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## TRACKING CONTROL SYSTEM OF THE MODELLING YARD

## SYSTÉM ŘÍZENÍ PROVOZU NA MODELOVÉM KOLEJIŠTI

**Abstract**

This article is focused on description of four ways of tracking control on the modelling yard. The yard is situated in the laboratory of Department of control systems and instrumentation. Control system was continuously developed by the help of students. First step was connecting the particular model's objects to input/output devices of the PLC control system and creating the basic programs. Next steps were design and creating of the hand control panel, creating of display views in InTouch software, design and creating of digital control panel and digitalization of locomotives. For every new created hardware and software control components, the program modules were developed (for PLC). The model yard is fully operable at present.

**Abstrakt**

Článek je zaměřen na popis čtyř způsobů řízení provozu na modelovém kolejišti. Modelové kolejiště je umístěno v laboratoři Katedry automatizační techniky a řízení. Systém řízení je neustále vyvíjen ve spolupráci se studenty. Prvním krokem bylo připojení jednotlivých objektů modelu k vstupním a výstupním jednotkám programovatelného logického automatu a vytvoření základního programu. Následoval vývoj a realizace panelu ručního ovládání, vytvoření jednotlivých obrazovek v software InTouch, návrh a realizace panelu digitálního řízení a digitalizace lokomotiv. Pro všechny nově vytvořené hardwarové a softwarové řídicí komponenty byly vyvinuty softwarové moduly (pro PLC). Modelové kolejiště je v současnosti plně funkční.

**1 INTRODUCTION**

The model yard (Fig. 1) is made-up from components for railways of sizes TT (exactly TT12) that means we work with the model in scale 1:120 with a track gauge 12 millimeters. The model consists of series of the functional components (switches, markers – signaling devices, a bar, etc.), but also from many decorative components (trees, buildings, a tunnel, etc.). The yard is divided into several sections. The complex is placed into a protective case, which protects it from damage [6].

This laboratory task is used for presentation of designed railway traffic management systems, as well as for independent work of students in the development of the Bachelor's and Master's theses. Further developments are expected in the control software development. The model is designed to be controlled by a computer program. The communication with the data capture unit is possible thru PLC and then using SCADA. It is possible to write the controlling program using any programming language that is capable to communicate over these interfaces. Another possibility could be the simulation of real traffic on this railyard. The solution could include a closed loop, where one process can take several hours and can control large number of locomotives or trains.

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**Fig. 1** The modelling yard.

## **2 THE MODEL YARD DESCRIPTION**

### **2.1 Basic Terminology**

In the article there are used special words using in the railway's terminology:

Wide track – is the track section between two adjoining stations or among stations and a station track at the tram-stop or the platform. The board between the wide track and the station is a gateway marker. A track on the wide track is called a railroad track.

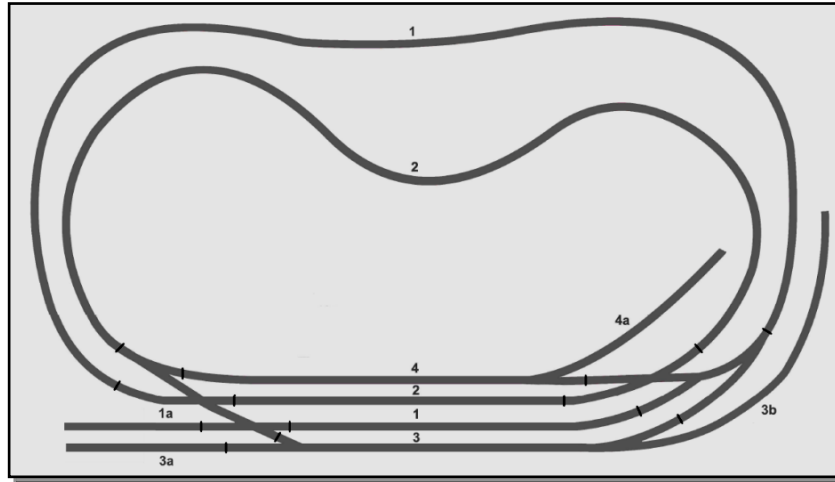
Station track – each track in the station is called the station track. The station tracks are divided into traffic tracks, handling tracks and tracks for exceptional purposes (e.g. catching, averting).

