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Design and Simulation of an Ultra Wideband (UWB) Antenna for Wireless Communication

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ABSTRACT : A design of a ultra wideband printed microstrip antenna which was fed by a microstrip transmission line for the wireless communication is presented in this paper. All the design parameters like dimensions of strip, position of antenna, thickness of substrate and selection of dielectric material are optimized for the suitable VSWR characteristics, required downlink frequency (2.0 GHz to2.4 GHz) and gain of 3db with the efficiency of 74%. The antenna parameters like radiation pattern, input impedance, current distribution and gain are obtained by simulating the designed antenna using IE3D Zeland Software.

Keyword : Ultra wideband, VSWR, radiation pattern, input impedance, current distribution, antenna gain

I. INTRODUCTION

Ultra-wideband is a radio technology that can be used at very low energy levels for short-range high-bandwidth communications by using a large portion of the radio spectrum. UWB has traditional applications in non-cooperative radar imaging. Most recent applications are target sensor data collection, precision locating and tracking applications. Since the first Report and Order by the Federal Communications Commission (FCC) authorized the unlicensed use of UWB which must meet the emission masks on February 14, 2002, both industry and academia have paid much attention to R&D of commercial UWB systems. In UWB systems, antenna design is one of key technologies, and a suitable UWB antenna needs to fulfill requirements set by UWB technology and by portable devices alike, such as ultra wide bandwidth, directional or Omni-directional radiation patterns, constant gain and group delay over the entire band, high radiation efficiency and small size [1-3]. Under the extensive demands of various wireless operations, UWB systems usually operate at close quarters with other wireless systems resulting in the intersystem interference. The frequency band allocated for UWB communications is 3.1-10.6 GHz. The typical existing narrow-band systems within this frequency band are WLAN (2.4-2.484 GHz / 5.15-5.35 GHz / 5.725-5.85 GHz), Wimax (2.5-2.69 GHz / 3.3-3.8 GHz / 5.25-5.85 GHz), E band applications (2–3 GHz) and C-band satellite communication (3.8-4.2 GHz) [4-6].

The UWB technology offers several advantages over conventional communications systems. For instance, there is no carrier frequency. Instead, UWB emits timed "pulses" of electromagnetic energy. Therefore transmitter and receiver hardware can be made very simple, which is necessary for the portable devices. There is a wide range of applications for UWB technology, which includes wireless communication systems, position and tracking, sensing and imaging, and radar. In this paper an antenna with bandwidth suitable for wireless and satellite communications and with sufficient gain is presented. This antenna covers major bands like GSM, AWS, WCDMA, UMTS, DSR, Wi. Bro. ISM application (Wi-Fi), Wi-max, Fixed microwave links and DMB, Onboard aircrafts internet based on the AMSS.

Table 1: Parameters of antenna.

Substrate Thickness	30 miles	Dielectric Constant	4.5
Patch Length, L	1300 mils	Patch Width, W	1200 mils
Inset Width, S	110 mils	Inset Depth, D	400 mils
Strip Width, T	50 mils	Feed Line Length, F	650 mils

II. DESIGN CONSIDERATIONS OF ANTENNA

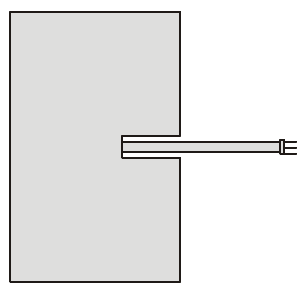

Fig. 1. Antenna.

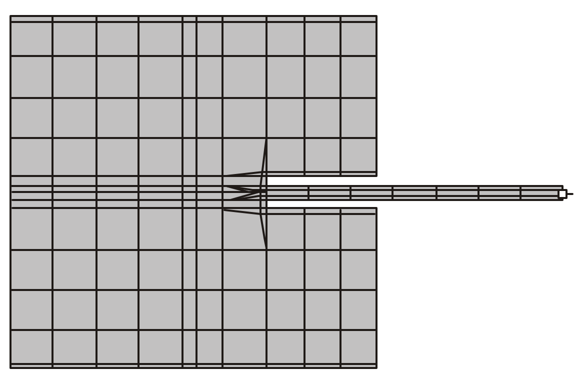

Fig. 2. Meshing result on the antenna.

