iSLI and Ultra Electronics BCF collaborate on an R&D project to improve the monitoring of wiring in aircraft

Whilst there are many avionics systems that monitor communications, navigation and display and management of multiple systems, wiring often gets overlooked in terms of in-flight monitoring. The current state-of-the art technology tests the behaviour of the wiring harness, but only on the ground. This requires the plane to be out of service and for separate sections of the wiring to be accessed directly with test equipment designed for that particular aircraft. Currently there is no system available that will tell manufacturers and operators when problems are likely to occur, or indeed if a problem has occurred. The design team at the Institute for System Level Integration (iSLI) has teamed up with Ultra Electronics BCF Ltd. to achieve a new capability that could eliminate this problem and make aircraft much easier to operate and maintain.

The two companies began collaborating under the ‘Network of Excellence’ (Patent Design for Micro & Nano Manufacture DfMM) project run under the ‘EU Framework 6’ funding programmes (FP6). The Network of Excellence aims to establish a new technical community that will address the underlying engineering science to ensure that problems affecting the manufacture and reliability of products based on MNT can be addressed before prototype and pre-production.

The project under research and development has two sections, the first of which aims to provide proof of principle of MEMs sensors being applied to monitoring the environment surrounding wiring in the aircraft, whilst the second aims to demonstrate that the gathered data can be sent wirelessly to a central hub where it can then be passed to the aircraft’s avionics systems.

The first section is funded by the South East England Development Agency, with the design group at iSLI acting as a sub-contractor to BCF. The sensors under development need to gather multiple types of appropriate data from a position intimately connected to the wiring. The ultimate goal is to be able to monitor how quickly the wiring will age, if it is constantly getting wet or stretched for example. This will allow maintenance to be done when it is needed rather than doing it much more frequently than strictly necessary or waiting for a failure.

Both iSLI and Heriot Watt University are conducting research and development into the types of sensors that can be made and how they can be realised in the available processes. The processes are also currently under review and development by Qudos Technology at the Rutherford Appleton Laboratories in Oxford. The first sensor devices will measure temperature, humidity, strain and changes in electrical current. They will be manufactured using MEMS processes based on silicon, with the ultimate aim being to make at least three of the sensors in a single process.

In order for the project to achieve its primary aims, there has been a significant requirement for research as the sensor technologies are not widely in use, but are found in academic literature. Head of the iSLI Design Group, Mark Begbie comments,

> *Moving the research outcomes from a disparate group, to a set of modeled designs which can be made on as near the same process as possible has been the biggest challenge to date, with choosing base designs, optimizing and making trade-offs in materials used and the like.*

At this stage in the research project the requirements and the performance modelling are poorly characterized, but the team is moving towards the point where a first set of these sensors will be tested and characterized in order to confirm the accuracy of the modelling. The designs will then be re-optimized to get to a point where we are designing for the level of performance that the BCF is looking for. As there are no equivalent products on the market that tackle this issue, the sensor system will be applicable across a whole variety of industries that need to monitor the effect of the environment on wiring; in building, bridges or trains for instance. The advantages of extending the set of sensors available are clear; aircraft equipped with this technology will be cheaper and more efficient to maintain and operate as well as having a higher safety margin.

The secondary aim of the research project is to develop a highly robust system that can gather data wirelessly to a central hub from which it can be passed to the aircraft avionics systems. The data will be moved from one sensor node to the next (a bucket chain) until it reaches the hub. The system needs to keep working even if the nodes die so the design needs to incorporate the ability to add new nodes without it causing a problem.

To achieve this, an appropriate platform has been designed with which to demonstrate the technology. This consists of a commercial radio chipset operating in the license free 433MHz band built onto a bespoke PCB designed by iSLI. It is smaller than a business card and runs on a single penny cell battery. Whilst this platform is used for demonstration, iSLI is not tied to the technology.

The design team has also created a communication protocol stack based on the Berkley MAC [B-MAC] which will implement the actual network behaviour. Developed in-house, this will run on the boards themselves. One of the boards (nodes) will be attached to a PC via USB and will act as the main hub that the data is ultimately passed to. The software is built in a layered fashion which means in the future the different layers can be modified (the physical communication hardware or the type and amount of data that is sent) without having to redesign the whole system.

The first generation wireless system therefore uses a universal 'node' board operating in the unlicensed 433MHz radio range to transmit and receive sensor data. All boards are the same, but one will be attached to a PC and will act as the final destination for the data. They will operate a bespoke network protocol to implement an ad hoc multi-hop data transfer protocol; whereby the data is passed from node to node until it reaches the hub.

Mark Begbie comments,

> *In the wireless project the first of the challenges was in finding suitable wireless hardware which will operate with low power consumption, reasonable range and without restrictions on use for the prototype stage. The 433MHz band satisfies all of these criteria. Then when designing the wireless protocol we chose to use the B-MAC as a starting point, stripping out those features we did not need and then building the software core up from the start. Academic literature provided the basis for the network protocol and traffic management layer of the software, but we were also extremely fortunate to have in-house experience of developing exactly this sort of thing for Bluetooth.*

With low power operation and a multi-hop self-healing network structure to increase reliability enabling the network to cope with the breakdown of individual nodes, the system is designed specifically to be optimized for gathering and transmitting data from remote low powered sensor modules. The modular design also enables other radio technologies to be used for different applications where required. The applications of this technology are in Health Management and Prognostics for structures such as aircraft or remote installations where other methods of maintenance management can be time-consuming and costly. Other applications could include building environmental control, asset and personnel tracking on a site. The wireless design however, is generally suited to any application where there is a distributed array of nodes and you want to get information across the space they occupy.

This application of a new technology (MEMs) in conjunction with a new twist on an existing technology to create a new capability has a myriad of implications for the avionics industry in the operation and maintenance of aircraft. If the research project is successful in the creation of sensors to record how and why wiring in aircraft ages, it is to be anticipated that in the next 5-10 years this technology, created by iSLI and BCF, may be an industry norm.

ENDS

Editors' notes:

Founded in 1998, iSLI (the Institute for System Level Integration) provides postgraduate education, professional training and research in system level integration incorporating cross over technologies such as hardware, embedded software, MNT/MEMS.

A collaboration of the computing science, informatics and electronic engineering departments of the universities of Edinburgh, Glasgow, Heriot-Watt and Strathclyde, and Scottish Enterprise, the Institute is the first centre of excellence in system level integration to be established worldwide. Its aim is to support the development of electronics systems design worldwide and to encourage the exploration of new technologies through research.

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