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KNOWLEDGE-BASED ALGORITHM OF HYBRID ELECTRONIC DEVICES IDENTIFICATION

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Abstract. *The algorithm of in-circuit components' and electric connections' identification into printed circuit boards (PCB) of the hybrid electronic devices (which include in their composition both analog and digital components) of unknown structure are discussed in the report. The algorithm provides considerable reduction of the task dimension by using the knowledge about their designing and constructing rules and it doesn't need increasing of measuring resources.*

The result of the algorithm work is the construct of PCB graphical image which maintain all information necessary for PCB mathematical model building up and automatic generation of in-circuit tests.

Introduction

The suggested algorithm presumes the solution of problems in two levels:

- the identification of an object structure (components' revealing, a location of its place and the identification of electric connections between them) [1];
- the identification of components' types.

The iteration process including the next main steps is realized for it:

- a solution of an upper level problem (after revealing of PCB components and connections between them) brings to a call of a next level problem;
- the initiated problem is solved completely or partially (in the case of absence of a sufficient information at the given stage) and after that a return to an upper level takes place;

• a next lower level problem the most full using accumulated information to this moment is chosen (including the available intermediate solutions)

In this case the possibility of excluding some identificating stimulus difficult for realization for of conversion of identificated component into a set of predetermined states is provided.

Thus, the main factors which provides the cutting of labor-consuming components' identification when realizing the given method are:

• information accumulation about each PCB component in the process of solving other independent problems of one and the same level;

• the use of knowledge about functional and structural characteristics both a separate reference components, and PCB in the whole.

Knowledge representation about the object of identification

Knowledge concerning the designing and construction of the PCBs are represented with the facts and production rules.

The example of the facts may be the next statements:

• the components are placed along the PCB geometrical coordinate axiswith the probability P1;

• the maximal distance between component pins isn't more than L.

Such knowledge is used for reducing of the identification problem dimension due to the limiting of the subsets' cardinalities of test points between which the measurements are made.

The examples of the production rules are the following:

• IF the digital component pin is connected with a ground bus THEN it is input with the probability P=1;

• IF two digital component pins are interconnected AND are not connected with any other pin THEN one of them is an output and another is an input with a probability P=1;

• IF the active analog component output is not connected trough passive two-terminal components with no other active analog or digital components' pins THEN this pin is auxilary pin with a probability P2.

The using of this rules in connection with the information received as a result of the object structure identification (the solving of the upper level problem) makes the decisions about the choice of identification stimulus application points easier in the process of the identification of components' types (the solving of the lower level problem).

Identification of structure of printed circuit board

Coordinates of PCB test points, to which the access from measurement tools are maintained, and, also, knowledge about design characteristic, for example, such as a relative location of component pins (a system library of reference components) and PCB design rules are initial dates for its structure identification [3]. An identification fulfills by means of measuring of R,L,C - parameters and p/n-junctions between test points with usage of group methods of testing, without an application of a supply voltage on PCB.

A classification of some multi-terminals components (MTC) on analog and digital is performed on the basis of parameters' measuring of characteristical two-terminals components (CTC), included in MTS. Under CTC we mean one or more random connected to each other elements of internal MTC structure (of R,L,C or p/n - junction type), to which the access via pair of its external terminals is possible. In this case, the property of digital component is, for example, the presence of input protective diodes and/or output spurious diodes [6], and the property of analog components is the presence of CTC of R,L,C or VD type.

The results of a device structure identification are represented in the form of graph, the vertices of which represent components, and the edges map the links between them. Moreover, graph contains an information about two-terminal passive components' parameters, about if some MTCs are analog or digital, and for individual MTC, about their type too.

Peculiarities of analog components' representation.

The matter of formal representation of digital components structural and functional characteristics from the point of view of the identification are considered in [4].

In contrast to digital components, the functions of analog components are included in explicit form into PCB functions too seldom. Because of this, the problem of identification of transferring functions' parameters not of individual analog components, but PCB analog fragments, formed by collection of active and set of passive two-terminal components arises.

Note, that majority of the most frequently used MTC can be considered as some generalized active three-terminal with two inputs and single output. Such three-terminal is represented in form of a graph the edges of which are determined by MTC properties. Other terminals representing pins of a supply, correction circuits, bias correction and etc. are auxiliary and can be excluded from consideration. A criterion of the fact that the given terminal is an auxiliary one the absence of link between corresponding pin and any pin of other active component via series of two-terminal components is.

Thus, the vector $Z(D_j^a)$ of structural properties of active analog MTC differs from the corresponding digital component vector by presence of three types of pins:

$$Z(D_j^a) = \begin{cases} 1, & \text{if } v_{i,j}^a \in X_j^a \\ 0, & \text{if } v_{i,j}^a \in Y_j^a \\ x, & \text{if } v_{i,j}^a \in C_j^a \end{cases}$$

where X_j -- a set of component inputs; Y_j -- a set of components outputs; C_j^a -- a set of its auxiliary pins.

Moreover, a system references' library can include the descriptions of standard variants of analog MTC connections, representing by the graph models of PCB corresponding fragments, including both MTC itself and auxiliary two-terminal components.

