Pantograph Damage Monitoring System

The system consists of an acquisition and Data Processing Module (DPM) installed on the live pantograph frame, which continuously monitors the acceleration at the pantograph head and detects when transient signals exceed user-defined limits. Upon detection, the event is recorded at 330 Hz and the module communicates information wirelessly to a carriage mounted receiver module.

Together with a time trace of such critical events, the precise GPS stamp provides time, date and location of their occurrence which is securely logged. The receiver can automatically alert designated personnel of severe impact events via TMS or GSM network, and can output signals to other on board systems (for driver notification if required).

Thresholds for alarm levels can be programmed by the user.

Example of a logged pantograph impact event, showing the time trace and associated data.

OVERVIEW

BACKGROUND

Electrically powered rail locomotives require good contact between the pantograph and overhead power line to maintain reliable service. Modern high speed rail vehicles can suffer from damage to the contact strip when the dynamic interaction results in excessive impacts. Transmission Dynamics, in conjunction with Serco Rail, has developed a PANDAS (pantograph damage assessment) system to monitor and automatically report potentially damaging events.

Following a series of long-term tests on routinely operating Pendolino trains supported by the key stakeholders, Virgin Trains, Alstom and Network Rail, the PANDAS is now implemented on routinely operating passenger trains in the UK.

GENERAL

Example of a logged pantograph impact event, showing the time trace and associated data.

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During normal operation the pantograph-mounted Data Processing Module (DPM) continuously acquires data from the accelerometers installed at the pantograph head. The 100 highest events are stored in the time domain, sampled at 330 Hz for a duration of 6 seconds (including 2 seconds before the event), along with an event ID, maximum detected value, and GPS-provided time, date, speed and location data. The lowest event is overwritten as and when subsequent higher events are recorded. The location data can be used to pinpoint the location of each recorded event to within 15 metres.

If the user-defined ‘low alarm’ or ‘high alarm’ values are exceeded, the DPM establishes a wireless connection to the carriage-mounted receiver and signal relay unit (RSRU) to transfer data. The RSRU can be configured to alert designated recipients (e.g. maintenance staff) immediately after the occurrence of critical events. Additionally, the RSRU can notify the driver, to provide instant visual notification of high alarm events. Investigation of the overhead line at the identified location can be conducted, and maintenance carried out to rectify any issues before further overhead line degradation results in damage to the pantograph.

The DPM is programmed to execute a daily download of all stored events to the RSRU. This data can be used to indicate where impacts have occurred, and allows long-term trending of faults developing in particular areas.

Data Processing Module (DPM)

The DPM is typically installed on the live pantograph frame. Intelligent power management allows long-term unattended operation, with the system powered from its internal batteries, supported by an array of PV solar cells which significantly extend battery life during average daylight conditions. The battery condition is monitored by the DPM, which gives an indication of when the batteries are approaching the end of their useful life. The battery pack will last on average 6 months between changes.

The DPM is designed for operation in a strong EMI environment. All inputs incorporate suitable EMI protection, and all internal electronic assemblies are enclosed in a Faraday cage.

Typical DPM dimensions are 525 x 225 x 55 mm with a mass of 6.5kg (including batteries). Much smaller packages can be designed to suit any specific pantograph implementation.

Two external accelerometers are installed at the pantograph head to detect impact events. Their outputs are conditioned using low-pass filters. A further two accelerometers installed in non-sensitive axes are used to detect and reject any events caused by EMI or other interference. The sampled signal is analysed to reject known false impact events caused by external sources, e.g. VCB closures and neutral line sections.

Receiver and Signal Relay Unit

The RSRU is contained within a 19” rack (2U height) located inside the carriage, and receives data from the pantograph-mounted DPM via a Class 1 Bluetooth module. Significantly smaller packaging can be developed to suit the available space envelope.

Alarm events are downloaded to the RSRU from the DPM immediately following any major impact event. All recorded events are downloaded from the DPM on a daily basis at a user-defined time (i.e. during overnight parking).
**Pantograph Damage Monitoring System**

**SIGNAL CONDITIONING**

- **Accelerometer excitation:** 3.3 V fixed—other optional
- **Input protection:** TVS/clamping diodes to protect against EMI
- **Signal filtering:** 6-pole Butterworth active filter:
  - -3 dB @ 100 Hz
  - -120 dB roll off per decade
  - other optional

**DIGITAL**

- **A/D Converter:** 4-channel, 8-bit resolution
- **Sampling rate:** 330 Hz per channel
- **Memory:** 512 kB RAM, 256 kB non-volatile flash in DPM
  - Removable SD storage card (up to 2 GB) in RSRU

**ELECTRICAL**

- **RSRU Power Supply:**
  - 120 to 240 V (AC or DC) - other options available.
  - 30 mA @ 120 V
  - Reverse polarity: fully protected
- **DPM Power Supply:**
  - Bank of 18 high-capacity cells, PV solar cell backup operational during daylight hours, providing average 6 months’ unattended operation
- **Operation:** -40 °C to +85 °C
- **Communication frequency:**
  - 2.54 GHz Bluetooth
  - Quad-band GSM, frequency dependant on network provider

**MECHANICAL**

- **Dimensions:**
  - 482 x 255 x 85 mm (RSRU)
  - 525 x 225 x 55 mm (DPM, excluding mounting bracketry)
- **Mass:**
  - 3 kg (RSRU)
  - 6.5 kg (DPM, including batteries)
- **Protection:** IP 67

**COMMUNICATION**

The DPM connects to the RSRU over a robust, high-speed Bluetooth link (up to 100 m range). Communication is established daily to download the all events. Communication with the TMS or data transfer via GSM network follows immediately after any major pantograph impact event.

In addition to notifying the driver or on-board crew via the train monitoring/GSM system of an event occurring, the intelligent data automation allows the dispatch of an instant SMS or packaged report via email to designated recipients (e.g. maintenance staff). Reports include all information about the alarm event, including a time domain trace, GPS time and location data, and the peak acceleration value detected.

**COMPLIANCE**

The system is fully certified for rail compliance to UKAS standard EN50121-3-2:2006 (emissions and immunity).