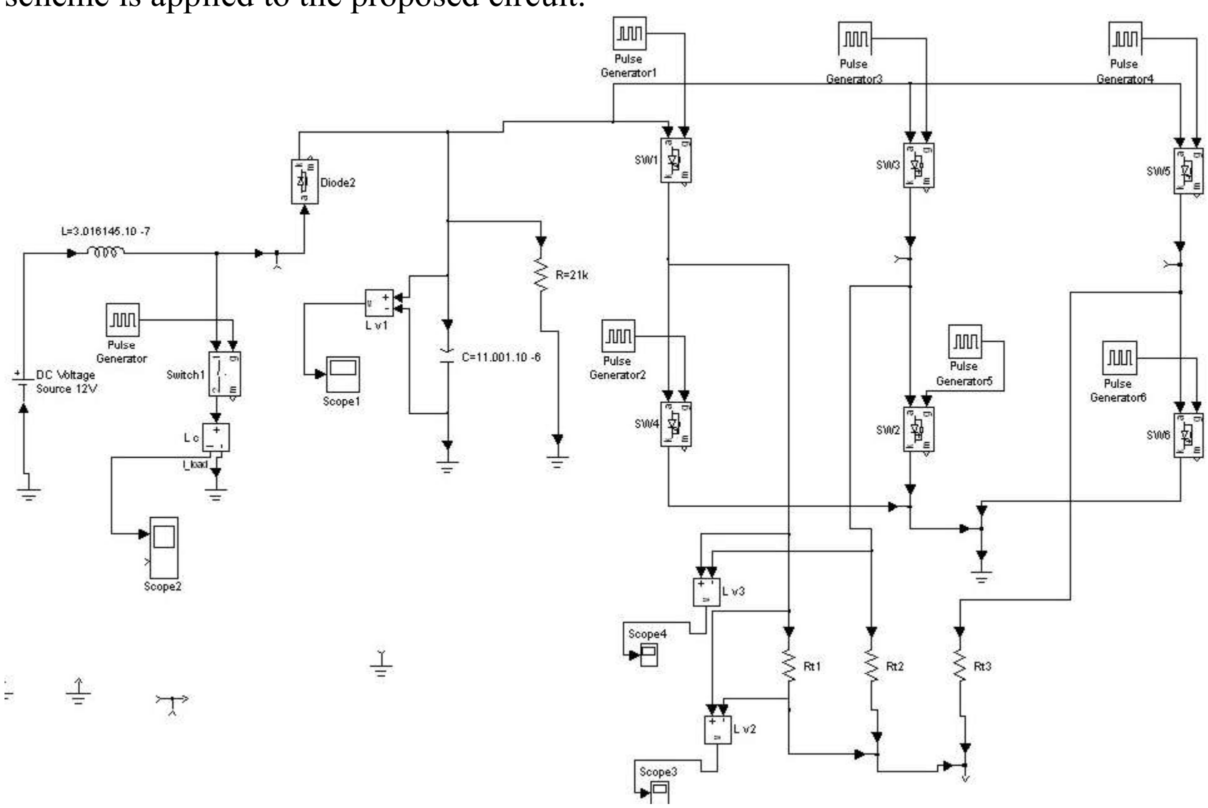

Figure 1. Simulink model of the three-phase invertor.

3. RESULTS OF THE SIMULATION

The simulations are performed at different parameters of load /resistance and inductance/ and different power of consumer.
The nominal full power of investigated inverter is 1800 VA. The load connected to the output is active or inductive-active, with compensation of reactive power.
The analysis and simulations allows determining the parameters of the sinusoidal mode in three-phase blocks of control and load.

