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Case Study: Improved Reliability with a Relion based IEC 61850 protection solution

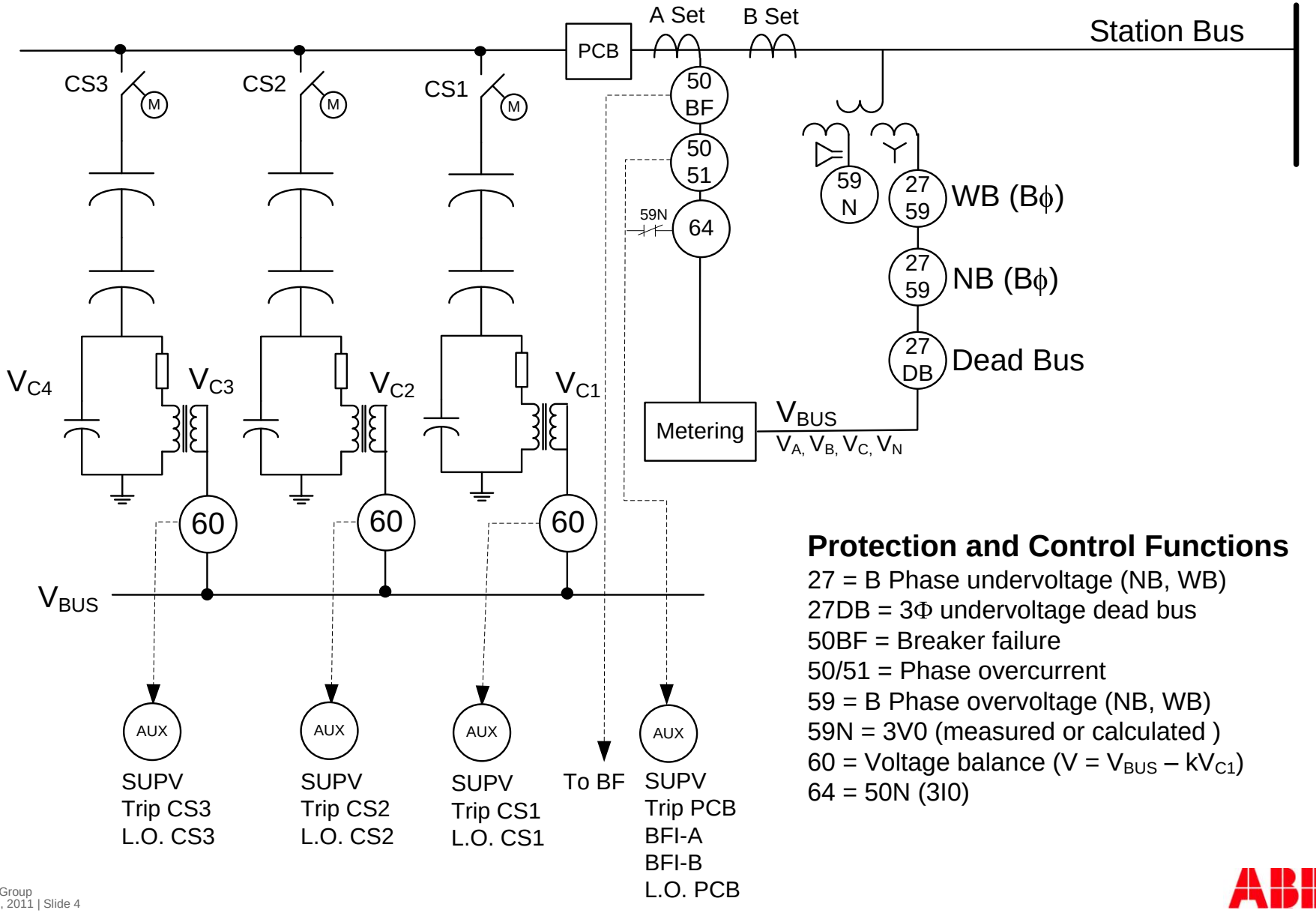
Two Applications will be Discussed

- Capacitor Bank Protection and Control
  - Taking a utility's standard philosophy's and integrating the design aspects into one Relion IED
- Line Breaker Bypass scheme
  - Complex designs involving instrument transformer switching can be drastically simplified and cost reduced by moving the switching functions into the Relion IED

Capacitor Bank Protection and Control

- The following presentation is based on phase voltage differential protection (60) and a control scheme based on a particular user's preference.
- Adaptations are possible with reconfiguration of the application with ABB's PCM600 application configuration tool.

Capacitor Bank Protection and Control



Protection and Control Functions

27 = B Phase undervoltage (NB, WB)
27DB = 3Φ undervoltage dead bus
50BF = Breaker failure
50/51 = Phase overcurrent
59 = B Phase overvoltage (NB, WB)
59N = 3V0 (measured or calculated)
60 = Voltage balance ($V = V_{BUS} – kV_{C1}$)
64 = 50N (3I0)

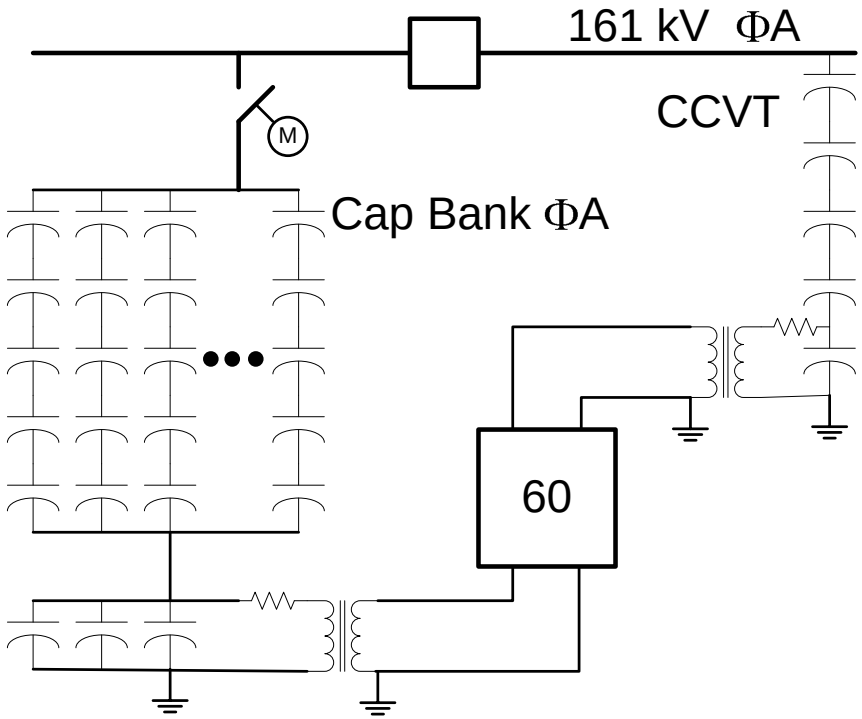
Protection

- 50 - Phase instantaneous overcurrent
- 51 - Phase time overcurrent
- 64N – 50N ground instantaneous overcurrent supervised by 59N (3V0)
- Breaker failure
- 60 – Voltage balance

- Existing protective solution consisted of four protective relays.
  - One for the breaker (50, 51, 64N, 50BF)
  - One for each capacitor bank

60 Voltage Balance Function

- Phase-to-ground voltage magnitude differential
- Application to each phase provides immunity to system unbalances
- Settable ratio correction factors
  - Each phase
  - Measured differential values can be read at commissioning
- Settable alarm level and timer
- Settable trip level and timer
- Low voltage blocking



Controls - Existing Solution

- Following controls solution was previously achieved by four logic controllers, five voltage transducers, and multiple control switches
  - All these functions, including the protections functions, can reside in one Relion IED.

Measurement

- 59WB – Wideband overvoltage
- 27WB – Wideband undervoltage
- 59NB – Narrowband overvoltage
- 27NB – Narrowband undervoltage
- 27DB – Dead bus

NB and WB measurements are made with service value measurement (metering) functions with a published accuracy of better than 0.5% rated. Actual accuracy measured with calibrated test set shows an error of about 0.06% at rated voltage.

