ANALOG DEVICES
AN-383
APPLICATION NOTE
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Embedded Shock and Temperature Recorder

by Robert Briano

Whenever a package is shipped, whether it contains an expensive piece of equipment or perishable food items, shocks and extreme temperatures can adversely affect its contents. Many types of equipment, no matter how ruggedly designed or carefully packaged, can be susceptible to mishandling. Sophisticated shipping recorders are sometimes attached to the container to monitor and time-stamp mishandling for insurance claims.

A similar shipping recorder can be embedded directly into any microprocessor-based equipment, not only for insurance purposes, but also for warranty, contractual and field service reasons. When equipment arrives at a customer's facility, knowing that it was mishandled, and how, will help in getting the equipment up and running faster.

The recorder, described here, can be used for more than just monitoring shipping problems. For example, this function is valuable in portable medical equipment for which calibration can be of critical importance. Shocks during use or misuse can cause misalignment for mechanical systems, printers, copiers, robotics, and many other types of equipment requiring proper alignment for reliable operation. Even if a system has no mechanical components, mishandling can cause calibration problems or cause electrical interconnects to come loose, creating intermittence. For these reasons scheduled maintenance is not always adequate.

The block diagram of Figure 1 illustrates the concept of a shock and temperature recorder that can be implemented with minimum additional cost and design effort. In some cases, all that is needed are the temperature and acceleration sensors and battery backup; the balance of the circuitry may already be present in the existing system. The design details will depend on various aspects of your system.

The sensing functions are accomplished using integrated circuit sensors which are mounted directly onto PC boards along with all the other electrical components. To measure shock levels, three ADXL50 accelerometers are used, one on each axis, to determine

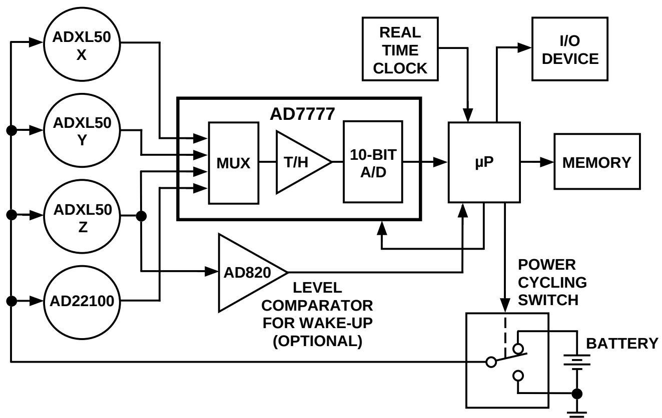

Figure 1. Shock and Temperature Recorder for Shipping and Transport

when and how the system might have been mishandled. An AD22100 temperature sensor is used to measure potentially damaging temperature changes.

In order to adequately couple the shock signal to the ADXL50, some care must be used both in the placement of the ADXL50 and the PC board as well as the securing of the board to the chassis of the equipment. Application Note AN-379 gives some helpful hints on this topic.

A microprocessor is at the heart of the recorder, controlling all the data acquisition and recording functions. The data acquisition can be done with a microprocessor-compatible ADC, such as the AD7777. The ADXL50s should be sampled at a rate of approximately 100 Hz, which is adequate to detect a signal from a drop or bump. When a shock signal is detected, the sampling rate can be increased to capture the transient signal with more resolution. Sampling from the AD22100 temperature sensor can be done at a much lower rate. In order to record the time of any shock or temperature event, a real-time clock is necessary.

Under most conditions, transient shocks will not last more than 1–2 seconds. Data can be stored during the event and stopped when the transient event has ended. Enough memory should be allocated to record a series of damaging events.

As with any system that is battery powered, current consumption is critical. The ADXL50 typically consumes 10 mA and the AD22100 consumes 0.5 mA from a 5 V power supply. For example, sampling at 100 Hz will allow cycling of the power supply where the sensors are on for only 10% of the time, reducing the average current to 1 mA. (Application Note AN-376 describes this in more detail.)

Another option for conserving power is to use one of the ADXL50s (Z axis in Figure 1) to trigger system wake-up when a shock level above a preset trigger level is detected. A low power comparator can be made from a low power, single supply op amp, such as the AD820. This technique can be used whenever the microprocessor has a higher power consumption than the ADXL50.

The shock and temperature recorder can often be embedded in your equipment using the existing electronics architecture with minimal additional components. This inexpensive system enhancement will help increase the reliability of equipment while being relatively easy to implement.

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