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ASONIKA system – radio-electronic facilities developer tool

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Abstract: This article deals with issues and analysis tasks, electronic elements and radio-electronic facilities reliability simulation with due regard for thermal, mechanical, electro-magnetic and other exposures, also software analysis is performed.

Key words: Radio-electronic facilities; Simulation; Electronic element; Physical processes; Reliability; Mechanical exposures; Thermal exposures; Electro-magnetic exposures

1. Introduction

All modern facilities (rockets, planes, land battleships, ships, submarines, cars) inevitably involve electronic equipment, consisting of circuit plates, electronic chips etc. And if one of them doesn't work, all equipment doesn't function.

Vibration, impacts, heat, electromagnetic fields, radiation and other exposures considerably impair equipment running. That's why all these exposures tests are important parts of electronic equipment manufacturing. Tests cost too much, involve much time and often don't enable to anticipate electronic equipment condition in actual practice, especially in critical modes.

Recently many space crafts have crashed, such as GLONASS, «Fobos-Grunt», «Meridian», PROTON etc. All these catastrophes are conditioned by the fact that hardly any space craft's electronic facilities simulation tests on disturbing factors exposure are conducted, including those in emergency situations (Shalumov et al., 2011; Chabrikov et al., 2012; Uriupin et al., 2012; Semenenko, 2012). Our government sustains multi-billion losses because of this (Kofanov, 2013; Shalumov and Kulikov, 2013). However, it's impossible to carry out space craft electronic facilities simulation tests without necessary specialized software, and electronic elements as well as construction materials database. This article presents such system and database. This refers to computer-aided equipment reliability and quality assurance system ASONIKA developed by authors (Uriupin and Shalumov, 2012; Shalumov, 2012, 2103; Shalumov and Shalumov, 2013; Sunder et al., 2014).

For thirty years overcoming all obstacles we have created and tested dual-use technology at many Russian enterprises, in the first place, in defense, space and aviation industries. The essence of this technology is as follows: using computer-aided equipment reliability and quality assurance system (ASONIKA), it's possible to foresee and prevent all and any malfunctions of not yet manufactured electronic equipment designed to run on military, space and civil objects. And all this is possible to make within several hours and it is very informative (Shalumov et al., 2013b).

2. Materials and methods

Use of ASONIKA system will provide computer-assisted designing of complex radio-electronic facilities (REF) under conditions of external disturbing factors exposure according to CALS-technologies requirements within stages designing–manufacturing–exploitation and thus will secure:
–Quality improvement of complex REF designing;
–Critical errors exclusion while designing complex REF;
–Time and work input cutting to design complex REF;
–achieving complete coverage of production life cycle stages from marketing research up to utilization according to CALS-technologies standards;
–Consideration of fullest influencing factors range (mechanical, thermal, electro-magnetic, radiation);
– designing terms and expenses decrease due to access of complex REF developer to offered software and simulation predictions sufficiency.

At the exhibition on 11th December 2009 in Saint Petersburg, V.V. Putin examined and supported tasks relevance related to computer-aided design and simulation of radio-electronic facilities (REF), as well

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as aerospace and defense equipment. V.V. Putin personally studied ASONIKA system, underlined importance of this project for home industry and recommended subject ministries to support this research development (see website www.asonika.com).

Decree of the President of Russian Federation dated 7th May 2012 #603 «On realization of buildup and development plans (programs) of Defense Establishment of Russian Federation, other forces, military formations and agencies and military-industrial complex upgrading» declares that «it's planned to implement full industrial cycle operating system of manufacturing armament, military and special machines – from modeling and designing to items serial production, securing their exploitation and further utilization». This decree article implementation is not possible without using ASONIKA system, for there are no analogous systems and schools of sciences with corresponding advanced development. To create analogue of ASONIKA system, not less than twenty years of intense work is needed.

This article gives the opportunity to REF developers to study computer-aided ASONIKA system and make grounded decision to choose it for using within REF designing process.

3. Results

On 29.06.11 School of science «School of science of simulation, information technologies and computer-aided systems (SS MITAS) » was officially registered by the resolution of General committee of Russian Academy of Natural History (school of science founder - professor A.S. Shalumov). Information about school of science SS MITAS was published in encyclopedia "Russian schools of science". Major result of its work is computer-aided equipment reliability and quality assurance system (ASONIKA).

