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THE AUTOMATION PROCESS PROCEDURES OF THE SUBSYSTEMS BLOCK VERIFICATION FOR SPACE VEHICLES MANAGEMENT

Described are the automation procedures for the software of logic verification in subsystem of the management perspective space vehicle block functioning. The achieved results by the implementation of these procedures are presented.

Keywords: management block, central-processor module, interfacing of the management block, independent working off, automation.

Modern requirements in the field of space services and technologies demand from space vehicle (SV) and onboard equipment manufacturers the reduction of terms and expenses from design, qualifications, the manufacturing and tests of onboard equipment and space vehicles, and the increase in reliability and the quality of the products. This is required at constant minimization of their energy and mass features. Thus, it is necessary to achieve an essential economization of resources: human, financial, and material during simultaneous reduction of design terms for spacecraft.

Modern radio-electronic equipment (REE) based on programmed logic integrated schemes (COTT software VELVET), microcontrollers, built-in computing modules etc. demand special debugging facilities. The designing of the REE is organized as a constant interaction between the software developer and the developer of schemes. Flexibly organized equipment, which gives a chance at any moment to spend fast reconfiguration of test apparatus and interesting experiments, allows spending optimally on the REE debugging works.

Currently at JSC Information Satellite Systems-Reshetnev Company – there is an intensity of schedules for manufacturing REE of modern space vehicles for carrying out working off tests at a scale of Earth-based experimental works; there is also a complete set of exclusively high regular products. The necessity to increase the efficiency of the working REE and to reduce its terms for restored products, involves the creation of unified and automated workplaces for experimental Earth-based REE works, which concern management blocks.

The blocks of management, which are part of an onboard complex of management developed at the enterprise (BM OCM) for modern and perspective space vehicles, are designed according to a modular principle. Inside the structure of the management block are: the central-processor module (CPM) and the interface modules of linking (IML or subsystems). The CPM allows realizing all logical functions for concrete equipment using software. The IML carries out the managements of the SV systems. The information logical communication CPM and IML is carried out by the consecutive peripheral interface (PPI). The BM management is carried out by an onboard computer complex (OCC) on the multiplex channel of exchange (MCE) (GOST P 52070–2003). The CPM accepts management commands of the MCE from the OCC, decodes them, and gives out words of data (WD), containing management commands (MC), in corresponding subsystems – the BM (IML). The OCC reads out WD from the CPM, which contain telemeteric information.

The REE on the base of programmed logic integrated schemes possesses specific features of test processing, inherited in the process of developing software products. The emphasis is on system integrated decisions. The scheme and the solution become simpler, but the architecture of the device since additional non-material makings has become part of its structure, and the software becomes complicated. It is necessary to provide the developer (the circuitry-designer-programmer) with special conditions of debugging and rapidly changing software tests.

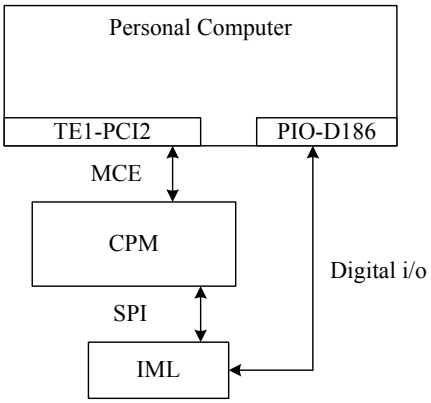
Today the service time and the active space vehicles existence are 10–15 years. For its maintenance, which is one of problems, the verification of reliability onboard REE is one of the issues is the verification of the logical functioning IML or subsystems and their components. The IML it is hardware that represent blocks consisting of several schemes executed in the form of a universal constructive. They carry out the specialized problems, carrying out a link role between the onboard computer complex and the SV systems.

During the verification of logical IML functioning, the put-in-pawn circuit and technical decisions on the conformity to the technical project (T3) should be confirmed. The given stage is called the laboratory-based work off IML tests and consists in the revelation of errors in their designing, manufacturing, and as errors in projects COTT software VELVET IML.

For the realization of this stage at a designing department and working out the onboard REE, the workplace (PM) we have created an independently working IML [1] (sce figure), on the base of a laboratory work off complex [2].

The workplace of the independent working IML consists of the personal computer (PC), the CPM and the connected IML. For information exchange between the personal computer and the CPM, circuit board TE1-PCI2 supporting report MCE manufactured by the firm “Elkus” is used. For the communication between the personal computer and the IML circuit board PIO-D186 with a digital input/output is used.

The hardware of such a workplace realizes the structure, and establishes information communications for its various elements. The basic tool for the achievement of the general purpose of such a system is the software.



The Workplace of an independent working IML

Such software should realize uniform information and logical space between the equipment of the control and fulfilled subsystems, to provide flexible and full verification of all logic functions of the fulfilled subsystems, and meet independent work with the deadlines at with the least expenditures of labour.

For the solution of the given problems, the creation of an automation process for the working IML is necessary. Introduction in software automation means it will allow reducing the human factor to a minimum, thereby raising the reliability of the subsystems working process. The performance of the majority of the functions in an automatic mode will allow to reduce time and the expenditures of labour demanded for the working subsystems.

In result of the detailed software analysis [2; 3] we have created a solution to the tasks in view of the independently working IML.

The developed software has following basic procedures of automation:

– the generation of tests;

– the preliminary analysis of the test;

– the automatic change of test data;

– the analysis of the received data for reliability;

– the transfer of the received WD values to corresponding physical scales.

