



# The X, Y, and Z of Circuit Breaker Control

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# Agenda

- Importance of Breaker Control
- The IEEE C37.11 Standard
- Breaker control circuit
  - 12 step program for breaker closing
  - Trip coil monitoring
  - Seal-in
  - Anti-pump
- Demonstrations

# The importance of breaker control

- Mechanical forces
  - Acceleration-Travel-Deceleration
  - Very fast from one closed to open, or open to closed (e.g. 3 cycles = 0.050 seconds)
- Electrical forces
  - Magnetic forces from fault currents (e.g. 40,000 Amps)



# The importance of breaker control



# The importance of breaker control



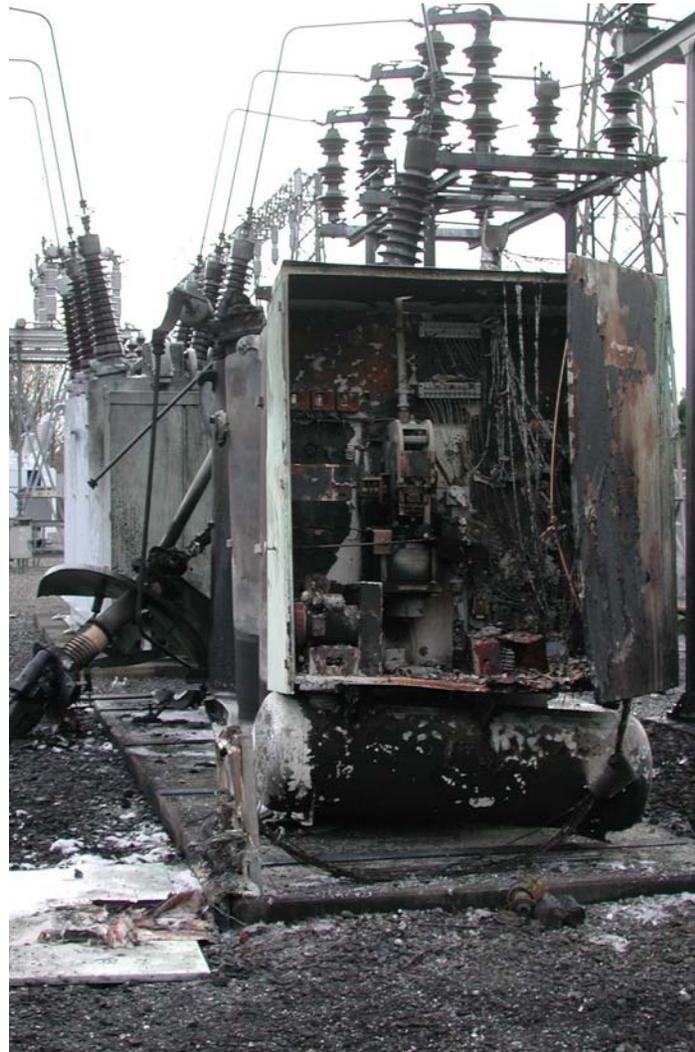
# The importance of breaker control



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# The importance of breaker control





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# IEEE C37.11

# IEEE C37.11

*IEEE Standard Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis*

## Contains 5 Sections

1. Overview
2. References
3. Functional Requirements
4. Devices and Auxiliaries
5. Wiring Requirements



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# IEEE C37.11

## Section 5:

# Wiring Requirements

# C37.11 Part 5: Wiring Requirements

**Table 1— Circuit breaker intended for use in metal-clad switchgear**

Closing power	Closing control	Tripping control	Figure
dc	dc	dc	1
ac	ac	dc	2
ac	ac	Capacitor trip	3
ac	dc	dc	4

**Table 2— Circuit breaker not intended for use in metal-clad switchgear**

Closing power	Closing control	Tripping control	Figure
dc	dc	dc	5
ac	ac/dc	dc	6
ac	ac	Capacitor trip	7
Pneumatic/hydraulic	dc	dc	8

# Section 5: Wiring Requirements

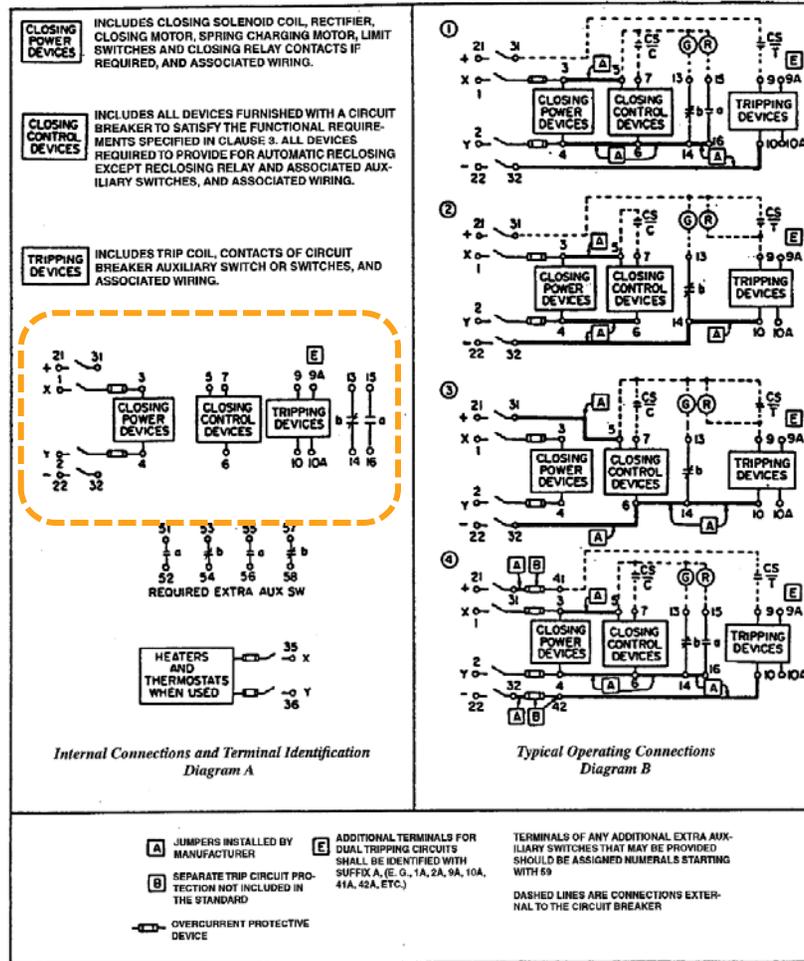
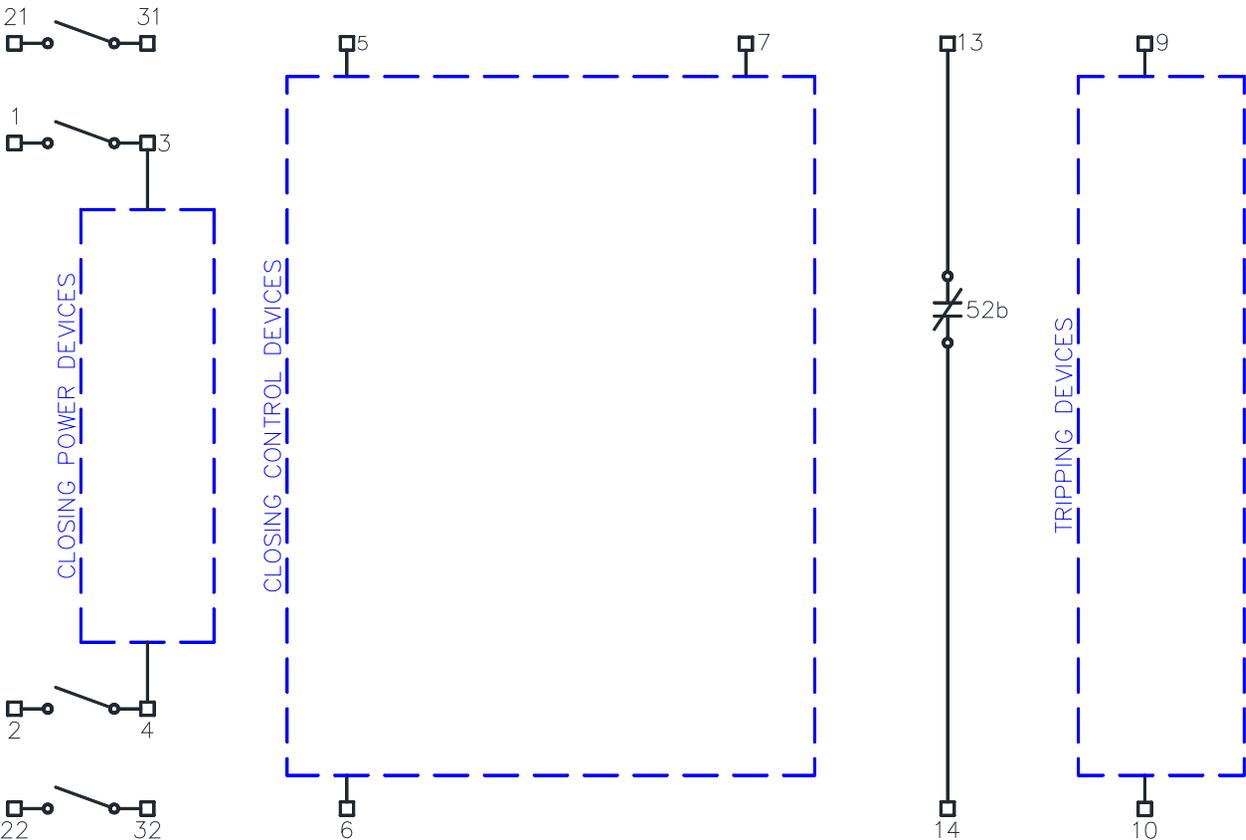


Figure 6— Circuit breaker NOT intended for use in metal-clad switchgear, where the closing power is ac; the closing control is ac or dc; the tripping control is dc

# Section 5: Wiring Requirements



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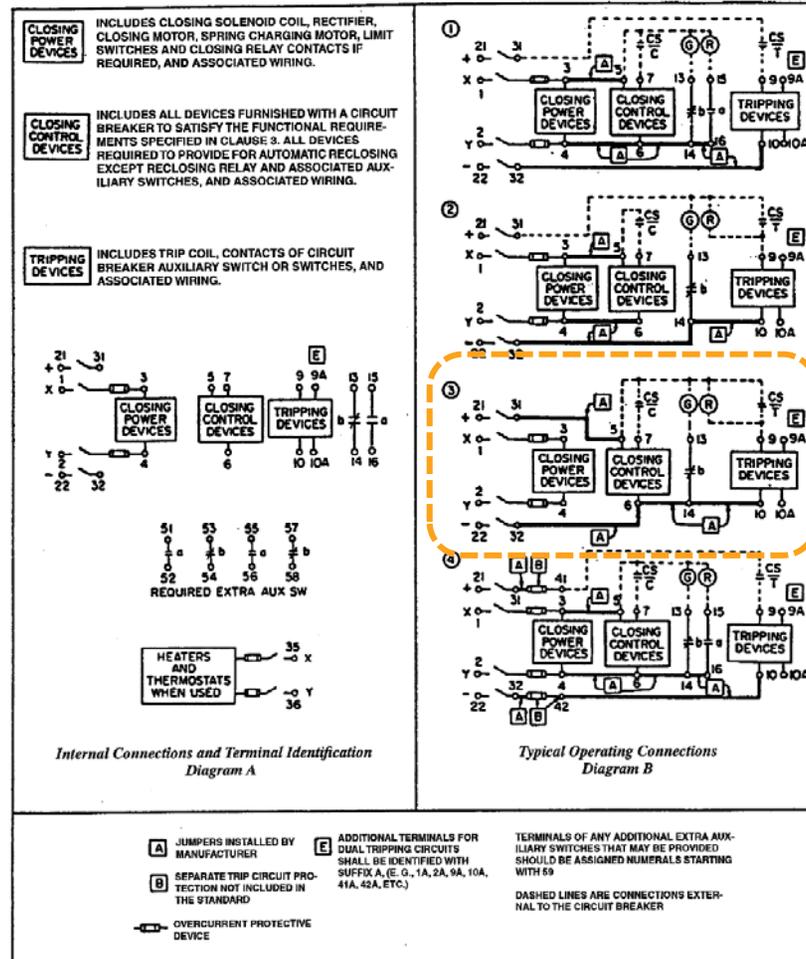
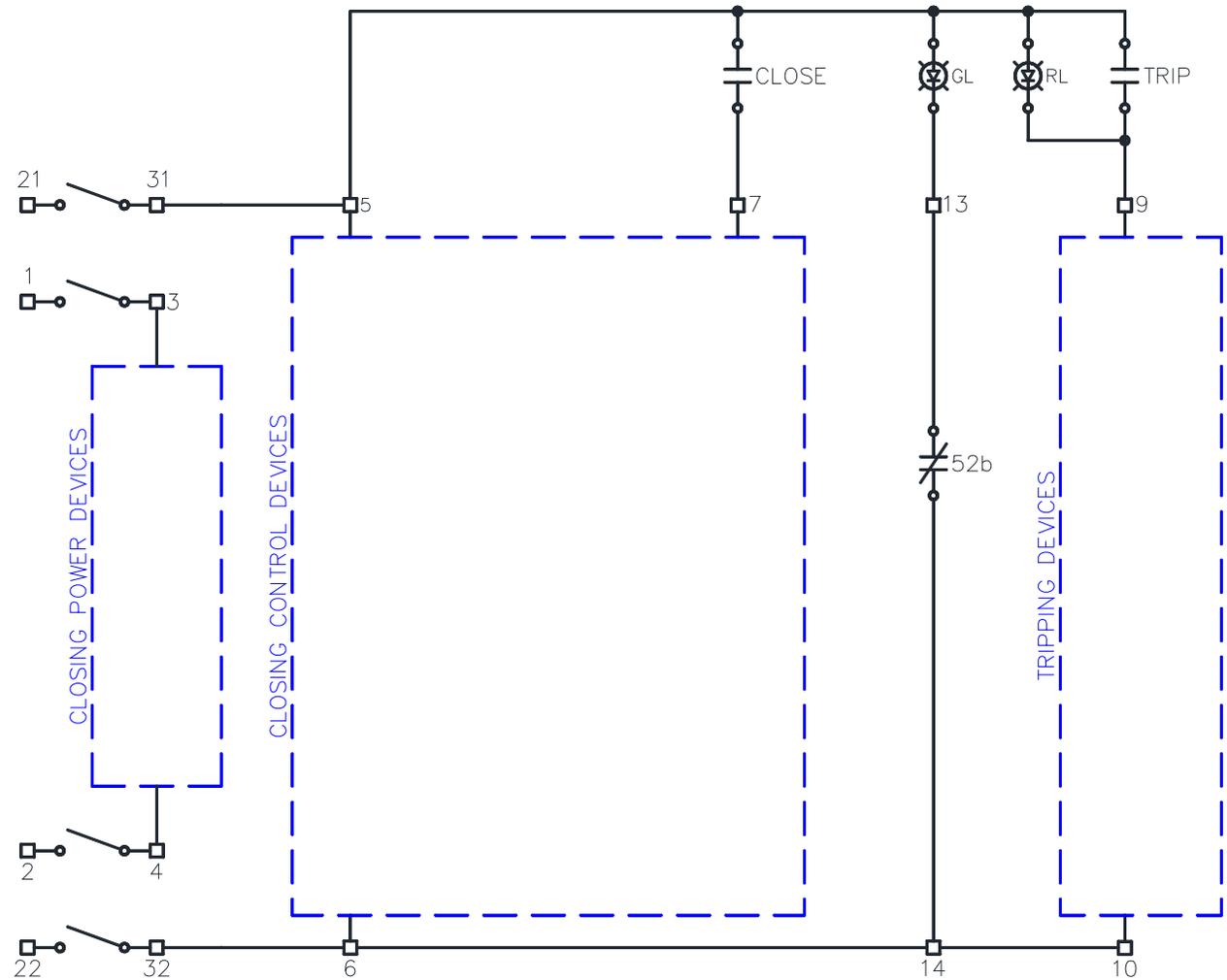
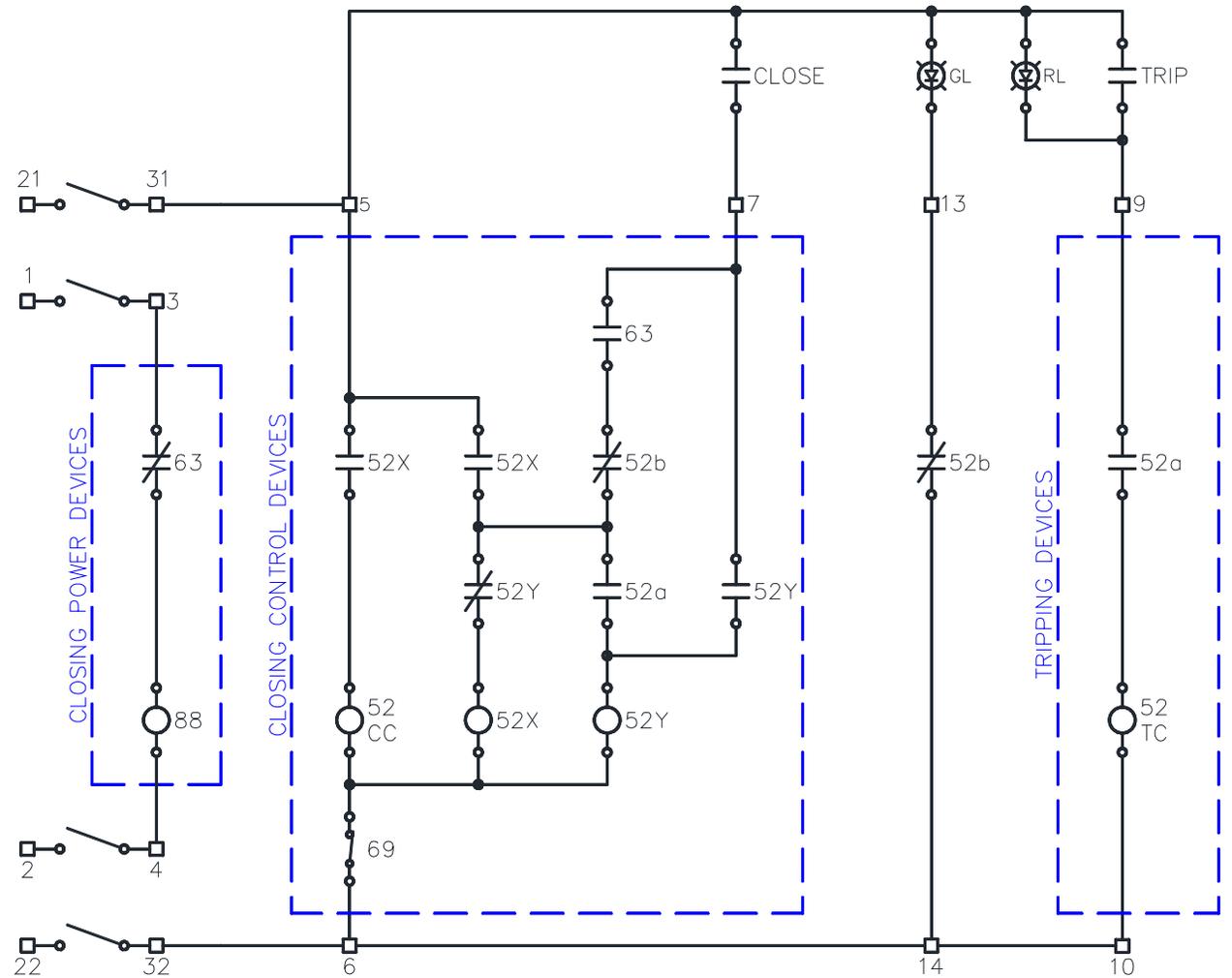


