KOLLMORGEN

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Motor Thermal Protection

This Application Note describes the various methods and combinations of methods that have been used in an effort to protect motors form overheating and shortening their life. Although motors can be sized for servo or spindle applications, so as not to exceed their continuous current ratings, this is seldom practical in terms of physical or economic constraints. For this reason, motors are typically sized with consideration for limited operation within the intermittent duty zone.

A motor's capability in this mode of operation without overheating is a function of several factors. These include the motor's ambient condition, the motor's steady-state operation temperature prior to an overload condition, the overload condition (percent increase in load/current beyond the motor's continuous rating), and the motor's thermal time constant. At rated current and beginning at its ambient temperature, a motor reaches 63.2 percent of the total or ultimate temperature allowable in one thermal time constant. Based on these factors, various protection methods or devices can be used offering varying degrees of protection.

In consideration of an overload condition, the amplifier must have sufficient overload capability. Danaher Motion's Kollmorgen Pulse Width Modulated (PWM) drives, whether for brush-type or brushless motors, have intermittent current ratings available for 5 to 8 seconds depending on the model, after which the current folds back to the continuous current rating. This is for the purpose of protecting the output transistors, not necessarily the motor. If the amplifier has a continuous current rating equal to or less than the motor's continuous current rating, the amplifier can serve to protect the motor as well.

The only drawback to this approach is that it limits the full capability of a motor in its intermittent zone. When a motor is expected to operate in the intermittent duty zone longer than the time allowed by the amplifier, the amplifier needs to be oversized such that it has a continuous capability at the required load. In this situation, and for Kollmorgen SCR DC Amplifiers not having current foldback, additional protective devices are suggested. These devices are described below.

Fusing

A fuse is the simplest and least expensive device used to protect a motor. Connected in a series with the motor and sized for the motor's continuous current, a fuse interrupts motor current directly after a very limited time as determined by the type and specification. It offers good protection, but may not provide sufficient operation time at intermittent duty levels. In addition, a controlled or orderly shutdown of the servo is not possible and its use may cause machine or part damage on multi-drive systems.

DANAHER MOTION

Overload Relay

The overload relay (OLR) is one of the most common devices used for motor protection. With properly-sized heater, the OLR allows continuous rating and intermittent operation beyond the continuous rating. The manufacturer's characteristic curves of a particular device indicate operation times at percentages of the continuous heater rating.The overload relay has a fixed thermal time constant. For a given OLR, the operation time allowed with respect to a percent overload condition is fixed regardless of the size or current rating of the motor. This thermal time constant is generally significantly less than the motor thermal time constant, particularly for large motors.

For example, a Westinghouse AA21P OLR at its nominal setting will allow a 200 percent overload for one minute. Our TT-4237-XX , for example, has a thermal time constant of 90 minutes and is capable of a 200 percent overload for 5 minutes at a 20 percent duty cycle or for 10 minutes at a 20 percent duty. As can be seen in this example, the OLR would heat up and "trip" prior to an actual overtemperature condition. The OLR may or may not be a limiting facto,r depending on the application. It should also be noted that the OLR does not interrupt motor current directly.

A set of isolated auxiliary contacts are provided to connect into the control for intelligent power-down sequencing. Connecting these contacts into the amplifier's inhibit circuitry is generally not recommended, especially on multiple-drive systems since the stopping of one drive with others still running can cause machine or part damage. Any automatically resetting device, such as an OLR in automatic mode, should never be connected into the amplifier's inhibit circuitry for safety reasons. The automatically resetting device resets upon cooling and potentially re-enables the amplifier, applying power to the motor without warning.

In contrast, the internal fault circuitry that disables the amplifier is latched and requires a re-enabling sequence.)

Motor Thermostats

Motor thermostats are generally one of two types. These are endbell-mounted devices commonly used with brush-type motors, and winding-embedded types used in the case of brushless motors having stationary windings.

An endbell-mounted thermostat offers protection for a long-term overcurrent situation when the overcurrent RMS value is only slightly beyond the motor's rating. It is not capable of protection against a significant overcurrent situation of long duration, since it is located remotely from the windings where thermal delays are a factor. For brush motors, the combination of an OLR and motor thermostat generally offers the best protection available.

In contrast, thermostats embedded in the motor windings of brushless motors see the exact condition of windings as compared to devices like the OLR that try to predict the winding temperature. For this reason, it is the preferred protection device. Normally-closed thermostats, one in each of two or three of the phases, are series connected and brought out to the motor connector. They are not directly connected to the amplifier, but left to the customer to connect into the control. This type of device automatically resets upon cooling and should not be connected to the amplifier's enable circuitry.

Westinghouse

This section contains instructions for Size 1 or 2 Type A Thermal Overload Relay, 1 Pole, Ambient Compensated or Non-Compensated

The Relay

The type A single-pole thermal overload relay (OLR) is a bimetallic device which, with the properly selected wire and heater, provides motor protection for running and stalled rotor overloads in motor circuits not exceeding 600 volts. The Size 1 and 2 OLR's have a maximum current rating of 25.2 and 43.9 amperes, respectively. Ambient-compensated OLR's are readily distinguishable by black reset rods. Non-ambient compensated OLR's have red reset rods.

