Various applications of wheel detection systems with inductive wheel sensors

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Modern wheel detection systems are mostly used for track vacancy detection. However, there are many different ways in which wheel detection systems can nowadays be used. Further to their detection function, they can help make use of additional information such as direction of traffic, train speed, wheel diameter, wheel centre pulse or number of axles, as well as modern interfaces, opening up further new fields of application.
The following chapters give an overview of their typical fields of application, followed by details of the evaluation capabilities of modern inductive wheel sensors.

1 Applications

1.1 Track vacancy detection

Axle counting systems are predominantly used for highly available and safe wheel detection systems in clear track signalling applications. In many countries all over the world, track circuit technology is increasingly superseded or replaced by axle counting systems [1].

Modern axle counting technology has in the meantime become an integrated part of higher-level interlocking and signalling systems. Today it is also able to provide a wide range of information to higher-level systems beyond simple track vacancy detection, e.g. direction of traffic, train speed or axle counter status (Fig. 1).

1.2 Securing of level crossings

Train detection systems are the main components of a level crossing protection system. The information from outdoor equipment is used in the control logic of the level crossing protection system to initiate the warning and operational sequences. In automatic level crossing control systems, the warning and closure/opening sequences are interrelated to the signalling system and are triggered by train movements. Nowadays the focus is on wheel detection, which is often combined with axle counting technology for synergistic effects (Fig. 2).

There is an unlimited range of available configuration options for wheel detection and axle counting systems. System configurations can, for instance, be based on detection points only, but also on track sections, overlapping track sections, combinations of detection points and track sections or the implementation of speed-dependent switching.

Additional information such as direction of traffic and train speed are also vital parameters for this application, used to meet various different customer-specific requirements. [2]

1.3 Speed-check facilities

Speed measurement systems monitor train speeds, particularly at the beginning of turnout areas, construction sites, tunnels or bridges, in order to improve safety and prevent derailments. If the set maximum speed limit is exceeded, a track magnet triggers the locomotive or traction unit's emergency brake.

Wheel detection systems must be capable of very precisely calculating speeds and of using the test equipment via a CAN interface when necessary. [3]

1.4 Cancellation of fault signals

In local public transport, train frequency is an important criterion. Malfunctioning track sections have a negative impact on train frequency. Before the station master can reset a track section, he/she must ensure that this track section is definitely clear.

'Fault signals' can be used here to make the reset process shorter and to save valuable time.

The station master sends this fault signal if a track section is malfunctioning. This gives the following train permission to drive through this section at sight. When the train passes, this fault

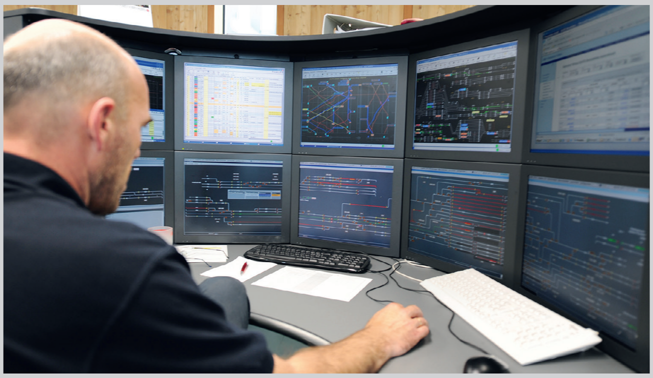


Figure 1: Control centre – track vacancy detection is the most important application for wheel detection

Figure 2: Trend towards wheel detection and axle counting to control level crossing protection systems

Figure 3: Hot box detection systems require reliable trigger pulses

Figure 4: Automatic warning systems are controlled by wheel detection systems

signal is sent back by the wheel detection system. Passing at sight means that the section is checked. If the section is then clear, the normal train timetable can be resumed.

1.5 Passenger information systems

Safety is the top priority for railway operations. This also affects passengers on the platform. Passenger information systems warn travellers that trains are about to pass. It is vital that the announcement is made immediately before the train passes. Otherwise, people waiting on the platform may forget the warning and recently arrived travellers will not have heard the announcement. Announcements can be automatically triggered in the right moment with the help of wheel detection systems, which can send additional train speed information [3].

1.6 Hot box and wheel flat detection systems

Early and precise localisation of hot boxes and flat spots is very important, both in terms of safety and preventative cost-efficient repair. Particularly in the case of high-performance tracks, reliable trigger pulses are required in high-speed areas, sometimes under extreme environmental conditions.

High-quality wheel detection systems are used to control the measuring process when a train passes. They are used to activate the system, generate a gate signal to evaluate the resulting measurement data and then deactivate to standby mode (Fig. 3).

Wheel detection systems supply their information in real time, thus enabling precise measurement and assignment to a specific axle.

1.7 Automatic warning systems

An automatic warning system (AWS) is a technical protection scheme warning crews that are working on the track that a train is approaching (Fig. 4).

