This webinar brought to you by the Relion® product family

Relion. Thinking beyond the box.

Designed to seamlessly consolidate functions, Relion relays are smarter, more flexible and more adaptable. Easy to integrate and with an extensive function library, the Relion family of protection and control delivers advanced functionality and improved performance.

ABB Protective Relay School Webinar Series

Disclaimer

ABB is pleased to provide you with technical information regarding protective relays. The material included is not intended to be a complete presentation of all potential problems and solutions related to this topic. The content is generic and may not be applicable for circumstances or equipment at any specific facility. By participating in ABB's web-based Protective Relay School, you agree that ABB is providing this information to you on an informational basis only and makes no warranties, representations or guarantees as to the efficacy or commercial utility of the information for any specific application or purpose, and ABB is not responsible for any action taken in reliance on the information contained herein. ABB consultants and service representatives are available to study specific operations and make recommendations on improving safety, efficiency and profitability. Contact an ABB sales representative for further information.

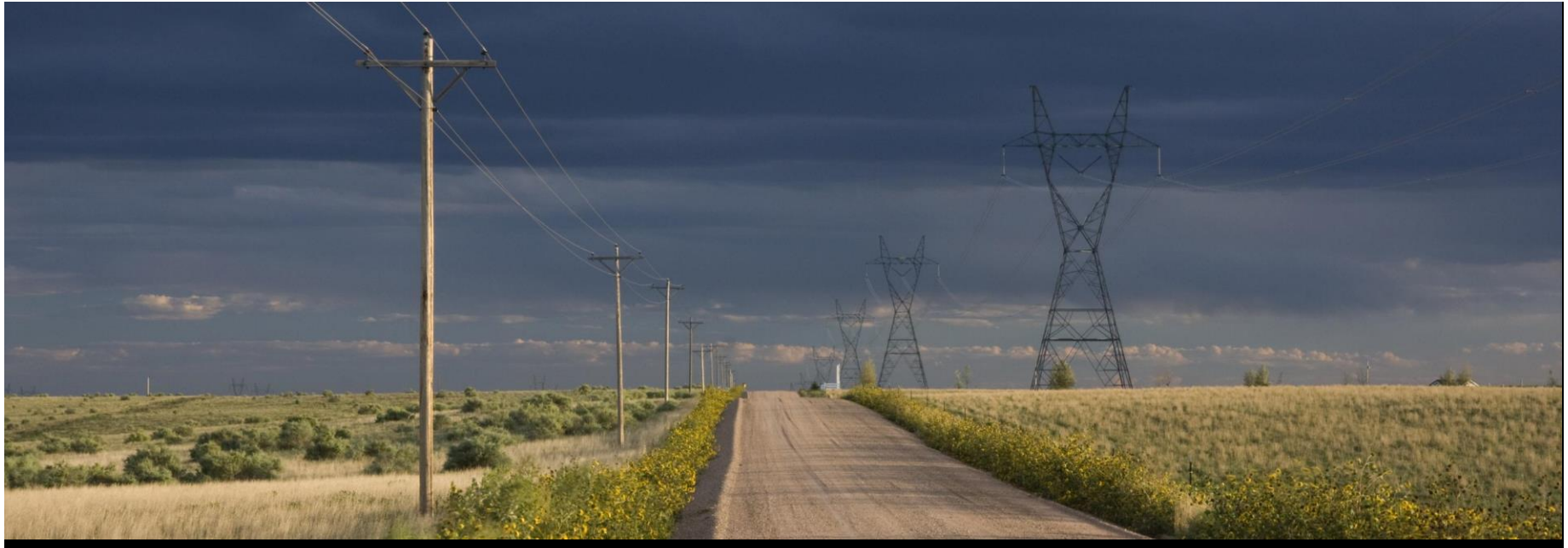


ABB Protective Relay School Webinar Series

Substation Controls Using Relays

Jay Hicks

10/28/2014

Presenter

Jay Hicks is a Regional Technical Manager serving the Southeast Region for ABB, located in Chattanooga, Tennessee. Primary responsibility is to support ABB's high voltage line of protective relays and controllers.

Prior to his work at ABB, Jay was a Senior Protection and Control Engineer at Tennessee Valley Authority. He was responsible for the Protection and Control design package, consisting of calculations, drawings, inter- departmental interface documents, and construction assisting documents for substations and switchyards.

