Displacing Unpredictable Nulls in Antenna Radiation Patterns

A simple method could be implemented at minimal cost.

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A method of maintaining radio communication despite the emergence of unpredictable fades and nulls in the radiation pattern of an antenna has been proposed. The method was originally intended to be applied in the design and operation of a radio antenna aboard a robotic exploratory vehicle on a remote planet during communication with a spacecraft in orbit around the planet. The method could also be applied in similar terrestrial situations — for example, radio communication between two ground vehicles or between a ground vehicle and an aircraft or spacecraft. The method is conceptually simple, is readily adaptable to diverse situations, and can be implemented without adding greatly to the weight, cost, power demand, or complexity of a system to which it may be applied.

The unpredictable fades and nulls in an antenna radiation pattern arise because of electromagnetic interactions between the antenna and other objects within the near field of the antenna (basically, objects within a distance of a few wavelengths). These objects can include general vehicle components, masts, robotic arms, other antennas, the ground, and nearby terrain features. Figure 1 presents representative plots of signal strength versus time during a typical pass of a spacecraft or aircraft through the far field of such an antenna, showing typical nulls and fades caused by nearby objects.

The traditional approach to ensuring reliability of communication in the presence of deep fades calls for increasing the effective transmitter power and/or reducing the receiver noise figure at the affected ground vehicle, possibly in combination with appropriate redesign of the equipment at the spacecraft or aircraft end of the communication link. These solutions can be expensive and/or risky and, depending on the application, can add significantly to weight, cost, and power demand. The proposed method entails none of these disadvantages.

The essence of the proposed method is to shift the pattern of nulls and fades by switching electrical connections to parasitic radiating elements. The concept of parasitic radiating elements is not new by itself: parasitic radiators have been used to shape radiation patterns since the earlier years of antenna design. What is new here is the concept using parasitic radiators to shift patterns of nulls and fades, without regard for precise shaping of beams. In a typical operation, one or more parasitic radiator(s) would be switched when the distant communication terminal (spacecraft, aircraft, or ground vehicle) entered a deep fade or null. In the resulting shifted radiation pattern, the distant terminal would likely not be in a deep fade or null (see Figure 2), and so communication could continue.

A parasitic radiating element need not be of any particular design. For example, it could be a simple rigid or springy monopole antenna element approximately a quarter wavelength long. An electromechanical relay could be used to make or break an electrical connection between the base of the element and the chassis of the vehicle. Alternatively, a transistor switch could be used.

In many cases, it would not even be necessary to add components to act as parasitic radiating elements: some of the structures already present, including those that give rise to fades and nulls, could be used as switchable parasitic radiators. For example, an inductor having significant radio-frequency impedance but little DC resistance could be inserted in the grounding path of a robot in parallel with a short-circuiting switch. Then the radio-frequency properties of the arm would be changed and the pattern of nulls and fades shifted by switching between shorting or not shorting the inductor.

This work was done by James Lux and Mark Schaefer of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30898

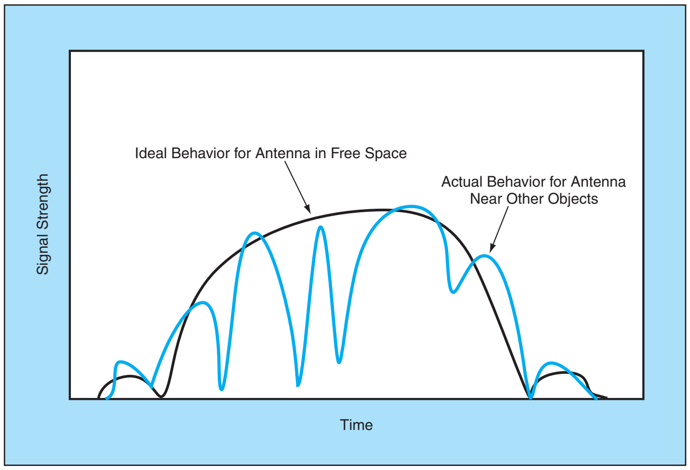

Figure 1. These **Plots of Signal Strength Versus Time** are typical of radio communication with a distant terminal crossing the beam of a stationary antenna. The relatively smooth plot would be obtained if the antenna were suspended in free space. In a more realistic case, nearby objects would give rise to deep fades.

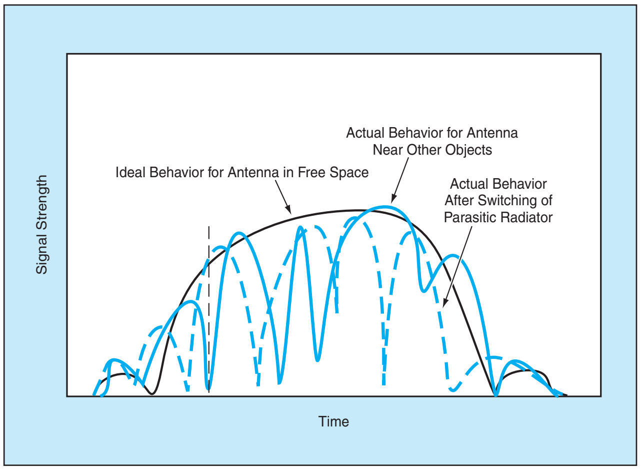

Figure 2. The **Radiation Pattern Would Be Shifted** and otherwise altered by switching of a parasitic radiator. At the time and position represented by the vertical dashed line, the distant terminal would be in a deep fade of the first radiation pattern but near a peak of the second (shifted) one.