A Simple Structured Planar Wire Antenna for Wireless Communication Applications

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***Abstract*— A simple structured planar wire antenna for WiMAX, Wi-Fi, WLAN, Bluetooth and satellite communication applications is presented. The antenna has four significant frequency bands with bandwidth of 194 MHz (2.956 – 3.15 GHz), 454 MHz (5.196 – 5.65 GHz), 79 MHz (6.538 – 6.617 GHz), and 424 MHz (12.812 – 13.236 GHz). The antenna is assumed to be feed by a 50 Ω coaxial cable. Application of RC network improves the antenna impedance behavior. It shows unidirectional radiation pattern with sufficient antenna gain. The antenna design cost is very low and about 200 BDT**

***Index Terms*—Multiband antenna, planer antenna, VSWR, antenna gain, return loss, radiation pattern, radiation efficiency, WiMAX, WLAN, satellite communications**

I. Introduction

The fast growing of wireless communications has recommended increasing possibility of using various service applications with different frequency bands in the same communication terminal. Thus, dual-band or even multi-band antennas are of increasing interest today [1]. The proposed antenna has four frequency bands with excellent characteristics. In design methodology, planar antennas are popular candidates for modern wireless communication systems because they possesses simple feeding structure, low profile, low manufacturing cost, and easy-to-integrate features[2,3]. So we chose planer structure. A usual antenna system uses 50 Ω transmission line [2,3]. So the designed antenna should be matched with this value. The input impedance values of the antenna at that bands show acceptably little deviation from 50Ω. It also fulfills the gain, VSWR and return loss requirements [3,4]. Another important consideration is antenna bandwidth. The wider the bandwidth, higher data rate and higher usability of the antenna is possible [4,5]. The first band ranges from 2.956 GHz to 3.151 GHz with satisfactory VSWR, return loss, gain, impedance and radiation efficiency. This band can be used in Radio frequency identification (RFID) services like railway vehicle identification, road tolling system etc [6]. The second band extends from 5.196 GHz to 5.65 GHz with a wide band of 454 MHz. The first portion of this can provide IEEE standard 802.11 WLAN communications in the frequency range 5.15–5.35 GHz [7-10]. The second portion can be used for WiMAX applications at frequency 5.25–5.85 GHz [2-4, 9, 11-15]. Both the first and second band can also be applicable for IEEE 802.16e standard mobile broadband wireless access applications [16,17,18]. The 6.538–6.617 GHz third band with bandwidth 79 MHz can be used by associated wireless communications. The fourth one provides wide bandwidth of 424 MHz from 12.812–13.236 GHz. It can be used for Ku band satellite communications. Generally 27, 36, 54 or 72 MHz bandwidths are used by satellite transponders [19] in Ku band. Moreover this band shows high gain and very high radiation efficiency. So it can be dedicated for efficient satellite communication applications.

II. Antenna Configuration and Design Considerations

The antenna is designed in the 4nec2X geometry editor interface. It is constructed of 12 gauge copper wire with all the pieces having same radius 1.026mm.

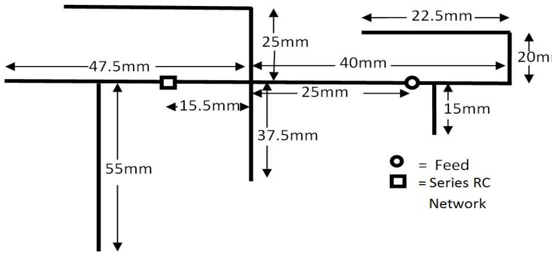

Fig. 1. Geometry of the proposed antenna

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The antenna structure is shown in Fig. 1. It is designed on MiniNec substance with conductivity 0.005 simens and dielectric constant 4.4. It is assumed to be fed by 50 ohm coaxial SMA. The feeding point is indicated in the figure as a circle. A series RC network with R=100 ohm and C= 9 pF is used for proper impedance matching and best approximation of gain, VSWR, return loss values at desired band of frequencies. The RC network is shown as a rectangle in the arrangement. The availability of the constructing materials allow low production cost i.e. about 200 BDT.

