Modeling and research signals conversion proceses of multhipase power measure and control devices

I.Kh.Siddikov
TUIT named after Muhammad al-Khwarizmi
Tashkent, Uzbekistan
ikhsiddikov@mail.ru

A.A.Abdumalikov
TUIT named after Muhammad al-Khwarizmi
Tashkent, Uzbekistan
akmalabdumalikov6@gmail.com

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***Abstract*— Without further processing the measurement and control results, the data displayed on the displays shall reflect all the characteristics of the electrical energy that determine whether or not these characteristics meet the requirements for the time interval obtained. This range includes analytical calculations of the measured parameters and graphical results based on their dynamic, static classifications. For them, an important functional feature of multiphase power measure and control devices, that determines the structural and climatic requirements, element base, power supply system, ability to store and transmit results is the type of measurement and control - continuous or periodic.**

Keywords*— graph model, signal, voltage, electric power, secondary signal, display tools, alphanumeric display, current.

I. INTRODUCTION

The main characteristics of transducers, which of conversing primary values of power systems (PS), to secondary voltage – signals, which need for control of PS, classically recommending on the basis of modern analytical models and computing technologies. The multiphase power measure and control devices (PCD) of the power supply systems should provide the ability to connect to an alternative voltage nets PS of 220 V or 380 V and to secondary circuits of measuring and control devices, with a voltage of 20 V, which PCD operation is allowed for dips in the range till 40% of the nominal nets voltage. In addition to signals from an external voltage nets, some PCD manufacturers offer the possibility of power from an independent voltage source. When designing autonomous power systems for portable PCD, it is necessary to take into account the duration of their work (7 days or more). An important characteristic of the power supply unit is the maximum power consumption, which for modern PCD should not exceed 20 V [1-3].

The design of the PCD must comply with similar requirements for electricity meters.

First of all, it concerns the requirements [1]:

1) ensuring electrical safety (housing design and the presence of a protective earth terminal);
2) protection against unauthorized access (the ability to seal controls and use a password system).

The electromagnetic compatibility of PCD must satisfy the requirements for immunity to external interference. SMI input channels must provide measurements and control in three phases of a monitored electrical nets with a grounded or isolated neutral.

Requirements for current input channels determined by the method of connecting PCD to measuring current of the one or three phases electrical nets [3].

To improve the accuracy of measurements and control of PCD, it is advisable to connect electric power quality control instruments used stationary by inserting current transformers into the secondary circuits without using current clamps, bearing in mind that for most primary current to secondary rated current is 0,1 A.

The principle of PCD operation should provide in real time continuous measurement of the PCD and auxiliary parameters of electricity according to the established GOST 13109-97 algorithms [1].

Measuring and control instruments elements of PCU intended for both continuous and periodic monitoring of the electricity quality should have sufficient non-volatile memory in volume, allowing long-term storage of measurement results. The archives with the results of the control, accumulated in the memory, should contain information about the time measurements.

These archives can't be adjusted and are the most reliable sources of information about the measurements were taken. Currently, there are several approaches to ensure long-term storage of measurement and control results [2].

PCD can have built-in RAM that can reach tens of megabytes in modern devices. Information can be stored on removable memory cards, the volume of which reaches tens of gigabytes. When PCD is implemented based on a laptop computer, the hard drive of this computer is the memory of the device. In addition, almost all modern PCD are delivered together with software that allows storing measurement archives of the device on a separate computer through standard interfaces. Such software significantly simplifies the processing and analysis of measurement and control results, and allows you to accumulate long-term statistics on the patterns of changes in PCD [1].

Measuring and control tools should provide the ability to display both the measurement results of the current parameters of the mode, and archive information.

Most of the existing PCD devices have an alphanumeric display for this, and a small number of devices are additionally equipped with a graphical display, which simplifies the measurement and operational analysis of the results [1-2].

The information displayed on the displays without additional processing of the measurement and control results, should reflect all the characteristics of the electric power quality that determine the conditions for fulfilling or not meeting the requirements for a given time interval during which these characteristics are obtained, as well as extreme values of the measured parameters in this interval [3].

