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Computer-based interlocking

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ABSTRACT

Computer based interlocking ESA 33 is a modern electronic interlocking that meets requirements of SIL 4 safety integrity level in accordance with specification EN 50 129. It consists of 3 levels, commanding, control and executive. Control level works on principle 2x2oo2. Executive level works on the principle 2oo2. It is possible to connect up to 12 commanding computers to the control level.

KEYWORDS: computer-based interlocking, safety, communication protocol, object controller, decentralization, centralised traffic control, diagnostics

1. Introduction

Station interlocking ESA 33 (further ESA 33 only) is a modern computer based interlocking, that serves for safety operation of railway traffic in stations with track branches or without them. It is the next stage of development of computer based interlocking produced by AZD Praha s.r.o. and meets SIL 4 safety integrity level in accordance with EN 50 129.

ESA 33 is computer based interlocking at all levels – commanding, control and executive ones. Coupling outdoor equipment is done electronically, i.e. by means of electronic modules that have been specially developed for different outside elements (for example modules for signal, point machine, track circuit and so on), possibly by relay interface if there is requirement to control non-standard outdoor element in station.

ESA 33 can work with cold or hot standby at commanding level and at control level. A processor unit and power supply unit at executive level can work with hot standby feature as well.

2. Detailed description of interlocking

ESA 33 consists of following three levels, se also fig. 1:

- Commanding level
- Control level
- Executive level

2.1. Commanding level

This level consists of commanding computers (ZPCs) that are connected through communication link to the control level. Commanding workplace is assembled by a keyboard, mouse, LCD monitors for displaying rail yard, and so called technological monitor for displaying pages with operational status of different parts of ESA 33 and text messages to operating staff.

It is possible to connect up to 12 commanding computers to the control level. All commanding computers can work in cold standby or hot standby mode as mentioned already.

Each commanding computer can be configured to have functional or geographical restrictions or combined (functional and geographical) restrictions.

Apart from the 12 commanding computers, from which the interlocking can be controlled, it is possible to connect theoretically unlimited numbers of computers, that don't allow operation. Such computers are used for displaying controlled yard on a large screen display.

Technological monitor is used for displaying of a list of non-fulfilled conditions in case of processing risk functions. The risk functions are those that function that involve cooperation with operational staff, for example setting calling on signal aspect, switching a point machine to opposite position when the track section is occupied and so on. Displaying the list of non-fulfilled conditions is vital. After reading the list of non-fulfilled conditions by the operational worker, he has to confirm or reject the list. Required action is processed in control level after confirming the list of non-fulfilled conditions by special confirmation sequence.

It follows, from above, that ESA 33 has vital commanding procedures in case of risk functions - it is guaranteed that ESA 33 will not generate and confirm risk function by itself.

2.2. Control level

Control level of ESA 33 consists of a pair of active and a pair of standby technological computers (TPC), which are interconnected by local network. The standby pair can work in cold or hot standby mode.

A concept of safety of the interlocking is based on the principle of composite safety in case of faults in accordance with EN 50 129. The control level is configured as 2 times 2oo2 with the same hardware and diverse software. The software is separated to mutually cooperating parts. One part is so called general software that includes program code for communicating processes and partially program code of some traffic safety algorithms, which don't differ from application to application on the lines operated by one railway administration, for example algorithm of switching of a point.

Second part is called an application software that includes information about shape of the rail yard of factual railway station, dependencies defined by an interlocking table and so on.

Communication network of control level is divided to three physically separated networks: T-LAN, Z-LAN and PENET.

Z-LAN network works on the principle of ETHERNET IEE 802.3 with ETMNET protocol (own communication protocol of AZD). This network connects control and commanding levels. Physical connection is realized by fibre optic elements.

T-LAN network works on the principle ETHERNET IEE 802.3 as well. All four technological computers are interconnected by this network. Pairs of computers TPC1 – TPC2 and TPC3 – TPC4 exchange the data required for verifying of right function through T-LAN. Moreover TPC1 – TPC3 and TPC2 – TPC4 exchange data required for mutual changeover between states "active" and "standby" in case both pairs work in hot standby mode.

