HARWiN

Maximizing Power in High-Reliability Applications: Applying SWaP to Connectivity

Introduction

How does Size, Weight, and Power (SWaP) relate to connector selection for high-rel applications? This white paper will look at key considerations design engineers face when selecting high-power components and present real-world applications in which power connectors are being used.

What is SWaP?

Size, weight, and power are three key elements when discussing connectors in general but they're particularly important for high-reliability and high-power connectors. High-reliability products withstand certain physical conditions such as temperature extremes, humidity, shock, and vibration.

Size

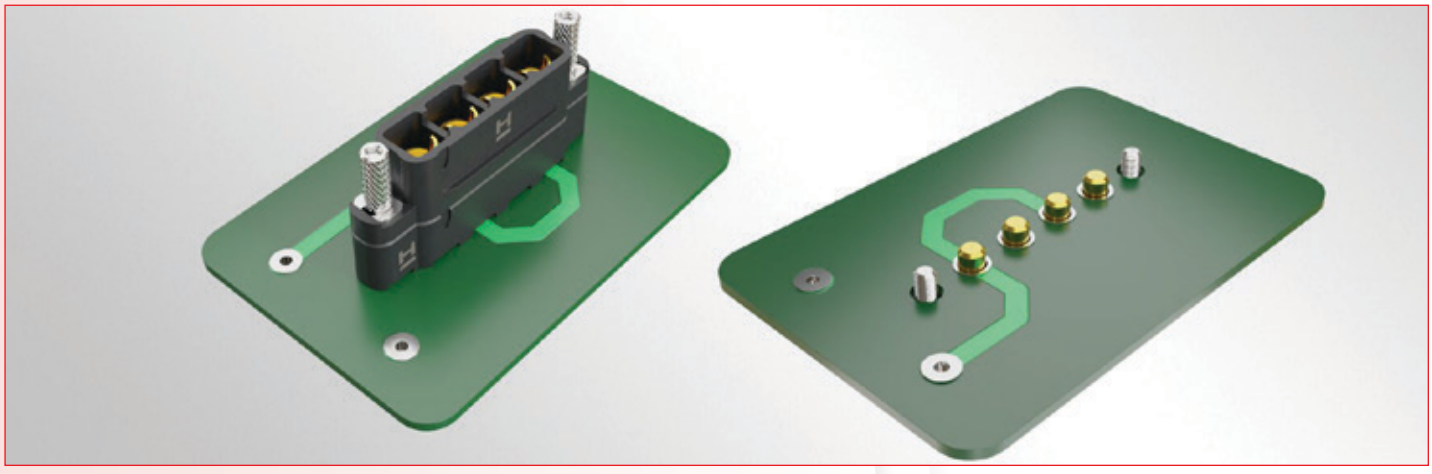
Let's first look at Size. In high-reliability applications, PCB space is often at a premium such as in the space industry for cube and nano satellites. Size is particularly important when evaluating power connectors, as these often tend to be larger and more rugged than smaller standard signal connectors.

There are a number of different features that can determine the amount of space a connector may need and these can be affected by:

