

## Multilayer Patch Antenna Surrounded by a Metallic Wall

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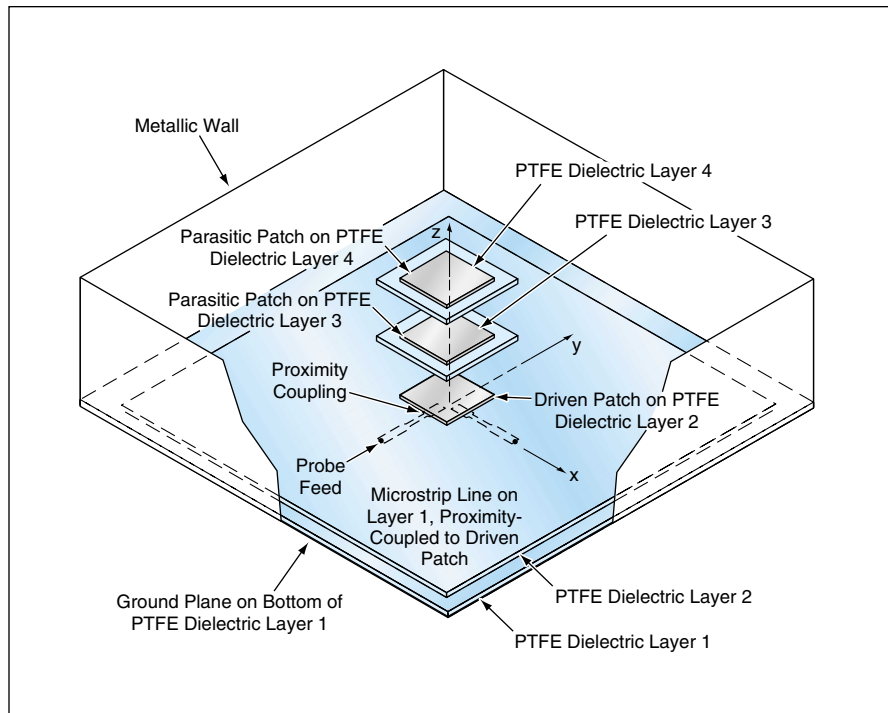
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A multilayer patch antenna, similar to a Yagi antenna, surrounded by a metallic wall has been devised to satisfy requirements to fit within a specified size and shape and to generate a beam with a half-power angular width of  $\leq 40^\circ$ . This antenna provides a gain of about 14 dB; in contrast, the gain of a typical single-patch antenna lies between 5 and 6 dB.

This antenna can be considered an alternative to a two-dimensional array of patch antenna elements, or to a horn or helical antenna. Unlike a two-dimensional array of patches, this antenna can function without need for a power-division network (unless circular polarization is needed). The profile of this antenna is lower than that of a horn or a helical antenna designed for the same frequency. The primary disadvantage of this antenna, relative to a horn or a helical antenna, is that its footprint is slightly larger.

This antenna (see figure) includes four dielectric substrate layers of polytetrafluoroethylene (PTFE) [which has a relative permittivity of 2.2], on which metallic patch antenna elements are formed. It also includes two thick spacer layers of a foam that has a relative permittivity of 1.08. A metallic wall surrounds the aforementioned components on four sides, forming an open cavity suggestive of a shallow, boxlike feed horn. The length of each side is about two wavelengths and the total height is about one wavelength. Without this cavity, the antenna gain achieved was 2 dB lower.

A microstrip feed line is etched on the upper side of PTFE dielectric layer 1 and is proximity-coupled to a driven patch element located on the upper side of PTFE dielectric layer 2. A ground plane is lo-



This Multilayer Patch Antenna protrudes less than does a horn or a helical antenna. For clarity, the layers of foam that support PTFE dielectric layers 3 and 4 are not shown in this view.

cated on the bottom of PTFE dielectric layer 1 and is electrically connected to the metallic wall. The foam layers support PTFE dielectric layers 3 and 4, on which are located two additional patches that function as "parasitic" antenna elements in that they are electromagnetically coupled to the driven element.

The use of proximity coupling by a microstrip feed line assists mainly in matching to the high input impedance attributable to the three-layer configuration of patch antenna elements. Some fine tuning of the proximity coupling is effected by widening of the microstrip

under the driven patch. By enabling the driven patch to exist on a substrate thicker than that of the microstrip feed line, the proximity coupling likely increases the bandwidth of the antenna moderately. One can provide for circular polarization by introducing a microstrip power divider with a  $90^\circ$  phase delay in the microstrip feed line to one of two proximity couplings.

This work was done by Mark Zawadzki and John Huang of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-21242