Fiber Brush Slip Ring Technology for Mission-Critical Aerospace and Military Applications

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Poly-Scientific's patented* fiber brush slip rings bring tremendous advantages to a wide variety of military/aerospace applications.
Already successfully proven in many systems, their popularity continues to climb as they offer improved performance in diverse aerospace, sea and land-based craft.

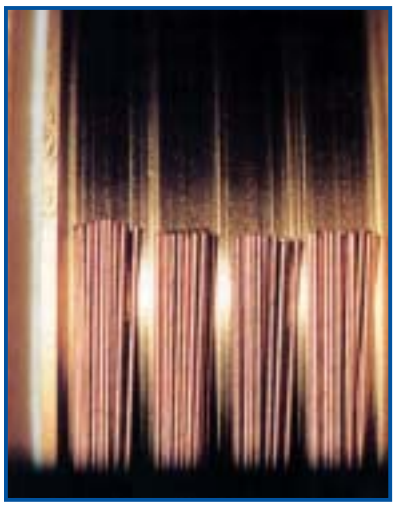
Fiber Brush Technology for Military/Aerospace Applications

Military/aerospace slip rings and brushes are generally designed using traditional contact technologies such as lubricated monofilament brushes or self-lubricating composite brushes. While these traditional approaches have proven to be successful through testing, and flight and field experience, improved performance is always desirable. To that end, we developed the patented fiber brush technology. A chart comparing the advantages of different contact technologies is shown on page four of this brochure.

Military/aerospace applications require slip rings that provide minimal debris generation, low electrical noise, both high and low current transmission capabilities, low outgassing and a long operational life. They must also operate flawlessly in a wide operating temperature range, and at a variety of brush/ring surface speeds, as well as in air or vacuum conditions.

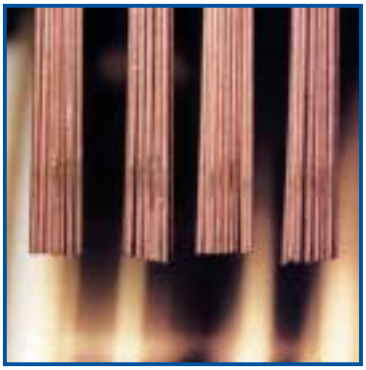
Fiber Brush Contact Technology

Fiber brush is the term for a particular design of sliding electrical contacts. Fiber brushes are simply a group of individual metal fibers (wires) that are collimated by and terminated into a metal tube as illustrated in the photo on the left. In this cantilevered design, the free, unterminated end of the fiber brush bundle rides in a groove on the ring surface.



Many Advantages

Fiber brushes have many distinct and measurable advantages over conventional slip ring contacts in military/aerospace applications:



- Multiple points of ring contact per brush bundle
- Ability to perform in ambient conditions as well as in vacuum conditions
- Contact surfaces that do not require lubrication

- Long life
- Low contact force per fiber
- Low contact wear rates
- High power circuit density
- Low dynamic contact resistance (noise)
- High and low current carrying abilities
- Low outgassing
- Very little debris generation
- Wide operating temperature range
- Wide range of brush/ring surface speeds

Proven Military Performance

An alternative to traditional slip ring contact designs, Poly-Scientific's fiber brush was developed to meet demanding aerospace applications - where extremely tight tolerances and virtually flawless performances are required. The technology has now been used in such demanding, mission-critical military applications as:

- Shipboard navigation and collision avoidance radar
- Helicopter flight control and de-icing blades
- Stabilized fire control systems
- Forward-looking infrared (FLIR) systems,
- Solar array drive assemblies (SADA)

And others.

