A WIMAX CONFORMAL BROADBEAM ANTENNA

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Abstract: The numerical model of a very simple conformal antenna, prepared to work in the 3.4–3.6 GHz WiMAX range, is presented. The pattern radiated by the proposed antenna, displays high gain and excellent linear polarization within the broad coverage zone.

INTRODUCTION

It is well known that today's communications technology is pointing towards the ubiquity of Internet connections, with clear attention to wireless broadband services. In this respect, WiMAX (Worldwide Interoperability for Microwave Access) standards [1] seem to be marking the trends for near–future wireless systems. In a broad sense, WiMAX is intended to obtain the same worldwide distribution for Internet as that reached for current mobile phone communications. Consequently, the research, and manufacturing, of both indoor and outdoor transmission equipments and devices fulfilling the requirements of that standard have increased since the idea took place in the technical and industrial community.

On the other hand, in the community of antennas designers, lately there has been an increasing interest on electromagnetically coupled patches (ECPs), in view of the fact that, among other things, they reach very good absolute gain values, and show broad $|S_{11}|$ vs. frequency bandwidths [2]. This latter feature unleashed intensifying the research on ECPs antennas, which suddenly became particularly suitable for LAN [3], Bluetooth [4], WiMAX [5], or any other related technology for which data streaming is of interest. Unfortunately most of the ECPs models presented in the technical literature have linear polarization along the angle measured from the normal of their planes, a feature that could reduce the polarization efficiency, since the electromagnetic signals of several transmitting and receiving antennas of that kind are difficult to align among themselves.

In this work, the numerical model of a novel conformal antenna composed of three electromagnetically coupled patches and prepared for working at the 3.4–3.6 GHz WiMAX frequency range [1] is presented. Such a model exhibits good performances concerning: maximum gain, beamwidth –covering a broad horizontal zone–, and $|S_{11}|$ vs. frequency curve. Its radiated field has vertical linear polarization, a convenient way of enhancing the efficiency of the radiation transmission (see comments above). As it will be seen, the antenna features (smallness, connection easiness, good coverage zone) make it suitable for being adaptable to whether indoors or outdoors communication devices.

ANTENNA CONFIGURATION

An FDTD (Finite Difference Time Domain) simulation software [6] is used for designing the antenna model, composed of three rectangular patches RP of length l_{RP}, width w_{RP}; see Fig. 1 in which is also indicated the distance d_{RP} between edges of contiguous elements. These RPs are electromagnetically coupled to their corresponding striplines SL of length l_{SL} and a width w_{SL}, being such SLs joined together through a common stripline of width w_{JSL}, and feed by a single pin P (1 mm of diameter) extended from the connector. The antenna is conformed over a trigonal hemi–cylinder ground plane made up of rectangular plates GRs, being the lateral ones positioned at an angle α_{GR} with respect to the central one. As it can be seen, both the RPs and SLs are parallel to their corresponding GRs. The whole model is considered to have as dielectric substrate a material (not shown for simplicity) with characteristics similar to those of the air (ε_r=1), as Foam, for example. All the remaining dimensions needed for describing the complete model can be obtained directly, or deduced, from Fig. 1.

During the design procedure (not described here for the sake of brevity) the following requirements are specified:

a) The $|S_{11}|$ vs. frequency curve is required to be, as usual, below –10 dBs for a range between f_L and f_H (lower and higher frequencies), and that range must include, at least, the 3.4–3.6 GHz band. The $|S_{11}|$ bandwidth is calculated as:

$$BW_{\%} = 100\left[\left(f_H - f_L\right)/f_C\right]; \text{ with } f_C = \left(f_H + f_L\right)/2. \qquad (1)$$

b) Maximize the minimum coverage angle $\Delta\varphi_{\min}$ on the θ=90º plane, see Fig. 1, within which the gain is above 4 dBi.

c) Make the minimum axial ratio $\rho_{\min}=20\log_{10}\{|\mathbf{E}_z|/|\mathbf{E}_y|\}_{\min}$ to be as large as possible within both the coverage zone and the frequency band f_H–f_L, thus guaranteeing a good linear polarization along the z axis, see Fig. 1.

The antenna model that best suites the requirements is described below.

RESULTS

Table 1 shows the values of the geometrical parameters obtained for the model that best fits the requirements given in previous section. The table also lists the design parameters.

The antenna is capable of radiating with good performance over the whole 3.4-3.6 GHz bandwidth. The $|S_{11}|$ curve, given in Fig. 2, shows the required tuning at f_C=3.5 GHz. Fig. 3 shows the horizontal pattern absolute gain ($|\mathbf{E}_z|$ component) at f_L, f_C and f_H, revealing a stable radiation (low ripple) all over the coverage zone. The maximum gain $G_{\max}$=6.95 dBi is reached at f_L. The minimum coverage zone $\Delta\varphi_{\min}$=135º (i.e. from φ=–67.5º to φ=67.5º the absolute gain is above 4 dBi) is also obtained at f_L. The vertical polarization is guaranteed by an axial ratio $\rho_{\min}$ equal to 20.30 dB obtained at f_H. Figure 4 shows vertical cuts (φ=90º, $0\leq\theta<360$º), obtained at extreme and central frequencies. As it can be seen, the pattern is very stable within the frequency band. The vertical coverage zone is of about 51º at all the three analysed frequencies.

