Added value through wheel detection with speed output

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Operators from various segments of the railway market, planning companies, and research institutions are showing an increasing interest in wheel detection and axle counting applications combined with speed information (Figure 1). Two key questions lie at the centre of this debate: how can speed data be made available economically and how can the reliability of the information be ensured? Frauscher Sensortechnik GmbH has been considering this issue for a number of years. Operational requirements vary widely and have a significant impact in terms on both technical implementation and assessment and consideration of safety standards. This is why the kinds of technology required should only be pushed forward in the context of joint development projects involving operators, system integrators, and wheel detection specialists. With this article Frauscher aims to illustrate the current state of the art in this area and to highlight potential future technical solutions with a view to prompting further debate.

Figure 1: A trend towards speed-dependent applications is emerging

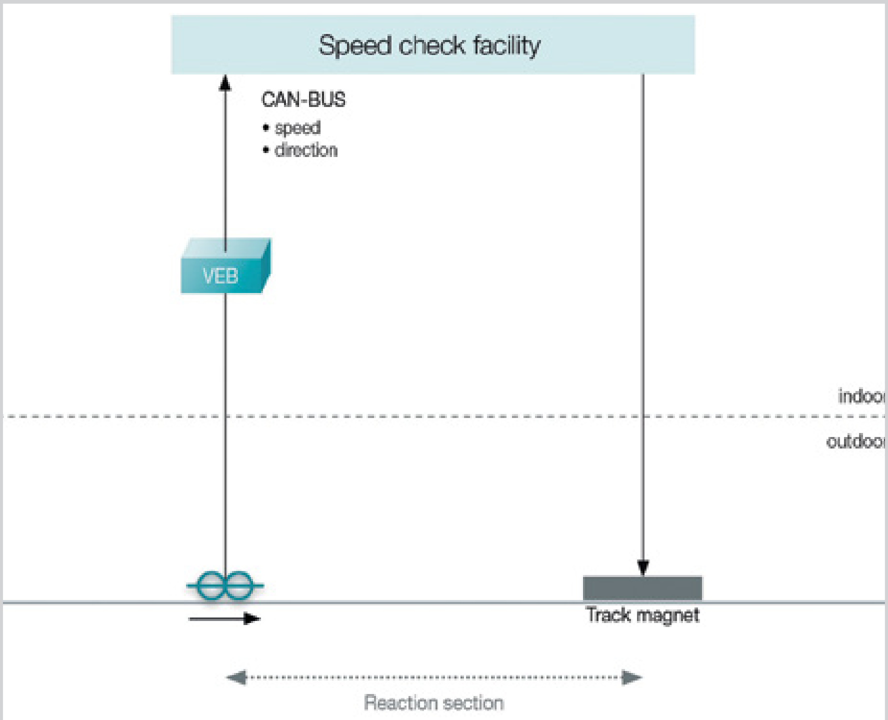

Figure 2: Operating principle for a speed-check device with one speed recording wheel sensor

1 Applications with speed-dependent control

1.1 Speed-check facilities

Speed-check facilities (SCF) monitor, for example, if a vehicle complies with the speed limit. If this limit is exceeded, a track magnet triggers the locomotive or rail car's emergency brake. This system is used to monitor the speed when approaching points, track works, tunnels or bridges in order to prevent a train from derailing, for example.

Frauscher has developed a speed measurement system for this application in collaboration with a railway operator and a manufacturer of SCF facilities. The operator uses speed-check facilities (SCF) which act on trains when a speed limit is exceeded.

The new system from Frauscher determines the speed via a single wheel sensor. The VEB evaluation board provides the SCF facility with the speed information via a CAN interface. The SCF controls an intermittent transmission system (PZB track magnet), in line with other parameters like signals or tolerances within the braking curve, in order to influence the vehicle (Figure 2).

Monitoring of compliance with speed limits within the railway network is now provided by two trackside devices (RSR123, PZB track magnet). This system has been successfully used for a year, delivering improved availability and significantly lower life cycle costs.

