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Planar Antennas for UHF RFID Reader Applications-A Review

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Abstract: In this paper, different antenna designs for UHF RFID reader applications are discussed. An RFID antenna needs to be designed keeping in mind various requirements like size, bandwidth, read range, polarization etc. Out of UHF range the band from 860MHz to 960MHz is assigned for RFID applications.
Index Terms: Circular polarization, UHF, RFID, Read range.

I. Introduction

RFID is an automatic identification technology which provides tracking and wireless identification capability [1]. It transmits data without contact and Line-Of-Sight. Thus, the items with RFID tags within the field can be identified irrespective of orientation or position of the tag. This arrangement permits instantaneous interrogation/identification of many itemswithout manual manipulation. The information is sent to and read from Radio Frequency Identification tags using radio waves.Radio Frequency Identificationtechnology operates in several frequency bands which are lowfrequency, High frequency, Ultrahigh frequency and micro-wave frequency. Ultrahigh frequencyrange lies from 860 MHz to 960 MHz is more popular due to some of the advantages such as large storage capacity, faster data transmission and longer read range [2]. A typical RFID system comprised of a reader, tags, and information management platform. The tag used contains an antenna and a chip for unique identity.For good antenna design is achieved by conjugate impedance matching between the chip and antenna. [3].It is also known as operating frequencies of eachcountry differ from one country to another in ultra-high frequency RFID system. Table 1 lists the operating frequency of various countries in the world [4].

TABLE 1: OPERATING FREQUENCIES OF SOME COUNTRIES

Country/Region	Operating Frequency, f_c (MHz)
New Zeeland	864-869
India	865-867
Europe	865-868
Hong-Kong	865-868 & 920-925
Singapore	866-869 & 920-925
North America	902-928
Japan	916-921 & 952-956
China	917-922
Australia	918-926
Taiwan	922-928
China	920.5 - 924.5
Brazil	902 - 907.5 & 915 - 928
Canada	902 - 928

II. RFID Antennas for Reader Devices

RFID readers operating in UHF range are transceivers which can transmit as well as receive at one frequency. For covering longer distance the read range can be maximized with the use of directional antennas with high gain. Readers can be either fixed or portable systems. Antenna used in RFID readers is an important part of the system. The choice of antenna is sometime limited by regulations of a particular country in terms of permissible antenna bandwidth, beam width and radiated power in UHF bands.

Reader is also called an interrogator consisting RF transmitter and receiver controlled by micro-processor or digital signal processor. To generate carrier frequency an oscillator is present in transmitter which is fed to modulator for data to be transmitted via carrier signal and an amplifier is used so that the signal is good enough to awaken the tag. The signal is transmitted and received by the antenna to and from the tag. There is a demodulator and an amplifier to recover and strengthen the signal. A control unit having a microprocessor performs deposit of data and tasks of operating system.The overall size of RFID reader relies on the main frequency chosen and the application part.

Readers can be divided intointo two class based on transmission between reader and tag.

- Active RFID Reader: This type of reader transmits the interrogator signals and also receives the acknowledgement from passive tags.
- Passive RFID Reader: This type of reader only accepts the signals from an active tag.

Further Radio Frequency Identification readers can be of two types as per application area:

Fixed RFID Reader

These readers are used to create portals for automated reading. These readers normally have 2-4 antennas so it can read tags as they pass by. These types of readers can be used to read the tags as they enter the room, pass through warehouse dock door etc.

Mobile RFID Reader

Mobile reader is a compact solution with an integrated antenna that enables a manual identification of objects. Mobile reader can be handheld or mounted on vehicles. These readers can be used to read the tags for asset tracking, inventory management etc. Fig. 1 shows various RFID readers available in the market.

Fig. 1 (a) Active RFID Reader [4] (b) Passive RFID Reader [4] (c) Fixed RFID Reader [4] (d) Mobile RFID Reader [4]

III. LITERATURE REVIEW

In [5] a square ring-slot antenna showing circular polarization is presented. As shown in fig. 2 the antenna is feed by a microstrip line ending in a stub on the bottom side of the substrate. The overall size of the antenna is 115mm x 115mm x 1.63 mm. The bandwidth achieved is from 879 MHz to 1002 MHz with gain around 3.5 dB in the whole band of interest.

