A Triangular Patch Antenna for UHF Band With Microstrip Feed Line for RFID Applications

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Abstract

This paper presents a novel microstrip antenna fed by microstrip line for Radio Frequency Identification (RFID) applications. With the reasonable gain, low profile and coupled with cheaper material, the proposed antenna is suitable for RFID applications. Antenna has been designed and optimized to operate at UHF band (0.89 GHz) using IE3d electromagnetic simulator. The fundamental parameters such as return loss, gain, radiation pattern, current distribution and efficiency are obtained. A parametric study of proposed antenna has been carried out by varying some parameters. Simulation tool, based on method of moments has been used to analyze and optimize the antenna.

Keywords*: U-shaped slot, Radio frequency identification (RFID), Microstrip line*

1. Introduction

In recent years, the radio frequency identification (RFID) has received wide spread attention in many services since it provides a convenient identification information, long reading range and fast reading speed. RFID has been an alternative identification technology to the barcode. This is an emerging technology gaining growing interest both from scientific and industrial communities [1-2] .A basic RFID system consist of a radio scanner unit called reader, and a set of transponder called tags [3]. The tag is a microchip combined with an antenna system in a compact package [4]. Compared with traditional bar code tag, the RFID tag can be read and written over a long distance with a very high data rates[5].RFID system provides an automatic means to identify physical

Objects without the need for line-of-sight communication [6].

The bands assigned for data transfer are-125 KHz, 13.56 KHz, 869 MHz, 902-928 MHz, 2.45 GHz and 5.8 GHz [7].Several papers have been published on RFID antennas for both active and passive tags including covered slot antenna design [8], circular patch antenna analysis [9],meander antenna optimization [10],planer inverted F antenna [11], folded dipole antenna [12] etc. However very few papers [13] provided an overview of criteria for RFID tag antenna design & an analysis of practical application aspects. At the same time, there exist many papers on practical analysis and design of particular classes of antennas used for other application [14-16].

In this paper, a new triangular patch antenna with U shaped slots is presented which resonates at 0.89 GHz which is the operating band of RFID application. The antenna is constructed with the help of microstrip feed line. The antenna dimensions have been optimized using EM simulation tool. This paper is organized as follows: In section II, the geometry of proposed antenna is described in detail. Simulation results and parametric study are given in section III and IV respectively. The return loss, gain, VSWR, current distribution, antenna efficiency and radiation pattern of proposed antenna is shown. Finally the paper is concluded in section V.

2. Antenna Structure

The geometry of microstrip fed patch antenna for RFID applications is shown in Figure 1. This antenna is designed on FR4 substrate with thickness (h) of 1.6 mm, dielectric constant (ϵ_r) of 4.4 and loss tangent 0.02.By properly adjusting the dimension of antenna and feeding structure the characteristics of the proposed antenna is improved. For getting UHF frequency band of antenna a U slot is cut. Optimized design parameters were found with the following dimensions: a=23.5 mm, b=49.9 mm, c=43.19 mm. The remaining antenna dimensions are given in figure 1.With the aid of simulation by IE3D Simulator which

is based on the method of moment (MOM), the antenna is optimized. The details of simulated performance are described briefly in next section.

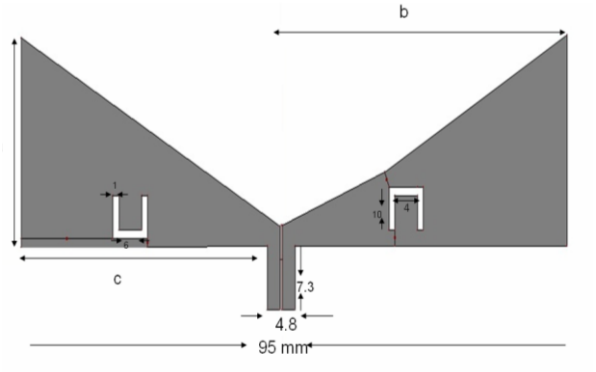

Figure 1 : Structure of triangular patch antenna with U slot

The proposed antenna was fabricated on FR4 substrate. Prototype fabrication is done using photolithography technology. A photograph of the fabricated prototype is shown in figure 2

