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APPLICATIONS OF BROADBAND CIRCULARLY POLARIZED MICROSTRIP ANTENNA (CPMA): A COMPREHENSIVE REVIEW

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Abstract

This letter introduces a circularly polarised dual-band patch antenna dedicated to satellite communications. By inserting a small X-band microstrip patch antenna into a big L-band one, the dual-band behaviour is obtained. Both patches are printed on the same substrate and fed into two perpendicular slots etched into their ground planes by electromagnetic coupling. Two separate 90 microstrip branch-line couplers printed on a stacked lower substratum feed these slots. With a 1.5 mm-thick upper layer substrate and a 0.758 mm-thick feed layer substrate, all of the same dielectric material with a relative permittivity of $\in_r$ *= 2 22, a prototype of the antenna was realised. In terms of frequency bandwidth, circular polarisation bandwidth, and separation between the two communication bands, simulation and measurement results are provided, showing that this compact dual-band antenna achieves the necessary Meteosat specifications.*

Keywords: *Circularly Polarized Microstrip Antenna (CPMA), Circular Polarization, Wireless Communication, Slot Antenna.*

I. INTRODUCTION

The circular polarization delivers better connectivity with both fixed and mobile devices. Rapid development in the wireless communication system, low profile and wideband antennas with good radiation performance are in great demand, particularly in space applications such as satellite, aircraft, and radar[1]. The slot antennas are suitable for these application because their tempting characteristics such as low profile, planar geometry, wideband, and easy integration with planar circuits[2].

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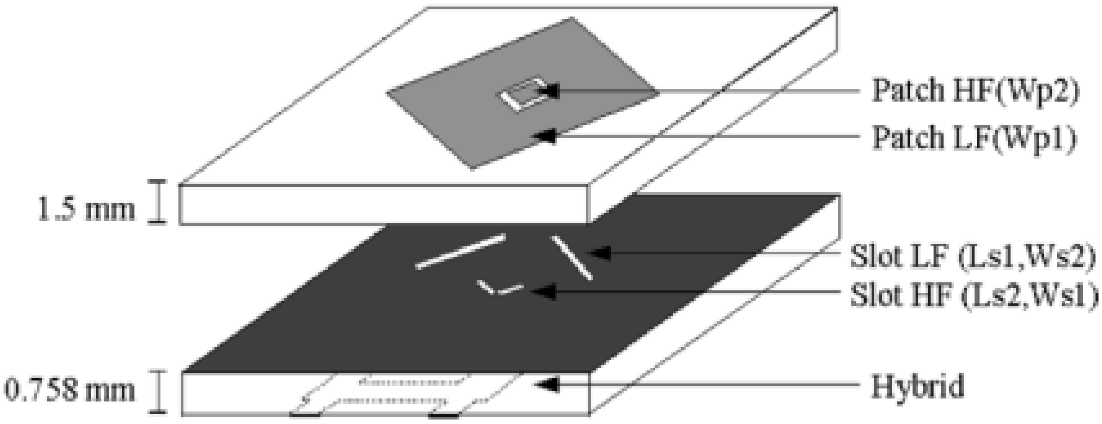

Fig. 1 Illustrates geometry of the CP dual-band antenna. A Multi-layer view of the antenna[3].

Since the electric and magnetic field vectors are always related according to Maxwell's equation, it is enough to specify the polarization of one of them. And commonly it is specified by the electric field. Polarization should be defined in its transmitting mode with reference to IEEE norms. The polarization plane is the plane containing the electric and magnetic field vectors and it is ever perpendicular to the plane of propagation. The contour drawn by the tip of the electric field vector describes the wave polarization[4].

Recent advances in the wireless communication industry continue to derive requirements from lightweight, compatible and inexpensive microstrip patch antennas in today's world of wireless communication. A patch antenna is a narrowband, wide beam antenna produced by etching the pattern of the antenna part in metal trace attached to an insulating dielectric substrate such as a printed circuit board with a continuous metal layer attached to the opposite side of the ground plane shaping substrate[5]

.

The width W of the microstrip patch antenna is calculated by using the following equation.

$$w = \frac{c}{2\, f_r \sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Where

f_r denotes the resonant frequency, and

r represents substrate dielectric constant

The effective dielectric constant (ε_{reff}) of antenna is derived by applying the given equations[6].

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\sqrt{\left(1 + 12\frac{h}{W}\right)}$$

Where h denotes the height of the antenna and W denotes the width.

The length of the antenna may be measured by applying the following equation.

$$L = \frac{c}{2\, f_r\, \sqrt{\varepsilon_{reff}}}$$

The antenna length extension is calculated by applying the equation below.

$$\Delta L = 0.412\, h\, \frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.246\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)}$$

Here W represents the width and h denotes the height.

The real length (L_{eff}) of the antenna can be calculated by using the following formula.

$$L_{eff} = L + 2\Delta L$$

II. LITERATURE REVIEW

The literature survey revealed that Deschamps first suggested the notion of the Microstrip radiator in 1953. A patent was given on behalf of Gutton and Baissinot in France in 1955. Production was accelerated by the availability of good substrates during the 1970s. Howell and Munson created the first practical antenna. Extensive research and development on Microstrip antennas has since been aimed at maximising their benefits.

Kumar et al. conducted a research on circularly polarized microstrip patch antenna. For mobile communication and GPS applications, a triple-frequency single-feed S-shaped circularly polarised microstrip antenna with a limited frequency ratio has been proposed. In the centre of a square patch of 84.5 to 84.5 mm2 for multi-band service, an S-shaped slot is removed. The proposed antenna geometry consists of a single microstrip line with an aperture-coupled feeding structure. The results of the simulation show that the proposed antenna can be used with an efficient return loss of -34.34 dB, -18.23 dB and -24.75 dB at 1.193 GHz, 1.454 GHz and 1.615 GHz respectively for multi-band service[7].

III. DISCUSSION AND CONCLUSION

Circular polarization (CP) has been extensively used in satellite communications. In scientific papers, many different solutions are reported to generate CP. Degenerated mode patch antennas are usually very compact structures due to their simple feed but they exhibit very limited bandwidths [1]. Antenna arrays with sequentially rotated patches have a very good axial ratio over a large frequency bandwidth in their broadside direction, at the expense of a large antenna size, poor copular gain and high cross-polarization lobes in the diagonal planes. For Meteosat's satellite L and X communication bands, a compact CP dual-band antenna has been successfully developed. By inserting a small patch into a wide one, the dual band antenna was obtained. Using two hybrid branch-line couplers on a lower substrate, reasonable coverage of the two frequency bandwidths was achieved. The calculated performances are as good as those obtained by a branch-line coupler fed with equivalent CP single-band antennas. Since two CP frequency bands are protected with the same antenna volume usually used for CP single band service, the proposed solution is a reasonable trade-off between size and output.

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