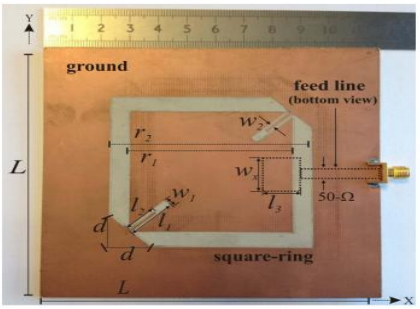

Fig. 2. Square Ring Slot Antenna [5]

In [6] authors presented a patch antenna witha ring shaped strip and two circular shaped patches. As shown in fig. 3 there is a suspended conducting strip with open circuited termination. Overall size of the antenna is 250mm x 250mm x 39mm. Circular polarization is achieved with excellent gain value of 9.1 dBic. The stacked structure is quite large for few applications but excellent impedance matching and bandwidth coverage makes it a good candidate in some of the RFID applications.

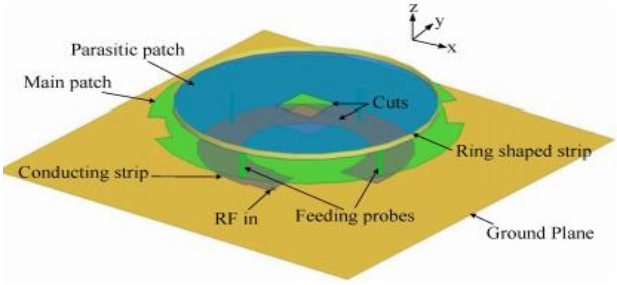

Fig. 3 Circular shaped Antenna [6]

In [7] a compact printed dipole antenna operating in UHF band is proposed. Meandered dipole is used along with a shunt line to obtain good impedance matching as shown in fig. 2. The ground plane is of finite size with overall size of 50mm x 40mm. The gain value obtained is 1.45 dBi with bandwidth of 5 MHz (920 MHz - 925 MHz).

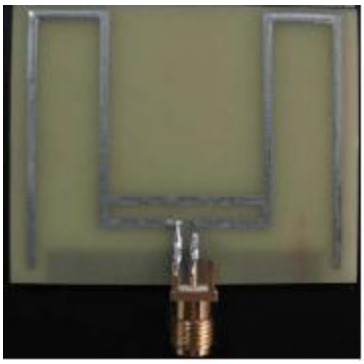

Fig. 4. Printed Dipole antenna [7]

In [8] the authors proposed a triangular monopole antenna with triangular slotting for RFID applications as shown in fig. 3. Presented antenna covers global UHF RFID band (860 MHz - 960 MHz) with peak gain of 2.84 dBi. The over-all size of the antenna is 105mm x 105mm x 1.9mm. Rogers 6006 substrate material is used which has higher dielectric constant.

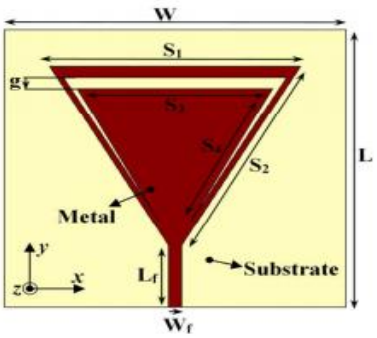

Fig. 5. Compact Triangular Monopole Antenna [8]

In [9] a slotted patch antenna with circular polarization applicable in both near-field region and far-field region RFID systems is proposed. The antenna is a rectangular patch with many circular, rectangular and cross shaped slots on it. The slots help in achieving circular polarization and uniform magnetic field for near field applications. The overall size of the antenna is 90mm x 90mmx 4.5mm. Bandwidth achieved is 11 MHz and peak gain of 3 dBic.

