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Automatic microprocessor-based performance diagnostics of switches of pneumatic transportation system

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Abstract. The article dwells on the up-to-date issues of the automatic microprocessor-based diagnostics of the automatic switches, which are a part of the pneumatic sample capsule transportation for an assay with the maximum use of the automatic control devices. A structural diagram of the pneumatic transport system has been developed. The article deals with the functioning of the main components of the pneumatic transport system. An algorithm for the functioning of the microprocessor control system in the diagnostic mode is developed and the structural diagram of the algorithm is shown. A scheme of a microprocessor control system for the components of a pneumatic transport system has been developed.

1. Introduction

Automatic control of any continuous or continuous-discrete process implies continuous or periodic monitoring of the process parameters that define this process. In ore dressing mills and metallurgical plants, such main parameters may include information about composition of the feedstock, reagents, fluxes, intermediate products, finished products, final tailings, and waste water. These days, enterprises receive analytical information from the automated analytical monitoring system (AAMS), which employs the capsule and non-capsule pneumatic transportation system. Automatic switches are used to upgrade the capsule route of the test sample transportation for assays, which ensure automatic transfer of the samples moving from the sample automatic charge stations via peripheral transportation pipelines of the loaded capsules to the central pipeline, which is used to deliver all loaded capsules to the automatic capsule sample discharge station. After unloading in the relevant automatic capsule discharge stations, the empty capsules are also delivered by means of the automatic switches.

The automatic switches are used in the pneumatic transportation system of the pneumatic representative sample capsule transportation for an assay and ensure optimal routing of the pneumatic capsule delivery for an assay of controlled engineering products [1, 2]. Systems for pneumatic sample capsule transportation for an assay are a part of automated analytical control of products manufactured at ore dressing and metallurgical plants [3-9].

The available systems of pneumatic cargo transportation via transportation pipelines vary greatly with regard to the design and various areas of application [10-12].

2. Main section

The system for automatic pneumatic representative sample capsule transportation for an assay consists of the following main units [12]:

- stations for automatic charging of an averaged sample into a capsule and conveyance of the capsule with the sample to a quick assay laboratory;
- stations for automatic discharging of the process samples from the capsule and automatic return of an empty capsule to a sampling point;
- a transport piping system between the sampling points and the analytical laboratories making assays;
- automatic switches that are used to change the direction of moving loaded capsules automatically from the automatic charging stations of an averaged sample to the central pipeline, which is connected to the automatic discharge station of the process samples delivered for an assay from the capsule and return of empty containers after their unloading.

The flowchart of a typical system for automatic pneumatic sample capsule transportation for an assay is shown in Figure 1.

This flowchart suggests that all samples are analysed in the same laboratory, samples 1 and 2 are taken from the process units located in the immediate vicinity from each other, and samples 5 and 6 are a process product received from different process units, which work by rotation. Samples 3 and 4 can be taken from any other process units, which are logically located along the route of the sample delivery for an assay.

