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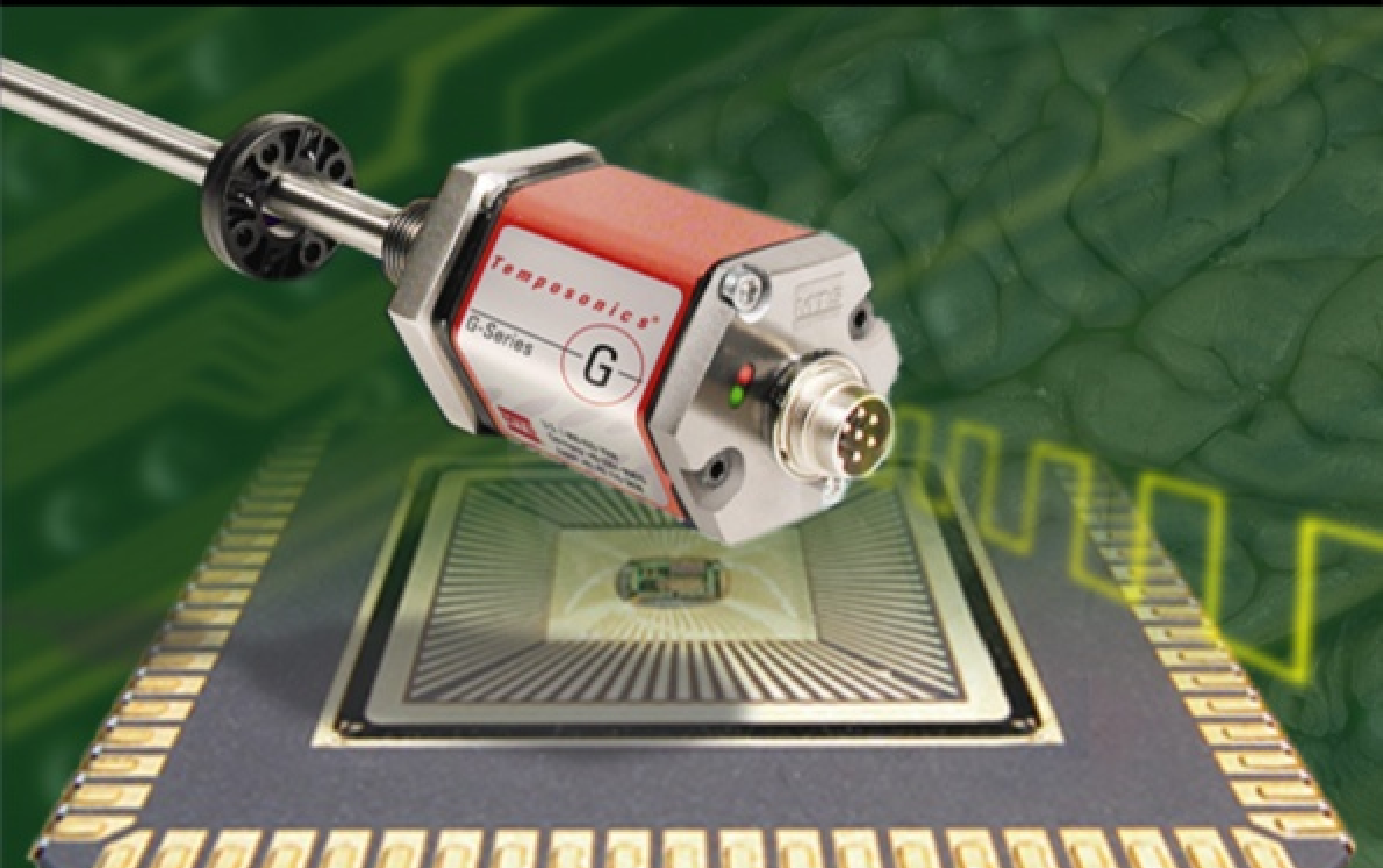

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Using RF Smart Points for the Improvement of Metrological Activities

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Abstract: This work describes the realization of a "radio-frequency identification system" for the improvement of the activities of a metrological laboratory. Some radio-frequency modules, called by the authors RF Smart Points ("radio-frequency smart points"), have been designed to store into their memories all data which are necessary for the instruments tracking (the type of instruments, their identification numbers or serial numbers, the manufacturer, the date when they have been admitted to the installed base of the laboratory, their working state, the elapsed time from the last calibration procedure).

