Allen-Bradley

Specifying and Using Vacuum Circuit Breakers

with PowerFlex 7000

Application Guidelines

Rockwell Automation

Important User Information

Read this document and the documents listed in the Additional Resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.

IMPORTANT Identifies information that is critical for successful application and understanding of the product.

Labels may also be on or inside the equipment to provide specific precautions.

SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.

BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.

ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

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1.0 INTRODUCTION

The purpose of this document is to provide information to be considered when purchasing, specifying or using circuit breakers that will be dedicated to controlling medium voltage power to or from Rockwell Automation medium voltage AC drives. This information will be useful to plant engineers, system designers, consultants, end users and circuit breaker manufacturers. It also provides guidelines for Rockwell Automation engineering use. This document is intended for use by personnel familiar with medium voltage and variable speed solid-state drive equipment.

This publication is designed to provide only general information on the use of medium voltage circuit breakers with Rockwell Automation medium voltage AC drives. The following topics are beyond the scope of this document:

- Configuration of circuit breakers into manual or automatic synchronous bypass schemes with Rockwell Automation medium voltage AC drives. Refer to related Rockwell Automation publications or contact the factory for details
- Customer or site specific information. Refer to the Dimensional and Electrical Drawings generated for each customer specific order. This document provides generic drawings for illustrative purposes only.
- Design of the medium voltage circuit breaker and other drive associated components for safety of access, operation and test functions. This is the responsibility of the equipment manufacturer.
- System coordination, electric system studies and transient studies. This document discusses these topics in a general way to make the reader aware of possible issues. It leaves their treatment up to the plant engineer, system designer or person responsible for the site management.
- Commissioning, testing, calibration and service instructions for the circuit breakers. This document covers only the points to be considered in this regard.

2.0 FUNCTION OF THE CIRCUIT BREAKER

In the application covered by this document, the circuit breaker to be used on the input to the drive is not considered a feeder breaker but is regarded as a branch circuit protective device. It is dedicated to protection of the drive input transformer/reactor as well as the drive and will not have other non-specific loads connected to it.

Where the circuit breaker is connected on the output of the drive it is used for drive isolation or directing the flow of variable frequency power and not for protection purposes. In this regard it is acting like a vacuum contactor.

3.0 BASIC CONCEPTS OF BREAKER CONTROL WITH THE DRIVE – A SUMMARY

a) **Closing of the Breaker:** In the traditional scheme it is typically the vacuum circuit breaker that initiates and controls the application of power to the circuit on the load side of the breaker. When used on the input of the drive, the drive will have control over when the breaker is permitted to close. Even though the drive is on the load side of the breaker it can perform this control function because the drive receives an independent control voltage. External contacts are not permitted to directly close the breaker.

b) **Opening of the Breaker:** The breaker is permitted to trip using any of the internal protective features as it is in any breaker application. The breaker can also be opened by the Rockwell Automation drive. External contacts are not normally permitted to directly open the breaker.

4.0 COMPARISON OF STANDARD AND R.A. CONTROL METHODS

a) **Standard Breaker Control (no Rockwell Automation Drive):** Figure 1 shows a circuit breaker control scheme that is typically supplied by a circuit breaker manufacturer. The breaker is closed by a control switch in the electrical 'Close Circuit' of the breaker. The breaker may also be closed remotely by an external contact closure wired to the 'Close Circuit'. Various defined conditions of operation of the local and remote controls are available.

Tripping of the breaker is by the control switch in the electrical 'Trip Circuit' of the breaker. There may also be provision for external tripping by means of a remote contact under certain defined conditions. Internal monitors in the Protection Circuit can also independently trip the breaker.

Sometimes a manual mechanical trip (push button) is mounted on the front of the breaker.

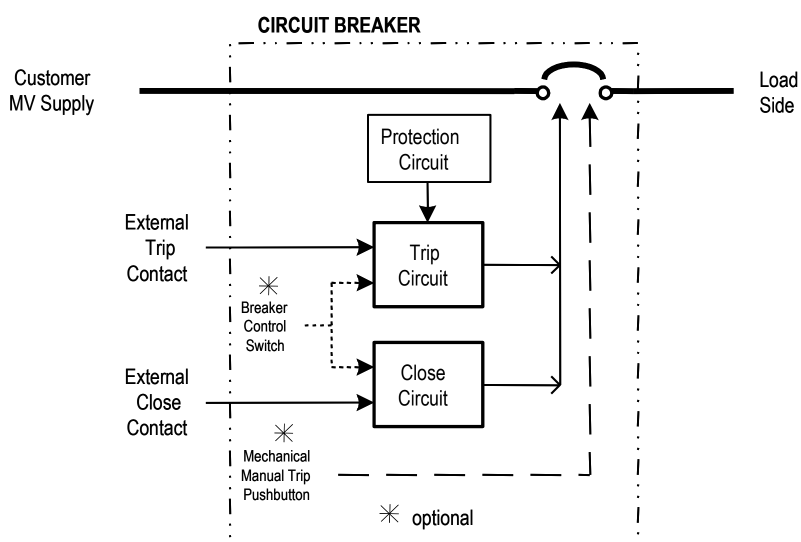


Figure 1 – Typical Circuit Breaker Control Scheme

b) **Breaker Control Using A Rockwell Automation Drive:** Figure 2 shows the arrangement when used with a Rockwell Automation medium voltage AC drive. The example shown is for a breaker on the input of the drive. The control scheme has changed from that of Figure 1 to provide proper protection for the drive. The drive closes the breaker when the drive has done a diagnostic check and determines that it is healthy. In some applications the drive is programmed to close the breaker only when it is healthy **and** it is commanded to start the motor. The drive can provide this type of control because it receives its control power not from the load side of the circuit breaker but from a separate source.

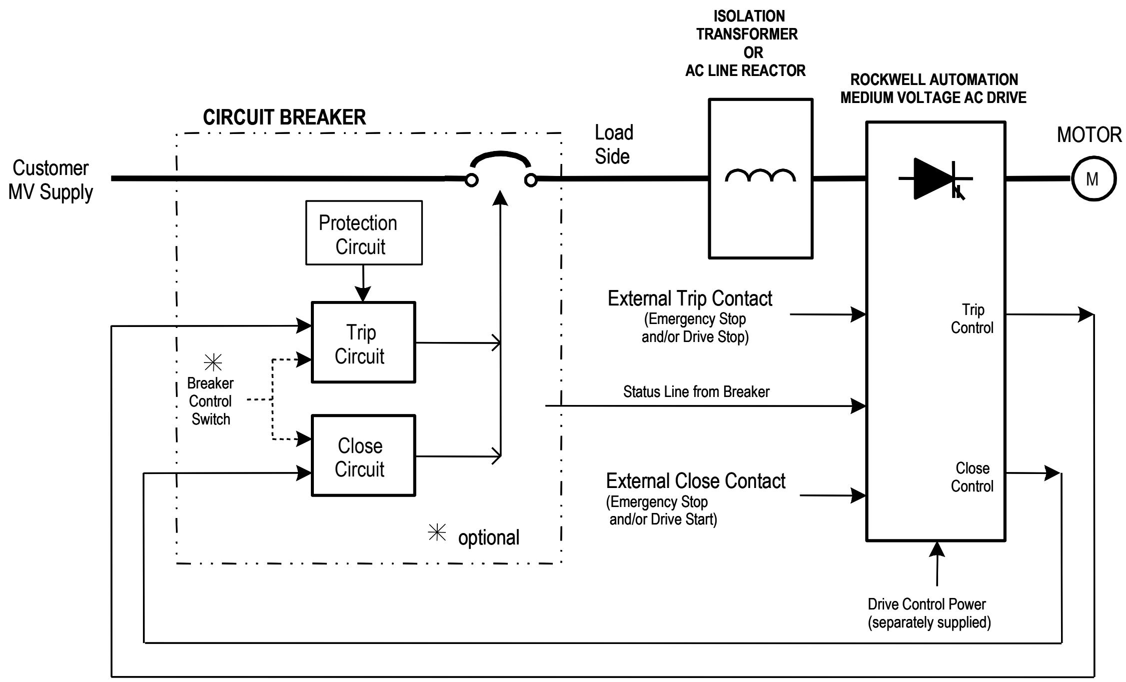


Figure 2 – Circuit Breaker Used with Rockwell Medium Voltage AC Drive

When the drive determines that circuit conditions are not normal and power interruption is required, then the drive issues a trip command to the circuit breaker. Also, the drive typically opens the breaker when an 'Emergency Stop' is requested. In addition to this, the standard protective features of the breaker and an optional breaker control switch are able to trip the breaker independently of the drive. Outside of these tripping means no other direct trip inputs to the circuit breaker are permitted. The reasons for this are explained in section 6.0. If there are other external conditions that require the breaker to open, it is recommended that they be taken to a specific external input of the drive. When the remote contact opens, the drive will trip the circuit breaker in a controlled fashion.

ATTENTION

As with any drive, it is good engineering practice to design the system so that the drive monitors the condition of the circuit breaker on the input of the drive and to know in advance when the breaker is about to open. This is a requirement for the drive input circuit breaker on Rockwell Automation medium voltage AC drives. The circuit breaker control interface must be connected to the drive as described in this document. If the circuit breaker is not connected and operated as described, damage to the drive can result if the current is not allowed to be brought to zero in a controlled fashion.

5.0 BREAKER DESIGN TO ALLOW DRIVE CONTROL

Figure 3 shows the recommended way of interfacing a Rockwell Automation medium voltage AC drive to the circuit breaker. The Drive Input Control (DIC) relay contacts from the drive will be connected to the input breaker to give the drive control over the closing and tripping of the breaker. This is required for the protection of the drive/motor under fault conditions. The concept is an 'OR' operation to trip the breaker and an 'AND' operation to close the breaker.

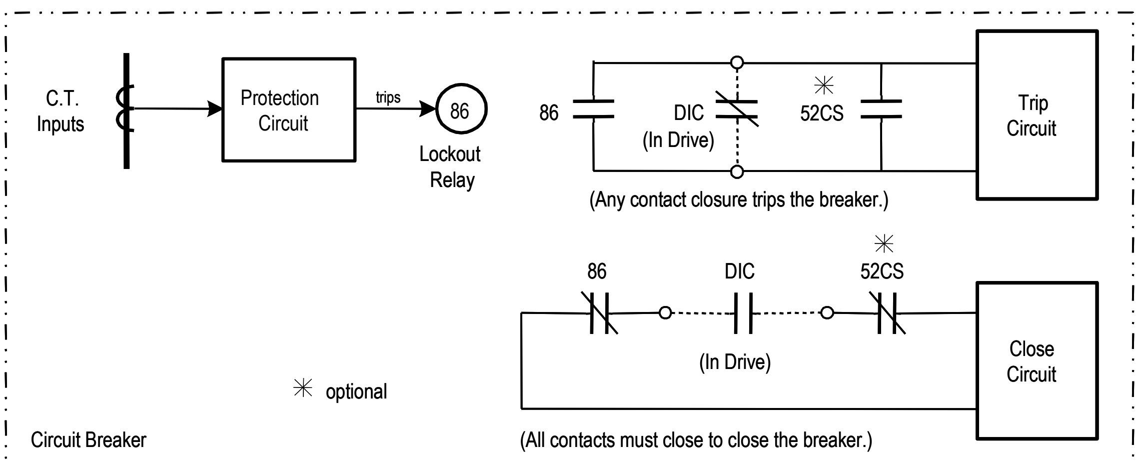


Figure 3 – Simplified Breaker Schematic for the Trip and Close Circuits

a) **<u>86 Contact</u>:** The use of an 86 Lockout Relay as shown in Figure 3 is required.