1.2 Level crossing protection systems

Many level crossing protection systems use wheel sensors and/or axle counting systems in order to detect trains and thereby control level crossings [1]. Figure 3 shows how a train can be detected using track sections via the FAdC® (Frauscher Advanced Counter) axle counting system (Figure 3).

The striking-in distance will depend on the maximum line speed and the time needed to secure the level crossing. The waiting time for private vehicles should be kept to a minimum. This represents a particular challenge when trains travelling at different speeds approach the level crossing. The graphic (Figure 4) illustrates the correlation between speed and time difference or waiting time at the level crossing.

Assuming the system is designed for a maximum speed of 120 km/h (a passenger train, for example), the striking-in distance for the level crossing protection system may be situated some 2000 m before the level crossing. If there are slower trains as well (a freight train, for example) travelling at a speed of 60 km/h, the private vehicles will have to wait at the level crossing some 60 seconds longer than technically necessary. If the train speed is measured at the striking-in distance, the level crossing activation for slow-moving trains can be delayed without any additional

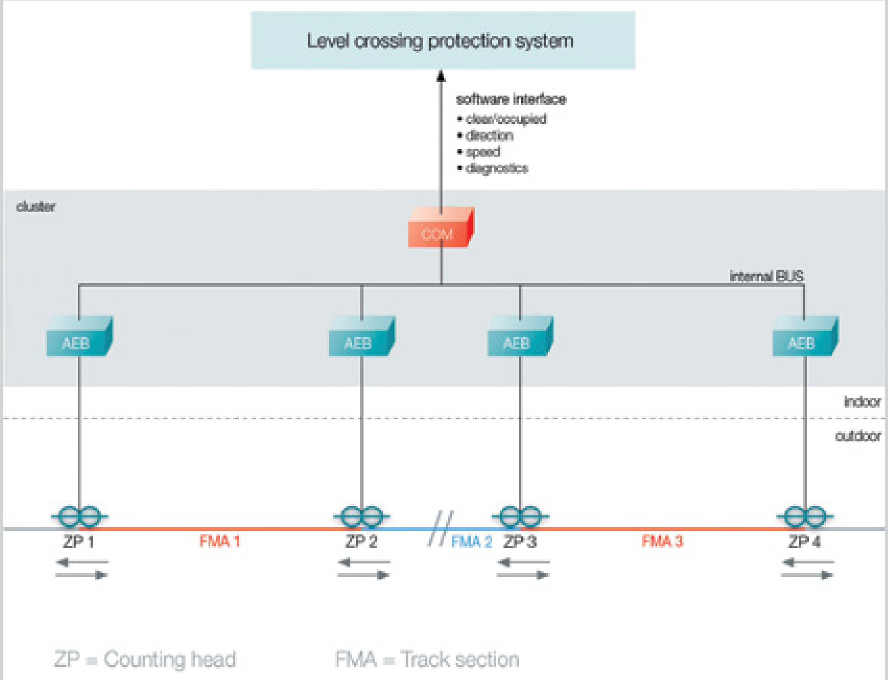

Figure 3: Architecture of the FAdC axle counting system based on a level crossing protection system with track sections

