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Generation of Multiresonator Based RFID System with Accurate Attenuation and Fill until Complete Mechanism (AAFCM)

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Abstract

Band pass filters are important components for RF/microwave systems providing a low insertion loss within the pass band and a large attenuation in the stop band .Recently; broadband band pass filters have drawn a lot of attention. The design of broadband microwave filter consisting of parallel-coupled lines usually has the realization problem of very narrow coupled-line gaps. In recent years, solutions especially related to broadband filter implementations have been studied in several literatures. In this paper we proposed Chipless RFID Multiresonators, fabricated with Accurate Attenuation and Complete until Fill until complete Mechanism. In AAFCM technique we assume the conductive material is filled into a mould with predefined dimensions. A chipless RFID transponder consists of a multiresontor connected between 2 tranceiving antennas. We present a new multiresonator loaded band-rejected planar monopole antenna for ultra wideband applications. Then we apply the concept of Non Redundant design procedure on that system so we can achieve much simpler and accurate synthesis in comparison to previous one.

Keywords

AAFCM, RFID, Multiresonator, Non Redundant Design

1. Introduction

RFID is a contactless data-capturing technique, which uses RF waves for automatic identification (ID) of objects. The contactless ID system relies on RF waves for data transmission between the data carrying device called the RFID transponder, and the interrogator, which is also known as the RFID reader [1], [2].

The broadband micro strip antenna (MSA) is realized by using the multi-resonator gap-coupled or stacked configuration [10]. The parasitic patch having slightly different resonance frequency is coupled to the fed patch and bandwidth (BW) depends upon the inter-spacing between these two frequencies. In the broadband wireless communication networks, the requirements for future multimedia applications exceed the capacity of the currently used microwave frequencies. Then, attention all over the world has gathered in mm-wave license free frequency band [3] [4] [5], in recent years, many papers of the active circuits and MMICs in the 60 GHz band has been published [6] [7] [8] [9]. In the 60 GHz band, where the oxygen absorption has its maximum, there is the benefit of reduced interference. And also this frequency band has advantages of the small antennas, and the compact and light equipment’s. On the other hand, in the case of the short distance communication system, the mm-wave band has the problem with narrow cover area by its directivity. And in recently a high security is requested in the wireless links. So we are studying the” multi beam” access-point of the wireless broadband communication systems. It seems to provide the high speed, secure, and effective wireless link to the wide cover area.

Researchers around the world have been working on developing chipless RFID systems, which seem to be a promising solution for low-cost item tagging. Thus far, the only commercially successful chipless RFID system is developed by RFSAW and it is based on surface acoustic waves (SAWs). Although, SAWtags are fully functional and could well replace the chipped tags, they do not provide a fully printable solution due to their piezoelectric nature, which could not be applied on banknotes, postage stamps, or other paper/plastic based items.

Fully printable chipless RFID tags have been reported using space-filling curves and capacitive tuned dipoles. The space-filling curves require considerable layout modifications for data encoding, while capacitive tuned dipoles could have undesired parasitic mutual coupling effects and size limitations restricting efficient data encoding.

The remaining of this paper is organized as follows. We discuss RFID in Section 2. In Section 3 we discuss about Multiresonator. In section 4 we discuss about Recent Scenario. In section 5 we discuss about the proposed work. The conclusions and future directions are given in Section 6. Finally references are given.

2. RFID

Radio-frequency identification (RFID) is a technology that ses radio waves to transfer data from an electronic tag, called RFID tag or label, attached to an object, through a reader for the purpose of identifying and tracking the object. Some RFID tags can be read from several meters away and beyond the line of sight of the reader. The application of bulk reading enables an almost-parallel reading of tags.

The tag's information is stored electronically. The RFID tag includes a small RF transmitter and receiver. An RFID reader transmits an encoded radio signal to interrogate the tag. The tag receives the message and responds with its identification information. Many RFID tags do not use a battery. Instead, the tag uses the radio energy transmitted by the reader as its energy source. The RFID system design includes a method of discriminating several tags that might be within the range of the RFID reader.

