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Verification of Digital Units with the Petri Nets

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***Abstract* - Digital units are synthesized with different methods using formals as the final automata theory, or empiric, which are based on the experience of designer. In all cases implementing connection on specific industrial elements indetermination indications, which were existing at the drafting of the tasks theoretical part are turning into determination. In the function process of digital unit determinations are becoming into specific process, what sometimes can cause unexpected results hazard. Elimination of indeterminations are changed by passing from the specific solution back to automata behaviors defining, what is comparatively complicated, cause of few available appropriate programs. For the elimination of the listed mistakes, logical equipment on chosen elements can be checked with the Petri net simulation programs.**

***Keywords:* digital devices, automata theory, Petri nets.**

I. Introduction

For synthesizing of simple digital devices usually are used manual or empirical methods. Applying those methods by an inexperienced designer may cause system malfunction. To avoid this, it is suggested formalizing the task. There exist several methods for problem solution; the more popular case is illustrated in Fig. 1.

Step. 1 Input -timing diagram, -truth table, -state transition table, - state diagram.	Step. 2 Finite state automata nondeterm inistic.	Step. 3 Desing - expressions, -encoding, -characterstic equation.	Step. 4 Realization -integrated circuits.	Step. 5 Finite state automata determini stic.

Fig. 1. Traditional steps for synthesis of digital devices.

Completing all sequential steps of digital syntheses, we can get principle scheme of device, which may contain additional logic states not mentioned in the task. Proceeding system analyses using any of well known methods, in result we get fully functioning device, as seen in the most common analysis process consecution on Fig. 2.

Step.1 Finite state automata deterministic.	Step. 2 Analyses -testing, -characterstic equation, -truth table.	Step. 3 Repair -testing, -characterstic equation, -truth table.	Step. 4 Sequential Circuit

Fig. 2. Traditional steps of digital analysis.

There is some of simulation programs used for digital analysis. 2 ways of solution include: circuit simulation or Petri nets [1, 2]. Probably the second way is simpler but it is necessary to transform the principal scheme into Petri network model. For better understanding let's have a look to a certain solution.

II. Synthesis of Finite Automata

We should synthesis the principal scheme, which has been described by timing diagrams from Fig. 3.

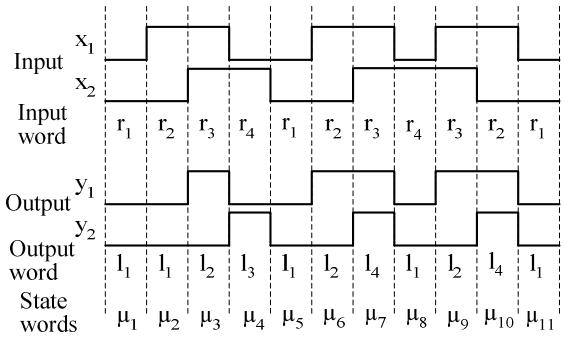

Fig. 3. The timing diagrams of digital device.

According to timing diagrams we have to fill the primary table of transitions-outputs in Tab.I and reduced table and the graph in Tab. II and Fig. 4.

TABLE I

Primitive State Table of Transitions-outputs

r / μ	r_1	r_2	r_3	r_4
1	1,1	2		
2		2,1	3	
3			3,2	4
4				4,3
5	5	6		
6	5,1	6,2	7	
7			7,4	8
8			9	8,1
9		10	9,2	
10	11	10,4		
11	11,1	2		

TABLE II

Reduced Table of Transitions-outputs

Y / X	00	10	11	01
00	00,00	00,00	00,10	01,01
01	01,00	01,10	11,11	01,01
11	?	?	11,11	10,00
10	00,00	10,11	10,10	10,00

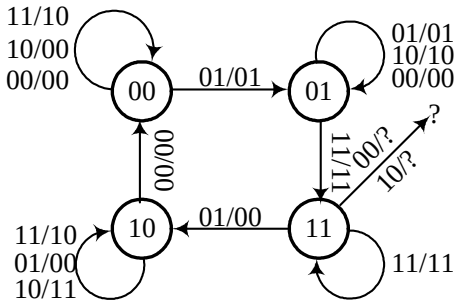

Fig. 4. The graph.

