PROJECT III.4
CIRCUITS & DEVICES FOR SENSOR NETWORKS & SYSTEMS

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Objectives

The main objective of the activity is the development of the technologies for future sensor networks and systems. In the context of this objective the research targets of sensor readout, wireless telemetry, RF remote powering in the near as well as the far field are pursued. Special consideration is given in operation within a spacecraft environment as well as in integration and packaging.

Funding

ESA Contract No. 21339/08/NL/GLC “Remote RF Powering and Passive Telemetry Link for a Wireless Strain Sensor System”

MAIN RESULTS IN 2008

Task 1: Wireless telemetry and RF remote powering of sensor tags

Health monitoring of structures is a major concern in the space and aviation community, where the need for more sophisticated structural health monitoring (SHM) systems is more and more recognized. The core of SHM technology is the development of self-sufficient systems that use built-in, distributed sensor/actuator networks not only to detect structural discrepancies and determine the extent of damage but also to monitor the effects of structural usage. SHM can provide early warnings of physical damage, which can be used to define remedial strategies before the damage compromises the spacecraft. Furthermore, it may be possible to quickly, routinely and remotely monitor the integrity of an air/spacecraft structure while in service.

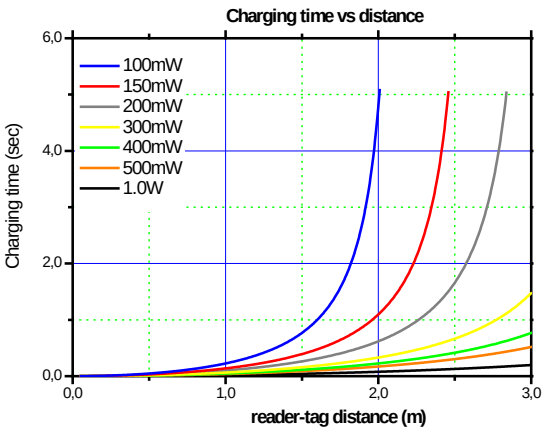

Figure 1. Charging time versus distance for different reader antenna power (ERP) for matched dipole antennas between reader and tag. Operating frequency is 900MHz. The maximum power consumption of the tag is approximately Pon = 80uW, while the estimated consumption in standby mode is about Pstandby = 12uW.

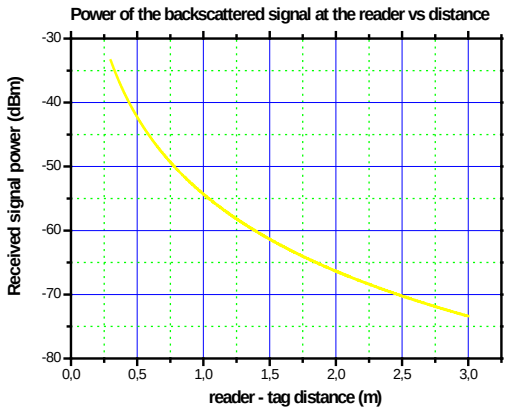

Figure 2. Power of the backscattered signal received by the reader as a function of reader – tag distance. Operating frequency 900MHz. Dipole antennas have been considered for the reader and the tag (Reader transmitted power: 0dBm).

In this task, a heterogeneous wireless network of strain sensors is developed which may be deployed to air or space vehicles. The network consists of battery powered nodes and batteryless nodes that are able to harvest energy from an incident RF field. Battery powered nodes are based on the Zigbee standard. Both battery and batteryless nodes will be able to include sensors but some battery powered nodes simply serve as relaying points to transfer data to the central computer.
In 2008, the theoretical and practical limits of this network were investigated and the first sensor tag prototypes were designed. It has been found that it is possible to provide enough power to operate the sensor tag circuitry at a distance of up to 2m with 100mW transmitter power, while reading the sensor tag data does not pose any additional limitation when using backscattering to transmit the sensor signal.