The structure of a typical means of measuring and control the quality of electric energy on the basis of PCD is given in fig.1

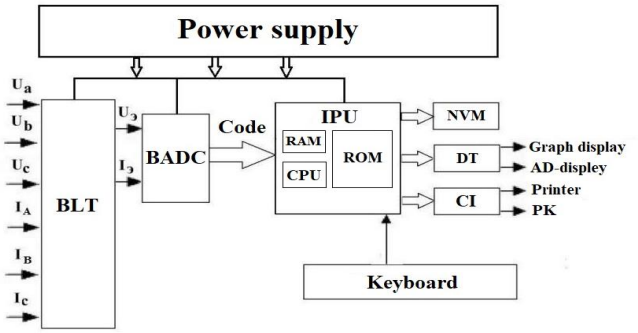


Fig. 1. The structure of a typical PCD or control of power energy.

The structure of measuring and control instruments:

BLT - a block of large-scale transformations;
BADC - block of analog-to-digital converter;
IPU - information-processing unit;
RAM - random access memory;
CPU - central processing unit;
ROM - read-only memory;
NVM - non-volatile memory;
DT - display tool;
CI - communication interface;
AD - alphanumeric display.

The measured and controlled voltages and currents are supplied to the input terminals of the block of scale converters (dividers), in which, by analog processing, signals proportional to the parameters of the input voltage are formed, i.e., scale transformations occur to the level (approximately 1 V) necessary for the normal operation of the analog block digital conversion. The instantaneous values of the signals at the outputs of the BLT are converted into digital codes using the BADC, in which the timing of the input signals and their digitization are carried out. Digitization is based on 256 samples of a 14-bit code for the period of the fundamental frequency. Codes of digitized signals enter the information processing unit. In BOI, the central processor processes the information received from the ADC in accordance with the programs of the permanent storage device. The measurement results are recorded in non-volatile memory for storage (if the device operates in the "measurement" mode), and also displayed on the display. In most instruments, the CO is an alphanumeric display. Some devices also have a graphic display that allows you to display vector diagrams, spectra, histograms and waveforms of currents and voltages. Using the communication interface of the RS-232 (RS-485 or GPIB) type, the measurement results are transmitted via communication channels to an external industrial electronic computer or printer. The instrument keyboard is used to control the device during its setup and viewing measurement results [2-3].

II. METHODOLOGY

Modelling of signal conversion processes in elements of PCD

A reliable assessment of electric power quality indicators (PQI) in the nets and the development of effective measures aimed at ensuring electric power quality are impossible without instrumental control. To carry out such control, specialized measuring instruments (SMI) are required. Intensive development of microprocessor technology has allowed domestic developers to create multifunctional SMI, designed to control and analyze the quality of electricity. The tasks of power quality control determine the specific requirements for PCD [3].

The only condition when choosing a SMI is that all means must comply with the requirements of GOST 13109-97 [3]. In part regarding the measurement and control algorithms of the PQI and the permissible measurement errors. The list of measured PQI is established by GOST 13109-97, but can be expanded depending on the tasks to be solved. Graph model of the signal conversion process in PCD given in fig. 2.

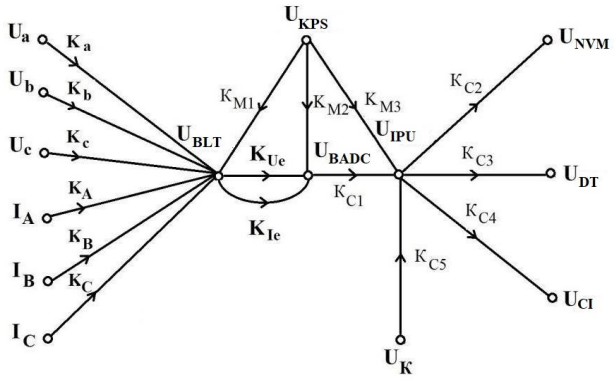


Fig. 2. Graph model of the signal conversion process.

