Measurement Chain Problem Solving Guide: JAQUET Speed Sensors DSD, DSE, DSF, DSH, DSY & IQ

General

A speed sensor is just one element in a measurement chain. An example chain might look like this:

Shaft – Pole Wheel – Air Gap – Sensor – Cable – Connectors – Terminals - Input Interface – Instrument Function – Output Interface – Process

The quality of the measurement chain is determined by the weakest link. If the whole chain is not working as intended, then this can have multiple reasons. This guide is intended to help you analyse the problem in detail. Please record data as you proceed.

Shaft

The shaft may have a pole wheel or pole band added for the specific purpose of generating speed information. In some cases the shaft itself can provide the target in the form of machined flats or grooves, drilled holes or screw heads in flanges.

A non contact speed sensor requires correct alignment with the target. Axial movement of the shaft due to mechanical play or temperature changes may cause a positional offset that stops the sensor working.

This could give rise to intermittent measurement problems.

Check shaft axial movement

With any electromagnetic sensor, the induced voltage is a function of the air gap. If the shaft is not running true or vibration is present, the sensor's output voltage may vary during one revolution or at worst additional pulses might be induced in the sensor. The same can apply to non amplified DSH models.

In the case of amplified DSD / DSF / DSH / DSY and IQ sensors, excessive shaft run out can cause the permissible air gap range to be exceeded, resulting in the sporadic loss of signal.

Check shaft run out and vibration

Torsional backlash in shafts or shaft couplings can result in pole wheel jitter which in turn can generate additional pulses in the sensor.

Check for torsional backlash

Pole Wheel

The pole wheel or whatever forms the target must create a suitable change in magnetic flux in the sensing element. A permanent magnet is normally provided in the sensor for this purpose. Except in the case of specific sensors that are intended for use with JAQUET magnet wheels, the pole wheel must not be magnetised or become magnetised during operation.

The pole wheel must therefore be ferro-magnetic with low remanance. Stainless steel and plating with › 8% CrNi are not suitable.

Check material and whether the wheel is magnetised

A JAQUET type DSE sensor can be used for this purpose. Please consult JAQUET for advice.

The technical data for all Jaquet sensors includes a section on permissible pole wheel geometry, expressed as a Module number. Involute gear teeth are preferred, with an effective Mark:Space ratio of 1:1. Please refer to JAQUET application notes and/or consult JAQUET for advice on other target shapes or Mark:Space ratios.

Check tooth profile and geometry

The centre of the sensor must remain within 3 mm of each edge of the pole wheel under all operating conditions (see also 'Shaft'). A pole wheel width of less than 10 mm is undesirable as this would impose tighter installation and operating tolerances. (see also general guidance notes in the sensor catalogue)

Check sensor alignment

Where the measurement chain is for over speed protection, only a small number of teeth may be used during each measurement period. Gear machining errors can then give rise to differences in instantaneous measurements and trip values. In Jaquet instruments this problem can normally be solved by increasing the measurement time and/or the number of teeth (pulses) used for the trip control.

Backlash in gearboxes can result in spurious pulses being generated in the sensor

Check for gearbox backlash

Air Gap

Under all operating conditions, the air gap must be maintained within the permissible range for the sensor based on the pole wheel being used. Sensor / pole wheel contact must be avoided.
(see also 'Shaft' & 'Pole Wheel')

The output voltage of a DSE sensor is partly a factor of the air gap. Data, graphs and formula are provided in the sensor catalogue to calculate the output voltage range and minimum permissible operating speed for a sensor in a given application.

Check air gap setting is appropriate for the sensor

Sensor

The sensor must be operated within its specified performance, electrical, temperature, vibration and other environmental conditions.

Some sensors such as DSD, DSY and IQ require correct alignment of the sensor with respect to the pole wheel.

Check alignment
Check supply voltage range
Check supply ripple & noise
Check current drawn
Check output signal levels over the speed range
Check temperature range
Check vibration and shock levels

Thermal cycling, especially over short time periods and perhaps combined with vibration can result in unique material and constructional problems. Only sensors specifically qualified for such environmental conditions should then be used.

Most JAQUET sensors have short circuit proof output stages. However, if a low resistance load is applied e.g. 50 Ohms, this can put the output current into a band where the protection circuit reacts too slowly to save the output stage. Where test equipment is being used, please ensure that any available 50 Ohm input loads are switched off.

Sensors have a very thin front wall. If the temperature limit has been exceeded this may be evident from a small bump at the front (where the internal potting material has expanded). If the sensor has come into contact with the pole wheel this can normally be seen from marks or indentations. In DSD, DSF, DSY & IQ sensors, Hall elements sit immediately behind the front wall and can be damaged by even small indentations. Sensors are therefore shipped with a protective cap.

Check whether the front wall is damaged

Sensors may be arranged around a pole wheel so as to generate phase shifted signals. Electrical phase shift is achieved by offset positioning of sensors in relation to tooth positions. 3 sensors with 120 degrees phase shift does not mean 3 sensors positioned with 120 degrees offset around the circumference of a gear. (see also JAQUET Application Note – Phase Shift)

Check sensor positions to generate required phase shift
e.g. with an oscilloscope

Large magnetic or electromagnetic fields (e.g. as may be present on large electrical machines) may affect the operation of the sensor.

Check for magnetic fields around the sensor

Cable

The sensor may come with an integral cable or connector. Either way the cable must be suitable for the temperature range, environmental & mechanical conditions and transmission distance.

After obvious faults such as short or open circuit cables, the most common problem with cabling is that the screen is not properly handled. Signal screens should be run back to the instrumentation, without interruption and without being connected to power or machine earth (or earth/screen rails) and then terminated at the instrument using the correct terminal provided. Improper screening can result in significant signal interference.

Check signal screening all the way from the sensor to the instrument

Please refer to the sensor catalogue for other general and specific advice on cabling.

Standard PVC cable should not be used where oil is present. Teflon cable should then be specified. Where harsh mechanical conditions are present, a protective hose or special cable is recommended. Please consult JAQUET.

Jaquet data sheets contain guidance on the minimum bend radius. These are static values. If dynamic cable bending is taking place please consult Jaquet as this can affect the cable life and cable exit sealing at the sensor.

Cable pulled out of the sensor?

Check possible cable pull figures

Connectors

Any form of termination represents a potential failure mode. Mechanical or environmental damage is normally self evident.

Check for loose/bent contacts
Check for moisture ingress

Connector pulled from the cable?

Check possible connector pull figures

Input Interface

The input interface is formed by the output stage of the sensor, the cable run, any intermediate components such as zener barriers and the input stage of the instrument. Data sheets for DSD, DSF, DSH, DSY & IQ sensors contain minimum high & maximum low signal levels under maximum load current conditions. These then represent worst case values. The input operating and trigger levels must be compatible with the levels generated by the sensor and after transmission over the cable run.

High input impedances reduce the current load on the sensor and increase the min. high and reduce the max. low sensor output values. Since these sensors generate square wave signals, normal line transmission rules apply. High cable capacitance represents a significant load on the sensor, which increases with cable length and signal frequency and can result in attenuation and signal distortion.

Check signal levels vs. input trigger levels

Where DSE sensors are used, 2 operating values should be checked, the minimum voltage derived from the sensor at the lowest speed to be measured and the maximum voltage at the highest speed.
It should be noted that the input impedance represents a load on the sensor that will affect the output voltage. Care is needed when using DSE sensors with square edged targets (rapid flux change) and high impedance loads as this can causing 'ringing' and double counting by the instrument at high speed.
(see also relevant application notes or consult JAQUET)

Check min / max voltages
Check for double pulses at high speed

Instrument Function

Having verified all of the above now check whether the instrument is working as intended and consult the relevant operating manuals or contact JAQUET for advice.

Output Interface

Having verified all of the above now check whether the output interface is compatible with the process and consult the relevant operating manuals or contact JAQUET for advice.

When contacting JAQUET for further support and advice, please have the results from the above investigations available as this will speed up the problem solving process.

Signal screening all the way from the sensor to the instrument?:
Air gap setting:

Tooth profile and geometry:

Shaft axial movement:
Shaft run out and vibration:
Torsional backlash:

Sensor alignment:
Gearbox backlash:

Supply voltage range:
Supply ripple & noise:
Current drawn:

Output signal levels over the speed range:
Temperature range:
Vibration and shock levels:

Front wall damaged:
Sensor positions to generate required phase shift:
Magnetic fields around the sensor:

Cable pull figures:
Loose/bent contacts:
Moisture ingress:

Connector pull figures:
Signal levels vs. input trigger levels - min / max voltages:
Double pulses at high speed: