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The Complex of Automated Control of Secondary Power Supplies Parameters

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***Abstract* — The present work describes the step-by-step development of an automated control and measuring system that monitors the electrical and thermal parameters of pulsed secondary power supplies (SPS) for laptops. The main guidance documents are considered, according to which the design of impulse SPS laptops is carried out. It is revealed that the existing methods for controlling the parameters of pulsed SPS laptops take into account only electrical, however, the thermal parameters make a significant contribution to the result of numerical values of electrical parameters. In this regard, an improved method for controlling both electrical and thermal parameters of pulsed secondary power supplies is proposed. The structure of the automated control and measuring system as a whole, as well as the structure of the multifunctional hardware platform with all its components are developed.**

***Index Terms*— pulsed source of secondary power supply, laptop, automated control, electrical parameters, thermal parameters, MyRIO.**

I. INTRODUCTION

Secondary power supplies are an integral part of computer hardware. Modern SPS have a wide range of tasks: conservation of energy, the security of the system, participation in the active cooling system. This is the main reason why there are high requirements for quality of power supplies.

Monitoring of quality measures and, first and foremost, the electrical characteristics is carried out throughout all stages of the life cycle. Special attention should be paid to control in the final stages of manufacture and during the life cycle.

The use of various control-and-measuring kits allows to realize the SPS screening test in the output and input controls, and to identify a fault caused in the course of active operation. Despite the high degree of automation modern measurement kits, they have a high cost, large weight and dimensions. For this reason, many manufacturers are limited to only functional control using a more simple measuring devices. This approach increases the likelihood of missing a defect and failure of SPS at the crucial moment.

In relation to the above, the task of developing a mobile control-measuring complex with the possibility of advanced control of SPS electrical characteristics is relevant.

It should be noted that in the current approach to the measurement of the electrical characteristics is not given due attention to improve the control performance by reducing expenditures. The existing recommendations [3, 7, 14] state that while measuring the electrical characteristics must be a pause of 10-30 minutes. It is rude and is not a reasonable average estimate is used to control all SPS types, including impulsing energy source. However, real time tracking of reaching the stationary thermal and electric mode of operation can significantly reduce the time between the measurement operations.

Thus, to improve the control efficiency it is necessary to develop a methodology of measurement, taking into account the peculiarities of physical processes in the SPS.

II. OVERVIEW OF KEY GUIDANCE DOCUMENTS

Any of the engineered item, including secondary power sources, must meet certain national and international standards depending on the specifics of their further application.

The following is the analysis of key documents (Russian and International), to be followed by SPS manufacturers

A. GOST R IEC 62623-2015

"Desktops and laptops. Measurement of energy consumption". This International standard is based on ECMA-383 [8] and supplements the rules given in GOST R IEC 62075-2011 [10]. The standard includes the definition of the power saving modes and General rules for energy conservation for developers on their desktops and laptops. These rules established the methodology for measuring energy consumption of the appliance in determining the classification criteria, which allows for comparison of energy consumption of similar products [11].

B. GOST R 54364-2011

«Low-voltage power supply DC. Operational characteristics». Description: this standard allows to determine the power source corresponding to a specific purpose, by defining parameters for the required levels of operation, to formulate the basic definitions related to this type of equipment, and implement a range of levels of availability. These levels are clearly demarcated, which allows the manufacturer and consumer to identify and choose those

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power supplies that correspond to the application [9].

C. ENERGY STAR® Program Requirements for Computers Partner Commitments

The standard has several versions, especially up-to-date version 5 and 6. This international standard describes the energy efficiency of consumer products [4]. Power supplies with the logo "Energy Star" consume electricity at 20-30% less than counterparts in terms of functionality without logo. But, in some aspects the requirements are lax in the imposition of standard TCO 99 [12].

D. Power Supply Design Guide for Desktop Platform Form Factors

This standard specifies the requirements on the electrical characteristics, geometrical dimensions, shape and location of connectors. More related to the PC power supply and includes a standard "ATX Power Supply Design Guide" [1].

III. Selection of the Object of the Research and Analysis of the Method of Control of Electrical Parameters

As object of research was chosen the pulse SPS of laptop Huntkey HKA090109050-7A with a maximum output power 90 W output voltage 19 V, output current of 4.7 A, and an efficiency of above 87%.

We present the existing generalized methods of control of electric parameters of the pulse SPS of laptops containing the following key factors:

Source [7] shows, that:

- for measurement of electrical parameters of the pulse SPS of a laptop you need to warm up with a load of 20-30 watts for 60 minutes.
- discretely to apply the load in increments of 10 watts.
- measurement of electrical parameters at each step shall be not less than 20 minutes.
- to test current protection, specifying a higher load (10% maximum).
- to test the short circuit protection.
- to test overheating protection, discretely increasing the load in increments of 5 W to disable SPS, while measuring its temperature.