Figure 2: Photograph of triangular patch antenna with U slot

3. Simulation Results

Return loss (S_{11}) of proposed antenna at 0.89 GHz is shown in figure 3. This antenna covers the frequency bands from 0.87 GHz to 0.97 GHz and VSWR of 1.48 is obtained at 0.89 GHz (figure 4)

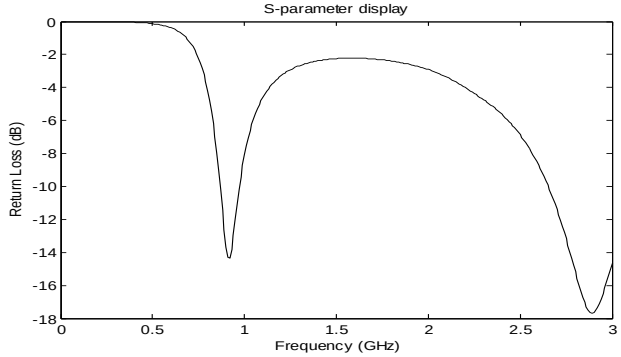

Figure 3: Return Loss of a Triangular Patch Antenna with U slot

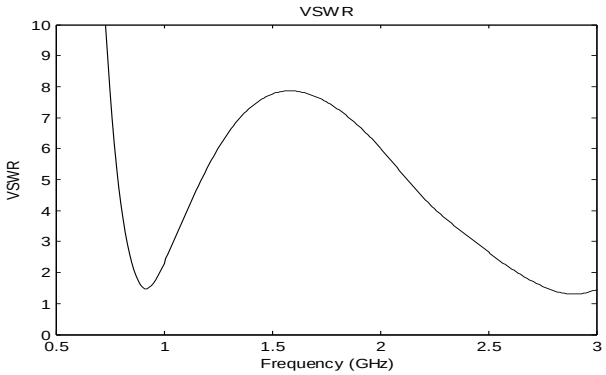

Figure 4: VSWR of a Triangular Patch Antenna with U slot

Antenna gain is a measure of directivity properties of antenna. The proposed antenna provides sufficient and appropriate gain required for operation in the RFID (0.89) band. Gain and efficiency of proposed antenna is shown in Figure 5 and figure 6 respectively. The gain of the proposed antenna is 1.2 dBi at 0.89 GHz. Simulation results indicate that the maximum antenna radiation efficiency is approximately 80.3 %.

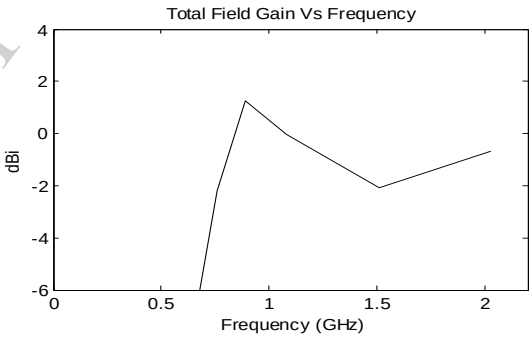

Figure 5 : Gain of a Triangular Patch Antenna with U slot

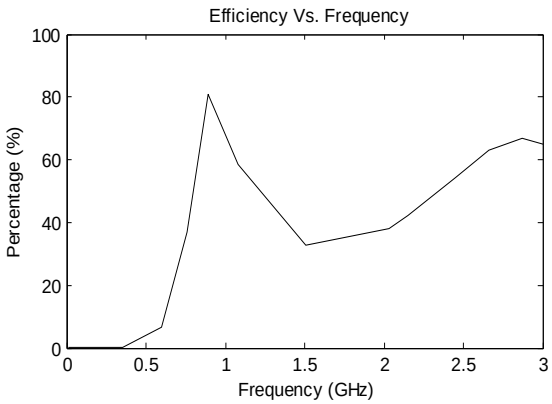

Figure 6 : Efficiency of Gain of a Triangular Patch Antenna with U slot

The current distribution pattern shows that how much of the current is flowing in the proposed structure. Maximum current in the proposed antenna is 1587.9 (A/m) at 0.89 GHz. The 3D current distribution plot gives the relationship between the co-polarization (desired) and cross-polarization (undesired) components. It gives a clear picture as to the nature of polarization of the fields propagating through the patch antenna.

