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Axle Counting System MC-AZ 2.0
Track Vacancy Detection and beyond

Content

1	FEATURES AND APPLICATIONS	3
2	DESIGN AND FUNCTION	3
2.1	Double wheel sensors	3
2.2	Evaluation Unit	3
2.2.1	Axle Counter Module AZB	3
2.2.2	Input Output Module IOB	4
2.2.3	NET Network Module	4
2.2.4	Power supply	4
2.3	Hardware Configuration	5
3	OPTIONS OF APPLICATION	6
3.1	Track Vacancy Detection in Relay Interlocking Systems	6
3.2	Track Vacancy Detection in Block Systems	7
3.3	Track Vacancy Detection in Electronic Interlocking Systems	8
3.4	Control of Level Crossing Protection Systems	8
4	SETTING UP AND OPERATION OF AXLE COUNTING SYSTEMS	10
4.1	Installation of the DSS wheel sensors	10
4.2	Configuration of the evaluation unit	10
4.3	Diagnosis and Maintenance	11

1 Features and applications

The MC-AZ 2.0 (second-generation microcomputer-controlled axle counting system) is based on double wheel sensors in conjunction with intelligent networked modules of an evaluation unit. The entire system has been developed in accordance with the CENELEC standards EN50126, EN50128 and EN50129 according to the safety integrity level SIL 4.

The main application of the axle counting system is the safe vacancy detection of track, points and line sections in interlocking and block systems, as well as shunting yards in a wide variety of forms.

In addition, the system is used for the automatic switching on and off of level crossings and offers significant advantages here through the intelligent combination of intermittent and sectional switching functions.

2 Design and function

2.1 Double wheel sensors

One innovation in the area of the outdoor system of the axle counting system is a new, enhanced generation of wheel sensors, which is represented by the type DSS500 developed in accordance with SIL 4, as well as the type DSS250, which has been designed for secondary and shunting-related applications.

The double wheel sensors of the new generation differ from their predecessors by their more efficient mechanical design and greatly simplified installation with the help of standard parts (see Figure 1). The dimension for the drill holes in the rail web is identical to that of the preceding types, so that existing drill holes can be used. A further option that is available is a simple fastening clamp, e.g. for temporary installations.



Figure 1: Wheel Sensor DSS

The interface between the wheel sensors and the axle counting evaluation unit is designed in such a way that it is compatible with other wheel sensors of the DSS series, e.g. the tried, tested and approved type DSS400RE wheel sensor for SIL 4 applications. With this it is possible to renew wheel sensors, evaluation units or the entire system even in existing axle counting systems independently of each other – while optionally keeping the existing cable system.

2.2 Evaluation Unit

2.2.1 Axle Counter Module AZB

The AZB axle counter module evaluates the sensor signals from up to two connected double wheel sensors and processes them to form axle counting information, in which a distinction is made between counting spot information and counting section information. An AZB can administer up to two counting spots and two counting sections whose data is made available in each case on the internal CAN bus of the axle counting system. A counting section can therefore process up to 16 counting spots networked via the bus system and generate the clear/occupied information for a vacancy detection section, for example. Functions for resetting the counting sections are also implemented on the AZB module and are controlled by corresponding commands in the form of secure data telegrams on the CAN bus.

2.2.2 Input Output Module IOB

The input output Module IOB provides a parallel interface with potential-free relay contacts for safe output, as well as safe inputs for entering information. For each module it is possible to output the clear and occupied signals of two axle counter sections, for example, and read in their axle count reset buttons. However, the module is not limited to this application and can be used in other applications, e.g. for the interface with a level crossing protection system (LCPS) or for a fail-safe digital transmission system.

2.2.3 NET Network Module

The NET network module is connected via the internal CAN bus to the other modules and provides the axle counting system with additional interfaces for communication. For example, the module has an Ethernet interface for secure communication with other remote axle counting systems, e.g. on longer track sections as a peer-to-peer network or for connection to an electronic interlocking system via a customer-specific or standardised network protocol. Similarly, diagnosis systems can be connected via Ethernet.

In addition to Ethernet, the module also offers an RS485 interface for the transmission of axle counting data using conventional signal and telecommunications cables, as well as a USB interface for easy access to diagnostic data.