The insertion of the data and the inquiry of the instruments are executed by the technical staff of the laboratory through a PDA (Personal Digital Assistant) or a PC, which manage the radio-frequency communication by using the RS 232 interface for sending messages to a RF Transceiver. The executable software for managing the communication between the Smart Points and the "PDA/PC-Controllers" is realized in LabVIEW graphical programming environment. *Copyright © 2007 IFSA.*

Keywords: RF Communications, Smart Instruments, RF Identification Systems

1. Introduction

The last years have been characterized by the necessity to make the objects smarter and more versatile, with the aim of increasing their capability to be useful in human activities. The technological growing up of the last decade has aimed at distributing the abilities of devices and systems assigned to the localization, visualization, and data collecting to get information about the evolution of the phenomena of the real world. The ref. [1] shows that wireless network nodes are becoming more and more selfsufficient, so to make lighter the duty of the controller for the centralized management of the processes. The measuring field, as an example, records the tendency to realize and to put on the market devices able to furnish their position and even an electronic version of the data related to their accuracy (in 2005 National Instruments and leading Sensor Vendors released more than 3200 transducer electronic data sheet smart sensors). There are fields in which the applications are mobile by definition, as in the event of a technical worker moving within and industrial facility (indoor or outdoor mobile). In such case it needs to facilitate as well as possible the capture of the information assuring timeliness, congruence and completeness of the data, achieving a management of the events on the spur of the moment in which they occur.

To capture and to manage the information on field implies the use of suitable tools: according to input type, output type, physical and functional characteristics, type of connectivity. The technology that exploits the RF communication has lately been considered of great interest in the scientific communities, thanks to the wide diffusion that the RFID (radio frequency identification) devices are having at the present, as one may see in ref. [2] and [3]. They're systems able to notice data, events and changes of state, as a natural result of the fact that a structured set of information (variables) is made available in a certain instant on board of the objects. The transponder, or RFID tag, can be compared to a dynamic memory file that can contain useful information for the management of the processes of the supply chain (the tracking related to the consignment of the goods, as an example, may reside directly on the container). As a matter of fact a RFID-based management system is nothing else but a RF system which is alerted when the transponder notices the field produced by the antenna connected to the RFID reader. A RFID-based management system is nothing else but a RF system which is alerted when the transponder notices the field produced by the antenna connected to the RFID reader. A lot of applications, even in “automotive and security” sector (as the unpublished [4]), use the RFID technology, and so design engineers working on RFID designs are becoming more and more.

Nevertheless in some cases it is interesting to be able to consider the possibility that the “controlled” device (without being inquired by the reader) advices the controller of possible changes of state, and this asks for a continuous and non-stop transmission.

The authors of the present work have examined the case of a metrological laboratory, in which the tracking of the instrumentation endowed with a device (the realized RF Smart Points) is achieved in an automatic and immediate way. The RF Smart Points are small elaboration units supplied by the electric network which have to be attached to the instrumentation. For their realization some RF transceivers are used; they work with the typical antenna powers of a low consumption radio-receiver, so the power required for their feeding is compatible (from an electromagnetic point of view) with all the equipments present in the laboratory.

2. Statement of the Problem

The instruments of a metrological laboratory may undergo state changes during their vital cycle; they’re due to different motivations: i) the instrument is requested by another department of the same laboratory, and therefore it changes room up to the carrying out of the assignment for which it has been in demand (internal displacement); ii) the instrument doesn't correctly work and therefore it leaves the laboratory because it needs the service assistance (faults are detected); iii) the instrument has to be recalibrated, because its reliability level doesn’t match a specific target of quality; it means that its measuring results can no more be evaluated by using the calibration certificate by which the instrument is equipped.

