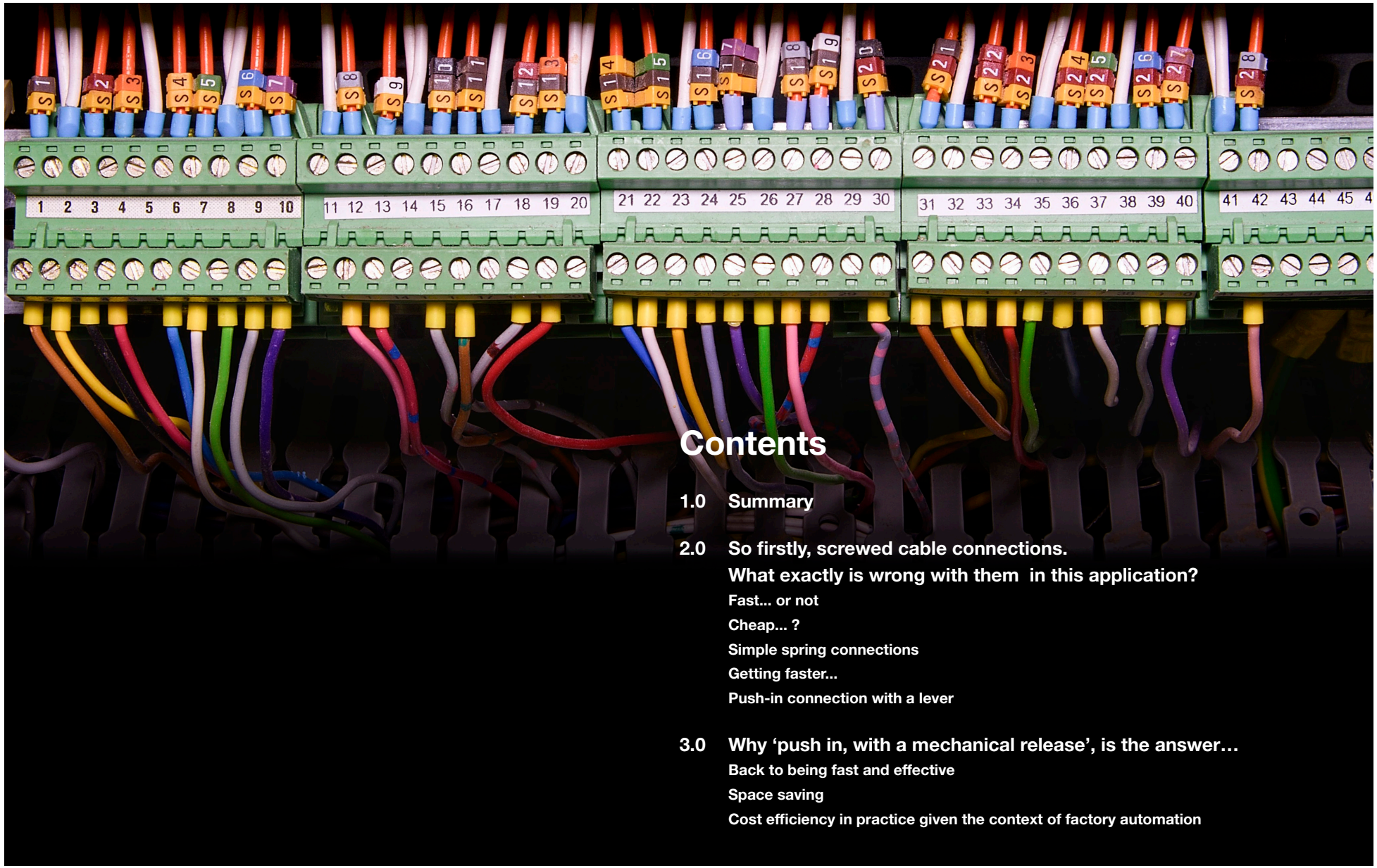
Technology discussion guide

MITSUBISHI ELECTRIC
Changes for the Better

Push-in terminal block technology

Why leaving the screws behind could speed up your installation and provide superior connections.