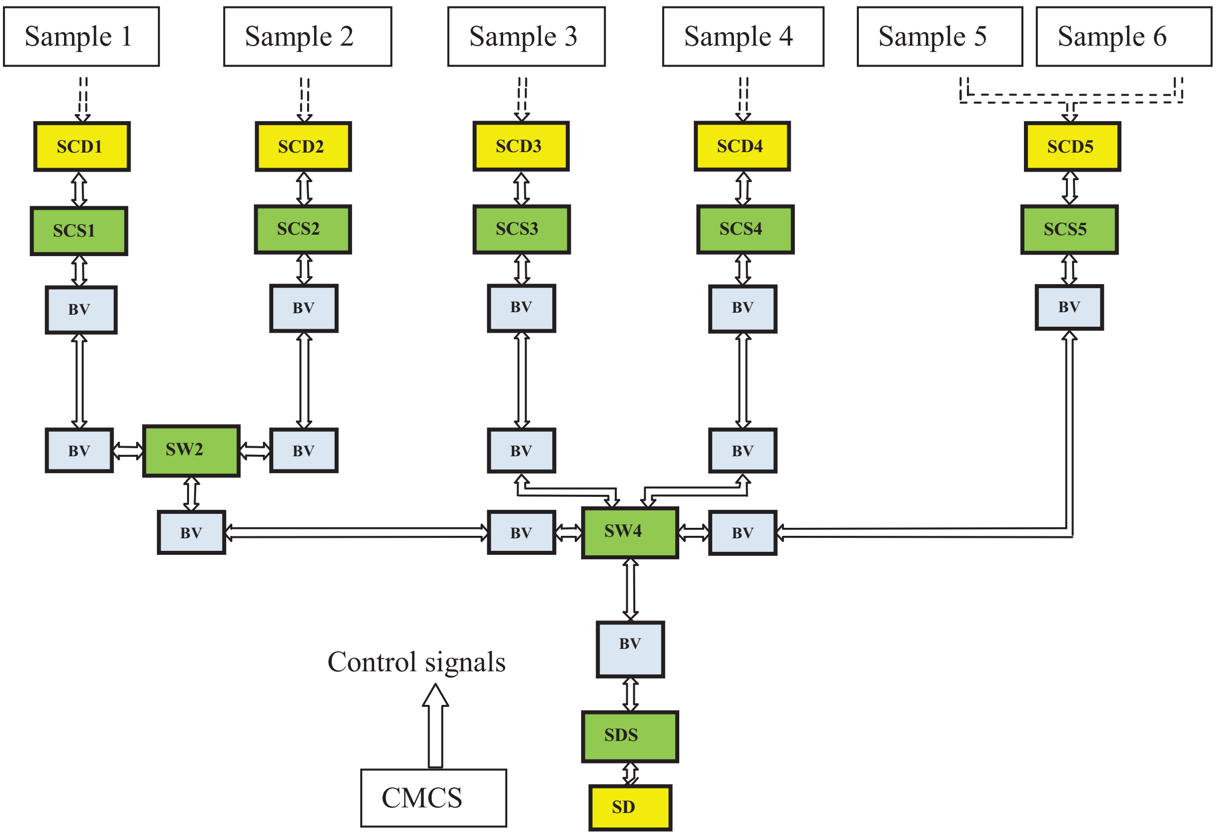

Figure 1. The flowchart of the system for automatic pneumatic sample capsule transportation for an assay.

The following symbols are used in Figure 1:
CMCS is the central microprocessor-based control system.

SCD is a set of devices for automatic preparation and conveyance for charging of an averaged sample into a capsule.

SCS is a station for automatic charge of representative averaged samples in the capsule that is used for:
- receiving an averaged sample prepared for transportation for a quick assay,
- automatic charging of a sample in the capsule,
- transporting a loaded capsule to the station for discharge of the sample from the capsule,
- receiving an empty capsule on its way back.

SW 2 and SW 4 – automatic switches that change direction of moving loaded capsules from the peripheral transportation pipelines (two or four accordingly) to the central transportation pipeline and an empty capsule from the central transportation pipeline to the relevant peripheral transportation pipeline.

SDS is an automatic station for discharge of the samples delivered for the assay that is used for:
- receiving a delivered charged capsule,
- automatic unloading of a delivered sample from the capsule,
- automatic cleaning of a capsule cavity from the leftovers of the delivered sample (if necessary),
- automatic dispatching of an empty capsule to the station that charges sample into the capsule.

SDD is a device for discharging and receiving a sample delivered for analysis, which is used for:
- receiving a sample delivered for analysis,
- transferring a delivered sample to the express laboratory (SD).