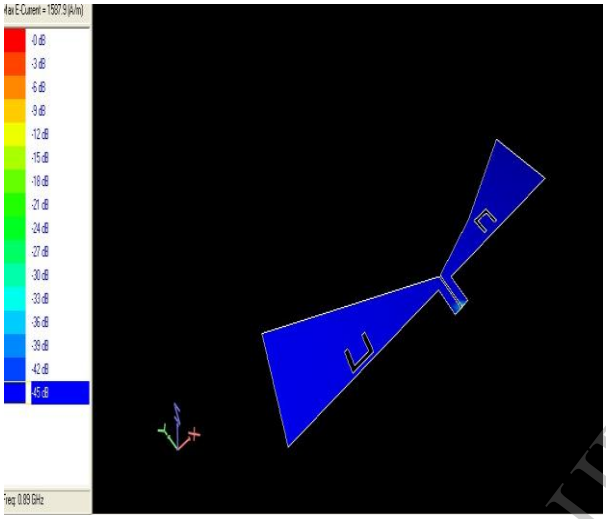

Figure 7 : Current distribution of triangular patch antenna with U slot

Simulated two dimensional radiation patterns for elevation and azimuth plane are shown in figure 8 .These patterns are desirable for RFID applications. Three dimensional radiation pattern is obtained by combining elevation pattern and azimuth pattern. Figure 9 shows three dimensional radiation pattern of proposed antenna.

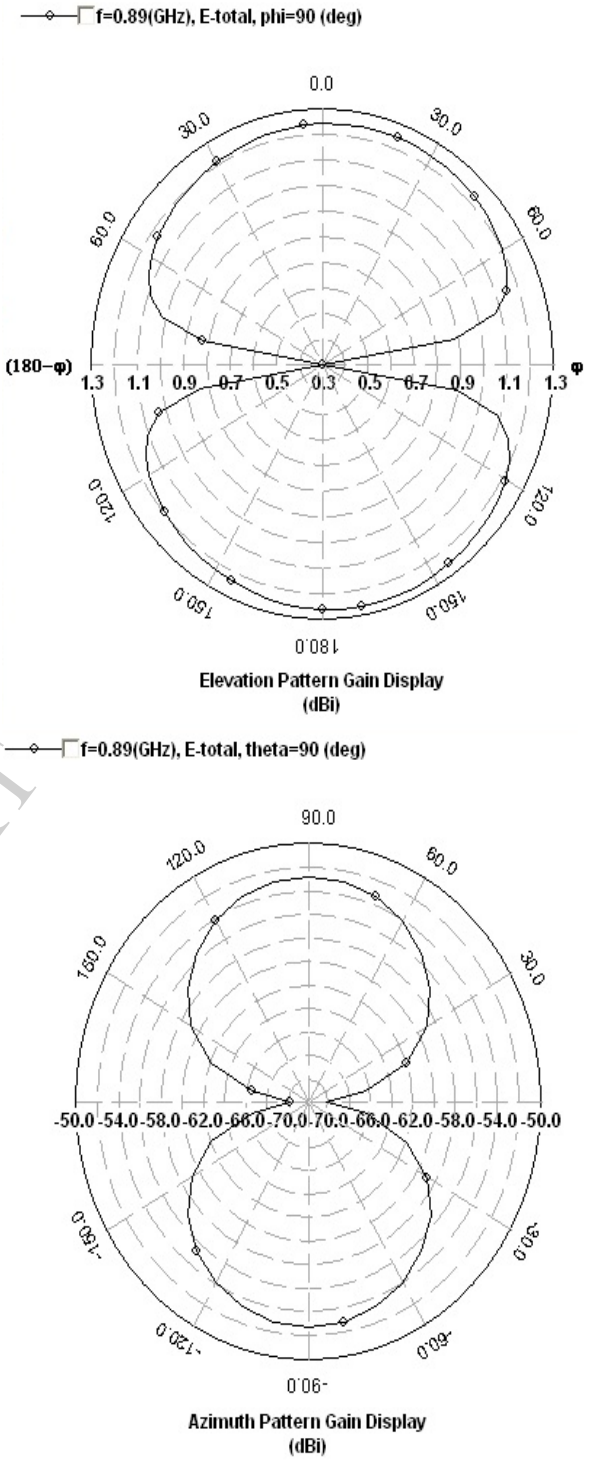

Figure 8 : Simulated 2-D Radiation pattern of triangular patch antenna with U Slot

