Multiple applications with a single subrack of multi-section axle counter BO23

Hrovje Horvat

Parallel usage of old relay interlocking systems in many locations together with microprocessor-based interlocking systems in modernised stations of the same railway operator places high requirements on new track section occupancy control devices. As microprocessor-based signalling systems with much smaller equipment dimensions replace the respective relay systems, the new track section occupancy control device should also be able to replace as many old section occupancy control devices as possible with less equipment and less power dissipation, without reduction of safety and reliability.
During line modernisation, many railway operators decide to use axle counters instead of track circuits for track section occupancy control, both in stations and on open lines, in view of their many advantages such as immunity to track resistance variations, greater section length, lower power dissipation per section, elimination of track insulation joints and track inductors as well as related traction power loss, etc. Since almost every railway operator in the European Union today uses a lot of different signalling systems with different dates of manufacture, the new axle counter should easily fit into both the relay and microprocessor-based interlocking or automatic block system, and should be able to replace both track circuits and old axle counters, if needed. It should also be able to control the occupancy of the long section between stations either via copper cables or fibre optics. The new axle counter should also accommodate various ways of resetting the section manually to the basic state.
The BO23 multi-section axle counter was developed to satisfy all the above-mentioned requirements and to provide a safe detection and counting of axles and section occupancy control with minimal maintenance costs and minimal equipment dimensions for a number of track sections.

Hrvoje Horvat, B. Sc. E. E.
Leading Engineer for Railway Signalling
Address: ALTPRO d.o.o., Drvinje 63, 10000 Zagreb, Croatia
E-Mail: hrvoje.horvat@altpro.hr

1 Introduction

Axle counters were first utilised as section occupancy control devices in relay automatic block systems on main lines in southeastern Europe back in 1970. Croatia was among the first to start using axle counters for vital track occupancy control. Now large numbers of axle counters on Croatian Railways have been in continuous operation for more than 30 years and have reached the end of their life cycle. As a replacement for these single-section axle counters, the Altpro company developed the BO1 single-section axle counter. BO1 axle counters are successfully installed both instead of old axle counters and in new signalling systems on modernised lines all over Croatia and neighbouring countries, as well as in other markets.
The wheel detection unit of the BO1 axle counter is the ZK24 double wheel sensor. Since the ZK24 proved itself in operation as a reliable wheel detection unit on lines with various traction voltages (25 kV AC, 3 kV DC, 1 kV DC) and various environmental conditions, the only part of the BO1 axle counter that needs to be improved to satisfy the demanding requirements of modern signalling systems is the indoor equipment. Accordingly, *Altpro* developed the new BO23 indoor axle counter unit in the same 19"×3U subrack that is capable of controlling up to 8 counting points + 1 remote counting point, configured to output the occupancy information of 1 to 6 sections.

