Electronics/Computers

Hilbert-Curve Fractal Antenna With Radiation-Pattern Diversity

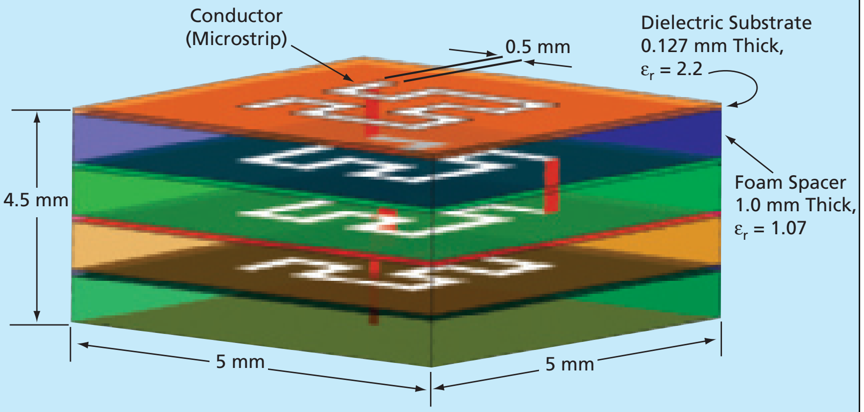
Two radiation patterns are attainable without active switching.

John H. Glenn Research Center, Cleveland, Ohio

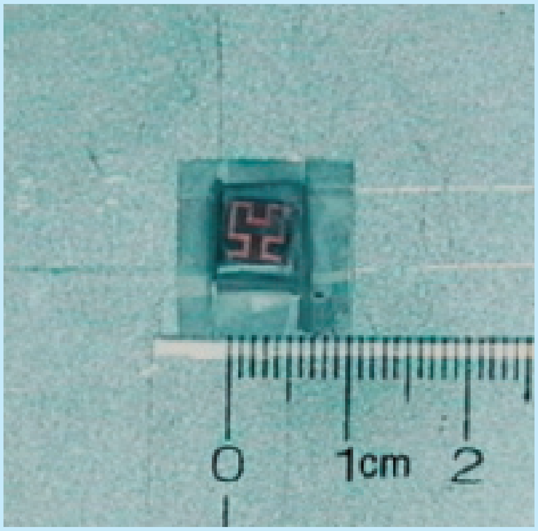
A printed, folded, Hilbert-curve fractal microwave antenna has been designed and built to offer advantages of compactness and low mass, relative to other antennas designed for the same operating frequencies. The primary feature of the antenna is that it offers the advantage of radiation-pattern diversity without need for electrical or mechanical switching: it can radiate simultaneously in an end-fire pattern at a frequency of 2.3 GHz (which is in the S-band) and in a broadside pattern at a frequency of 16.8 GHz (which is in the Ku-band). This radiation-pattern diversity could be utilized, for example, in applications in which there were requirements for both S-band ground-to-ground communications and Ku-band ground-to-aircraft or ground-to-spacecraft communications. The lack of switching mechanisms or circuitry makes this antenna more reliable, easier, and less expensive to fabricate than it otherwise would be.

Fabrication of the antenna begins with etching of its Hilbert-curve fractal conductor pattern onto a single 5-mil (0.127-mm)-thick substrate of a dielectric material that has a relative permittivity (ε_r) of 2.2. The conductor is formed as a microstrip 0.5 mm wide. Notches are cut into the substrate to facilitate folding. Then the patterned, notched substrate is folded, along with 1-mm-thick separation layers made of a dielectric foam having $\varepsilon_r = 1.07$, to form the multilayer structure shown in Figure 1. This multilayer structure is mounted onto an aluminum ground plane.

The antenna is excited via a probe feed. At 2.3 GHz, the antenna presents a matched reactive load to the probe feed and functions as a miniature dipolelike antenna that produces the end-fire radiation pattern [see Figure 2(a)]. The antenna can be tailored at this frequency by adjusting the length of the probe feed in conjunction with the location of the probe connection and by choice of strip-line width, strip-line spacings, and interlayer spacings. At frequencies in



LAYOUT



PHOTOGRAPH

Figure 1. This **Multilayer Microstrip Antenna** radiates in an end-fire pattern (maximum gain in plane) at 2.3 GHz and in a broadside pattern (maximum gain perpendicular to plane) at 16.8 GHz. Dimensions shown here are typical and can be adjusted to optimize performance, change operating frequencies, or both.

