"Black Box" for Trains
using the LogBook/300

Application Summary

For the transit authority of a major U.S. city, train maintenance and repair represents a substantial part of its operations budget. By collecting detailed information about conditions aboard a transit train at the time of a breakdown, the transit authority hoped to lower costs by expediting repairs and improving preventive maintenance. To capture the breakdown data, the transit authority decided to install a data logger on each train. Permanently installed, the data logger would be set to trigger on the electronic controller's Quick Shut Down (QSD) signal, in the same fashion that a flight recorder or "black box" on an airplane captures pre-crash information. When a fault was detected by the train's controller, the QSD signal would trigger the data logger to acquire several seconds of data, before and after the QSD signal.

Potential Solutions

In the past, transit authority engineers had temporarily connected a strip-chart recorder to a troubled train to perform continuous data logging. Although the strip-chart recorder was easy to operate, it had several limitations, including lack of triggering, an inability to measure all channels, excessively large size, and high cost.
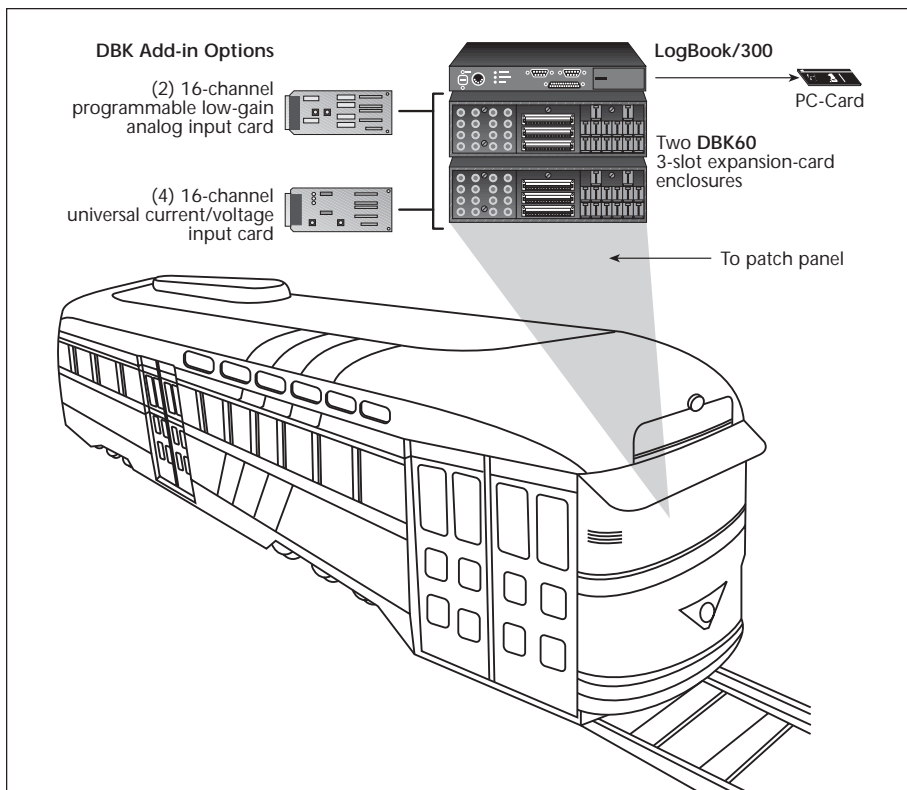
Because the strip-chart recorders lacked triggering capability, they collected endless spools of event-less data. Once a roll of paper was delivered to Engineering, many hours were required to inspect the charts for relevant events. So as not to use up paper too quickly, the charts were set to run slowly. Slow events were captured adequately, but fast events such as over-voltage spikes were not. Chart recorders also suffered from low channel count, allowing only 16 channels to be recorded at any one time.

