

Distributed Motor Control

What is it, what are the benefits and where can it be used?



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Introduction

New products, installation practices and control architectures are being adopted rapidly in industrial and commercial applications to reduce costs and maximize productivity.

Distributed motor controllers deliver the cost reduction and productivity improvements that customers are demanding.

The Cutler-Hammer *IT* family of starters, soft starters, communication and IO modules and power supplies from Eaton Corporation provides all of the functionality required in these applications.

IT products are “smart” for use in communication networks. Highlights of the *IT* family include:

- Electronic design platforms with advanced functionality — selectable control and protective functions and configurable parameters
- DeviceNet enabled motor control and IO
- Monitoring of application parameters and faults, status indication and diagnostics
- Modular stand-alone components or assemblies
- UL, CSA, KEMA and CE approvals
- Small size
- 24V DC control
- Low power consumption and low heat generation
- Reduced wiring, installation and snap-on accessories

The unique feature set of the *IT* family provides:

- Lower installed costs
- Enhanced safety
- Improved process and application management
- Increased up-time

The purpose of this paper is to provide an overview of distributed motor control, so that it can be evaluated and considered as an alternative to centralized motor control. The following topics are addressed:

- What is distributed motor control?
- What benefits does distributed motor control provide?
- What has made distributed motor control possible?
- What industries have implemented distributed motor control systems and what are the applications?
- What are the key products typically found in distributed motor control systems?

Centralized Motor Control vs. Distributed Motor Control

Distributed motor control systems can provide significant customer benefits compared to traditional centralized motor control installations. As a foundation of this paper, following are working definitions and system diagrams describing these two methods of installation.

Centralized Motor Control

Multiple motor controllers are installed in a single enclosure or motor control center, located remotely in a control room or on the plant floor, often times out-of-sight of the motors/equipment being controlled. Motor controllers might be electromechanical starters, soft starters or variable frequency drives. Separate auxiliary system devices such as safety switches, HMI, sensors, pushbutton stations, alarms and stacklights are generally hard-wired back to the main enclosure or MCC. Systems are engineering- and installation-intensive and have limited flexibility for extension/reconfiguration. Installation characteristics include: many control wires, long home-runs and the need to calculate conduit size and fill. See Figure 1.