Figure 6— Circuit breaker NOT intended for use in metal-clad switchgear, where the closing power is ac; the closing control is ac or dc; the tripping control is dc

# Section 5: Wiring Requirements



# Circuit Breaker Controls



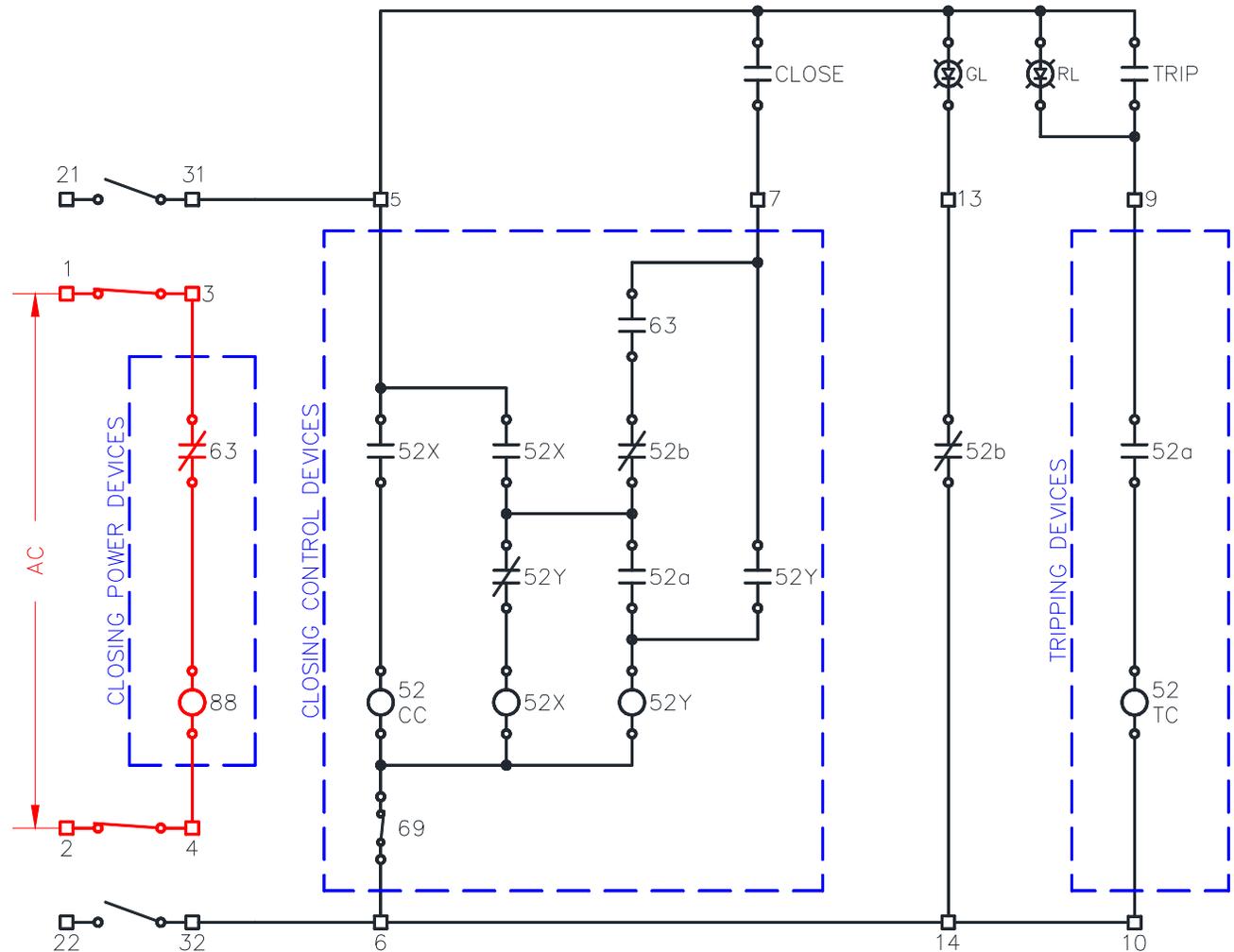


# The 12 Step Program for Successful Breaker Closing



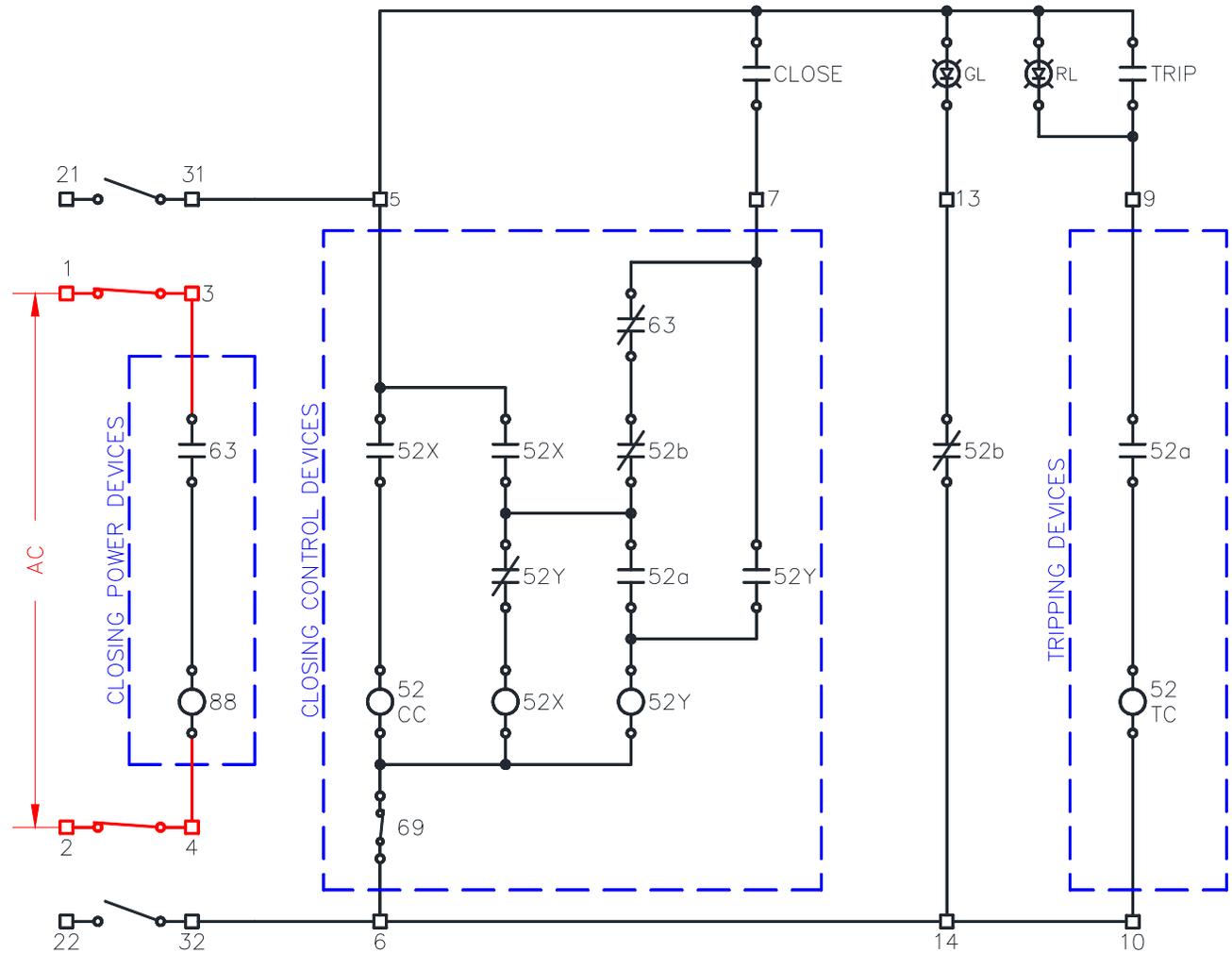
## 2. Apply Closing Power

- Motor (88) runs to charge mechanism



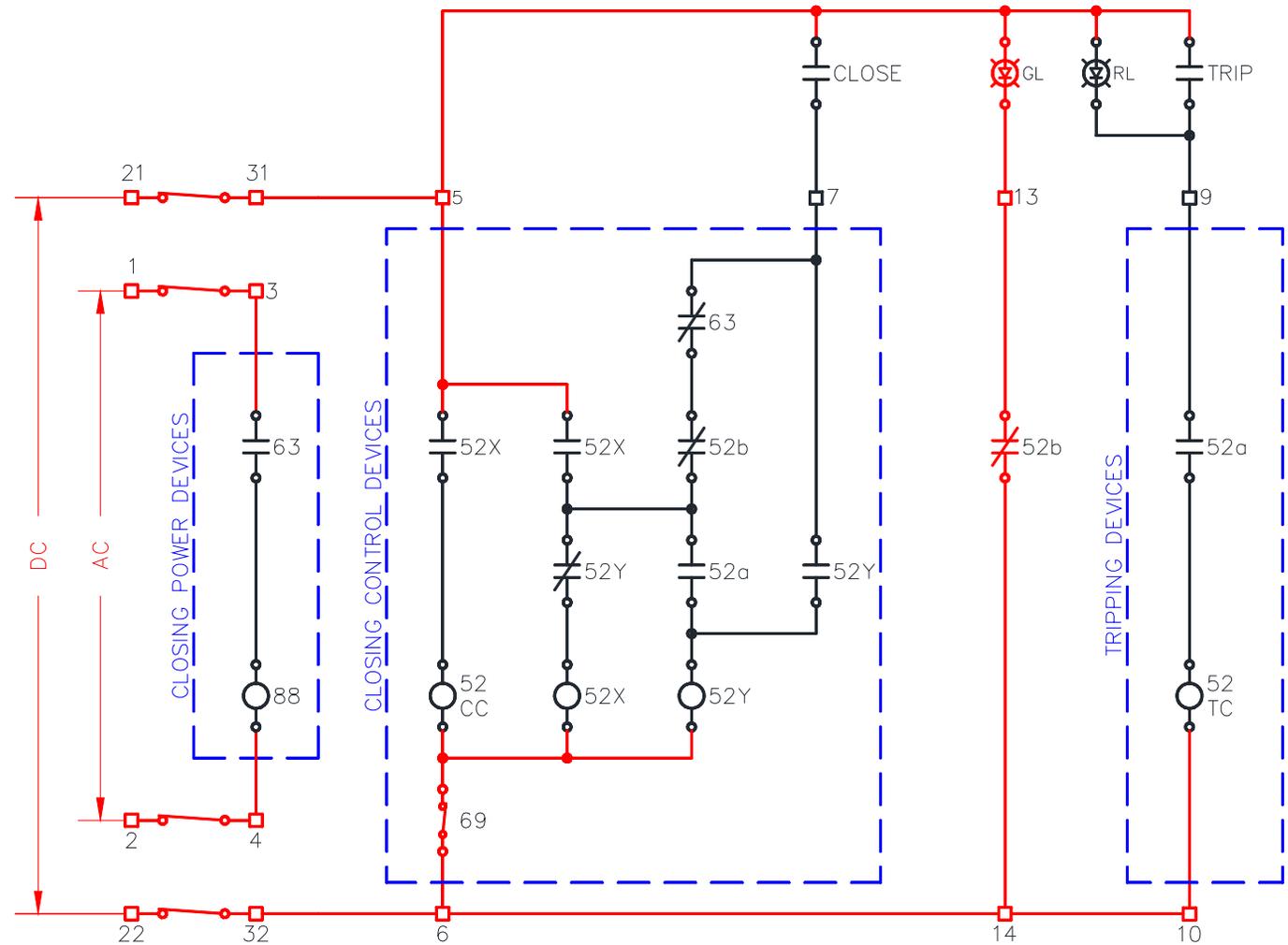
# 3. Mechanism charged

- All 63 contacts change state
- Motor stops running



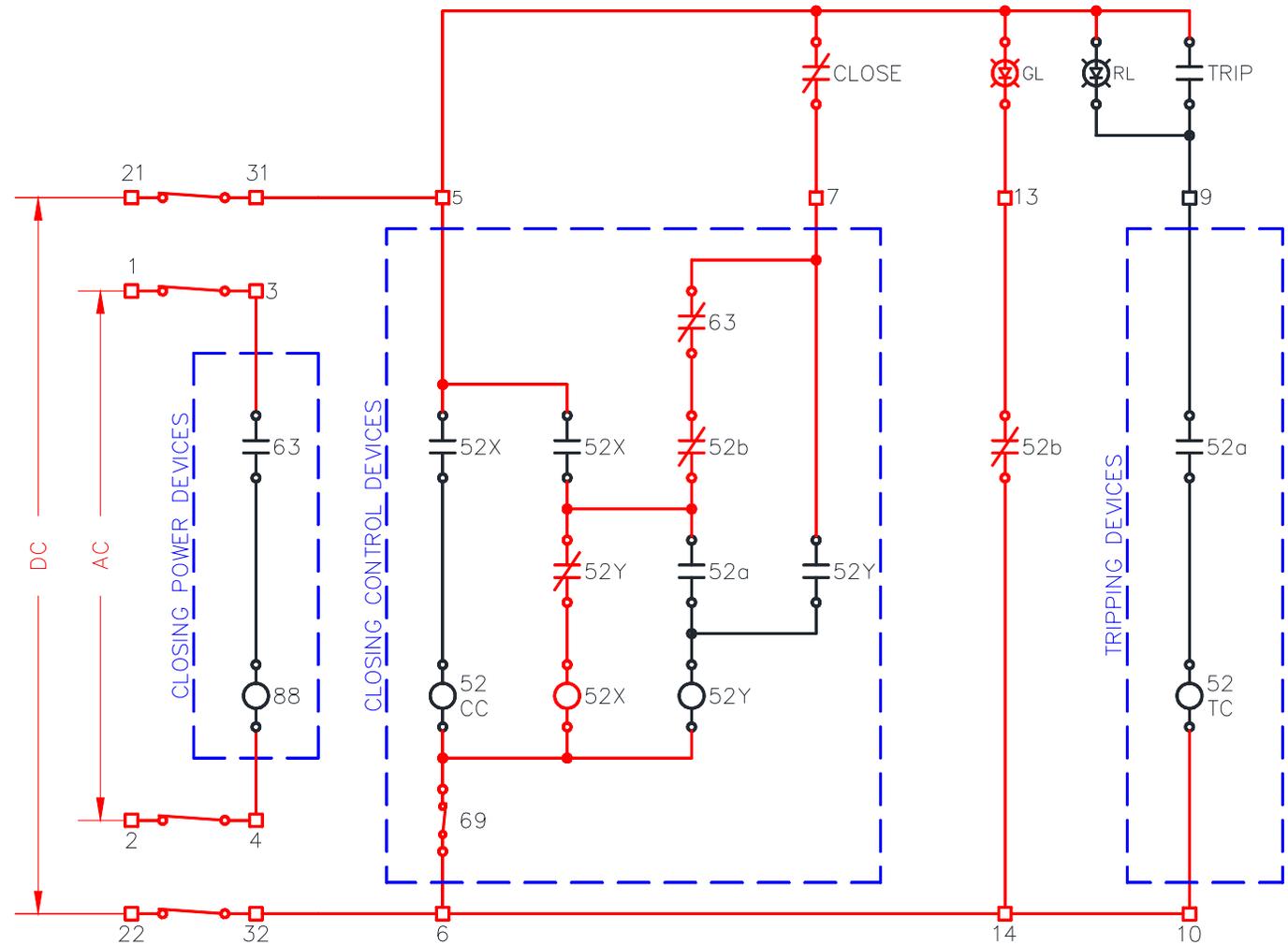
# 4. Apply Control Power

- Breaker is still open
- Green light is on



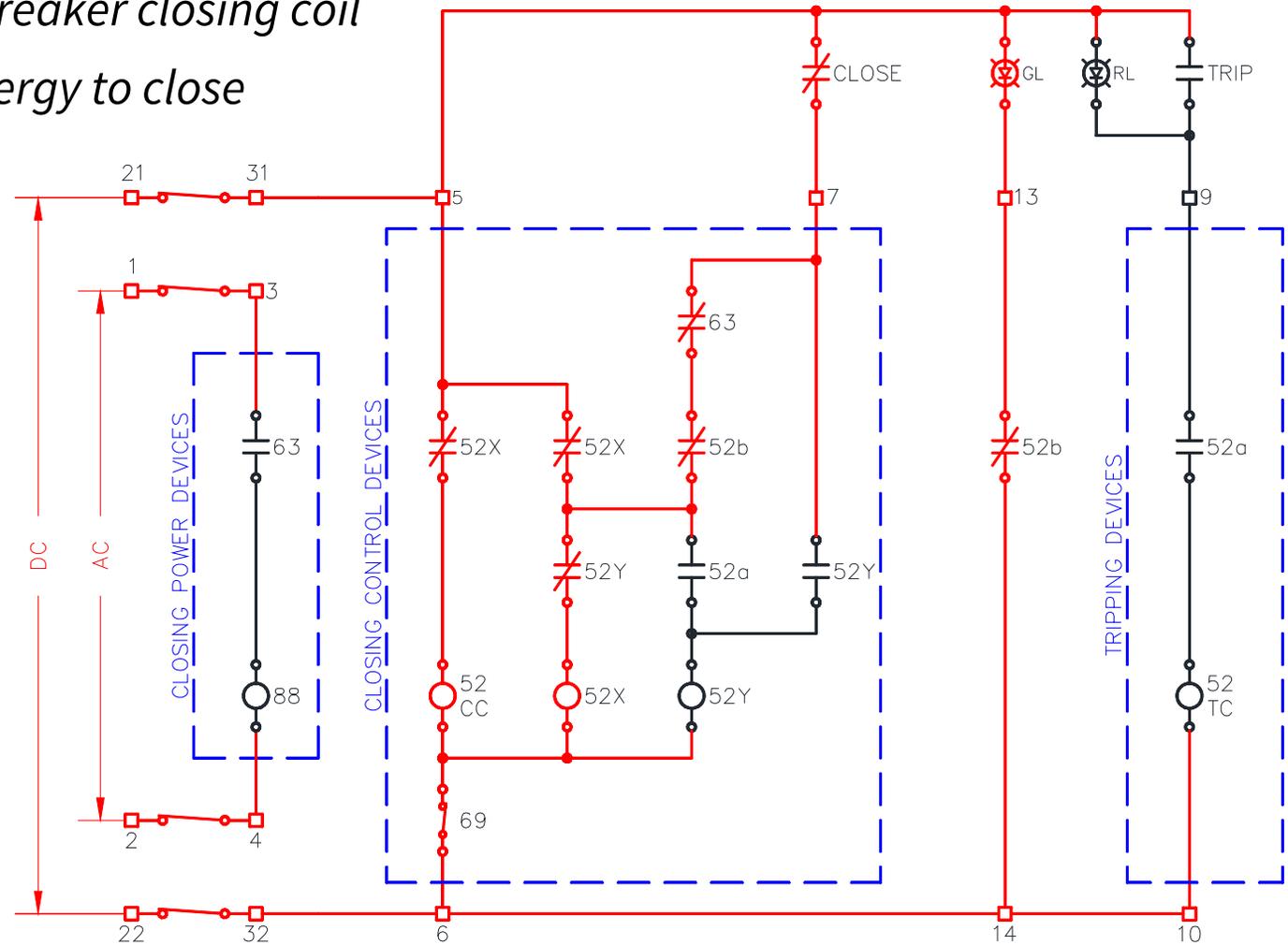
# 5. Close Command

- Energizes 52X relay



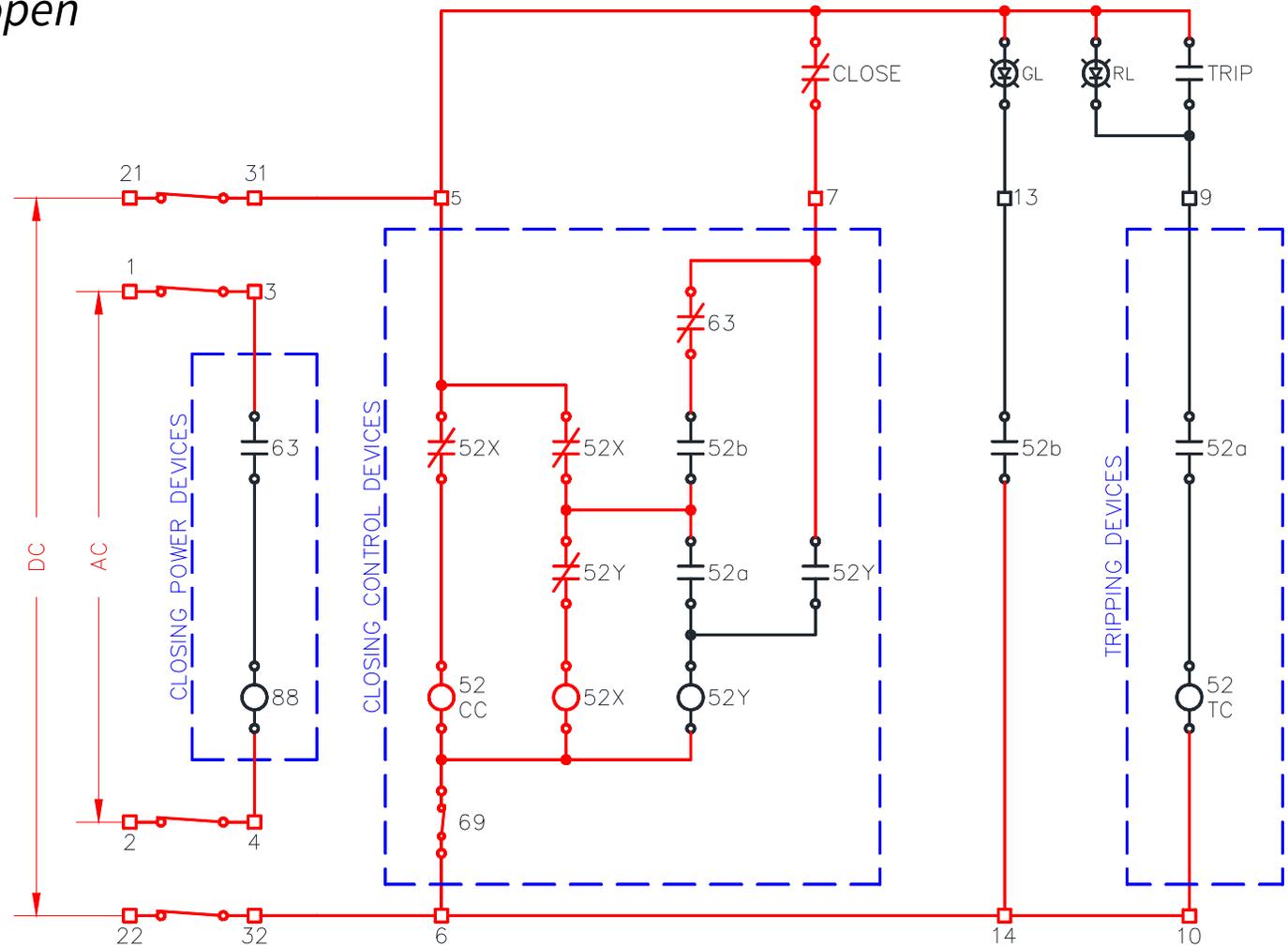
# 6. 52X Relay Operates

- All 52X contacts change state
- Energizes 52CC breaker closing coil
- 52CC releases energy to close the breaker



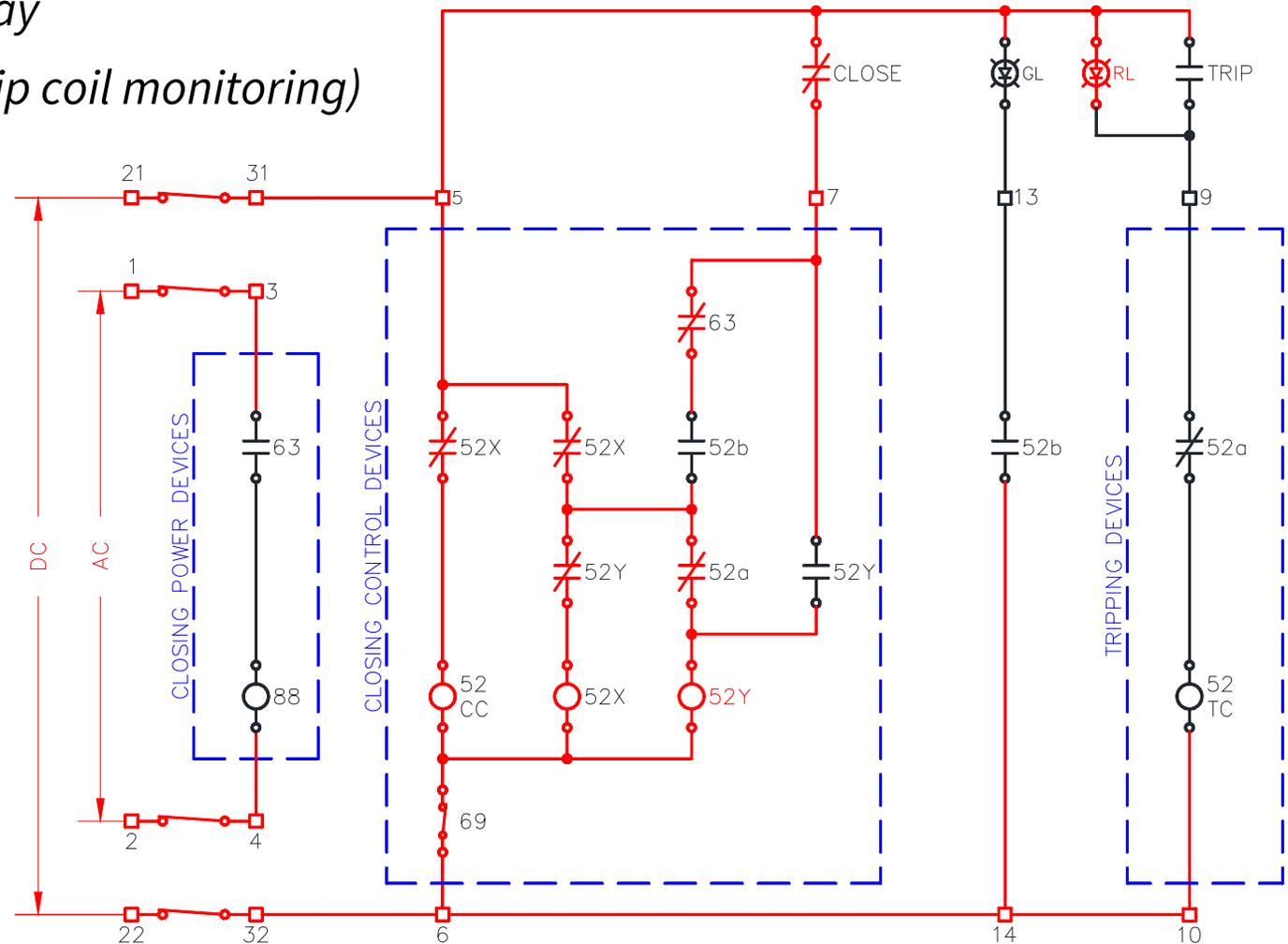
# 7. Breaker Closing

- Breaker begins to close
- All 52b contacts open



# 8. Breaker Closed

- All 52a contacts close
- Energizes 52Y relay
- Red light is on (trip coil monitoring)



# Sidebar: Trip Coil Monitoring

- Q: *Why does this circuit not trip the breaker?  
It is a complete circuit.*
- A: *Circuit is a voltage divider (two impedances in series), and the Red Light is a much larger impedance than the Trip Coil.*
- Example: *48 Vdc control circuit  
Red Lamp = 1200 ohms; Trip Coil = 3 ohms*

*Voltage across the Red Light =  $48 \times 1200 / (1200+3) = 47.88 \text{ V}$*

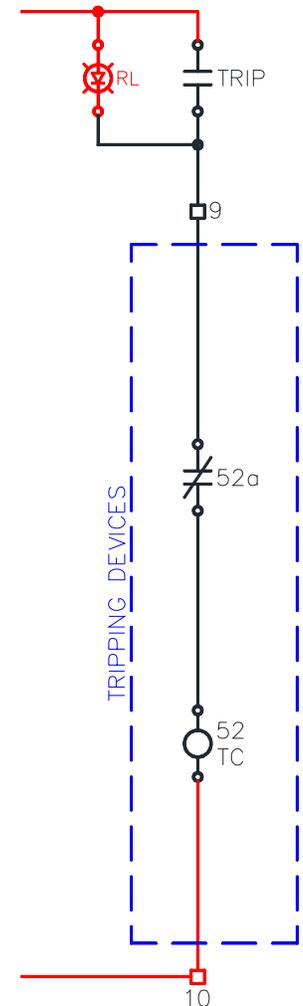
*Voltage across the Trip Coil =  $48 \times 3 / (1200+3) = 0.12 \text{ V}$*

*Power absorbed by the Red Light =  $47.88^2 / 1200 = 1.9 \text{ Watts}$*

*Power absorbed by the Trip Coil =  $0.12^2 / 3 = 0.005 \text{ Watts}$*

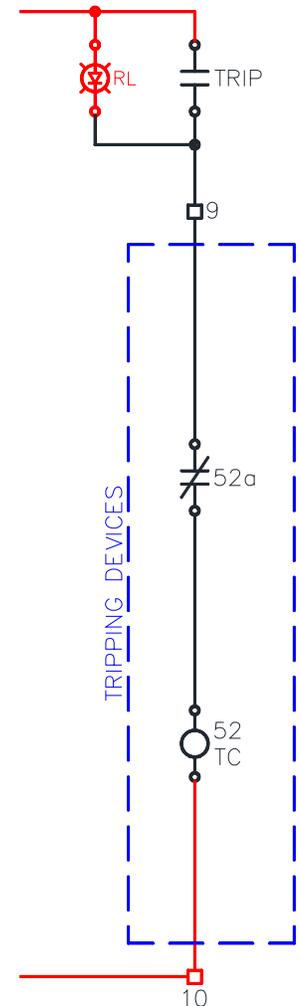
*Current in the circuit =  $48 / (1200+3) = 0.040 \text{ A}$*

