at locations that are partly or totally inaccessible and (2) ensuring the necessary precise alignments between hidden coupled transmission lines. In contrast, in the modified configuration, the integrated circuitry is mounted on the outside, where it is visible and accessible.

The figure shows examples of simple conventional and modified coaxial probe feeds. In the example of the conventional configuration, the outer conductor of a coaxial cable is connected to, and terminated at, a ground-plane metal layer, while the central conductor extends through a single dielectric layer to a connection with a patterned metal radiator element (e.g., a microstrip patch).

In the example of the modified configuration, the outer conductor of the coaxial cable extends through the thickness of the dielectric layer between, and is electrically connected to, both the ground-plane metal conductor and the patterned metal layer on the radiator plane. The central conductor of the coaxial cable extends through the thickness of the dielectric substrate of an integrated circuit to the integrated circuit, which is located on the outer surface. The integrated circuit then excites the cavity formed by the bounding top and bottom planes, by means of an electrical connection passing through an aperture in the patterned metal radiator element (see figure).

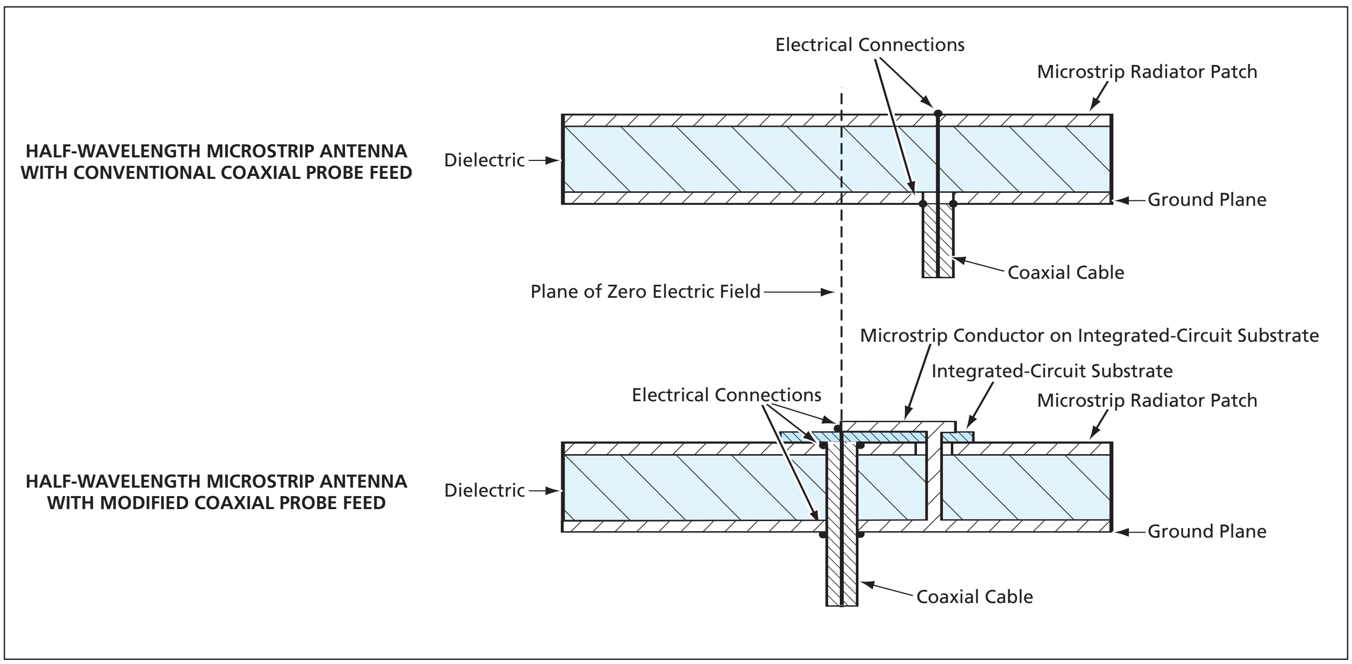
Although the coaxial outer conductor constitutes a short circuit between the ground and radiator planes, the effect of the short circuit is minimal because care is taken to locate the coaxial intrusion at a node of the standing-wave mode of the antenna electromagnetic field; that is, the effect of the short circuit is minimal because at its chosen location, the electric field is nominally zero in the absence of perturbations. In the ideal case, the diameter of the outer conductor of the coaxial cable would be zero and there would be no perturbations. In reality, the outer conductor has a finite diameter, leading to a slight shift of the resonance frequency of the antenna. However, the resonance frequency is easily adjusted by slightly changing the length of the antenna.

In some designs, the metal radiator and ground plane are intentionally short-circuited by use of a post at a specified location to shift the resonance frequency by a specified amount. In an application of the modified configuration to such a design, the coaxial intrusion could be substituted for the post.

The modified feed can also be applied to the so-called PIFA (planar inverted-F antenna), which has achieved great popularity due to its compact size. In this application, the coaxial intrusion provides all or part of the required short circuit between the ground plane and the patterned metal layer on the radiator plane.

This work was done by Patrick W. Fink, Andrew W. Chu, Justin A. Dobbins, and Greg Y. Lin of **Johnson Space Center**.

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, Johnson Space Center, (281) 483-0837. Refer to MSC-23549.



In the **Modified Coaxial Probe Feed**, the outer conductor of the coaxial cable constitutes a short circuit between the ground plane and the radiator patch.