Using transitions-outputs table we derive Boolean expressions for specific logic base which can be determined during process of analysis. For simple solution the principal scheme is built from logical elements such as NOT, OR, AND, also RS flip-flops. See in Fig. 5.

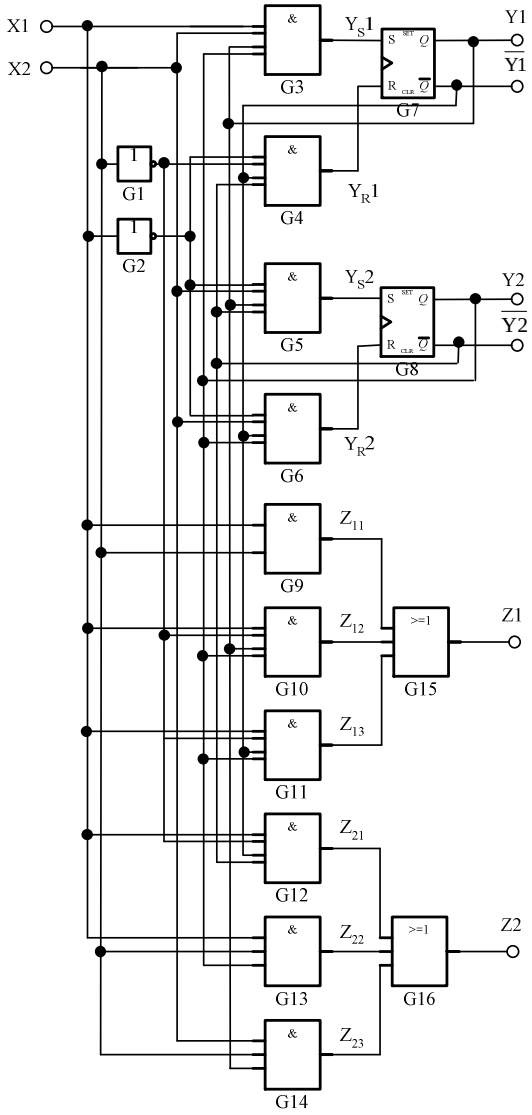

Fig. 5. Principal scheme of digital device.

III. Digital Equipment on Petri Net Approach

There are different types of Petri networks [3]. For analysis we choose the simplest form. The logical elements must be replaced with transitions, while inputs, outputs and links with positions. Simplified model of Petri net without implementation of output signals is illustrated in Fig.6.

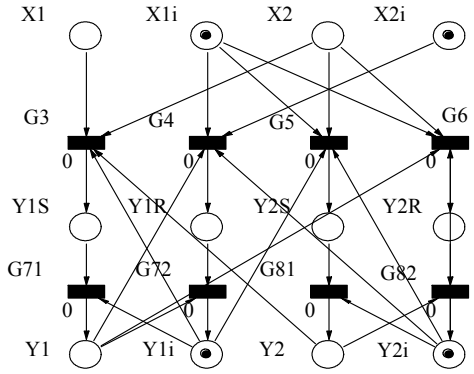

Fig. 6. Simplified model of principal scheme of digital device.

The inverse values of logical elements in Petri nets are noted adding the index „i". R-S flip-flops model is very simplified and replaced with transitions G71, G72 and G81, G82.
Here network represented as an incidence matrix:

$$I = \begin{vmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & -1 & -1 & 0 & 0 & 0 & 0 \\ -1 & 0 & -1 & -1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & -1 \\ 0 & -1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & -1 & 1 & -1 & 0 & 0 \\ -1 & 0 & -1 & 0 & -1 & 1 & 0 & 0 \\ -1 & 0 & 0 & -1 & 0 & 0 & 1 & -1 \\ 0 & -1 & -1 & 0 & 0 & 0 & -1 & -1 \end{vmatrix}$$

Roves represent positions and columns- transitions. Theoretically any state of network is definite by the following relevance:

$$M_{i+1}=M_i+I\times T, \quad (1)$$

where: T-transition of column matrix,
I - incidence matrix,
M – marking matrix.