*Current through the trip coil during a trip =  $48 / 3 = 16 \text{ A}$*



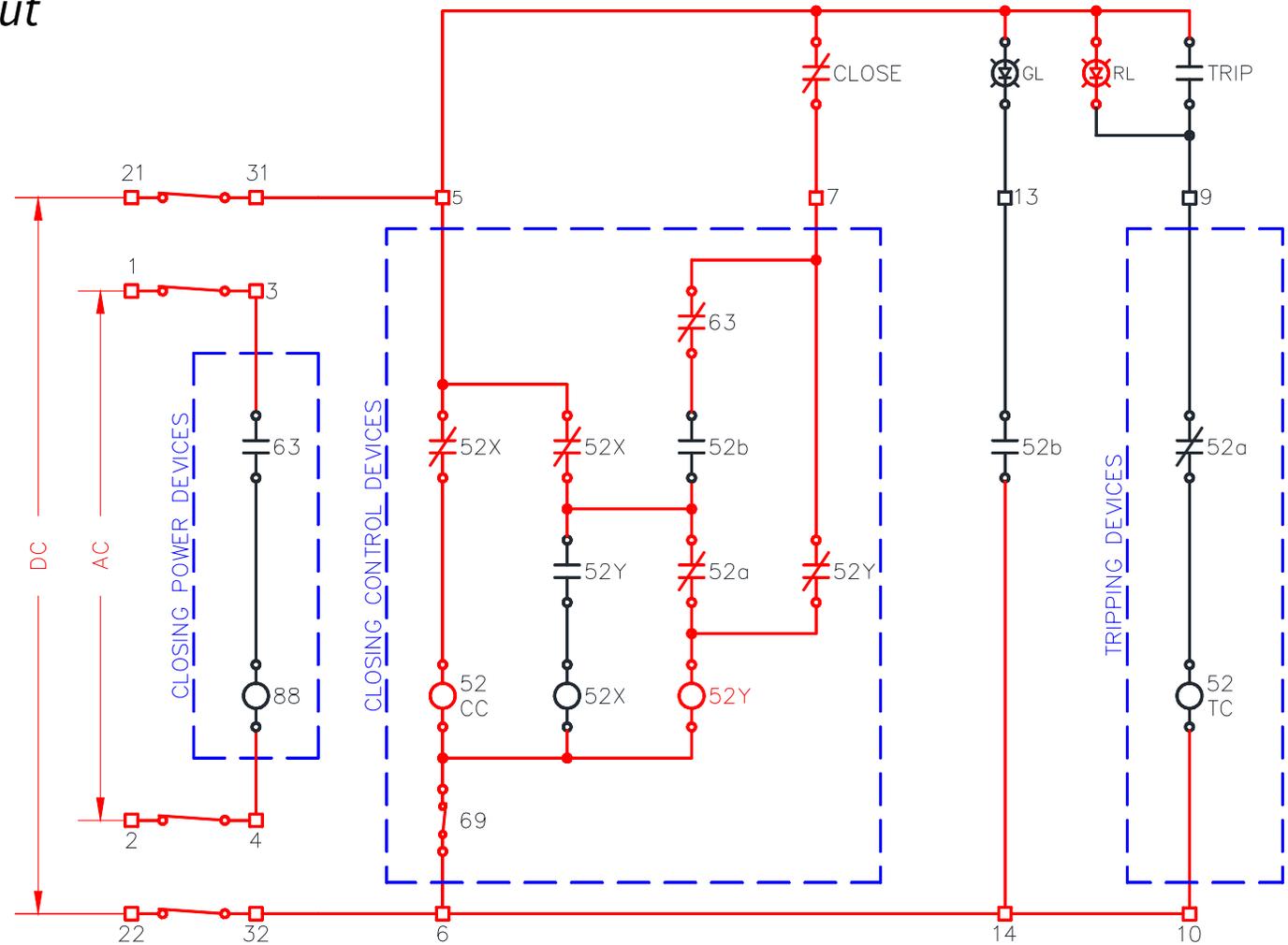
# Sidebar: Trip Coil and 52a Contact

- Q: *Why does the trip coil always have a 52a contact in series with it?*
- A: *3 Reasons:*
  1. *Block energizing the coil when the breaker is already open.*
  2. *Trip coil passes a lot of current (e.g. 16 Amps in the previous example; often more). 52a is a heavy-duty contact that is rated to interrupt that current so that the tripping devices (relays) do not have to.*
  3. *Trip coil is not rated for continuous current. It needs to be de-energized as soon as possible after it has done its job to trip the breaker.*
- Q: *Why use a coil that isn't rated for continuous use?*
- A: *Speed.*
- *And... Because we are intentionally over-dutying the trip coil, trip coil monitoring is critically important.*