A. VSWR Calculations

The voltage component of a standing wave in a uniform transmission line consists of the forward wave (with amplitude V_f) superimposed on the reflected wave (with amplitude V_r). Reflections occur as a result of discontinuities, such as an imperfection in an otherwise uniform transmission line, or when a transmission line is terminated with other than its characteristic impedance. The reflection coefficient Γ is defined thus:

$$\Gamma = \frac{V_r}{V_f}.$$

For the calculation of VSWR, only the magnitude of ρ, denoted by Γ, is of interest. Therefore, we define $\rho = |\Gamma|$.

At some points along the line the two waves interfere constructively, and the resulting amplitude V_{max} is the sum of their amplitudes:

$$V_{max} = V_f + V_r = Vf + \rho V_f = V_f(1 - \rho).$$

At other points, the wave interfere destructively, and the resulting amplitude V_{min} is the difference between their amplitudes.

$$V_{min} = V_f - V_r = V_f - \rho V_f = V_f(1 - \rho).$$

The voltage standing wave ratio is then

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{1+\rho}{1-\rho}.$$

Equal to :

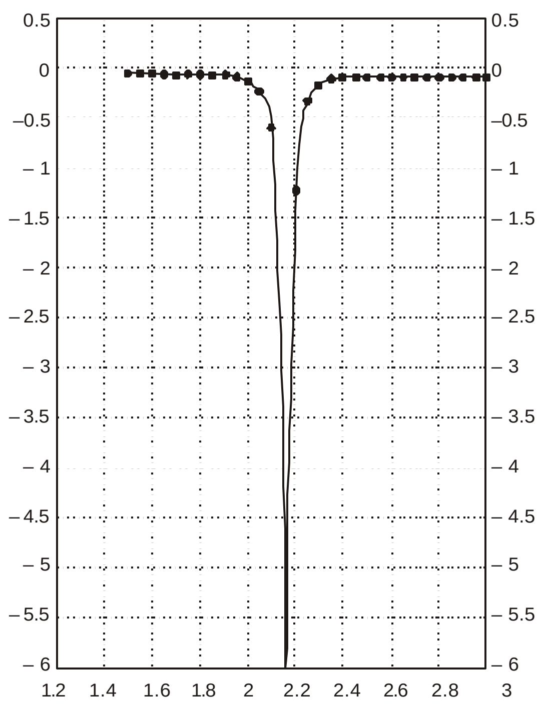

Fig. 3. VSWR Vs Frequency Graph.

As ρ, the magnitude of Γ, always falls in the range [0, 1], the VSWR is always $\geq$ +1.

B. Input Impedance

Technically, antenna impedance is the ratio at any given point in the antenna of voltage to current at that point. Depending upon height above ground, the influence of surrounding objects and other factors, our quarter wave antenna with a near perfect ground exhibits a nominal input impedance of around 36 ohms. A half wave dipole antenna is nominally 75 ohms while a half wave folded dipole antenna is nominally 300 ohms. The two previous examples indicate why we have 75 ohm coaxial cable and 300 ohm ribbon line for TV antennas.

