# Rectangular or Circular? Rectangular Connectors offer More for Less

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Connectors have been serving industry exceptionally well for decades. They outperform hard-wiring of machines and control systems in most situations from a design and project cost standpoint, and by quite a margin on a total cost of ownership basis. They make a reliable and robust connection. But there is a subtext in selecting the best connector for the job: Will that be rectangular or circular? – two different approaches with some very different attributes.

Circular connectors have a long history in military applications and in food and beverage processing. Rectangular connectors now dominate in modular machine design, factory automation, robotics, rail transportation and power generation, and are moving into many applications where circular connectors once were unchallenged.

In most applications, the advantages of rectangular connectors now outweigh those of circular for every stakeholder from the designer to the end user. The net benefits for rectangular fit three broad categories: lower costs, greater design flexibility, superior ease of handling. (The latter include field friendly termination options unique to rectangular models, and a lower risk of mating, locking and other types of mishandling.)

**Circular costs more**

The cost issue is straight forward: circular connectors cost more. In apples-to-apples comparisons, using manufacturer's suggested retail pricing for major brand name connectors, including inserts, housings and contacts, circular usually costs more, as much as 40% more. The harnessing price per contact is similarly more expensive. That's on a unit basis. The project cost of using rectangular connectors is much lower when a single modular rectangular connector is employed instead of multiple single purpose connectors, saving on labor as well as materials. From the end user's perspective, that also means less downstream maintenance cost and a lower risk of unscheduled production interruptions.

The design advantages of rectangular connectors can beneficially impact how a machine or production line is wired, even improve the design and save on materials.

Those advantages include:

- **User-defined modularity:** Most rectangular connectors are modular and user-configurable, capable of carrying multiple different signals; circular connectors are much more limited in that respect.
- **Greater cabling flexibility:** Most rectangular connectors come with a choice of top, side and even angled cable entry and cable gland sizes up to M50 – circular doesn't do side entry or wide diameter cables well at all.
- **Unique placement options:** Rectangular offers more placement flexibility. In side by side arrangements, they can be more tightly aligned. They have surface mount capability; circular connectors do not; some rectangular models can be connected directly to a PCB using a PCB adaptor. A rectangular blind mating connector without housing can support direct panel mounting in drawer systems.

**Rectangular unrivalled in modularity**

User-defined modularity has been a game changer for rectangular connectivity. It easily trumps the limited and inflexible modularity offered with circular connectors. Today, most rectangular connectors being installed are modular. That's a reflection of the complexity of new machinery with so many sensors monitoring operating systems and controls that regulate individual sub-systems, backup and safety features. It also mirrors the continuing switch by OEMs to modular machine design, which modular rectangular connectors complement perfectly.

Modular rectangular connectivity offers compelling convenience and pricing. A modular rectangular

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connector is assembled entirely from standard, stocked, parts – hood, housing, cable gland and modules – to suit the precise and often complex needs of the application. Designers can choose housings that can accommodate 1 to 12 modules, and create what amounts to a custom connector without the premium price. Multiple contact densities and media can be combined in a single connector, including low or high voltage power, Ethernet, PoE, coaxial, fiber optic (PoF or glass fiber) or pneumatic lines. Low, medium and high voltages can be combined: up to 200A or 5000V. (Blanks modules can be inserted to reserve space for future upgrades).

**Many contact combinations possible**

Being able to combine different Amperage-rated contacts, therefore different sized contacts, also produces a smaller connector. Contacts with ratings of 4A, 10A, 16A, 40A, 70A, 100A, and 200A are combinable. High density monoblock inserts are available in some models, with up to 108 contacts. Some HARTING models offer space and cost-saving multiplier inserts and bridge blocks to bring potential multiplication into the connector, dispensing with the need for terminal blocks in a switch cabinet. That, in turn, may allow the OEM to reduce the size of the box.

By contrast, circular connectors offer only limited modularity, and are not truly user-configurable. Users may choose a single, dual-purpose insert (usually power and signal) from the selection offered by the manufacturer. Inserts do come in many contact sizes and cover the full spectrum of media, but are not combinable in a single connector.

**Rectangular saves on space**

Rectangular connectors are more space-efficient. One modular rectangular connector can do the job of two or more circular connectors, economizing on space, simplifying the wiring layout inside and outside the device and saving on materials.

Rectangular connectors have smaller minimum spacing requirements. A circular connector requires sufficient space for a hand to grip it when mating and un-mating. Rectangular connectors can be gripped by the ends or sides. Locking levers can be located on either the ends or side(s). Many large users set their own minimum requirements, based on experience, that invariably require wider spacing for circular connectors.

Rectangular connectors offer other unique space-saving opportunities. A rectangular connector can be connected directly to a PCB using a PCB adaptor, which can allow the engineers to produce a better electronic package.

Only rectangular offers surface mounting capability. While most connectors are mounted right on the machine or control panel, some customers prefer an extension cord style. This involves locating a connector on a flat surface nearby, such as a concrete floor. When locked, the connector retains its water tightness and IP rating.

**Many more cabling options**

For cabling, rectangular offers a great deal more flexibility for optimizing the connector location, cable selection and even wiring path.

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Rectangular hoods are available with side, top and even angled entry on the cable side and many surface mount housings with cable entry options.

