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TEST DIAGNOSTICS OF MULTIMEDIA DEVICES

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Abstract: a method is analyzed and an implementation of synthesis of verification sequences for homogeneous networks with observable outputs is proposed by using test generators on shift registers. The upper bound of the length of the complete test sequence is obtained.

Keywords: testability, controllability, observability, homogeneous network, distinctive sequence, counter.

1. Introduction

Diagnostics of multimedia devices (MD) is carried out to assess the technical condition, indicating if necessary the place, type and cause of the defect. The technical state (of MD) refers to a set of internal properties that determine the changes during production and operation and characterize the conformity or nonconformity of the quality of the device with the requirements established by the operational and technical documentation for this equipment. The technical state of MD is characterized by certain characteristics which in turn depend on the quantitative and qualitative characteristics of the equipment properties.

The internal properties of the MD are determined by the set of properties of the interrelated and interdependent functional elements of which it consists. The total number of states in which this or that MD can be is determined by the number of functional elements and connections between them. Diagnostics is used at all stages of the existence of MD, so it is not a goal, but a means of increasing production efficiency in the collection and establishment of MD, a means of increasing its reliability during operation.

Depending on the method of delivery of diagnosing test actions to the equipment, the systems of test and functional diagnostics are distinguished. Functional diagnostic systems are used as test influences of operating signals. These influences correspond to operational algorithms of the equipment operation and can not be selected arbitrarily. The systems of test diagnostics use testing influences that are made by diagnostic devices. In this case, to obtain the effects and reactions of the response, it is possible to use not only the main inputs and outputs of the equipment, but also internal nodes and circuits. This helps to get a greater depth of defect search in a shorter time and with a reduced number of equipment.

It is known that providing the testability of complex MD is associated with certain costs and limitations which are currently supported by two standards of testable engineering IEEE1149.1-4 and IEEE P1500. The key basis of the standards is the need to meet certain technical requirements within the permissible material costs which reduce the cost of the procedures of generating tests and simulating failures. It determines the adaptability of complex systems to detecting and search for the fault location and implementing test diagnostic procedures.

Experience in the use of automated generating tests systems and simulating failures made it possible to accumulate a number of qualitative observations related to the complexity of the test synthesis. First of all, it is determined by the topology of the realized schemes and the features of their automatic models [1-3].

Attempts to quantify the complexity of verification procedures and test diagnostics of complex discrete devices led to a wide use of such concepts as "controllability" and "observability" that occurred in mathematical control theory. Namely, the controllability of a homogeneous network refers to a property of a network that provides an application to any inner cell of the variety of admissible input sets. Observability could be defined as a property of a homogeneous network that provides the ability to identify in any internal cells of the network its state and transportation of possible faults to the observable outputs of the network.

2. The synthesis method of test sequences

The analysis of the synthesis methods of test sequences for homogeneous networks with observable outputs shows that a network whose cell has a distinctive sequence is C-testable. If a network cell does not have a distinctive sequence, then any conversion of the transition-output table (TOT) of the cell will allow the entire network to be converted to a C-tested one.

For homogeneous networks with observed outputs $x_i^{'}$ in [4] it was proposed to extend the TOT of a network cell by adding another column x_a with a counting function of transitions and outputs (Table 1). Meanwhile, regardless of the properties of the TOT of the given cell, such a transformation provides for the modified TOT the minimality, strong coherency and the existence of a homogeneous distinctive sequence $(n-1)$ a symbol x_α long. The upper limit of the length of the complete test sequence $\ell(T)$ for a modified homogeneous network is determined with the expression [4]:

$$\ell(T) \le 2n^2(m+1). \qquad (1)$$

All this will lead to hardware redundancy introduced into the circuit cell of a homogeneous network as a result of its TOT transforming in accordance with Table 2.