In the MC-AZ 2.0 axle counting system, the NET module serves simultaneously as a configuration data store for the axle counting system of an area, typically for the components that are housed together in a switch cabinet. The Ethernet interface is also used for uploading the configuration data. As a result, the module can play a key role in axle counting systems of a larger size, which is why a redundant configuration with two NET modules is also possible.

2.2.4 Power supply

The aforementioned modules of the MC-AZ 2.0 axle counting system are available as versions for supply voltages of 12 V DC or 24 V DC, where 24 V represents the standard. Technically, the modules are designed in such a way that industrial power supply devices can be used for the power supply to an axle counting system or subsystem. These components are selected within the framework of the project design of a system according to their size, the existing energy connections (AC or DC), as well as the respective environmental conditions and availability requirements (UPS, n+1 etc.). As a result, the greatest possible degree of flexibility is available for the integration of the axle counting systems into signalling systems, so that a wide variety of user requirements are fulfilled.

2.3 Hardware Configuration

The AZB, IOB and NET modules are provided as Euro plug-in cards for installation in standardised module racks (MRs) with a width of 19" (standard) or in shortened versions. Figure 2 shows an example of a 19" rack with modules for 12 double wheel sensors and 8 axle counter sections with parallel interface.

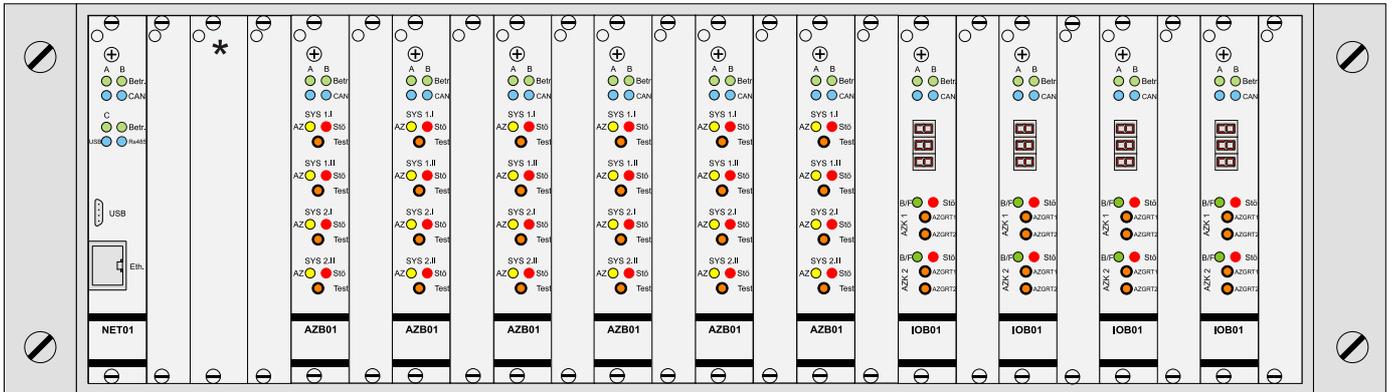


Figure 2: MC-Z 2.0 Evaluation Unit

In order to minimise the wiring requirements, different backplanes are available for the MRs, with which single and multiple section axle counting systems of different forms can be built up. The backplanes have not only the connections to the CAN bus and power supply, but also special socket strips for retaining pluggable system cables. The system cables provide a particularly efficient interior cabling system with which the connections to the outdoor system (cable termination frame) and the transfer to higher-level equipment (e.g. the interlocking system) are established.

Module	Function
BP400AZ	Backplane for 4 units of AZB01-modules
BP040AZ	Backplane for 4 units of IOB01-modules
BP202AZ	Backplane for 4 units of AZB01 and 2 units of NET01-modules
BP211BÜ	Backplane for 2 units of AZB01, 1 unit of IOB01 and 1 unit of NET01-module

Table 1: Overview of available backplanes

In general it can be stated that with the MC-AZ 2.0 axle counting system, up to two-thirds of the space in the indoor system can be saved compared to the Pintsch Axle Counting System with a comparable hardware configuration and system size. This is due to the higher degree of integration of modern electronic circuits with SMD technology and the resulting much lower number of modules required for each counting spot and counting section.

