Wideband Metal Mount UHF RFID Tag

K. V. S. Rao, Sander F. Lam, and Pavel V. Nikitin*
Intermec Technologies Corporation
6001 36th Ave W, Everett, WA 98203
www.intermec.com
Email: {kvs.rao, sander.lam, pavel.nikitin}@intermec.com

Abstract

This paper presents a wideband UHF RFID tag designed for operating on multiple materials including metal. We describe the antenna structure and present the comparison of modeling and simulation results with experimental data.

Introduction

There is a strong interest from many industries (airplane, automotive, construction, etc.) in tagging metal items (airplane or automotive parts, metal containers, etc.) using both active and passive RFID tags [1-2]. Passive tags are generally cheaper and simpler compared to active ones. They contain no batteries and can be fully encapsulated for ruggedness and protection. On top of that, UHF RFID band offers significantly longer read distance when compared to LF and HF frequencies. However, there is a challenge related to the influence of material properties and the presence of other objects in the near field zone on tag antenna characteristics and hence on tag range [3]. This effect is especially severe in UHF band for metal objects.

Several metal mount passive UHF RFID tags have been recently described in literature [4-9], patented [10-11], or produced commercially [12-14]. Those tags typically work in a single country-specific UHF band. In this paper, we describe a different, wideband, metal mount tag [15] which was developed independently of the works mentioned above. This tag has been successfully commercialized [16] and is currently used in many applications.

Analysis and Design

The tag is a patch structure with an offset coplanar tapered feeding and a virtual ground short formed by the outer rectangular ring. The antenna structure is shown in Figure 1. It has the two resonant frequencies (defined by complex conjugate matching to the chip impedance) to enable the wideband performance. The overall length and width of the outer rectangular ring structure determine the lower resonant frequency while the inner radiator length determines the upper resonant frequency. The tapered trace connecting the two structures provides the complex impedance matching for RFID chip.

The flexible antenna inlay was designed so that it could be placed on top of longer dielectric piece to form a large tag with high range or wrapped around smaller piece of the same dielectric to form a small tag with less range.

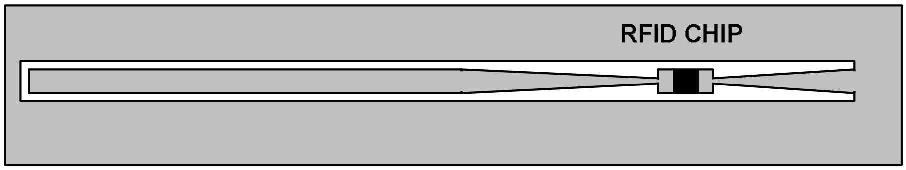

Figure 1. Metal mount tag antenna (top layer antenna inlay)

We used a UHF Gen2 RFID chip by Impinj in TSSOP package with sensitivity -12 dBm and packaged chip impedance Zc = 40 − j 120 Ohm. The antenna was designed using electromagnetic simulation tool *Ansoft Designer* which allowed us to calculate antenna gain, impedance, and matching to the chip. Simulated antenna gain pattern and input impedance for large tag in free space are shown in Figure 2.

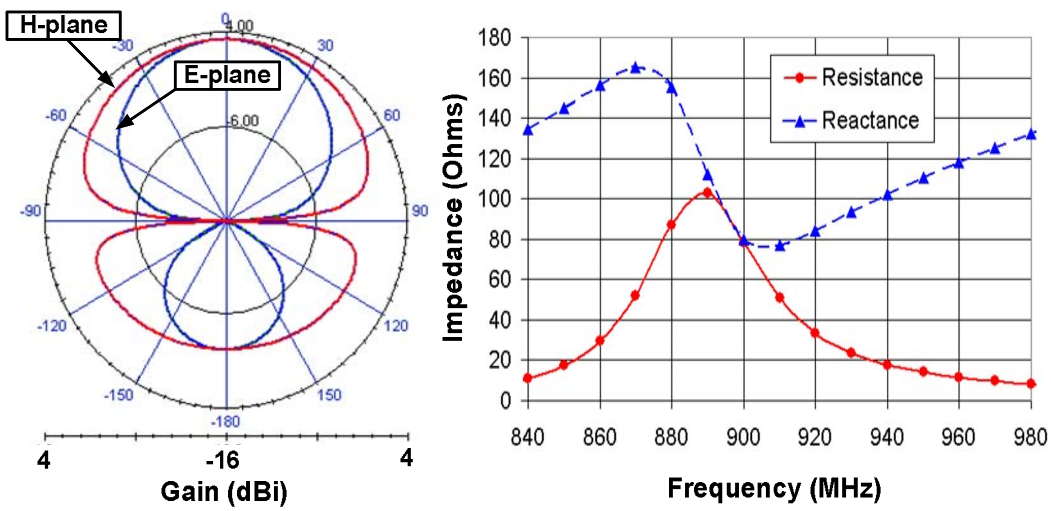

Figure 2. Gain pattern (left) and input impedance (right) of the tag antenna.