Manual Control of Circuit Switches

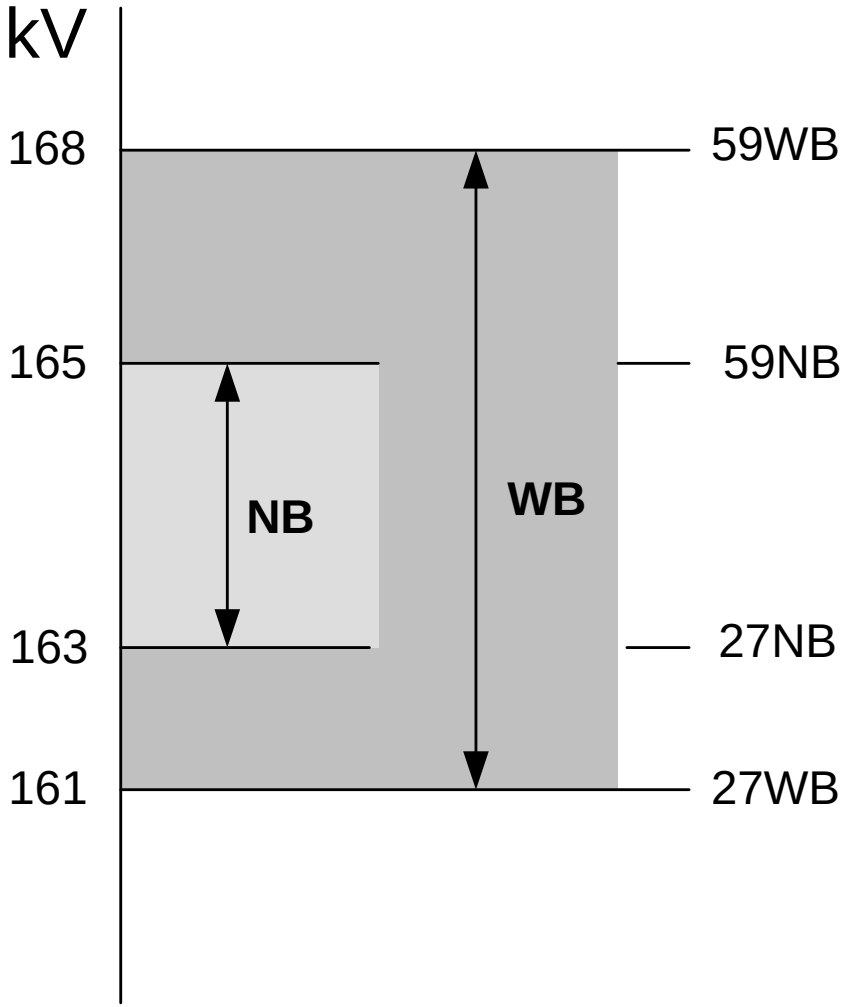
- Operate bank circuit switchers (CSW)
  - Local HMI graphic screen control
- Remote SCADA (IEC61850 or DNP 3.0)
- Added functionality by using developed logic in the Relion IED
  - Local or Remote “manual” switch operation equalization logic
  - Used to select the circuit switcher that was next in line to be operated

Automatic Control

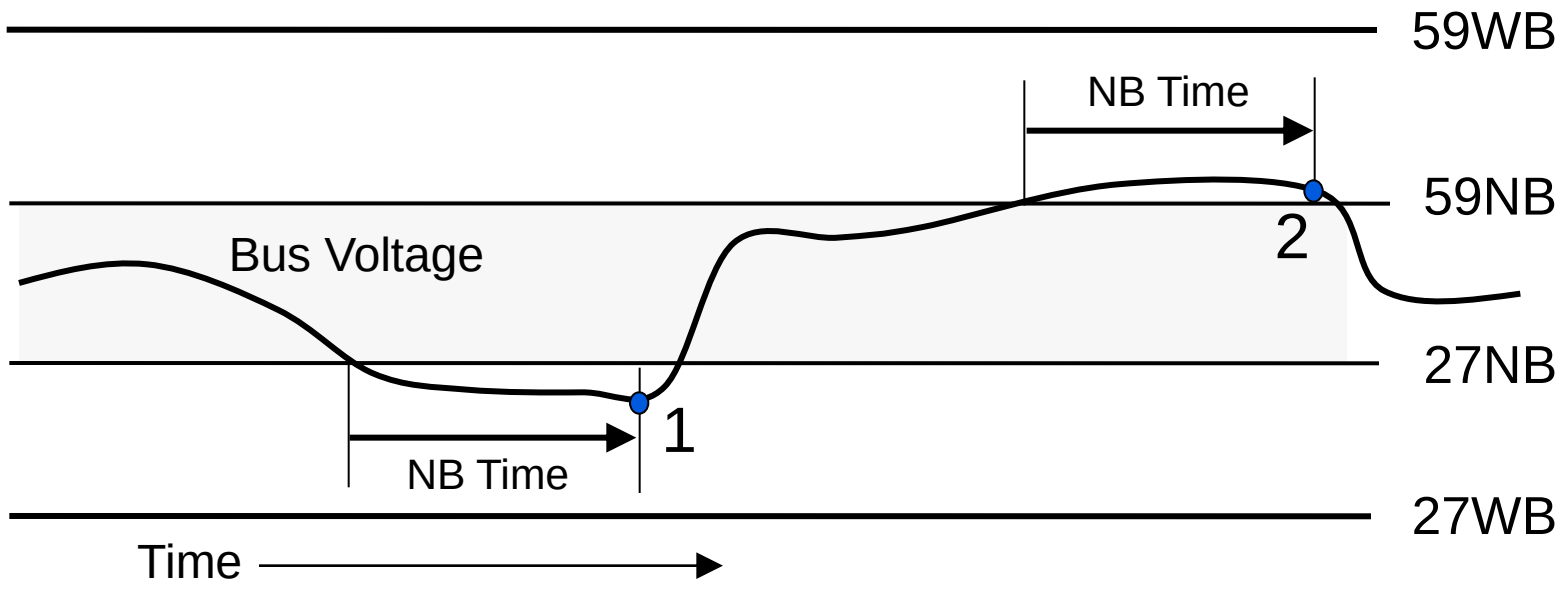
- NB or WB voltage regulation
- NB to WB transfer logic
- NB hunting and WB transfer logic
- WB hunting and manual control transfer logic
- Switch operation equalization logic

NB or WB Voltage Regulation

- Example: Add or subtract system KVAR to regulate 161 kV substation bus voltage
  - Load level
  - Amount of load switched
  - System kVAR

