



POWER SYSTEMS ENGINEERING

# CIRCUIT BREAKER CONTROL SCHEME



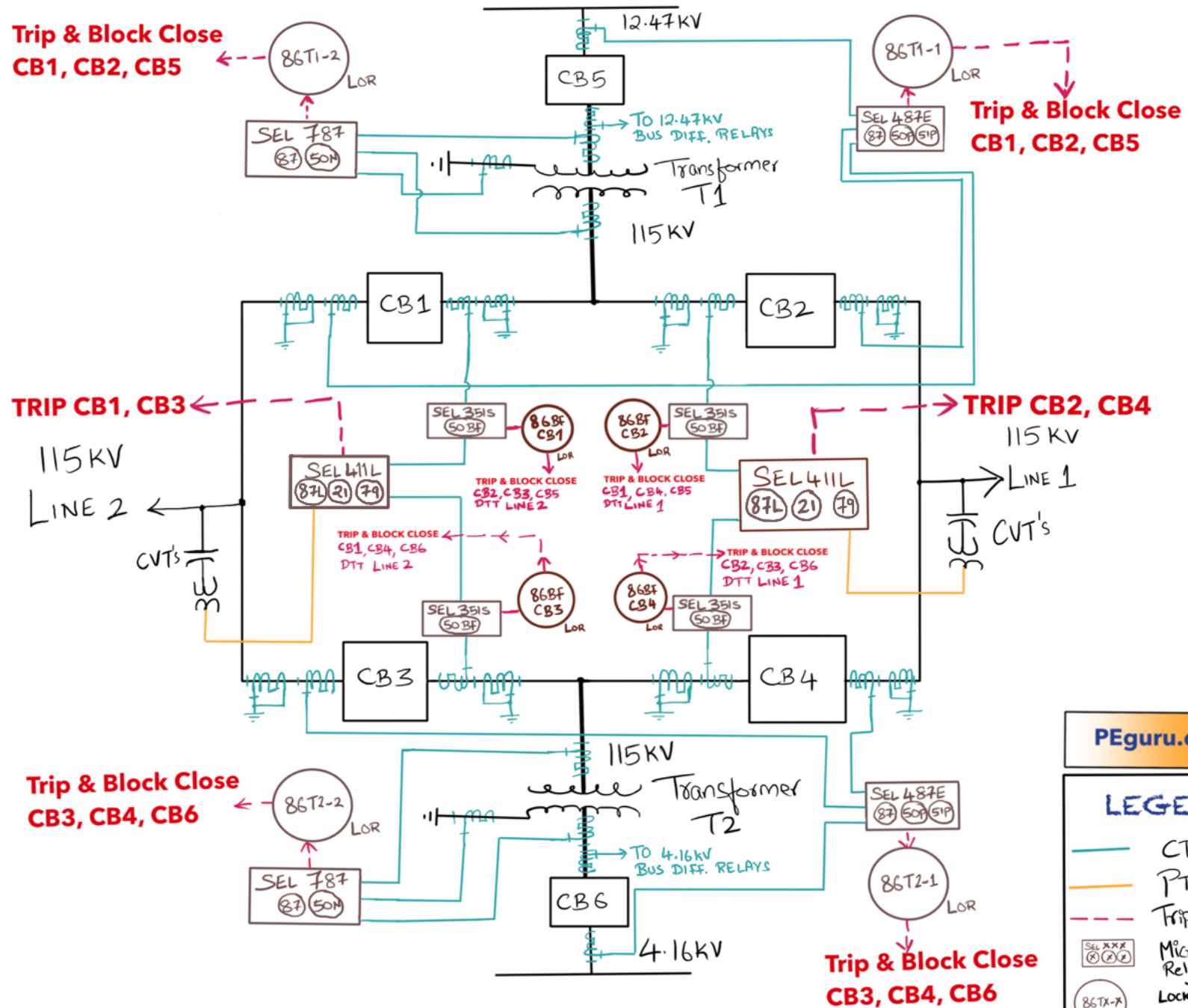
LEARN TO WIRE LOCKOUT RELAYS  
AND MICROPROCESSOR RELAYS

ALEEN MOHAMMED

# TABLE OF CONTENTS

- 1 THE RING SUBSTATION**  
Substation relay oneline
- 2 METHODOLOGY**  
Reasoning for the oneline
- 3 BREAKER CONTROL SCHEME**  
Trip & close breaker scheme
- 4 THE STRAIGHT BUS SUBSTATION**  
Substation relay oneline
- 5 EXERCISE**  
Test your knowledge

