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Development of a Flexible and Scalable Measurement System for EM Pollution Monitoring

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Abstract- The aim of this work is to present the activities planned by the Electric and Electronic Research Group of Polytechnic of Bari, Department of Electric and Information Engineering, under the strategic project named "Magna Grecia – Rafforzamento Strutturale", funded by the Italian Ministry of Education, University and Research (MIUR) within the PON-REC (National Operating Program Research and Competitiveness) 2007-2013. The project aims to cooperate with many Apulia Regional Authorities (mainly with ARPA Puglia, the authority for environment protection) to build a network of laboratories for the monitoring of many pollution sources in the Province of Taranto, which are causing the degradation of air, water, soil and EM Spectrum.

I. Introduction

The big industrial plants are playing a decisive role in the life of the Province of Taranto. The increasing of the industrial production has leaded an undeniable economic and social growth, but, at the same time, has exposed the whole area to great environmental stresses. In this situation, the problem become of primary importance. Several researches related to soil and materials characterization, [1], [2], [3], renewable energies useful to reduce fossil fuel, [4], [5], automatic quality control to avoid dispersion of pollutants in manufacturing industry, [6], [7], and estimation of the pollution effects on human body have been proposed, [8], [9], [10].
With these premises the main purpose of the project is to realise a Campus Consortium for environmental measurements useful to deal with the serious problems which affects land, water and air of the Taranto city.
The core of the Multifunctional Network Laboratory for environmental research is an interdisciplinary scientific collaboration in measurement and technology science to analyse the physical and chemical processes operating in Taranto in order to improve environmental monitoring capabilities and to support services for reduction of environmental pollution.
Another important aspect is connected to electromagnetic pollution problem which is dangerous at high intensity or for frequent and prolonged less-intensive field. In order to monitor and control electromagnetic smog, a suitable system able to "in situ" measurement has been designed and realized. The system consists of a modular architecture, fully reconfigurable, based on a *software defined* concept.

II. The proposed approach

Nowadays there is an increasing use of radio-frequency (RF) energy in several areas, among with biomedicine and medical therapy, industry and material processing, wireless communication systems and household appliances as the microwave ovens. During the two past decades, a true revolution has been observed in electronic market, since there is a massive interest toward wireless connectivity in household devices and in several other areas.
Electrical devices can radiate secondary and undesired RF power. Other well-known RF sources are as examples the space-based satellite navigation system as Global Positioning System (GPS), and Wi-Fi networks. Therefore, electromagnetic interference (EMI), radio-frequency interference (RFI) and bio compatibility are words largely used by both technicians and common people.
The involuntary nature of electromagnetic radiations, their interference with electrical apparatus and their interaction with human body have caused a contagious concern about possible health effects. Another important issue is pertaining to the electromagnetic field exposure of workers to both high and low frequency

electromagnetic fields as it occurs for the electrical equipment assemblers, aluminium workers, radio and radar operators, subway and railway operators, electrical power and telephone linemen, electrical and electronic engineers and operators, welders and flame cutters, etc. [11], [12], [13]. Moreover, microwaves are used in many respects for remote sensing applications. Since microwaves can penetrate clothing and a number of other materials exhibiting dielectric properties, they can be applied for security aims to the imaging of persons, strategic services and large areas during public events. Microwave remote sensing focused to personnel inspection, to detect weapons and explosives, is nowadays largely applied. Ever higher resolution via real-time system technologies will be feasible within few years in the millimeter-wave as well as in the lower frequency region. Therefore further bio-compatibility investigations will be necessary. RF identification (RFID) systems perform timely track and trace information allowing an actual and fast drug pedigree. This technology can be applied as object localization system in heterogeneous fields among which logistics, supply chain, anti-counterfeiting, etc. However, the large-scale spread of these innovative technologies is limited by health concern of people.

