# Addressing Market Trends in Rail with Innovative Sensor Solutions

Technical Paper

Urban areas are facing increased public transportation needs due to several global trends. First, the environmental impact of public transportation is lower than motorway commute, which drives governments to invest in and stimulate the use of public transportation. Second, more and more congested roads and highways increase the commuting time, while public transportation offers a more reliable and attractive alternative.

In combination with the demand for more safety, the common market trend is increased rail transportation throughput - or more trains per hour on existing infrastructure.

To meet this demand, train control systems will need to be upgraded and, in many cases, a secondary, redundant system will need to be installed. These systems will need independent speed sensor inputs which can be provided for by the use of Jaquet multi channel speed sensors. TE Connectivity (TE), with a center-of-excellence for speed sensors at their facility in Pratteln-Basel/Switzerland, is a leader in the development of components to help reduce Co2 emission, promote renewable energy sources and advance efficient and reliable public transportation systems.

## Introduction

According to the Swiss Economy Forum 52% of the population world-wide was living in cities in 2011, in 2020 it will be 70%, and in 2040 it will be 80-85%. With this growth, the demand for more efficient public transportation systems will be of fundamental importance for humankind. The subway and metropolitan lines of cities with more than five million inhabitants like London, Paris, Berlin, Mexico City, Sao Paulo, Tokyo, New York, Beijing, Shanghai and others have already achieved saturation with the incumbent technology. For cities like these, innovation and modernization of public rail transportation is a constant challenge.

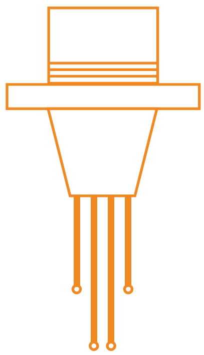
Many of the subway and commuter train lines in large cities hit a saturation point as defined by adopted train management system (TMS) policies. To increase the density of trains on a particular track, the best option is to adopt modern communication-based train control (CBTC) systems. To change a TMS, a security integrity level 4 (SIL-4) application, is not a one-day task. The existing system must coexist with the new CBTC system over several months to validate the system security integrity. This parallel operation of two completely independent systems requires additional independent speed sensors; which presents specific challenges.

TE's new family DSD 25 of 3 channel and 4 channel Hall-effect speed sensors for railway applications provides an elegant solution to these challenges. The multi channel speed sensor family (DSD 25) comprises two galvanically separated circuits, each having up to two phase-shifted square wave signals proportional to the rotary speed. They have 3 or 4 independent sensing elements consisting of magnetic biased differential Hall-effect semiconductors with static behaviour (frequency down to zero Hz). This technology lowers jitter and static characteristics that are extremely important for modern propulsion control systems.

The versatility of these multi channel sensors provides flexibility in different combinations for applications such as propulsion control, wheel slip protection (WSP) and signalling; automatic train protection (ATP), automatic train control (ATC), train protection & warning system (TPWS), European train control system (ECTS), communications-based train control (CBTC ). This can be a very cost-effective solution for retrofit and upgrade cases, as well as for new designs.

Another relevant trend is the introduction of more high-speed trains, sometimes crossing different countries as is the case in Europe. This demands the co-existence and parallel operation of more than one TMS on board, and, correspondingly, additional speed sensors.

High-speed trains and stricter environmental regulations require lower energy consumption of the trains by reducing weight of the rolling stock. Standards already exist covering the need for light weight cables. Technical specifications for rolling stock increasingly consider the total cost of ownership (TCO) during the fleet life time as critical. In this sense, every gram of weight is important. Combining two independent sensors into one multi channel sensor helps drive technical requirements and cost and weight considerations.