# 01 THE RING SUBSTATION



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**LEGEND**

- CT Circuit
- PT Circuit
- - - Trip Signal
- SEL XXX (87, 50P, 51P) Microprocessor Relay
- 86TX-X LOR Lockout Relay

# 02 METHODOLOGY

## OBJECTIVE:

- Develop breaker control scheme of 115kV circuit breaker CB1 from the Ring Substation. Schematic drawing will show how to connect trip contacts and close (or block close) contacts of relays.
- Test your knowledge using a different substation layout.

## Making sense of the Ring substation online

### Why ring layout?

- Ring layout is chosen for most new substations. Not too elaborate and very reliable (from operation standpoint).

### What is the methodology for relay selection?

- Current differential is the best form of protection. Any relay with this functionality should be your first choice. There are exceptions, will be described below.
  - For **Transformer protection** –
    - Schweitzer SEL787 chosen. It implements current differential using current transformers (CT) on the power transformer bushings.
    - Schweitzer SEL487E also chosen. CT's from breaker bushing chosen in this case. Zone of protection is much larger and encapsulates the one from SEL787.
    - Both relays can implement overcurrent protection 50 and 51 on phase and neutral/ground as backup.

## 02 METHODOLOGY

- Not shown, the sudden pressure relay – internal to transformer, trips the 86T lockout relay directly.
- For **Bus protection** –
  - Ring layouts do not need separate relays for bus protection. All pieces of bus fall inside either transformer or transmission line zone of protection.
  - For any other bus layout (straight, breaker-and-a-half, etc), bus differential relay is required. A short-circuit on a bus generates incredibly high fault currents. If CT saturation is possible then use high impedance bus differential relay like SEL587Z. Otherwise a low impedance relay like SEL487B works just fine.
- For **Line protection** –
  - Relay choice for line protection cannot automatically be a line differential relay. It is driven by following reasoning

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## 02 METHODOLOGY

- When fiber is not present, power-line carrier is the next best option. However, line differential protection scheme cannot be