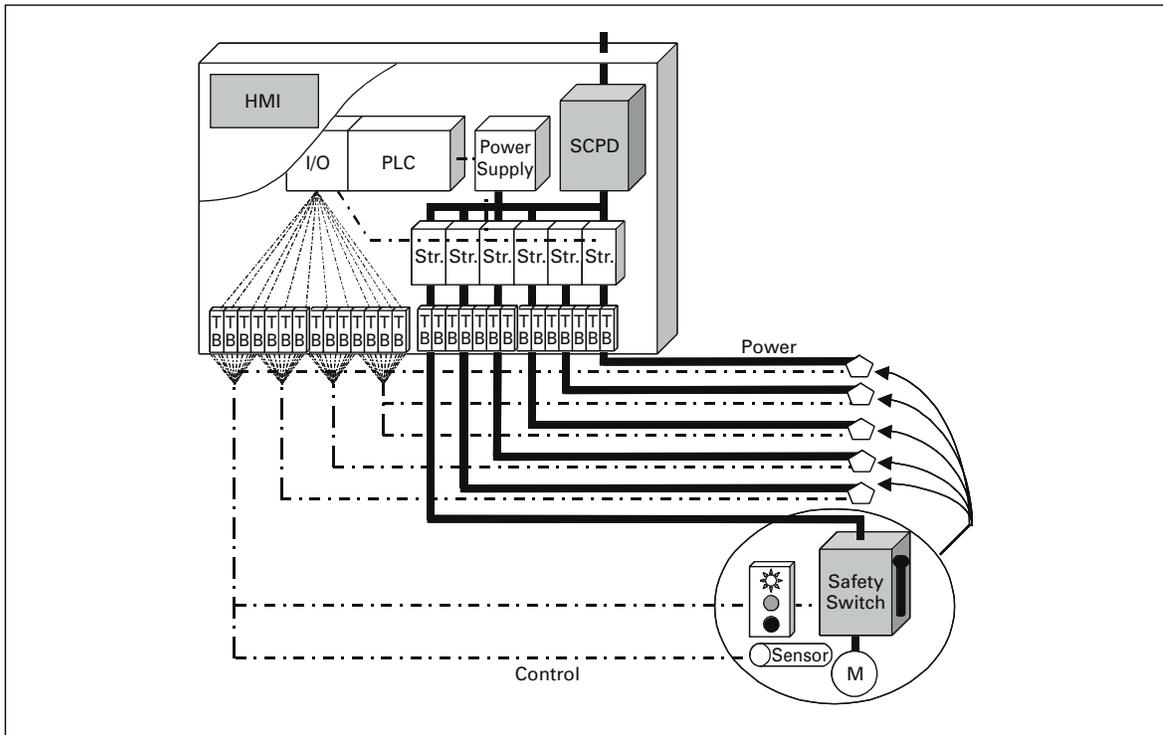


Figure 1: Centralized Motor Control

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Distributed Motor Control

Individual enclosed motor controllers are installed on the plant floor, adjacent to the motor being controlled. Motor controllers might be electromechanical starters, soft starters or variable frequency drives and are typically “smart devices” and part of a communication network (for example DeviceNet). Separate auxiliary system devices, such as sensors, pushbutton stations, alarms and stacklights (which may or may not be “smart devices”) are wired directly to the enclosed motor controller. Many separate auxiliary devices are eliminated (such as safety switches) because their functions (disconnecting means and operator interface) are integral to the enclosed starter. System engineering and installation is simple and flexible for easy extension/reconfiguration. Network communications minimize control wiring and can eliminate conduit. See Figure 2.