The functional purpose of an active MTC may be defined only by identificating of the object's transferring function which is formed by it together with the main passive two-terminal components which are the parts of the fragment PCB endued by MTC. The known configuration of this two-terminal components gives the possibility of receiving the family of the taken fragment transferring functions depending on the type of an active MTC which endues the fragment. This family defines the functionally-algebraic model of the analog MTC which, thus, includes the description of the set of relations between the output and input signals defining by different connection diagrams of the main two-terminal components concerning the identificating active component.

The required transferring functions' family can be received by using the graph analyzing algorithms, for example, with the help of Rabisho formula:

$$W = \sum_r C_r \delta_r / \delta,$$

where C_r -- the transmission of the r-th direct path from the input node (the external pole of the circuit passive part connected with the active three-terminal input trough the passive two-terminal components) to the three-terminal output node;

δ_r -- the determinant of the completion to the direct path;

r = 1,2,3... — the number of the path among the set of possible direct paths;

δ — the graph determinant.

The presents of the transferring functions' family gives the possibility to synthesize the optimal identificating stimulus for confirming the proposed hypothesis about the type of the active analog component.

Representation of the search space

The total search space is devided into several subspaces, which differ in analogs' and digitals' components and a number of outputs of the component-candidates making up the every such subspace. Besides, such of the above-mentioned subspaces is divided in its turn into two subspaces: the functional subspace (FSS) and the structural subspace (SSS). Each of these subspaces can be present both in evident form, i.e. as matrix, and in non-evident form by the set of FAM and SFAM [1,2] component-candidates.

. Identification algorithm

The whole point of identification algorithm is in parallel decision search in two fixed search subspaces: FSS and SSS. In the identification process, the serial reduction of FSS and SSS occur by means of the identificating component transformation into a certain of states and by analysis of these states taking into account the rules available in the knowledge base.

The algorithm work come to forming current values of identification vector (IV) coordinates A_j. The dimension of this vector corresponds to the number of components, presented in the etalons' library. The value of i-th bit $a^k_{i,j}=1$ in case when on k-th step of j-th component identification, presented by the value IV - A_k, the component of the i-th type is among the candidates. The algorithm successfully completes the identification of j-th component only when at the k-th step of identification in IV there is only one non-zero bit. Taking into account the presence of two search subspaces FSS and SSS we can present IV as:

$$A_j = \tilde{A}_j \oplus \overline{A}_j,$$

where $\tilde{A}_j$ -- a functional component of the identification vector A_j; $\overline{A}_j$ -- a structural component of the identification vector A_j; $\oplus$ -- a sign of mathematical operation of bit wise addition of the vectors according to the mod2.

Conclusion

The discussed method of identification of components "black box" type which are an integral part of hybrid ED is based on the following approaches and solutions:

- the usage for putting forward the hypothesis concerning external structural features of the components being identified of heuristic knowledge of specialists about rules of design and assembling;
- division of search space into two fixed subspaces SSS and FSS, and organization of parallel search in both subspaces;
- usage of decomposition representation of analog and digital components by means of FAM

and SFAM correspondingly.

The proposed method and algorithms are realized in Borland Pascal 7.0 with Objects for IBM PC. The functioning of the program was tested on electronic device comprising up to 100 components (about 40 digital components and 60 analog components: 20 MTC and 40 passive analog components) and showed the efficiency of the used approach.

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ASPECTS OF THE ACOUSTIC PARAMETERS' INFLUENCE ABOUT THE BASS-REFLEX TYPE SYSTEM'S PERFORMANCES

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Abstract

In the synthesis of the basic parameters of a complete loudspeaker system or an enclosure for a given loudspeaker driver we must make a compromise between the different acoustical, mechanical or electrical parameters (for example the radiation power efficiency, the lowest limiting frequency of the reproduction range, the nonlinear distortion products, the volume of enclosure, etc.). The paper presents a method for determining the influence of acoustic parameters about the bass-reflex type system's performances (particularly a flat acoustic power / frequency response and a large bandwidth), using the PSPICE program. Closed-box and vented-box (bass-reflex) type systems are considered and the method is applicable to any system that can be modeled (by example passive-radiator type system).

Introduction

When a diaphragm vibrates in free space, positive and negative sound presure are produced alternately in front of and behind the diaphragm. Cancellation between the positive and negative pressures occurs at low frequencies since the loudspeaker has an omnidirectional characteristic at these frequencies.

In an enclosure, the pressure radiated behind the diaphragm is contained, so that it does not negatively interfere with the sound generated in front of the diaphragm. The three enclosure types most commonly used for loudspeaker systems are the closed-box type, the bass-reflex (or vented-box) type and the passive-radiator type.

When a vent (or duct) is added to a closed box, the loudspeaker system is named vented-box or bass-reflex. The mass of air inside the vent and the springlike compliance of the air in the enclosure constitutes a resonance circuit. If the resonance is properly tuned, the sound radiated through the vent opening from inside the enclosure effectively adds to the direct sound and can improve the response near the low cut-off frequency. Below the enclosure resonance, however, the pressure response decays very sharply as the frequency decreases due to the interference between the direct and indirect sounds.