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Design of Free Space Inverted U Shaped Antenna for ISM Band, GSM-900 and S-DMB Application

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ABSTRACT

An inverted U shaped free space antenna is developed in YZ plane to achieve a bandwidth of 83MHz from 873MHz to 956MHz at 914 MHz resonance frequency with 1.82dB forward gain and -36dB reflection coefficient for ISM band and GSM-900 application. This proposed antenna also operates at 2.6 GHz for S-DMB application. The key configuration of the proposed antenna is connected of capital 'U' and small 'u' backs one another. The small 'u' arms helps to obtain SWR around 1.The input impedance of the antenna is 49.67ohm so without any matching network it is matched with characteristic impedance 50 ohm cable. A prototype of the inverted U shaped antenna has been presented in this paper by using a valid simulation and measurement results.

Keywords : Free space antenna, ISM (industrial, scientific and medical) band, RFID antenna, GSM-900, S-DMB (Satellite-Digital Multimedia Broadcasting)

1 INTRODUCTION

WIRELESS communications have been developed widely and rapidly in the modern world especially during the last decade. In the near future, the development of the personal communication devices will aim to provide image, DMB (Digital Multimedia Broadcasting), video telephony, speech and data communications at any time-any where around the world. The industrial, scientific and medical (ISM) radio bands were originally reserved internationally for the use of radio frequency (RF) energy for industrial, scientific and medical purposes. Examples of applications in these bands include radio-frequency process heating, microwave ovens, biomedical application [3]. The inverted L- antenna contains substantial gain with less than 0.6 and 1.8 dBi gain variation within the -10 dB return loss bandwidth at 2.3 and 5.5 GHz operating frequency respectively [2]. A novel compact loop type antenna for Bluetooth, satellite-digital multimedia broadcasting, wireless broadband, and wireless local-area network applications [1]. Although quite a few multiband antennas for portable WiFi/WiMAX applications have been proposed [4]-[7]. A prototype of the dual-frequency RF-ID antenna is presented [8]. A new design of a compact, lightweight, low-cost, multistandard antenna for GSM/PCS/UMTS cellular telephone system and Hiprelan applications was presented [9].

In this paper, we propose a novel inverted 'U' shape antenna that is operate in the frequency range from 873 MHz to 956 MHz for ISM band, GSM application and at 2.65 GHz for S-DMB (Satellite- Digital Multimedia Broadcasting) application. The proposed antenna can be used efficiently as mobile antenna and RF-ID antenna. Numerical simulation is carried out using method of moments in Numerical Electromagnetic Code (NEC-2) and agilent vector network analyzer, watts antenna trainer, and microwave engineering trainer are used for the hardware measurement.

2 ANTENNA CONFIGURATION

The schematic configuration of the proposed antenna is shown in Fig. 1. The total size of the antenna is 9.7cm x 4.25cm.This antenna contains seven wire segment of radius 1.026mm.The connection of the wires and feeding are shown details in the fig. 1. The dimensions of the proposed antenna are shown in table- 1. The proposed antenna is assumed to fed by a 50 Ω coaxial cable.

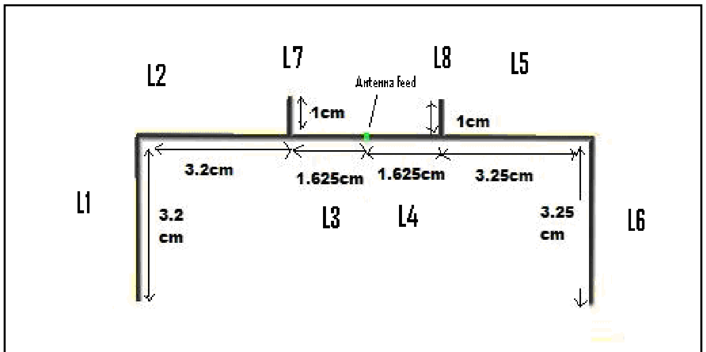

Fig. 1. Antenna configuration

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Table-1 Dimension of the proposed antenna

Parameter	Dimension(cm)
L1 = L2	3.2
L3=L4	1.625
L5=L6	3.25
L7=L7	1

3 SOFTWARE SIMULATION RESULTS

Software simulation carried out using method of moments in Numerical Electromagnetic Code (NEC-2). The input parameters of the prescribed antenna shown in table 2.