Up to now these information have been made available from processes of centralized cataloguing and data collecting on the technical card of the specific instrument; the documentation is furnished therefore on papers that can encumber or take the risk of dismaying. Besides, manual labeling processes for the individualization of a specific instrument inside the laboratory are necessary. Imagine for instance the case in which an instrument is not present, for error, in one determined area or division to which it had been assigned. With the methods till now used, once the lack of the aforesaid equipment has been noticed, a visual inspection is in demand for tracing it (with notable losses of time).

This paper deals with a metrological laboratory constituted by instruments which are made smart thanks to the application of a RF Smart Point on them; this last one is able to furnish a detailed report (when inquired) about: a) the really state of service, and that is the divisions of the laboratory in which the instrument has been employed, with indication of the time of use; b) the really working state, and that is the indication around the good or bad working of the instrument; c) the elapsed time to the next calibration of the instrument, according to a methodical maintenance planning based on the search of the optimum calibration intervals, as described in ref. [5]; d) the collocation of the instrument.

The terminal of control can question one or more tools contemporarily, which are classified and gathered for typology, metrological characteristics, working state, and other parameters which may be selected by the user/technician.

In practice it is possible to be provided, from time to time, with a list of the instruments that correspond to the selected requisite of search.

In Fig. 1 one may observe a simple configuration of the realized system of radio-identification, which makes smarter the typical instrumentation of an Electronics Measurement Laboratory.

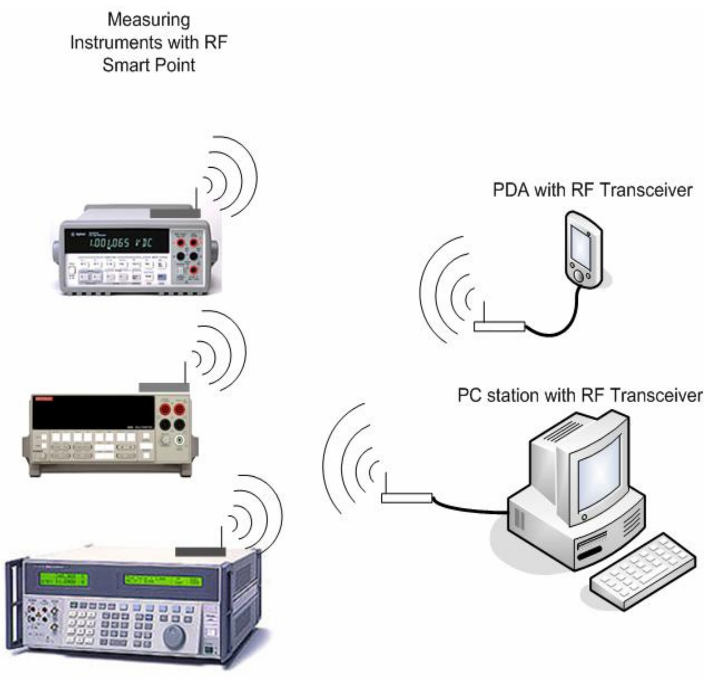

Fig. 1. The RF identification system based on RF Smart Points.

3. The RF Smart Point

A. RF Identification System Architecture

Each RF Smart Point (see the circuital schematics of Fig.2) consists of six principal components: a) A I^2C 1Mb EEPROM Microchip 24AA1025 PDIP 8; b) A microcontroller PIC17F877A PDIP 40 pins;

c) A RF Transceiver (433MHz); d) a Dallas Semiconductor DS1338 Real Time Counter with backup battery; e) A buzzer, status leds, and generic control buttons.

The microcontroller has got a UART (Universal Asynchronous Receiver Transmitter) port for the serial communication with the RF module at 9600 baud/rate. The formality of working of the same module is managed by the microcontroller, realizing the transmission, receipt or stand-by operation of the radio-frequency devices.

