Patch Antenna Fed via Unequal-Crossed-Arm Aperture

The antenna could be made significantly smaller in one dimension.

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A proposed rectangular-patch antenna for transmitting or receiving microwave circularly polarized (CP) radiation would be fed via a cross-shaped aperture that would have unequal arms and would, in turn, be fed at a single point via a microstrip transmission line. As a consequence of the unequal-arm aperture design, the antenna could be made smaller in one dimension, relative to a typical prior CP antenna that comprises a nearly square patch fed via an equal-crossed-arm aperture. Hence, in designing a phased array of such antennas, the antennas could be packed together more closely along one dimension, making it possible to scan the beam radiated by the antenna over a wider angular range in a plane that includes that dimension. Alternatively or in addition, one could lay out transmission lines in the extra spaces created by the shortening in one dimension.

In designing a rectangular-patch CP antenna, one chooses the dimensions of the patch and of the crossed arms of the aperture to introduce a 90° phase shift between the two orthogonal electromagnetic modes of the patch. In the case of a conventional "nearly square" design, the aperture arms are constrained to have equal dimensions, it is assumed that the value of the resonance quality factor (Q) is the same for both modes, and the effects of the electromagnetic modes of the crossed aperture arms are neglected. In designing an antenna according to the proposal, one allows the aperture arms to have unequal dimensions and does not assume equal Q values. Instead, one explicitly includes the aperture modes in the calculations and assesses the overall effects (including possibly unequal Q values) on the patch modes and the characteristics of the radiation.

The decision to allow unequal dimensions of both the patch and the aperture arms gives the designer more degrees of freedom than could be utilized to optimize the antenna. Among other things that one seeks to do in optimization is to obtain an axial ratio as close to 1 as possible and an axial-ratio bandwidth as large as possible. (As used here, "axial ratio" signifies the ratio between the radiated power polarized along one axis of symmetry of the antenna and the radiated power polarized along the other, perpendicular axis of symmetry of the antenna. An axial ratio of exactly 1 corresponds to perfectly circular polarization. "Axial-ratio bandwidth" signifies the width of the frequency band over which the axial ratio is acceptably close to 1.)

In designing an antenna as proposed, to compensate for an axial ratio that deviates from 1 by an unacceptably large amount, the dimensions of the aperture arms along one direction could be adjusted in tandem with the corresponding orthogonal patch dimension. For example, if the vertical dimension of the patch were modified, then the horizontal dimensions of the aperture arms would be adjusted accordingly. Consequently, an additional benefit of the proposed design approach would be that the axial ratio of an antenna would be closer to 1, and the axial-ratio bandwidth would be greater, relative to the corresponding parameters of the prior "nearly square" antenna.

This work was done by Larry Epp of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30508

LC Circuits for Diagnosing Embedded Piezoelectric Devices

Failures are readily identified through changes in resonance frequencies.

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A recently invented method of nonintrusively detecting faults in piezoelectric devices involves measurement of the resonance frequencies of inductor-capacitor (LC) resonant circuits. The method is intended especially to enable diagnosis of piezoelectric sensors, actuators, and sensor/actuators that are embedded in structures and/or are components of multilayer composite-material structures.

In this method, a small induction coil is connected to each piezoelectric component that is embedded in the affected structure, composite material, or component by way of the electrical leads used for the basic sensor/actuator function. This connection is made manually or remotely during diagnosis of the piezoelectric component. Thus, what is formed, in addition to the basic sensor/actuator circuit, is an LC resonant circuit, in which the piezoelectric component acts as the capacitor. The inductance of the coil does not vary appreciably under most conditions, but the capacitance (and, hence, the resonance frequency) changes significantly if the piezoelectric device fails. Hence, a significant change in the resonance frequency can be taken as an indication of a failure of the piezoelectric device.

The resonance frequency can be measured in a conventional manner, either by induction or by direct connection via electrical leads. If a structure contains multiple embedded piezoelectric devices and the LC circuit of each piezoelectric device has a unique assigned resonance frequency, then one can rapidly and easily interrogate all the devices in a spectral scan over the range of assigned resonance frequencies. In the resulting spectral plot, a significant deviation of any of the resonance peaks from its assigned frequency indicates the failure of the corresponding piezoelectric device.

This work was done by Richard L. Chattin, Robert Lee Fox, Robert W. Moses, and Qamar A. Shams of **Langley Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.techbriefs.com/tsp*** *under the Semiconductors & ICs category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center, at (757) 864-3521. Refer to LAR-16549-1.