A number of organizations have set standards for RFID, including the International Organization for Standardization (ISO), the International Electro technical Commission (IEC), ASTM International, the DASH7 Alliance and EPCglobal. There are also several specific industries that have set guidelines including the Financial Services Technology Consortium (FSTC) has set a standard for tracking IT Assets with RFID, the Computer Technology Industry Association CompTIA has set a standard for certifying RFID engineers and the International Airlines Transport Association IATA set tagging guidelines for luggage in airports.RFID can be used in many applications. A tag can be affixed to any object and used to track and manage inventory, assets, people, etc. For example, it can be affixed to cars, computer equipment, books, mobile phones, etc. The Healthcare industry has used RFID to reduce counting, looking for things and auditing items. Many financial institutions use RFID to track key assets and automate compliance. Also with recent advances in social media RFID is being used to tie the physical world with the virtual world. RFID in Social Media first came to light in 2010 with Face book's annual conference. RFID is a superior and more efficient way of identifying objects than manual system or use of bar code systems that have been in use since the 1970s. Furthermore, passive RFID tags (those without a battery) can be read if passed within close enough proximity to an RFID reader. It is not necessary to "show" the tag to the reader device, as with a bar code. In other words it does not require line of sight to "see" an RFID tag, the tag can be read inside a case, carton, box or other container, and unlike barcodes RFID tags can be read hundreds at a time. Bar codes can only be read one at a time.

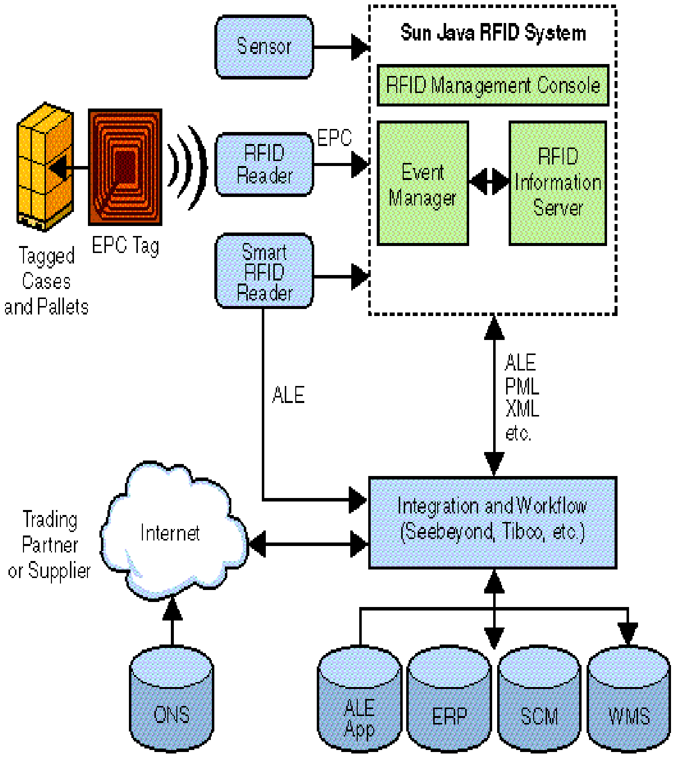

Fig 1 RFID Function

3. Multiresonator

In an RFID system where the RF frequency is defined by a resonator there are three variables: (1) the resonant frequency of antenna, (2) the resonant frequency of transponder and (3) the RF driving frequency. Where a PLL is used, there are only two variables, since the resonant frequency of the antenna and the RF driving frequency are the same.

Analysis suggests that, for a system having defined tolerances on the antenna and transponder side, the range where one demodulation chain (AM) with fixed sampling point can be used is much narrower for a PLL system. In fact, taking in account technically achievable tolerances the resonator system using one sampling point is not feasible; two channels with 90-degree shifted sampling points are needed (AM/FM). This leads to more expensive system which is also more complex to operate.

A PLL system with one sampling point has also limitations for the tolerance range of transponder and antenna. As a general rule, the higher the quality factors (Q) of the two resonant circuits are, the tighter tolerances that are required (this is also true for a resonator system).

An RFID system with air transponder coils is normally not problematic. For transponders with a Q lower than 15, a tolerance of kHz on the antenna and transponder side is acceptable. Transponders with ferrite core coils have usually higher quality factors (up to 40) and are therefore much more sensitive to tolerance variations.

