Sensors with Embedded Memory for SHM Applications

Vladimir GRACHEV[*], Ilya KARKIN[**]
[*]GPPB Ltd (Russia, Ekaterinburg, D. Ibarruri 2 str.,)
[**] SITIS Ltd (Russia, Ekaterinburg, D. Ibarruri 2 str., sprut@sitis.ru)

Abstract. When SHM systems are designed and build at construction period of new or renovated buildings, their intensive usage for structure performance analysis will be tens or hundreds years later. It may be expensive to maintain the data collecting and processing equipment for such a long period of time. By the other point of view the data processing devices will be cheaper and more efficient several years later, so there is no reason to use extensively the equipment during the long period of proposed service life of structure. In many cases it is enough to collect data from sensors installed on the structure during construction period, and then use the data together with contemporary data for service life evaluation and performance assessment. When the data are stored in the embedded sensor memory it is possible to automate the data collection and analysis together with improving robustness and reliability of SHM systems.

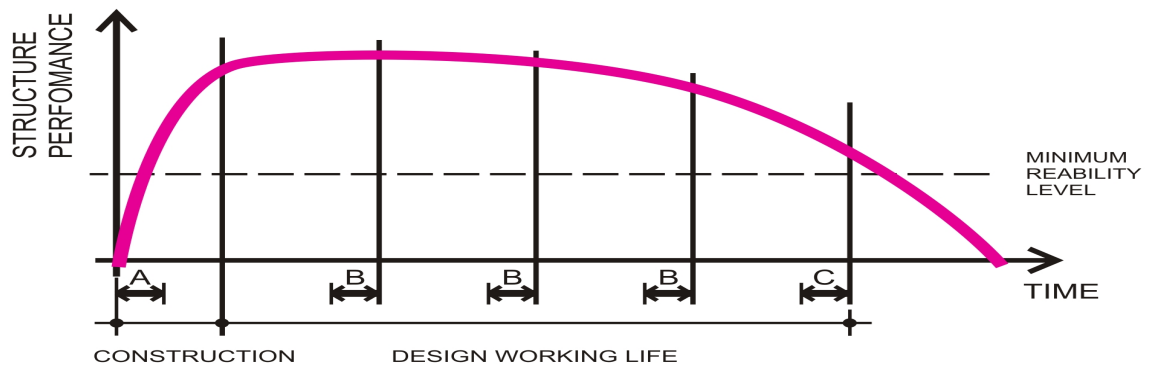
The benefits and advantages of SHM systems employing sensors with embedded memory will be discussed on several case studies for bridges, buildings and special structures, where SITIS sensors and datalogges were used.

1. Introduction

The working life of conventional building or facility structure is hundred years and more. During this period there are several moments when structural health assessment or monitoring usually will be needed.

First it is time of scheduled assessment of structure due to building law, structure design or maintenance procedures (Point B on figure 1). Also assessment of structure is needed at the end of design working life if further usage is planned (point C on figure 1). Sensors usually are calibrated during the erection and loading period at constructing time (point A on figure 1).