Jay graduated from Tennessee Technological University with BSEE degree and is a member of IEEE. Jay can be reached at jay.b.hicks@us.abb.com

Learning objectives

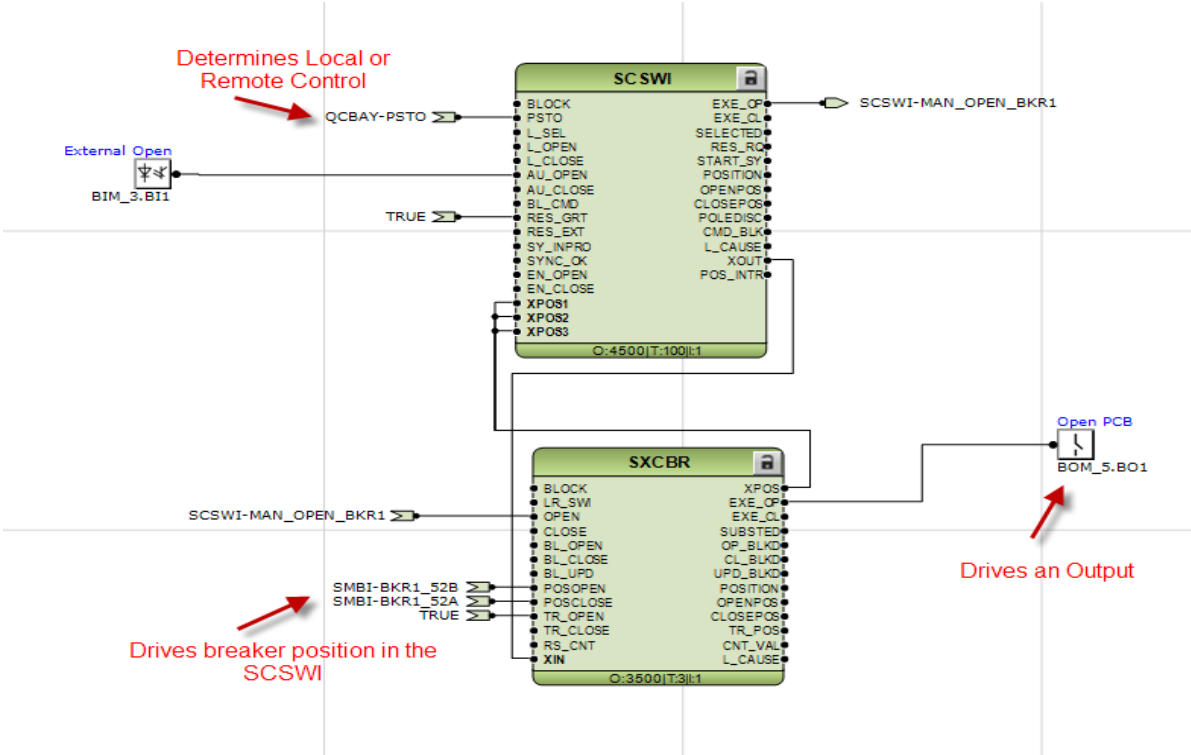
- Review of Manual Trip and Close logic and considerations for a power circuit breaker
- Review Capacitor Bank Manual and Automatic Control
  - Understand the control philosophy of using a Automatic Capacitor Bank Control scheme and integrating manual control to that scheme to optimize bank usage.
- Review Line Breaker Bypass scheme
  - Complex design involving instrument transformer switching can be drastically simplified by using logic in the IED.

Manual Trip logic

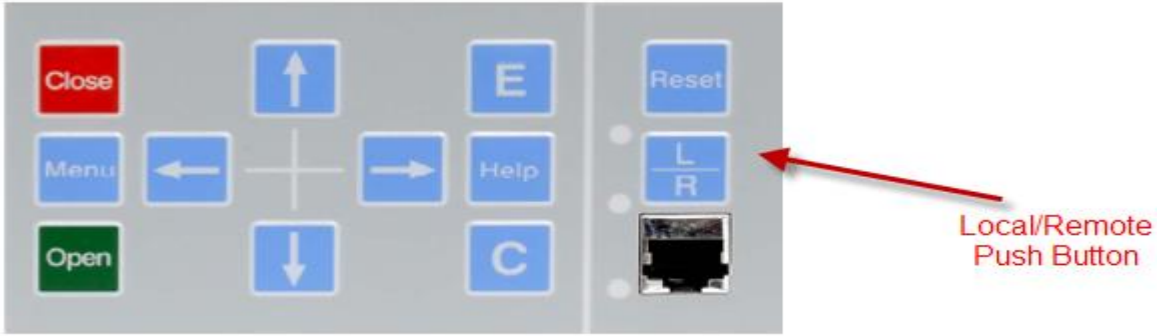
- Considerations
  - Manual Tripping of a breaker must be supervised by the remote/local switch.
  - Must have ability to Trip breaker locally or by DNP 3.0.

