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ELECTRONIC INTERLOCKING

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Abstract – *This paper describes the* ***Electronic Interlocking - EI*** *system produced by Signalling & Control d.o.o., Belgrade. The system is developed, realized and tested in Serbia. It is verified and approved for use on Serbian Railways by the Directorate for Railways of the Republic of Serbia. EI is a computer system based on the PLC family - HiMax, produced by the German company HIMA Paul Hildebrandt GmbH, which has the highest safety integrity level - SIL4 in accordance with European railway standards - CENELEC. EI is a standardized, modular and scalable system practically independent from the track layout and the country of the application. The operational, functional and traffic requirements and safety principles of an interlocking system are converted to general interlocking software of EI. The track layout dependent data and particular interlocking requirements, which are usually 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 can be used as a simple data file for further computer processing. 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 also described. The described approach allows a fast and efficient realisation of a railway station interlocking system and contribuites to the significant cost reduction of the complete interlocking system.*

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

1. INTRODUCTION

A railway interlocking system controls the traffic in a railway station, and between adjacent stations. The control includes train routes, shunting moves and the movements of all other railway vehicles 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 for every railway administration [2].

EI is developed and realized on the bases of world wide experience and know how of Serbian engineers [3]. EI system is produced by Signalling & Control d.o.o., Belgrade and approved for use in Serbia.

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.

It is dedicated to cover all types of the railway stations and lines between the stations (automatic blocks or permissive inter-station dependency).

EI represents an economical system, which is very competitive to other Computer-based Interlocking - CBI systems, as well as, to the conventional Relay Interlocking – RI systems.

2. HARDWARE ARCHITECTURE

EI is realized as a modular and scalable system, which can cover all types of various stations track configurations and signalling arrangements, from simple (small) to very complex (large), for various country practices and various railway authorities [4]. Architecture of the system consists from five levels:

- **Level 1**: HMI - Operator console (single or duplicated for availability, typically SIL0.
- **Level 2**: Central safety controlling system (SIL4) realized with HIMA PLC family HiMax or HiMatrix (for small and simple interlocking systems, like simple crossing loops or mobile interlocking systems).
- **Level 3**: Safety controlling sub-systems (SIL4)

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realized with HIMA PLC family HiMatrix.

- **Level 4**: Interfaces for the control of signalling elements are realized as standardized modules (SM - signal module, PM - points module, DIM – digital input module, DOM – digital output module).
- **Level 5**: Signallling elements: signals, point machines, track circuits, axle counters, etc.

An example of EI for is presented in Figure 1.

Fig.1. EI - Prototype for Serbian Railways

2.1. HMI

HMI (Human Machine Interface) is an electronic system that allows the interactive communication between the operator and the central EI system.

Fig.2. HMI - Serbian Railways layout

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

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

HMI is typically realized as a single SIL0 system and can be duplicated for the availability.

It can also be connected to other computer-based interlocking systems via appropriate communication protocols.

An advanced method of representing the layout of a railway station for HMI purposes is realized for EI. An exapmle is HMI layout presented in the previous picture that is realized in accordance to the standardized Catalogue of symbols of Serbian Railways.

2.2. Interface to the relay interlocking system

This subsystem is realized as an independent system that can be used with relay interlocking system or an other computer-based interlocking.

The same HMI operating console, with the appropriate communication protocol, uses for this purpose.

The HMI interface for relay interlocking system SpDrS64-JZ (Siemens), with Simatic S7 communication protocol and Simatic S7 PLC family (Siemens) is shown on the picture.

Fig.3.HMI Interface for RI for Serbian Railways

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, I-01-1 No. 6/08, from 19.01.2009.y.

2.3. Central safety controlling system (SIL4)

Central computer controlling system is realized by use of the safety HIMA PLC family HiMax (SIL4), which is also highly reliable and highly available system.

Each safety module individually is realized in the

safety architecture - "2 out of 2".

HiMax PLC for EI application is typically realized in the architecture - "2 times 2 out of 2" with hot swap-ability feature for the failed modules (worm replacement of the failed module).

