IntelliSense RFID

An RFID Platform for Ambient Intelligence with Sensors Integration Capabilities

O. Vermesan, H. Rustad, R. Bahr, D. Rognlien, J. Østby, M. Viktil, SINTEF ICT, Norway
N. Pesonen, O. Oja, J. Marjonen, M. Hirvonen, J. Saarilahti, J. Lamy, J. Mäkipää, VTT, Finland
C. Rusu, T. Pettersson, K. Persson, B. Ottosson, IMEGO, Sweden
P. Enoksson, H. Rahimi, Chalmers University, Sweden

The "Ambient Intelligence Society" is the vision of a future where it is assumed that people will be surrounded by low cost wireless devices carrying context information. Radio Frequency IDentification (RFID) is the key technology for local connectivity and an early vehicle for readying these future proactive computing systems. RFID devices are the main candidate to implement such distributed networks thanks to their promising low cost. An RFID device will be associated to a product, person or a location through a simple ID and will be capable to sense, measure, acquire and monitor physical, chemical, and biological environments through sensing of temperature, pressure, humidity, etc. Nanoelectronics allows the mass production of such new silicon RFID devices with sensing capabilities and this makes massive and low-cost tagging of objects feasible. The whole infrastructure of "readers-RFID devices" will form the future "Internet of Things" that will be one of the main element of the "Ambient Intelligence" and "Ubiquitous Information" society.

In this context, the aim of the IntelliSense RFID project is to develop multi-protocol RFID devices with built-in sensing capabilities, operating at multi-frequency bands. The device can be associated with an object, a person or a location through a simple ID and is capable of measuring and acquiring data about the user's behaviour and his environment (such as temperature T, pressure P, humidity H, pH), thus creating a smart environment based on surrounding "invisible intelligent devices".

The project is devised into two phases:

- *Phase 1: Technology specification, requirements definition, research and block design*: Deliver the detailed RFID requirements and specifications required to perform the intended functions, and study the means to meet such specifications. The devices will combine the ISO 15693 (18000-3) HF standards at 13.56 MHz and the ISO 18000-6c (EPC Class 1 Gen 2) UHF standards that work from 860 to 960 MHz. The third frequency band – 2.45 GHz supporting the 18000-4 standard will be developed later.
- *Phase 2: Integrated design implementation, evaluation and testing*: Deliver and test a first demonstrator at the end of 2007. This demonstrator will be used to validate the main technological choices, with a reduced complexity and reduced environmental specifications.

The project research and innovative aspects can be summarised by the following project results:

- *RFID platform*: novel, passive/semi passive RFID platform with a generic mixed signal interface for sensors
- *Multi band antennas*: two new antenna concepts for multi-band operation were demonstrated for covering the relevant ISM bands at 13.56 MHz, 869MHz, 915 MHz and 2.45GHz. The first antenna type is a combination of inductive coil at 13.56 MHz and electromagnetic multi band antenna PIFA (planar inverted F antenna) designed for covering the European UHF band 865.6-867.6 MHz and American UHF band 902-928 MHz. The second antenna type is a multi-band Minkowski fractal optimized for 2.45GHz and 868 MHz operation.
- *RFID front ends and protocols*: low power/low voltage RF front end circuit with the capability of operating at different frequency bands, digital control and communication protocol supporting multi-band operation and sensor data management are evaluated. An optimized system (blocks sharing) combining multi-band RF front end (13.56 MHz and 869 MHz), logics was designed, simulated and processed with UMC 0.18µm. Simulations on the multi-band and multi-protocol tag showed a power consumption of 30 µW for the front end, 20 µW for the HF logic (ISO 14443-A) and 100 µW for the UHF logic (EPC Gen 2). Measurements on the processed packaged chips confirmed the simulations.
- *Generic sensor interface*: a sensor interface based on a successive approximation register (SAR) analog digital converter (ADC) implementation that consumes 20 µW with a temperature dependency of 50 ppm/°C was designed and simulated. In the read out circuit a switched capacitor charge integrator was used to compare the sensor capacitance to a reference capacitor and convert the capacitance variation into a voltage variation that is then digitized with an analog to digital converter. Two architectures for the ADC based on resistive network and a charge redistribution capacitor array were designed. The simulation results and the preliminary measurement results for the resistive implementation show that the power consumption is less than 10 µA with an accuracy of 8-10 bit and a sampling frequency of 10 kHz. The resolution (8-10 bits) obtained was adapted to the operation mode and the power consumption requirements. In order to have very low power consumption, the system operates in a switched configuration.
- *MEMS/micro sensors*: Four individual capacitive sensors (pressure, temperature, humidity and pH) were designed in the project. The pressure and temperature sensors are surface micromachining sensors with a honey comb configuration. The capacitive humidity sensor is based on the principle that a humidity sensitive polymer absorbs or releases moisture and the dielectric properties (permittivity) change as a function of the relative ambient humidity. The sensing principle of the pH sensor is based on the changes in the dielectric properties and/ volume change of a sensitive polymer film due to pH change. Interdigitated electrodes are used and on top of these electrodes a sensitive polymer is applied.
- *Near field communication*: A symmetrical rectangular antenna was implemented on a demonstrator tag and similarly on the reader side and experiments show that power can be transferred accordingly. Evaluation of a combination of 868 MHz as the communication frequency between reader and tag and 2.45 or 5.8 GHz as the return link is pursued (Dual mode operation: Tag powering using UHF/Communication at ISM band).

IntelliSense RFID is a 2 years project that started in 2006 and involves SINTEF (Norway) as the institute leading the project, VTT (Finland), Chalmers University of Technology (Sweden), and IMEGO AB (Sweden). The NORDITE programme aims to support research institutes and universities from Sweden, Norway and Finland to enhance state of the art research in the fields of SW radio, wireless sensors, short-range wireless networks and RFID or MEMS utilising RF technology.