Miniaturized Wideband and Directional antenna for 4G Base Station Application

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A miniaturized wideband and directional antenna is proposed for 4G base station applications. To improve the front-to-back ratio, and miniaturization of the proposed antenna, a metal cavity reflector is designed. One cross-shaped and four rectangular slots are etched at the center and edge of the radiating patch respectively to improve the isolation. The coupling feeding is achieved by Y-shaped stubs printed on the top of the substrate. Moreover, the prototype of the antenna was fabricated and tested. The measured results show that the antenna achieves a bandwidths ($|S_{11}|$<-10 dB) of 50.4% from 1.63 GHz to 2.73 GHz. And an average isolation and front-to-back ratio (FBR) between the two ports is about 30 dB and 20 dB whereas the cross polarization level maintains lower than -12 dB across the entire operating band. The half-power beam width (HPBW) of around 79±3° and average gain of 8.0±1.0 dBi during the operating band are also obtained. Due to the metal cavity, compared with other antennas of the same type, the proposed antenna has a smaller size. The antenna has a wide bandwidth, high isolation, stable radiation patterns, ideal FBR and smaller size, so it is suitable for 4G base station applications.

Introduction: For the past years, different mobile communication systems were designated with different frequency bands. And the dense environment in urban areas determines that the base station antenna must have excellent radiation performance. As we all know, the half wave dipoles [1-2] have been widely used in the design of base station antennas to achieve broadband characteristic. To obtain the excellent port isolation of the antenna, the feeding technologies have been studied by many researchers. It includes Y-shaped feed, differential feed, and balun feed, etc. Especially in differential feed technology [3-4], the isolation of the antennas can achieve even more than 40 dB. Moreover, in order to achieve ideal half-power beamwidth (HPBW) [5], high gain [6-7] and front-to-back ratio (FBR) [8-9], the metal cavity structures are widely studied. However, the large size of the above antennas is not conducive to the placement of the urban base stations in limited space, so, miniaturization of the base station antenna is necessary.

In this letter, we present a miniaturized wideband antenna for 4G base station applications. A metal cavity is used to improve the front-to-back ratio, impedance matching and miniaturization of the proposed antenna. Measurement shows that the broad impedance bandwidth is achieved with less than -10dB from 1.63 GHz to 2.73 GHz, which can cover the 4G system frequency bands, i.e., 1710-1920MHz, 1880-2170MHz, 2300-2400MHz and 2570-2690MHz. High port isolation, high gain, and stable radiation patterns are also obtained.

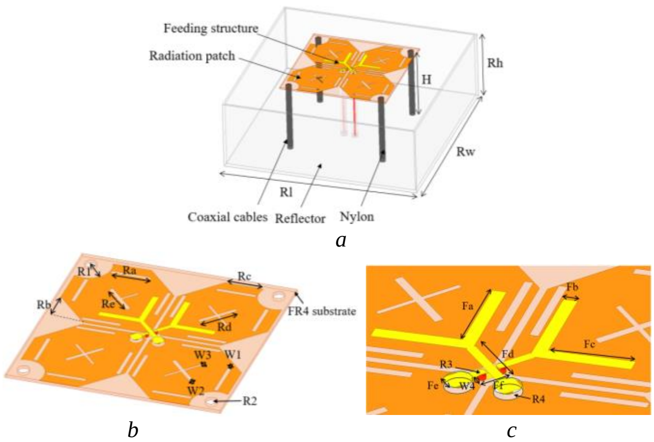

Fig. 1 *Configuration of the proposed antenna: (a) overall diagram of the antenna and reflector; (b) the main radiator; (c) the feed structures; R_l=100, R_w=100, R_h=35, R_1=5.5, R_a=10, R_b=8.5, R_c=9.8, R_d=10, R_e=R_d=10, W_1=1.2, W_2=1.2, W_3=0.8, F_a=F_c=9.9, F_b=1.6, F_d=7.7, F_e=2.5, F_f=3.5, W_4=1.1, R_2=1.5, R_3=0.5, R_4=1.6, H=30(Units: mm).*

