Six Attributes of High Performing RFID Tags for Retail Apparel Market

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***Abstract*—In this paper, the most important six requirements of high performing RFID tags for retail apparel market are presented. We discussed in detail why these attributes are of vital importance to a good tag. An example of GB3 tag is presented to outline effectiveness of the analysis.**

Keywords—RFID tag; Bandwidth; Orientation; Antennas

I. INTRODUCTION

As the apparel retailers evolve their business models to meet the demands of the digital age consumer, they need to be able to achieve real-time inventory visibility to improve inventory accuracy and operational efficiency. Passive Radio Frequency Identification (RFID) tagging at item level gives you real time, accurate stock information enabling a clear view of inventory status.

Early retailers have used RFID tagging for a number of different reasons and found benefits across their businesses. People found the key for a successful RFID project rely on how to select the right tags for their needs. This is actually very difficult because there's many things needs to be considered for a "good tag".

Recently, RFID provide an emerging solution to identify and track various objects [1]. The communication in passive UHF RFID systems consist of two parts: the reader and the tag. Reader transmits energy and commands. An RFID tag consists of an antenna and a microchip. Tags get all the energy for functioning from the electromagnetic radiation emitted by the reader. There is no internal source of energy in the tag's microchip to support the functioning [2]. For the passive UHF RFID, it is very critical to make the tag antenna working in a proper mode [3].

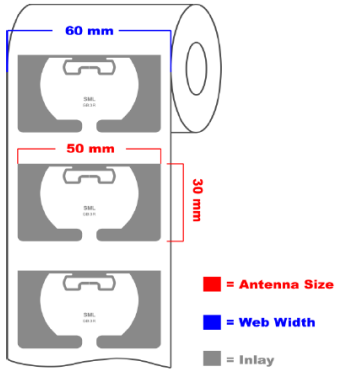
Conventional RFID tags are orientation sensitive and therefore fail to perform in all orientations and reading directions. This fact has prompted the design of a circular polarized antenna for the tags. The antennas in an RFID system are easily influenced by many factors such as the weather, electrical and magnetic circumstances, various materials etc.. Recently, many papers have been published to deal with this kind of problems. For example, influence to the system performance of bending the tag antenna has been studied in [4]. By comparing the performance of bending several kinds of dipole antennas, a new robust antenna structure has been proposed and this structure provides the antenna with an acceptable level of performance under several kinds of deformation of the RFID tag. In [5], the author has studied the circular polarized RFID tag antenna design when the tags were hold by human hand. Some has studied the performance of tag antenna on different materials, which gives a good direction for selecting the application areas of RFID [6]. Some papers have studied the influence of the application circumstances to the tag performance. For example, the influence of a limited size metal to the antenna radiation pattern has been studied in [7]. At the same time, the printing antennas are studied in [8] such that the huge volume production of the tags are possible.

There are always compromises of designing tags. For example, if we want high gain tag antenna to read long distance, then the tag antenna coverage angle will be small. If we want the antenna to be broad frequency bandwidth, then the peak performance on a certain frequency will drop. In this paper the author would like to offer the reader the opportunity by describing more about the technology, and illustrating the use cases from the apparel industry and how we can get a good compromise over different constraints and requirements. We use the SML's GB3 series tag to show that with a single tag design, the tag can function in a retail environment in various aspects.

II. ATTRIBUTES OF HIGH PERFORMING TAGS

1. The size of tag should fit for most existing label size

As we all know, typical apparel tag sizes are 1.5x2inch, 2x3 inch, 2x4 inch, 1.5x3inch, 1.5x4 inch. Traditional long-range UHF tags are manufactured with an RFID chip attached to a dipole antenna that totals 160 mm (6 inches) in length. While with the GB3 tag antenna minder-lines and the center loop for matching the imaginary part of the impedance, the size of the antenna was significantly reduced within 2 inches. Now the



GB3 tag antenna only measures 1.18x1.96 inches which can fit for most of the apparel hang tags or labels. What's more, the GB3 tags can be either converted to hang tags or wet/paperface labels, which can deliver in both single piece or roll format.

2. The tag antenna should be robust on different apparel materials

After a careful study of the dielectric properties of retail apparel consumer goods, it has been determined that we can group the apparel application to 3 cases:

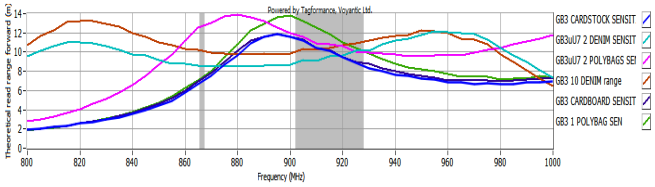
(1) Hang tags; (Tags hanging in free air)

(2) Medium load case;(Tags in light dielectric material)

(3) Heavy load case. (Tags in large dielectric materials)

a. A Hang tag case can be simulated by placing the tag directly on the cardstock.
b. A Medium load case can be simulated by placing the tag between 2 poly bags (as shown above picture).
c. A Heavy load case can be normally simulated with the inlays stacked within denim.

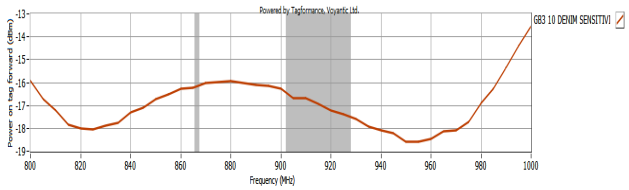
The frequency shifting between the case (1) and case (3) can be maximized to 150MHz. Therefore the GB3 inlays were designed to resonant on multiple frequencies and those frequencies was carefully selected such that they can fit for all materials.

