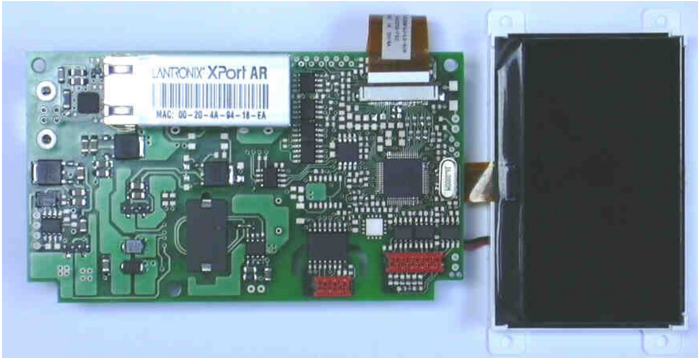
Ubi_Odo_01

C-SIGMA

Multi-purpose Wheelset Monitoring Board



Implements our proprietary method of processing jitter on signals from speed sensors

On existing applications it can monitor speed signals without interfering with them

Monitoring jitter noise allows detection of wheelset defects/wearing, as well as derailment

On-board 3-axes micro-accelerometer allows correlation with "low frequency" events

Combining speed sensor and micro-accelerometer data yields road gradient measurements

It naturally complements GPS receiver boards, allowing effective dead reckoning

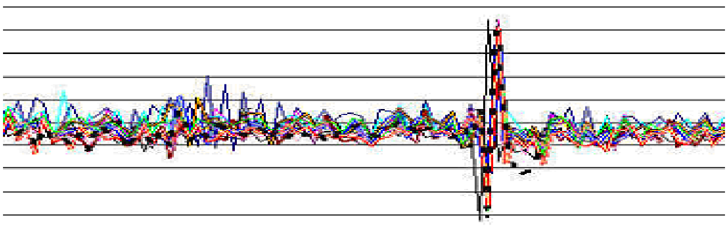
A variety of interfaces are available to suit most data buses: CAN, ETHERNET, USB, RS232

On-board FPC ZIF connector for direct driving of various brands of graphic 128x64 LCDs

DESCRIPTION

Ubi_Odo_01 is a rugged board implementing our proprietary method for monitoring of jitter noise on signals from conventional speed sensors (odometers) used in railway applications.

C-Sigma is an independent supplier of Electronic Brake Control solutions for Railway Pneumatic and Electro-Hydraulic Brake Equipments. Recently, we have added to our controllers a unique feature (patented) allowing the detection of defects in wheels, bearings, tracks, as well as the monitoring of bearings wear and the detection of derailments. By a proprietary processing of jitter on speed signals, suitable plots are generated to highlight such defects. Here below is an example of wheel flat detection. The figure shows the overlap of 10 plots corresponding to 10 consecutive complete wheel revolutions. All plots indicate a defect at exactly the same angular position of the wheelset.



When such spikes occur isolated (i.e.: not correlated by complete wheel revolutions), but on all 4 axles, and with time delays whose correlation is given by the vehicle speed and distance between axles, then the probable cause is a defect of the rail-track (excessive gap or misalignment).

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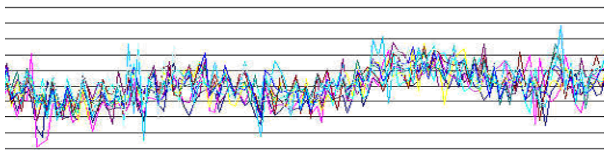
A GPS board would then allow the recording of the defect's location. In case of derailment, the periodic "hitting" of wheels over sleepers would also results in clearly detectable spikes.
When no defects are present, no spike shall appear. However, correlated plots can still be recorded to monitor axle's bearings wear. The figure below shows the same overlapping of plots as above, but for an axle without defects.

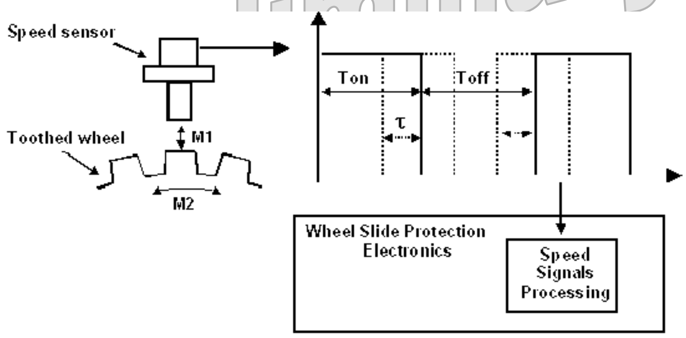


A pattern, common to all the complete wheels revolutions depicted in the graph, is clearly visible. Its shape is determined by the inherent eccentricities and inaccuracies resulting from standard machining and mounting techniques. By comparing similar plots recorded at different times (e.g.: once a year, every 1 million Km, etc.), the evolution of bearings wear can be monitored (standard deviation would increase with wearing).