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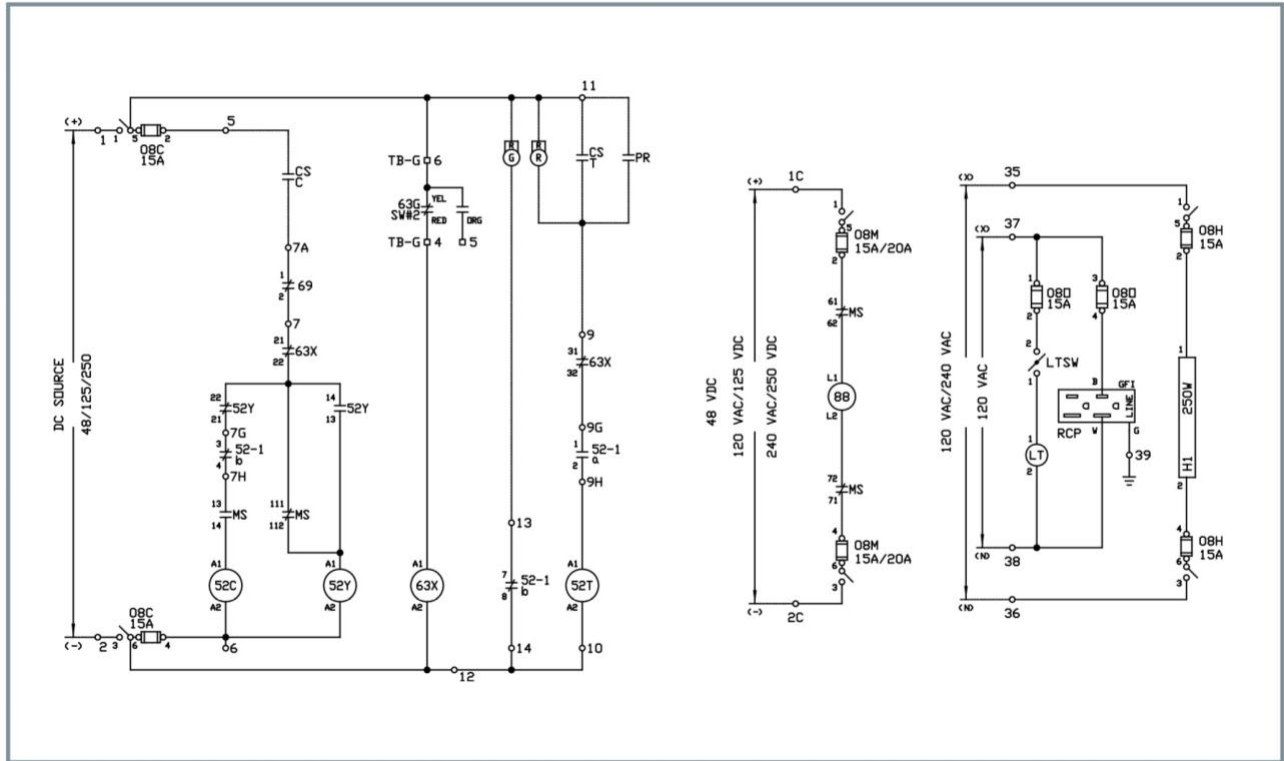
### The Fine Print

For the relay oneline developed above, in the interest of legibility,

- Backup protection relays not shown.
- 12.47kV & 4.16kV bus protection not shown.
- Auxiliary tripping relays not shown.
- Equipment rating and CT ratios not shown.

# 03 BREAKER CONTROL SCHEME

Let's begin the development of breaker control scheme for circuit breaker CB1. For this effort a 138kV Siemens SPS2 breaker is chosen. The below scheme is taken from the brochure.



DEVICE	DESCRIPTION	LEGEND	DEVICE	DESCRIPTION
01	BREAKER CONTROL SWITCH		G	GREEN INDICATOR LIGHT
08C	CLOSE POWER DISCONNECT		H1	CABINET HEATER
08H	HEATER POWER DISCONNECT		H2	CABINET HEATER
08M	MOTOR POWER DISCONNECT		LT	HOUSING LIGHT
08D	RECEPTACLE & LIGHT POWER DISCONNECT		LTSW	HOUSING LIGHT TOGGLE SWITCH
08T	TRIP POWER DISCONNECT		MS	SPRING CHARGE MOTOR SWITCH
23	CONTROL HOUSING THERMOSTAT		PR	REMOTE PROTECTIVE RELAYS
52-a, b	BREAKER AUXILIARY SWITCHES (a=OPEN/BKR OPEN b=CLOSED/BKR OPEN)		R	RED INDICATOR LIGHT
52C	BREAKER CLOSE COIL		RCP	DUPLEX RECEPTACLE (GFCl)
52T	BREAKER TRIP COIL			
52Y	BREAKER CLOSING CUTOFF RELAY (ANTI-PUMP)			
63G	GAS PRESSURE SWITCH (SF6)			
	SW#1 LOW PRESSURE ALARM			
	SW#2 LOW PRESSURE CUTOFF			
	SW#3 LOW PRESSURE CUTOFF			
63X	INTERRUPTER SF6 LOW PRESSURE CUTOFF AUXILIARY RELAY			
88	MOTOR (MECHANISM)			

**NOTES:**  
1. ALL EQUIPMENT SHOWN WITH: CIRCUIT BREAKER OPEN, CONTROL VOLTAGE OFF, SF6 PRESSURE LOW, SPRING DISCHARGED, TEMPERATURE LOW.

