Adaptation of the electronic device design route using Russian software

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Abstract. Today in the development of Russian electronics is mostly using foreign computer-aided design systems (CAD). Because of sanctions Russia is facing a risk of losing access to foreign software products and systems. Since most of the Russian projects are using foreign CAD systems, a sudden switch to national software can cause significant difficulties in production. The transition to Russian software involves rebuilding the design route based on foreign CAD systems, due to the difference of the functionality of programs and file formats of engineering documentation. The purpose of this work is to assess the possibility of switching to Russian CAD systems and adjust the design route in accordance with them. The paper deals with the study and use of modern Russian CAD software, such as “KOMPAS-3D”, “Delta Design”, and “ASONIKA”, using the example of creating a low-frequency amplifier.

1. Introduction

The quality and competitiveness of the created electronic devices (ED) depends on the use of information technologies at all stages of the ED life cycle. One of the most labor-intensive stages is the design stage due to the duration reaching up to 3-5 years for complex ED. But the amount of product information generated that provides the release of documentation in electronic form. Moreover, despite such a significant time frame for the creation of ED, the development of serial production and the first years of operation are accompanied by numerous improvements that arise due to various kinds of shortcomings and defects. The reasons for this situation lie in the shortcomings of the design processes of created ED models. This process associated primarily with an insufficient level of development of end-to-end automated design methods based on complex mathematical modeling of physical processes in ED. It combined with the methodology of modern information technology for the design of CALS technologies that implement continuous information support for the entire product life cycle. In connection with, there is a need for the unification of various physical processes models. Thus, to create competitive and highly reliable ED models, an urgent problem is the development of complex mathematical modeling issues that occur in ED schemes and designs, as well as their coordination with the ideology of CALS technologies. In addition to the problems described above, at present there is another problem that is relevant for Russian enterprises. In connection with sanctions that imposed on Russia, Russian enterprises and developers has a risk of losing access to foreign software products. Since most of the domestic development uses foreign products, a rapid transition to domestic software can cause considerable difficulties. The transition to domestic software provides for the restructuring of the design path, due to this, functionality of the foreign programs and file formats of design documentation are different. The aim of this work is to evaluate the opportunity of shifting to domestic CAD systems and adjust the design route by them. The study and the use of modern Russian CAD systems are carried out, using the example of creating a low-frequency amplifier, which electric circuit is taken from [2].

1.1. CALS ideology in end-to-end design

One of the fundamental parts of the CALS ideology is the technology for storing and managing product data (PDM technology), which allows developer to solve the problems of standardization using a standardized integrated product description, which, in turn, is based on the ISO 10303...
Standard for the Exchange of Product Model Data (STEP). STEP allows developer to describe the entire product lifecycle, including manufacturing technology and product quality control. The standard regulates the logical structure of the database, the nomenclature of information objects, their relationship and attributes, which in this standard are called “integrated resources”. Sections of the STEP standard do not define physical data storage issues. It is assumed that all logical data structures are stored in a "text exchange file" (repository). In practice the STEP standard can be applied in several ways:

- Data can be stored as a text exchange file. In this form, it is convenient to transfer them between automated systems that have a corresponding module (Converter) for working with a file in STEP format.
- Data structures can be created in a ready-made PDM system by configuring it accordingly and developing appropriate visual applications.
- Ready-made solutions (integrated resources) can be used.

The second fundamental methodological aspect of CALS-ideology after PDM-technology is the standardized methodology of functional modeling (IDEF0), which is used for functional modeling (analysis and restructuring) of management processes (business processes). Figure 1 shows an example of a fragment of a functional model of an algorithm for the computer-aided design of a print node of the low-frequency amplifier. The presented model gives a complete picture of the structure of the process and design and can be used to improve its efficiency.

