Recording Environmental Data with a Triaxial Accelerometer

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Data recording is a form of science developed with the objective of decreasing the odds that a problem will repeat itself. High-performance products are today being introduced that, by logging past occurrences, allow the prediction of future events. For instance, a variety of data recorders are available that can statistically summarize many types of phenomena: shock, impact, temperature, pressure, and even wind speed. A classic example is the use of flight recorders on commercial airlines.

Perhaps one of the most interesting types of data recording is the detailed study of elapsed shock, vibration, and impact events through the use of solid-state accelerometers. Portable environmental data recording units using these accelerometers are being placed within shipping containers to audit the distribution environment during shipping and to monitor potentially damaging shock events. With such information, packaging engineers can create improved designs to reduce the chances of freight damage. Other uses for this instrument include testing railcar coupling impacts, vehicular environments, naval vessel shock, and avionics environmental reliability.

One important design guideline is that the recorder be small, lightweight, and self-contained for field use. Since the accelerometers must survive high-impact forces, a device with built-in damping and overshock protection is recommended; high-impact strength, low cost, excellent low-frequency response characteristics, and long-term reliability are also important considerations. For optimum performance, it is best that the accelerometer have triaxial measurement capability so that lateral, longitudinal, and transverse impact information, as well as composite acceleration vector data, can be examined. To determine package orientation, a piezoresistive accelerometer with a stable DC response should be chosen. With these characteristics in mind, a silicon-based, solid-state, low-cost accelerometer is a legitimate candidate.

The recorded data should be easy to analyze using software written for a PC-DOS-compatible computer. Software highlights must include user-friendly statistical data reduction routines, complete with a wide selection of data distribution chart formats. Portable data recorders are now available that offer unprecedented shock and vibration data collection and analysis power for packaging, handling, and product transportation technology. One such recorder is Instrumented Sensor Technology's (IST) Model EDR-2, which combines a unique, piezoresistive triaxial accelerometer with an innovative microcomputer system to allow remote, untended recording of shock and vibration over extended periods of time. The accelerometer consists of three high-performance sensors made by IC Sensors. These ultralight weight sensors are rigidly mounted within the recording unit enclosure. Once programmed using provided menu-driven software, the EDR-2 records potentially damaging shock, impact event, relative humidity, and environmental temperature data at preselected time intervals. Accelerometers and circuitry function on low power, permitting battery operation for up to several weeks.

GENERAL FEATURES

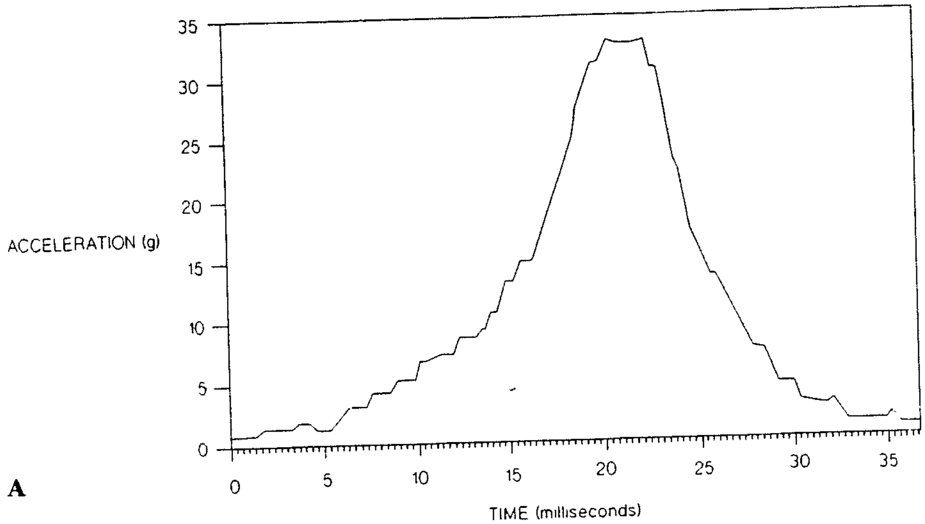
The 4.3-lb unit is composed of a high-impact polyurethane, gasket-sealed case and is equipped with threaded inserts for a mounting bracket. Optional external accelerometers and an external temperature sensor can be interfaced to record information from lower mass structures. The three accelerometers are mounted to the recorder's center of gravity for more accurate sensing. The recorder comes with an operating software package and is programmable via a standard RS-232 interface with a host PC-compatible. After a recording period, data can be transferred to the computer for processing and analysis.

SOFTWARE

The software package is custom-designed to perform two basic tasks: recording shock, vibration, and temperature data based on user-selected parameters; and providing a powerful yet user-friendly environment for retrieving and analyzing recorded data.

The EDR-2 is user-programmable to operate under either amplitude-based event or periodic time-triggered recording, by which events are recorded only when a time lapse or any accelerometer signal level exceeds the preset thresholds. Other software-controllable parameters include digital sample frequency selection, overall start- and stop-time selection for active sensing, and time-interval control for temperature measurements. Because the user may not want to store certain information in memory, two storage modes exist. The first records only those data frames that satisfy the trigger requirement until the memory is full; the second mode overwrites a preselectable number of frames having the largest RMS levels of all frames measured. Since the EDR-2 has 1 mB of on-board RAM storage, up to 2048 samples per event can be taken, depending on the sampling frequency.

Upon completion of the test-recording period, all data can be downloaded via the serial communications port for further processing. The menu-driven



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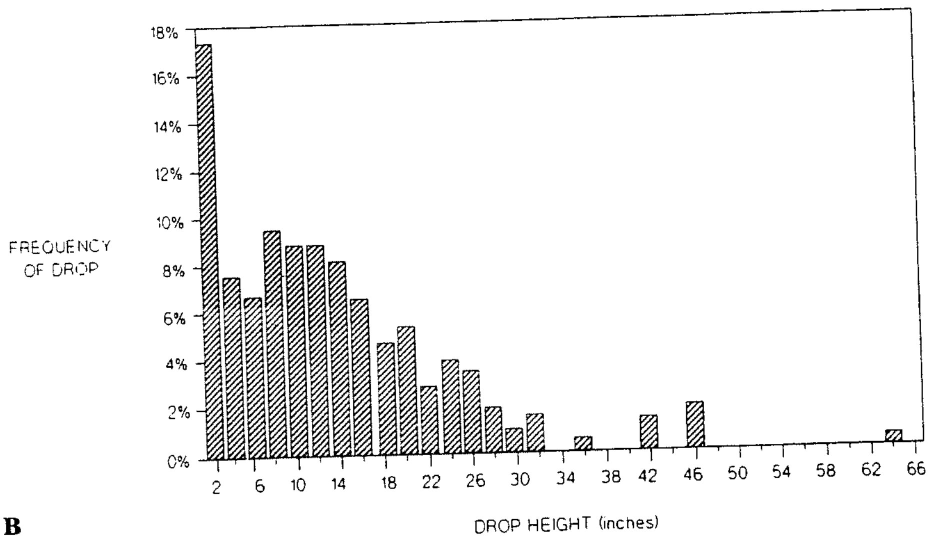

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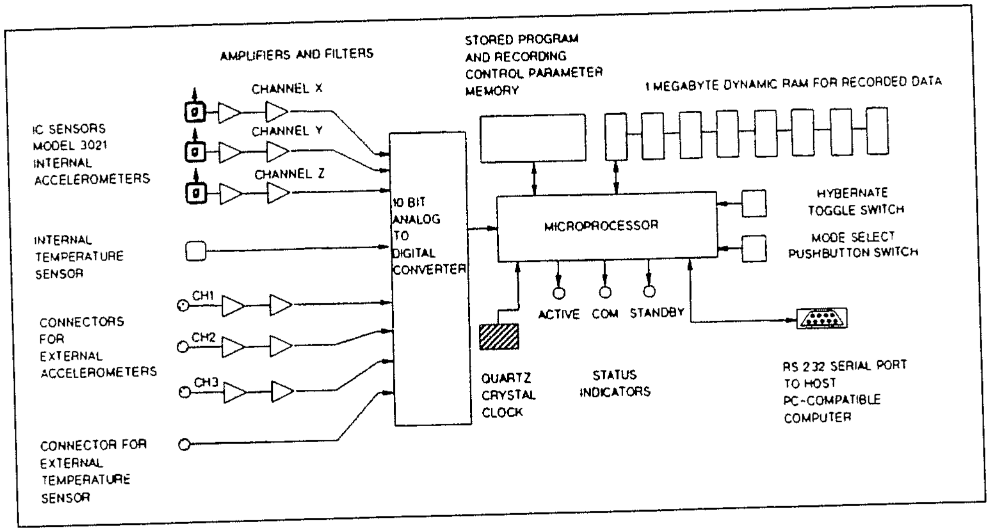
Figure 2.1
Plots are shown for the impact acceleration vs. time of dropped products (A) and frequency distribution of drop heights (B). The histogram illustrates one of the several data-reduction features of the EDR-2 system.

software package features automatically tabulated reporting on shock or vibration frame number, date, and time of measurement, and individual or combined-axis peak g level and duration information. RMS levels for each frame are also calculated. Statistical data-reduction features are included that provide an automatic generation of histograms for drop height, peak g levels, and RMS levels over all frames and/or channels. A complete summary is also listed detailing maximum, minimum, mean, and standard deviation estimates for peak g levels, RMS levels, and measured shock durations over all recorded frames for each of the three channels. Example plots are shown in Figures 2.1A and 2.1B. Additionally, three-channel interactive wave-form graphics are provided for analyzing individual acceleration-time histories, as

Figure 2.2
The EDR-2, shown here as a block diagram, combines a piezoresistive tri-axial accelerometer with a microcomputer system to allow remote, untended recording of shock and vibration over extended periods of time.