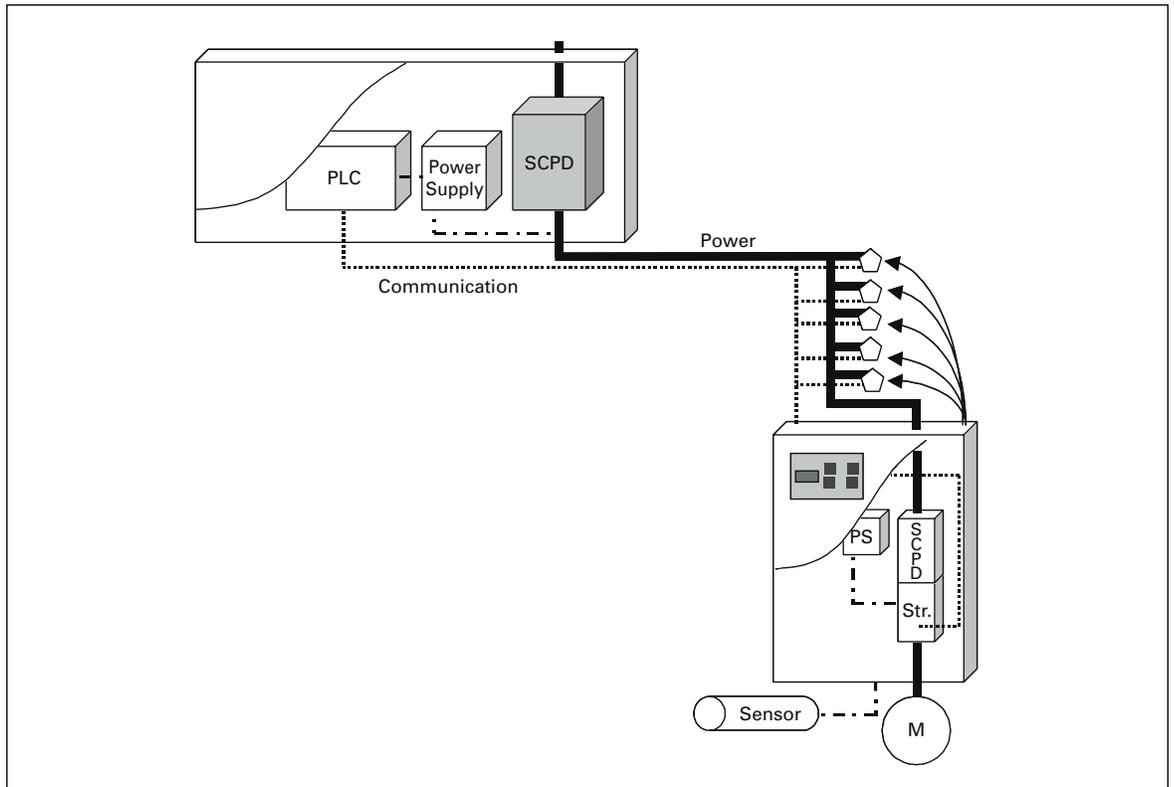


Figure 2: Distributed Motor Control

Benefits of Distributed Motor Control

Distributed motor control offers significant benefits throughout all stages of a product's or equipment's useful life and provides benefits across the organization to engineers, manufacturing, maintenance, services and management. The primary benefits of distributed motor control include:

- **Reduced control system engineering and planning costs**
 - A single device, with standard physical attributes can often times be specified to meet the functional requirements of a variety of different applications and replace a number of individual components that would typically be required.
 - Distributed motor controller designs are typically modular assemblies of standard components.
 - Distributed motor controller designs include multiple, integrated functions including communications.

- **Lower installation and maintenance costs**
 - Device status indication and diagnostics reduces troubleshooting, thus decreasing start-up time. Because distributed motor controllers are networked, commissioning can be performed from a centralized location that is usually off the plant floor.
 - Less point-to-point wiring (as a result of utilizing a communication network) and plug-and-play capability — control, power and network communication wires often utilize plug-and-socket connectors making distributed motor controllers easy to install.
 - Fewer components need to be installed and wired. The amount of wiring materials can generally be reduced (by eliminating home-run wiring from the motor to the central panel).
 - Maintenance is faster and easier when the controller is close to the motor — safety procedures are simplified.

- **Lower operating costs and increased productivity**
 - Application parameters, device status and diagnostics can be monitored and communicated over a network. The process can be managed proactively instead of reactively.
 - System performance can be improved because smaller decentralized processors reduce the demand on the centralized processor, reducing network traffic.
 - Individual distributed motor controllers can be isolated, enabling smaller zones/ parts of equipment to be serviced without shutting down the whole system (likewise, a fault condition can be “contained” to a single zone without shutting down the whole system).
 - Systems can be easily expanded/reconfigured and replacement devices can be quickly and easily installed (for example, when more advanced functions are required or if a distributed motor controller has failed).

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What Makes Distributed Motor Control Possible?

The introduction of new products incorporating new technologies have contributed greatly to making distributed motor control possible, the most important of which include:

- **Microprocessor based devices with communication capability**
Due to the declining cost and increased functionality of electronics, it is now cost effective to incorporate these components into standard industrial control devices like starters. Incorporating electronics provides enhanced functionality including: network communication capability and advanced protective and control functions.
- **Open (non-proprietary) industrial communication networks**
The global standardization on a limited number of open communication networks such as DeviceNet, Foundation Fieldbus and Ethernet has enabled users to comfortably and confidently specify control networks and associated components in their own facility. Because there is a broad range of products available, they don't have to be "tied" to a single supplier (as was the case with proprietary networks).
- **Small size devices with modular construction**
Small size devices are the result of higher performing materials, electronics and 24V DC control. Small size contributes to modular construction — enabling accessories like communication adapters to be easily added to starters in the field. IO points can be added incrementally instead of having to purchase and add whole blocks (which may be more than needed depending on the IO module granularity). Small size and modular construction provides customers with the flexibility to specify and purchase just what is needed for each application and also gives them the ability to expand in the future when increased functionality is required.