Manual Trip logic needed

- The Switch controller (SCSWI) initializes and supervises all functions to properly select and operate switching primary apparatuses.
- The purpose of Circuit breaker (SXCBR) is to provide the actual status of positions and to perform the control operations, that is, pass all the commands to primary apparatuses in the form of circuit breakers via output boards and to supervise the switching operation and position.

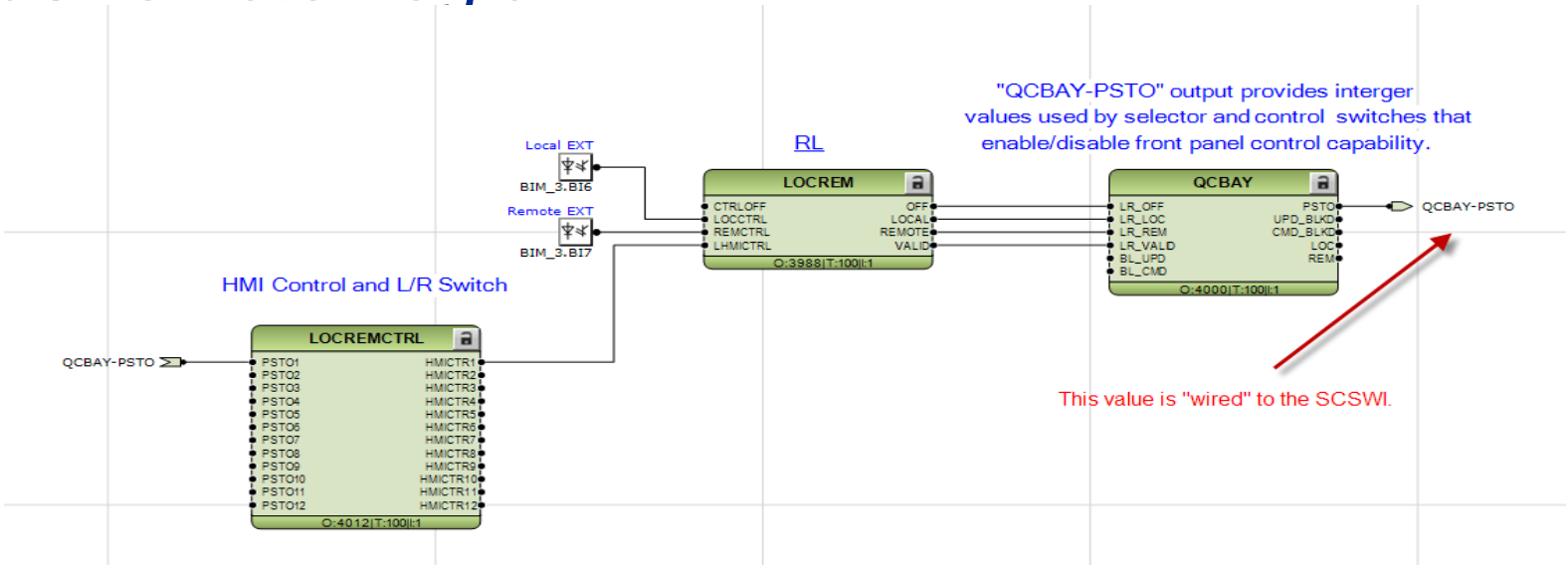


Local/Remote Logic



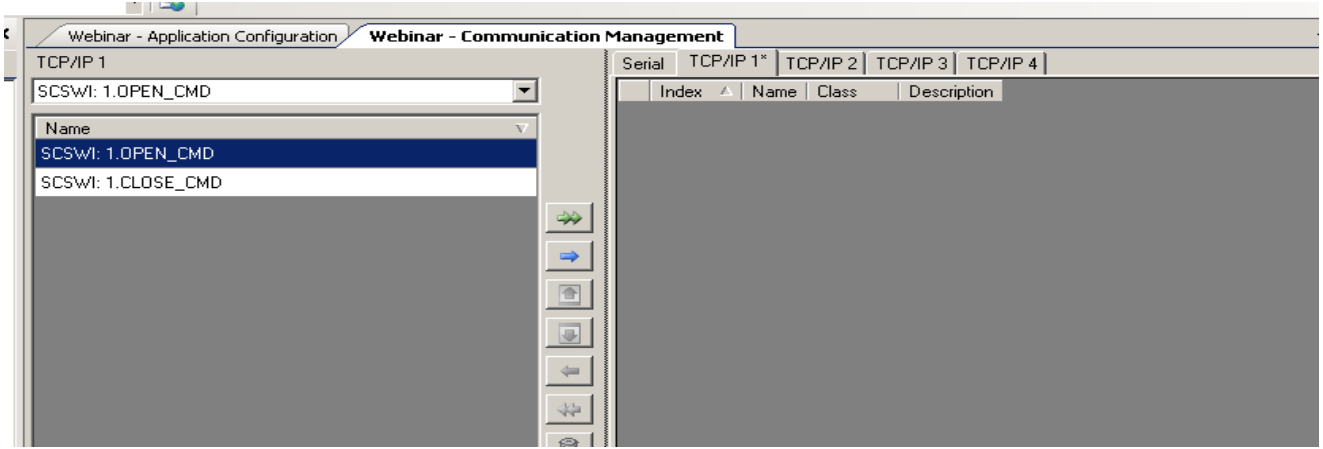
- Local/Remote can be controlled externally or internally.
- LED’s beside L/R switch indicate position.