BV is bypass valves installed on a transportation pipeline in the immediate proximity of SCS, SW and SDS, which ensure reliable transportation of a capsule (loaded or empty) via the transportation pipeline by closing BV installed near the station dispatching the capsule, and opening BV installed near the station receiving the capsule. The command is sent to close the bypass valve at the same time with the command to supply compressed air. Once the transporting compressed air is shut off, the bypass valve opens.

As one can see from the above flowchart, the routes of the capsule delivery of samples for analysis are upgraded with the help of the switches, which are installed to make sure that the total length of the transportation pipelines is minimum with account of ensuring maximum convenience for servicing all hardware of the system of pneumatic capsule delivery of samples for the assay.

The design and operating principle of the automatic sample charge station in the capsule is described in [13].

The design and operating principle of the automatic sample discharge station in the capsule is described in [12].

The design of the automatic switch is specified in Figure 2.

The operating principle for the switch is described in the monograph [1] and depicted in Figure 3.

Figures 2 and 3 use the following symbols: MP1.0, MP1.1 and MP 1.2 are magnetic pick-up responsible for formation of data commands on a capsule arrival into SW via transportation pipelines; MP 2.1, MP 2.2, MP 3.1, MP 3.2, MP 4.0, MP 5.0, MP 4.1, MP 4.2, MP 5.1 и MP 5.2 are magnetic pick-ups of SW piston, positioning air cylinders responsible for the formation of data commands when the pistons in the air cylinders move to the end positions; EPD 1.1, EPD 1.2, EPD 2.0, EPD 2,1, EPD 2.2, EPD 3.0, EPD 3.1 and EPD 3.2– electro pneumatic compressed air distributors which govern the air cylinders; EBV 1.0, EBV 1.1 and EBV 1.2 – electro pneumatic bypass valves which govern compressed air supply for capsule conveyance from SW via the transportation pipeline; BV 1.i – bypass valves that ensure necessary conditions for acceptance and dispatch of the capsules, MCSi – microprocessor-based control system for the relevant section of the switch during the transfer of the loaded capsule form the peripheral pipeline to the central pipeline and backwards - an empty capsule from the central pipeline to the relevant peripheral transportation pipeline.

In the initial condition of the automatic switches, the receiving sockets 1.1 and 1.2 of the gauge carriage 2.1 and 2.2 are under peripheral transportation pipelines in the position that ensures acceptance of the delivered capsule. The power is not supplied to any microprocessor-based control systems, electro-pneumatic distributors and electro pneumatic valves; the compressed air is supplied to the relevant air cylinders through normally open outlets of all EPD. The initial condition of SW is characterized by simultaneous sending information signals from MP 2i, MP 4.0 and MP 5i in MCS.

The central control system (CMCS) controls the direction of movement of the container. The CMCS generates the signal "Start", which is sent to the devices of the pneumatic transport system, which must work at this time. The devices of the pneumatic transport system, having completed the work, send an information signal "End" to the CMCS.

