

Application Notes for MAP/CAP Contactors

Introduction - Product Capabilities And Typical Applications

TE KILOVAC MAP/CAP contactors are designed to be the highest performance, smallest and lightest weight, sealed High Voltage contactors in the industry. With current carrying capability of up to 500A and power switching up to 200kW, they are used in a variety of commercial aerospace and military applications. Primarily designed to switch resistive loads, they can be used in a variety of circuit applications bearing in mind a few important considerations. This application note focuses on a few of the more common circuit configurations, and what to consider when selecting, installing and using the contactors.

1. Installation

TE KILOVAC MAP/CAP contactors can be mounted in any orientation, and due to the nature of their hermetic seal and isolated enclosure, can be mounted in close proximity to other equipment. However, care must be taken with regard to the termination of the power cables to the main terminals. It is important that the main power connection lugs are mated directly to the terminal seats. Be sure that the hardware stackup is in the proper order, and that washers and other spacers are not placed between the lug and terminal seat. Extraneous connection resistance can cause considerable power dissipation and terminal heating at high current carry. Refer to Figure 1 and Table I for the recommended hardware stackup and torque.

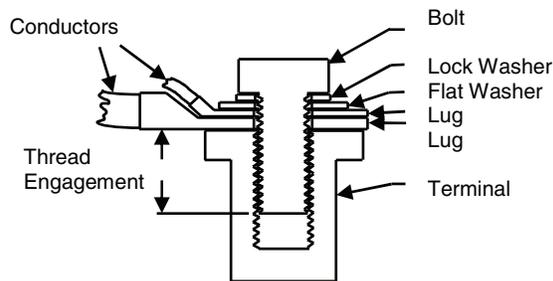


Figure 1
Main Terminal Hardware Installation

THREAD ENGAGEMENT(turns)	TORQUE
Less than 5	Use longer fastener
5 TO 7	7.9 Nm (70 in-lb) MAX
7 TO 8	9.0 Nm (80 in-lb) MAX
8 TO 11	9.0 Nm (80 in-lb) 11 Nm (100 in-lb) MAX
Mounting Feet (all)	1.7-3.3 Nm (30-35 in-lb)

Table I

Use the same guidelines and torque maximum values for stud terminal contactors as well.

2. Coils, Drive Circuits and Coil Economizing

Since the power required to close the contacts is generally much greater than the required holding power, many contactors can be packaged with low-profile coils that utilize either an electronic economizer (switchmode PWM, electronic cut-throat), or mechanical cutthroat economizer. The economizer lets-through the higher power required for contact closure, then reduces the power for holding, greatly reducing the coil power consumption and heating. These circuits are packaged with the contactor, and in most cases include coil suppression components as well. For customers who wish to provide their own circuitry, TE can provide suggestions for driving the coils of all versions of contactors. Four types of actuators are typically used:

- Single Coil requiring customer economizer circuit
- Single Coil with supplied electronic economizer
- Dual Coil with supplied mechanical "cut-throat" economizer
- Dual Coil with supplied electrical "cut-throat" economizer

The advantages of each type of coil circuit are shown in Table II.

Type	Advantage
Electronic PWM	Operates over widest voltage range
Electronic CT	Simple, Robust, EMC Compliant
Mechanical CT	Simple, robust, fastest operate time
Single Coil - (customer economized)	Flexibility, lower initial cost

Table II
Coil Configurations

3. Load Types and Power Switching Recommendations

In general, all MAP/CAP contactors are designed primarily for connection and interruption of resistive loads and slightly inductive loads ($L/R < 1\text{ms}$). High currents (up to 2000A) can be interrupted in case of circuit faults, and high continuous currents upwards of 500A can be maintained through closed contacts. Some important points to consider are:

- Closing into current spikes due to uncharged filter capacitors. Capacitors should be pre-charged whenever possible to avoid excessive contact erosion and nuisance welds. Keep inrush current spikes below 650A at all times. Care should also be taken when considering other high-inrush loads such as lamps or motors.

