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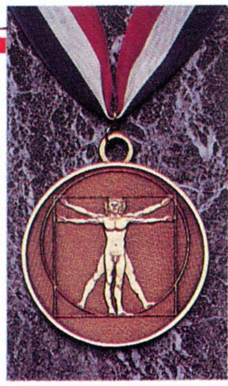


Roll Rings Transfer Signals and Power in Space

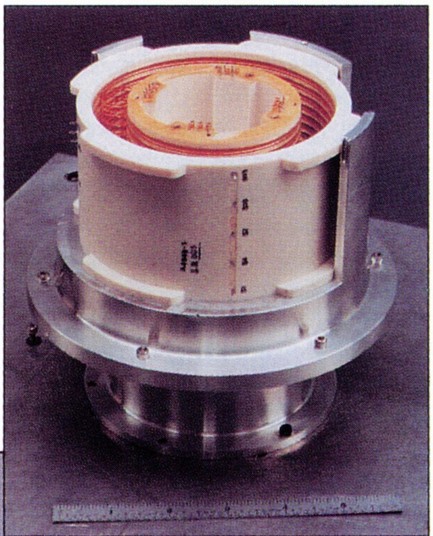
Pete Jacobson's system eliminates wear debris and offers low torque, longer life

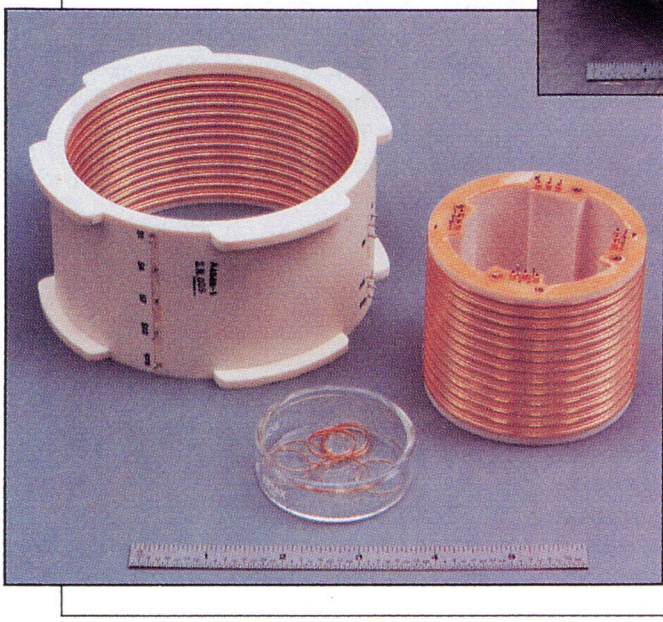
Gail M. Robinson, Associate Editor

Phoenix, AZ—Designing a system to transfer signals and massive amounts of power across several rotating axes represented a complex issue for Space Station Freedom designers. Slip-rings, commonly used in this sort of application, cause certain unavoidable problems.

For example, wear debris created by slip rings can cause massive short circuits that lead to spacecraft failure. Further, driving slip rings requires high torque, and they can be designed to operate in an air- or vacuum environment, but not in both. For the design engineer, this means that test procedures become longer and more complicated.

Engineers at Honeywell's Satellite Systems Operations (HSSO) have developed an efficient alternative means of transferring ac and dc signals and power by replacing slip rings with roll rings. Looking much like a wedding band, a typical roll ring (or flexure) measures about 0.5-inch in diameter. The concept is to fit or capture the flexure in the annulus between two grooved inner and outer concentric rings (with diameters that vary from one inch to 10 inches) that are aligned with a common axis. When attached, the conductive flexure provides a precise, mechanically stable, electrical coupling between the inner and outer rings.





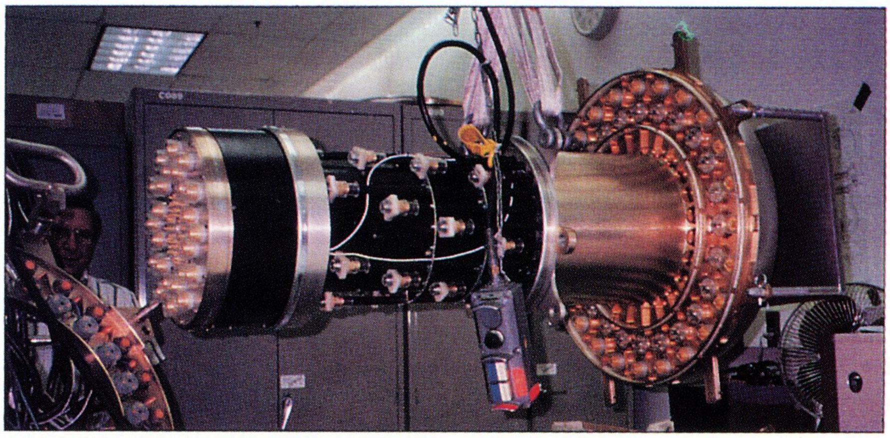
A simple design concept, signal roll ring modules consist of three major components: outer ring (left); inner ring (right); and the 0.5-inch-diameter flexures. In operation, the flexures are captured in the annulus space between the inner and outer rings (upper left). The rolling electrical interfaces offer stable electrical coupling between the two larger rings. When the system is compared to slip rings, drive torque reductions of two orders of magnitude are not uncommon.