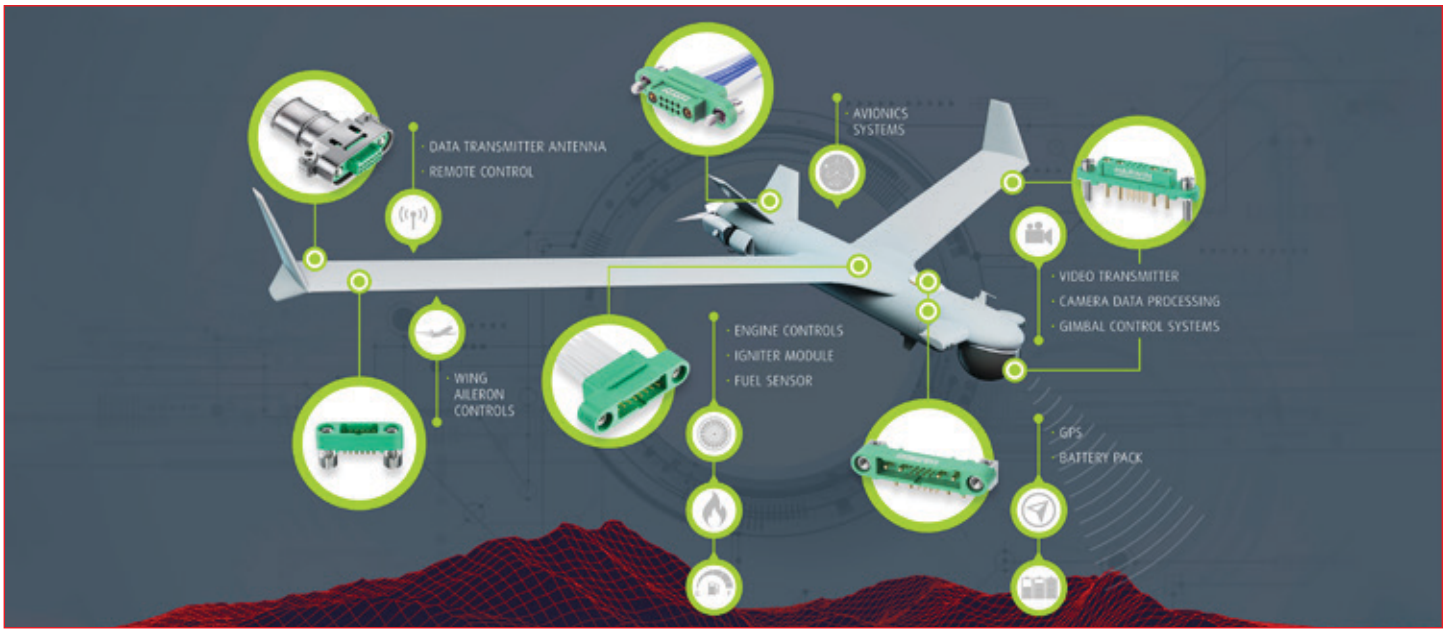
- **Pitch**: This is the spacing between contact centers. A higher current will require larger contacts, which will increase the pitch. More distance between contacts also allows for higher maximum voltages. The pitch (combined with the number of contacts) will impact the overall size of the connector.
- **Locking mechanism:** The locking mechanism or securing feature you need will require additional PCB real estate. Latches take up a minimum of additional space, whereas jackscrews require more space but provide a more robust and secure connection.
- **Termination method:** Customers can choose between surface-mount (SMT) or through-hole terminations when mounted to a PCB. The chosen connector will likely be dictated by volume, assembly methods, or real estate available on the board.
- **Connection type:** The type of mating pair chosen can also affect the size of your solution. If you opt for a board-to-cable connection, you need to ensure there is enough space to run cable assemblies. Higher-power contacts may be designed for use with thicker or bigger cables, meaning a larger bend radius.
- **Number of contacts:** This also will determine the size of the connector.

Weight

Weight is the second part of SWaP and is a crucial factor in terms of connector selection. Weight savings can often lead to cost savings in high-reliability applications, particularly in autosport and space markets. The metric used in the space industry is weight vs. cost. A typical satellite launch can cost up to $70,000 per kilogram of weight, which translates to $70 per gram, so every



Hardware, such as screws, adds reliability, but is a trade-off with space, on both sides of the PCB.



Gecko-MT connectors are suited for power applications where weight and space are at a premium such as aerospace and New Space.

gram saved can reduce the cost of the launch or enable more functionality to be added to the payload.

High reliability is also needed in the expanding market of high-altitude UAVs. These lightweight vehicles are expected to carry out longer flights with heavier payloads, often using battery or solar-powered propulsion. The weight metric within this industry is often mass versus mission time; one gram saved can add one extra minute to a mission.

To help reduce the weight of a connector system, you may choose connectors manufactured of lightweight engineering-grade plastic that provides strength and drastic weight savings, particularly compared to products that use a metal shell. Not only does weight savings contribute cost savings but it also ensures increased functionality in the same board area and extra mission time capabilities.

Power

Power is the P in SWaP. There are a number of considerations design engineers face when dealing with power connectors, from designing, manufacturing, and testing them, to specifying the right connector for the end application.