In addition, a number of other characteristics (but to a lesser degree) have helped make distributed motor control possible:

- Industrially designed connectors and physical media
- Industrially hardened components and assemblies
- Devices with integrated functionality
- Ability for customization
- Improved short circuit coordination/protective devices
- Application and configuration software
- Changes to product standards and installation codes

Industries and Applications for Distributed Motor Control

Distributed motor control systems are becoming popular today because of the significant benefits they provide when compared to centralized motor control: reduced control system and engineering and planning costs, lower installation and maintenance costs and lower operating costs and increased productivity.

Ironically, these were the same benefits that made centralized motor control and motor control centers popular in the past when compared to traditional installations of stand-alone hard-wired non-combination or combination starters. The stand-alone non-combination and combination starters in traditional installations could really be considered “dumb” distributed motor controllers. When considering centralized motor control versus distributed motor control today, implementing a distributed motor control solution may be a good alternative to centralized control and MCCs when any of the following application characteristics are present:

- Motors are small (ex. 10 horsepower/7.5 kW or less)
- There are a small number of motors (ex. less than the number of starters in a single MCC section) on the equipment, machine or cell (there may be many motors in the whole facility)
- The application requires a high degree of ingress protection (IP66 or NEMA 4/4X for wash-down)
- There are a significant number of connected auxiliary devices (such as sensors)
- System upgrades and expansions or reconfigurations are expected
- Equipment and machines are large and must be shipped to the application site in pieces, where the final system assembly and installation is performed
- The central control panel would have to be located far away (out-of-sight) from the motor/equipment being controlled

While distributed motor control can provide benefits in a wide variety of applications, the primary applications where it has been implemented most successfully include:

- Material Handling
 - Conveyors
 - Elevators, lifts and escalators
 - Cranes
 - Automated storage systems
- Packaging
 - Palletizers
 - Wrapping equipment
 - Bottling and filling equipment

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Following is a summary of industries, applications and their characteristics that make them well suited for distributed motor control solutions.

| Application | Description | Small Motors | Small No. of Motors on the Equipment | High Degree of Ingress Protection | Many Auxiliary Devices | Upgrades and Expansions Expected | Equipment Large, Shipped in Pieces | Location of a Central Control Panel Far Away |
|-----------------------------------|---|--------------|--------------------------------------|-----------------------------------|------------------------|----------------------------------|------------------------------------|--|
| Airport | | | | | | | | |
| Conveyor | Machinery and equipment for moving shipping cargo containers | • | • | | • | • | • | |
| Elevator/Lift | | • | • | | | | • | |
| Crane | | • | • | | | | • | |
| Automotive | | | | | | | | |
| Conveyor | Vehicle assembly | • | • | | • | | • | |
| Elevator/Lift | Power train assembly transfer station | • | • | | | | • | |
| Crane | Vehicle body paint booth and processing | • | • | • | • | | • | |
| Logistics and Distribution | | | | | | | | |
| Conveyor | Parcel sorting and distribution | • | • | | • | • | • | |
| Automated Storage | Inventory pick and place | • | • | | • | • | • | • |
| Mining | | | | | | | | |
| Conveyor | Machinery and equipment for removal and loading of crushed rock from a quarry | | • | • | | • | • | • |
| Crane | | | | • | • | | | • |
| Food Processing | | | | | | | | |
| Palletizer | Stacking and palletizing beverage cases | • | • | | • | | | |
| Wrapping | Machinery and equipment for shrink wrapping vegetables | • | • | • | • | | | |
| Bottling/Filling | Machinery and equipment for filling bottles of water | • | • | • | • | • | • | |
| Conveyor | Moving containers through sterilization equipment | • | • | • | • | • | • | • |
| Pharmaceutical | | | | | | | | |
| Bottling | Machinery and equipment for bottling tablets | • | • | | • | | | |
| Conveyor | Moving bottles through marking and labeling equipment | • | • | | • | | • | |

