

Electrical Equipment - Course 230.2

SWITCHGEAR: PART 7

CIRCUIT BREAKER CONTROL

1. OBJECTIVE

The student must be able to:

1. State the six essential features of a circuit controlled by a circuit breaker.
2. State the essential differences between a contactor control scheme and a circuit breaker control scheme.
3. Given a simple breaker control scheme, explain the operation and function of:
 - (a) the closing system.
 - (b) the tripping system.
 - (c) the electrical protection and other safety features.
 - (d) the indication system.
 - (e) the blocking switches.

2. INTRODUCTION

In Ontario Hydro, contactors are used to control motor and other loads which consume less than 50 A at 600 V. Circuit breakers are used to control circuits which operate at voltages greater than 600 V and have load currents in excess of 50 A.

Breakers vary in size from those having a 600 V 200 A rating to the largest air blast units which have a 500 kV and 4500 A rating. The power circuits and control systems for these breakers vary greatly but they all have certain essential common features. This lesson, by considering representative power circuits and control systems, explains these essential common features.

3. FEATURES OF A CIRCUIT CONTROLLED BY A CIRCUIT BREAKER

3.1 Essential Features

Every circuit controlled by a circuit breaker requires the following six essential features:

- (a) A means of isolating the power circuit.
- (b) Protection of the power and control circuits, in the event of an electrical fault.
- (c) Circuits for opening and closing the breaker from remote and local locations.
- (d) Protection for the circuit in the event of an overload - as distinct from an electrical fault.
- (e) Indications of position and/or conditions.
- (f) Grounding.

4. POWER AND CONTROL CIRCUITS

4.1 Power Circuits

As explained in lessons 230.22-2, 3, 4 and 5, air breakers and vacuum breakers are racked out for isolation. Because they cannot be racked, the larger oil and air blast breakers use disconnect switches for isolation.

4.1.1 Circuit Controlled by an Air Circuit Breaker. Figure 1 shows a typical motor circuit which has the following features:

- (a) The air circuit breaker which can be racked in (for service) and out (for isolation).
- (b) Three overload protection current transformers and the associated relays. The principle of current transformers (which are used to proportionally reduce the load current being applied to the relay) is covered in lesson 230.24-1. The principle of the thermal relay is covered in lesson 230.21-1.

- (c) The ammeter circuit. Again, a current transformer proportionally reduces the load current before it is applied to the ammeter.
- (d) The motor casing ground. Should a short circuit occur between the motor windings and the motor casing, the ground ensures the motor casing remains at zero potential with respect to ground.