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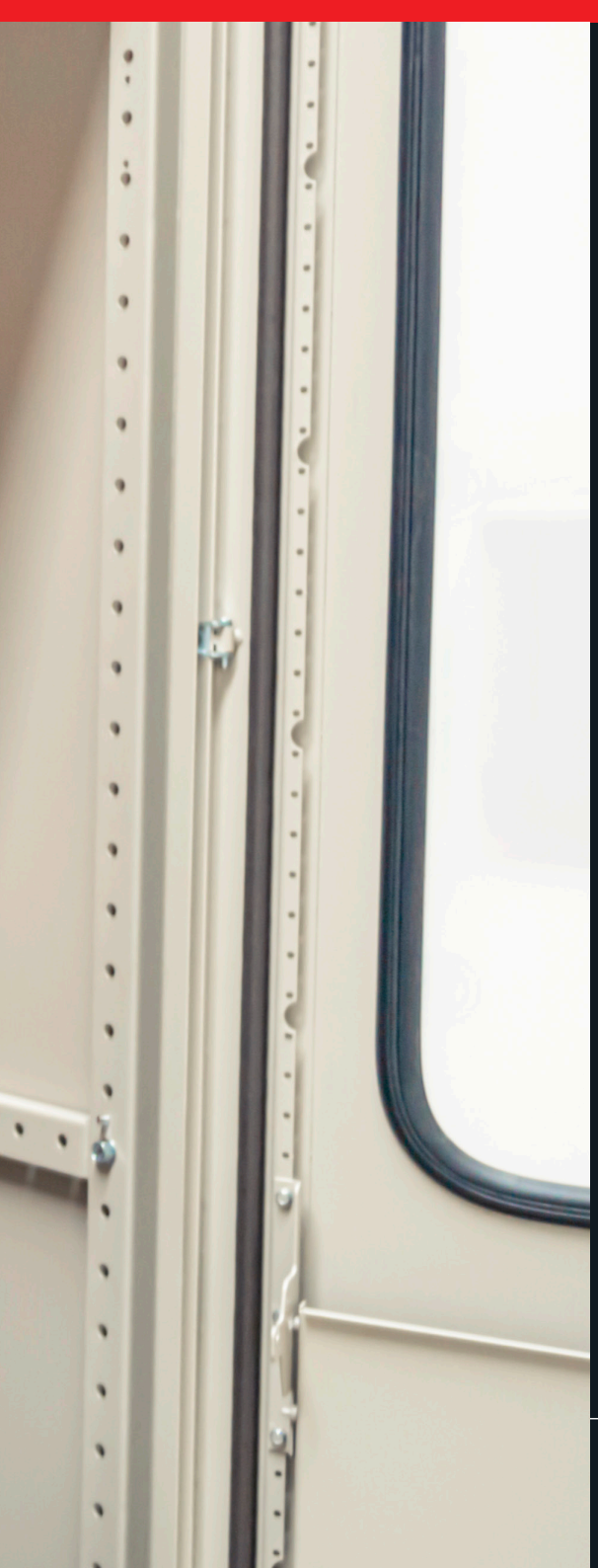

1.0 Major global automation vendor Mitsubishi Electric is renowned for the quality and operational longevity of its automation equipment. Hence it is a big step when its engineers opt for a wholesale change in technology. In this case, they have done away with the trusty stalwart screwed terminal and chosen an advanced form of push-fit terminal technology for the company's range of I/O terminal blocks.

This guide aims to establish why the change of heart and consider what the current options are when it comes to cable termination in automation system installs. Understanding this decision may assist those choosing I/O or their next terminal block for any industrial application.

“It is often said that a job cannot be done well and at the same time be fast and cheap, but does that still apply here?”

When it comes to cable connections, especially in large-scale manufacturing facilities, the consequences of a termination issue developing are at best, a maintenance task which is time-consuming and expensive to diagnose and resolve, or at worst, have a huge negative knock-on effect on plant-wide productivity due to the resultant unplanned downtime. Cable terminations are something that should be taken seriously. They need to be extremely robust, easy to get right and ideally - very flexible.

2.0 So firstly, screwed cable connections. What exactly is wrong with them in this application?

Fast… or not

When an electrical engineer is clamping the end of a large and heavy cable, think three-phase power at 100s of amps for example, then the clamping force required can’t be practically achieved by the return spring pressure of a push-fit connection. In this situation a screwed clamp (more accurately a bolted one – usually employing more than one bolt) is used as it can exert enough pressure over a wide area of the conductor so as not to compromise the integrity of the individual strands but provide enough clamping force to keep the cable safely located.

Figure 1. Example of a large connector where torque can be accurately judged when clamping.

It’s a slow and laborious operation, but in this scenario, it is often the only practical option. A sprung connection would need to apply so much force it would be very difficult to actuate manually, or it would damage the conductor because it would need to employ a sharp edge to provide grip. Two considerations that will appear again later in this discussion.

