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A MULTIBAND FREE SPACE ANTENNA FOR HIGH BANDWIDTH WIRELESS APPLICATIONS

Strictly as per the compliance and regulations of:

A Multiband Free Space Antenna for High Bandwidth Wireless Applications

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Abstract - **This paper presents a free space wire antenna having two larger bandwidths with satisfactory forward gain, return loss and VSWR. With center frequency 914MHz the antenna provides a bandwidth 174MHz from 880MHz to 1054MHz. Another band lies between 1478MHz and 1540MHz range with center frequency 1508MHz. These two larger bandwidths enable the antenna to support a wide range of wireless applications such as GPS, cellular communication, CT2, ZigBee, Wi-Fi and biomedical applications. The simulation of the antenna in 4NEC2 shows VSWR 1.08002, Return Loss -28.298dB and Gain 1.99dB. The characteristic impedance of the antenna is 49.7346 Ω without the use of any matching network. Both the simulation and experimental result shows that the antenna is omni-directional in nature.**

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I. Introduction

Wire antennas [6] are the most common and simpler type of antenna. The antenna is generally made by copper or other metallic substances. A wire antenna may be a single piece or a combination of different pieces of variable length and radius. Whatever the types of antenna the use of it depends upon several characteristics such as VSWR, antenna gain, return loss, radiation characteristics etc.

Voltage Standing Wave Ratio (VSWR)[9] is a important term in describing the performance of an antenna. It is the ratio of the maximum to the minimum voltages along an antenna. Ideally it is desired that an antenna posses VSWR value 1 with all the power reaching the destination and no reflected power. But in practical case due to impedance mismatches in the antenna the VSWR deviates from this standard value. Again due to this power reflection from the destination to the source causes loss in signal power. This loss is called return loss [8]. Return loss is expected to be as smaller as possible. Antenna gain is another characteristic that indicates the ability to direct the input power into radiation in a particular direction.

The proposed antenna in the two specified bandwidths has VSWR 1.08002 and return loss -28.298dB that is desirable for practical wireless communications. The gain of the antenna is 1.99dB that is also acceptable. A usual antenna system uses 50 Ω transmission line. So the designed antenna should be matched with this vale to decrease return loss significantly. Our antenna provides characteristics impedance of 49.7346Ω.

An antenna's bandwidth [7] is the range of frequencies over which its performance does not suffer from poor impedance matching. The higher the bandwidth of an antenna, the greater is the possibility to use it in different wireless applications. Sometimes an antenna operates over two or more frequency bands with satisfactory performances. Such type of antenna is called a multiband antenna [11]. The proposed antenna shows two bandwidths. Depending upon the allocated frequency band, an antenna can be used in different wireless applications. The wider the bandwidth, the higher is the usability of the antenna in wireless communication. The first band of this antenna provides a wide band of 174 MHz and the second one 62 MHz. Such wide frequency bands enables the antenna to be used in RFID, ZigBee, CT1, CT2, GPS, bluetooth and mobile communications.

Radio Frequency Identification or RFID [1], is a technology for automated identification of objects and people. This can operate in LF, HF and UHF in the 860-960 MHz range [3]. It is desirable the antenna size be smaller. The highest dimension of our antenna is 9cm. So it can be used to identify larger objects such as cars, ships and other types of vehicles. The antenna can also used for personal area network such as ZigBee[12]. It is a specification for high level communication protocols using small, low-power digital radios based on an IEEE 802 standard. Applications of it include wireless light switches, electrical meters with in-home-displays, and other consumer and industrial equipment that require short-range wireless transfer of data. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPAN systems such as Bluetooth. The standard specifies operation in the unlicensed 2.4 GHz worldwide, 915 MHz in Americas and Australia and 868 MHz in Europe. Our antenna can be used to support this.

