

New EtherCAT plug-in modules: Integrated I/O solution reduces assembly and wiring costs

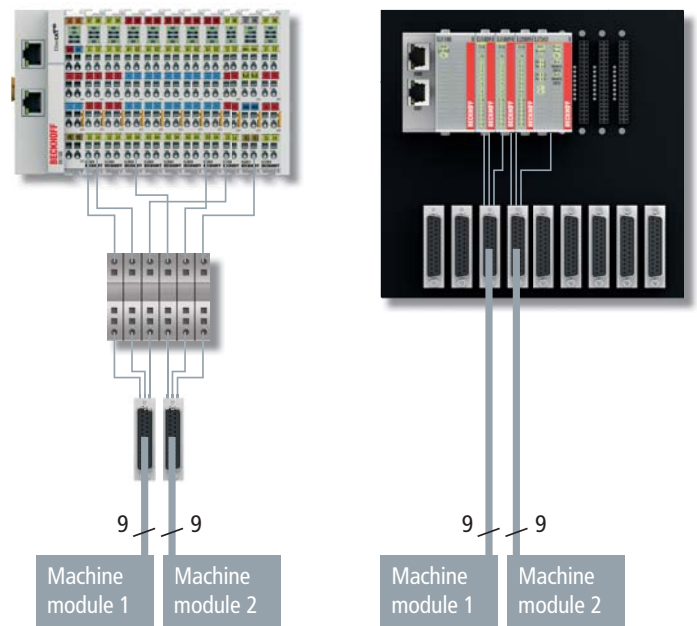
“Plug & Work” – Bus Terminals for circuit boards

The new EJ series EtherCAT plug-in modules from Beckhoff are based on the successful line of EtherCAT Terminals and provide access to a wide variety of signal types. Thoughtful electromechanical design brings the ability to plug the modules directly into an application-specific signal distribution board. The routing board distributes signals and power to machine modules via prefabricated cables with application-specific plug connectors. This elimination of elaborate manual wiring, which is common in traditional control cabinet construction, reduces assembly times and the risk of errors due to manual wiring.

The Beckhoff Bus Terminal technology has been the benchmark for signal variety, compact design, and robustness in fine-grained I/O systems since 1995. EtherCAT Terminals have extended and optimized usage options since 2003, offering maximum transmission performance and an even more extensive range of signal options. The EtherCAT plug-in modules also build upon the well-known EtherCAT communication standard. With regard to the construction, assembly, and wiring of the components, they offer an optimized solution for large-scale production.

Traditional connections between the I/O system and the sensor/actuator level use conventional machine wiring; signal distribution occurs via single-core wiring. Each connection between an I/O channel and, for example, proximity switches and relays, is achieved by laying electrical cables according to a circuit diagram. The cables frequently feed from the I/O system to the sensor/actuator or to a complete machine module via terminal blocks or plug connectors. This concept guarantees high flexibility, since the sensor and actuator topology is simple to modify and extend. Changes to the I/O system configuration can be made flexibly and quickly. For small and medium lot sizes, this solution – “signal distribution via single-core wiring” – is ideally suited due to its flexibility, standard component makeup and minimal requirements for engineering expenditure.

However, signal distribution with single-core wiring requires extensive man-hour investment and necessitates skilled personnel, as the wiring must be implemented according to a detailed circuit diagram. Nevertheless, there is always a risk of wiring errors. Additional checking of the wiring layout minimizes this risk, with the downside of further increasing the requirements for skilled personnel and time. Therefore, in many cases, a customer-specific “black-box” solution is chosen for high-volume production. However, this type of solution is inherently inflexible and offers no possibility for system expansion.

