Ka-Band Multibeam Aperture Phased Array Being Developed

Phased-array antenna systems offer many advantages to low-Earth-orbiting satellite systems. Their large scan angles and multibeam capabilities allow for vibration-free, rapid beam scanning and graceful degradation operation for high rate downlink of data to users on the ground. Technology advancements continue to reduce the power, weight, and cost of these systems to make phased arrays a competitive alternative in comparison to the gimbled reflector system commonly used in science missions. One effort to reduce the cost of phased arrays is the development of a Ka-band multibeam aperture (MBA) phased array by Boeing Corporation under a contract jointly by the NASA Glenn Research Center and the Office of Naval Research. The objective is to develop and demonstrate a space-qualifiable dual-beam Ka-band (26.5-GHz) phased-array antenna. The goals are to advance the state of the art in Ka-band active phased-array antennas and to develop and demonstrate multibeam transmission technology compatible with spacecraft in low Earth orbit to reduce the cost of future missions by retiring certain development risks. The frequency chosen is suitable for space-to-space and space-to-ground communication links.

The phased-array antenna has a radiation pattern designed by combining a set of individual radiating elements, optimized with the type of radiating elements used, their positions in space, and the amplitude and phase of the currents feeding the elements. This arrangement produces a directional radiation pattern that is proportional to the number of individual radiating elements. The arrays of interest here can scan the main beam electronically with a computerized algorithm.

The antenna is constructed using electronic components with no mechanical parts, and the steering is performed electronically, without any resulting vibration. The speed of the scanning is limited primarily by the control electronics. The radiation performance degrades gracefully if a portion of the elements fail. The arrays can be constructed to conform to a mounting surface, and multibeam capability is integral to the design. However, there are challenges for mission designers using monolithic-microwave-integrated-circuit- (MMIC-) based arrays because of reduced power efficiency, higher costs, and certain system effects that result in link degradations. The multibeam aperture phased-array antenna development is attempting to address some of these issues, particularly manufacturing, costs, and system performance.

A performance requirements and specifications document was developed in-house at Glenn to provide all relevant performance, interface, and environmental specifications for successful operation in the space environment. The array architecture proposes a multi-element module providing a scalable array architecture that addresses both small low-rate and large high-rate users. Systems engineering has provided array antenna pattern analysis, radiofrequency performance predictions against projected link analysis, and power management. MMIC designs for the power amplifier, phase shifter, and buffer amplifier have been completed. Radiofrequency link analysis through the array has been conducted to address waveform and performance specifications. Fabrication of a 16-element prototype array is scheduled for the middle of fiscal year 2004, with a full-scale 256-element array in the middle of fiscal year 2005.

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