

Also mounted on the bracket are two drift-compensating angular-position sensors. One of these sensors is typically a two-axis bubble inclinometer that generates voltages proportional to tilts, relative to the gravitational field, about the roll and pitch axes. The other sensor is typically a flux-gate compass that measures the flux densities of the ambient magnetic field along the roll and pitch axes. In principle, the combination of the magnetic-field information and the tilt information can be used to determine the heading in the horizontal plane or, equivalently, the angular position in rotation about the vertical (gravitational) axis.

Because the bubble inclinometer gives accurate readings only when the head is motionless, success in its use depends on the fact that head motion ceases occasion-

ally — on the average, about once every 10 seconds. Within about $\frac{1}{4}$ second after motion has ceased, the fluid in the inclinometer settles to a steady configuration and an inclinometer reading and the associated compass reading are taken at that time. These readings are digitized and fed to the drift-compensator module. The output of this module is a corrected angular-orientation signal, which both (1) constitutes the main orientation-signal output of the system and (2) is fed back to the integrator module for use in coordinate transformations needed to calculate angular velocities and angles.

In a simplistic approach, each set of drift-compensation readings can be used to reset the system, removing all the drift accumulated since the most recent prior reset. However, the abrupt removal of ac-

cumulated drift could jar the user or adversely affect external equipment that utilizes the orientation output. To prevent such jarring, the drift-compensator module removes the drift from the output gradually, rather than all at once. Thus, the drift compensator generates a set of angular-position signals that gradually approach the correct values over time.

This work was done by Eric M. Foxlin of Massachusetts Institute of Technology for Ames Research Center. Further information is contained in a TSP (see page 1).

This invention has been patented by NASA (U.S. Patent No. 6,361,507). Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at (650) 604-2954. Refer to ARC-14132-3.

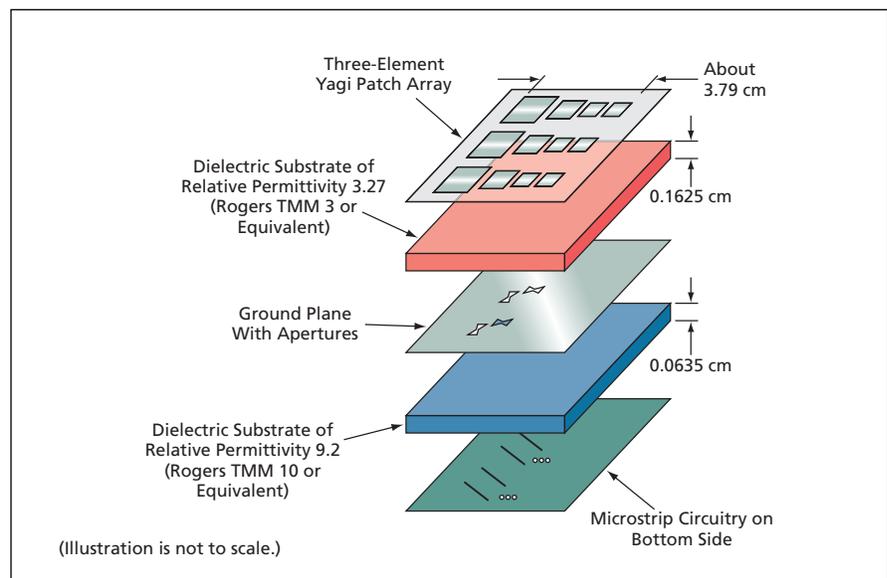
Microstrip Yagi Antenna With Dual Aperture-Coupled Feed

This antenna would have a relatively simple, elegant, low-profile design.

NASA's Jet Propulsion Laboratory, Pasadena, California

antenna is to combine features of a Yagi antenna with those of a microstrip patch to obtain an antenna that can be manufactured at low cost, has a low profile, and radiates a directive beam that, as plotted on an elevation plane perpendicular to the antenna plane, appears tilted away from the broadside. Such antennas are suitable for flush mounting on surfaces of diverse objects, including spacecraft, aircraft, land vehicles, and computers.

The design of the original version of the prior L-band microstrip Yagi antenna utilized a dual coaxial probe feed to generate circularly polarized radiation. (In some other versions of the prior antenna, a single aperture-coupled feed has been used to obtain linear polarization, but this would be of no help in contemplated applications in which circular polarization would be required.) The coaxial feed in the original circular-polarization version introduces electrical and mechanical complexities and difficulties. Electrically, it is difficult to match the impedance of the coaxial cable to that of the antenna because of the parasitics involved in the coaxial through-feed connections. Mechanically, the geometry of the coaxial feed makes it difficult to impart a low profile and predominantly planar character to both the antenna and its feed structure. In contrast, in the proposed X-band microstrip Yagi an-



This **Simplified Exploded View** depicts the main components of the three-element microstrip Yagi antenna featuring dual offset aperture-coupled feed for each patch.

tenna, a dual aperture-coupled feed would be used to obtain circular polarization, simplifying both the electrical and mechanical aspects of design and imparting a predominantly planar character to the overall shape.

Stated somewhat more precisely, what has been proposed is a microstrip antenna comprising an array of three Yagi elements. Each element would include four microstrip-patch Yagi subelements: one re-

flector patch, one driven patch, and two director patches. To obtain circular polarization, each driven patch would be fed by use of a dual offset aperture-coupled feed featuring bow-tie-shaped apertures (see figure). The selection of the dual offset bow-tie aperture geometry is supported by results found in published literature that show that this geometry would enable matching of the impedances of the driven patches to the 50-Ω impedance of the mi-

crostrip feedline while maintaining a desirably large front-to-back lobe ratio.

This work was done by Ronald Pogorzelski and Jaikrishna Venkatesan of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Innovative Technology Assets Management
JPL
Mail Stop 202-233

4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-2240
E-mail: iaoffice@jpl.nasa.gov
Refer to NPO-41791, volume and number of this NASA Tech Briefs issue, and the page number.

Patterned Ferroelectric Films for Tunable Microwave Devices

Microwave performance is enhanced by appropriate patterning.

John H. Glenn Research Center, Cleveland, Ohio

Tunable microwave devices based on metal terminals connected by thin ferroelectric films (see Figure 1) can be made to perform better by patterning the films to include suitably dimensioned, positioned, and oriented constrictions. The patterns (see Figure 2) can be formed during fabrication by means of selective etching processes.

The following observations regarding prior ferroelectric-based microwave devices and circuits constitute part of the background and impetus for the present patterning concept:

- The basic principle of design and operation of a ferroelectric-based microwave device calls for a continuous film of ferroelectric material that extends from one metal terminal to another on a low-loss dielectric substrate.
- The performances of conventional ferroelectric-based devices and circuits can be degraded by excessive losses and spurious resonances.
- Designers often seek to obtain linear tuning-versus-bias-voltage profiles. In general, the tuning-versus-bias voltage profile of such a device is difficult to control in the absence of suitable patterning. The desired linear profiles (more specifically, changes in frequency or phase proportional to changes in bias voltage) have not been observed.
- Ferroelectric materials are intrinsically lossy, and losses are especially pronounced in ferroelectric-based narrow-band filters, in which resonant elements must be separated by large distances to obtain the necessary isolation. In a typical prior ferroelectric-based device, the electric field is distributed uniformly across the unpatterned ferroelectric film; hence, if such a film is part of a narrow-band filter, spanning the required large distance, and the loss can be unacceptably high.

- Heretofore, the high permittivities of ferroelectric materials have given rise to large capacitances that have been detrimental to performance at microwave frequencies.

If the width of the ferroelectric film in such a device is reduced at one or more locations, then both the microwave field and any applied DC bias (tuning) electric field become concentrated at

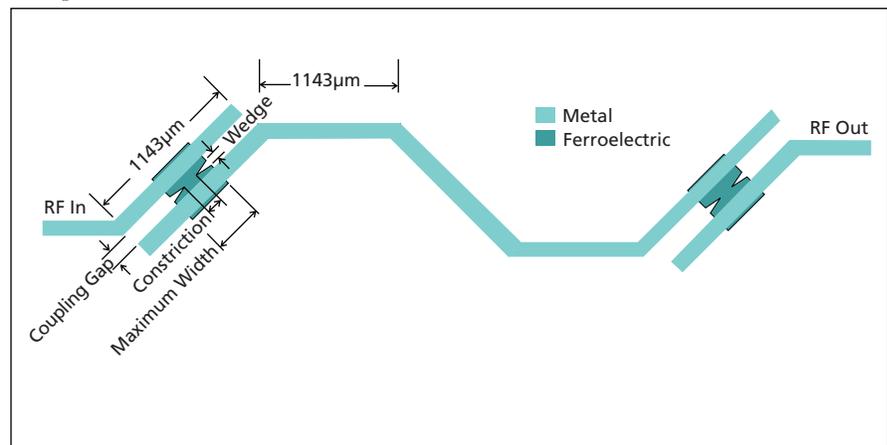


Figure 1. A Tunable Microwave Device is exemplified here as a one-pole microstrip filter with etched ferroelectric layer.

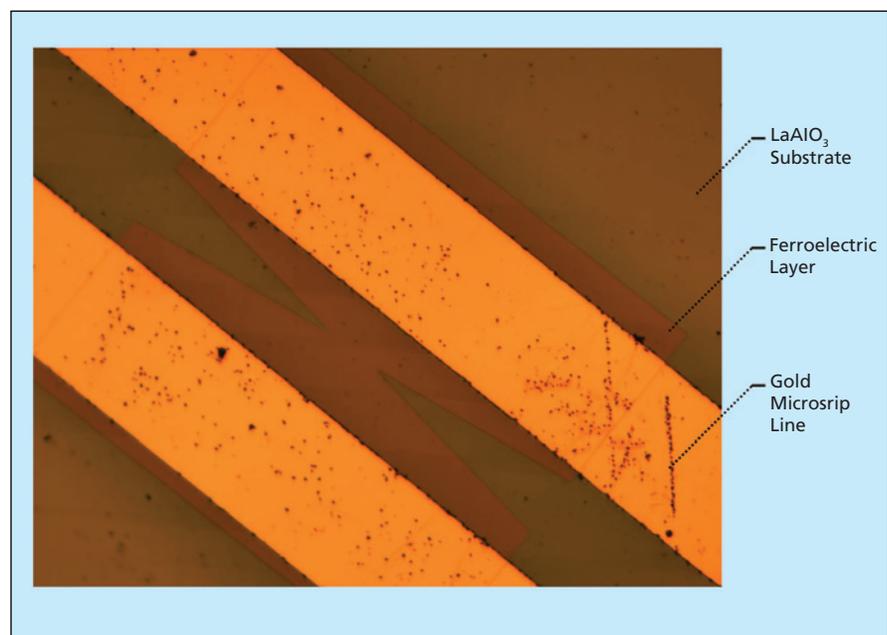


Figure 2. A Coupled Section of the Filter shows etched ferroelectric layer.