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IMPROVED GAIN OF DUAL POLARIZED PRINTED DIPOLE ANTENNA FOR BASE STATION APPLICATIONS.

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Abstract — A dual polarized printed dipole antenna developed for wireless communication base station applications. Three with a back plane and shaped feed probe is used to achieve wider bandwidth and better port isolation. This antenna operates at 1.7Ghz to 2.4Ghz in attrition it exhibits better gain of 8.4 dbi. The back lopes are suppressed by adding a reflector plane at the bottom side of the antenna. Thus the surface waves back lobes and side lobes of the radiation pattern are reduced effectively. Hence the overall antenna efficiency are improved and the VSWR is < 1.5. this design can be effectively used in 2G/3G/LTE base station application.

I. INTRODUCTION

In recent years the wide band antenna design has been a research focus because of the rapid development of wireless communication. The printed dipole antenna are widely used in many areas such as wireless communication radar system and base station due to many salient features such as light weight, low cost, case of fabrication and their suitability from integration with microwave integrated circuit models.

It is mainly suitable for base station applications over the frequency band of 2nd generation(2G) such as GSM 1800 and GSM 1900, the third generation(3G) such as CDMA – 2000, WCDMA and long term evaluation (LTE) system LTE 2300 and LTE 2500 designated at 1G. Including the frequency band 2300-2400MHZ and 2500-2600 MHZ.

The dipole antenna bandwidth is enhanced by the shaped feed line in the rectangular patches of vertical substrate. A balun is a device need for a low loss impedance matching to connect a balanced dipole to an unbalanced coaxial transmission line.

In this paper a new method is proposed by adding a backplane and it brings high gain. Calculation and experiments show that the gain of the dipole antenna is better than that of the model proposed in [1].

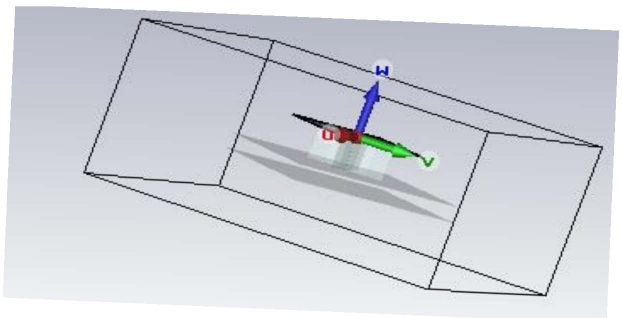
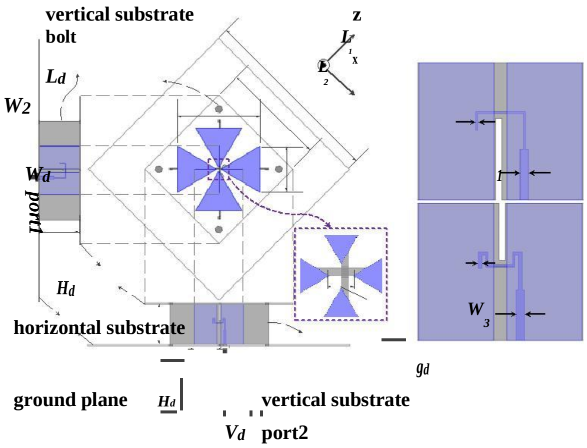


Fig 1 dipole antenna with back plane

II. ANTENNA GEOMETRY

Figure 1 shows the geometry of the proposed dipole antenna with detailed dimensions. The antenna consist of three substrates namely ground plane, horizontal substrates and a vertical substrate coaxial feed and a backplane.

Ground plane is made up of aluminum plate with FR4 material having thickness of 1.0mm. The vertical substrate is mounted between the ground plane and the horizontal substrate. The four rectangular patches are etched on the side of vertical substrate. These patches are connected to the triangle patches which are printed in the horizontal substrate and shorted at the ground plane. Horizontal substrate is provided by the four triangle patches. The patches are printed on bottom side horizontal substrate. The rectangular and triangular patches are like symmetrical. Hence the gap between them is S



(a) (b)

Fig. 2. (a) Geometry of antenna D, (b) Baluns for port1 (top) and port 2(bottom)

A back plane is etched on the bottom side of ground plane with some distance 50mm. moreover the slots are produced in the vertical substrate and the plastic bolts are etched on the corner of the horizontal substrate. This slots and bolts are used in this hardware of the antenna.

Two integrated baleens are connected to the feeding probe of a 50Ω SMA is printed on the side of the vertical substrate. One of the balun is bent at the middle of the feed point for isolation between the two dipole antennas.