III. Performance Analysis

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

A. *Radiation Pattern*

The simulated radiation pattern of the antenna is illustrated in Fig. 2. These patterns represent the radiation distribution in far distances from the antenna. The patterns illustrate that the antenna radiates in one direction only.

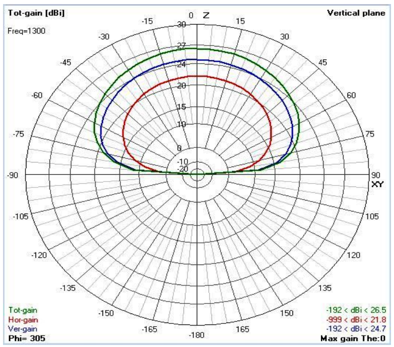

Fig. 2(a). 2D radiation pattern of the proposed antenna showing total, horizontal and vertical distribution of radiation

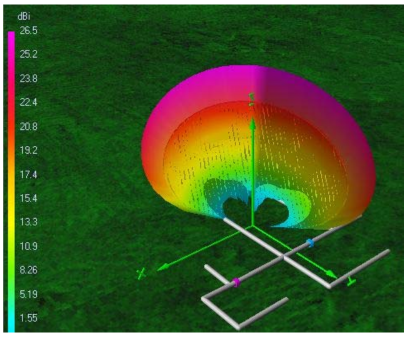

Fig. 2(b). 3D radiation pattern of the proposed antenna

B. *VSWR*

The VSWR characteristics of the antenna are depicted in Fig. 3. This demonstrates VSWR

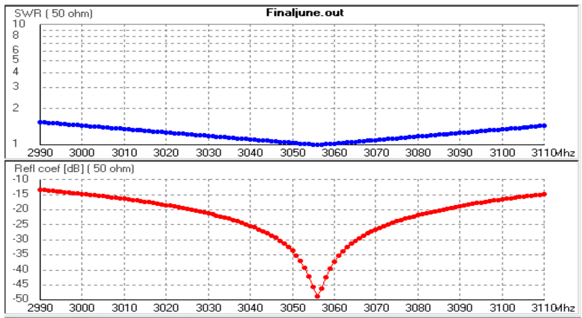

Fig. 3(a) Illustration of VSWR and return loss value at 3056 MHz band (from 2953 MHz to 3115 MHz)

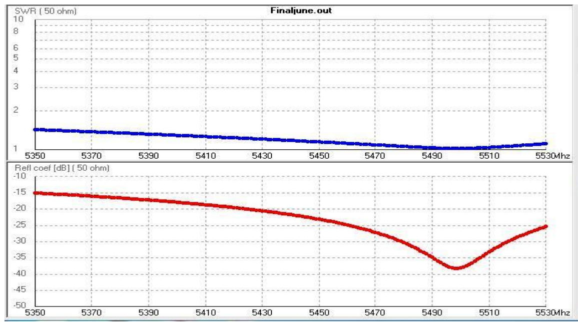

Fig. 3(b) Illustration of VSWR and return loss value at 5500MHz band (from 5196 MHz to 5650 MHz)

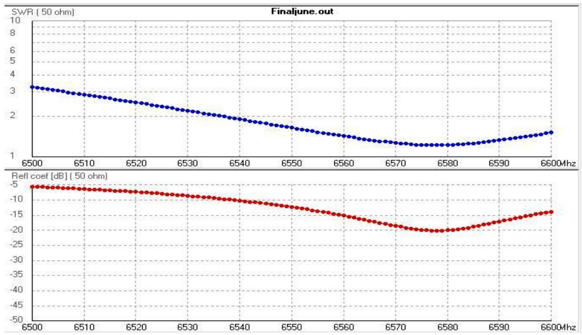

Fig. 3(c) Illustration of VSWR and return loss value at 5500MHz band (from 6538 MHz to 6617 MHz)