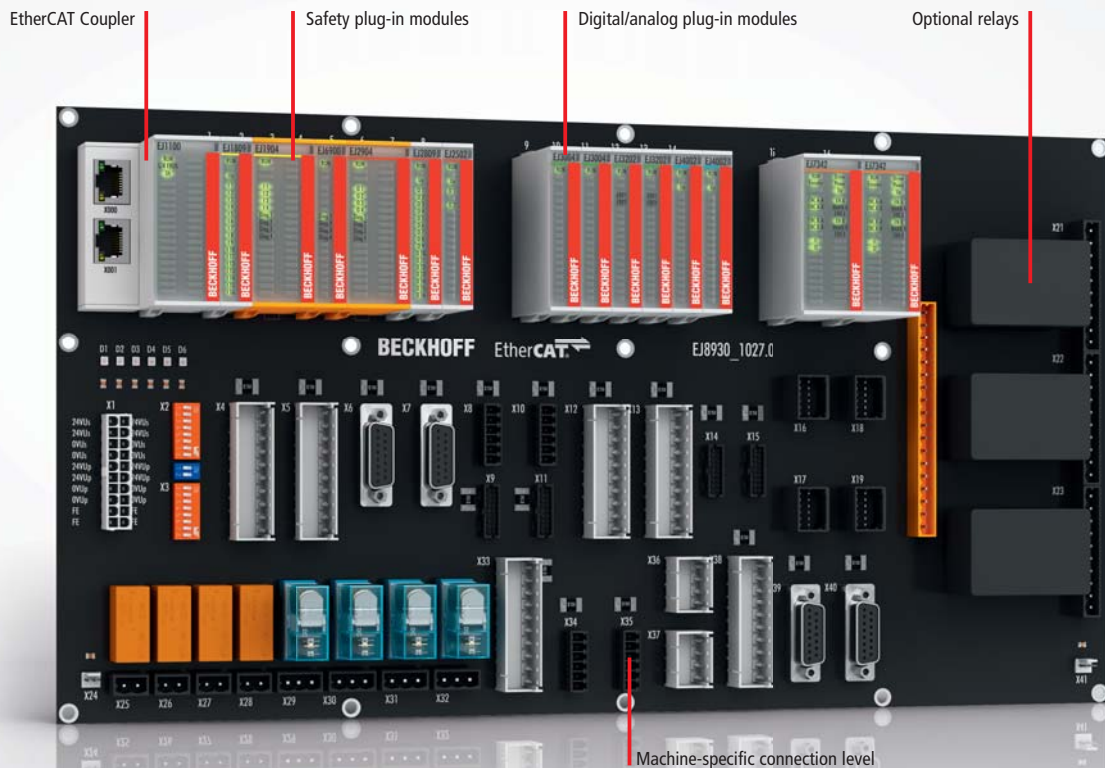


Signal distribution via
single-core wiring

Signal distribution via application-
specific plug connectors

Standardization and cost reductions with high flexibility for large-scale production

EtherCAT plug-in modules, as an alternative to legacy concepts, enable optimization of the wiring efforts, system installation time, and testing costs where machines are manufactured in high numbers. This innovative I/O solution combines both standardization and flexibility, increasing cost-effectiveness and value for system implementers.



The distribution board replaces conventional point-to-point wiring between I/O and the plug level. The connection is made by means of PCB tracks.

The EJ system consists of the EtherCAT plug-in modules and a distribution board. This application-specific circuit board – also called a “routing board” – establishes a connection between sensors, actuators, or machine-module-specific plug connectors and the EtherCAT plug-in modules. Apart from the slots for the EtherCAT plug-in modules, the distribution board provides connections in the form of PCB tracks between I/O module and plugs, as well as additional components such as relays. As a new routing level, the distribution board replaces manual routing with single wires. In the production of standard machines or plants, this minimizes error risk and enables faster construction of the control system, possibly even without the intervention of higher skill workers.

The EtherCAT plug-in modules and the plug level for sensors and actuators can be placed flexibly on the distribution board according to the application. The distribution board is developed either by the users themselves or as a customer-specific solution by Beckhoff. Useful in large-scale machine production, where many of the I/O modules used are identical, the board fulfills the platform concept.

EtherCAT plug-in modules: compact design for a smaller machine footprint

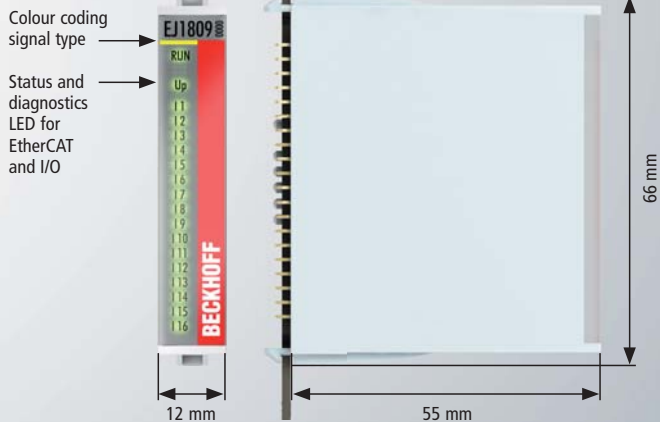
As with the Beckhoff EtherCAT Terminal system, a variety of Bus Couplers and I/O modules are available. The most significant difference is the elimination of tension spring contacts on the EtherCAT plug-in modules, since communication, signal distribution, and power supply of the modules takes place via the plugs on the rear side of the modules and the PCB tracks of the distribution board.

The EJ modules are exceptionally compact, measuring just 12 x 55 x 66 mm. Compared with EtherCAT Terminals, they are almost 50 % smaller in volume. Coding holes in the distribution board coincide with coding pins on the underside of the EJ modules, offering the possibility to implement protection against incorrect connection. As a result, the risk of errors is reduced considerably during assembly and service.