**Figure 1.** Functional model of a fragment of the end-to-end design methodology for a low-frequency amplifier

After executing each of the function blocks, the following formats are generated:

- Synthesis and calculation of an electronic circuit (.sch, .ngc)
- Synthesis of PU construction geometry (.gerber, .pcb, .brd)
- Calculation of thermal and mechanical characteristics (.txt, .doc (WORD), .xls (EXCEL), .bmp)
- Synthesis of 3D model design (.stp, .stl, .dwg, .dxf)
According to the logical structure of the STEP standard database, the ED can have several versions. Elements of the logical structure of the STEP database allow the components of the electronic layout (EL) of the ED to be translated into interactive electronic technical manuals (IETM) of the developed ED using the appropriate CALS-technology standards. The EL configuration model can be configured in full, as shown in figure 2. And be transmitted between divisions of the developing enterprise on some electronic medium. In General, the configuration model allows developer to:

- Configure the structure and parameters of the system complex model (set the number of important submodels for research and determine the scheme of relationships between them).
- Define a list of CD and so on that determines the degree of the description of the information project space.
- Include in the EL a set of engineering techniques necessary for conducting research.
- Include in the EL a set of CAD-, CAE -, CAM-systems necessary for the implementation of engineering techniques.

![Figure 2. The structure of the electronic layout with a full configuration.](image-url)
Each EL element defines standard file formats in accordance with the STEP standard, described below:

- For the electric model ED (.sch)
- For the ED mounting space model (.pcb,.gerber)
- For a complex model of physical processes (.txt,.doc (WORD),.xls (EXCEL),.bmp)
- Set of CD, TD (.pdf,.xml)

In the end, with any configuration, all EL components can be distributed using the conversion model for information objects of the integrated ED description, which is determined by the logical structure of the database, by the STEP standard.

1.2. Software used in the work

To create an electrical circuit are used: Altium Designer 20.11, Delta Design 2.7, SimOne 3.2.1.

To model the processes that affect the created board are used: ASONIKA-TM, ASONIKA-M-3D (9.2 for both products), and the SolidWorks 19 SP 1 modeling module.

To create the case in which the board will be placed are used: SolidWorks 19 SP1, KOMPAS 18.1.

2. Analysis of foreign and Russian EDA systems

Comparison of the layout and topology is made in two programs Altium Designer (Altium) and Delta Design (Eremex). Comparison of the results of thermal modeling is carried out from the Solidworks (Dassault Systèmes) and ASONIKA-TM (ASONIKA) programs.

2.1. Designing a low frequency amplifier in Altium Designer

The process of modeling analog, digital and mixed electrical circuits in the Altium Designer system begins with creating an electrical schematic diagram of the RED in the electrical diagram editor.

Electrical circuits obtained as a result of circuit design serve as input information for technical design, which includes engineering and technological design.

The main goal of engineering design is to move from the functional scheme of the equipment to a specific set of related structural elements, modules, and devices that implement this scheme; to determine their size, shape, material, and relative location, as well as to issue the necessary technical documentation for its production and operation[3]. In this case, the connections between individual structural elements can be mechanical, electrical, electromagnetic, and thermal. The main task to be solved at this stage is the equivalent conversion of the circuit of the device being developed into the circuit of connections of structural elements (chips, modules, semiconductor and hybrid BIS, etc.). After that, the structural elements are assembled into functionally complete nodes, blocks, and aggregates according to the criterion of minimum external links between individual structural units of the RED.

After solving the layout problem, the elements are placed within each separate structural unit. At the same time, the most important thing is to create favorable conditions for subsequent connection tracing.

Electrical connections of structural elements can be performed both by volume installation and using switching boards, where, depending on the selected production technology, printed conductors are separated in one, two or more layers, which, in turn, puts forward individual requirements for tracing algorithms. As a rule, the criteria for optimal tracing are the criteria for the minimum total length and number of intersections of conductors when completely wiring circuit connections. Tracing the connections of printed circuit boards is completed by obtaining a punched tape for the photodetector, which is used for manufacturing photomasks. Placement of components and tracing of conductors on the signal layers of the board that connect the terminals of components, according to the list of connections in the Altium Designer system, is performed in the board editor.

