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PRESENTATION OF A VARIANT SOLUTION OF THE PNEUMATIC SYSTEM FOR REALIZING THE TERNARY STATE

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Abstract. *The paper discusses the ternary (three-valued) logic application at the level of the technological capacities of the pneumatic components while considering the problem intricacy so far as the logical operation application to the real system is concerned. By using the existing pneumatic components, the circuit of the basic operator of the proposed symmetrical ternary system has been realized so that one of the logical values of variable* $x_i \in \{-p, 0, p\}$ *corresponds to each range. The vacuum induction nozzle is used as the basic component in the scheme realization. The given issues are illustrated by using an example of the integrated ternary system for manipulation within the sequential control.*

Key words: *Pneumatic System, Pneumatic Components, Ternary (Three-valued) State, Ternary Logic, Logical Function of the Variable, Manifold.*

1. INTRODUCTION

On the basis of various definitions the ternary (three-valued) encoding provides for the presentation of discrete information by means of three-member sets $x_i \in \{0,1,2\}$, that are usually sets of the figure symbols of the ternary numerical systems:

$$N_{(3)} = a_n 3^n + a_{n-1} 3^{n-1} + ... + a_0 3^0$$

If the set $\{-1,0,1\}$ is used for denoting ternary discrete values, then we are dealing with the so-called *symmetrical ternary numerical system*. Conceptually speaking, this system has special importance regarding the physical realization in view of the symmetrical three-valued character of many physical processes that can be used for defining the signal level.

Accordingly, the defining of the three different logical states represented by the

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ternary logic symbols points to the possibility of applying this logic to designing and realizing sets or devices on the whole, independently or together with the binary logic.

Our further analysis is focused on realizing the ternary state at the level of the technological capacities of the pneumatic components while considering the problem intricacy so far as the logical operation realization to the real system is concerned.

2. Application of the Ternary State

2.1 Basic Operator Realization

Starting from the ternary state requirement on the basis of the existing binary pneumatic component the basic operator circuit of the proposed ternary state has been realized. The "vacuum induction nozzle" or VIN represented in Fig. 1 will be used as the basic component in the scheme realization.

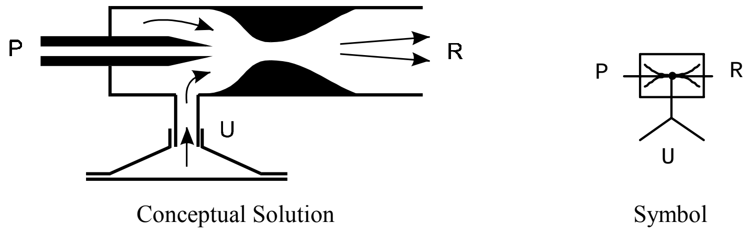

Fig. 1. Vacuum Induction Nozzle Based on the Venturi Principle Implying that the Compressed Pressure Flow from P to R Creates Vacuum at Connection R

In the concrete case, for the physical modeling of the three-valued logic the air under pressure with the following relations will be used:

(−1) → (−p) - *vacuum* (*subpressure*);
(0) → (0) - *no pressure* (*atmospheric pressure*);
(1) → (p) - *industrial pressure* (*superpressure*);

Fig. 2 symbolically represents the realization of the physical parameters of the established ternary logic correspondence {-p, 0, p} with the use of the VIN.

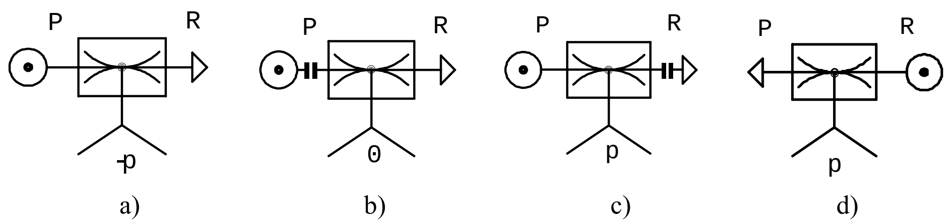

Fig. 2. Symbolic Representation of the Ternary State Realization {-p, 0, p} with the use of the VIN: a) **-p**, in the Case of Free Flow from P to R (P→R); b) **0**, in the Case of Break at P; c) **p**, in the Case of Break at R, and d) **p**, in the Case of the Current Direction Change (R→P).