The detail diagrams show the internal wiring for three SF6 pressure switches. SW#1 (LOW SF6 PRESSURE ALARM) has terminals 40 (BLK), 41 (WHT), and 42 (BLU). SW#3 (LOW SF6 PRESSURE CUTOFF) has terminals 7 (PUR), 8 (BRN), and 9 (GRN). The third diagram (LOW SF6 CUTOFF ALARM) has terminals 33 and 34.

# 03 BREAKER CONTROL SCHEME

Schematic drawing for the breaker reveals the following:



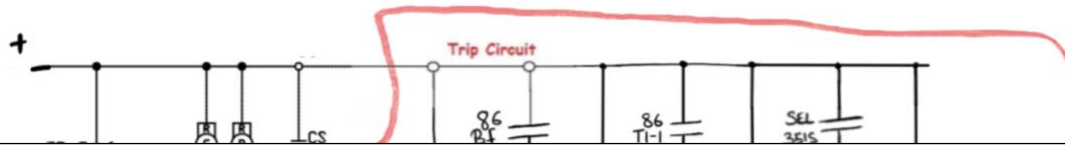
Anything tied to close coil is part of close circuit.

Anything tied to trip coil is part of trip circuit

for lights, outlet & heaters



# 03 BREAKER CONTROL SCHEME



Tripping scheme for 115kV circuit breaker CB1

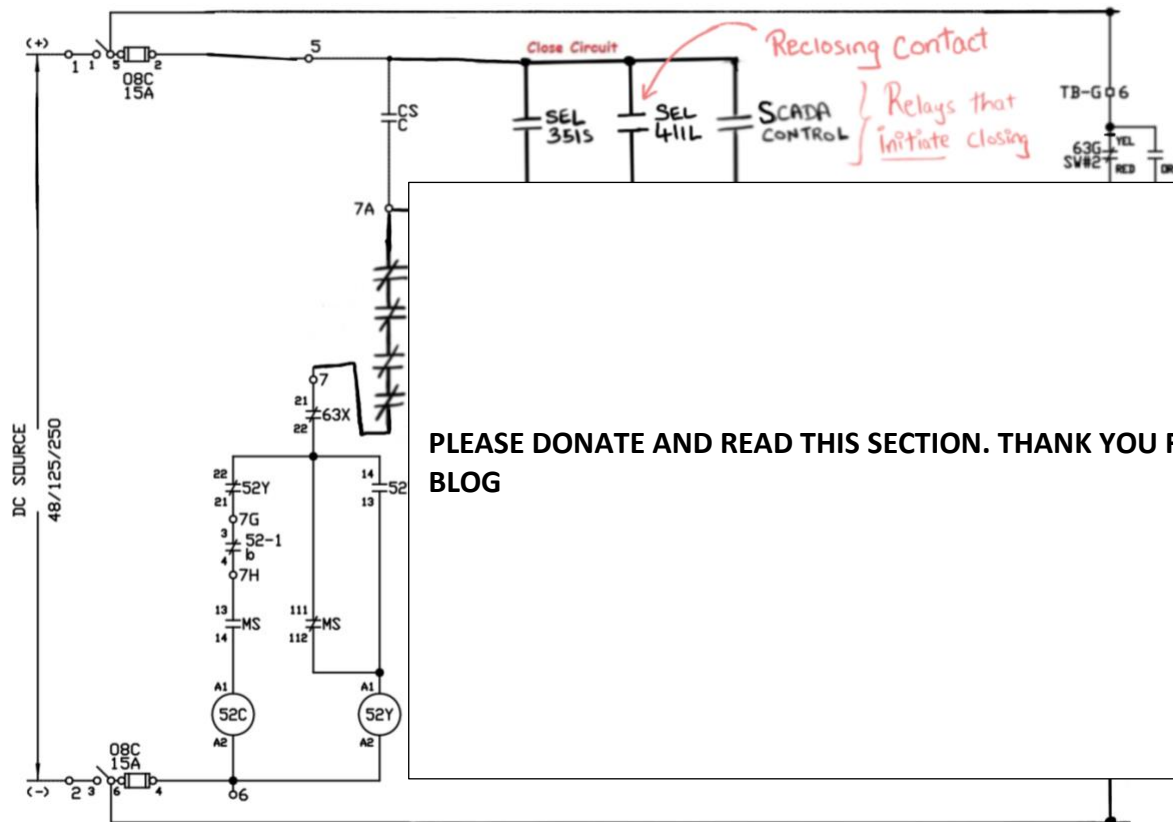
Note this breaker is in the 115kV

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isolates CB2 and 86BF-CB3 isolates CB3.

equipment it is protecting. For instance, 86T1-1 and 86T1-2 isolates transformer TR1, 86BF-CB2

# 03 BREAKER CONTROL SCHEME



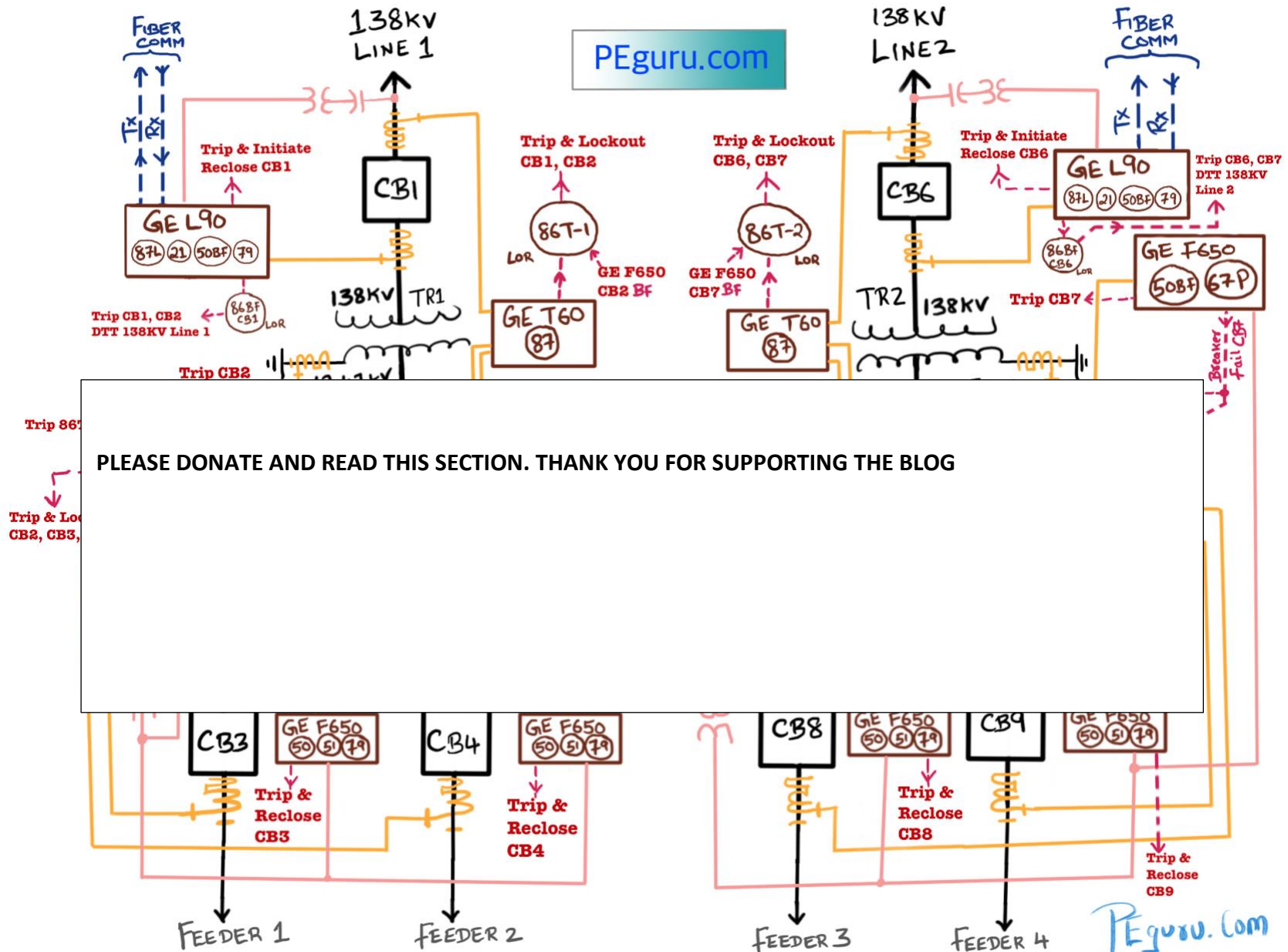
Closing scheme for 115kV circuit breaker CB1