IOtech's Solution

After investigating various hardware options, the engineering team selected IOtech's LogBook/300™ data logging system for their application. It offered the requisite number of channels in a low-cost, triggerable design. The team liked the system architecture because it allowed them to easily add signal conditioning in the form of DBK expansion cards, and because the DBK60™ enclosure allowed them to customize the system with their choice of connection terminals. The system included LogView™ *Out-of-the-Box*™ software, which allowed them to quickly define channels and triggers without programming. Finally, the team appreciated the convenience of being able to store acquired data to a removable, low-cost PC-Card memory (PCMCIA).

Using LogView software, the engineers configured the LogBook/300 system to measure more than 80 parameters that represent various operating characteristics of the train. The digital channels include signals such as: no-motion detected, slide condition detected, emergency relay energized, overspeed detected, chopper is on, line voltage within limits, and over-temperature detected in chopper. The analog channels include signals such as: current for each motor pair, tractive effort, traction motor armature voltage, thyristor duty cycle, line voltage, load weight, and brake tractive effort.
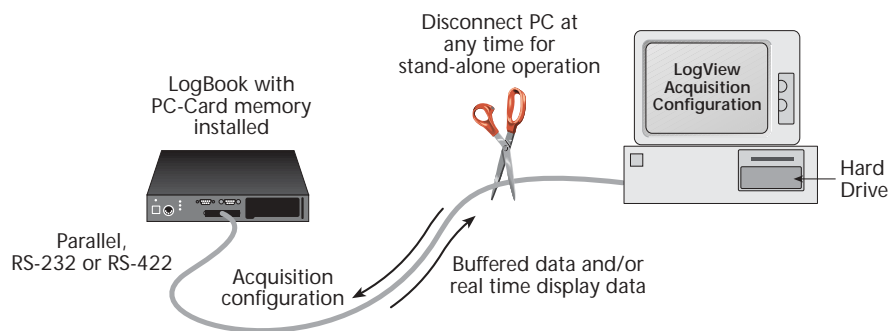
A simple wiring harness allows a technician to connect signals from a patch panel on the train to the LogBook/300 system's removable screw terminal blocks. The majority of the

DBK Add-in Options
- (2) 16-channel programmable low-gain analog input card
- (4) 16-channel universal current/voltage input card

LogBook/300
PC-Card

Two **DBK60** 3-slot expansion-card enclosures

To patch panel

Test setup of a LogBook/300 data logging system set to log more than 80 channels of analog and digital data in the event of a transit train breakdown

LogBook/300 Operating Modes

Disconnect PC at any time for stand-alone operation

LogBook with PC-Card memory installed

LogView Acquisition Configuration

Hard Drive

Parallel, RS-232 or RS-422

Acquisition configuration

Buffered data and/or real time display data

LogView can download acquisition configuration over any of its communication interfaces. Stored data and real-time readings can be uploaded in the same way.

LogView Acquisition Configuration

Hard Drive

Collected data

Acquisition configuration
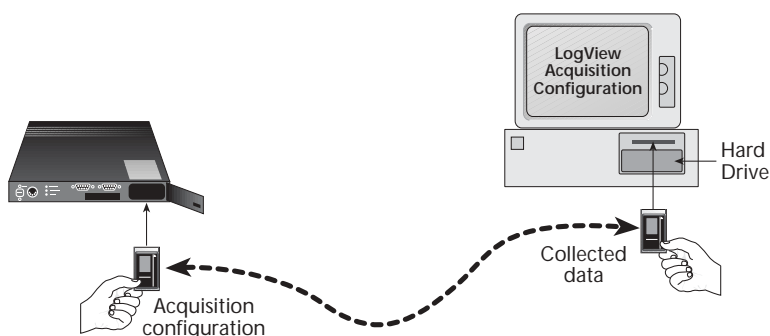
LogView downloads acquisition configuration to a PC-Card in the PC's socket for transport to remote LogBook. Data is transported back to the PC via the PC-Card.