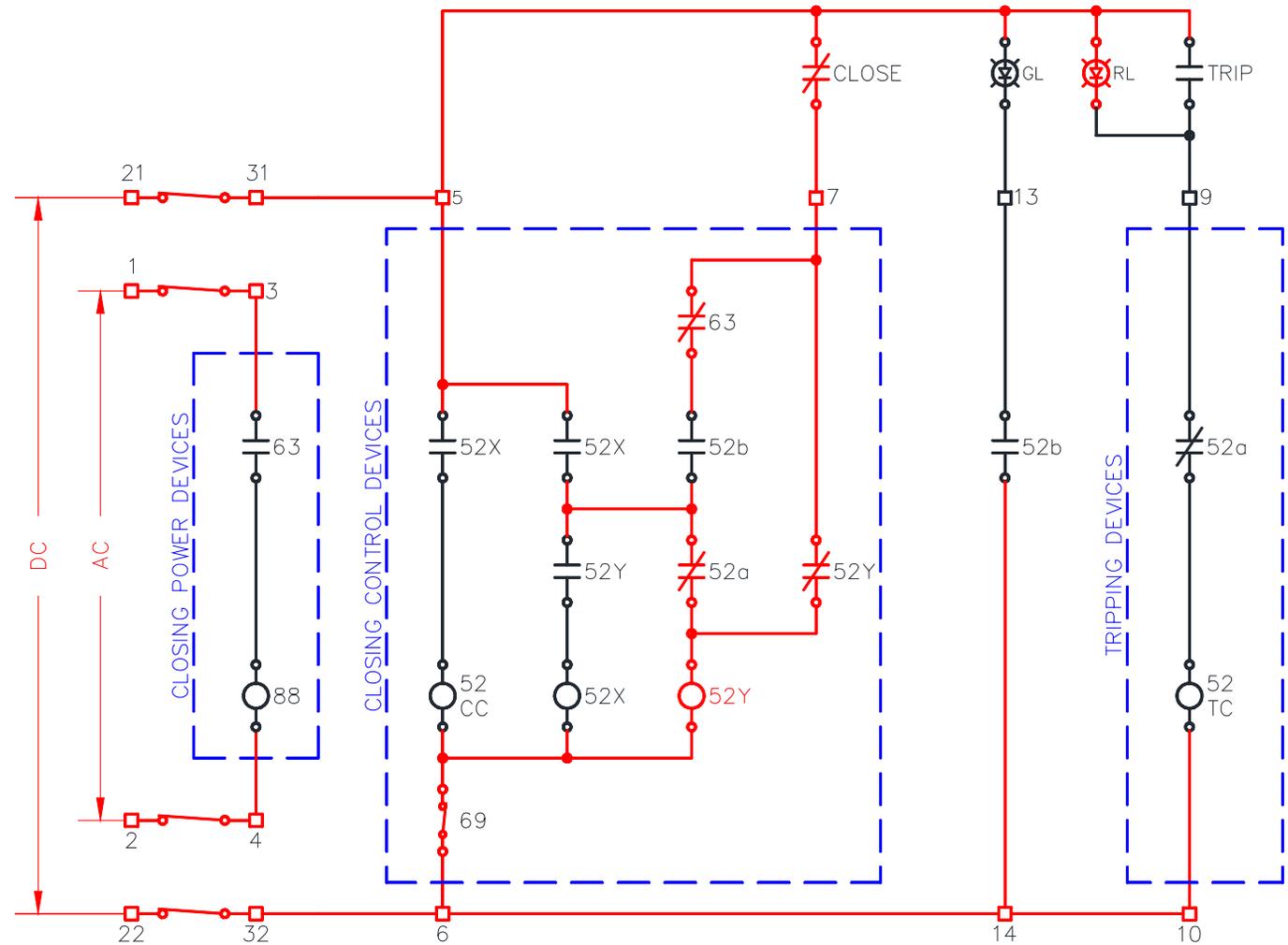
# 9. 52Y Relay Operates

- All 52Y contacts change state
- 52X relay drops out



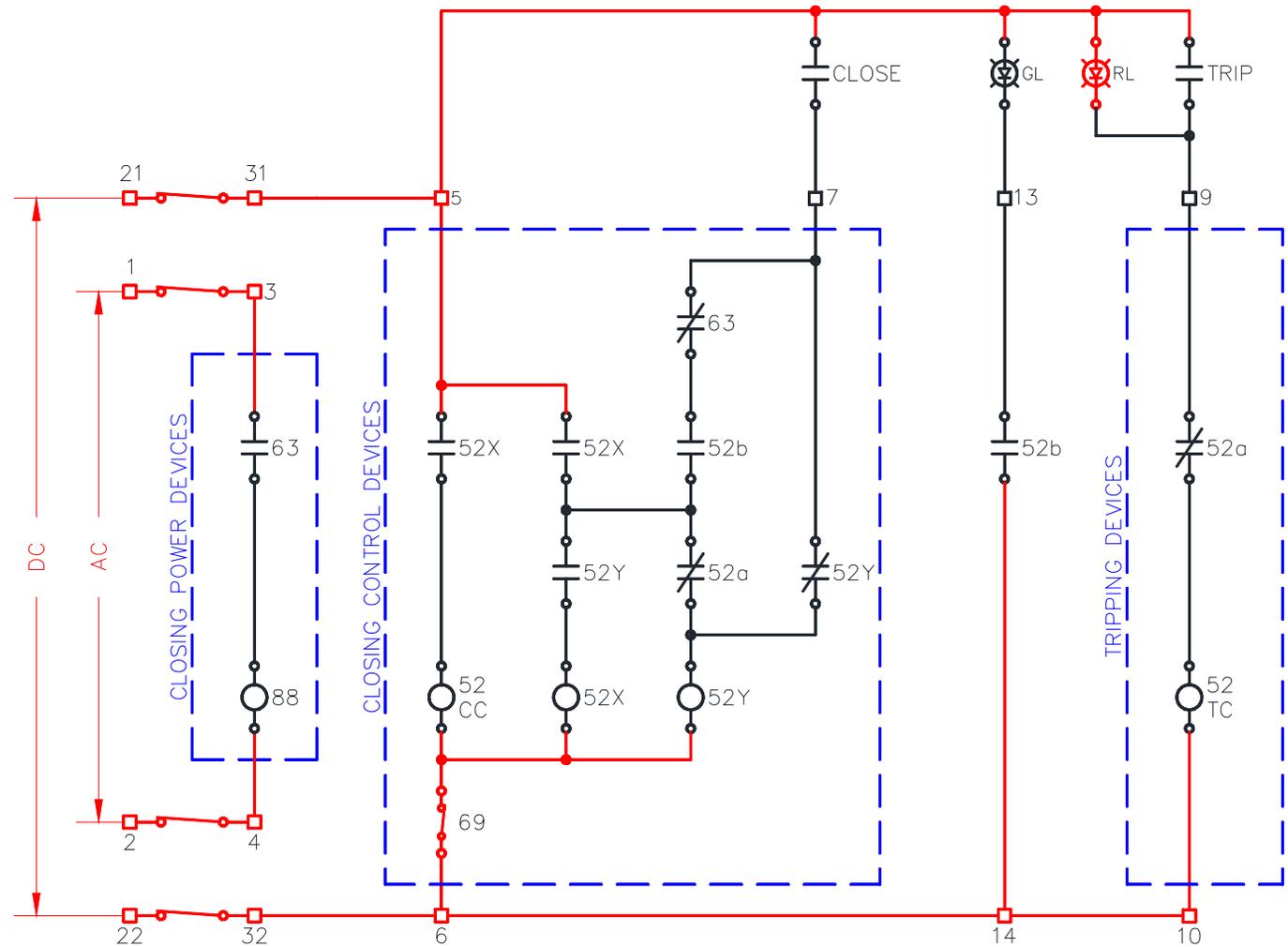
# 10. 52X Relay Resets

- All 52X contacts change state back to normal
- 52CC drops out



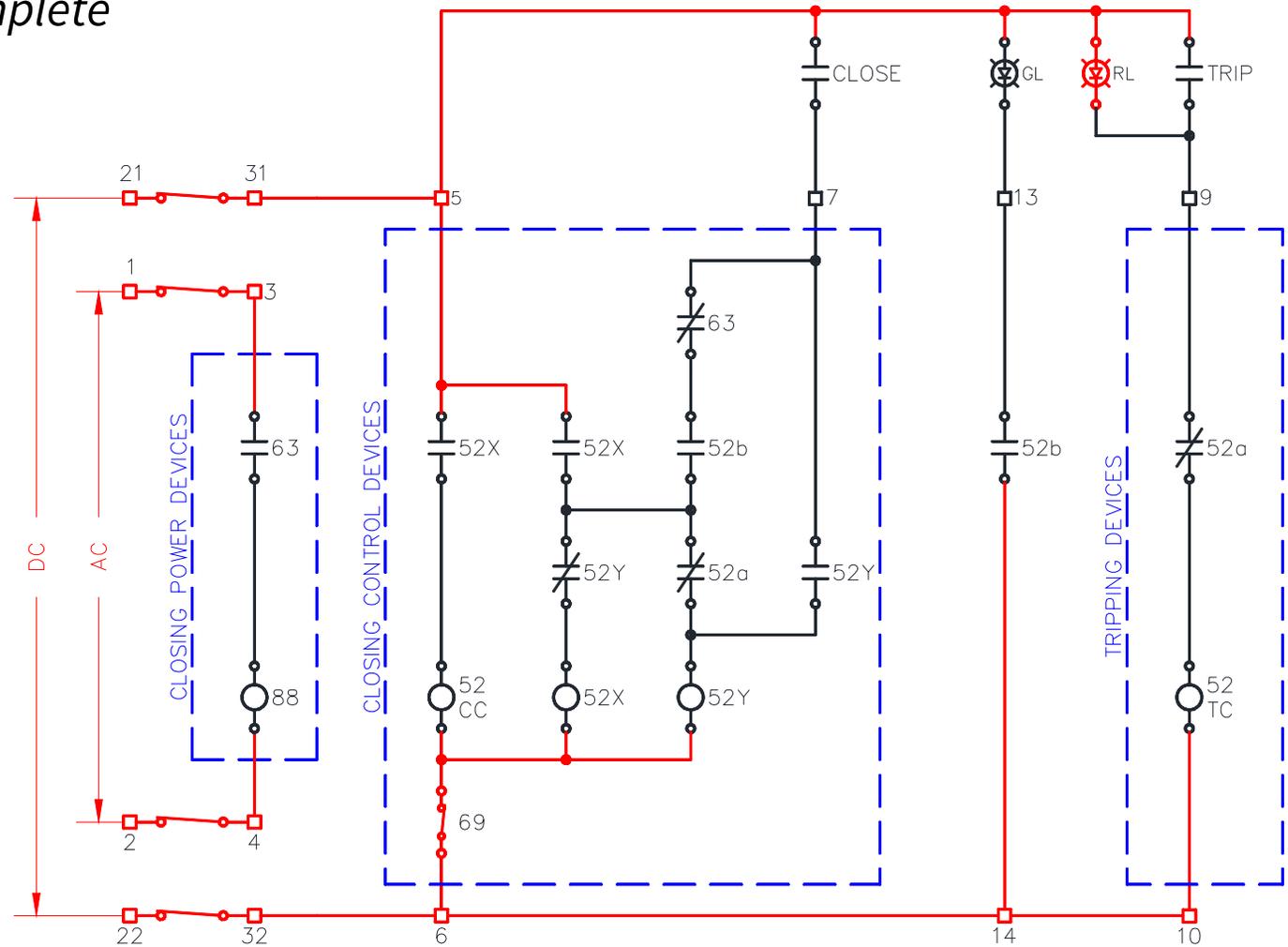
# 11. Close Command is Released

- 52Y relay drops out



# 12. 52Y Relay Resets

- All 52Y contacts change state back to normal
- Closing cycle complete

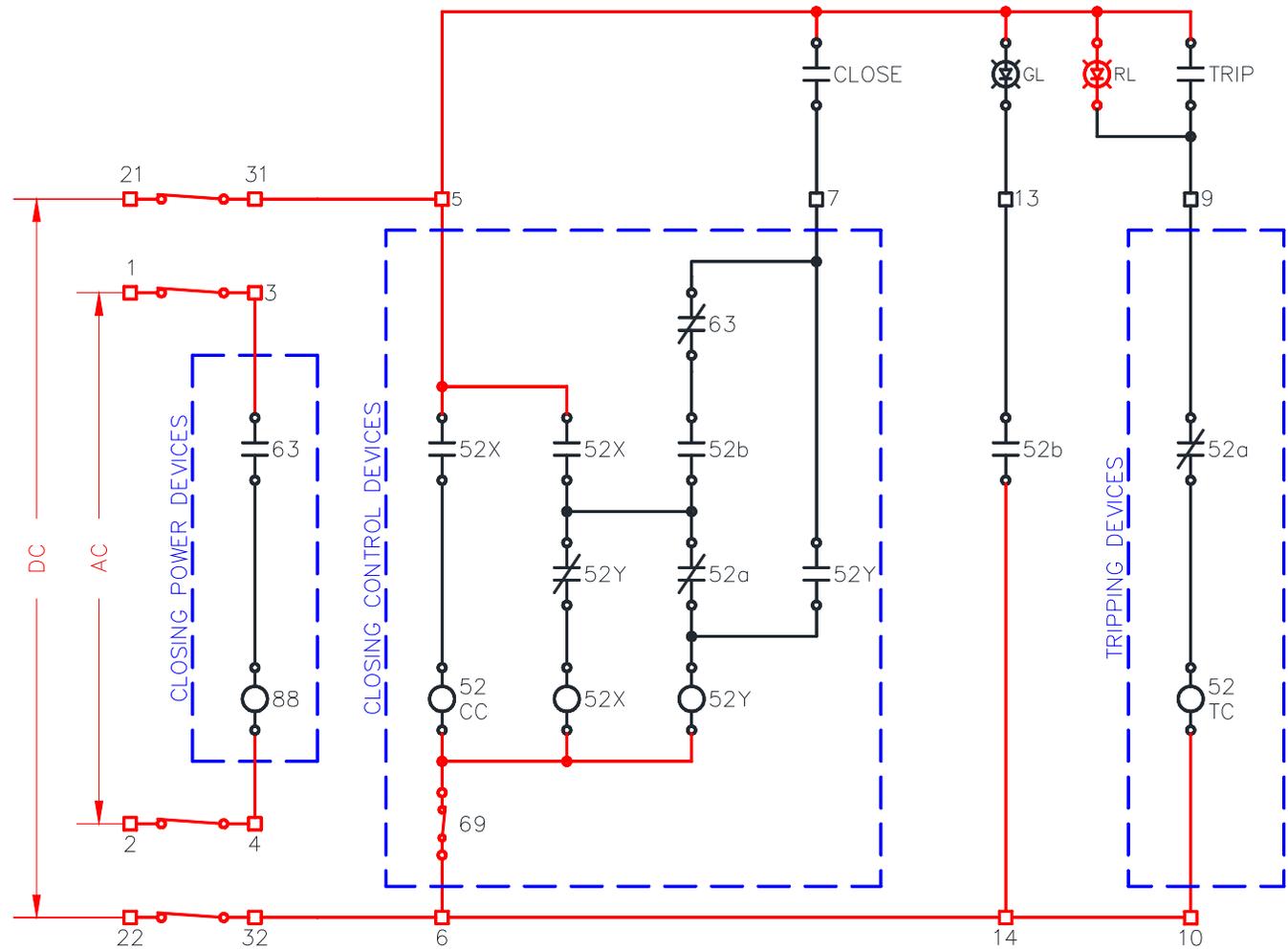




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# Breaker Tripping