Table 1. TOT with column

$Z(t)$	$Z(t+1)$, $\lambda(t)$	
	$x_1 \div x_m$	x_α
z_1	…	$z_2, 0$
z_2	…	$z_3, 0$
…	…	…
z_{n-1}	…	$z_n, 0$
z_n	…	$z_1, 1$

Table 2. Modified TOT

$Z(t)$	$Z(t+1)$, $\lambda(t)$	
	$x_1 \div x_m$	x_α
z_1	…	z_2, y_α^1
z_2	…	z_3, y_α^2
…	…	…
z_{n-1}	…	z_n, y_α^{n-1}
z_n	…	z_1, y_α^n

If the implementation of the output function in the column x_α is performed by convolution of the 'AND' operation of the cell outputs, then the complexity of implementing the transition function in the column x_α is not obvious and regular. In the general case, if the network cell has q inputs $(s_1, s_2, \ldots s_q)$ and, therefore, $2^q = n$ states of *Z*, then the transition function in the column x_α is realized by a multi-output combinational circuit having $(q+1)$ inputs and q outputs, and each of the outputs implements the function $f_i(s_1, s_2, \ldots s_q, x_\alpha)$, $i = \overline{1, q}$.

3. Implementation on shift registers

Let's consider an example of the solution of this task on the basis of a variant of coding states of the automaton with a shift-register sequence. If *n* states of the automaton are encoded by the variety of states of the subgraph of transitions $G_n \le G_{2^k}$ of the *k*-bit shift register where the sequence $P_q(n)$ generates the Hamiltonian cycle, then the introduction of an additional column x_α with a shift register transition function and output function $y_\alpha = P_q(n)$ additionally entails the implementation of the following functions:

$$\begin{aligned} y_\alpha &= f(s_1, s_2, \ldots s_q, x_\alpha) \\ s'_1 &= f_1(s_1, s_2, \ldots s_q, x_\alpha) = y_\alpha^1 \,, \\ s'_2 &= s_1; \;\; s'_3 = s_2, \ldots s'_q = s_{q-1} \end{aligned} \qquad (2)$$

where s'_i – a cell outlet in the direction of *s i*-th by number; y_α^1 – the function of the cell output in the direction of *x* at the output pole with number 1.

If the cell has *k* output poles in *x* and $k \le q$ direction, then using all *k* outputs of the implementing functions

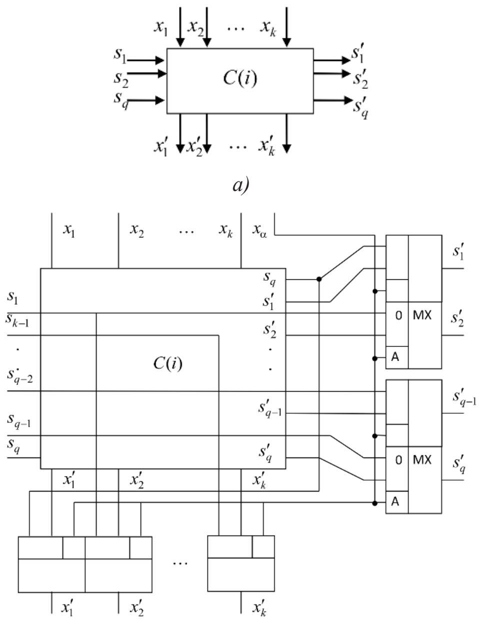
$$y_\alpha^1 = s'_1, \;\; y_\alpha^2 = s'_2, \ldots y_\alpha^k = s'_k, \qquad (3)$$

allows to obtain in the modified cell a distinctive sequence of minimum length, which is equal to

$$L_0 = \left\lceil \frac{\log_2 n}{k} \right\rceil \,. \qquad (4)$$

Thus, for the proposed method of modifying a TOT of a network cell, it is additionally required to implement one logical function $(q+1)$ of the variable $f_1(s_1, s_2, \ldots s_q, x_\alpha)$.