The following example presents the EM4095 front-end using on-off-keying (OOK) communication protocol from the reader to transponder (uplink). Some helpful equations are presented here. They can be used for principal design, but the calculations have to be verified by measurement. Eventually the results have to be adjusted to compensate possible parasitics and second order effects.

A reader system with a high Q antenna will be specified. The system will operate at
f0 = 125 kHz
To design a low cost read/write (R/W) basestation using OOK communication protocol for the uplink communication, the "Typical Operating Configuration" (figure1) is used.
The antenna inductivity is usually chosen from within the range from 300 uH to 800 uH. In this example the following inductivity and quality factor have been selected.
LA = 725 uH ± 1 percent QA = 40.
The ohmic antenna resistance can be found by applying the formula

$$R_{ANT} = \frac{2\pi f_0 L_A}{Q_A}$$

RANT = 14.23 ohms
The antenna driver resistance and the power supply voltage of
RAD = 3 ohms VDD - VSS = 5V
will be used in following calculations.
System will operate at 125 kHz. The resonant capacitor CRES is calculated by

$$C_{RES} = \frac{1}{(2\pi f_0)^2 L_A}$$

CRES = 2.24 nF
Remark: Until this point of the calculation, Cdv1 and Cdv2 effect (the real resonant frequency value) has been neglected, as they are not yet calculated.
Calculate the reader antenna current and voltage by the given antenna driven in the bridge-driver configuration and applying the equations

$$I_{ANT(peak)} = \frac{4}{\pi}\frac{V_{dd} - V_{ss}}{R_{ANT} + R_{SER} + 2R_{AD}}$$

And

$$V_{ANT(peak)} = \frac{I_{ANT(peak)}}{2\pi . f_o . C_{RES}}$$

the current and the voltage at the reader antenna are (Rser=0):
IANT (peak) = 315 mA
VANT (peak) = 182 V
To suite the maximum specifications at DEMOD_IN, the antenna voltage would have to be divided by nearly a factor of dC = 100. Decimating the antenna voltage ensures a proper demodulation of the received transponder data signal.
Applying a serial resistor RSER to the resonance circuit can reduce the division factor dc.

4. Recent Scenario

In 2008, Tzyh-Ghuang Ma et al. [10] present a new multiresonator loaded band-rejected planar monopole antenna for ultra wide band applications. The proposed microstrip-fed antenna is composed of a flared metal plate, a truncated ground plane, and two pairs of folded strips. By applying the resonance nature of the folded strips and the associated cross coupling effects, the proposed antenna demonstrates band stop-filter-like response with bandwidth controllability at the targeted rejection band.

In 2009, Stevan Preradovic et al. [11] presented a fully passive printable chipless RFID system. The chipless tag uses the amplitude and phase of the spectral signature of a multiresonator circuit and provides 1 : 1 correspondence of data bits. The tag comprises of a micro strip spiral multiresonator and cross-polarized transmitting and receiving microstrip ultra-wideband disc loaded monopole antennas. The reader antenna is a log periodic dipole antenna with average 5.5-dBi gain. Firstly, a 6-bit chipless tag is designed to encode 000000 and 010101 IDs. Finally, a 35-bit chipless tag based on the same principle is presented. They proposed that the tag has potentials for low-cost item tagging such as banknotes and secured documents.

In 2010,Stevan Preradovic et al. [12] presented a RFID system with a chipless RFID tag on a 90- 11m thin Taconic TF290 laminate is presented. The chipless tag encodes data into the spectral signature in both magnitude and phase of the spectrum. The design and operation of a prototype RFID reader is also presented. The RFID reader operates between 5 - 10.7 GHz frequency band and successfully detects a chipless tag at 15 cm range. The tag design can be transferred easily to plastic and paper, making it suitable for mass deployment for low cost items and has the potential to replace trillions of barcodes printed each year.

In 2011, Jeng-Shien Hsieh et al. [13] observe that the non-redundant synthesis of BPFs with dual-mode and triple-mode stepped impedance resonators. Network models of the multi-moderesonator filters and conventional parallel-coupled-line filters are shown to be equivalent. Non-redundant design procedure is proposed and design equations are then derived based on broadband approximate design procedure.

In 2011, Olivier Jamin et al. [14] presents a broadband fully integrated high dynamic range RF front-end with a single-inductor programmable RF amplitude equalizer, 45dB variable gain range, 4.5dB NF, 60dB CSO/CTB, and 25dB anti-aliasing protection. It is designed in a 40GHz-ft BiCMOS 0.25µm process, consumes 400mW from a 3.3V supply, and enables a cable full-spectrum receiver to capture >16 channels over an 50MHz-1GHz RF band.

5. Proposed Work (AAFCM)

We define four broad types of multi-tags in our proposed method:

I. Redundant tags - two or more independent tags carrying identical information and performing identical functions.
II. Complementary Tags - two or more disconnected tags that complement each other for a common purpose.
III. Dual-Tags - two tags connected to each other and having one or two antennas;

All memory is shared by the tags; each tag has its own memory and no memory is shared; both tags have their own memory as well as shared memory; N tags connected to each other and having one or more antennas.

We base our analysis of multi-tags on the expected angle of incidence of the radio signal from the reader to the tag. We perform the analysis for inductive coupling as well as for far-field propagation. In the case of inductive coupling, the angle α of the tag relative to the perpendicular direction of the signal transmitted from the reader, and gives the formula of the voltage induced in the tag by the received signal The results obtained from the analytical computations agree with the experimental results for one and two tags. These raises our confidence level in the correctness of the simulator's results for larger tag ensembles (i.e., three and four tags), which were computed only using the simulator, since the complex geometries involved make it intractable to analytically compute these quantities.
The expected incidence angle for one tag is:

$$\frac{\int_0^{\frac{\pi}{2}} x\,(2\pi\cos(x))\;dx}{2\pi} \approx 32.7\;(degrees)$$

The expected incidence angle for two tags is:

$$\frac{\int_0^{\frac{\pi}{4}} x\,(2\pi\cos(x))\;dx + \int_{\frac{\pi}{4}}^{\frac{\pi}{2}} \left(\frac{\pi}{2}-x\right)(2\pi\cos(x))\;dx}{\pi} \approx 48.0\,(deg)$$

Then we apply fill until complete mechanism where we mould these values with predefined values and according to these mould we then apply non redundant design procedure on that system so we can achieve much simpler and accurate synthesis in comparison to previous one. A chipless RFID transponder consists of a multiresontor connected between 2 tranceiving antennas. A multi resonator is designed to be functioned as a stop band filter at 1.94, 2.58 and 3.49 GHz. The 3-bit signal can be encoded at these frequencies to represent 000 to 111 IDs. Chipless RFID multiresonator prototypes are designed, fabricated and measured. The measured insertion loss exhibited accurate attenuation at the defined frequencies. We also provide simulation which shows the comparison by which we can conclude that our result is better than the previous one. To reduce the length of spiral resonator to change the resonant frequency and analysis on insertion loss ,return loss to improve the result at low frequency because of our work on low cost, we also use the concept of backscattered method to reduce the error and analysis the received signal and phase on the basis of backscattered signal. The test results are given in the Fig 2, Fig 3, Fig 4, Fig 5 and Fig6.

Test result
The below result shows that the changes in spiral length based on frequency. Other test results are based on frequency and phase. We also proof more negative insertion loss in the subsequent graph.

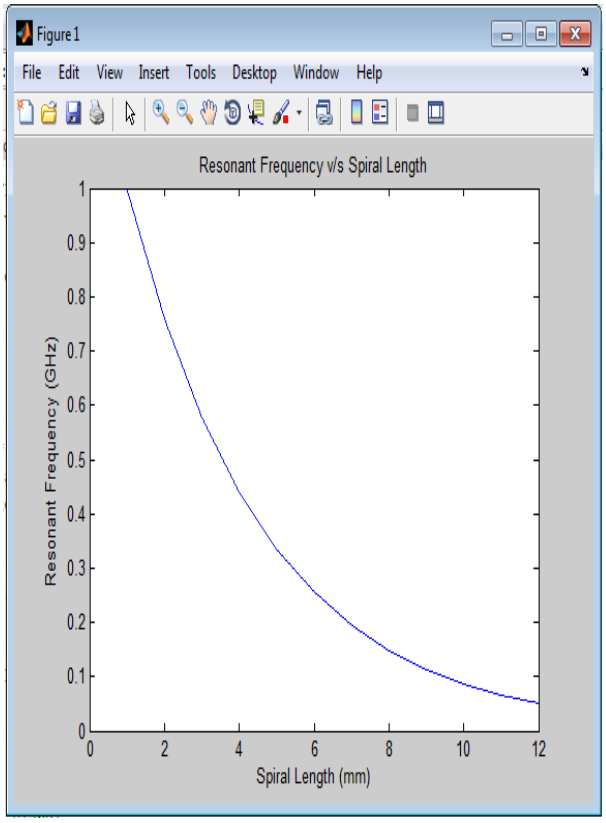

Fig 2 Resonant Frequency vs Spiral Length

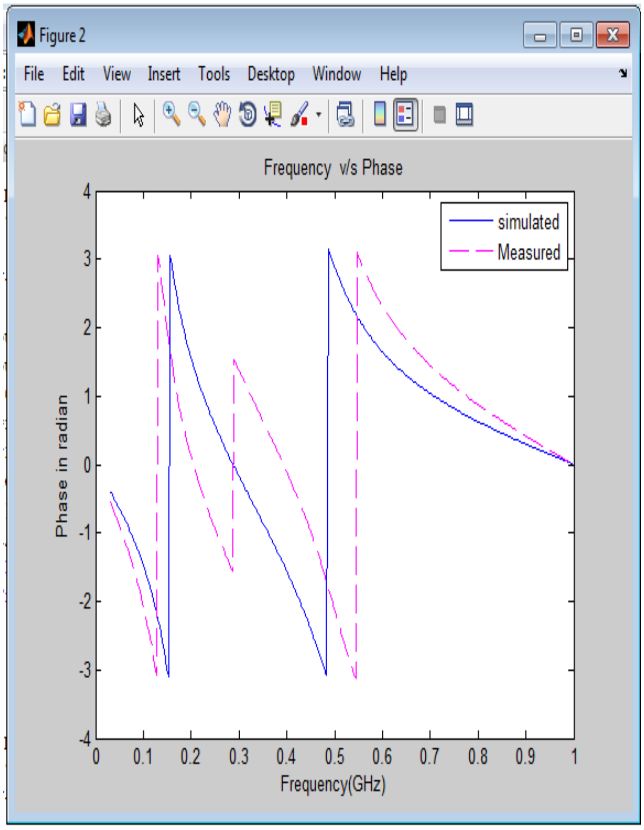

Fig 4 Frequency vs Phase

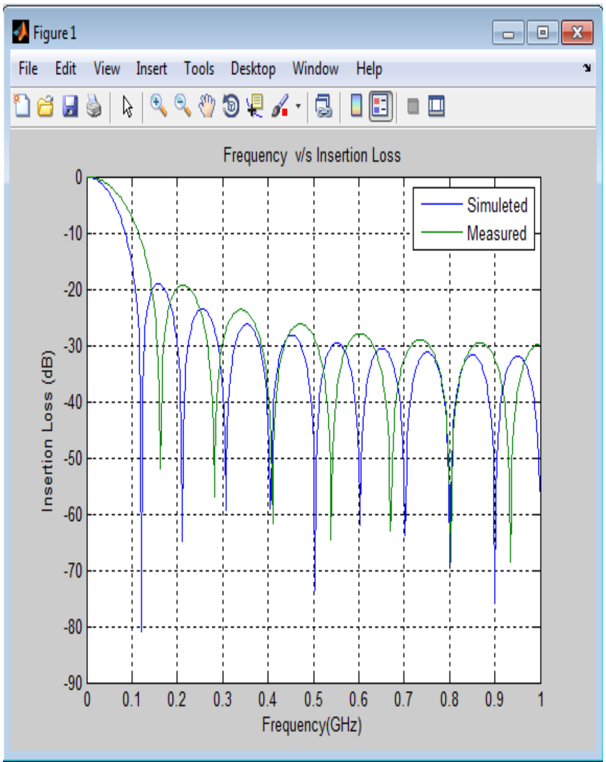

Fig 3 Frequency vs Insertion Loss

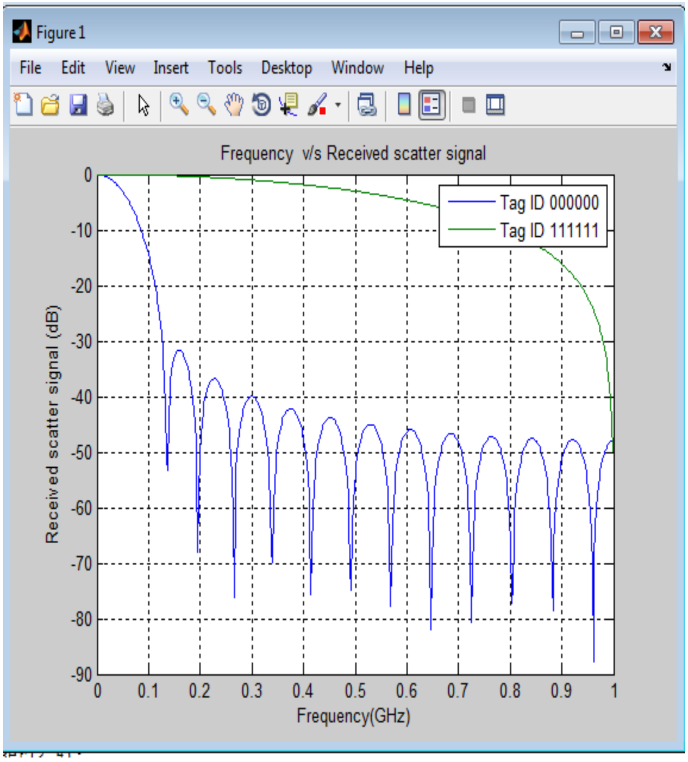

Fig 5 Frequency vs Scatter Signal

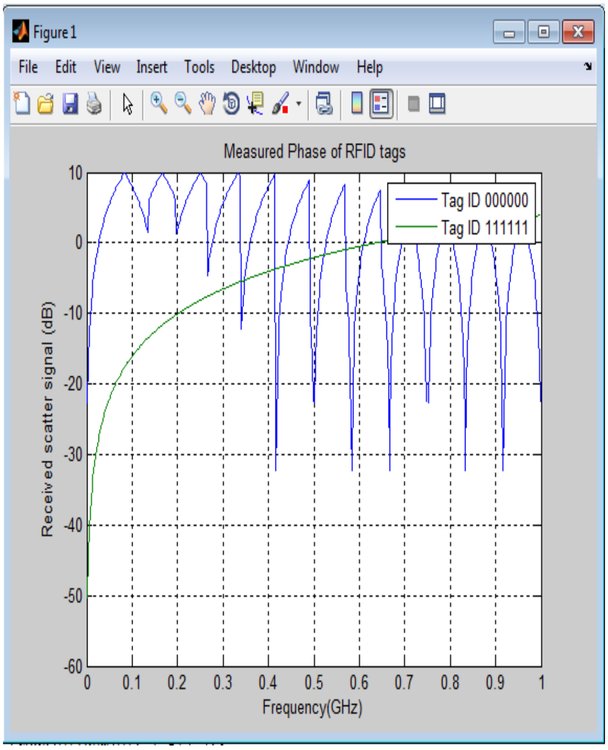

Fig 6 Frequency vs Received Signal

6. Conclusion and Future Directions

In recent years, solutions especially related to broadband filter implementations have been studied in several literatures. In this paper we proposed Chipless RFID Multiresonators, fabricated with Accurate Attenuation and Complete until Fill until complete Mechanism. We base our analysis of multi-tags on the expected angle of incidence of the radio signal from the reader to the tag. We perform the analysis for inductive coupling as well as for far-field propagation. In the case of inductive coupling, the angle α of the tag relative to the perpendicular direction of the signal transmitted from the reader, and gives the formula of the voltage induced in the tag by the received signal. The results obtained from the analytical computations agree with the experimental results for one and two tags. These raises our confidence level in the correctness of the simulator's results for larger tag ensembles (i.e., three and four tags), which were computed only using the simulator, since the complex geometries involved make it intractable to analytically compute these quantities.

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