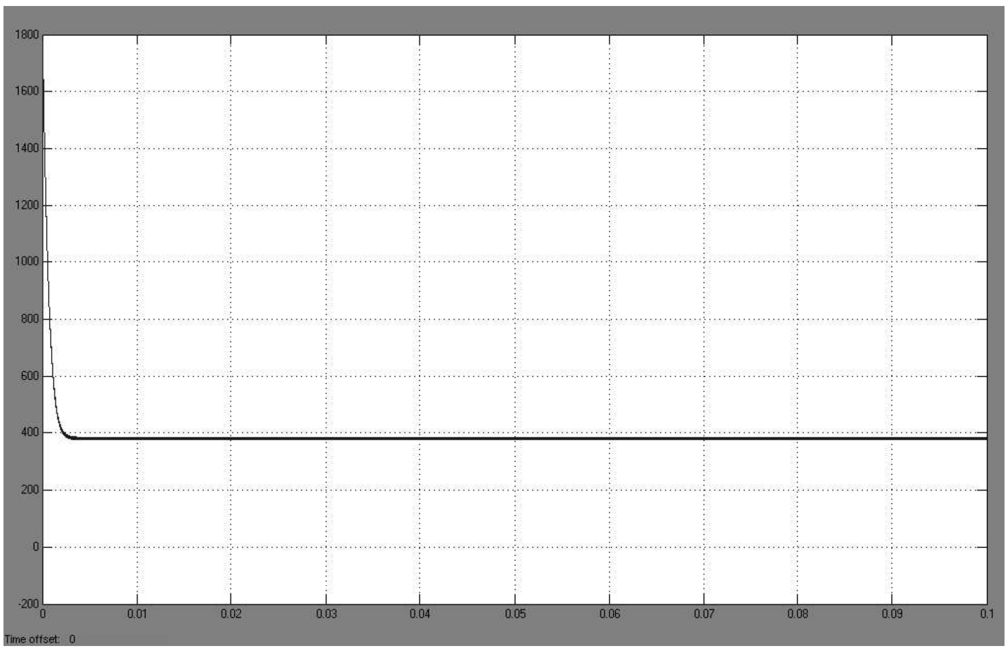

Figure 2. Transient process for forming of the voltage in output capacitor.

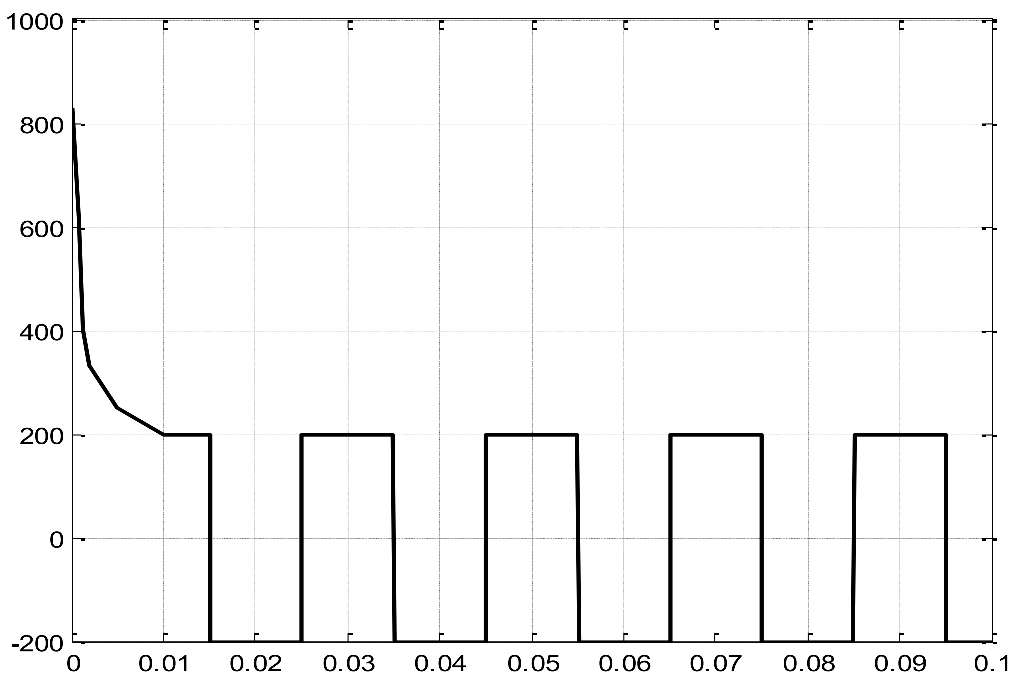

Figure 3. Transient process for forming of output voltage.

