September 1993

Eureka

ENGINEERING MATERIALS & DESIGN

Sound Wave System Changes The Economics Of Torque Sensing

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Acoustics sense torque at low cost

Tom Shelley reports on a signal processing technology which also provides a better way of measuring strain. Designers in many industries will welcome its appearance

By mounting tiny slivers of quartz on a shaft and electrically vibrating them, it is possible to measure applied torque to within a few parts per billion. All this, without any mechanical contact between the shaft and outside world.

The base technology comes from the world of electronic signal processing, where devices which pass vibrations across them as SAWs (Surface Acoustic Waves) allowing the selection of narrow frequency bands with exceptionally high precision.

The availability of high accuracy, low cost, non-contact torque measurement affects many industries, from condition monitoring in bank telling machines to the monitoring of cement mixers. But the first application – an electric power steering system – could bring noticeable benefits to drivers of cars too small to be equipped with hydraulic or pneumatic equivalents.

Sensor Technology of Banbury have made no secret of the fact that for the some time, they have been developing a low-cost torque sensor in conjunction with the University of Manchester as part of a DTI LINK scheme.

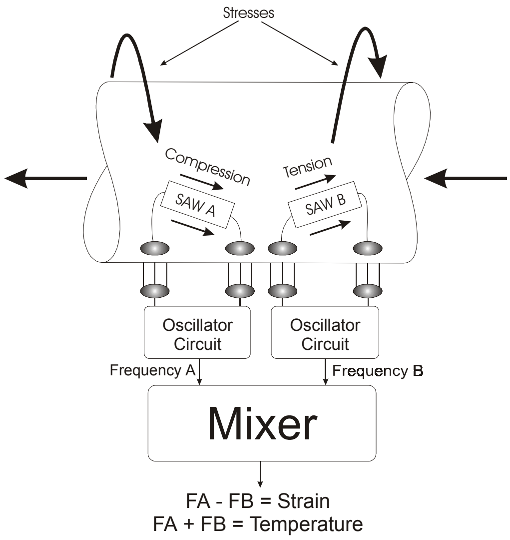
Most engineers who have been aware of the development have assumed that it was somehow based on the optical displacement technology for which the firm is noted. What is now revealed, however, is that the technology used is based on SAW resonators, working at around 400MHz.

Design Pointers

- Use of SAW transducers allows the achievement of a resolution strain of at least one part in a million, or even a few part per billion. Linearity is better than 0.1%
- Because the system uses very little power, it is intrinsically safe, with long term reliabilty
- Costs are likely to suit the automotive industry and makers of consumer goods

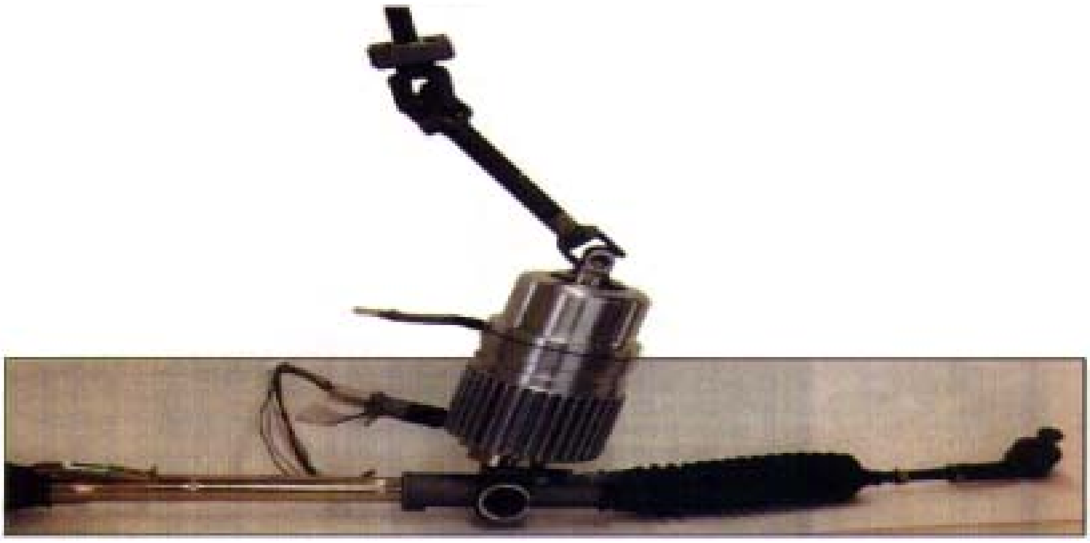
Fragments of quartz, lmm X 3mm with etched aluminium electrodes are placed on flattened areas of shaft in association with electrical pick-up elements on printed circuit boards: along with transmitting elements which form part of the return loop to the fixed, driving electronics.

