International Journal of Electronics Engineering (ISSN: 0973-7383)
Volume 10 • Issue 2 pp. 940-943 June - Dec 2018 www.csjournals.com

Dual frequency and dual polarised compact microstrip patch antennas

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Abstract: Dual-frequency patch antennas may provide an alternative to large-bandwidth planar antennas, in applications in which large bandwidth is really needed for operating at two separate transmit-receive bands. When the two operating frequencies are far apart, a dual-frequency patch structure can be conceived to avoid the use of separate antennas. In this paper, a critical overview of possible solutions for dual-frequency patch antennas is presented. In this contribution a dual-band, dual-polarized microstrip antenna is presented. The antenna is designed for ground-based Ka-band satellite communications.. The dual-frequency characteristics allow to integrate transmitter and receiver terminals operating at different frequencies, which, in turn, reduces the overall size. The antenna features two distinct polarization ports suitable for dual circular polarization.

Key words: microstrip antenna, dual polarized.

Introduction

Dual-frequency operation is an important subject in microstrip antenna design and many such designs are known. These dual-frequency microstrip antennas include the use of multilayer stacked patches , a rectangular patch with a pair of narrow slots placed close to the patch's radiating edges and a square patch with a rectangular notch , a rectangular patch loaded with shorting pins and slots , a rectangular patch fed by an inclined coupling slot , among others.

To achieve dual-frequency operation in reduced-size or compact microstrip antennas, many promising designs have been reported . Details of these compact dual frequency designs and some recent advances in regular size dual frequency. Compact microstrip antennas capable of dual-polarized radiation are very suitable for applications in wireless communication systems that demand frequency re use or polarization diversity.

The demand for high data rate internet access is steadily increasing. In remote areas without terrestrial coverage (e.g. on the oceans, or in aircrafts) wideband satellite services such as KA-SAT or Inmarsat 5 at Ka-band offer well suited solutions[1-4]. On the downside high gain antennas are required for an adequate link budget thus making constant tracking a necessity for mobile communications.

Patch antennas are popular for their well-known attractive features, such as a low profile, light weight, and compatibility with monolithic microwave integrated circuits (MMICs) Their main disadvantage is an intrinsic limitation in bandwidth, which is due to the resonant nature of the patch structure. On the other hand, modem communication systems, such as those for satellite links (GPS, vehicular, etc.), as well as emerging applications, such as wireless local networks (WLAN)

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The construction of a shared transmit and receive aperture with dual-polarized radiators is challenging. To avoid grating lobes in an array, the overall element size has to be kept smaller than half the frees pace wavelength at the upper frequency, thus preventing the usage of standard wideband antennas. Furthermore, coupling between the feeds is a critical issue since it deteriorates the polarization properties[5-8]. A wideband dual polarized antenna is proposed. However it is compatible to neither Ka-band services, nor to standard PCB processes. Dual-polarized two-band antennas have been reported for L and X-Band and recently as a concept for Ka-band.

Thus, a stacked patch approach on the two upper layers is taken]. The upper patch is square and designed for the higher frequency. For the bottom one a square-ring is utilized, yielding a lower resonant frequency than a conventional patch of the same size. Thus, the overall element size is smaller than 0.3 $\lambda_{0,30\ \mathrm{GHz}}$, allowing an integration into an array with sufficiently low coupling. The inner cutout has to be carefully adjusted, since it reduces the radiation efficiency and thereby also the available bandwidth. The patches constitute a coupled system, which has to be taken into account when optimizing their resonant frequencies. The designed stacked-patch is depicted in Fig.1.