First, the transient process for the forming of output voltage is investigated.
The transient process for the forming of voltage in output capacitor of DC-DC group is shown in Fig.2. Using PWM strategy the periodical voltage in the load is synthesized.
The transient process for the forming of output voltage is shown in Fig.3.
The received voltage is a sequence of periodic rectangular pulses. It differs significantly from the desired sinusoid. The harmonic composition of the obtained voltage is too large. An amplitude spectrum of received rectangular voltage is shown in Fig 4.

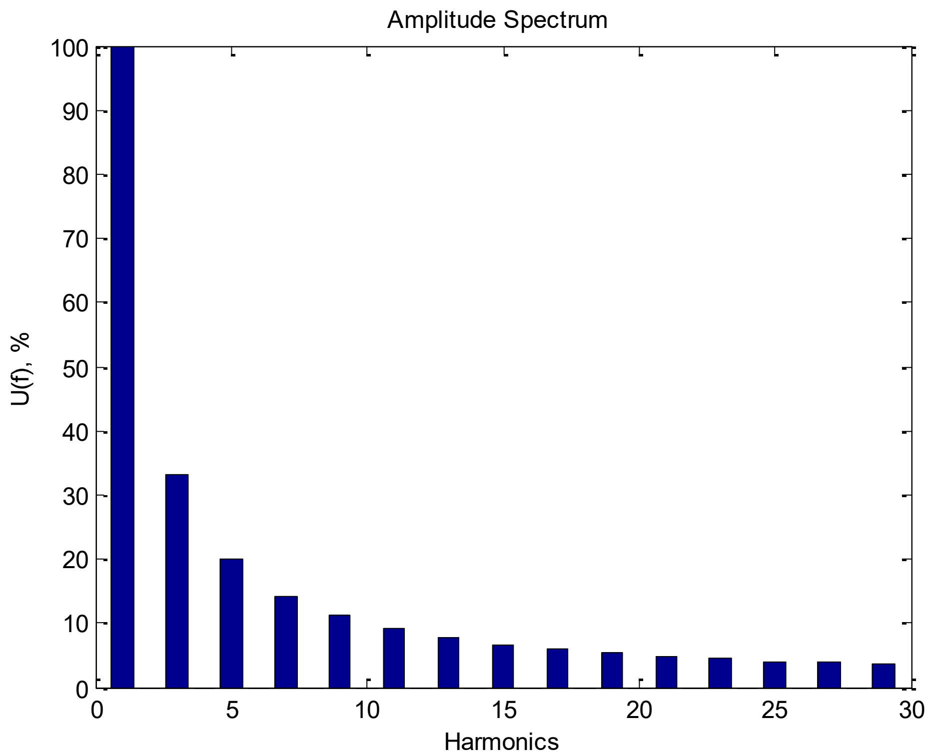

Figure 4. Amplitude spectrum of the synthesized rectangular voltage.

Total Harmonic Distortion THD for the obtained voltage is $k_U = 47\%$.

The high harmonics value is too large and does not satisfy the requirements for these class inverters. Therefore, it is necessary to improve control of the switching keys moment of the bridge inverter.

Next, the transient process for the forming of improved output voltage is investigated.

By changing of modulation strategy and control of three-phase bridge inverter, the new form of output voltage is obtained. The received voltage is a sequence of periodic rectangular pulses also, but it is with more complicated structure. This leads to improvement of the synthesized voltage. The shape of the obtained voltage approximates to the sine wave, and this leads to a reduction of the harmonic composition.

The transient process for the forming of improved output voltage is shown in Fig.5.
The harmonic composition of the obtained voltage decreases. An Amplitude spectrum of improved output voltage is shown in Fig.6.