Two triangular patches are act as one dipole antenna. Here four triangle patches antenna are used to produce two dipole antennas. Each antenna have different polarization either horizontal or vertical polarization..Thus antennas have linear and dual polarization.

III. IMPEDANCE MATCHING

Figure 3 shows the mechanism of impedance matching. The balun consists of three sections. They are a Γ-shaped microstrip line, shorted stub and a slot line. The a Γ-shaped microstrip line has three main sections which are two microstrip lines and a open stub .

The dipole is excited by the slot line which is coupled by the Γ-shaped microstrip line at the feed point. The characteristic impedances of the two microstrip lines and the open stub are denoted as Z_a, Z_b and Z_c, respectively. Z_s represents the characteristic impedance of the balanced transmission line composed of the outer conductors of the microstrip lines and the open stub.

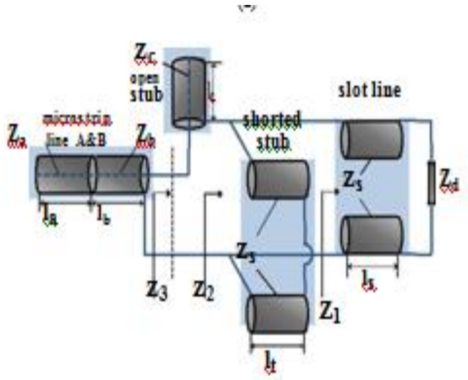


Fig3 Equivalent-circuit of antenna

Z_d is the input impedance referred to at the current at the input terminals of the dipole. As can be seen, the shorted stub is parallel connected to the input impedance Z_1. A relationship of the input impedances Z_1, Z_2 and Z_3 is given by

$$Z_3 = -jZ_c \cot\beta_c l_c + Z_2 = (-jZ_c \cot\beta_c l_c + jZ_s \tan\beta_t l_t) // Z_1$$

where β and l are the phase constant and physical length.
The input impedances Z_1 can be directly calculated by the equations presented in [2, 11]. According to the impedance equation of a transmission line,

$$Z_a = Z_b \frac{Z_3 + jZ_b \tan\beta_b l_b}{Z_b + jZ_3 \tan\beta_b l_b}$$

where Z_a is equal to the port impedance of SMA (50 Ω). The initial dimensions of the balun can be estimated through above equations and the microstrip line formula.

IV. RESULT AND DISCUSSION

Fig. 7 shows the simulated VSWRs for the two ports. Due to the small difference between the two baluns, the operating frequency bands for port 1 and port 2 are slightly different. It can be seen that the simulated and measured VSWRs for both ports are in good agreement and are less than 1.5, ranging from 1.7 GHz to 2.9 GHz.

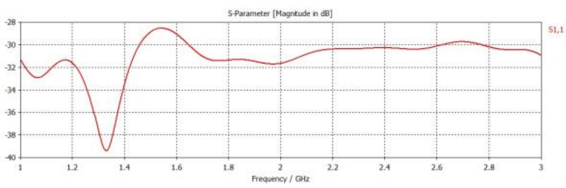


Fig. 4 Simulated VSWR versus Frequency

The impendence bandwidth is wide enough for base station applications covering GSM1800 (1.7–1.88 GHz), CDMA1900 (1.85– 1.99GHz), TD-SCDMA (2.01–2.025GHz), WIFI (2.4-2.48 GHz), and LTE (2.5-2.69GHz)

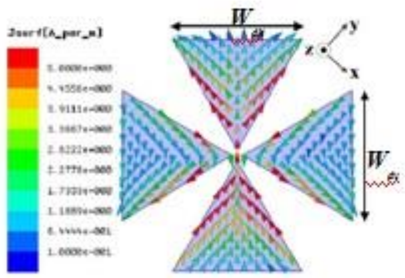


Fig. 5 current distribution of triangular patches

Fig. 5 depicts the current distribution of the four triangular patches at 2.3GHz when port 1 is excited. It can be clearly observed that the current flows along the -45^{o} direction conformably. Current on the two triangular patches in the $+45^{o}$ direction is coupled by the patches in the -45^{o}direction. It can de supposed that the coupled dipole in $+45^{o}$direction introduce the extra resonant frequency.

The VSWRs versus different width W_{dv} of the triangular patch in the $+45^{o}$direction while the width W_{dh} of the triangular patch in the -45^{o}direction remains unchanged.