When a train is nearing a construction site, the warning can be activated by wheel detection systems. The personnel on the worksite are warned by optical and acoustic signals so that they have enough time to leave the danger area. The train can then pass the worksite. The ongoing warning can then be switched off via another wheel detection point. The communication between wheel detection points and the central warning system may be established via either radio or cable.

Figure 5: Reliable train detection, thanks to high-quality wheel detection systems

1.8 Train detection

Automated marshalling and clearing systems are only effective if the vehicles are recorded and assigned in an highly reliable way. The wagon number is its unique identifier and the common basis for communication between rail transport companies, infrastructure operators and the relevant state authorities.

The detection of individual vehicles may, for example, be carried out via RFID tags or with highly developed camera systems, the latter being used particularly for freight wagons travelling across borders. Here too, wheel detection systems are frequently used to activate and trigger these optical devices. Speed and direction information help to improve the reliability and accuracy of vehicle detection (Fig. 5).

1.9 Track lubrication

Track lubrication systems reduce wheels and rail wear. Lubrication, particularly on narrow curve radii, reduces friction and therefore energy consumption as well as noise.

Wheel detection systems recognise that a vehicle is approaching and trigger lubrication. The lubrication amount and frequency can be optimised using the additional axle counting information.

1.10 Marshalling systems and yards

Rail freight transport essentially consists of block trains and single wagons.

While block trains cover the entire route between the departure and the destination station, single wagons or groups of wagons are combined to trains before they can travel to their destinations. This requires marshalling systems, better known as marshalling yards.

Train braking systems are of critical importance in gravity marshalling yards. They must ensure that wagons, whatever their load, are braked to a speed below the maximum before they come into contact with the previous wagon. It is important, however, to avoid excessive braking to ensure that the wagons will reach the desired position.

If wheel sensors and axle counting systems are used to control turnouts, they may also be used to supply speed information. This information can be used for a further optimisation of the track braking function. Expensive and complex additional devices are no longer required (Fig. 6).

Figure 6: Wheel detection integrated into marshalling systems for various uses

1.11 Further switching applications

Wheel detection systems are also often used for switching and triggering tasks such as weigh-bridges, rolling stock washing systems, clearance gauge measurements/checkpoints, gates, tunnel lighting and much more. The options are limitless.

2 Evaluation options with modern wheel detection systems

State-of-the-art wheel detection systems are clearly characterised by inductive wheel sensors – particularly the 'double sensors'. All Frauscher wheel sensors are built in accordance with this principle and therefore have two inductive sensor systems. This redundant design is required for SIL4 applications and also allows to receive additional information such as direction of traffic and train speed.

2.1 Operating principle

Both Frauscher wheel sensor systems are arranged alongside one another along the track. The two wheel sensor signal values are available as load-independent current values. These can be evaluated/analysed over the entire length of the cable by an intelligent evaluation board in the indoor equipment using different algorithms [1, 4].

In this case, the sensor status information related to its safe operation can also be transmitted along with the actual operational wheel sensor signals, i.e. failure detection, correct assembly, defective damping, drift values and interference in the sensor system. This principle is a viable alternative to installing sensitive and expensive electronics on the track. It not only reduces investment in the installations but also their long-term life-cycle-costs (LCC).

2.2 Axle passage

Figure 7 shows the analogue and digital signal process for a typical Frauscher wheel sensor with two independent sensor systems (Sys1 and Sys2) when an axle/wheel passes. The overall potential signal range can be divided into the following zones:

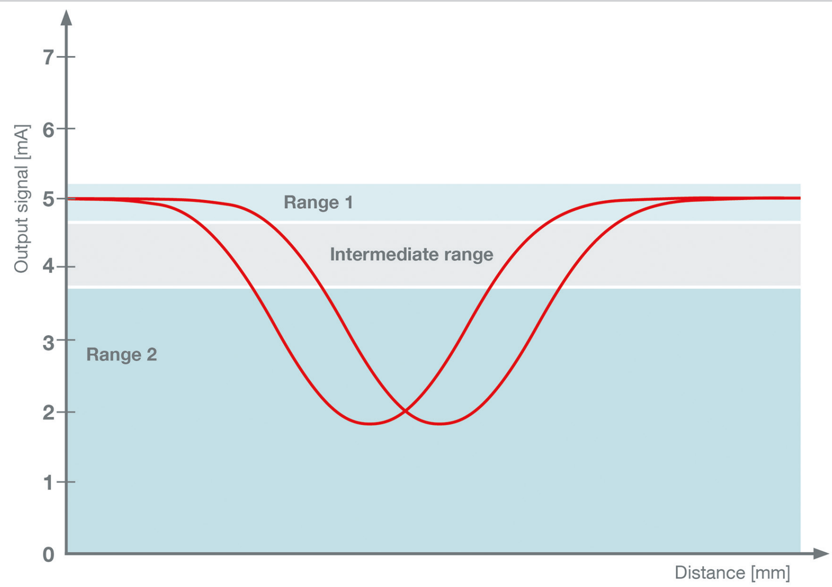
Zone 1: Sensor correctly on rail, no wheel influence

Zone 2: Sensor occupied by a wheel

The analogue signal aspect is proportional to the damping effect of the wheel and is transmitted to the evaluation board as a direct current signal. The task of the relevant evaluation board is to evaluate this signal and to make the appropriate digital switching patterns available at the interface, in accordance with the customer application.

