

Modeling the work of electrical circuits elements in SIMPLORER environment

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Abstract — The article considers the technology of CAD Simplorer application in electric circuits modeling where mathematical models of multipole elements are used. The mechanism of interaction between the model and CAD system is studied. Simulation of electrical circuit work was taken as an example.

I. INTRODUCTION

Modern electronic and electric circuits are complicated and multifunctional in structure.

That is why their study, projection and modeling is impossible without computer systems use. Such as Micro-CAP, OrCAD or PSpice are among the most popular CAD system. Their disadvantage is the necessity to use only traditional physical and topological methods. And they are less effective in the process of modeling electric circuits multipole components.

As we know [1] dynamic multipole is quite easy to describe due to macro model. Thus mathematical model describes only functional dependences between incoming and outgoing signals of multipole. The inner structure and inner interconnections remain disregarded.

To transfer from physical and topological methods to the methods of modeling in CAD environments, for instance, in PSpice, a special translator is created, able to convert macro model description into input language of the system. The matters regarding such approach are considered in a number of works, particularly [2,3].

In this article we suggest another approach, that does not require a special translator. We will consider it at the example of Simplorer system.

II. SIMPLORER MODELING LANGUAGE

CAD Simplorer contains an inset programs interface based on high level C language. It enables to add mathematical models of separate components to the schematic description of electric circuits.

The work of a described circuit can be simulated in a program. All parameters of simulating process are given with the help of so called description language SML (Simplorer Modelling Language) in the file with the expansion “sml” [4]. The program written down with SML defines SML-scenario of simulation. SML consists of the following elements:

1) Sections SML - sections, indicating the location of main elements and described by operators:

Operator	Reduction
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.CONTROL	.CTR
.OUTPUT	.OUT
.EXPRESSIO	.EXPR
N	.CCT .CKT
.CIRCUIT	.BL
.BLOCKS	.ST
.STATES	

2) operator, indicating the end of SML-scenario - .END

3) Comments to the elements of SML-scenario limited /*...*/ or {...}

4) Macrocalls – defined by user program subsystem (macros), which is declared as outer procedure in structure languages of high level programming. In Simplorer the following macrocalls are used:

```
#INCLUDE
#MACRO
#ENDMACRO
#MACROUSE
```

The way to the file storing the macros is indicated inside every macrocall.

III. TYPES OF MATHEMATICAL MODELS FOR SIMPLORER

Program C-interface Simplorer provides the opportunity to connect components of any type, particularly multipole, to the system model of circuit. Thus a user can connect a code of his own model of components, which as a program in C/C++ language is written down with the help of any text ASCII editor to the corresponding file.

Through C–interface user can set the input and output values of own programmed unlinear characteristics of multipole for circuit simulation process. Thus they can be connected by different equations, in particular by equations of state, which are convenient to express dynamic properties of multipoles [5].

Simplorer can use two types of models:

- Components defined by a user– UDC (User-Defined Components)
- Models defined by a user – UDM (User-Defined Models).

The difference between the types of models lies in a complication of models that can be described with the help of UDM or UDC. In case when UDM model is described only by one unlinear dependence between input and output. To produce whole complex of relations it is necessary to apply UDC.

UDC should have the following features:

1. Possibility to connect algorithms of schematic stimulation trough solutions of algebraic or differential equations.

2. Ability to influence integration step size.

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UDC are the systems where behavior is defined by ratio of algebraic or differential equations. With the help of programming manager UDC interact with simulation scheme through point-unit, that are input and output of multipole component. But in UDC structure, besides equations describing dependences between input and output units, there can be other equations describing dependences between inner variables.

In general case UDC would be the following:

$$A \frac{d\bar{v}}{dt} + B\bar{v} + C \frac{d\bar{x}}{dt} + D\bar{x} + E = \bar{0} \quad (1)$$

where \bar{v} : vector of variables in outer units of model;

\bar{x} : vector of variables of state;

A, B, C, D, E : ratio matrix.

Programming manager entirely undertakes connecting outer equations of simulation scheme with inner equations of model into a common system. Thus a user can optimize UDC structure benefiting most of it.

In case of UDM a user must independently coordinate the simulation scheme with the model. Also a change of simulation parameters requires total change of a model.

UDM can be represented as follows:

$$y=f(x_1, x_2, \dots, x_n, u_1, u_2, \dots, u_m)$$

where y – output variables, u – input variables, x – variables of state.

Function f must be the following:

- Unlinear, also to be a complex of any kind.
- Modulling – independent variables and algorithms management inside a model.
- Multifunctional – simultaneous application of unlimited number of models of different types.
- Programming – possibility to use high level languages for model construction.
- Open - unified interface for simulation kernel.

Besides UDM can describe any dependences, particularly elements of block-scheme.

IV. MODEL PROGRAMMING REALIZATION

Simulation of circuit work in Simplorer looks like a target realized in a program. It is solved due to the system simulator. The simulation algorithm is given in Fig. 1.

In corresponding simulation programme scheme model of circuit is defined with connected to it UDC or UDM. Outer components are described as SML-text.

UDM description begins in the section.EXPRESSION, where model name and parameters are indicated as follows:

$$\text{Model_name:=UDM(Model_type, Parameter_list)} \quad (3)$$

Here Model_name – model name is given by a user. It identifies model in the programme, also is used by Simplorer simulator to connect other components. Parameter Model_type corresponds with the name of

the file comprising the component model. With the help of Parameter_list parameter model parameters are given by a user.

