Platform Tolerant UHF RFID Tag Design using Multi-resonant Surface for Supply Chain Visibility

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***Abstract*—This paper presents a platform tolerant ultra-high radio frequency identification (UHF RFID) tag design for hard to tag supply chain items such as large metal and wooden containers.The proposed design consists is backed by multi-resonant surface carefully designed using characteristics mode analysis.As a result,this tag design features a long read range and covers most of UHF RFID frequency bands. The evaluation of the read range associated with fabricated prototype of proposed tag configuration is done through turn on power measurements using Tagformance Pro setup. A variety of subjects with different physical constitutions such as metal,wood and glass are considered in order to demonstrate the robustness of our solution. The proposed tag offers a relatively longer reader range of 12.5 m after mounting on piece of metal, wood and glass materials. Therefore, this tag design is suitable candidate for supply chain visibility and cargo monitoring.**

I. Introduction

Internet of Things (IoT) and RFID are synergy player enabling numerous vertical applications beyond identification such as sensing, supply chain visibility, localization and tracking of assets. UHF RFID technology is most prevalent due to its low-cost inkjet printable tags,long read range and multi-tag reading capabilities. However, it is challenging to tag surfaces such as Metal wood that are considered to be hard to tag items due to inherited sensitivity issues of UHF RFID technology [1]. This tagging challenge is magnified further, if the size and physical composition of tagging surfaces is unknown. However, there were number of techniques has been emerged for solving aforementioned issue. A folded dipolar type tag antenna with embedded artificial magnetic conductor (AMC) for metal mountable applications was proposed in [2].The dipolar tag achieved read range of 9.8 m with following dimensions 30 × 50 × 3.35 mm^3, however, this tag design is tested only on small thin-sheet metallic boxes. Another tag solution using AMC has been proposed in [3] for getting enhanced read range and platform tolerant features. moreover, this tag design featured a read range of 7.3 m in European RFID band (865 - 868 MHz) with dimensions 72 × 53 × 3.4 mm^3. In [4], a dual band tag antenna was proposed using 4 × 4 periodic metasurface metallic plates. This metasurface based tag design achieved a read range of 6 m with fairly large dimensions 190 × 190 × 15.8 mm^3. Therefore, this paper presents a tag design backed by multi-resonant surface designed using characteristics mode analysis. The proposed tag offers a read range of 12.5 m after mounted on metal,glass and wooden materials. The dimension of proposed design are relatively compact 85 × 28 × 4 mm^3. The robustness of tag is tested after being mounted on materials of different sizes. Therfore, the proposed tag antenna is suitable for for supply chain visibility, cargo monitoring and IoT applications.

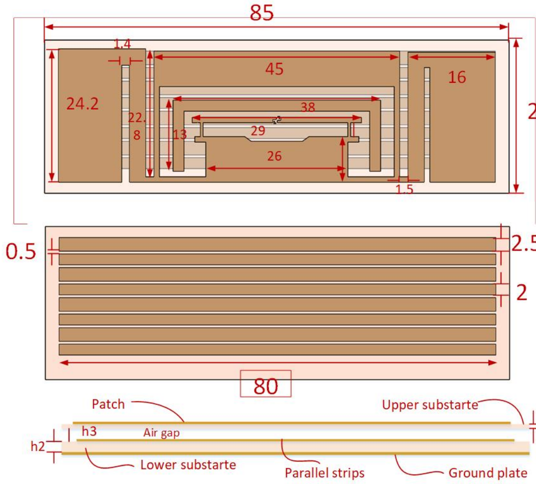

Fig. 1. Detailed dimensions and layout of proposed tag antenna and multi-resonant surface.

II. Tag Antenna Concept and Design

Fig. 1 shows the detailed dimensions and layout of overall tag configuration as well as individual antenna and multi-resonant surface. AP-S summary papers are limited to two pages. The overall tag design consists of two substrate layers separated by 2.5 mm air gap. The tag antenna and multi-resonant surface is printed on FR-4 substrates of thickness 0.5 and 1 mm,respectively. The tag design is based on T-match, loop, parasitic strips and capacitive-end for size reduction and getting best match with Impinj monza R6 chip with impedance of 16-140j at 915 MHz. The multi-resonant surface composed of metallic strips of different widths 2.5 mm and 2 mm separated by 0.5 mm.

