A Broadband Dual-Polarization Base Station Antenna Element with a Coupling Feed

Yuan He
College of Information Engineering
Shenzhen University
Shenzhen, Guangdong, China
heyuan0022@126.com

Yejun He*
College of Information Engineering)
Shenzhen University
Shenzhen, Guangdong, China
heyejun@126.com

Manos M. Tentzeris
School of Electrical and Computer Engineering
Georgia Institute of Technology
Atlanta, Georgia, USA
etentze@ece.gatech.edu

***Abstract*—This paper presents a broadband, dual-polarized base station antenna element by reasonably designing two orthogonal symmetrical dipole, four loading cylinders, balun, feed patches, specific shape reflector and plastic fasteners. Coupling feed is adopted to avoid the direct connection between the feed cables and the dipoles. The antenna element matches well in the frequency range of 1.7-2.7 GHz and the return loss (RL) S_{11}<-15 dB and the isolation S_{21}< -30 dB. Low cross-polarization, high front-back ratio (>25dB) and stable half-power beam width (HPBW) with 65±5° are also achieved. The proposed antenna element covers the whole long term evolution (LTE) band and is backward compatible with 3G and 2G bands.**

I. Introduction

With the growing development of base antennas technologies, base station antennas increasingly become low-profile. Although there are some literatures on the broadband antenna and dual-polarized antenna, but the tradeoff between the circuit parameters and radiation parameters is difficult to obtain. Many attractive methods such as parasitic patch and aperture-coupled feed[1-2], L-shaped probe feed [3-4], meandering line feed [5] have been used to partially overcome some disadvantages such as narrow band, bad isolation. These methods still do not reach the requirements of broadband base station antenna. Further more, base station antennas with low profile and simple micro-strip structure become complicated. Some improved electromagnetic dipole antennas are presented in [6-7], but the voltage standing wave ratio (VSWR <2) does not meet the requirements of base station antennas and also has many shortcomings such as large weight, complex assemblies and so on. Although some antennas can achieve dual-polarized characteristic during frequency range from 1.7 to 2.7 GHz, they directly used coaxial feed, and separation between the support structures and cross-dipoles and wide HPBW bring inconvenience in founding and third order intermodulation when forming a large antenna array.

II. Antenna Geometry

The structure of the antenna element is shown in Fig. 1. Fig. 2 shows the proposed element simulation model and prototype placed on the reflector. Fig. 3 plots the couple patches. Some key parameters are given in Table I. The proposed antenna element uses a square hollow cross dipole which can fully broaden its size. Square ring size is 24 mm×24 mm, and

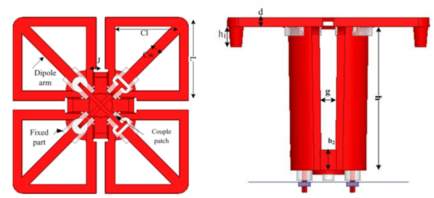

Fig. 1. The proposed antenna element: the left is top view, and the right is side view.

two symmetrical dipoles are placed orthogonally with 45° slant to produce dual-polarization character. For the reason that one dipole arm acts as the parasitic dipole of the other one,the bandwidth can broaden significantly. The design of semi-open balun with height of h=38 mm (about $\lambda/4$)and opening gap width of g=3.6 mm can produce magnetic flow between rectangular slit of the balun when the antenna works. This design improves the isolation characteristics and beam convergence. Four small terminal loading cylinders can adjust the VSWR and the frequency range of the element. More importantly, the radiation body will produce a small part of current component in the vertical orientation to strengthen the two sides polarization and then enhance cross-polarization ratio.

The radiation body is fed by the double inverted Γ-shaped coupler patches which are fixed in the center of the balun as shown in Fig. 3. One patch is lower than the other patch by Hg=3 mm in the middle part to avoid mutual interference. The first vertical portion metal patches are connected to the feed cable and transmit current from the coaxial feed line to the second part of the patches, namely the horizontal portion. Horizontal section of the metal patches feed the cross dipole by coupling and adjusting the input impedance of the antenna. The third of the feed patches acts as open circuit transition line. By appropriate adjusting the length and the width of open circuit transmission line, the effect of capacity achieved can balance out inductive effect caused by the level transition line and finally ensure the antenna element impedance matching.

A reflector with improved two side walls and a bottom size of 240 mm × 126 mm are employed. A hole is drilled on the middle of the plate to fix the dipole and allow the feed

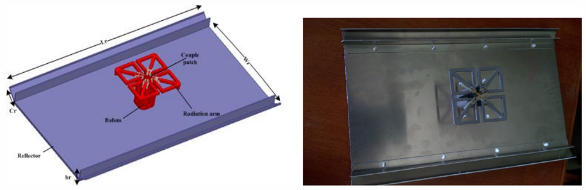

Fig. 2. Simulation model and prototype of the proposed antenna element with reflector