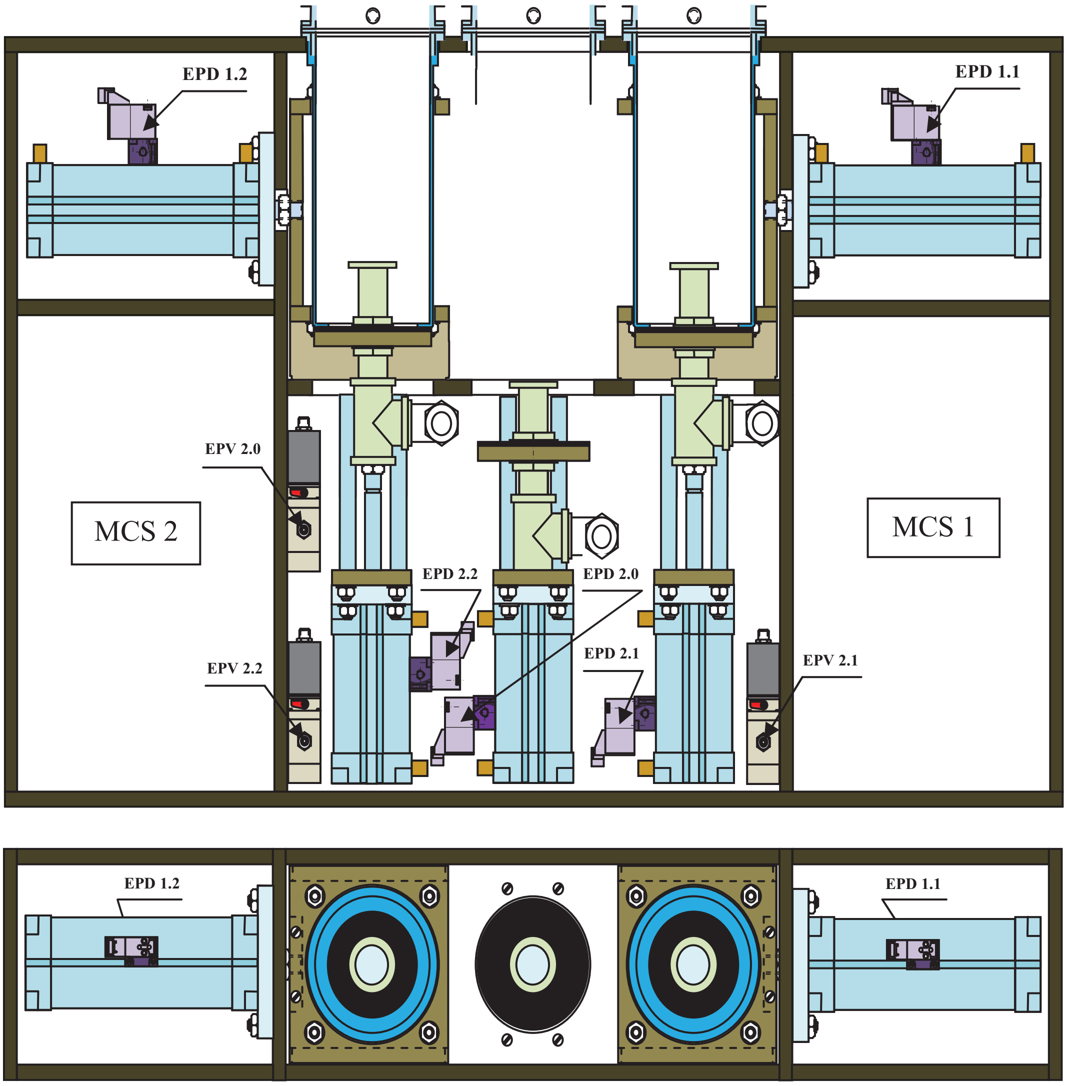

Figure 2. Automatic switch design.

The operating experience of the effective automatic pneumatic system of the capsule transportation for an assay allowed for developing and implementing the automatic microprocessor-based system for diagnostics of SW performance, which algorithm can be seen in Figure 4.