g relays as  
 ed breaker  
 pls close of  
 push button  
  
 line  
 is used  
 reclosing.  
 ct is wired  
 51S. Note:  
 fires voltage

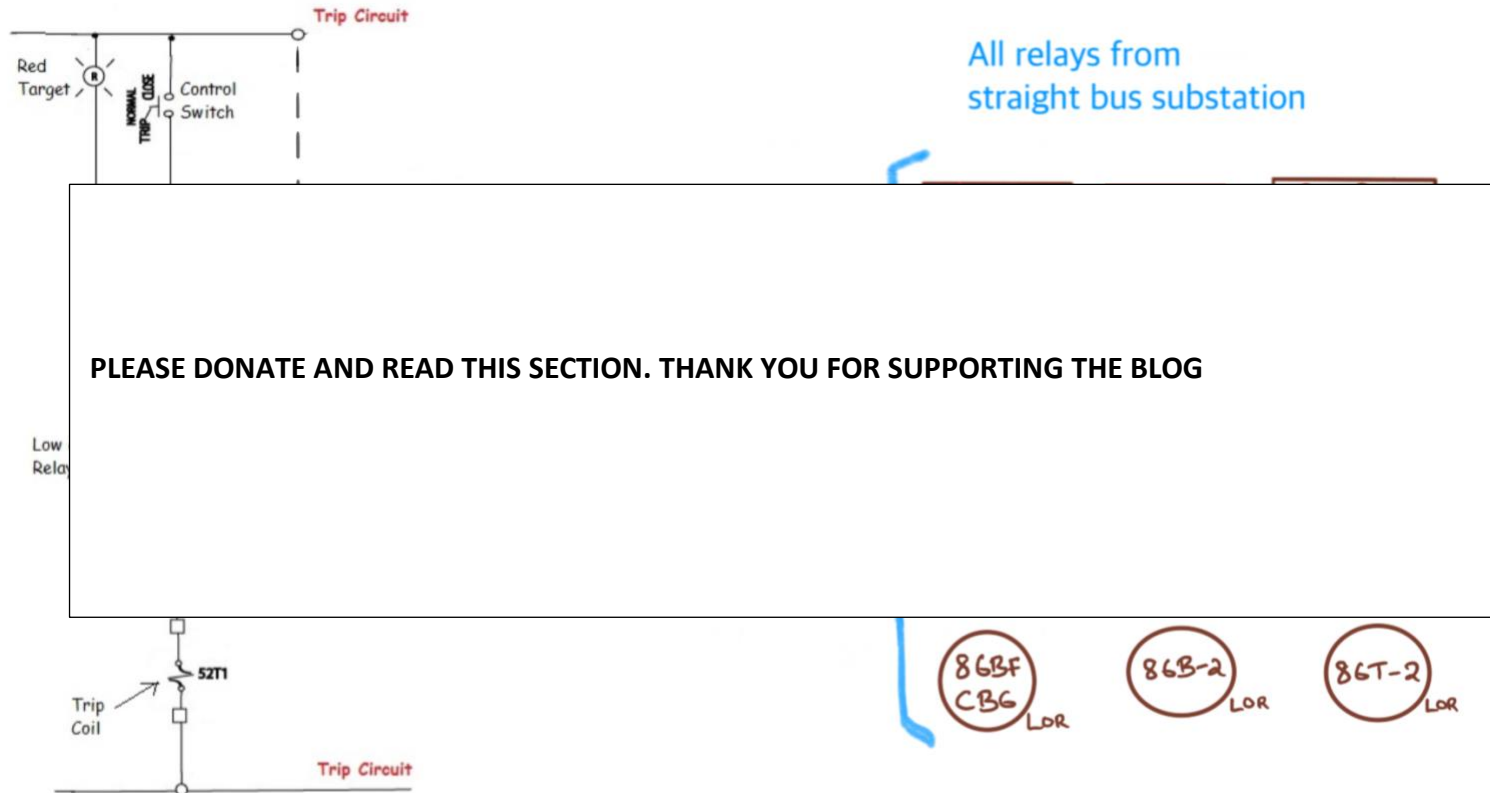
input from the transmission line (see ring substation online to view the voltage connection to this relay).