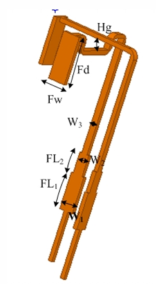

Fig. 3. Design of the coupled patches

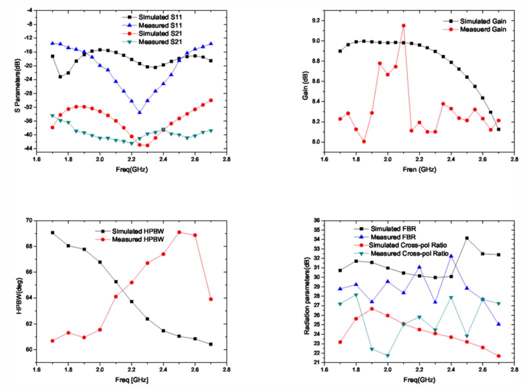

Fig. 4. S parameters, Gain, HPBW, FBR and cross-polarization ratio

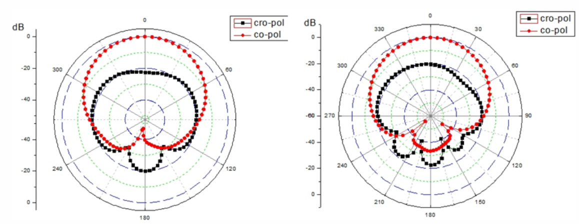

Fig. 5. Antenna element radiation pattern: the left is 1.7GHz, the right is 2.7GHz

patches go through. By elaborately designing the parameters of the reflector, a good front back ratio and stable HPBW can be received.

III. Simulation and Measurement Results

The antenna element is modeled and simulated in HFSS14. Figure 4 shows S_{11} between 1.7 GHz-2.7 GHz is less than -15 dB and isolation S_{21} is less than -30 dB, and the measured S_{11} results in some points below -12 dB near 1.7 GHz and 2.7 GHZ. This may results from the connecting devices and the measuering environments. The gain is above 8 dBi in the entire wideband. Due to the symmetry of the two feed ports, only one port's main polarization and cross-polar polarizations are presented. The HPBW stabilizes in the range from 60.42° to 69.06° (65±5°). The cross-polarized ratio is greater than 20 dB and the front-back ratio is above 25 dB. Figure 5 presents the E plane symmetrical radiation patterns of the antenna element in two frequencies.

IV. Conclusions

In this paper, a broadband dual-polarized base station antenna element is designed. By using the cross dipole and couple feed, the antenna element achieves a bandwidth of 45% (1.7-2.7 GHz) with S_{11}<-15 dB and S_{21}<-30 dB. High gain (more than 8 dBi), symmetrical pattern, high front-back ratio (>25dB), stable beamwidth (65±5°) and cross-polarization ratio (>20 dB)have met the base station antenna standards. Integrated metal casting for the antenna element makes the manufacturing process simple when forming large antenna arrays. The proposed antenna element is being applied in practical base station antennas.

TABLE I
Important parameters value(unit:mm)

Parameters	L	d	Fd	Fw	Cl	W_3
Values	24	2.5	9	3.5	18.5	0.8
Parameters	Hg	h	h_2	J	g	L_c
Values	3	38	5	0.3	3.6	6
Parameters	Lr	Wr	FL_1	W_1	FL_2	L_d
Values	240	126	7	2.8	4	20
Parameters	W_2	hr	Cr	h_1	C_W	
Values	1.5	12	15	5	3	

Acknowledgement

The work was partially supported by the National Natural Science Foundation of China under Grants No. 61372077 and No. 60972037.

References

[1] S. Gao, L. W. Li, M. S. Leong, and T. S. Yeo,“ A broad-band dual-polarized microstrip patch antenna with aperture coupling, ” *IEEE Trans.Antennas Propag.,* vol. 51, no. 4, pp. 898-900, Apr. 2003.
[2] Steven (Shichang) Gao,and Alistair Sambell,“Dual-polarized broad-band microstrip antennas fed by proximity coupling, ” *IEEE Trans. Antennas Propag.,*vol. 53, no. 1, pp. 526-530, Jan. 2005.
[3] T.-W. Chiou and K.-L. Wong, “Broad-band dual-polarized single microstrip patch antenna with high isolation and low cross polarization, *IEEE Trans. Antennas Propag.,* vol. 50, no. 3, pp. 399-401, Mar. 2002.
[4] H. Wong, K. L. Lau, and K. M. Luk,“Design of dual-polarized L-Probe patch antenna arrays with high isolation, *IEEE Trans.Antennas Propag.,* vol. 52, no. 1, pp. 45-52, Jan. 2004.
[5] H.-W. Lai and K.-M. Luk,“Dual polarized patch antenna fed by meandering probes, *IEEE Trans. Antennas Propag.,* vol. 55, no. 9, pp. 2625-2627, Sep. 2007.
[6] Bi Qun Wu and Kwai-Man Luk, “A broadband dual-polarized magneto-electric dipole antenna with simple feeds,” *IEEE Antennas Wireless Propag. Lett.,* vol. 8, pp. 60-63, 2009.
[7] Wen Xing An, Hang Wong, Ka Leung Lau, Shu Fang Li, and Quan Xue,“Design of broadband dual-band dipole for base station antenna ,” *IEEE Trans. Antennas Propag.,* vol. 60, no. 3, pp. 1592-1595, Mar 2012.