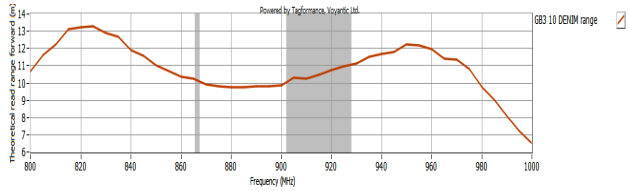


Testing the different cases shows the GB3 inlays perform very well in all of the circumstances stated above.

3. "The good tag" should have broad frequency bandwidth to cover global RFID frequencies

In July 2016, GS1 reported 98% of its member countries UHF passive RFID using frequencies within 860~960MHz. The other 2% are not available yet. Most countries are using 902~928MHz as the UHF RFID frequency. In Europe, most country uses 865~868MHz. The global UHF RFID frequencies requires the RFID tag antenna to have a broad frequency bandwidth.





With a simple test for a tag under the most heavy load “10 pairs of denim”, we can see the GB3 tag sensitivity is lower than -16dBm and reading distance higher than 10 meters based 4W EIRP in 800~980MHz. Which is broad enough to cover the global 860~960MHz with a big margin.

4. The good tags will need flexibility for multiple IC options

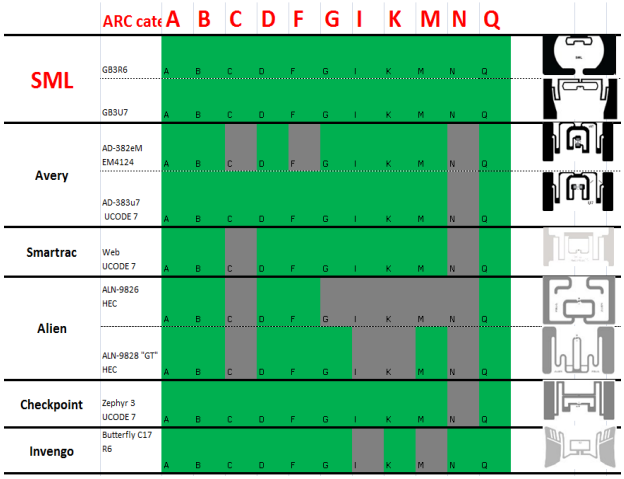
NXP and Impinj is considered two of the largest UHF IC suppliers in the world. Respectively, they published their new generation ICs named UCODE7 and MonzaR6, which all sensitivities already exceed -20dBm. Because UCODE7 and MonzaR6 offer different functions and features, it will be very helpful for multiple choices of ICs for the same model. For example, SML GB3 tag provides both IC options:

	IC manufacture	IC model	EPC
GB3U7	NXP	UCODE7	128bit
GB3R6	Impinj	MonzaR6/R6P	96/128bit

5. *Third party certifications like ARC is a very important indicator for a good tag*

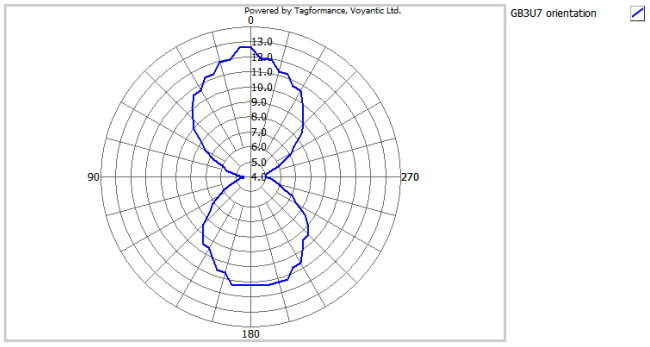
The ARC (Auburn Radio Compliance) program is manage by a 3rd party testing lab located in Auburn Alabama–(RFID Lab of Auburn University). The purpose of the ARC program is to ensure that retail suppliers are able to deliver RFID tagged product to retailers that meet or exceed the levels of performance necessary to provide benefit to both the retailer and the retail supplier in a consistent and cost effective manner. Up to date, the ARC program has published category A, B, C, D, F, G, I, K, M, N, Q. Each category contains different RF performance requirements. That's why it is extremely difficult to get one single tag to pass all categories. The following table shows the GB3U7 and GB3R6 have passed all the categories with the tag size of 50x30mm (Green is PASS).

Each category is actually a big retail application. For one tag to cover multiple categories, it means much less change over time on the production, much less cost on raw materials because of volume, and much less management cost as well.



6. *Tags for retail apparel should have no dead zone of orientation*

Most tag antenna is with single dipole. When the tags hanging, the polarization is vertical to the ground. When the apparel is stacking to the shelf, the tags are normally horizontal polarized. We want the orientation of tag as wide as possible because the tag needs to be read from different directions while we cannot visually see the direction of tag.



As shown in the illustration above, the orientation pattern of GB3 tag shows that even with the minimum radiation angle at 90 degree and 270 degree, the GB3 tag still achieves a min of 4 meters in theoretical reading distance. (Tested with Voyantic Tagformance system) This omni-directional pattern is very important for retail apparel because the GB3 tag performs in the blind spots that are common in the industry.

III. CONCLUSION

Radio Frequency Identification (RFID) is widely adopted by the retail apparel market now. With billions of tags being used, it's very critical to understand what's the important attributes for a "good tag". This paper summarizes the most important six attributes of a good tag. It's shown that the SML GB3 tags provide a solution for the retail apparel industry. The distinct advantages of the GB3 tag come together combining its perfect size, resonant frequencies, performance, multiple IC options and omni-directional performance, which provides the decision-makers of retail apparel a clear choice of managing their supply chain.

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