RFID system evaluation against radiated transient noise

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Abstract— **In this paper a radiofrequency identification system according to standard ISO/IEC 14443 type-B is evaluated in presence of transient noise. This real time communication system working at 13.56 MHz is interfered in a controlled environment by different transient bursts varying their level, frequency and duration. The transient burst interference is applied in an AC main wire close to the system and the effect over the digital communication system is evaluated using two different methods. The first one is observing directly an RFID equipment in presence of transient signals, and the second one is capturing the interference in time domain an evaluating its effect by means of simulation. The RFID system is affected by these transient noises causing different types of errors. It is shown that it is essential to measure and evaluate in time domain the transient phenomena to ensure that the RFID system do not have susceptibility problems.**

Keywords- transient; RFID; measurement; digital communications

I. INTRODUCTION

Nowadays the use of radiofrequency identification (RFID) is increasing in many and different applications due to wireless flexibility. An RIFD system is composed by the reader and the tag that is time limited at the reading position. This time limitation makes this wireless technology a real time communication (RTC) system where retransmissions are not allowed.

The highpoints of being a wireless system is also an inconvenience if we think in terms of interference. The antenna would receive the useful signal and also the interferences present in a noisy environment. RFID system operates in several frequency bands. The exact frequency is controlled by the Radio Regulatory body in each country. The most common frequencies are: 125 - 134 kHz (LF), 13.56 MHz (HF), 400 – 960 MHz (UHF), 2.4 GHz, in this paper the system under study works at 13.56 MHz. At this frequency band, unwanted signals are produced mainly by electric and electronic devices and could easily be propagated through, and radiated by, the power wires [1].

An electronic device could produce continuous interferences and also transient noise. This study is centered in the degradation that could cause transient noise phenomena over an RFID system working according to the standard ISO/IEC 14443 type-B [2] [3]. A transient could be generated, for example, by a spark or a switching power supply. The pulses of this transient noise can have significant energy from DC to hundreds of MHz and its energy is propagated as an electromagnetic wave. Part of this energy would be captured by the RFID antenna, interfering the system and producing errors on the real time communication [4] [5] [6]. Because the transient has components at the useful communication system frequency band, it could not be avoided by filtering techniques.

Moreover, as RFID is a real time communication system, transient noise would produce irrecoverable errors if the interference occurs at the reading time slot. This usually produces no tag identification. As an example, applications such as RFID-based payment systems, like the non-stop highway ones, could cause critical disconformities. Also RFID applications placed in a factory production chain could be interfered by transient noise producing expensive errors.

In this paper, a RFID system is evaluated against different radiated transient interferences. Different types of transients will produce different types of error on the RFID system. The errors produced will not depend only on the level of the transient pulses. Taking into account only the level of the transient interference at the RFID system frequency band, is not enough to evaluate its effect because two transients with the same level but different repetition rate, frequency or duration could cause different errors. To perform a correct evaluation of the RFID system is necessary to take into account these differences, by considering the whole transient signal in time domain.

II. METHOD

A scenario has been built to observe the different responses of an RFID system against transient noise. The test is performed inside an anechoic chamber to avoid possible uncontrolled interferences.

The set-up emulates a real situation; many times an RFID system works in close vicinity to many AC main wires. At these wires there could be a lot of electrical devices connected at some point of the electrical network, producing transient noise that could go through the wires and be radiated. A Schölder transient generator model SFT 1400 is used in our set-up to produce the bursts at main wires. The transient noise used to evaluate the transient signal is the pulse defined in standard EN 61000-4-4 [7]. The rise time of the pulses

generated according to the standard is 5 ns, this means that the transient noise has noticeable energy till 200 MHz. The no terminated wire is 2 m long and is located at the same height as the RFID system, 80 cm far away from the middle of the wire (Figure 1). The wire is no terminated to emulate a real situation where there are many no terminated wires or wires with an unknown termination.
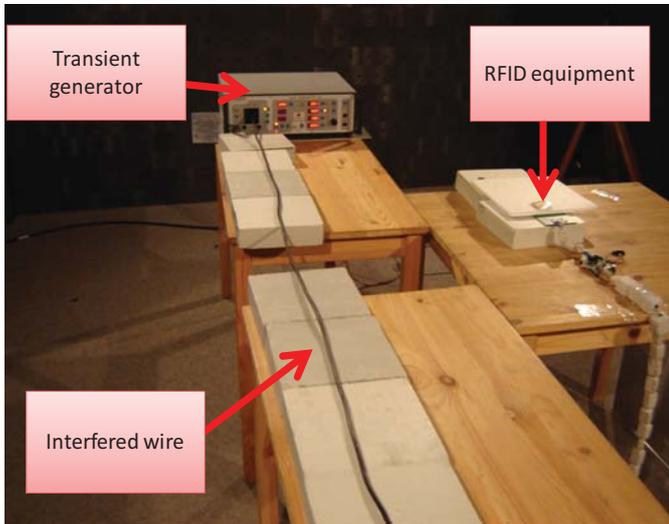