With the help of ASONIKA system, computer-assisted design and complex computer simulation of highly reliable REF according to CALS-technologies requirements are carried out at the stages designing–manufacturing–exploitation. Offered technology has been created to be used within designing REF and it will replace tests with computer simulation at early stages of designing which allows decreasing tests quantity and possible iterates within designing REF.

ASONIKA system is designed to solve four main issues existing within modern REF development:

– preventing of possible malfunctions within exploitation at the early stages of designing due to diversified physical processes complex modeling;

– providing safety for individuals while flying on planes (preventing plane crashes) due to complex computer aided analysis of aircraft control system on basis of created electronic model with all types of external disturbing factors, including critical modes;

– Decreasing designing terms and expenses due to access of equipment developer to offered software and simulation predictions sufficiency;

– Workflow automation and REF electronic model creating due to integration of offered software within PDM-storage system, engineering data control and equipment life cycle.

Exploitation of aboard REF is marked by exposure of many tough external factors acting simultaneously which leads to system malfunctions. Such malfunctions are hard to detect while testing, for there are no constructions which would enable to reproduce simultaneously electrical processes of functioning, concomitant thermal, mechanical, aerodynamic, radiation and other external exposures, technological effects of parameters random scatter, age, corrosion and other degradation factors. The issue becomes more complicated because modern REF includes complex microelectronic items, possessing particular physic-technological properties, which also must be considered within complex mathematic simulation (Shalumov et al., 2013a; Shalumov et al., 2014). All these factors in its cumulative and interrelated occurrence must be considered in a right way within scheme construction technological designing which can be done only on computer. In this case reasons for system malfunctions can be detected and eliminated and high rate reliability of REF will be provided.

The reasons for existence of four above mentioned issues are in flaws of designing processes and created samples development, related to rare use of computer-aided designing methods and modern information technologies, based on complex mathematic simulation of simultaneously carrying out processes in REF (electrical, thermal, mechanical, aerodynamic, electromagnetic and others). They are stipulated by equipment running and exposure of external factors, as well as its wear out and aging. Solution in this situation will be to unify mathematic simulations of diversified physical processes on the basis of existing behavior analogy. It will enable to decrease human effort of their integration into single complex model, provide completeness and authenticity of simulation results, develop corresponding methodology and absolutely new multifunctional computer aided analysis system of scheme technical, construction technological solutions and reliability of designed REF. This system was named ASONIKA (Shalumov, 2013; Shalumov and Pershin, 2013). ASONIKA system is implemented on many military industrial complex enterprises of Russian Federation.

It is first Russian computer aided modeling system, which is recommended by special guideline documents of Ministry of Defense of Russian Federation to replace electronic equipment tests at the early stages of designing, which enables to create competitive equipment within minimal terms and minimal expenditures.

ASONIKA system completes construction documentation general list with calculation data and simulations according to which these calculations were conducted. Thus electronic virtual experimental model of equipment to be made is compiled, which can be transmitted at the manufacturing stages and exploitation. Within ASONIKA system special program complex is carried out which forms structure of electronic (virtual) experimental model of equipment to be made, fills this structure with working results of troublesome ASONIKA system subsystems. These subsystems allow creating of electrical, thermal, aerodynamic, and mechanical and degradation processes simulations in equipment, making diagnostic simulation, analyzing reliability indices, and also allow integrating into topological layout design systems and telecommunication facilities Mentor Graphics, Altium Designere, PCAD etc.

Program complex regulates modeling tests results presentation on geometric layout, which is included in electronic experimental model, and also transforms electronic experimental model after its processing into ISO 10303 STEP standard format. Data included in electronic experimental model are used at the further REF life cycle stages.

Currently ASONIKA system consists of thirteen subsystems:

– REF standard design unit analysis on mechanical exposures ASONIKA-M;

– REF standard design cabinets and supports analysis on mechanical exposures ASONIKA-M-SHKAF;

– Analysis and providing of unspecified three dimensional frame structures durability made in systems Pro Engineer, Solid Works and other CAO-systems in formats IGES and SAT, to mechanical exposures ASONIKA-M-3D;

– Analysis and providing REF constructions mechanical stability assembled on vibration isolators ASONIKA-V;

– Analysis and providing equipment constructions thermal characteristics ASONIKA-T;

– Analysis of REF printed circuit assemblies' constructions on thermal and mechanical exposures ASONIKA-TM;

– Computer-aided cards filling of electronic components working modes (EC) ASONIKA-R;

– Analysis of REF reliability indices considering real working modes of EC ASONIKA-B;

– Electronic components and materials reference database on geometrical, physic mechanical, thermal physic, electrical and reliability parameters ASONIKA-BD;

– Identification of physic mechanical and thermal physic parameters of REF models ASONIKA-ID;

– Analysis of printed circuit assemblies and electronic components constructions permanent stability on mechanical exposures ASONIKA-UST;

– Analysis and providing REF electromagnetic compatibility ASONIKA-EMC;

– REF modeling control while designing ASONIKA-UM.

ASONIKA system includes the following convertors with specified CAD systems:

– System integration module of electrical processes modeling in PSpice schemes and subsystems ASONIKA-R, ASONIKA-B (development of integration modules with systems Mentor Graphics and Altium Designere is carried out);

– designing systems integration module of printed circuit assemblies PCAD, Mentor Graphics, Altium Designere and subsystem ASONIKA-TM;

– 3D model integration module created in systems KOMPAS, Pro Engineer, Solid Works, Inventor, T-FLEX in formats IGES, SAT and subsystem ASONIKA-M (version ASONIKA-M-3D).

ASONIKA-RAD - REF radiation stability subsystem - is to be developed.

Computer aided system ASONIKA structure (fig. 1) stipulates that item electronic model is compiled within designing process, according to CALS-technologies requirements, on the basis of data management subsystem while modeling ASONIKA-UM (PDM-system) and using simulation subsystems.

With the help of specialized graphic editor electrical scheme is put in, which is saved in projects database, in subsystem ASONIKA-UM and transferred as file in electrical schemes analysis systems PSpice, Mentor Graphics and Altium Designere, as well as printed circuit assemblies place-and-route systems PCAD, Mentor Graphics and Altium Designere. PCAD system output files in PDIF format and Mentor Graphics and Altium Designere IDF format are saved either in ASONIKA-UM subsystem, or they are transmitted to systems AUTOCAD, KOMPAS, Pro Engineer, Solid Works, Inventor, T-FLEX for making drawings and again they are saved in ASONIKA-UM subsystem. In ASONIKA-UM subsystem REF 3-D cabinets and units models are transmitted, they are created in such systems as KOMPAS, Pro Engineer, Solid Works, Inventor, T-FLEX in formats IGES and SAT, which are transferred from it to subsystems ASONIKA-M and ASONIKA-V (1) to analyze mechanical processes in REF cabinets and units, as wells as in subsystem ASONIKA-T (3) to analyze thermal processes in REF cabinets and units.

Stress, movement, notching up and temperature in cabinet and units constructions obtained as modeling results are saved in subsystem ASONIKA-UM (2, 4). Printed circuit assemblies (PCA) drawings and their specifications, as well as files in formats PDIF and IDF are transmitted from subsystem ASONIKA-UM in subsystem ASONIKA-TM (5) for complex thermal and mechanical processes analysis in PCA. Moreover, air temperature values in units obtained in subsystem ASONIKA-T are transferred, as well as supports notching up, obtained in subsystem ASONIKA-M (6). EC temperature and notching up values obtained as modeling results are saved in subsystem ASONIKA-UM (7).

EC list (8), files with EC electrical properties (9), EC temperature and notching up values (10), electromagnetic (15) and radiation (16) analysis results, obtained in subsystems ASONIKA-EMC and ASONIKA-RAD, are transmitted from subsystem ASONIKA-UM in REF reliability indices analysis subsystem ASONIKA-B. REF reliability indices obtained as results are saved in subsystem ASONIKA-UM (11). EC list, files with EC electrical properties (12), EC temperature and notching up values (13) are transmitted from subsystem ASONIKA-UM into EC working regimes card forming subsystem ASONIKA-R. Obtained working regimes card are saved in subsystem ASONIKA-UM (14).

