Developing the structure of the quality control system of power supply units in mobile robots

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***Abstract*— The problem of protecting the power supply of separate units of a mobile robot is quite similar to the problems of protecting the electrical mains. In one case we have to re-distribute the electrical energy due to lack of stability in its consumption, in another case we have to re-distribute the energy due to uneven load on separate units of mobile robots. It is impossible to predict, when this load on separate units will change. That is why, it is necessary to use the power quality control system. The article examines the possibility of controlling the quality of the electrical power when it is transmitted pulsewise.**

Keywords—Quality of the electrical power, mobile robot, power consumption, interferences in circuits, modelling, IT

I. INTRODUCTION

The introduction of mobile robots into the country's economy demands accurate study of qulity power supply for their separate units. To ensure this quality, each hardware-software system of robot control is supplied with the independent system of controlling the quaity parameters of the power supply [1]. Let us define the groups of tasks performed by the control system:

1) checking the consistency of the power supplied to each unit with the set parameters [2];

2) determining the reasons for deviation of the quality parameters from the set values [3].

The second task implies determining the interferences in the power supply circuit and finding their causes. The known methods of measurement and control of quality parameters for power supply are aimed at processing the data obtained as a results of measuring electricity supply characteristics [4]. For example, the model in Figure 1, that realizes the calculation of average mean value of voltage Uy and deviation dUy, shows that it is necessary first to accumulate data (block Buffer) and then process them (blocks Calc_Uy and Calc_dUy). To solve the given task, the subsystem was developed that controlled the quality of the power supply of mobile robot units.

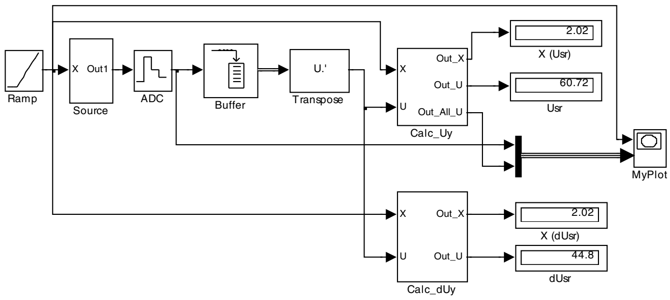

Fig. 1. The model that realizes the calculation of values for averaged voltage U_y

The scheme consists of subsystems listed in Table 1. The suggested model reflects the fact, that the operation of storing the information and its processing are distributed in time. However, the development of the control system for mobile robot units requires the real time control [5].

TABLE I.

№	Block name	Block type	Function
1.	Ramp	Generator of ever-increasing signal value	Realization of growing values (arguument of the function)
2.	Source	Subsystem	Power source
3.	ADC	Zero-Order Hold block Parameters: Simple time - 0.001.	Analogue-digital converter modelling
4.	Buffer	Buffer block Parameters: Output buffer size 10. Buffer overlap 0. Initial conditions 110.	Storing the output values of ADC block
5.	Transpose	Matrix transposition	Transposition of output values of Buffer block.

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6.	Uy	Subsystem	Evaluation of average voltage. Input values: X – argument value (time); Y – function value (voltage); Output values: Out_X – value of time for minimal averaged voltage. Out_Y –minimal value of averaged voltage. Out_All – all values of averaged voltage.
7.	dUy	Subsystem	Calculating the values of voltage deviation. Input values: X – argument value (time); Y – function value (voltage); Output values: Out_X – time value for the minimal voltage deviation. Out_Y – minimal value of voltage deviation.
8.	X(Usr)	Display block	Representation of the time of minimum average voltage
9.	Usr	Display block	Representation of minimum average voltage
10.	X(dUsr)	Display block	Displaying the time of voltage deviation.
11.	dUsr	Display block	Displaying the values of voltage deviation.
12.	MyPlot	XY Graph block	Graphic presentation of results

These control problems can be roughly considered as the spectral analysis problems with fast Fourier transform [6]. The use of Simulink software package allowed to provide reliability of the developed model.

