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MEASURES OF ELECTROMAGNETIC COMPATIBILITY: RFID AND ELECTROMEDICAL DEVICES IN THE HOSPITAL ENVIRONMENT

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Abstract **–** The objective of this paper is to assess whether some Electromedical devices are susceptible to electromagnetic waves emitted from sources for remote identification. We examine the occurrence of electromagnetic interference with a measuring method developed by the University of Florence from protocol ANSIC63.18. We have also conducted several in-situ tests, to characterize the EM appliances, from the point of view of electromagnetic compatibility, directly in to the hospital environment.

Keywords**:** ElectroMagnetic Compability (EMC), Radio Frequency IDentification (RFID), Medical device, essential performance, ElectroMagnetic Interference (EMI), in-situ test.

1. INTRODUCTION

The purpose of this paper is to evaluate any electromagnetic interference between RFID (RFID - Radio Frequency IDentification) sources and electromedical (EM) devices of life support in hospital environment and therefore to study one of the main problem to be solved: **the electromagnetic compatibility** between electronic devices. The main reason of this work is due to the fact that in daily medical practice we assist to malfunctions due to electromagnetic interference. The presence of many electromedical and wireless devices causes within these environments a real "electromagnetic pollution".
This situation occurs despite the fact that many electromedical devices are of the latest generation and therefore comply with the latest standards: the problem is that there is always the possibility that there may be disturbances that could completely change the performance of the other appliances. We note that many old medical instrument are today still, with their low or absent immunity levels, thereby increasing the risk of interference.
Considering the technological evolution of the wireless devices and in particular the benefits that these technologies bring to us, we can understand the inevitable spread of these systems even within health care facilities. Some technologies that have evolved in the recent years and have had a great diffusion are the RFID technologies. In recent years this technology, defined "silently pervasive" [1], spread in many areas of health care: management of drugs, identification and tracking of surgical specimens, blood transfusion, situation of emergencies, traceability of people/medical equipment, EM equipment maintenance [2, 3, 4, 5, 6, 7].
The inevitable introduction of these systems increases the risk of potential serious errors in medical devices. For this reason, before using technologies in hospital environment, we you should carefully evaluate whether the introduction of these devices (i.e. antennas that operate at radio frequencies) can cause a serious degradation of the electromagnetic field. Despite the widespread development of this technology, the literature does not provide useful documents about the safety and reliability for the use of RFID systems in healthcare environment [8], although there are many studies showing examples of implementation and/or evaluation of the electromagnetic compatibility between mobile phones and medical devices [9, 10].
An a priori evaluation consists in practice to insert the RFID source within a department of the medical department, and than checking the correct performance of each individual medical apparatus present in that environment. So it is necessary to provide a measurement standard that allows to test each medical apparatus under examination in all its essential performance and external surfaces. Moreover, the second purpose of this paper is to determine which RFID technology, among those tested (in our case one active and one passive) is causing less electromagnetic interference and therefore is more suitable to be implemented in a hospital.
We should also emphasize in the field of electromagnetic compatibility that is very important to determine if the electromedical devices that comply with the latest standards (and therefore involve low levels of immunity to electromagnetic waves and emission limits with the objective of avoiding all malfunctions) actually improve the electromagnetic situation of the environment in which they are inserted. The way in which we will develope this study is the following: initially we'll carry out a theoretical study on the RFID topic and the electromagnetic compatibility examining the current standards and the and state-of-the-art technology.

After that we will proceed with the analysis of the literature to have an idea about the current situation on these issues at the international level. All this is necessary to "develop and design" a method for the evaluation of EMI that will be applied to a sample of electromedical devices currently used in the intensive care ward of the hospital of **Santa Maria Nuova in Florence**: in moreover the experimental tests will be performed directly in the place of use of the appliances, or **in-situ**. The final part will be dedicated to the collection and data processing to predispose them to a scientific validation. A posterior statistical analysis and subsequently an inferential analysis will be conducted to see if the results are due to the simple case, or are related to each other.

2. RFID OVERVIEW

RFID stands for **Radio Frequency Identification** and indicates all the systems that allow automatic identification at a distance of objects via radio waves. From a practical point of view the remote identification of objects has many applications and this technology offers a considerable advantages. These devices are classified as wireless devices and operate on the basis of electromagnetic waves.