# Jaquet rail speed sensors – DSD 25 family

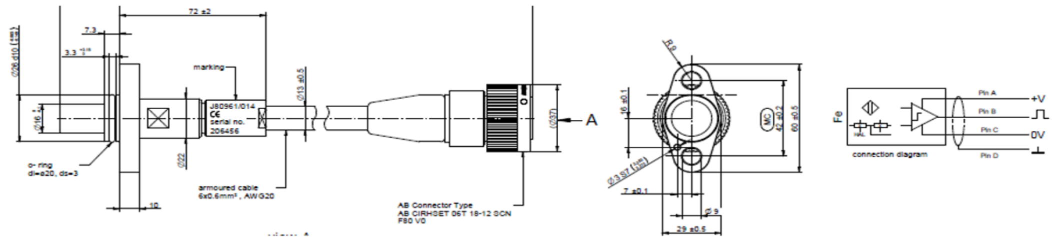
The main data of this family is:

| **General** | |
|---|---|
| Function | The speed sensors family DSD 25 are composed of two galvanically separated circuits having each up to two phase-shifted square wave signals proportional to the rotary speed. They have 3 or 4 sensing elements consisting of magnetic biased differential Hall-effect semiconductors with static behaviour, so that pulse generation is provided down to a speed corresponding to a frequency of 0 Hz. |
| **Technical data** | |
| Supply voltage V1 | 9 VDC to 30 VDC, protected against transient over-voltages and reverse polarity (nominal 15V) |
| Supply voltage V2 | 9 VDC to 30 VDC, protected against transient over-voltages and reverse polarity (nominal 15V) |
| Circuit1 | • 2 phase shifted square wave signals, minimum edge shift with an involute gear wheel: phase shift of 90° ± 45° for a gear module 2 between output 1 (S1) and output 2 (S2)<br>• Push-pull outputs : Imax = ± 30 mA<br>o Output voltage HI (for I = Imax): $U_{HI}$ >Usupply - 1.5 V<br>o Output voltage LO (for I = Imax): $U_{LO}$ < 1.5 V |
| Circuit 2 | • 1 single channel or 2 phase shifted square wave signals, minimum edge shift with an involute gear wheel module 2: minimal phase shift of 20° between output 1 (S3) and output 2 (S4)<br>• Push-pull outputs : Imax = ± 30 mA<br>o Output voltage HI (for I = Imax): UHI > Usupply - 1.5 V<br>o Output voltage LO (for I = Imax): ULO < 1.5 V |
| Current consumption | max. 30 mA (without load) for Circuit1 and 2 channels<br>max. 30 mA (without load) for Circuit2 and 2 channels |
| Frequency range | 0 Hz ... 20 kHz (higher frequencies on request) |
| Electromagnetic compatibility (EMC) | compliant with EN 50121-3-2 |
| Protection class | • Sensor head: IP68 |
| Shock & Vibration | compliant with EN 61373 Cat.3 |
| Operating temperature | • Sensor head: -40° ... +125°C<br>• Cable: -40°C to +150 °C for the standard cable type 824L-36808 |
| Requirements for pole wheel | Toothed wheel of a magnetically permeable material (e.g. Steel 1.0036)<br>• Module: 1.5 up to 4<br>• Optimal performance with involute gear module 2<br>• Tooth width ≥ 10 mm, Side offset < 1.0 mm, Eccentricity < 0.2 mm |
| Air gap between sensor housing and pole wheel (depending on pole wheel shape) | Module 1.5 0.5 ... 1.3 mm<br>Module >=2 0.5 ... 1.5 mm |
| Insulation | • Insulation between electronics and housing: 700 VDC, > 100 MOhm<br>• Insulation between shield and housing:700 VDC, > 100 MOhm |

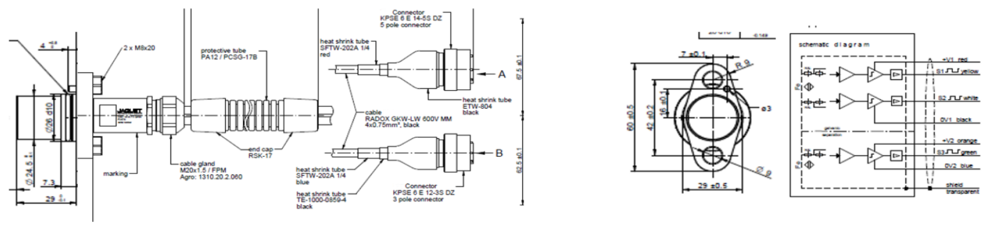
Some examples of the combination of independent sensors into a multi channel sensor of the family DSD 25 are shown below. This is valid for both retrofit/modernization as well as for new design.

Example of replacing the 1 channel WSP sensor with a 3 channel DSD 25 to add two additional channels for the train control system :

## Typical WSP speed sensor (1 channel)

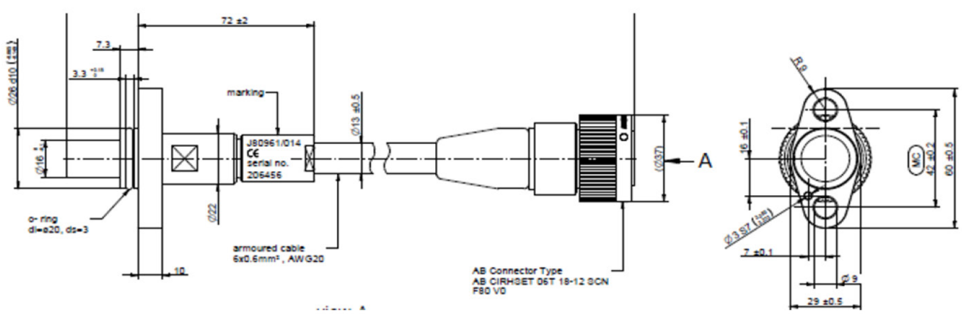


## Upgrade to WSP+Signalling (TPWS) speed sensor (1+2 channels)

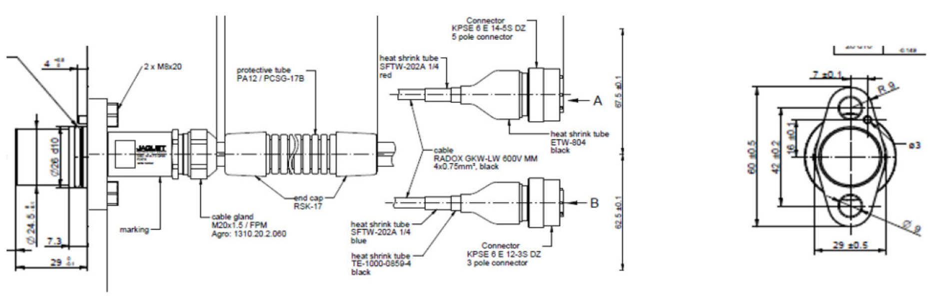


Example of replacing the propulsion sensor with a 4 channel DSD 25 to add two additional channels for the train control system:

## Typical traction motor ( TM ) speed sensor (2 channels)



## Upgrade to TM+Signalling (TPWS) speed sensor (2+2 channels)



## About TE Connectivity

TE Connectivity is a global technology leader, providing sensors and connectivity essential in today's increasingly connected world. We are one of the largest sensor companies in the world. Our sensors are vital to the next generation of data-driven technology. TE's portfolio of intelligent, efficient and high-performing sensor solutions are used for customers across several industries, from automotive, industrial and commercial transportation and aerospace and defence, to medical solutions and consumer applications.

## About the author

Cassiano Reginato is a Senior Field Application Engineer at TE Sensor Solutions in Pratteln-Switzerland. Working previously for BBC Brown Boveri, ABB Transportation, ADtranz and Jaquet Technology Group cumulating 26 years' experience in the Railway Application in the field of engineering, product development, product management, project leading and sales.

TE Connectivity is already supplying the multi channel Hall speed sensor with galvanic insulation for tramways in Austria and several recent and important railway projects in UK. All sensors are compliant with the European Railway Standard EN50155.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