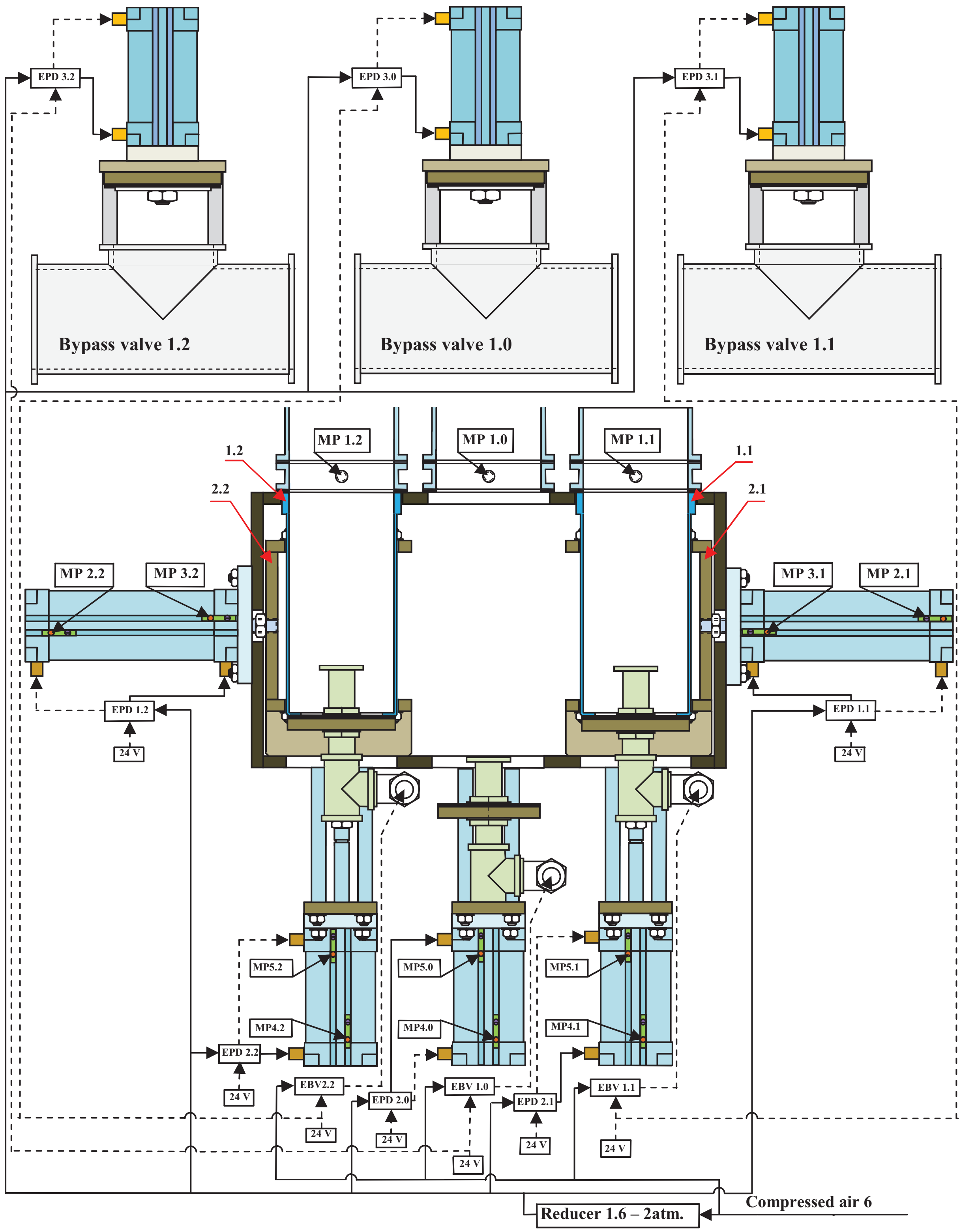

Figure 3. Automatic switch. Initial condition.