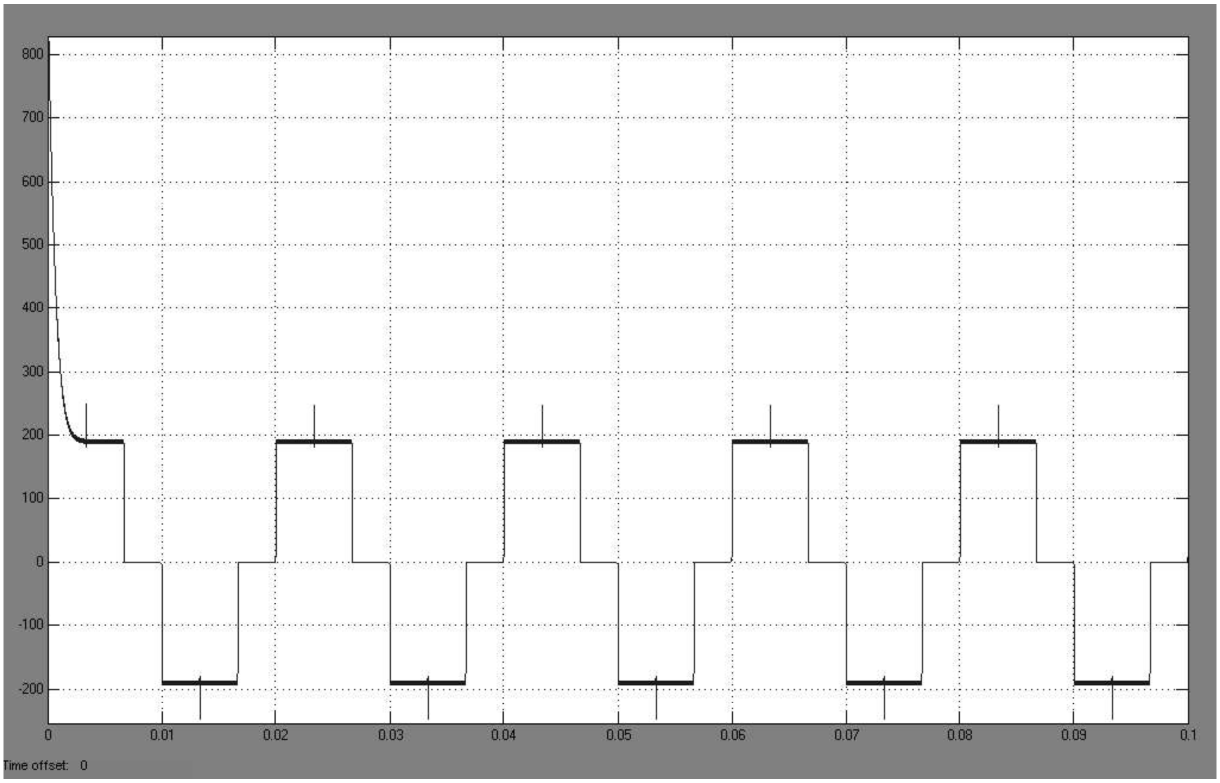

Figure 5. Transient process for forming of the improved voltage.