Operation

The strip bimetal in the OLR is indirectly heated by the replaceable heater element that carries the motor current. Excess heat is generated in this heater element by an overloaded motor. The heated bimetal deflects to open the normally-closed contact, thereby opening the coil circuit of a magnetic contractor that disconnects the overloaded motor for the line. After approximately 2 minutes, the relay(if hand reset), may be reset by pressing the reset rod. For relays in the auto position, resetting occurs automatically.

Installation

The OLR must be installed on a vertical surface with the control terminals at the bottom. The relay is accurately calibrated at the factory. Do not tamper with it. Installation is made with the proper wire size (see heater selection table) for the application and all wires must be securely fastened. Preferably, the OLR should be located in the same ambient as the motor to be protected and in an area free of drafts. The heater element is supplied separately and must be properly selected and securely mounted. One heater is used on each OLR. One OLR is used for single phase applications. Three separate OLR's are required for three phase applications.

This industrial type control is designed to be installed, operated, and maintained by adequately trained workmen and is not covered in this document. Care must be exercised to comply with local, state, and national regulations, as well as safety practices for this class of equipment.

Control Circuit Contacts

The normally-closed (NC) control circuit contact is to be connected in series with the coil of a magnetic contactor. This NC contact is equipped with a follow contact and provides reliable electrical continuity during a tripping condition. A factory-installed, normally-open (NO) control circuit contact (single pole double throw -Form C) is available for remote trip indication applications.

Manual or Automatic

The overload relay is normally furnished with a set for "HAND" reset operation. The relay may be set for either "HAND" or "AUTO" reset by positioning the reset spring (2) in the properly-marked recess in the molded case.

Automatic reset should not be used with 2-wire control circuits where automatic starting of the motor may be hazardous.

Adjustable Trip

The trip rating of a specific heater element can be adjusted over a range of approximately 85% to 115%. This is accomplished by turning the adjustment knob (1) on the top of the relay to the respective stop position. This to alleviate nuisance tripping; or conversely, to gain closer protection when desired.

Trip Indication

An immediately visible indication of trip is standard on the Type A overload relay. When an overload occurs that causes the relay to operate, a trip indicator projects out through a small opening at the bottom of the relay.

Do not tamper with this trip indicator as it is an integral part in the calibration and tampering with it may cause changes in trip characteristics.

Ambient Compensation

Ambient-compensated OLR's have substantially the same trip characteristics for ambient temperatures from -40^{0}C to 75^{0}C (-40^{0}F to 167^{0}F). Because of a compensating bimetal that maintains a constant travel to trip distance independent of ambient conditions, operation of the bimetallic relay is responsive only to heat generated by the motor overcurrent passing through the heater element. The compensating feature is fully-automatic and no adjustments are required over normal fluctuations in ambient temperatures. Overloads relays having ambient compensation can be identified by black reset rods whereas non-compensated overload relays have red reset rods.

Heaters

A Heater is not included with the overload relay and must be ordered separately. When installing the heater, be sure that connecting surfaces are clean and the heater is attached securely to the relay in the proper location with the screws provided. The trip rating of a heater in 40^0C Ambient is 125% of the minimum full load current. When tested at 600 percent of its trip rating, the relay trips in 20 seconds or less (class 20).

The heater should be selected on the basis of the actual full load current and service factor as shown on the motor nameplate or in the manufacturer's published literature. When the service factor of the motor is 1.15 to 1.25, select the heater form the heater application table. If the service factor of the motor is 1.0, or there is no service factor shown, or a maximum of 115% protection is desired, select one size smaller heater than indicated. When motor and overload relay are in different ambient and when using non-compensated overload relays, select the heater using adjusted motor currents as follows:

- Decrease rated motor current 1% for each ^{0}C motor ambient exceeds controller ambient
- Increase rated motor current 1% for each ^{0}C motor ambient exceeds controller ambient
- Increase rated motor current 1% for each ^{0}C controller ambient exceeds motor ambient

For ambient compensated overload relays no adjustment in heater selection is necessary for normal variations in ambient temperatures.

Short Circuit Protection

The relay provides protection against abnormal load conditions to current values exceeding normal locked rotor current. To protect the relay from short circuit currents, branch circuit protection must be provided per the National Electric Code. Protective device ratings should not exceed the maximum values listed in the heater application table. The relays, as protected, are suitable for use on a circuit capable of delivering not more than 5000 rms. symmetrical amperes, 600 volts maximum

Maintenance

Other than the normal tightening of all wire and heater connections, no maintenance should be attempted on the unit. Complete replacement of the unit must be made in the event of damage.

To provide continued protection against fire and shock hazard, the complete overload must be replaced if burned out!