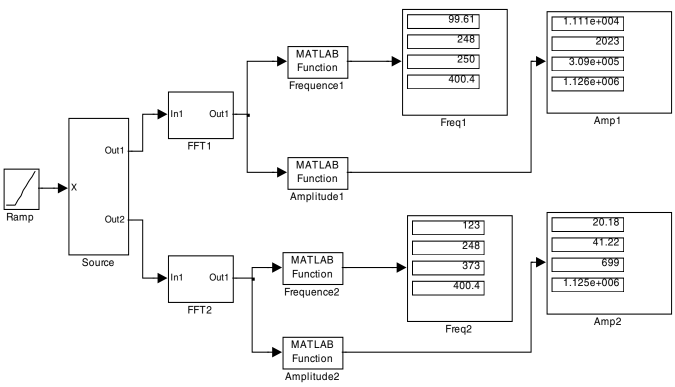

Fig. 2. Simulink-model for determining the frequency components of the signal

Figure 2 shows the Simulink-model for determining the frequency components of the signal. The Source subsystems generates two signals which then undergo, with the help of FFT1 and FFT2 subsystems the fast Fourier transform. Following that, with the help of Freq1 and Freq2 subsystems 4 frequency values are chosen, which showed the maximum amplitude, and with the help of Amp1 and Amp2 these maximum values are determined.

Subsystems FFT1, Freq1 and Amp1 are similar to corresponding subsystems FFT2, Freq2 and Amp2 in structure.

The Simulink-model consists of subsystems listed in Table 2.

TABLE II.

№	Block name	Block type	Function
1.	Ramp	Generator of ever-increasing signal value	Realization of growing values (argument of the function)
2.	Source	Subsystem	Power source Input parameters: X – argument value. Output parameters: Out1 – Signal with three frequencies. Out2 – Signal with one frequency
3.	FFT1, FFT2	Fast Fourier transform block.	Time-and-frequency signal conversion
4.	Frequence1, Frequence2	MatLab function	Determining the frequency
5.	Amplitude1, Amplitude2	MatLab function	Determining the amplitude components of the signal
6.	Freq1, Freq2	Display block	Displaying the frequencies
7.	Amp1, Amp2	Display block	Displaying amplitude values

As a result of system work, displays Freq1, Freq2, Amp1, Amp2 and the graph (Fig. 3) give the graph of changing the values of amplitude and frequency components of the initial signals.

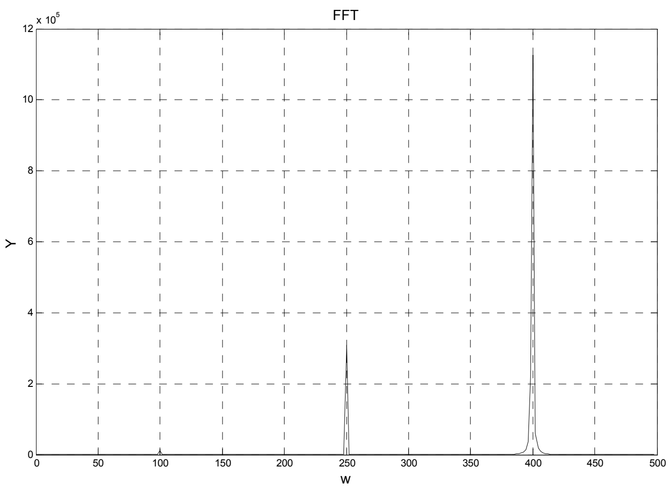

Fig. 3. Values of amplitude and frequency components of the initial signals

The system of quality control for power supply of separate units, based on spectral analysis of signals in energy systems, is efficient with periodic interferences, but it works badly with impulse non-periodic interferences. This served as the basis for defining the problem of interference identification: impulse non-periodic and periodic harmonic ones. This problem was solved on the basis of studying mathematical models of interferences [7,8].