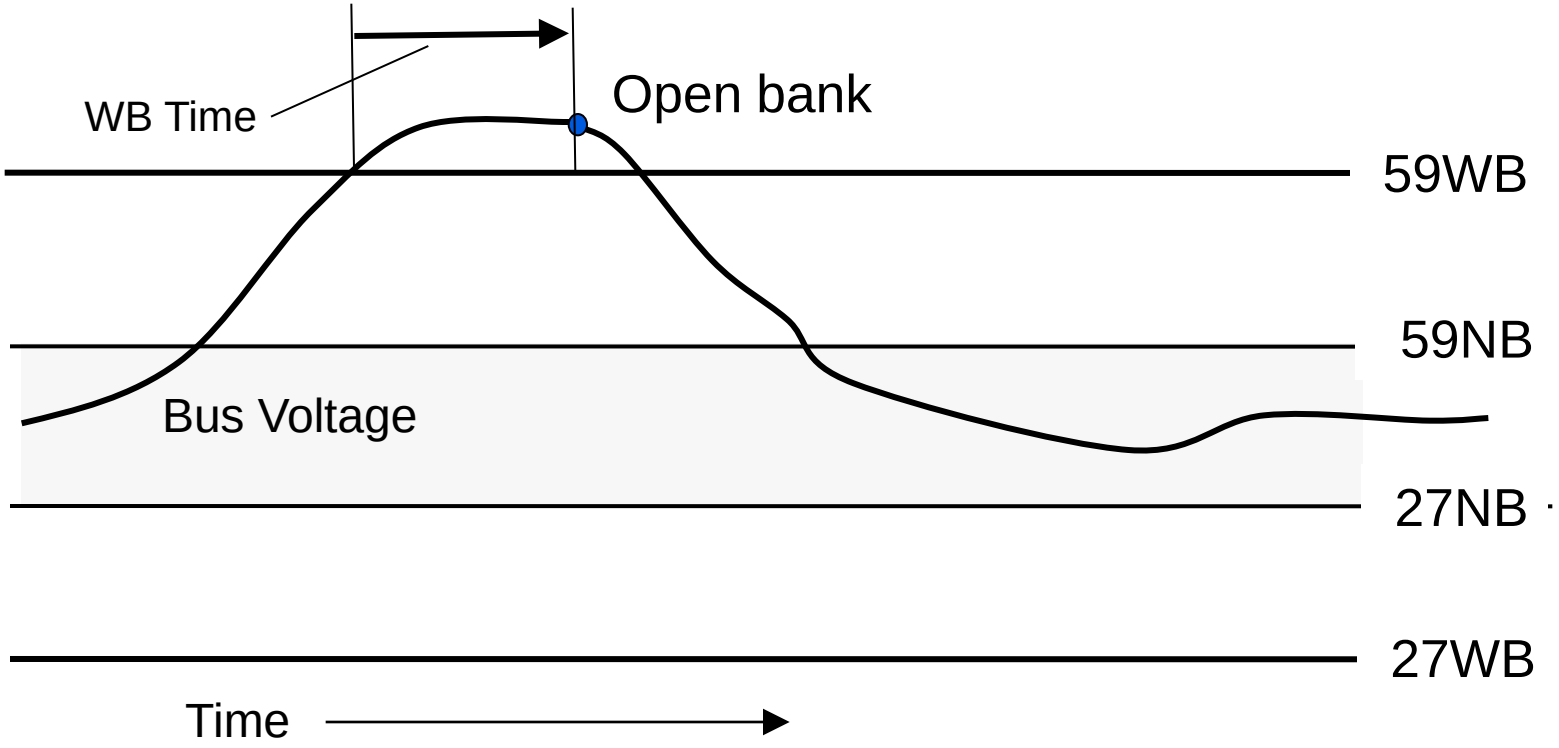


Narrowband Operation

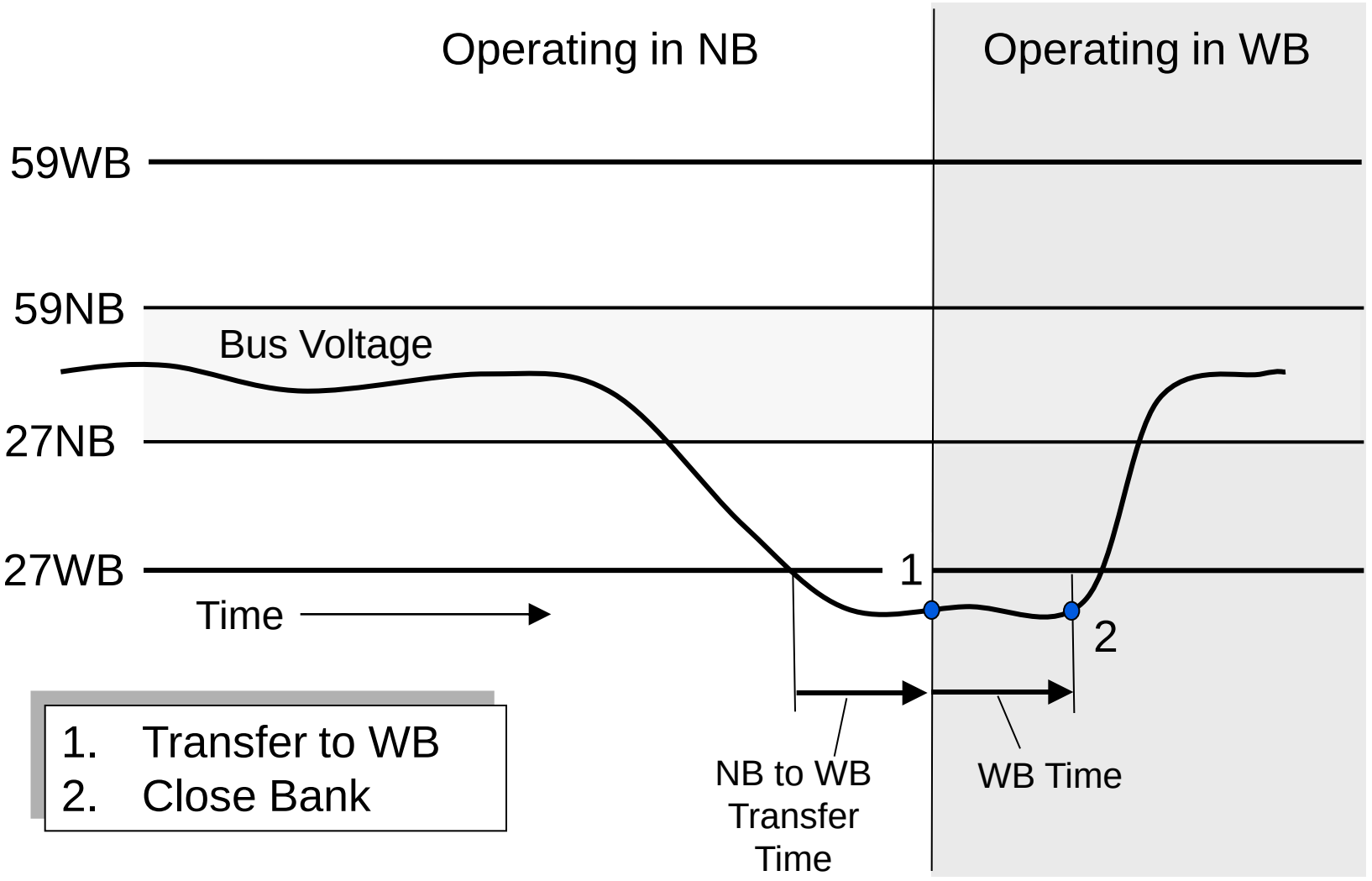


1. Close bank
2. Open bank

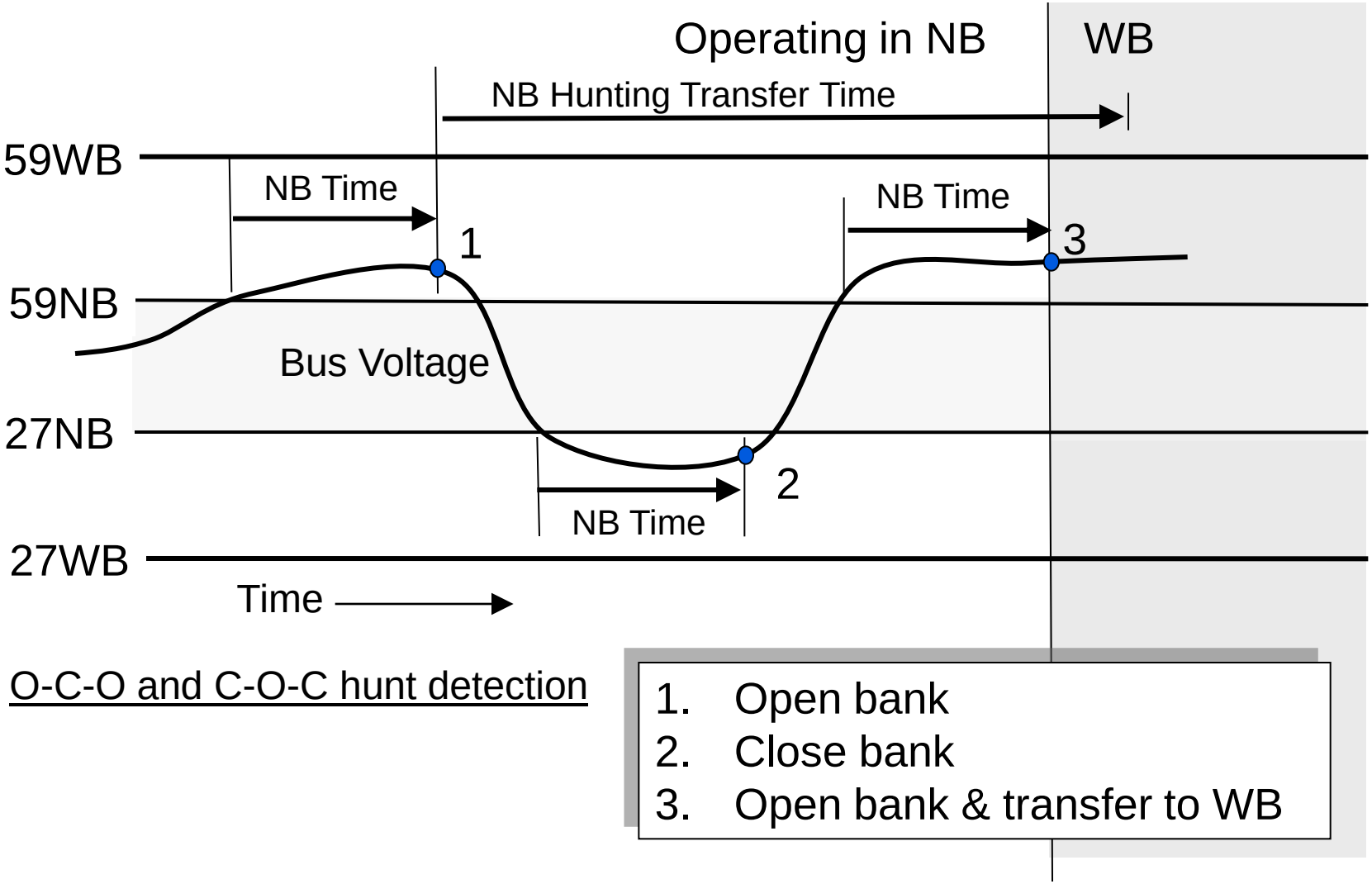
Wideband Operation



NB to WB Transfer



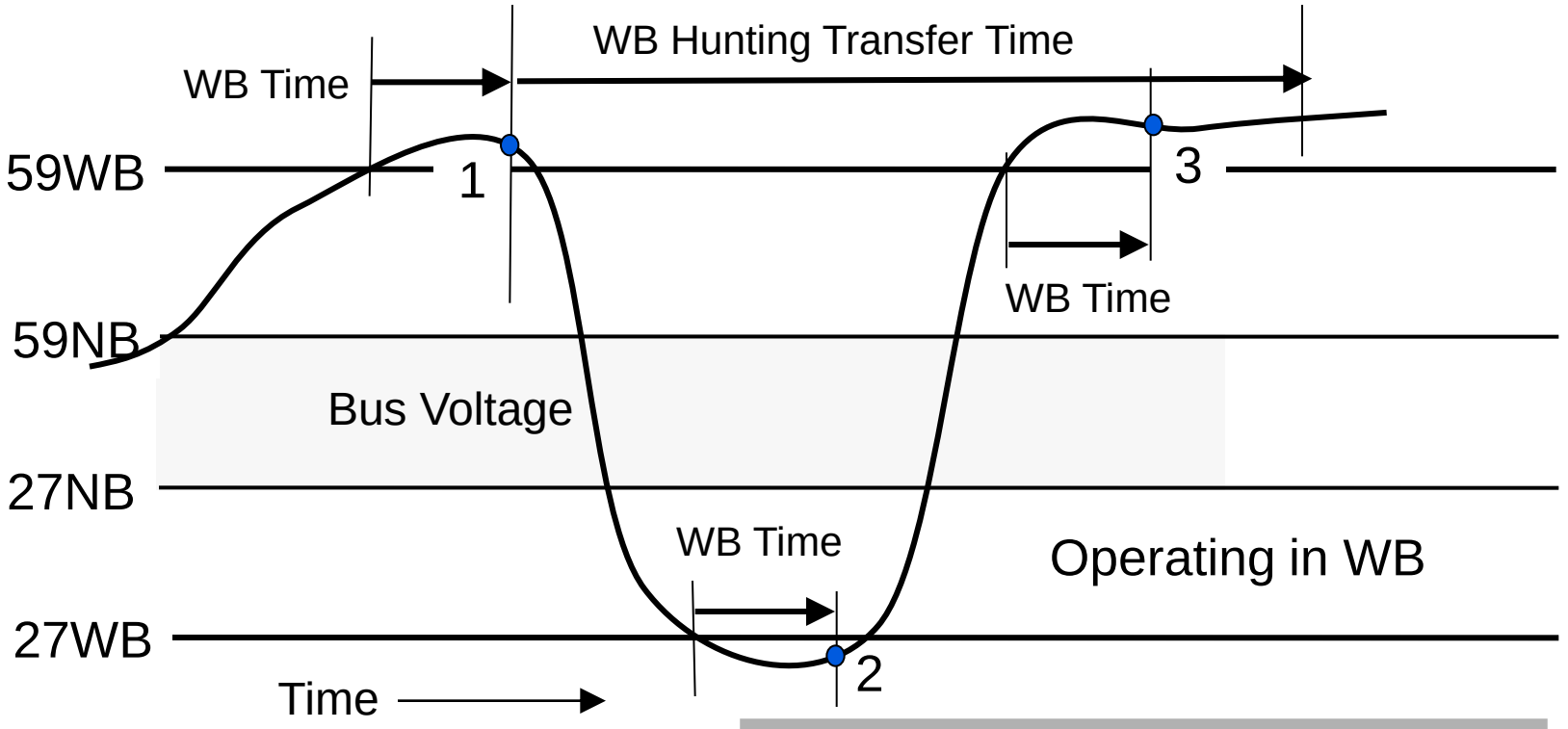
NB Hunting and WB Transfer



O-C-O and C-O-C hunt detection

1. Open bank
2. Close bank
3. Open bank & transfer to WB

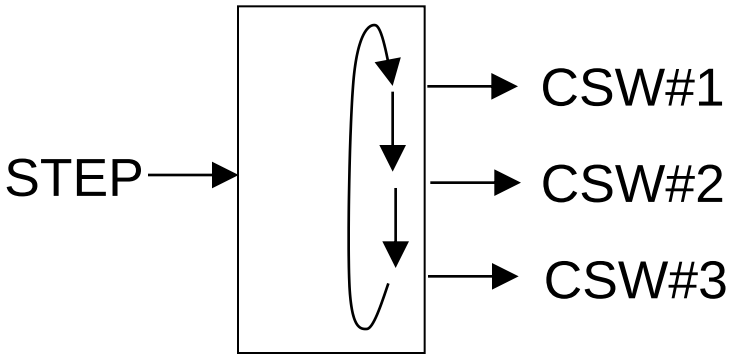
WB Hunting and MANUAL Transfer



O-C-O and C-O-C hunt detection

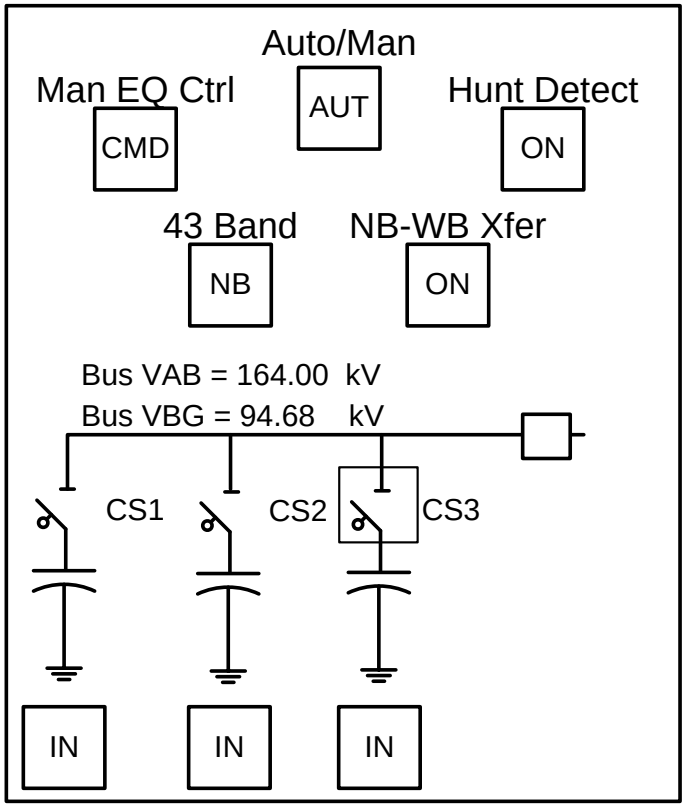
1. Open bank
2. Close bank
3. Open bank & transfer to MAN

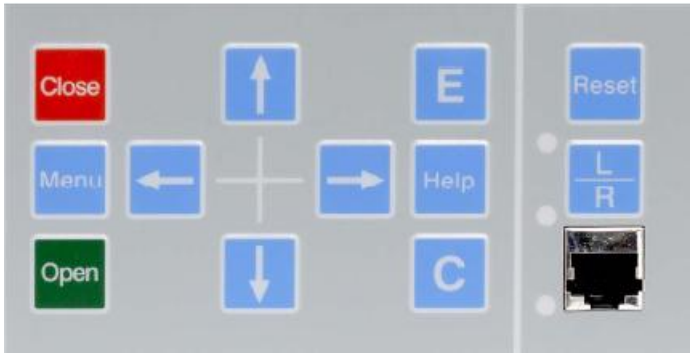
Switch Operation Equalization Logic



- Switch open and close operations are handled independently
- Only one switch is enabled to open [close] on next open a switch command [close a . . .]
- On operation command, if selected switch to open [close] is not ready (e.g. out of service, switch already open [closed]) a STEP is issued
- A STEP is issued on switch open [closed] confirmation by switch position

Control Configuration





Switch	Pos	Operation
Auto/Man	MAN	Permits manual operation of the circuit breaker and capacitor bank circuit switches from the HMI graphic controller.
	AUT	Puts the control of capacitor bank circuit switchers in the automatic mode and blocks manual operation.
Man EQ Ctrl	CMD	Provides switch operation equalization whle the Auto/Man switch is in MAN. The switch is momentary and provides an open or close pulse to the next switch scheduled to be operated. Operation is affected by the Open or Close button.
Hunt Detect	OFF	Hunt detection is off.
	ON	Hunt detection is on.
43 Band	WB	Band control is currently WB.
	NB	Band control is currently NB.
NB-WB Xfer	OFF	NB to WB transfer is off.
	ON	NB to WB transfer is on.
CS# [Service]	OUT	CS# is out of service and cannot be operated.
	IN	CS# is in service.