In this scenario a wide literature has been produced with reference to wireless computer networks in schools [14], [15], population occupational exposure to Wi-Fi, e.g. wireless local area networks in office environments [16], [17], general public exposition [18], [19], [20], [21], radiation from mobile phone base stations, broadcast transmitters, personal radio frequency electromagnetic field exposure [22], [23], microwave imaging [24]. Anyway, part of these investigations cannot be considered exhaustive. Exposure systems to enable studies of the effects of RFID systems on solid and liquid pharmaceuticals have been proposed in [25]. The evaluation of thermal and non-thermal effects of UHF RFID exposure on biological drugs is reported in [26].

III. Measurement System

In this section the measurement system is proposed. The complex system, acquired thanks to the funding of the Italian Ministry of Education, University and Research (MIUR), under the project "Programmi Operativi Nazionali (PON) 2007-2013" named "Magna Grecia – Rafforzamento Strutturale", is able to synthetize and analyse wideband RF signals, even if modulated (both scalar and vector).

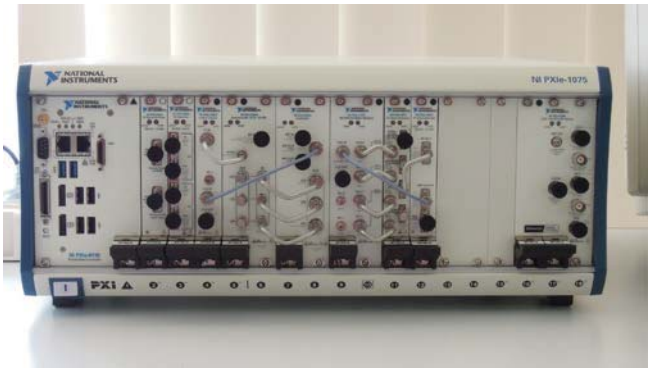

Figure 1. Measurement System

The system, shown in Figure 1 is based on the modular PXI (PCI eXtensions for Instrumentation) Open Standard, which allows to configure a generation and acquisition system for analogue and digital signals, with the possibility to choose even other modules for specific applications in a wide range of products already present on the market or of future production.

In particular, the system, available in the Electric and Electronic Measurements Laboratory of Taranto, is specifically oriented to the synthesis and the acquisition of RF signals with different modulation modes, I/Q too.

In detail, the system is all made by National Instruments' products:

- a PXI chassis with 18 slots type PXIe-1075
- an embedded controller type PXIe-8135
- a RF signal generator in the band 500 kHz - 1.3 GHz type PXI-5650
- a programmable RF attenuator, type PXI-5695
- a vector RF signal analyzer made up by:
  - o a signal synthesizer type NI-PXIe5653
  - o a downconverter NI-PXIe5603 (20 Hz – 3.6 GHz)
  - o a 16-bit IF digitizer NI-PXIe5622
- a vector RF generator made up by:

- o a 400 MSa/s I/Q signal generator NI-PXIe5450
- o a I/Q vector modulator NI-PXIe5611
- o a RF signal generator NI-PXIe-5651

- a dynamic signal digitizer, two channels with 5 GHz bandwidth, 12.5 GSa/s sample rate and 8 bits of nominal vertical resolution PXIe-5186).
- a vector network analyzer (VNA), dual port, type NI-PXIe5632, with 6 GHz bandwidth.

It was decided to implement a measurement set-up with this modular system, based on PXI technology, because it is updatable and adaptable in function of present and future applications. In case of necessity the system is extensible by means of the MXI-4 interface, which allows interconnecting two or more chassis.
The system, once programmed, being equipped with a built-in system controller can operate in fully autonomous mode or supervised by remote host; the control program is developed in LabVIEW® on a remote host and downloaded on the embedded controller which is based on LabVIEW Real Time be developed for acquisition and processing of real-time signals, in function of highly sophisticated applications.
This system when equipped with an external large array of discs can be used for continuous RF spectrum monitoring applications in narrow as well as wide bands.

IV. Conclusions

The paper concerns the organization of the Multifunctional Network Laboratory. It is an innovative Campus Consortium for environmental measurements in Taranto city. In order to assist the authorities in monitoring of land, water and air pollution a multidisciplinary solution has been preferred. In particular, in this paper a very powerful system for electromagnetic smog monitoring is proposed.

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