A PACKAGED RECONFIGURABLE MULTIELEMENT ANTENNA FOR WIRELESS NETWORKING

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Next-generation cellular networks deployment will require systems with broadband capabilities in high-mobility environments. Data rates up to 100 Mbits/s and above, high spectral efficiencies and stronger fading mitigation have to be achieved. Technologies needed to obtain these specifications, include multibeam antenna systems, wideband transceivers, and robust and efficient space-time coding. In this paper we present a new reconfigurable miniature antenna architecture, compatible with the packaging constraints, able to change its working frequency, polarization, or radiation pattern in order to get, single broadband or dualband behavior, for a single widebeam or multibeam diversity configuration.

1 Introduction

The new antenna architecture, based on a miniature multilayered broadband antenna [1] as individual radiating element (diameter < 0.2λ and thickness < 0.06λ), consists of two or four such antenna elements, combined with a set of switches (either PIN or MEMS depending on the application) [2]-[3], located on specific points of the antenna geometry: either into the resonant aperture to change the working frequency or into the feeding line to select the active radiation beam.

2 Single Antenna Element

The geometry of the single element, Fig. 1, consists of two stacked circular (1.a) or semicircular (1.b) patches (p_l and p_u), embedded in dielectric material, with slot lengths (S_u, S_l) close to λ/2, over a cavity backed ground plane, forming two dielectric layers with respective thickness of h_l and h_u, connected by two sectorial pieces (w_u and w_l). For every single antenna, two planar transmission lines, ended by cylindrical slots and limited by the two connecting sectorial walls, are formed between the three planes.

Fig1. Geometry of the single antenna element. (a) Circular shape, (b) Semicircular shape
From the feeding voltage, applied between the ground plane and the lower patch, the two slots \( (S_u, S_l) \), slightly different in length, are simultaneously fed through the matching planar lines mentioned above. The resonant frequencies are defined by the \( \lambda/2 \) dimension of the two cylindrical slots and the optimal length of the feed to ground path. From the radiation pattern point of view, each antenna radiates as two stacked circular magnetic slots, electrically equivalent to a vertical electric dipole, producing an almost omni directional pattern, slightly upper-tilted due to the stacked structure and short-circuiting walls. In order to explore the capabilities of this antenna to work under real conditions at the new wireless communications frequencies (in particular the future Bluetooth C-band frequency) a 5.2 GHz circular prototype was designed and fabricated according to the above parameters. The diameter of the antenna was 10 mm, and the total thickness of 3 mm. The Fig. 2 shows the measured results for the return loss with a frequency bandwidth of 13 \%, in accordance with the numerical simulations.

![Fig 2](image)

Fig 2. Calculated and measured return loss of the fabricated circular patch antenna operating at 5.2 GHz. The dimensions of the antenna; \( h_u=h_l=1.55\text{mm}, \theta_s=125^\circ, r_a=5.5\text{mm}, S_u = 24.2 \text{ mm}, \) \( S_l = 33.5 \text{ mm} \).  

\[ \text{---- calculated; \quad \text{----- measured.} } \]

### 3  Multielement Parametric Study

Combining several circular or semicircular single antenna elements, different geometries can be defined. In Fig.3, a two-element architecture with an overall dimension of \( \lambda/2 \times \lambda/2 \times \lambda/20 \) is shown. In order to get different array behaviors, one of the radiating elements can be rotated an angle \( \alpha \) with respect to the other. A series of simulations based on Finite Element Method full-wave analysis tool (Ansoft HFSS7) have been carried out to investigate the sensitivity of the input impedance, bandwidth and mutual coupling, to the \( \alpha \) relative position, both linear and angular, of the two radiating element geometry.
The results for the $(S_{11})$, Fig. 4a, show a bandwidth of 5% and a behavior basically independent of the relative position ($\alpha$) between the two antennas. Fig. 4b shows the influence of the relative position ($\alpha$) on the mutual coupling ($S_{21}$). At the 5.2 GHz frequency, a variation from $-8$ dB for $\alpha=0^\circ$ orientation, up to $-24$ dB for $\alpha=180^\circ$ is observed.

For most of the communication applications, where spatial or angular diversity techniques [4] are needed, in order to get low correlation coefficients between the different radiating elements, a mutual coupling under $-15$ dB is needed. From the above given results, $\alpha$-orientation between $90^\circ$ and $180^\circ$ are suitable, permitting a large variety of spatial combinations, to form different arrays geometries as the one shown in Fig. 5 for $\alpha=90^\circ$, with an overall dimension of $0.8\lambda \times 0.8\lambda \times 0.05\lambda$.
Different S-band and C-band (actual and future Bluetooth frequency bands) antennas have been designed, fabricated and tested for validation and prototyping purposes. Numerical and experimental results for different 4-element prototypes will be presented, and its circuital and radiation characteristics will be discussed, in terms of reconfigurability and diversity enhancement capabilities.

Conclusions

A novel miniature reconfigurable antenna, compatible with the packaging constraints, has been presented and its electrical parameters discussed. Owing to its very small size and radiation capabilities, very well suited for communications diversity enhancement, it is an exceptional candidate to be integrated in a big variety of portable devices.

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References
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