Table 2 Input parameters

Input parameters		Values	
Name	Unit	Real	Imaginary
Voltage	Volt	15.8	0
Current	Amp	0.32	.01
Input power	Watt	5	0
Impedance	Ohm	49.7	1.5
Radial power	Watt	4.995	0

Total gain pattern in the vertical plane of the antenna is shown in fig. 2. From the fig. 2 it is shown that the total gain is circular in the far field region.

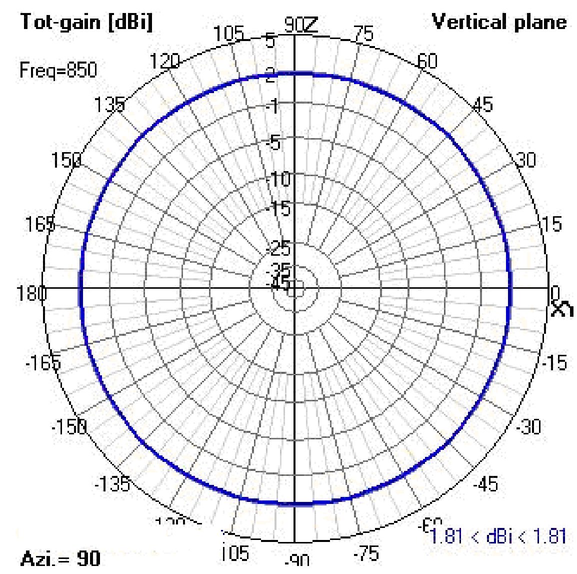

Fig. 2. Total gain patterns in [dBi]

For efficient design of an antenna return loss should be lower than -10dB.From the simulation results in fig. 3 return loss of this antenna at resonant frequency is -36dB which is very efficient for better performance at 914MHz for ISM band and GSM application. This antenna also can operate at 2.6 GHz for S-DMB at desired return loss.

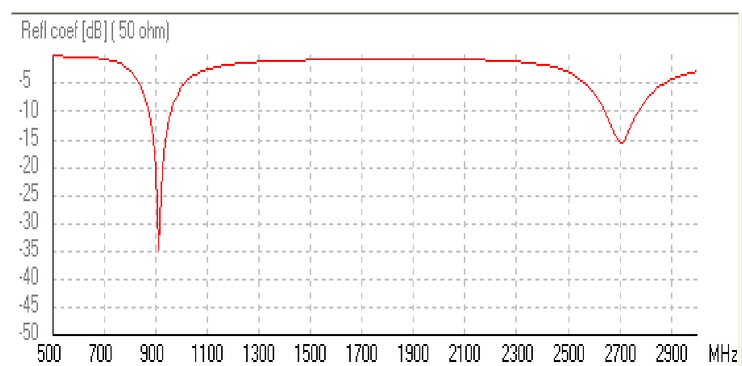

Fig. 3. Reflection coefficient (Return Loss) [dB] of the proposed antenna

Incident wave and reflected wave interference causes standing wave which results distorted transmission of the signal so it is not desired the reflected wave occurring in the antenna. At matched condition reflected wave dose not exits so standing wave ratio at matched condition is near about 1. From the simulation result the obtained SWR in fig. 4 is 1.03

at 914 MHz and 1.45 at 2.6 GHz which is better for an antenna.