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- b.** Large current spikes through closed contacts. Large current spikes through closed contacts in excess of 3000A can sometimes cause spot welding or contact levitation. Consult with the factory if your application requires passing large current pulses. Many contactors can be ordered with "Dual Contact" arrangements (Arcing contacts of harder material in parallel with high current carry material).
- c.** Circuit inductance. Contactor break-arcs generally last as long as it takes to dissipate the stored inductive energy of the load ($t(\text{arc}) = 1.1 \cdot L/R$).

Longer arcs due to circuit inductance can accelerate contact wear, and in extreme cases, can cause contactor failure. TE recommends that the time constant of the load be less than 1ms for safe operation and maximum life.

Contactor life is a function of the power level switched. Higher make/break currents erode contact materials faster and accelerate loss of dielectric withstanding between the open contacts. Figure 2 can be used as a guideline for estimating product life at a given load.

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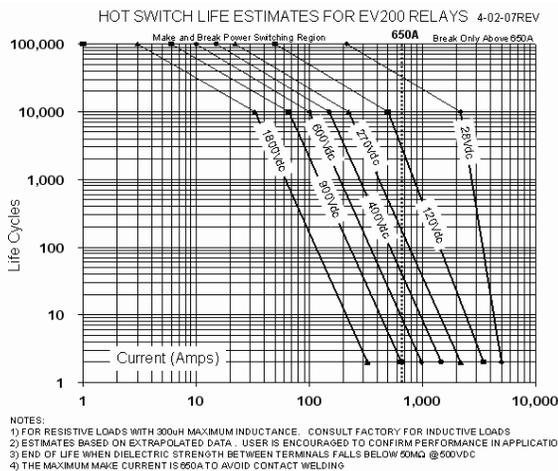


Figure 2
Life Cycle vs. Power Switched

4. Recommended Conductor Sizes for Continuous Current Carry

Many sources exist for recommending the proper conductor size for a given current carry. Many of these sources are concerned primarily with wire insulation safety issues. Cable bundling, conduit types, length of runs, etc., are all important considerations. With regard to a contactor placed in line with the conductors, it is important to make sure that the wire size is sufficient such that the contactor terminals themselves do not overheat, leading to a failure of the device. In most cases, the primary path for removal of heat from the contactor terminals is the conductors themselves. Convection to atmosphere and conduction via the base mountings play a lesser role in this type of contactor due to the nature of the construction. TE has performed basic characterization of many of the styles of contactors discussed herein, and the data is presented in Figure 3.

The recommended maximum power terminal temperature for all MAP/CAP contactors is 150° C continuous and 175° C for 1 hour.

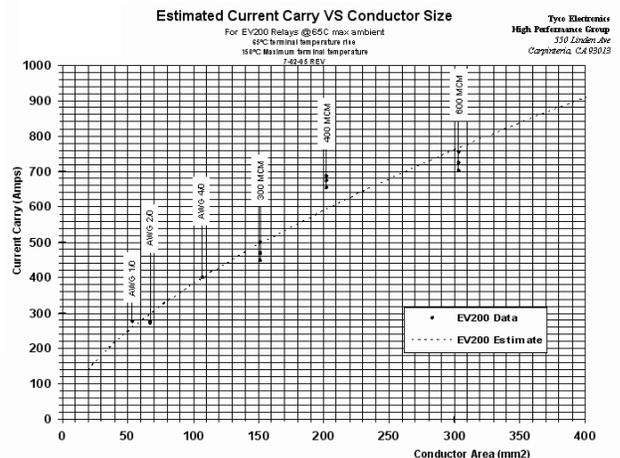


Figure 3
Recommended Conductor Sizes

For applications requiring larger conductors than can practically be installed with single 4/0 AWG cable and lugs, adapter buss extensions can be obtained from TE.

5. Auxiliary Circuits

Auxiliary contacts are available on most models. Configurations available are: SPST-NO, SPST-NC and SPDT. Auxiliary contacts are rated at 125Vac/ 1A or 30Vdc/3A. Contacts with gold plating for low level loads are also available. For circuit voltage below 10V/0.1A, gold contacts are recommended. The auxiliary contact actuating method will indicate the true position of the main contacts. The auxiliary contact actuation is directly coupled to the main contact moving bridge, and will not indicate "open" unless both contact gaps of the double-make, Form X contact are fully disconnected. Keep in mind that the auxiliary contact is mainly a status indication, and should not be used to directly power other loads such as a relay coil or high power lamp load.