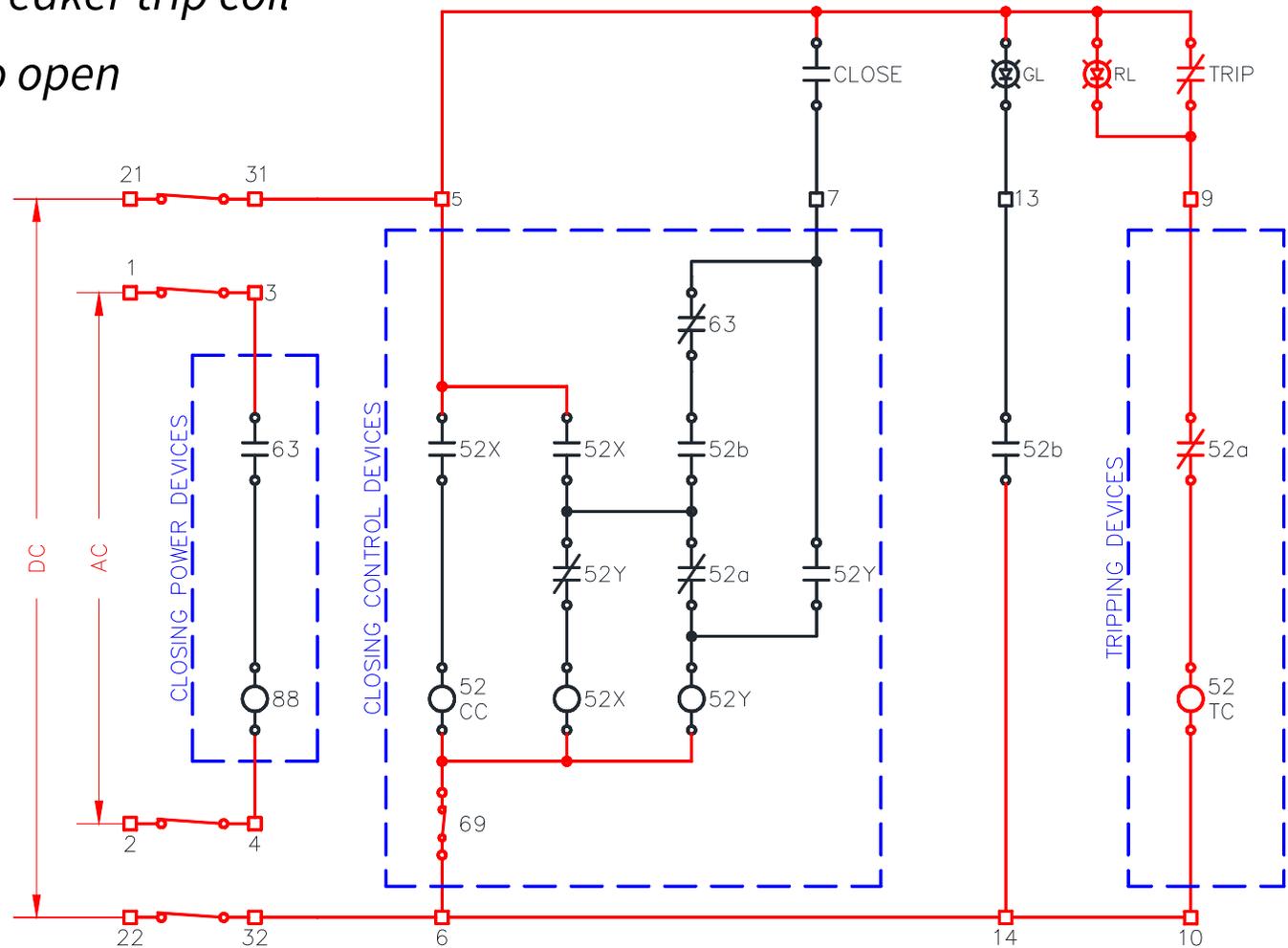
# Breaker Trip





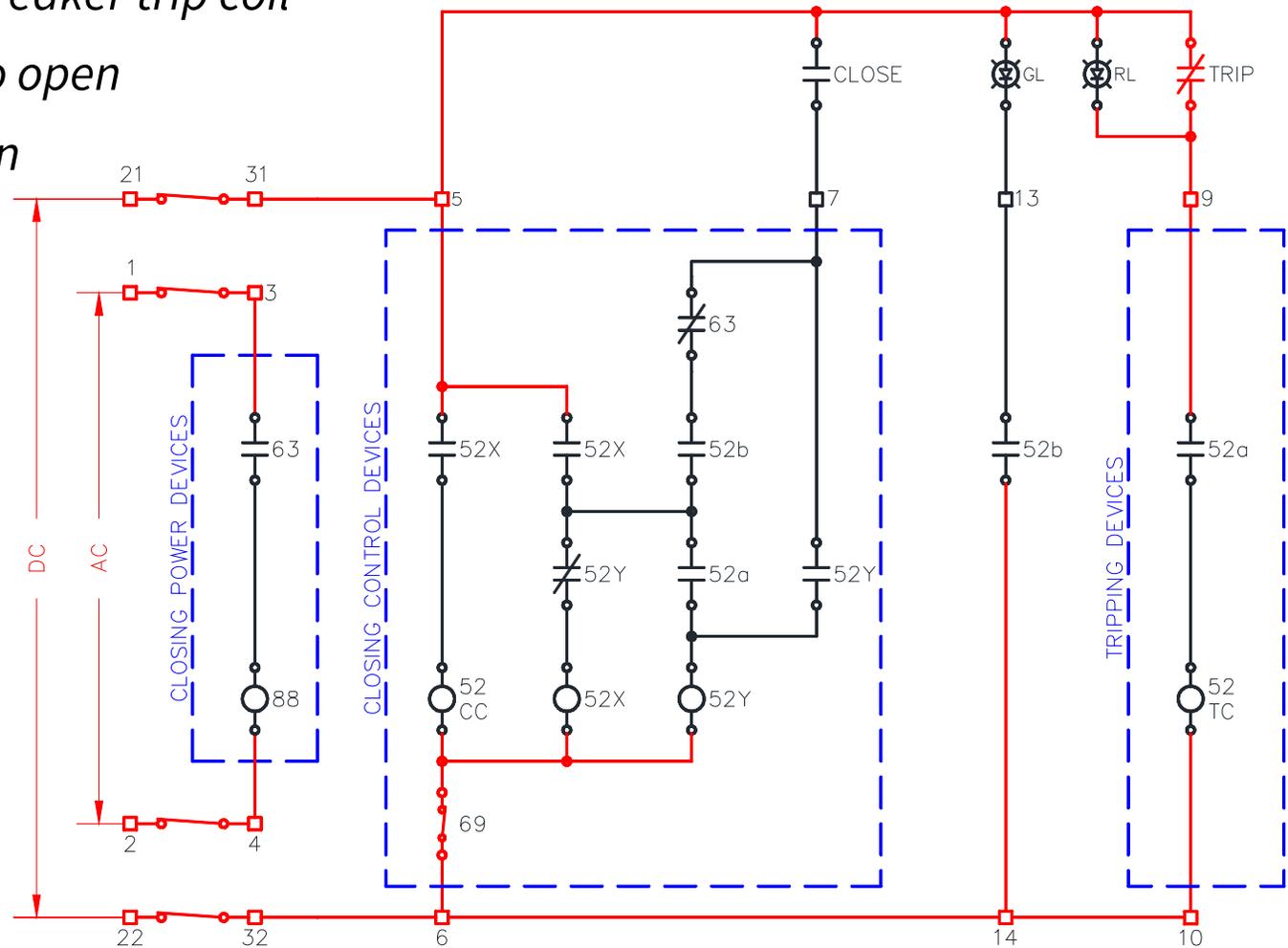
# Breaker Trip

- Trip command
- Energizes 52TC breaker trip coil
- Breaker begins to open



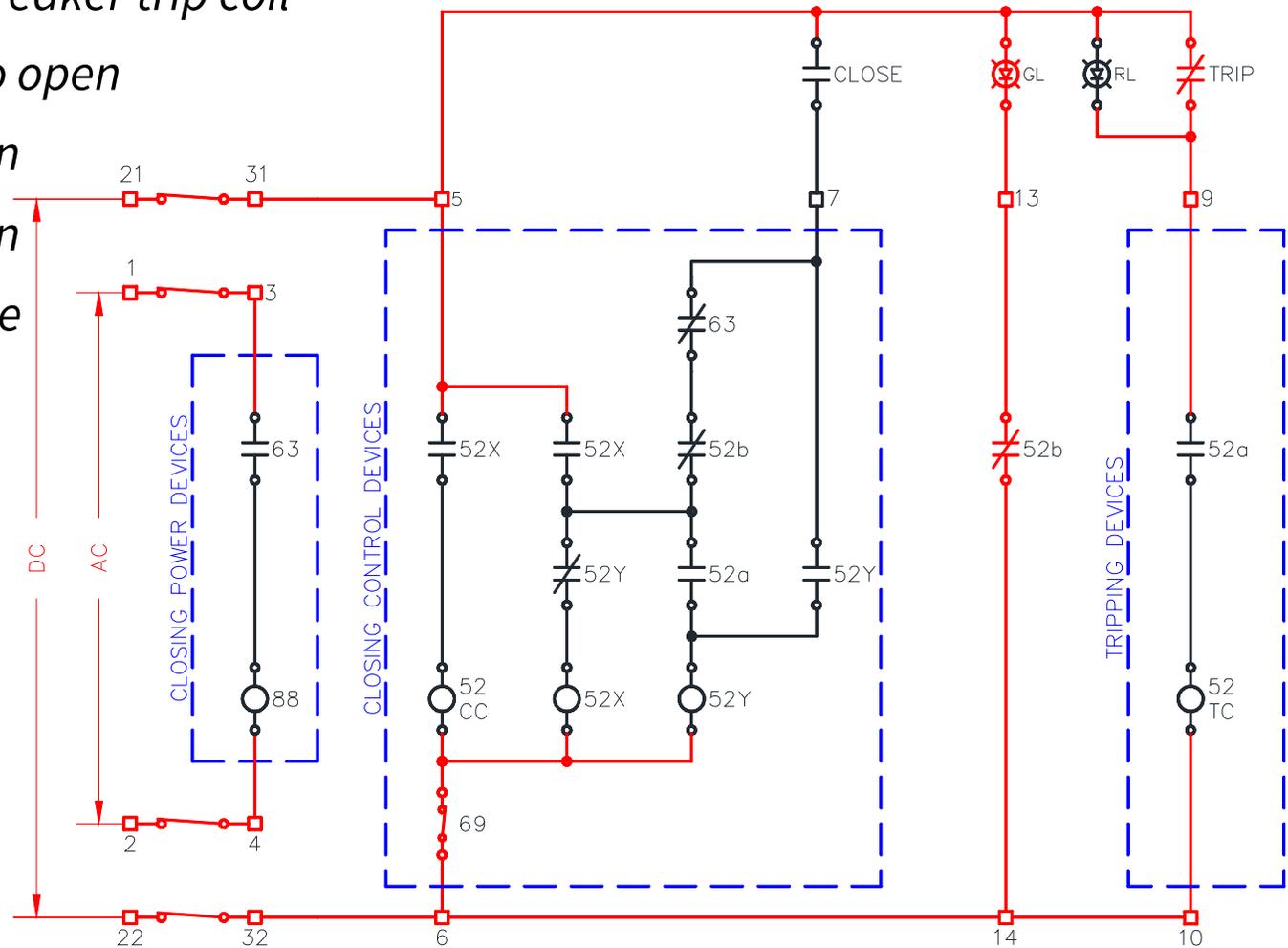
# Breaker Trip

- Trip command
- Energizes 52TC breaker trip coil
- Breaker begins to open
- 52a contacts open



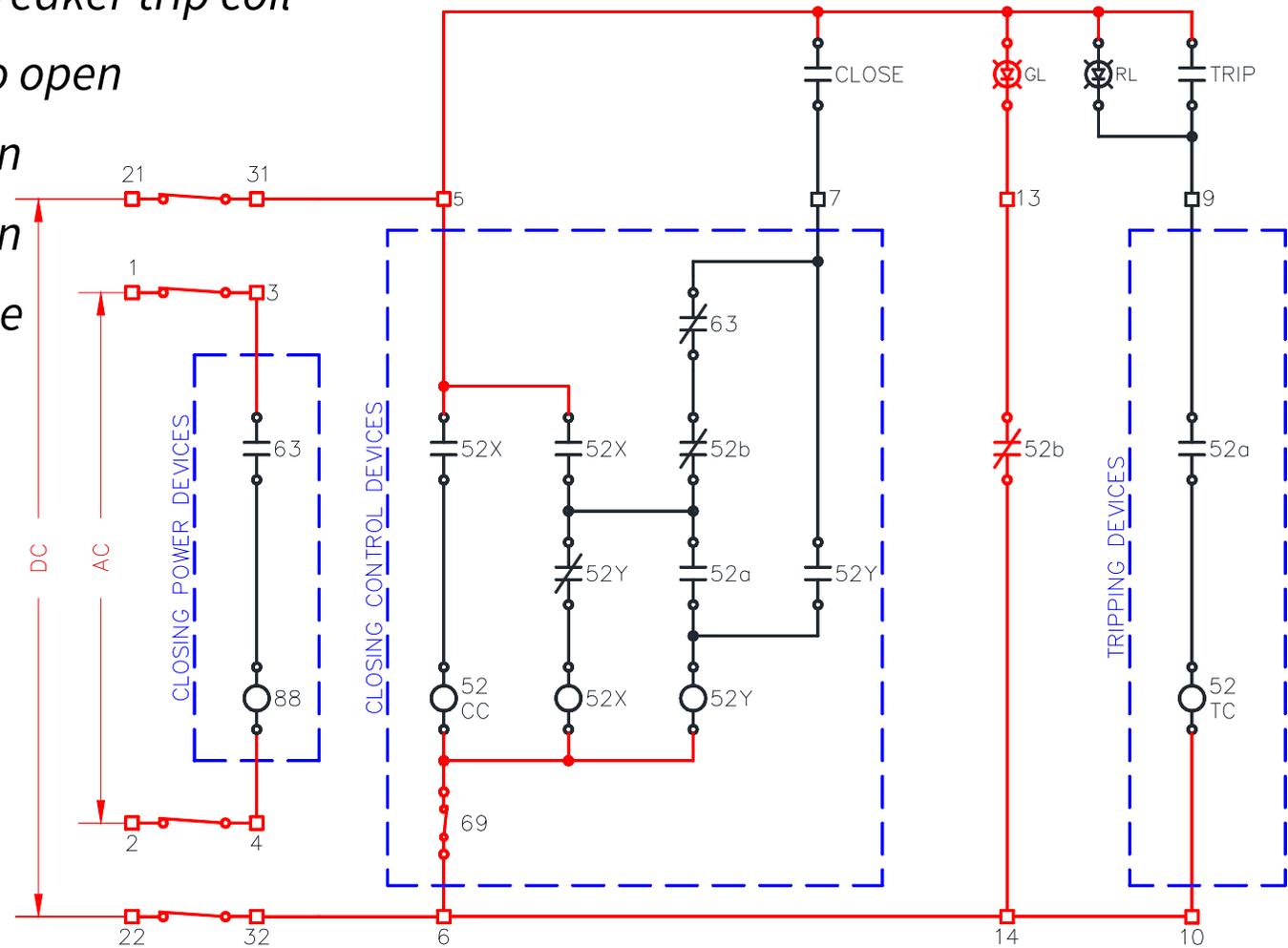
# Breaker Trip

- Trip command
- Energizes 52TC breaker trip coil
- Breaker begins to open
- 52a contacts open
- Breaker fully open
- 52b contacts close