Local/Remote Logic

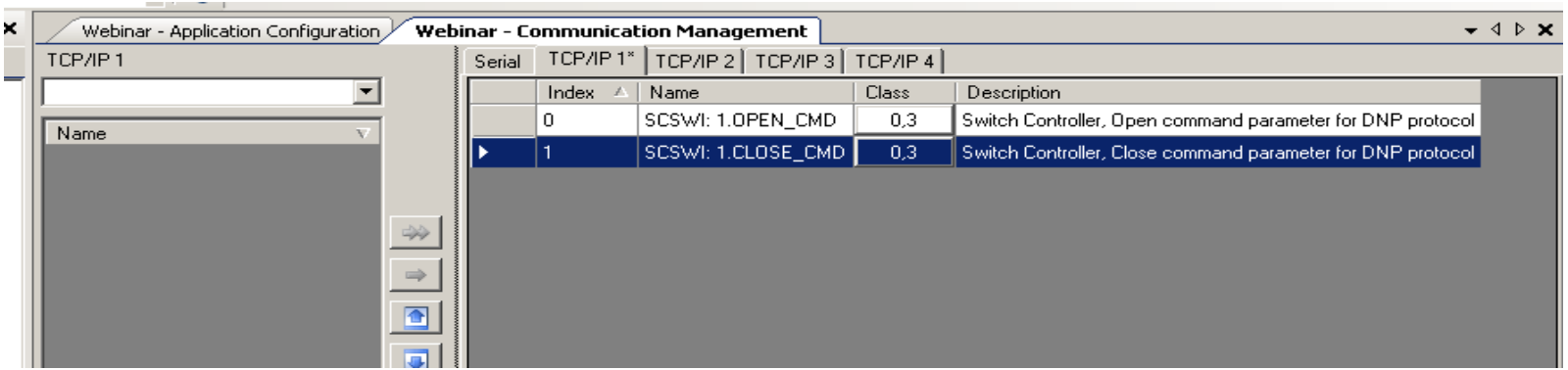


- Setting in the “LOCREM” can be set to “Internal LR” or “External LR”,

DNP Control



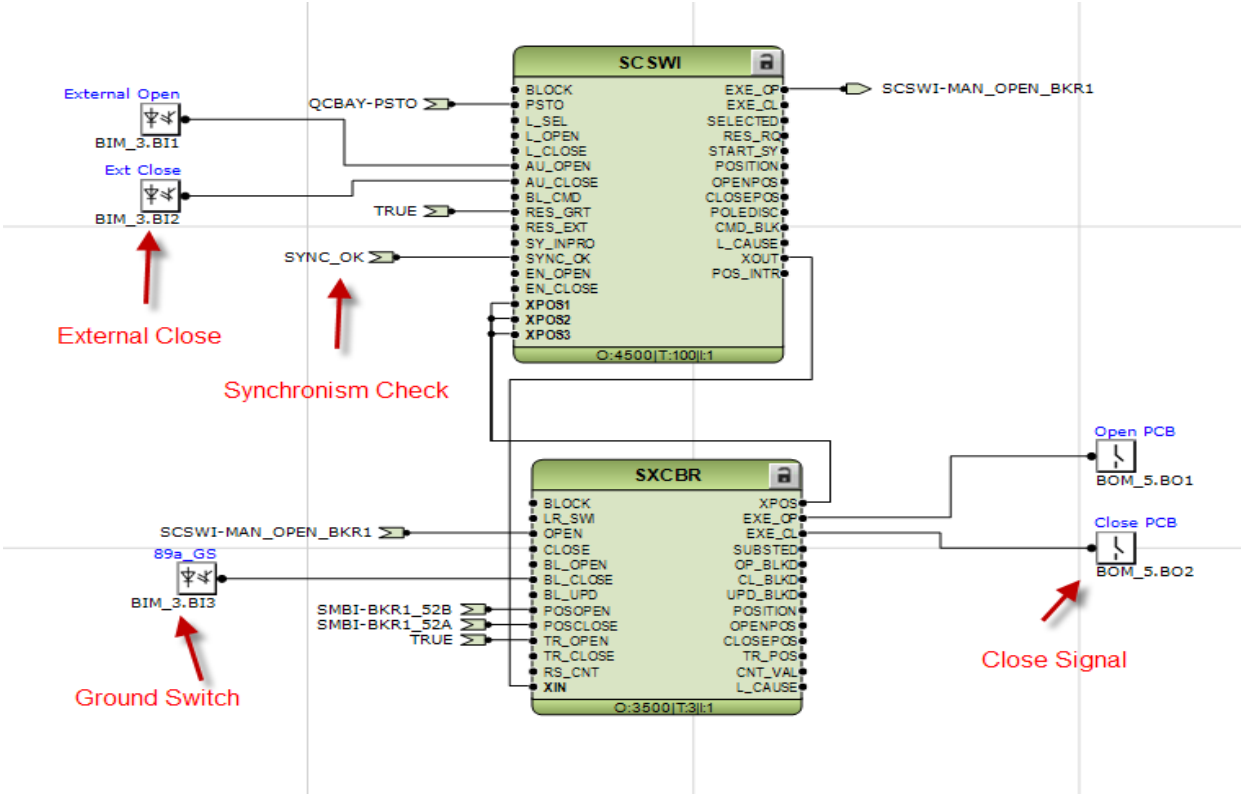
- Move selected DNP controls to desired master.