Experimental Data

Several prototypes of the tag were made and tested. The antenna inlay was copper etched on 2 mil flexible polyester substrate and placed on top or wrapped around the piece of polycarbonate plastic with bottom layer of conductive material, slightly longer than the dielectric itself, as shown in Figure 3.

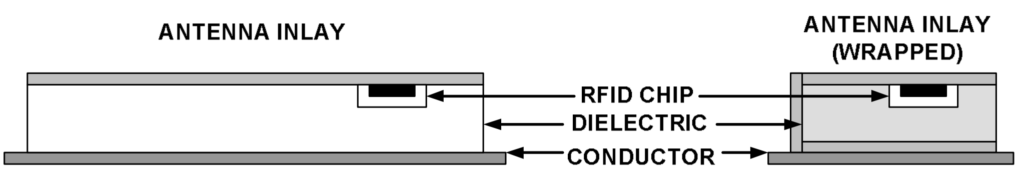

Figure 3. Cross-sections of large (left) and small (right) versions of tag.

The final tag antenna and RFID chip were integrated and encapsulated inside rugged plastic packages capable of withstanding extreme temperatures and hazardous exposures, shown in Figure 4. The antenna design was slightly modified to take into account the influence of the plastic package. The large tag dimensions are 15.5 cm x 3.2 cm x 1 cm and the small tag dimensions are 7.9 cm x 3.1 cm x 1 cm. For more specification details, see [15-16].

Figure 4. Large (left) and small (right) metal mount UHF RFID tags.

Tag read range was measured in anechoic chamber using National Instruments PXI RF LabView system [17]. Figure 5 presents experimental and theoretical read range (boresight direction) in free space, on plastic and on metal (12x12 in.). Modeling and simulation results were in good agreement with measurements. To avoid cluttering, a theoretical curve only for large tag in free space is shown. Separating two resonances allowed us to make this tag more wideband at the expense of range (bandwidth vs. range tradeoff). If higher tag range in more narrow frequency band is desired, it can also be easily realized by bringing the resonances together.

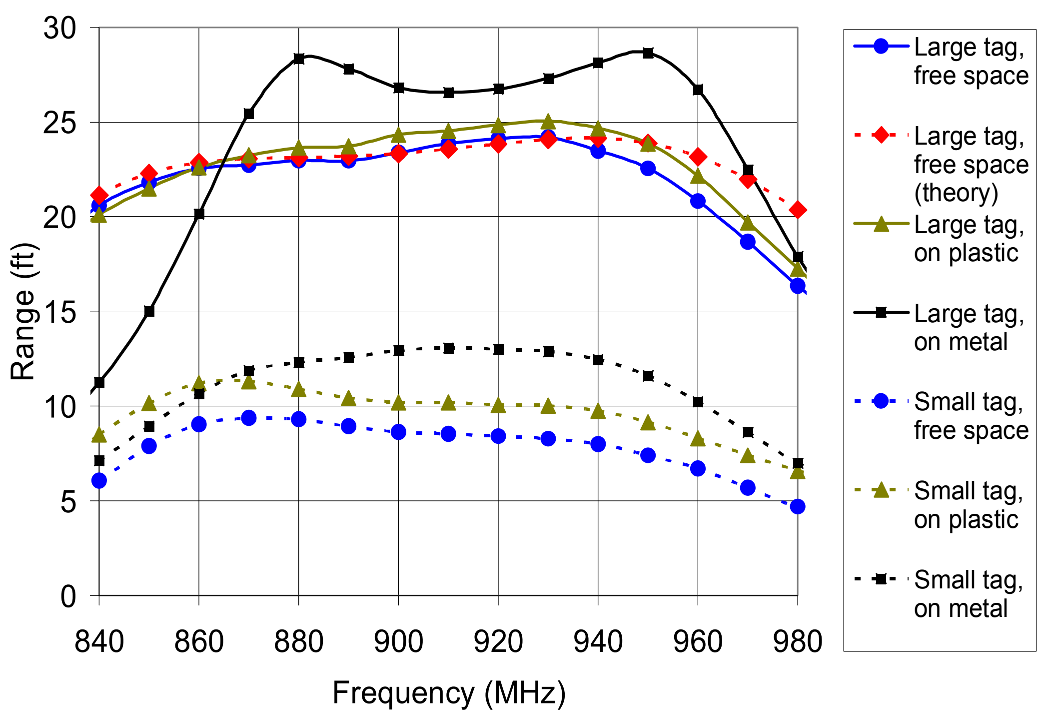

Figure 5. Experimental and theoretical read range (boresight direction) of large and small metal mount tags in free space, on plastic, and on metal (4 W EIRP).

Conclusions

In this paper, we described a metal mount RFID tag that works reliably on various materials, including metal, across the worldwide UHF RFID frequency band (860-960 MHz). The tag has two versions (large and small) which are based on the same antenna inlay and deliver a global minimum read range on metal of 25 ft and 10 ft accordingly. This tag can be used to identify and track goods and articles in various production, supply chain, or asset management scenarios, including item-level applications.

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