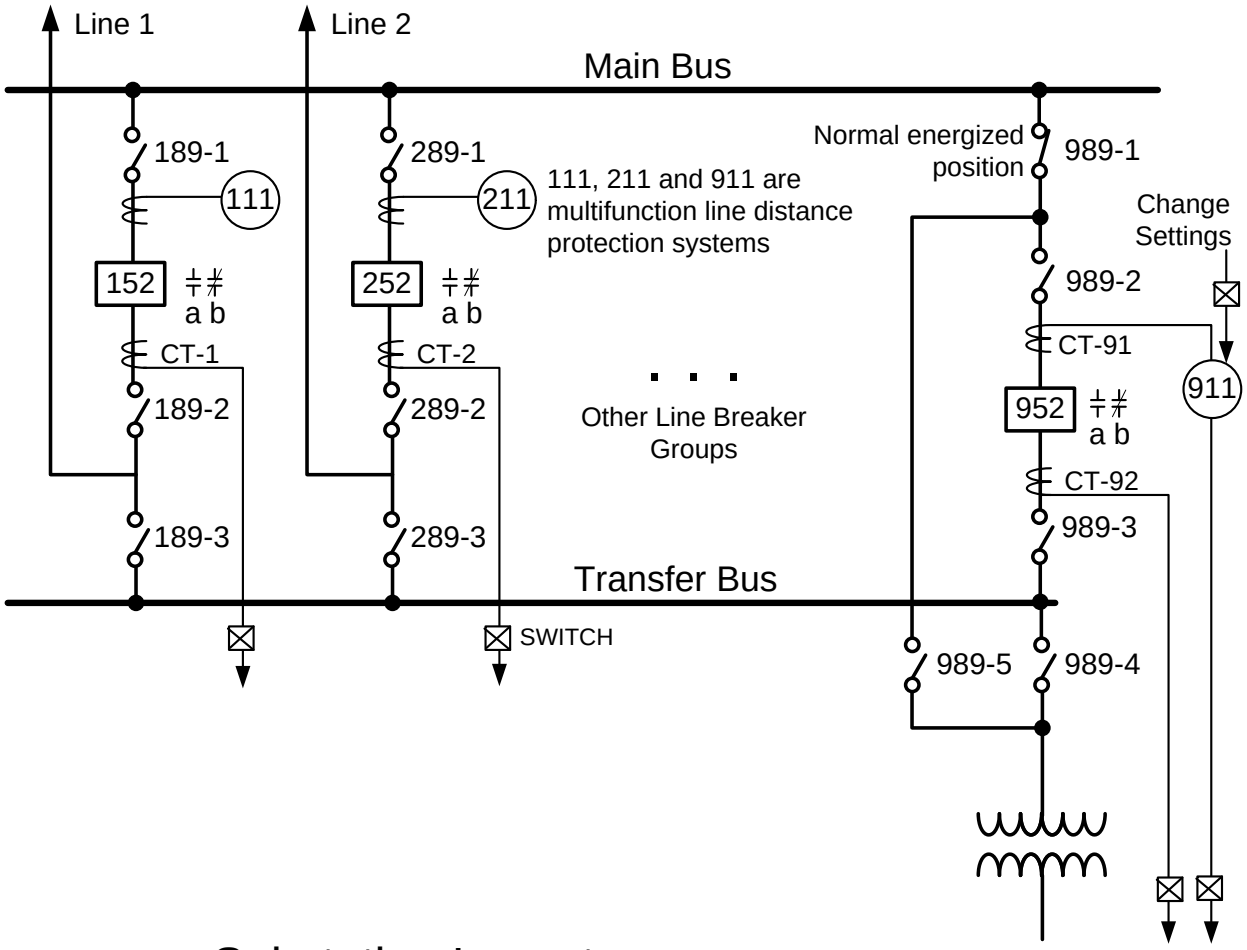
Benefits to the Customer

- Saves copper by reducing wiring
- Testing time reduce by having the controls and protection in one box
- Flexibility in the relay to add additional functionality without the need to buy additional control equipment

Line Breaker Bypass scheme

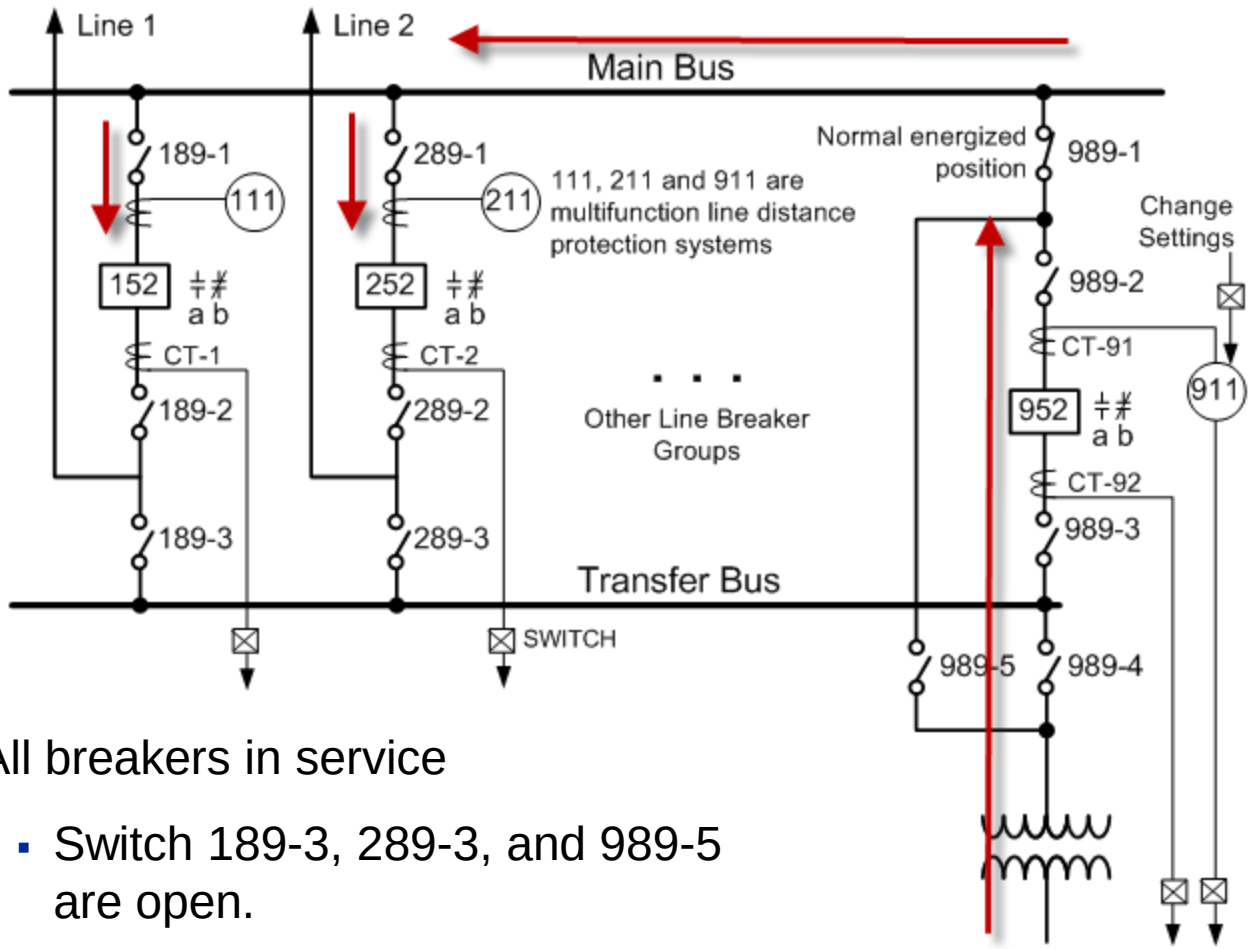
- The transformer bank differential and the bus bar differential protection is effected by which breaker is bypassed.
- Benefit of this substation layout is that any breaker can be bypassed at anytime.
- Drawback – Complex current switching scheme is needed. Protection settings must me interlocked with which breaker is bypassed.