# Breaker Trip

- Trip command
- Energizes 52TC breaker trip coil
- Breaker begins to open
- 52a contacts open
- Breaker fully open
- 52b contacts close
- Trip command is released





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## Section 3:

# Functional Requirements

# C37.11 Part 3: Functional Requirements

- 3a) Seal-in for close
- 3b) Anti-pump
- 3c) Reset after an incomplete close
- 3d) No close operation if already closed
- 3e) Block close for low stored energy
- 3f) Low gas block trip and close
- 3g) Low gas alarm
- 3h) Block close if tripped free
- 3i) Pressure nuisance alarms
- 3j) Pole disagreement tripping

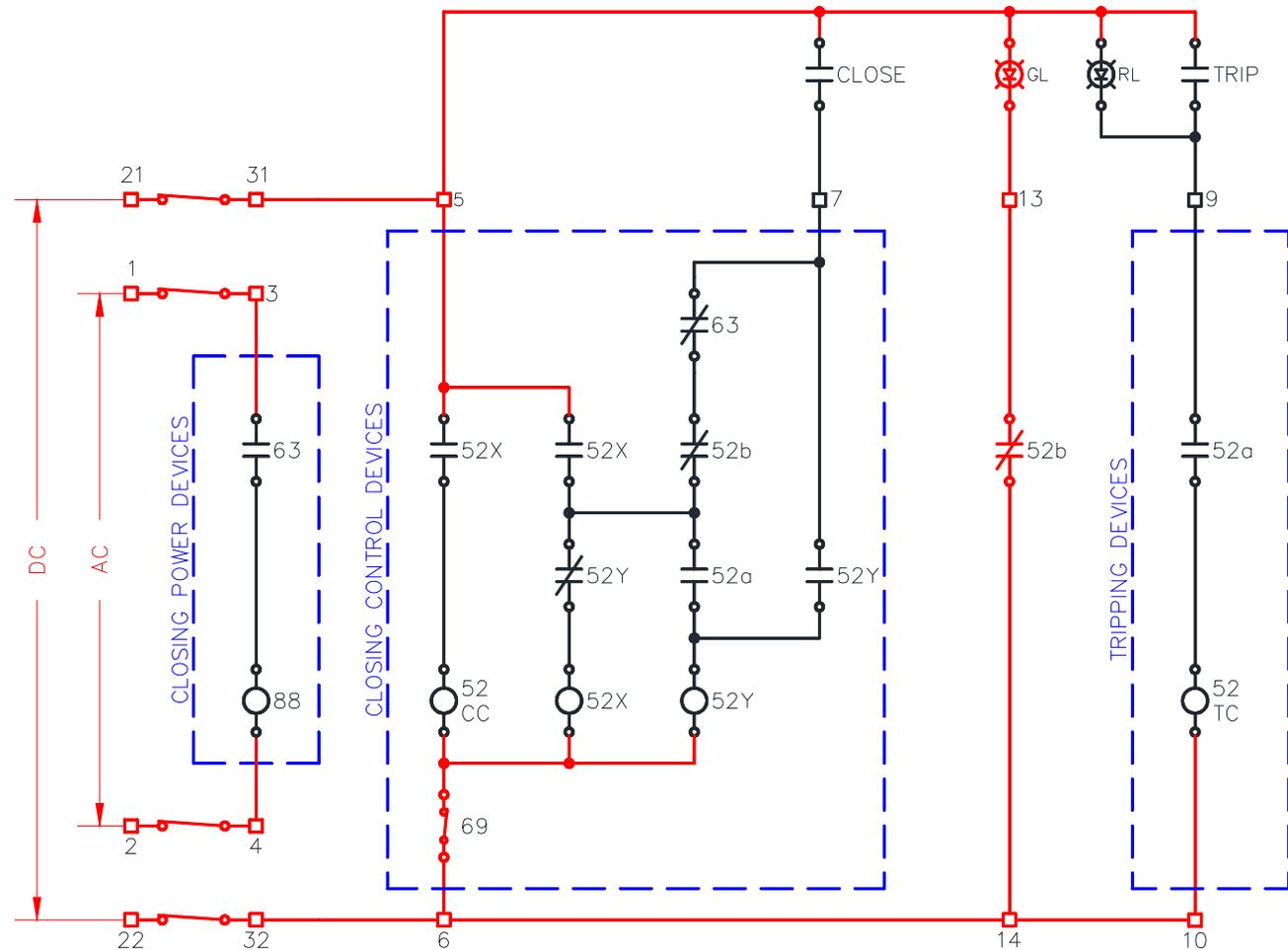


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# IEEE C37.11 Section 3e

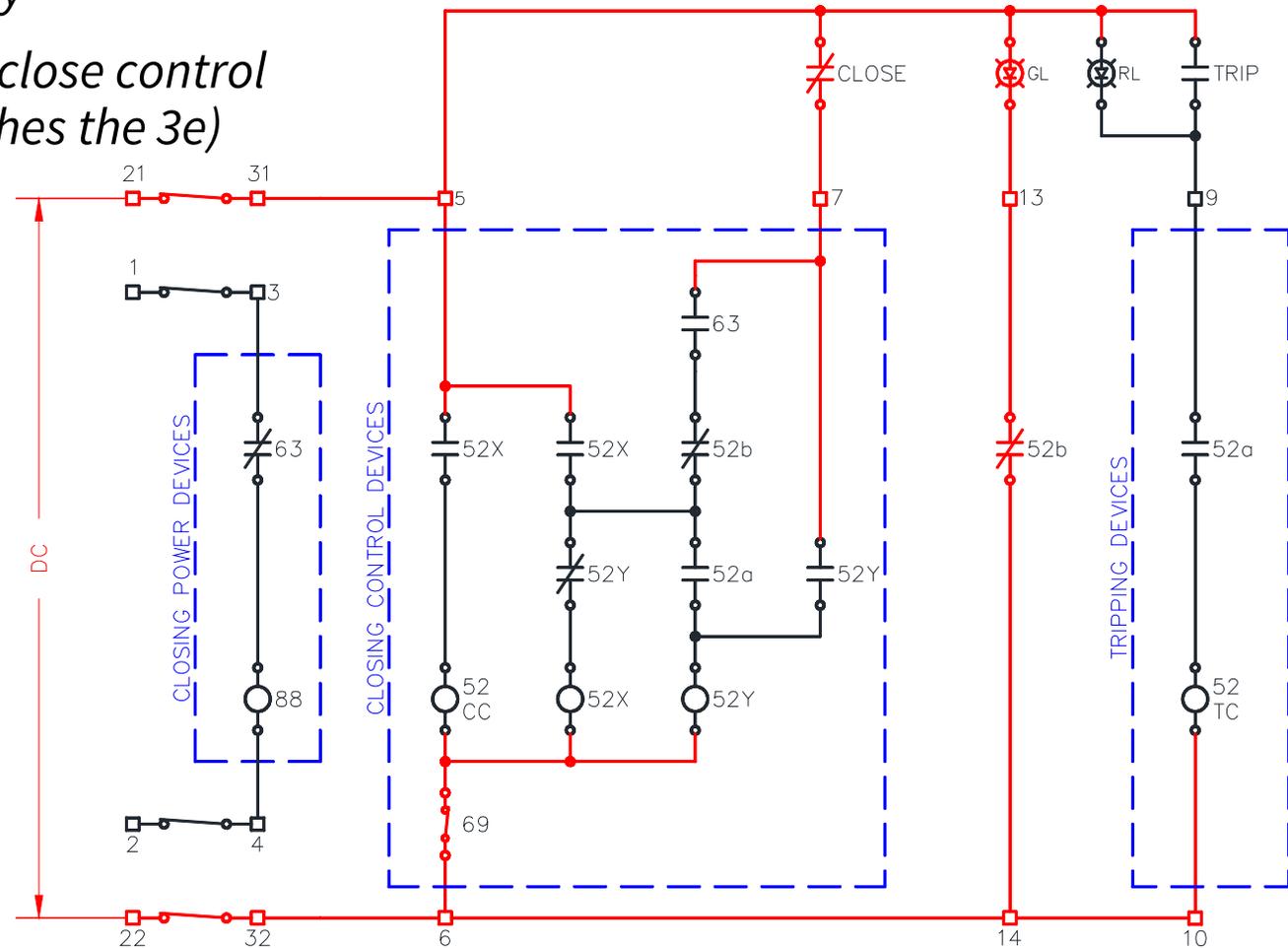
# 3e) Block close for low stored energy

- *Breaker is open*



# 3e) Block close for low stored energy

- Breaker is open
- Low stored energy
- 63 contact in the close control circuit accomplishes the 3e) requirements





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# IEEE C37.11 Section 3d



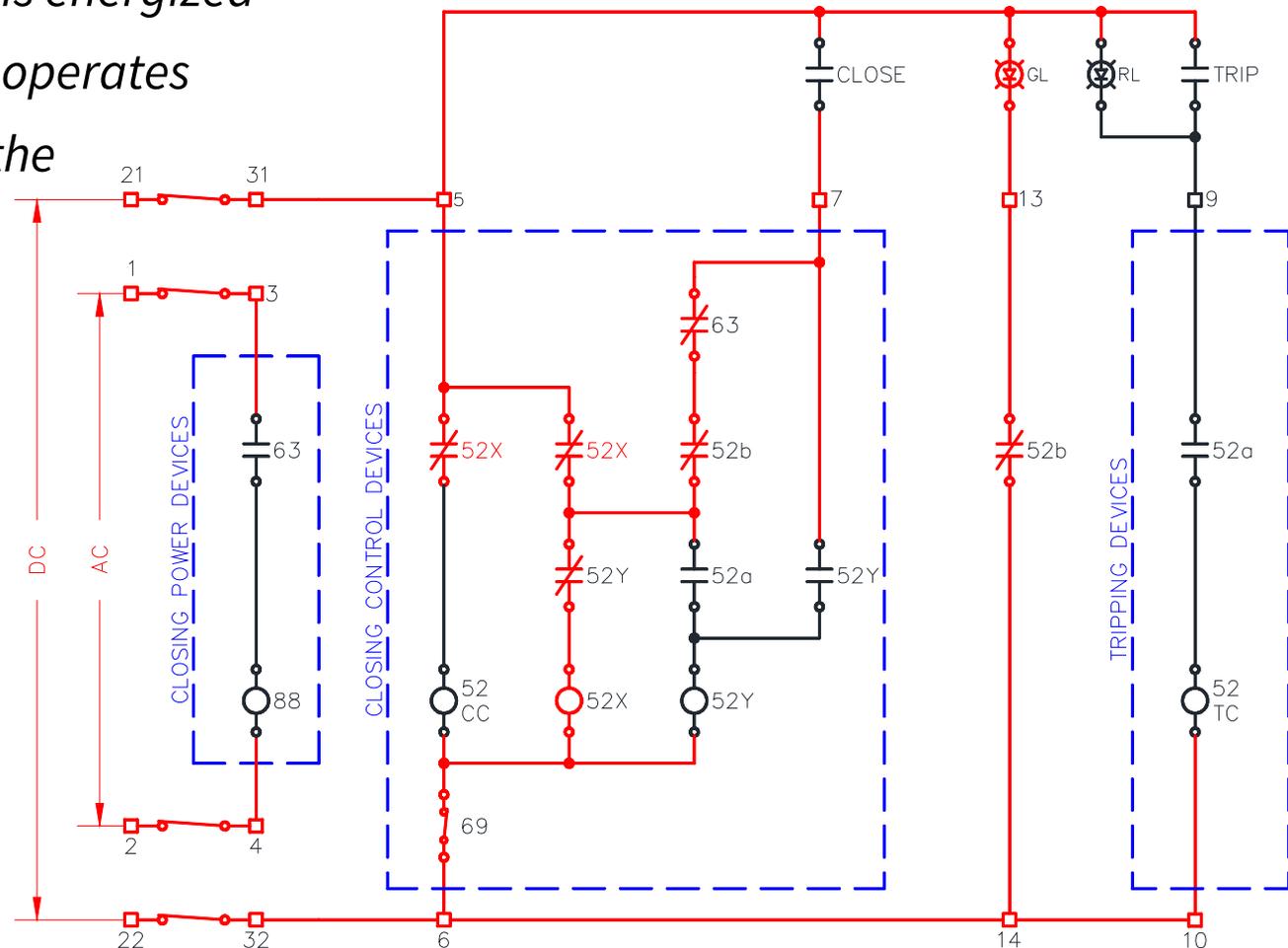


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# IEEE C37.11 Section 3a

# 3a) Seal-in for close

- Breaker is open
- Step 5. 52X relay is energized
- Step 6. 52X relay operates
- What happens if the close command drops out before the breaker completes its close cycle?
- Doesn't matter. 52X is sealed-in.
- Demonstration