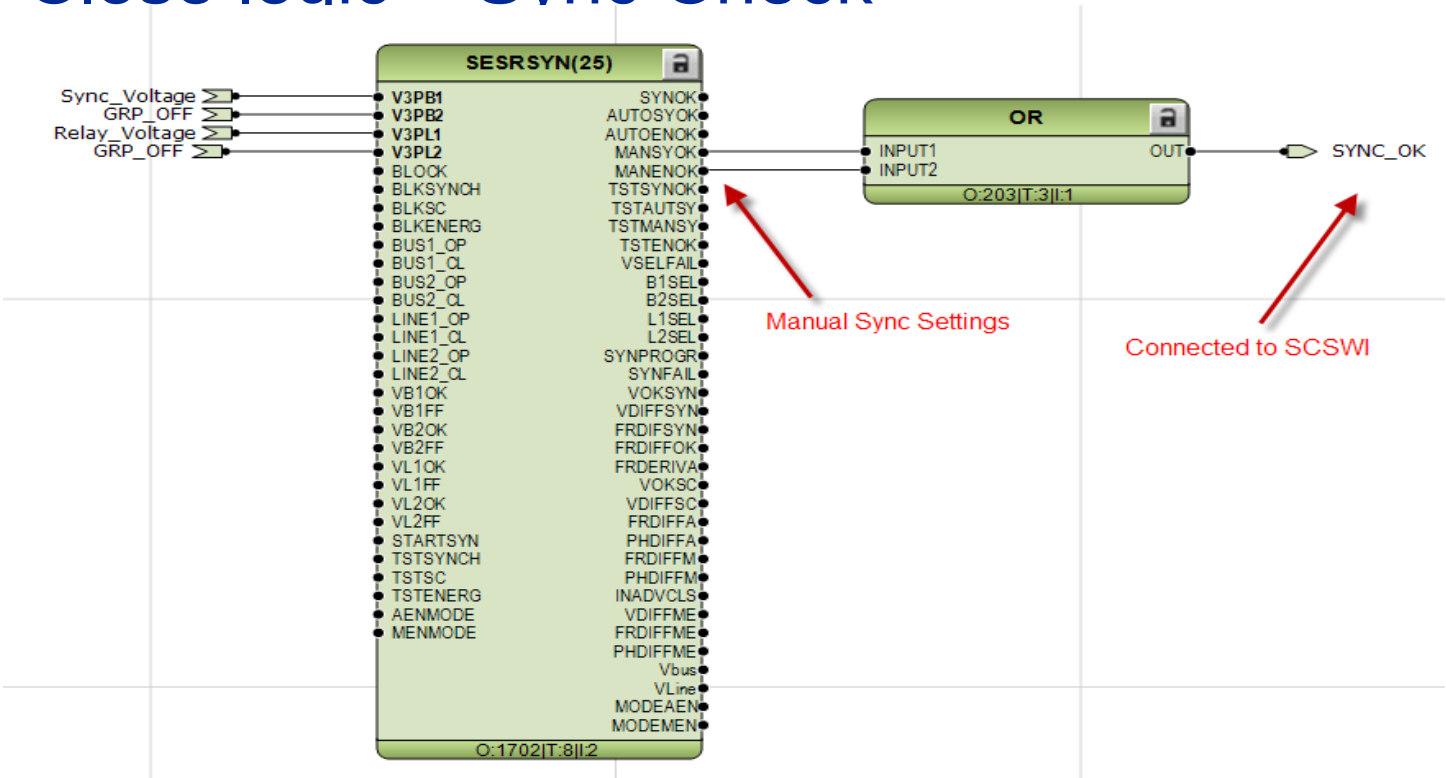
Manual Close logic

- Considerations
  - Manual Closing of a breaker must be supervised by the remote/local switch.
  - Must have ability to Close breaker locally or by DNP 3.0.
