Jewell Instruments

Communication-Based Train Control

- **Objectives:** Eliminate disrtorted data due to vibrations
- **Solution:** Jewell Instruments **LCA-165** and **LCF-500**
- **Benefits:** High-precision and ruggedness
- **Results:** Reliable and precise measurements

Overview

High-speed train systems require precision measurements for efficiency, accuracy, and most importantly: the passengers' safety and comfort. To this end, train control systems normally require multiple sensors (and in this case from two different manufacturers) for redundancy and ensuring any failure and/or incorrect measurement will not jeopardize the reliability of the entire system.

Jewell Instruments LCA-165

Background Of Issue

When the outputs of the redundant sensors do not match, the control system reads this result as a fault and essentially locks. In this situation, there were control systems in two different trains that had experienced a lock situation.

1) The 3 sets of accelerometers had unusually high lock counters in these control systems. The limit of 300 could be reached after a dozen of hours by any of three couples. Other control systems of the line reached 0 to 70 in 24 hours.

2) Train #1 also had a failure of another manufacturer's sensor in January 2016 that was fixed.

3) The problem was not related to calibration of accelerometers. They were correctly calibrated when it happened.

4) The problem was not a hardware failure of accelerometer or any piece of hardware in the sensor. The problem was still there after hardware replacement. After swapping the complete sensor with another in the same train or another accelerometer from another train, the problem remained.

5) The issue came from a phenomenon at train level or sensor installation level, which impacts all accelerometers, but has differing impacts on the two types (Jewell accelerometer with pendulum in air vs another supplier's sensor with pendulum in oil) leading to differences in data.

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Project

The differences in the Jewell unit and the second sensor's bandwidth validated the theories discussed with the customer. Based on further observation, there was a shock (or high-level vibration) that caused a spike in the Jewell Instruments' sensor's bandwidth that could be seen by the second sensor. The spike occurred in both sensors' sensitive axis along the train's moving axis. The customer mentioned that anomalies almost always occur at a switcher in the track but not at one specific switcher.

The customer mentioned that the train sets were > 4 years old and there could be mechanical wear in the bogie's suspension (or possibly car to car coupler) that was being exaggerated at the switchers. They were going to re-test performance after installing a new bogie on the front of the lead care that contains the equipment rack with the accelerometers. If the anomaly was coupler-related, changing the rear bogie (or replacing the coupler) would potentially be a solution, but that was not the case. A quick test was run to insert a Sallen Key low pass filter in line with our unit that would emulate the second sensor's response of 2 to 3 Hz.

"Jewell accelerometers have been used for nearly 50 years in rapid transit and people-mover systems as crucial components in safety and control systems providing a secure, controlled ride by providing train acceleration, deceleration, and position information."

LCA-165's Performance

The custom LCA-165-0.5 had no output filter. The servo output is the unit output and has a nominal frequency response of 60 Hz. The servo output will clip somewhere around 2g, or 4x the 0.5 g range, so we suspected the problem in the metro train was not from output clipping. The units built by Jewell had 86 Hz bandwidth and 0.6 damping ratio. Figure 1 shows the response bode plot.

The theoretical plots for the second sensor with 3 Hz bandwidth, 2nd order response bode plot is below. Obviously, the output from the LCA would look much different from second sensor at higher frequencies, and signal processing in the train's control system had an important role in analyzing the sensor's response with respect to the other.

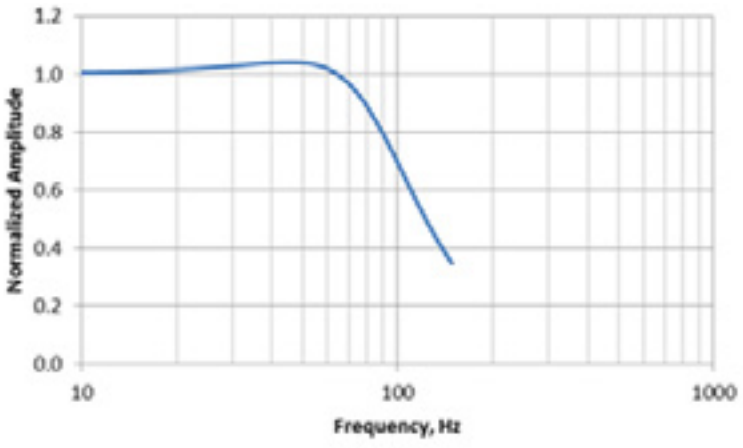

Figure 1

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Samples were fabricated to emulate the second sensor's response and solved the problem. As a result, the customer was very satisfied with the performance of our custom LCA-165 with the same dynamic response as the other sensor, which proves Jewell technical expertise and application experience to work with customers to develop a custom solution that meets your needs.

Jewell's successful analysis further demonstrates the expertise that has led to more than 30,000 Jewell Instruments accelerometers have been used in the rail industry, of which 8,000 have been LCA-165 or LCF-500 servicing 807 stations over one thousand kilometers worldwide including China, France, USA, Canada, Saudi Arabia, India, UK, Italy, Denmark, Turkey, Peru, Greece and Belgium.

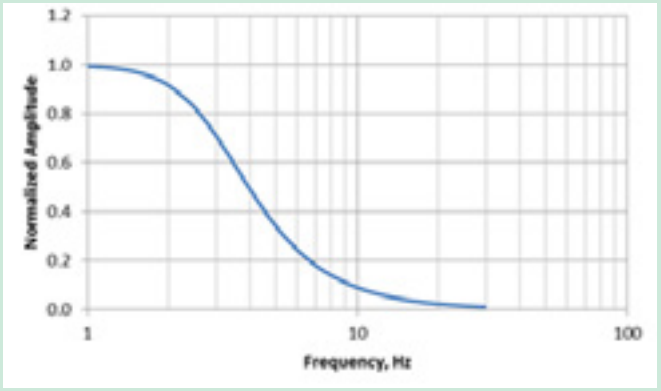

Figure 2 shows Jewell Instruments' LCA-165's performance

"...more than 30,000 Jewell Instruments accelerometers have been used in the rail industry, of which 8,000 have been LCA-165 or LCF-500..."

About Jewell Instruments

Jewell Instruments is a world leader in the design, manufacture, and distribution of high-precision products. Our expertise includes acceleration and tilt sensors, electronic compasses, avionics components, solenoids, and panel meters. The extensive application knowledge we have obtained through decades of experience allows us to provide custom solutions for a diverse group of industries. In fact, customers from all over the globe contact us for solutions to aerospace, medical, industrial, and telecommunications applications - to name a few.

To find out more, visit our website!

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