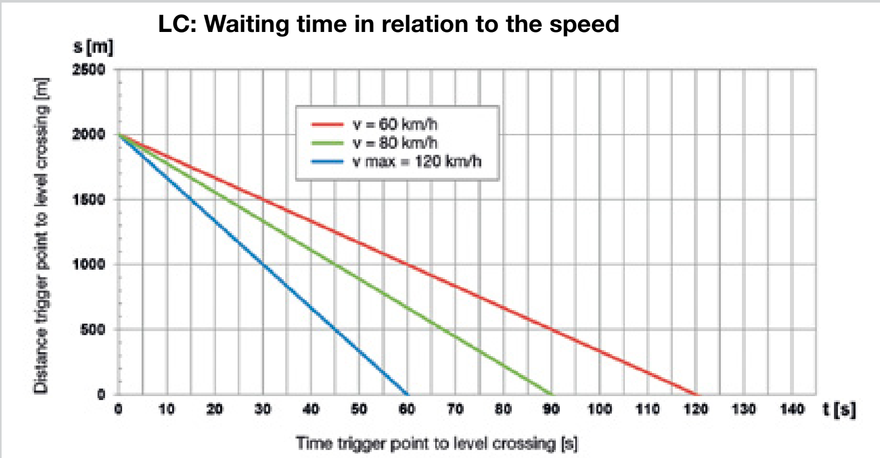

Figure 4: Speed-dependent control of level crossing protection systems reduces waiting times at level crossings

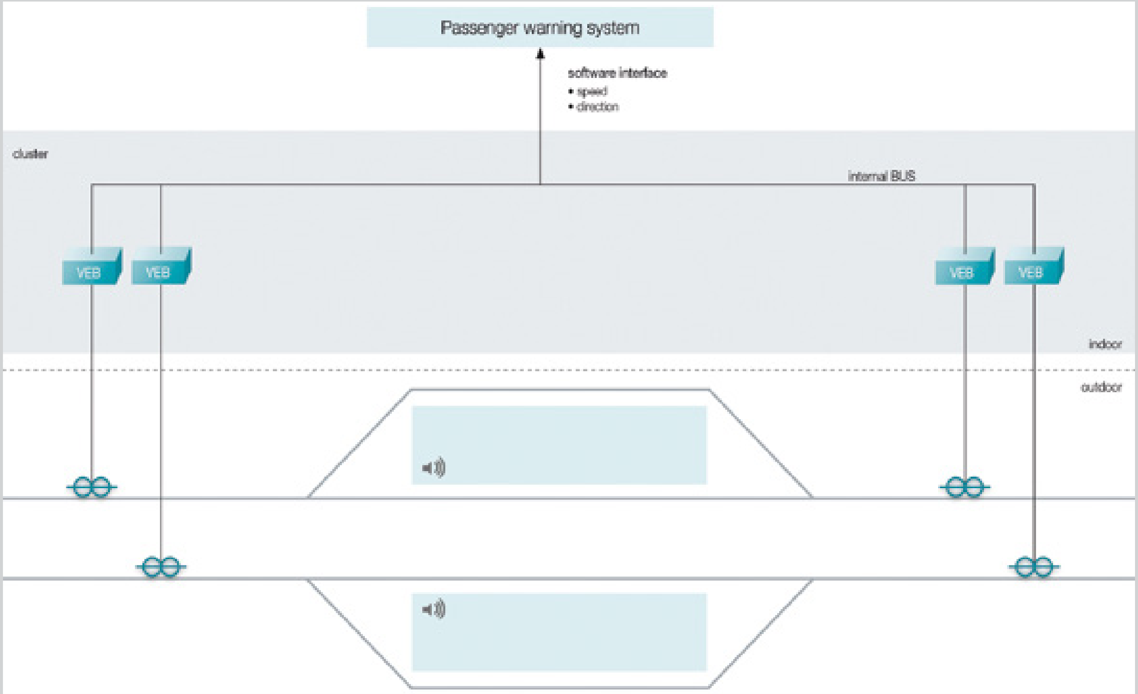

Figure 5: Attention paid to passenger warnings increases thanks to speed-dependent control

components, thereby reducing waiting times.

1.3 Train detection

Automated marshalling and billing systems can only work if the actual position of the vehicles actually is known. For this purpose vehicles are often fitted with RFID tags. It can, however, prove difficult to install RFID tags in 100 % of cases, particularly for freight wagons travelling across borders. In view of this, camera systems are often used to detect vehicle numbers in such cases. Here too axle detection systems (wheel sensors) are frequently used to activate and trigger these optical devices. Speed and direction information can further help to improve the reliability and accuracy of vehicle detection.

1.4 Passenger warning

Passenger safety is one of the most important objectives for railway operators. This also applies to passengers still on the platform. It is especially important to warn passengers about trains runnig non-stop through stations to prevent carelessness. Experience shows that this kind of announcement must be made immediately before the train passes, otherwise the attention of persons on the platform wanes again or new people arrive who are unaware of the announcement. Frauscher's VEB evaluation board can be used to deliver automatic speed-dependent announcements at just the right time (Figure 5).

1.5 Gravity hump yard

Train braking systems are of critical importance at humps. They must ensure that wagons, whatever their load, are braked to a speed below the maximum before they come into contact with the next wagon. It is important, however, to avoid excessive braking or wagons will fail to reach the desired position. If wheel sensors and axle counting systems are used to control points, these components may also be used to provide speed information. Additional expensive and complex devices are no longer required (Figure 6).

Figure 6: Efficient checking of speed via wheel sensors on gravityhump yards

2 The technical solution

A core requirement is the ability to provide speed information economically. To facilitate this, the evaluation and transfer of speed information should be implemented as an additional feature of an existing counting point, and it should also be possible to easily forward information to higher-level systems. The use of multiple counting points for speed determination will no longer be considered in future, as additional costs are high. The speed measurement accuracy provided by "double" sensors (inductive sensors with two systems along the rail) is now so high that most requirements can be met with just a single wheel sensor.

2.1 Speed measurement with one sensor

Frauscher's wheel sensors RSR180 and RSR123 are "double" sensors and have the advantage of using just one sensor to deliver speed information as an extra function in addition to their other tasks. These sensors are mounted on the inside of the rail and detect the influence of the wheel flange via two upward-facing coils. This effect is used to detect the wheel flange and thus the axle [2] (Figure 7).

As mentioned, the wheel sensors consist of two sensor systems with the two coil systems arranged in line along the rail. This ensures, among other things, that the direction of a vehicle can be detected unambiguously. The two signal values of the wheel sensor are available as load-independent analogue current values. These can be evaluated/analysed via a cable by an intelligent evaluation module in an indoor equipment using different algorithms.

Figure 7: Frauscher wheel sensors support speed measurement via a single sensor

A measuring grid is placed over 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 special procedure. The VEB evaluation board provides the speed information in a simple and cost-effective way, using a CAN interface with additional status and diagnostics information.

2.2 Accuracy of speed information

Although the speed is determined by a single sensor only and thus the two measurement points are just a few cen-

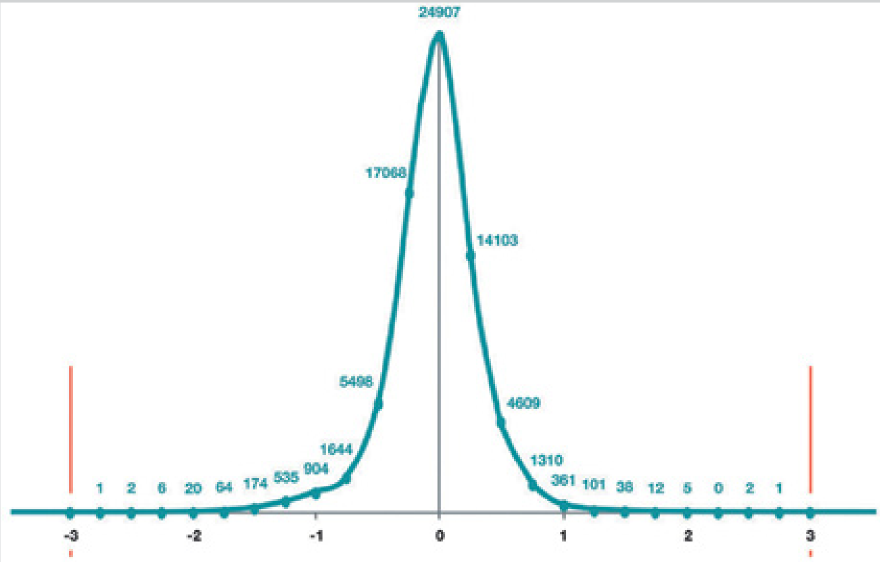

Figure 8: High accuracy: 99 % of the measurement results lie within a tolerance of ± 1 %