The optional LBK1 remote operation terminal provides control of the LogBook/300 system in the field when no PC is present

Data Access

When a train comes in for service after a QSD is encountered, the memory PC-Card is simply ejected from the LogBook/300 data logger and installed into a PC in the Engineering Department. The transit engineers then load the data onto the PC's hard drive, and import the data into a standard Excel template for analysis and easy report generation.

The LogBook/300 system's recorded data provides exact troubleshooting information to the mechanic, since all parameters associated with the fault are visible in one set of spreadsheets. Once the train is repaired, the data from the LogBook/300 is archived for future engineering analysis. The database allows Engineering to track the performance of each train and the service life of major components across multiple trains.

Some problematic trains are also equipped with cellular modems attached to the LogBook/300, allowing an operator in a central office to inspect the channel levels at any time, without having to be on the train. When connected to a LogBook/300 via a modem, an operator can perform virtually any activity on any LogBook/300 in the field, including viewing specific channels, changing the trigger conditions, and uploading acquired data.

train's analog transducers provide outputs from 0 to 10V, although some source 0 to 37V. The train's digital signals switch between 0 and 15 VDC.

Event Capture

Using the LogBook/300 data logging system's triggering capability, only the desired events are captured. In most cases, the LogBook/300 system is set to trigger on the train's QSD signal, but in some special cases, a more sophisticated trigger is applied whereby signals from multiple channels are combined into a trigger equation. For example, to diagnose a motor problem on a series of trains, engineers attached thermocouples to the motors and the heat sinks of the chopper drives. Then they set the LogBook/300 to trigger on either the QSD signal or excessive heat on any of 10 thermocouples. With the pre-trigger set for three minutes and a post-trigger set for one minute, all parameters leading up to, then after, the event were captured. With a sample rate of 300 Hz, each trigger block consisted of 72,000 points per channel. Using a 500-Mbyte memory PC-Card, more than 150 trigger blocks of 20 channels could be collected before the card was full.

The upload scheduler software option automates the process of uploading data from one or more LogBooks
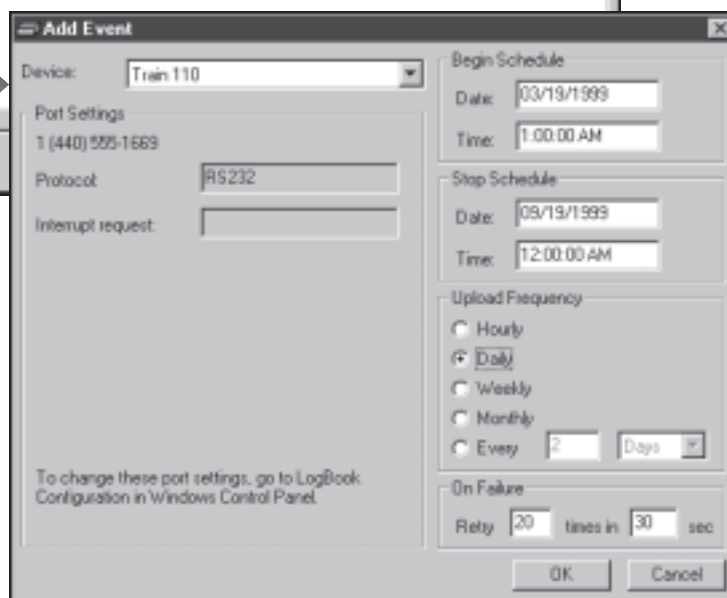
Upload events can execute once or periodically

IOtech provided optional Upload Scheduler software that automated the upload process so that data can be uploaded from one or more LogBook/300 systems without operator intervention. Using the Upload Scheduler software, the operator can set up a system where five LogBook/300 systems are automatically called every night at midnight and have their data uploaded.

For LogBook/300 systems installed without a modem, an operator can periodically connect the LBK1 hand-held terminal to see if a trigger condition has occurred. If so, the operator ejects the PC-Card holding the acquired data and replaces it with a fresh PC-Card. To ensure that the cards from multiple LogBook/300s are never confused, the system creates a file name which is a combination of its serial number plus the time and date of the acquisition, thus linking that PC-Card and file to only one possible LogBook/300 system.