In the end, the basic electrical circuit and its topology were created, shown in figures 3,4,5, respectively.
The main advantages of the editor revealed through the work:

● working with metric and inch system of measures;
● three types of layers: electrical (signal and screen), mechanical;
● the Altium Designer PCB editor has the traditional capabilities of importing/exporting files in standard DVG and DXF formats, which allows developer to add pre-prepared design elements or circuit boards to the drawing and transfer the project to mechanical CAD (AutoCAD, etc.) for further documentation;
● possibility to view inside the system a three-dimensional view of the projected boards based on OpenGL technology.
● Comprehensive documentation and training materials on working in the system

Disadvantages of Altium Designer identified through the work:

● incomplete component models, many standard elements either do not have 3D models, or they are incomplete (no contacts).
● non-standard keyboard shortcuts to simplify work, for example, in many similar EDA keyboard shortcuts CTRL+R or R allows developer to rotate the element clockwise, but in Altium Designer, pressing the R key opens the context menu.

2.2. Designing a low frequency amplifier in Delta Design

The Delta Design system[4], according to the creators, is a Russian universal tool for the development of electronic devices, combining various means of computer-aided design, which provides end-to-end design. As in the case of Altium Designer, the first electrical circuit was created in the SimOne product. The diagram is shown in figure 6.

However, after creating the schema, it was not possible to upload it to Delta Design, since the SimOne schema has a format .sch that cannot be uploaded to other systems, including Delta Design. As it was found out after a conversation with a representative of the company, SimOne is a separate product from Delta Design, although different information was provided on the developer's website (figure 7).
At the same time, a different SimOne is used inside Delta Design when exporting the schema from which the standard .sch format is used. Because of this misunderstanding, the electrical circuit principle had to be created again inside Delta Design. Besides, Delta Design has a very limited library of components, and if developer does not install examples of ready-made diagrams during installation, even standard components will not be available. In the end, the following results were obtained: an electrical schematic diagram, a topology, and a 3D model of the topology shown in figures 9, 10, 11, respectively.

It was as well noticed that when transferring the project to another computer in another copy of Delta Design, the project was incorrectly exported, the connection between the scheme and the topology was lost, which is contradictory to the ideas of end-to-end design, and specifically the portability of the created radio elements information model.

Advantages of Delta Design identified in the process of operation:
- Responsive support service
- Ability to work in different systems of measures
- Intuitive interface
- Ability to estimate the received board in 3D

Delta Design shortcomings identified in the process:
- Lack of components in the electronic library
- 3D models are missing for some standard elements
- There are errors and inaccuracies when transferring between different formats
- Transferring a project within Delta Design causes difficulties
- Lack of comprehensive documentation and training videos
- Instable performance of the system
2.3. Thermal analysis of a low-frequency amplifier circuit in Solidworks

The initial data for thermal analysis in Solidworks are the geometric parameters of radio components and their thermal capacities obtained as a result of the electrical modeling of the circuit. The calculated capacities are shown in table 1.

**Table 1. Component capacities.**

| ERE designation | P (mW) | ERE designation | P (mW) | ERE designation | P (mW) |
|-----------------|--------|-----------------|--------|-----------------|--------|
| R1              | 1.2    | R10             | 8.     | D4              | 1.     |
| R2              | 1.3    | R11             | 70.    | Q1              | 2.     |
| R3              | 0.3    | R12             | 80.    | Q2              | 2.     |
| R4              | 27.    | C1              | 0.     | Q3              | 1.     |
| R5              | 0.1    | C2              | 0.     | Q4              | 20.    |
| R6              | 0.01   | C3              | 0.     | Q5              | 50.    |
| R7              | 38.    | D1              | 1.     | Q6              | 70.    |
| R8              | 3.     | D2              | 1.     | Q7              | 180.   |
| R9              | 7.     | D3              | 1.     | Q8              | 220.   |

The geometric parameters of the diagram are passed to Solidworks in STEP format. Due to the lack of a full display of radio components in the Altium Designer program, it was decided to add them from the database of 3D models of Proteus components. If it is not possible to use other development environments, developer can create these elements himself in Solidworks, as well as pass them to Altium Designer[5]. After the diagram has been passed to Solidworks, its separate built-in Solidworks Simulation module is launched and a thermal study is selected.