Line Breaker Bypass scheme



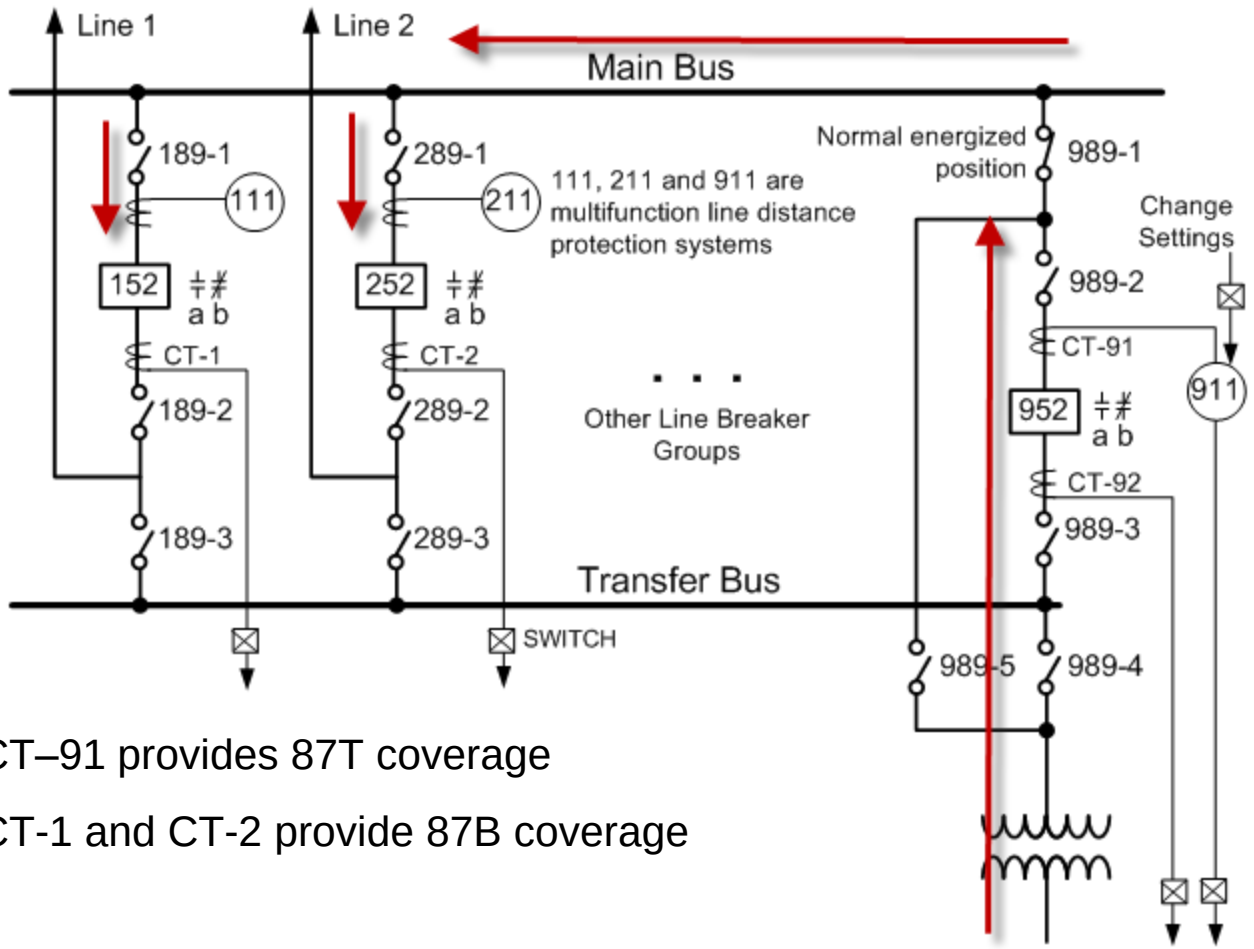
Substation Layout

Line Breaker Bypass scheme - Normal



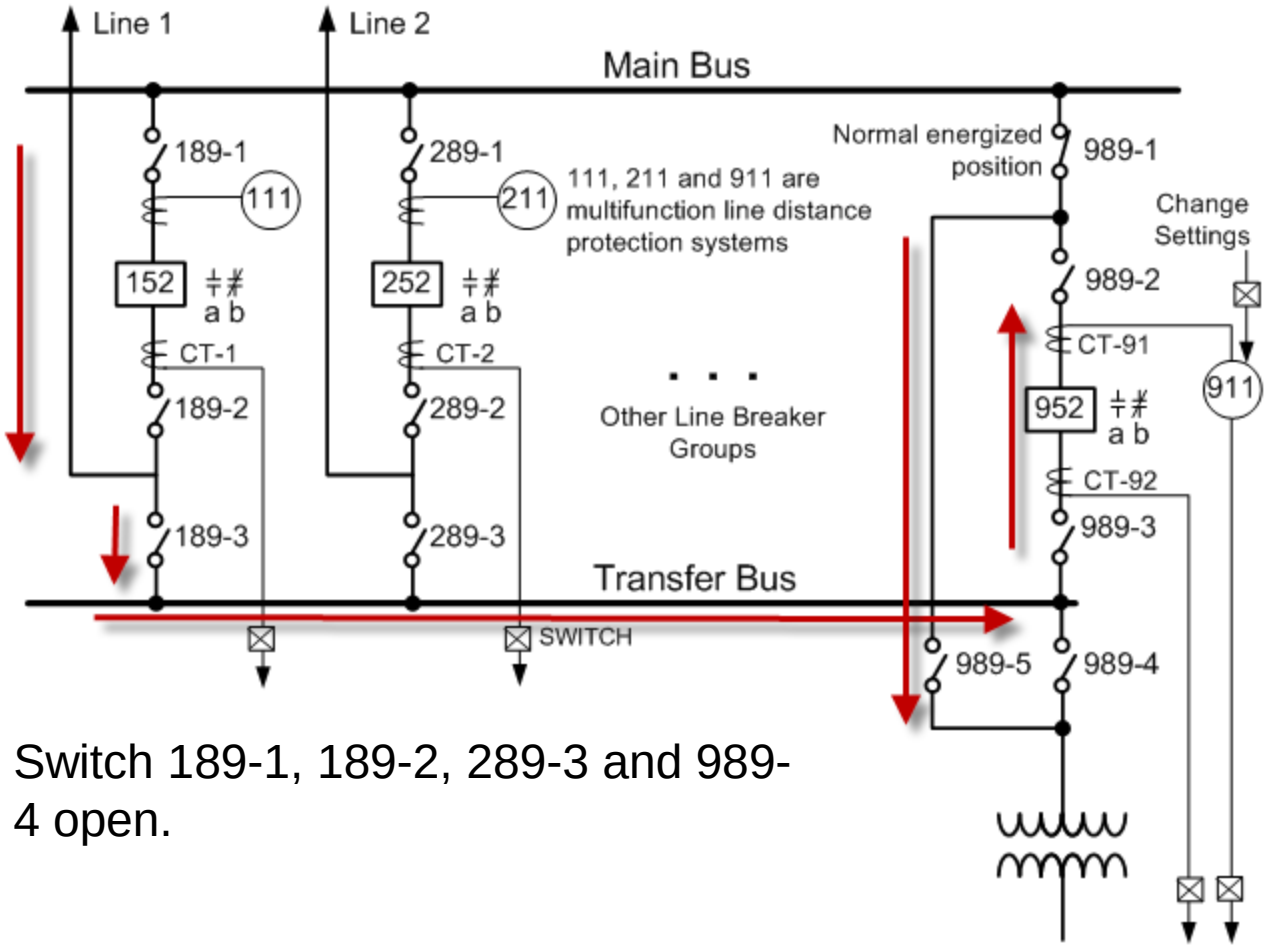
- All breakers in service
  - Switch 189-3, 289-3, and 989-5 are open.

Line Breaker Bypass scheme - Normal



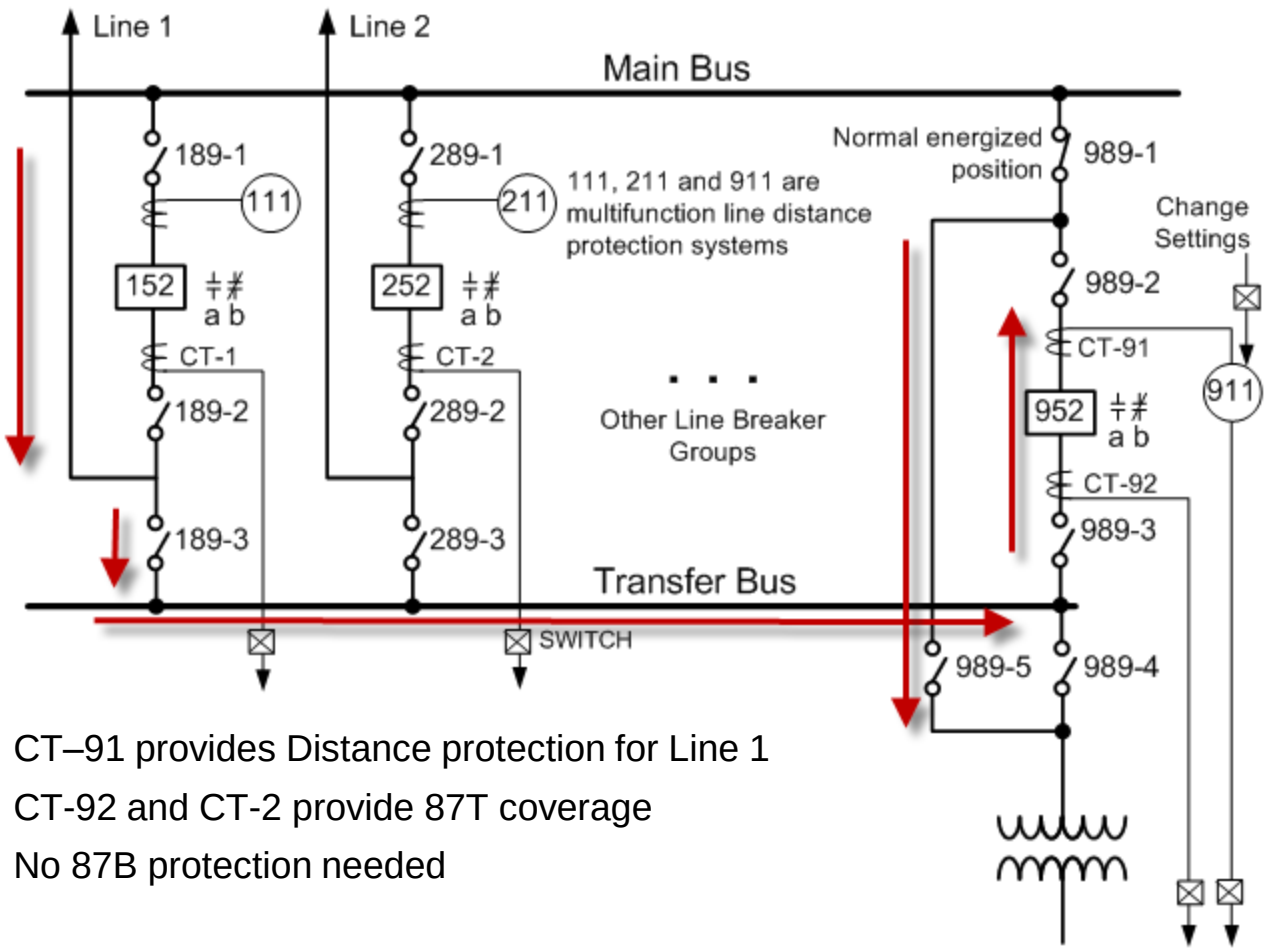
- CT–91 provides 87T coverage
- CT-1 and CT-2 provide 87B coverage