Metrological data characterizing the instrument, to which the RF Smart Point is attached, are available (read/write) in the 1 Mbit EEPPROM Microchip 24C1025 in ASCII code; the memory has a I^2C (2-wire) interface at 400 kHz.

The RTC device, communicating with the microcontroller through the I2C sharing with the EEPROM, deals with the scanning of the time furnishing information on the date and on the current time; operations are guaranteed for months also in absence of the external feeding thanks to the presence of a backup battery.

Finally some reset and configuration buttons are present on the RF Smart Point, together with status leds and a buzzer, which can be activated for the localization of the instrument within the laboratory or within a depository.

The management of the peripheral of the microcontroller is committed to a simple but efficient system of interrupt software implemented in C code. The PIC recognizes the application sent to the consumer or technical supervisor through PDA or PC and answers or performs some operations, in function of the data which are present in the memory.

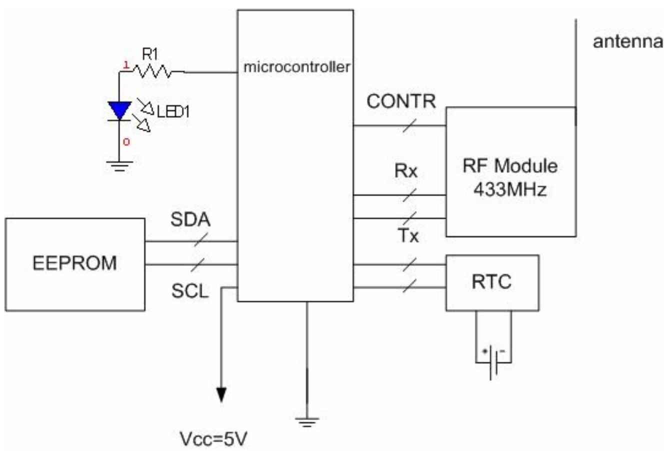

Fig. 2. Circuital schematics of the RF Smart Point unit.

B. The Anti-collision protocol

To avoid the contemporary transmission of data to/from more devices (it causes the well known problem of the collision of information), each RF Smart Point is questioned previous the dispatch of an identifiable code (it is univocal), that establishes which instrument has to send/receive the message. In the case in which an application to the RF Smart Point ends with a transmission of information to the user, an acknowledgement message of confirmation is provided; it closes the communication and informs the RF Smart Point that the transmission has gone successfully. On the contrary case the procedure is again performed for a determined number of times, until it doesn't conclude with positive result.

C. The Application-oriented Software

The RF Smart Point unit is questioned by a PDA/PC terminal which executes an application-oriented software implemented in NI LabView^{TM} (vers. 7.1) environment. It manages the RS232 communication with the RF Transceiver (it is a smart module "read and write" which consists in the same circuital schematics depicted in Fig. 2, but of the EEPROM) as showed in Fig. 1.

As a default condition, all the RF Smart Points reached by the signal send their ID Code (instrument serial number) stored in the EEPROM of their microcontrollers, every hour (under the condition of RF Smart Points supplied, and the application in execution). And so the user is provided of a list of all the devices which are present in the laboratory division which is selected in the front panel of the software, as in Fig. 3. Each time a change in the composition of the laboratory occurs, it is detected by the microcontroller of the RF Transceivers module, and then is notified in the front panel of the software interface with an alarm signal.