CONCLUSIONS

This letter has presented a conformal antenna that works with good performance over the 3.4–3.6 GHz WiMAX range. Its main features are: large axial ratio for vertical polarization, maximum gain over 6.95 dBi and broad radiating coverage zone, this latter being a characteristic that makes it especially suitable for indoor or short range outdoor applications. Two additional advantages are that the model is small and has a relatively simple geometry, therefore being easy to construct.

ACKNOWLEDGEMENT

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REFERENCES

[1] The IEEE 802.16 Working Group on Broadband Wireless Access Standards, “Developing the IEEE 802.16 WirelessMAN® Standard for Wireless Metropolitan Area Networks,” available on the Internet at http://www.ieee802.org/16/

[2] J. C. Brégains, G. Franceschetti, A. G. Roederer, and F. Ares, “New Toroidal Beam Antennas for WLAN Communications,” *IEEE Trans. Antennas Propag.*, **55**, 2007, pp. 389-398.

[3] Y. J. Guo, A. Paez, R. A. Sadeghzadeh, and S. K. Barton, “A Circular Patch Antenna for Radio LAN's,” *IEEE Trans. Antennas Propag.*, **45**, 1999, pp. 177-178.

[4] J. S. Roy, and M. Thomas, “Investigations on a New Proximity Coupled Dual-Frequency Microstrip Antenna for Wireless Communication,” *Microwave Review*, **13**, 2007, 12-15.

[5] X. N. Low, W. K. Toh, and Z. N. Chen, “Broadband Suspended Plate Antenna for WiFi/WiMAX Applications”, *6th International Conference on Information, Communications & Signal Processing*, 2007, pp. 1-5.

[6] Schmid & Partner Engineering AG, “SEMCAD X. Reference Guide”, SPEAG, 2007. More information at www.semcad.com.

FIGURES AND TABLE CAPTIONS:

Fig. 1. Top: Front, left side, bottom views and small perspective of the geometry of the proposed conformal antenna, and its relevant dimensions.

Fig. 2. $|S_{11}|$ (in dBs) vs. frequency curve of the model.

Fig. 3. Gain of $|\mathbf{E}_z|$ field at central f_C and edge f_L, f_H frequencies over the θ=90º cut, see Fig.1.

Fig. 4. Gain of $|\mathbf{E}_z|$ field at central f_C and edge f_L, f_H frequencies over the φ=0º (vertical) cut, see Fig.1.

Table 1. Parameters of the obtained numerical model (see text and Fig. 1 to specify the meaning of the symbols).

