A Low-profile Full-band Subarray Cavity-backed Slot Antenna with a Compact Feed

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A cavity-backed four-element slot antenna fed by a compact microstrip line covering the entire X-band (40% bandwidth) is proposed. Such element is envisioned a building block (tile) for design and construction of scalable ultra-wideband antenna arrays. The antenna is composed of a thin cubic cavity of dimensions $1.65\,\lambda \times 1.65\,\lambda \times 0.2\,\lambda$ on which four slots are cut out for electromagnetic radiation. The slots are on one of the broad walls to create a fan beam in the boresight. The radiating slots are excited in-phase by a slot etched on the center of the opposite broad wall of the cavity. The cavity-back slots, in essence, as reported in the literatures have narrowband characteristic. A slotted cavity can be modeled as a combination of series and parallel resonators. Excited by the dominant TE_{10} mode, the cavity is operated near the series resonance and in turn excites the dominant resonance of the radiating slots. However, the wave is prevented to propagate at other parallel resonance frequencies by using metallic septums at appropriate locations. The passband and the stopband regions are determined by the cavity dimensions and the shape and position of the radiating slots. In the proposed design, the passbands at which the resonances of the cavity occur corresponds to TE_{320} and TE_{340} modes. To suppress the other unwanted parallel resonances which fall within the desired bandwidth, a set of metallic septums with appropriate shape and orientation are inserted inside the cavity. These septums perturb the fields and current inside the cavity and can be designed to cancel the undesired in-band parallel resonances. By this technique, a bandwidth of 57% is achieved (when the antenna is excited by a waveguide) which exceeds those reported in the literatures for slot antennas so far. To reduce the antenna thickness, the cavity is fed by a microstrip line through a compact transition. The cavity is backed by a double sided etched microstrip layer with a thickness of less than $\lambda/100$. An aperture with the same dimension of that of the waveguide feed on the ground plane side of the microstrip layer couples the power from the microstrip feedline into the cavity. Keeping the maximum length of the proposed topology for the microstrip feedline smaller than $0.65\,\lambda$, a quasi TE_{10} field distribution on the input aperture of the cavity is produced. This is accomplished by adjusting the current as well as the position of different branches of the feedlines crossing over the slot aperture. The overall antenna bandwidth when integrated with the microstrip feed section is reduced to about 40% (8-12 GHz). The antenna gain over the entire bandwidth is larger than 11 dB with an efficiency of better than 95%. While this design provides easiness of fabrication, the proposed subarray antenna structure is compatible with RF front-end section of transceivers and can be considered as a suitable candidate as building block of large arrays.