To achieve an optimum clamped connection, the threaded fastener has to be within a precise torque range as specified (and tested) by the manufacturer. This is straightforward when you are using a socket set to tighten a large terminal, but not so practical when you are using a small gauge electrical screwdriver.

The smaller the screw on the terminal, the harder it is to judge torque. When it comes to terminal blocks for automation systems, then the conductors can often be very fine multi-strand sensor cables. So applying the correct torque to screwed terminal connections is critical to avoid damage to the core conductor, whilst also providing appropriate cable retention. When not torqued correctly, they can also come loose very quickly with localised vibration – something that is common in industrial manufacturing and process environments.

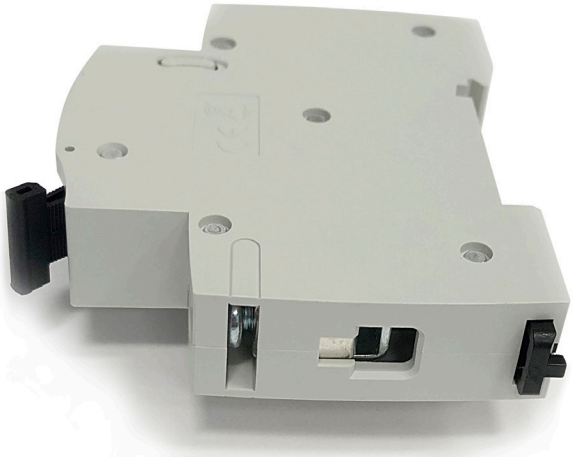

Figure 2. Example of a screwed terminal block, where it is next to impossible to judge torque accurately.

Screwed connectors of any size are unquestionably slower, which is fine when they are huge and you only have three of them to fix but not when they are tiny and you have hundreds of them. So screwed terminals are arguably neither fast nor particularly effective in this application.

Cheap…?

It's worth stating that in this context, it isn't a cost saving exercise by the manufacturers, certainly not of I/O solutions from mainstream automation vendors, so 'cheap' is out of the aforementioned equation too. A push-in connection may save the installer time and possibly the end user money as a result, but that is a different story. Push-in is certainly faster, especially if you don't need to prepare the cable end by adding a ferrule or solder. However, the 'cheap' solutions are also out of the question for multiple reasons…

Simple spring connections

A simple spring connection is definitely the cheapest way to create a screwless terminal. Using a single flexible metal strip as both a conductor and as a clamp allows a stripped, or otherwise prepared cable end, to be inserted into an aperture. Thus, an electrical screwdriver (paperclip / nail / thicker piece of copper strand – we've all done it!) can be used to push-in behind the strip to open the aperture.

This solution can be very effective for power cables with single strand cores that aren't too wide or too fine, so it fits exactly through the square aperture and doesn't snag on the edges. Downsides are, as you've probably guessed (or experienced already) it's very easy to force the conductor strip over too much and bend it, thereby losing the clamping force. Also, you may be using a fine multistrand cable that isn't suited to the aperture or could be cut-through by the back edge of the spring clip.

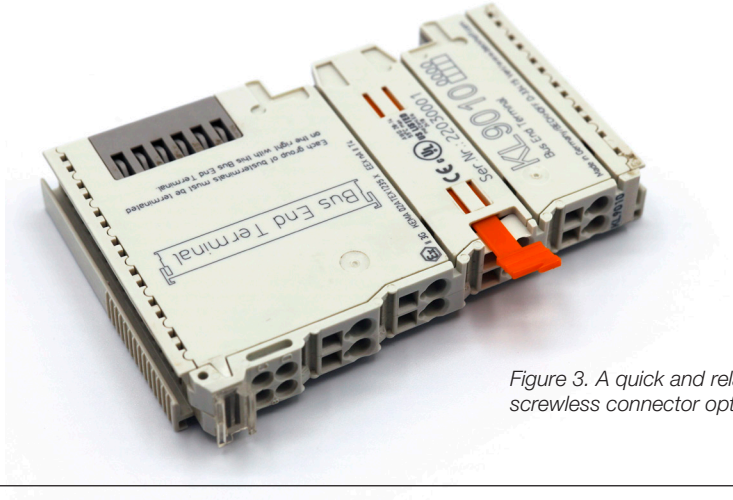

Figure 3. A quick and relatively cost-effective screwless connector option has some downsides.

For connecting field devices in an automation system there is a host of other downsides. Most of these are based around how exposed the connection needs to be in order to see when it's clamped properly and the cable is inserted cleanly or not, which you can't do when it is enclosed in plastic.

