Tamper-Proof RFID Security Tag

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Abstract— **In this publication we present a tamper-proof long range platform tolerant uhf smart RFID tag to identify valuable or security sensitive products. The smart tag functions as a platform tolerant tag but once detached from the host object, it will permanently stop functioning by rendering the RFID chip unusable. The tag is platform tolerant and the substrate design is proposed for future additive manufacturing. Electromagnetic performance and read range are considered.**

Keywords—RFID; Security

I. INTRODUCTION

Many high-value and security sensitive products require anti-tampering and anti-counterfeiting protection during manufacturing, transportation, storage and loading/unloading processes [1-3]. Radio-frequency identification technologies offer tremendous potential benefits for anyone who needs to identify, track and ensure the security of everything from tools and equipment to shipment containers passing through the world's ports [4]. However, until manufacturers begin building RFID capabilities directly into products, the technology has one major weakness: RFID tags can be removed. Conventional RFID labels can be non-destructively detached and re-applied. Tamper-Proof labels however can only be attached once. Any attempt to peel the label from its original mounting original component automatically destroys it. Most tamper-proof passive RFID tags use a layered design where removal from an object compromises the antenna and destroys the tag. Unauthorized reuse is therefore ruled out, unless the RFID chip is reattached to a new antenna [5-7]. The smart tag presented here offers additional levels of security, which when removed not only renders the tag unreadable, but the RFID chip is also destroyed, therefore eliminating reuse on another antenna. A further advantage of the proposed tag is to minimize damage to the product upon legitimate removal, since unlike most tamper-proof tags require permanent or strong adhesive if they are to tear or break if removed. However, permanent adhesive is not required to attach this tag and therefore less residue and surface damage occurs.

II. TAG DESIGN

The smart tag in Fig.1 is designed to identify metallic and water rich products at long range in harsh environments. The antenna is encapsulated in hard plastic (ABS) for protection. The encapsulated substrate (marked as Support substrate in Fig. 1) is designed to support the tag antenna between two guiding slots (antenna guide slots). The tag antenna is printed or stamped on a 1mm thick flexible plastic substrate and fitted through the guiding slots. A thin conductive layer is printed on the back of the support substrate to function as the antenna ground plan and covered with a thin layer of adhesive tape, as shown in Fig. 1. A small device (ASIC chip fixer) is glued permanently to the RFID ASIC which is then glued to the antenna terminals. The tamper-proof tag support substrate is covered by a 2mm thick ABS cover with a small open window. The tag is 123x40x8mm^3 in size.

III. TAG TAMPER PROOF PRINCIPLE

It is well known that metallic casings or water rich products can significantly reduce passive RFID tag read performance directly related to the power collected by the tag antenna. Therefore, a thin and flexible platform tolerant antenna was selected to enhance the smart tag performance in harsh electromagnetic environments at long rang [8].

As mentioned above, the antenna is exposed through the casing window, but is not fixed to the encapsulation and is free to extend in length. In its initial relaxed state the antenna is fitted through the guiding slots and lies over the curved surface of the support substrate. The antenna substrate in this state projects out from the slots by 2mm. The antenna ground plane shields the antenna from the underlying object, thus providing the platform tolerance. A small pressure is used to fix the smart tag on the surface of the tagged object. This force is sufficient to push the projected ends of the tag antenna inwards and consequently push the antenna away from the curved surface of the support substrate, and out of its relaxed state. The antenna is now in its 'primed' state. The upward movement of the antenna pushes the ASIC chip fixer into ASIC chip fixer window. When attempting to remove the tamper-proof tag from the tagged object, the antenna will slip back into its relaxed position. However, since the ASIC chip fixer is attached into the ASIC chip fixer window, the ASIC connections to the antenna terminals will be the weakest point and thus separate from the antenna, therefore rendering the antenna and ASIC useless.

IV. SIMULATION OR MEASUREMENT

The simulated reflection coefficient of the tamper-proof tag on air and on a large metallic plate (300x300mm^2) and on a water

bottle (200x200x30mm^3) are shown in Fig. 2. The tag is designed to resonate just below the US RFID frequency band in its primed state, and thus maximum power is transferred to the chip from the antenna when the tag is in attached to an object. However the design also allows the tag to be detected at shorter range in its relaxed state, as shown in Fig. 4. The Tamper-proof tag has a directional radiation pattern as shown in Fig. 3, with 5dB boresite directivity and -1.2dB radiation loss on air in it primed state. The tag directivity on the large metallic plate increases to 8.3dB, but since total radiation efficiency is lower, the realized gain reduces to 6.5dB. The high gain and high power transfer ratio on the large metallic plate result in a very long read range as shown in Fig. 4. However, higher total radiation loss for the tag on the water bottle results in a shorter read range. The tag performance can be improved on metallic or water rich objects by adopting a platform independent approach at the cost of a narrower bandwidth as discussed in [8].