The disadvantage of this method is the fact that dwell time at low load before the measurement (60 minutes), and 10-30 minutes according to the sources [3, 7, 14] is not scientifically justified. Probably, time caused by transient thermal processes that affect the working mode of operation of pulse SPS as the electrical transient phenomena lasts, as a rule, not more than a tenth of a second. Therefore, it is required to clarify the time of establishment of the stationary mode which determines the completion of the electrical and thermal transients in the pulse SPS. In reference [6] noted that non-original power supply unit can be heated to 50 C for 90 minutes of work at maximum load.

IV. The Structure of the Control Parameters System of the Pulsed SPS of Laptops.

The control parameters system of the pulse SPS of laptops proposed in the framework of this project contains two main components (Fig. 1): personal computer / laptop and a multipurpose hardware platform (MHP).

Prototype multifunctional hardware platform consists of a platform and the NI MyRIO adapter unit (AU).

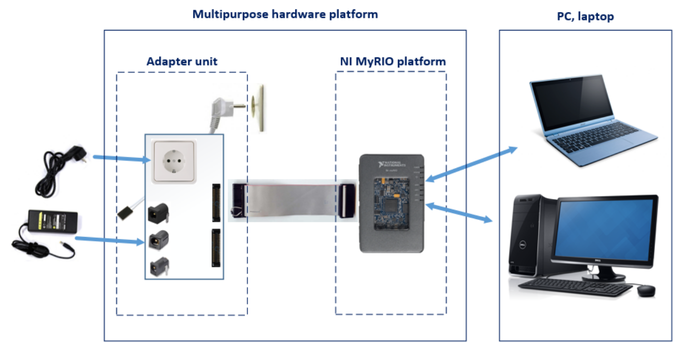

Fig. 1. Structure of the monitoring system for the parameters of pulsed SPS laptops.

Controlling the process of monitoring the parameters of laptops pulsed SPS is carried out using a personal computer or laptop with a special software package installed, which is compatible with the NI MyRIO platform [13]. This requirement is met by LabView. By means of it, the NI MyRIO platform is programmed and a detailed analysis of the received data is made based on the results of the input inspection tests. NI MyRIO [2] is an intermediate link between a personal computer / laptop and a test and measurement platform. However, it plays a key role in the entire system: it takes information through the input ports, generates the waveform and provides the necessary effects through the output ports, transmits information on Wi-fi technology.

With the help of the AU, the voltage levels are converted into the allowable range of the NI MyRIO and imitation of the work of the components of computer equipment is realized by the consumption of the load current.

The adapter unit consists of measuring and load modules, standard connectors (sockets) for connection of various types of plug-in of laptops pulse SPS, PLD plugs for connection to expansion ports (MXP and MSP) of NI MyRIO and an electrical outlet for connecting a network cable of laptops impulse SPS (Fig. 2). The operation of the DC is carried out from the 220 V network. To monitor the steady-state thermal conditions of the product under investigation, a contact temperature sensor is provided, located on the body.

Modules for measuring electrical parameters are necessary to limit the levels of detected voltages in connection with the previously mentioned NI MyRIO port conditions.

The stable power supply module is necessary for the uninterrupted operation of the electric load equivalent modules and the cooling module.

Electric load equivalent modules (ELE) are required to simulate the operation of SPS at various capacities. To date, it is most rational to use for these purposes an electrical schematic based on a field transistor, the principle of which is to regulate the magnitude of the current along the drain-source circuit by changing the voltage across the gate of the transistor (pulse-duration modulation).

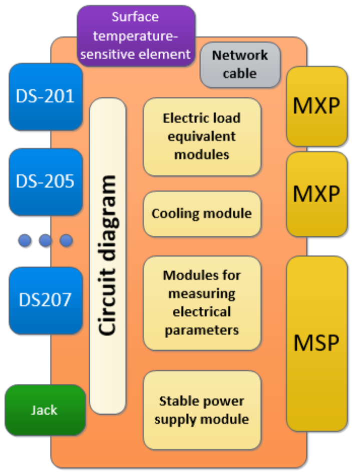

Fig. 2. The structure of the adapter unit.

The inclusion of a cooling module in the interface device is justified by the large heat release of some electronic components electronic load by the flow of currents reaching 12 A. This module is included in the electronic load modules and consists of radiators, temperature sensors and a cooler.