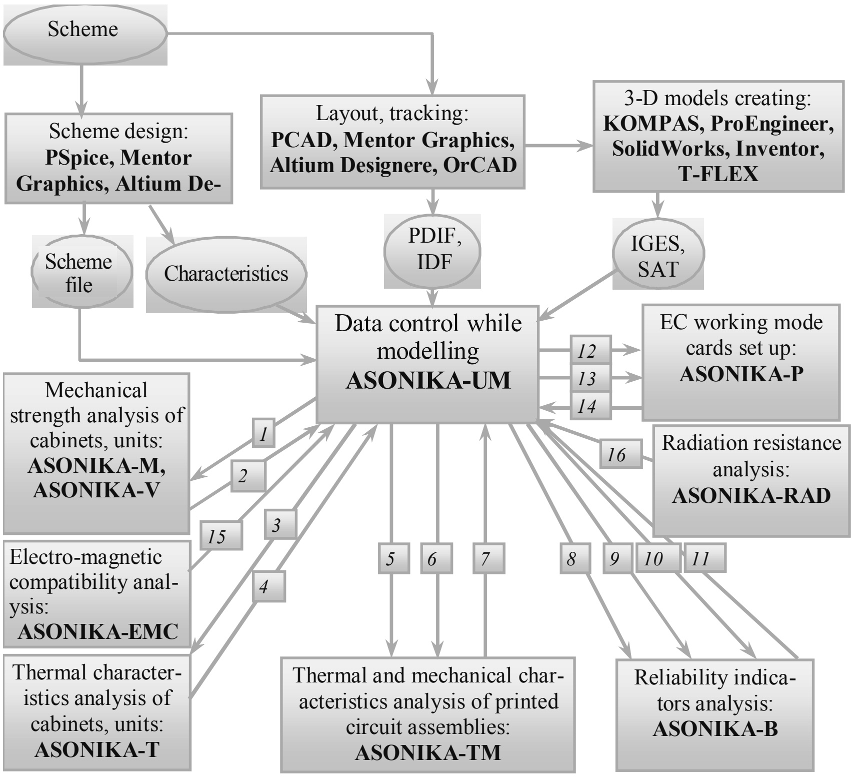

Fig. 1: Computer aided system ASONIKA structure

System is oriented on REF developers. With this aim special interfaces to input standard equipment constructions – cabinets, units, and printed circuit assemblies are made in subsystems ASONIKA-M and ASONIKA-TM which makes it much easier to analyze physical processes in REF.

If user created complex cabinet or unit mechanical processes model in common end point element system as, for example ANSYS, he would have to get a specialized training and obtain experience, which would take approximately a year, and then the very model input would take several hours. To work with ASONIKA system you don't need to have special training, it's quite enough to input the information presented on drawing in language available to designer. Information input of very sophisticated cabinet can take 30 minutes.

Thus, complete complex cabinet analysis on thermal and mechanical exposures up to each EC (we receive notching up and temperature on each and every element) can be carried out within 1 day.

Subsystem ASONIKA-M enables to analyze cassette, stack and cylindrical unit types, radio-electronic facilities cabinets and calculate the following mechanical exposures types:
– Harmonic oscillation;
– Random vibration;
– Impact;
– Linear acceleration.

The following data can be obtained as simulation results:
– notching up dependence on frequency and time in check points and structural components;
– Movement, hogging, notching up and straining of units and cabinets constructions sections;
– Units and cabinets deformation;
– notching up in printed circuit assembly attaching points, necessary for the further analysis up to each and every REF in subsystem ASONIKA-TM.

Subsystem ASONIKA-M includes database with reference geometrical, thermal physical and physic mechanical parameters of construction materials.

Subsystem ASONIKA-B is designed to analyze cabinet constructions mechanical characteristics, supports and units in REF, mounted on vibration isolators while being exposed to harmonic oscillation, random vibration, impulse loads, and linear acceleration, under influence of acoustic noise and on the basis of obtained mechanical characteristics, decisions regarding securing equipment durability under physical impacts can be made. Subsystem has special graphical interface of construction input on vibration isolators. Subsystem enables to identify vibration isolator parameters, and optimize them to decrease structural loading. As a simulation results, construction notching up dependence on vibration isolators due to frequency and time can be obtained. Subsystem ASONIKA-V includes database with reference vibration isolator parameters database.

Subsystem ASONIKA-T enables to analyze thermal characteristics of the following REF construction types: micro assemblies, radiators and heat-removing bases, hybrid integrated circuit modules, stack and cassette construction units, cabinets, supports, as well as unspecified REF constructions (Shalumov et al., 2014).

Subsystem enables to analyze equipment immobile and mobile thermal modes, which runs with natural and forced convections in air, under normal and decreased pressure.

While making unspecified constructions analysis detailed isothermal volumes temperature values are defined and temperature dependence diagrams on time for mobile thermal mode are shown.

