The Challenges of Spaceflight for Connector Designers

Technical Article

Positronic®

The future of space exploration

We are in a new era for space travel. The launch of the SpaceX Crew Dragon in 2020 saw the birth of commercial space travel and with it, renewed interest in space exploration. While spaceflight is no longer in its pioneering phase, when every launch was front page news, there is a new understanding of the opportunities that space can provide.

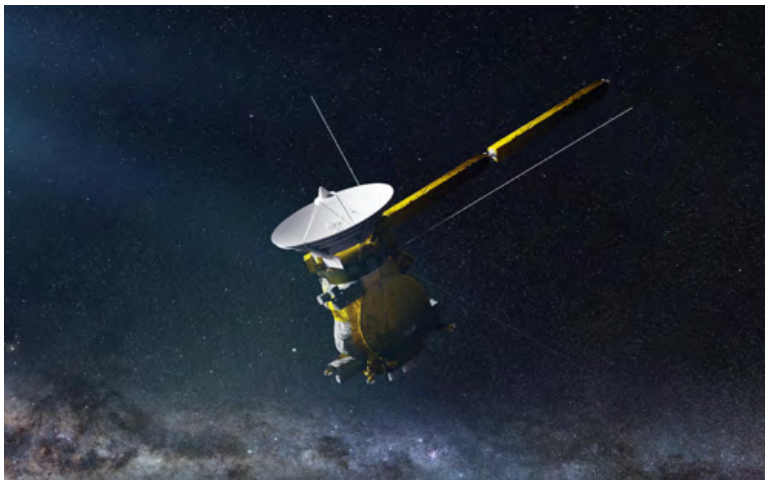
The commercial use of spaceflight is an increasingly important, but often unseen, element in modern society. From communications and navigation to weather forecasting and farming, we are dependent on the services and information that are provided by the constellation of satellites in orbit around our planet.

Nor has the scientific community been idle. The exploration of space using both manned and unmanned techniques is providing key insights in a wide range of scientific fields. The next decade will see new expeditions to the moon, Mars and beyond.

Positronic has over four decades of experience in designing connectors for spaceflight applications. With a range of products that are certified by the world leaders, Positronic designs offer the features and materials needed to provide superior performance in this demanding industry.

The Environment

Space is an unforgiving environment. The vacuum of space, combined with extreme temperatures and long-term exposure to radiation, makes the task of designing equipment for use in space a unique challenge. On Earth, our atmosphere is a protective layer of gas that provides pressure, thermal insulation, and safety from harmful radiation. In space, this protection is stripped away, exposing equipment to potential damage.

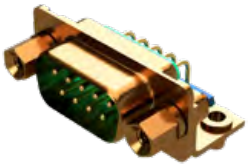


The harshest environment

Without the atmosphere, any object in space receives the full force of the sun's radiation. When exposed to direct sunlight, temperatures can quickly become dangerously high while, in contrast, areas in shadow are very cold. These extremes of temperature need to be considered when selecting the materials to be used aboard space vehicles. Positronic connectors employ high-grade materials and plastics that provide a very wide operating temperature range.

The lack of atmospheric pressure also causes materials to behave in unique ways. Outgassing is a process in which a gas that has become trapped inside another material is released. This is a common problem when plastic is exposed to a vacuum during spaceflight. The gas that has been released can condense onto cold surfaces, often the optics and sensors of scientific equipment. This can degrade or even negate their effectiveness and put the entire mission at risk. The Positronic D-subminiature connectors designed for space employ plastics which exhibit high stability in vacuum conditions. The standard density family uses plastic insulators manufactured from glass-filled DAP (Diallyl Phthalate), while the high-density and combination families use PBT (polybutylene terephthalate).

High-density insulator material, PBT (polybutylene terephthalate)



Standard-density insulator material, DAP (Diallyl Phthalate)

Reliability

Typical space missions last many years, and systems designed for spaceflight need to perform without the chance of repair. At the same time, the cost of launching heavy vehicles into space is high, so designers do not have the luxury of including backup systems. Connectors designed for spaceflight therefore need to provide long term reliability and resistance to the rigors of launch while remaining as light as possible.

