micro usage monitoring systems

The Micro Usage Monitoring Systems (MUMS) concept captures information on usage and events rather than the raw data, thus minimising the need to subsequently store, retrieve and analyze information. MUMS offer an affordable new technology enabling engineering asset management to be taken to the next level on a wide range of equipment not usually associated with health and usage monitoring systems.

introduction

For many years Automatic Identification Technologies (AIT) has been playing a critical role in the developments and improvement of asset management. The technology has become an integrated part of manufacturing control, logistics supply chains and maintenance management. Systems have become automated with improvements in efficiency, reduced errors and increased levels of asset visibility within the supply chain.

Whether the AIT is bar code, radio frequency, contact memory or other forms of technology the key elements is that asset data can now flow within a shared data environment.

Taking the management of assets to the next stage we understand the importance of equipment health and usage monitoring systems (HUMS) for critical items and we understand the importance of accurate data for integrated logistics and maintenance management. Providing a range of low level Micro Usage Monitoring Systems (MUMS) or components shows significant benefits in the development of Reliability Centred Maintenance (RCM) and preventative maintenance techniques.

electronic tagging technologies

There are a wide range of tagging technologies and components available for AIT applications. It is important to note that not all technology are suitable for all AIT applications and the requirements need and associated costs need to be carefully considered in any AIT or data capture application. The following table gives a basic overview of the spectrum of typical AIT technology.

(From the paper presented at the International Conference on Health and Usage Monitoring - Melbourne, Australia, 15-17 March 2005)

Table 1 – Spectrum of electronic tagging technologies

Applications	***Attributes***	***Technology***
Location tracking Containers	**Active** Long range High cost	**Global positioning systems**
Asset security & visibility Remote vehicle locking Building security Local positioning systems		**Active RFID tags**
Maintenance management Engineering asset management	**Passive or Active** Zero range Large memory	**Contact memory tags**
Personal data storage Access control Bank account details Biometrics		**Smart card technology**
		Passive RFID tags
Retail source good tagging Product authentication Security	Low cost Small memory Short range	**Passive RFID labels**
Auto-identification Retail inventory control	**Passive**	**Bar code identification 2/3D**

Contact memory is not as well understood within the supply chain as, for example, bar codes or RFID due to the relative costs and number of suppliers, but within the engineering asset management environment it is having a significant impact, particularly where assets are dispersed, require off-line access to equipment information, configuration or usage.

Contact memory is a non-volatile, passive (no battery) technology that utilises EEPROM memory for the storage of data on the tag. The tags have a read/write functionality so information stored on the tag can be easily updated via a rugged 2-wire serial connection to the tag from a host PC. The figure below shows the typical configuration of tag on an item of equipment and the read/write probe.

The power required for communication with the tag is taken from the hosts computer through a serial or USB connection eliminating the need for battery management in the tag and reader probe.

Figure 1. Oxley etag contact memory device and reader probe

(From the paper presented at the International Conference on Health and Usage Monitoring - Melbourne, Australia, 15-17 March 2005)

This technology has been well established in a range of military and commercial equipment application and has formed an ideal basis for the integration of sensors for the purpose of micro usage monitoring.

Figure 1 Shows the typical application of contact memory technology in a military communications system. (The tag can be seen above the two connectors at the centre of the picture)

Technology Application

The application of contact memory technology has been well established both in the UK and USA on various military platforms.

For example, all of the UK BOWMAN communication systems have been tagged, 300,000 items to provide complete logistics and asset management for the British Army.

The memory buttons were integrated with the Bowman Integrated Logistics Systems (BLIS) and this enables BLIS to provide complete a logistics information system that enables asset tracking, configuration management, maintenance management and data capture of asset usage and fault metrics. The system covers the organisation of front line repairs, which are often carried out in or near the field of operations, industrial repairs and the return to the field operations. The rugged read/write contact memory tag technology used to manage the data enables all this information to be stored on individual items and assets of the system.

Other applications of the technology include helicopter maintenance and configuration management where tags are used to both measure and minimise the documentation involved in the through life support of aircraft and as an essential part of the configuration management of the platform. Maintenance and logistics engineers have visibility of the same information whether at the aircraft or at an airbase.

The applications of the technology are extremely varied and not only limited to the avionics environment. Other applications include: maintenance within the rail industry; industrial plant and equipment maintenance; consignment and cargo management and security management.

(From the paper presented at the International Conference on Health and Usage Monitoring - Melbourne, Australia, 15-17 March 2005)

industry requirements

The scope of the MUMS development covers low cost, non-volatile data capture solutions that record usage data and can be easily integrated into configuration control and engineering asset management applications.

The MUMS requirement was not to miniaturise an existing health and usage monitoring system, traditionally associated with an equipment platform, but to strip out many of the key elements required for maintenance and logistics of the sub-systems or line replaceable units (LRU) and to establish a device that interfaces with AIT and configuration management systems.

micro usage monitoring systems

There are often several key conditions that influence the maintenance of a particular component or sub-system e.g. hour run, distance travelled, stress levels. The measurement of these parameters usually also plays an important factor in the logistics and maintenance environment.

