



LOW COST ELECTRONIC INTERLOCKING SYSTEM FOR THE RAILWAY STATION ELEMIR

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Abstract – This paper describes the low cost **Electronic Interlocking - EI** system installed at the railway station **Elemir** in Serbia. The system is developed and produced by Signalling & Control d.o.o. Belgrade. EI is a computer system based on the PLC family - HiMax, produced by the German company HIMA Paul Hildebrandt GmbH. The system is verified and approved for use on Serbian Railways by the Directorate for Railways of the Republic of Serbia and has the highest safety integrity level - SIL4 in accordance with European railway standards - CENELEC. Elemir EI is a standardized, modular and scalable system configured to the specific track layout of the Elemir railway station. The operational, functional and traffic requirements and safety principles of the previous, outdated Elemir electro-relay interlocking system are converted to general interlocking software of the Elemir EI. The track layout dependent data and particular interlocking requirements, which are presented in a form of a conventional control table are standardized and converted into a new form of the computer control table. This table is used as a simple data file for further computer processing and formal proving. Also, an advanced method of representing the layout of a railway station for HMI purposes in accordance to the standardized Catalogue of symbols of Serbian Railways is used. The described approach enabled a fast and efficient development and implementation and contributed to the low cost realisation of the complete Elemir EI.

Keywords - Railway computer interlocking system, railway signalling, safety integrity level 4, safety critical software, control table, reliability, availability and maintainability, lifecycle cost.

1. INTRODUCTION

EI system is installed at the Elemir station in December 2025, under contract with the Infrastructure of Serbian Railways, for the control and supervision of the traffic in the railway station Elemir. The control includes routes on the main line and two industrial lines in accordance with railway rules, regulations and technological processes required for the operation of the railway station [1]. It gives the authority for moves through the station areas and defines the route and the speed of the move in every particular situation. Hence, it is of paramount importance for the safety and security of the railway traffic [3].

Elemir EI system is a HIMA, HiMax and HiMatrix PLC, based controlling system of the highest safety integrity level - SIL4 in accordance with CENELEC European railway standards. EI is produced by Signalling & Control d.o.o., Belgrade and it is approved for use in Serbia by the Directorate for Railways of the Republic of Serbia.

Elemir EI covers area of the railway station Elemir with the track layout and the outside signalling equipment as shown on the signalling arrangement of the railway station Elemir presented in Figure 1.

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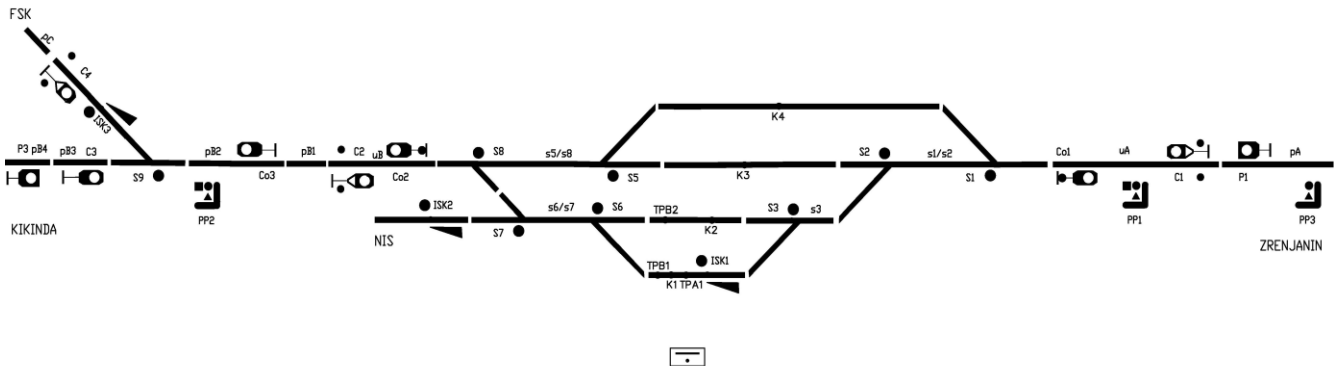


Fig.1. Elemir railway station - Signalling Arrangement

The task was to replace the existing, outdated electro-mechanical relay interlocking in the relay room, which is no longer functional, with a new computer system while maintaining the operational logic and signal dependencies of the existing interlocking.

Elemir EI represents an economical, low cost system, which supports the existing conventional outside equipment with LED signals and reuses the existing cable network. It has fully replaced the existing - Conventional Relay Interlocking system.

2. HARDWARE ARCHITECTURE

EI for railway station Elemir is realized as a modular and scalable system [1]. Architecture of the system consists of the following five levels:

- **Level 1:** EHMI - Operator console.
- **Level 2:** Central Safety Controlling system (SIL4) realized with HIMA PLC family HiMax, with DIM – digital input modules, and DOM – digital output modules.
- **Level 3:** EAC - Electronic Axle Counting system (SIL4) [4] - Safety controlling sub-systems realized with HIMA PLC family HiMatrix for the Train Detection functionality.
- **Level 4:** Interfaces for the control of the signalling elements are realized as standardized control modules:
 - SM - signal module,
 - PM - points module,
 - L-xing - level crossing module and
 - PS - power supply module.
- **Level 5:** Controlled signalling elements: signals, point machines, axle counter sensors, level crossings and power supply.

2.1. EHMI

EHMI (Electronic Human Machine Interface) is an electronic system that allows the interactive communication between the operator and the Central EI system. It is produced by Signalling & Control

d.o.o., Belgrade. Directorate for Railways of the Republic of Serbia issued the permanent approval for use of the EMMI - Electronic Man Machine Interface on the Serbian Railways in 2009.