*U.S. Patent #4398113 and other foreign patents

A Growing Aerospace History

Performance of aerospace systems is often judged on flight history, and Poly-Scientific's fiber brush aerospace rated slip rings have proven that they can perform in this demanding environment. They have an impressive heritage of actual spacecraft usage and are continuing to accumulate test data during vacuum operations. Flight history has proven that the contacts function equally as well in air as in vacuum conditions, eliminating the need for expensive vacuum test facilities. Following is a partial list of spacecraft on which the technology is presently serving:

- EOS-AM
- A2100
- A2100-AX
- Astrolink
- P-91-1
- Olympus
- SBIRS
- Eurostar/Inmarsat

Military Roots

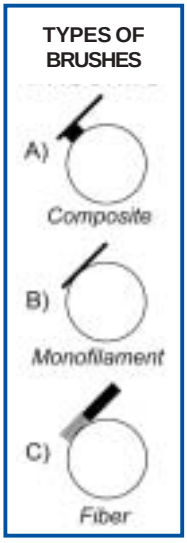
Poly-Scientific has its roots and expertise based deep in the area of government/military manufacturing. The quality and precision demanded to conform to space, weapons, aircraft and other mission-critical program requirements have long been a tradition in our company. This stringent quality is still prevalent today in all of the design and manufacturing processes within Poly-Scientific. While we've adapted our technology for use in the commercial marketplaces, the defense community remains a cornerstone of our business.

All of our experience and expertise helps military/aerospace customers in a very real and measurable fashion. We fully understand military requirements. And by teaming with our customers, we are able to efficiently coordinate their needs with our engineering department. This approach slashes development time and enables us to pursue very aggressive design schedules. We utilize computer-aided models to both characterize and optimize the mechanical and electrical design parameters. The resulting outputs are used to ensure that hardware performance meets our customer's system requirements, while reducing design risk.

As a Joint Services Provider to all branches of the military, we can put our decades of experience to work for you.

Technology Comparison - Fiber Brush and Traditional Contacts

Generally, aerospace slip rings and brushes (sliding electrical contacts) are designed using traditional contact technologies such as lubricated monofilament wire brushes or self-lubricated composite brushes. These approaches have been proven successful many times through testing and actual flight experience. There are, however, some disadvantages to these approaches.



Composite Brushes

Unlike monofilament brushes, composite brushes provide their own lubrication through the addition of an embedded solid lubricant to the composition of the brush. The nature of this lubrication mechanism requires that the brush must experience wear to transfer the lubricant from the brush to the ring. This wear results in some amount of electrically conductive debris being generated within the slip ring. While small amounts of this debris can generally be tolerated if proper design procedures are followed, the extended life requirements of new aerospace slip rings could result in the generation of intolerable amounts of this conductive debris.

Also, the contact materials used in composite brush slip ring designs can be contaminated by absorption of airborne gasses. The principal form of this contamination is silver sulfide, which appears as tarnish. When exposed to temperatures of less than 178°C, these films have semiconducting properties (increase in electrical conductivity with increased temperature). The presence of silver sulfide films at low temperatures may cause unacceptably high contact resistance on low current circuits.[1] On the following page is a chart that summarizes the characteristics of the different types of contact technologies.

Monofilament Brushes

Aerospace rated monofilament brushes depend on intentional lubrication of the contact surfaces to perform properly. Many of the liquid lubricants used will not meet NASA outgassing requirements, and the ones that do typically have poor viscosity characteristics at low temperatures. Designs using this contact technology must be analyzed to ensure that sufficient lubrication is maintained throughout the system life requirements.

Materials Choices

One of the most important features of any military or aerospace design is the choice of component materials. Materials must be carefully chosen to reduce outgassing, control dissimilar thermal expansions, reduce galvanic corrosion, and provide nuclear hardening, among other concerns. Materials choices for fiber brush slip rings are much the same as used in traditional slip ring designs with the major exception of the contacts. Fiber brush contacts (fiber and ring surfaces) can be manufactured using alloys of copper, gold, silver and palladium. The actual choice of contact materials depends largely on the electrical requirements of the slip ring. Poly-Scientific controls all materials and materials suppliers to verify and ensure consistent quality.

Integrated Motion Technology Systems

While we've highlighted our slip ring expertise in this brochure, we can offer much more to your program. In addition to our core rotary motion and control products including motors, resolvers, slip rings and higher order assemblies, we offer drive and control electronics. These higher order assemblies range from simple combinations of slip rings and resolvers to sophisticated electromechanical assemblies such as high-end actuators complete with precision gearing and the associated control electronics - a system we describe as Integrated Motion Technology (IMT). IMTs can include rotary motion products, harmonic

Comparison of sliding electrical contacts for space applications.