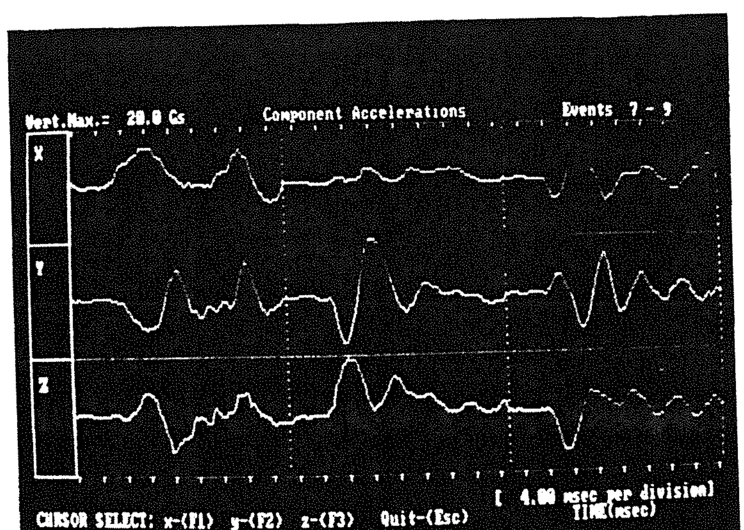


well as for viewing statistical distributions. For frequency-domain analysis, an optional fast Fourier transform composite power-spectral-density analysis package is also available.

Hardware

Within the enclosure are state-of-the-art electronics instrumentation and three solid-state piezoresistive accelerometers. A simplified block diagram of an EDR-2 circuit is shown in Figure 2.2. The data recorder consists of two basic units: the accelerometer signal-conditioning circuit and the microprocessor-based digital data-acquisition system with on-chip serial communications and up to 1 mB of dynamic RAM storage control.

Figure 2.3
The graphics capabilities of the EDR-2 let you see what is happening.



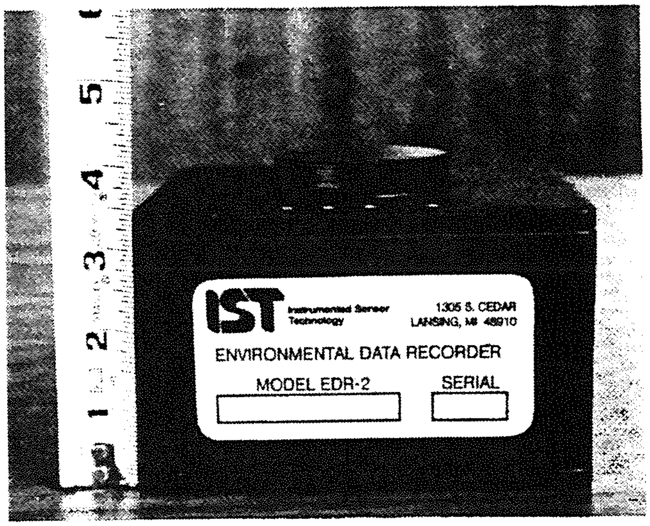


Figure 2.4
The EDR-2 has proven to be an economical, reliable, and easy-to-use data-collection and analysis device.

Weighing less than 1.5 gm, each accelerometer is configured as a Wheatstone bridge and produces a typical DC output of + 50 mV at F.S. acceleration. The sensors' small size and low mass give the recorder its small volume, making on-site environmental data study very convenient. For an accelerometer with a range of + 10 g's, the frequency response is rated from 0 to 500 Hz with a damping factor of 0.707 as a standard value. This bandwidth permits the measurement of high-frequency vibration. In addition, 50- and 200-g options that feature wider bandwidths are available. Built-in mechanical-overforce stops enable acceleration-overforce protection for up to 20 times the rated F.S. acceleration. For each channel, an accelerometer signal is amplified and filtered before entering a 10-bit A/D converter. Input sampling and data storage occur as specified by preprogrammed recorder control information.