In operation, the module has the same function as a slip-ring brush assembly. But it operates by means of rolling electrical contact interfaces instead of sliding contact, as in the case of slip rings. The number of flexures can vary from one for signal levels, or many for high-current transfer.

Developed and patented by Senior Staff Engineer Pete Jacobson, this simple design offers significant advantages over traditional technology including: torque reductions of up to two orders of magnitude; near-zero wear; long life; reduced sensitivity to the environment; reduced assembly and test costs; and high power transfer efficiency.

The geometries of the ring grooves and the flexure stabilize rolling dynamics and kinematics. This stability ensures that the flexure does not escape the ring grooves, even under high-G loading, and that the flexure/ring contact tracks remain uniform and predictable. The design also tolerates normal radial, axial, and angular misalignment. It produces two contact footprints at each inner and outer ring track, independent of reasonable misalignments. The machined-in geometry controls this radial preload.

A key feature is the compartmentization of the sets of circuits into



Power and signal roll rings in the UTA provide efficient alternatives to slip rings and rotary transformers. They transfer signals at millions of data bits per second and as much as 100 kW of power across rotating interfaces in both air and vacuum.

modules. Each module consists of the inner and outer ring, the flexures, and an end cap on each end of the device. Secured to the inner-ring assembly, the end caps provide both radial and axial clearances to the outer-ring assembly. When the module is mounted in the final assembly, ball bearings support it. The modules are stand-alone units that can be assembled, tested, and stored for subsequent loading into a bearing/housing subassembly.

This basic arrangement allows for a variety of different configurations, such as the separation of shielded and nonshielded circuit sets, high voltage and low voltage sets, low current and high current designs, and various other arrangements. Most important, no adjustments are required after assembly. Slip rings, on the other hand, require a number of stages of assembly, and after assembly skilled technicians must adjust the brushes to achieve proper alignment and preload. "Assembly is easier than putting together an erector set," says Jacobson. "There are no adjustments because the assembly establishes the proper loads and alignments. Basically, the engineer just slips it into the mechanism."

The technology has proven ideal for two systems in the Space Station Freedom: The Utility Transfer Assembly (UTA), designed to transfer signals and power across the Alpha axis, and the Power and Data Transfer Assemblies (PDTA) which provide signal transfer through the rotating radiator joints.

David Koehler, section head of the engineering project, says the UTA can transfer as much as 100 kW of power and millions of data bits per second across rotating interfaces in air and vacuum environments. It has 48 channels of signal and data transfer and 24 channels of high level power transfer. The assembly transfers the signals on 1553 data buses and communication networks, as well as both low and high level power.

Ease of assembly represents a key advantage in the design of both systems. "To assemble 12 or 15 circuits only takes 30 minutes. With slip rings, where you would have to preset each brush, it can take two or three days," says Jacobson. "Once you put the roll ring module together you're through with it."

In the case of high power transfer, the improved efficiency of the power units reduces the conversion of electrical power to heat. For example, only 50W of heat are generated when 60 kW of power is transferred across the UTA.

The UTA is 99.9% efficient, which according to Koehler, "is the highest efficiency we know of." Both units have been successfully life-tested under extreme temperature and vacuum environments at HSSO and NASA's Lewis Research Center in Ohio. They reportedly meet all the required performance specifications.

Where to go from here? Jacobson and Koehler believe this design is just the beginning of a budding technology. With its many operational advantages, they expect roll ring modules to find a place in both aerospace and terrestrial mechanisms.

Pete Jacobson officially retired as Manager of the Applied Sciences Dept. at HSSD three years ago. Acknowledging his expertise, Honeywell hired him back as a subcontractor in charge of the roll ring design in the Space Station. He now works part-time on the project—he calls that 40 hours a week. He has 23 patents with four pending.

OTHER APPLICATIONS

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