This statement is based upon the fact that if the compressed air inflow is broken at P, the induction also stops (0), that is the free air discharge is broken at R, so that pressure (p) appears at connection U instead of vacuum (-p). However, in the case of the change of the air flow direction through the VIN pressure (p) is also obtained at connection U.

2.2 Variant Solution of the Pneumatic Mechanism

The present capabilities of the ternary logic application are primarily based upon those research results aiming at overcoming the limitations peculiar to the binary logic.[1] At the moment, we are going to take into consideration the quality of the examples of some possibilities of modeling the basic ternary logical functions (one and two independent variables) by means of the proposed pneumatic mechanism while tending, at the same time, toward further application.

In the concrete case we are going to accept an example of the pneumatic mechanism realization as a variant solution consisting of the pneumatic manifold 4/3, that is, 5/3 and the VIN. Fig. 3 gives the above-mentioned example by using the rules implied within the above-mentioned norms; the same will be further on regarded as the *pneumatic mechanism* or PM [1].

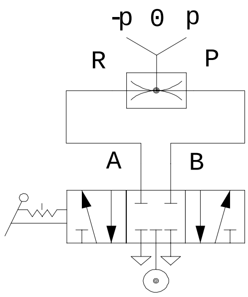

Fig. 3. Pneumatic Mechanism for the Three-valued State Realization {–p, 0, p} with Manifold 5/3 (4/3)

Without going into details, depending on the manifold handle position, one can observe the air flow direction through the VIN and thus, the realization of the three desired states {-p, 0, p}.

Further analysis of the adopted PM behaviour will be done regarding the realization of some basic ternary logical functions of one and two independent variables.

2.3 Ternary Logical Functions of One Variable

Considering three possible positions of manifold 4/3 (5/3) under the handle command for {-p, 0, p}, they can be treated as an independent ternary variable x. As a dependent variable y we will analyze the exit from the VIN with respect to Fig. 4.

Thus, for instance, in the initial position the air flow is interrupted as can be defined by the following conclusion:

if $x = 0$, then $y = 0$.

By moving the manifold handle to the left (–p), the connection providing for the air flow under pressure through the VIN from P to R (P→R) is provided for and this corresponds to the conclusion:

if $x = (-p)$, then $y = (-p)$.

[1] Regarding the binary logic the air used under pressure can be used from the pneumatic aspect for realizing the states 0- no pressure or 1-pressure. In the technological sense, for the physically (real) model regarding the realization of the basic logical functions of one and two variables, the pneumatic manifold 3/2 or 4/2 (5/2) has been used [2].

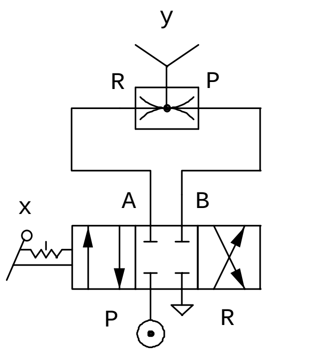

Fig. 4. Representation from the Aspect of Defining Input and Output Variables

Finally, by moving the manifold handle to the right (p), the connection changing the flow direction of the air under pressure through the VIN in the opposite direction R→P is established; this corresponds to the conclusion:

if x = p, then y = p.

Therefore, the logical connection of the analyzed PM at the exit reproduces the input signal, that is, it serves for the physical realization of the *logical function of iteration* as shown in Table 1.

Table 1.

x	y
-p	-p
0	0
p	p

If in the previous PM assembly the VIN is connected in the sense of changing the compressed air direction from R to P (R→P), the following case of the ternary logical function realization is obtained:

if x = p, then y = – p
if x = 0, then y = 0
if x = – p, then y = p

The previous results represent a ternary logical function that is defined as inversion that Combination Table 2 corresponds to.

Still, it has to be stressed that such a defined inversion of the ternary logical function differs from the binary logical function inversion thus excluding the possibility of making any direct analogy.

2. 4. Ternary Logical Functions of Two Variables

Table 2.

x	y
-p	p
0	0
p	-p

To illustrate, let's interpret the basic ternary logical functions of two variables (x_1, x_2) for the case of logical multiplication (conjunction) and logical addition (disjunction). The processed examples of the pneumatic systems represent a physical connection of the previously analyzed PM shown in Fig. 4 and manifold 4/3. It is necessary to mention that the titles are chosen regarding the functions of the binary logical multiplication and addition.

a) *Ternary Logical Multiplication (Conjunction).* If, with respect to Fig. 5, manifold 4/3 and the PM are connected in series, an assembly corresponding to the realization of the function of two independent variables x_1 and x_2 known as logical multiplication is obtained.

