A security system for paper or plastic-based items using chipless RFID

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Abstract— The purpose of this paper is to develop an innovative system which uses chipless RFID tags to protect sensitive paper/ polymer-based documents, such as intelligence agency reports, financial securities, envelopes, stamps, and banknotes. The significance of this project is vital as the expected outcome from this new system can be used to strengthen the security of important documents and banknotes and thus unauthorized copy and fraud can be identified and avoided. In order to achieve this, the idea of embedding or printing invisible RF reflecting fibers/ inks that are made of tiny chemical particles (having various magnetism), is designed and developed, by usage of a multi-frequency RFID reader that will beam the waves and capture the attenuation from the transponder in the form of analog signals and digital codes, then compared with a database that will provide authenticity.

Keywords- barcode, chemical, chipless, paper, plastic, rfid, system

I. INTRODUCTION

Electronic tracking of products is a widely growing field now-a-days. Conventional optical barcodes are the most familiar one. The barcodes are widespread due to their very low cost and ease of fabrication. They are impossible to read if there is any obstruction between the reading device and the barcode. In addition to that, they are limited, however, by their short range of reading. When reading a barcode, the orientation of the reading device relative to the barcode also causes problem. If the reading device is not properly aligned or is held at an improper angle, the encoded information cannot be read. As a result a human operator is required for that individual reading operation. Another very familiar tracking technique is the magnetic strips, which are widely employed in business to perform several identification purposes. Magnetic strips are quite similar to Smart Cards in terms of usage. In reality, a contact based Smart Card, or magnetic strip requires the insertion of the card into a contact reader. In the specific case of magnetic strips reader, the mechanical part is very important which leads to a dramatic increase of the reader production and maintenance costs. It is why the global cost of this identification technique remains high. However the inherent limitations of barcodes and magnetic strips– costs and not contactless – have prevented their use in a wide range of applications for machine-readable data storage. The above hurdles may be overcome by reading another technology based on radio waves. Radio frequency IDentification (RFID) is an automatic technique of capturing information coming from a label containing the data by remote radio reading.

The label consists of a microchip and an antenna which ensures the communication with a dedicated reader. Recently, this technology has become inevitable for item identification and tracking applications and also very popular as a device for storing and transmitting information. Most RFID tags present a longer reliable range than barcodes. Even though rapid growth is predicted by many exploratory studies, its progress is slowed down due to several economical, technological and social factors like the size and high cost of the tags, limitation of frequency band, range of reading, mobility of the object, lack of safety and reliability of the information contained within RFID chip, and difficulties in recycling tags [1]. Because applications using RFID present various constraints, each tag design is dedicated for a specific application. And it can be found many variant of RFID depending on several parameters.

The most significant parameters that best describe a RFID tag are the way of empowering, the reading range, the data processing, the read/write capability and the protocol used. For realizing low cost RFID tags, one of the most promising techniques is printable chipless RFID tags [2]. Benefit from the removal of chips, the price of a unit chipless tag is expected to be significantly lower than the chip based tags. Moreover, incorporating high-throughput printing techniques and low cost paper substrates, these chipless tags can be massively produced at extremely low expense. Indeed, the major change of this technology is the absence of any chip IC connected to antenna. For these reasons, the realization of chipless tags constitutes a very attractive solution for specific or everyday life applications. The principle of the information encoding, which consists in encoding the identification number of the tag, is based on the generation of a specific temporal or frequency footprint. This temporal footprint can be obtained by the generation of echoes due to the reflection of the incidental pulse. In the frequency domain, one can characterize the spectrum of the backscattering pulse.

There have been many researches on chipless RFID in the past but extensive research has not been done yet to tag documents and large volume of paper/ plastic-based items such as intelligence agency reports, financial securities, banknotes, postage stamps, tickets, and envelopes due to the relatively high price of the tag when compared to the price of the tagged item and the presence of an application-specific integrated circuit (ASIC) chip. In this project an idea of using a mixture of various chemical components in the paper or polymer-based items will be developed. The chemical mixture can either be embedded or printed and form a invisible binary code in a particular point/ end of that item. Thus the reliable identification and saving of cost can be assured.

II. METHODOLOGIES

The proposed chipless RFID system will have spectral (frequency) signature-based chipless passive RFID transponders/ tags, so the transponders will not need any power supply for its operation [3]. A system will be developed which will randomly embed tiny fibers (with different chemical composition) in paper or print invisible chemical mixture of "nanometric" materials (tiny particles of chemicals with varying degrees of magnetism) that will resonate when bombarded with electro-magnetic waves from a reader. Each chemical will emit its own distinct radio frequency that will be picked up by the reader, and all frequencies that will be emitted by a specific mix of different chemicals are then interpreted as a binary number. If the system uses up to n different chemicals, each chemical will be assigned its own position in n-digit binary number.