Composite Brushes Ag/MoS_2/Graphite	**Monofilament Brushes** Lubricated	**Fiber Brushes** Unlubricated
Most flight history	Considerable flight history	Growing flight history
Meets outgassing requirements	Does not meet outgassing requirements	Meets outgassing requirements
Self lubricating contacts (solid lubricant in brushes)	Requires liquid lubricant on contact surface	No oil or dry film lubricant application required
Requires largest ring-to-ring axial pitch	Requires smallest axial pitch (50% of composite brush pitch)	Requires less axial pitch than composites (70% of composite brush pitch)
Manufacture subject to greatest number of process variables	Manufacture subject to few process variables	Manufacture subject to few process variables
Greatest amount of wear debris generation (approximately 100 times the wear rate of fiber or monofilament brushes)	Much smaller amount of wear debris generation than composite brushes	Smaller amount of wear debris generation than composite and monofilament brushes
High electrical noise if operated in humid environment	Low electrical noise in air and vacuum	Low electrical noise in air and vacuum
Must operate in vacuum or dry inert atmosphere	Operational in air or vacuum with lubricant present	Operational in air or vacuum
Wide operating temperature range	Viscosity limited operating temperature range	Wide operating temperature range
Wide range of surface speeds	Limited range of surface speeds	Wide range of surface speeds

drives, potentiometers, fiber optics, RF rotary joints and other components that naturally integrate with such systems.

IMTs provide our customers with many, measurable benefits, including:

1. ***Compact systems that operate at peak performance.*** The IMT approach ensures precision performance of all of the components. Our unique expertise enables us to design a system that typically results in reduced size and weight. IMTs are electrically and mechanically aligned, fully tested and ready to integrate into your system.

2. ***Resource Optimization.*** Many of our customers have reassigned their in-house IMT resources to other areas. By focusing their resources on their global mission, they can concentrate on what they do best.

3. ***Accountability.*** You are assured that all system components will integrate properly and work optimally. And, in the rare case that a technical problem should occur, you know exactly who to call for immediate help. Dealing with one IMT source streamlines purchasing, technical and program management efforts.

Fiber Brushes in Commercial Applications

This same fiber brush technology is also successfully serving in many commercial applications such as manufacturing and process control equipment, robotics, electrical test equipment, medical equipment and cable reels, to name a few. Our line of standard, off-the-shelf fiber brush slip rings includes designs with 1-1/2" and 4" through-bores, high speed and compact models. These products are also benefitting military customers in many applications to meet their Commercial-Off-The-Shelf (COTS) demands. To find out more, call us for a brochure, or visit our web site.

Our Staff

Our staff includes electrical, mechanical, manufacturing and software engineers, metallurgists, chemists, physicists and materials scientists. Our emphasis on research and product development has provided us with the expertise to solve real-life manufacturing problems. Using state-of-the-art tools in our complete analytical facility, our capabilities include a full range of environmental test, calibration and inspection services. We have recognized expertise in tribology (the science of friction and wear), precision gearing, magnetic circuit design, PWM amplifier design and in the supporting materials sciences.

Our engineers can work from your designs, or create a custom design for you.

Consistent Quality

Poly-Scientific places a continuing emphasis on quality manufacturing and product development to ensure that our products meet our customer's requirements as well as our stringent quality goals. In 1990 we committed to the Total Quality Management Program with a policy of "Do It Right the First Time" and a goal of "Zero Defects". We are ISO 9001 Certified to ensure the consistent quality and reliable performance of our products.

The newest initiative of our division is Demand Flow® Technology (DFT). DFT is a demand driven manufacturing flow system that economically manages in-process inventory. The concept operates with a "line-of-sight" premise which provides visibility for all in-process work. This concept has helped the division be more efficient and flexible to customer schedule changes, reduced inventories and improved organizational operations. Benefits include streamlined processes to accommodate jobs with a quick turnaround, reduced cycle time to cut costs, and greater customer responsiveness.

(1)Roberts E.W., *Sliding Electrical Contracts in Space: Observations on Existing Technology and New Trends in Low-Speed Applications*, European Space Tribology Laboratory.

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