To solve the problem of identification, let us group the signals into: periodic - stable, with relatively stable spectre, and impulse - well localized in time [9,10]. The impulse interference characteristic of localization in time allows to use polynomials for their description [11]. Polynomials are, in a sense, the simples functions, and their qualities are quite well studied :

$$y(t) = K_0 + K_1 x_1 + K_2 x_2 + \ldots K_n x_n \,, \quad (1)$$

where $K_0, K_1, K_2, \ldots K_n$ – polynomial coefficients.

According to the Weierstrass approximation theorem, every continuous function defined on an interval or real line, can be approximated with any degree of accuracy by polynomial of type (1), the degree of polinomial n sets the approximation accuracy. Polynomials are natural structural element for studying continuous functions at closed intervals. The order of polynomial approximants potentially contains all properties of the studied function. As the polynomial is characterized by its roots, let us use the multiplicative notation.

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$$y(x) = (x - x_1)(x - x_2)\ldots(x - x_n) \,, \quad (2)$$

where $x_1, x_2, \ldots x_n$ – polynomial roots.

Thus, having determined the moments of the analyzed signal transversing the zero level, in this way finding its roots, we have a convenient description of an impulse interference well localazed in time, and this description will be used for its interference identification [12,13]. The imitation modelling will help to illustrate this. On the basis of expression (2) the Simulink-model was developed, shown in Fig. 4.

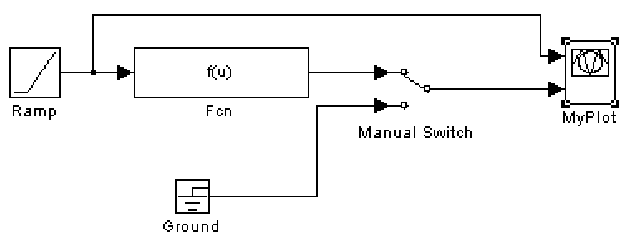


Fig. 4. Simulink-model of the generator of polynomial signals

Block Fcn determines the polynomial roots. To demonstrate the work of the Simulink-model the standard blocks will be used: Ramp for generating the argument t in the form of a linear trend, visualization block MyPlot, that was specially designed for building graphs.

The given Simulink-model generates the polynomial given in Fig. 5.

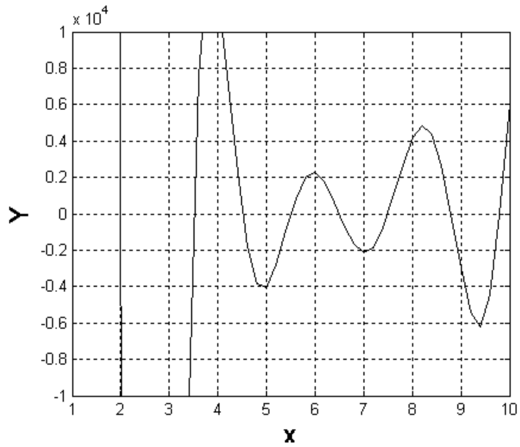
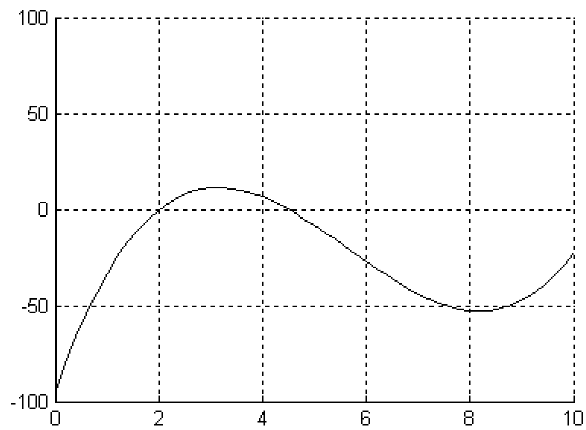


Fig. 5. Polynomial model of the signal

Depending on the number and meanings of the roots, the given Simulink-model generates different polynomials, shown in Fig. 6.