Figure 1. Interference scenario composed by a generator coupling transients to a wire close to a RFID system

The RFID system used is the STMicroelectronics Reader USB CRX14 which is according to the standard ISO14443-B. This system uses a carrier frequency of 13.56 MHz. The modulation used at reception is a BPSK with an 848 kbps rate. This RFID system is capable of detecting errors but cannot correct them.

A group of five different interference transients are defined varying the level, the repetition rate, the burst frequency, the burst duration and interval between bursts (Table 1) Burst duration, burst interval and frequency repetition are limited by Schölder generator limitations, and the level is determined by pre-examination. The goal of using these five transients is to study if they cause different type of interference over the RFID system.

TABLE I. DIFFERENT TRANSIENT INTERFERENCES APPLIED IN THE SCENARIO

Level	Burst Frequency	Burst interval	Burst duration	Reference
3000 V	125 kHz	200 ms	4 ms	A
3000 V	1 kHz	200 ms	0.01 ms	B
3000 V	5 kHz	200 ms	4 ms	C
3000 V	1 kHz	200 ms	4 ms	D
2000 V	125 kHz	200 ms	4 ms	E

To evaluate the different effect over the RTC system, different types of errors are defined according to the malfunction level that appear when the transient interference is applied (Table 2).

TABLE II. ERROR TYPE DESCRIPTION

Error type	Description
Fatal Error (FE)	The equipment do not identify the TAG
Major Error (MAE)	The equipment identify the TAG but an error >2% is produced reading TAG's adresses
Minor Error (MIE)	The equipment identify the TAG but an error ≤2% is produced reading TAG's adresses
No Error (NE)	The equipment identify the TAG and no error is produced reading TAG's adresses

Two methods are used to evaluate the system response against the radiated transient noise. The first method is to observe the real equipment, monitoring its status with a computer. The computer is connected via USB to the equipment and it could detect if the tag is recognized and if the information (128 addresses) is properly read. The tag is placed 2 cm apart of the RFID reader, this is the maximum reading distance without errors.

The second method is based on capturing the transient interference in time domain and determining, by means of simulation, the errors that would be produced on the real equipment [8].

The method developed in this paper allows us to evaluate the RTC system without need of placing the real equipment working in the actual place. Evaluating the RTC system in the scenario without using the real equipment is a key point before the installation of the RTC system. Instead of the real equipment an equal antenna is placed and connected to an oscilloscope and an EMI receiver. The transient in the RFID bandwidth is captured in IQ with the EMI receiver. The oscilloscope is used to generate a trigger signal for the EMI receiver to start the measurement when a transient takes place. After that, with a digital communication simulator, we can determine the errors that would be produced on a real RFID system by the five different transients considered. (Figure 2)
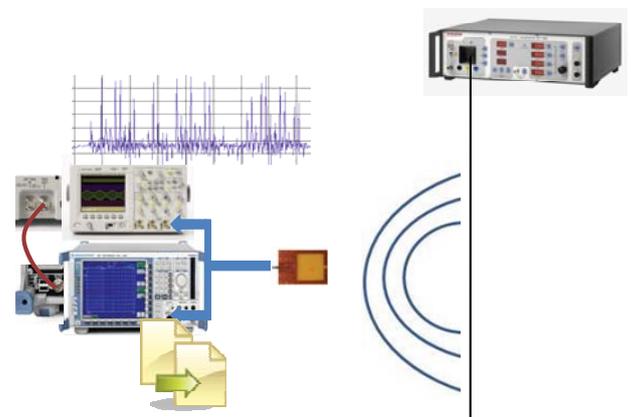

Figure 2. Transient capture using the method proposed. An RFID antenna, an oscilloscope and an EMI receiver are used.

III. RESULTS

The results have been obtained by using both methods: observing directly the behavior of the real RFID equipment, and using an antenna equal to the RFID device connected to an EMI receiver and simulating the RFID system behavior.

First of all, the effect of the different transient noises is evaluated observing the response of the RFID real equipment. The five different transient bursts defined in table 1 are applied producing different errors in the RTC system. The results show us all the different possibilities of errors defined in table 2. For example when type A and type C interferences are applied to the AC main wire, the tag is not detected by the RFID equipment. On the other hand, when type D and type E interferences are applied, the tag could be detected by the communication system but the tag information could not be fully read. Finally, when type B interference is applied a minor error takes place.