Solidworks Simulation is a list of tools for structural analysis using the finite element method. This analysis allows developer to predict the behavior of a product in a real environment by testing CAD models in a virtual environment. Each element is assigned material from the Solidworks material database, as well as its own heat output, derived from calculations, that acts on its surface. It is worth noting that the power acts on the surface, so the results may be inaccurate since the structural features of the components are not taken into account. Set of boundary conditions described in table 2 for the given case.

**Table 2. Boundary conditions for thermal modeling in Solidworks**

| Name of parameter | Value |
|-------------------|-------|
| Convective heat transfer coefficient ($\frac{W}{m^2\cdot K}$) | 20    |
| Mass ambient temperature (K) | 308   |

After grid building and model calculation, the results are shown in figures 12, 13.
It can be seen that the maximum temperature in this study is assigned to the resistor R12 (see figure 4). The temperature is 389K, which is about 116°C. This is the permissible operating temperature for the resistor, but it is already on the verge of the limit. Back to Sarafanov description[2] of this scheme and its calculations, the maximum temperature reaches the transistor VT8 (Q8) having the highest power.

Moreover, in Solidworks, developer can view the temperature in any polygon that the grid is divided into (figure 13). Data from this analysis can be downloaded from the design system in Excel or TXT file format.

2.4. Thermal analysis of a low-frequency amplifier circuit in ASONIKA-TM

The initial data for thermal analysis in ASONIKA-TM are likewise the geometric parameters of radio components and their thermal capacities obtained as a result of the electrical modeling of the circuit. The calculated capacities are shown in table 1 above.

Geometric parameters of the scheme are transmitted to ASONIKA-TM[6] from Delta Design in the format IDF (.brd). During the process of opening the IDF file in ASONIKA-TM, it became clear that there were not enough precise geometric parameters for the specifically selected components. The problem was solved easily. The solution is to select the appropriate enclosure for the radio component, and then configure its exact geometric parameters in the settings window. After that, one should place the component on the diagram in the place where the component was provided for by the topology if
this value has changed when changing the parameters of the enclosure. Materials of radio components are already contained in the ASONIKATM database and are stored together with standard cases.

After that, the boundary parameters are set. For the purity of the experiment, the same boundary conditions were used as shown in table 2. ASONIKATM uses more parameters since its system is configured to perform thermal analysis of electrical circuits, in contrast to the thermal analysis of Solidworks. Finally, the results presented in figures 15 and 16 were obtained.

![Figure 14. The result of thermal modeling in ASONIKATM top view.](image1)

![Figure 15. The result of thermal modeling in ASONIKATM isomerism view.](image2)

![Figure 16. Excerpt of the report on the temperatures of radio elements from ASONIKATM.](image3)

The temperature report is presented in Excel or TXT format. Unlike the Solidworks report, the ASONIKATM report contains the temperature of each element. The calculation results are shown in figure 16.

3. Analysis of foreign and Russian CAD systems

Comparison of 3D modeling is carried out in Solidworks (Dassault Systèmes) and KOMPAS-3D (ASCON). Results comparison of mechanical modeling is carried out from the Solidworks (Dassault Systèmes) and ASONIKAM-3D (ASONIKATM) programs.

3.1. Designing a low-frequency amplifier enclosure in Solidworks

The input data for 3D modeling is the geometric and thermal parameters of the circuit. Geometric parameters of the scheme are transmitted from Altium Designer in STEP format, which makes it easier to analyze and work with them. The thermal parameters are obtained after the thermal analysis of the circuit.