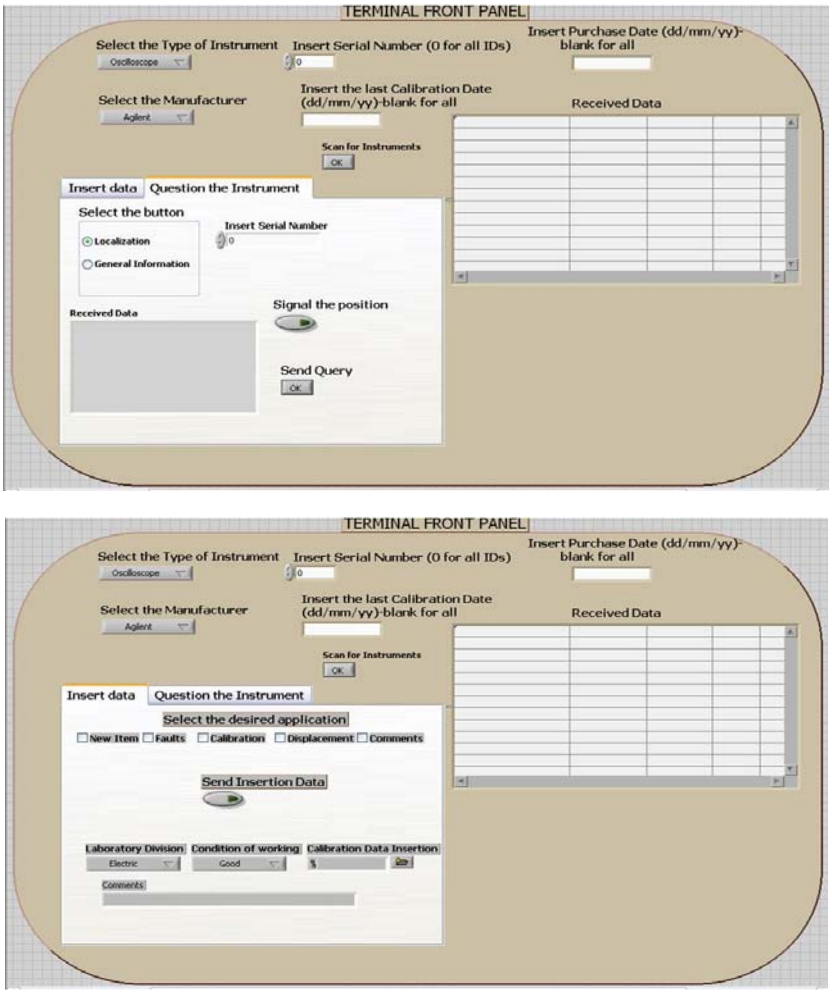

Fig. 3. The front panel of the application-oriented software used for the RF communication. In the first figure (above) the mask for questioning the instrument is showed. In the second one is presented the menu of data insertion.

A stack of records is stored in the non-volatile memory of the terminal, and these records are structured in fields as expressed in the following logic schematization.

- INSTRUMENT is a record with the fields: ID (serial number of the instrument), TYPE OF INSTRUMENT, MANUFACTURER, DATE OF PURCHASE, DATE OF THE LAST CALIBRATION, ACCURACY, SERVICE STATE, CONDITION OF WORKING.

- LABORATORY is a record of the fields: LABORATORY DIVISION (electric measurements, electronic measurements, and telecommunication measurements), MAINTENANCE, ID (ID code of the instruments present in the laboratory).
- DISPLACEMENT is the record of the fields: IN/OUT (identifies if a movement is related to an admission or to a coming out of the instruments), ID, DATE.

The Laboratory Management System involves the processes which are synthesized by the Data Flow Diagram of Fig. 4.

When the technician cannot find an instrument in the division under its supervision, he may personally inspect the other departments of the laboratory with the PDA, or may direct its request to the other

