Industrial Motor Control

ECET 4530

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An Introduction To
Motor Controllers
and
Motor Control Systems

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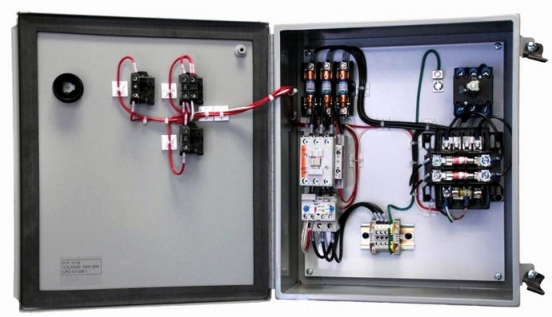
Motor Controllers

A **motor controller** is a device or group of devices that serves to govern, in some predetermined manner, the performance of an electric motor.



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Motor Controllers

A **motor controller** is a device or group of devices that serves to govern, in some predetermined manner, the performance of an electric motor.

The most basic function of a **motor controller** is to **safely start and stop a motor**.

Although the starting and stopping of a motor may initially appear to be simple tasks, these operations can actually be quite complex, especially when the motor is part of a larger electro-mechanical system.

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Starting a Motor

A **small motor** can often be started by simply plugging it into an electrical receptacle, or by using a switch or a circuit breaker to energize the motor.

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Motor Starters

On the other hand, **larger motors**, or those that require automatic or remote control, typically require a specialized switching unit called a **motor starter**.

A **motor starter** provides the means for **safely connecting/disconnecting** a motor to/from its source of electric supply in order to start/stop the motor.

In addition to connecting a motor to (or disconnecting a motor from) its electric supply, a **motor starter** contains a protective device that **provides overload protection** for the motor.

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Starting/Stopping Considerations

Although a basic motor starter may be sufficient to provide for the needs of the motor being controlled for simple applications, **industrial applications** often demand greater functionality than a basic motor starter can provide.

When **starting or stopping industrial-sized motors**, there are many **concerns** that must be considered including (but not limited to):

- Can the motor be **started with full-rated voltage** applied across its terminals or does the it need to be **soft-started***?
- Can the motor be **started while under (mechanical) load**?

* – **Soft-starting** of a motor entails the use of some method to limit the currents that flow into a motor during the startup process.

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Other Starting/Stopping Considerations

When the controlled motors are **part of a larger system**, additional concerns may also arise, such as:

- Is there a required **start-up/shut-down sequence**?
- Are there any **conditions** that must be met before the motor can be **safely started/stopped**?
- Does the motor require **starting/stopping from local, remote and/or multiple locations**?
- Are there **Emergency Shutdown** or **lockout** concerns?
- Does the system need to be **flexible in design**, or are there plans for **future expansion** of the system?

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Functions of a Motor Control System

Thus, along with the starting and stopping of a motor, a **motor control system** may also be required to:

- Provide **protection** for the motor, the electro-mechanical system, the operator or other personnel, by providing:
  - **Overload Protection**
    (Prevents damage to the motor from overheating due to excessive load, abnormal or improper operation, starting problems, etc.)

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- Provide **protection** for the motor, the electro-mechanical system, the operator or other personnel, by providing:
  - **Overload Protection**
  - **Soft-Starting / Limiting the Starting Current**
    (Minimizes the stresses placed upon the motor and the electro-mechanical system due to the large currents that are typically drawn during start-up.)

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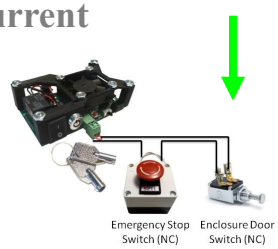
- Provide **protection** for the motor, the electro-mechanical system, the operator or other personnel, by providing:
  - **Overload Protection**
  - **Soft-Starting / Limiting the Starting Current**
  - **Safety Interlocks**
    (Ensures safe operation of a motor or other electro-mechanical system by preventing start-up unless certain conditions are met or shutting-down the device(s) if an unsafe condition exists.)



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  - **Soft-Starting / Limiting the Starting Current**
  - **Safety Interlocks**
  - **Emergency Shutdown / Lockout Ability**

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Functions of a Motor Control System

Thus, along with the starting and stopping of a motor, a **motor control system** may also be required to:

- Provide **complex control** of the motor(s), such as:
  - **multiple** (preset) **operational speeds**
  - **variable speed operation**
  - **reversing the direction of rotation**
  - **jogging / position control**
  - **plugging / braking**
  - **torque control**

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Functions of a Motor Control System

Thus, along with the starting and stopping of a motor, a **motor control system** may also be required to:

- Provide **Control** of the devices, and **Monitoring/Indication** of the system's status by means of:
  - **Pilot Devices**

Note – A **pilot device** is a device that provides control and condition monitoring of a device or process.

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  - **Analog or Digital Meters**

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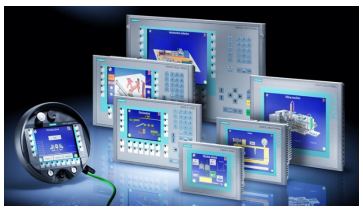
  - **HMI Panels**

    HMI ≡ Human Machine Interface



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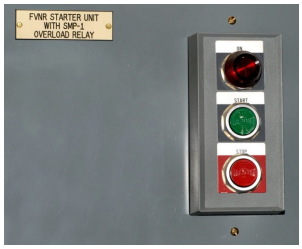
Functions of a Motor Control System

Thus, along with the starting and stopping of a motor, a **motor control system** may also be required to:

- Provide **Manual** (operator) **Control**, **Automated Control**, or a combination of the two methods.
  - **Manual Control**
    (Direct operator interaction, such as a physical button press or execution of a command on an HMI panel, is required in order to change the operational state of the system.)