Getting faster…

We are starting to see some of the advantages of the spring type connection though, as it enables you to make a quick, more vibration-resistant conductor connection, provided the clamping force can be relied upon to be accurate. Some manufacturers will recommend their use for all types of conductors from less than 0.1 to over 180 mm^2 but it is by no means a universal solution.

Push-in connection with a lever

A push-in connection with an individual clamping lever makes it a potentially tool-free connection, especially if the cable ends are already prepared (adding ferrules or soldering onsite is obviously fiddly and time-consuming). The lever does away with the 'shove something down the side' operation, which is fraught with potential issues; and for cable ends of similar diameter, offers a consistent clamping force.

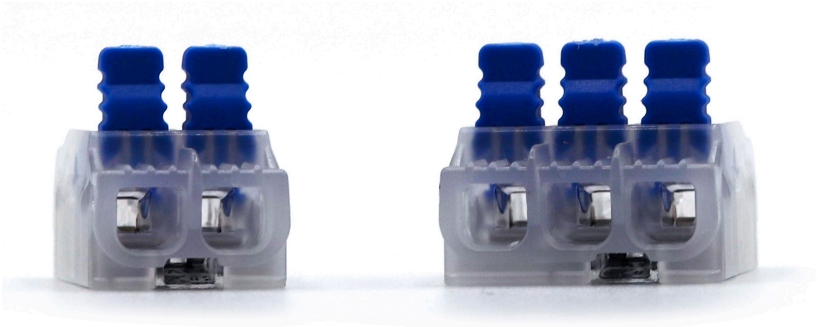

Figure 4 - Push-in connection with an individual clamping lever

So, it is time saving and does avoid some of the downsides of a simple spring connection, however, the packaging doesn't suit every application. In an open PCB environment within a device, for example, lever-type terminals are fast and convenient and ideal for connecting simple switches, lights and buzzers. To really compete with a screw connection though, it needs to provide a more compact solution.

A typical I/O block will be enclosed within a control cabinet or machine mounted enclosure but it has to be safe and secure for direct access during maintenance. The vertical space available is also extremely limited, so a lever at 90deg to the cable entry isn't a great solution.

A spung connection, which applies a constant clamping force for an indefinite period of time so extremely vibration resistant, is therefore highly desirable. We've mentioned vibration before but a screw connection subject to movement at a range of frequencies can work itself free very quickly, especially if it has been over or under tightened, which on small terminals is very easy to do.

The lever also provides a helpful visual guide as to whether the connection has been made and correct clamping force applied. It's very easy to miss one screw that looks the same regardless of whether it has been tightened properly, so technicians will test the pull strain on individual cables and / or go over all the screws 'one last time' to make sure they haven't missed one. Not good practice from a time management point of view – especially since some factory wide automation systems might have thousands of individual connections. Spotting a lever that's been left up is a much easier and more consistent approach.

3.0 Why ‘push in, with a mechanical release’, is the answer…

Push-in technology with a mechanical release alongside each terminal arguably offers the best of the screwless technologies in this application. It enables easy and direct conductor connection as simple pressure on the terminal release button opens the connection. Allowing multi-strand cable, with a range of dimensions* to be easily inserted, with or without solder or ferrules. Stiffer single core cables can simply be pushed in with a low insertion force.

The sprung conductors are profiled so they accept a wide range of cables, but also provide a consistent, high pull-out force. Due to the spring design, they are also highly vibration resistant and maintenance-free.

Push-button release also makes it a safe and fast conductor connection. The conductor can be easily released without special tools. The contact spring opens automatically when the conductor is pushed in and tightens if the cable is pulled without the push button release.