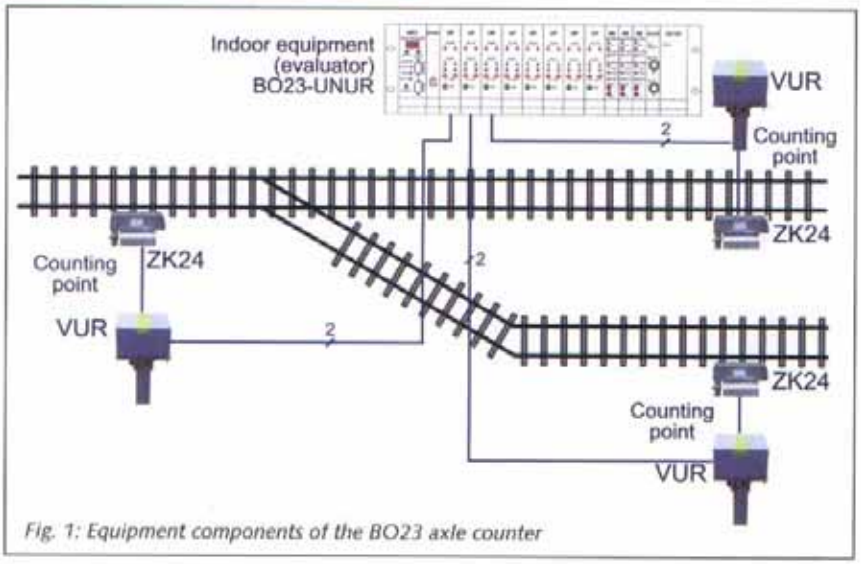

Fig. 1: Equipment components of the BO23 axle counter

2 System description

The BO23 axle counter consists of the outdoor and indoor part of the equipment. The outdoor equipment on each counting point consists of the ZK24 railwheel sensor mounted on the inner side of one rail and the VUR trackside electronic unit in the connection box beside the track (*figure 1*). As the ZK24 wheel sensor has a double sensing head structure (in a single casing), the VUR trackside electronic unit on the counting point is used only for the purpose of multiplexing the signals from both heads of the ZK24 and sending the AC signal to the indoor equipment via only one 2-wire twisted pair. The DC power supply for the counting point is also applied on the same twisted pair.
The BO23-UNUR axle counter evaluation unit (indoor equipment) is located in the relay room of the station or in the trackside block equipment housing. Since it is made up of a standard 19"×3U subrack unit, it can be easily fixed into relay room racks, 19" or wider. As shown in *figure 1*, the BO23-UNUR indoor equipment is connected with each counting point via one 2-wire twisted pair and provides potential-free safety relay contact outputs for track clearance/track occupancy of each section to the interlocking system.

Fig. 2: ZK24 railwheel sensor

Fig. 3: Electromagnetic brake influence test in Hungary

Fig. 4: UTR245 relay interface module for connection of ZK24 sensor to level crossing system

2.1 ZK24 wheel sensor

The basic system component for reliable and stable functioning of the BO23 axle counter is the ZK24 railwheel sensor (*figure 2*), developed at Altpro for their first type of axle counter (BO1). It is an electronic inductive type of wheel sensor with two sensing systems in the same case (different frequency on each system). It detects the wheel flange presence above each system. Each sensing system works independently and has its own electronic analogue/pulse signal conditioning and filtering, adjusted optimally to reduce electromagnetic (EMC) noise and to pass the wheel pulses to the output. Each sensing system output signal is two-state (binary) DC current 8 mA/2 mA. The sensing system will give 8 mA output only in the case of no wheel flange above the system with the sensor mounted in the correct position to the rail. In the case of wheel flange presence or drop-away from the rail, the sensing system will output 2 mA. The complete sensor electronic circuit is sealed with a special insulation compound and complies with protection class IP68. It has been tested for the temperature range -40 to +80° C and for vibrations of 28 g RMS (5 to 2000 Hz) and shocks of 200 g, according to EN 50125 3.

The ZK24 is mounted on the inner side of rail using the mounting clamp fixed to the rail foot (see *figure 2*). There is no need for rail drilling and the same mounting clamp can be used on rail types from S45 through S49 and UIC54 to UIC60 (including all types between the mentioned profiles).

The big advantage of the ZK24 is its very simple and quick installation and maintenance. Installation requires no electrical adjustment (no potentiometers or similar adjustment), either on the ZK24, or on the VUR trackside electronic unit; only mechanical position adjustment using the plastic template is required. Maintenance is reduced to only a six-monthly position check using the plastic template (without occupying the section) and simple voltage measurement with a standard voltmeter on the VUR trackside electronic unit.

The ZK24 wheel sensor was tested for electromagnetic compatibility (EMC) according to EN 50121-4 (in conformity with Council Directive 89/336/EEC) in the TÜV Rheinland Group laboratory in Köln, and many on-site EMC tests were carried out in Croatia, Slovenia, Hungary and Sweden with modern electric trains. For example, in Hungary the influence of the electromagnetic brakes of a Siemens Desiro train was tested using one train without passengers solely for ZK24 testing purposes (*figure 3*). The ZK24 sensor was found to be immune not only to EMC noise coming from electromagnetic brakes, but also to EMC noise from thyristor traction converters both on AC and DC traction, and 1-to-3 phases traction converters.

The wheel sensor ZK24 is also used as a replacement for old mechanical and magnetic switch on/off points for level crossings. On relay level crossing systems sensor ZK24 is connected via the relay interface module UTR245 (*figure 4*).

