

*testing, simulation, computer panel,  
poinits, railway traffic control equipment*

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## MODEL OF SIMULATOR OF RELAY-BASED RAILWAY TRAFFIC CONTROL EQUIPMENT

This paper present testing concept of newly constructed railway traffic control equipment with computer panel as well as utilization of computer panel simulator for operators' training purposes.

## MODEL SYMULATORA PRZEKAŹNIKOWYCH URZĄDZEŃ STEROWANIA RUCHEM KOLEJOWYM

W artykule przedstawiono koncepcję testowania nowobudowanych urządzeń srk z pulpitem komputerowym oraz wykorzystanie symulatora pulpitu komputerowego do celów szkoleniowych personelu obsługi.

### 1. INTRODUCTION

The railway technology, and especially railway traffic control domain, strives to achieve simplicity, functionality and reliability of railway equipment whose correct operation should ensure safety of railway traffic.

Many relay-based devices remain in operation for many years, and their domino panels require overhauling or frequent repairs, resulting in more and more costly maintenance.

Rapid development of computerization resulted in the fact that computers became indispensable for almost every area of live including railway traffic control. It is obvious that also in the relay based systems there exists a possibility of installing computer panels for control of equipment

In the case when we exchange the hitherto domino panel to the computer based one it becomes also necessary to train the railway staff in the operation of new equipment. In order to ensure a more efficient training it seems purposeful to create a simulator of computer panel. Thus, it will be possible for railway personnel to train on the simulator created for the particular station where they will operate the equipment in the future. Such a solution will

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enable the personnel to get acquainted with the basic functions and principles of operation of new equipment.

One of enormous advantages of computer panel is that they have a possibility to check certain dependencies using special diagnostic software.

## 2. TESTING AND FUNCTIONAL CHECK OF EQUIPMENT

Testing of the system is aimed at [5]:

- Achieving full functionality of equipment through realization of all control functions from the computer panel
- Verification of system operation from the computer panel according to the matrix of dependencies
- Check of diagnostics and recording operation for the compliance with technical and operational instructions

Before getting to startup work of equipment built in, it is necessary to prepare startup documentation. Components of such a startup documentation are shown on Fig.1.

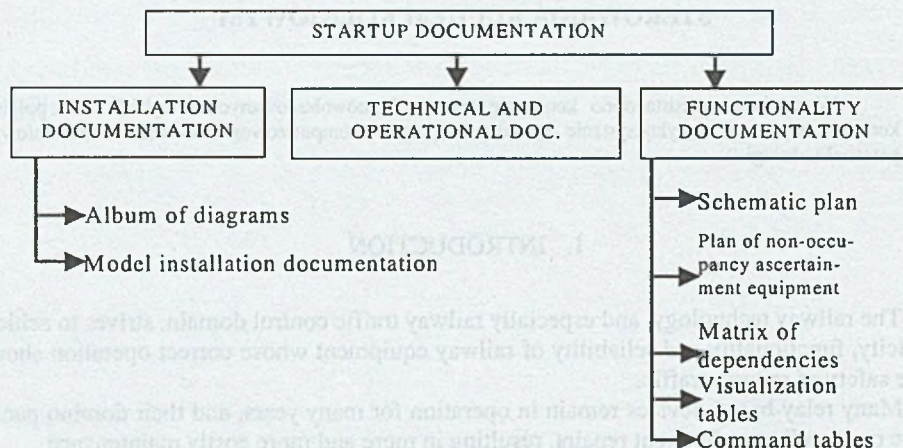


Fig.1. Startup documentation [5]

Functional tests are performed by checking the compliance of processes described in the startup documentation with real operation of equipment

After completion of assembly, tests and functional check of SRK equipment takes place with control coming from computer panel; this process is called "internal startup". Fig.2 shows the stages of computer panel testing.