The source cell has *m* inputs and *n* outputs of X', as well as *q* inputs and outputs in the direction of s Figure 1 (a). Modification of the cell into the C-tested one can be accomplished by introducing additionally $(q+k)$ multiplexers 1 of 2 and a combination circuit realizing the function $f_1(s_1, s_2, ... s_q, x_\alpha)$. In the mode of operation $(x_\alpha = 1)$, the cell structures coincide, in the functioning check mode $(x_\alpha = 0)$ at the outputs x' and S' Figure 1 (b) of the cell, the equality system (2) and (3) is realized, i.e. the function of the transitions and outputs of the column x_α of Table 2.



a - original cell form;
b - the structure of the modified cell
Fig. 1 Implementation of a cell of a C-tested homogeneous network

A complete testing experiment for a homogeneous network of modified cells is determined by the length of the input set that verifies the TOT cell transition

$$\left|V(\delta_{ij})\right| \le \left|x_j X_0 T(z_i)\right|, \qquad (5)$$

where $|X_0| = L_0$ – is determined from (4); $|T(z_i)| \le (n-1)$ – a transferred sequence determined by the transition function of the column x_α of the TOT.

Thus, the number of tests verifying the transition δ_{ij} in all cells of a homogeneous network is determined from (5):

$$\left|V(\delta_{ij})\right| \le \left(n + \left\lceil \frac{\log_2 n}{k} \right\rceil \right). \qquad (6)$$

To check all $(m \times n)$ transitions, it is necessary to apply a sequence T_n of length $\ell(T_n)$:

$$\ell(T_n) \le mn\left(n + \left\lceil \frac{\log_2 n}{k} \right\rceil \right). \qquad (7)$$

Taking into account that all transitions in the column x_α are checked by *n* tests, the complete checking sequence of the entire homogeneous network has an upper bound of length

$$\ell(T_n) \le mn\left(n + \left\lceil \frac{\log_2 n}{k} \right\rceil \right) + n \; . \qquad (8)$$

Thus, for the example reviewed, the length of the complete verification sequence for the proposed method of transforming a homogeneous network is almost half the length of the sequence determined by the modification of the network cell proposed in [4].

Another advantage of the proposed method of cell transformation of a homogeneous network is the simplicity and algorithmic regularity of constructing a complete verifiable experiment for a network of modified cells. In accordance with the synthesis method of checking tests for homogeneous networks that have distinctive sequences, *n* tests are used in the phase of identification of network cell states:

$$\begin{aligned} & z_1 \frac{x_\alpha}{} z_2 \frac{x_\alpha}{} z_3 ... \frac{x_\alpha}{} z_1 \frac{x_\alpha}{} z_2 ... \\ & z_2 \frac{x_\alpha}{} z_3 \frac{x_\alpha}{} z_4 ... \frac{x_\alpha}{} z_2 \frac{x_\alpha}{} z_3 ... \; . \\ & z_n \frac{x_\alpha}{} z_1 \frac{x_\alpha}{} z_2 ... \frac{x_\alpha}{} z_n \frac{x_\alpha}{} z_1 ... \end{aligned} \qquad (9)$$

In the phase of the transition check $z_i \frac{x_j}{} z_j$

$$z_i \frac{x_j}{} z_j \frac{x_\alpha}{} z_a \frac{x_\alpha}{} z_b ... \frac{x_\alpha}{} z_i \frac{x_j}{} z_j \frac{x_\alpha}{} z_a ..., \qquad (10)$$

where $(z_i, z_j, z_a, z_b) \in Z$.

The symbol x_j in the checking sequence is running against the background of the symbol x_α, because in accordance with the modification of the TOT, the symbol x_α provides a strong coherency of the automaton and simultaneously forms a homogeneous distinctive sequence.

Thus, the most labour-intensive part of the testing experiment is that the phase of verifying the correctness of the transitions in each cell of the network is carried out by the "running x_j" test, $j = \overline{1, m}$ which is quite simply realized by using test generators on shift registers.

4. Conclusions

The article proposes a method of modification of the cell that does not have a distinctive sequence of the automatic diagram. Which involves the providing for the introduction of an additional input symbol and the use of state codes generating the Hamiltonian cycle in the sequence of transitions. The regularity of the implementation of the redundant part of the scheme and the regularity of constructing of the testing experiment in the phase of checking the correctness of state transitions of each cell in the form of a test «running» symbol x_j also ensure the property of the C-testability of the network.

5. References

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