PENET network works on principle RS485 with communicating protocol PENET+ with transfer rate 115,2 kBd. PENET+ is again the own communication protocol of AZD. PENET network connects control and executive level.

PENET network is "two branches" network, i.e. the first branch, called master, connects executive level with TPC1 and TPC3, the second branch, called slave, connects executive level with TPC2 and TPC4.

Hardware comparators, marked as C1 to C4 at the fig. 1, are used to switch of a faulty pair of technological computers. If technological computer works all right it transmits to its own comparator six signals. The next condition for transmitting these six signals to the comparator is the correct functioning of the second technological computer in the pair. The comparator compares the received signals in the preset shape. If there is a discrepancy between the received and the preset signals, power supply to the particular TPC is switched off. Because switched off TPC cannot communicate with the second TPC in a pair, it stops transmitting signals to its own comparator and consequently power supply to the second TPC in the pair is switched off too.

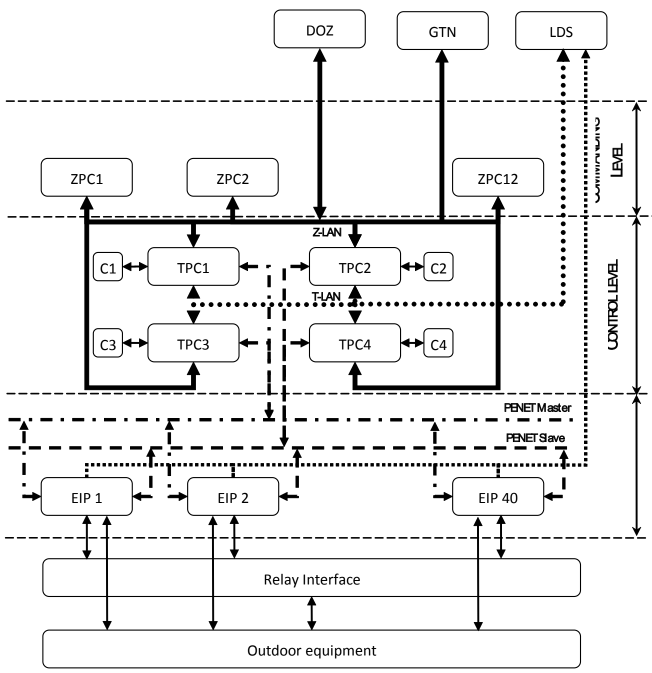

Fig.1. Block diagram of interlocking ESA 33

2.3. Executive level

Executive level comprises of EIP object controllers. A block diagram of EIP object controller is presented in fig. 2.

From the point of view of architecture the EIP object controller is designed as "two levels" object controller:

- level of Element Controller – EC
- level of Interface Controller - IC

2.3.1. EC unit

EC are processor units that arrange vital communication between control level on the one side and units IC on the second side. It works as multiplexer and demultiplexer and modifies transmitted data on base of the state of IC units. The EC units collect diagnostic data for local and remote diagnostics. It is possible to use one EC card in one EIP object controller; in this case the EC unit has no standby, or two cards EC. In case when two EC cards are used in the EIP object controller, they work in hot standby mode. Each EC unit works in 2oo2 mode.

EC unit communicates with IC units by communication protocol EINET. This communication protocol is used on interface RS485 similarly as protocol PENET+.

2.3.2. PSU unit

This is power supply unit. If two PSU pieces are used, they work in hot standby mode. Input and output voltage is isolated from each other.

2.3.3. IC units

IC units are designed as the units with inherent safety. They are intended for straight control of elements. Because of concept of safety 2oo2, they are designed for working in such system. Both branches are placed on the one module. All types of IC units include microprocessor unit with input and output circuits. I/O circuit differs in type of controlled element.