Solidworks provides many tools for 3D design. The process of creating a 3D model is based on creating three-dimensional geometric elements and performing various operations between them. The 3D model contains the most complete description of the physical properties of the object (volume, mass, moments of inertia) and gives the designer the ability to work in virtual 3D space, which allows developer to bring the computer model to the appearance of the future product at the highest level, excluding the stage of the layout.

The design process in SolidWorks does not end with the development of three-dimensional parts and assemblies. The program allows developer to automatically create drawings based on a given 3D model, eliminating designer errors that inevitably occur when drawing product projections manually. SolidWorks supports GOST, ANSI, ISO, DIN, JIS, GB, and BSI drawing standards. SolidWorks drawings have bidirectional associativity with 3D models so that the dimensions of the model always match the dimensions in the drawing.

Part design in Solidworks begins with creating an initial component or its part. The shape of the case for this case was taken from the fact that the low-frequency amplifier is the simplest device that
has an input and output. The material in Solidworks is set for further research and is for this case ABS plastic. The design result is shown in figure 17.

During the work, the advantages of Solidworks were identified:

- a single library of the physical properties of materials, textures and hatch patterns;
- dynamic changes in real-time;
- working in the context of Assembly; designing "bottom-up", "top-down";
- mutual determination of the position of parts in the Assembly, car fasteners;
- possibility of contextual substitution of components;
- editing and automatic stitching of imported surfaces;
- developed documentation will meet all requirements of the ESCD, the ability to create a multi-sheet drawing.

3.2. Designing a low-frequency amplifier enclosure in KOMPAS-3D

The input data for 3D modeling is likewise the geometric and thermal parameters of the circuit. Geometric parameters of the scheme are transmitted from Delta Design in DXF format, which allows developer to make measurements of the scheme parameters. The built-in KOMPAS output function from Delta Design outputs only parameter sets, not the 3D model. Sets of parameters are not transmitted to KOMPAS and, as the practice has shown, do not carry a semantic load. The thermal parameters are based on the calculation of element temperatures.

KOMPAS-3D[7] does not lag behind Solidworks in its capabilities in 3D modeling. The program has an intuitive interface and a variety of possible modeling tools that are somewhat similar to AutoCAD in perception and logic. KOMPAS-3D furthermore imports and exports easy-to-use basic formats and can recognize 3D models from other programs without losing data.

Getting started in Solidworks initializes with creating a sketch or just a solid model of a standard shape. The case was created identical to use the same design elements. The result of the design can be seen in figure 18.

In the course of working with KOMPAS-3D, the following advantages were identified:

- accounting for properties of various materials;
- parametric and solid-state development that allows developer to use sketches to create a model that applies all the main properties of the software;
- standard model library allows developer to use the built-in catalog of simple parts for development;
- includes bottom-up and top-down design, initial development is possible from both the lower level and the upper;
- interface is easy to develop for novice engineers, and certified training centers help beginners learn the software in a short time;
- developed documentation meets all the requirements of GOST, ISO, DIN or standards established at the enterprise.

The disadvantages of the KOMPAS-3D CAD system should be noted, although they are very insignificant:

- designing in 3d is more difficult for a beginner than 2d, and requires a full mastering of modeling;
- not very well to visualize objects;
- surface modeling system has drawbacks in its design.
3.3. Mechanical analysis of the case in Solidworks

Solidworks allows to perform a wide variety of mechanical studies using the Simulation module. The most popular and simple study is the impact load study, which simulates the fall of an object from a given height. The input data is a 3D model of the case. Since the actions take place on the same system, no additional files are required other than the Assembly or part file that is already created in Solidworks. For each part, developer specify a material from the material database that already exists in Solidworks. Then the boundary conditions given for this case in table 3 are set.

| Name of parameter | Value |
|-------------------|-------|
| Acceleration ($\frac{m}{s^2}$) | 9.81 |
| Drop height (mm)  | 2000 |

The results of the study are shown in figures 20 and 21.

