



ENABLING Smarter Industrial Product Designs

The shift from analog to digital technology has reshaped modern life, transforming traditional products into smart, connected devices. By integrating digital technologies, sensors, and wireless connectivity, original equipment manufacturers (OEMs) have elevated product capabilities enabling real-time monitoring, data collection, and enhanced safety features. Leveraging technologies like the Internet of Things (IoT), artificial intelligence (AI), 5G, machine learning, and robotics to boost efficiency, cut costs, and enrich user experiences. **High-speed connectors are vital in this evolution, supporting OEMs in creating smarter products across sectors, including automotive, consumer electronics, and industrial applications.** This article examines connectivity options for smarter industrial product designs.



Application Examples

Smart industrial products feature advanced sensors and connectivity solutions to enable real-time data collection and analysis. These capabilities drive enhanced functionality, automation, and actionable user insights. Common examples include augmented reality (AR) systems, additive manufacturing, industrial robots and cobots, automated guided vehicles (AGVs), and autonomous mobile robots (AMRs). Such products are critical for improving efficiency, boosting productivity, and reducing manufacturing costs.

Connector Requirements

Building a reliable, high-speed network for smart industrial products driven by AI and IoT comes with unique challenges. Many industrial applications operate in harsh environments, requiring solutions that can withstand signal interference (noise), extreme temperatures, dust, moisture, shock, and vibration. Additionally, considerations like size constraints, power capabilities, and compatibility with various communication protocols are essential for ensuring efficient and reliable performance.

PROTOCOL COMPATIBILITY

High-speed connectors are engineered to support diverse communication protocols, addressing the rising demand for faster data transmission across industrial applications. Smart industrial products rely on protocols like Modbus, Ethernet/IP, Profibus, Profinet, OPC-UA, EtherCAT, FANUC FOCAS, IO-Link, and CAN bus to enable efficient data exchange and connectivity. These protocols facilitate real-time monitoring, data collection, and advanced functionality in industrial systems. Selecting a protocol often depends on application requirements, existing infrastructure, and vendor preferences. Modern systems frequently support multiple protocols to enhance flexibility.

When selecting high-speed connectors for specific protocols, four key factors should be considered:

Data rates: Ensure the connector supports the protocol's required data transmission speeds.

Signal integrity (SI): Maintain signal quality at high frequencies with designs that include shielding to reduce electromagnetic and radio frequency interference and impedance matching to minimize signal reflections.

Environmental factors: Ruggedized connectors may be necessary for harsh industrial environments while ensuring protocol compatibility.

Compact Design: Space efficiency is crucial when designing many smart devices. Connectors should be space-efficient and lightweight for seamless integration into constrained designs.

MINIATURIZATION AND HEAT ISSUES

Excessive heat can cause electronic components, like connectors, to malfunction and potentially fail completely. The miniaturization of IoT devices exacerbates heat issues, with increased component density concentrating heat in smaller areas. This results in localized hotspots and higher overall temperatures, which can compromise device performance and reliability.

Compact designs also reduce space for traditional cooling methods like heat sinks or fans, & limit natural air circulation, making it harder to dissipate heat effectively. To ensure reliable operation, selecting connectors with high-temperature ratings ensures proper performance and long-life operation in these applications.

SI AND EMI ISSUES

Miniaturization of IoT devices significantly impacts signal integrity (SI) & electromagnetic interference (EMI) in several ways. Closer proximity between traces increases the risk of electromagnetic coupling and crosstalk. Shorter traces and tighter bends can also create impedance discontinuities and mismatches, leading to signal reflections and degradation. Additionally, smaller conductors and thinner PCB layers can increase signal attenuation, reducing signal strength.



Smaller footprints further limit space for proper shielding and grounding, making devices more susceptible to external EMI and less effective at containing internal emissions. Noise from compact power distribution networks, such as switching power supplies, can also elevate EMI levels.

The introduction of 5G has intensified these challenges. Operating at frequencies up to 39 GHz or higher, 5G increases susceptibility to signal loss, attenuation, and electromagnetic interference. Its broader bandwidth further complicates designs, leaving devices more vulnerable to EMI.

To address these issues, designers must adopt advanced PCB layout strategies, carefully select high-performance connectors, and employ innovative shielding solutions. High-density and mezzanine connectors are particularly effective in maintaining signal integrity and minimizing EMI in compact IoT applications.

Connector Solutions



HIGH-DENSITY CONNECTORS

Smart products integrate multiple components such as sensors, displays, batteries, microcontrollers, and communication modules. As OEMs strive to pack more functionality into increasingly smaller devices, high-density connectors have become essential in advancing AI and IoT technologies, enabling seamless integration and accessibility.

High-density connectors provide more contacts in a smaller area (pitch) to support higher data rates in a compact design. For example, the DF40 board-to-FPC connector series provides high-density mounting and space-saving benefits. Supporting USB4 Gen2 (10 Gbps) transmission, the DF40 features a 0.4 mm pitch and a mounting depth of just 3.68 mm. The series includes high-temperature, positive lock, and EMC-shielded versions, as well as configurations with or without retention tabs.



FFC/FPC

FFC (Flat Flexible Cable) and FPC (Flexible Printed Circuit) connectors offer compact, cost-effective, and tool-free installation, making them ideal for space-constrained applications. These connectors are economical yet reliable solutions for implementing interconnects in tight designs.