Definition: *86 Lockout Relay – 86 is an IEEE and ANSI designation of a hand or electrically reset auxiliary relay that is operated upon the occurrence of abnormal conditions to maintain associated equipment or devices inoperative until it is reset.*

The 86 lockout contact in the Trip circuit closes when the Protection Circuit of the breaker requests the breaker to open. Its function in tripping the breaker is not influenced by the drive circuit. However, the breaker cannot be closed until the drive sends a close signal. This scheme is necessary and must be followed for drive protection.

b) **<u>52CS Control Switch Contact</u>:** Sometimes the circuit breaker will have a manually operated rotary control switch on the front of the breaker. There is a Trip and a Close position. This switch is not required for drive operation but may be requested by the user. It is sometimes designated '52CS'. The control switch is to be wired as shown in Figure 3. Similar to the 86 lockout contact, it can trip the breaker independent of the drive control but it cannot close the breaker unless the drive contact is closed. This scheme is necessary and must be followed for drive protection. Actually, 52CS should be closed before the drive requests the breaker to close or the drive may interpret this as a loss of input control and annunciate an alarm. If a control switch is not used on the circuit breaker, it is recommended that terminal blocks be provided in the Close, Trip and Status circuits to make possible future field installation easier.

c) **<u>DIC Contact from the Drive</u>:** Two DIC relay contacts from the drive must be wired to the circuit breaker to give the drive control over the tripping and closing of the input breaker. The DIC contacts are fail safe contacts. They are shown with no power on the DIC relay coil (located in the drive). This is a tripped state for the drive. When the breaker is used on the output of the drive it will be wired to the Drive Output Control (DOC) relay or the Output Control Relay (OPC) contacts in the drive instead of DIC contacts. Refer to section 20.0 for more information on applying drive output circuit breakers.

d) **<u>External Trip Contacts</u>:** If there are external conditions other than DIC that require the breaker to open, it is recommended that they be taken to a specific external input of the drive such as the drive Emergency Stop line. When the remote contact opens, the drive will trip the circuit breaker in a controlled fashion.

Refer to section 7.0 for variations on deriving the contacts controlling the trip circuit. Refer to section 8.0 for optional configurations of the trip and close signals from the drive.

6.0 BREAKER DESIGN TO PROVIDE STATUS CONTACTS FOR THE DRIVE

The drive must monitor the condition of the circuit breaker and know in advance when the breaker is about to open. This will give the drive time to electronically reduce the current through the power semiconductors and the DC Link Reactor before the power poles in the breaker interrupt the current. This will provide a safe and orderly shutdown of the system. To accomplish this shutdown sequence, the drive **must** receive a status line from the breaker that opens a minimum of 2 cycles before the main power poles of the circuit breaker start to open. Figure 4 shows the recommended arrangement to use. The status line consists of three contacts in series. They are composed of an 86 lockout relay contact, a power pole auxiliary contact, and an optional control switch contact.

Definition: Power Pole - *In this document the term 'power pole' refers to the main vacuum bottle contact that passes power from the line side of the circuit breaker to the load side.*

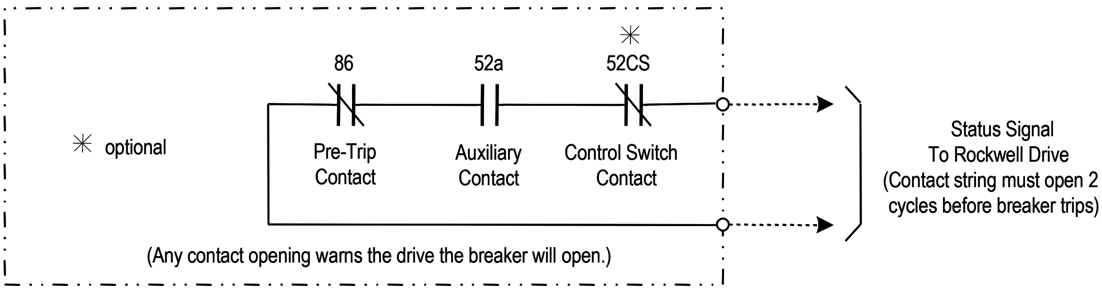


Figure 4 – Typical Breaker Status Contacts Required by the Rockwell Automation Drive

a) **86 Contact:** The 86 lockout contact in the status string opens when the Protection Circuit of the breaker requests the breaker to open. Note that the 2 cycle timing mentioned above must occur between the time the 86 contact opens and the start of the power poles opening. Rockwell Automation refers to this contact on their drive schematics as a 'pre-trip contact' because it opens before the power poles open.

b) **52 Contact:** Shown in series with the 86 lockout relay contact is a power pole auxiliary contact – designated as a '52' contact. The 52 contact shown in Figure 4 is typically from a switch that is physically mounted on the breaker frame and mechanically tied to the main primary interrupting contacts (i.e. the power poles) on the breaker.

The contacts are often referred to as a/b contacts. The 'a' contacts follow the breaker main contacts, i.e. when the breaker is open the 'a' contacts are open; when the breaker is closed so are the 'a' contacts. The 'b' contacts are the opposite. In this terminology the 52 contact shown in Figure 4 is an 'a' contact and is shown as '52a'. It must open prior to or at the same time as the power pole opening – not <u>after</u> the power pole opens.

This contact has various names in the industry. Sometimes it is referred to as a Stationary Contact (STA), a 52STA stationary contact, an a/b contact and as a Mechanism Operated Contact (MOC). When selecting the contact to use, its description of operation must match the description above. The contact provides a warning to the drive when the breaker power poles open by any means not shown in Figure 4 (e.g. manual trip or internal device failure). Rockwell Automation refers to this contact on their drive schematics as an 'auxiliary contact' because it is a control rated contact that operates with the power pole contact.

c) **<u>52CS Control Switch Contact</u>:** When a control switch is used, it is recommended that a contact from this switch be added in the status feedback line as shown in Figure 4. The contact should open when the control switch is moved to the Trip position. This contact will give the drive an advance notice that the circuit breaker is about to open.

   If a control switch is not used on the circuit breaker, it is recommended that terminal blocks be provided in the Close, Trip and Status circuits to make possible future field installation easier.

The contacts shown in Figure 4 must have not have any power on them from the circuit breaker. They are often referred to as 'dry' or 'clean' contacts. They will be wired back to a voltage source in the drive (typically 110VAC or 120VAC). Current draw will be signal level only. Refer to section 7.0 for variations on deriving the status contacts from the circuit breaker.

7.0 VARIATIONS ON THE TRIP AND STATUS CIRCUITS

There may be cases when the preferred configurations of Figures 3 & 4 do not give the required 2 cycle advanced warning of the main power poles opening. There may be other cases when the circuit breaker is existing and must be modified in the field or the circuit breaker manufacturer does not wish to alter his standard design the way that we have shown. In these cases, one of the variations shown in Figure 5 may provide the solution. The examples shown in Figure 5 are for the 86 lockout relay but they can also be adapted to the 52CS control switch if there is a timing issue with the switch. Whatever solution is used must fit the requirement that the drive **must** receive a status line from the breaker that opens a minimum of 2 cycles before the main power poles of the circuit breaker start to open.

Breakers can have a rating in terms of cycles. For example, a 5-cycle breaker means that the manufacturer guarantees interruption of the primary current within 5 cycles of the call to trip. Therefore, 5 cycles is the longest time from the trip call. However, the breaker could open faster than 5 cycles and probably will. It could open in 2 or 3 cycles. The circuit breaker manufacturer will have to evaluate test data to determine a minimum opening time. This time can have a bearing on which circuit variation in Figure 5 is used.

Figures 5.A to 5.H depict the variations in the trip circuit control and the status line that can be used with Rockwell Automation medium voltage AC drives. A couple of configurations that are not recommended are also shown. The use of very fast acting breakers is not recommended since this will make it more difficult to get the 2 cycle advance warning of the breaker power poles opening.

Variations in Developing the Status Contacts for use by the Rockwell Automation Drive

This is the circuit as described in sections 5 & 6. It can be used when the inherent delays in the circuit breaker mechanism will amount to a minimum 2-cycle delay between the status line opening and the power poles opening.

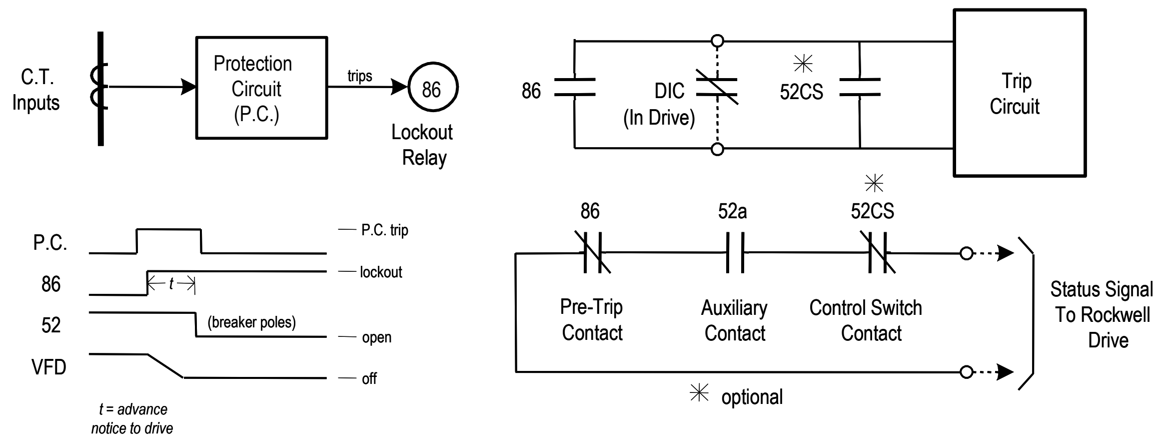


Figure 5.A – Standard Configuration Preferred by Rockwell Automation

By using a second output from the Protection Circuit that has the same timing as the output to the 86 Lockout Relay, the status line will open earlier by an amount equal to the operating time of the 86 Lockout Relay.

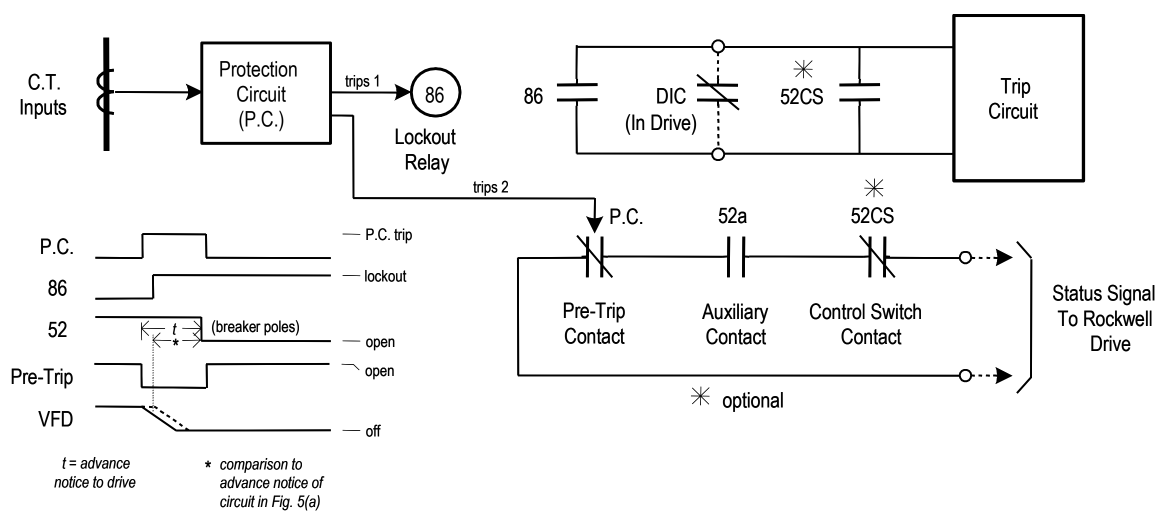


Figure 5.B – Using a Second Output from the Protection Unit

By adding an additional relay between the 86 Lockout Relay and the Trip, the trip circuit is delayed by an amount equal to the operating time of the added relay. The status line should still receive a status contact directly from the 86 Lockout Relay. The use of this relay should not degrade the circuit breaker protective features and must have the sanction of the circuit breaker manufacturer.

