Low Profile Rigid UHF RFID Tags

K. V. S. Rao, Sander F. Lam, Pavel V. Nikitin
Intermec Technologies
Everett, WA 98203, USA
email: {kvs.rao, sander.lam, pavel.nikitin}@intermec.com

***Abstract*— In this paper, we describe three passive UHF RFID tags designed for operating on various surfaces. One tag is designed for operating on non-metal surfaces (such as plastic and wood) in both ETSI (865-870 MHz) and US (902-928 MHz) bands and provides a minimum read range of 33 ft. Two other tags are designed for operating specifically on metal, in ETSI and US band respectively, with a minimum read range of 17 and 20 ft accordingly. All these tags have the same low profile form factor (5 mm thickness). We describe the tag design, present simulation and measurement results, and discuss typical applications.**

I. INTRODUCTION

Rigid and rugged fully encapsulated passive UHF RFID tags are becoming a popular choice in many industrial RFID applications where objects like containers, boxes, or pallets need to be tagged and potentially exposed to harsh environment.

There exist many works on various designs of rigid UHF RFID tags, primarily for on-metal applications. In our previous two papers on rigid tag designs [1-2] we already included extensive bibliographies of prior works which we will not duplicate here. A few good examples of recent relevant works on rigid tags are [3-6]. These as well as most of the tags referenced in [1-2] are patch type antennas with incorporated ground planes. As correctly noted in [3], there is always a trade off between the tag thickness, its footprint, and its read range performance on metal. One other important aspect is how the tag is attached to the object. Method of attachment (adhesive foam tape of certain thickness, metal screws, etc.) can also strongly affect tag performance.

In this paper, we present three rigid tags designed for operating on various surfaces. All these tags are based on single layer 60 mil FR4 boards and as a result have low profile and low cost. The tags can be mounted using either foam tape or metal screws, with no significant change in performance.

II. DESIGN

All three tags use linearly polarized folded dipole type structures of various shapes shown in Figure 1. Tag 1 is a wideband tag for operation on non-metal surfaces. Tags 2 and 3 are single band tags for operation on metal surfaces. The RFID IC used in tags was Impinj Monza 4QT chip in uDFN package with sensitivity -17.4 dBm [7]. All tag antenna boards used low cost single layer 60 mil FR4 PCB material. The boards were encapsulated in plastic cases with screw holes for optional mounting using M3 size screws. These tags could also be mounted using adhesive foam tape.

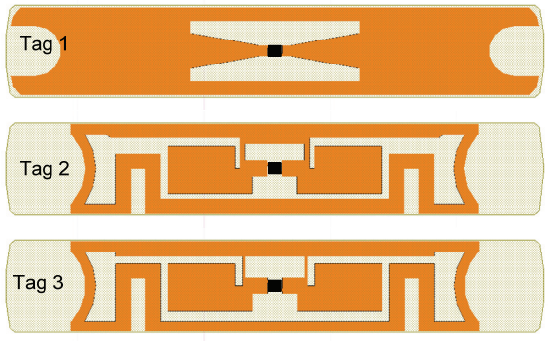

Figure 1. Tag antenna structures etched on FR4.

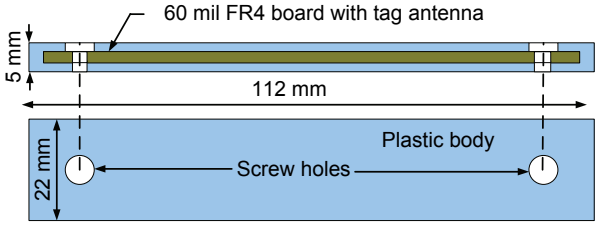

Figure 2. Cross-section and dimensions of the tags.

The tags were designed using EM simulation tool *Ansoft HFSS* which calculated tag antenna gain, impedance, matching to the RFID chip, and allowed us to optimize tag read range. The simulations were carried for situations when tags were encapsulated and then mounted on sheets of various materials (plastic and wood for tag 1, metal for tags 2 and 3) either with foam tape or with screws as shown in Figure 3.

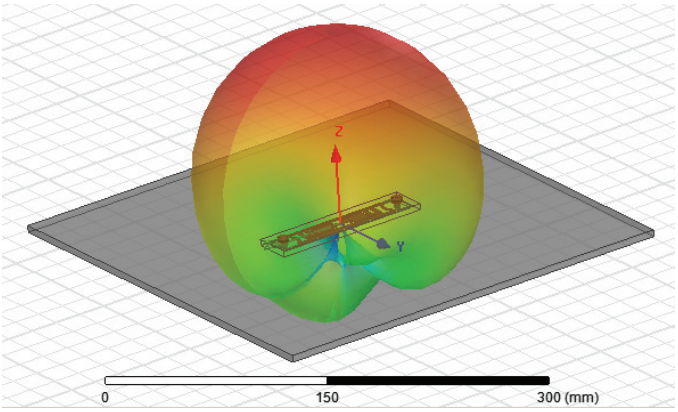

Figure 3. Simulated 915 MHz radiation pattern of tag 2 mounted with screws on 30 cm x 30 cm metal sheet.