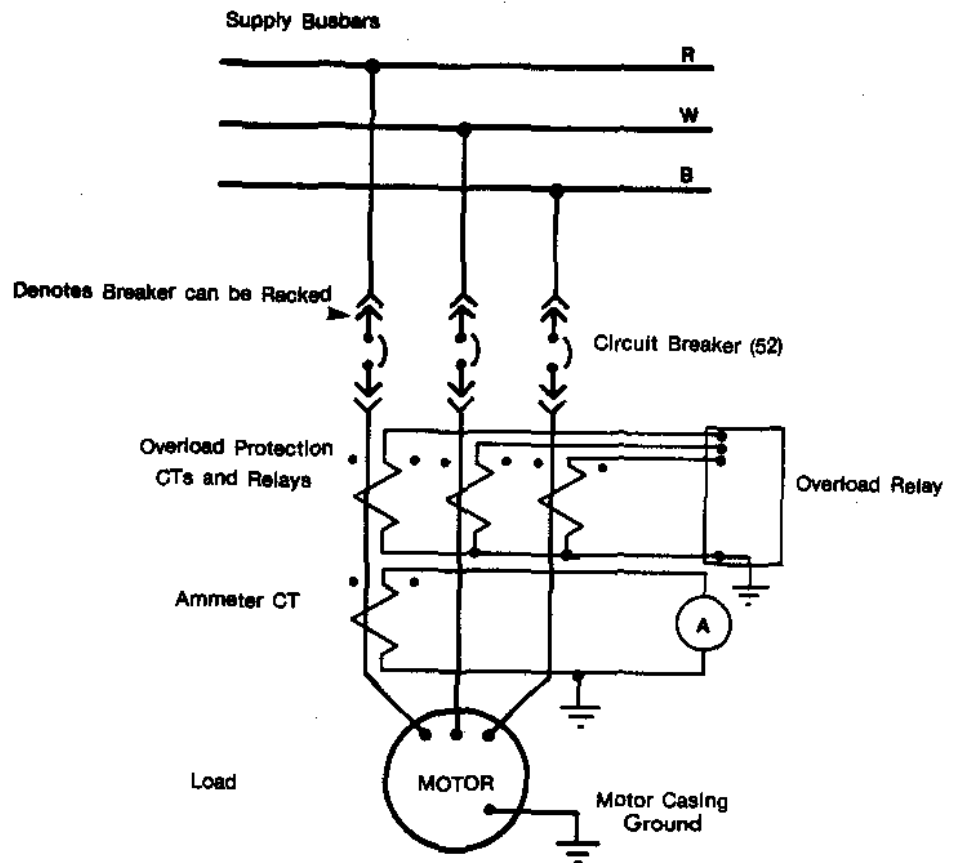


Figure 1: Motor Circuit Controlled by a Rackable Air Circuit Breaker.

4.1.2 Circuit Controlled by an Oil or Air Blast Circuit Breaker. Figure 2 shows a typical circuit controlled by an oil or air blast breaker. The circuit contains the following features:

- (a) Circuit isolation is achieved using disconnect switches which are located on either side of the breaker.
- (b) Overload protection current transformers and the associated relays. Note that the overload current transformers are situated on the busbar side of the breaker. The breaker, as far as the protection is concerned, is part of the load circuit and this arrangement gives the maximum amount of load circuit covered by the protection.
- (c) Ammeter circuit. This circuit is similar to that described in 4.1.1 (c).

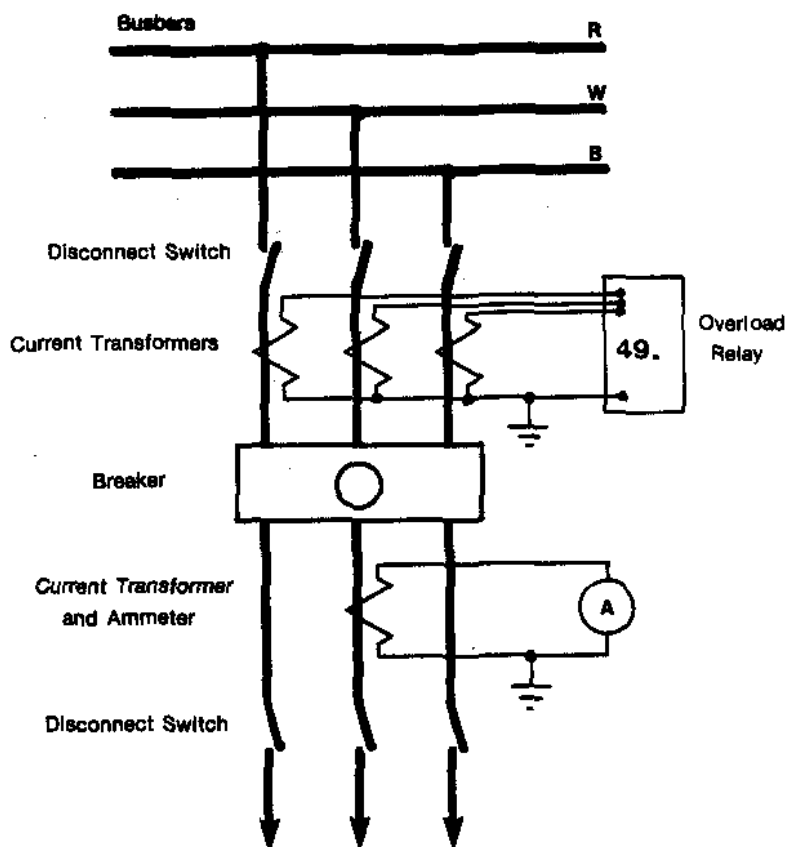


Figure 2: Load Controlled by an Oil (or Air Blast) Circuit Breaker.

