Miniaturized Broadband Adaptively-Steered Smart Antenna for Lunar/Mars Surface Networks

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NASA is planning a series of human and robotic missions to explore the Moon and later Mars, and needs electronically steerable antennas for fixed and mobile platforms in surface networks for these missions. An antenna system currently under development for this application at WEO is shown in Fig. 1. This antenna has an instantaneous bandwidth covering 1.9–2.4 GHz, and can adaptively steer its transmit and receive beams for enhanced RF link in an IEEE 802.16 or IEEE 802.11 network that utilizes time division duplexing (TDD).

Fig. 1. Breadboard beamsteered array

The complete antenna system, including an embedded control system, has been reduced to a disk of 13 cm diameter and 5.2 cm height, as shown in Fig. 1 with a contrasting pen. The radome enclosing the antenna has low thermal conductivity and capacitance. This antenna system is a miniaturized and embedded design evolved from the Circular Traveling-Wave Array (J. Wang, D. Triplett, and C. Stevens, *IEEE Trans. Antennas and Prop.*, Nov. 2006). The antenna beam is steered by controlling the impedance states of parasitically excited surface waveguides (SWG) (array elements) surrounding a central driven broadband antenna element. The microcontroller-based embedded system enables the antenna's high reliability, low cost, small size, and scalability.

The smart antenna has two modes of operation: autonomously adaptive and externally controlled. In the autonomous mode, the array searches and monitors a credible received signal, and sweeps its directional beam in azimuth to follow the highest received signal strength (RSS). When the RSS drops below a preset threshold value, the array searches for a new direction of highest RSS. In standby, the antenna radiates omnidirectionally.

In a slow-moving TDD system, the transmit and receive propagation paths are substantially similar, even in a multipath environment. Thus the selected beam state maximizes both received and transmitted signals. It is presumed that noise/clutter in the RF environment for the Moon/Mars surface networks is low, or not present, thus a simple algorithm is adequate to identify the desired signal. The system is scalable, however, to more sophisticated steering algorithms and identification of the signals.

The smart antenna has an optional external operator interface over standard USB or RS-232 serial links, with an open data format, thus is compatible with a wide range of systems and applications. Power consumption has been reduced by about 90% from previous designs by the authors, primarily by replacing RF p-i-n diodes in the SWGs with CMOS RF switches.