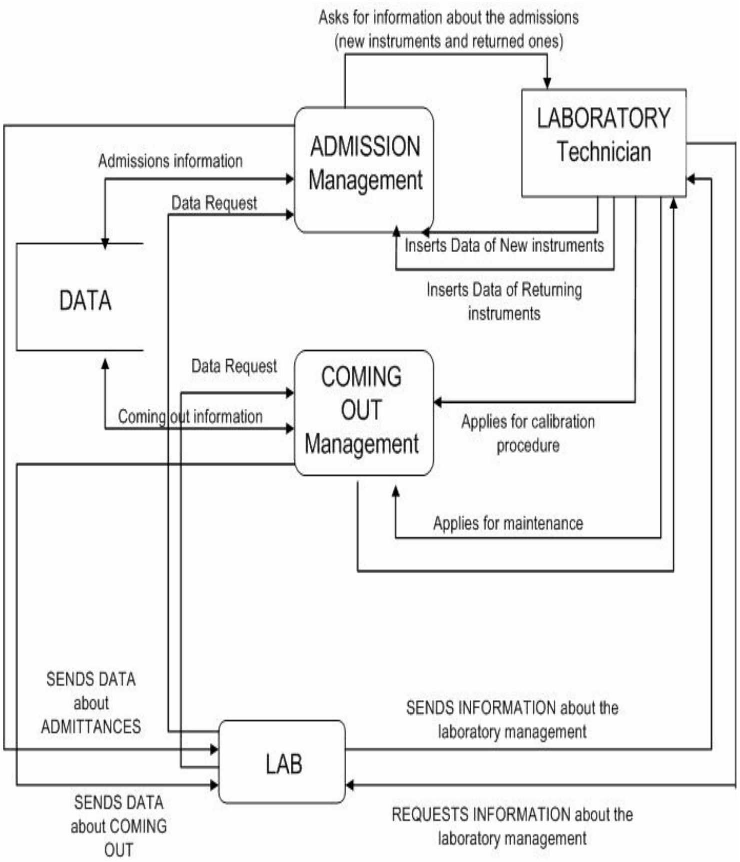

Fig. 4. The Data Flow Diagram for the proposed Laboratory management System.

superintendents (of the other divisions), who are, in turn, provided with PDA/PC communicating with RF Transponders. Once the instrument asked for has been detected (see Fig. 3), a sound signal is uttered from the RF Smart Point attached to it by pressing the “Signal the position” button.

4. Future Applications

The presented application implies very low costs and encourages the authors to search for future applications. Taking the project of realization of a distributed remote laboratory (as described in ref. [6]) as a starting point for giving a hint in this direction, the authors suggest to consider the RF transponders as remote resources of the online laboratory. In Fig. 5 the double client-server architecture for an online experiment system is showed.

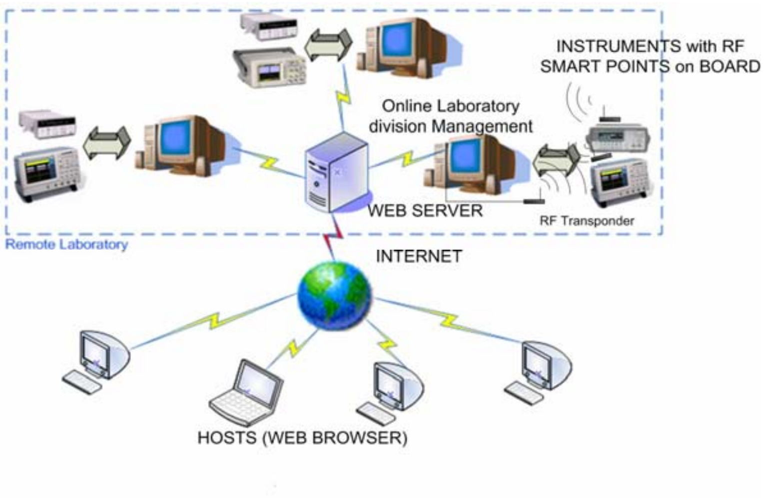

Fig. 5. The Remote Laboratory for online experiments. The RF Smart Points are attached to the Instruments and a RF Transponder is considered a remote resource of the online laboratory.

The user who wants effect the online experiments with the remote instruments may question their RF Smart Points for obtaining accuracy data. He connects to the online laboratory management system using a web browser. The first architecture client-server is related to the communication between the hosts and the web server. The second client-server architecture is between the online laboratory division management system and the distributed resources. Web Services are used for communication between the online laboratory and the remote resources.

5. Conclusions

In this work the authors have presented the realization of a radio-frequency identification system with the aim of furnishing a sensible help in the typical activities of a metrological laboratory. The “RF identification system architecture”, the anti-collision protocol, and the PDA/PC facility are described.

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Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726- 5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In additional, some special sponsored and conference issues published annually.

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Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

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- Sensor instrumentation;
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