4.2 The Control Circuit

The essential difference, between the control system of a breaker and that of a contactor, is that a contactor requires a continuous supply of electrical current to keep its coil magnetized. A breaker, because it has a latching mechanism, only requires a flow of current through the closing coil to close the breaker and cause the breaker to latch in the closed position. Once the breaker is closed, the closing coil is de-energized. To trip (open) the breaker, a flow of current is required through the trip coil. The plunger operated by trip coil releases the latch and the breaker rapidly opens. Once the breaker is open, the trip coil is de-energized.

Figure 3 shows a simplified circuit for a circuit breaker. The circuit has two main paths, one for closing and one for tripping.

4.2.1 The Closing Circuit. The closing circuit has the following features:

- (a) A separately fused supply. The closing and tripping circuits are supplied from separate fuses. This is done to ensure that if the closing fuse blows, the breaker still has a tripping supply. This is very important. If the closing and tripping supply was taken from the same fuse, the fuse may blow during closing and then the breaker could not be electrically tripped.
- (b) The closing coil 52C. This coil operates the breaker closing mechanism. Energizing 52C closes the breaker.
- (c) Closing coil auxiliary relay 52X. This relay will only operate when a close signal is given from either the local or remote pushbuttons or from the control logic. The breaker closing coil 52C, when energized takes a large current (typically 80A). This current is too great to pass through the control system, and this is the reason why the auxiliary relay 52X is used. The contacts on relay 52X are heavy duty.