3 Options of application

3.1 Track Vacancy Detection in Relay Interlocking Systems

Relay interlocking systems remain an integral part of the signalling landscape. Design types such as geographical circuit interlocking systems, which were developed in the 1960s and built up to the 1990s, are characterised above all by their durability with relatively low maintenance costs. However, in the case of relay interlocking systems, the systems for automatic vacancy detection usually consist of track circuits of an older type which are no longer state-of-the-art in terms of their requirements regarding high availability and low maintenance costs. The dependence of the detection quality from permanent way conditions also represents a problem for many operators. Here, the replacement of the track circuits by modern axle counting systems offers significant advantages.

Relay interlocking systems are structured in many cases as centralized systems for larger areas. Similarly, the MC-AZ 2.0 axle counting system can be project designed as a multi-section system with a central evaluation unit in the indoor system (relay room) of the interlocking system. For this purpose, corresponding cable connections have to be provided for each individual double wheel sensor. As an interface, IOB modules are used for the output of the clear/occupied information of the respective section via relay contacts which replace the contacts of the track relays or the receiver facilities of the track circuits. In addition, axle count reset buttons have to be configured which are also connected to the IOB and read in through it. Figure 3 shows as an example the block diagram of a multi-section axle counting system.

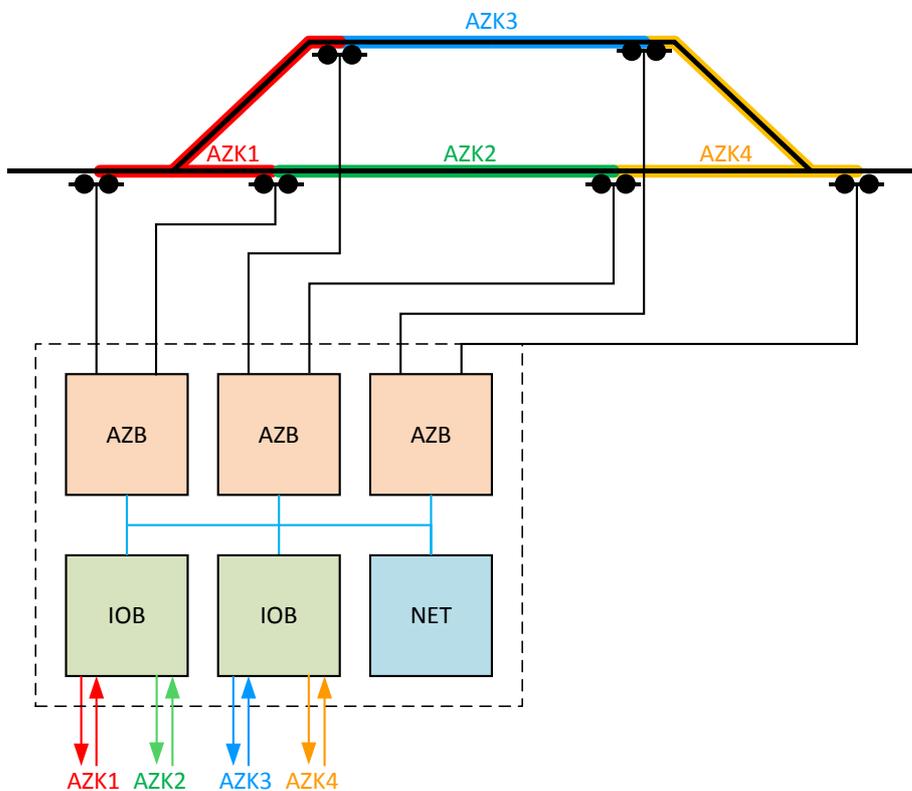


Figure 3: Multisection axle counting system with centralised structure (example)

Besides the central installation of multi-section systems with a parallel interface in the indoor system of a relay interlocking system, such systems can also be designed to be partially decentralised. This means that the entire parallel interface with the indoor system is arranged with IOB and NET modules in the relay room, while the AZB and NET modules are arranged in outdoor cabinets distributed locally as close as possible to sections of points or track with sizeable collections of wheel sensors. The decentralised cabinets are connected to the central part of the indoor system via Ethernet. The use of glass-fibre cables with corresponding converters that are free from electromagnetic interference even at long distances and which enable high data rates is typical in this field today. Alternatively, however, DSL connections via copper cable can also be used, for which corresponding modems are required.