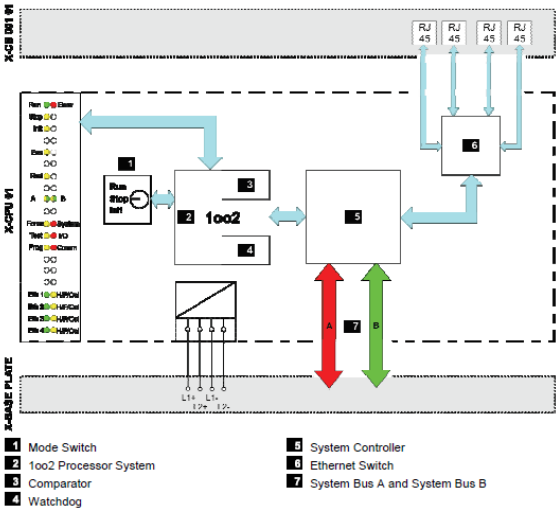

Fig.4.Safety structure of EI safety processors

2.4. Safety controlling sub-systems (SIL4)

Safety sub-systems of the EI are individual safety computer controlled systems, which are realized by use of the safety HIMA PLC family HiMatrix (SIL4):

- ELC – Electronic Level Crossing System
- EAC – Electronic Axle Counter System
- Electronic Interfaces

The sub-systems are typically connected to EI via Safe-Ethernet, but they can, also, be connected to the EI (or the other relay or computer-based interlockings) via DIO (hardware connection)

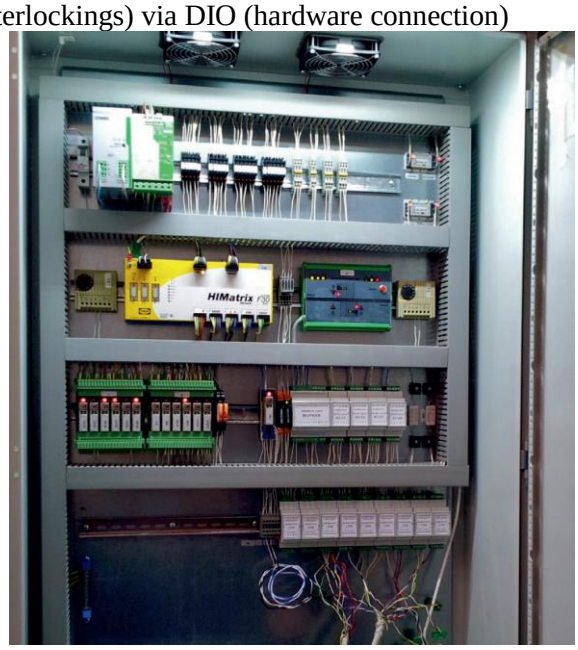

Fig.5. An Electronic Interface module for EI

2.5. Interfaces for control of signalling elements

Interface modules are realized as standardized functional modules such as basic functional modules:

- SM - signal module,
- PM - points module,
- DIM - digital input module,
- DOM - digital output module

and additional functional modules:

- EFL – Electronic Flasher,
- ECD – Electronic Current Detector,
- RM – Relay Interface,
- IP – Indication panel,
- GSM – SMS diagnostic,
- LPM – Lighting Protection,
- TERM – Electronic Thermostat,
- ETIM – Electronic Timer,
- EODT – Electronic Off-Delay Timer.

Fig.6. Electronic flashing module for EI

3. SOFTWARE

EI software is realized on the bases of the PhD dissertation of Dr. Dejan Lutovac: "Universal Computer-Based System for Railway Interlocking Control" [5].

Software is realized as an integrated package that contains all necessary data and functional modules.

It covers complete safety principles and functionality of the railway authority, independently of the station track layout.

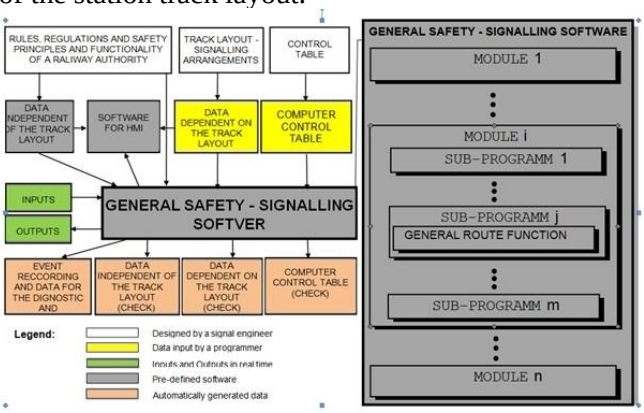

Fig.7. Structure of EI software

EI is a standardized, modular and scalable system practically independent from the track layout and the

country of the application. The operational, functional and traffic requirements and safety principles of an interlocking system are converted to general interlocking software of EI. The track layout dependent data and particular interlocking requirements, which are usually 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 can be used as a simple data file for further computer processing.

4. MODULARITY AND SCALABILITY

EI is realized as a modular and scalable system and covers whole range of interlockings, from simple (small) to very complex (large).

Minimum configuration is: 10 modules inside a single housing (rack).

Maximum configuration is: 16 housings (racks) with total 288 modules.

Mixture of HiMax (SIL4) and HiMatrix (SIL4) depending on the requirements and complexity is possible.

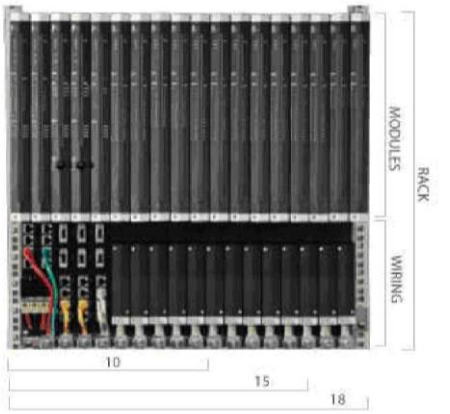

Fig.8. HiMax rack arrangement

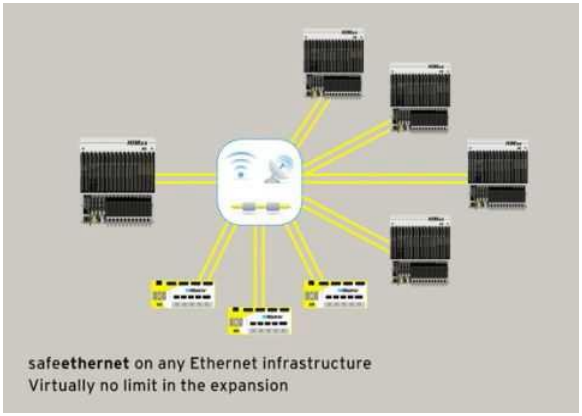

Fig.9. An example of EI mixed architecture

5. COMMUNICATION

EI communication is duplicated for the availability. Depending on the safety requirements, each communication channel is realized as:

- Ethernet (non-vital): HMI (SIL0) with HiMax (SIL4) or HiMatrix (SIL4), or
- Safe-Ethernet (vital): HiMax (SIL4) with HiMatrix (SIL4).

6. MSEI

MSEI - Mobile Simple Electronic Interlocking represents simplified Electronic Interlocking with dependencies between stations entrance signals and applicable principle of one entrance route at the time. Announcement of a train and replacement of the entrance signal after passage of the train is achieved via ERC - Electronic Rail Contacts (short track circuits).

MSEI is realized by HiMatrix HIMA PLC Family and other stated standard functional modules that are produced by the company Signalling & Control Ltd.

It is used instead of the station interlocking system during the reconstruction to provide safe entrances of the trains to the station. It is connected to the existing outside equipment via the existing cables from the equipment room, or uses new outside equipment with temporary cables.

7. CONCLUSION

The described way of realization of EI system allows a fast and efficient realisation of a railway station interlocking system and contribuites to the significant cost reduction of the complete interlocking system. Directorate for Railways of the Republic of Serbia issued the permanent approval for use of the EI on the Serbian Railways, I-01-1 No.: 340-142-3/2016, from 09.03.2016.y.

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