V. Development of the Adapter Units

In the development of the AU, emphasis is placed on the equivalent of electrical load. The NI MyRIO platform has PWM outputs, which are programmed using LabVIEW. Therefore, the control of the opening and closing of the field transistor and, accordingly, the load current can be ensured by sending commands from these NI MyRIO pins by changing the pulse relative duration, i.e. their duration. The values of the load currents can be different - it depends on the type of the pulse SPS and on the type of tests. The average value of load currents for laptops varies from a few mA to 7 A.

Smooth adjustment of the load current is achieved by dividing into channels that are characterized by capacity in a certain limited range due to load resistances (resistors of different denominations).

To effectively manage powerful MOSFET transistors, special high-speed field transistors drivers are used. They are necessary for a balanced interaction between the control part of the circuit and the field transistor. They allow to reduce the rise time, recession, delay and improve other characteristics. The structure of the electric load equivalent is shown in Fig. 3

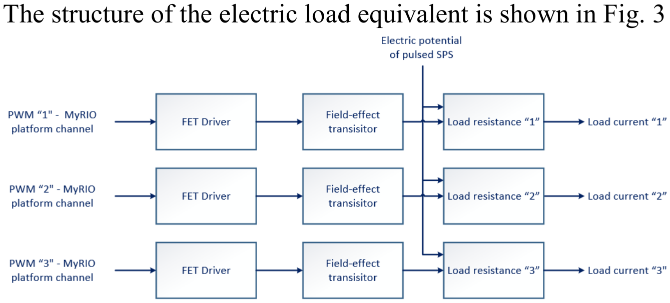

Fig. 3. Structure of the equivalent of electrical load.

The results of modeling the electrical parameters of the three-channel ELE are summarized in Table 1. The load currents of the channels are summed.

TABLE I
Results of Simulation of Electrical Parameters of a Three-Channel ELE

Channel	Voltage of the pulsed SPS, V	Min. current, A	Max. current, A	Max. dissipated power on the transistor, W	Max. dissipated power on the resistor, W
1	15	0.016	0.15	0.3	2.2
	20	0.022	0.197	0.5	4
2	15	0.12	1.20	2	16
	20	0.16	1.6	3.5	29
3	15	0.95	9.4	8	133
	20	1.27	12.5	14	240

VI. Modeling of Electrical and Thermal Processes of the Selected Pulsed SPS

The simulation of the operation of the basic circuit diagram selected pulse IVEP was carried out in Multisim PC (Fig. 4).

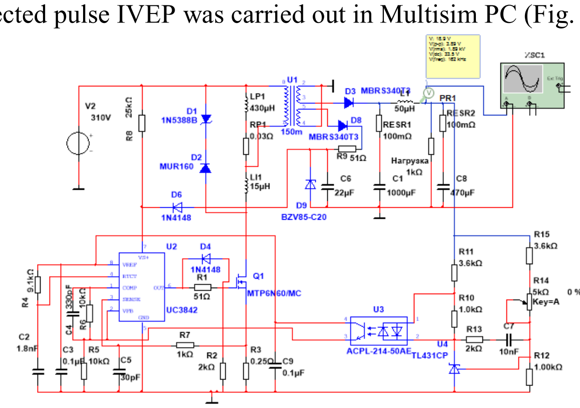
Fig. 4. Schematic diagram of pulsed SPS in Multisim PC

Simulation of thermal processes for the purpose of determining the time of the SPS release to a stationary thermal mode is possible using Solidworks PC.

Figure 5 shows the temperature distribution of the board assembly of the pulsed SPS of the laptop in a steady heat process at the maximum electrical load.

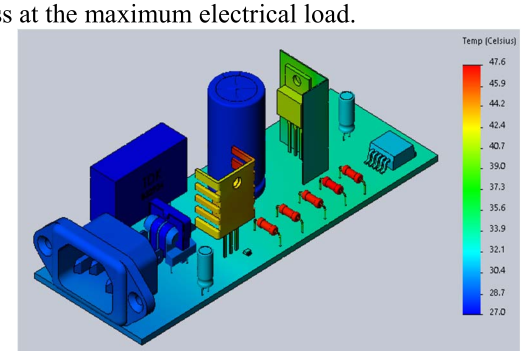

Fig. 5. Temperature distribution on the board assembly of a pulsed SPS laptop in a steady heat process at the maximum electrical load.

Figures 6 and 7 show the temperature dependence at certain points of the SPS board assembly versus time at the maximum electrical load and the load is 4 times lower than the maximum.