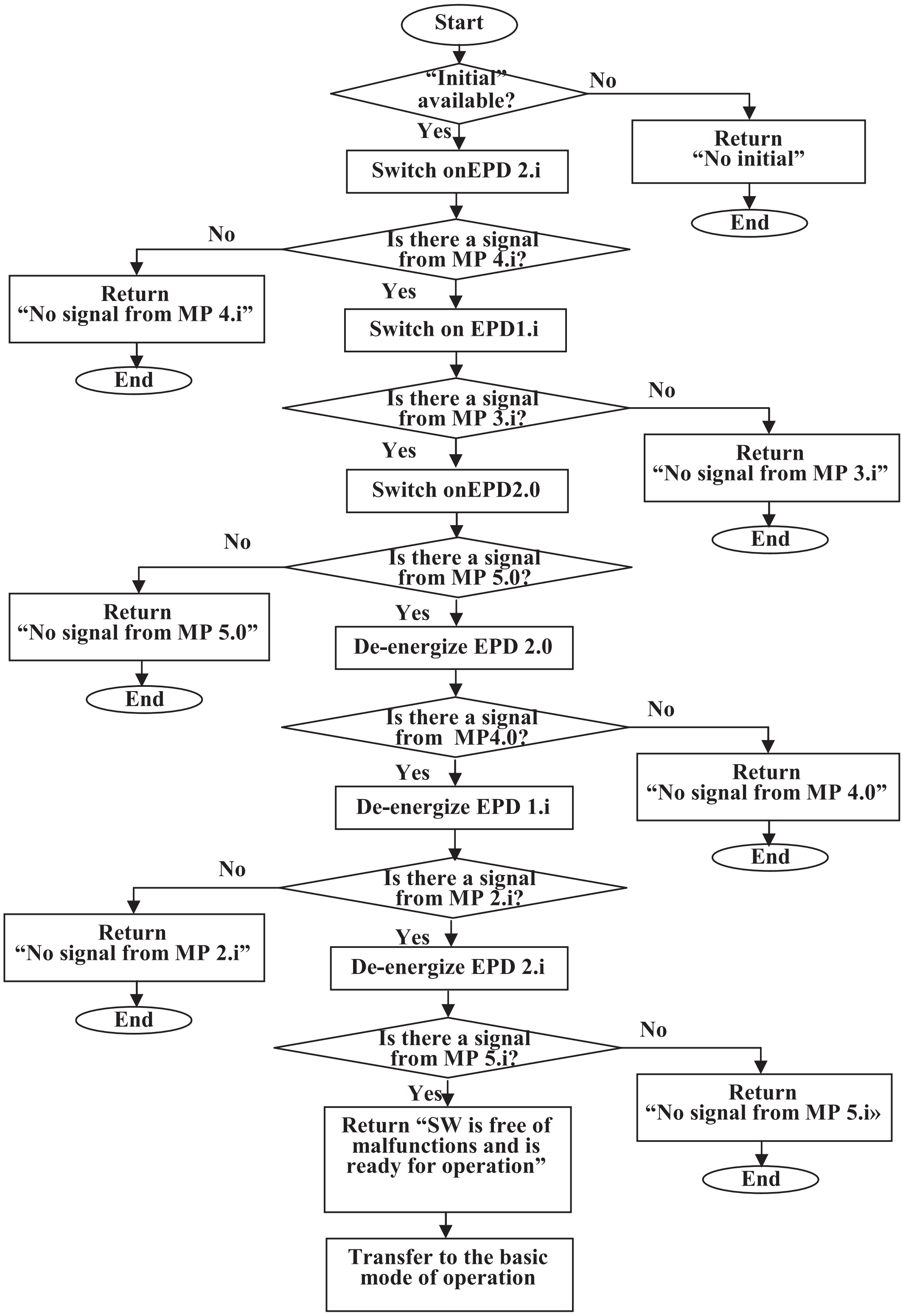

Figure 4. Algorithm for technical diagnostics of SW, when starting in "Work" mode.

The program that runs this algorithm is introduced into the universal standard systems of microprocessor control [12] and uses information about the condition of own magnetic pick-ups (MP) of the piston location of the air cylinders.

The developed algorithm of the automatic technical diagnostics of the performance of the automatic switch can be implemented every time the pneumatic transportation system is turned on or at any time of its operation based on the request from the operator servicing this system.

In this case, relating to Figure 1, the functional electric diagram of the automatic switch SW 2 is shown in Figure 5, and SW 4 – in Figure 6.

