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Time Optimization for Test Generation

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The problem of optimal length definition is considered for initial random search by test generation for discrete devices with further use of deterministic method. The optimization criterion is the time costs.

It is known [1] that pseudo-random methods are appropriate for discrete devices at initial stage of test construction. The dependence of total fault removal on the time of test construction is shown in [2] by deterministic methods, methods of random search and combined use of these two methods. The results obtained indicate that the best temporal characteristics are achieved by combining these methods. In practice it is evident that outside certain limits, the use of pseudo-random methods becomes inefficient. This boundary should be determined at the initial search to save computer resources.

The problem is formulated as follows: what number of sets of input actions t should be controlled at a random search based on fault simulation? Here the deterministic method was used for minimization of computer time T.

The following reasoning is based on the assumption that the fault class to be considered is single constant faults, devices are rather large and distribution of input signals is stationary.

The total time T involves time costs of initial action of the pseudo-random test synthesis method and time costs of the further work of the directed deterministic method.

A general scheme of the pseudo-random method of test generation consists in stopping of faults simulation after their detection. To construct the method it is necessary to add the block to the program implementation of fault simulation. This block compares output pole value of operable device with the defective devices after each input action set. The working time of the unit is insignificant as compared to the time of fault simulation.

The part of faults detected on t random sets is designated by $P(t)$. The part of faults detected on ith set is $P(i) - P(i-1)$ and the time costs for simulating these faults are $iH_m(P(i) - P(i-1))$. Here $H_m = k_m L^2$, where H_m is the computer time of fault simulation for the circuit with L gates, k_m is the factor specifying the device and method to be considered.

Time costs of the pseudo-random synthesis of test based on the fault simulation with not more than t sets, are

$$H_m \sum_{0}^{t} i\,(P(i) - P(i-1)),$$

or

$$H_m\,((t+1)\,P(t) - \int_{0}^{t} P(x)\,dx + Q),$$

where $|Q| < 1$. This is a result of monotonicity of growing function $P(t)$ and $P(t) < 1$ $(P(0) = 0)$. Then the part of faults $P(t)$ is detected.

For estimating time costs for test generation by the deterministic method the estimate [2—4] $H_d = k_d L^3$ is used where H_d is the computer time needed for test generation for the circuit with L gates, k_d is the factor specifying the above device and method. Time costs of the deterministic method can be described by the expression $H_d(1 - P(t))$. The relationship of the random test length t to the part of detected faults $P(t)$ can be adequately described by

$$P(t) = 1 - \exp(-A \log_{10}(t)), \tag{1}$$

where A is the factor specifying the device studied [2]. Therefore, by this problem statement, the computer time minimization is reduced to T minimization, i.e. to t definition when

$$T = k_m L^2\,((t+1)\,P(t) - \int_{0}^{t} P(x)\,dx + Q) + k_d L^3\,(1 - P(t)) \Rightarrow \min.$$

Taking $dT/dt = 0$, we find

$$t = (k_d/k_m)\,L \tag{2}$$

(even without differentiating $P(t)$).

The accuracy of t estimate depends on k_d and k_m estimates. A statistical approach may be followed which is used by the estimation of test totality [5, 6] combining the problem solutions. To do this it is necessary to select in a random way approximately 400 faults and to define the totality of a random test of the given length t by means of fault simulation.

We find A by (1). By fault simulation the estimation of k_m is just possible. For k_d definition the deterministic synthesis method should be used. The real values k_d and k_m can be evaluated by means of a confidence interval using the Student distribution with 0.95 reliability, like in the case of A definition. Therefore having performed two labour-saving statistical experiments, it is possible to define the number of random test sets which optimizes the total costs by test synthesis. Here the forecast of the length and totality of random test can be obtained.

Note that the estimate (2) is consistent with the known estimate $P = \log(L)$ from [3] and it gives grounds to use the methods of random search at the length of test successions t of the L order.

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