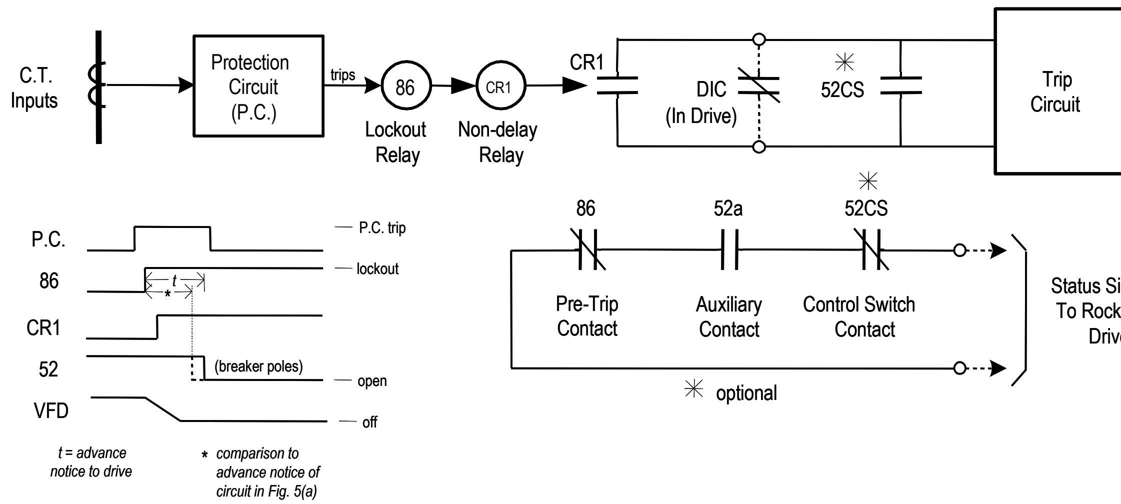


Figure 5.C – Using an Additional Relay on the Output of the 86 Lockout Relay

The operation of the Trip Circuit is delayed by an amount equal to the operating time of the added relay. The status line should receive a status contact from the added relay and not the 86 relay. The use of this relay should not degrade the circuit breaker protective features and must have the sanction of the circuit breaker manufacturer.

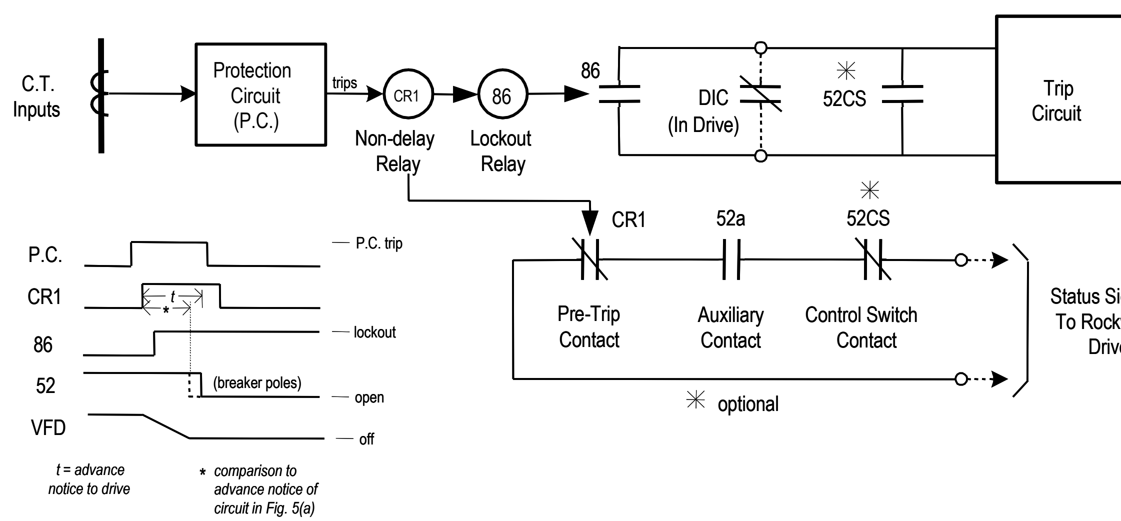


Figure 5.D – Using an Additional Relay on the Output of the Protection Circuit

The operation of the 86 Lockout Relay is delayed by an amount equal to the setting on the timer relay. An instantaneous output from the added relay is used in the status line. The use of this relay should not degrade the circuit breaker protective features and must have the sanction of the circuit breaker manufacturer.

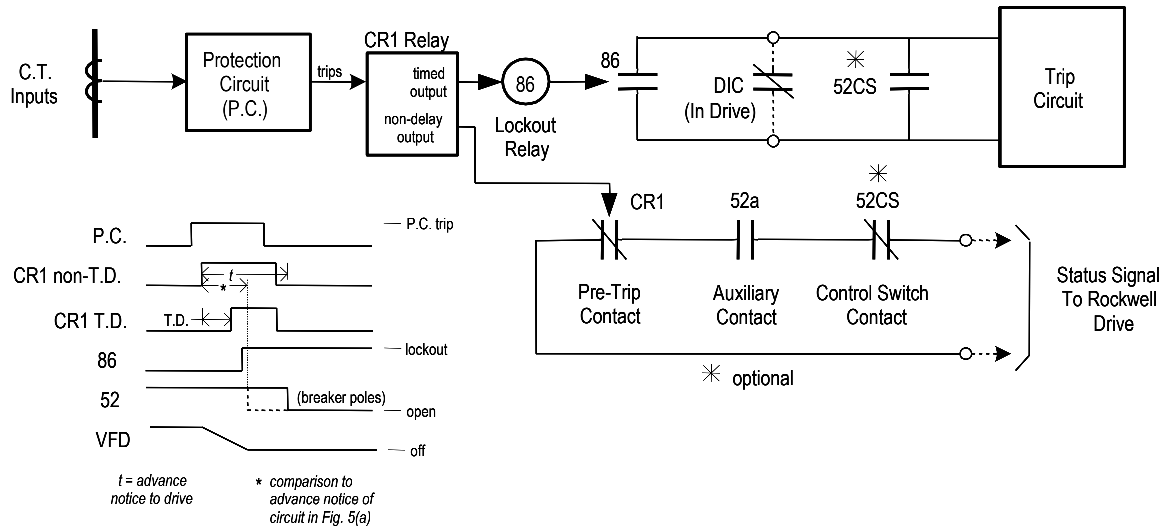


Figure 5.E – Using a Time Delay Relay on the Output of the Protection Circuit

It is possible to derive one of the status functions from a relay that is added across the point in the circuit where this function is derived from. This is shown in Fig. 5(f) for the 86 Lockout Relay function. An example of when this modification can be used is when the 86 'Pre-Trip' contact for the status line is not available. Careful attention to circuit breaker and relay timing is required. A fast response relay should be used.

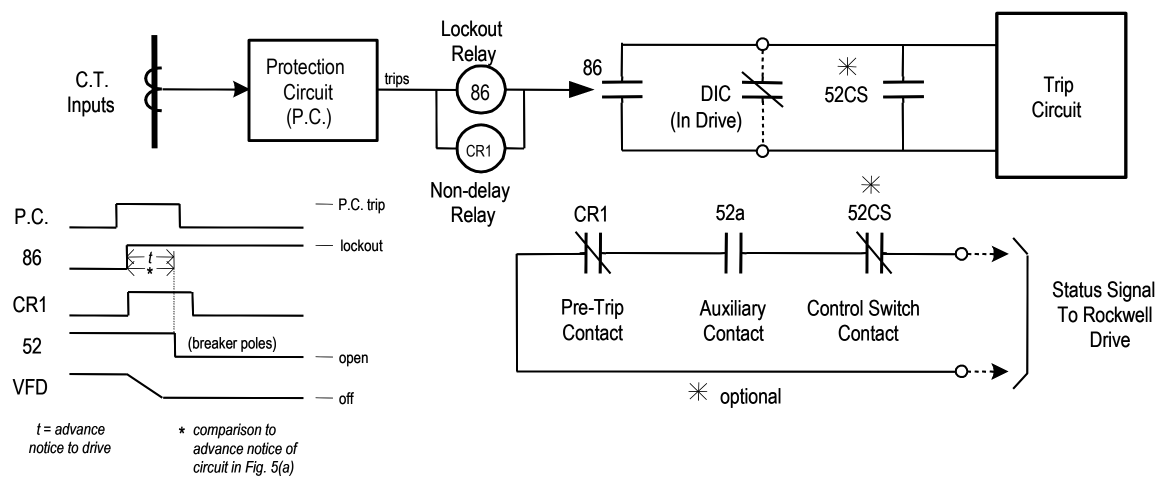


Figure 5.F – Using a Relay in Parallel with a Status Function

It is **not** recommended to replace the status line of the three contacts as shown in Fig. 5(a) with a contact from a relay added across the Trip Coil. The problem with this is that the operating time of this additional relay will subtract from the advance opening time that we require and may result in less than the minimum 2-cycle advance notice even if a fast response relay is used. Careful attention to circuit breaker and relay timing is required.

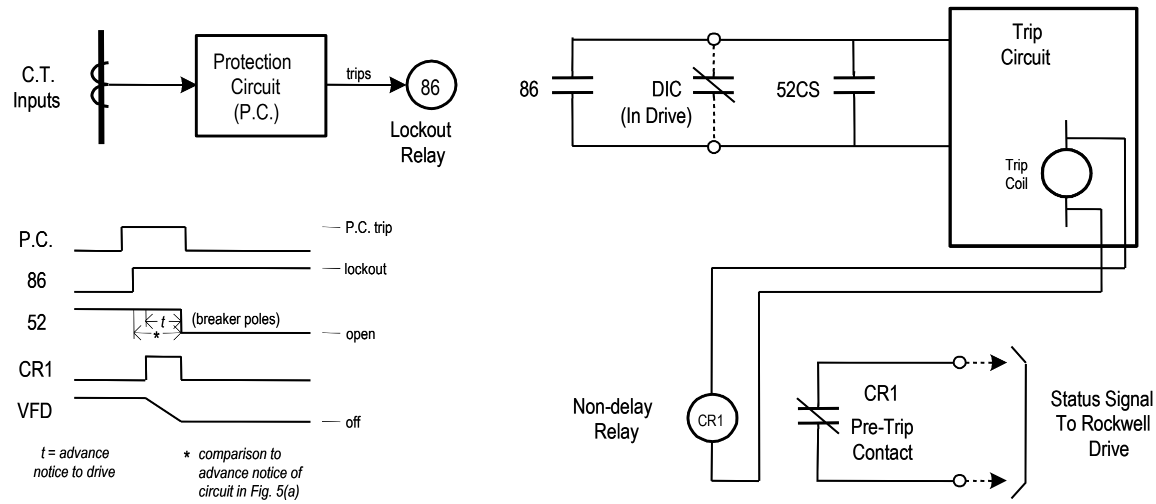


Figure 5.G – NOT RECOMMENDED – Using a Relay Connected Across the Trip Coil for a Status Contact

It is **not** recommended to derive the status contact that is to represent the 86 Lockout Relay from adding an additional relay that will be controlled by the 86 relay. This applies to the 52a and 52CS functions as well. The problem with this is that the operating time of this additional relay will subtract from the advance opening time that we require and may result in less than the minimum 2 cycle advance notice even if a fast response relay is used. Careful attention to circuit breaker and relay timing is required.

