Int. J. Electron. Commun. (AEÜ) 69 (2015) 1880–1884

Contents lists available at ScienceDirect

International Journal of Electronics and Communications (AEÜ)

journal homepage: www.elsevier.com/locate/aeue

New microstrip radiator feeding by electromagnetic coupling for circular polarization

Alicia E. Torres [a], Francisco Marante [a], Antonio Tazón [b,*], Juan Vassal'lo [c]

[a] Department of Telecommunications and Telematics, ISPJAE, Havana, Cuba
[b] Telecommunication Engineering Department, University of Cantabria, Plaza de la Ciencia S/N, 39005 Santander, Spain
[c] Antenna Technology Group, CSIC-ITEFI, Serrano 144, 28006 Madrid, Spain

ARTICLE INFO

Article history:
Received 24 November 2014
Accepted 27 September 2015

Keywords:
Circular polarization
Electromagnetic coupling
Microstrip radiator
Perturbation method
Photoetching antenna

ABSTRACT

We present a novel feeding system for microstrip radiators which is based on electromagnetic coupling. The effects of the antenna's key design parameters have been studied and discussed. This new feeding system was found to be very simple and useful in the design of flat arrays and reflectarrays using microstrip patches. A novel circularly polarized patch radiator fed from only one input line and based on the proposed feeding system is also presented in this paper. The result of the developed prototype in axial ratio bandwidth is double that obtained with a typical microstrip patch fed from two inputs.

1. Introduction

The increasing demands and requirements of emerging communications systems have been a dominant factor in the development of microstrip antennas. Numerous advantages, such as their low profile, light weight, compactness and conformability, together with an easy manufacturing process, have contributed to their success in almost all commercial markets, in both civil and military areas [1,3,4].

Typical feeding techniques used in microstrip antennas can be divided into two groups: contact and non-contact feeding. In the first group, the RF power is transferred directly to the microstrip patch through connective elements such as microstrip lines on the radiating face, or by coaxial cables through the ground plane [1,2]. In contrast, the second group is composed of a proximity couple or an aperture couple between the patch and the feeding line, where the power transfer takes place through electromagnetic coupling [3,5]. As an example, it can be seen that this kind of coupling is usually achieved through a slot aperture in the ground plane, and also in some cases through a capacitor element placed on the radiating face at the contact point of the coaxial feeding line [6], or through an inductor element in the coaxial probe when thicker substrates are used [7].

In order to select a suitable feeding technique, the most important consideration is to study the power transfer efficiency between feeding and radiating structures, which is known as impedance matching. It has been found that some feeding techniques can increase the impedance bandwidth, which is the major limitation of microstrip radiators [5,8] (about 2% in a typical case). Different kinds of proximity or aperture feeding systems are proposed to increase the bandwidth, but practical implementation of many of these structures involves a complex design due to the use of stacked or multilayered configurations [9,10]. Therefore, it should be pointed out that one of the primary advantages of microstrip radiators lies in their simplicity of design and manufacturing.

The coupling to a microstrip patch in a single layer (only on the radiating face) may be achieved by means of a gap between the feeding line and the resonant patch [11]. In [12], a small capacitive feeding is proposed for ultra wide-band operation, but a multilayered configuration is also necessary. Other designs where the coupling takes place continuously along the edge of the patch rather than on a narrow portion of it, using different patch geometries, have also been reported [13]. The advantage of this feed system is the possibility to feed several microstrip radiators from the same distribution line in the case of linear arrays.

Looking for improved feeding configurations, a novel one, based on electromagnetic coupling and amenable to be indistinctly applied to square or circular microstrip patches, is proposed in

* Corresponding author. Tel.: +34 942200889.
E-mail addresses: atorres@electrica.cujae.edu.cu (A.E. Torres), marante@electrica.cujae.edu.cu (F. Marante), antonio.tazon@unican.es (A. Tazón), juan.v.abuelo@gmail.com (J. Vassal'lo).

http://dx.doi.org/10.1016/j.aeue.2015.09.016
1434-8411/

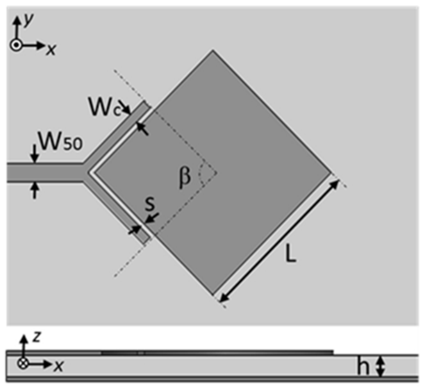

Fig. 1. Geometry of the square microstrip radiator fed by electromagnetic coupling on radiating face.

