UDC 621.317.7.083.92(045)

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MEASURING PULSE-WIDTH MODULATION CONVERTER

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The problem of illumination of the converting error during high-frequency measuring was investigated. The structural scheme of the pulse-width modulation converter with the intermediate transformation into the DC voltage was designed. The reasoning of usage of such converter for the definite group of sensors was given.

Key words: pulse-width modulation signal, accuracy, pulse-width modulation (PWM) converter, voltage transformation, sensor.

Introduction and formulation of the problem. In the engineering the pulse-width modulation signal (PWM-signal) is characterized by pulses sequence of strictly defined amplitude and duty cycle (on-off time ratio). The term duty cycle describes the proportion of 'on' time to the regular interval or 'period' of time and defined as the ratio between the pulse duration and the period of a rectangular waveform. The on-off time ratio is known as informative parameter of PWM-signal.

The effect of converting the multilevel analog (discrete) input value to PWM-signal (output value) is that the input value transforms to the binary signal. This signal has two discrete levels – on/off or 1/0. In this case mean values of input and output (i. e. constant components, that are determined on the long period of time) are equal.

It can be described by the formula:

$$\overline{x(t)} = \overline{A\Delta t},$$

where $x(t)$ – input measured value; A – amplitude; Δt – duty cycle of PWM-signal.

The mean of the measured value is defined by the formula:

$$\overline{x(t)} = \frac{1}{T}\int_0^\infty x(t)dt.$$

And its estimate at the finite time interval:

$$\overline{x(t)_f} = \frac{1}{t_2 - t_1}\int_{t_1}^{t_2} x(t)dt.$$

The average value of PWM-signal

$$\overline{Y} = \frac{1}{T}\sum_{i=1}^{\infty} A\Delta t_i,$$

where i – number of PWM-signal period.

The estimation of the average value of PWM-signal at the finite time interval that is aliquot to the PWM-signal period:

$$\overline{Y_f} = \frac{1}{T}\sum_{i=1}^{N} A_i\Delta t_i,$$

where N is the final quantity of the PWM-signal periods.

There are a lot of sensors that are used to transform the different physical quantities into the PWM-signal.

Traditional approach to solving the problem. Usually, PWM-signal appears when there is some periodic process, for example, periodic pulsing in the system. Converting the PWM-signal to the code (that is necessary for transferring signal on the distance and/or future digit processing) usually is realized by means of pulse calculating with definite clock frequency during the time, that is equal to duration of one impulse or the sum of pulses durations of PWM-signal, and then the obtaining result is divided on the duration of pulse-repetition interval. However, we can avoid this division if the clock frequencies and PWM-signal pulses frequencies are aliquot.

In this case, during the process of creating the pulse-width modulation (PWM) converter developers deal with the complicated engineering problem, sometimes even unsold [1 – 6]. The point is that for achievement of the high resolving ability of the measuring converter (if it, of course, is provided by the corresponding sufficiently small error of sensor) it is necessary to obtain sufficiently large number of digits in the output code of the converter. As the result, very high clock frequency is needed, and its value can be higher than available one for the concrete element base. So, developers have a lot of difficulties because of limiting processing speed of the digital elements. What's the solution?

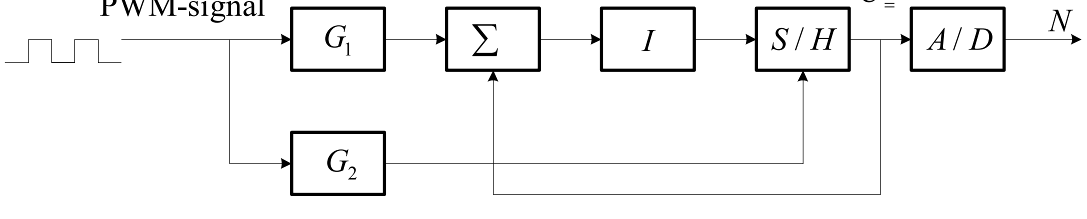
Classification of measured values. All measured (transforming) values are considered to be divided on three groups. The first one consists of measured values, that nowadays can be measured with the very high accuracy, for example, interval of time and values, that are connected with it, length, etc. The physical values, which accuracy is rather small, correspond to the second group. The AC voltage, inductivity are the examples of this group. There are the third group of values, the measuring accuracy of which places between the standards of the first two groups. It includes the DC voltage and all connecting with it values during the converter process, for example, electric capacity and electrical charge.

Such division of physical values leads to the appearing of the rule of creating the measuring device. In general case it consists of measuring converter or series of measuring converters. During the creation of any measuring device developer must make the minimal measurement conversion and try to get the measured value with the standards of accuracy from the first group. Using this rule we can convert PWM-signal into the code by performing direct counting of clock frequency pulses.

The problem solution. With the development of science a new approach to the methods of measurement technologies appears. Nowadays, the accuracy of the DC voltage measurement significantly increases and approximate to the accuracy of physical values from the first group.

In our case it gives the possibility to construct converter of PWM-signal to the code with the intermediate transformation into the DC voltage. Then it is possible to reach high converter accuracy without using high frequency digit circuit elements. So, at such way we find out the effective solution of the problem that is discussed above.

The scheme of measuring device. The structural scheme of the pulse-width modulation (PWM) converter (signal into the code) with the intermediate transformation into the DC voltage [3; 4] is shown in the Figure.



The pulse-width modulation (PWM) converter (signal into the code) with the intermediate transformation into the DC voltage: G_1 – pulses generator of the etalon voltage (current); G_2 – generator of the gating pulses (for the control of S/H); Σ – adder; I – integrator; S/H – sample and hold device; A/D – analog-to-digital converter

The achieved results. The application of the described above the pulse-width modulation (PWM) converter (signal into the code) with the intermediate transformation into the DC voltage allowed to perform the requirements specification successfully, avoided the necessity of the using the extremely high frequency digit circuit elements and reaching a given resolving ability of the converter for the given limited time conversion. The given scheme was successfully realized by the author during the designing of the flow rate gauge, at the output of which the sensor with PWM-signal was used.

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Измерительный преобразователь широтно-импульсного сигнала в код

Исследована проблема уменьшения ошибки преобразования при выполнении высокочастотных измерений. Разработана структурная схема измирительного преобразователя ШИМ-сигнала в код с промежуточным преобразованием сигнала в напряжение постоянного тока. Обоснована рациональность использования данного прибора для датчиков определенной группы.

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Вимірювальний перетворювач широтно-імпульсного сигналу в код

Досліджено проблему зменшення похибки перетворення при виконанні високочастотних вимірювань. Розроблено структурну схему вимірювального перетворювача ШІМ-сигналу в цифрову величину з проміжним перетворенням сигналу у напругу постійного струму. Обгрунтовано раціональність використання даного приладу для датчиків певної групи.