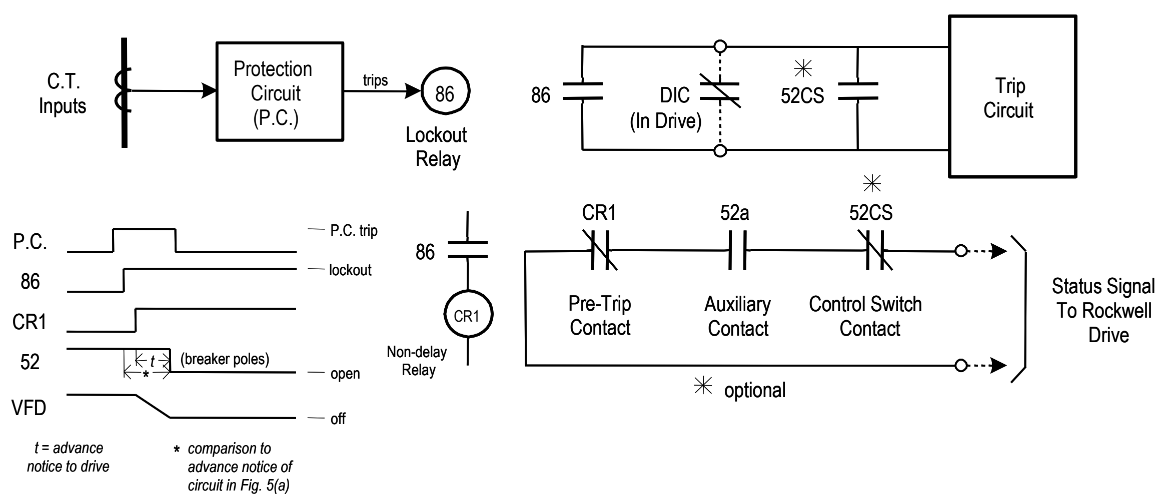


Figure 5.H – NOT RECOMMENDED – Using in Intermediate (Interposing) Relay for a Status Contact

8.0 OPTIONAL CONFIGURATIONS OF THE TRIP AND CLOSE CONTACTS

The Trip and Close contacts from the Rockwell Automation drive that will be wired to the circuit breaker can be configured in different ways to accommodate circuit breaker or customer requirements. In some cases maintained contacts are satisfactory but in other cases the circuit breaker will require pulsed or momentary contact operation for the activation of the Trip and Close circuits. These breakers may not be built to accept a continuous close or open signal. There may also be cases when the circuit breaker will operate with continuous close or open signals but the manufacturer's preference is for momentary signals only.

Two standard configurations of circuit breaker interface offered by Rockwell Automation are described in this section. Other configurations based on customer or vendor requirements can also be considered. Rockwell Automation's customer is responsible for providing us with the requirements for the open and close signals. If Rockwell Automation is providing the circuit breaker then we will obtain this information from the breaker source. The standard offering by Rockwell Automation is the first configuration below and this is what will be supplied if we do not receive information requesting any other configuration.

a) **Continuous Trip and Close Signals:** The 'DIC', 'DOC' and 'OPC' relay contacts (see Appendix A) referred to in this document are maintained contacts as shown in Figure 6 (using the example of DIC). The contacts are always shown in the de-energized state of the relay (the breaker tripped state). The DIC contact in the Trip circuit will remain closed as long as the drive is requesting the circuit breaker to be opened. The Trip contact is a failsafe contact that will request a trip under loss of power to the relay. The DIC contact in the Close circuit will remain closed as long as the drive is requesting the circuit breaker to be closed. These are the standard interface contacts to the circuit breaker offered by Rockwell Automation. The contact ratings are shown in section 9.0.

   In this configuration the open and close contacts from the drive are from the same relay. Therefore, when the drive calls for the breaker to trip, the Close contact will be open. If the drive is requesting the breaker to open due to a drive fault condition, the drive will latch into the fault state. It will stay faulted until a reset command is issued to the drive. Also, if the breaker trips due to its internal protective function, the drive will sense that the input has opened and will latch into a faulted condition.

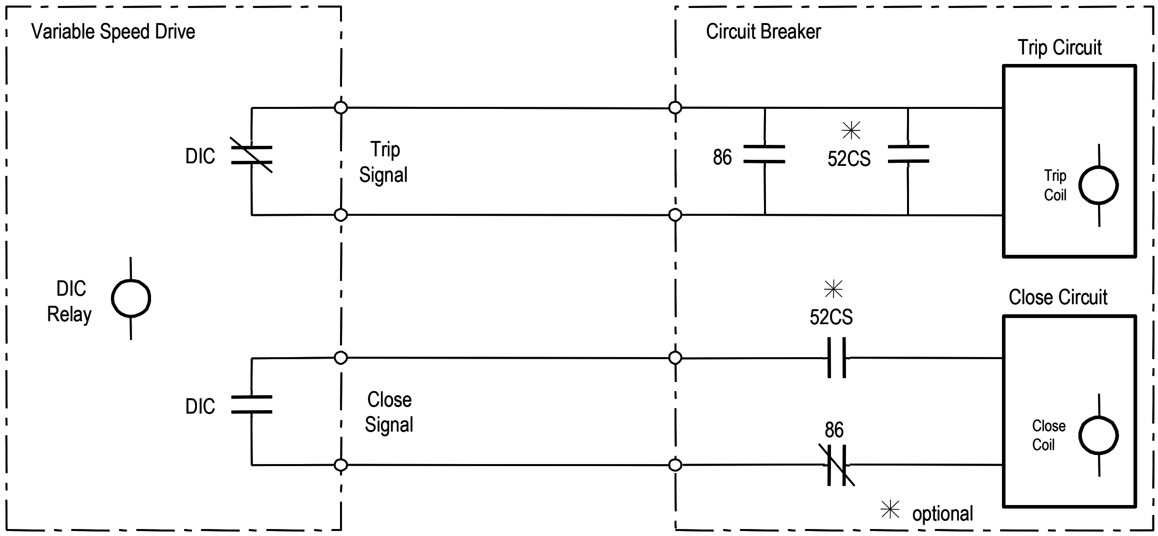


Figure 6 – Continuous Trip and Close Signals

b) **Pulsed or Momentary Trip and Close Signals:** Rockwell Automation can design their circuit to incorporate pulsed operation as shown in Figure 7. Note that in this case the Trip and Close contacts from the drive will have a designation other than 'DIC', 'DOC' or 'OPC', which this document refers to. However, they will have the same ratings as shown in section 9.0. Rockwell Automation should be given recommended pulse times when this configuration is requested. The trip circuit will be activated when DIC relay de-energizes. The normally-closed DIC contact in series with CBOT contact will close. CBOT relay de-energizes when DIC relay de-energizes but its timed delay contact in series with DIC contact will delay opening for a set time interval. This will send a trip signal to the Trip Circuit of the circuit breaker for a fixed time interval. CBOT relay should be a pneumatic off-delay timer to provide a trip pulse in the event of loss of control power. The CBCR contact in the Close circuit will close for a set time interval when the drive requests the circuit breaker to close. Refer to Appendix A for relay and contact symbols used.

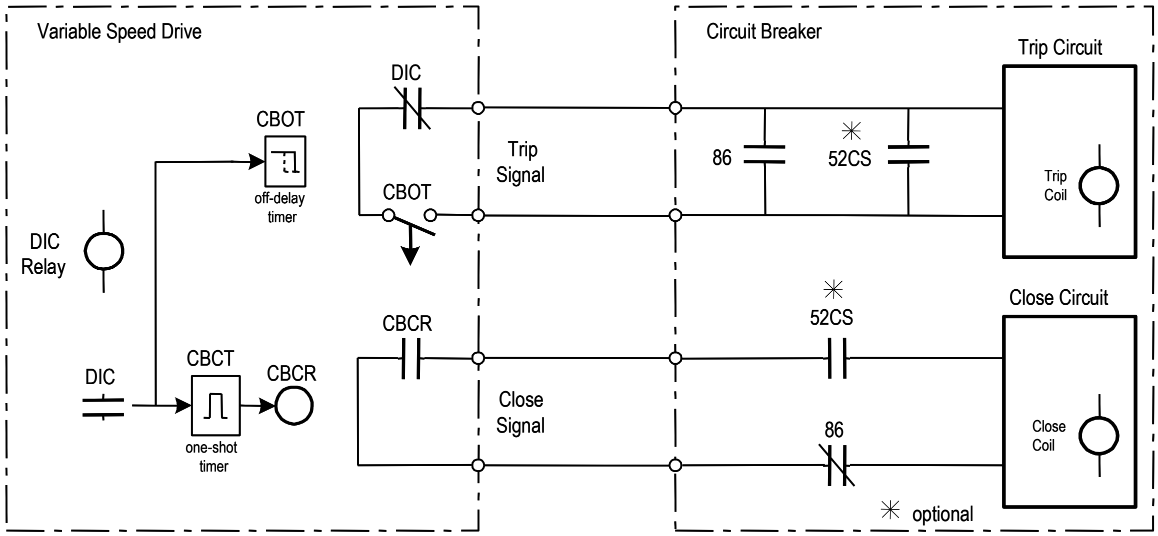


Figure 7 – Pulsed or Momentary Trip and Close Signals

9.0 RATING AND USE OF THE TRIP AND CLOSE CONTACTS FROM THE DRIVE

If the breaker is used on the input of the drive, it is controlled by a 'DIC' contact (Drive Input Control relay). If the breaker is used on the output of the drive, it is controlled by a 'DOC' or 'OPC' contact (Drive Output Control relay or Output Control Relay) depending on the circuit configuration. 'DIC', 'DOC' and 'OPC' contacts are maintained contacts. With pulsed or momentary control, additional relays are used and the contact designation will change (see section 8.0). Contact Rockwell Automation or the job specific drawings for the most recent rating information.

If the application in a circuit breaker will exceed the ratings we show for our Trip and Close contacts, then the circuit breaker manufacturer or end user must install an interposing relay within the breaker that will interface between the drive contact and the breaker circuit. For existing circuit breakers the end user must be aware of our contact rating and check if this will be sufficient for the voltage and loading present in his breaker. It may be that the trip and close circuits use '52' contacts (or 'a/b' contacts as described in section 6.0) to disable the trip and close coils after they are energized.

Note that when the customer wires the Trip and Close contacts to his circuit breaker he must follow the wiring guidelines described in the Drive Installation section of the drive User Manual. These control wires must be segregated from other wiring groups. Size the conductors based on the current required for the trip and close coils and on applicable wiring codes. It is recommended that surge suppressors appropriate to the circuit voltage be used on the trip and close circuits and/or the drive Trip and Close contacts to limit switching surges. If an interface relay within the circuit breaker is used, this method will also keep the switching of the higher current Trip or Close circuit away from sensitive wiring within the drive. The use of a surge suppressor is still recommended. Refer to Figure 8 for a summary of the wiring considerations discussed in this section.