For example, the presence of a chemical component is defined by 1 and absence by 0. If chemicals P, Q, R and S are assigned to the first, second, third and fourth positions in the n-digit number, then a mixture consisting of P and R will represent the binary number 1010 followed by (n-4) zeros. Suppose for banknotes, each banknote will possess a unique ID and it will be done by the printer or the manufacturer applying a specific chemical mix corresponding to the ID being printed. Once a banknote's ID code is printed, the system will be able to scan the code from a certain distance, without a line-of-sight requirement.

Thus the chemically embedded tag encodes data in the frequency spectrum hence having a unique binary ID or "spectral signature". The spectral signature is obtained by interrogating the transponder by a multi-frequency signal and observing which frequencies are attenuated [4]. Depending on the attenuation, an alarm can be generated when bit errors will be detected. RFID reader sends out a multi-frequency interrogation signal which might be higher than the frequencies commonly used by wireless LANs and handheld computers [5]. The receiving and transmitting tag antennas should be cross-polarized to minimize the interference between the interrogating signal and the retransmitted encoded signal of the spectral signature.

Finally, when someone will bear/submit the paper/plastic based items then the reader will read the RFIDs without being in line-of-sight. Next, the algorithm programmed in a connected computer will compare the embedded ID with the database (kept in the PC). If the any of the IDs does not match with the database then it will give alarm and vice versa. Thus, a system will be able to detect any forgery. The whole process can be showed in following flow chart:

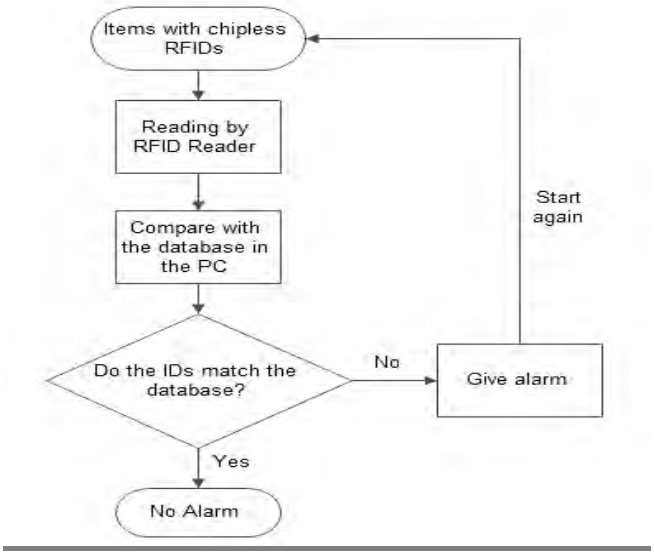

Figure: A security system for Paper or Plastic-based Items using chipless RFID

Readers can also be placed inside copy machines to prevent unauthorized copying. One application would be to require that any document printed on such special paper be photocopied onto the same type of paper. That way, an intelligence agency, financial institutions like banks or even a company wanting to protect its intellectual property from counterfeiting could install readers at building exits to prevent unauthorized people from copying documents and leaving the building with them. One of the big advantages will be that the tag can be printed on just about anything. Therefore, it will not complicate the process of producing the product and the printing can be done in invisible mode for extra security.

Additional work may be concentrated on improving the resonators as well as investigating the phase of the received signal encoded by the tag as phase is more resistive to the effects of noise and other interferences.

III. PREDICTED RESULTS

The proposed methodology will be applied to any of the paper/ plastic based items, such as any bank notes, low cost and secured paper/ polymer-based items. The project concerns design and implementation of passive devices design, antennas, proper frequency band, analog and digital electronic design, signal processing algorithm, middleware, and finally, implementing them in FPGAs and micro-controllers for the RFID reader. The performance of the proposed methodology will be judged in terms the ability to extract the spectrum phase to decode the transponders' ID and to detect bit errors. If any item gives alarm, repeated examination can be done to ensure whether it is giving false alarms or not. The possible pitfall is, in environments where there are lots of metallic or water-filled objects, however, readers may not be able to scan the codes printed because metal reflects RF signals and water absorbs them, which are also the major constraints for conventional RFID systems.

IV. CONCLUSION

Though this is a theoretical idea, there are few question that need to be asked like how many chemicals may be used, how the right ones can be chosen and which combinations will give accurate results. Besides ample study should be done to find out the operating frequencies that the reader will use so that the frequencies will not create interference with other existing signals. For a successful operation, a frequency range needs to be specified too. Extreme research can be done to find out the distance from which the system will be able to detect the RFID tags and how this can be increased without compromising the accuracy. Furthermore the sensitivity of the RFID reader needs to be studied and the false alarms should be minimized. This paper doesn't give any solution to find these answers but it is just a mere proposal which can increase the potentiality of using chipless RFID tags in paper or plastic based items to increase its security which might come handy for many countries, agencies and/or personnel.

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