



Is the Future of Machine Design Cabinetless?

Evolving hardware capabilities enable smaller footprints and distributed intelligence, but some components will keep cabinets around for now

From the Industrial Revolution and Moore’s Law to Industrie 4.0 and lot size 1, industrial technology has always aimed to make production faster, smarter and as compact as possible. Machines continue to get smaller and more efficient through innovations in controllers, industrial networking and motion control. Manufacturers across industries benefit from purposeful implementation of new automation technologies, experiencing greater throughput, higher quality and more space for additional systems in the factory. However, one large piece of the machine continues to take up substantial space on production floors: the electrical cabinet.

The idea of cabinetless machine design, although not entirely new, has been gaining significant ground. Whether for new designs, redesigns or retrofits, the concept requires highly durable industrial components that can mount directly to the machine and withstand harsh production environments. This includes everything from motion control systems and I/O terminals to even the machine controller. Several real-world examples will highlight how to approach the idea, what results others have already achieved and what barriers still exist. First, it is important to understand the goals behind the trend toward cabinetless machines.



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Benefits of cabinetless design

Increasing available space on the factory floor is a main driver of cabinetless design. If companies could eliminate the square footage needed for electrical cabinets, they could use that space to add more machines. This is a win-win for the manufacturer and for the machine builder OEM or integrator. It generates additional business opportunities for both – more products and lines means more machines and systems to build and install. As such, the space taken up by the supply-cabinet-sized metal box wastes profits for everyone involved.

Eliminating the cabinet, however, should not make implementation more complicated and time-consuming than the traditional approach.

Simplification is another goal of cabinetless design. With machine-mountable components, engineers should have the power to create more modular designs and to reduce cables and installation effort. Beyond eliminating electrical cabinet requirements, this removes potential points of failure, minimizes the risk of incorrect wiring through the use of standard connectors, enhances troubleshooting capabilities and cuts costs. Shrinking cabinet requirements can also reduce transportation costs when delivering machines to the end user facility.

Another factor is the push for more functional distributed devices. Installing smart components across a machine or line also allows for faster decision making and data acquisition. This could include secondary controllers, programmable safety devices, servomotors with integrated drives that include safety logic and IoT gateways, among many other technologies. The

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key to this is ensuring that the machine does not grow in size just because it grows in functionality. Fortunately, many new component and cabling options make this goal achievable.

Smart components in a small footprint

Designing or retrofitting a machine to shrink or eliminate the electrical cabinet requires rethinking most of the major components.

- **Distributed I/O terminals:** Field-mounted EtherCAT I/O boxes in IP67 and IP69K enhance communication and diagnostics directly on the machine. These provide functionality far beyond simple input/output of data, such as programmable safety, compact motion control and condition monitoring.

For example, terminals with built-in accelerometers can measure machine vibration to benchmark machine health and schedule maintenance. The compact box modules come in industrial-hardened plastic, stainless steel and zinc die cast form factors with many cabling and connector options to suit the specific application requirements.

- **One cable automation (OCA):** Combining power and communication in a single cable greatly reduces the amount of space required on the machine and the number of cable runs back to the controller. The open EtherCAT P (EtherCAT + Power) standard, for example, delivers these capabilities for various field devices and motion control components. In addition, it offers the same robust diagnostics and functional principles of the EtherCAT industrial Ethernet system. In this case, the free selection



With EtherCAT P, Beckhoff combines communication and power in a single 4-wire standard Ethernet cable. The currents of U_s and U_p are coupled directly into the wires of the 100 Mbit/s line, enabling the realization of a highly cost-effective and compact connection.

and mixing of topologies offers another important benefit for highly modular, if unconventional, wiring.

- **Motors and drives:** Traditionally, motors are ruggedized for the field while a metal cabinet protects the more sensitive drives, and they remain separate. The solution for the cabinetless concept is servomotors with integrated drives, which come in many different sizes and can be distributed across the machine. These distributed servo systems, such as AMP8000 from Beckhoff, ensure that both the motor and drive are hardened for tough production environments and reduce space requirements and spread intelligence, such as on-board safety logic (SS1, STO, etc.), throughout the machine. In certain product families, including AMP8000, multiple integrated motor-amplifier components link to a main IP65 supply module via EtherCAT P, and that module communicates with a single cable back to a single servo drive or machine controller.
- **Machine controllers:** Programmable logic controllers (PLCs), programmable automation controllers (PACs) and Industrial PCs (IPCs) are some of the last components that engineers would imagine installing outside a protective enclosure. They require a safe environment, free from any possible collisions, and they may have fans, buttons, interfaces and other openings where water, dust and other contaminants could enter. A new generation of machine controllers from Beckhoff – both IPCs and Panel PCs – is addressing these problem areas head on. Passive cooling, new connector types and robust housings are enabling IP65/67-rated IPCs that withstand shocks, extreme temperatures and easily connect to I/O and motion systems spread across the machine.



With the new C7015 ultra-compact Industrial PC, Beckhoff combines its extensive expertise with PC-based machine control and IP65/67 components. The result is an Industrial PC (IPC) designed with field-mounted IP65/67 protection for direct installation on the machines or other equipment.