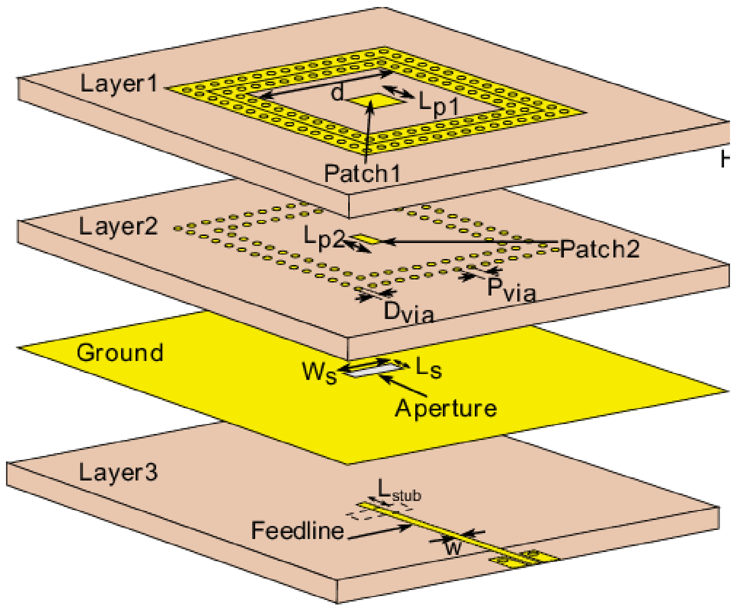

Fig 1. Stacked microstrip patch antenna

Feed and aperture for dual polarization , the designed radiating element is symmetric and can thus support two linearly polarized modes. To excite both independently, two perpendicular feeds below an appropriate aperture are needed. Their placement is crucial to obtain a low return loss and low cross-coupling. Ideally both feed lines are crossed below the center of the aperture. Since this would result in an overlap, they are conventionally placed closer to the patch edges which results in higher cross-coupling and an asymmetrical pattern[9-10]. As a solution, the multilayer feed structure used and is adapted for the proposed dual-band antenna in a standard PCB process to meet the alignment challenges at higher frequencies. The feed lines traverse in the middle of a cross-shaped aperture and are only separated by a very thin substrate layer. The ends of the feed are fanned out like a tuning fork to minimize blockage. The close proximity of the layers in combination with the tuning-forkshape enable quasi equal coupling of both feeds to the patch and an adequate isolation. Length and width are adjusted for optimal match in both frequency bands.

Dual-Frequency Operation with Same Polarization Planes .

Design with a Rectangular Patch

It has been demonstrated that, by loading a rectangular microstrip antenna with a pair of narrow slots placed close to the patch's radiating edges, dual-frequency operation can be obtained. In such dual-frequency designs, the two operating frequencies are associated with the TM10 and TM30 modes of the unslotted rectangular patch. In addition, the two operating frequencies have the same polarization planes and broadside radiation patterns, with a frequency ratio generally within the range of 1.6–2.0 for the single-probe-feed case [11-12]. Recently, it has been shown that, by placing the embedded slots close to the patch's non radiating edges instead of the radiating edges

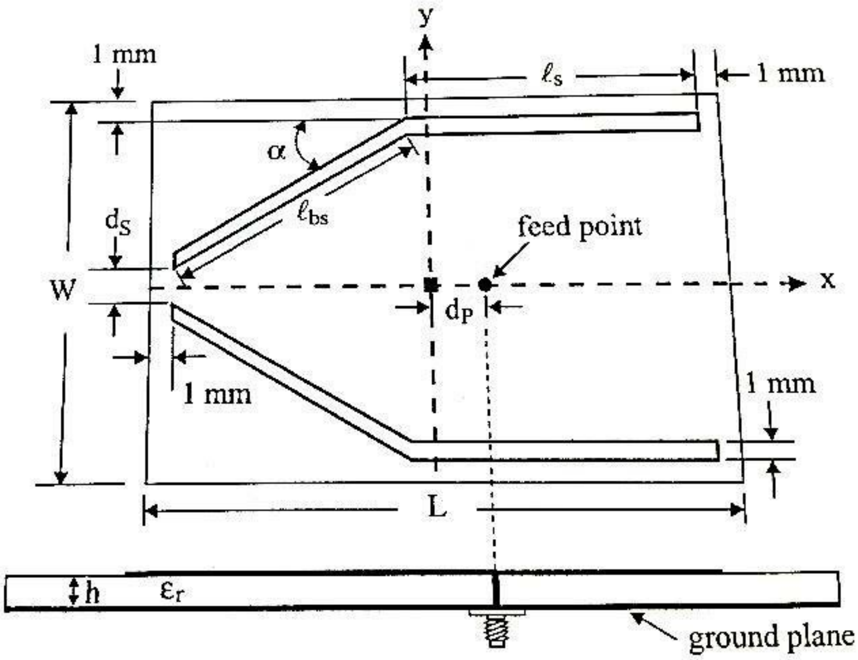

Fig. 2 Geometry of a dual-frequency rectangular microstrip antenna with a pair of bent slots placed close to the patch's non radiating edges.

COMPACT DUAL-FREQUENCY OPERATION WITH SAME POLARIZATION PLANES

Some novel dual-frequency designs of compact microstrip antennas are presented in this section. In these designs, the two operating frequencies have the same polarization planes. In Section. The technique of embedding a pair of narrow slots to a meandered rectangular patch [and a bow-tie patch is described. Results show that with increasing slit length in the rectangular patch or flare angle of the bow-tie patch, the antenna's first two resonant frequencies are both quickly lowered. This behaviour suggests that an antenna size reduction can be achieved for this kind of antenna in fixed dual-frequency operation. Recently, it has been demonstrated that compact dual-frequency operation for short-circuited microstrip antennas can be achieved. Triangular microstrip antennas are a good substitute for regular rectangular microstrip antenna due to their similar radiation properties and smaller patch dimensions.

Conclusion

Dual-frequency patch antennas may provide an alternative to large-bandwidth planar antennas, in applications in which large bandwidth is really needed for operating at two separate transmit-receive bands. An overview of dual-frequency patch antennas has been carried out, with special emphasis on configurations that are particularly attractive for their simplicity and design flexibility. Attention has been focused on the geometry of the radiators.

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