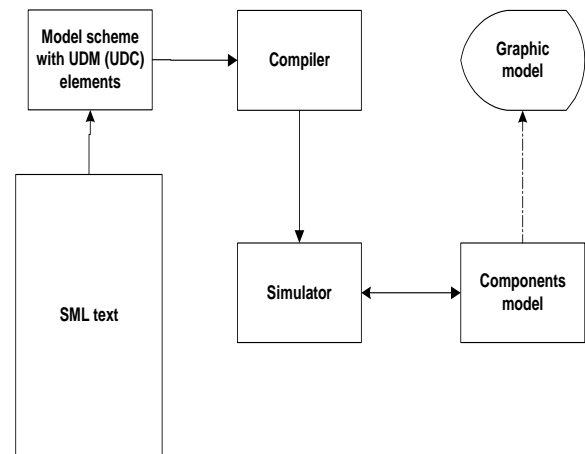


Fig. 1. Simulation algorithm in Simplorer environment.

Due to section.OUTPUT model informs simulator about the units which receive the sizes of the signals outside.

Example 1.

.EXPRESSION

oper:=udm(OPERATI, 10, 2.5e-4, 5, 0.5, 0.005, current, last)

.OUTPUT

G:n"oper"(1, 0);

For UDC section.EXPRESSION has extended format:

Model_name:=udm(Model_type, node_list| parameter_list); (4)

where Node_list – additional list of input-output units for model.

Example 2.

.EXPRESSION

oper:=udm(OPERATI, 1, 2 | 10, 2.5e-4, 5, 0.5, 0.05, last);

.OUTPUT

G:n"oper"(1, 0);

Based on scheme model of circuit Simplorer compiler creates objective code comprising instructions for system simulator. During their study simulator interacted with the corresponding component models through determined control points of algorithm (model simulation kernel).

Graphic module Simlorer Schematic for UDM, UDC enables to construct their graphic image which will be placed into the system element base and can be used while constructing other scheme models.

Irrespective of what kind they are (UDC or UDM) all models are realized as a separate DLL (Dynamic Link Library) with standard set of interaction. This enables to be very flexible in the use of the models.

When the selected UDM or UDC model simulation process begins, simulator opens the corresponding DLL file. After that between the model simulation kernel and the model occurs interaction (Fig. 2).

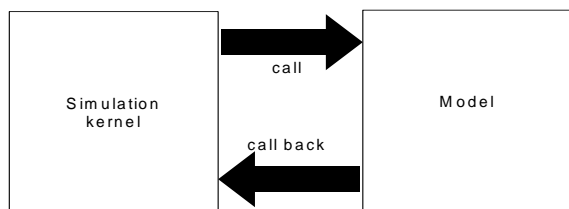


Fig. 2. Interaction of simulation kernel with the model.

There are two kinds of interaction between the simulation kernel and the model:

1) call – a set of functions, called by the model parameters;

2) call back – a set of functions of model simulation results receiving.

During the interaction of a simulation kernel with a model there must be at least one function of every kind present. Otherwise a mistake report is displayed.

V. SIMULATION EXAMPLE

Simlorer was applied during the simulation of directed with the help of voltage oscillator (DVO). Fig.3 illustrates the circuit scheme.

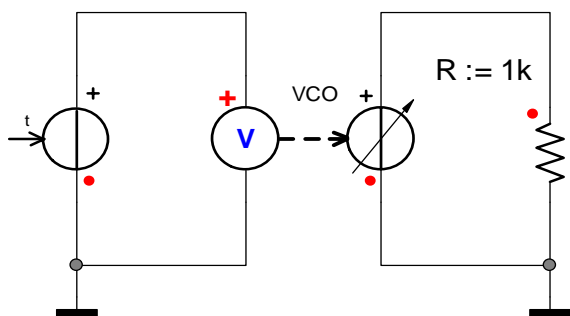


Fig. 3. DVO Scheme.

This model was described with the help of UDC. At the Fig. 4 the simulation result is represented, it coincides with the theoretical calculations.

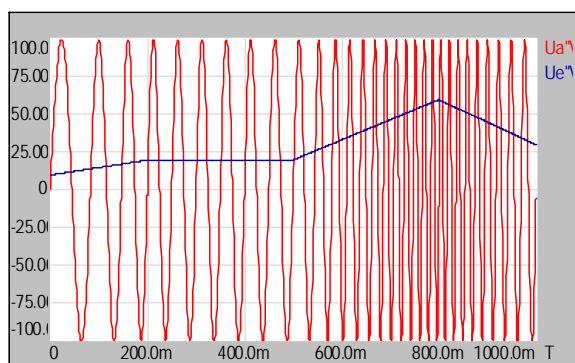


Fig. 4. Change of frequency with the change of pressure.

VI. CONCLUSIONS

Simlorer system is an effective instrument of electrotechnical circuits work study with the components described in different ways. It provides mutual use of physical, topological and mathematical models. Existence of developed interface enables to integrate the elements independently described and stored in separated from CAD system libraries to the

electrotechnical circuit under research. Thus it is possible to use the newest methods of macromodelling [6].

It is easy to describe the used macro models with the help of standard methods of programming language C. Integration of models libraries with Simlorer environment is provided in the same way.

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