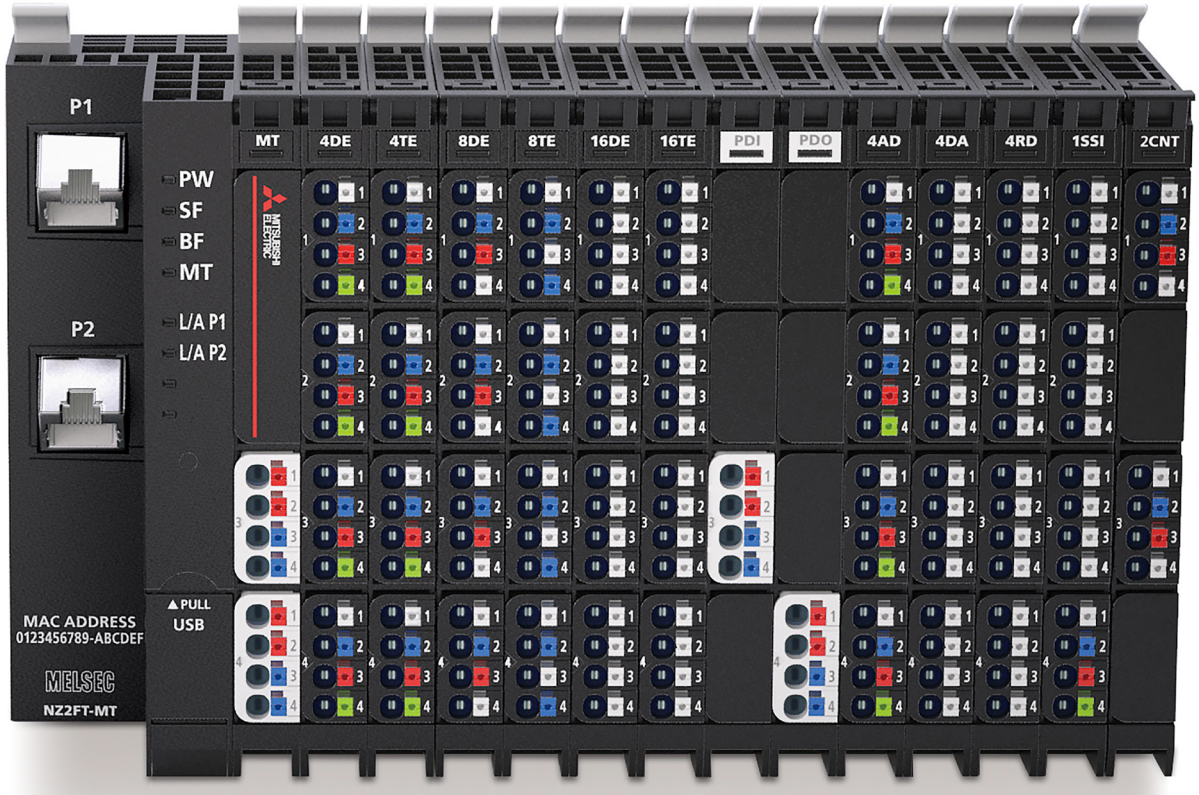

Figure 5. The Mitsubishi Electric I/O module pictured offers vibration resistance of 5 Hz ≤ f ≤ 8.4 Hz: 3.5-mm amplitude as per IEC 60068-2-6, 8.4 Hz ≤ f ≤ 150 Hz: 1 g acceleration as per IEC 60068-2-6

*Dimensionally, most wires terminated in a DIN rail mounted I/O block will range from finely stranded wire with a minimum cross section of 0.14 mm² - up to wire with a solid single strand max at 1.5mm².

Back to being fast and effective

By eliminating screwing operations, this connection solution also considerably reduces installation time as well as the size of terminal blocks. This benefits productivity and space utilisation, helping end users get the most out of their upgrades and digital transformation projects.

Finally, the absence of screws makes it possible for builders to operate at an angle that is convenient for them and have a clear view of the working space. This can further reduce insertion errors whilst supporting operators when limited room is available.

Mitsubishi Electric has been offering advanced push-in connection solutions for decades to help system integrators and end users take advantage of the key features of this technology. Thanks to the company's extensive expertise, companies can drive key efficiencies in terms of costs, time, footprint and resources whilst improving reliability, safety and scalability.

Space-saving

The NZ2FT Series slice type remote I/O module used as an example is equipped with 16 points, has a width of 11.5 mm. Up to 64 modules can be connected per station, allowing multi-point configuration, realising space-saving. Moreover, when an external power supply is connected to coupler modules and extended power supply modules, the power is supplied to all modules. Thus, it is unnecessary to connect the power to each I/O module.

Cost efficiency in practice given the context of factory automation

Terminal blocks are one of the most common components in industrial automation. Their wiring is typically perceived as tedious and non-value adding but necessary. Whilst this applies to the insertion of conventional connectors, new solutions address these shortcomings. By identifying these, companies can actively contribute to the ROI on their digitalisation / automation projects.

As the number of digital transformation projects increases, delivering future-oriented, competitive operations relies on making sure that wiring is optimised and can lead to high-quality results. More precisely, streamlining and simplifying this process can help companies make their digitalisation cost, time and resource effective.

A key aspect to consider when addressing this goal is the selection of a suitable connection technology. The most traditional solution is securing cables and wires under terminal screws. Examples of this include clamping yokes and bolt connections. Whilst this method is effective, innovative spring connection alternatives can drive key benefits for builders and end users.

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