2.2 BO23-UNUR indoor equipment (evaluator)

The BO23-UNUR indoor equipment of the BO23 axle counter receives signals from counting points, counts the axles, and outputs the track clear / track occupied information for each section. It provides control of up to 8 counting points (8 UP receiving modules) and is able to give the safety relay output (track clear/occupied) for 1 to 6 sections (3 RE double-channel relay output modules).

The MPU processing unit (on the first left slot of the subrack) comprises 3 vital microcontrollers configured as a 2-out-of-3 voting system and 4th microcontroller for diagnostic and data logging purposes. The MPU module has indicator LEDs for basic section status indication and one display that continuously shows the current number of axles on the section chosen by the push-button. The basic functioning of the system can be quickly checked during maintenance by observing those indicator elements, even without a laptop. However, a serial RS232 diagnostic port is provided for laptop connection to read out diagnostic data for the last 800 train passages on each section.

Since the MPU processing module is able to simultaneously control 8 counting points with various configurations of track sections (9 configurations total), appropriate operating software for the MPU module has to be selected. This is done during the first installation without any programming, by presetting the DIP-switches on the main-board on the rear side of subrack. The DIP-switches are then covered and sealed, and further replacement of the MPU module (e.g. in the case of failure) requires neither resetting of the DIP-switches, nor any programming.

The relay output of each section is made by the serial connection of potential-free contacts of the TRACK CLEAR safety relay, and TRACK OCCUPIED safety relay. The auxiliary contact of each relay is connected to the digital input of the MPU processing module to control the state of the relay and to improve safety of the system. There are two galvanically insulated digital inputs for reset of each section (for clearing the section in case of miscount or disturbance). One of two reset modes can be chosen by jumpers on the main-board (rear side) during the first installation: immediate reset mode and postponed reset mode – clearing the section after regular passage of the next train (sweep train).

Power supply for the BO23 indoor equipment can be applied in a very wide range: from 18 V to 80 V DC without any change of modules. Power supply for each counting point is already galvanically separated and stabilised to 96 V DC in the BO23-UNUR indoor equipment. Each counting point input is already protected from overvoltage on the indoor equipment by an easily replaceable ZAG2Z small lightning protection module on the rear side of the subrack.

3 Application

Given its high level of safety, the BO23 axle counter is used for vital track section occupancy control on both station sections and open line block sections with train speeds from 0 to 350 km/h, connected to either relay or microprocessor interlocking systems. As mentioned in section 2.2, one single BO23-UNUR subrack evaluator can control various configurations of track sections. *Figure 5* shows four different configuration examples for the control of independent sections: one section with up to 8 counting points (configuration 8A), 2 sections with 4 counting points each (4A-4B), 3 sections with 3/3/2 counting points

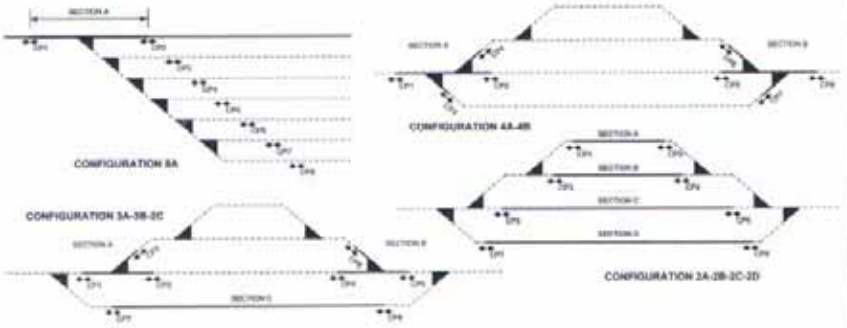

Fig. 5: Configurations for independent sections occupancy control with single BO23-UN-UR indoor unit