Considerations When Wiring the Trip and Close Signals

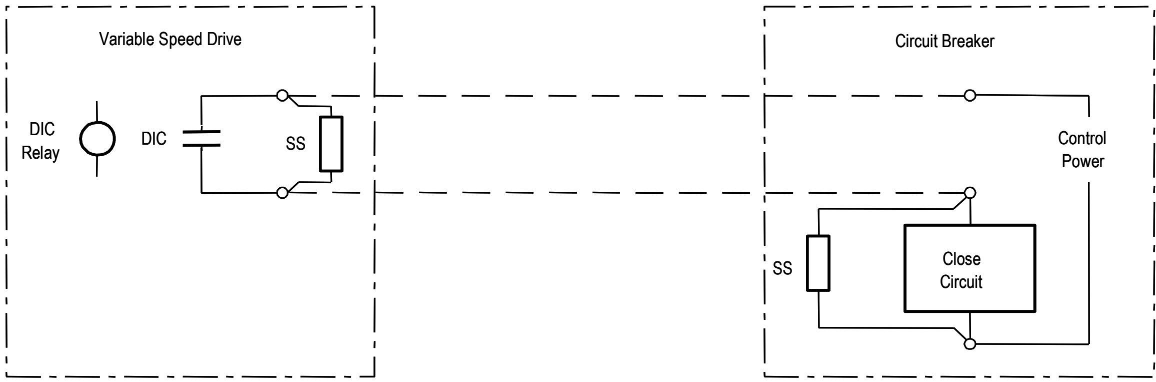


Figure 8.A – Typical Wiring When the Drive Contact is Rated to Handle the Breaker Control Circuit Current and Voltage

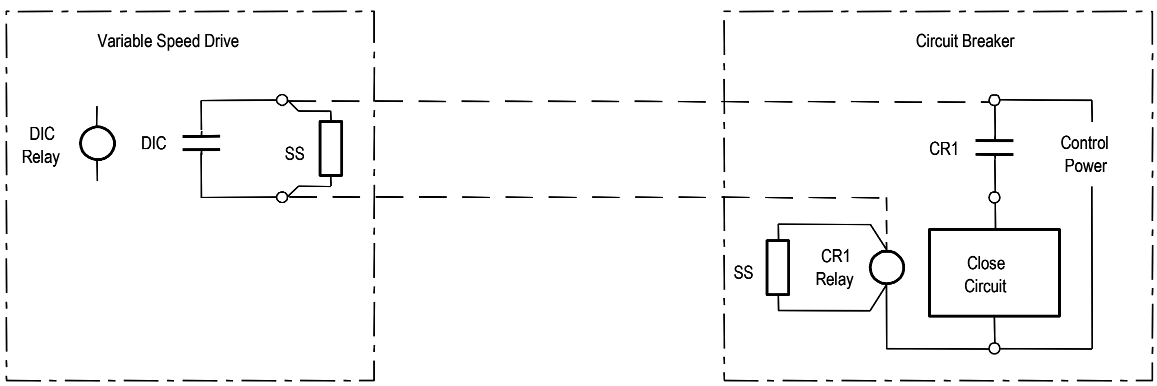


Figure 8.B – Typical Wiring When the Drive Contact is Not Rated to Handle the Breaker Control Circuit Current and Voltage

Notes:

- The circuit shown is typical for the Close Circuit of the circuit breaker. The same wiring considerations also apply to the Trip Circuit.
- The circuits shown are typical only. Check the job specific drawings to determine how to wire the drive/breaker interface.
- 'SS' represents a customer supplied surge suppressor. Two suggested locations are shown. Only one location is needed. Consult the job specific drawings to determine the best location and type of surge suppressor to use.
- — — — represents the customer wiring added between the Drive and Circuit Breaker. Refer to the description in this section regarding wire sizing and routing.
- 'CR1' represents an interposing relay to be used when the drive contact is not rated to carry the current and voltage seen in the circuit breaker control circuit. This method will also keep the switching of the higher current Trip or Close circuit away from sensitive wiring within the Drive. The use of a surge suppressor is still recommended.

10.0 FEEDER BREAKER CONSIDERATIONS

As described in section 6.0 it is generally good engineering practice to design the system so that the drive monitors the condition of the circuit breaker on the input of the drive and to know in advance when the breaker is about to open. What about a circuit breaker (or contactor) that is upstream from the drive input circuit breaker? The treatment depends on several factors. The closer the drive input voltage is to a complete open circuit when the breaker opens the higher the risk to the drive. The presence of other loads on the load side of the breaker that is opening will help the situation but it is difficult to quantify in a general manner the amount or type of load required. Transformer fed drives where it is the primary of the transformer that is being interrupted will be much less of a concern. Regenerative operation is more vulnerable to line loss than motoring operation but with the newer protection scheme built into the PWM Rectifier drives it is becoming less of a requirement to monitor the upstream breaker status. On the other hand, having the 2 cycle advance notice mentioned in section 6.0 reduces the risk to virtually zero for all conditions and versions of drive.

If a 2 cycle advance notice from the feeder breaker is used, it can be done by connecting a contact string from the feeder breaker that consists of the contacts shown in Figure 4 to the drive. These contacts will connect in series with the advance notice contacts from the drive input unit as shown in Figure 9.

When the drive input unit is a circuit breaker, another possibility is to connect the contact string of the feeder breaker as an additional trip of the 86 lockout relay of the drive input breaker.

It is not necessary for the drive to have control over the tripping and closing of the feeder breaker as described in section 5.0.

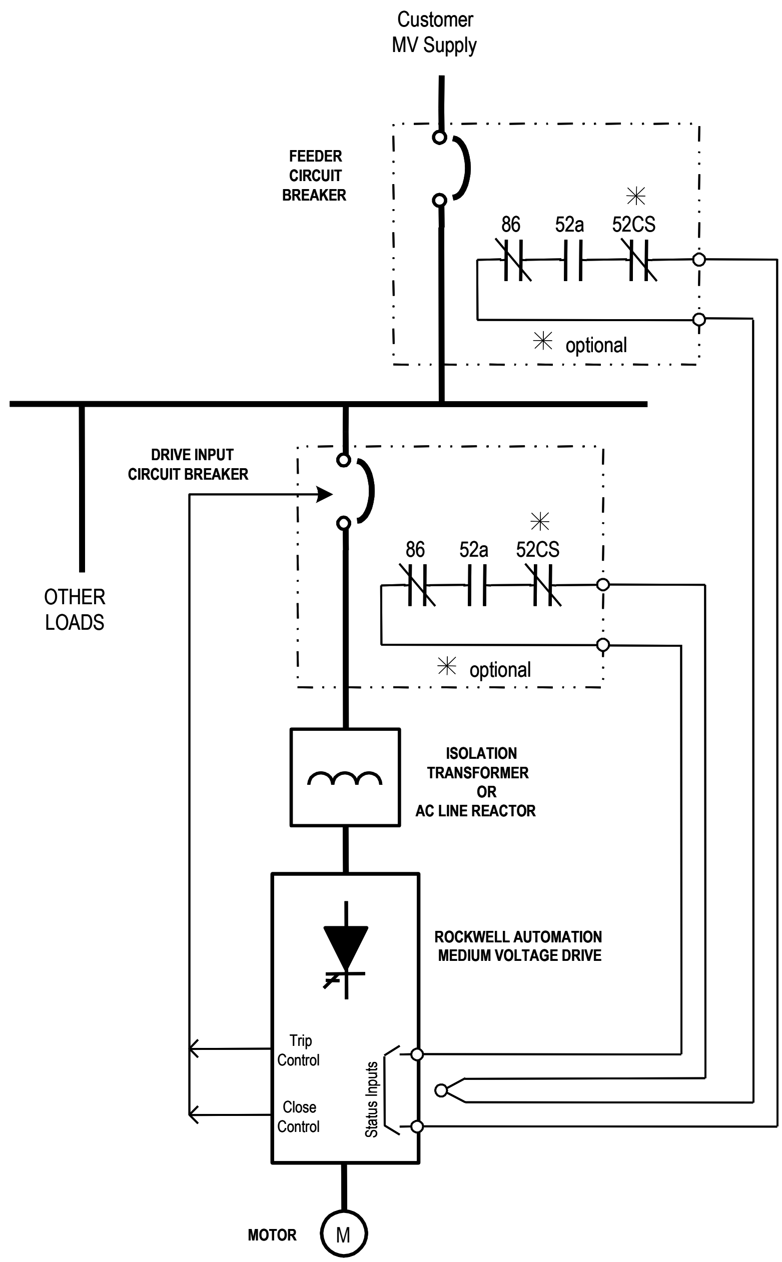


Figure 9 – Providing Feeder Circuit Breaker Status Feedback to the Rockwell Medium Voltage Drive

11.0 EMERGENCY STOP

Emergency Stop pushbuttons and E-Stop contacts should be connected to the drive and not to the drive input circuit breaker. By connecting the emergency stops to the appropriate drive terminals, the drive will trip the circuit breaker in a controlled fashion. This also applies to an optional Emergency Stop pushbutton that may be connected on the front of the circuit breaker. In this case it should be wired to terminal blocks on the breaker panel. It can then be field wired to the emergency stop input terminals in the drive.

The standard Emergency Stop function for the drive is to stop the gating of the power semiconductors and then to open the input unit (circuit breaker or contactor) of the drive. The motor will then coast to a stop. There are terminal blocks in the drive that will accept external operator emergency stop controls and contacts. Figure 10 shows the typical arrangements for a PowerFlex 7000 AC Drive when the motor is to coast stop on an Emergency Stop. Figure 10(a) is common for systems with a basic E-Stop function. Figure 10(b) or a variation of this is used in system applications when a Master Emergency Stop and separate motor E-Stop functions are required.

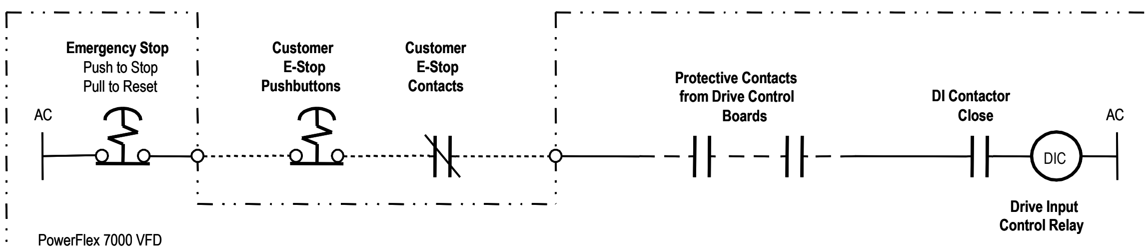


Figure 10.A – Typical Emergency Coast Stop Function

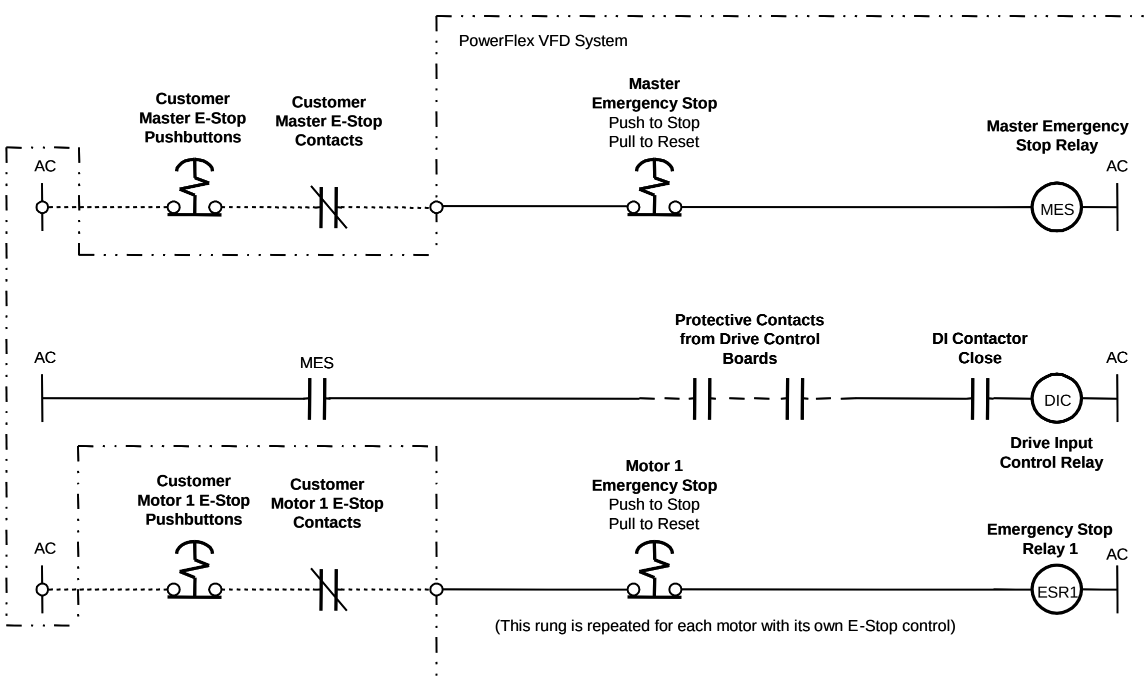


Figure 10.B – Typical Systems Emergency Coast Stop Function

If a circuit breaker is used on the output of the drive for drive isolation or directing the flow of variable frequency power, it should not have Emergency Stop functions tied into its control circuit.

It is possible that the customer may require that an Emergency Stop not cause the motor to coast to a stop but to stop in a different speed profile. Contact Rockwell Automation regarding the implementation of control schemes not shown in this document.