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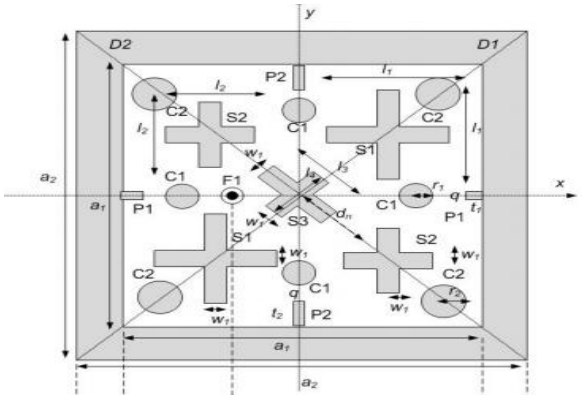

Fig. 6. Slotted Patch Antenna [9]

In [10] author presented a mobile antenna for searching tagged items on the shelves. Alternating orthogonaldouble dipoles fed by the meander microstrip line forms a microstrip array as shown in fig. 2. To achieve wide bandwidth, individual dipoles were designed accordingly. To excite the double dipoles in phase at 867 MHz, the distance between them is adjusted which further creates two orthogonal electric-field components. To achieve direction diversitythe inter-element distance and the number of dipoles had to be adjusted.

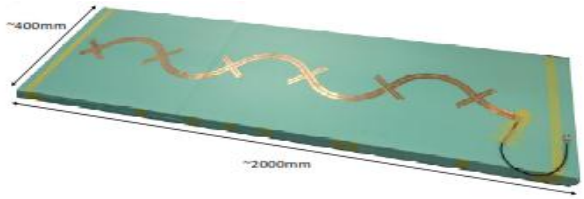

Fig. 7. Meander 6 Double dipole array [10]

In [11]authors proposed a reader antenna for nearfield UHF RFID applications.As shown in Fig. 3 the antenna has two microstrip meander lines with open ends and there is EM coupling between them. The bandwidth covered by the antenna isfrom 914 MHz to 929 MHz (15 MHz). The region of uniform magnetic field is 200mm × 480mm × 20mm and due to uniform linear electrical field the reading region is 420mm × 420mm × 300mm. The presented design is suitable for near field applications.

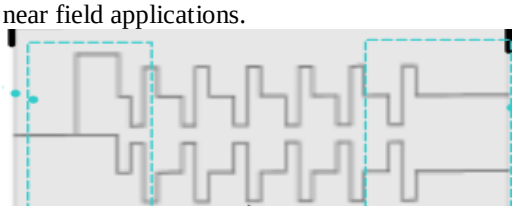

Fig. 8. Two Open Ended Meander Line Antenna [11]

In [12]an ellipse shaped circularly polarized monopole antenna is presented. A slanted slot is added into the antenna to enhance 3-dB axial ratio bandwidth as shown in fig. 4. The antenna operates at ultrahigh frequency (UHF) band for radio-frequency identification (RFID) reader applications. The measured bandwidth of standing wave ratio (SWR) < 2 is 535 MHz (553 MHz-1088 MHz) and the measured 3-dB axial ratio (AR) bandwidth 45MHz (900MHz-945MHz). The size of the radiating element is 137mm x 122mm.

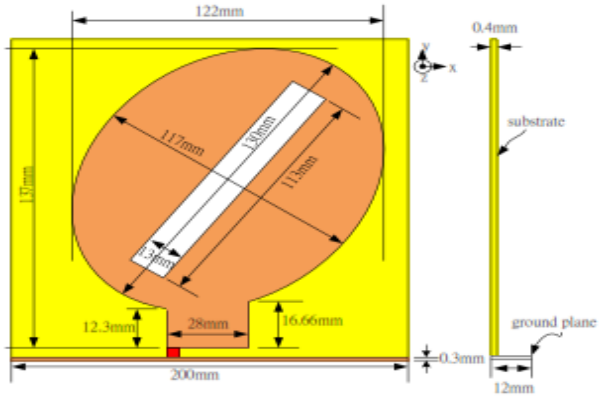

Fig. 9. Ellipse Shaped Printed Monopole Antenna [12]