In this way, the developed model (Fig. 4) is used for generating the signals, that have polynomial form. In constrast to impulse interferences well localized in time, the periodic interferences are rather distributed in time [14]. Let us us trigonometric functions for their description.



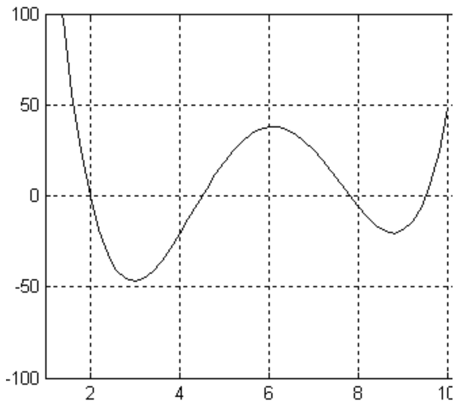


Fig. 6. Trigonometric model signal

According to regulatory documents, five groups of parameters are singled out, that can be described by trigonometric functions [6, 15]:

1) *Voltage deviation* (power fail, voltage swell, pulsing voltage).

2) *Frequency deviation* (deviation of the actual value of frequency of alternating voltage from the nominal value in the set mode of the power supply system operation).

3) *Voltage fluctuation* (degree of voltage fluctuation, flicker indicator).

4) *Unbalanced voltage in three-phase system* (reverse and zero coefficient).

5) unsinusoidality of voltage curve (distortion of sinusoidal voltage waveform coefficient, nth component frequency coefficient).

The electrical receivers with non-linear current/voltage diagram consume current, the waveform of it is nonsinusidal. The current of such flow in the elements of the electric circuit leads to nonsinusidal voltage drop, and this is the reason for distorting the sinusidal form of the voltage waveform. Quality control of the power supply implies the assessment of the compliance of electricity supply parameters with the norms, and the further analysis of the quality of power is in determining the responsible for this distortion agents.

To determine the power supply parameters, it is necessary to perform a large amount of measurements with high speed and simultaneous mathematical and statistical processing of gathered data. The large group of signals in energy systems can be considered modulated ones. Usually the evnelope of square wave is normalized, but for practical purpuses the analysis of more diverse envelopes, including those of random character, becomes more important. Let us develop the imitation models of the corresponding signals. Simulink-model of the generator of the trigonometric signal with the envelope in the form of the square signal is given in Figure 7.

Block Ramp generates varying temporary component t, block Constant - contant values, *Pulse Generator* – square signal, block *Gain* defines the initial level of the output square signal, equal 0.2. Block *Add* is used for input addition. Block *Fcn*1 generates value of function *sin*(0.7·pi·u), that multiplies with contant values. *Simulink*-block of *MyPlot* visualization is designed for building graphs.

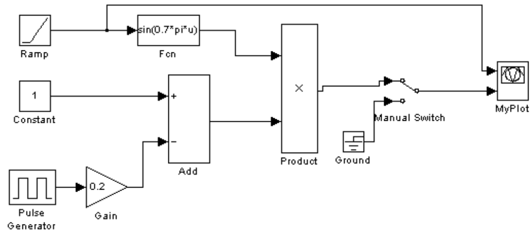


Fig. 7. Simulink-model of the generator of the trigonometric signal with the envelope in the form of square signal

With the change of parameters of the block Gain (signal initial level) the form of the trigonometric signal changes, as shown in Fig. 8.