By analyzing carefully the proposed system with respect to Fig. 5, that is, by testing it, it is easy, on the basis of Combination Table 3, to determine the behavior of variable y depending on the input combinations x_1 and x_2.

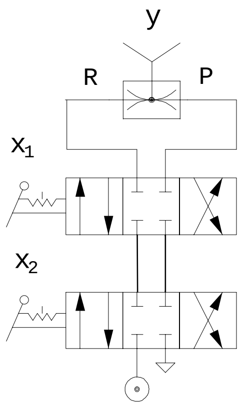

Fig. 5. System of the PM Series Connection for the Ternary Function Realization for Logical Multiplication

Table 3.

i	x_1	x_2	y
0	0	0	0
1	0	p	0
2	0	-p	0
3	p	0	0
4	p	p	p
5	p	-p	-p
6	-p	0	0
7	-p	p	-p
8	-p	-p	p

b) *Ternary Logical Addition* (*Disjunction*) is the following characteristic ternary logical function of two independent variables x_1 and x_2 within the three-valued logic that Combination Table 4 is valid for.

Regarding Fig. 6, the realization of this function is achieved by parallel connection by means of the adopted PM and manifold 4/3. In view of indefiniteness for y at input combinations (p, –p) and (–p, p) that respectively correspond to input variables x_1 and x_2, they should be treated as forbidden. In Combination Table 4 the sign "–" is taken for these combinations for variable y.

On the basis of Table 4 it easy to determine whether the system properly functions regarding the realization of the analyzed ternary logical function.

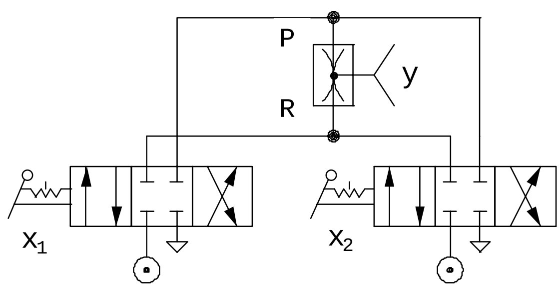

Fig. 6. System of the PM Parallel Connection for the Ternary Function Realization for Logical Addition

Table 4

i	x_1	x_2	y
0	0	0	0
1	0	p	p
2	0	-p	-p
3	p	0	p
4	p	p	p
5	p	-p	-
6	-p	0	-p
7	-p	p	–
8	-p	-p	-p

Therefore, the presented problems of realizing the ternary logical functions by means of the represented assemblies in Fig. 4, Fig. 5 and Fig. 6 confirm that the concept is cor-

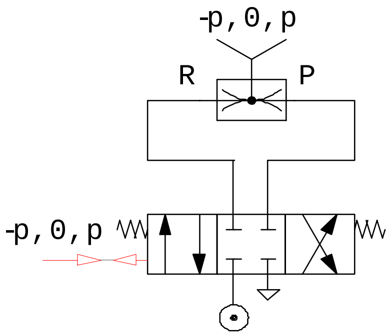

Fig. 7. Conceptual Solution of the PM in the Case of Pneumatic Activation

rect with respect to the given combination tables in addition to the statement that all that has been previously done can serve for further algebraic interpretation. At the same time, the possibility is available for using respective theorems and assumptions, that is of the derived methods related to the automate synthesis.

Likewise, regarding Fig. 7, it is possible to consider the movement of the handle of manifold 4/3 (5/3) as its modification in the sense of moving the manifold piston to the left under subpressure (–p) effect, that is, to the right under superpressure (p) effect.

3. Pneumatic control system in the manipulation procedure

The solution concept represented in Fig. 8 assumes that the subsequent stroke is initiated within the sequential control whose working cycle also comprises the technological operations based upon the vacuum manipulation system. Vacuum valve 2.2 comprising the head for the vacuum boundary value and manifold 3/2 is used as a component. After completing the operation of gripping the workpiece, the achieved vacuum value activates manifold 3/2 and thus it initiates the following sequential motion of the piston rod of pneumatic cylinder 2.0 by transferring manifold 2.1.