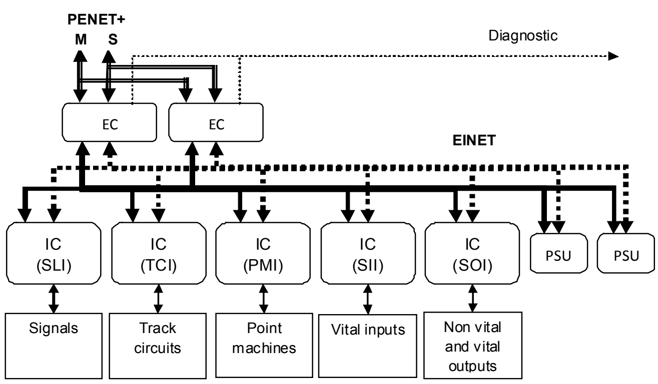

Fig. 2 Block diagram of EIP object controller

2.4. Type of IC units

2.4.1. SLI unit

SLI unit provides contactless control and detection of lighting of signals. The unit can control 8 signal lights at the most (the number of controlled lights is subject to configuration), 4 lights out of these 8 can be prohibitive lights. Independent replaceable switching modules are used for switching on/off the lights. The outputs are adjusted to control loads 20W, 50W and 80W.

2.4.2. PMI unit

PMI unit provides contactless control and detection of position of point machines. It is possible to control 2 point machines by the one PMI unit, whereas each point machine is powered independently. Each output can control two physically coupled points, i.e. points with consecutive switching on of electric drive. If needed, relays detecting position of the point machine can be connected to the unit too.

2.4.3. TCI unit

This unit reads contacts of track receivers and transmits additional code of continuous automatic train protection system to a track circuit. The unit can control 8 coded spots at the most, i.e. for example 4 track sections without branches. The coding is carried out by external (independent) high power switches.

2.4.4. SII unit

There are two types of SII unit in this type – SII-1 and SII-2

Unit SII-1 provides contactless reading of inputs. Power level of inputs shall be 24V DC. One unit has 32 inputs at the most. Activation of the input (reading LOG 1) is carried out by connecting +24V to the input against common negative potential.

Unit SII-2 provides contactless reading of inputs too. There are 24 inputs at the SII-2 unit. 16 inputs are single pole ones, i.e. activation of input is the same as on SII-1 unit. 8 inputs are double pole ones. Activation of the double pole input is carried out by connecting 24V DC voltage to particular inputs with the right polarity.

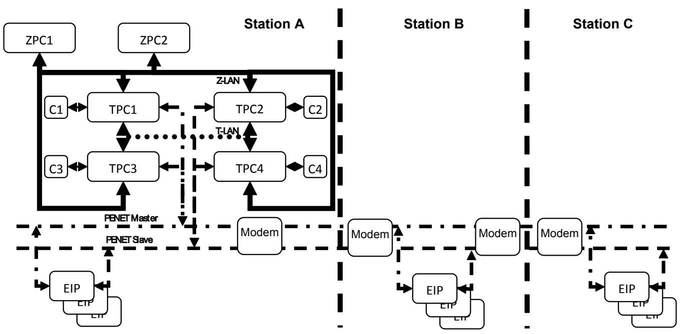

Fig.3. Example of structure of ESA 33 with decentralized EIP object controllers

2.4.5. SOI unit

This unit is designed for contactless controlling of interlocking elements. The unit has 8 vital outputs and 8 non-vital outputs. In both cases the voltage level of outputs is 24V DC.

Active non-vital output is 24V DC positive potential on the output terminal against common negative.

Active vital output is 24V DC potential between two particular outputs. Voltages of vital outputs are isolated from each other as well as from all other voltages.

3. ESA 33 with decentralized EIP object controllers

The control level has relatively huge computing capacity. In this time, one control level, i.e. four TPCs, can control station with 1200 logical elements that is railway station with approximately 300 physical interlocked points. Because there is not many such "big" stations around the world, the possibility to control by one control level with decentralized (remote) EIP object controllers more stations (especially neighbouring stations) is suggested. It allows reducing amount of hardware; it means that acquisition cost of such solution is lower. Example of structure of ESA 33 with decentralized EIP object controllers is at fig. 3.

Physical connection of decentralized groups of EIP object controllers is realized by fibre optic cable and optic modems. In this case it is possible to move each group of EIP object controllers away up to 40 km from previous one.