Detecting Negative Obstacles by Use of Radar

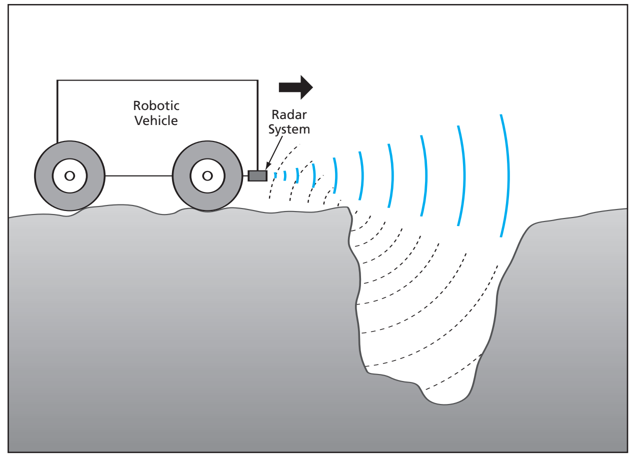
Changes in diffraction and reflection would be used to detect abrupt downslopes.

NASA's Jet Propulsion Laboratory, Pasadena, California

Robotic land vehicles would be equipped with small radar systems to detect negative obstacles, according to a proposal. The term "negative obstacles" denotes holes, ditches, and any other terrain features characterized by abrupt steep downslopes that could be hazardous for vehicles. Video cameras and other optically based obstacle-avoidance sensors now installed on some robotic vehicles cannot detect obstacles under adverse lighting conditions. Even under favorable lighting conditions, they cannot detect negative obstacles — at least in part because they cannot see around corners. Other obstacle-avoidance sensors that utilize thermal-infrared radiation from terrain features cannot detect obstacles when temperatures change too rapidly, as they often do at dusk and dawn. The proposed radar systems would not be subject to these limitations.

Radar systems partly similar to the proposed ones are already used in some cars and trucks to warn drivers during backing toward objects that cannot be seen from the drivers' positions. However, those systems are not designed to detect negative obstacles. A radar system according to the proposal would be of the frequency-modulation/continuous-wave (FM/CW) type. It would be installed on a vehicle, facing forward, possibly with a downward slant of the main lobe(s) of the radar beam(s) (see figure). It would utilize one or more wavelength(s) of the order of centimeters.

Because such wavelengths are comparable to the characteristic dimensions of terrain features associated with negative hazards, a significant amount of diffraction would occur at such features. In effect, the diffraction would afford a limited ability to see corners and to see around corners. Hence, the system might utilize diffraction to detect corners associated with negative obstacles. At the time of reporting the information for this article, preliminary analyses of diffraction at simple negative obstacles had been performed, but an explicit description of how the system would utilize diffraction was not available.



A **Robotic Vehicle Approaching a Ditch** would carry a radar system that would detect the ditch by recognizing through differences between (1) the signals actually diffracted and reflected and (2) the signals that would be diffracted and reflected from level or nearly level ground.

Alternatively or in addition to using diffraction, the system might utilize the Doppler effect and/or the radiation pattern of the radar antenna for detecting negative obstacles. For example, if the forward speed of the vehicle were known, then the approximate direction from the radar apparatus to a reflecting object could be determined from the difference between the Doppler shift of the reflection and the Doppler expected of a reflection from an object straight ahead. For another example, if the main lobe of the radar beam were horizontal or nearly so, then the amount of power reflected from a nearby negative obstacle would be less than that reflected from level ground at the same horizontal distance from the vehicle. Combining these two examples, it might be possible to detect approaching negative obstacles through changes in the reflected power and/or in the spectral distribution of the reflected power.

This work was done by Anthony Mittskus and James Lux of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-40413

Cryogenic Pound Circuits for Cryogenic Sapphire Oscillators

Thermomechanical instabilities and associated frequency instabilities are reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two modern cryogenic variants of the Pound circuit have been devised to increase the frequency stability of microwave oscillators that include cryogenic sapphire-filled cavity resonators. Invented in the 1940s and named after its inventor (R. V. Pound), the original Pound circuit is a microwave frequency discriminator that provides feedback to stabilize a voltage-controlled microwave oscillator with respect to an associated cavity resonator. Heretofore, Pound circuits used in conjunction with cryogenic resonators have included room-temperature electronic components coupled to the resonators via such interconnections as coaxial cables. The thermomechanical instabilities of these interconnections give rise to frequency instabilities. In a cryogenic Pound circuit of the present improved type, all of the active electronic components, the interconnections among them, and the interconnections between them and the resonator reside in the cryogenic environment along with the resonator and, hence, are thermomechanically stabilized to a large degree. Hence, further, frequency instabilities are correspondingly reduced.

The active microwave devices required in a Pound circuit are two amplitude detectors and a phase modulator. A Pound circuit generates a frequency-error signal by converting a phase modulation (PM) to an amplitude modulation (AM). The AM in question is generated when a microwave signal that is reflected from a resonator has a high value of the resonance quality factor (Q) and the signal frequency differs from the resonance frequency. A pure PM signal is required because any AM at the input terminal of the resonator would generate a frequency error.

In the present cryogenic Pound circuits (see figure), the active microwave devices are implemented by use of state-of-the-art commercially available tunnel diodes that exhibit low flicker noise (required for high frequency stability) and function well at low temperatures and at frequencies up to several tens of gigahertz. While tunnel diodes are inherently operable as amplitude detectors and amplitude modulators, they cannot, by themselves, induce significant phase modulation. Therefore, each of the present cryogenic Pound circuits includes passive circuitry that transforms the AM into the required PM. Each circuit also contains an AM detector that is used to sample the microwave signal at the input terminal of the high-Q resonator for the purpose of verifying the desired AM null at this point. Finally, each circuit contains a Pound signal detector that puts out a signal, at the modulation frequency, having an amplitude proportional to the frequency error in the input signal. High frequency stability is obtained by processing this output signal into feedback to a voltage-controlled os-