PROGRAMMING OF COMBINATIONAL CIRCUITS USING THE MATHEMATICAL APPARATUS OF BOOLEAN ALGEBRA

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Annotatsiya: *Eng oddiy hollarda mantiqiy boshqaruv tizimini dasturlashda mantiqiy algebraga asoslangan matematik apparatdan foydalaniladi. Masalan, istalgan vaqtda chiqish signallarining kombinatsiyasi kirishdagi signallarning kombinatsiyasi bilan yagona aniqlanadigan dasturlash qurilmalari uchun (n, m) - qutblar nazariyasidan foydalanish mumkin.*

Annotation: *In the simplest cases, when programming a logic control system, a mathematical apparatus based on Boolean algebra is used. For example, for programming devices, in which the combination of output signals at any time is uniquely determined by the combination of signals at the input, one can use the theory of (n, m) - poles.*

Kalit so'zlar: *mantiqiy boshqaruv tizimi, ta'minot signali, algoritm, elektroavtomat, Gidravlik bosim, dasturlash quyi tizimi, aloqa moduli.*

Keywords: *logical control system, supply signal, algorithm, electroautomatic, Hydraulic pressure, programming subsystem, communication module.*

Let there be a system of m functions:

$$\begin{cases} \varphi_1(x_1, x_2, \dots \dots, x_n) = y_1 \\ \varphi_2(x_1, x_2, \dots \dots, x_n) = y_2 \\ \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \\ \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \\ \varphi_n(x_1, x_2, \dots \dots, x_n) = y_n \end{cases}$$

It is required to construct a circuit in which the work of the i-th output would be determined by the function φi. Such circuits with n inputs and m outputs are called (n, m) - poles. The function φi determines some (n, 1) - pole. The scheme for the whole system will be a set of m such (n, 1) - poles. Let's consider an example of programming some functions of electro automatics of a SA-700 CNC lathe manufactured by JSC SASTA: emergency stop functions φESC, functions for signaling the activation of drives φENABLE and functions for the readiness of the hydraulic system φHYDR. To program the functionality, we need the following signals presented in the table.

Table 1 - Signals of electro automatic machine CA-700

Signal designation	Signal Description
X_0	Emergency limit switch at the beginning of the X-axis
X_{MAX}	Emergency limit switch at the end of the X axis
Y_0	Emergency limit switch at the beginning of the Y-axis
Y_{MAX}	Emergency limit switch at the end of the Y-axis
A_{DOOR}	Protective cover closing sensor

A_{POW}	Drive power signal
B_X	X-axis drive ready signal
B_Y	Y-axis drive ready signal
A_{PRES}	Hydraulic pressure signal

The emergency stop function is activated and stops the drive when one of the conditions is met: limit switches X_0 , X_{MAX} , Y_0 , Y_{MAX} are pressed or the protective cover is not closed, i.e. A_{DOOR} signal is active. This function can be defined by a truth table of the following form:

Table 2 - Truth table of the "emergency" function

$X_0 \cup X_{MAX}$	$Y_0 \cup Y_{MAX}$	A_{DOOR}	φ_{emer}
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

According to the truth table, we compose a Boolean function:

$$\varphi_{emer} = (X0 \ \cup \ XMAX) \cup (Y0 \ \cup \ YMAX) \cup ADOOR$$

The drive enable signaling function is active when there is a ready signal from both drives B_X, B_Y and there is a power supply signal for the A_{POW} drives. The function is given by the following truth table:

Table 3 - Actuator power supply truth table

A_{POW}	B_X	B_Y	φ_{Enable}
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

According to the truth table, we get a function of the following form:

$$\varphi_{Enable} = A_{POW} B_X \, B_Y$$

The readiness function of the hydraulic system depends on two signals: the presence of the APPS power supply and the presence of the necessary pressure of the DABP and is given by the following truth table.

Table 4- Truth table of the hydraulic system readiness function

A_{POW}	A_{PRES}	φ_{hydr}
0	0	0
0	1	0
1	0	0
1	1	1

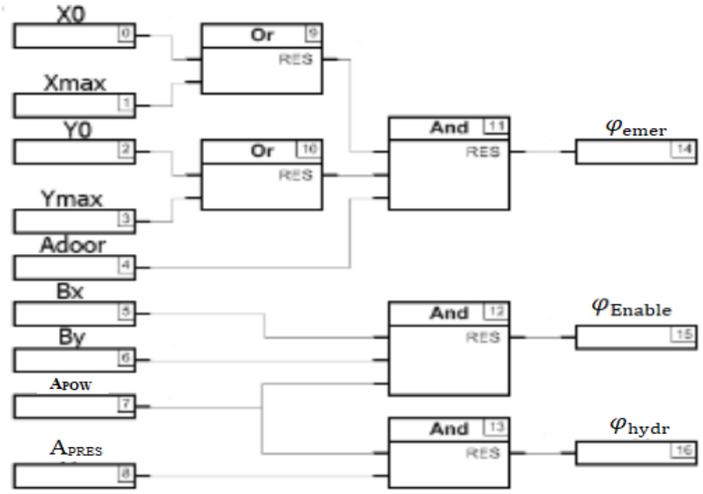
According to the truth table, we get a function of the following form:

$$\varphi_{hydr} = A_{POW}A_{PRES}$$

Combining, we get a system of the form:

$$\begin{cases} \varphi_{emer} = (X0 \cup XMAX) \cup (Y0 \cup YMAX) \cup ADOOR \\ \varphi_{Enable} = A_{POW}B_X B_Y \\ \varphi_{hydr} = A_{POW}A_{PRES} \end{cases}$$

Having built a circuit for each function separately in the programming environment, we get a set of circuits shown in Figure 3.



1 - Logic program for the implementation of (n, m) - pole for controlling individual functions of the CA-700 machine

Such a synthesis will not always be optimal; in the presence of a large number of signals, it is necessary to use the methods of simple implicants or a cascade for the synthesis of (n, m) - poles, which are widely used in technology.

The new principles underlying the construction of logical control systems, which have arisen with the development of computer technology, suggest a form of organization of systems that is different from the existing ones, which required the formulation of new methodological foundations for their design.

As a hardware computing platform for building logic control systems, modern unified solutions can be used that allow the use of standard tools for designing and implementing software. Unified solutions can be: personal, industrial and single-board computers.

The process of designing and implementing logical control systems is iterative, complex and ambiguous in the choice of methods and means. In this regard, there is a need to develop system design tools. As such a tool, a methodology is proposed that determines a fixed set of practical steps leading to the desired result.

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