The connection between decentralised axle counting cabinets and double wheel sensors is provided by branch cables which are relatively short due to the decentralised structure. With this partially decentralised design it is possible to significantly reduce the expenditure for the copper cables of the axle counting systems. Through the use of glass-fibre or data cables instead of trunk

cables with many copper wires, the operator is also spared the additional expense of underground cable laying through additional or extended cable routes.

3.2 Track Vacancy Detection in Block Systems

Additionally, if the block systems are equipped with the MC-AZ 2.0 axle counting system, its flexible project design options and networking capabilities offer considerable advantages. The possibilities of a central or partially decentralised structure described in section 3.1 apply to systems with a central block, as these systems represent extensions of central interlocking systems. Decentralised automatic block systems require a decentralised structure of the axle counting system, which is also possible with the system. The important aspect here is the possibility of outputting the clear/occupied information for a specific track section at both ends of this section by means of a relay interface (see Figure 4). This feature also facilitates the automation of semi-automatic block systems where the axle counting system takes over control of the train integrity, and optionally also the function of train-activated contribution at the destination station.

The Ethernet interface of the NET module in conjunction with corresponding converters for glass-fibre cables or DSL modems can also be used for exchanging the axle counting data between the decentralised evaluation units.

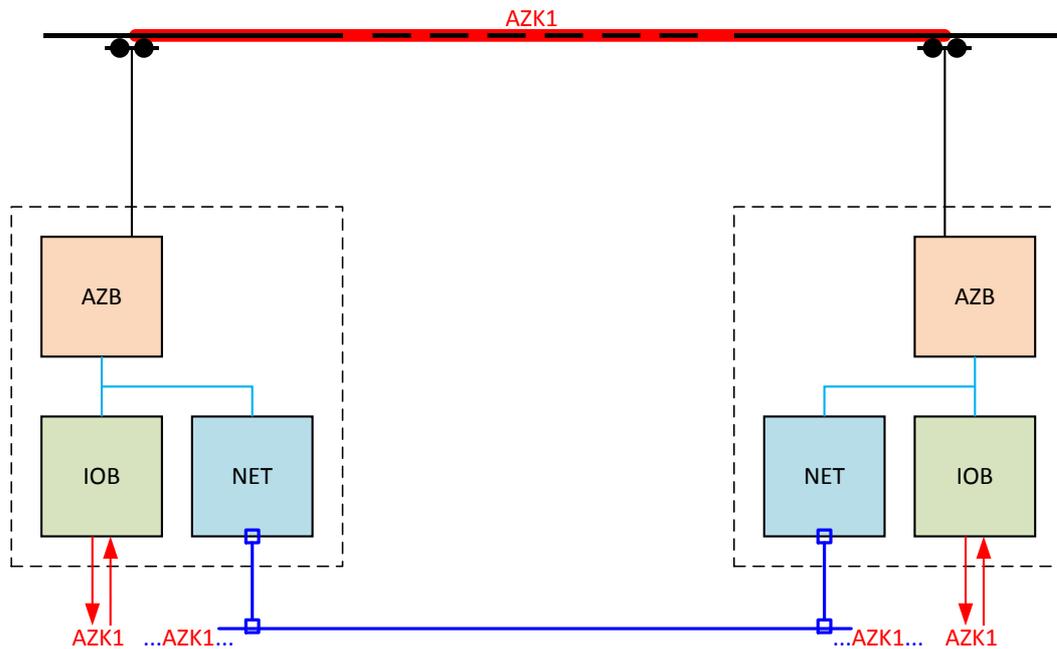


Figure 4: Axle counting system for vacancy detection of a block section (example)

The possibility of using the axle counting system as a fail-safe digital transmission system and modernising the existing older transmission system of the block section with it offers the user additional added value. For this purpose, additional IOB modules are provided, whose digital input signals are transferred directly to digital relay outputs of the receiver and vice versa.

3.3 Track Vacancy Detection in Electronic Interlocking Systems

Current designs of electronic interlocking systems have the option of linking axle counting systems via Ethernet. In addition to the significant savings in terms of hardware (I/O modules) and wiring requirements in the indoor system, further technical options for the more efficient use of the axle counting technology open up with this serial interface. The transmission of vacancy detection and reset information is performed through the use of secure data protocols, whose exact contents are to be agreed with the respective manufacturer of the interlocking system or provided in a standardised form by large railway operators. Furthermore, additional information such as signals about trains travelling over counting spots (with or without a direction criterion) or commands for the activation or inactivation of counting spots can be transferred in the transmission protocols. In this way, MC-AZ 2.0 axle counting systems can be ideally adapted to the requirements of the respective operator, thereby generating added value.