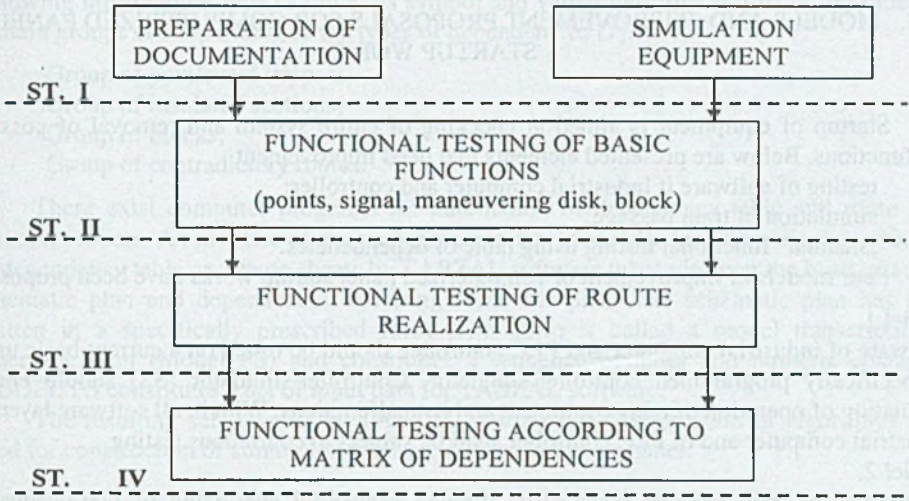


Fig.2. Stages of testing of a computerized panel

Upon detecting incorrect operation of devices it is necessary to check the actuating system compliance with the documentation as well as correctness of control, visualization, dialog and recording software. Incorrect operation may be due to various reasons, so all systems of the device being tested should be checked. After removal of these reasons, the tests, during which the irregularity was detected, should be repeated.

The last stage of work related with the installation of computer panel in place of domino one is testing of equipment and training of personnel

The entirety of works related with the commissioning of equipment for use is divided into stages. While establishing these stages, each time, besides scope of work, also operational restrictions and necessary conditions such as introduction of telephone announcement. Based on time of duration of each stage and with assumed time reserves, a time schedule for each stage of connection is established and the duration of entire process is being determined. Number of stages, their duration and possible reserves are determined depending of type of equipment started up, size of station and local conditions. In addition, as a separate document, a schedule of disassembly of hitherto equipment has to be prepared. Both for the schedule of work at connection of new equipment and disassembly of old one, for the duration of works a Temporary Regulation for Traffic Handling have to be prepared.

### 3. MODELS AND IMPROVEMENT PROPOSALS FOR COMPUTERIZED PANEL STARTUP WORK

Startup of equipment is aimed at checking of entire system and removal of possible malfunctions. Below are presented elements that need improvement

- testing of software if industrial computer and controller;
- simulation of train passage;
- „manual” functional testing using table of dependencies.

Four models of improvement of computerized panel startup works have been proposed:

#### Model 1.

Software of industrial computer and PLC controller should be tested on a current basic using a specifically programmed controller-simulator. Controller-simulator (SS) should enable simulation of operation of relay equipment and its malfunctions. With it, all software layers of industrial computer and of PLC controller shall be subject to continuous testing.

#### Model 2.

Simulation of train passage takes place through sequential energizing of non-occupancy detecting circuit relays. It is performed “manually” using switches located on a special board. Improvement of this process consists in use of computer that could control these relays using a special interface and thus simulation of passage would take place automatically.

#### Model 3.

In order to perform automation of the functionality testing process using dependency table as a reference, a testing computer is necessary (KT). Its software should enable an automatic test of realization of contradictory routes, taking into consideration all combinations of the latter. The computer should be able to record the entire testing process.

#### Model 4.

This model constitutes a combination of the above models. Combination of testing computer, controller-simulator and computerized simulator of train passage (KSPP) will enable connection of all processes, their synchronization and automation of their testing process.

New functions of the testing computer include:

- Functional testing of route realization by issuing route simulation processes to KSPP
- Testing of event recording software by issuing commands to simulate malfunctions of relay equipment to SS

Programming of controller-simulator and computerized simulator of train passage has to be expanded by functions related with cooperation with the testing computer.