2.3 Direction of traffic

Alongside actual axle detection, these systems are capable of sending additional information, e.g. direction of traffic. Here, different variants of the direction pulses can be used: direction pulse at the start of passage (1-edge direction pulse) or at the end of passage (4-edge direction pulse).



Zone 1: Sensor correctly on rail, no wheel influence
Zone 2: Sensor occupied by a wheel

Figure 7: Analogue and digital signal when passing

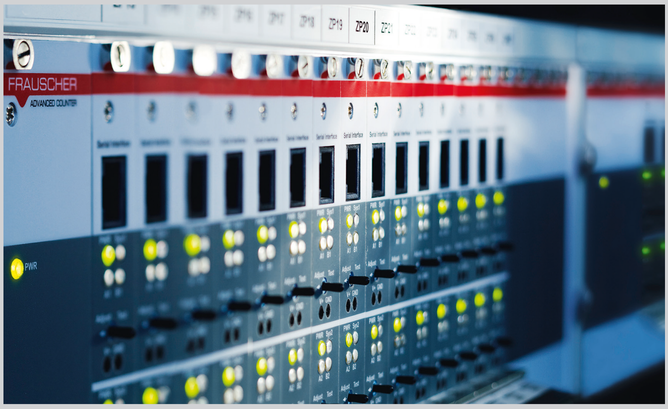


Figure 8: Evaluation board with a secure Ethernet-based software interface

2.4 Train speed

As already mentioned, Frauscher's wheel sensors are 'double' sensors and have the advantage of using just one sensor to deliver speed information as an extra function further to their other tasks.

A measuring grid is placed above the sensor curves and the time difference between the two systems is measured. The individual measurement values for each axle are then evaluated by means of a specially developed algorithm. The evaluation board VEB makes the speed information available in a simple and cost-efficient way, using a CAN interface with additional status and diagnostics information.

Although the speed is determined by a single sensor only and thus the two measurement points are just a few centimetres apart, the measuring system VEB guarantees accuracy of ±3 % up to speeds of 160 km/h [3].

2.5 Wheel diameter

The analysis and evaluation of the analogue wheel sensor signal can be used as a basis for recording and calculating wheel diameters. Evaluation of the wheel sensor damping level and accompanying consideration of time components and spacing for the two wheel sensor systems allow to make use of this function.

2.6 Wheel centre pulse

When analysing and evaluating the analogue wheel sensor signals for both sensor systems in a general context, a corresponding algorithm in the evaluation board can generate a wheel centre pulse. This is then sent when an axle or wheel is located precisely between the two wheel sensor systems, i.e. directly in the centre of the wheel sensor. This allows an extremely high precision in the reproduction of the length/spacing assignments. The wheel centre pulse is generated and sent irrespectively of the direction of travel.

2.7 Number of axles

Alongside clear track reporting which can compare the number of axles counted in and out of a track section, simply knowing the number of axles can be useful for a wide range of applications. Evaluation boards allow to record the number of axles that have passed in a buffer and then send their information when requested or timed to the linked systems.

2.8 Interfaces

One fundamental question for all these application fields is how the evaluation data are sent to the higher-level system and/or how interfaces are integrated. Here, the flexible Frauscher systems offer every possible communication technology option – from optocouplers and relays to secure Ethernet-based software interfaces. Standardised output characteristics in accordance with CENELEC are available at all levels (SIL0 to SIL4) (Fig. 8).

3 Summary

The modularity and flexibility offered by the hardware and software components in the Frauscher wheel detection systems provide a wide range of extras in addition to their standard functions. They are based on an almost inexhaustible differentiation in timing, software protocols, signal behaviour, pin assignments, home setting behaviour, etc.

Additional information such as direction of traffic, train speed, wheel diameter, wheel centre pulse or number of axles, as well as modern interfaces, open up a whole new range of areas of application.

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ZUSAMMENFASSUNG

Anwendungsmöglichkeiten von Raddetektionssystemen mit induktiven Radsensoren

Modularität und Flexibilität der Hard- und Softwarekomponenten der Frauscher-Systeme zur Raddetektion bieten neben Standardfunktionen vielfältige weitere Funktionalitäten. Eine beinahe unerschöpfliche Differenzierung in Timing, Software-Protokoll, Signalverhalten, Pinbelegungen, Grundstellungsverhalten etc. bilden hierfür die Basis.
Zusätzliche Informationen wie Überfahrtrichtung, Überfahrtgeschwindigkeit, Raddurchmesser, Radmittenimpuls oder Achsanzahl sowie moderne Schnittstellen eröffnen weitere, neue Anwendungsmöglichkeiten.