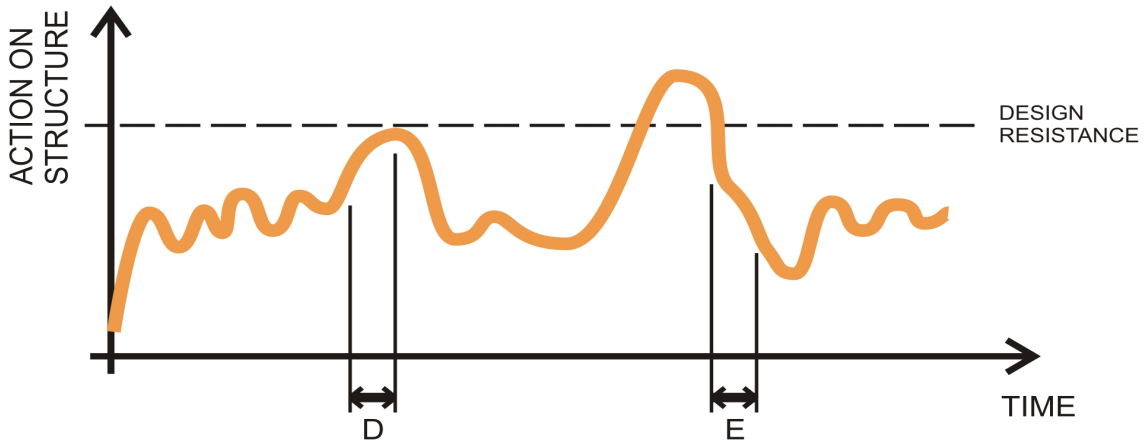
Figure 1. Structure performance



License: http://creativecommons.org/licenses/by/3.0/

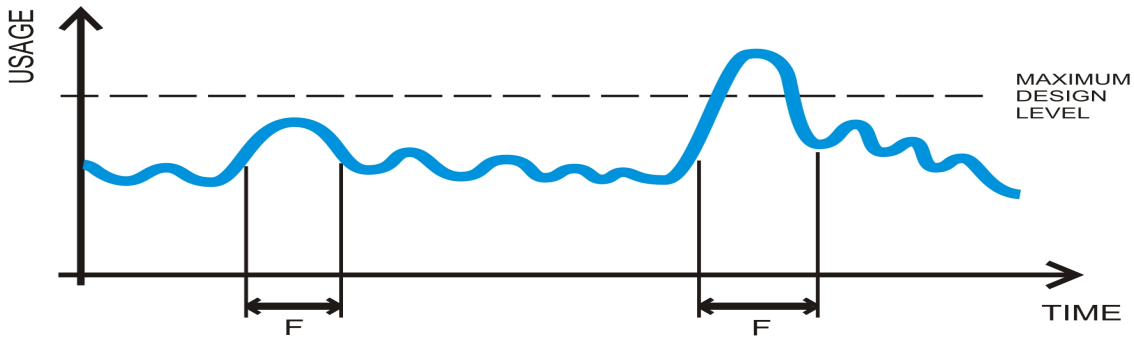
Monitoring and assessment of structures is needed during the expected extreme action on the structure (e.g. Wind or snow, point D on figure 2) or after unexpected extreme action (e.g. earthquakes, point E on figure 2).

Figure 2. Actions on structure



Also monitoring can be used during the high level of usage of structure (e.g. events with crowds at entertainment in temporary or not specialised buildings, storage of expensive belongings in ware houses, etc. Points F at figure 3), when preventive measures can be used in extreme circumstances of building performance like people or goods emergency evacuation.

Figure 3. Usage of structure



Often for large amount of buildings and facilities there is no economical reason to install permanent SHM system with sensors and automated data loggers for real time monitoring, but permanent installation and calibration of sensors on structure with additional periodical manual or automated data collection at periods from A to F mentioned above can be useful.

To effectively utilise this approach sensors and SHM equipment must be designed for quick and robust manual and/or automated data readout. The way to solve this task is to use embedded unique sensor identification information together with data transfer protocols allowing “plug-n-play” technology.

2. Smart sensors

Sensors with memory containing unique identification information and calibration data where developed for automation applications in 1990-th – IEEE 1451 group of standards. In the standard "smart transducer" is defined as sensor or actuator with associated electronic data sheet and with circuit that can transfer both signal and data sheet data.

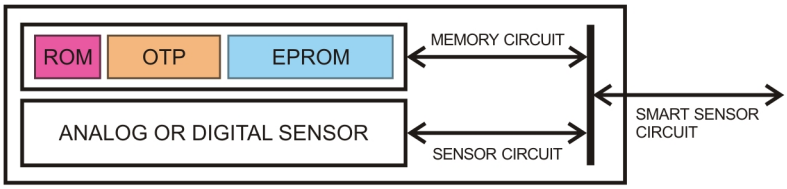
The best way to associate data sheet with sensor for robust plug-n-play systems is to use embedded in the sensor memory. Different types of memory in embedded smart SHM sensors can be used:

ROM – read only memory – memory to locate unique identification tags and manufacture specific information.