On the basis of graph model determining the parameters and values of conversion processes of PCD [1]:

$$U_{BTL} = K_a U_a = K_b U_b = K_c U_c = K_A I_A = K_B I_B = K_C I_C = K_{M1} U_{KPS}; \quad (1)$$

$$U_{BADC} = K_{Ue} U_{BTL} = K_{Ie} U_{BTL} = K_{M2} U_{KPS}; \quad (2)$$

$$U_{IPU} = K_{M3} U_{KPS} + K_{C1} U_{BADC} + (K_{C5} - K_{C4}) U_K; \quad (3)$$

$$U_{NVM} = K_{C2} U_{IPU}; \quad (4)$$

$$U_{DT} = K_{C3} U_{IPU}; \quad (5)$$

$$U_{CI} = K_{C4} U_{IPU}; \quad (6)$$

$$\frac{U_{IPU} - U_{KPS}}{K_{M3}} + \frac{U_{IPU} - U_{BADC}}{K_{C3}} + \frac{U_{IPU} - U_K}{K_{C5}} = K_{C3} U_{DT}; \quad (7)$$

$$U_{IPU} = (K_{C3}U_{DT} + \frac{1}{K_{C4}}U_{KPS} + \frac{1}{K_{C3}}U_{BADC} + \frac{1}{K_{C5}}U_K) / (\frac{1}{K_{M3}} + \frac{1}{K_{C3}} + \frac{1}{K_{C5}}); \quad (8)$$

$$U_{IPU} = f(U_{KPS}, U_{BADC}, U_K, K_{M3}, K_{C3}, K_{C5}); \quad (9)$$

That is U_{IPU} of the model IPU node size KPS, $BADC$, K sizes in nodes and K_{M3}, K_{C3}, K_{C5} depending on the transmission functions (coefficients) of the model parts and determining on the basis of hext equations [2]:

$$U_{IPU}(t) = KU_{ap}(t); \quad (10)$$

$$U_{IPUap}(t) = K(1 - e^{-\frac{t}{T}})U_{ap}(t); \quad (11)$$

$$\frac{U_{IPU_{ap}}(t)}{dt} = \omega(t) = \frac{K}{T}e^{-\frac{t}{T}}U_{ap}(t), \quad (12)$$

$$U_{IPU_p}(t) = U_{IPU}(t)Sin\omega t; \quad (13)$$

$$U_{IPU\sum}(t) = U_{IPU_p}(t) + U_{IPU_{ap}}(t); \quad (14)$$

III. RESULTS OF RESEARCH

a) The Static characterictics

The static kharacteristics of PCD given in fig.3. On the basis of static kharacteristics calculated difference between teoretical (T) and expimental (e) measure or controle dates, which equal 3-4%.

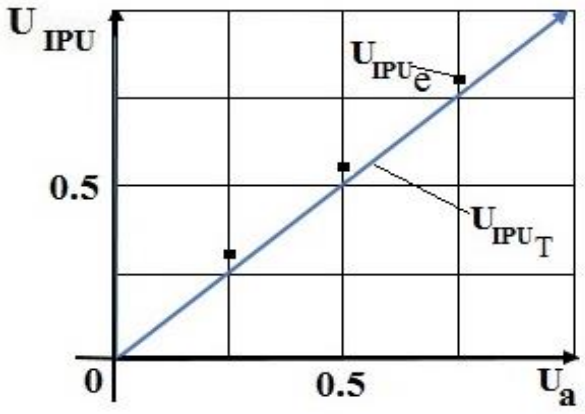


Fig.3. The static kharacteristics pf PCD.