On the contrary, the antenna can be used in bluetooth communications. Today bluetooth wireless technology operates on an open frequency within the 914MHz band, which is the same cordless phones and various other wireless devices. Bluetooth is able to share the same frequency band without experiencing any interference because it utilizes various key

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technologies. It can also be used in cordless telephone version 1 and 2 with proper radiation and gain characteristics.

The wider frequency band of the antenna also enables to support space-based satellite navigation system GPS and Mobile communications. GPS [14] provides location and time information in all weather, anywhere on or near the Earth. The satellite communication for GPS comprises two frequencies i.e. uplink and downlink. These two frequency band lies in the second band of our antenna [13]. On the other hand the antenna can be used for widely adopted mobile communications. In mobile phone technology, there are two main transmission protocols. One is GSM and the other is CDMA. The Global System for Mobile Communication (GSM) is the dominant protocol used in India and most European countries. GSM phones use transmission frequencies of 890 - 915 MHz or 1710 - 1785 MHz for uplink (handset to base station) and 935 - 960 MHz or 1805 - 1880 MHz for downlink (base station to handset). The CDMA phones use frequencies of 824 - 849 MHz for uplink and 869 - 889 MHz for downlink. These frequency ranges lie in the first band of our antenna. So it can be used in mobile communication applications.

Nowadays, the wireless local area network (WLAN) and the worldwide interoperability for microwave access (WiMAX) systems are very popular techniques for wireless internet access. With the complementary capability between WLAN and WiMAX systems, seamless internet access for mobile users becomes possible. To cover WLAN and WiMAX operation, however, a wide operating band for the employed antenna in portable mobile devices is required. Having two larger bands, our antenna is very promising in providing a wide operating band with a compact antenna size.

II. Antenna Geometry

The antenna is made of 12 gauge copper wire With all the pieces of same radius. The antenna structure is shown in figure 1. The longest dimension is 90mm that is along the main axis of the antenna. The total wire length required to construct the antenna is 310.06mm.

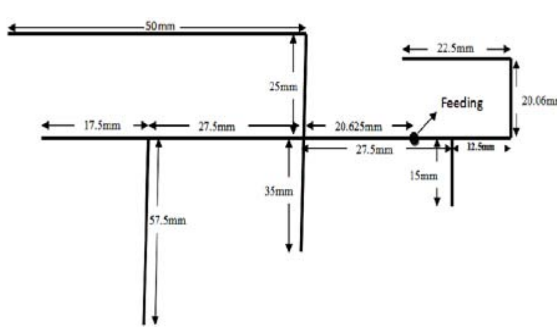

Fig 1 : Physical structure of the antenna for 914MHz

The antenna is assumed to be fed by 50 ohm coaxial cable with its central conductor connected to the feeding point. The feeding point is indicated in the figure.

III. Simulated and Experimental Result

The antenna is designed and simulated in 4NEC2 software air interface. The analysis is done for radiation pattern, return loss, VSWR, impedance curve and forward gain.

a) Radiation Pattern

Radiation pattern [6] of an antenna is a graphical representation of the radiation properties of the antenna as a function of three dimensional space coordinate. The simulated radiation pattern of the antenna is shown in figure 2(a) and 2(b) for E (horizontal) and H (vertical) plane. The two figures for horizontal and vertical plane are almost identical. Figure 2(c) and 2(d) demonstrates the radiation pattern that was found in our experiment.