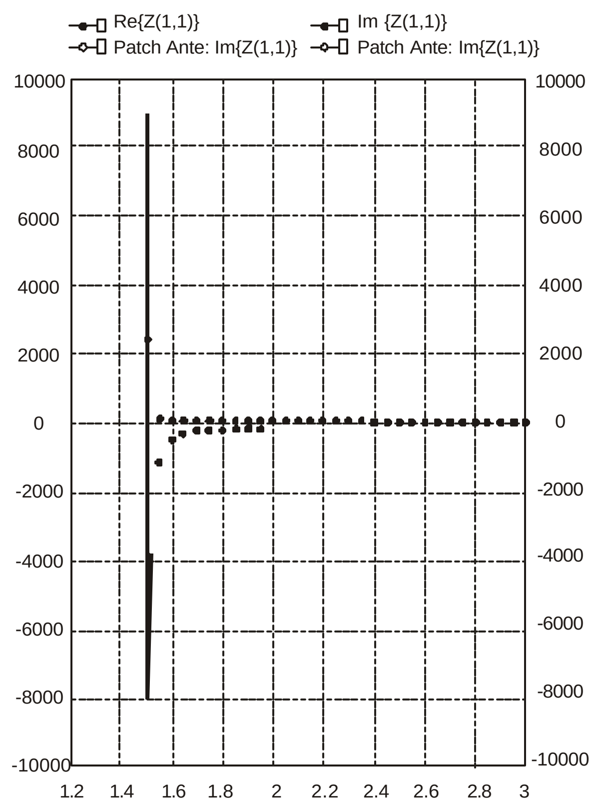

Fig. 4. Parameter.

C. Current Distribution

For a given antenna structure the conductors can be broken into "segments", and the currents on the segments can then be determined. The "moment" is numerically the size of the current times the vector describing the little segment (length and orientation). One matches the currents at the ends of the segments. A set of "basis functions" may be assumed into which the current distributions are decomposed.

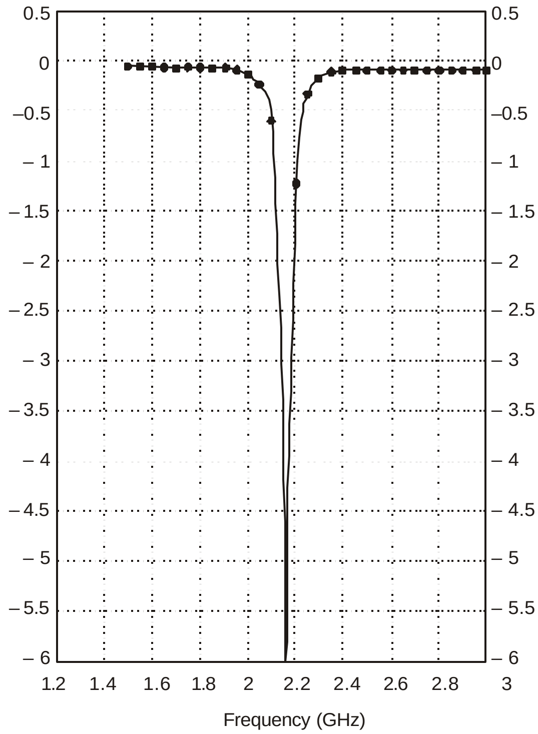

Fig. 5. S parameter.

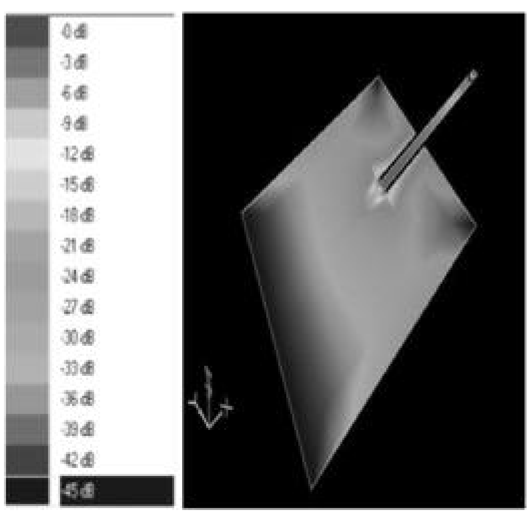

Fig. 6. The current distribution display at 2.18 GHz.