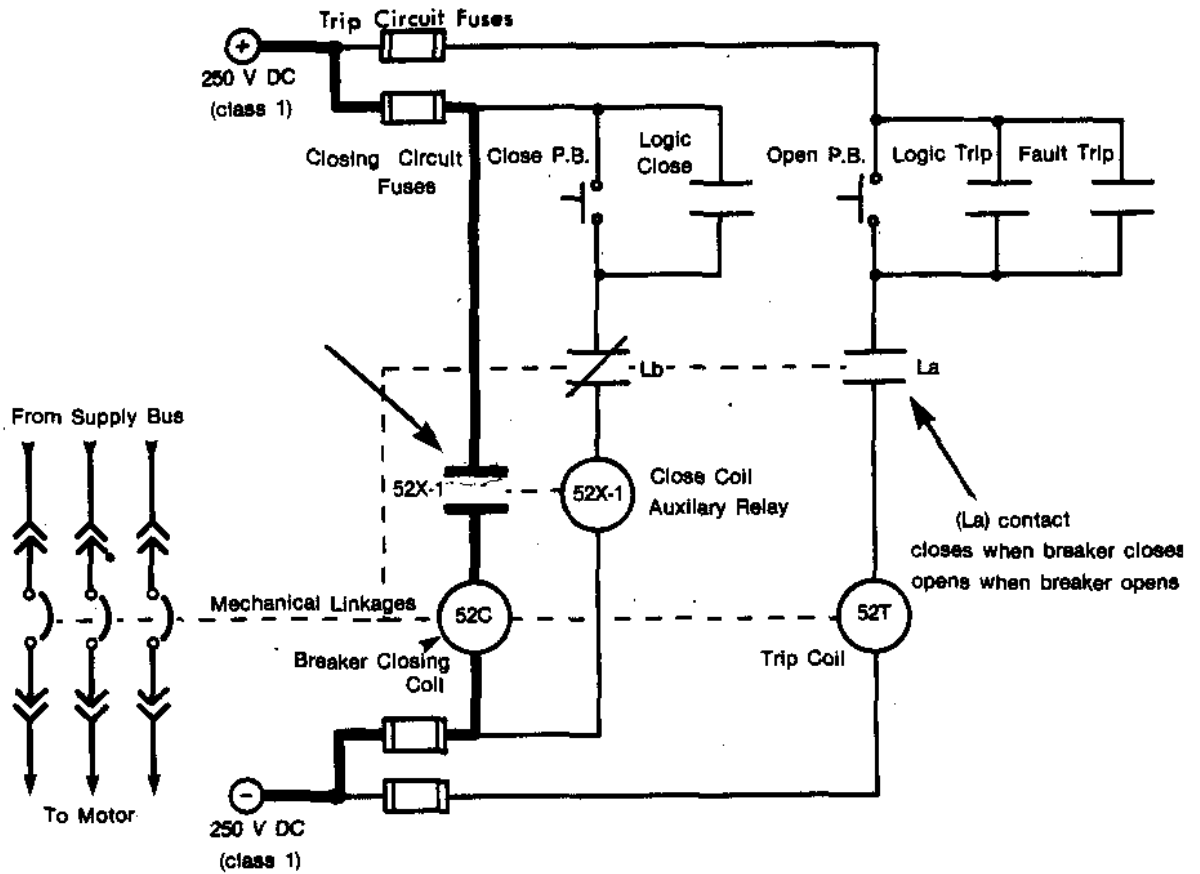


Figure 3: Circuit Breaker Basic Control Circuit.

- (d) The pallet (auxiliary switch) contacts Lb. This pallet switch like the other pallet switches, is operated by a linkage from the breaker opening and closing mechanism.

Each Lb contact:

- opens when the breaker closes.
- closes when the breaker opens.

Examining Figure 3 shows that when the breaker is open, the Lb contact in series with the auxiliary relay 52X is closed. When a close signal is given from the close pushbuttons or from the control logic, current will flow through the coil of 52X, closing 52X-1, energizing the main closing coil 52C. The breaker will now close and latch closed. As soon as the breaker has closed and latched, the Lb contact opens, de-energizing 52X and 52C. This will prevent 52C burning out (it is short time rated) and minimize battery drain.

- NOTE: (1) So far, this lesson has explained breaker closing using a closing coil 52C. Many air circuit breakers use a charged spring to close the breaker. The difference in the control circuit is that the closing coil 52C is replaced by the spring charging motor. The energy stored in the spring is released by the latch release mechanism which is operated by the plunger of coil 52X.
- (2) With air blast circuit breakers, when 52X is energized, it opens the air valves causing compressed air to close the isolating contacts which closes the breaker.
- (3) With oil circuit breakers, when 52X is energized, it opens the air valve causing compressed air to enter the closing cylinder which closes the breaker.

- 4.2.2 The Tripping Circuit. The tripping circuit supply is separately fused. The fuse rating is specified to be high enough to allow the trip coil to burn out but low enough to prevent breaker internal wiring from overheating to the point where there is a fire risk.

When the breaker is closed, the La contact closes. This contact is in series with the trip coil. When a trip signal is received from either:

- (a) manual operation of the pushbutton or,
- (b) the logic operated trip contact or,
- (c) the fault trip (for example the over-load relay operating),

the trip coil 52T will be energized and the breaker will trip open. As soon as the breaker has opened, contact La will open cutting off the supply to the trip coil 52T. This will prevent 52T burning out and minimize battery drain.

- 4.2.3 Other Breaker Control Features. Most breakers have additional control features which, for the sake of simplicity, have been left out of Figure 3. These features include.

- (a) Anti-Pumping - sometimes called anti-hunting. If a breaker receives simultaneous closing and opening signals - due to operator error or equipment malfunction - the breaker controlled by a circuit similar to that shown in Figure 3 will rapidly open/close/open/close/open. In a short time (seconds) the breaker will be damaged - and so may the load due to repeated power surges. Therefore an additional relay and other circuitry is provided to ensure that a breaker can only make one attempt at closing per operation of the closing circuit, ie the breaker will close/trip and then lock-out preventing further closures. The closing signal must be removed before a further close can be done.