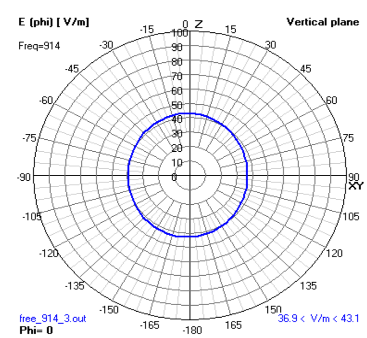

Fig 2(a) : Simulated Radiation pattern for E - Plane

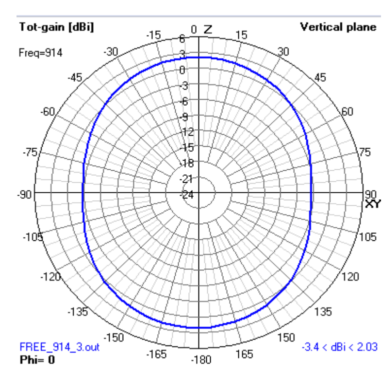

Fig 2(b) : Simulated Radiation pattern for H-plane

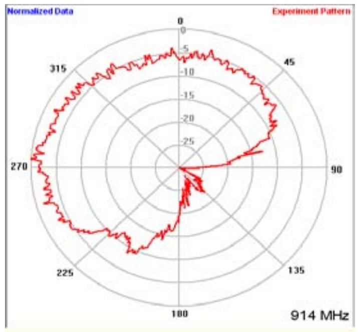

Fig 2(c) : Experimental radiation pattern for E-plane

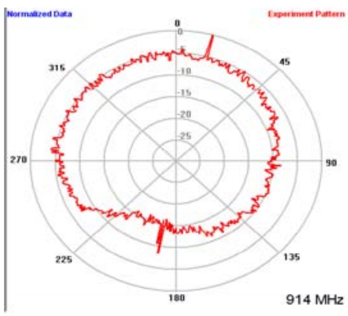

Fig 2(d) : Experimental radiation pattern for H-plane

The radiation patterns of the antenna are almost circular in two dimensional planes. It denotes that the antenna is omni-directional. So it can be used efficiently for a wireless communications.

b) VSWR

The voltage standing wave ratio of the antenna is depicted in figure 3 for different frequencies. From the curve we see that VSWR is almost 1 in three frequency bands. The VSWR values at the centre frequencies of these bands are given in Table 1. VSWR at these frequencies are very near to the ideal value.

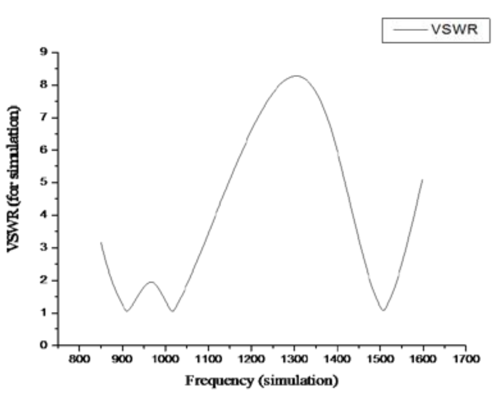

Fig 3 : Simulated VSWR curve

Table I : VSWR and Return Loss

Frequency (MHz)	VSWR	Return loss (dB)
914	1.08002	-28.298
1012	1.05894	-30.805
1506	1.07928	-28.373

Within frequency band from 880MHz to 1054MHz, VSWR $\leq$ 2. So it can provide wideband applications sufficiently. Another band lies between 1478MHz and 1540MHz where VSWR is very near to 1. Here VSWR change is sharp. So it can also be used for narrowband applications.

c) Return Loss

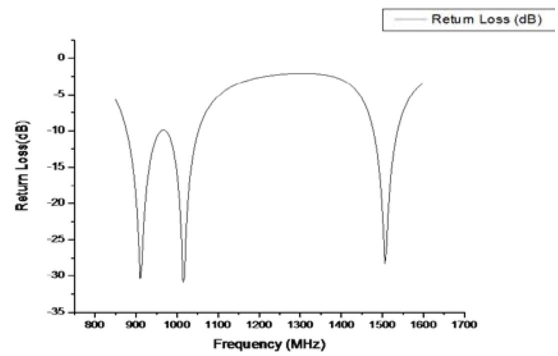

Fig 4 : Simulated Return loss Curve

The simulated return loss curve is demonstrated in figure 4. The lower the return loss the better the antenna and it provides lower loss. In the three bands return loss peaks touch -30 dB. This value is satisfactory to use in typical wireless applications.

d) Gain

The gain curves 5(a), 5(b) and 5(c) shows the variation in antenna gain for different directions and at different orientations. It may be noticed that horizontal gain equally varies with distance but vertical gain does not.