12.0 CIRCUIT BREAKER CONTROL VOLTAGE

The type of control voltage used in the circuit breaker is usually specified by the purchaser or end user. Typical arrangements preferred by Rockwell Automation are:

a) AC control voltage generated from control transformer(s) internal to the circuit breaker. With this option the control circuit should have a 'Capacitor trip' or similar device on the Trip Circuit and the 86 Lockout Relay so that the breaker has protection and can be tripped when there is no power on the incoming lines.

b) DC control voltage as specified on the purchase order. The source will be supplied by the end user. A 'Capacitor trip' or similar device will not be necessary.

c) An arrangement as specified on the purchase order. The breaker must have a reliable means of ensuring that the opening spring is fully charged when the breaker closes. This will allow the drive to be able to open the breaker when required.

Refer to section 20.0 (e) when the circuit breaker is on the output of the drive.

13.0 MANUAL MECHANICAL TRIP

Sometimes a manual mechanical trip (push button) is mounted on the front of a breaker. This is not recommended unless the drive can be given a 2 cycle advance notice as required under section 6.0. If it is specified or already existing and the timing is not reliable, a warning label should be mounted near the switch to state that the variable speed drive is to be shut off before the pushbutton is used.

14.0 TRIP-FREE OPERATION

The circuit breaker should have a linkage that is mechanically trip free in any location on the closing stroke. This will allow the drive to trip the breaker, after the auxiliary contacts in series with the trip coil change position, when energizing the trip coil while the breaker is closing. The circuit breaker should fully open.

15.0 AUTOMATIC RECLOSING

Automatic reclosing in circuit breakers is used to maintain service continuity and usually applies to distribution networks with overhead lines. Motor circuits do not use reclosing of breakers after a protective trip. Reclosing of circuit breakers should also not be used when the breakers are used as input circuit breakers to Rockwell Automation medium voltage AC drives.

16.0 CIRCUIT BREAKER PROTECTIVE FEATURES

Keep in mind that the drive provides motor overload protection and the input circuit breaker provides short circuit protection. If the breaker feeds an isolation transformer connected between the breaker and the drive, it should be selected for transformer primary protection.

The circuit breaker should not have any directional power relays that are used to open the breaker under conditions of reverse power flow. These devices are designated by IEEE or ANSI as a '32' device which is a relay that operates on a predetermined value of power flow in a given direction such as that resulting from the motoring of a generator upon loss of its prime mover. The Rockwell Automation medium voltage drive has the capability to operate in the regenerative mode in which it will send power back into the supply. A directional power relay may unnecessarily open the circuit breaker under these conditions.

A breaker used on the output of the drive should also not have an underfrequency or undervoltage relay because both these quantities will vary with motor speed. Note that if a drive uses an input AC Line Reactor in place of an Isolation Transformer it will have zero sequence ground fault protection built into the drive input. If the supply is an ungrounded supply this protection will be omitted. If an input circuit breaker has a requirement for ground fault detection, the protective relay should have the features of adjustable ampere setting and adjustable time delay to provide coordination and sensitivity adjustment.

There may be other protective relay options that may cause nuisance trips or not function due to incompatibility with the drive or misadjustment for drive operation. These would have to be examined for the specific situation.

17.0 KEY INTERLOCKING OF THE CIRCUIT BREAKER

Standard Rockwell Automation practice is to key interlock the input circuit breaker to the medium voltage AC drive. The key interlock system prevents access to the medium voltage sections of the drive until the medium voltage supply is locked off at the drive input circuit breaker. 'Locked off' means that by removing the key at the circuit breaker, the breaker will not be allowed to close. Depending on the breaker design this may or may not involve racking out the breaker.

Key interlocking described here will also apply to an output breaker when there is a possibility of power being backfed to the drive from a source on the load side of the breaker. A typical situation where this occurs is when the drive has a bypass scheme for starting the motor by another means. It can also occur in multi-motor situations when the drive will be switched among two or more motors in which each motor will also have its own supply for full speed operation (i.e. a synchronizing bypass scheme). There can also be cases when the characteristics of the load may require the use of an output circuit breaker/contactor that will be key interlocked to the medium voltage drive. These will be situations where the motor shaft can turn due to the process without the drive supplying power to the motor. A rotating or freewheeling motor can generate voltage that will be backfed to the drive. If access to the drive medium voltage sections is possible under this situation then key interlocking of the output circuit breaker/contactor is recommended.

The drive must employ a key interlocking system for safety of access to the medium voltage sections of the drive. Rockwell Automation will supply a drive that has all its medium voltage doors key interlocked to a master station on the drive. This station will contain a master key that controls the release of the drive door keys. We recommend that the customer use this master key to interlock to the input breaker (and output breaker, if required) to prevent access to live equipment.

Contact Rockwell Automation regarding the manufacturer and key number of the key interlock that we use in our drive. The key number must coordinate with the number used in the drive.

ATTENTION

The customer and/or the people responsible for the site design must take the responsibility for ensuring that there is safe access to our equipment by incorporating the key interlock system on our drive into the safety plan of the site.
They must also ensure that they use a key interlocking system that will prevent damage to our equipment by the use of other components in the system. The supplier of the circuit breaker must ensure that the breaker safety features are compatible with the drive. If the customer has any concerns about interlocking or proper drive operation, contact Rockwell Automation.

ATTENTION

System integrity of the key interlocking scheme depends on having only one key for each interchange designation or an amount as shown on the Rockwell Automation job specific drawings. If more keys are available the interlocking integrity is lost. Safety of personnel and equipment will be affected which can result in severe injury or death. When specifying, purchasing or using a circuit breaker that contains a key interlock that matches the master lock in the Rockwell Automation drive, beware that the drive is shipped with one master key unless other arrangements are made with Rockwell Automation.

18.0 CIRCUIT BREAKER FREQUENCY OF OPERATION AND SWITCHING CONDITIONS

A circuit breaker is intended usually to operate infrequently, although some types are suitable for frequent operation. Circuit breakers used on the input and output of Rockwell Automation drives should be rated to handle the frequency of operation and circuit conditions described in this section.

Input Breaker Operation

In the typical application with a Rockwell Automation medium voltage AC drive the breaker on the input of the drive will be opened only on a protection trip. This can be a trip from the protection circuit internal to the breaker or from the protection circuit internal to the drive. Certain remote devices such as a remote Emergency Stop pushbutton can also be configured to open the input circuit breaker. In some applications the drive can be programmed to open the circuit breaker every time the motor is stopped. This is a situation that will see more frequent operation of the breaker and thus it should be rated for this frequent operation although the breaker will not be interrupting a loaded motor.

When the drive input breaker is interfaced to the drive as recommended in these guidelines and it is requested to open, the drive will first attempt to bring the motor current to zero and shut off before the input breaker opens. In this case the breaker is not likely to interrupt motor power being fed to the drive. The standard Emergency Stop function for the drive is to stop the gating of the power semiconductors and then to open the input unit of the drive. The motor will then coast to a stop. If Emergency Stop is being done because of system malfunction then it is possible that the breaker will interrupt running currents. Depending on the drive configuration (see below) there may be other components contributing to input breaker current.

When the drive closes the input circuit breaker it will be closing onto a circuit that will not be drawing motor current. The drive will not be drawing current until after the input voltage is established although there may be input capacitors that will be energized, depending on the configuration as shown in Figure 11.

A circuit breaker used on the input or output of the drive will see one of the configurations depicted in the single line drawings of Figure 11 below.

Typical Configurations of Rockwell Automation Medium Voltage AC Drives

When the drive closes the input breaker it will energize an unloaded transformer. Under normal stops the breaker will be opening an unloaded transformer.

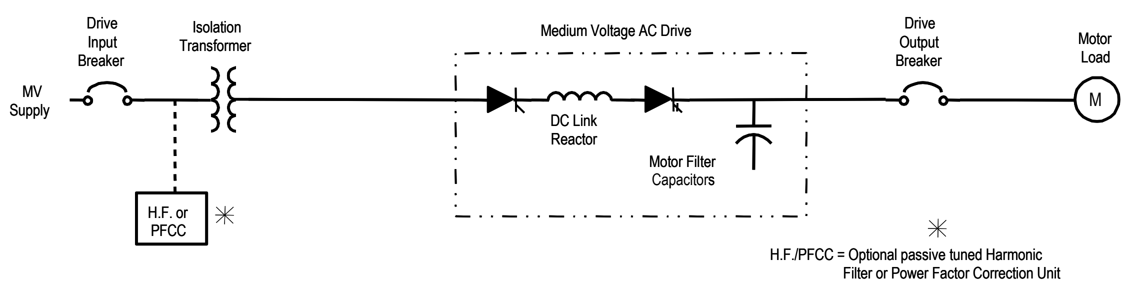


Figure 11.A – Breaker Feeding an Isolation Transformer on the Drive Input

The drive is a PWM Rectifier type of drive (with an 'active front end'). The drive converter current is still zero when the breaker closes or opens. However, there are filter capacitors between the isolation transformer and the converter. This will present a capacitive load on the transformer.

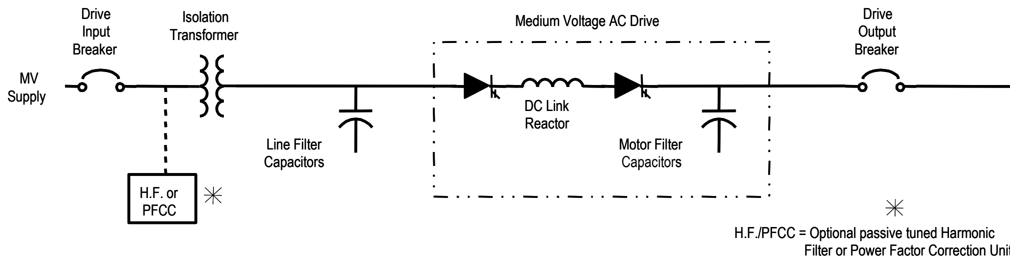


Figure 11.B – Breaker Feeding an Isolation Transformer on the Drive Input with Line Filter Capacitors on the Secondary

The drive is a PWM Rectifier type of drive (with an 'active front end'). The breaker will energize input filter capacitors that are connected between the reactor and the drive. The converter is normally off when the breaker closes or opens so the load will be an L-C tuned circuit.

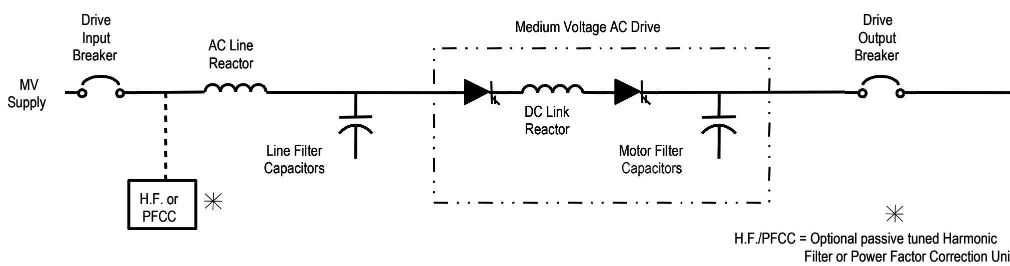


Figure 11.C – Breaker Feeding a Line Reactor on the Drive Input with Line Filter Capacitors

The breaker will not see any appreciable inrush or steady state load on closing. The converter is normally off when the breaker closes or opens.

