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THE ALGORITHM FOR PLACING ELEMENTS ON PRINTED CIRCUIT BOARDS WITH A UNIFORM FILLING OF THE SPACE

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АЛГОРИТМ РОЗМІЩЕННЯ ЕЛЕМЕНТІВ НА ДРУКОВАНИХ ПЛАТАХ З РІВНОМІРНИМ ЗАПОВНЕННЯМ ПРОСТОРУ

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The authors have studied a heuristic algorithm of forming the orthogonal tree Steiner for contacts chain, and explored its statistical characteristics. In this study, it was found that the length of the Steiner tree is statistically associated with the mean square deviation of the circuit terminals
Keywords: *algorithms, mounting space, objective function, tracing,, entire surface*

INTRODUCTION

The problem of placing electronic components on a printed circuit board is one of the most important tasks in automated designing of electronic equipment. How optimally placed elements on the mounting space, rely heavily on the results of the subsequent trace of the printed conductors and, as a result, the electrical, operational and constructive-technological parameters of the developed CIRCUIT BOARDS. To solve this problem, we use a large number of algorithms, mostly iterative, the purpose of optimization which is a simplification of the problem solution tracing by reducing the length of the chains, easier configuration, etc.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Most known algorithms are based on minimizing the total length of chain, length of chain is accepted proprietor rectangle covering all circuit terminals. The result of this objective function is often that the subsequent trace, in some regions of the mounting surface will need to spend too many chains. Some circuits may be simply impossible to implement at all, or their implementation will be quite complex, and lead to overloaded circuits other neighboring areas trace. In the end, you may have to carry out a manual revision of the project trace, or use a larger mounting surface. That is, in these algorithms, the quality of the automated placement may be low and unsatisfactory practices.

It is intuitively clear that we need to implement is the placement of the components, which nowhere on the mounting surface will not be a big saturation of the surface chains. Then the subsequent tracing of the circuits can be performed easier.

OBJECTIVES

This work is devoted to an attempt to formalize this idea, based on the concept of the density of the circuit. The authors have studied a heuristic algorithm of forming the orthogonal tree Steiner for contacts chain, and explored its statistical characteristics.

THE MAIN RESULTS OF THE RESEARCH

In study, it was found that the length of the Steiner tree is statistically associated with the mean square deviation of the circuit terminals along the axes X and Y, the following equations.

$$M_x(c) = (\sum X_i(c)) / N(c); \quad (1)$$

$$M_y(c) = (\sum Y_i(c)) / N(c); \quad (2)$$

$$\sigma_x(c) = \sqrt{\sum X_i^2(c) - \sum X_i(c))^2 / N(c)) / N(c)}; \quad (3)$$

$$\sigma_y(c) = \sqrt{\sum Y_i^2(c) - \sum Y_i(c))^2 / N(c)) / N(c)}; \quad (4)$$

$$L(c) = (\sigma_x(c) \times \sqrt{N} + \sigma_y(c) \times \sqrt{N}) \times (1{,}5 \pm 0{,}14); \quad (5)$$

where $X_i(c)$ and $Y_i(c)$ are coordinates of the i-th circuit terminal C at the X and Y axes;

$N(c)$ - the number of contacts of the circuit C;

$M_x(c), M_y(c)$ mathematical expectations of the coordinates of the circuit terminals X and Y;

$\sigma_x(c), \sigma_y(c)$ - slightly modified standard deviation of circuit terminals from mathematical expectations;

$L(c)$ - the length of the Steiner tree built on the contacts of the circuit.

To verify the adequacy of the proposed evaluation of the real chain length, we performed a simulation on a computer. With the help of random number generator has created a chain in the form of orthogonal trees prima with the number of nodes from two to twenty. The result was obtained the following dependence of the averaged relationships $L_{реал} / L_{оц}$ for circuits with different number N (curve 1) in the figure. For comparison $L_{реал} / L_{оц}$ to propriety covering rectangle (curve 2).

As the graph shows, the proposed assessment does not depend on the number of contacts of a circuit is proportional to the chain length with a constant error and therefore more accurately estimates the length of the chains.

As for the chain position on the mounting surface, it is well described by a rectangular area defined by the following conditions:

$$x \in [M_x(c) - \sigma_x(c) \times \alpha, M_x(c) + \sigma_x(c) \times \alpha] \quad (6)$$

$$\& \ y \in [M_y(c) - \sigma_y(c) \times \alpha, M_y(c) + \sigma_y(c) \times \alpha] \quad (7)$$

α – the coefficient of expansion of the area of the circuit, which must be equal to 1,5±0,15.

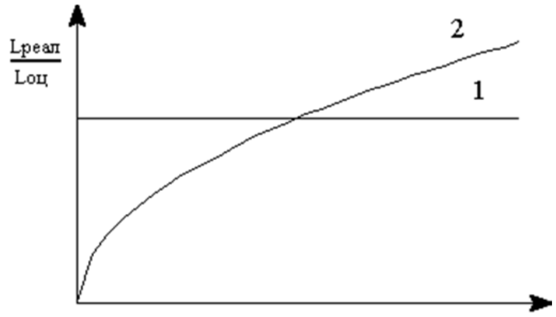

Fig. 1. The dependence of the ratio $L_{реал} / L_{оц}$ of the number of circuit terminals

To determine the "density" of the circuit, divide the length of the chain to the size of a rectangular area presumably occupied by the circuit. Then we get the following determination of the density of chains at the stage of placing components:

$$P_c(x, y) = L(c) / (4 \times \sigma_x \times \sigma_y \alpha^2) \quad (8)$$

$$x \in [M_x(c) - \sigma_x(c) \times \alpha, M_x(c) + \sigma_x(c) \times \alpha] \quad (9)$$

$$\& \ y \in [M_y(c) - \sigma_y(c) \times \alpha, M_y(c) + \sigma_y(c) \times \alpha] \quad (10)$$

Otherwise

$$P_c(x, y) = 0, \quad (11)$$

where $P_c(x, y)$ – density of the chain in the mounting surface.