• = typical characteristic/requirement

Eaton's Cutler-Hammer Solutions for Distributed Motor Control Systems

Distributed motor control systems in industrial and commercial applications include a broad range of components and assemblies to provide the required control, protection, logic, sensing and communication functions. The primary devices found in these applications include:

Electromechanical Contactors, Starters and Overload Relays

Electromechanical contactors, starters and overload relays are designed for across-the-line control and protection of motors and non-motor loads.

- IEC and NEMA
- Non-reversing and reversing devices
- Electronic, bimetallic or eutectic alloy overload relays



Soft Starters

Soft starters are solid-state reduced voltage starters designed to control and protect single- and three-phase motors. They may include built-in overload protection and a run bypass contactor.

- Control functions: kick start, ramp start, current limit start, soft stop and pump control to eliminate water hammer
- Protective functions: overload, overtemperature, jam, stall, phase loss, phase reversal and shorted SCR detection



Variable Frequency Drives

Electronic devices for the precise control of motor speed, torque, horsepower and direction of rotation. They often include built-in overload protection and other advanced protective functions (for example, stall).



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Enclosed Control

A complete assembly of multiple distributed motor control components such as electromechanical starters, IO modules and cover controls in industrially rated enclosures.



IO Modules

Input and output devices that integrate motor controllers, sensors, actuators and operator interfaces with communication networks.



Network Communication Components

Network adapters provide communication, control and monitoring functions for any devices that do not include embedded communications capabilities.

Communication gateways monitor and control multiple system devices and typically concentrate data from connected devices into a single node and act as a bridge between two different communication networks.



Power Supplies

Power supplies provide regulated output of 24V DC for individual component and communication network power requirements. Power supplies typically have input voltages up to 500V AC and can be DIN rail or panel mounted.



Connectors and Cables

Plug-and-socket and multi-conductor cables for control, power and communications connections. Connectors and cables have ingress protection ratings suitable for use on the plant floor.

Photo of connectors and cables

Short Circuit Protective Devices

Short circuit protective devices provide protection to motor branch circuit components against overcurrents ranging from 10 times motor full load current to 100 kA or more. There is a wide variety of devices available with different performance characteristics:

- Molded case circuit breakers and motor circuit protectors
- Manual motor starters/protectors
- Fuses



Sensors and Actuators

Electronic or electromechanical devices for condition sensing (such as temperature, pressure, flow and level) or presence sensing. Common presence sensing devices include:

- Proximity sensors
- Photoelectric sensors
- Limit switches



Actuators include valves, cylinders and solenoids.

Cover Controls and Operator Interface

Cover controls and operator interface devices provide actuation functions for motor controllers and other solenoid operated devices, as well as indication functions. A wide variety of devices are available including:

- Electronic operator interfaces
- Electromechanical pushbuttons, selector switches and pilot lights
- Cover controls with both electronic and electromechanical features



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Enclosures

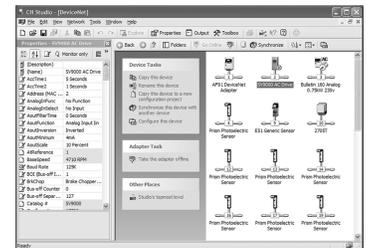
Metallic or nonmetallic housings used to protect open style components from environmental conditions (dust, oil, water, etc.) and to protect personnel by guarding against accidental contact with live parts. Enclosures are available with a variety of constructions and ratings including:

- Hinged door or lift-off cover
- Nonmetallic or metallic, including stainless steel
- Ingress protection: NEMA 1, 12, 4/4X and IP54, 65 and 66



Software

An integrated software development environment with a graphical interface for configuration and monitoring of individual network products or complete systems.