III. MEASUREMENTS

The tags described in the previous section were prototyped and tested. Tag read range was measured in anechoic chamber using our National Instruments PXI RF LabView system which was described in [8]. Figure 4 presents experimental read ranges (boresight direction) for tag 1 on plastic and on wood; and for tags 2 and 3 on metal when mounted using either 25 mil self adhesive foam (3M 4646) tape or M3 metal screws. The size of the material sheets was 30 cm x 30 cm x 5 mm. The read range is plotted for 4 W EIRP in free space.

Modeling and simulation results were in good agreement with measurements and are shown in Fig. 4 for tag 1 on plastic and on wood. Our HFSS models for encapsulated tags included a thin layer of air between the tag board and the plastic case which exists there due to manufacturing process. One should note that since tags 2 and 3 do not have incorporated ground planes, their on-metal tape-mounted performance depends on foam tape thickness. In addition to that, as is the case with all metal-mount tags, the performance is affected by shape, size, and where on the metal object the tag is mounted on.

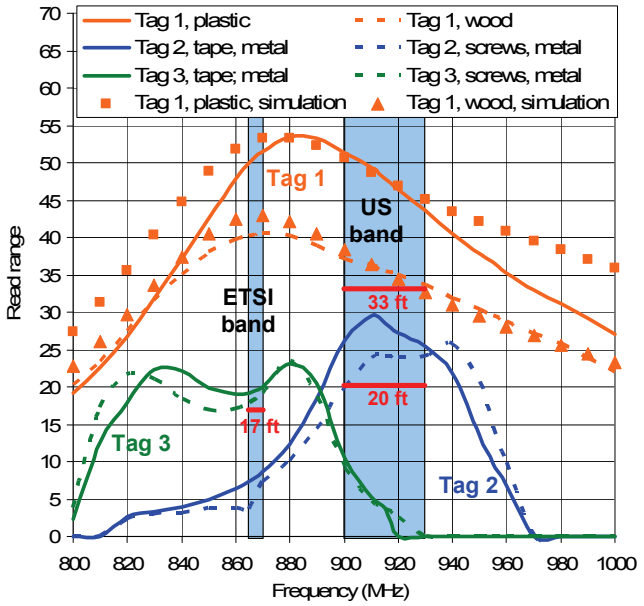

Figure 4. Measured and simulated read range of tags 1, 2, and 3 on various materials.

The tags were commercialized under the model names IT36, IT75, and IT76 [9]. The tags are summarized in Table I and are also shown in Figure 5. The read range is given for 4 W EIRP (for 3.3 W EIRP, the read range will be 10% smaller).

Tag	Name	Application	Band	Minimum read range
1	IT36	Non-metal	FCC/ETSI	33 ft
2	IT75	Metal	FCC	20 ft
3	IT76	Metal	ETSI	17 ft

Table 1: Summary characteristics of developed tags

Figure 5. Encapsulated tag prototypes.

Typical applications of these tags include returnable and reusable plastic and wood containers, totes, bins, trays, boxes, pallets, and carts (tag 1); and various metal containers, cages, pallets, and trailers (tags 2 and 3).

IV. CONCLUSIONS

In this paper, we described three low profile rigid passive UHF RFID tags designed for operating on various non-metal and metal surfaces. The tags are low cost due to their FR4 based construction, have good read range performance, and can be used in various applications where they can be mounted using either adhesive tape or metal screws.

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REFERENCES

[1] K. V. S. Rao, S. Lam, and P. V. Nikitin, "UHF RFID Tag for Metal Containers", IEEE Asia Pacific Microwave Conf., 2010, pp. 179-182

[2] K. V. S. Rao, S. F. Lam, and P. V. Nikitin, "Wideband metal mount UHF RFID tag", IEEE Antennas and Prop. Symposium, 2008, pp. 1-4

[3] T. Bjorninen et al., "Long range metal mountable tag antenna for passive UHF RFID systems", IEEE RFID-TA conference, 2011, pp. 202-206

[4] P. Yang et al., "Compact Metallic RFID Tag Antennas With a Loop-Fed Method", IEEE Transactions on Antennas and Propagation, vol. 59 , no. 12, 2011, pp. 4454-4462

[5] H.-D. Chen et al., "CP RFID tag design for metal surface mount", IEEE CSQRWC conference, 2011

[6] Hae-Won Son, Seung-Hwan Jeong, "Wideband RFID Tag Antenna for Metallic Surfaces Using Proximity-Coupled Feed", IEEE Antennas and Wireless Propagation Letters, vol. 10, 2011, pp. 377-380

[7] Impinj Monza 4 RFID Tag Chips [Online]. Available: http://www.impinj.com/Monza_4_RFID_Tag_Chips.aspx

[8] P. V. Nikitin and K. V. S. Rao, "LabVIEW-based UHF RFID tag test and measurement system", IEEE Transactions on Industrial Electronics, vol. 56, no. 7, pp. 2374-2381, July 2009

[9] Intermec Low Profile Durable Asset Tags [Online]. Available: www.intermec.com/products/rfid