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IC PACKAGES TOPOMETRIC MODEL DATABASE WITH PRODUCTION RULES

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Printed circuit board (PCB) design plays a vital role in the production of radio-electronic devices. While there are several CAD systems available to automate the process, they often fail to consider the scheme topology. To address this, a high-quality automatic system for tracing printed circuit boards is needed. This involves several steps, including the placement of components on the board, the creation of topometric lines, determining the intersection of graph edges with topometric lines, and tracing connections through crosspoints.The creation of topometric lines involves adding additional edges to the graph that connect the outputs of neighboring components. This results in a model consisting of a topological part (connections graph and topometric lines) and a geometrical part (footprints). To facilitate the integration of these parts, a topometric model of a component is introduced.The implementation of a database to store these models is crucial for CAD systems. The database should include information about the package type, geometrical size, conductors' drawing, topology, production rules, and setup scripts for topological lines. Storing production rules in conjunctive-disjunctive form allows for efficient processing and smaller data volume.The topometric database should contain records for each type of IC package, including the package type, footprint image, cycle of the graph, geometrical bindings, production rules, and initialization script for additional poles.To use the IC package topometric models database, the user selects the package type for each element of the circuit. The corresponding record is loaded from the database, including the geometrical and topometric model, which is then copied into the local project base. Additional cases can be initialized and rules for forming conductors under the package can be edited. The application of these rules determines the ability to carry out connections under the package.The author suggests that this approach, utilizing an expert system, can be used for automatic routing of printed circuit boards using a topological approach

Key words: *topometric model, production rules, PCB design, planar graph.*

Сгадов С. О. База даних топометричних моделей пакетів ІС із правилами виводу

Дизайн друкованих плат (PCB) відіграє важливу роль у виробництві радіоелектронних пристроїв. Хоча існує декілька систем САПР для автоматизації процесу, вони часто не враховують топологію схеми. Для вирішення цієї проблеми необхідна якісна автоматична система трасування друкованих плат. Це включає кілька кроків, зокрема розміщення компонентів на дошці, створення топометричних ліній, визначення перетину ребер графа з топометричними лініями та відстеження з'єднань через точки перетину. Створення топометричних ліній передбачає додавання додаткових ребер до графіка, які з'єднують виходи сусідніх компонентів. Це призводить до того, що модель складається з топологічної частини (графік зв'язків та топометричні лінії) і геометричної частини. Щоб полегшити інтеграцію цих частин, вводиться топометрична модель компонента. Реалізація бази даних для зберігання цих моделей має вирішальне значення для систем САПР. База даних повинна містити інформацію про тип упаковки, геометричні розміри, креслення провідників, топологію, правила виводу та сценарії налаштування топологічних ліній. Зберігання правил виводу у кон'юнктивно-діз'юнктивній формі забезпечує ефективну обробку та менший обсяг даних. Топометрична база даних має містити записи для кожного типу упаковки ІС, включаючи тип упаковки, зображення відбитка, цикл графіка, геометричні прив'язки, правила виводу та сценарій ініціалізації для додаткових полюсів. Щоб використовувати базу даних топометричних моделей упаковки ІС, користувач вибирає тип упаковки для кожного елемента схеми. Відповідний запис завантажується з бази даних, включаючи геометричну та топометричну модель, яка потім копіюється в локальну базу проекту. Можна ініціалізувати додаткові кейси та редагувати правила формування провідників під пакет. Застосування цих правил визначає можливість виконання з'єднань під пакетом. Автор припускає, що цей підхід, що використовує експертну систему, може

бути використаний для автоматичної маршрутизації друкованих плат з використанням топологічного підходу

Ключові слова: *топометрична модель, правила виводу, проектування друкованої плати, планарний граф.*

Introduction. An important role at production of radio-electronic devices plays the design of printed circuit boards. There is a lot of CAD systems for such purpose allowing to automate the process (Altium Designer [1], Eagle [2] OrCAD, TopoR [3], Proteus[4], and others[5]), however all of them still badly consider scheme topology, even TopoR, so the problem of development of qualitative automatic system of trace of printed circuit boards still requires attention. For the purposes of synthesis of the drawing of conducting tracks of printed circuit boards approach with use of the topological drawing of the graph corresponding to connections in the scheme can be applied. At the same time it is important to know how edges of flat parts of the graph in the drawing will pass. Thus the following actions should be made for carrying out connections of flat constructs (for example, radio components) [5, 6]:

- placing of elements on the printed circuit board;
- building of so-called topometric lines;
- determination of intersection of edges of the graph with topometric lines;
- actually tracing connections through crosspoints.

The stage of building of topometric lines includes creation of the additional edges of the graph connecting outputs of the next radio components [7]. Therefore as a result we will receive the model consisting of a topological part (connections graph + topometric lines) and a geometrical part (footprints). For approval of those parts it is necessary to introduce the interface named as topometric model of a component. Now we will consider as it is possible to define a concept of topometric model. For this purpose author introduce such assumptions:

For any electronic component one can draw around its area in which there will be geometrical drawing of conductors of a component, and outside – the topological drawing of the electrical circuit graph.

Places of intersection by conductors of this area will serve as poles – junctions with the graph of schemes. In most cases poles match signal connect pads of a component.