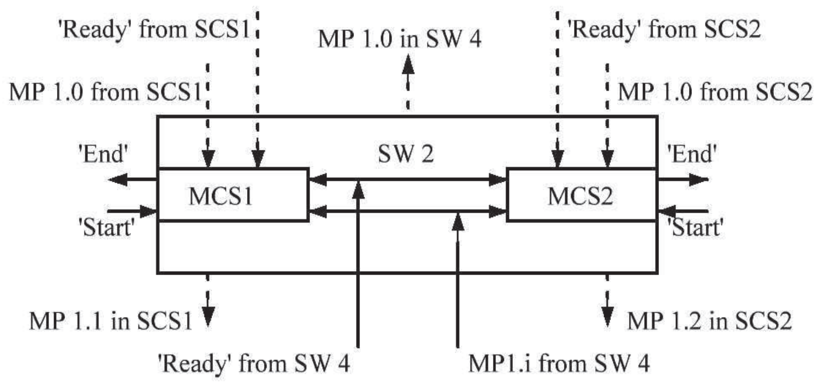

Figure 5. Functional electric diagram of automatic switch SW 2.

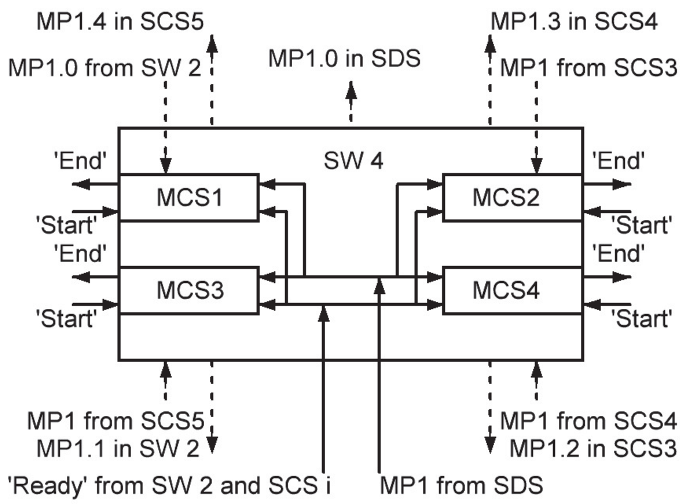

Figure 6. Functional electric diagram of automatic switch SW 4.

The information signals shown in the figures provide interaction between the devices of the transport system. The information signal "Ready" is generated by the devices when they are ready for operation.

The results of technical diagnostics of automatic SW performance (lack of necessary information signals from the magnetic pick-ups) can be seen on the relevant display boards, which allow the maintenance staff to identify a malfunctioning unit SW 2 or SW 4 quickly. In the absence of malfunctions, the display board shows a relevant message and the control system automatically proceeds to implementing the primary algorithm of the pneumatic transportation system operation [12].

The Flow Chart of Microprocessor-Based Control System and Automatic Technical Diagnostics of the Automatic Switches of the Pneumatic Transport System, which can be seen in Figure 7, have been designed considering the foregoing.