By iteration (1) is possible to define the real values for undefined states and fulfill in Tab. 2 the empty positions with 11,11. Analysis can be provided by means of programs for determination.

IV. CONCLUSION

For analysis of digital devices it is gainful to use Petri nets and its simulating software.
Process of execution:
-the principal scheme of connections first must be translated into simple Petri net model.
-analysis can be provided mathematically by using the states of networks or by programming means.

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Tālis Celmiņš, Armands Pundurs, Ciparu iekārtu pētīšana ar Petri tīkliem.
Ciparu iekārtu sintezē izmanto formālos vai empīriskos paņēmienus, kas pamatojas uz projektētāju pieredzi. Projektētājiem, izstrādājot iekārtu principiālās shēmas, izveidojas darbības stāvokļi, kurus neizmanto jeb tā sauktie nenoteiktie. Visos gadījumos iekārtu slēgumu principiālās shēmas realizējot uz konkrētiem rūpnieciskajiem elementiem izzūd pazīmes par nenoteiktību, kas pastāvēja pie uzdevumu sastādīšanas teorētiskās izstrādes. kas dažkārt var izsaukt neparedzētas darbības. Lai novērtētu pilnīgu iekārtas darbību, loģiskās iekārtas uz izvēlētajiem elementiem var pārbaudīt ar simulējošām programmām. Ja izmanto ciparu iekārtu simulējošās programmas, lai noskaidrotu nenoteiktību patiesiskumu, jāpārbauda visi iespējamie gadījumi, kas ir samērā sarežģīti un ne vienmēr praktiski iespējams. Uzdevuma risināšanai ieteicams izmantot Petri tīklu simulējošās programmas. Tādā gadījumā iekārtas principiālā shēma jāpārveido Petri tīkla modelī. Lai to varētu izdarīt, vispirms jāatrod vai jāizveido elementu loģiskajiem atbilstošie tīklu modeļi. Pēc tam izmantojot Petri tīklu simulējošās programmas, kas nodrošina stāvokļu sasniedzamības noteikšanu, jāpārliecinās par iekārtas pilnīgu darbības drošumu. Piedāvātais paņēmiens ieteicams arī, ja dotas iekārtu principiālās shēmas, neatkarīgi no rūpnieciskajiem izvēlētajiem. Sasniedzamība ir nosakāma teorētiski ar Petri tīklu palīdzību, uzdodot punktu marķējumu, pie dotās incindentu matricas. Dotais uzdevuma piedāvājums formalizējams.

Талис Целминш, Армандс Пундурс. Исследование цифровых устройств сетями Петри.
Цифровые устройства синтезируются с формальными или эмпирическими методами, которые являются основанными на опыте проектировщика. При разработке, проектировщиками, принципиальные схемы устройств, часто образуются так называемые неопределённые состояния. Во всех случаях, осуществляя реализацию на определенных индустриальных элементах неопределенности, которые существовали при составлении задач, превращается в определённые. В процессе функционировании цифровых устройств, неопределенности превращаются в определенный процесс, которые иногда может вызвать неожиданные результаты как неустойчивые. Определение неопределенности возможно с помощью симулирующими программами цифровых устройств, в этом случае необходимо проверить все возможные шаги функционирования, которые из-за сложности или объемности не всегда удаётся. Для облегчения данной задачи целесообразно использовать симулирующие программы сетей Петри. В этом случае принципиальные схемы устройств необходимо превращать в соответствующих моделях сетей Петри. Сначала здесь должны быть найдены или созданы элементы, соответствующие моделям сетей Петри. Целесообразно использовать симулирующие программы сетей Петри, имеющих возможностей определять достижимость и тем определять неопределенности и иметь полное представление о действии устройств. Данный способ позволяет проверять функционирование устройств независимо от использованной элементной базы. С помощью сетей Петри достижимость можно определять теоретически, задавая соответствующую маркировку точек и имея матрицу инцидентностей. Данный способ формализуется.