- (b) Trip-Lockout. A circuit which has tripped due to overload or an electrical fault must be investigated before a re-close is attempted. The trip-lockout feature prevents a re-close until the trip-lockout relay has been re-set. This re-set feature is local to the breaker and ensures the operator must visit the breaker and reset the lock-out relay before a re-close is attempted. (The operator should of course fully investigate the reason for the trip).
- (c) Indications. Indicating lamps located in the control room show a breaker's open or closed state. The circuit for the indicating lamps is operated from the breaker pallet switches. Other indications and alarms are provided to show, for example:
- (i) dc supply failure.
 - (ii) low air pressure.
 - (iii) relays operated.

4.2.4 Breaker Abnormalities. Explained below are some of the abnormalities that can occur with breakers.

- (a) Loss of 250 V dc for Opening and Closing. A breaker is a latched device and requires separate signals for opening and closing. Any failure of these signals or the supply to these signals causes the breaker to be "SOLID" in the closed (or open) position. Because of this, the closing and tripping devices are made from high quality components and the electrical closing and tripping supplies are taken from the Class 1 250 V dc battery.
- (b) Loss of 48 V dc Logic Supplies. If there is a loss of the 48 V dc logic supply, the breaker will not be able to be controlled from the control room. However, it will be possible to electrically control the breaker from the controls located at the breaker.

- (c) Loss of Compressed Air Supplies. In the case of air blast and oil breakers having compressed air closing and tripping, there is the added complication that the air pressure must be kept at the specified pressure which is above the closing and tripping lockout pressures. Should the pressure fall below the lockout pressures, the breaker will be "SOLID" in the closed (or open) position.
- (d) Incorrect Current Ratings and Pallet Switch Arrangement. Air circuit breakers, made by a particular manufacturer, are made to fit into standard cubicles. However breakers which at first look similar, may have different current ratings, different pallet switch arrangements and in some instances different interlocking arrangements. Because of these differences, before interchanging breakers, a complete compatibility check is required.
- (e) Blocking Switches. Under certain operational, maintenance and test conditions, it is necessary to prevent inadvertent breaker closing and tripping. It may also be necessary to prevent operation of annunciators. Blocking switches are provided to enable sectionalizing to be done on closing, tripping and annunciator circuits. This prevents unwanted operation of these circuits.

NOTE: To ensure safe operation, before any blocking switch is operated, it is essential that the appropriate diagrams are consulted. Opening (or closing) the wrong blocking switch will render closing and tripping inoperative (operative) and severe damage may follow.

Blocking switch handles are colour coded, the code is listed on the following page:

- (i) Red: This is the standard blocking switch handle colour. When used in ganged formation they are used to isolate complete 250 V dc protection systems. When used individually, they are used to isolate sections of tripping and closing circuits.
- (ii) Orange: Auto reclosing blocking switches. Breakers on the 115 kV, 230 kV and 500 kV systems are equipped with a high speed automatic re-closure scheme. Opening the orange blocking switch will prevent the breaker from automatically being re-closed.
- (iii) Green: Master blocking switch. When this switch is opened it blocks all electrical tripping to the breaker. Circuits having double protection systems, ie, A and B, will have two green master blocking switches.
- (iv) Blue: Gas relay blocking switch. Transformers equipped with gas accumulation and oil surge relays have a blue blocking switch, which when opened prevents tripping from these relays.
- (v) White: Annunciator blocking switches. These blocking switches are opened to prevent unnecessary or undesirable operation of annunciators.

CAUTION: Blocking switches are alive at 250 V dc (or 48 V for annunciators) and are connected to closing, tripping and annunciator circuits. Great care must be observed when working with blocking switches. For example, shorting can blow fuses or cause incorrect operation of breakers and other equipment.