These poles on the one hand are connected in a cycle of the graph; on the other hand have a binding to coordinates concerning a component and form topometric model of a component.

Let's notice that in terms of topology the form of a cycle is not something essential, but it is possible to select a rectangular form which will allow to appropriate to poles of topometric model attributes of position of South, North, West, East concerning the center and to simplify an algorithm of carrying out topometric lines to the "opposite" party in a cycle, and between components. Also it is necessary to notice that it is not always correct to reduce topometric model to a projection of contacts on perimeter. For example in case of passing of tracks between outputs of the large-scale integrated circuit it is necessary to enter additional poles in places of intersection of perimeter.

Types of packages of the base construct

The base types of package used in electronics are:

– **DIP package.** Construction of DIP package means through hole mounting. That is its outputs are present at all layers of the printed circuit board. As a rule, lead spacing allows at least one track between next.

– **SOIC package.** Buildings of SOIC are used for superficial mounting, i.e. they and their conductors are present at one layer of the printed circuit board. The distance between side outputs most often a little will also not allow to carry out tracks between signal connect pads. But it is possible to bring conductors on top or from below payments and also on other layers.

– **LQFT package.** LQFT packages are also used for superficial mounting. Lead spacing usually does not allow to carry out between them tracks, however on other layers of a payment of a track it is possible to carry out freely.

– **3rd lead packages of through mounting.** It's widespread kind of the building including for transistors, mounting allows leading of the conductor from any party to contact.

– **SMD resistors, condensers, etc.** This type of the package is used for a wide number of the two-output components having the different geometrical sizes, what influences mainly that how many it is possible to carry out lines in an interval between contacts from mounting. To avoid loops in the graph, surely one can introduce additional poles.

From the above-stated classification one can see that at a stage of building of topometric model there are two problems: a problem of creation of an algorithm and a problem of carrying out connections under the package of construct. And these two problems are connected and for each class of constructs there can be the algorithm which, in turn, depends on external parameters – such as thickness of the conductor, minimum admissible conductor spacing, topology of the graph, package geometry. Thus, the author comes to a conclusion about necessity of matching of the construct package type to an algorithm of creation of topological model and a way of trace whithin.

Implementation of storage of set of constructs is important aspect of creation of CAD for distributing of payments. Here at implementation of model of the database there will be a need, first, to store including, topologic model of construct, i.e. a cycle of the graph, secondly, information on an algorithm of processing of the model. At first sight can seem that one can rigidly record in the program a certain set of algorithms on connection of poles building for different topometric models, but it is not quite right approach – databases of radio-electronic components are open systems which are actively complemented and thus it will be ever possible to come it is impossible to add new type of the package to a situation or to interfere with processing already entered to base.

Record of the database may contain the following information:

– package type
– geometrical size
– drawing of a seat
– topology and its geometrical bindings
– production rules of carrying out contact lines
– script of setup of topological lines

Here production rules concerns how do connections under the package of the large-scale integrated circuit proceeding from already carried out. They are in the form of a set of Boolean functions

$$R_{ij} = f_{ij}(\vec{v}) \tag{1}$$

Where R_{ij} = true , if poles i and j can be conduct and R_{ij} = false otherwise. $\vec{v}$ is a vector of poles such that v_k=true, if the pole has a connection. It is obvious that if more than two contacts connect, then it is possible to apply consistently production rules for

these couples in the form of logical connection. It makes sense to store these rules R_{ij} in the database in conjunctive-disjunctive form. It will allow to store them not as line expression, but numerical matrixes of the table of conjunctives and the table of conjunctives in a binary look that occupies smaller data volume and can be processed quicker.

Topometric database of models content

Records in the database related to each type of an IC package should contain:

Package type;

Image of footprint;

A cycle of the graph on vertices (automation is possible);

Geometrical binding of the cycle's vertices;

Production rules (1) of the conductors overcrossing prohibiting to carry out in topometric model. It can be made as directly and is automated proceeding from an opportunity to calculate intersections of edges of the graph on its connectivity matrix;

The script initializing the provision of additional poles proceeding from external parameters.

The item 5 could gain further development, for example, it can is possible to add the additional text box containing a script of automation of creation of rules. This script implies its execution during manual editing record of the database. It is also possible to implement automatic generation of rules for typical cases of packages.

Usage of IC package topometric models database. As it was specified by the author earlier it is going to use further the base of models of cases described above for obtaining the drawing of printed circuit boards, using the procedure of laying of flat sugraph of connections. At the same time several options of the most flat parts of the graph of connections from which the most suitable is selected at trace along sugraph edges turn out. It is necessary to take into account and geometry of cases of construct. Therefore the typical operation algorithm with such database looks as follows:

– The user's selection of the kind of package for an element of the electric circuit.

– Loading record about this package from the database, including geometrical and about topometric model of the package, copying it in local base of the project.

– Initialization of additional cases put of execution of a script.

– Editing by the user rules of forming of conductors under the case.

– Application of rules at a trace stage for definition of a possibility of carrying out tracks under the package (if rules are not set, then it is supposed what under the package of connection cannot be carried out).

Thus the approach to creation of the database assumed by the author using an element of expert system can be used in application to automatic routing of printed circuit boards using topological approach.

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