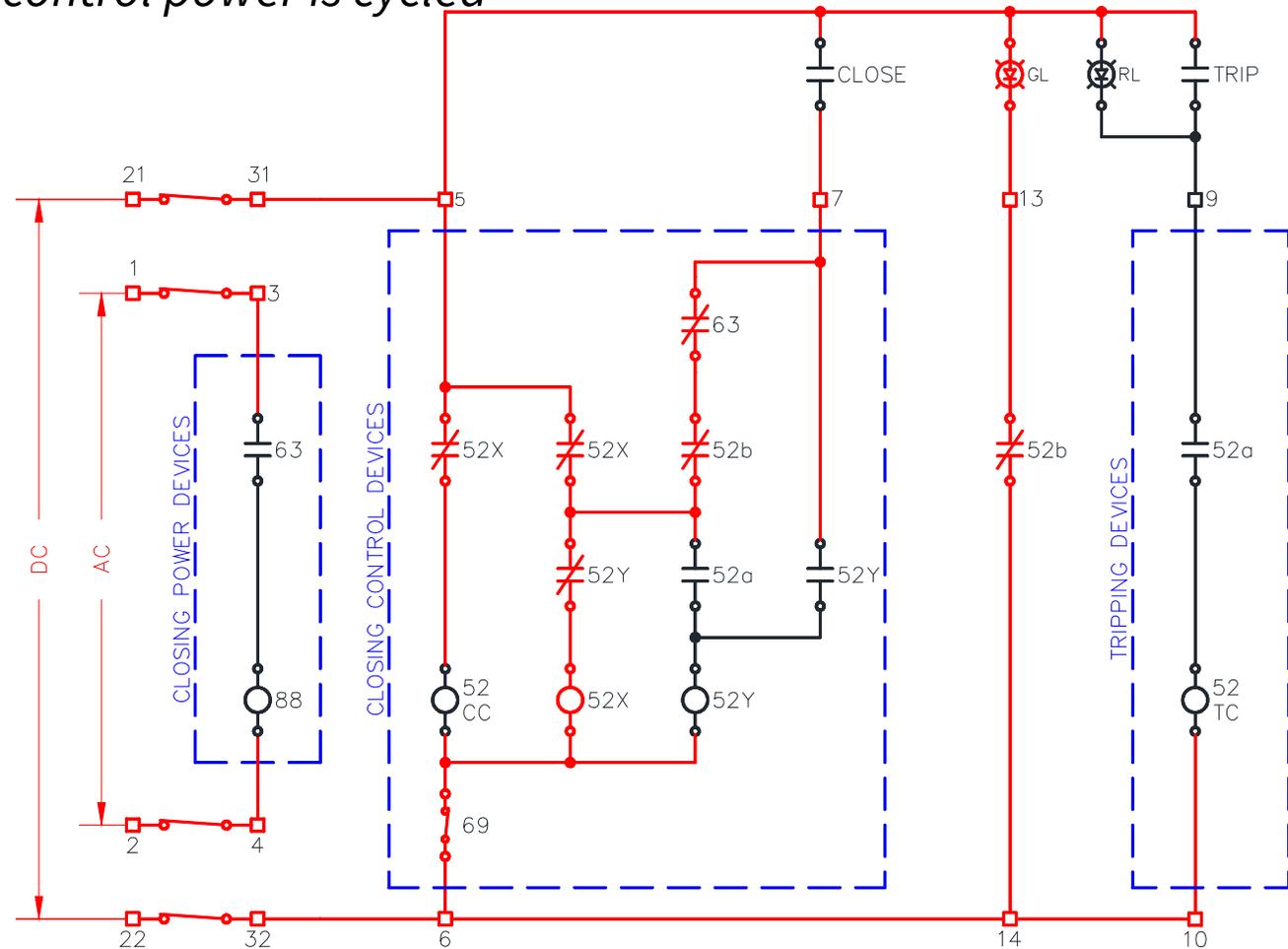


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# IEEE C37.11 Section 3c

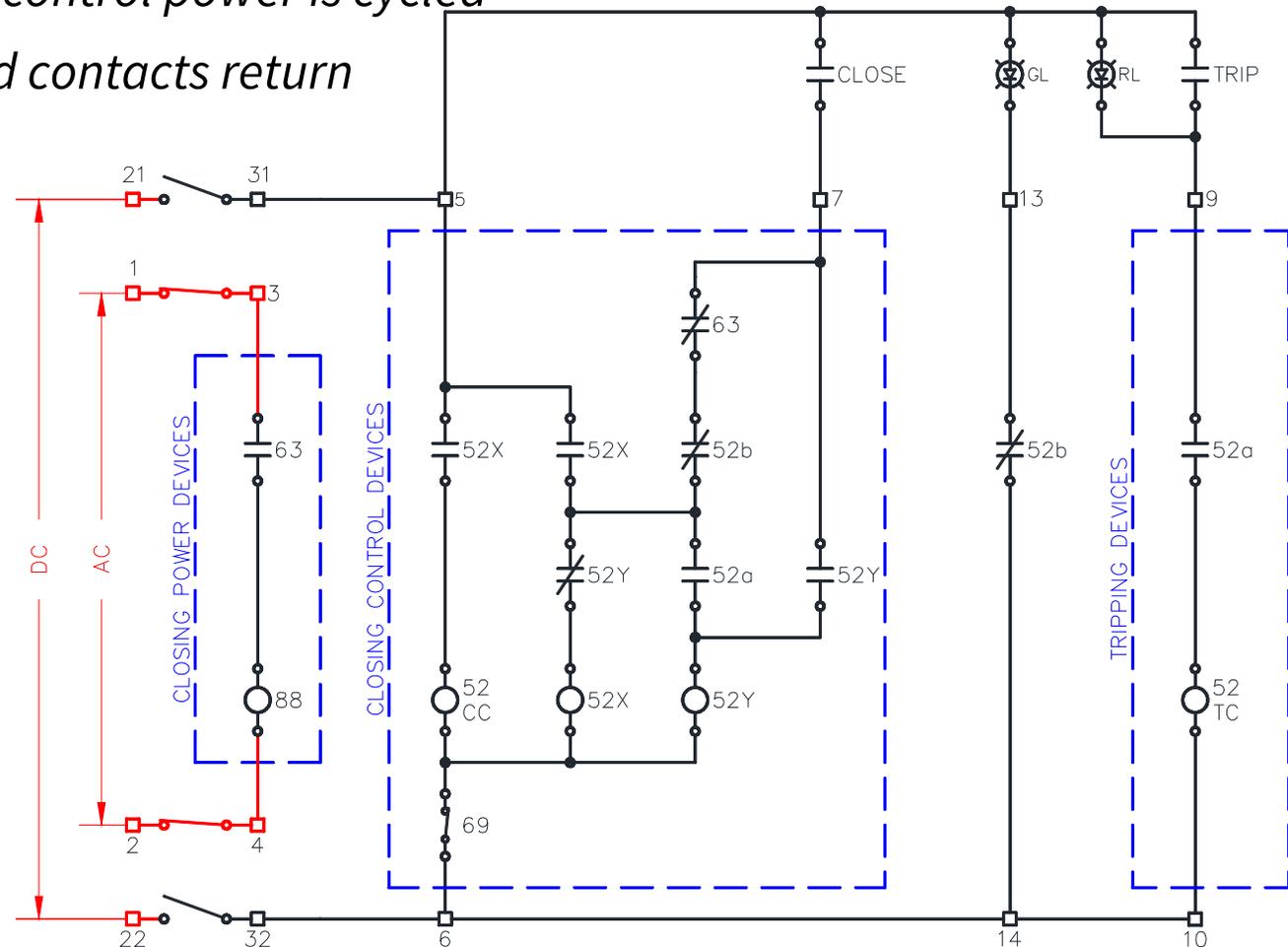
# 3c) Reset after an incomplete close

- *52X seal-in lasts forever*
- *Must fully reset if control power is cycled*



# 3c) Reset after an incomplete close

- 52X seal-in lasts forever
- Must fully reset if control power is cycled
- 52X drops out and contacts return to normal





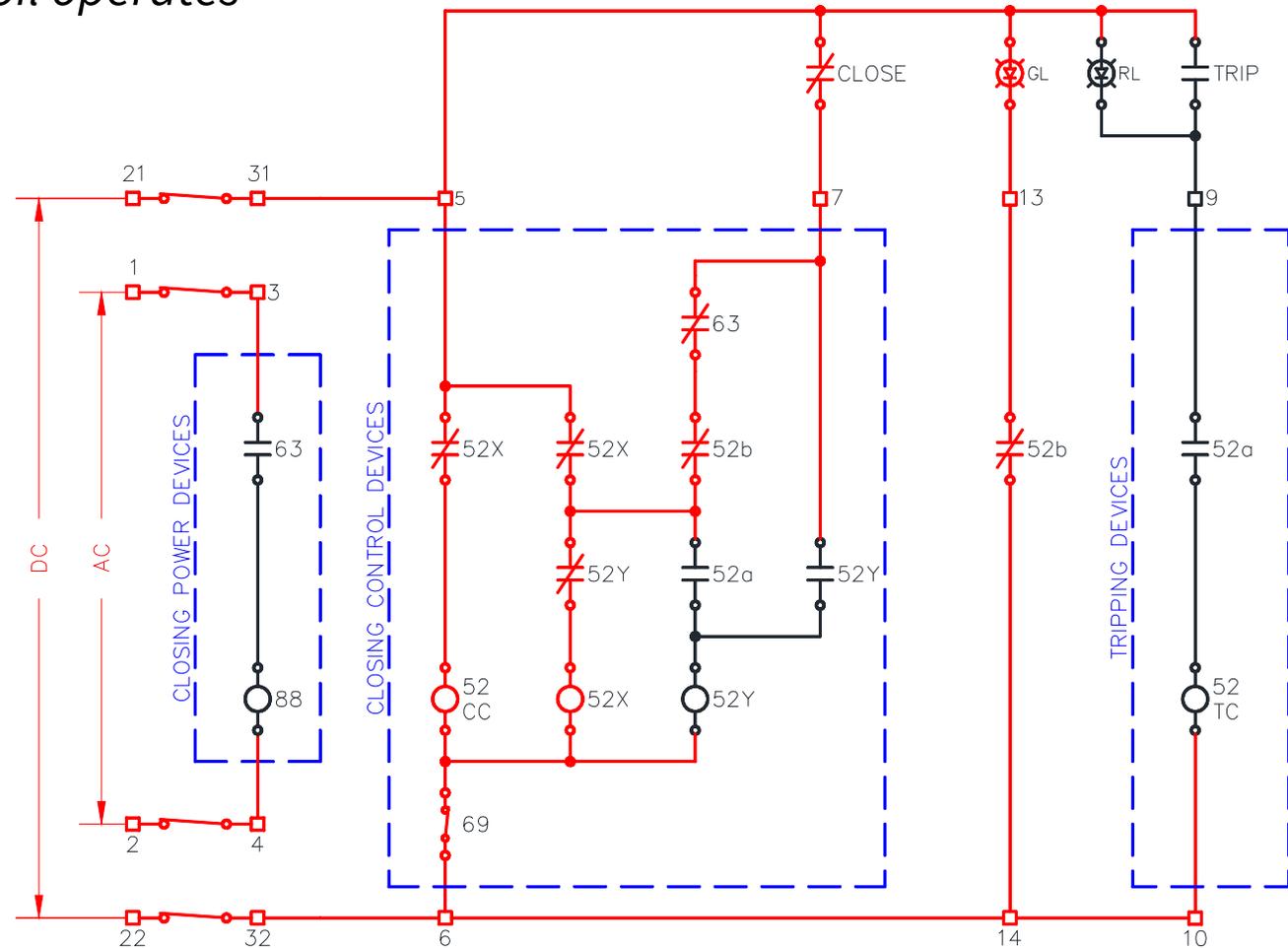


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# IEEE C37.11 Section 3b

# 3b) Anti-pumping

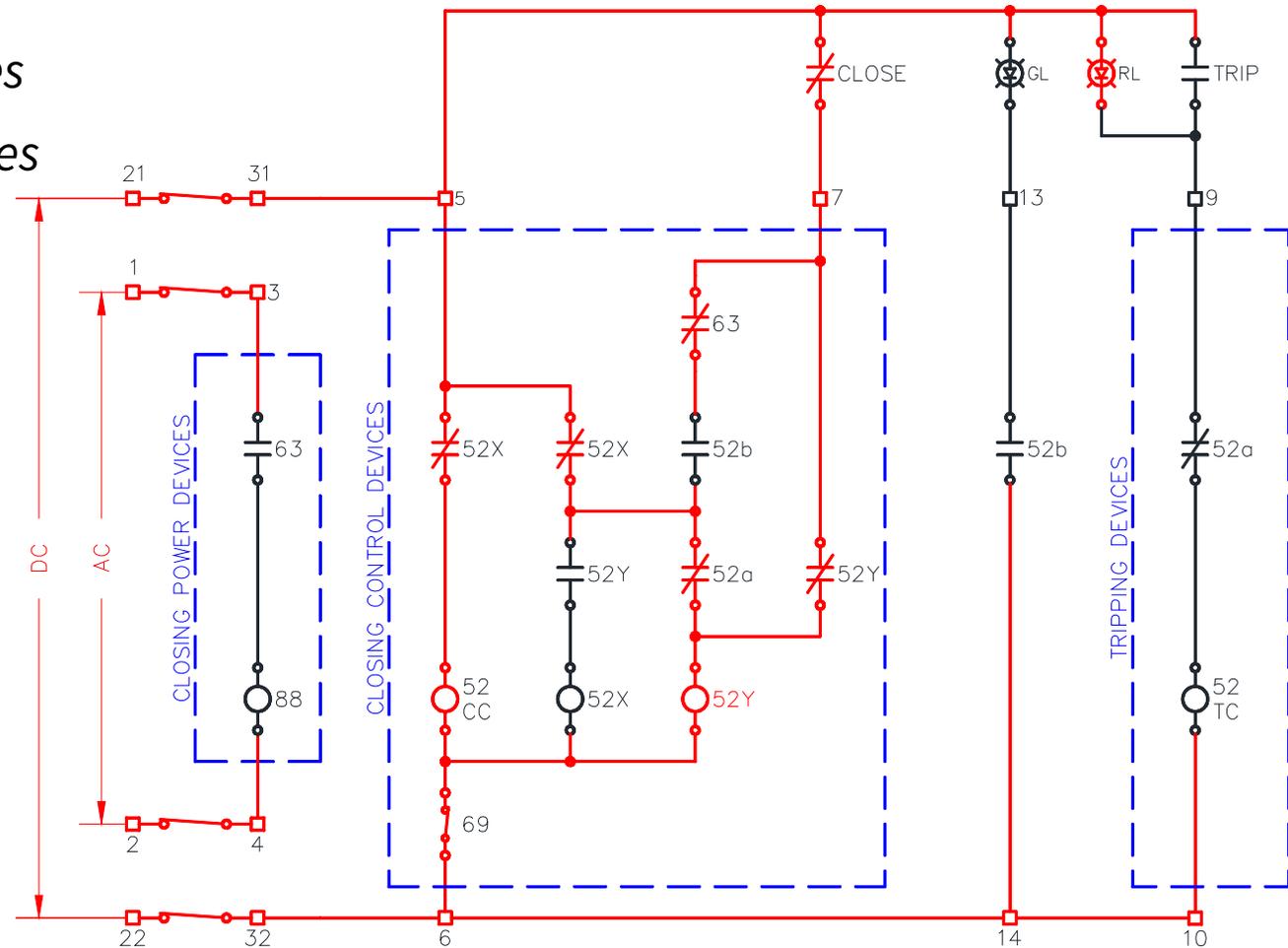
- *Breaker is open*
- *Step 7. Closing coil operates*





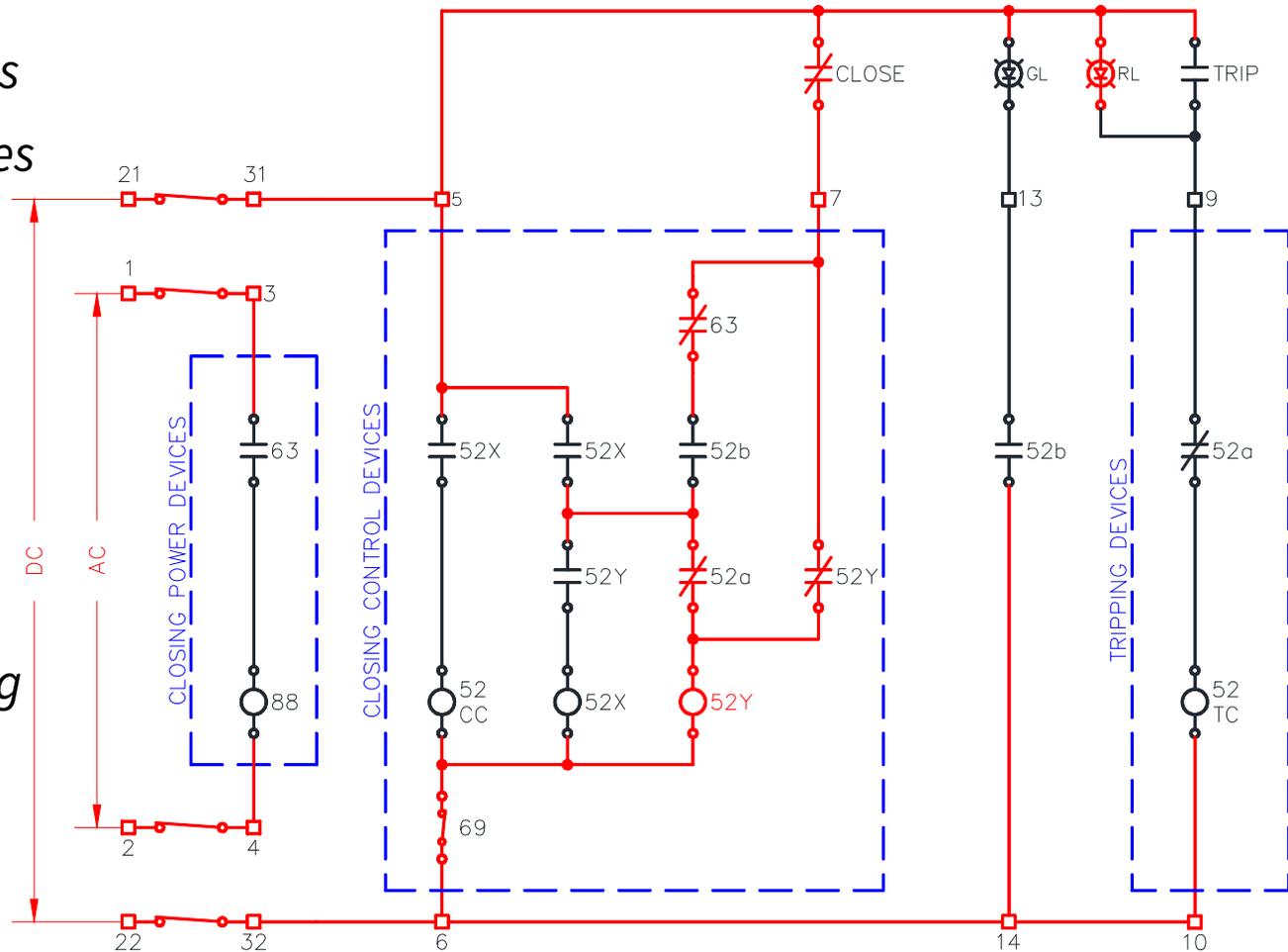
# 3b) Anti-pumping

- 52b contact opens
- Breaker closes
- 52a contact closes
- 52Y relay energizes
- 52Y contacts change state