The railway-station – it is haulage with a track division and given extent of offering transit services. The railway-station on the model consists of 4 station tracks (Fig. 2). It deals with the main train tracks (track N. 1 and track N.2), a ranging track, being used for a pushing away vans and driving vehicles (track N. 3), and a station track with a connection on a trailer (track N. 4).

Locomotive depot – it is a building, in which blind tracks lead further (so-called dead-end siding tracks) and in this depot they are ended by a bumper. In our model they are presented by a track with mark 1s and a track marked like 3a, these tracks are continuation of the main track N. 1 and ranging track N. 3.

Railway trailer - this track is used for the own operator's needs or for the other enterprisers. On the model there is a dead-end siding track marked as 4a and it was produced by extension of station track N. 4.

Lay-by track - is extended part of the ranging track N. 3 and it is used for laying-by of the vans, driving vehicles or of the whole train sets for the trailer. On the model it is marked as 3b.



**Fig. 2** Diagram of the model yard with marked tracks.

## 2.2 Description of the railway elements and their wiring

The model railway consist of two circuits (outer and inner loop) and a railway-station, which links these two circuits together. Outer one is called as a railroad track N .1 and it is connected to station track N. 1. Inner track is called track N. 2 and it is connected on the station track N. 2. Then the railway-station is formed by 4 station tracks, a railway's trailer and a locomotive depot. The signs of all railways' tracks are shown in the pictures. The signs arise from regulations; according to them they are designed [1]. On the model there is a quantity of preventive and electric elements used (points, semaphores, etc.).

## 3 CONTROL METHODS OF THE MODEL YARD

The model yard can be controlled by several ways. It makes it usable for many laboratory tasks. These ways of controlling the traffic on the model yard are assumed:

- Using PLC AC800M made by ABB company,
- Using the manual control panel,
- Using the SCADA/HMI InTouch system,
- Using the digital control system.

### 3.1 The control system based on PLC AC800M

PLC AC800M is a modular industrial computer that is compounded of several single modules. Thanks to that, the controlling platform can be adapted for using in the widest spectrum. Platform PLC AC800M, that is used in this model yard, consists of following modules (Fig. 3):

- Processor module AC800M type PM860,
- Communication extension ProfiBus CI854A,
- Module CI830 for interface I/O cards to bus bar ProfiBus,
- Input module DI801,
- Check out module DO801,
- Power supply SD821.

The used system for control of the model yard does not make it possible to operate directly into the yard. For installing other control elements, there are not enough free inputs in PLC. That is why the control program is constructed to be controlled alone depending on its state. Starting and stopping is operated manually [2].

The program had been designed for rides of two train sets, their points of departures are station tracks N. 1 and N. 2. Designed program directs the operation on three different train railways.

The first route begins in the station on the station track N. 1. After program's start-up, the train set starts to ride clockwise. It continues on railroad track N. 2 and it returns into the station on station track N. 4.

The second train track begins in the station on the station track N.2. The train set continues on railroad track N. 1 and it finishes in the station on station track N. 1. The third route begins in the station on station track N. 4. The train set continues clockwise to the railroad track N. 2 and it rides to its finish in the station on the station track N. 1. After completing the last train's route, the program sets up into the starting position that means the opening of the first train's route.

### 3.2 The control system by the help of the hand control panel

The panel (Fig. 4) contains buttons, levers and LED diodes. Each rail stage is controlled by buttons and levers. LED diodes were used as a visual control component, if the section is active, the diode at it's button switches on. If the operator presses an arbitrary button on the manual control panel, it will reach to the setting of variables pressing of a given button [3].

A boot timer is installed there, so the button could not be pressed repeatedly at his holding, and this boot timer can unplug it. If there were two buttons of two sections pressed simultaneously, then setting of the points will start to work and after their setting we can see licensing sign on the marker and the train begins to move.

The train sets in the yard can stop at the station or on the wide track in front of the entrance marker only. To depart the train out of the station, the button of the station of departure has to be pressed, and then also the button of appropriate track to send the train to. After route completing the train stops at the entrance marker, which prevents the train to drive into the station until allowed. To allow the train set to drive into the station, a button of the track, on which the train is located, must be switched on, and also the button of the stage on which the train set should arrive, has to be switched on, too.