V. CONCLUSIONS

Long read range is achieved with this novel design for rigid tamper-proof tags to securely identify large valuable items in harsh electromagnetic environments.

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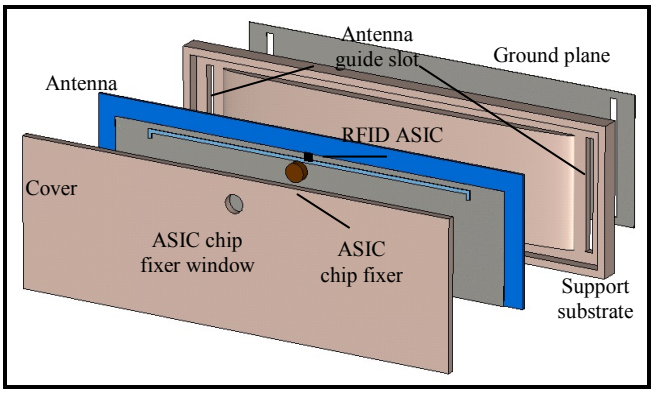

Fig. 1, Temper proof tag's blown up schematic

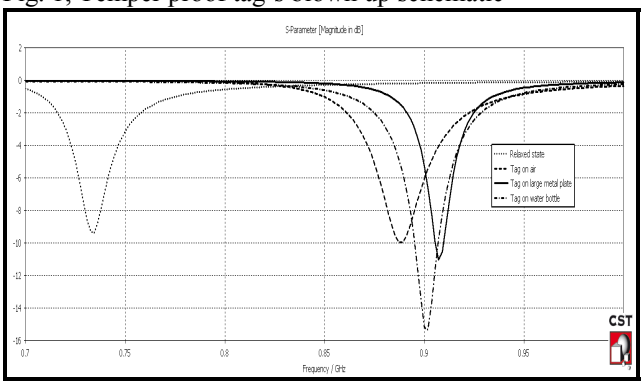

Fig. 2, Tag's S11, relaxed state (doted line), loaded state (dashed line), on large metallic plate (solid line), on water bottle (dashdotted line)

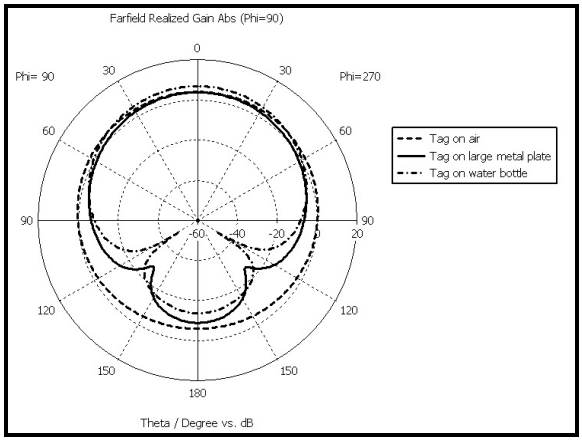

Fig. 3, Simulated realized tag gain, relaxed state (doted line), loaded state (dashed line), on large metallic plate (solid line), on water bottle (dashdotted line)

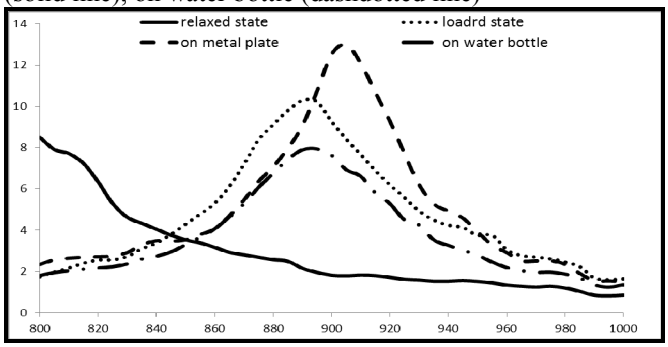

Fig. 4, Measured tag read range, relaxed state (solid line), loaded state (doted line), on large metallic plate (dashed line), on water bottle (dashdotted line)