In the case of electronic interlocking systems, both central and decentralised architectures are found, both of which are supported by the MC-AZ 2.0 axle counting system. In centralised systems, the components of the modules of the evaluation unit are installed in indoor cabinets or racks. In decentralised systems, installation in outdoor cabinets next to the track is typical. The modules are designed for corresponding environmental conditions, so that air conditioning of the outdoor cabinets is not necessary and, for example, standard commercially available control cabinets can be used for them.

In a decentralised structure, the required number of AZB modules are networked within the outdoor cabinet via a CAN bus with a NET module, which in turn provides the Ethernet interface for the networking of this group with other groups, as well as the electronic interlocking system.

3.4 Control of Level Crossing Protection Systems

Automatic level crossing protection systems (LCPS) are equipped in many cases with their own track switching devices that enable vehicle-activated switching on and off, without having to resort to vacancy detection or switching equipment of an interlocking or block system. The project design of interlocking and block systems and LCPS can therefore in most of the cases be carried out independently of one other, which offers advantages with respect to the operation and maintenance of the systems. In other cases, the track vacancy detection systems of the interlocking and block systems are also used for switching the LCPS on and off, which necessitates an integrated view of the signalling systems design of a railway line.

The MC-AZ 2.0 axle counting system offers flexible options to fulfil the different requirements of the manufacturers and operators of signalling systems for the respective application case. For example, for use in LCPS with autonomous, vehicle-activated switching on and off, evaluation units with a special application software are offered with which the entire switching functions for a track of an LCPS are mapped. The switch-on signal for a track is output when a train enters the approach zone. The switch-on signal for the corresponding track is withdrawn with the sequence of entering and clearing the approach zone and road crossing area (island zone, IZ, see Figure 5). In the case of multiple-track level crossings, the switch-on signals generated for each track are linked with a logical OR and their withdrawal by means of a logical AND. This ensures that a switch-on signal of the LCPS can be issued and maintained for each track and from any direction until the withdrawal has been issued in all tracks of the level crossing. Due to the detection of the train's direction of travel, no switch-on signal will be triggered if the approach zone of the opposite direction is occupied.