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Functions of a Motor Control System

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- Provide **Manual** (operator) **Control**, **Automated Control**, or a combination of the two methods.
  - **Manual Control**
  - **Automated Control**
    (Changes in the operational state of the system happen automatically without any direct interaction from an operator.)

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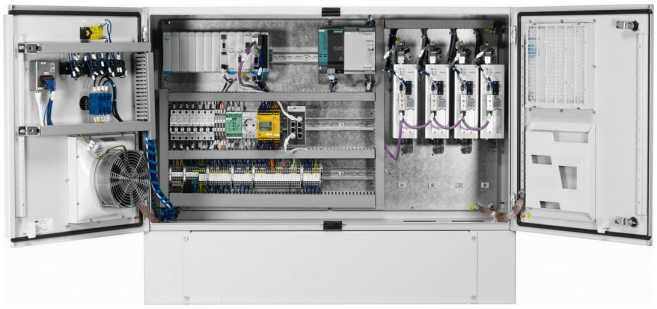
Functions of a Motor Control System

Thus, along with the starting and stopping of a motor, a **motor control system** may also be required to:

- **Coordinate the operation of multiple motors or devices**.



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Functions of a Motor Control System

Thus, along with the starting and stopping of a motor, a **motor control system** may also be required to:

- **Coordinate the operation of multiple motors or devices**.
  - **Sequence Control**
    (Provide the logic and/or timing required for proper start-up, operation and shut-down of a system that operates in a repetitively sequential manner.)
  - **Real-Time Control**
    (Control based upon a pre-defined set of operational steps that may be modified by the system's current status, operator input, or feedback from sensors/detectors.)

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Motor Control System Components

Although many of the motor controller's **basic tasks** can be performed by utilizing a combination of:

- **Pushbuttons, Switches, Indicator Lamps** (Pilot Devices)
- **Relays**
- **Contactors**
- **Timers**
- **Overload Relays**
- **Sensors & Detectors** (Optical, Pressure, Temperature, etc.)

complex tasks may require the additional use of:

- **PLCs (Programmable Logic Controllers)**
- **VFDs (Variable Frequency Drives)**
- **other electronic devices**

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Programmable Logic Controllers

Programmable Logic Controllers (PLCs) are event-driven, process-control computers that are often used in modern motor control systems.

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Programmable Logic Controllers (PLCs) are event-driven, process-control computers that are often used in modern motor control systems.

Instead of using discrete components (relays, timers, etc.), a PLC can be **programmed** to provide the basic operational logic required to control (one or more) motors and/or other devices.

PLCs can also provide high-level logic functions that are difficult to realize using a discrete set of components, along with other features such as network communications & interfacing, data storage, remote monitoring, and system flexibility due to their ease of reconfiguring and reprogramming.

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Variable Frequency Drives

Variable Frequency Drives (VFDs) are power-electronic devices that produce AC, variable-frequency voltages in order to supply and control the operation (speed) of an AC motor.

VFDs are often used in motor control systems that require accurate speed control, variable speed operation, directional control, torque control, and/or soft-starting of AC motors.

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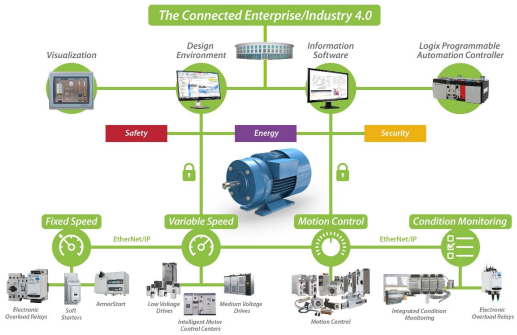
Motor Control System Design

The design of a motor control system should be based upon the operational requirements of the system, along with other considerations such as safety, cost, complexity, flexibility, durability, and the operating environment.



http://literature.rockwellautomation.com/idc/groups/literature/documents/br/imc-br004_-en-e.pdf

Explosion-Proof Variable Frequency Drive

http://www.cooperindustries.com/content/dam/public/crousehinds/resources/pdfs/literature/ace20-vfd-brochure.pdf

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Simple vs. Complex Solutions

Although PLCs are widely used throughout the industry, when designing a PLC-based system, you should also consider:

- Is a PLC necessary or **will a simpler solution suffice**?
- What is the **skill level** of the operators and other personnel?

For example – Consider a small motor that will be used to drive a pool-pump; What kind of motor controller is needed for this device?

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Example – Pool Filtration Pump

Considerations when designing a controller for a pool-pump motor:

What are the **characteristics** of a pool-pump?

- Typically requires a 1Φ, fractional-to-single-horsepower, low voltage motor that draws a "low" starting current
- Minimal load at startup (pump-type load → quick starting)
- Direct drive, small, safe (no exposed moving parts)

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Example – Pool Filtration Pump

Considerations when designing a controller for a pool-pump motor:

What are the **operational requirements** of a pool-pump?

- Run continuously (as needed)
- Does not require speed control
- Does not need to reverse direction
- Operates independently of other devices
- May not require overload protection (provided the supply circuit is properly protected)

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Example – Pool Filtration Pump

What kind of **motor controller** is needed for this device?

A **GFCI*-protected, switched receptacle** will suffice**.

* – GFCI ≡Ground Fault Circuit Interrupter

** – Beware the urge to **over-engineer** a simple system.

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