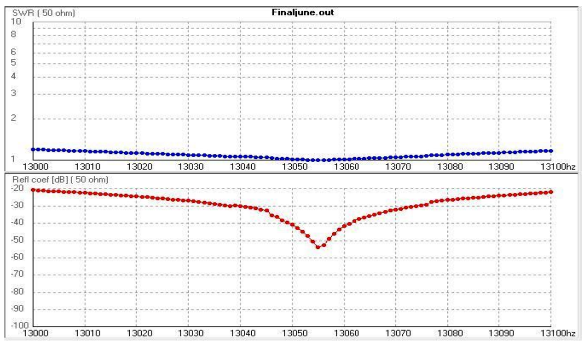

Fig. 3(d) Illustration of VSWR and return loss value at 13048 MHz band (from 13035 MHz to 13054 MHz) curves as blue colored lines in terms of frequency bands. At center frequencies 3.056 GHz, 5.5 GHz, 6.57 GHz and 13.048 GHz, VSWR values are 1.007, 1.025, 1.269 and 1.025 respectively. So the antenna shows very good VSWR characteristics at the specified bands.

C. Return Loss

The simulated reflection coefficient curves are shown in Fig. 3 as red lines. The lower the reflection coefficient values, the lower the return loss occurs and the better the antenna performance is at that frequency. The reflection coefficient values at frequencies 3.056 GHz, 5.5 GHz, 6.57 GHz and 13.048 GHz are -48.6 dB, -38.1dB, -18.5 dB and -38.2 dB respectively. The marginal value of reflection coefficient is -10 dB. This criterion is satisfied by four different frequency bands 2.956-3.15GHz, 5.196-5.65GHz, 6.538-6.617GHz and 12.812-13.236GHz around the above four center frequencies respectively. So the antenna can be applied for a large number of communication channels simultaneously.

D. Gain

The excellent gain characteristic of the proposed antenna is demonstrated by Fig. 4.

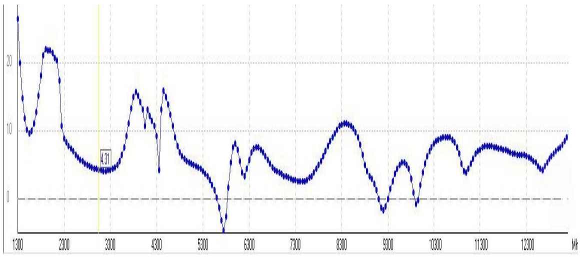

Fig. 4. Gain characteristics of the proposed antenna

The gain values are 4.3, 2.17, 7.16 and 7.8 dB at center frequencies 3.056, 5.5, 6.57 and 13048 GHz respectively. These values are satisfactory for typical communications.

E. Impedence curve

The simulation result of the proposed antenna shows that impedance values are nearly unaltered within satisfactory width of bands. Fig. 5 depicts the impedance characteristics of the proposed antenna. Input impedence values are 50.37 Ω, 50.82 Ω, 50.74 Ω and 50.78 Ω respectively at the four investigated frequency bands. These are almost equal to standard value 50 Ω