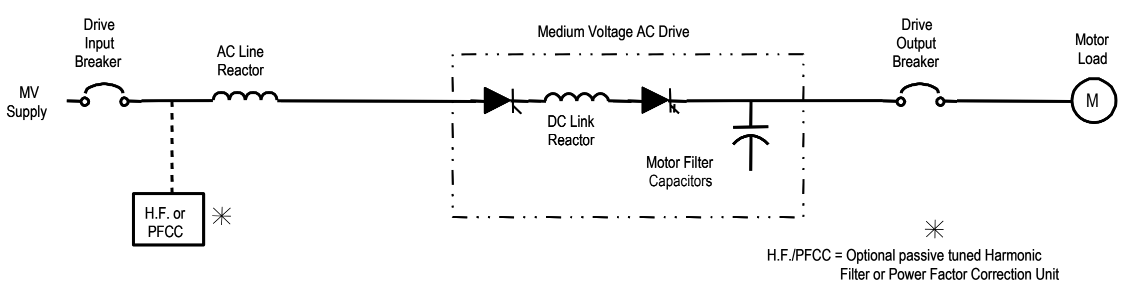


Figure 11.D – Breaker Feeding a Line Reactor on the Input of a 6-pulse Rectifier type of Drive

Note: In Figures 11.A to 11.D, the ***Breaker feeding a combination of a drive with a front end passive-tuned filter*** is an optional configuration used infrequently with the drives. It is shown as a box identified as "H.F. or PFCC". It will be more common with the 6-Pulse Rectifier type of drive. The capacitors in the filter will also be energized and de-energized by the circuit breaker.

Output Breaker Operation

There may be applications in which the circuit breaker is required to operate on the output of the drive. The various configurations of Figure 11 show where an output circuit breaker would be added. The capacitors shown on the output of the drive are motor filter capacitors that are an inherent part of a drive with a DC Link Reactor. The output circuit breaker will be used for drive isolation or directing the flow of variable frequency power much as a vacuum contactor would. The output circuit is current limited by the impedance of the drive DC Link Reactor and the components on the drive input. The drive provides motor protection and the drive input breaker or starter provides overcurrent protection.

The drive is typically programmed to open the output circuit breaker every time the motor is stopped. It will not normally see any inrush or steady state load on closing or opening. This is because the breaker is typically closed before the drive sends power to the motor and opens after the current is brought to zero.

There can also be infrequent cases when the output breaker will trip from the protection circuit internal to the breaker or from the protection circuit internal to the drive. The drive will attempt to bring the current to zero and shut off before the output breaker opens. In this case the breaker is not likely to interrupt variable frequency and variable voltage power being fed from the drive to the motor if the breaker is interfaced to the drive as recommended in the guidelines of this document.

19.0 CIRCUIT BREAKER SWITCHING SURGES

Vacuum circuit breaker switching of loads can result in conditions called current chopping, multiple reignitions, pre-striking and virtual current chopping. These conditions can result in transient overvoltages or switching surges. Transient overvoltages are of concern due the amplitude they can achieve and the fast rate of rise inherent with them. As overvoltage magnitude increases, the possibility of insulation breakdown increases. Very fast transient voltage rate-of-rise can cause the overvoltage to be non-uniformly distributed in motor and transformer windings – leading to inter-winding insulation degrading or breakdown in the most stressed areas. [1]

With the latest designs used in contact materials, many of the switching transients seen in earlier vacuum contactors are not a problem or are a relatively infrequent phenomenon. Switching transients can become a reliability issue under certain combinations of inductance, capacitance and contact gap. [2]

When the plant engineer or system designer determines what is needed to modify the existing system or designs a new system, he typically relies on electric system studies. They help him to evaluate the performance of the existing or future system and help in selecting a cost-effective solution as well as arriving at adequate equipment ratings. There should be some attention paid to the possibility of circuit breaker switching surges in the system. These can be evaluated in switching transient studies. Rockwell Automation cannot say when such studies are warranted, as each system is different. It is difficult to predict when surge voltage protection is required. Have an experienced person review the previous section with the particular project in mind to determine if a transient study is indicated. Equipment manufacturers such as the breaker and transformer supplier may also have guidelines to recognize situations that will be suspect.

Transient Recovery Voltage

Circuit breakers provide the mechanism to interrupt the short-circuit current during a system fault. When the breaker contacts open, the fault current is not interrupted instantaneously. Instead, an electric arc forms between the breaker contacts, and is maintained as long as there is enough current flowing. The arc will extinguish at the first current zero. However, at the location of the arc, there are still hot, ionized gases and, if a voltage develops across the opening contacts that exceeds the dielectric capability of the contact gap, it is possible that the arc will re-ignite. Circuit interruption is a race between the increase of dielectric strength of the contact gap of the circuit breaker and the recovery voltage. The latter is essentially a characteristic of the circuit itself. [3]

This system-generated voltage, called the transient recovery voltage (TRV), is impressed across the opening breaker contacts and stresses the gap insulation. Failure to interrupt due to excessive TRV can occur with low-magnitude short circuit currents as well as current at or near full rating. The TRV can be characterized by two parameters, namely, the peak value of the TRV and the time after current zero to reach the peak value. These two parameters are used in the ANSI Standards to specify TRV-related circuit breaker ratings. [4]

Close Coupling of Breaker to Transformer or Reactor

A failure mode described as a part-winding resonance can occur under favorable circuit conditions. The cause is excitation by a switching operation in the external circuit resulting in excessive electrical stress of the winding insulation. Windings in some ways are similar to transmission lines but they have mutual couplings between different sections which lines do not have. The transformer will have natural frequencies that can manifest as standing waves along the winding with nodes and antinodes. If losses in the external line are low, the voltage at the antinodes can be considerable especially when the capacitance of the winding comes into play. The corresponding stress on the insulation can be excessive, perhaps destructive. [5]

The fast transient produced by the vacuum breaker can produce a resonant condition within the transformer winding. This causes the voltage in the middle of the winding to rise to very high magnitudes, resulting in a winding failure. This is not the more classic line-end failure problem seen in transformer windings from transients. The condition exists with the right combination of transformer design characteristics, breaker design, system impedance, cable or bus design and frequency of operation. The failures have occurred more prevalently in transformers with high impedance that are switched frequently. If a transformer is to be close-coupled to a breaker, and is switched frequently, a system study may be wise to prevent the problem from occurring. Unfortunately, more often than not, the problem is identified only after it has occurred. [6]

Surge Suppression

If required, surge protection can be supplied to offer protection against transient voltages. These voltages can come from lightning, circuit resonances, intermittent grounds, switching surges and accidental contact with higher voltages. Note that, depending on the situation, the best location of surge protection may be in a location other than the circuit breaker.

If a switching transient study suggests that there could be undesirable switching surges present or other criteria require it, surge suppression networks can be added to provide protection of equipment being switched. The type and design of these networks is beyond the scope of this document. One thing to keep in mind is that, depending on the circuit configuration and components used, the lines to be protected may see elevated line-to-ground and neutral-to-ground voltages. This will affect the ratings of the suppression components. Under these conditions the maximum continuous operating voltage (MCOV) of the arrester should be above the maximum line-to-ground voltage seen at the point of connection. MCOV is an rms rating of arresters. Similarly, the voltage rating of the surge capacitor would have to be checked to make sure it is above the maximum line-to-ground voltage seen at the point of connection.

Because of the various configurations and future design changes, it is recommended that Rockwell Automation be contacted for relevant information on specific applications.

20.0 DRIVE OUTPUT CIRCUIT BREAKERS

There may be cases in which the circuit breaker requested would be connected on the output of the Rockwell Automation medium voltage AC drive. These applications include cases when the drive has a bypass scheme for starting the motor by another means. An output breaker can also be used in multi-motor situations when the drive will be switched among two or more motors in which each motor will also have its own supply for full speed operation (i.e. a synchronizing bypass scheme). An output circuit breaker or contactor is recommended in certain applications as described below.

ATTENTION

A rotating or freewheeling motor can generate voltages that will be backfed to the drive. This will occur in situations where the motor shaft can turn due to the process without the drive supplying power to the motor. If access to the drive medium voltage sections is possible under this situation the result can be severe injury or death. The use of an output isolating circuit breaker or contactor that is key interlocked to the medium voltage drive is recommended. Refer to the User Manuals of the equipment supplied for specific procedures and information.

The comments in this document generally also apply to output circuit breakers with additional considerations as shown below:

a) **Drive Control of Output Breaker:** Drive Output Control (DOC) relay or Output Control Relay (OPC) contacts will be connected to control the breaker in the same manner as DIC contacts in section 5.0 and will have the same ratings. The choice of whether DOC or OPC relay is used will depend on the circuit configuration as engineered at Rockwell Automation.

b) **Breaker Status Contacts:** Just as for an input circuit breaker, the drive must monitor the condition of the breaker and know in advance when the breaker is about to open. It does this by monitoring the status contacts as described in section 6.0.

c) **Emergency Stop:** If a circuit breaker is used on the output of the drive for drive isolation or directing the flow of variable frequency power, it should not have Emergency Stop functions tied into its control circuit.

d) **External Trip Contacts:** As with the input circuit breaker, external contacts should not be taken to the breaker control circuit to trip the breaker. These contacts should be taken to the trip input terminals on the drive.

e) **Breaker Will See Variable Frequency/Voltage:** Note that the drive has a variable frequency and variable voltage output that changes with motor speed and loading. The circuit breaker should not derive its internal control power from the main incoming lines of the breaker. The power must come from an external source. This source should not drop out when there is a momentary power loss on the medium voltage system.

f) **Circuit Breaker Protective Features:** A breaker used on the output of the drive should not have an underfrequency or undervoltage relay because both these quantities will vary with motor speed and loading. Set the protective functions as high as possible while still protecting the breaker. The breaker is not intended for circuit protection but for drive isolation or directing the flow of variable frequency power much as a vacuum contactor would. The output circuit is current limited by the impedance of the drive DC Link Reactor and the components on the drive input. The drive provides motor protection and the drive input breaker or starter provides overcurrent protection. Ground fault detection circuitry is not recommended in an output circuit breaker due to the variable frequency/voltage nature of the output and ground fault detection will most likely take place ahead of the drive.

   There may be other protective relay options that may cause nuisance trips or not function due to incompatibility with the drive or misadjustment for drive operation. These would have to be examined for the specific situation.

g) **Key Interlocking:** There are conditions mentioned in section 17.0 in which it is recommended that the output circuit breaker be key interlocked to the drive or drive input breaker.

h) **Circuit Breaker Frequency of Operation and Switching Conditions:** Refer to Section 18.0 for information on this issue.

21.0 COMMISSIONING, TESTING, CALIBRATION AND SERVICE

Circuit breakers for use with Rockwell Automation medium voltage drives can be supplied in several ways:

- They may be purchased directly by the end user from the circuit breaker manufacturer;
- They may be supplied by another party under contract to the customer;
- Rockwell Automation may be required to furnish the breakers as part of its scope of supply.

In addition to supplying the circuit breaker there are several related items and services that must be addressed. The roles and responsibilities of all involved parties should be defined in this activity. The factors to be considered are:

- Who is responsible for commissioning, testing and calibration of the breaker? Some customers have the experience to commission the breaker themselves. Other times the contractor installing the circuit breaker is capable of doing the start-up. The customer must define responsibilities.
- Often the manufacturer does not quote start-up services when quoting a circuit breaker. That price will come from their local office or authorized representative.
- What are the terms and conditions for warranty and service from the manufacturer? How do they compare with what is required at the site? Will a separate service contract with an authorized representative be required? Who is responsible for these?
- Are spare parts within the scope of supply? What is available from the manufacturer and who supplies them?
- In most cases the customer will have to provide the settings for the person doing the calibration of the protective relay. It should be made clear that he is to supply this data.
- If the customer wants a coordination study or switching transient study done then they must purchase that in a separate transaction with people capable of doing such a study. Make sure that the customer understands whether or not we are supplying these studies.

REFERENCES

[1] J.F. Perkins, "Evaluation of switching surge overvoltages on medium voltage power systems," *IEEE Trans. Power App. Syst*., vol. PAS-101, pp. 1727-1734, June 1982

[2] P.G. Slade, "Vacuum interrupters, the new technology for switching and protecting distribution circuits," *IEEE Trans. Ind. Applications,* vol. IA-33, pp. 1501-1511, Nov./Dec. 1997

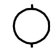
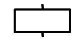
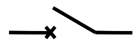
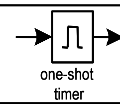
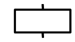
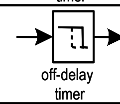
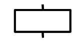
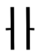
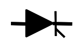
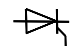
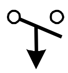
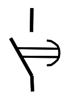
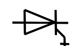
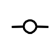
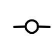
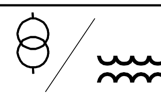
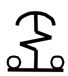
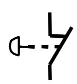
[3] IEEE Brown Book: *IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis,* 1998

[4] D.L. Swindler, P. Schwartz, P.S. Hamer and S.R. Lambert, "Transient Recovery Voltage Considerations in the Application of Medium-Voltage Circuit Breakers," *IEEE Trans. Ind. Applications,* vol. IA-33, pp. 383-388, Mar./Apr. 1997

[5] A. Greenwood, *Electrical Transients in Power Systems,* New York: John Wiley & Sons, Inc., 1971.

