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Chipless RFID Tags based on Multiple Band-rejected Planar Log-Periodic Antennas

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Abstract—A passive chipless Radio-frequency identification (RFID) tag is proposed based on the tailorible band-rejection property of the log-periodic (LP) antennas. The proposed tag principle is successfully demonstrated using full-wave simulations, where the absence and presence of the band-rejection in VSWR and thus radiation gain, is shown to carry the bit information. Due to the large number of dipole radiators on the LP aperture, the proposed tag can easily support large number of codes, providing a potential solution for limited number of bits in conventional chipless tags.

I. INTRODUCTION

A log-periodic (LP) antenna has impedance and radiation characteristics that are repetitive as a logarithmic function of frequency, resulting in a multi-octave bandwidth property, with applications in communications, electronic warfare systems from UHF to terahertz applications and UWB applications [1]. An LP antenna consists of number of resonant dipoles whose dimensions are scaled by a constant parameter $\tau$, as shown in Fig. 1. In this paper, a new proposal is made to utilize the resonant dipoles of an LP antenna to encode data bits in a Radio-frequency identification (RFID) system.

RFID systems have diverse applications in fields of communications, ticketing, transportation, logistics, tracking, inventory, human identification, and security, to name a few. A typical RFID system comprises an interrogator (also called a reader) and many tags (also called labels). RFID systems which are powered up by their own power supply or by the RF energy provided by the interrogating signal, are referred to as the passive systems. Passive tags can themselves be classified as chip and chipless tags and are restricted to relatively small distances to the reader. The latter are attractive because of their low-cost due to the absence of an integrated circuit, but typically suffers of low number of bits that can be encoded [2]. A potential solution to solve this issue is presented here, based on an LP antenna whose resonant dipoles can be used to encode large number of data bits.

II. CHIPLESS RFID TAG BASED ON LP ANTENNA

A. Tag Description

The proposed RFID system is shown in Fig. 2(a) where an interrogating signal $v_{in}(t)$ is incident upon the tag, which imprints a code on it and resent the output signal $v_{out}(t)$ back to the RFID reader. In this system, an interrogating signal could be a frequency ramp, and the coding by the tag is

\[ \tau = \frac{R_{n-1}}{R_n} \]

\[ \sigma = \frac{r_n}{R_n} \]

Radiating dipoles

\[ v_{in}(t) \] \[ v_{out}(t) \]

RFID Tag

Coding Unit

Tag #1

Band-rejection locations

Gain

Frequency

\[ f_1 \]
\[ f_2 \]
\[ f_3 \]
\[ f_4 \]

Fig. 1. Planar log-periodic (LP) antenna aperture geometry with different parameters.

Fig. 2. Proposed RFID system. a) Code interrogation and the typical encoded signals, and b) Tag based on band-rejected LP antennas.
based on introducing signal absorption at specific combination of frequencies, and thus specific time instants. This precise control of frequency absorption is achieved by using the proposed LP antenna based tag.

A planar LP antenna consists of number of resonant dipoles, as shown in Fig. 1. Each dipole pair in the LP aperture is responsible for far-field radiation within a specific frequency band. This property can be exploited to encode bit information on the aperture itself, as illustrated in Fig. 2(b). The proposed tag consists of an LP antenna aperture from which a specific combination of resonant dipoles are removed to introduce a band-rejection in the gain response of the antenna, as first shown in [3]. By choosing a specific combination of the resonant dipoles, the presence or absence of a null in the gain at a given frequency can be tailored, thereby encoding a specific bit combination. This is the principle of the proposed tag.

Figure. 3 shows the FEM-HFSS simulated VSWR of various LP aperture from which different combinations of resonant teeth have been removed to create specific band-rejections in the frequency response. A band-rejection in VSWR implies a null in the radiation gain at the same band. The absence of null in the gain at a given frequency can be considered as bit-0 and bit-1 otherwise. As can be seen, by different combination of the dipoles removed (indicated by the indices $N_i$), various combinations of the band-rejections are introduced, which then can be interpreted as different bit-combinations.

**B. Features and Benefits**

The proposed tag offers several benefits. Firstly, its a completely passive and chipless tag, thereby low in cost and compatible with planar PCB fabrication. Besides, the tag is simple to design as the LP aperture acts both as a radiator and the coding element. Secondly, the tag is frequency scalable and can potentially be designed at millimeter waves. It is also inherently broadband owing to the intrinsic property of the LP radiator, thereby capable of fast interrogation response. Thirdly, for a given aperture size, large number of radiating dipoles $N$ can be placed by controlling the growth parameter $\tau$. The total number of codes that can be encoded is $2^N$, which can easily be a large number. And finally, the field-of-view of the LP antenna is large (typically larger than 120°) due to its dipole-like bi-directional radiation pattern, thereby making the tag suitable for interrogating from a bigger radiation space.

**III. CONCLUSION**

A passive chipless RFID tag has been proposed based on the tailorable band-rejection property of the LP antennas. Due to the large number of dipole radiators on the LP aperture, the proposed tag can support large number of codes, which is typically a major issue in conventional chipless tags. The proposed tag principle has been successfully demonstrated using full-wave simulations, where the absence and presence of the band-rejection is shown to carry the bit information. The issue of tag miniaturization and its scattering analysis is currently under investigation.

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**REFERENCES**