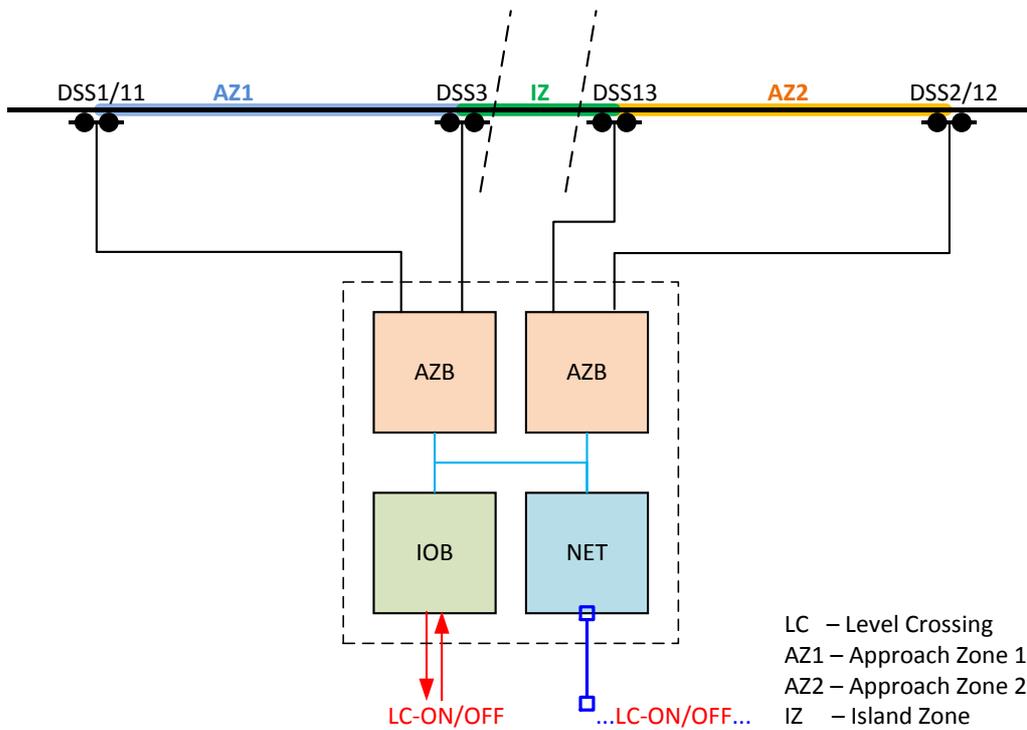


Figure 5: Axle counting system for the control of a level crossing protection system (example)

The use of axle counting systems for controlling LCPS is particularly advantageous due to the linear effect of the axle counter circuits. Trains that come to a halt at the strike-in point do not trigger other switching procedures when they move off, as it would be the case with punctual track switching facilities (e.g. treadles). Similarly, as a result of the occupancy of the island zone over the road area, the switch-on is maintained in the respective track, thereby preventing the LCPS from being switched off if a train is standing on the level crossing. Due to the linear effect of the axle counter section, it is also possible to maintain the switch-on status when a second train follows the first into the approach zone, as can be the case for trams, for example, which travel one behind the other in a row on line of sight.

4 Setting up and operation of axle counting systems

4.1 Installation of the DSS wheel sensors

The new type DSS250 and DSS500 wheel sensors are attached as standard – like the preceding models – with a secure screw connection to the rail web, which is provided with two drill holes for this purpose. As an option, the attachment can be provided using a clamp on the rail foot, e.g. in the case of temporary installations or if no drill hole in the rail is desired by the operator for other reasons.

Calibration of the new wheel sensor types is carried out electronically, by means of without the mechanical adjustments to the sensor that have been standard until now. After a test gauge has been placed on the sensor for the switching distance, the calibration is performed by the press of a button on the connected test device. The type R58/135 test device, which has also been newly developed, logs every sensor calibration with calibration values, the sensor's serial number and time stamp. For the further development of the device, the recording of the geographic position of the sensor is also planned, which will automatically be recorded and logged during the calibration process. The logged data can be transferred via a Bluetooth interface to a smartphone or other portable device, where it is displayed in a corresponding app, saved and further processed if necessary.

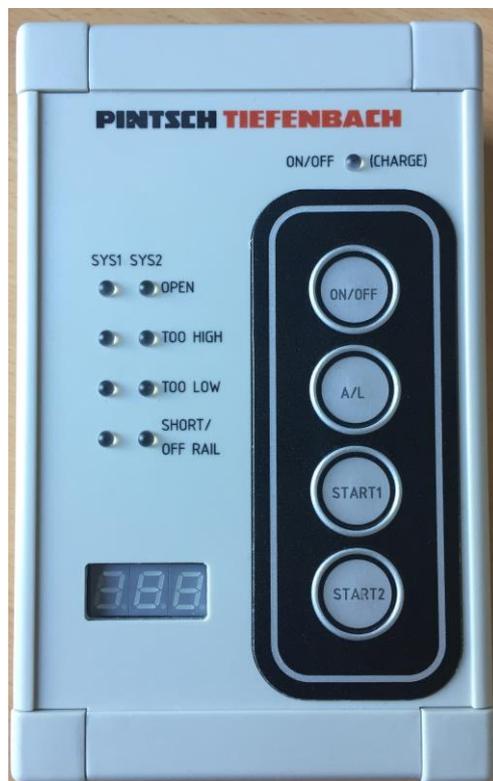


Figure 6: DSS-Test device R58/135

With these new technical possibilities, processes associated with the installation and maintenance of the wheel sensors can be automated and simplified, which will have a positive effect on the life-cycle costs.

4.2 Configuration of the evaluation unit

The counting spots in the evaluation logic of the AZB modules are permanently allocated to the wheel sensors connected via the cabling. Within the indoor system, the wiring is provided by means of pre-assembled system cables up to the cable termination frame in the distribution station, or in the case of decentralised systems up to the cable outlet strip in the external switching cabinet.

The assignment of the counting spots to the counting sections and their assignment to the interfaces is configured using a software tool. This configuration tool also creates the necessary project planning documentation in table form for the documentation of the planned system.

