ECET 4530

Industrial Motor Control

Introduction to Motor Controllers and Motor Control Systems

Motor Controllers

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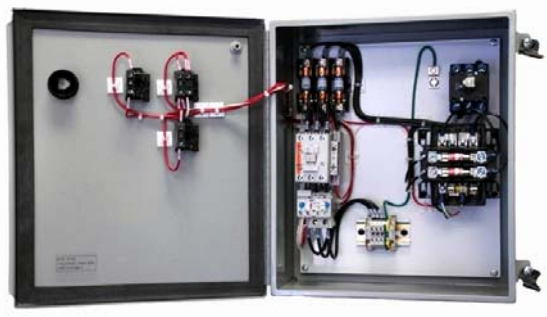

Motor Controllers

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.

Starting/Stopping Considerations

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

- **Can the motor be started with applied full-rated voltage or does the motor need to be soft-started?**
- **Can the motor be started while under (mechanical) load?**
- **Does the motor require overload protection in case of an overload, failed-start or locked-rotor condition?**

Other Starting/Stopping Considerations

When the controlled motors are part of a larger system, additional concerns may 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" concerns?**

Starting a Motor

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Larger motors, or those that require automatic, complex, 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.

Motor Starters

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

For simple applications, a basic motor starter may be sufficient to provide for the needs of the motor being controlled.

Yet, industrial applications often demand much greater functionality from the motor(s) being controlled, in-turn greatly increasing the complexity of the system.

Functions of a Motor Control System

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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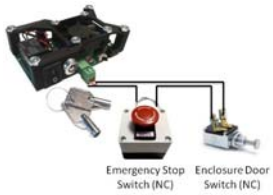
- **Provide <u>protection</u> for the motor, the electro-mechanical system, the operator or other personnel, by providing:**
  - Overload Protection
  - Soft-Starting / Limiting the Starting Current
  - **Safety Interlocks**

    (Ensures safe operation by shutting-down, preventing start-up, etc. of the motor or the electro-mechanical system unless certain conditions are met.)



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

Functions of a Motor Control System

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 / real-time control**
  - **reversing the direction of rotation**
  - **jogging / position control**
  - **plugging / braking**

Functions of a Motor Control System

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

- **Provide Indicators / Feedback to an operator pertaining to the operational status of the system.**
  - **Pilot Devices**

Note – A pilot device is a device that provides indication and control of a process to an operator.

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  - Pilot Devices
  - **Buzzers or other Audible Devices**
  - **Analog or Digital Meters**

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  - Buzzers or other Audible Devices
  - Analog or Digital Meters
  - **HMI Panels**

    HMI ≡ Human Machine Interface

Functions of a Motor Control System

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

- **Provide for Manual Control (by an operator) of a system, Autonomous Control of a system, 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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- **Provide for Manual Control (by an operator) of a system, Autonomous Control of a system, or a combination of the two methods.**
  - Manual Control
  - **Autonomous Control**

    (Once the system is started, changes in the operational state of the system happen automatically without any required operator interaction.)

Functions of a Motor Control System

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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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.)

Motor Control System Components

The simplest of the motor controller's tasks may be performed by utilizing a combination of push buttons and relays or contactors.

Added functionality can be provided by utilizing pilot devices, timers, sensors, detectors, and other common control system components.

Complex tasks may require the use of PLCs (Programmable Logic Controllers), VFDs (Variable Frequency Drives), or other electronic devices.

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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A PLC can be programmed to provide the operational logic required to control a motor instead of using discrete components such as relays and timers.

Depending on its number of inputs and outputs, a single PLC can be used to simultaneously control multiple motors or even an entire electro-mechanical system.

Programmable Logic Controllers

Basic PLCs can provide many higher-level logic functions that would otherwise be very difficult to realize using a discrete set of components (relays, timers, etc.).

More advanced PLCs may also provide other useful functions such as data storage, network communications / interfacing of devices, remote monitoring or system control, etc…

Furthermore, PLCs provide a flexibility that was previously unavailable when using discrete logic components, allowing for a system's operating parameters to be modified in real-time simply by updating the software contained in the PLC.

Variable Frequency Drives

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

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

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

Questions to Ask

- Can the motor be started by applying full rated voltage?
- How often will the motor be started/stopped?
- Does the motor need the ability to reverse direction?
- Is variable speed operation or speed control required?
- Does the motor require overload protection?
- What are the operational and safety requirements for the motor/system?
- In what environment will the system operate?
- Are there any safety concerns for the operator or other personnel?

Additional Questions to Ask

- Do I need a "complex" controller or will a simple solution suffice?
- Are there plans for future expansion of the system?
- Does the system need to be flexible in design and/or easy to reconfigure?
- If there are multiple motors/devices to be controlled, can they be controlled independently or do they require coordination?
- What is the skill level of the operators?

Example – Pool Filtration Pump

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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Consider a small motor that will be used to drive a pool-pump:

What are the characteristics of the pump?

- **Typically a fractional-horsepower, low voltage, 1Φ, motor that has a "low" starting current**
- **Minimal load at startup due to nature of a pump-type load → Quick starting**
- **Direct drive, small, safe (no exposed moving parts)**

Example – Pool Filtration Pump

Consider a small motor that will be used to drive a pool-pump:

What are the operational requirements?

- **Can runs continuously (as needed)**
- **Does not require speed control**
- **Does not need to reverse direction**
- **May have built-in overload protection**
- **Operates independently of other devices**

Example – Pool Filtration Pump

Consider a small motor that will be used to drive a pool-pump:

What kind of motor controller is needed for this device?

A GFCI-protected, switched receptacle may suffice.