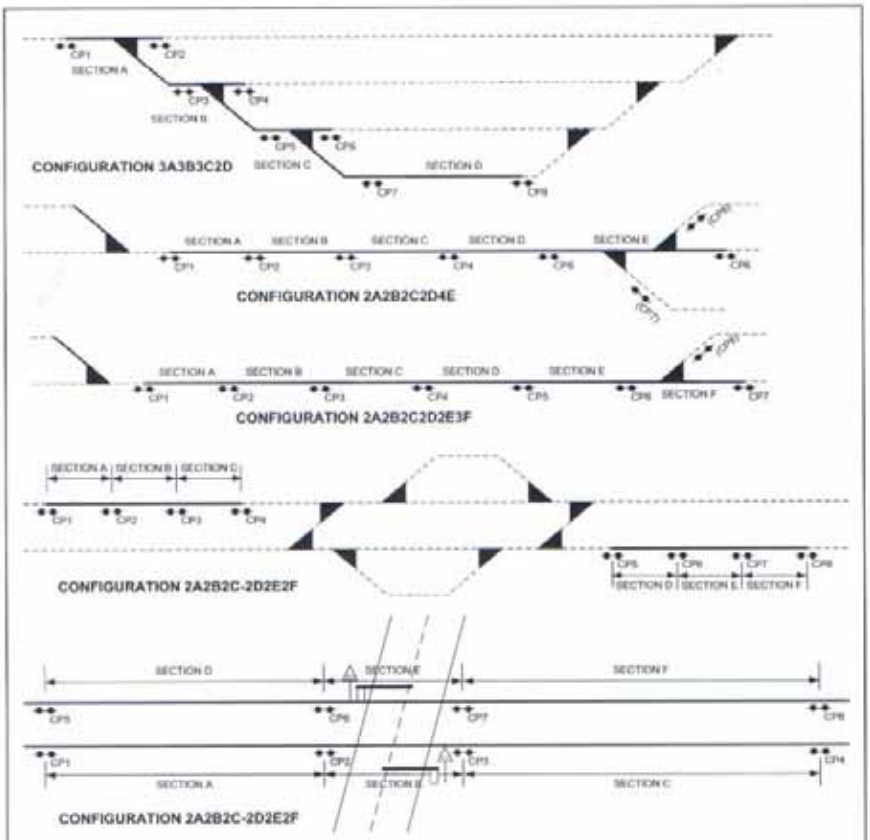

Fig. 6: Configurations for neighbouring sections occupancy control with single BO23-UN-UR indoor unit

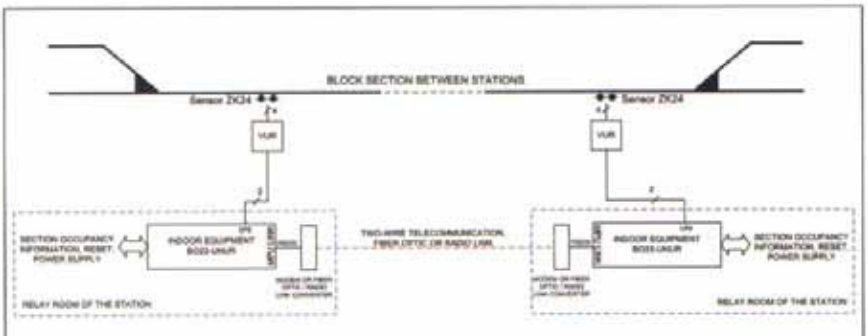

Fig. 7: Occupancy control of the block section between stations using serial communication between two BO23-UNUR indoor units

(3A-3B-2C) and 4 sections with 2 counting points each (2A-2B-2C-2D) (*figure 5*).

In the case of neighbouring sections occupancy control (sections with a common counting point), the BO23 provides configurations that use the same digital input to the processing module for a common counting point, so that the subrack space is used to the full (*figure 6*). For example, there is a possibility to control 3 neighbouring switch points and one station track (configuration 3A3B3C2D), 5 automatic block sections (the last section can even be the station entrance switch point section with 4 counting points, configuration 2A2B2C2D4E), or 6 automatic block sections (2A2B2C2D2E3F) – all with one 19"×3U subrack of the indoor equipment. There are also two examples in figure 6 (*figure 6*) for controlling 2 sets of 3 automatic block sections (configuration 2A2B2C-2D2E2F). The other example of the same configuration is train detection for double track level crossing. The train is detected on 3 sections per track: incoming section from one side (section A/D), level crossing area section (section B/E) and incoming section from the other side (section C/F); all 6 sections are controlled by only one subrack of the BO23 indoor equipment that can be easily mounted in the level crossing housing or cabinet. The BO23-UNUR indoor equipment has been tested for the temperature range -30 to +70° C, so it can be mounted even in a non-climate-controlled metal level crossing cabinet.