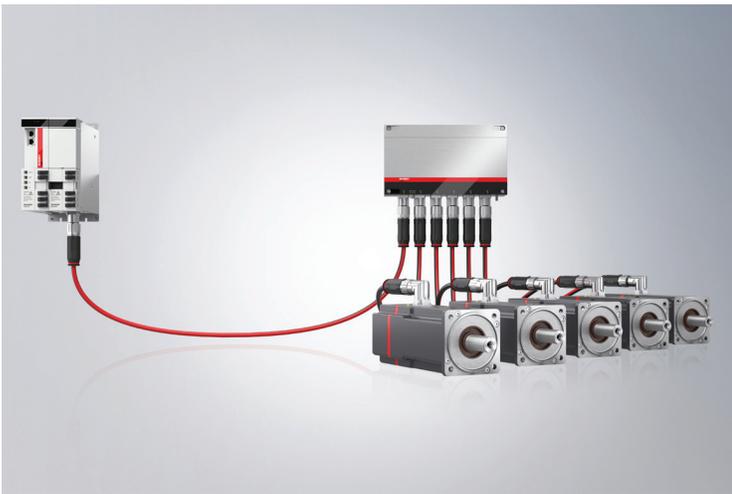
- **Power supplies:** Literally taking the electricity out of the electrical cabinet, some manufacturers now offer power supplies that can be mounted in the field. These can supply power for a broad range of needs, from controllers to motors and beyond. However, as a relatively new development, field-mounted power supplies do not have the proven track record yet that other components do, so the engineering community may be slower to adopt this innovation. In addition, safe power delivery is one of the more problematic aspects cabinetless design, especially in motion-intensive applications, and these issues will come into the discussion shortly.

Of course, this list is not exhaustive, and as components become more functional and spread out, the lines will blur somewhat. Consider, for example, the recent Beckhoff AMI812x range of compact drive components that combines the servomotor, output stage and multiple fieldbus connections in a space-saving design. With standstill torques from 0.5 to 1.1 Nm, this component family meets many motion control requirements, reduces the number of standard I/O modules needed and offers monitoring of motor parameters (e.g. overvoltage, undervoltage, overcurrent or motor load).

Small additions can create big opportunities to shrink or eliminate control cabinets. The cabinetless concept has implications for nearly every industry. However, intralogistics and packaging stand to benefit immediately, maybe more so than others.

Cabinetless design in intralogistics

Automation for material handling in fulfillment in distribution centers (DCs) was growing steadily before the COVID-19



The AMP8000 Distributed Servo System from Beckhoff enables the connection of five servomotors with integrated drives via a distribution module to controls equipment.

pandemic, and has accelerated as a result of it. Automated guided vehicles (AGVs) and autonomous shuttle systems already incorporate IPCs, I/O and motion control directly into the machine. However, more traditional DC technologies have not adopted these capabilities as quickly. Long runs of conveyors and sorters that stretch across the warehouse floor suffer from fieldbus shortcomings, including inability to use line topology, lack of diagnostics and limits in physical distance. This affects high-speed merges and sortation system drops, leading to expensive order returns in the competitive e-commerce market.

Cabinetless concepts and EtherCAT solved these issues for intralogistics equipment supplier EuroSort. When installing a large split tray sortation system and other solutions at the Gap Inc. distribution center in Fishkill, New York, EuroSort implemented field-mounted EtherCAT I/O and one-cable technologies. Along with shorter scan times, EuroSort reduced wiring and panel requirements, simplified commissioning and distributed intelligence, including functional safety, across the DC. Considering the equipment footprint reductions and higher system performance, tangible benefits of new EuroSort split tray sorters have already piled up for Gap, as well as other clients.

"Achieving 100% faster scan times and increasing overall accuracy of PC- and EtherCAT-based sorters have been huge advantages," says Greg Meyer, VP of Sales and Marketing at EuroSort. "Once Gap Inc. began using the new EuroSort split tray sorters in a new fulfillment center, order fulfillment accuracy went up 2% compared to the technology it replaced. These improvements avoided what otherwise would have been thousands of costly returns for the retailer."

"Machine-mounted EtherCAT Box I/O modules spread data acquisition and other functionality..."

Cabinetless design in packaging

The packaging industry continues to create new ways to maximize throughput and minimize downtime for changeovers, for example with linear transport systems and other motion control advances. However, machine footprint remains a significant barrier for consumer packaged goods (CPG) manufacturers and contract packagers. These businesses need

to produce more products in varying quantities and with greater customization, down to lot size 1. Cabinetless design helps make this possible.

To make this happen, Syntegon (formerly Bosch Packaging) uses pole-

mounted IP65 panel PCs in roughly 40% of its applications, pole-mounted control panels making up another 40% and built-in, cabinet-mounted control panels making up the last 20%. This visualization program, which the packaging machine company calls HMI 4.0, brings machine control directly to the multi-touch operator interface with custom push-button extensions. The panel PCs also allow for greater IIoT capabilities, which was another major factor in Syntegon's standardization decision.