timetres apart, the VEB measuring system guarantees an accuracy of ± 3 % up to speeds of 160 km/h. Over 70,000 axles have now been recorded and assessed in field trials. The speed distribution graph illustrates that over 99% of the measurements lie within a tolerance of ± 1 %. (Figure 8)

The distribution of measurement tolerances of individual axles forms a Gauss bell curve, allowing subsequent statistical averaging of numerous values. Accuracy is thus further improved, even at high speeds.

2.3 Safety considerations

It is essential in all cases to consider the safety level requirements associated with the speed information. These will depend on the application and operating regulations. As opposed to binary information – a track section is either "clear" or "occupied", for example – accuracy is a key criterion in terms of speed output.

As already mentioned, accuracy is now at a very high level. However, electro-magnetic and other influences may also distort the measurement result. The signal evaluation associated with the algorithm determines whether the speed information is correct. This information, combined with functional interactions, makes it possible to achieve CENELEC's SIL 2 or SIL 4 safety level.

In terms of applying the level crossing protection system, therefore, the safety aspects might be summed up as follows: control of closing the level crossing is speed-dependent. If the signal evaluation generates any uncertainty, however, the level crossing is closed as soon as the detection point is traversed. Of course, any speed-dependent delay in closing must take into account the vehicle's maximum acceleration, buffer times, and track conditions.

3 Outlook

Where it is possible to reliably evaluate speed via a single sensor used as an additional feature, a wealth of interesting potential applications emerge. The considerable scope for integration reduces the number of required components, thereby lowering investment and operating costs.

Initial practical experience and trials show we are not dealing with a purely technical vision, but that individual applications are actually already using this method. Frauscher Sensortechnik already offers wheel sensors and evaluation platforms able to provide highly accurate information on the speed at which an individual wheel sensor is passed. The company is also working on other concepts and development projects associated with safety and integration options.

The ability to control applications based on speed opens up a wealth of possibilities for operators. In future many applications will feature speed-based control as a standard. Innovative wheel detection and axle counting systems will make speed information available as an additional extra, thereby offering genuine added value.

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ZUSAMMENFASSUNG

Raddetektion mit Geschwindigkeitsausgabe bietet echten Mehrwert

Betreiber unterschiedlicher Bahnsegmente, Planungsunternehmen sowie Forschungseinrichtungen interessieren sich zunehmend für Raddetektions- und Achszählungsapplikationen in Kombination mit Geschwindigkeitsinformation. Im Mittelpunkt dieser Diskussion stehen zwei wesentliche Fragestellungen: Wie kann die Geschwindigkeitsangabe einerseits kostengünstig und andererseits als sichere Information zur Verfügung gestellt werden?

Frauscher Sensortechnik verfügt bereits über Radsensoren und Auswerteplattformen, die die Geschwindigkeit bei Überfahrt eines einzelnen Radsensors in hoher Genauigkeit zur Verfügung stellen können. Zudem arbeitet das Unternehmen an weiteren Konzepten und Entwicklungsprojekten zum Thema Sicherheit und Integrationsmöglichkeit.

Applikationen geschwindigkeitsabhängig zu steuern eröffnet den Betreibern sehr viele Möglichkeiten. In Zukunft wird bei vielen Anwendungen eine geschwindigkeitsabhängige Steuerung standardmäßig integriert sein. Innovative Raddetektions- und Achszählsysteme werden die Geschwindigkeitsinformation als Add-on zur Verfügung stellen und somit einen echten Mehrwert bieten.