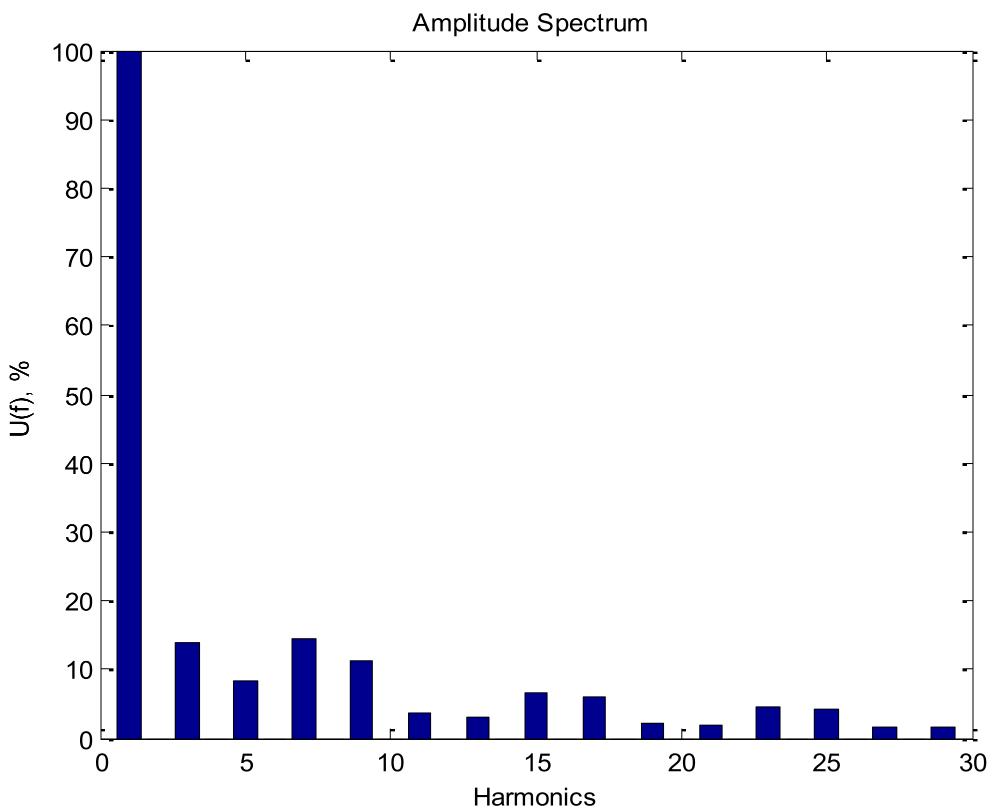

Figure 6. Amplitude spectrum of improved output voltage.

Total Harmonic Distortion THD of the improved output voltage is $k_U = 27\,\%$.

The decreasing of Total Harmonic Distortion is a half, but THD value is still high and does not satisfy the requirements.

The voltage control scheme is improved. The linear dependence of the active power in load and regulation angle, the first harmonic amplitude of load voltage and regulation angle, respectively is achieved.
The transient process for the forming of quasi sinusoidal voltage in the load is shown in Fig.7.

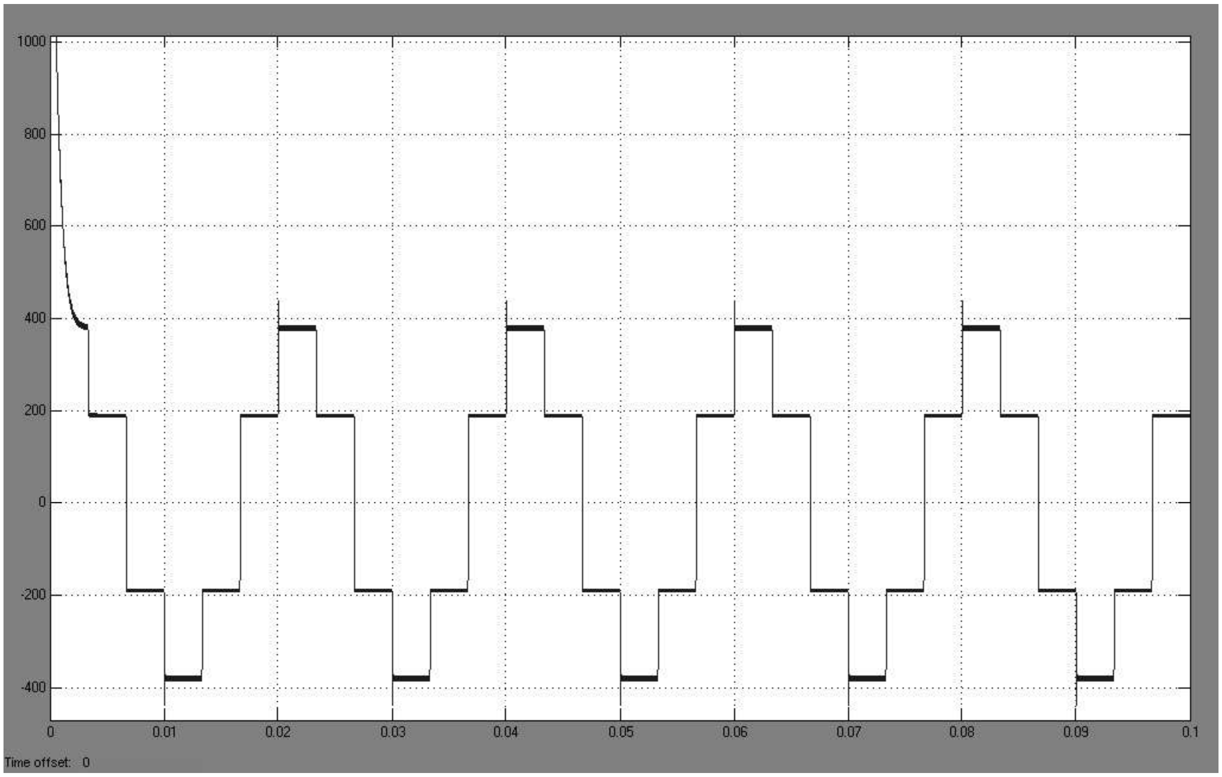

Figure 7. Transient process for forming of the quasi sinusoidal voltage.

