The Challenges of Power and Signal Connector Solutions for Harsh Environments

Whether a military defense vehicle traveling through the desert on a support mission or a deep space probe gathering millions of dollars worth of research data, harsh environments pose various challenges for electrical power and signal connectors.

Figure 1. *Harsh environments include sand, dust, extreme temperatures, and shock loadings. Image provided courtesy of Pixabay.*

This white paper focuses on the challenges of power and signal connectors operating in harsh environments; explains how the Positronic SP Max product line provides the rugged, reliable, versatile performance needed by harsh environment applications; reviews the key features of the SP Max solution; and discusses the specifications and typical applications of the SP Max.

Defining Harsh Environments

Harsh environments refer to a set of conditions that make it difficult for a specific electrical and electronic component to function properly. For electrical and electronic connectors, harsh environments include extreme temperatures, shock, vibration, humidity, water, corrosion, dust, outgassing, and electromagnetic interference/radio frequency (EMI/RF).

As connectors are used in a variety of industries, each harsh environment presents its own challenges. Aerospace and automotive connectors are regularly subjected to aggressive shock and vibration loadings, shaking the connector loose and compromising the connection. Military land vehicles need connector solutions to keep out the dust, sand, and moisture they are often exposed to.

Connectors for space applications, such as satellites, must meet stringent requirements involving outgassing. In the pharmaceutical and chemical industries, harsh environments include exposure to corrosive chemicals impairing the exterior of the connector and causing damage.

Figure 2. *Connectors for space applications face their challenges, including shock loads and outgassing. Image provided courtesy of Pixabay.*

Challenges for Connectors in Harsh Environments

A harsh operating environment makes it difficult for power and signal connectors to perform reliably. One of the challenges for connectors operating in harsh environments is consistent functionality and performance over a range of conditions.

Extreme temperatures and Temperature fluctuations
Engineers expect connector solutions to provide consistent performance over a wide range of temperatures, resulting in issues with heat dissipation. Temperature fluctuations, often found in aerospace applications, may also impact performance and connectivity.

High power transmission
Some connector solutions must be able to handle high-power transmission — an ability in increasing demand. Solar power and other forms of renewable energy are examples of applications in which connectors must provide consistent performance despite extreme temperature fluctuations and exposure to dust and moisture.

Limited visibility for installation
Limited visibility is a problem in many situations making it difficult for technicians to achieve a solid connection. Being able to install connectors ensuring the contacts (blind mating) are aligned or where connection points are in highly space-constrained areas is particularly important in high-stress conditions, such as defense applications.

Space, Weight, and Power (SWaP) constraints, shock and vibration loadings
The SWaP requirements are critical for defense, aerospace, satellite, space, and commercial air applications. Weight can impact fuel consumption, and the available load-carrying capacity and space are always at a premium.

One of the challenges with SWaP is keeping connectivity solutions lightweight enough to minimize their impact on power consumption but rugged enough to handle shock loadings and vibration that can compromise the connections. Devices such as Unmanned Air Vehicles (UAVs), for example, must remain lightweight to minimize the unnecessary loss of battery power.

EMI/RF interference
EMI/RF interference pose a severe issue for signal transmission, especially for control signals in mission-critical applications. Emitted interference can affect the functionality of nearby equipment, while received interference can scramble data and control signals. Good quality connectors provide EMI/RF shielding.

Positronic SP Max

The Positronic SP Max rectangular connectors (Figure 3) were developed specifically for power and signal management in military, space, satellite, commercial air, and applications under expected harsh conditions.

Figure 3. *The Positronic SP Max connectivity solution.Image source.*

These connectors are reliable over a temperature range of -55°C to 175°C, made possible through liquid crystal polymer (LCP) insulators coupled with a slim metal housing that promotes rapid heat dissipation. Positronic SP MAX connector solutions also handle wide temperature fluctuations.

For applications with limited visibility, the Positronic SP Max is engineered with integral blind mating capability, allowing for up to 2mm of offset and for connections in tight spaces or in other situations with limited visibility.

The compact, lightweight Positronic SP Max is rated up to 35A per contact at a temperature rise of 30°C, making it capable of handling high-power loads and performing effectively in high-power need applications. SP Max connectors are rated at 500 mating cycles, and their size, weight, and power density make them ideal for SWaP applications.

These connectors are versatile, suited for a variety of applications, with numerous configurations available. Accessories include fixed male jackscrews, rotating female jackscrews, quick locking pins, quick locking sockets, and four different keying guides. Angle bracket options and standoffs are also available. In addition, these connectors can have either a wire of printed circuit board (PCB) terminations and the contacts can be fixed or removable.

SP Max connectors are constructed with thin, heat-dissipating aluminum shells that are precision machined and available in 3 sizes:

- X, 18 mm of active insulator
- S, 40 mm of active insulator
- M, 65 mm of active insulator

Also available are a range of contacts, including #12, #16, #18, and #22, and 21 layout options, a few of which are shown in Figure 4. Furthermore, the shells provide outstanding EMI/RF protection.

Figure 4. *The SP Max comes in a wide variety of contacts and layout options. Image source.*

Positronic SP Max Technical Specifications

Electrical Characteristics

The insulator resistance is at 2.5 GΩ with an initial contact resistance as low as 0.5 mΩ. The proof voltage is up to 2200V (rms), and the working voltage is up to 600V (rms). The Positronic SP Max connectors are rated up to 35A per contact at 30ºC temperature rise. The contact current ratings are 35A for power and 3A for signal.

Contacts

The contacts, available as fixed or removable, are manufactured from a copper alloy available with gold flash, 0.76µm Au (min), and 1.27µm Au (min) contact plating options. The black LCP insulators have a UL 94V-0 flammability rating. Also, note that the contacts' retention is between 27N and 67N.

Performance Standards

The Positronic SP MAX complies with several strict performance standards, including EN4165, ESA/ESCC-3401, DO-160, and low outgassing per ASTM E595. They are also FAR-25-853(a) and FAR-25-855(d) qualified.

Applications of the SP Max

The SP Max connectivity solutions are well-adapted for various harsh environment applications including deep space complex and planetary-based communications. Other applications include:

- Line Replaceable Units (LRUs) for military, space, satellite, and commercial air applications
- Battery and solar power distribution and management
- High-wattage switchable power supplies
- Inside-the-box power and signal distribution
- Ground, air, and space-based transport
- Power and signal I/O

Conclusion

The challenges posed by harsh operating environments demand robust and reliable electrical and electronic connectors. Positronic SP Max connectors offer a comprehensive solution tailored specifically for harsh environment applications, combining rugged construction, versatile performance, and stringent compliance with industry standards.

With features such as blind mating capability, high power transmission capacity, and heat dissipation, SP Max connectors excel in scenarios ranging from military missions to space exploration. Their adherence to rigorous specifications and standards and a wide range of layout options and accessories make the connectors ideal for critical applications requiring consistent functionality and performance.

As technology continues to push the boundaries of exploration and innovation, the Positronic SP Max provides resilient connectivity solutions for the challenges of harsh operating environments.

For more information, please reach out to a Powell representative at posiinfo@powell.com, call us at 800-235-7880, or visit our website at www.powell.com.