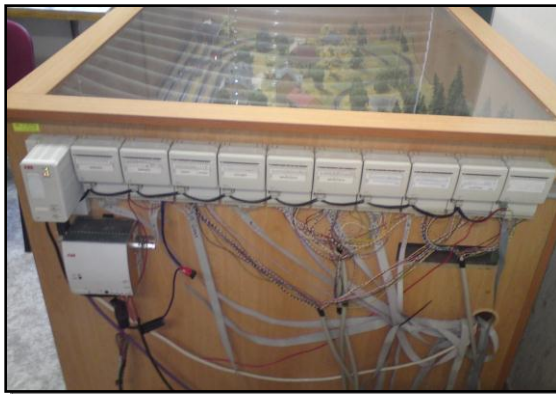


Fig. 3 Components of PLC on the model yard.

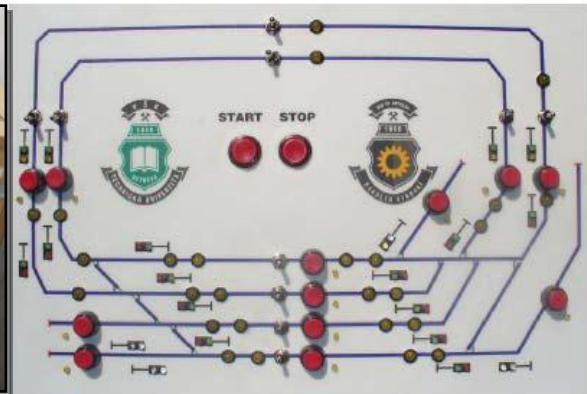


Fig. 4 Manual control panel.

### 3.3 The control of operation by the help of SCADA/HMI system

The main window of the application (Fig. 5) consists of three parts that give us the information about the state on the model yard [4].

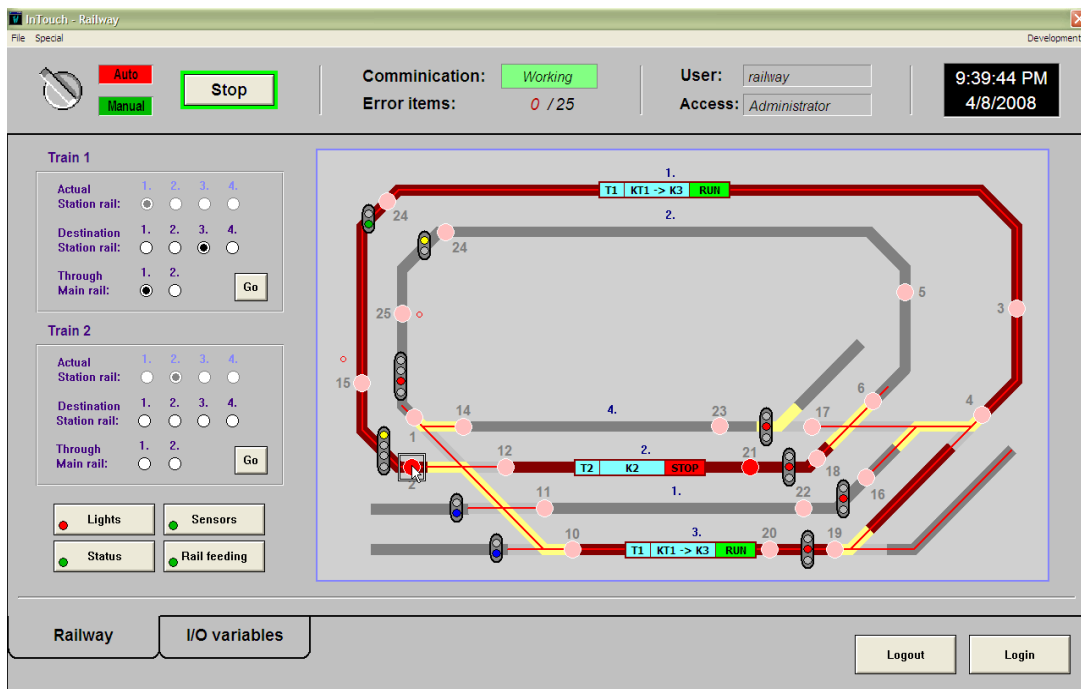
Upside part has rather an informative function, but it contains also a button start/stop and a switch enabling to choose the mode. Then we can find there an information about the state of communication between program InTouch and PLC. In case of any problem with variables, this part of screen provides also the information about a number of mistaken I/O variables. The other information relates to login and, of course, there is also the date and time shown on the screen.