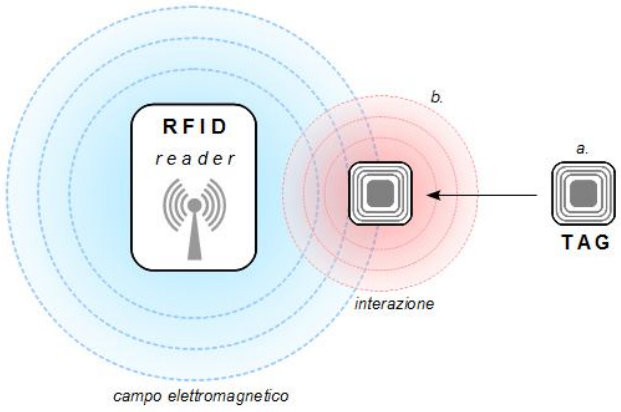

Fig. 1. RFID System

1. TRANSPONDER or more simply TAG: is the key element of the system which is to be connected to the object to be identified. This is substantially formed by an antenna and a chip and can contain a memory. At the moment in which the tag enters into the electromagnetic field of the reader and perceives its presence, the tag answers with a radio signal to inform the reader of his presence. Tags are classified on the basis of the power type:

• ***Passive***: They are equipped with no type of internal power supply and for the transmission they use the radiofrequency wave emitted by the reader. The physical principles of this operation are: ***inductive coupling*** in a "near field" condition (which is similar to a transformer coupling) and ***electromagnetic coupling*** in "far field" conditions (backscatter coupling). Generally the first work in the LF and HF bands while the seconds in the ULF and SHF bands.
• ***Semi-Passive***: also called ***Battery Assisted Passive*** (BAP); Tags are equipped with internal battery that is used to supply the various internal sensors and possibly a memory but do not provide energy to the antenna [7].
• ***Active***: tag is equipped with a radio transmitter with an internal battery to send signals. The power source is used to power the chip, the antenna, the memory and also any on-board sensors. From a functional point of view these tags can begin broadcasting and do not need to be questioned as it occurs for those *Passive* and *Semi-passive* [7]. Operating frequencies are greater than those of the other tag: 433 MHz, 868 MHz, 915 MHz, 2.45 GHz and 5.8 GHz.

2. READER: is a transceiver with the purpose to question the various tags present in its area of irradiation. Depending on the complexity of the system, the reader can also write and then store information about the various active tags. The basic elements are **"the Controller Unit"** for the management of the various antennas and message traffic and the "antennae" for physically interfacing this unit to the various tags.
The entire RFID system cannot operate unless it is implemented in a management system that is directly connected to the reader, this allows the identification of the tags and extracts all the possible information associated to the objects. This takes the name of **"information system"**.
The applications are closely related to the technology with which the TAG are realized: in fact now it is possible to realize passive tags of small size and low cost [1]. The main areas of application include: Anti-counterfeiting, Access Control, Electronic Ticketing, File Management, Automotive, Veterinary Medicine, healthcare (the one we're interested in), etc. The great popularity is also due to the activities of standardization that has governed the design and the evolution of these technologies: for instance important standards are: ISO 11784, ISO 14223, ISO/IEC 15961, ISO/IEC 18000, etc. The standards may be found to relevant internet sites [25-26].

An other important topic to mention concern certainly the standards because the great evolutionary process of RFID in recent years has made extremely complex all the standardization process. The most important aspects are:

- ***Emission power***: the power levels must be adjusted with great attention because electromagnetic waves of high power can be hazardous to human health. The WHO, World Health Organization reassures and says that "Whereas very low levels of exposure and the results of research collected up to now, there are no convincing scientific evidence that RF signals emitted a low power radio stations, and wireless networks can cause harmful effects to health" [11].

- ***Frequency Bands Allocation***: These devices fall within the definition of Short Range Devices (SRD); radio devices that offer a low risk of electromagnetic interference with other radio services because the transmitted power is extremely

low [12]. The problems are related to "bandwidth-sharing" and to "the regional allocation of frequencies". The regulations are enacted at the European level by the European Telecommunications Standards Institute (ETSI) and can be found at the internet address [26].

Fig. 2. Testing on RF sources

3. CONCLUSIONS

The literature analysis shows that in the majority of the tests there is interference with the EM appliances of life support, although there are cases in which there were no disturbances. The results obtained in this paper aligns perfectly with those that show many authors such as in [8]. We found results necessary to ensure that you will be able to reduce the number of electromagnetic interference within the health structures starting from encounters, in surgeries until you arrive to departments more than critics, such as operating rooms and intensive therapy: the evaluation model built and subsequently applied can be generalized to any local for medical use.

The first point to address this problem is the awareness of the engineers about the inevitable interference with the EM appliances inside hospital environment, because it is unthinkable to build devices completely immune from RF waves. It is important to take into consideration for instance: the increasing in the levels of immunity and emission, the compatibility testing also on blocks that are more susceptible to electromagnetic waves (we have encountered problems in the defibrillators plates), attention to the type of power supply systems, etc.

The new wireless technologies at 2.45 GHz and low power cause electromagnetic interference on EM appliances. Our tests do not compare two RFID systems, but starting from two equivalent systems establish which is the best practical solution. The most significant aspect of this study is not to decide which of the two sources produces the fewest number of electromagnetic interference, but to check which active RFID source produces interference at shorter distances than the passive source (we have used the Wilcoxon and other statistical tests). In conclusion, about RFID technology, we can say that the best implementation of these systems in a medical environment is the active solution (high frequency and low power emission), because this causes less interference on EM appliances, in particular at shorter distances.

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