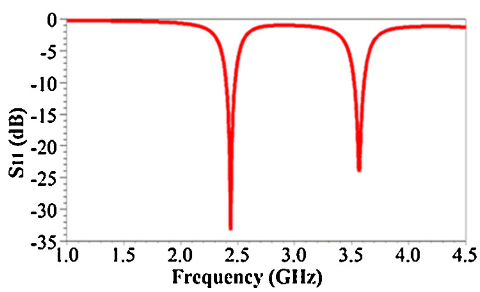

Fig. 2. Return loss of the microstrip radiator of Fig. 1.

this paper. This configuration would allow wide bandwidth performance while keeping the advantages of an easy design and manufacturing due to the use of a single layer. Besides, considering the suitability of the feeding circuitry when the radiator is to be integrated with others in arrays or reflectarrays applications, as well as the added value if a circular polarization (CP) may be also generated, the possibility of exciting two orthogonal modes on the square patch with wider impedance and axial ratio bandwidths, by means of only one feeding input and introducing an adequate asymmetry to our electromagnetic coupling feeding system, is demonstrated. As explained in Section 4, the bandwidth of the axial ratio obtained is about 4% higher than that reported earlier by any researcher.

Table 1
Dimensions of the optimized design for 2.4 GHz.

Parameter	Value
Length of the radiator patch (L)	28.6 mm
Width of the feed strip (Wc)	1.3 mm
Separation of feed strip from the patch (s)	0.2 mm
Angle of the feed (β)	90°
Width of the 50Ω strip (W50)	2.9 mm
Relative dielectric constant (ε_r)	4.2
Thickness of substrate (h)	1.5 mm

2. Basic feeding system configuration

The newly proposed feeding system consists of electromagnetic coupling between the feeding line and a patch, both in microstrip technology, photo-etched on the same substrate surface. The feeding line is ended by two arms with the same length which hug the patch near the edge in a symmetrical manner with a constant capacitive gap.

Fig. 1 shows the feeding system configuration in the case of a square patch where the design parameters can be appreciated; the arm length is referred to a central patch angle parameter (β) to maintain the symmetry of the feeding system. This coupling configuration can also be applied to any patch with a regular polygonal shape, including a circular geometry.

A prototype was designed using a commercial substrate at 2.4 GHz, considering a possible application in the ISM band. The design was carried out using the Ansoft HFSS (V.12) 3-D electromagnetic field software and the values of the optimized dimensions are listed in Table 1.

Fig. 2 shows the return loss of the microstrip radiator, and the two first resonant modes can be seen. The fundamental mode works logically at the design frequency (2.44 GHz), and the 2nd mode works at 3.56 GHz.

In order to give a physical insight allowing the identification of both modes, Fig. 3 shows the E-field distribution in both cases. It is obvious that the first resonance corresponds to the TM_{11} mode of a typical square patch, and also the 2nd resonance to the TM_{22} mode.

Fig. 4 shows two orthogonal cuts of the radiation pattern at both frequency resonances. The E plane corresponds to the phi = 0° cut which corresponds to the horizontal direction in Fig. 1, while the H plane represents the phi = 90° cut corresponding to the vertical direction. As can be seen in Fig. 4, both patterns present a different

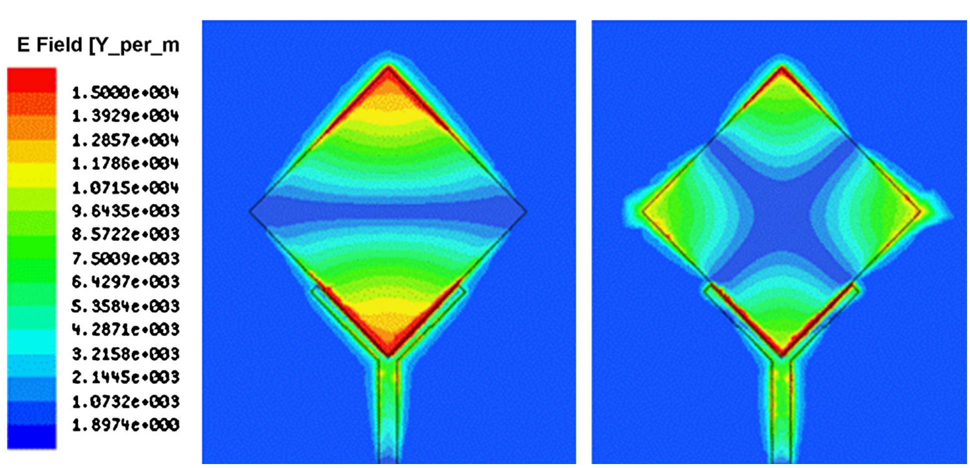

Fig. 3. E field distribution for the radiator in Fig. 2 at (a) 2.44 GHz; and (b) 3.56 GHz.