Antenna construction and analysis: Fig. 1 shows the configuration of the simple miniaturized antenna, which consists of a main radiator, two transformed Y-shaped stubs, four Nylon pillars, and a metal cavity reflector. The two Y-shaped microstrip stubs are printed on the top of the FR-4 substrate ($\varepsilon_r = 4.4$, $\tan_\delta = 0.02$) with thickness is 0.8mm. By using this formation, good impedance matching and stable radiation patterns with ideal beam can be easily achieved. And four rectangular slots are etched at the edge of each radiation patch, while a cross-shaped slot is etched in the middle to enhance the isolation between ports. The feeding structure is consisted of two transformed Y-shaped stubs (Y-shaped A and B) are printed on the top of the FR4 substrate and are perpendicularly placed. The antenna is fed by a 50ohm coaxial cable whose inner conductor is connected to the transformed Y-shaped feeding lines that printed on the top side of the substrate and the outer conductor is connected to the arrow headed patch of the main radiator. Besides, a metal stub is printed on the bottom of the substrate, and then connected to two shorting pins to keep electrically connection for one of Y-shaped feeding lines, i.e., the Y-shaped. Note that the shorting pins have no effect on the performance of the proposed antenna. A metal cavity is designed to achieve the desired FBR and HPBW without increasing the size of the proposed antenna. And the antenna is designed above the metal cavity. The overall size of the proposed miniaturized antenna is 100mm×100mm×35mm.

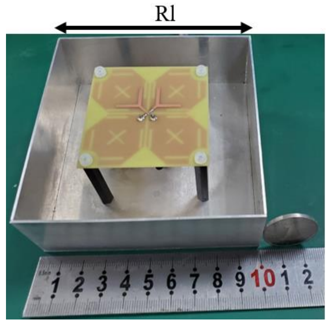

Fig. 2 *The photograph of the dual-polarized antenna.*

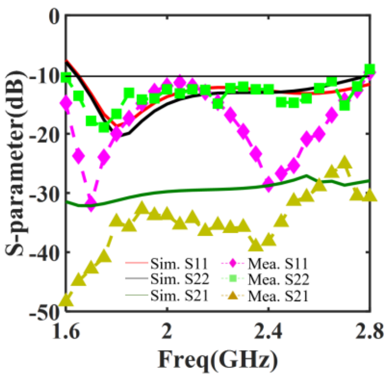

Fig. 3 *The simulated and measured S-parameter.*

Simulated and measured results: Fig. 2 shows the prototype of the proposed miniaturized antenna. The simulated and measured S-parameter and radiation patterns results are depicted in Fig. 3 and Fig. 4. Measurements and numerical results consistent with each other. Measurement report that $|S_{11}|$ / $|S_{22}|$ <-10 dB impendence BWs are 1.63~2.73 GHz (49.3%) and 1.66~2.73 GHz (48.7%) respectively. The measured average isolation and FBR are higher than 32 dB and 20 dB, while the simulated are 30 dB and 22 dB during the whole band. And the disparity between the simulated and measured mainly by process manufacturing and measurement error or environment. Fig. 4 shows the measured and simulated radiation patterns of the proposed antenna at 1.7, 2.2, and 2.7 GHz, respectively. We can see that the simulated and measured results are in good agreement. The measured HPBW is 58.1° to 72.6° in E-plane, and varies from 76.8° to 85.5° in H-plane in operating band. The cross-polarization level of the proposed antenna is