- Lockout 86 relays: Transformer T1 failure, fault within overall transformer differential scheme, breaker CB2 failure and breaker CB3 failure prevent CB1 from closing.

# 04 THE STRAIGHT BUS SUBSTATION

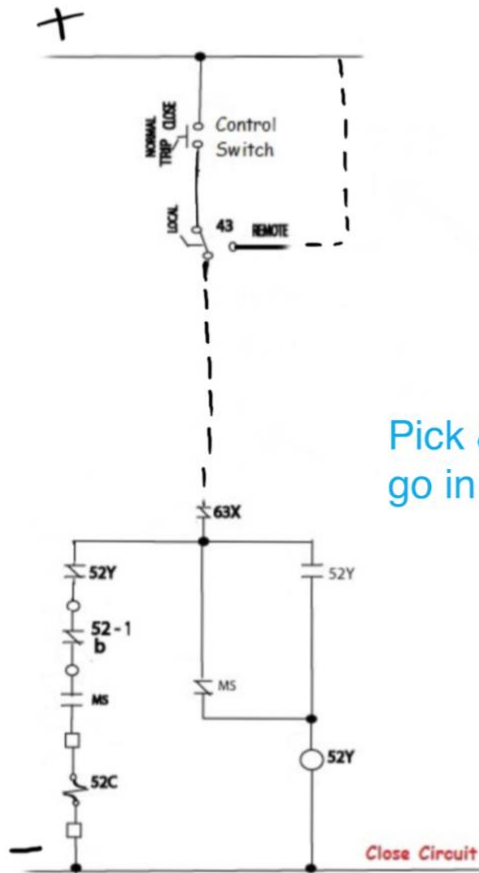


# Practice problem - CB2 Trip Circuit



# 05 EXERCISE

## Practice problem - CB2 close circuit



Pick & choose relays that go in the dotted area

All relays from straight bus substation

GE F650 (50BF) (67P)	GE T60 (87)	GE L90 (87L) (21) (50BF)
GE B30 (87)	GE F650 (50) (51) (79)	
86BF CB1 LoR	86B-1 LoR	86T-1 LoR
86BF CB6 LoR	86B-2 LoR	86T-2 LoR

SOLUTION

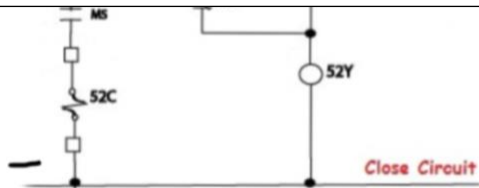
Practice problem - CB2 Trip Circuit  
SOLUTION

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# Practice problem - CB2 close circuit

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BONUS INFORMATION

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