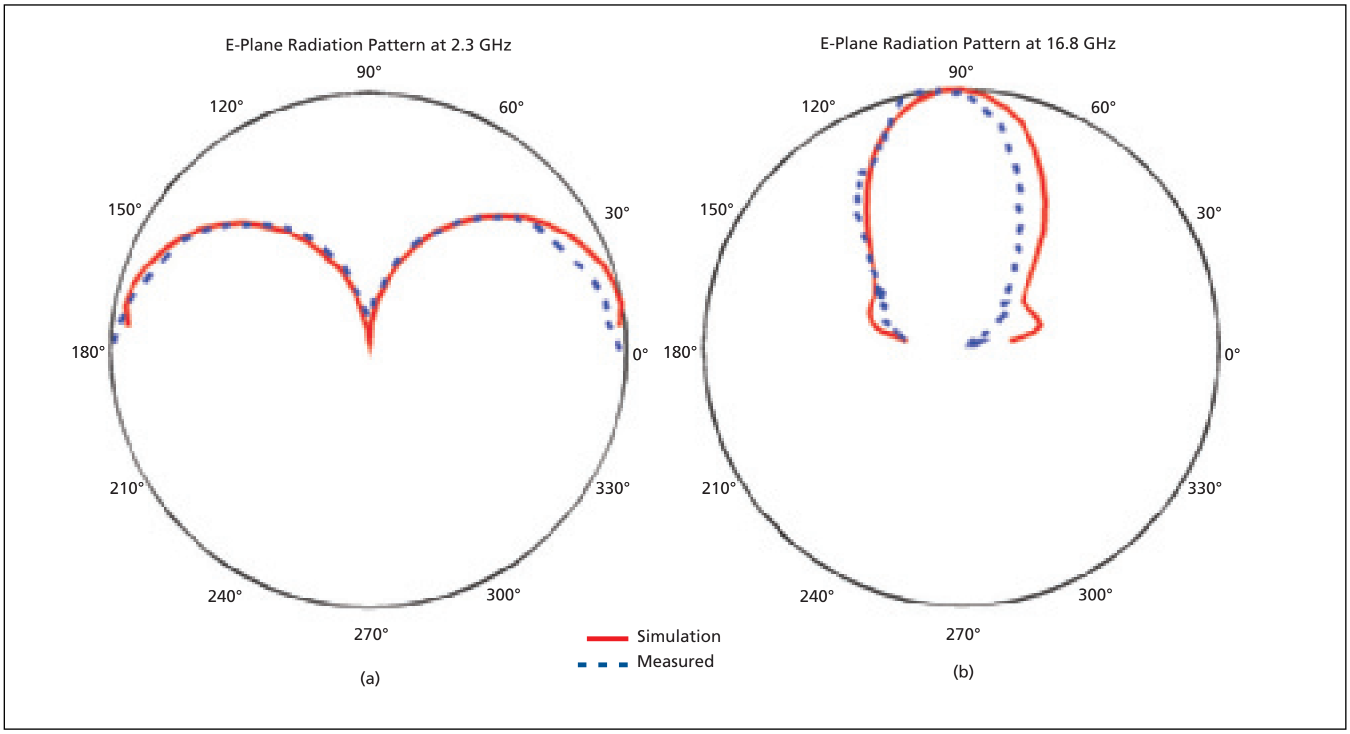


Figure 2. **Two Radiation Patterns** are attainable, as shown : (a) end-fire radiation pattern at S-band and (b) broadside radiation pattern at Ku-band.

the vicinity of 16.8 GHz, the antenna resembles a square patch antenna having dimensions close to a half wavelength, resulting in a broadside radiation pattern characterized by gain and bandwidth comparable to those of a microstrip patch antenna designed for operation in the same frequency range [see Figure 2(b)].

This work was done by James A. Nessel, Félix A. Miranda, and Afroz Zaman of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17927-1.

Single-Camera Panoramic-Imaging Systems

It is not necessary to use multiple cameras covering narrower fields of view.

Marshall Space Flight Center, Alabama

Figure 1. A **Prototype PDS Mounted on Top of a Car** acquired a panoramic image of the surroundings.

Panoramic detection systems (PDSs) are developmental video monitoring and image-data processing systems that, as their name indicates, acquire panoramic views. More specifically, a PDS acquires images from an approximately cylindrical field of view that surrounds an observation platform. In example of a major class of intended applications, a PDS mounted on top of a motor vehicle could be used to obtain unobstructed views of the surroundings (see Figure 1). In another such example, a PDS could be mounted above a roadway intersection for monitoring approaching and receding vehicles in order to provide image data on the vehicles as input to an automated traffic-control system. In either application, a running archive of the image data acquired by the PDS could be maintained as a means of reconstructing the events leading up to a vehicular collision: used in this way, a PDS would be analogous to an aircraft "black box" data recorder.

The main subsystems and components of a basic PDS are a charge-coupled-device (CCD) video camera and lens, transfer optics, a panoramic imaging optic, a mounting cylinder, and an image-data-processing computer. The panoramic imaging optic is what makes it possible for the single video camera to image the complete cylindrical field of view; in order to image the same scene without the benefit of the panoramic imaging optic, it would be necessary to use multiple conventional video cameras, which have relatively narrow fields of view.

The panoramic imaging optic can be any one of several different types of