It is observed that the simulated port isolation is better than 39 dB over the entire operating frequency band from 1.7 GHz to 2.9 GHz, while the measured result is higher than 35dB. Dual-polarized antenna in IMT-Advanced system is required for high isolation. However, high isolation usually can`t cover such a wide bandwidth. To overcome this problem in existing antenna , two baluns are placed orthogonally and symmetry axes of their feed points are overlapped.

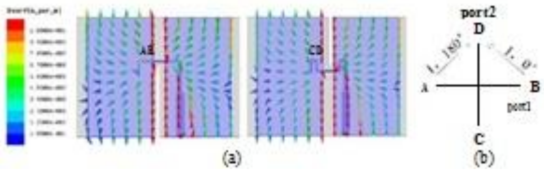


Fig 6. (a)Current distribution of rectangular patches. (b). topology of the four feed points

In Fig 6 (a) depicts the current distribution of two pairs of rectangular patches at 2.3GHz when port 1 and port 2 are excited, respectively. It is observed that currents with the same amplitude and anti-phase are coupled around the two sides of the slot lines by the two feed points. This is caused by the baluns which transform unbalanced mode to balanced mode. To be clearer, A, B, C, and D are marked symmetrically near the slot line

Fig 6 (b) Currents on the four points have the same amplitude (normalized to 1), while the phases on A and C delay 180 ^{o}to B and D. Thus, the coupling between the two ports can be approximately equal to the coupling between B and D.

It is observed from Fig.6 (b) that the coupling from B to D can be cancelled by the coupling from A to D when port 1 is excited. Thus the isolation between B and D is improved, in other words, the port isolation is enhanced. It has the same mechanism when port 2 is excited. I

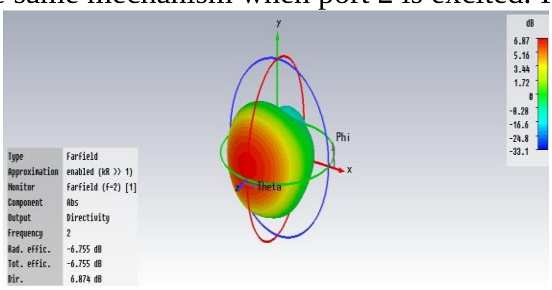


Fig 7.dipole antenna radiation pattern

Fig. 7 shows the measured radiation patterns in both of E-and H-planes at 1.7, 2.3, and 2.9 GHz for port 1 (-45º-pol). Due to the symmetry of the antenna, there is only a slight difference in the radiation patterns for both ports, thus only the results for port 1 are shown. The cross-polarization levels within the main lobe in both E- and H-plane are less than -18dB. The front-to-back ratios remain over 15dB and changes slightly against the frequency. In addition, the 3dB beam width is stable in the E-plane over the operating frequency band but increases slightly at high frequency in the H-plane.

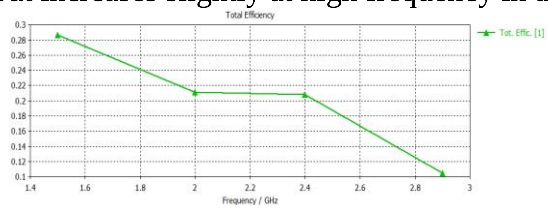


Fig. 8 Gain and efficiency of dipole antenna

The gain and efficiency of the proposed antenna is shown in Fig. 8. The gains for the two ports range from 7dBi to 8.6dBi within the operating frequency band. The increased 3dB beam width at higher frequencies causes a little reduction in gain. The radiation efficiencies are stably around 80% across the operating frequency band.

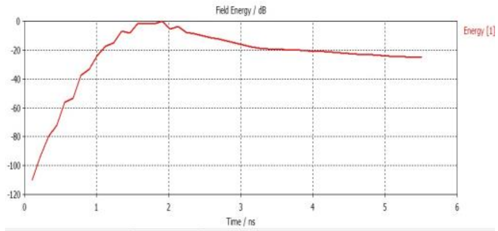


Fig.9

V. CONCLUSION

A dual polarized printed dipole antenna is designed and compared with the conventional printed dipole antenna. Based on the dual polarized dipole antenna a backplane is added and the gain is verified by experimentally. Thus the proposed dipole antenna has the advantages of high gain with 8.4db and good radiation performance. Also the proposed dual-polarized printed dipole antenna achieves an isolation better than 35dB within an impedance bandwidth of 52% (VSWR<1.5). The dipole antenna is suitable for next generation IMT-Advanced wideband base station applications covering GSM1800, CDMA1900, TD-SCDMA and LTE.The proposed dipole antenna is suitable as an array element and can be used for wideband base station antennas in the next generation IMT-Advanced communications.

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