They are easily optimized for flat cables, large diameter cables, hybrids or multiple single cables. The appropriate selection will maximize strain relief on the cable. Some users employ cables with a bigger jacket thickness to withstand physical abuse, like being run over by forklifts. Rectangular hoods are available with very large size cable entry (such as M40 and M50 in a size 16B hood) to accommodate that; many hood sizes offer a choice of at least two metric cable entry diameters. HARTING has female threading in its hoods, allowing the user to incorporate a range of cord grips for different cable diameters, materials or plating types.

In contrast, the overwhelming majority of circular connectors are top entry only. They often come packaged with one back shell for one metric thread size. That may lower their unit cost, but limits the diameter range of that thread size. The integrated cord grip cannot be changed. Circular connectors have restrictions on the use of large cables, and unlike rectangular, provide no IP protection for multiple wires in the same unit.

**Rectangular more robust, easier to install**

In the field, rectangular connectors are more user-friendly in most respects. With panel punches and CNC machining of panels, it's just as easy to make rectangular cutouts. In some cases, it is even possible for a rectangular connector to be mounted over a circular panel cutout.

**More termination options:** There are more ways to terminate wires in rectangular connectors. Both rectangular and circular offer crimp and solder termination. Screw termination is widely available with rectangular, but with circular, is limited mainly to terminating large power connectors and often for a maximum of three contacts.

The rectangular world offers three additional, *unique* termination options: axial screw, cage clamp and a HARTING proprietary system, Han-Quick Lock®. While crimp and solder require special tools with either style connector, these other three termination technologies need only a common slot screwdriver or hex tool to do the job. That makes them ideal for fast field installation or maintenance. Axial screw, a HARTING invention, is preferred for larger gauge wires, where it makes a solid, safe and reliable connection. Many rectangular connector models offer two or more termination options from which to choose. Rectangular also can provide crimp contacts for thermo couple applications.

**More robust PE:** Rectangular connectors have a robust, reliable PE grounding built into the housing. A PE connection is available on circular connectors, but can be expensive and tricky to assemble, and the exterior tab format is vulnerable to vibration.

**Easier mating, with less risk:** It's almost impossible to mate rectangular connectors incorrectly. They offer visually obvious polarization. There are only two ways the halves might fit. Even blindfolded, an installer has a 50% chance of mating a rectangular connector correctly on the first try and a 100% chance of getting it right on the second. Robust coding and optional guide pins prevent mis-mating; the pins touch before the modules do, preventing damage.

The mating of a circular connector is keyed, so if the process is even one degree off, the user has to spin the connector 180° again to find the right spot. In real life, he or she often applies too much force, jamming in the shell, which may result in cross-threading and damage. (In the unmated state, circular connectors do enjoy one advantage: They are more easily factory-sealed. They can even come potted, meaning they are water tight even when unmated. Rectangular connectors can be sealed, but it's easier to use the protection covers designed for each.)

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Han-Yellock®: A *Canadian manufacturer of a new high speed servo hoist for the concert and stage industry simplified the design of its motor controllers by substituting one multi-purpose rectangular connector for three single-purpose, circular connectors on each control box using standard inserts to create custom configurations. One connector simplifies the interior and exterior wiring layout, accelerates mating and un-mating, hence the time needed to set up or disassemble the hoist. This one modular connector is less expensive than the old connector array.*

**Locking certainty:** Of course, most of the time, installed connectors will be in a locked state. There are great differences in how each style is locked. The locking mechanism of circular connectors is internalized. With most rectangular connectors, it's either an external screw or locking lever. A correctly locked circular connector can't unlatch itself. Though rare, the lever on a rectangular could be unlocked accidently. However, unlike circular connectors, the locking status of a rectangular connector is clearly visible. Circular connectors are vulnerable to inadvertent cross-threading; there's no telling if one is properly mated. Just because you can't turn the shell any more doesn't mean it's locked. If the locking mechanism is damaged, it's a difficult fix. The connector has to be disassembled, the pins disconnected, a new hood or back shell installed and all wires re-crimped.

With rectangular, if the locking lever breaks, a rare occurrence, just put on a new one – a quick, inexpensive fix. Rectangular connectors have several locking styles, with a pair of levers on the ends, or a single side or over-the-top lever – all of which provide secure locking and IP65 protection or greater when locked.

The versatility of the modular rectangular concept continues to increase, underscored by new models:

- Optimized for high mating cycles – up to 10,000 – for prototyping, test and inspection, automatic tooling systems, etc.
- Made of economical, lightweight, reinforced thermoplastic, a rugged reliable alternative to more expensive metal connectors
- Designed to withstand temperatures up to 200C like casting machines, or reinforced for all-weather outdoor operations or extreme hazards, such as rock chips, icing, salt mist, UV radiation, exhaust gases and oils
- With an embedded RFID chip for fast ID of part numbers and other user defined data for faster maintenance and procurement

No company is responsible for more innovations in rectangular connectivity or a stronger commitment to growing the concept than HARTING. Company founder Wilhelm Harting invented the rectangular industrial connector in the 1950s. The company still owned and managed by his descendants is the world leader in heavy duty connectors and one of the largest in all industrial connectivity. The HARTING Technology Group launched user-configurable modularity with the Han-Modular® concept in the early 1990s. There are more than 50 modules for different transmission media in the Han-Modular® series alone, for hoods and housing sizes 6B-48B. HARTING developed axial screw and Han-Quick Lock® termination technologies. Its multiple award winning Han-*Yellock*® connector introduced fast and secure push button mating and locking technology.

As for the future, HARTING is in the forefront of developing smart connector technology that will integrate with the modular plant production concepts coming from collaborative initiatives such as Germany's Industry 4.0 and the Smart Manufacturing Leadership Coalition in the US.

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