Line Breaker Bypass scheme –PCB 152 Bypassed



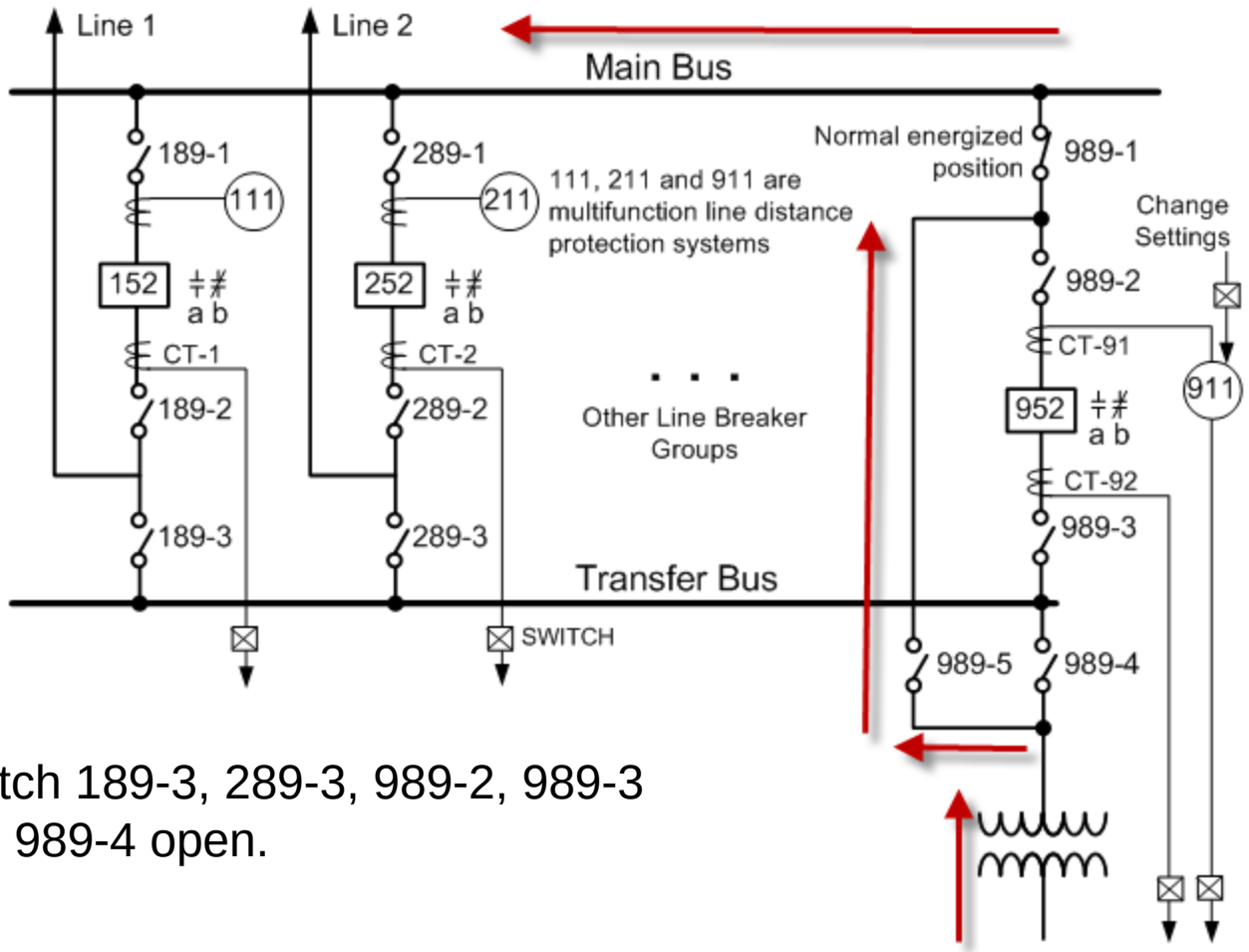
- Switch 189-1, 189-2, 289-3 and 989-4 open.

Line Breaker Bypass scheme –PCB 152 Bypassed



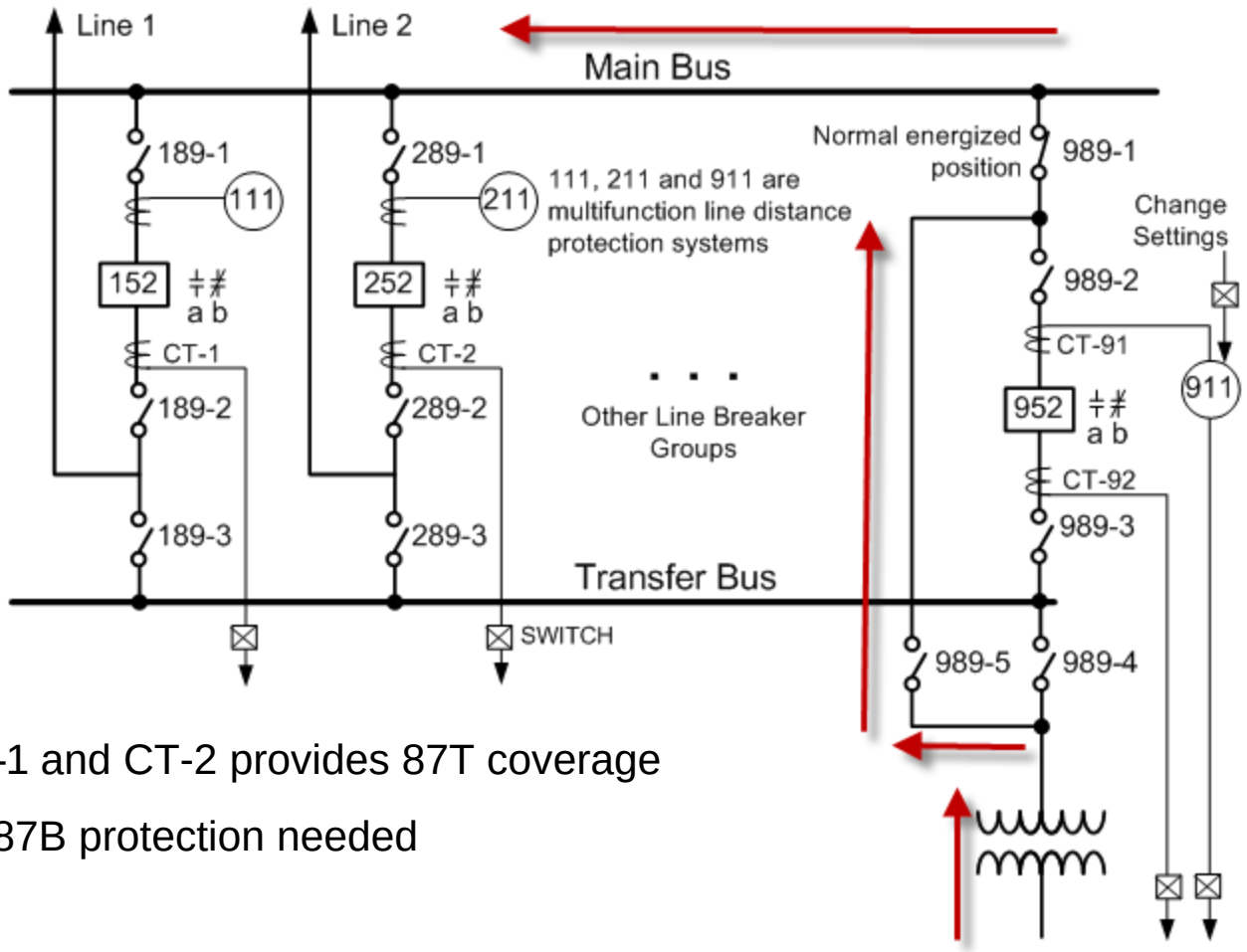
- CT–91 provides Distance protection for Line 1
- CT-92 and CT-2 provide 87T coverage
- No 87B protection needed

Line Breaker Bypass scheme – PCB 952 bypassed



- Switch 189-3, 289-3, 989-2, 989-3 and 989-4 open.