After evaluating the RFID system in presence of the different transient signals, the real equipment is substituted by an equivalent antenna connected to an EMI receiver and the oscilloscope. The instrumentation permits us to measure the transient signal in the system band as it has been explained before. Once the different transient signals have been captured, the error types that would be produced over a RFID ISO 14443-B system are determined by means of simulation. WinIQSIM software [9] is used to evaluate the RTC system using the data obtained in time domain, measuring with the proposed method. To determine the effect of the transient noise, the constellation, the i(t) q(t), the eye diagram, the vector diagram and the CCDF are analyzed when the captured transient signal is added. As an example we could study the degradation that occurs due to type A interference. In the constellation diagram (Figure 3), the symbols change their values due to the transient noise.
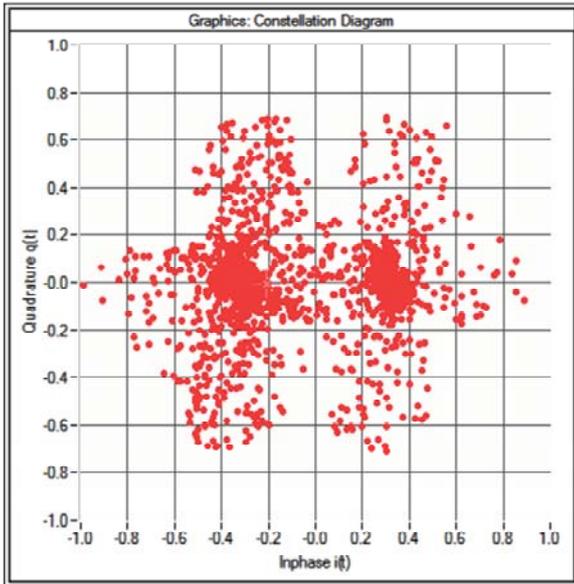

Figure 3. Constellation diagram of the RFID system when transient type A is applied.

After analyzing 5000 symbols, 14% of the symbols are affected by the transient signal causing decision errors. Due to this high symbol probability error the RTC system is clearly affected, the transient noise type A produces a fatal error (FE).

Comparing the results obtained with the developed method with the results obtained directly from the measure of the RFID equipment (Table 3), we obtain the same error type results.

TABLE III. ERRORS CAUSED BY TRANSIENT NOISE WHEN THE REAL EQUIPMENT IS PLACED AND WHEN THE PROPOSED METHOD IS USED

Interference	Measurement			Developed method
Reference	TAG detection	Number of errors reading TAG addresses	Error type	Expected error
A	NO	-	FE	FE
B	YES	1	MIE	MIE/NE
C	NO	-	FE	FE
D	YES	4	MAE	MAE
E	YES	5	MAE	MAE

Concerning the results obtained using both methods it can be observed that type A and type E interferences produce different errors to the RTC system. Type A transient produces a fatal error with no tag detection while E transient produces just a major error with tag detection and a large number of erroneous readings. This result is as expected because type A level of the pulses is 3 kV and type E is 2 kV, maintaining all other transient burst parameters.

When type A and type D interferences are evaluated, the level of the interference, the duration and the repetition rate is the same; the only difference is the frequency rate of the transient signal. The RTC system could not detect the tag with type A interference but type D interference allows the system to detect and identify the tag. Comparing the described effect of type A and D interferences it is clearly shown that considering only the maximum level of the transient signal is not enough to correctly determine the type of error that the transient would produced in the RTC system.

IV. CONCLUSIONS

A scenario emulating a real interference situation has been built to study the behavior of an RFID system in presence of radiated transient noise. It has been demonstrated that an RFID system according to ISO/IEC 14443-B standard could be interfered by radiated transient signals generated in a close mains wire. The RFID interference has been analyzed using two different methods. In the first method, a real equipment working in a real interference scenario are used to evaluate the system susceptibility. In the second method, an antenna equal to the RFID equipment is used to capture the transient in time domain, the effect on the RFID system is analyzed by means of simulation software. Both methods are equivalent as has been shown by the results obtained.

Also it has been demonstrated that it is essential to take into account the transient interferences to ensure the correct behavior of the digital communication systems. The technique

consisting in capturing the transient in time domain can be used to evaluate efficiently the digital communication system without any need of using the real equipment in the noisy environment.

Finally, the work shows that the transient signals have to be studied in time domain. The transient level is an important parameter but also other transients' parameters like the duration, the repetition rate and the frequency have to be considered to perform a correct evaluation.

R<small>EFERENCES</small>

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