Zero insertion force (ZIF) locks, an improvement over conventional low insertion force (LIF) connectors, simplify the mating process while enhancing connection strength. New **One Action** locking connectors streamline this further by arriving with the latch pre-closed, enabling the mating operation without the need to open the latch.

For example, the **One Action FH63S Series** is specifically designed for space-limited environments where access to actuators for flip-lock ZIF connectors is restricted. Its innovative design allows secure mating in tight spaces without requiring latch manipulation. The FH63S also supports high-temperature operation up to 105°C and includes EMI shielding for reliable performance.

Efficiency Benefits: One Action connectors significantly reduce mating times. While traditional front-flip ZIF locks take about three seconds per mating cycle, One Action connectors complete the process in less than a second. This streamlined approach saves time and costs, particularly in high-volume production environments.

Automation Advantages: The contactless operation of One Action connectors is ideal for robotic assembly. Automated systems can insert flex cables without manual intervention. Advanced flex connectors also allow production lines to verify proper mating using camera-based inspection systems, ensuring accuracy and reliability.

Connectivity and Compatibility: Smart products must communicate seamlessly with devices such as smartphones, tablets, or computers. Hybrid connectors can include standard interfaces such as USB, HDMI, or other industry-standard connectors, ensuring compatibility and interoperability.

FH63S Series supports USB 3.0, HDMI 1.4a, Embedded DisplayPort 1.3 transmission, and V-by-One HS protocols. Its shielded housing ensures high-speed transmission capabilities while minimizing noise.



HYBRID CONNECTORS

Hybrid board-to-board connectors consolidate power and data signals into a single, space-saving solution. This approach simplifies device design while maintaining high-speed transmission and minimizing noise through shielded housing. The result is a more efficient and compact connection for the complex array of elements in modern smart devices.

Using separate connectors for power, data, and signal connections often creates a tangled web of cables and components. Hybrid connectors streamline the manufacturing and assembly process by reducing the number of individual connectors that need to be soldered or attached to the PCB. This simplification can lead to faster assembly times and lower manufacturing costs.

The **MT Series** exemplifies the versatility of hybrid connectors, offering hybrid power/signal configurations along with waterproof capabilities. These features make the MT Series ideal for applications involving compact motors, which are increasingly prevalent in smart industrial environments. Designed for user convenience, these connectors incorporate a lever lock mechanism for easy mating and unmating, enabling quick assembly and disassembly. This user-friendly design is especially advantageous in industrial settings, where minimizing downtime is critical.

STACKABLE MEZZANINE

Stackable mezzanine connectors simplify the design and assembly of smart consumer and industrial products. By enabling the vertical stacking of PCBs, these connectors help maximize space utilization in compact smart devices, making them invaluable for small form factor products with limited internal space.

These connectors support modular designs, allowing manufacturers to easily add or swap out boards and components. This flexibility simplifies product iterations and customization.

The stackable design also reduces the need for complex wiring harnesses between boards. Boards can connect directly in a vertical configuration, simplifying assembly and reducing potential failure points.

Many of Hirose's mezzanine connectors support high-speed data transmission protocols like USB 3.0 and PCIe, enabling advanced functionality in smart industrial devices. Ultra-low profile options, like the BM series connectors, have stacking heights as low as 0.6mm, allowing for incredibly thin and compact product designs.

Stackable connectors are also available in hybrid versions, like the **BM29 series**, which combines both power and signal in a single compact connector. This reduces component count and manufacturing complexity. By offering these benefits, stackable mezzanine connectors empower product designers to innovate, accelerate time-to-market, and deliver more reliable, high-performance smart devices.

FLOATING CONTACT SYSTEMS

Board-to-board connectors with floating contact systems streamline assembly, reduce labor costs, and save space. These systems are particularly well-suited for densely populated setups requiring multiple connectors on the same two boards. The floating design offers superior vibration resistance, enhancing reliability by reducing stress on solder joints caused by misaligned connectors. This feature also increases durability by preventing solder cracking.

By combining floating contact systems with high data rate capabilities, EMI shielding, & compact pitches, these connectors simplify the design and assembly of smart industrial products.

Connectors like the **FX23/FX23L Series** offer a floating range of ± 0.6 mm in both the X- and Y-axis directions and ± 0.75 mm tolerance between boards in the Z direction. This floating feature prevents misalignment during board installation and mounting. The spring portion of the terminal absorbs assembly errors, reducing the need for corrective rework. **BM54 Series**, the world's smallest floating board-to-board connector, provides ± 0.4 mm of floating range in the XY direction while maintaining a compact width of just 3.8 mm. With a heat resistance of 125°C, the BM54 Series is ideal for in-vehicle and industrial equipment. It also supports PCI-ex Gen4 (16 Gbps) and MIPI D-PHY Ver. 2.1, all within a 0.4 mm pitch.

[Click here for a digital brochure & additional information on Industrial Connectors](#)

Conclusion

Smart industrial product systems are becoming more advanced and feature-rich, adding a wide range of new functions. These devices demand a diverse range of connectors tailored to specific application requirements and constraints. By carefully selecting connectors that balance functionality, modularity, and reliability, manufacturers can address the complexities of modern designs. Often, a combination of connector types provides the optimal solution for achieving performance and efficiency in today's dynamic industrial environments.