Temperature rise versus current establishes the amperage rating of connectors. Current de-rating uses the same data as temperature rise versus current testing; however, the results are inverted to provide a de-rating graph. Current de-rating enables customers to understand in which applications and conditions the connector can be used while supplying a certain amount of power.

Size and current combine to determine the power density of a connector. Values are calculated by taking the maximum current per contact, multiplying by the number of contacts, and dividing by the overall length of the connector. These values just consider the amperage, not the voltage or other operating parameters of the connectors. So, when choosing a connector, ensure that it suits all desired specifications.

Working voltages are calculated from maximum voltages. A mated connector pair is wired or routed with two adjacent series circuits to create two powered channels within the system. The voltage is then raised until a voltage drop is observed. This is the start of voltage flashover between the two circuits, either across an air gap or through the insulating housing. Once a failure level is established, the connectors are subjected to a marginally lower voltage for 60 seconds; during this time, current leakage is monitored and must stay below 5 milliamps. This is set as the maximum voltage specification. Working voltage is then chosen with a safety factor, but customers can be confident that the connectors will function without issue up to the maximum voltage.

For high-rel connectors, this test is repeated in air pressures lower than 1 atmosphere to recreate performance at altitude, providing a voltage proof specification for aerospace and aviation applications.

Material Selection

When designing a high-rel connector, material selection is a critical factor. The material will have an impact on the connector's

performance specifications, particularly when it comes to SWaP.

UL94V-0 flame-retardant materials are used for all Harwin high-rel products, suiting the product for all safety-critical applications. By selecting plastic housings instead of metal, the weight factor is minimized and the cost of manufacture is lower. The chosen contact material must also be manufacturable and capable of performing to the levels of power, mating cycle durability (avoiding permanent set), and temperature resistance required. In a large connector system — whether it be a high pin count or a high current contact — the majority of weight is often accountable to the contacts. The size of the contact will completely depend on its design requirement.

The final element to consider is the fixing hardware. Jackscrew and screw lock systems extend the length of the connector, taking up more PCB real estate; however, they provide greater security in keeping the connector halves together when mated. Locking these halves together is particularly important when vibration and shock are expected. The alternative would be a latch system, which adds less length to the footprint of the connector while still providing a secure fastening system.

M300 series can withstand rocket and payload/satellite launch shocks, and vibration at the takeoff stage of an aircraft.

Datamate connectors are used in advanced robotics systems as well as submarine and UAV applications.

PCB Tracking

When transitioning between high power and signal applications, different considerations and design guidelines must be followed for the PCB design. Whether it be single, double, or multilayer boards, there are many design options for tracking that are completely dependent on the application of the connector. There are many available resources and guidelines to help you design your PCB.