### 4. AUTOMATION OF DEPENDENCY TABLE AND ROUTE SHEETS CREATION

The entirety of conditions and devices establishing their mutual dependencies is shown in the SRK equipment dependency table using certain designations [3]. Frequently, during modernization of SRK equipment track system of the station is being changed. Then adequate changes should also be made to the existing dependency table.

List of dependencies may be also presented as routing sheets; Number of routing sheets corresponds to the number of routes on this particular station the routing sheet consists of description of route and list of dependencies. Description of dependencies contains the



following information: type of route, its symbol and verbal description. List of dependencies contain groups corresponding to the types of dependencies [7]:

- Group of points and trippers;
- Group of insulated sections;
- Group of blocks;
- Group of contradictory routes.

There exist computer programs for automation of dependency table and route sheet creation process. An instance of such a program is TABZAL [8]. An automatic determination of dependency table and route sheets by TABZAL software takes place on the basis of station schematic plan and dependencies resulting from this plan. The schematic plan has to be written in a specifically prescribed form. This form is called a model transcription of schematic plan (Model PS) and constitutes a sequence of letter and numeric characters. MODEL PS constitutes a set of input data for TABZAL software.

The resulting sets created by TABZAL will be used for creation of algorithms to be used for construction of simulation software for the computer panel.

## 5. SWITCH MODEL

Fig. 3 represents a switch point model, where the following fields are shown:

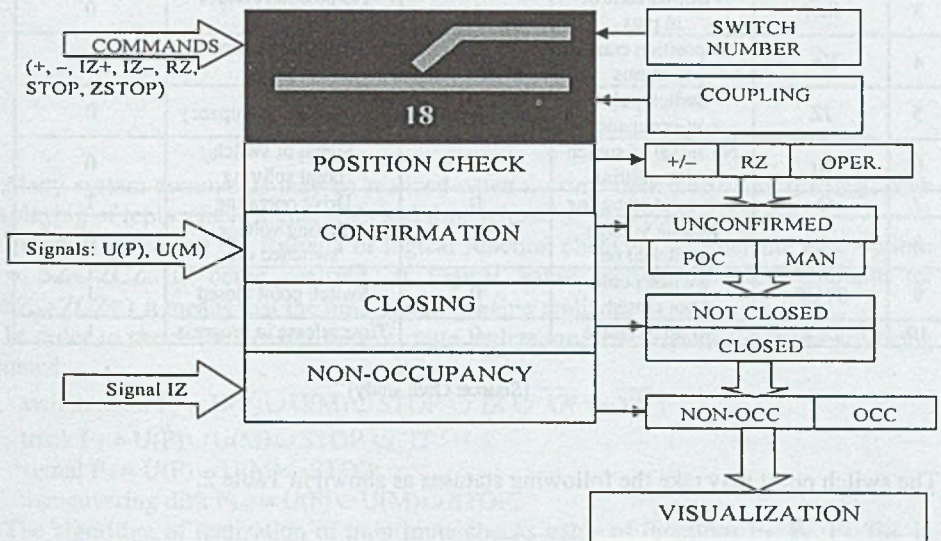


Fig.3. Model diagram of switch points

Introduction of commands or change of signals caused by other processes results in the change of object status. The present object status is reflected on the display by the visualization program

Below are listed available commands for control of switch point model [9]:

- „ZWR +” – moving the switch point into plus position;
- „ZWR -” – moving the switch point into minus position;
- „ZWR IZ +” – moving the switch point with the non-occupancy control switched off into plus position plus;
- „ZWR IZ -” – moving the switch point with the non-occupancy control switched off into minus position minus;
- RZ – reset of switch point splitting signal;
- STOP – individual closing of switch point;
- ZSTOP – individual release of switch point closing.

Table 1 shows signals in the switch point's model.

