Wireless Passive Resonant SAW Sensors for Monitoring Temperature, Strain, Torque and Pressure

Victor Kalinin

Transense Technologies plc
1 Lanscape Close, Weston-on-the-Green, Bicester, Oxon., OX25 3SX, UK
e-mail: victor.kalinin@transense.co.uk, web page: http://www.transense.co.uk

ABSTRACT

The first suggestion to use SAW resonators as non-contact passive strain and torque sensing elements is dated by 1990 [1]. Since then, passive wireless SAW sensors based on resonators were a focus of intensive research for a number of groups [2,3] and, by 2010, such sensors were developed for pressure, temperature and torque sensing, in particular, for automotive applications [4]. Nowadays, development of wireless SAW resonant sensors continues for other sectors of industry as well, for instance, for condition monitoring of engines, gearboxes, switchboards, hydraulic couplings, etc., in order to implement procedures of their preventive maintenance. The aim of this paper is to give an overview of the principles of operation of wireless SAW resonant sensing systems and present solutions for automotive and industrial applications that have been developed at Transense Technologies plc up to the present moment.

Advantages and disadvantages of SAW resonators are considered in comparison with SAW reflective delay lines, another type of SAW sensing elements, in conjunction with the existing EMC regulations. Principles of design of differential resonant elements and their sensitivity to strain and temperature are discussed. Special attention is payed to packaging and methods of attachment of the strain sensing elements to achieve their good repeatability and long-term stability.

Influence of antenna parameters on resonant sensor characteristics is discussed. Designs of some near-field RF antennas/couplers for non-contact measurement of torque, force and vibrations on rotating components are presented.

Methods of interrogation of wireless resonant SAW sensors are reviewed and the design of some readers developed at Transense is presented. A trade-off between the sensor bandwidth, the read range and the sensor resolution is discussed for different frequency estimation algorithms.

A number of applications of wireless passive resonant SAW sensors are presented for monitoring pressure and temperature in automotive tyres, for measuring torque in electrical power assisted steering, at the output of engines and at the input of gearboxes, for monitoring torque at the output of wind turbine, marine and industrial gearboxes, for monitoring temperature at high voltage and in other types of harsh environment.

In conclusion, prospects for further development of wireless SAW resonant sensors are discussed.

REFERENCES

[1] A. Lonsdale and B. Lonsdale, “Method and apparatus for measuring strain”, Int. patent public. No. WO 91/13832, 19 Sept. 1991, Int. Applic. No. PCT/GB91/00328, Int. filing date: 4 March 1991, Priority: 9004822.4, 3 March 1990, GB.

[2] L. Reindl, G. Scholl, T. Ostertag, H. Scherr, U. Wolff, and F. Schmodt, “Theory and application of passive SAW radio transponders as sensors”, *IEEE Trans. Ultrason., Ferroelectrics and Freq. Control,* vol. **45**, No. 5, pp. 1281–1292, (1998).

[3] W. Buff, S. Klett, M. Rusko, J. Ehrenpfordt, and M. Goroll, “Passive remote sensing for temperature and pressure using SAW resonator devices”, *IEEE Trans. Ultrason., Ferroelectrics, and Frequency Control*, vol. **45**, No. 5, pp. 1388–1392, (1998).

[4] V. Kalinin. “Wireless physical SAW sensors for automotive applications”, *Proc. 2011 IEEE Int. Ultrason. Symp.*, pp. 212–221, (2011).