III. RADIATION PATTERN

The radiation power density of the transmitting antenna is

$$W(\theta,\Phi) = \frac{G(\theta,\Phi)}{4\pi r^2} P_t.$$

Here, the arguments θ and Φ indicate a dependence on direction from the antenna, and P_t stands for the power the transmitter would deliver into a matched load.

The power delivered by the receiving antenna, is

$$P_r = A(\theta,\Phi)W.$$

Here W is the power density of the incident radiation and A is, the effective area or effective aperture of the antenna.

The power transferred from transmitter to receiver is

$$P_r = A\frac{G}{4\pi r^2} P_t.$$

For transmission from the reference antenna to the test antenna the power is

$$P_{1r} - A_1(\theta,\Phi)\frac{G_2}{4\pi r^2} P_{2t}$$

and the transmission in the opposite direction

$$P_{2r} = A_2 \frac{G_1(\theta,\Phi)}{4\pi r^2} P_{1t}.$$

The power delivered to the receiver is therefore more usually written as

$$P_r = \frac{\lambda^2 G_r G_t}{(4\pi r)^2} P_t.$$

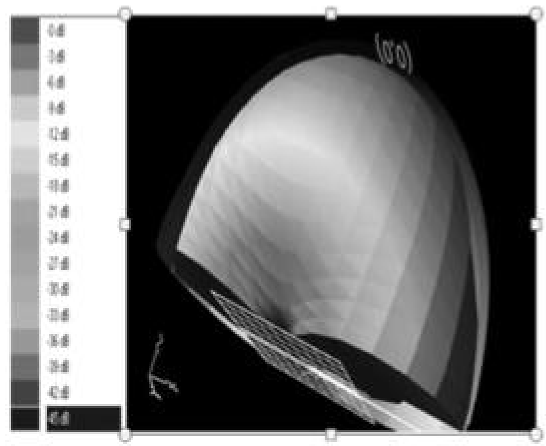

Fig. 7. Radiation pattern.

A. Gain

Power per unit area of the sphere's surface is

$$p = P/ 4pr^2$$

Power received from isotropic radiator over area, S is

$$P_S = Sp$$

Power received over area, S, if all power is focused uniformly on that area by Antenna with gain, G

$$P_S = GSp_s = P$$

Power density in S with idealized focused antenna

$$p_s = P/ GS$$

Idealized antenna gain is

$$G = P/Sp_s = 4\pi r^2/S$$

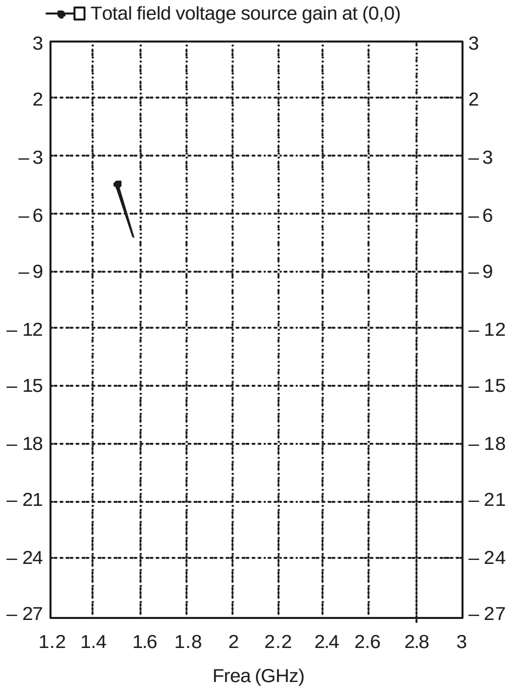

Fig. 8. Field gain Vs Frequency result.