Conclusion

Distributed Motor Control is the installation of individual enclosed motor controllers on the plant floor, adjacent to the motor being controlled. Motor controllers are typically “smart devices” and part of a communication network (for example DeviceNet).

Distributed motor control offers significant benefits throughout all stages of a product’s or equipment’s useful life and provides benefits across the organization to engineers, manufacturing, maintenance and services and management. The primary benefits of distributed motor control include:

- Reduced control system engineering and planning costs
- Lower installation and maintenance costs
- Lower operating costs and increased productivity

Distributed motor control is possible in great part due to the introduction of new products and technologies, the most important of which include:

- Microprocessor based devices such as starters with communication capability
- Open (nonproprietary) industrial communication networks (for example DeviceNet)
- Small size devices with modular construction

Implementing a distributed motor control solution may be a good alternative to centralized motor control and MCCs when any of the following application characteristics are present:

- Motors are small.
- Motors are distributed throughout the equipment, machine or cell.
- The application requires a high degree of ingress protection.
- There are a significant number of connected auxiliary devices (sensors, actuators).
- System upgrades and expansions or re-configurations are expected.
- Equipment and machines are large and must be shipped to the application site in sections where final system assembly, installation and start-up is performed.
- The central control panel would have to be located far away (out-of-sight) from the motor/equipment being controlled.

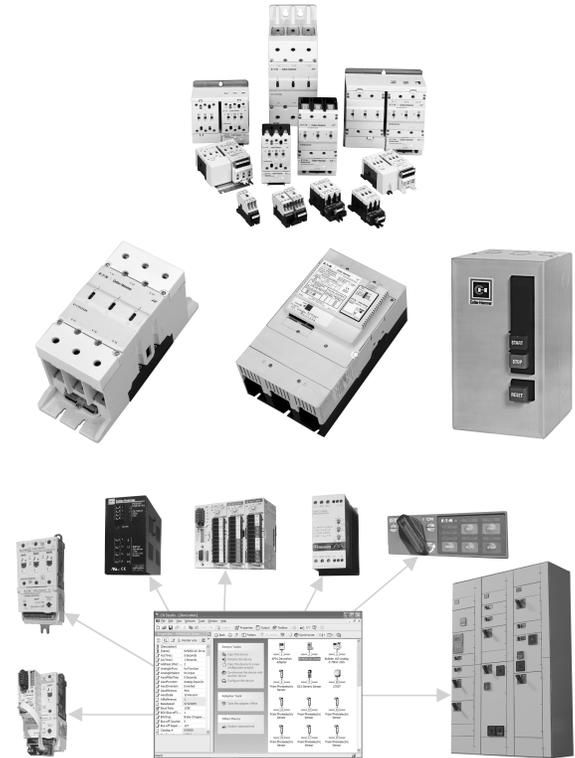
Distributed motor control can provide benefits in a wide variety of applications, the primary applications where it has been implemented most successfully are material handling and packaging. Industries with substantial material handling and packaging applications, making them ideal for distributed motor control include:

- Airport
- Automotive
- Logistics and Distribution
- Food Processing
- Mining
- Pharmaceutical

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Distributed motor control systems in industrial and commercial applications include a broad range of components and assemblies to provide the required control, protection, logic, sensing and communication functions. Eaton's Cutler-Hammer offers devices found in these applications, including:

- Electromechanical contactors, starters and overload relays
- Soft starters
- Variable frequency drives
- Enclosed control
- Terminals
- Pushbuttons
- IO modules
- Sensors
- Operator Interface
- Network communication components
- Power supplies
- Connectors and cables
- Short circuit protective devices
- Cover controls and operator interface
- Enclosures
- Software



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Eaton Corporation
Cutler-Hammer business unit
1000 Cherrington Parkway
Moon Township, PA 15108-4312
USA
tel: 1-800-525-2000
www.cutler-hammer.eaton.com