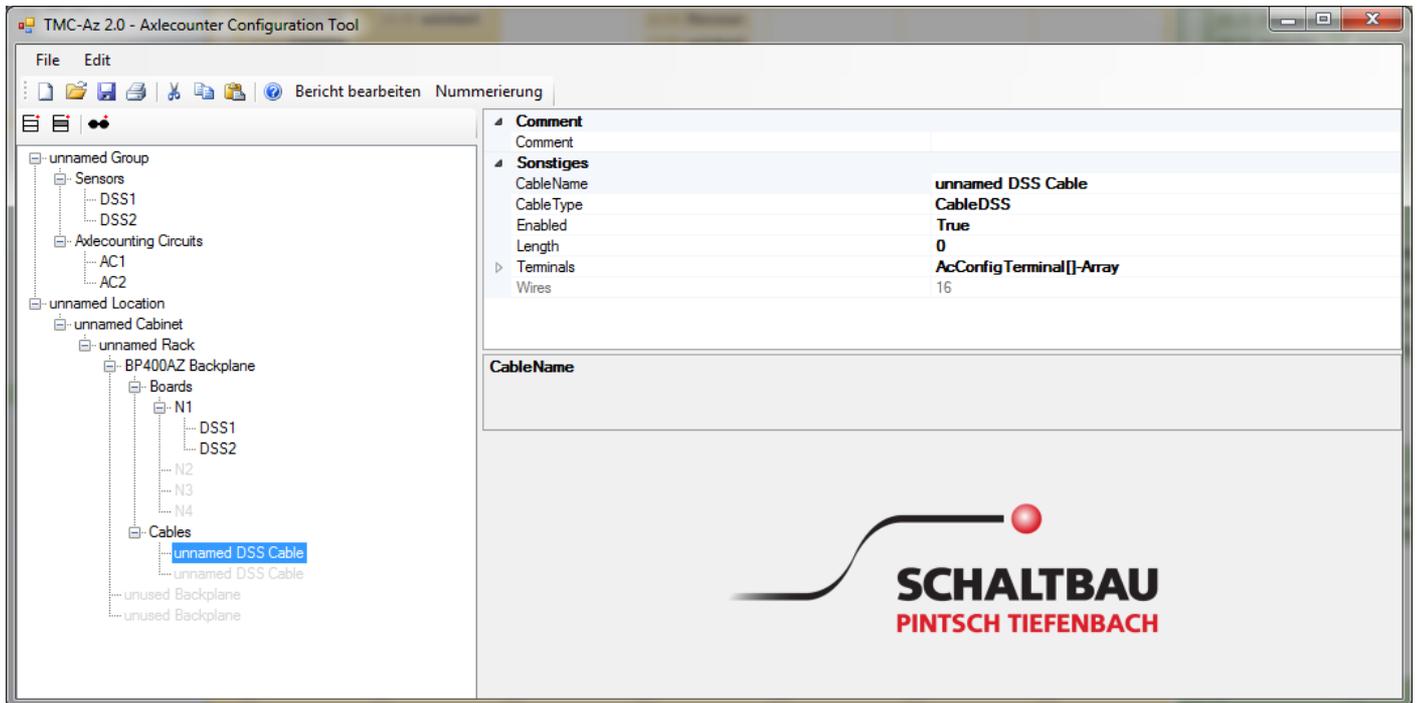


Figure 7: Software configuration tool

After the creation and check of the system configuration, this is uploaded in the form of a file via the USB interface to the NET module of the axle counting system provided for this purpose. This can also be carried out locally with the help of a flash drive.

4.3 Diagnosis and Maintenance

On the front panels of the modules there are light-emitting diodes (LED) which indicate all of the important system states and enable "diagnosis at first sight" in the event of a malfunction.

As a result of the storage of the configuration data on the NET module, all other modules (AZB, IOB) automatically download the data they require when the system is rebooted and can therefore be simply exchanged, which makes the handling of spare parts and troubleshooting in the event of a malfunction considerably easier.

All events which occur in the system and which are relevant for operation and advanced diagnostics are logged in an event memory with a corresponding time stamp. These are events such as a train passing over wheel sensors, the occupancy and clearance of sections, the reset of sections or a system start.

Fault states identified independently by the system, such as failures that have triggered a safety response, are stored as failure messages ("alarms") and tagged separately.



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