The middle part shows the model railway itself. Then on the left side we can see the window for choosing the train routes for both trains, and a button that allows us to show or hide additional information like a state of the semaphore for retrace, information about a train on busy stages, visualization of sensors and displaying power supply state of the tracks.

The folds make the lower part of the window; they are designed to switch among the windows and the login/logout buttons. The main window of application shows the model yard with all its operating elements, like e.g. signals, points and power supply of the sections.

We can note also other information there on the picture, which applies to currently busy sections (section of the tracks that are actually engrained in red). On busy stages there are informative blocks shown, informing about a number, a route and a state of a train which is going on given part of the route at the moment. (E.g. Informative block of a wide track 1 announces that the train n. 1 is riding there and it shows that its actual position is on the track between the wide track 1 and the station track 3. The informative block of the station track 2 then informs about the train n. 2, which is standing on this track actually) [7].

There on the screen, we can see that one train is standing on the station track 2 and the second is preparing to pass the station track 3 to the wide track 1 now. The signaling of the departure marker is showing the “go” signal.



**Fig. 5** InTouch – Runtime mode.

### 3.4 The system of operating by the help of digital control

Another milestone in a railway's clay-modeling branch was the using of a digital control. The digital control caused that the locomotives are able to behave on any sections of the yard unconditionally. Until the locomotives were controlled by the help of operating of the power supplied sections of the yard, the engine of a locomotive was linked directly with the power supply in the given section and behaved according to a polarity and size of voltage in it.

For digital control of model railways, an independent bus called DCC (Digital Command Control) has been developed. It allows to control both engines, as well as accessories such as signaling, switches and others. The part of the DCC bus that is designed for locomotives control, had been named LocoNet.

This bus operates on the principle of variable length pulse (Fig. 6) that is modulated on the railway supply voltage. The track signal is superimposed with the so called DCC Exchange. Each locomotive has integrated a decoder, which can separate the control signal out of the power supply, and respond accordingly. Each engine has its own address, so multiple engines can be controlled at once this way.

The mentioned technology is used for a manual control of the model yard. However, for the realization of the given task, it is needed to extend this technology to be able to link the digital operating with PLC [5].

The whole modification of the technology consists of modification of HUGO 4 drivers. The modification consists in making a bridge across switches and thereby the direct linking of connection of one-chip ATMEL with one-chip PIC. This solution has been chosen because it is impossible to obtain a tenet bus bar with LOCONET. The solution consists of up to eight handlers, each of them communicates thru bus bar I2C control unit that is operated by I/O signals from the control PLC (Fig. 7).

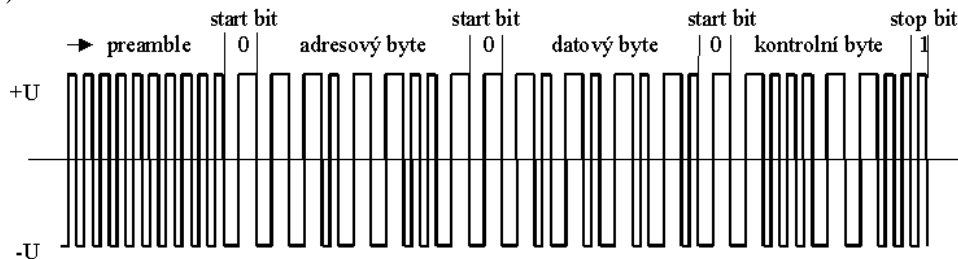


Fig. 6 Sample of DCC controlling signal.