The generation of the tests. The basic stage of any REE test is the creation of a set of tests at which there is final completeness and the degree of working REE will depend on. The automated procedure of test generation allows facilitating the procedures of their creation for the operator and bringing possible errors for manual input to zero.

The procedure of automatic test generation allows creating tests for any subsystem. For the generation of the test it is necessary for the operator to enter the initial parameters for a concrete subsystem. On the basis of the entered data the software builds the time diagram of performance for the test. Even before the direct development of the test, the operator can visually see its structure with the time delays between various operations. The given decision allows him to manually replace the creation of a set of packages with some manipulations of the operator in the program.

The preliminary analysis of the test. The preliminary analysis procedure of the test analyzes the accomplished sequence of operations on its completeness and correctness of figures. In case of default for these conditions, corresponding preventions that excludes possible errors brought by the operator stand out, during operations updating of the test. For example: if there is an operation of delivery for a 2nd IML circuit board command, there should be an operations of reading for the 2nd board and an operation for the execution of the given command. In a case when there is not a single one of the specified, there are negative results of the analysis with the list of missing operations.

The given procedure automates the search for missing operations for the manual task of tests and for their editing that in turn, reduces the probability of not completing the working IML.

Automatic change of test data. The carried out test is limited by static values of data which are set in them by the operator. For the fast change of the information in tests, a procedure of automatic data change has been created. Its essence consists in the following: after the performance of the test with single data elements, there is a change in data and the performance of the current test is already different. Change of data occurs in advance of set masks. Thus, the given procedure allows starting the set tests with an automatic data change for each cycle of their performance; the volume of the changeable data is set preliminary by the operator.

The analysis of the received data for reliability. While carrying out of any test, a great volume of the targeted information, which is necessary for analyzing turns up. For a person, a similar analysis represents a long and time-consuming process and the chance of error increases.

The procedure of the received data analysis makes the analysis of the exchange report, revealing errors in the functioning IML. On the base of the analysis, displayed to the operator is the detailed information by the revealed negative results. Such results can be: the absence of the corresponding bit in the WD on the given out command; occurrence of additional bits in the WD, on a command on which they should not appear; the absence of various signs of subsystems in the WD, etc.

The transference of received WD values in corresponding physical sizes. IML developers write the containing codes of values for various parameters in SD devices; these are temperature, pressure, resistance etc. During independent IML workings it is necessary for the operator to translate the received codes in corresponding physical sizes, for the further analysis of the data.

The machine translation procedure is adjusted depending on the fulfilled IML. As an options the price of the younger category for a code, various factors of formulas of recalculation, etc can be specified. The given procedure allows the reduction of time spent by the

operator to translate the codes of WD values read from the IML.

Introduction results of the automation procedures. The developed software has completely solved the tasks in view of independent working IML, and thanks to the automation procedures, allowing:

– to automate the process of independent working IMLs to 90 %, leaving the operator only the performance and the analysis of specific checks;

– to reduce time spent for working out concrete IMLs, from several weeks to 1–2 working days;

– to spend simultaneous working to 8 IMLs as a part of a workplace, connected among each other on interblock sockets and connected to the CPM;

– to check the working IML capacity during irregular situations, by their modelling;

– to independently fulfill each complete the IML set (basic/reserve) connected to each complete the CPM set (basic/reserve);

– to fulfill the BM in gathering, with use regular cables as the IML connections;

– to use the PM at any stage of REE tests thanks to flexibility and universality.

Currently, the given software – the independent working IML is used in space vehicle management blocks – "Monsoon", "Glonass-to", "Amos-5"; and is used at the working SV "Luch-5". During the tests, the correctness of the construction of the software and correctness of the approach connected with design of the automated procedures have been confirmed.

Thus, the developed software has proved its reliability, universality, and simplicity in use, thanks to what it is applicable for the working of the subsequent IML management block of perspective SVs. The procedures of the automated software and their algorithms are applicable for designing the software of workings REEs.

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A MULTIDIMENSIONAL ANALOG OF THE COOLEY-TUKEY FFT ALGORITHM

In this article a recurring sequence of orthogonal basis in the n-dimensional case has been applied to derive formulas of n-dimensional fast Fourier transform algorithm, which uses $\frac{2^n-1}{2^n}N^n\log_2 N$ *complex multiplication and* $nN^n\log_2 N$ *complex addition; where* $N = 2^s$ *– is a number of counts on one of the axes.*

Keywords: space of signals, orthogonal basis sequence, multidimensional discrete Fourier transform.

Recurrent sequence of orthogonal bases in space of signals is well studied [1] and has numerous applications, including the derivation of Fourier's formulas of fast transformation.

In this article the recurrent sequence of orthogonal bases to a *n*-dimensional case is applied in order to derive formulas of a fast *n*-dimensional Fourier transformation variant, using $\frac{2^n-1}{2^n}N^n\log_2 N$ complex multiplication and $nN^n\log_2 N$ complex addition, where $N = 2^s$ – is a number of counts on one of the axes (known in studies as in [2]). This variant *n* FFT contains a smaller number of complex multiplication operations than other algorithms, where the multidimensional Fourier transformation is carried out by repeated application of one-dimensional FFT (for example, see [3; 4]).

Furthermore, we give definitions and basic statements from the theory of multidimensional signals, which are used in the article.

To construct *n*-dimensional recurrent sequence of orthogonal bases we use the scheme of the statement, given in [1] for a one-dimensional case.