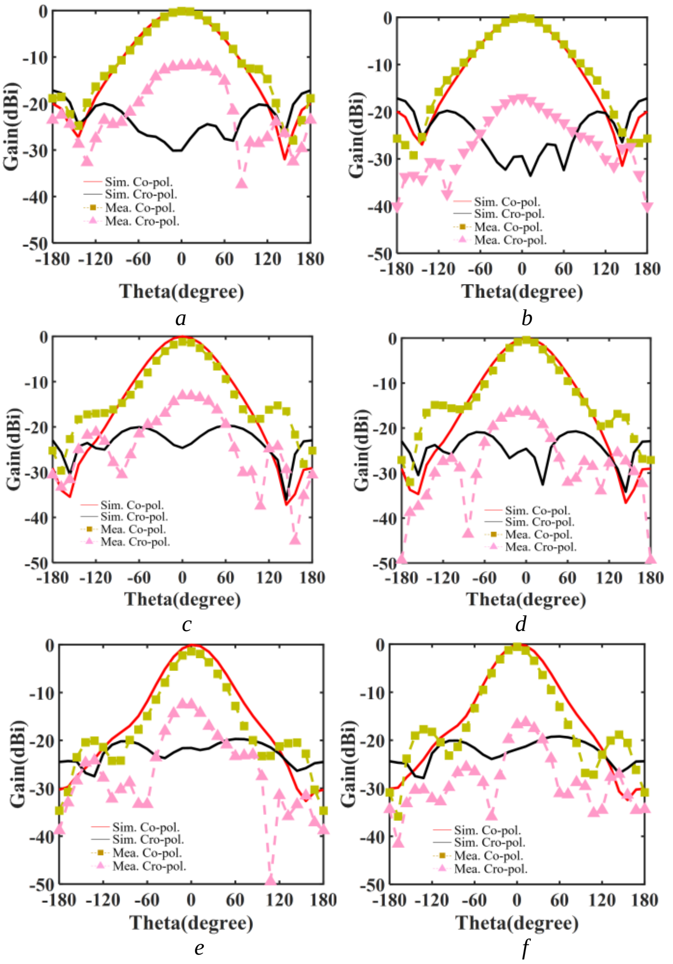

Fig. 4 *Simulated and measured the radiation patterns. For the +45 ° polarized port in xz-plane at (b)1.7 GHz, (d) 2.2 GHz and (f) 2.7 GHz; for the -45 °polarized port in yz-plane at (a)1.7 GHz, (c) 2.2 GHz and (e) 2.7 GHz.*

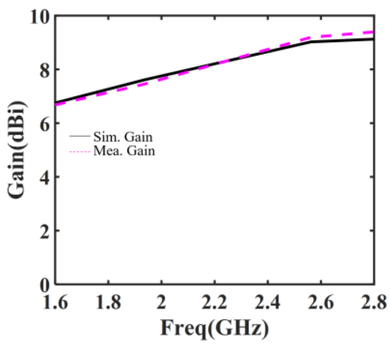

Fig. 5. *The simulated and measured gain of the proposed antenna*.

Table 1: Comparison of dual-polarized base station antennas

Ref.	Bandwidth (GHz)	$\|S_{11}\|$ (dB)	Avg. isolation (dB)	Gain (dBi)	Size (mm³)
[3]	1.7~2.7	-15	30	8.5	134×200×36
[7]	1.6~2.3& 3.4~3.7	-10	20	10.5, 5.8	120×120×24
[9]	1.7~2.75	-15	45	9	160×160×40
[12]	1.7~2.7& 3.3~3.6	-10	28	9, 8.2	160×160×41.8
[14]	1.7~3.22	-10	29	5.8	106×106×39
This work	1.63~2.73	-10	32	8.4	100×100×35

below -15 dB. The measured result of gain is displayed in Fig. 5.The gain is about 8.4 ± 0.9 dBi in the whole band. The comparison of the proposed antenna with some existing works are plotted in Table I.

Conclusion: This letter presents a simple miniaturized directional antenna for 4G base station applications. A metal cavity is used to improve the front-to-back ratio, impedance matching and miniaturization of the proposed antenna. The samller size of the antenna is 100×100×35mm3. The proposed antenna achieves a bandwidth of 50.4% (1.63~2.73 GHz) for $|S_{11}|$ <-10 dB and average isolation of the two ports are better than 32 dB. The measured average gain and FBR is about 8.4 dBi and 20 dB in the operating band. And the HPBW is 58° to 85° . The measured average cross polarization level is below -15 dB. The proposed antenna has dual-polarized operating, high isolation, compact size, stable radiation pattern. Therefore, it can be a good candidate for 4G base station applications.

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