Table 1

Signal description for switch point's model

Item	Signal description	Basic status		Operating status	
		Description	Signal status in the model	Description	Signal status in the model
1	U(P)	Switch point not confirmed – train mode	0	Switch point confirmed – train mode	1
2	U(M)	Switch point not confirmed – maneuvering mode	0	Switch point confirmed – maneuvering mode	1
3	Kn+	Position control in plus	1	No position control in plus	0
4	Kn-	No position control in minus	0	Position control in minus	1
5	JZ	Switch point non-occupancy	1	Switch point occupancy	0
6	Kr	No signal of switch point splitting	1	Signal of switch point splitting	0
7	Or	Drive not operating	0	Drive operating	1
8	NN	Setting voltage switched on	1	Setting voltage switched off	0
9	STOP	Switch point not closed	0	Switch point closed	1
10	ZCZ	No time release	0	Time release in progress	1

[Source: Own study]

The switch point may take the following statuses as shown in Table 2.



States of switch points model

Table 2

Item	Switch point status	Kn +	Kn -	IZ	Kr	U(P)	U(M)	Or	NN	STOP	ZCZ
1	Position in +	1	0	1	1	0	0	0			
2	Position in -	0	1	1	1	0	0	0		0	0
3	Occupied in +	1	0	0	1			0		0	0
4	Occupied in -	0	1	0	1			0		0	0
5	Splitting signaling				0			0		0	0
6	Confirmed train mode in +	1	0	1	1	1	0	0		0	0
7	Confirmed train mode in -	0	1	1	1	1	0	0		0	0
8	Confirmed maneuvering mode in +	1	0	1	1	0	1	0		0	0
9	Confirmed maneuvering mode in -	0	1	1	1	0	1	0		0	0
10	Closed individually in +	1	0		1	0	0	0		1	0
11	Closed individually in -	0	1		1	0	0	0		1	0
12	Switched	0	0			0	0	1	1	0	0
13	Setting voltage switched off							0	0	0	0
14	Time release in +	1	0					0		0	1
15	Time release in -	0	1					0		0	1
16	No control	0	0					0			

[Source: Own study]

### 6. LOGIC FUNCTIONS

Many system commands may be realized when no time option is being realized, such as: displaying of replacement signal (SZ) and time release of train route (ZCZ).

Below is presented the formula of logical function checking whether the time option:  $F_{time} = SZ \cup ZCZ$ . Is being realized. If logical value of this function amounts to:  $F_{time} \equiv SZ \cup ZCZ \equiv 1$  it means that the time option is being realized.

In order to check the possibilities of route realization, four logical functions are being determined:

- switch point  $F_Z = U(P) \cup U(M) \cup STOP \cup \overline{IZ} \cup \overline{KR} \cup \overline{NN}$  ;
- track  $F_T = U(P) \cup U(M) \cup STOP \cup \overline{IT}$  ;
- signal  $F_S = U(P) \cup U(M) \cup STOP$  ;
- maneuvering disk  $F_{Tm} = U(P) \cup U(M) \cup STOP$ .

The algorithm of realization of train route checks value of functions  $F_Z, F_T, F_S, F_{Tm}$  in order to determine whether the route may be realized or not. Each of four above functions is assigned to a specific route element (switch point, track, signal, maneuvering disk). The route will not be realized when the value of logical functions is:  $F_Z \equiv 1, F_T \equiv 1, F_S \equiv 1, F_{Tm} \equiv 1$ .

## Function:

- $F_z$  is used for checking the availability of commands of points setting;
- $F'_z$  is used for checking the availability of commands of points setting with non-occupancy control switched off;
- $F_{zSP}$  is used for checking the availability of commands of points setting (this function applies to the coupled switch point);
- $F'_{zSP}$  is used for checking the availability of commands of points setting with non-occupancy control switched off (this function applies to the coupled switch point)

## 7. CONCLUSIONS

Names of signals presented in this paper and their basic statuses are in accordance with the signals in real relay-based devices E with computer panel. The proposed model may be used to create software for Computerized Simulator of Train Passage (KSPP). This device was presented as an instance of improvement of relay-based equipment startup with computer panels. Present development tendencies indicate that the number of computerized panels in Polish railways will grow, thus training of present and future train dispatchers should take place using simulation software.

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