[6] S.P. Kennedy, "Design and Application of Semiconductor Rectifier Transformers," *IEEE Trans. Ind. Applications,* vol. IA-38, pp. 927-933, July/Aug. 2002

Table of Symbols
Used in This Document

Description	This Document	IEC	Description	This Document	IEC
Capacitor			Coil, Operating - Relay		
Circuit Breaker			Coil, Operating - One-Shot Timing Relay		
Contact Normally closed - Break			Coil, Operating - Off-Delay Timing Relay		
Contact Normally Open - Make			Silicon Controlled Rectifier (SCR)		
Time Delay Contact - Normally Open with time delay closing			Symmetrical Gate-Commutated Thyristor (SGCT)		
Current Transformer			Terminal		
Motor - Induction Machine			Transformer		
Switch, Mushroom Head, (Maintained)			Reactor or Inductor		

Device Designations Used in This Document

DIC - Drive Input Control Relay
DOC - Drive Output Control Relay
CBCR - Circuit Breaker Close Relay
CBCT - Circuit Breaker Close Time Delay Relay
CBOT - Circuit Breaker Open Time Delay Relay
CR1 - Control Relay (may have a timed output)
ESR1 - Emergency Stop Relay
MES - Master Emergency Stop Relay
OPC - Output Control Relay
P.C. - Protection Circuit
VFD - Variable Frequency Drive
52a - Circuit Breaker Auxiliary Contact that mimics the main power poles
52CS - Circuit Breaker Control Switch Contact
86 - IEEE/ANSI designation for a lockout relay

DATA SHEETS FOR SPECIFYING A CIRCUIT BREAKER

Purchase Order Number	P.O. No. ____ Item ____ Qty ____ Issued by ____
P.O. Technical Contact	Name ____ Phone ____ Fax ____
Job Site Location	____
Requested Ship Date	____ Required at Job Site ____
Rockwell Automation Document	The circuit breaker must meet the requirements of this document. Ξ
Applicable Breaker/ Switchgear Standards	
Approval Job	____ No: Send information drawings. ____ Yes: For Approval Jobs manufacturing is to be held until approval is issued by P.O. office. Approval drawings and data required by ____
Final Documentation	Send a copy of 'As Shipped' drawings, manuals and renewal parts list with the circuit breaker. _____ Sets of 'As Shipped' drawings, manuals, renewal parts list and reports. Send to: ____ Dept. ____ Location: ____ Electronic copies required where possible: ____ No ____ Yes Send drawings in DXF and/or PDF format via: ____ CD to address above. ____ E-mail to: ____
Location	____ Indoor ____ Outdoor
Operating Altitude (Above Sea Level)	___ Up to 1000m ___ 1001-2000m ___ 2001-3000m ___ 3001-4000m ___ 4001-5000m
Environmental Conditions (Ambient temp, atmospheric conditions, vibration, etc.)	
Shipping/Storage Conditions	
Enclosure	Exterior Color: ____ ANSI 61 light gray (standard) ____ Other ____ Misc: ____ Encl. Type: ____ (must meet Environmental Conditions described above). Size/ventilation restrictions:
Line Side Power Entry Information	____ Cable Entry Top ____ Cable Entry Btm Size: ____ #/Ph. ___ ____ Bus link to switchgear located ____
Load Side Power Exit Information	____ Cable Exit Top ____ Cable Exit Btm Size: ____ #/Ph. ___ ____ Bus link to ____
Is close coupling of breaker to output required?	____ No ____ Yes: Refer to Section 19.0 of this document. Ξ Specify details and responsibilities on attachment.
Trip-Free Operation	This is required as described in Section 14.0 of this document. Ξ

Ξ *(Specifying and Using Vacuum Circuit Breakers with PowerFlex 7000 – Application Guidelines, publication number 7000-AT003_-EN-P).*

DATA SHEETS FOR SPECIFYING A CIRCUIT BREAKER

Automatic Reclosing	Do not use.	
Fast Acting Operation	Do not use.	
Status Signal Required	Provide Status contacts as described in Section 6.0 of this document. Ξ Provide interface terminal blocks for drive connections.	
Upstream grounding system used. (Provide details)	________________________________	
Selection of Breaker on Input or Output of Drive		
Indicate breaker location: (✓)	____ **Breaker on Input Side**	____ **Breaker on Output Side**
Circuit Breaker Function	Breaker is a dedicated branch circuit protective device. It controls line voltage to the drive (possibly through an isolation/step down transformer).	Breaker is used as a vacuum contactor for drive isolation only. It controls variable frequency power out of the drive. Refer to Section 20.0 of this document. Ξ
Rated Supply Line to Line Voltage/freq/phase	________ V _____ Hz 3 Phase	Variable Frequency from Drive: 0-_______ V 0.2 -_____ Hz 3 Phase
Maximum continuous RMS Current of load	________ A	________ A
Short Circuit Current	________ kA	Short circuit current is limited by the DC Link Reactor inside the VFD.
Circuit Configuration	Refer to Figure _________ in Section 18.0 of this document. Ξ	Refer to Figure __________ in Section 18.0 of this document. Ξ
Major Load-Side Component Values (Refer to circuit configuration above)	___ th ___ th ___ th Harmonic Filter ______ kVA/ _____ V Isolation Transf. ______ mH 3 phase AC Line Reactor ______ kVAR Line Filter Capacitor ______ mH DC Link Reactor	______ kVAR Motor Filter Capacitor ______ HP / ______ KW Motor
Protective Features (Refer to Sections 16.0 and 20.0 in this document, *7000-AT003_-EN-P)*		
Ground-Overcurrent Protection (Refer to Sections 16.0 and 20.0 in this document.) Ξ		Not Recommended.
Emergency Stop pushbutton on front of breaker	____ No ____ Yes: Must be wired as shown in Section 11.0 of this document. Ξ	Not Recommended.
Trip & Close Contacts	Reference Sections 5.0, 7.0 and 8.0 of this document. Ξ	
Breaker Trip and Close Circuit Design	Design must allow breaker protection and drive control as described in Section 5.0 of this document. Ξ Provide a Lockout Relay and interface terminal blocks for drive connections.	
Rating of Trip and Close contacts from the drive.	AC Rating: ____ A at ____ V ____ A at ____ V DC Rating: ____ A at ____ V ____ A at ____ V	
Requirement to install interposing relay for Trip and Close contacts.	If the application in the circuit breaker will exceed the ratings shown above for our Trip and Close contacts, then an interposing relay must be installed within the breaker that will interface between the drive contact and the breaker circuit. Refer to Section 9.0 of this document. Ξ Relay to be installed by: ____ Breaker Manufacturer ____ End User (Consult bkr mfgr)	
Configuration of Trip and Close contacts from the drive.	The contacts provide continuous trip and close signals to the circuit breaker. We can provide optional momentary (pulsed) signals if that is preferred. Rockwell Automation must be notified if this is required as well as the duration of the trip and close signals.	

Ξ *(Specifying and Using Vacuum Circuit Breakers with PowerFlex 7000 – Application Guidelines, publication number 7000-AT003_-EN-P).*

DATA SHEETS FOR SPECIFYING A CIRCUIT BREAKER

Control Voltage	✓	Reference Section 12.0 of this document Ξ.
Internal AC voltage	____	Internally generated AC with 'Capacitor Trip' feature on trip and protection circuit. If desired, specify voltage: ________ VAC Do **not** use this method for a breaker located on the output of a drive.
External DC Voltage	____	Externally supplied DC control voltage. Voltage source: ________ VDC
Other control method	____	____
Key Interlocking		Reference Section 17.0 of this document Ξ.
Key Interlocking Required		The circuit breaker must be key-interlocked to the drive for safety of access to the medium voltage sections of the drive. There are two choices available: _____ One keyed lock on the breaker to lock open the breaker when the key is removed. _____ Custom system as described on attached document.
Additional lock features		____
Key and Lock Sourcing		_____ Circuit breaker manufacturer to obtain and install a suitable locking mechanism to meet requirements above. Use Rockwell supplier ________________________ available at: Phone _______________ Web site: ____________________ Rockwell to supply the key number based on the drive key interlocking scheme. _____ Alternate arrangement: ____
Key Safety		The standard arrangement is to ship the circuit breaker **without** any keys. For safety reasons, contact Rockwell Automation if keys are required to ship with the circuit breaker.
Other Options		
Power Bus Options		_____ A
Ground Bus Options		____
Control Wire Options		____
Space Heater		_____ Internal Source _____ External Source: ________ VAC / 1 ph
Special Nameplate Engraving		____
Special Nameplate Material/Mounting		____
Bilingual safety labels		English and ____________________________
Breaker Control Switch on front of breaker		____ No ____ Yes Use is optional. See Sections 5.0 and 6.0 of this document. Ξ If not used, supply terminal blocks for future use.
Manual Mechanical Trip		____ No ____ Yes This option is not recommended unless it meets the requirements in Section 13.0 of this document. Ξ
Extra Auxiliary Contacts (beyond what is requested in other selections)		Describe the contact function, quantity and the state of the contact when the breaker is open. ____
Status Lights – breaker open and closed		Color: Open _______________ Closed _______________ Type: ____
Other pilot lights		____
Allen-Bradley control devices required		____ No ____ Yes This option requires that operator devices such as pushbuttons, pilot lights, selector switches and Emergency Stop pushbutton, where used, be Allen-Bradley type. It does not include the Breaker Control Switch or Manual Mechanical Trip if used. Devices are to be sourced by the circuit breaker manufacturer. Specify device style: ____

Ξ *(Specifying and Using Vacuum Circuit Breakers with PowerFlex 7000 – Application Guidelines, publication number 7000-AT003_-EN-P).*

DATA SHEETS FOR SPECIFYING A CIRCUIT BREAKER

Metering (Note that a breaker on the output side of the drive will see variable voltage/frequency)	Describe the metering function, signal source and preferred type of meter:			
Certified Test Reports	____ No	____ Yes	(Send with documentation.)	
Lift Truck Required *	____ No	____ Yes		
Renewal Parts Required *	____ No	____ Yes		
Warranty Period/Terms *	____________________			
Inspection Required *	____ No	____ Yes		
Witness Testing Req'd *	____ No	____ Yes		
System Test Required *	____ No	____ Yes:	Location: ____________	
On-site Work Required *	____ No	____ Yes:	Commissioning, testing and calibration.	
	Note: Manufacturer may require this to be set up with a local authorized representative.			
Surge Protection	____ Surge Arrester	Location:	____ Breaker Input	____ Breaker Output
	____ Surge Capacitor	Location:	____ Breaker Input	____ Breaker Output
	____ Other protection. Describe arrangement:			
Note: When the breaker is on the output side of the drive it will see a variable frequency and voltage as indicated previously.	Note: Special operating condition when the breaker is used on an ungrounded side of the drive – Peak Line to Ground Voltage seen: ________ Vpk maximum. Note: The surge protection specified does not rule out manufacturer recommendations for surge suppression and snubber circuit arrangements that he deems to be appropriate for his product and the situation. Rockwell Automation should be consulted in this regard.			
Other special features / terms & conditions *				

* These options may be shown as separate line items on the purchase order. Do not duplicate.

Signature and Date

www.rockwellautomation.com

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Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

Medium Voltage Products, 135 Dundas Street, Cambridge, ON, N1R 5X1 Canada, Tel: (1) 519.740.4100, Fax: (1) 519.623.8930, www.ab.com/mvb

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