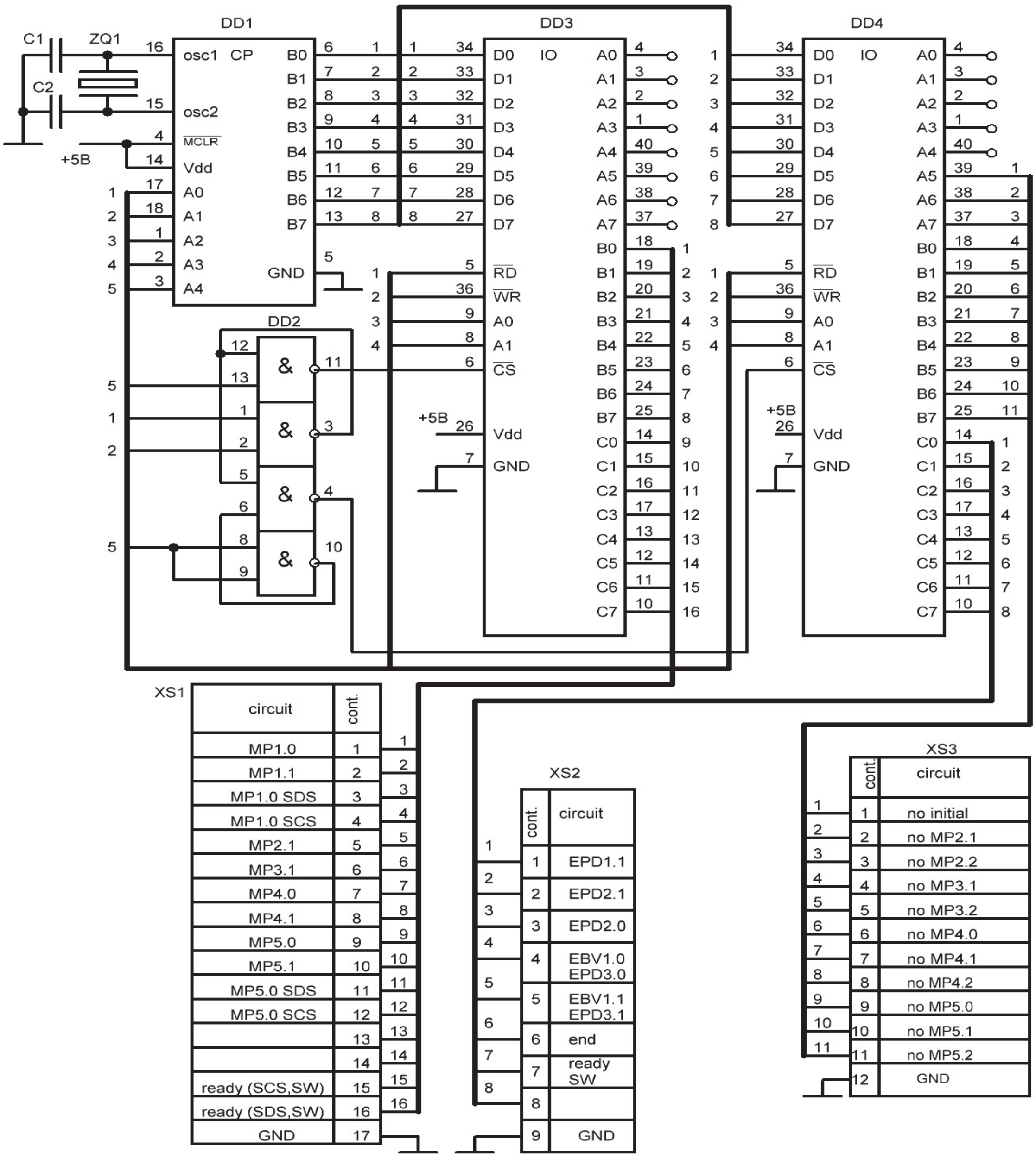

Figure 7. Flow chart of microprocessor-based control system and automatic technical diagnostics.

The chart is based on the microchips, namely: DD1–microcontroller (PIC16F84A); DD2–logical elements I-NE (CD4011A); DD3, DD4–I/O devices (NTE8255).

The flow chart has hardware redundancy to enable connection of additional sensors and devices, and thus expand functional capabilities of the capsule sample delivery system.

The information needed for operation of the control system comes via contacts of the XS1 connector. The information comprises commands generated by magnetic pick-ups (MP i).

Contacts of the connector XS2 are intended for connection of electro pneumatic distributors (EPD i) and valves (EPV i.).

Information about potential abnormal conditions in the controlled devices is the output on the contacts of the connector XS3.

3. Conclusion

The designs, schematics and algorithms developed and discussed in this article are universal and can simplify the processes of the pneumatic transportation equipment set-up and maintenance, and can be widely used to design sample pneumatic delivery systems for further analysis, aimed at optimizing the processes at mining, ore dressing and metallurgical plants.

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