$$\delta = \frac{U_{IPU}T - U_{IPU_e}}{U_{IPU}T} * 100 = 3\%; \quad (15)$$

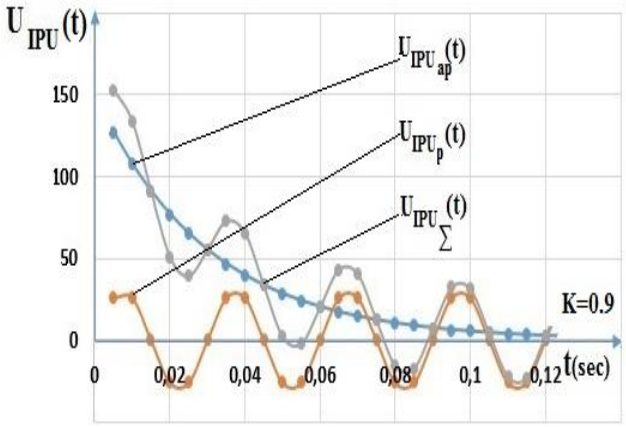
An essential functional feature of PCD, which determines the structural and climatic requirements for them, the element base, the power supply system, the ability to store and transmit measurement results, is the type of measurement and control - continuous or periodic [1-2].

Existing standards recommend periodic monitoring of the quantity and quality of electricity at various intervals between subsequent control measurements. So, according to GOST 13109-97, the duration of continuous measurements and control of PCD to monitor compliance with the requirements of this standard determined by 24 hours as mandatory and seven days as recommended. The frequency of power quality control established by this standard is, depending on the type of PQI, from twice a year to once every two years [3].

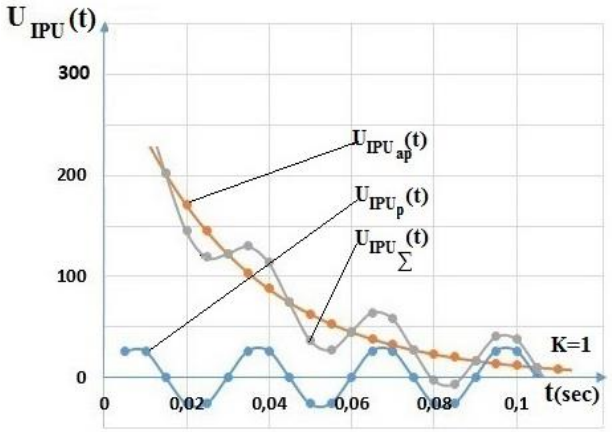
a) The Dynamic characteristics

The dynamic characteristics of PCD with different input values (K=0,9 – 1.1) and periods of ranging (T=0,1 – 0,3), given in fig.4.

1)K=0.9, T=0.03



2) K=1, T=0.03



3) K=1.1, T=0.03

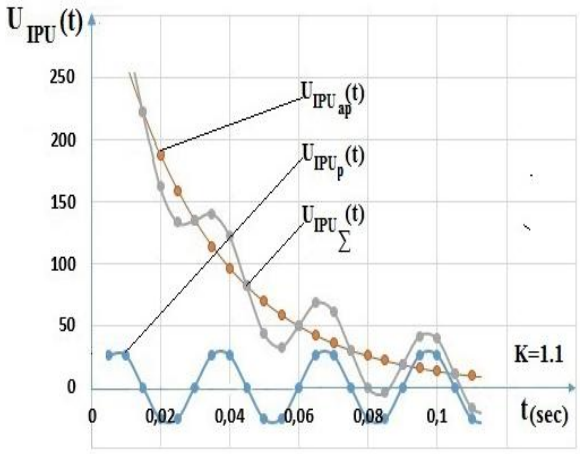


Fig.4. The dynamic characteristics of PCD

IV. CONCLUSION

1. The graph model for research and design has been developed based on magnetic currents generated by multiphase currents of power sources based on the highly formalized and transparent physical and technical effects, PCD structure involved in the conversion process, which can be exploring static and dynamic characteristics of multiphase sensors of PCD.

2. The graph model of PCD of multiphase current or voltage generated by power sources and the analytical equations, based on the model are adequate to actual linear static outputs, and results of researches showed, that sensitivity of the sensors of PCD can be increased by 3-4%.

3. The output voltage values and change graphs model of PCD depending on arguments and parameters of output voltage are static and dynamic changes in the sensor stabilize after 0.01-0.02 seconds later, when controlling power source connecting to nets of power supply systems.

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