ASSIGNMENT

1. State the six essential features of a circuit controlled by a circuit breaker. (Section 3.1)

2. State the essential differences between a contactor control scheme and a circuit breaker control scheme. (Section 4.2)

3. Draw the power circuit for a circuit controlled by:
 - (a) an air breaker.
 - (b) an air blast or an oil breaker.(Section 4.1)

4. For the circuits shown in Figures 1 and 2, briefly explain the function and purpose of each component. (Section 4.1)

5. For the circuit shown in Figure 4 briefly explain the function and purpose of each of the 14 components. State the purpose of each of the following circuit breaker control features.
 - (a) anti pumping.
 - (b) trip lockout.
 - (c) indications.(Section 4.2)

6. State and briefly explain the consequences of three abnormalities associated with an:
 - (a) air blast circuit breaker.
 - (b) oil circuit breaker.(Section 4.2.4)

7. State three checks that must be done before air circuit breakers can be interchanged. (Section 4.2.4 (d))

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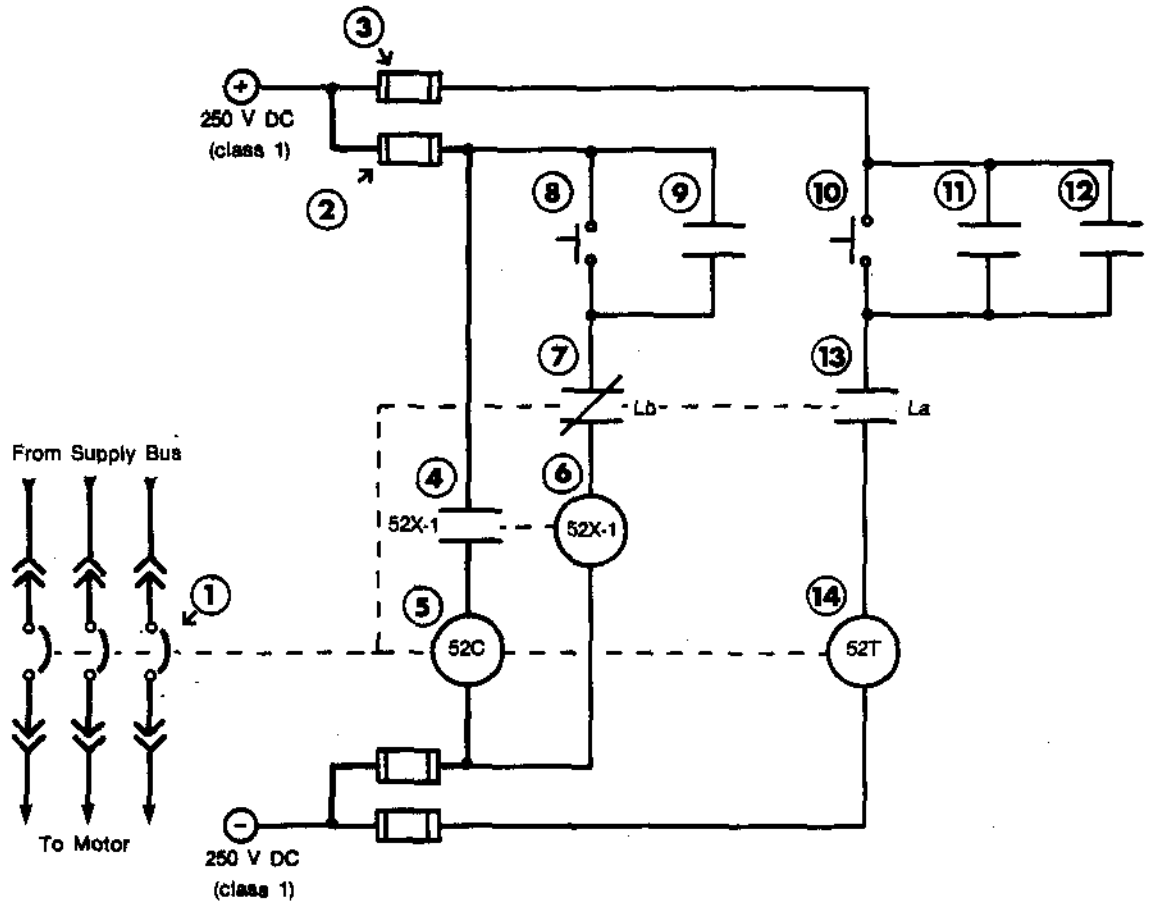


Figure 4: Breaker Control Circuit.