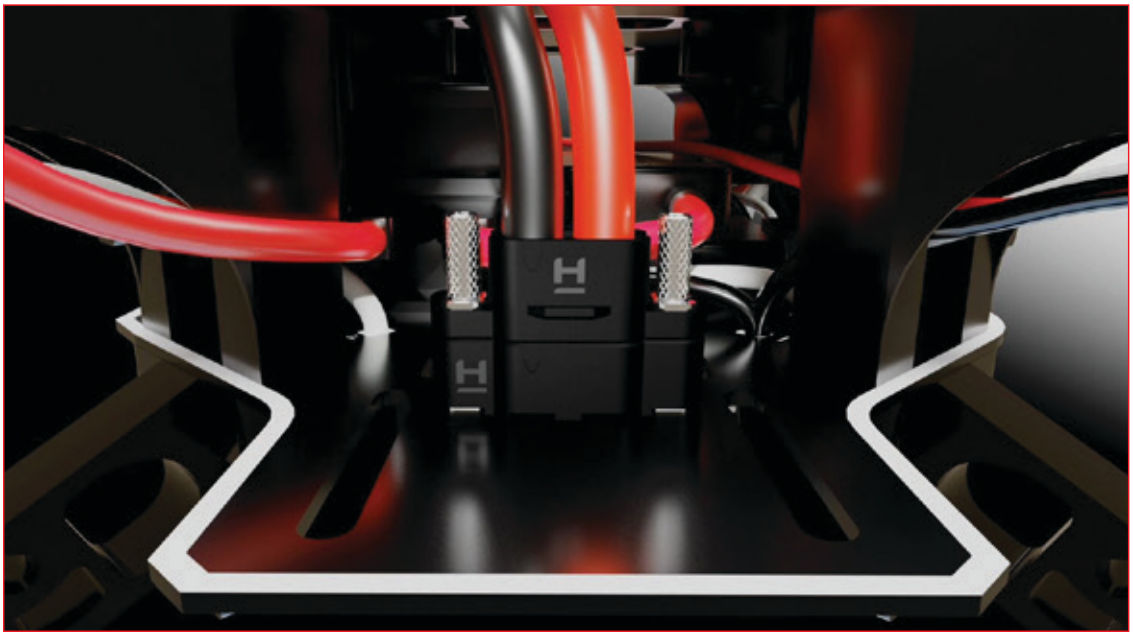
Following IPC standards, track widths must accommodate the potential power throughput of the connector and application. If you design your PCB with 1mm-wide copper tracks to handle signal transmission, it's strongly advised that you do not connect this to a power track transferring 40 amps of current — unless you wish to burn out the system and literally fry the PCB. In many cases, you'll have to move away from single-track PCBs and use power planes through the board, vastly increasing the copper area available for power transfer. PCB materials are also important; the PCB will act as a large heat sink when pushing through high power, so consider whether you specify FR4, aluminum, or other alternatives.

Specifying the Right Connector

Once you understand your requirements, how do you specify which power product is right for your application based on what's important — size, power capability, reliability, design flexibility, and cost?

Harwin offers an expansive choice of power products in multiple ranges with different pin spacings and pinout options, varying levels of current-carrying capacity, and design flexibility in terms of hardware options, terminations, wire sizes, and pin counts. Each family has different performance specifications in terms of current rating, mating cycles, shock, and vibration specs.

Starting with the smallest, lightest mixed technology connector, Gecko-MT is an evolution of the existing Gecko Screw-Lok family. It has added power contacts rated at 10A per contact, providing a combination of signal and power in one housing with 1.25mm pitch



Kona 2-way connectors enable power-to-board transfer on a lightweight drone.

for signal and 3mm pitch for power. This product was specifically designed to address the full extent of SWaP characteristics covered earlier.

Gecko-MT is suited for applications that require power where weight and space are at a premium. As such, it is ideal for aerospace within rockets and spacecraft propulsion systems. The screw-lok fixing hardware is easy to use and resists flight vibration and shock.

The M300 family is designed on a 3mm pitch and is rated at 10A per contact. This rugged connector system combines up to 1,000 mating cycles with a temperature range from -65°C to as high as 175°C. The connection can withstand rocket and payload or satellite launch shock or the levels of vibration required at the takeoff stage of an aircraft. These characteristics are also crucial in defense and military applications in equipment and vehicles such as optronics modules for panoramic vision systems for radars, navigation systems for surveillance, and military testing equipment.

The Datamate Power Series is available in dedicated power-only connector variants featuring 20A or 40A contacts on a 4-mm pitch, or as hybrid connectors combining power with signal contacts at 3A on 2mm pitch. The series is proven in multiple markets requiring high-rel power products, from robotics to military and defense, and from down-hole to New Space.

The Kona series is the latest and most powerful addition to the Harwin range. It is a dedicated high-power connector series that can handle up to 60A current per contact. The 8.5mm pitch provides a maximum voltage rating of 3,000V. Larger metal contacts for the power also provide a lower contact resistance than the other product families. Designed and fully tested to withstand high levels of shock and vibration, Kona is suited for military and aviation applications, such as advanced power solutions, or in AC/DC power conversion modules for aircraft platforms.

Developed using a lightweight engineering-grade plastic for strength and weight savings and including easy-to-use thumbscrews, Kona is also suited for UAV applications. The reduction in weight over other options available in the connector industry is crucial for the larger-wattage units such as fuel cell battery drones.

About the Authors

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Visit **www.harwin.com** to learn more.