In [13] author presentedan optimally designed corner trimmed microstrip UHF reader antenna fabricated using screen printing of silver ink on an FR4 substrate. As shown in fig. 5 the reader antenna, 12 x 12 cm^2 in size, is fed through a single micro-strip line with a connector attached to the antenna board. The measured results shows reflection coefficient better than -15 dB as well as 3dB-beamwidth greater than 60° over the 900 MHz – 930 MHz frequency bandwidth. The measured co-axial ratio lower than 3 dB with-in the range of 910 MHz - 920 MHz shows the antenna polarization is circular in the frequency range. The designed antenna is low cost, light and easy to manufacture and thus can beeasily used as a reader antenna in RFID retail monitoring applications.

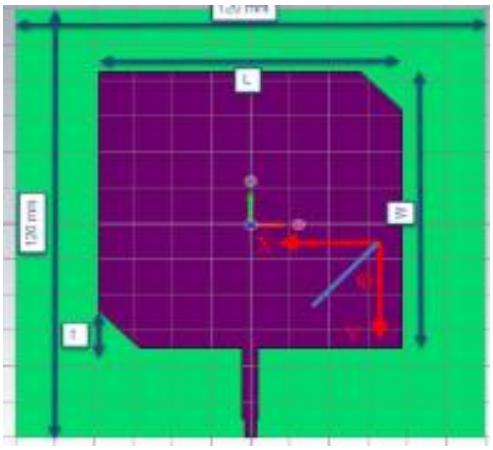

Fig. 10. Circularly Polarized Patch Antenna [13]

In [14] a design of the universal reader antenna applied for RFID system with the operating frequency from 840 MHz to 960 MHz is presented. Fig. 6 shows the antenna structure consists of a rectangular feeding patch and a rectangular loop which are the main elements to produce the circular polarization. The total size of the reader antenna is 120mm ×120mm fabricated on the FR4 substrate with thickness of 3.18mm and with the dielectric constant of 4.3. From the calculated results, it is clear that the presented antenna radiates a bidirectional pattern with the circular polarization, covering the operating frequency from 750MHz to 1150MHz with co-axial ratio bandwidth

of 42%. The co-axial ratio and gain at the bore-sight direction are 1.03 dB and 3.62 dBic, considering at900MHz which the center frequency band of universal RFID standard.

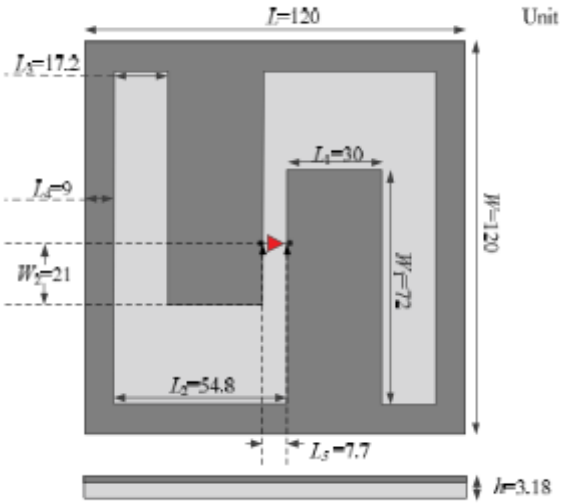

Fig. 11. Wide Slot Antenna [14]

IV. CONCLUSION

In this paper, we discussed different designs of antennas for UHF RFID Readerapplications and their characteristics. These papers are discussed based upon their size, return loss (RL) bandwidth, size, bandwidth and their read range. In most of the papers available in literature the overall size of the antenna is large for some applications requiring compact RFID system. The gain values are also not good as they are below 1.5 dB in most of the designs making the read range of the antenna shorter. RFID antennas working in UHF range needs to be compact in size with good gain and directivity to achieve longer read range.

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