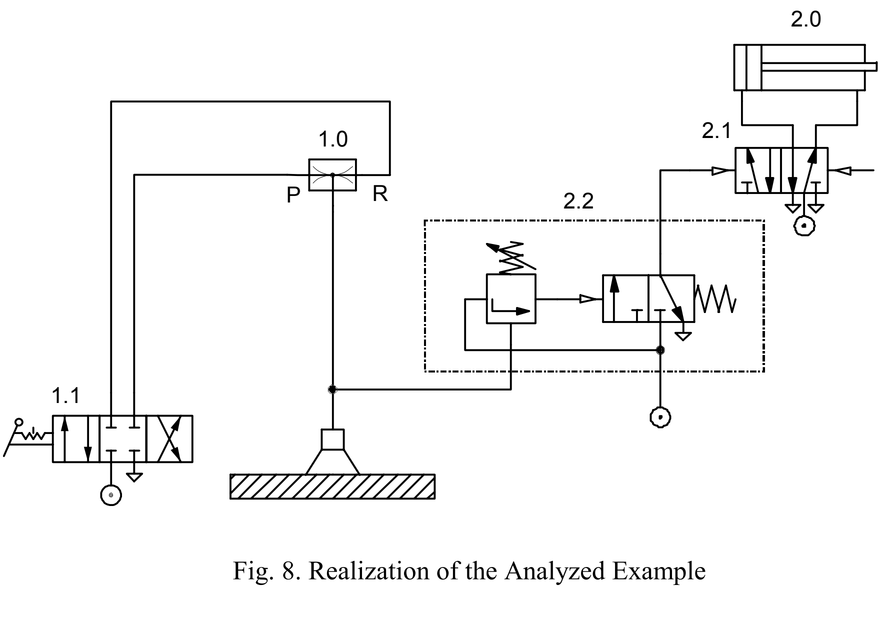

Fig. 8. Realization of the Analyzed Example

The use of the applied PM does not need any of the so-called controlled irreversible valves since the system prevents, by means of manifold 1.1, any release (drop) of the workpiece in the case of energy supply break.

It is easy to conclude that the previous variant solution of the analyzed example represents good foundation for various sequential controls while the hand manifold 4/3 for gripping and releasing may be substituted by respective end pickups.

Without going into much deeper analysis of the presented problems the appropriate solutions can be conceived of by means of the standard "intelligent vacuum valves" in the domain of gripping and moving the part [4].

Likewise, in the hybrid control systems instead of vacuum valves one can use certain transformers of the active vacuum signal into electrical, that is, electronic ones. In addition, it is possible to expand the presented issue to the application of the detection and follow-up of irregular states during the working cycle [3].

4. CONCLUSION

The above-presented research in the field of the ternary logic discussed in this paper confirm the possibility of realizing the ternary state by means of the PM composed of standard components. The obtained results regarding the derivation of some logical functions initiate further consideration both regarding the logical algebra application and the conceptual approaches to the domain of the pneumatic component technology.

The integrated vacuum system for manipulation within the sequential control represents an example of possible simplification in adding, transferring and ejecting the workpiece with the tendency toward finding its application in solving the above-presented issues.

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PRIKAZ VARIJANTNOG REŠENJA PNEUMATSKOG SISTEMA ZA REALIZACIJU TERNARNOG STANJA

Miodrag M. Stojiljković, Vladislav A. Blagojević

U radu se razmatra primena ternarne (troznačne) logike na nivou tehnoloških mogućnosti pneumatskih komponenata, imajući pri tome u vidu složenost problema u delu sprovođenja logičkih operacija kod realnih sistema.

Korišćenjem postojećih pneumatskih komponenata, realizovano je kolo osnovnog operatora predloženog simetričnog ternarnog sistema tako da svakom opsegu odgovara jedna od logičkih vrednosti promenljive $x_i \in \{-p, 0, p\}$. *Kao osnovna komponenta pri realizaciji šeme koristi se vakuum usisna mlaznica. Na primeru integrisanog ternarnog sistema za manipulaciju u okviru redoslednog upravljanja, ilustrovana je tretirana problematika.*

Ključne reči: *Pneumatski sistem, pneumatske komponente, ternarne (troznačne) veličine, ternarna logika, logičke funkcije, razvodnik*