The software package WinCC (Siemens) on the PC is used as a base for the realization of the EHMI.

Communication with HiMax PLC is realized over the Ethernet using the HIMA XOPC server.

An advanced method of representing the layout of a railway station for EHMI purposes is realized for EI. An example is EHMI layout presented in the following picture that is realized in accordance to the standardized Catalogue of symbols of Serbian Railways. EHMI installed at the railway station Elemir is presented in Figure 2.

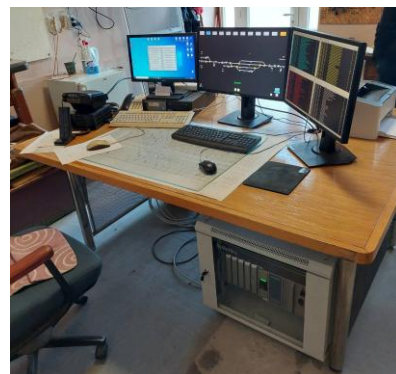


Fig.2. EHMI - at the railway station Elemir

2.2. Central Safety Controlling system (SIL4)

Central Computer Controlling system is realized by use of the safety HIMA PLC - HiMax (SIL4), which is also highly reliable and highly available system and provides low maintenance costs over its lifetime [2]. Each safety module individually is realized in the safety architecture - "2 out of 2". HiMax system for Elemir EI application is realized in the architecture - "2 times 2 out of 2" with a hot swap ability feature (warm replacement of the failed module). Elemir EI Central Safety Controlling HiMax system with the redundant DC power supply and

controlling interfaces to level crossings (the last three rows in cabinet) is presented in Figure 3.



Fig.3. Central Safety Controlling System of Elemir EI

2.3. EAC - Electronic Axle Counting system

The EAC system is realized as an independent safety sub-systems to cover Train Detection function. EAC system is developed and produced by Signalling & Control d.o.o., Belgrade [4]. EAC system is a HIMA, HiMatrix PLC based controlling system of the highest safety integrity level - SIL4 in accordance with CENELEC European railway standards. It is approved for use in Serbia by the Directorate for Railways of the Republic of Serbia. EAC train detection system at the railway station Elemir is presented in Figure 4.

2.4. Interfaces for control of signalling elements

Interface modules are realized as standardized functional modules (SM-signal module and PM-points

module) and placed into the appropriate cabinets. Cabinet for PM is presented in Figure 5 and cabinet for SM is presented in Figure 6.



Fig.4. EAC based Train Detection system for Elemir



Fig.5. Cabinet with PM modules for Elemir EI

3. MODULARITY AND SCALABILITY

Elemir EI is realized as a modular and scalable system. It contains 11 identical PMs and 13 SMs for signals and indicators. Also, the interface modules for 3 level crossings and one for PS. Elemir EI Central Controlling Computer HiMax uses single housing (rack) with 15 modules (12 active and 3 spare modules). It has 128 DI-digital inputs (64 redundant DI) and 96 DO-digital outputs (32 redundant DO). The redundant DIO are used for the outside signalling elements whose failure would cause the most

restrictive impact on system availability or would disable the greatest number of train routes, such as, for example, the facing points on the main track.



Fig.6. Cabinet with SM for Elemir EI

4. SOFTWARE

Software is realized as an integrated package that contains all necessary data and functional modules. It covers complete safety principles and functionality of Serbian Railways applicable for the railway station Elemir [1].

The operational, functional and traffic requirements and safety principles of the interlocking system Elemir are converted to general interlocking software of EI. The track layout dependent data and particular interlocking requirements, which are presented in a form of a conventional control table, are standardized and converted into a new form of the computer control table. This table is suitable for the application of formal proving methods and it is used as a simple data file for further computer processing.

5. COMMUNICATION

Elemir EI communication is duplicated (two channels) for the availability. Each communication channel is realized as an independent Safe-Ethernet (vital) ring and connects Central Controlling Computer HiMax (SIL4) with EAC sub-system for train detection

consisting of three HiMatrix (SIL4) PLCs. Elemir EI communication structure is presented in Figure 7.

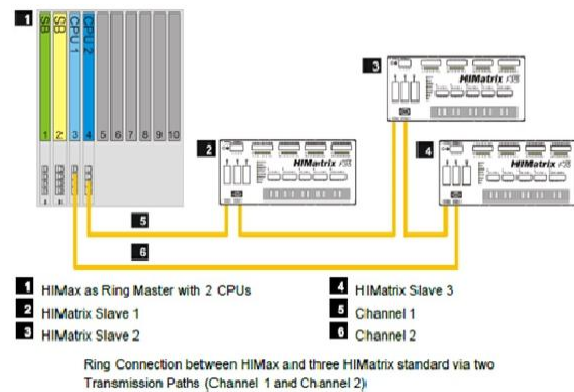


Fig.7. Elemir EI - Communication Structure

6. CONCLUSION

The described Elemir EI Computer Based Interlocking system represents continuation of the development efforts and good examples of the realisation of the domestic interlocking systems in the past. The first examples of the development and use of domestic electro-relay systems were "free wiring electro-relay system" and "coordinate system" developed at the Railway Research Institute (Institute Kirilo Savic, Belgrade) about 40 years ago and installed at several stations. The second example was discrete electronic interlocking who used fully electronic solid-state modules and was in service at the railway station Banja Koviljaca until few years ago. These systems have reached the end of their lifespan, and the manufacturing technology has been surpassed by new computer technology.

Elemir EI is based on newer generation computer technology that is current, state of the art, and still indispensable for points control, even for modern high-speed systems, so it can be used as an economical solution for securing railway stations for many years to come.

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