Each SAW device – there are two on each shaft at 45deg to the axis and at 90deg to each other – forms part of an oscillator circuit. The natural resonant frequency of each element depends on length, affected by strain, and also temperature.



If the shaft on which the elements are placed is twisted, one element becomes shorter, so that its natural frequency increases, while the other becomes longer, so that its natural frequency decreases. Taking the different between the two natural frequencies then establishes the amount of strain. Temperature effects on transducer elements and shaft cancel each other since they act on each device in the same way. By adding the frequencies from the two devices, it is possible to determine temperature, free from the effects of strain if this is desired.

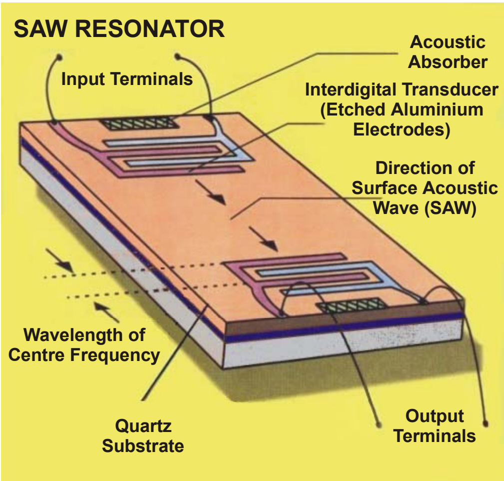
The driving electronics are designed to run from an unstabilised 24V supply commanded and read by PCs or PLCs. About 1mW RF at 0.2V is available to the transducer elements. This renders the system intrinsically safe, especially as there is no possibility of generating even the tiniest sparks as would be the case with conventional strain gauges and slip rings.



Above: Adwest Engineering's prototype electric power steering system uses the Sensor Technology torque transducer.

The use of frequency measurement to determine strain offers very high accuracy, typically 1 or 2Hz in the 400 million Hz currently in use, and renders the system much more resistant to electrical interference effects than analogue techniques. For this reason, one of the participants is interested in using the SAW technology as an alternative to conventional strain gauges in fixed mode, since eventual costs of the two techniques at the same volume production levels is thought likely to be similar.

The exact method of exciting the transducer elements depends on spacing between driving electronics and shaft – capacitive techniques being considered most appropriate for close spacings; inductive for 20 to 30mm; and radio frequency techniques for greater distances.



The first major application to be announced is at Adwest Engineering, who make hydraulic power steering systems for Land Rover, who have revealed a demonstration all-electric system making use of the technology. Inventor, and company director, Anthony Lonsdale says his system has a compliance of less than 0.1deg as opposed to orders of magnitude worse in previous systems. While hydraulic and pneumatic power steering servos are quite common in larger cars, most companies, including Lucas, have for some time been saying that it is necessary to develop much more compact, all-electric systems for the smaller cars favored in Europe's crowded capitals.

Other applications under consideration include the bearing condition monitoring of coal conveyors for power stations and bank cash dispensers. It is apparently considered that monitoring the torque profile of cash dispensers as they worked could be used to give clear indication of when they are in need of maintenance attention, long before they jammed in the process of accepting or issuing somebody's money.

Other obvious applications are in mixing machines including cement mixers, where torque monitoring can be used to measure viscosity, and assist in process control, so that only just sufficient time and energy are applied to accomplish the task. Motor drive controls generally may wish to make use of torque transducer input as part of their control strategy, this being a more direct and immediate indication of system load than motor current, and it is possible that even washing machines might one day have them to prevent motor and bearing damage from overloads.

Apart from the power steering system, the development is presently at the stage of prototype units being delivered to the other LINK members. The technology is patented.