Within this environment it is often the basic usage data for low level items of equipment that either maintenance engineers or logistics operators need in order to maximise the availability or reliability of the equipment. This information is often only available either if the item has been integrated with a higher level health and usage monitoring systems or the item of equipment has its own monitoring system. The integration of simple non-volatile usage monitoring has often been desirable.

The objectives of the MUMS development were to develop a product that could be integrated into equipment at as low a level as practical and to make them as smart as possible.

Figure 1 - Typical configurations of the Micro Usage Monitoring System

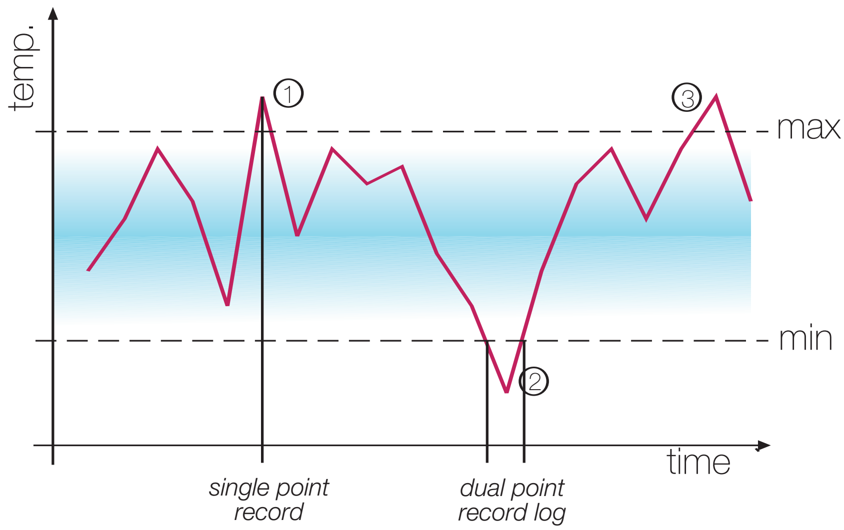
The integration of sensors and non-volatile EEPROM memory technology provides an ideal low cost solution to automatic data capture. Sensors can be an integral part of the systems or vibration sensors could form a non-invasive solution to usage monitoring.

One of the key concepts in the development of the MUMS device was to capture the results and not the data for post processing. Give the user the answer and not the information to 'find' the answer.

(From the paper presented at the International Conference on Health and Usage Monitoring - Melbourne, Australia, 15-17 March 2005)

Low level processing of the raw data at the component level, effectively making the sensor smart, enables the sensor to log only the 'out of tolerance' event information and record that specific event.

Figure 2 – Typical out of tolerance event log (a) single point measurement of the event, (b) dual measurement introducing out of tolerance period.



Events logged are then retained within the non-volatile EEPROM until either reported or a communication event triggered (also see wireless communications section)

MUMS features

The MUMS device can be configured to typically include one or several of the following parameters.

Temperature logging capability

The device reads the instantaneous temperature at the time of reading and the time and date appended by the reader if required.

The device will check the temperature at a programmable interval and update a minimum and maximum value registers. There will be no record of real time but there will be a total of time beyond specified programmable limits.

The device records the temperature every hour whilst running but there will be no real time available. A maximum of 10 years data at 1 hourly interval will be available.

The reading accuracy is +-1degC over the range –55 to +125 with a greater accuracy over the centre of the range. A resolution of +-0.25 degC can be achieved however calibration of the device would be required

Shock logging capability

The device is capable of logging shocks greater than a programmed minimum shock value over time. The device must also keep a total of how many times the device has received an "over shock". This is logged against the running hours that had elapsed when the shock events occurred.

(From the paper presented at the International Conference on Health and Usage Monitoring - Melbourne, Australia, 15-17 March 2005)

Range and Resolution - The range would be 0-50g and the resolution 0.2g. Typically logging - A minimum of 1000 over shocks would be logged against the running hours value at the time the event occurred.

Running hours
The device keeps a total of the accumulated time that it has been powered up. The total will be 1 million hours with a resolution of .001 hours, (3.6s). The accuracy will be better than 1%. (1 part in 10^9 i.e. 32bit values).

Power up events
The device will keep a total of the number of times it has been powered up whilst ignoring spikes and noise. Up to 1 million power up events can be logged. Optionally the running hours at which the power up occurred may be logged. Similarly power down events could be logged.
Optionally the running hours at which the power up or down event occurs may be also be logged.

External analog measurement input
The device has an external analog input line that can be connected to any analog sensor depending on the application. A measurement can then be taken at a configured frequency in a similar way to the temperature logging. The device will be able be able to automatically measure the analog level at every power-up event.
The resolution will be 12 bit (0.025%) and the maximum voltage will be 5V. The capacity is 10yrs at one reading /hr

External binary events
The device can accumulate the number of times an external event line has been activated and optionally the running hours count at which the event occurred.