When secondary lines are modernised in Europe, often only one block section occupancy control (dependency between two stations) is required instead of several automatic block sections (as a cheaper solution). Such a section can sometimes be several tens of kilometres long. Although the distance between the outdoor and indoor equipment of the BO23 axle counter can be up to 30 km (with wire diameter 1.4 mm), there is a configuration (*figure 7*) that provides fail-safe communication about an additional remote counting point, controlled by another BO23-UNUR evaluator in the other station. Each evaluator controls only one (the closer) counting point, and the information about the other counting point comes via a RS232 serial connection from another BO23-UNUR indoor equipment.

Instead of modems and 2-wire connection, fibre optics or radio communication can be used, depending on the telecommunication infrastructure of the railway. Maximum section length is then limited only by the technical parameters of the transmission system. Fail-safe communication called MPU LINK between two MPU processing modules complies with EN 50159-1. Many modern microprocessor-based interlocking systems require "track clear/track occupied" information in both stations. In this case the indoor equipment in each station controls the same section and "track clear/track occupied" information is provided in both stations.

4 Summary

The axle counter outdoor equipment (ZK24 wheel sensor and VUR trackside unit) is already in operation on vital railway signalling infrastructure in southeastern Europe as part of the BO1 single-section axle counter. Now the same ZK24 wheel sensor is used in the BO23 multi-section axle counting system with a much wider set of track occupancy control options and with a processing unit with a 2-out-of-3 voting system that provides greater availability and safety. Using potential-free safety relay contact outputs, various options for resetting the section to clear state, extremely wide power supply range and fail-safe serial communication for remote counting point, the BO23 multi-section axle counter is able to fit into any electronic or relay interlocking system.

Bibliography

[1] Altpro, Zagreb 2005: Axle Counter BO23 Operating Instructions.

ZUSAMMENFASSUNG

Mehrfache Anwendungen mit einer einzelnen Einheit des Mehrschnittsachszählers BO23

Die gleichzeitige Verwendung älterer Relais-Signal-Sicherheitseinrichtungen (SS) in vielen Bereichen sowie mikroprozessorgesteuerter SS-Einrichtungen in modernisierten Betriebsstellen des gleichen Bahnbetreibers hat hohe Anforderungen an die neuen Gleisfreimeldeanlagen gestellt. Da heute sowie in Zukunft bestehende Relaiseinrichtungen durch viel kleinere mikroprozessorgesteuerte signalisierende Systeme ersetzt werden, müssen die neuen Gleisfreimeldeanlagen kleinste Dimensionen und geringsten Stromverbrauch, ohne Beeinträchtigung der Sicherheit und der Verfügbarkeit, haben. Während der Streckenmodernisierung entscheiden sich viele Bahnbetreibern für Achszähler anstelle von Gleisstromkreisen für die Gleisfreimeldung sowohl der Bahnhofsabschnitte als auch der Abschnitte der freien Strecke aufgrund ihrer Vorteile, wie keine Auswirkung auf die Funktionstauglichkeit bei Veränderung des Bettungswiderstands, größere max. Länge des Abschnittes, keine Isolierstöße, usw. Da heutzutage fast jeder Bahnbetreiber in der EU verschiedene SS – Einrichtungen aller Altersklassen benutzt, sollte sich der neue Achszähler leicht in Relais-Signal-Sicherheitseinrichtungen, in mikroprozessorgesteuerte SS – Einrichtungen oder Selbstblock (SB) einfügen lassen können, sodass es mit dem neuen Achszähler möglich sein sollte die Gleisstromkreise und bei Bedarf auch ältere Achszähler auszutauschen.
Der Mehrabschnittsachszähler BO23 wurde entwickelt, um alle diese heute von Bahnbetreibern angesprochenen Forderungen zu erfüllen und zwar mit räumlich kleinsten Abmessungen und minimalen Instandhaltungskosten.