Line Breaker Bypass scheme – PCB 952 bypassed



- CT–1 and CT-2 provides 87T coverage
- No 87B protection needed

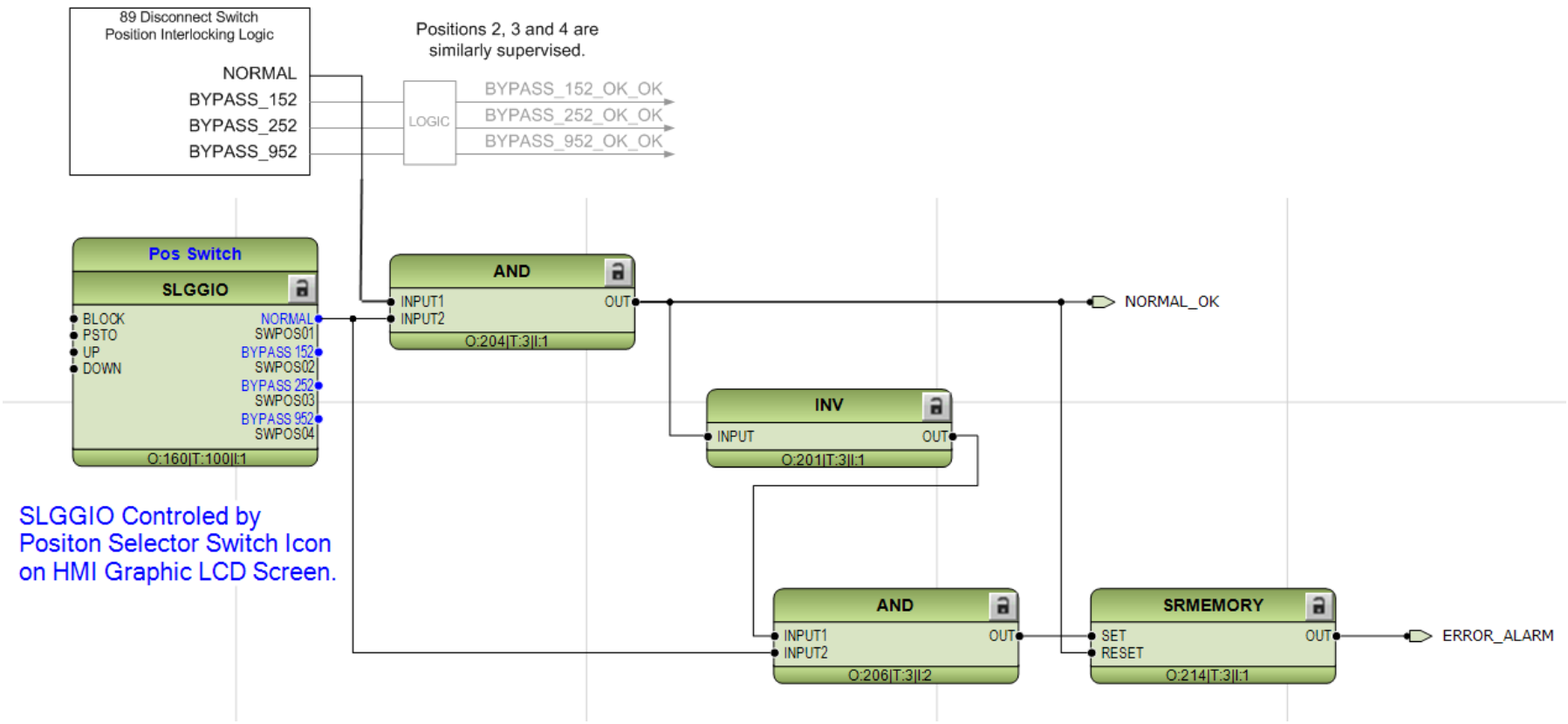
Line Breaker Bypass scheme – Existing setup

- Switching is done manually with a stacked (multiple contacts) position selector switch.
  - In this case the positions are Normal, Bypass 152, Bypass 252 and Bypass 952
  - This includes switching the CTs to the correct protection zone, changing the 911 settings [usually through contact input] when bypassing a line breaker and appropriately switching the 87B and 87T lockout circuit to meet the bypass configuration.
- This scheme requires lots of wiring and terminations, large switches, comprehensive design and installation effort and considerable testing, most of which can be eliminated.

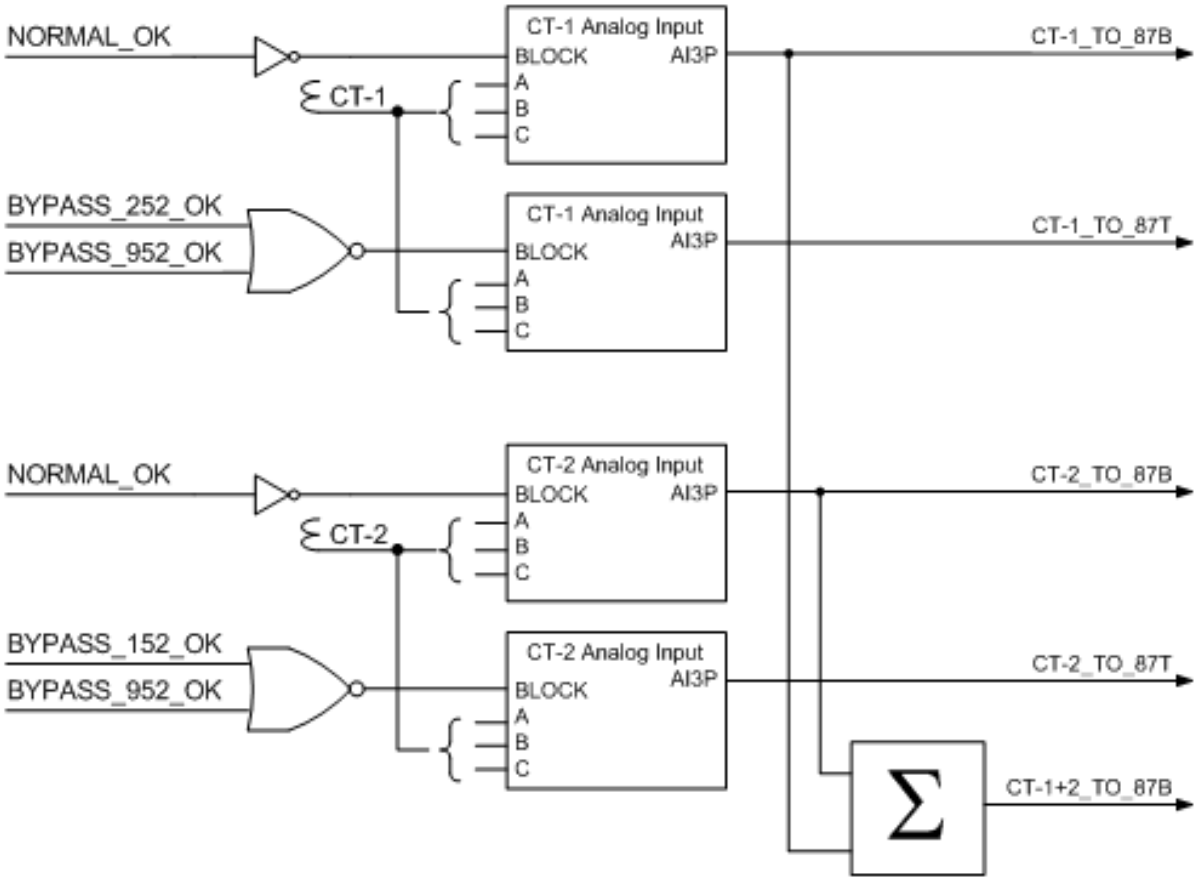
Line Breaker Bypass scheme – Relion Solution

- Develop logic to determine what configuration the substation is in.
  - Use the substation disconnect switch positions to develop interlock logic
  - Supervise with a virtually selector switch on relay or station HMI

Line Breaker Bypass scheme – Relion Solution



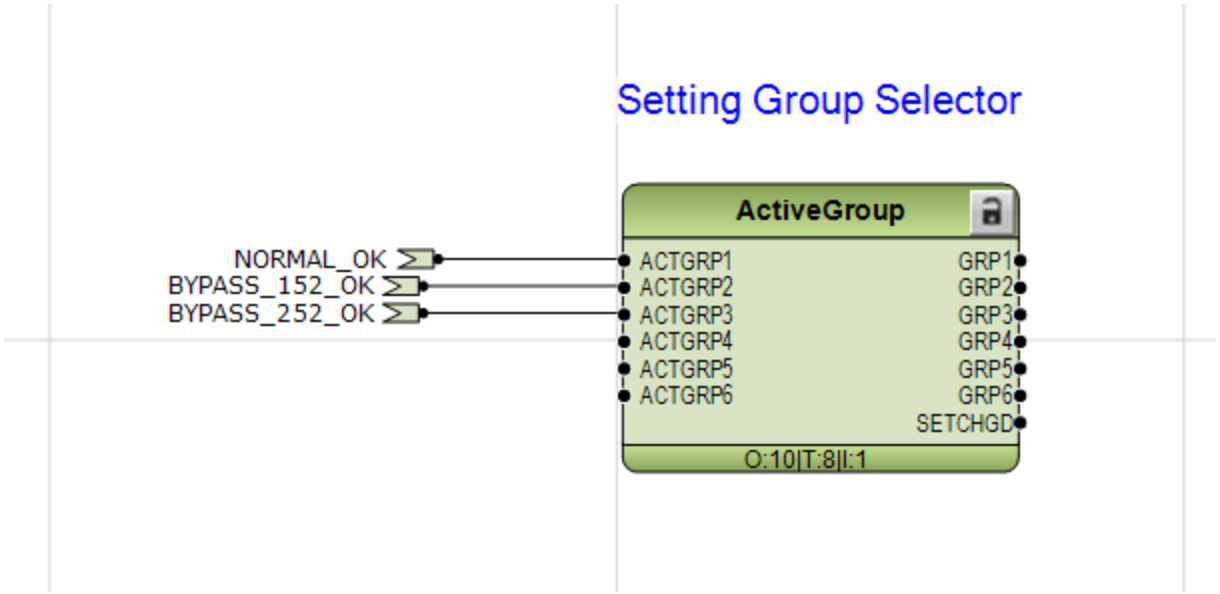
Line Breaker Bypass scheme – Virtual CT Switching



- Once virtual wiretags are developed, they can be used to control which current transformers are used for the transformer differential and bus differential (87T and 87B). Logic for switching CT-91 and CT-92 can be similarly developed.

Line Breaker Bypass scheme – Changing the 911 Settings

- Use same virtual wiretags to supervise the active setting group of the 911 relay.



Benefits to the Customer

- Complex current switching scheme can now be easily addressed with the use of IEC 61850 function blocks
- Interlocks can be easily developed and verified with the use of function blocks to prevent system misoperations by applying an incorrect setting group to the relay
- Switching currents virtually instead of using a gang operated disconnect (prevents opening a current transformer)

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