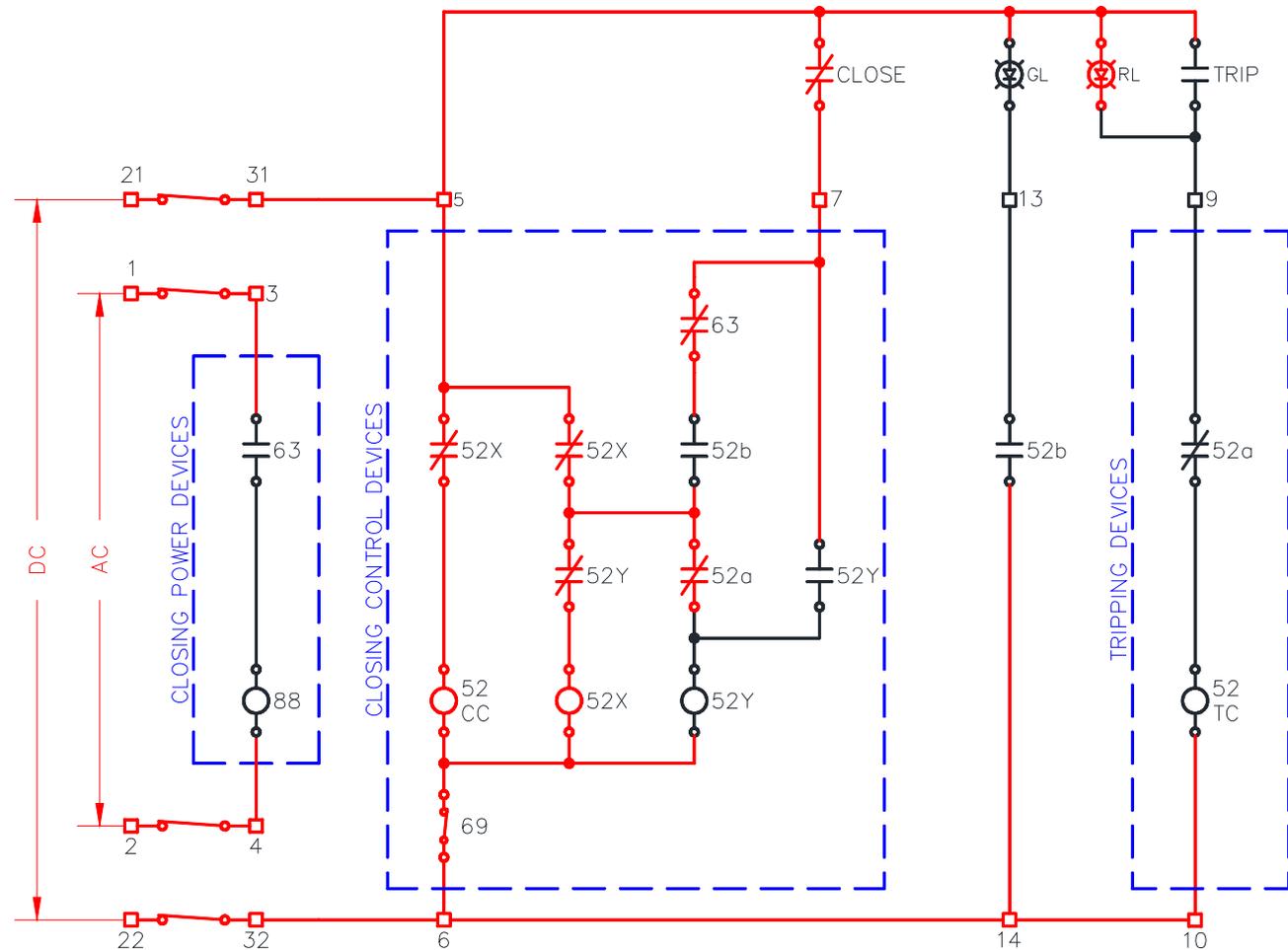
# 3b) Anti-pumping

- 52b contact opens
- Breaker closes
- 52a contact closes
- 52Y relay energizes
- 52Y contacts change state
- 52X relay drops out
- 52CC drops out
- But what if closing in to a fault?



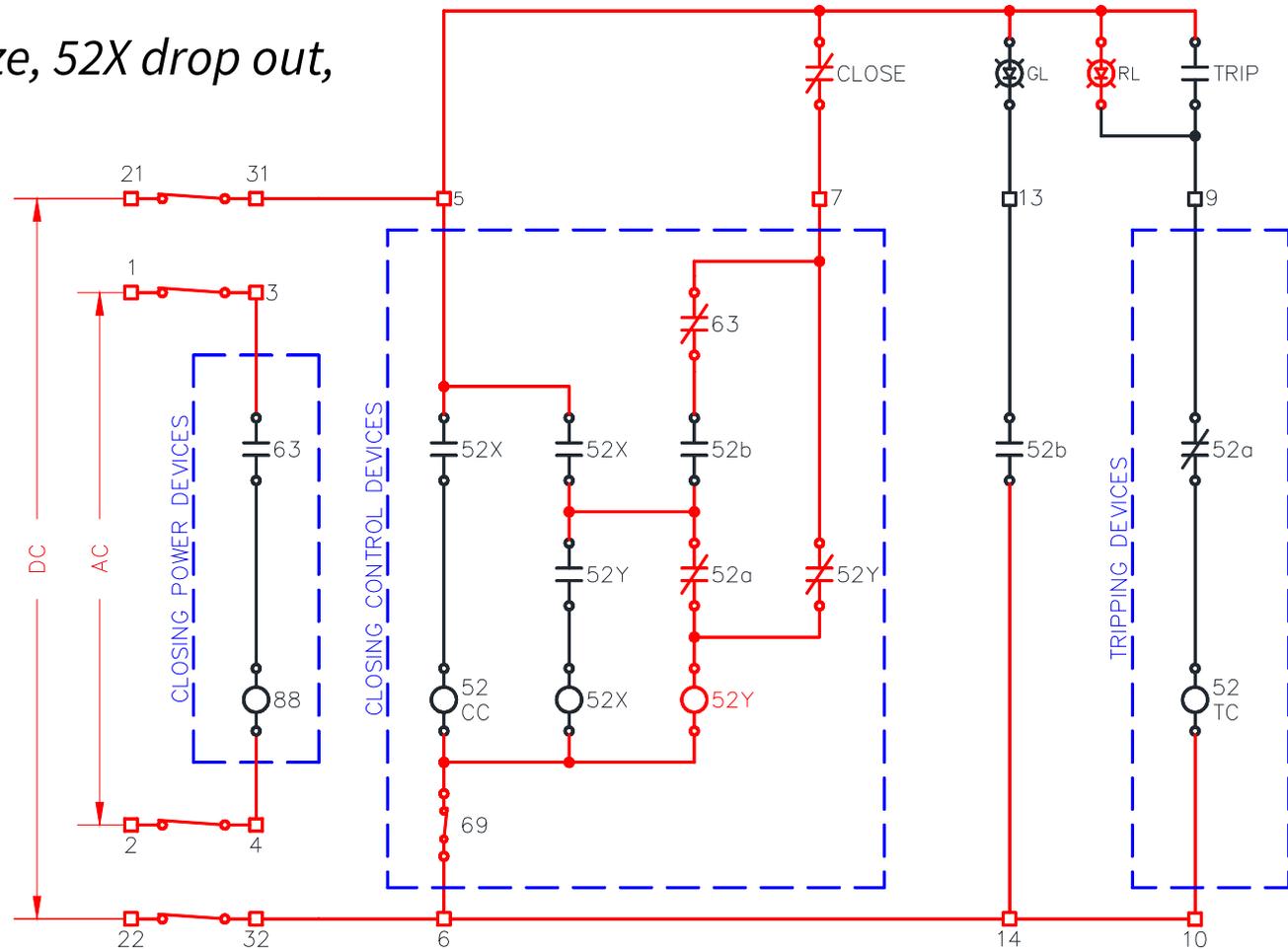
# 3b) Anti-pumping

- Breaker closes  
... Into a fault!



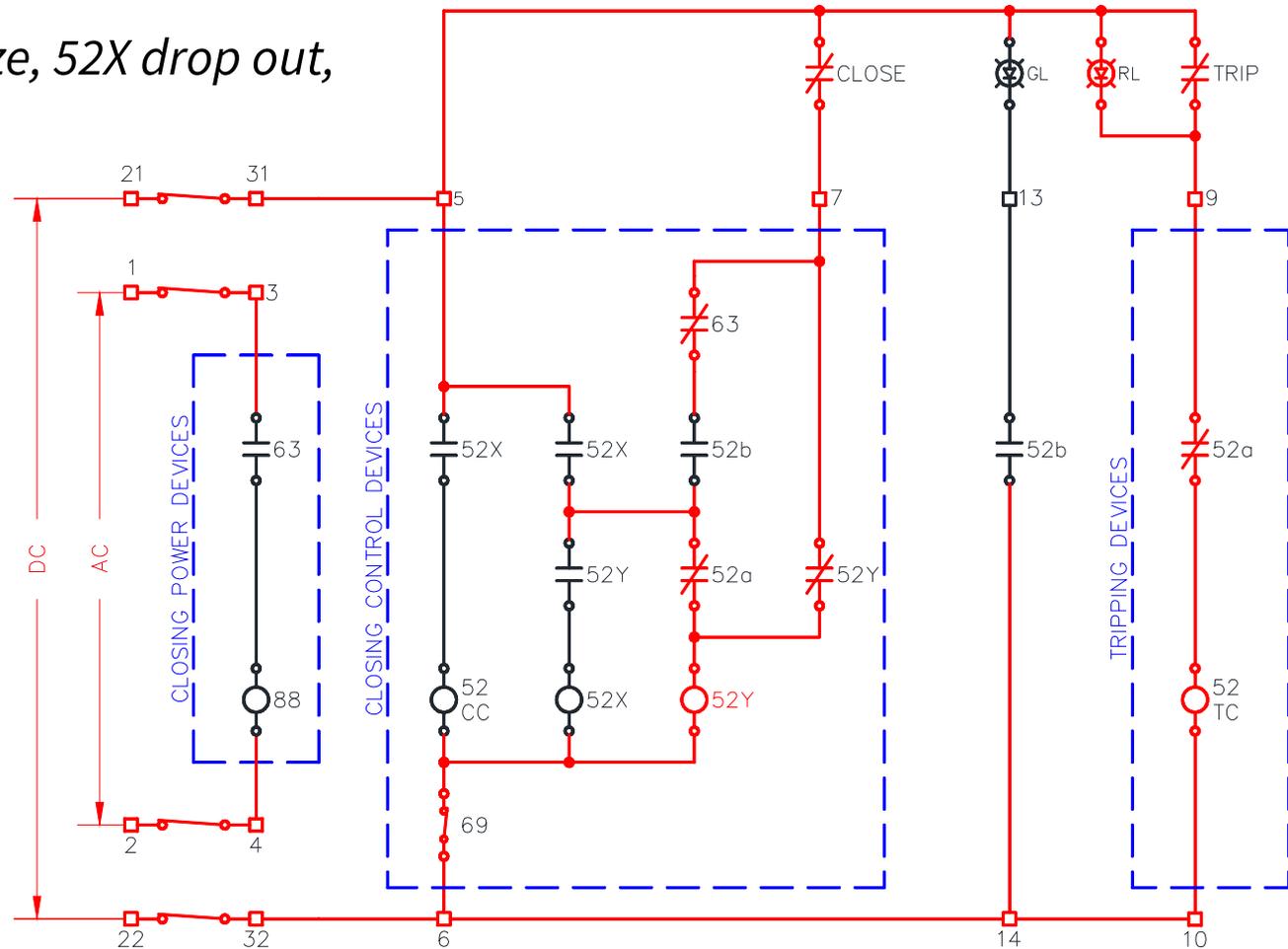
# 3b) Anti-pumping

- Breaker closes  
... Into a fault!
- Same 52Y energize, 52X drop out,  
52CC drop out



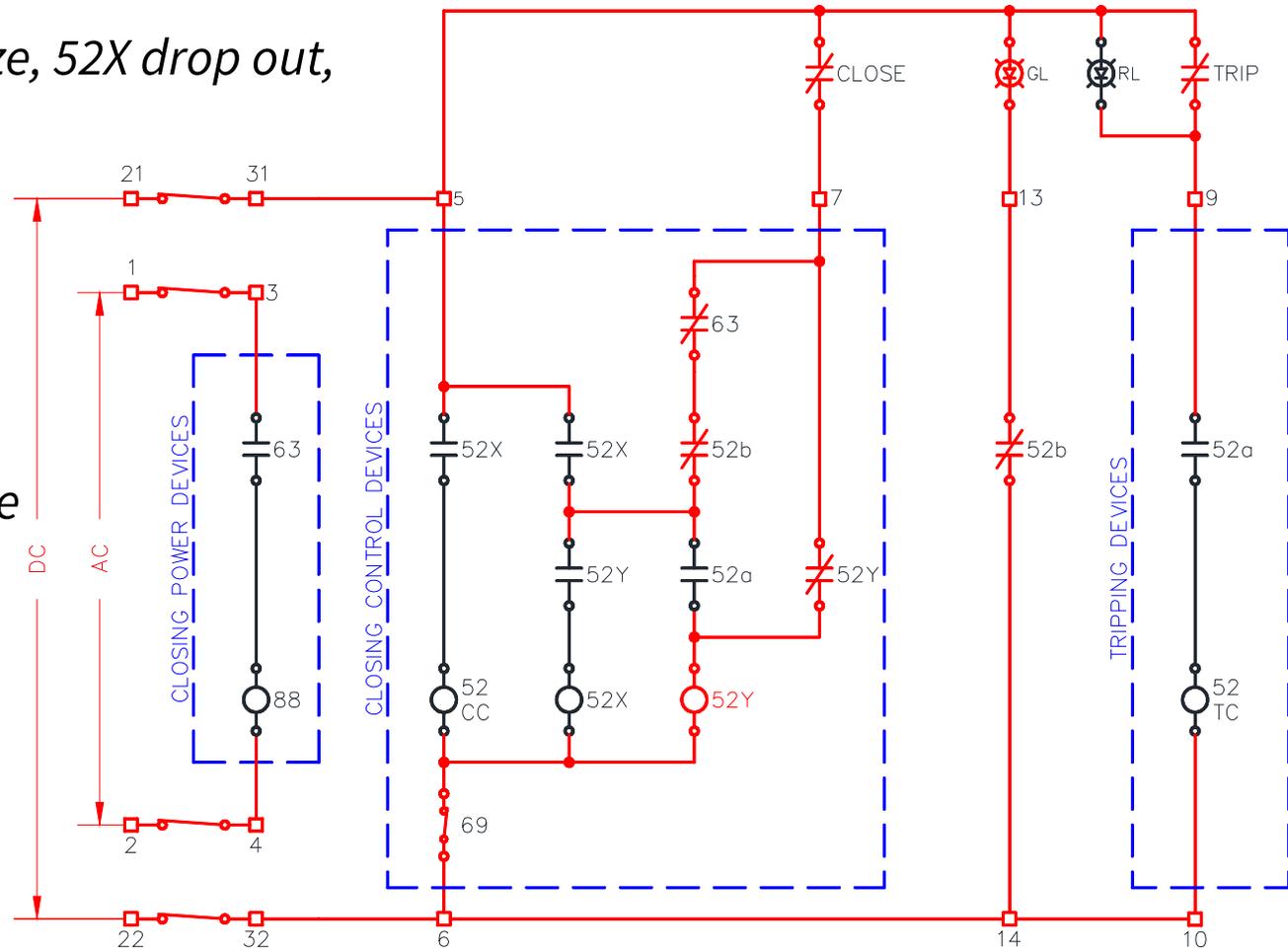
# 3b) Anti-pumping

- Breaker closes  
... Into a fault!
- Same 52Y energize, 52X drop out, 52CC drop out
- Relay trip to the breaker



# 3b) Anti-pumping

- Breaker closes  
... Into a fault!
- Same 52Y energize, 52X drop out, 52CC drop out
- Relay trip to the breaker
- Breaker opens
- Even though there is still a close command, the breaker will not close.
- Demonstration



## 3b) Anti-pumping



# 3b) Anti-pumping





# Summary

# Summary

- Breaker terminal block numbers
  - Specified in IEEE C37.11
  - Can vary depending on type of breaker and AC/DC
- Trip Coil Monitoring (TCM)
  - Required in the standard for most breaker types
  - Good practice for other devices as well (86 lockout relays), especially when the coil is not rated for continuous duty
- IEEE C37.11
  - Primarily applies to circuit breaker manufacturers
  - But... it is important for engineers and techs and wiremen to understand X/Y schemes
    - Maintenance, testing, and troubleshooting operations

# Summary

- X/Y Schemes
  - Protect the breaker and are required by IEEE C37.11
  - Schematics can be confusing; work through one action/reaction one step at a time.
  - If you can sequence an X/Y scheme, you can do any schematic!
- 52X relay provides Seal-In for closing
  - Remember this if troubleshooting a stuck breaker
  - Not all breaker types need a 52X relay
- 52Y relay provides Anti-Pump protection
  - The breaker's 52Y relay can be fooled by chattering closing relays (25, 27/59, 79) or worn contacts on closing devices (relays, 01, SCADA)



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