Fields of application

In principle, the EJ system supplements the modular Beckhoff I/O portfolio for medium and high lot-size machine controllers. It is also suitable for applications where the reduction of error probability is a major concern, such as in the “copy exactly” replication of a machine which is essential e.g. in the semiconductor industry. Individual consideration must be given to the lot sizes, as well as to the added time and expense found in the development of a distribution board. Note, however, that this time frame is amortized by the savings made in repeated assembly, wiring, and checking of the wiring. Previous applications and analyses indicate that, on the basis of a routing board, this is typical in lot sizes greater than 100.

Possible areas of application include mass-produced, low-cost machines for the worldwide market, or the use of modular controllers of various “tools” in the semiconductor industry. Semiconductor manufacturers particularly value the compactness of the modules for cleanroom implementations. In general, the EJ system is ideal for machine manufacturers who want to increase the number of common parts across their product portfolio.



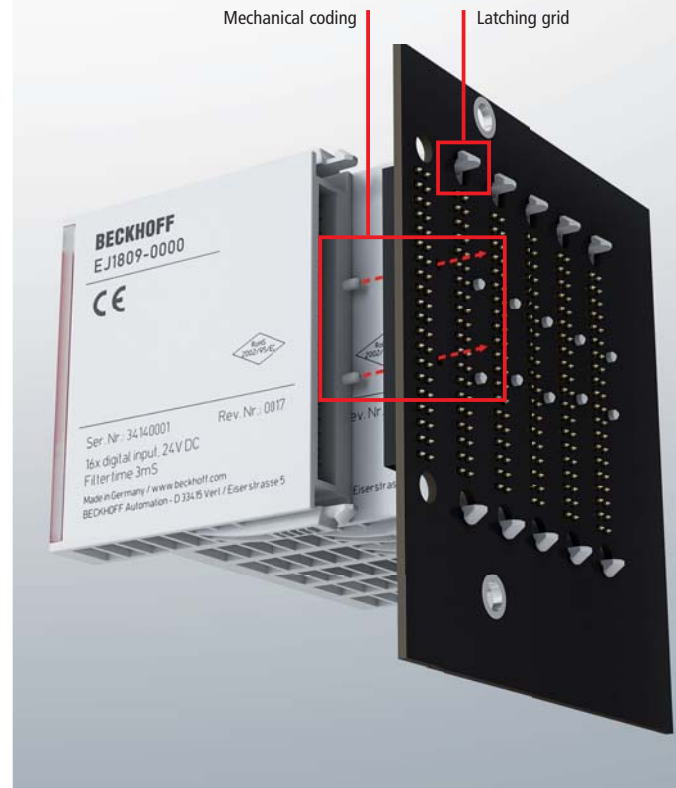
The EJ modules are exceptionally compact, measuring just 12 x 55 x 66 mm.

In addition, the EJ system directly addresses projects with a shortage of skilled workers. In applications where machines are manufactured in various locations with employees of different skill levels, error risk is directly proportional to the degree of complexity. With the distribution board and prefabricated cables, the EJ modules offer "Plug & Work" solutions for machine controllers, reducing the production complexity. Similar concepts have long been proven in areas such as the automotive industry, which now find a home in automation technology as well.

Scalable platform and module strategy

Various strategies for modularization are used in the automotive industry. The EJ system assists in transferring these concepts to automation technology. Examples include such avenues as platform and modular construction kit strategies. Platforms form the basic technical structure of a product, while at the same time standardizing the greatest possible number of the parts used as the basis for a product, improving re-usability. This leads to high lot numbers and justifies higher initial development expenditure with the ultimate goal of lowering series production costs.

In the module strategy, basic functions are divided into individual, self-contained units. These are clearly differentiated from each other, facilitating the combination of modules in these implementations. As an extension of the platform strategy, the module strategy consists of standardized modules that can be used universally. Based on a platform, a module variant that differs with regard to performance and price, for example, can be chosen from the individual segments according to the customer's specifications when assembling a machine.



These strategies are partially transferable to the EJ system and to the automation industry, leveraging the EJ system's mixture of standardization and flexibility. For a large number of identical or at least very similar standard machines, certain identical components used in all machines simply combine with modules that are specific for one machine.

In relation to the EJ system, a platform strategy entails development of a standard machine on which standardized components can be accommodated. The extended platform strategy means that various modules can be supplemented beyond the standard platform. Placeholder modules enable additional components, including future technologies, to be added later. This enables the extension of machine complexity from "basic" to "extended" to "high-end":

- The **basic version** covers basic functions; placeholder modules are used on the platform for functions that are not used in this version.
- In the **extended version**, placeholders are replaced by functional assemblies in the form of EtherCAT plug-in modules. These differ depending on the machine, such as employing different feedback modules for different motor types.
- A **high-end version** features the full range of functions for which the complete distribution board can be used. In addition, EtherCAT provides the possibility of an optional extension through EtherCAT Terminals or EtherCAT Box modules in order to implement modular extensions of the machine. This allows the implementation of application-specific elements of the control system that may only be required on rare occasions.

Author: Michael Jost, Product Manager, Fieldbus Systems and EtherCAT, Beckhoff