Smart Sensors Interface for Wireless Data and Power Transmission

Jerzy Weremczuk, Krzysztof Plotczyk, Grzegorz Tarapata*, Ryszard Jachowicz
Institute of Electronic Systems
Warsaw University of Technology
Warsaw, Poland
jwer@ise.pw.edu.pl

Xue Chuan Shan, Chee Wai Patrick Shi Hon Tat Hui *
Singapore Institute of Manufacturing Technology
(SIMTech) Singapore, xcschan@simtech.a-star.edu.sg
*National University of Singapore, Singapore elehht@nus.edu.sg

Abstract—The paper presents the interface designed for wireless data and power transmission. The interface operation idea was tested using build up hardware and software. The sample construction of the temperature sensor embedded with this type interface was designed. Measurements show that the sensor can be wirelessly supplied with energy and is capable to sent data (temperature readings) in 5 cm distance. The interface is universal and can be used after some modifications with any type of sensors.

Keywords-component; smart sensors, wireless data acquisition, measurements systems

I. INTRODUCTION

Microsystems and microsensors have to contact to surrounding environment to measure its parameters (e.g. humidity, chemical composition, etc), therefore they should be open to the environment. From the other hand to protect the electrical contacts between microsystem/microsensor and the rest of measurement system it is necessary to protect them from the environment harsh influence. These two opposite requirements are difficult to meet with wire connections. Because of that, in many cases, sensors/microsystems have limited reliability.

This problem can be avoided with wireless signal transmission from microsensor/microsystems to the universal transceiver which is regularly connected (e.g. using wire bus) to measurement system. The sensor structure has not wire connections and is encapsulated to protect electronic circuits from environment destroying influence. Required supply energy is transmitted to the sensor wirelessly using special coils embedded in sensor structure and in transceiver [1,2,3]. Those coils are also used for digital data transmission. The proposed wireless interface system is universal and can be applied to any type of sensors. This interface idea creates a new class of sensors which can be supplied using electromagnetic energy and can communicate with digital protocol.

II. INTERFACE IDEA

The interface idea is shown in Fig.1. The typical microsensor/microsystems structure is split on two parts. The upper (top) part contains a sensor, measurement circuits with microcontroller, data transceivers and power receiver. That part is completely passive, even it has not battery. To activate the sensor it has to be placed in electromagnetic field. The second part of interface (bottom) forms the universal data and power transmission unit that is connected by wires to the measurement system. Both parts are facilitated with inductive coils dedicated for wireless data and power transmission.

Figure 1. The idea of wireless communication of removable “smart sensor” structure with control/data transceiver unit.

The smart sensor structure can operate with some distance to the transceiver unit e.g. sensor can measure some chemical quantity in liquid environment and send data to transceiver which is located nearby in unaggressive environment. Using this idea of the wireless interface the sensor part is easy to exchange and has no wire connections which considerably increase reliability of the sensor.

III. INTERFACE CONSTRUCTION

The proposed interface was design using Radio Frequency Identification (RFID) principle with wireless power transmission. A low power 13.5 MHz electromagnetic wave is able to deliver enough energy in short distance to supply simple analog and digital circuits (with microcontroller).

A. Hardware

The Warsaw University of Technology (WUT) designed smart sensor and wireless interface. The project included...
structure design, layout design, simulation and optimization of the interface. The Singapore Institute of Manufacturing Technology (SIMTech) fabricated the sensor board using Low Temperature Co-fired Ceramic (LTCC) technology and PET foil.

The Fig.2 shows the block diagram of the system with wireless transmission to removable “smart microsensor” structure using control and data transceiver unit. The wireless interface provides near-field and close proximity coupling. With this approach, the sensor part can only be mechanically pluggable and allow gaining key advantages:

- the replacement of sensors, especially valuable for disposable sensors and sensors with short lifetime;
- the realization of a standard universal platform for different sensors applications.

![Figure 2. The block diagram of sensor digital interface with wireless power transmission.](image)

The practical realization of microsensor unit (top, yellow part shown in Fig.2) was based on the MSP430F2012 low power microcontroller (from Texas Instruments). To test the interface operation, the sensor part has been facilitated with temperature sensor. Temperature data were treated as test information. After measurement (A/D conversion) data were transmitted to transceiver (bottom part in Fig.2) using wireless interface.

![Figure 3. The top view of sensort unit (befor encapsulation) which is placed on transceiver coil (black box) realized using epoxide (top photo) and LTCC (bottom photo) PCB.](image)

The sensor part is presented in Fig.3. The Printed Circuit Board (PCB) dimensions are 2 x 1.5 cm. The sensor PCB has soldered electronic components. The inductive coil for data and power transmission is located on the PCB borders on the bottom side therefore is invisible in Fig.3.

### B. Data frame

The data frame for digital transmission was defined in the following manner. The first part at the beginning of the frame contains 16 of “1” for transceiver synchronization. Next there are 2 of “0” for data separation and transceiver setting for data receiving. Finally we have data flag “1”, control data - 1bit, data (temperature reading) – 11 bits and CRC – 3 bits to check frame correctness. In summary, there are 32 bits frame where 12 bits carry measurement information. The rest of bits are used for frame construction and transceiver synchronization. The scope of sample frame is presented in Fig.4.

![Figure 4. Scope of sample frame.](image)
C. Software

To control data exchange between two electrically separated parts i.e. sensor part and transceiver part the special software has been created in LabView environment. The software operates on laptop and communicates with transceiver unit by USB interface. The software allows tracing all frames which are received or send by transceiver. All bad frames are marked in red and the reason of frame excluding (e.g. CRC error) is presented in screen. The control panel is shown below.

The software is used to configure the measurement process parameters: the source of temperature data (microprocessor build in sensor or separate sensor), the measurement repeating time, and the measurement mode (continuous or command triggered). All received data can be saved by computer in a file for off-line analysis.

IV. Tests

To test the interface operation the Bit Error Rate (BER) during temperature reading was investigated. The sensor structure was shifted in both horizontal (x, y) and axial (z) directions. The sample measurement results are presented in Fig. 6.

![Figure 6. BER during test temperature data transmission in a function of horizontal (x,y) and vertical (z) shift of sensor and transceiver modules.](image)

It can be seen that at distance 5 cm (horizontal shift) and 8 cm (vertical shift) the BER significantly increases. Transceiver and sensor coils misalignment is not as important as was observed for analogue interface [3] - interface operates well in the distance shorter than 5 cm.

V. Conclusion

The presented in the paper interface for wireless data and power transmission was build and tested. The operation range of temperature readings (in digital format) was about 5 cm. The interface is universal and after simple modifications, can be used with different types of sensors.

REFERENCES