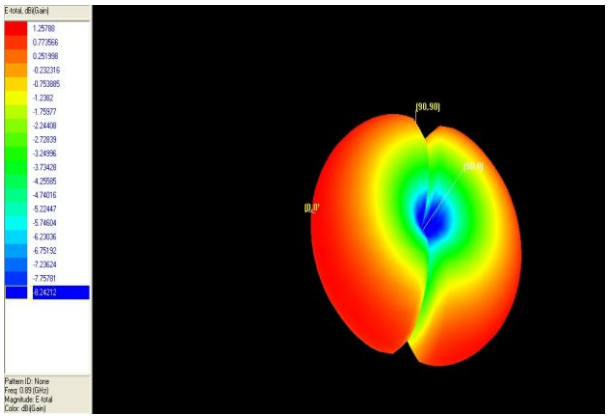

Figure 9 : Three dimensional view of triangular patch antenna with U slot

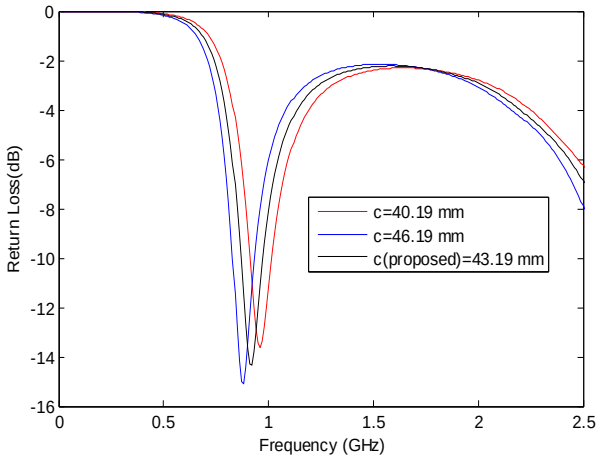

Figure 10 : Effect of parameter 'c' on return loss and resonant frequency

4. Parametric Study

A parametric study has been carried out and it demonstrates that many parameters affect the performance of the proposed antenna. The parametric study is carried out by simulating the antenna with one geometry parameter slightly changed from the reference design while all the other parameters are fixed. The simulated return loss of the proposed antenna as a function of frequency for different values of parameter 'c' is shown in figure 10 . We can see from Figure, as we increase 'c' from optimum value resonant frequency shift to lower value (0.86 GHz) and as we decrease 'c' resonant frequency increases (0.95 GHz) and bandwidth will also increase (0.2 GHz). Table 1 shows the simulation results of return loss and resonant frequency.

Figure 11 shows the effect of change in feed length of triangular patch .It can be seen from Figure, as we increase the feed length from optimized value the bandwidth will increases and the value of return loss in dB (-ve) will decreases and as we decrease the feed length from optimum value then bandwidth will increases and value of return loss in dB (-ve) will increases.

Table 4.1 shows the simulation results of return loss and resonant frequency

c (mm)	Resonant frequency (GHz)	Return Loss(dB)
40.19	0.95	-13.5
46.19	0.86	-14.5
43.19	0.89	-14.2

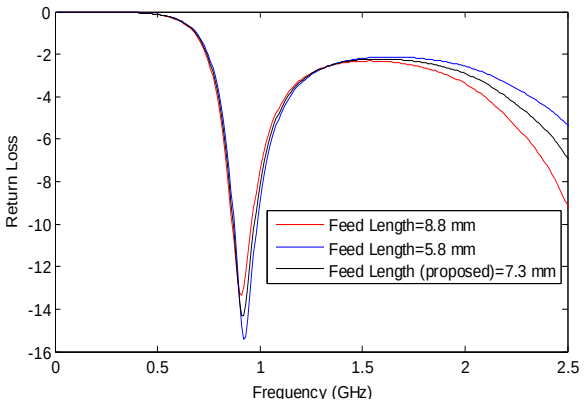

Figure 11 : Effect of feed length on return loss

5. Conclusion

A new microstrip fed triangular patch antenna for RFID applications with U slots has been presented in this paper. The proposed antenna was designed and simulated with IE3D simulator which has resonant frequency of 0.89 GHz. By embedding U slot in radiating patch 80.3 % efficiency was achieved. The proposed antenna design fulfilled the requirements needed to operate in RFID UHF band. It provides appropriate return loss and gain characteristics.

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