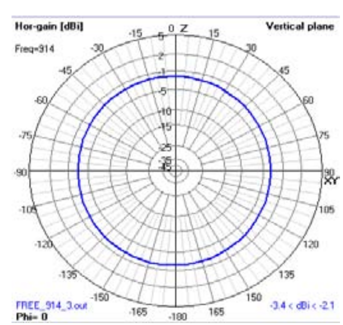

Fig. 5(a) : Simulated Radiation for Horizontal Gain

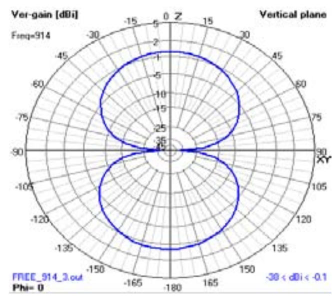

Fig. 5(b) : Simulated Radiation for Vertical Gain

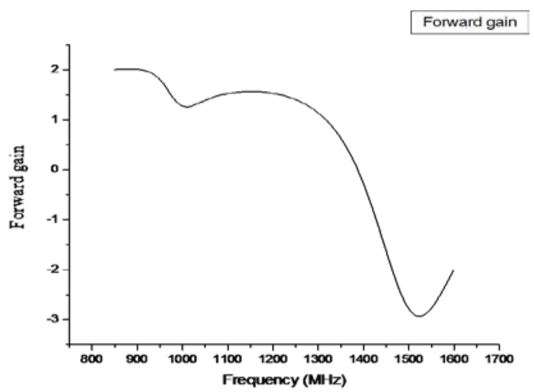

Fig 5(c) : Simulated forward gain

From the figures we see that forward gains in 914 MHz and 1012 MHz are 1.99 and 1.26 respectively. These values are satisfactory. But gain in third band is negative that is undesirable. It is not a major problem. This problem can be overcome using additional networks.

e) Impedence Curve

For maximum power transfer from transmitter to the antenna or from antenna to receiver, the antenna should be impedance matched.

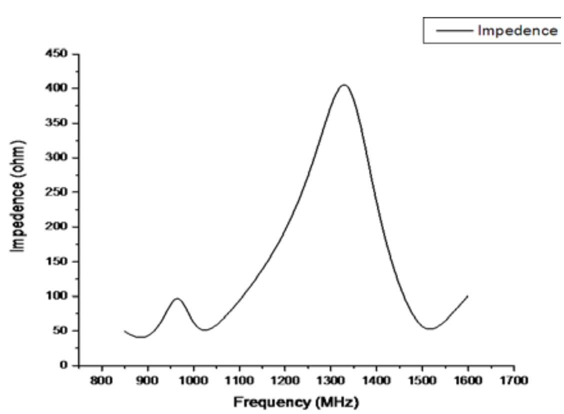

Fig 8 : Simulated impedance curve

The proposed antenna is designed for 50 Ω transmission line feeding. At the three bands, the antenna chows characteristics impedance almost the ideal value with negligible deviations. So there is no need of a matching network while practically using them.

IV. Conclusion

A multiband wire antenna with wider bandwidth is designed, implemented and has been presented in this paper. The antenna provides three successive band of operating frequencies with excellent performance measures. Each of these band is wider enough to serve wider bandwidth requiring applications. In these bands the antenna shows satisfactory VSWR, return loss, gain, impendence and radiation properties. So the same antenna can support GPS, cellular communication, CT2, ZigBee, Wi-Fi, bluetooth and WiMAX applications. It does not require any additional matching network for feeding with 50 **Ω** transmission line or coaxial cables. In addition to this, the proposed antenna provides simple structure, thin profile and low cost. Therefore, it can be used in inexpensive communication applications with sufficient bandwidth and radiation properties.

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