Digitally Controlled Slot Coupled Patch Array

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A four-element array conformed to a singly curved conducting surface has been demonstrated to provide 2 dB axial ratio of 14 percent, while maintaining VSWR (voltage standing wave ratio) of 2:1 and gain of 13 dBiC. The array is digitally controlled and can be scanned with the LMS Adaptive Algorithm using the power spectrum as the objective, as well as the Direction of Arrival (DoA) of the beam to set the amplitude of the power spectrum. The total height of the array above the conducting surface is 1.5 inches (3.8 cm).

A uniquely configured microstrip-coupled aperture over a conducting surface produced supergain characteristics, achieving 12.5 dBiC across the 2-to-2.13-GHz and 2.2-to-2.3-GHz frequency bands. This design is optimized to retain VSWR and axial ratio across the band as well. The four elements are uniquely configured with respect to one another for performance enhancement, and the appropriate phase excitation to each element for scan can be found either by analytical beam synthesis using the genetic algorithm with the measured or simulated far field radiation pattern, or an adaptive algorithm implemented with the digitized signal.

The commercially available tuners and field-programmable gate array (FPGA) boards utilized required precise phase coherent configuration control, and with custom code developed by Nokomis, Inc., were shown to be fully functional in a two-channel configuration controlled by FPGA boards. A four-channel tuner configuration and oscilloscope configuration were also demonstrated although algorithm post-processing was required.

This work was done by Thomas D'Arista and Jerry Pauly of Nokomis, Inc. for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18540-1.

Reconfigurable Robust Routing for Mobile Outreach Network

The envisioned lunar network comprises many heterogeneous assets integrated by various protocols and technologies.

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The Reconfigurable Robust Routing for Mobile Outreach Network (R3MOON) provides advanced communications networking technologies suitable for the lunar surface environment and applications. The R3MOON technology is based on a detailed concept of operations tailored for lunar surface networks, and includes intelligent routing algorithms and wireless mesh network implementation on AGNC's Coremicro Robots.

The product's features include an integrated communication solution incorporating energy efficiency and disruption-tolerance in a mobile *ad hoc* network, and a real-time control module to provide researchers and engineers a convenient tool for reconfiguration, investigation, and management.

A new routing protocol extends existing routing methods such that more alternate routes can be found between the source and the destination. This leads to better packet delivery rate as well as larger extent of delivery. Alternate routes can also be used for route optimization wherein the most energy efficient route is chosen. The criterion of energy efficiency can be readily reconfigured to accommodate different design objectives and network requirements.

When disruption occurs, a data buffering mechanism is established so that the undeliverable packet is stored at a dynamically selected storage node while awaiting redelivery. Since the undeliverable packet is not discarded but buffered, robustness is achieved. A proper storage node is chosen by considering its buffer space, battery power, and location.

A hardware prototype network is developed based on AGNC's product solutions such as Coremicro Robot and Coremicro 40 GIS. The multi-robot demonstration scheme incorporates mesh and relay networking. With three network nodes, routing capability is tested, verified, and monitored on this platform with a real-time Coremicro 40 GIS based robot Operator Control Unit (OCU). Multimedia data is exchanged in the network through effective communication and routing, even upon disruption. When one of the direct links is disrupted, an alternative two-hop path can be used to accomplish the communication.

R3MOON offers the following novel features in a complete and comprehensive communication solution:

- Energy-efficient routing achieved through path selection. This approach is highly feasible and implementable.
- Disruption-tolerant routing achieved through data buffering and retransmission mechanism. This approach is also based on AODV (*ad hoc* on-demand distance vector) routing protocol. Retransmission from the storage node achieves more graceful packet discarding rate, faster restoration, and higher redelivery rate than retransmission from the source node.
- Implementation and performance demonstration through software and hardware realization. The simulation shows animation for the route discovery process, and validates the performance of the proposed method in vari-