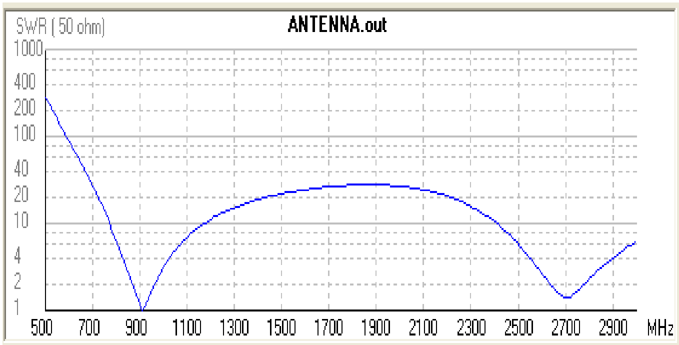

Fig. 4. SWR curve of the proposed antenna

Antenna gain relates the intensity of an antenna in a given direction to the intensity that would be produced by a hypothetical ideal antenna that radiates equally in all directions (isotropically) and has no losses. The antenna forward gain is obtained 1.82 as shown in fig. 5. For free space antenna this gain gives better performance in ISM band application.

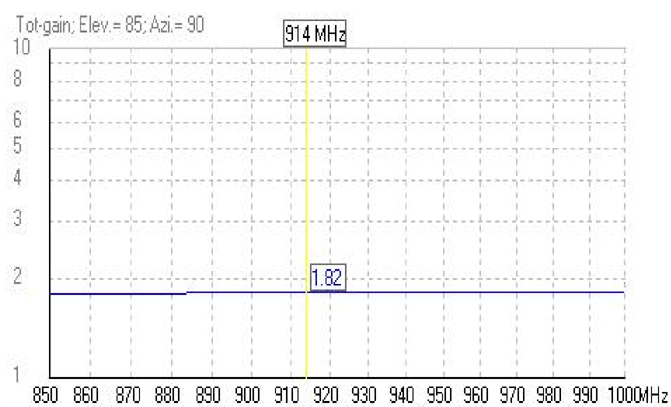

Fig. 5. Forward gain

At each interface, depending on the impedance match, some fraction of the wave's energy will reflect back to the source, forming a standing wave in the feed line. Minimizing impedance differences at each interface (impedance matching) will reduce SWR and maximize power transfer through each part of the antenna system.

Complex impedance of an antenna is related to the electrical length of the antenna at the wavelength in use.

The impedance of an antenna can be matched to the feed line and radio by adjusting the impedance of the feed line, using the feed line as an impedance transformer. More commonly, the impedance is adjusted at the load (see below) with an antenna tuner, a balun, a matching transformer, matching networks composed of inductors and capacitors, or matching sections such as the gamma match. Without any matching device the antenna gives 49.67Ω forward impedance as shown in figure 6 which is better matching with the cable with 50Ω characteristic impedance.

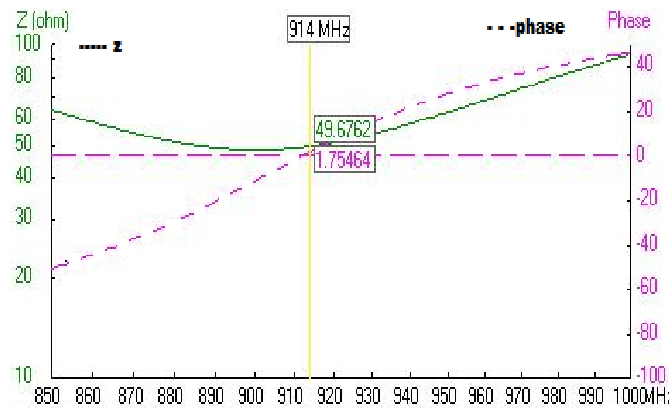

Fig. 6. Forward impedance

From plotting of parameters in the smith chart it has been seen that the above said parameters all together in fig. 7.