An amplitude spectrum of quasi-sinusoidal output voltage is shown in Fig.8.

Total Harmonic Distortion THD of the quasi-sinusoidal output voltage is $k_U = 16\%$. It almost satisfies the standards for electromagnetic compatibility [8, 9].

The level of high harmonics is relative small and the synthesized output voltage of the three-phase invertor approximates sinusoidal wave.

Mitigation of non-eliminated harmonics may change electromagnetic interference negligible [5].

Certainly, achievement of an ideal sine wave is possible [7]. This requires complication of the inverter structure and using of a power inductor and divided transformer in each phase of the three-phase inverter. But this is related to increased costs.

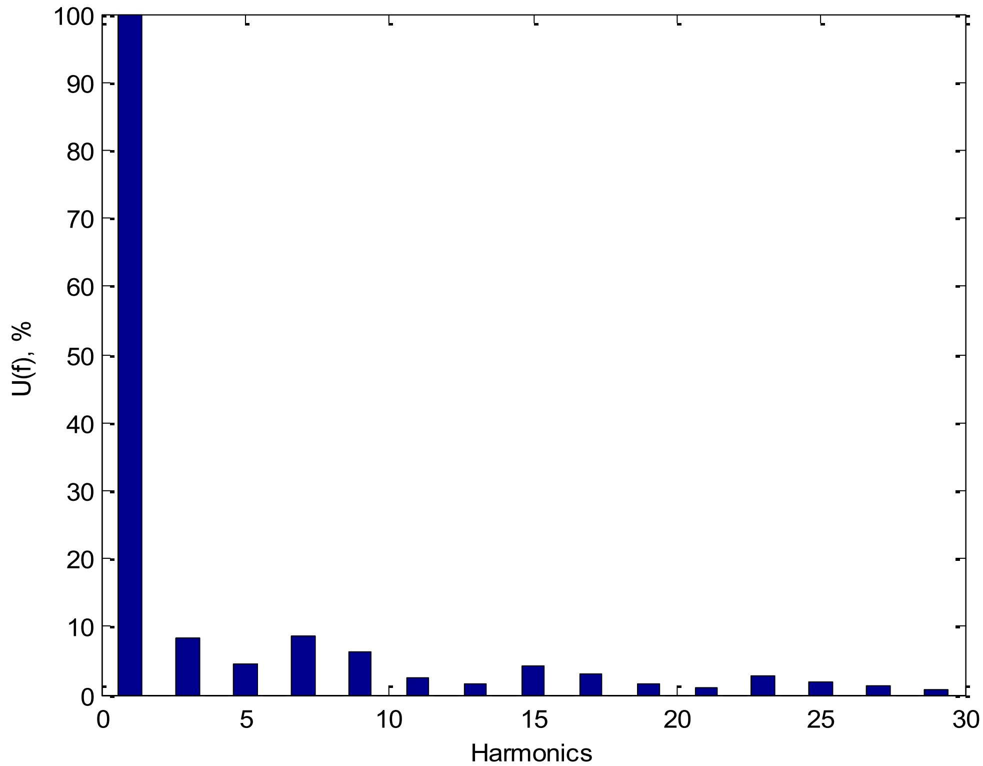

Figure 8. Amplitude spectrum of quasi-sinusoidal output voltage.

4. CONCLUSION

The simulation model of the three-phase invertor is created.
As a result of the analysis and simulations, obtained through SIMULINK of the program package MATLAB, the capabilities of the inverter for the synthesis of output voltage like a sinusoidal wave is proved.
The obtained quasi-sinusoidal voltage is not ideal one, but leads to a significant reduction of harmonics in the converter load. This ensures lower level of electromagnetic interference and improves electromagnetic compatibility.

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