In addition to the need for mechanical reliability, systems used in space are often designed for long-duration missions. Over the course of the mission, the management of power is of primary concern, and many space vehicles operate with a strict power budget to ensure the longest possible operational life. With such a strict power budget, any component that introduces unwanted electrical resistance will risk jeopardizing the mission.

The nature of the mission must also be considered when specifying connectors. Sophisticated instruments mounted to space probes are frequently used to measure low-power signals, whether they are sensitive scientific observations or communications from hundreds of millions of miles away. In these examples, unwanted electrical resistance can prevent a critical signal from being collected.

The design of the electrical contacts within a connector is the greatest factor in the overall reliability of the system. Positronic has developed the PosiBand contact system that offers the best combination of physical robustness and resistance to vibration with excellent electrical characteristics.

PosiBand Contacts

High Performance Contact Design

High reliability electrical contacts, such as those used in aerospace and spaceflight, have traditionally been of solid machined construction. They use a split-tine design to provide contact retention, one which can be pried open under harsh conditions. This results in a reduction of the normal force, which in turn affects the electrical performance of the contact. These are unsuitable for the demanding conditions found in space applications.

The PosiBand is a closed entry contact design. The mating end of the female contact is a solid ring, preventing foreign objects or mechanical forces from causing damage. Electrical contact is maintained by a separate spring clip which provides a more reliable retention force, making PosiBand an ideal solution for the demanding conditions of spaceflight.

In addition, the construction of the PosiBand contact itself helps to provide improved reliability. Conventional contacts are often annealed to make the crimp barrel of the contact pliable. However, if the mating end of the contact is also annealed, the elastic characteristics of the split tine design are compromised. This can adversely affect the retention force of the contact. In contrast, as the PosiBand contact uses a separate spring clip, the body of the contact can be manufactured from materials that do not need to be annealed. This eliminates the chance of vibration causing mechanical relaxation of the contact area.

The annealing process also reduces the conductive properties of the contact, increasing its electrical resistance. The PosiBand contact does not need to be annealed and so, when combined with the large surface area afforded by its design, the result is a contact with a lower electrical resistance. This low resistance translates into a more efficient electrical circuit, allowing engineers greater control over the strict power budget. It also results in reduced losses of sensitive signals in communications or science experiments. The PosiBand contact can also be manufactured in high conductivity copper alloy to improve contact resistance even further.

Sensitive Instruments

It is important to reduce the magnetic signature of the components themselves. If you have ever tried to use a magnetic compass inside a vehicle, you will be aware that the body of the vehicle can affect the accuracy of the instrument. The electromagnetic interference encountered in space, whether found in the environment or generated by the spacecraft itself, can similarly interfere with onboard systems.

D-subminiature spaceflight connectors

To reduce this risk, connectors destined for spaceflight applications use materials that provide the best possible performance. The trapezoidal shells of D-subminiature connectors provide protection to the contacts and ensures correct mating. Traditional D-subminiatures use shells made of steel, but the versions destined for spaceflight use brass to minimize their magnetic signature.

The shell also provides protection against electromagnetic interference (EMI). In the vacuum of space, unprotected by a blanket of atmosphere, equipment is exposed to solar radiation which can interfere with scientific observations or even damage sensitive instruments. The shells of Positronic D-subminiature connectors are gold plated to provide the best possible protection against EMI.

Connectors for the Future

The future of spaceflight is exciting. The entrance of commercial ventures into the realms of science, communication and even tourism mean that the next decade will see a growth in demand for systems that can withstand the rigors of spaceflight. Designers will need access to a range of components that provide the performance and reliability required for long-duration missions in harsh environments, away from the safety of earth.

Positronic connectors have a proven track record of over 40 years use in the demanding spaceflight arena. Trusted by engineers around the world and conforming to some of the toughest specifications in the field of electronics, the range of space-qualified connectors from Positronic provide the technology for the next era of space exploration.