Miniaturized and high gain RFID reader antenna at 13.56MHz

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Abstract. Technology for radio frequency identification (RFID) is commonly used worldwide. RFID is a developing wireless technology which make new vital challenge. The ability to precisely read a set of RFID tags become major concern in RFID networks coverage Detailed analysis of the design based on the 13.56 MHz radio frequency was suggested to design a kind of RFID reader antenna. Previously, researchers did facing problem with the size of the antenna which was to maintain the compact size at low frequency is challenging. The proposed antenna will be designed in the shape of rectangular spiral which contribute into miniaturize of the antenna size. The antenna will be fabricated after the optimum length and width had been achieved. The goal of this project is to design a small size antenna with 55 mm x 55 mm at frequency resonance of 13.56 MHz. to reduce the antenna gain on the future. We are going to design and add the metamaterial to the RFID reader antenna and combine them together and that will help to reduce the antenna gain.

1. Introduction
Radio Frequency Identification (RFID) collects identity information from RFID tags to RFID readers and in the current world this a promising wireless identification technology [1]. RFID has the features of long distance, no-sight-of-see, fast identification and, large volume, and that is suitable for the surveillance of mobile objects as well [2]. Much attention has grown-up into the 13.56 MHz frequency in the last era of technology more than the VLF, LF and UHF bands. It is proven that the use of 13.56 MHz is more useful compare to others band that discussed in [3].

The RFID is a tag (or transponder) system that includes an electronic microchip and a reader (or interrogator) to read and write information.[4].The magnetic and electromagnetic fields are used to exchange data with the reader. The antenna will help move the production data that the microchip has stored to several meters or more than 10 meters. The host computer receives the data from reader after the tag data is decoded. RFID has comparatively multi-tag recognition and extensive transmission range, conventional bar-code system can be replaced as it is a core technology that is used in the field requires security, safety, and logistics [5].
Numerous issues affect coverage in RFID networks; thus, some of these issues are problem area width, tag density, overlapping into readers and number of deployed readers [6]. There are several matters make the antenna designer need to concern about and those are size, shape, and weight, [7]. The author in [8] discussed the HF antenna that operates at 13.56 MHz and to reduce the size of the antenna for HF antenna there is several approaches has introduced in [7]. Hence the objective of this project is to design a small size antenna at frequency resonance at 13.56 MHz and to verify the simulated design by fabricating and testing the RFID reader hardware antenna.

Now a passive system is 13.56MHz RFID network, its operating mode is combined with inductance. It is possible to exchange energy and pass information between the reader and the tag via electromagnetic coupling between the antenna coil[7]. The antenna of the RFID device is the antenna of the user and the antenna of the mark. To order to improve the performance of the RFID system, two things can be considered, including improving the reader antenna quality and improving the tag antenna efficiency. Nevertheless, the performance of the tag's antenna is hardly improved to preserve the tag's advantages, such as low cost, small size, long life and so on[8]. So, the keyway to improve RFID system performance is to enhance reader's antenna quality.

2. RFID Reader Antenna Design Configuration

The most effective antenna design on any antenna with small size is the loop type antenna that will be printed in circuit board (PCB). PCB is made from the dielectric material named FR-4 with thickness of 1.6mm. The designed antenna is known as rectangular shape spiral that has multiples rectangular loop structure consisting of stripped copper lines with curved corners [9]. In the Figure 1, it shows the loops of the antenna and how is it follow with the same gap between each loop with distance 0.3mm.

![Figure 1. The design of RFID patch antenna](image)

The determination of the antenna parameter’s design has been found using some equation which is mention bellow:

\[ W = \frac{c}{2f\sqrt{\varepsilon_r} \cdot \frac{1}{2}} \]

To Find Width (W):

- \( f = \) operating frequency
- \( \varepsilon_r = \) dielectric constant.
- \( C = \) speed of light \((3 \times 10^8)\) m/s

To find the effective dielectric constant:
\[
\varepsilon_{\text{ref}} = \varepsilon + \frac{\varepsilon}{2} + \varepsilon - \frac{1}{2} \left(1 + \frac{12}{w} \right)^{\frac{1}{2}}
\]

To find Effective length: \[- L_{\text{eff}} = \frac{c}{2f} \cdot \sqrt{\varepsilon_{\text{eff}}}
\]

To find the fringing length (\(\Delta L\)):

\[
\Delta L = 0.412h \left(\varepsilon_{\text{eff}}0.3\right) \frac{w}{h} + 0.264 \left(\varepsilon_{\text{eff}}0.258\right) \left(\frac{w}{h} - 0.8\right)
\]

Where; \(h\) = substrate thickness

To find the actual length: \(- L = L_{\text{eff}} - 2\Delta L
\)

For Finding The Length and Width Of The Ground: \(- L_{g} = 2*\) and \(W_{g} = 2 * W
\)

By using those equation, we got the value that is showing below:

| Parameters | Mm |
|-----------|----|
| W         | 55 |
| L         | 55 |
| Er        | 4.3|
| H         | 1.6|
| Ht        | 0.035|
| S         | 0.3|

**3. Antenna Fabrication**

The design methods of 13.56MHz reader's antenna is according to the basic formula of the antenna. The design of the RFID reader antenna started with one loop and extended to two and multiple loops until 13.56 MHz is achieved which we put high frequency during the design and then start with one loop at 500 MHz and the others basically will help the s11 graph to shift from high frequency to the low frequency by adding loop. The simulated design has been fabricated according to the actual size in the simulation design and process of fabrication include developer, etching and photoresist have been done.

![Figure 2](image-url)
After the measure process we have got the data from the measurement and then also from the CST and it will be showing in the figure 3. we can see that the data from the CST is operating at the required frequency which about 13.56MHz and then the data from the measurement have operate at 17 MHz and that shows a bit different of the frequencies range and that because the much of looping that have been use on the design.

Figure 3. RFID reader antenna measurement

4. RFID Reader Antenna Design Results Analysis
In order to determine the characteristics of the designed antenna either it achieved the objective of this project which is to design and minimize the size of the antenna at the low frequency w 13.56 MHz. The characteristics that will cover are return loss response (S11), and the size of the antennas to reveal the ability of the antenna performance. Return loss is a factor used to calculate the antenna's reflected power due to the antenna's discrepancy.

Lower value of the return loss provides the high performance of the antenna. The return loss of the antenna is -20.8 dB at 13.56 MHz as performed in the Figure 4.

Figure 4. Return loss of proposed RFID Reader Antenna
5. Conclusions
The RFID reader antenna has become an expeditiously developing area of research. RFID reader antenna is design with small size and ease of fabrication. RFID reader antenna must fulfil the requirements of antenna with suitable antenna specifications. In this research project, the RFID reader antenna has been designed and got the simulation result by using CST software tools to obtain good performance. The return loss (S11) obtained at resonant frequency of 13.56 MHz with small size of 55mm x 55 mm.

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