**ATMEL - 8-bit Microcontroller with 2/4-Kbyte Flash – Features:**

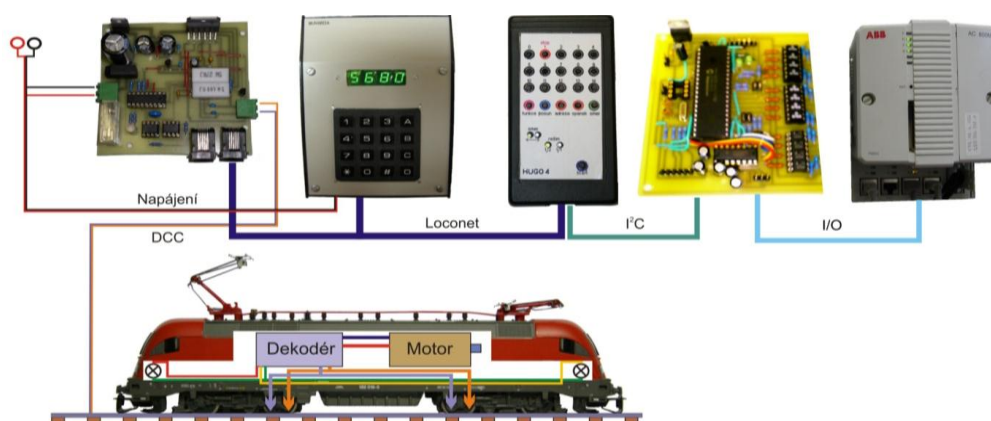
- Compatible with MCS®51 Products
- 20 MIPS Throughput at 20 MHz Clock Frequency and 2.4V, 85°C Operating Conditions
- Single Clock Cycle per Byte Fetch
- 2/4K Bytes of In-System Programmable (ISP) Flash Memory
- Serial Interface for Program Downloading
- 32-byte Fast Page Programming Mode
- 32-byte User Signature Array
- 2.4V to 5.5V VCC Operating Range
- Fully Static Operation: 0 Hz to 20 MHz
- 2-level Program Memory Lock
- 256 x 8 Internal RAM
- Hardware Multiplier
- 15 Programmable I/O Lines
- Configurable I/O with Quasi-bidirectional, Input, Push-pull Output, and Open-drain Modes
- Enhanced UART with Automatic Address Recognition and Framing Error Detection
- Enhanced SPI with Double-buffered Send/Receive
- Programmable Watchdog Timer with Software Reset
- 4-level Interrupt Priority
- Analog Comparator with Selectable Interrupt and Debouncing
- Two 16-bit Enhanced Timer/Counters with 8-bit PWM
- Brown-out Detector and Power-off Flag
- Internal Power-on Reset
- Low Power Idle and Power-down Modes
- Interrupt Recovery from Power-down Mode



### LocoNet DCC Exchange – Features:

- Supports all NMRA DCC formats of locomotive decoders
- It is compatible with any LocoNet<sup>®</sup> driver
- It allows to control up to 8 locomotive addresses simultaneously
- Up to 8 drivers can be connected at the same time
- Data are displayed on 4-sign 7-segment LED display
- Numerical keyboard is included for easy operation
- Both short (1-127) and long (128-9999) addressing can be used
- Smooth speed control is possible in 128 steps
- Lights control (FL) and other functions F1 - F8 are included (depend on driver)
- Supports also 14 and 28 speed step modes
- Contains small booster (600 mA) for direct control of one locomotive
- It helps to read/write address and to program CV registers, be it whole BYTE or particular BITS
- It supports direct programming mode according to NMRA standards on single programmed track
- Any locomotive at railyard can be programmed and set in operation mode

For the safe operation, and mainly for protection of each part of the set, the components were placed into the plastic protective shield. Standard plastic main electric box had been used as the shield.



**Fig. 7** The modified technology of the digital control.

There are single components of the digital set there in the box, as show on Fig. 8. Each part is fixed to the bottom, or to the lid box, pertinently plugged into the connectors (drivers). On the upper side of the box, a programming track is set to allow a locomotive to lie up to be pre-set and tested. Stops are installed at the end of each rail, to prevent a locomotive to go out of the track and to fall. On the back of the box, there is a set of connectors. These connectors are useful for connection of single circumferences [8].

## 4 CONCLUSIONS

This article presents actual state of development of the model railyard, from the point of view of its control systems. There were four railyard traffic control systems designed, realized and debugged:

- Using PLC AC800M made by ABB company,
- using the manual control panel,
- using the SCADA/HMI InTouch system,

- using the digital control system.

This is how the designated hardware functionality of this model task had been reached. Further development will focus on the software sphere.



**Fig. 8** The frontal panel of the digital control unit.

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