Then, the "density" of all circuits on the mounting surface, obviously, is determined using the following expression:

$$P(x, y) = \sum\nolimits_c P_c(x, y) \quad (12)$$

where the summation is conducted on all circuits posted circuits.

After that, it is easy to formulate the following objective function defines the value of the quality criterion components placement:

$$\iint_S P^2(x, y) \times dx \times dy \to \min \quad (13)$$

Analyzing this expression, it is easy to establish that it is dimensionless, and evaluates the quality of accommodation irrespective of the scale of the placed component and the mounting surface.

Given that the formula for density, use constants that do not affect the minimization of the integral, you can determine the value $P_c(x, y)$ using a different expression:

$$P_c(x, y) = \sqrt{N} \times (1/\sigma_x + 1/\sigma_y) \quad (14)$$

Considering that the area presumably occupied by the chain, is sufficiently imprecise, we assume that it always describes an integer rectangle. Then the integral can be replaced by a finite amount. In this case, the value of P(x,y) to the total density of chains is defined only for integers x and y that will really take advantage of the possibilities offered by the target function.

Consider the algorithm for the placement of components in Assembly area (PCB, crystal, BIS, etc.) that implements the criteria described above.

The purpose of the proposed algorithm is to facilitate subsequent tracing due to the uniform filling of the electrical circuits in space. To do this, the entire surface of the mounting space is divided into equal rectangles and support during placement is minimized by the density of circuits in these boxes:

$$Q = \sum_{i=1}^{n} \sum_{j=1}^{m} \left(\sum_{k=1}^{c} P_{ijk} \right)^2 \quad (15)$$

where n,m – number of rows of the reference rectangles to the coordinates x and y;

c – number of circuits;

P_{ijk} – "density" of k-th chain in the reference rectangle (I,j).

The placement of elements is performed using a sequential and iterative procedures.

During the serial placement at the beginning all components are conventionally placed in the center of the mounting space, and all space is considered as the initial free area. The placement is to divide in half the largest free area and the redistribution of the components from the old center of the region in the centers obtained by dividing regions. The division is conducted until then, until you have defined spots for each component.

The procedure of component distribution by regions is as follows. Checked the proportions of the "filling" chains and as the area for installation is chosen less populated area. Selection of the next component for placement is made by looking at the list of Unallocated components of the source area and finding the item, the installation of which in the selected area gives a minimum increment in the objective function.

The complexity of the process will significantly decrease if the number of sample rectangles will increase as division areas. It is therefore proposed to determine the number of reference rows of rectangles N in each coordinate based on the ratio.

$$N = 2^n + 1, n = 1,2,3... \qquad (16)$$

where n is the number of stage placement.

New deployment phase begins when the number of layout areas will be increased four times compared to the previous stage. Received sequential algorithm a variant of the placement is optimized using the iterative procedure of permutations components places.

Experiments with the algorithm of pairwise permutations of the components showed that the proposed objective function provides a higher quality of accommodation than the traditional objective function.

Note another advantage of the proposed assessment of the length of chains in comparison with traditional spanning rectangle, which is particularly important when iterative algorithms embed. By rearranging the element to calculate propriety rectangle required viewing and analysis coordinate all contacts circuit for recalculation of spanning borders of the rectangle. There is no such necessity when using the proposed rating, if for each chain store and, in the case of reallocation, to correct the amount $x_i(c), y_i(c), x_i^2(c)\ u\ y_i^2(c)$, consequently, the complexity of the adjustments does not depend on the number of contacts of the chain.

CONCLUSIONS

The proposed objective function provides a higher quality placement of electronic components on a circuit Board than a traditional objective function, thus achieving reduction of the complexity of the decision tasks in automated designing of electronic equipment and optimizing the placement of elements on the mounting space.

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Ганжа С.М., Марченко Д.М. Алгоритм розміщення елементів на друкованих платах з рівномірним заповненням простору

Автори використали евристичний алгоритм формування ортогонального дерева Штайнера для моделювання контактів електричних кіл і досліджували його статистичні характеристики. Було виявлено, що довжина електричних кіл статистично зв'язана із середньоквадратичним відхиленням координат контактів ланцюга

Ключові слова: *алгоритм, монтажний простір, компонент, цільова функція, розміщення, трасування.*

Ганжа С.Н., Марченко Д.Н. Алгоритм размещения элементов на печатных платах с равномерным заполнением пространства

Авторы использовали эвристический алгоритм формирования ортогонального дерева Штайнера для моделирования контактов электрических цепей и исследовали его статистические характеристики. Было обнаружено, что длина электрических цепей статистически связана со среднеквадратичным отклонением координат контактов цепи.

Ключевые слова: *алгоритм, монтажное пространство, компонент, целевая функция, размещение, трассировка.*

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