OTP – one time programmable (write once read many) memory – can be used to store critical sensor information like sensor location information, first calibration data, etc. This data will be protected from accidental or premeditated modification or deleting.

EPROM – erasable programmable read only memory, for data reading and writing - can be used to store ordinary non critical sensor data and data that are modified during readouts.

Figure 4. Smart sensors with embedded memory



3. Smart sensors benefits for SHM applications

Sensors with embedded memory with unique identification tag and service data have many advantages for use in SHM systems for buildings and facilities structures. There are few of them in comparison with conventional sensors and data loggers:

Improved robustness – using of sensor tags reduce number of errors at wrong sensor identification during manual circuit wire connections, associating calibrating data with sensor and similar mistakes during SHM system installation and maintenance.

Reduced life-cycle cost - price of smart sensors and there data loggers is similar to conventional analog and digital sensors for SHM applications, but cost for SHM system integration and maintenance is reduced due to plug-n-play features of smart sensors.

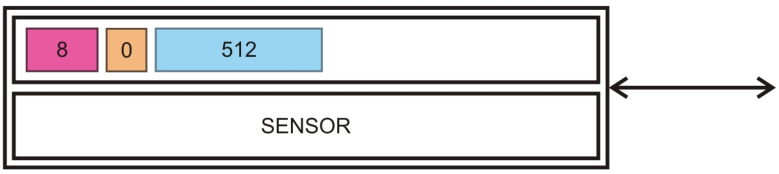
Reduced installation and time – sometimes SHM systems must be installed and put into operation in very short periods of time, especially during emergency operations at extreme events like fire, floods, etc. Smart sensors with plug-n-play equipment can offer short installation and maintenance time.

4. SHM Sensors with embedded memory available on the market

First, there is a set of IEEE 1451.4 compatible sensors and actuators that can be used for SHM installations. Usually they use the compact form of TEDS (Transducer electronic data

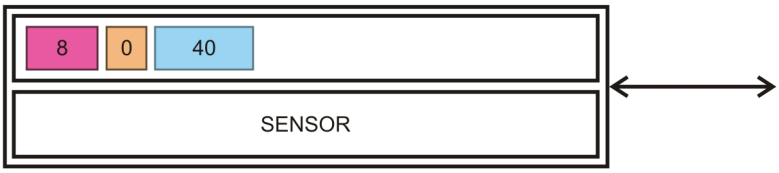
sheet) format, that contain a 8 byte tag and from 32 to 512 byte EPROM memory. (figure 5).

Figure 5. IEEE 1451.4 TEDS-C Smart sensor



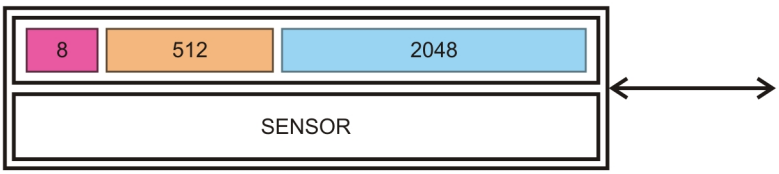
Also there is a SITIS:Sprut sensors, data loggers, application controllers and software, designed and manufactured by Sitis Ltd company. The sensors contain 8 byte ROM tag and 40 byte EPROM memory (figure 6).

Figure 6. Sitis Compact Memory sensor



To store in sensor memory protected information sensors Sitis Ltd plan to manufacture sensors with "extended" memory at the end of 2012 year. The simplest sensor of this type is dummy sensor, that have embedded memory but have not sensing device. This product can be used to store information about group of associated conventional sensors, to calibrate, transform and interpret data not from a single sensors, but of a set of several sensors installed on a particular structural member.

Figure 7. Sitis Extended Memory sensor



5. Summary

Usage smart sensors in SHM systems will allow to create more robust and effective applications and reduce cost of building and infrastructure maintainance.

References

[1] IEEE 1451.4 Standard for A Smart Transducer Interface for Sensors and Actuators—Mixed-Mode Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats