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Design and Simulation of UHF RFID Reader Antenna Based on General Purpose Applications.

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Abstract: The fast expansion of global manufacturing and commerce has led to an increasing need for the automated and univocal identification of goods everywhere in the globe. In this regard, radio frequency identification (RFID) technology has been developing as a suitable and more advanced substitute for barcodes. RFID technology is already being used in a wide range of everyday applications, and the on-metal tagging solutions that are currently available are thicker and significantly more expensive than conventional RFID tags. Additionally, it is currently difficult to create miniature RFID tags with uniform (or nearly uniform) reading patterns that would enable identification of small objects regardless of their orientation. As opposed to that,, The design of RFID tags with optimum reading distance is an intriguing study topic within the context of RFID technology since some applications demand maximizing the reading distance, even at the price of the tag dimensions.

The primary goal of this paper is to design a UHF RFID reader antenna for emerging identification and sensor applications. To better select the best antenna based on the application and design it, the antenna theory required for a reader designed for a particular application is investigated. By exploring antenna size reduction and optimization strategies, which leads to the creation of computer-aided simulations, , a brand-new UHF RFID reader with low cost and tiny size and high gain and directivity was invented. Despite being tiny, this antenna was nevertheless able to deliver an excellent free space read range performance. Analysis and measurement findings were explained, and HFSS was used to introduce antenna analysis.
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Keywords: (Radio Frequency Identification (RFID) technology, Voltage Standing Wave Ratio (VSWR), Return Loss (S))

1. Introduction

RFID is a technology that is more reliable than a bar code and offers wireless identification and tracking capabilities. A reader is primarily a radio frequency (RF) transmitter and receiver, managed by a microprocessor or digital signal processor, and is now more frequently referred to as an RFID interrogator. Where an RFID tag receives electricity from it, an RFID reader emits electromagnetic signals. The circuits inside the microchip are subsequently powered by this energy. The chip modifies the waves and then transmits the modified wave back to the reader. Where the reader can see the tag, this technique is known as backscattering. Antennas (for reader and tag) play a crucial part in RFID systems. The chip may broadcast the identification-related data thanks to the antenna. Since the tag antenna can be placed anywhere on the target, the reader antenna should have circular polarization characteristics. The system developer's main concerns have been shrinking the size of the UHF RFID reader antenna and increasing its gain.

Microstrip antennas are often used in telecommunications due to their many benefits, including their tiny weight, low volume, affordable production, and ability to operate at two or three frequencies simultaneously. Microstrip antennas, however, have a variety of drawbacks. These microstrip patch antenna's narrow bandwidth is a severe drawback [1], but by reshaping the antenna as a bow tie, it may be used as a great example of a frequency-independent antenna. And the primary reason for selecting this antenna is to include a new communication technology that is improved and effective for sophisticated applications.

This article describes the construction of a single band Bow-Tie Octagonal antenna for wireless communications and RFID readers that will resonant on the UHF RFID band of 860 to 960Mhz. HFSS simulation software is used to do the theoretical simulations.

2. Design of Bow-Tie antenna for UHF RFID Reader Application

Antennas play a crucial role in radio transmission systems. The selection of an antenna is dependent on the requirements of the application, such as frequency, gain, price, coverage, weight, etc. Bow tie antennas are renowned for their beneficial qualities and multiband capabilities. An antenna's properties (such as its impedance, polarization, radiation pattern, etc.) will vary if its dimensions change even if it was constructed with ideal conductors and dielectrics. will not vary as long as the operating wavelength is altered by the same amount. As a result, if an antenna's shape is only dictated by angles, its performance would be independent of frequency since it would be scale-invariant [2]. A great illustration of a frequency-independent antenna is the bow tie. And the primary reason for selecting this antenna is to include a new communication technology that is improved and effective for sophisticated applications.

An antenna is built into the mobile UHF RFID device, also known as a hand-held RFID reader. The antenna needs to be significantly smaller than the typical reader antenna for these applications. With a 2-4 dBi antenna gain, the read range of handheld RFID scanners is really three to five meters. Applications requiring portable RFID readers have employed a variety of antenna designs. For the RFID reader in [2], two corner truncated stacked patches are employed. In this study, a straightforward modified bow-tie antenna is suggested for use with handheld, all-purpose RFID readers. The antenna is made up of two arms, a stepped transformer, and a bow-tie antenna..

3. Bow-Tie antenna dimensions calculation

The Bow-Tie antenna's [4] construction is straightforward since the antenna structure is entirely determined by its angle and length L1, Figure 1. The Bow-Tie antenna's length and degree of inclination both affect its impedance and operational bandwidth.

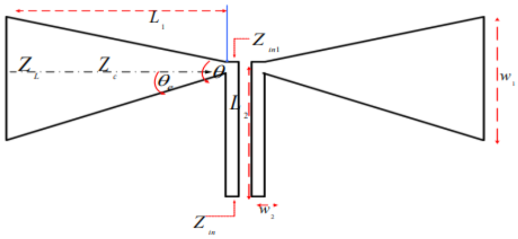

Fig. 1: Conventional Bow-Tie antenna geometry.

Following formula/equations are used in the Bowtie Antenna Calculator.

Wavelength λ = c/f

Length in mm: L=0.375xλ.= 125.

Width in mm: w=0.25xλ=83.3.

4. Optimization of antenna design workflow

This study starts by modeling and optimizing a traditional printed bowtie antenna supplied by a coaxial wire. The intended parameters, however, cannot be met since the greatest size of the substrate is less than a fourth of the working wavelength. Then, significant low values of VSWR at the operational frequency are acquired by introducing and modifying adjustments to the antenna's shape, and an omnidirectional gain is achieved. The gain of a conventional printed bowtie antenna is maintained since the introduced alterations do not impair the antenna's radiating pattern. The overall process for the antenna design is as follows.

1. Create a Traditional Bow-Tie antenna as indicated in Figure (2) without using a typical ground plane.

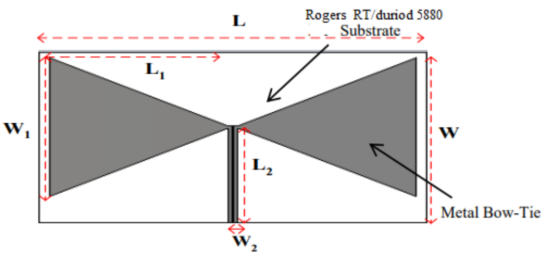

Fig. 2. Traditional Bow-Tie antenna.

2. Improve the standard bowtie antenna.
3. Add rounded arms to the traditional bowtie antenna, as illustrated in Figure 3, to lower the size by 40%.

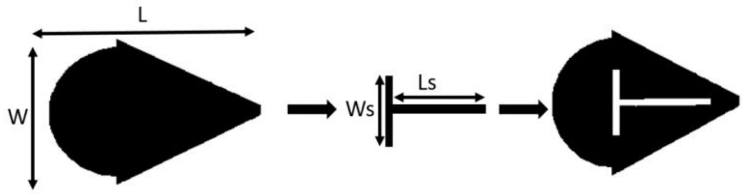

Fig. 3. Rounded Bow-Tie antenna.

Table1. Traditional Bow-Tie antenna parameters at 900 MHz.

L	W	Ls	Ws
54.2	39.4	28	20

4. Add a T slot to the radiating arms of the conventional bowtie antenna, as illustrated in Figure (4), as the initial alteration.

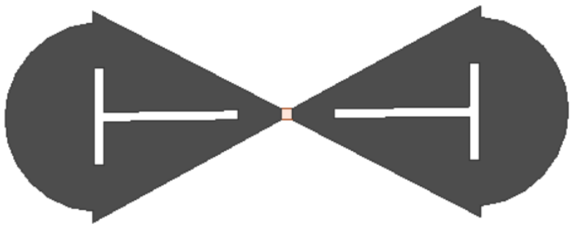

Fig. 4. Proposed Bow-Tie reader antenna geometry.

5. Modify the settings of the two modifications introduced to boost the performance of the antenna and meet its requirements. the performance and handling requirements of the antenna.

Utilizing the Ansys HFSS software, all computational models were created. Figure (5) displays the final dimensions following simulation and optimization.

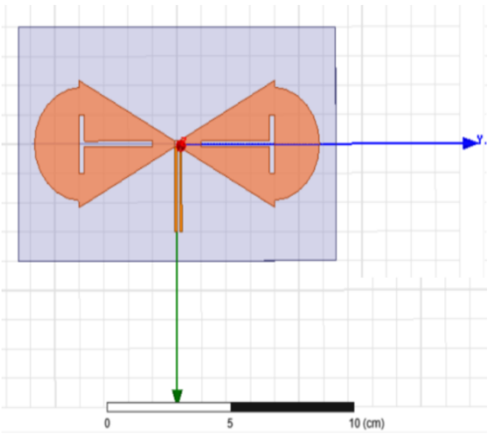

Fig. 5. View of Bow-Tie reader antenna, dimensions (mm).

In HFSS, the published structure is implemented. To acquire the scattering parameters, the required simulations are run. The collected findings lined up with the data those had been published, completing the antenna validation.

3.2 Simulated Results

For designing, simulation is employed, which is quite common for designing antennas. Antenna gain, total directivity, return loss, VSWR, current distribution, and radiation patterns are only a few of the simulated graphs that are created and displayed in the images. Using electromagnetic full wave simulation (HFSS), this has been verified.

a- Antenna Return Loss

Figure (6) displays the 2x1 microstrip antenna array's simulated reflection coefficient.It is clear that the reported antenna has a bandwidth that ranges from 838 MHz to 1 GHz and can operate in the band (under -10 dB) at centered 900 MHz (-20.98 dB). Therefore, it is evident that this working spectrum complies with UHF RFID's design specifications.

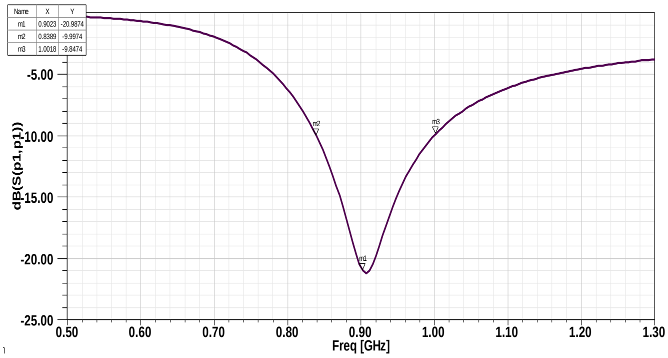

Fig. 6. Simulation results of the Bow-Tie reader antenna.

b- Voltage Standing Wave Ratio (VSWR)

Figure (7) depicts the UHF RFID antenna's VSWR. At 900 MHz, we recorded 1.18 dB with excellent values, indicating good received signals.

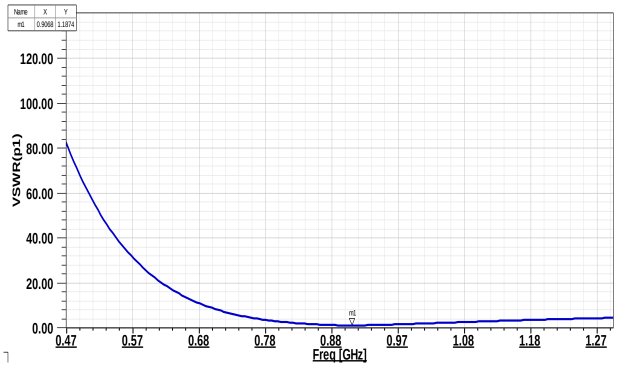

Fig. 7. VSWR of the Bow-Tie reader antenna.

c- Radiation Pattern in 3D

Figure (8) displays the radiation patterns for the UHF RFID design reader antenna array.

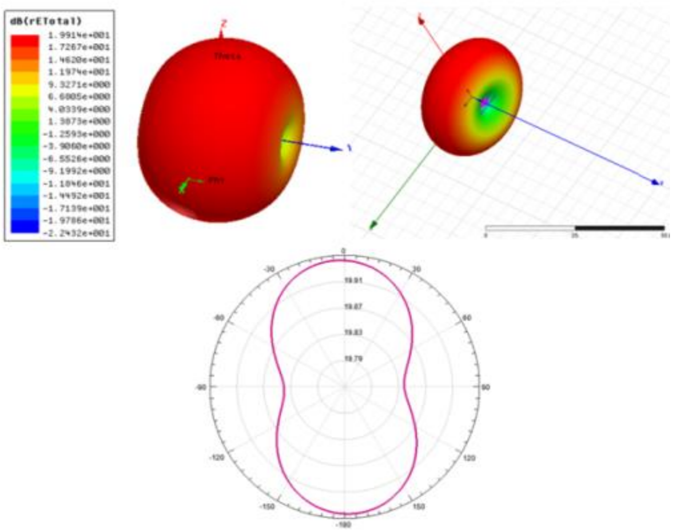

Fig. 8. 2D and 3D radiation pattern of the Bow-Tie reader antenna.

Since the antennas are patch type, they exhibit directional radiation patterns in the phi=0 deg (x-y plane) and phi=90 deg (y-z plane) planes. There is a directional pattern on the antenna.

c- Gain and Directivity

The intended antenna radiates with a gain of 2.21dB and a directivity of 2.22dB in the broadside direction. Figure (9) below shows 3D far field plots for gain and direction. The gain and directivity of the antenna are good.

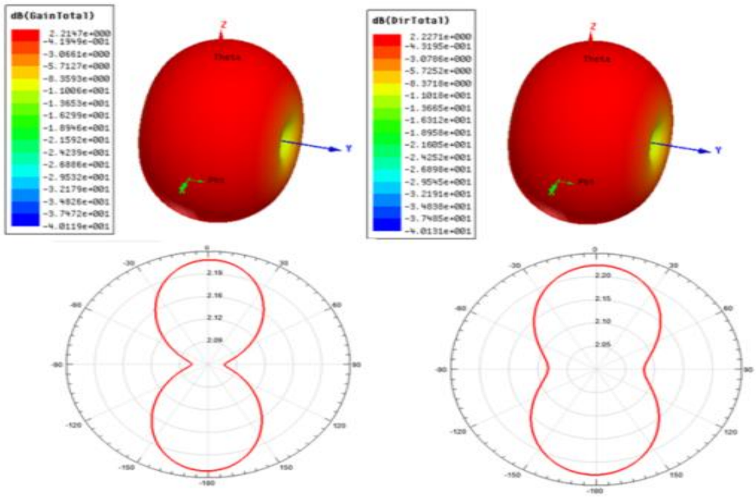

Fig. 9. 2D and 3D of Gain and directivity of the Bow-Tie reader antenna.

f- Current Distribution on the antenna

The field distribution between the patch and the ground plane is referred to as the current distribution, and it is utilized as a gauge for the radiation from microstrip patches. The 900 MHz current distribution pattern is seen in Figure (10). At this frequency, the maximum current in the proposed antenna is 40 (A/m). The red arrows depict the strongest current distribution in the antenna patch.

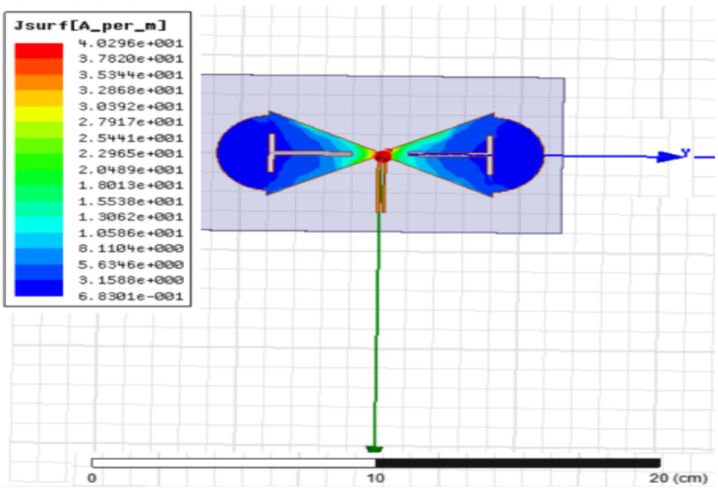

Fig. 10. Current distribution on the Bow-Tie reader antenna.

4. Conclusion

The following observations are reached in light of the simulation findings presented in this article. This study provided an illustration of the UHF RFID band RFID reader antenna design method. Despite the recent surge in popularity of RFID technologies, there is still a sizable gap in the appropriate design of tags depending on particular applications or uses, such as inventories, apparel, medications, etc. Optimal reader performance parameters, such as read range, antenna radiation, gain, and antenna efficiency, among others, are the major challenge that antenna designers must solve.

This study offers a systematized RFID reader antenna design process to close this gap. Because Bow-Tie antenna have been a fast expanding area of study due to its light weight, compact size, and simplicity of manufacture, a small reader antenna for UHF-RFID applications has been described. In this study, a Bow-Tie antenna that increases gain and directivity is constructed, and the effects of adding T-shape slots for a UHF RFID reader are explored. For the UHF band, the return loss was less than 10 dB (-20.9 dB). The value of the radiation pattern changes to be directional once the slot is added, with a gain of 2.21 dB and a dircativity of 2.22 dB. also When compared to conventional antennas, the projected size decrease is roughly 40It can be readily and cheaply manufactured. By using a substrate material with a low dielectric constant, the antenna is small and thin. These qualities are notably helpful for RFID applications and the mobility of wireless communication equipment throughout the world.

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