Signal Conditioning & Channel Expansion

The LogBook/300 data logger has 16 on-board analog input channels, 40 on-board digital I/O lines, and several analog output and frequency I/O channels. However, as is the case with the train test system, additional channels and channels with higher voltage ranges may be required to accomplish all measurements. The LogBook/300 is designed to be easily expanded using its wide selection of more than 30 signal conditioning and expansion options, including RTD, thermocouple, accelerometer, current, high voltage, isolation, strain, and load cell. Using these modules, the system can be expanded to 256 analog inputs, and 192 digital I/O points. The compact signal conditioning and expansion options are neatly housed in two DBK60™ expansion enclosures, which allow the user to create a custom signal input panel. In this case, the user chose quick-disconnect screw terminal panels that allow a LogBook/300 system to be easily installed or removed for service or calibration in a matter of minutes.

Occasionally, a specialized test is configured to characterize train performance or troubleshoot a failing component. An example of such a test involved measuring the vibration of the train and its suspension relative to its location and speed. Five channels were monitored: two accelerometers, GPS (global positioning system) longitude and latitude, and one speed channel. When the vibration magnitude exceeded a set threshold, all five channels were recorded for 15 seconds.

Using the captured data file, the engineers were able to isolate sections of track that caused excessive vibration at certain speeds. A frequency-to-voltage module converted a tachometer pulse into speed, the latitude and longitude from the GPS reported the location of the train, while

the two accelerometers captured the vibration in the passenger compartment and on the train axle.

The modularity of the signal conditioning and expansion hardware allows the system to be configured quickly into a robust package that is easy to field install. The externally accessible connector panels simplify connection of system components.

Conclusion

The IOtech LogBook/300 data logger is instrumental in collecting failure and performance data in mass transit trains. The data is used to expedite maintenance and repairs, characterize failure scenarios, and better understand the trains' vital parameters.

Like an airplane's "black box", the LogBook/300 system helps engineers understand the root causes of failures, from which preventive maintenance schedules are developed to reduce downtime. Collected data is also used to communicate performance parameters to the manufacturer of parts and subsystems.

LogBook/300

IOtech's LogBook/300™ data acquisition system provides high speed, low cost, and ease-of-use, without requiring a PC at your test site. The intelligent LogBook/300 executes your data acquisition applications and saves acquired data using low-cost PC-Card memory. And since you don't need a PC at the test site, you save cost, space, and avoid the threat of damage or theft to your PC.

Features
- 16-bit, 100-kHz A/D converter with digital calibration
- 16-channel analog inputs — expandable up to 256 channels
- Digital I/O, frequency I/O, and analog output expandable to over 200 channels
- Non-volatile storage of up to 250 million samples via low-cost and removable PC-Card memory
- Infinite acquisition duration by swapping PC-Cards
- Direct communication with PC via serial, parallel port, or modem if desired
- Optional control terminal for triggering & reviewing acquired data
- Signal conditioning options for strain gages, thermocouples, accelerometers, and nearly every other signal type
- AC or DC powerable
- Vehicle network interface option
- GPS option

Signal Conditioning Options
- Expansion cards and modules for high-voltage/current, strain gages, thermo-couples, isolation, relays, accelerometers, filtering, simultaneous sample & hold, vehicle network measurements, and more

LogView requires no programming or block diagram configuration

Software
- Includes LogView™ *Out-of-the-Box*™ software for easy setup, calibration, and more; no programming required
- Simple spreadsheet-style interface provides powerful setup features for immediate startup
- Acquisition configurations can be transported to the LogBook via PC-Card, serial port, parallel port, or modem connection
- Provides direct support for a wide variety of transducers
- Includes eZ-PostView™ for post-acquisition data viewing

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