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6. Environmental Considerations

All TE KILOVAC contactors are characterized for operation in thermal, vibration, moisture and fluid environments. Consult the appropriate data sheet for limits concerning shock, vibration, temperature range and altitude limits. In some cases, there may be variations in limits with regard to "specified operation" or "survival only".

7. Custom Configurations

Most parts can be ordered with a variety of combinations of main terminal and coil configurations, auxiliary contacts, interface connectors, coil voltages, etc. If you have a requirement for a particular configuration not shown on the data sheet, consult the factory for information regarding custom configurations.

8. Summary

This Application Note is meant to address some of the more common questions regarding the use of MAP/CAP contactors. In all cases, please refer to the applicable product data sheet for specific information.

Also, Product Application Engineers are available to answer questions regarding these products by calling 800-253-4560 x2055, or 805-220-2055.

Application Notes on Coil Power Economizing using PWM Circuits

Introduction - Reducing Coil Power Dissipation through the use of PWM Circuits

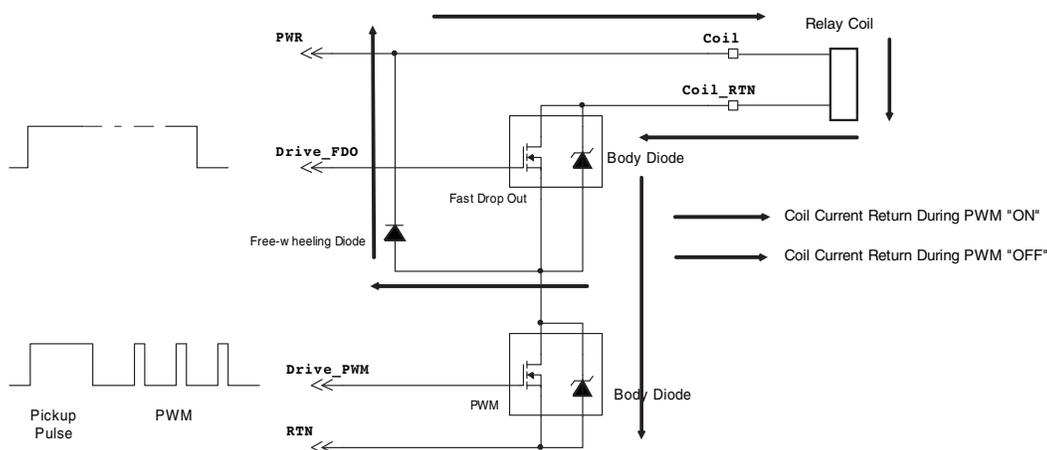
The coil power of most TE KILOVAC Relays and Contactors can be reduced after Pickup by using several economizing schemes. One of the most popular methods used in many of our standard products, and one that is suitable for implementation by customers, is the Pulse Width Modulated (PWM) coil driver.

In the circuit shown, the "Fast Dropout" (FDO) and PWM driver are energized simultaneously for a sufficient time to allow the contacts to fully close. The PWM driver is then modulated such that the stored coil energy is utilized during the PWM driver "OFF" time to circulate holding current through the FDO driver and freewheeling diode. Since the holding current is much lower than the current required for pickup, the holding power for the contacts is greatly reduced.

1. Typical PWM Coil Drive Circuit

Figure 1 shows a typical PWM coil drive/economizer circuit.

The Fast Dropout circuit allows for the switching in/out of the "free-wheeling" diode. When power is removed, the FDO and PWM drivers will turn off, causing the stored energy of the coil to be rapidly dissipated in the body diodes. This minimizes the decay time of the coil current and facilitates a fast opening of the relay contacts.



Fast Drop-out FET stays on during operation. FDO and Power can be applied simultaneously

Filtering/Protection should be applied to FET gates as required.

For higher energy coils, additional TVS protection may be required across FET drain-to-source.

Figure 1
Coil Drive Circuit