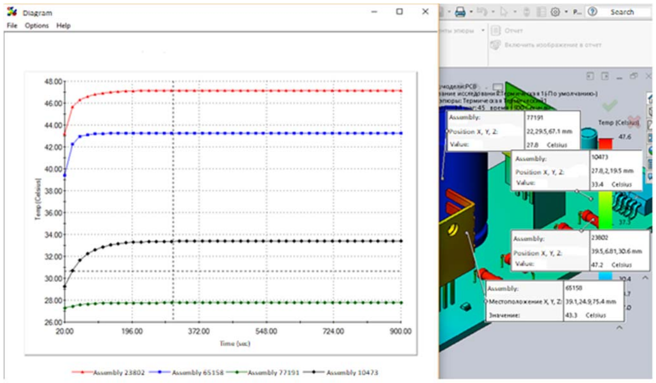

Fig. 6. Dependence of temperature at certain points of the SPS board assembly against time at the maximum electrical load.

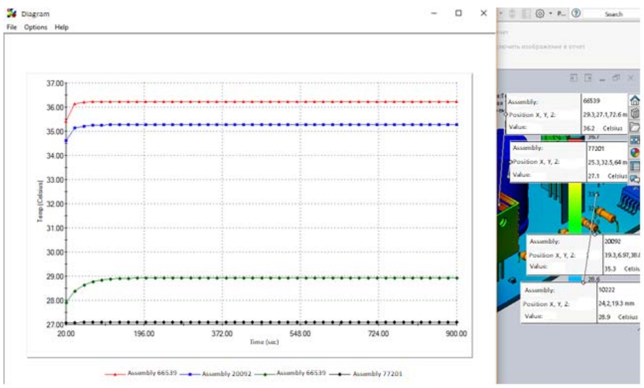

Fig. 7. Dependence of temperature in certain points of the SPS board assembly on time at a load 4 times less than the maximum.

It can be seen from Fig. 7 that the stationary steady-state thermal process of the selected components (the most loaded) in the considered pulsed SPS comes after the expiration of 300 seconds, which corresponds to 5 minutes [5].

However, when the load decreases, the time to reach the stationary thermal process decreases to 200 seconds (Fig. 8). Therefore, to use the recommendations given in [3, 7, 14] is not rational and the actual measurement time can be reduced by half.

VII. Development of a Technique for Monitoring the Parameters of Pulsed SPS

A technique for monitoring pulsed secondary power supplies for laptops was developed on the basis of the study. This technique consists of stages and is divided into two stages: the first - design, the second - the output control, operation.

The initial stage is electrical modeling, as a result of which electrical characteristics (input, output, time) must be obtained. An important result besides the values of the voltages U is the time of the electric transient phenomena t_{ETP}. Then the received parameters are transferred to the database (DB) for storage.

At the next step, it is required to conduct a thermal simulation of the SPS to obtain not only the temperature values at different points, but also the time of the output of the pulsed SPS to the steady temperature condition t_{STC}. This procedure should be performed under various electrical loads.

The results obtained in the course of mathematical modeling are used in the development of design documentation (DD). And the final document of the modeling results is a passport for a pulsed SPS, in which its electrical, thermal parameters, etc. are indicated.

At the stage of the output control, the pulsed SPS should be brought to the stationary mode with the given electric load according to the passport or information contained in the database. In this case, the time to enter this mode should be taken from the passport.

Further, the characteristics are measured with the help of the developed control and measuring system. The measurement is carried out, guided by GOST (for example: GOST 27300-87, GOST 23854-79, GOST IEC 61010-1-2014, GOST R 51318.24-99).

After the measurement, additional parameters are calculated, such as power, ripple level, efficiency, etc. This requires special software compatible with the CMS.

Analysis of the results of monitoring is carried out with the help of special software. Based on the results of measurements of the parameters of the pulsed SPS and the calculated additional parameters, they are compared with the database (passport) and the requirements of standards (for example: GOST R 54364-2011, Power Supply Design Guide for Desktop Platform Form Factors).

The result of analysis of monitoring results is the determination of the technical state of a pulsed secondary power supply.

The change in electric load occurs only if a faulty condition is not detected.

At each measurement procedure, it is necessary to output the SPS to the stationary mode of operation. However, it is recommended to consider the parameters stored in the database or in the passport.

VIII. Conclusion

A review and analysis were made of methods and means of monitoring the electrical parameters of the SPS. Their shortcomings are indicated. It is revealed that the existing control methods do not take into account the time of the transient thermal process when measuring electrical parameters. The structure of the control and measurement system has been developed, which includes a personal computer / laptop, and a multifunctional hardware platform. The adapter unit, which includes a set of standard connectors for connecting different brands of laptops pulse SPS, has been developed. The AU also contains the developed measuring and loading modules. A methodology for monitoring the electrical and thermal parameters of the SPS has been developed.

The proposed hardware complex and methodological support allows to increase the efficiency of monitoring the electrical characteristics of the SPS due to the increase in the accuracy of their evaluation, the reduction of the overall dimensions and weight of this equipment, and also the reduction of the operating time of the human-operator.

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