Mechanical configuration
The physical embodiment of the device will typically be a panel mounted thumb-sized assembly. This lends itself to both integration at manufacture and the retro fit to other systems.

Due to the harsh environmental conditions in many of the applications the device has been designed to meet the basic standard of MIL-STD-339

Data security
The functionality and communications with the data logger can be protected by initialising the security feature on the memory tag. This effectively sets a 'true' on-chip software password on the contact memory tag and can only be reset using the correct password.

Serial data interface
This allows commands to be sent to the device from the reader probe and data to be read back from the micro-controller and the memory. During this process, and when the host equipment is switched off, the internal power supply regulator derives its power parasitically from the serial data. This process is known as "cold read" and will allow the user to access the data without powering up the equipment.

Host equipment connections
Connections are provided for detecting when the host equipment is switched on to allow running hours to be measured by the micro-controller. The internal regulator derives the internal power from the host equipment power during periods of operation.

Auxiliary analogue input
This is an analogue input signal that allows the device to take readings from any form of transducer using the analogue to digital converter (ADC). An internal thermo-couple is also included which can be used in place of this auxiliary analogue input.

Non-volatile EEPROM memory
The non-volatile EEPROM memory holds a combination of configuration data, user data files and historical readings such as running hours, analogue readings and event counts etc. The allocation of this memory is re-configurable by the user through simple serial commands.

Software development kit
Establishing the range and resolution together with logging periods and alarm levels are software defined. However, software development kits and drivers to enable third party integrators to use the technology are essential if the MUMS units are to operate with engineering asset management software tools.

systems integration and open systems
One of the biggest hurdles to the adoption of next generation data capture device technology such as MUMS is not the costs of the hardware but the associated costs of integrating the technology with the various software asset management systems!

Within several significant engineering asset management programs worldwide a strategy of the open systems is being employed in the development of the software environment. Standard data structures are being defined that enable the information to be utilised within one or many enterprise resource planning (EPR) systems.

The use of, for example, XML in the data structures means that data can be defined and schemas developed that enable information to be used within a number of systems. Both data and schema can be storied within the MUMS device so that this information can be integrated into configuration management, logistics and maintenance systems. The same data can then be used within the manufacturing, supplier, operator or support environment.

Retaining the data on the electronic tag also enables the data to interface with various management systems thus eliminating the need to build ‘middleware’ or import/export routines.

The benefit of having both data and schema on the MUMS module is the history of the equipment is retained with the item throughout its life. Equipment fitted with a MUMS device could capture both the complete life history and configuration, but also the usage data for as long as it is practical or useful to the management of the equipment.

future developments
Wi-MUMS concept development
The application of wireless interface communications has been pervasive over the past few years.

One of the fundamental benefits of introducing wireless communications with either retail goods or items of military equipment has been to improve the efficiency of managing assets.

This is also true in the areas of preventative maintenance. Traditional HUMS technology has utilised wireless communications for many years and the standard wireless protocols have been essential in the development of the technology.

The ability to provide a basic MUMS device coupled with a wireless interface also gives the users various options regarding the type of wireless protocol selected, the frequency and the range of the interface. The range will however be limited by the available power and the configuration of the system.

Establishing wireless nodes within the MUMS environment has also been reviewed and the concept of integrating a wireless communication device established. A MUMS module with a wireless transmit/receive module fitted to the basic MUMS units could connect the various individual items of equipment to a network and transmit used data and or alarm information based on usage.

Power harvesting

The integration of either piezo-electric or micro mechanical components to supply low levels of power from the mechanical movement or vibration of the equipment has also been considered and the feasibility of such components established. To utilise current power harvesting technology a combination of other technical development will need to be deployed, including low power electronic and micro systems packaging technologies.

conclusion

The development of micro usage monitoring systems provides a solution for the automatic identification, usage monitoring and data capture of information for equipment not previously considered suitable for health and usage monitoring systems. In the same way electronic tagging has become an integral part of the logistics so low cost micro usage monitoring devices will enable the integration of monitoring techniques in equipment and structures to improve engineering asset and maintenance management.

Company approvals:
BS EN ISO 9001:2000
QAS/34/61 REG No. FM 01759
CECC Approval No. M/1034, BS 9000
Approval No. 1048/M
BS EN ISO 14001:1996 EMS 60559

Oxley Developments Company Ltd

Priory Park
ULVERSTON
Cumbria
LA12 9QG
United Kingdom

t: +44 (0) 1229 582621
f: +44 (0) 1229 585090
e: sales@oxley.co.uk

w: www.oxleygroup.com/etag

Oxley Inc

25 Business Park Drive
BRANFORD
CT 06405
USA

t: +1 (203) 488 1033
f: +1 (203) 481 6971
e: sales@oxleyinc.com

Oxley Group Australia Pty Ltd

PO Box 24
Artarmon
NSW 1570
Australia

t: +61 (0) 2 9967 9488
f: +61 (0) 2 9967 9433
e: sales@oxleygroup.com

ODCSM40647/1/2005