An advantage of this technique is that it does not require any additional external sensor(always very difficult to install in existing vehicles), but it only processes in an innovative way the signals from conventional speed sensors, already present on the wheelset for ABS control.

The method has been tested in C-Sigma's ABS Electronic Brake Controllers, installed on Bombardier Transportation's tram vehicles (Rostock and Leipzig, Germany). Graphs as those shown above can be remotely captured and downloaded, while the vehicle is running, thanks to a GPS GSM-GPRS board.

The reason why jitter noise contains information about mechanical shocks seen by the wheelset, as well as of wear and/or defects of bearings, can be understood by studying the following drawing:



The drawing depicts the effect due to the onset of the following vibration or disturbance modes:
- Radial Mode M1, which results in small variations of the gap between the sensor's reading head and the toothed-wheel.
- Peripheral Mode M2, which results in small variations of the relative speed between the sensor's reading head and the toothed-wheel.
- Orthogonal Mode, along the direction orthogonal to M1 and M2, but less important because variations along this direction do not significantly modify the jitter modulation (the corresponding tooth dimension is larger that the sensor's reading head).

Said vibration modes are, in turn, triggered by shocks and-or vibrations due to defects of the wheel (wheel-flats), and-or bearings, and-or rail track. Their net effect on the output signal is the presence of jitter, indicated with the Greek letter τ in the above figure. Here, jitter is defined as a modulation of the pulse-width of the output signal. So that, by watching for example said output signal on an oscilloscope, and setting the trigger point on the rising edge, we would notice continuous small variations of the instant at which the falling edge occurs.

A minimal amount of jitter is unavoidable, and it will always be present due to manufacturing tolerances, and various other sources of background noise. In a typical application said minimal modulation is usually contained within **± 1%**

Conventional speed signals processing electronics disregard this modulation as merely one more source of noise, being only interested in the measurement of the frequency of the speed sensor's output signal. ***On the contrary***, our technique does not disregard this source of noise, but it includes specific means to accurately measure its value (with microseconds resolution) and periodicity of occurrence, with the specific aim to obtain precious diagnostics information about defects of the wheels, bearings, rail track.

Micro-accelerometer

The technique described above is very effective in detecting "High Frequency Content Events" such as rail-tracks gaps and misalignments, wheels or bearings damages, as well as the periodic hitting of wheelset on sleepers as it would occur in case of derailments.

"Low Frequency Content Events" (such as for example those resulting from subtle tracks "sinking" or "drifting", etc.), are instead effectively monitored by the on-board 3 axis micro-accelerometer.

By combining the micro-accelerometer output with the signals from the speed sensors, it is also possible to accurately measure the instantaneous gradient of the rail-road.

This is possible because the micro-accelerometer output is proportional to the projection along its axis of the vector sum among the acceleration of gravity and the acceleration of the vehicle.

To extract an accurate measurement of the road gradient, considerable care must be taken towards obtaining a signal processing algorithm effective in filtering out the effect of perturbing vibrations and shocks. However, this is definitely possible, and the team that designed Ubi_Odo_01 is the same that has succeeded in implementing the very same principle in CLINO 401 (visible at www.clino.it), a cyclocomputer with real time road gradient measurement capabilities.

Improving Safety

The possibility to correlate "High Frequency Content Events", detected by suitable processing of jitter noise, with "Low Frequency Content Events", detected thanks to the 3-axes micro-accelerometer, paves the way to novel approaches for preventive maintenance and accident prevention.

We believe that this product will help in improving overall safety for railway transportation, being able to detect defects before it is too late, and contributing as well to a reduction in overall Life Cycle Cost (thanks to the optimisation of preventive maintenance, allowed by the constant monitoring of axle bearings wear). The importance of being able to quantify in a precise and objective way the presence of potentially fatal defects can never be overemphasised,

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