It is not necessary to have commanding level located at the station where the control level is installed. Commanding level can be installed even in more than one station. In these cases the commanding level is connected to the control level similarly as groups of decentralized EIP object controllers.

3.1. Remote control

It is possible to connect ESA 33 interlocking to the system of remote control. Remote control of DOZ-1 type is an integral part of ESA 33. Theoretically, it is possible to connect unlimited number of stations. Practically it depends on the ability of the dispatcher, how many stations and what density of traffic with he can control.

Up to date there are apart from several section control (typically dispatcher controls 3 or 4 neighbouring stations) two central traffic control (CTC) centres installed in the Czech Republic. The CTCs covers approximately 100 km and 80 km of line with 15 and 8 controlled stations.

Workplace of the CTC is fully equipped commanding place. It is possible to set all functions including risk functions (e.g. setting a calling on signal aspect) from the CTC workplace. It is possible to define functional or geographical restrictions for each CTC workplace similarly as for regular commanding place used for controlling one station. It is allowed to hand over control from CTC to local control as well as take over controlling the station from local control to the remote control by the CTC workplace.

3.2. Graphical and technological layer (GTN)

Graphical and technological layer (GTN) can be connected to the ESA 33. GTN is a telematic layer of the interlocking equipment. This layer from AZD production allow in connection with ESA 33 following functions.

- automatic recording of traffic documentation
- graphic displaying of a train traffic diagram
- building of prospective plan of traffic
- transmissions of information from/to other sources (for example systems for train position monitoring)

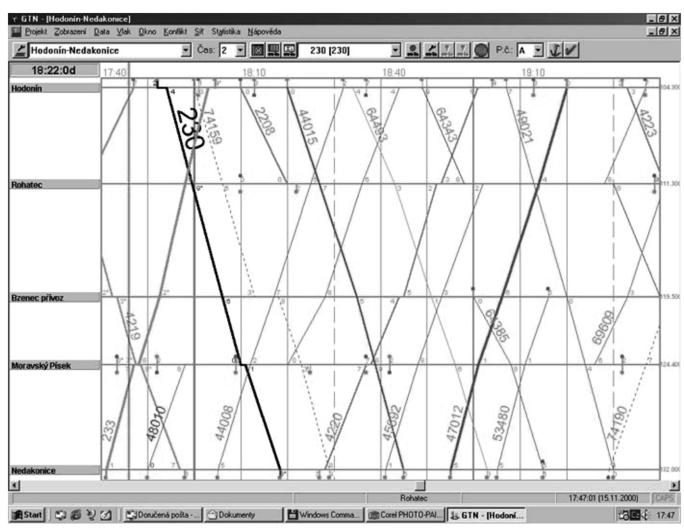

Fig.4. The train traffic diagram

- building of statistics of traffic
- recording of operation of operational staff and interlocking activity

Data including train numbers, that are necessary for function of such telematics application, is get from the Z-LAN of the control level. Example of graphic displaying of the train diagram is at the fig. 4.

3.3. Diagnostics

Interlocking system ESA 33 includes its own internal status diagnostic. Data archives are stored to the RAM disk, which are part of each technological and commanding computer. EIP object controller has diagnostics archive too. All archives can be stored to the portable media and browsed on the other computer with installed special program later on. However, it is possible to connect diagnostic server, marked as LDS at the fig. 1. This server is connected to the control and executive level and server program saves all archive data to the server hard disk automatically. Moreover, it is possible to connect modules for measuring analogue values, such as voltage, insulating resistance, throwing current, temperature and so on. These data are stored as well.

Access to the data stored in diagnostic server is possible through the computer with installed client program and connected to an access point of the diagnostic network.

4. Conclusion

ESA 33 is a modern, fully electronic world-class interlocking with safety integrity level SIL 4 in accordance with European specification EN 50 129. Its modular structure allows variable design for different application to meet various requirements of a customer.

Up to date there are 25 stations equipped with ESA 33 in the Czech Republic (e.g. Prague main station) and 1 in the Slovak Republic. Next 8 applications are going to be installed in Lithuania.