Subsystem ASONIKA-T includes database with reference construction materials thermal physic parameters.

REF printed circuit assemblies' constructions analysis subsystem on thermal and mechanical exposures ASONIKA-TM enables to analyze REF printed circuit assemblies and carry out calculations of steady and unsteady temperature modes:
– Under normal as well as decreased pressure;
– On the following mechanical exposures: harmonic oscillation; random vibration; impact; linear acceleration; acoustic noise.

Subsystem has special graphical interface to input printed circuit assembly construction.

The following data can be obtained as simulation results:
– notching up dependence on frequency and time in construction check points;
– max. Temperature values, notching up and printed circuit assembly straining sections and electronic components;
– Oscillation modes of printed circuit assemblies on their own frequencies;
– Thermal and mechanical modes cards of electronic components.

Subsystem ASONIKA-R is designed to simplify and speed up process of EC working mode cards filling up. Subsystem contains all possible working modes forms cards of last revision RDV.319.01.09-94 (2000). Subsystem operation results – EC modes filled up cards – are automatically converted by program into text processor WORD, where they can be edited and printed. Subsystem has necessary database which contains information about EC parameter limits, obtained from normative and technical documentation (NTD).

Subsystem ASONIKA-B enables to analyze cabinets, units, printed circuit assemblies, REF and solve the followings tasks:
– To define reliability indices of all REF;
– To justify necessity and evaluate REF reservation efficiency.

Subsystem backs up:
– Passive reservation with dead loading;
– Active loaded reservation;
– Active cold redundancy;
– Active lightweight reservation.

As simulation results exploitation breakdown rates, faultless operation probability and mean time of REF non-failure operation can be obtained. Subsystem ASONIKA-B service backup includes database with mathematic simulations to calculate REF exploitation breakdown rates values and coefficient values, included in models, as well as database editor. Subsystem enables to import data on construction makeup from other electronic design automation (P-Cad), as well as REF thermal and electrical characteristics from other subsystems of ASONIKA system.

Subsystem ASONIKA-UM, designed to control REF simulation while designing enables to integrate electronic design automation, installed on enterprise (Pro/ENGINEER, P-CAD, ASONIKA, KOMPAS, AutoCAD, PSpice etc.), and regulate data transmitting among subsystems while making simulation within process of REF engineering designing. Subsystem integrates into any PDM-system used at enterprise. While designing subsystem enables to form complex REF electronic model within mathematic models of thermal, electrical, aerodynamic, mechanical processes and mathematical REF reliability and quality model.

Realization of above mentioned integration gave rise to development and implementation of CALS-technologies at radio-electronic and instrument-making enterprises. Practical and innovative results of the work are as follows: program products integration enables to perform point-to-point computer-aided REF designing on the basis of complex physical processes simulation. User interface language is maximally approximated to REF developer language. It doesn't take much time to take in offered programs. If they are implemented, high speed modelling problem solving and considerable material resources saving are gained due to decrease of tests quantity. Reliability and quality of REF designed on the basis of offered integrated CAD system are increased.

Whole system compliance is ensured on the REF electronic model level, information in which is presented in form of data objects collection and interrelations among them, regulated by ISO standard 10303 STEP, without information duplication. In this case only interfaces among each selected subsystem and ASONIKA-UM subsystem are needed. These interfaces enable to transform information objects collection of REF electronic model, which describes basic data for target subsystem, in this subsystem project files. It also works vice versa, transforming basic subsystem project files into information objects collection of REF electronic model and interrelations among them, regulated by ISO standard 10303 STEP. Thus it guarantees information representation uniqueness in REF electronic model.

This solution of information compliance secures structure flexibility of ASONIKA system. Thus, while updating and replacing existing subsystems, and adding new subsystems to this structure, only integration interfaces with ASONIKA-UM subsystem, subsystems which are to be replaced or implemented in structure should be changed. Interfaces complexity is defined by REF program systems used as components of point-to-point CAD system.

4. Conclusion

The aim of ASONIKA system implementation is to increase work efficiency of enterprises structural departments, bring them into compliance with modern world and home quality standards, decrease designing terms and science-based REF development, increase reliability of elaborated REF.

Implementation of this program complex enables to save lots of material resources due to tests quantity decrease while introducing offered software.

Thus, ASONIKA system implementation will result in switch to conceptually new information technologies level, which enables to expand output product list, diminish new products launch terms, cut rejects and production costs.

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