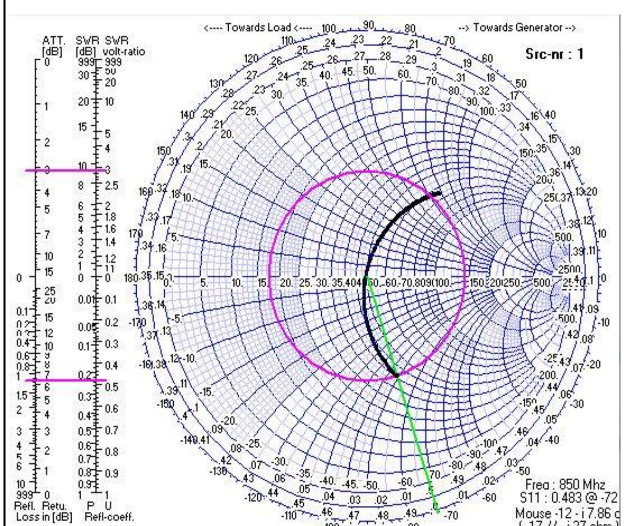

Fig. 7. Smith chart

4 HARDWARE SIMULATION RESULTS

Hardware simulation of the proposed antenna is carried out using Watts Antenna Trainer and Microwave Engineering

Trainer. The material of the wire antenna is copper. The radius of the wire is 1.026 mm and the seven segment length of the antenna is given in the fig. 1. Keeping all the arrangement same it is implemented in free space and taken the parameters to compare with the software simulation results. The practical normalized radiation pattern of the antenna is shown in fig. 8. as well as the total gain pattern obtains from the software simulation (fig. 2.). From the figure below it is seen that both radiation pattern are most likely same and omnidirectional.

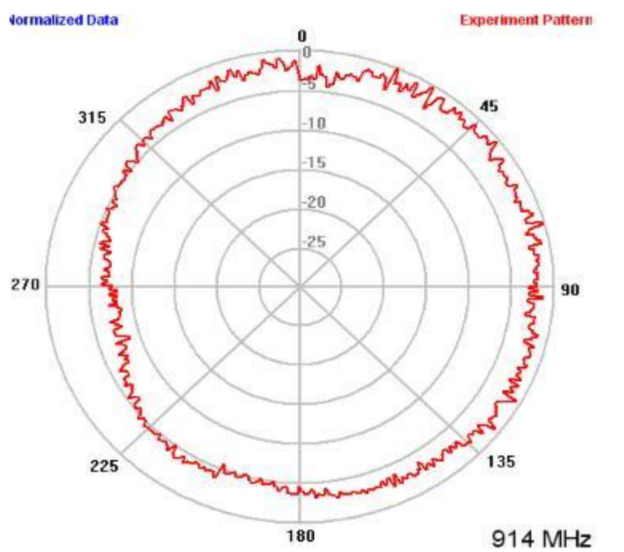

Fig. 8. Normalized radiation pattern from practical simulation

The practical SWR curve is shown in fig. 9. which shows that at -8 dB attenuation, we get the SWR near about 1 that is desired for the better performance of an antenna.

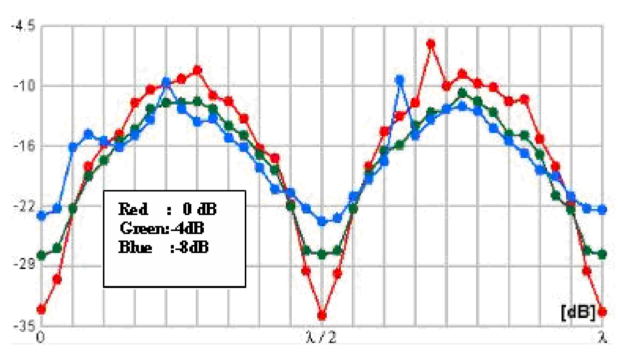

Fig. 9 practical SWR curve of the proposed antenna

5 CONCLUSION

The inverted U shaped free space antenna that has been designed in a small shape with dimension 9.7cmx4.25cm actually shows a good performance in free space for the ISM band, GSM-900 and SDMB application. Comparing software simulation results and hardware simulation results, this proposed antenna has good SWR and forward gain as well as the radiation pattern. The most significant characteristic of this antenna is the simple construction.

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