Task 2: FPGA based capacitive sensor array system

Capacitive sensor interfacing receives a lot of attention in recent years, as more and more sensors of this type are being developed in view of the advantages they offer in terms of sensitivity, reliability, low temperature dependence and low power consumption. To this end a great number of techniques have been developed to translate the minute changes of capacitance of these sensors into an electrical signal. These make use of full custom switch capacitor or continuous time circuits or even use discrete components. These solutions, though offering high accuracy, precision or high sampling rate, lack the luxury of processing power thus not facilitating their use in systems where quick on the spot processing of the input signal is necessary.
In this task we have designed an embedded system, implemented into a programmable IC (FPGA) which comprises a subsystem able to convert capacitance changes into frequency changes and allows for the embedding of a NIOS processor. The circuit has been implemented on a commercial programmable logic array with a mean sensitivity of 15 Hz/fF. The system is intended to be used in portable, processing-power hungry sensor applications such as identification of complex odors with an electronic nose and point of care diagnostics devices which require the fast processing of the input signal of biosensor arrays. In addition, the system is highly versatile as the FPGA may be easily reprogrammed to add new functions and adapt to a sensor array with different characteristics and sensor population.

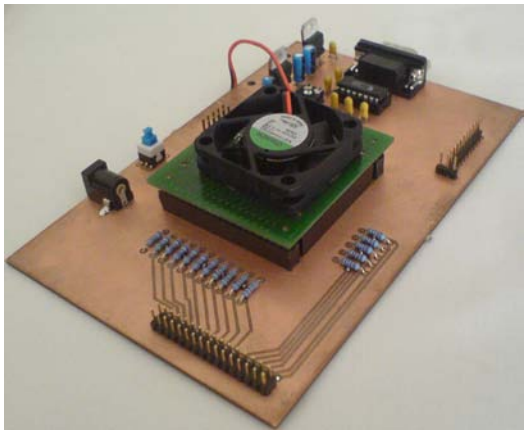

Figure 1. Testing Board with MAX II FPGA.

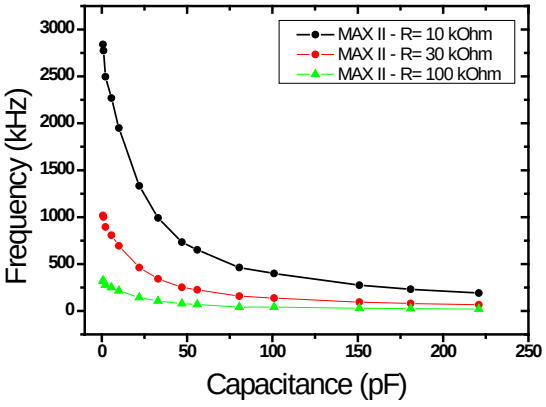

Figure 2. Response of the capacitive sensing circuit for three different resistor values..

PROJECT OUTPUT IN 2008

PUBLICATIONS in REFERREED JOURNALS

J1. P. Robogiannakis, E.D. Kyriakis-Bitzaros, K. Minoglou, S. Katsafouros,A.Kostopoulos, G. Konstantinidis, G. Halkias, **"Metallic bonding methodology for heterogeneous integration of optoelectronic dies to CMOS circuits"**, Microelectronic Engineering Vol. 85, April 2008, pp. 727-732.

J2. E. Grivas, E.D. Kyriakis-Bitzaros, G. Halkias, S.G. Katsafouros, G. Morthier, P. Dumon, R. Baets, T. Farell, N. Ryan, I. McKenzie, E. Armadillo, "**Wavelength division multiplexing based optical backplane with arrayed waveguide grating passive router"**, Optical Engineering Vol. 47, No. 2, Feb. 2008, pp. 025401-1-7.

CONFERENCE PRESENTATIONS

C1. S.Pavlos, E.Kyriakis-Bitzaros and S.Chatzandroulis, "A Embedded Readout System for Capacitive Sensor Arrays" , VLSI-SoC 2008, 16th IFIP/IEEE International Conference on Very Large Scale Integration Systems, October 13-15, 2008, Rhodes Greece.

Bachelor Thesis

S.Pavlos, "A Embedded Readout System for Capacitive Sensor Arrays" in co-operation with TEI of Pireas, Department of Electronics.