IV. SIMULATED RESULTS

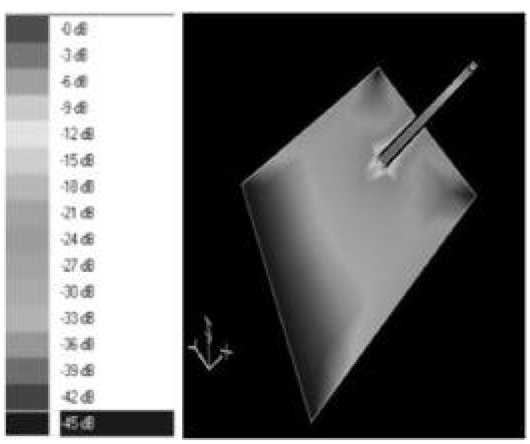

Fig. 9. 3D view of antenna.

V. CONCLUSIONS

A wideband microstrip antenna was designed with the suitable dimensions and position co-ordinates. With this design we conclude that this antenna is well suited for the wireless LAN applications with the frequency of 2.0 GHz to 2.4 GHz. The measured gain is also suited with the required value. By using the Zeland IE3D software all the radiation parameters and gain were simulated. The experimental details like the antenna efficiency of 74%, the gain of 3db and VSWR of 10 db show that it is fit for this application. The simulated results were very close to the measured values. All the graphs and charts show the simulation results of the antenna. It is ideal for wireless communication.

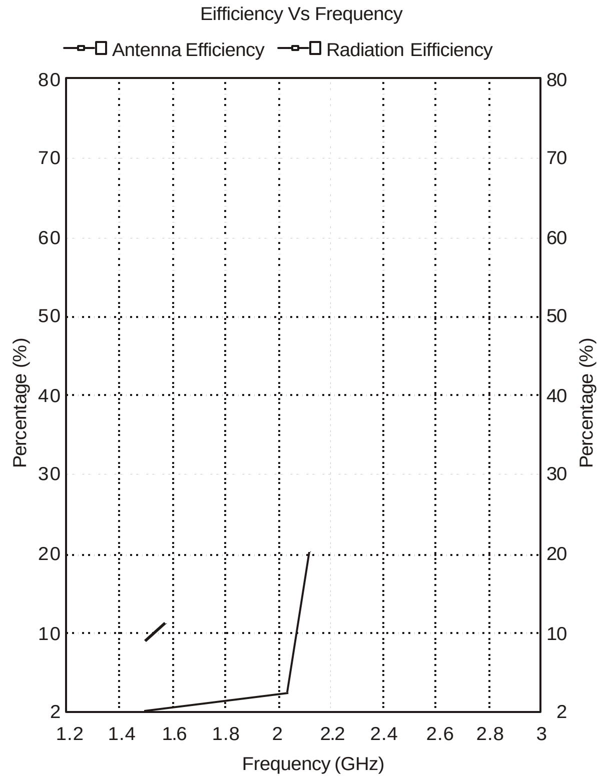

Fig. 10. Efficiency Vs Frequency.

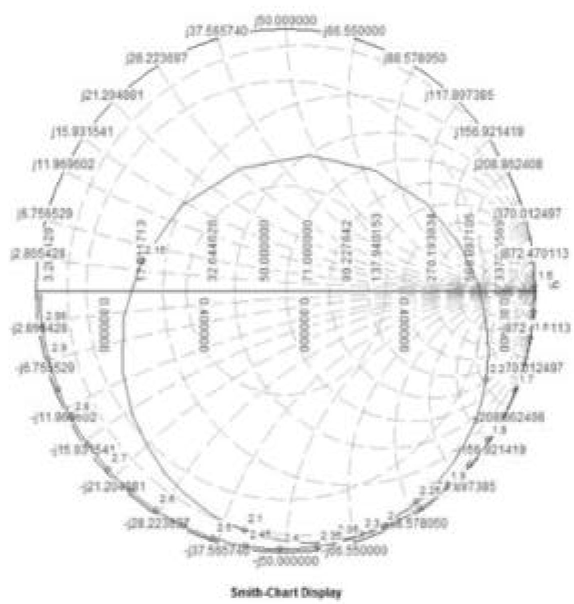

Fig. 11. Smith chart.

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