A Universal Printed Antenna for UHF RFID Applications

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ABSTRACT
In this paper, a printed rectangular monopole antenna is designed for RFID (Radio Frequency Identification) reader applications. The antenna is designed to operate at a frequency of 860 MHz to 960 MHz allocated for UHF RFID universal (worldwide) band. The antenna simulation is analyzed using 3D EM simulator, FEKO Software. The result of the antenna parameters such as radiation pattern, reflection coefficient and gain are also discussed. The proposed antenna is simple in design and fair in size.

Keyword: printed rectangular monopole antenna, RFID, UHF, radiation pattern, return loss

I. INTRODUCTION
Radio Frequency Identification (RFID) is a form of wireless communication that uses radio waves to identify or track objects. These transmissions are of unique serial numbers or codes. This is known as a contactless technology whereby the tag or item does not need to be manually touched or wired. Now RFID finds many applications in various areas such as electronic toll collection, asset identification, retail item management, access control, animal tracking and vehicle security.

The common frequency used by RFID are low frequency (125-134 kHz), high frequency (13.56 MHz), ultra high frequency (860-960 MHz), and microwave frequency (2.4-5.8 GHz). Radio waves behave differently at each of these frequencies with advantages and disadvantage associated with using each frequency band. RFID system consists of radio frequency transponders (tags), radio frequency transceivers (reader), and a host computer. The antennas for RFID systems also play a crucial role in the continuous development of this technology; it is the most important components in the optimization of the signal data to spread out into the air.

Printed monopole antenna is one of the most suitable antennas for achieving large bandwidth and omnidirectional radiation pattern. Printed monopole antennas are new version of micro strip antennas in which the ground plane below the patch is etched out. It gives wider bandwidth. Several printed monopole antenna configurations have been proposed and such antennas have been designed for various applications using different simulation software.

In this paper, a single band rectangular shaped printed monopole antenna for RFID reader application is designed to resonate on Ultra High Frequency (UHF) universal band of 860-960 MHz. The theoretical simulations are performed using FEKO Software.

II. ANTENNA DESIGN
The proposed design of printed rectangular monopole antenna is simple in construction. The antenna is designed for universal UHF (860-960 MHz) RFID applications. The antenna uses a 1.6 mm thick FR4 substrate with a relative permittivity of 4.4 and loss tangent of 0.02. The front view of the antenna is shown in Figure 1 and the back view of the design is shown in Figure 2.
The design of printed rectangular monopole antenna consists of substrate width (Ws), substrate length (Ls), antenna width (Wp), antenna length (Lp) and a feed line which have impedance of 50 ohm where its feed width (Wf) and feed length (Lf) are introduced. Dielectric substrate materials are used for design printed rectangular monopole antenna.

There are equations used to calculate Ws, Ls, Wp, Lp, Lf and Wf of the proposed antenna. The calculations are given as follows by equations (1) - (7).

**Patch width,**

$$W = \frac{c}{2f_0} \left(\frac{\varepsilon + 1}{2}\right)^{-1/2}$$  \hspace{1cm} (1)

**Effective dielectric constant,**

$$\varepsilon_{\text{eff}} = \frac{\varepsilon + 1 + 12\frac{h}{W}}{2}$$  \hspace{1cm} (2)

**Effective length,**

$$L_{\text{eff}} = \frac{c}{2f_0 \varepsilon_{\text{eff}}}$$  \hspace{1cm} (3)

**Length extension,**

$$\Delta L = 0.412h \left(\frac{\varepsilon_{\text{eff}} + 0.3}{\varepsilon_{\text{eff}} + 0.264}\right)$$  \hspace{1cm} (4)

**Ground plane extension**

$$L_g = 6h + L$$  \hspace{1cm} (6)

$$W_g = 6h + W$$  \hspace{1cm} (7)

Where:

$$h = \text{substrate thickness}$$

The feed line for the printed rectangular monopole antenna determines to be fed for 50 ohm for line impedance (Zo). The length and width for the feed line can be calculated using equations (5), (8) and (9).

**Feed Length,**

$$L_f = \frac{L}{2 \varepsilon_{\text{eff}}^{1/2}}$$  \hspace{1cm} (8)

**Feed width,**

$$Z_o = \frac{60}{\varepsilon_{\text{eff}}^{1/2}} \ln \left[\frac{8h + W_f}{4h}\right]$$  \hspace{1cm} (9)

Where:

$$h = \text{substrate thickness}$$

$$Z_o = \text{line impedance}$$

Table I shows the results calculation of printed rectangular monopole antenna operated at UHF band.

**Table I:** The Parameters of Proposed Antenna

| No. | Component                  | Value    |
|-----|----------------------------|----------|
| 1.  | Width of the substrate (Ws)| 100 mm   |
| 2.  | Length of the substrate (Ls)| 100 mm |
| 3.  | Width of the patch (Wp)    | 72 mm    |
| 4.  | Length of the patch (Lp)   | 50 mm    |
| 5.  | Width of the feed (Wf)     | 8 mm     |
| 6.  | Length of the feed (Lf)    | 40 mm    |
| 7.  | Width of the ground (Wg)   | 100 mm   |
| 8.  | Length of the ground (Lg)  | 32.5 mm  |
| 9.  | Operating frequency (f_o)  | 860-960  |

**III. Results and Discussion**

The parametric simulation results using the FEKO software of printed rectangular monopole antenna for UHF RFID reader such as reflection coefficient, radiation pattern, and gain are shown. The design of the antenna is shown in Figure3.

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**Figure 2. Back View of the Antenna**
The simulated reflection coefficient of the proposed antenna is shown in Figure 4. In order to get a better performance of an antenna, the reflection coefficient should be less than -10 dB. The simulated reflection coefficient is -10 dB on 850-970 MHz at over the frequency range of RFID Universal UHF band (860-960 MHz). The obtained bandwidth is 100 MHz.

The simulation result of the proposed antenna gain is shown in Figure 5. The designed printed rectangular monopole antenna has a moderate gain of about 1.4dBi over the desired RFID UHF band of 860-960 MHz.
Another useful measurement describing the performance of antenna is the radiation pattern. An antenna radiation pattern is defined as a mathematical function or graphical representation of the radiation properties of the antenna as a function of space coordinates. Figure 6 shows the radiation pattern at \( \Phi = 0 \) degree and the Figure 7 shows the radiation pattern at \( \Phi = 90 \) degree for the designed antenna at 960 MHz.

IV. CONCLUSION

The printed rectangular monopole antenna becomes a rapidly growing area of research. A printed rectangular monopole antenna was designed and simulated in this paper. The printed rectangular monopole antenna has -10 dB at 850-970 MHz, a moderate gain of over 1.3 dBi and omnidirectional radiation pattern. Thus this printed rectangular monopole antenna can be used for UHF RFID reader at worldwide frequency band of 860-960 MHz.

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