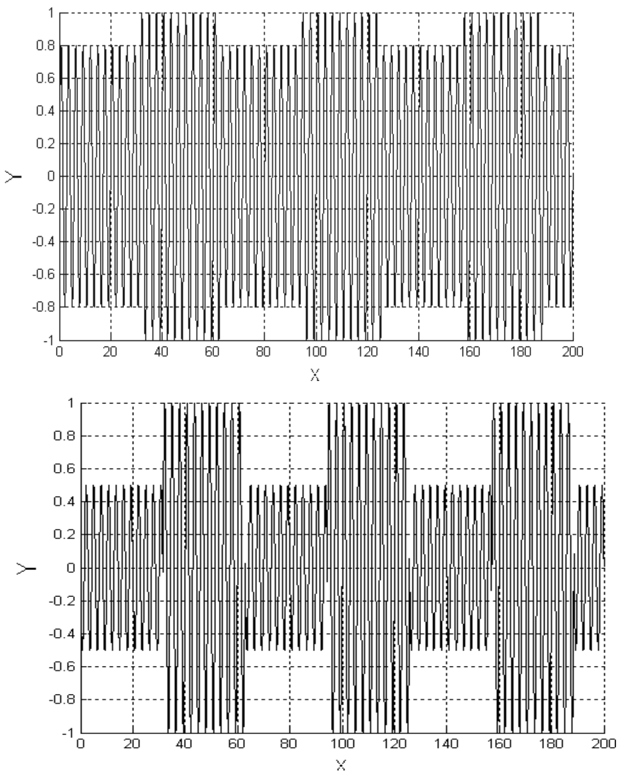


Fig. 8. Trigonometric signal with the envelope in the form of square signal

Simulink-model of the trigonometric signal with sine-type envelope is given in Fig. 9.

Block *Ramp* generates varying temporary component t, block *Constant* - contant values. Block *Add* is used for input addition. Block *Fcn*1 generates value of function *sin*(0.7·pi·u), that multiplies with contant values. Block *Fcn*2 generates value of function *sin*(0.1·pi·u). Block *Gain* defines the initial level of the output sine signal, equal 0.2. *MyPlot* block shows the resultant signal.

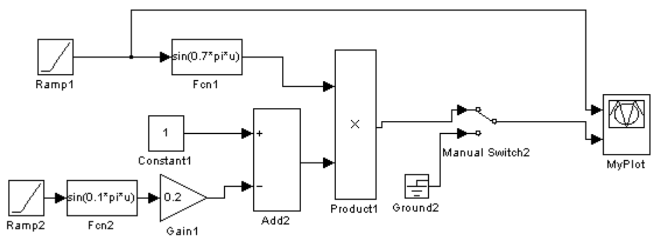


Fig. 9. Simulink-model of the trigonometric signal generator with sine-type envelope

The given Simulink-model generates the trigonometric function shown in Fig. 10.

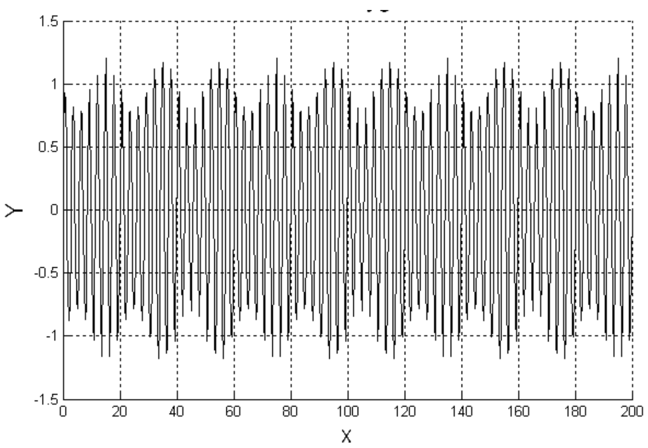


Fig. 10. Generated trigonometric signals

This allowed to receive the analytical description of impulse non-periodic interferences and periodic harmonic interferences, and to develop the set of imitation models for solving the problems of identiying the interferences characteristics of mobile robot power supply.

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