A particularly apt example is one new tray and carton former, which uses a panel PC for control and operator interface. Machine-mounted EtherCAT Box I/O modules spread data acquisition and other functionality across the machine. Most importantly, the distributed servo system provides coordinated, multi-axis motion with a single distribution module powering multiple servomotors with integrated drives. The machine delivers performance of up to 240 cartons per



EuroSort used elements of cabinetless design in the distribution center redesign for Gap, Inc., which optimized space, performance and cost.

minute with versatility for multiple carton types, while only requiring a very small, attached cabinet for fusing. Which brings us to the main sticking point.

Reasons to be cautious: power and plant environments

The main barrier to cabinetless machine concepts is and will continue to be power. Dust, dirt, moisture and other hazards may make it difficult to install IPCs, I/O, motors that require regen capabilities and other components in the field, but it is possible – or will be in the near future. However, the outlook is not as bright for electrical supply and fusing components.

First, these products not typically hardened for installation out in the open. Also, for machine manufacturers hoping to build standard products, it is much easier to meet the National Electric Code (NEC), along with other global and local standards, if the electrical components are in a separate cabinet. Often an isolation transformer is needed, as well as an additional safety circuit branch for machines drawing power above 20 A. That is, most machines. In these cases, the electrical cabinet reassures both the OEM and end user that the machine can be installed and pass inspection with no issues.

The optimistic response is that eventually these components can also integrate directly into the machine. However, some are quite large and generate substantial heat, making it unfeasible and potentially unsafe to incorporate them.

In fabrication, for instance, large CNC plasma, laser and waterjet cutters require significant power. The supplies can range from 8 kW for an average fiber laser cutter to more than 60 kW and 300 A for many plasma cutters. These units are large on their own, and they require large fuses as well.



Syntegon packaging machines use various Beckhoff Panel PC and Control Panel solutions with customization for arm-mounted or built-in versions as well as options with or without electromechanical buttons, as required. This helps to reduce space requirements in control cabinets.

Some components could still move outside the cabinet, helping to reduce footprint, simplify implementation and distribute intelligence. However, fabrication applications often have other difficulties, such as abrasive material used in water jets, metal shavings, large moving objects and arcs that must be protected.

Due to these factors, the electrical cabinet will not go away completely, so engineers in these fields may view designing automated loading or other systems to reduce space requirements on the fab shop floor as a better use of time. However, that does not negate the benefits of cabinetless design in many other applications.

Minimize cabinets whenever and wherever possible

Despite current difficulties in certain machines and industries, cabinetless design is the future. As automation continues to spread, companies need to install more machines to do more tasks in less space. The space freed up by eliminating electrical cabinets will allow them to invest in new product lines rather than new real estate.

As with IIoT and Industrie 4.0 concepts, we are beginning to see applications from early adopters of cabinet-free technology. As more engineers embrace this new paradigm in machine design, vendors will produce more components to support that vision.

Machine builders can already implement many machine-mounted devices. From controllers and control panels to I/O and motion systems, a range of powerful automation devices have the protection rating and capabilities needed to shrink electrical cabinets significantly for now, until enclosures become obsolete.



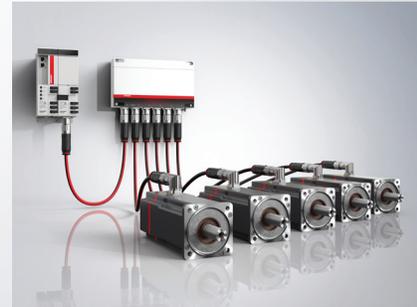
Systems with high levels of drive technology require substantial fusing, and machines with significant power requirements, such as CNC laser, plasma and waterjet cutters, use power supplies drawing up to 300 A, in some cases. Both the fusing and large power supplies above 20 A must remain protected in electrical cabinets.

Cabinetless components: New products available from Beckhoff

AMP8000 distributed servo drive system

- robust IP65-rated integrated servo drive technology and power supply with onboard EtherCAT P for cabinetless machine designs
- several motor options with flange codes F4 (87 mm) and F5 (104 mm), standstill torques from 2.25 to 12.7 Nm (M_0)
- rated speeds ranging from 2,000 to 8,000 min^{-1}
- TwinSAFE STO/SS1 safety functions integrated with extra options

► www.beckhoff.com/amp8000



AMI812x integrated servo drive series

- compact drive technology up to 48 V DC, power range up to 400 w
- flange code F2 (58 mm), standstill torques from 0.48 to 1 Nm (M_0)
- rated speeds ranging from 2,000 to 4,500 min^{-1}
- standardized M8 (EtherCAT) and M12 (power) connectors for cost-effective, industrially compatible connection technology
- TwinSAFE STO/SS1 safety functions integrated

► www.beckhoff.com/ami812x



C7015 ultra-compact Industrial PC

- IP65/67-rated for direct machine mounting in the field: ideal for simultaneous, high-performance automation under harsh real-time conditions, visualization and communication
- onboard interfaces: 3 x LAN, 2 x USB, mini DisplayPort, EtherCAT P
- 40 GB M.2 SSD with 3D Flash
- Intel Atom® processors with 2 or 4 cores

► www.beckhoff.com/c7015



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