However, since the purpose of the work is to compare the mechanical modeling of Solidworks and ASONIKA-M-3D, then the tests should be carried out accordingly. The study of the frequency corresponds to the shake-table test. To perform the study, the materials of the parts and the places where the housing is attached (namely, the mounting holes) were specified. Solidworks defines resonant frequencies in a user-defined number (5 in this case). Acceleration as well set as a boundary condition - from 0 to 9.8 ($\frac{m}{s^2}$).
After grid constructed and models calculated, the following results are shown in figures 22, 23, 24, 25 (presented in two frequencies).

**Figure 21.** Frequency 1830 Hz top view.  
**Figure 22.** Frequency 1830 Hz bottom view.

**Figure 23.** Frequency 3124 Hz top view.  
**Figure 24.** Frequency 3124 Hz bottom view.

### 3.4. Mechanical analysis of the case in ASONIKA-M-3D

For mechanical analysis in ASONIKA-M-3D, the initial data are the geometric parameters of the case and the 3D model of this one, made in KOMPAS-3D.

Data in ASONIKA-M-3D is transmitted in IGES or STEP format. The STEP format excludes any errors and is more desirable. Geometry is imported incorrectly from IGES, and after talking to the developers, it was found out that this happens because many CAD systems export IGES differently. It happens that the surfaces are not glued together and there are no shells and solids. Therefore, STEP is more in demand. The case representation in ASONIKA-M-3D is shown in figure 25.

**Figure 25.** Representation of a 3D model of the housing in ASONIKA-M-3D

**Figure 26.** The parameters of the study.
After that, the case needs the material and its elastic modulus parameters to be set, Poisson's ratio, and mass density if the material is not represented in the library. In Solidworks, the library is more complete and such problems do not occur.

ASONIKA-M-3D conducts mechanical research that corresponds to real research of the shake-table test. Just like in Solidworks, developer can set the attachment points for the housing (mounting holes). To search for resonant frequencies, set the frequency range from which the desired ones are selected. It either sets the signal pulse as shown in figure 26 and the acceleration.

After the calculations, the results shown in figures 27 and 28 were obtained. Please note that the results are presented for the same frequencies as in Solidworks. Both systems came to almost the same conclusion at 1900 Hz.

![Figure 27: The resonant frequency of 1900 Hz top view.](image1)

![Figure 28: The resonant frequency of 1900 Hz bottom view.](image2)

Moreover, unlike Solidworks, ASONIKA-M-3D allows developer to view the behavior of the 3D model at other frequencies, while Solidworks allows to see the result of the study at only a few frequencies.

But at the same time, Solidworks allows developer to conduct more diverse mechanical studies, as already described above.

4. Conclusions

As a result of the work it was revealed that with the help of domestic CAD systems, the transition is possible, but with great difficulties. CAD "SolidWorks" makes it possible not only to create a 3D model but besides this to produce thermal and mechanical modeling within the same software. Although thermal modeling in "SolidWorks" is not entirely focused on the study of printed circuit boards, since it does not fully consider the adherence of the component on the board. There are also few boundary conditions for research. The KOMPAS does not have the functions of virtual modeling of thermal and mechanical effects, but as a CAD system, it proved to be very good and did not cause difficulties. Additional software “ASONIKA” is used to solve the problem of not being able to perform virtual tests of models. “ASONIKA-M-3D” has limited testing capabilities and has problems importing files, but the program is generally suitable for use. “ASONIKA-TM” does not have a complete database of elements, but the ability to edit parameters of standard enclosures is very convenient. At the same time, “Delta Design” is not a complete analog of “Altium Design”. “Delta Design” provides identical opportunities for creating analog circuits and topologies of electronic boards, but small library of components, unstable system performance and conversion errors can make it difficult to migrate to an “Eremex” product. “SimOne” is only suitable for creating an electronic circuit. As a result, the transition to domestic software is possible but is fraught with difficulties, such as using an additional number of programs and the difficulty of reproducing the end-to-end design method on this software.
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