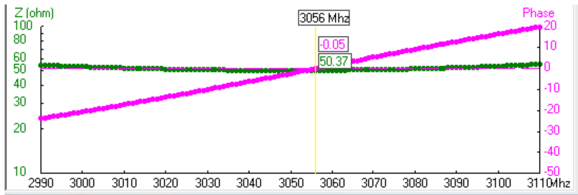

Fig. 5(a). Depiction of impedance values at 3056 MHz band

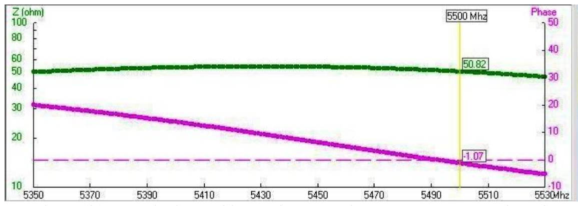

Fig. 5(b). Depiction of impedance values at 5500 MHz band

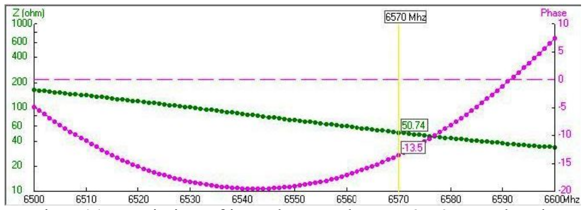

Fig. 5(c). Depiction of impedance values at 6570 MHz band

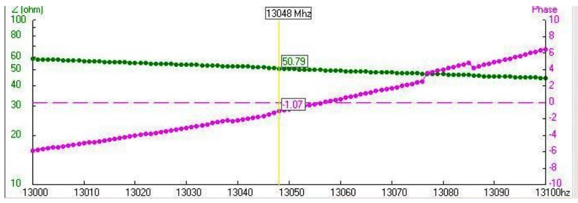

Fig. 5(d). Depiction of impedance values at 6570 MHz band

F. Radiation Efficiency

The proposed antenna is found to have efficiencies 12.13%, 22.39%, 99.99% and 94.79% at frequencies 3.056 GHz, 5.5 GHz, 6.57 GHz and 13.048 GHz respectively. These outcomes are found from power budget analysis of the antenna using 4nec2X. As an example, power budget analysis result for 13.05 GHz frequency is shown below:

- - - - - - FREQUENCY - - - - - -
FREQUENCY= 1.3050E+04 MHZ
WAVELENGTH= 2.2973E-02 METERS

- ANTENNA ENVIRONMENT - -PERFECT GROUND

- - - POWER BUDGET - - -
INPUT POWER = 2.4733E-01 WATTS
RADIATED POWER= 2.3450E-01 WATTS
STRUCTURE LOSS= 1.2826E-02 WATTS
NETWORK LOSS = 0.0000E+00 WATTS
EFFICIENCY = 94.81 PERCENT

The analysis results of the multiband antenna can be summarized as TABLE I. From this we can compare all four frequency bands of interest. These bands has excellent VSWR, return loss and impedance values. The second band has slightly less gain than the standard value (3 dB). But this is acceptable considering the other fine characteristics of this band.

TABLE II
Comparison among Frequency bands

Frequency (GHz)	**VSWR**	**Return loss (dB)**	**Gain (dB)**	**Radiation Efficiency (%)**	**Impedance (Ω)**	**10 dB return loss band (GHz)**
3.056	1.007	-48.6	4.3	12.13	50.37	2.956-3.15
5.5	1.025	-38.1	2.17	22.39	50.82	5.196-5.65
6.57	1.269	-18.5	7.16	99.99	50.74	6.538-6.617
13.048	1.025	-38.2	7.8	94.79	50.79	12.812-13.236

The third and the fourth bands have superior radiation efficiency values. It suggests that they can be used for long distance wireless communications. The 10 dB return loss bands proposed are of width 194 MHz, 454 MHz, 79 MHz and 424 MHz. These bands are high enough for modern wireless communications with necessary prerequisites well-fulfilled.

IV. CONCLUSION

A simple structured planar wire antenna for multiband applications has been presented. The antenna is applicable to WiMAX, Wi-Fi, RFID, Bluetooth and satellite communication applications. The antenna design cost is low. Application of RC network improves the antenna impedance. The investigation for VSWR, return loss, power budget, gain and radiation behavior in all the specified bands suggested that it can be efficiently used in multiband applications. Due to the low cost and design simplicity, the antenna is promising for gross production.

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