Figure 1

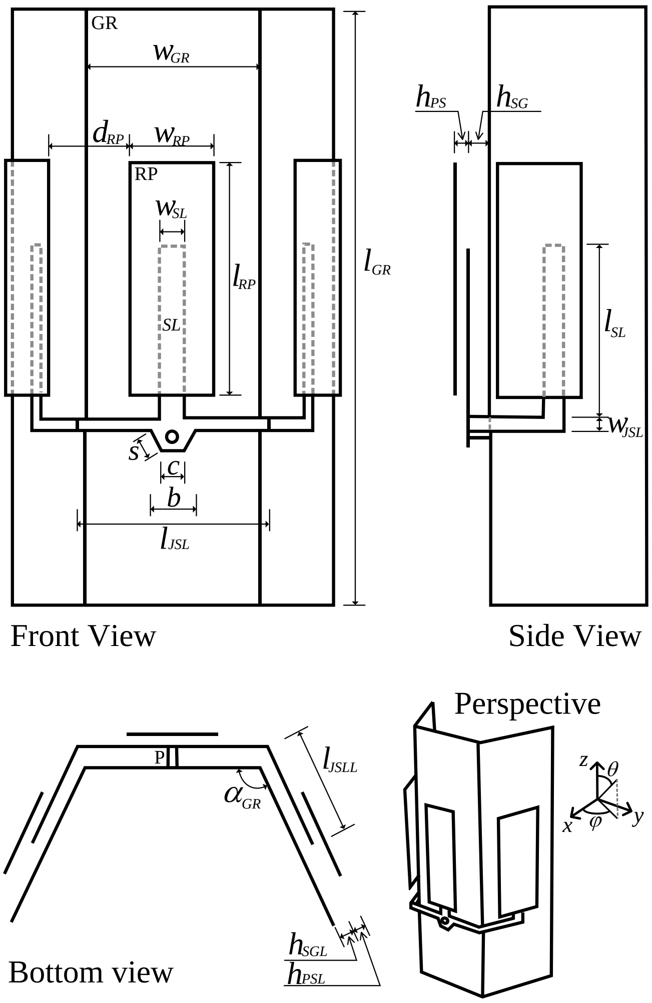

Figure 2

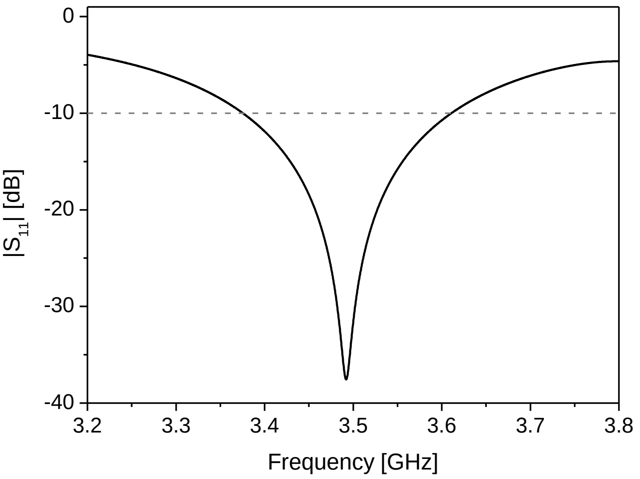

Figure 3

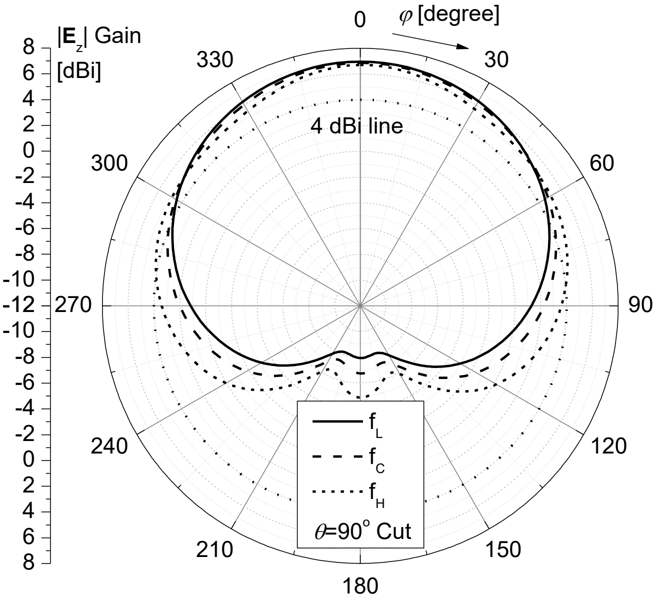

Figure 4

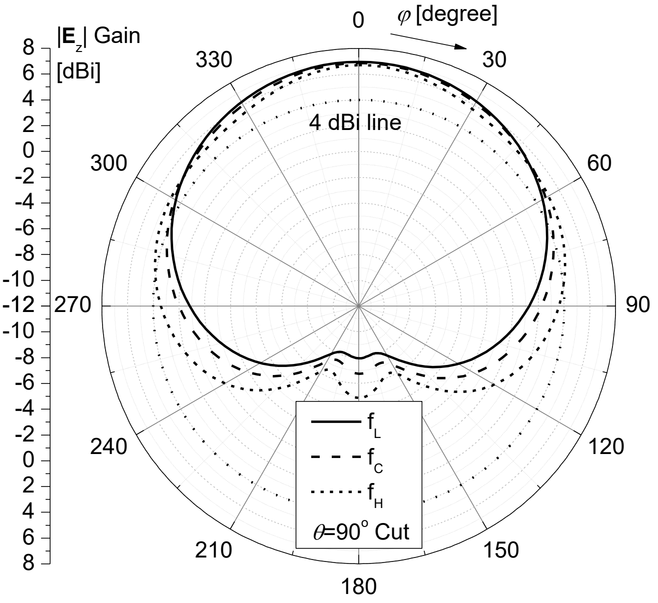

Table 1

w_{GR}	l_{GR}	α_{GR}	w_{RP}	l_{RP}	d_{RP}	w_{SL}	l_{SL}
[mm]							
25.00	85.70	60.00	15.00	30.75	10.85	4.20	22.75
w_{JSL}	l_{JSL}	l_{JSLL}	s	c	b	h_{PS}	h_{SG}
[mm]							
1.85	27.25	15.70	3.20	3.20	6.40	3.00	3.00
h_{PSL}	h_{SGL}	f_L	f_C	f_H	$BW_{\%}$	$G_{\max}$	$\rho_{\min}$
[mm]		[GHz]				[dBi]	[dB]
2.47	2.30	3.38	3.50	3.61	6.58	6.95	20.30