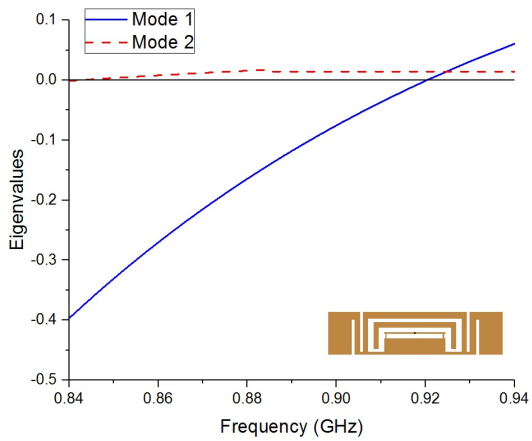

Fig. 2. Eigenvalue plot of first two modes of single layer of tag antenna.

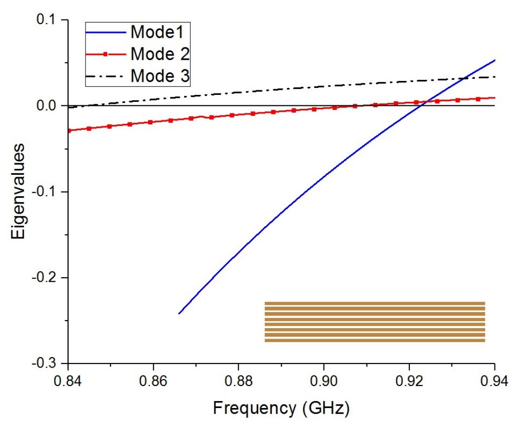

Fig. 3. Eigenvalue plot of first two modes of single layer of multi-resonant surface.

Fig. 2 shows the Eigenvalue plot associated with first two modes of single layer tag design extracted from CMA. The tag layer configuration only provide one resonant mode in US RFID frequency band (902 - 928 MHz), which does not cover much bandwidth. The Eigenvalue plot associated with first two modes of multi-resonant surface over PEC boundary is shown in Fig. 3. The multi-resonant mode surface provides two resonant modes in frequency band of interest. The CMA of overall configuration after placing single layer tag over multi-resonant surface with air gap of 2.5 mm is also done. The overall configuration provides the multiple resonant modes in band of interest that further leads to performance enhancement of proposed tag in terms of bandwidth, isolation, read range and platform tolerable features.

III. Results and Discussion

Fig. 4 shows the S11 parameter of overall tag configuration with and without multi-resonant surfaces. It is clear from Fig. 4, that single layer tag cover a fraction of bandwidth and demonstrate a poor match after mounted on metallic surface.However, tag design shows a promising performance in terms of bandwidth and impedance match after backing with multi-resonant surface. A prototype of proposed design is fabricated for read range and impedance measurement. The measured S11 result matched well with simulated results. From read range perspective, the tag antenna achieved a read range of more than 12.5 m after being mounted on metallic,glass and wooded pieces.

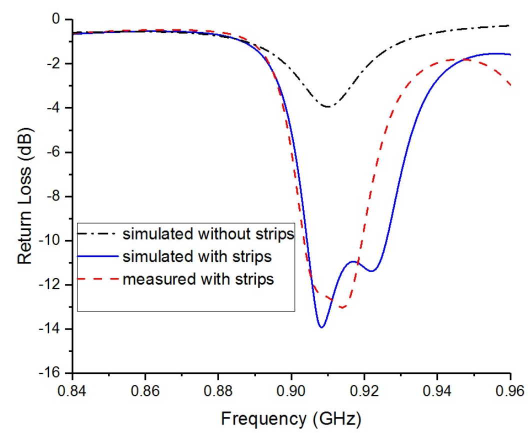

Fig. 4. S11 parameter of overall tag configuration with and without multi-resonant surfaces after mounted on metallic surface.

IV. Conclusion

A tag design backed by multi-resonant surface using characteristics mode analysis was proposed. The proposed tag offers a read range of 12.5 after mounted on metal,glass and wooden materials with relatively compact size of 85 × 28 × 4 mm^3. The robustness of tag is tested by measuring the read range after being mounted on materials of different sizes. Therefore, the proposed tag antenna is suitable for for supply chain visibility, cargo monitoring and IoT applications.

Acknowledgement

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