  - Prevents closing based on system conditions.

Manual Close logic

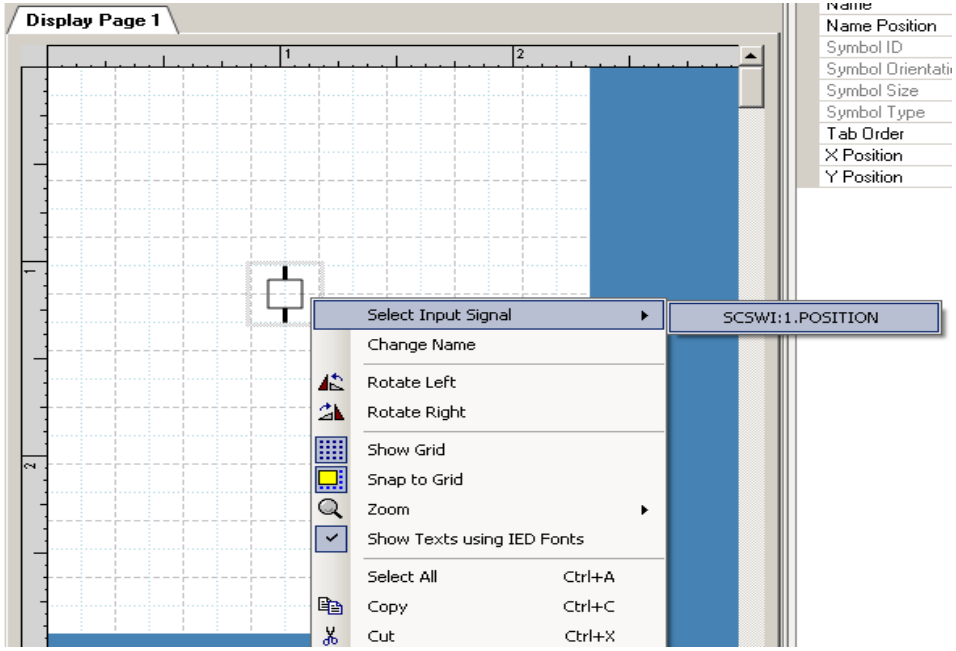


Manual Close logic – Sync Check



- Manual Sync is used to allow for the addition of DBDL close.

Manual Close logic – HMI Control

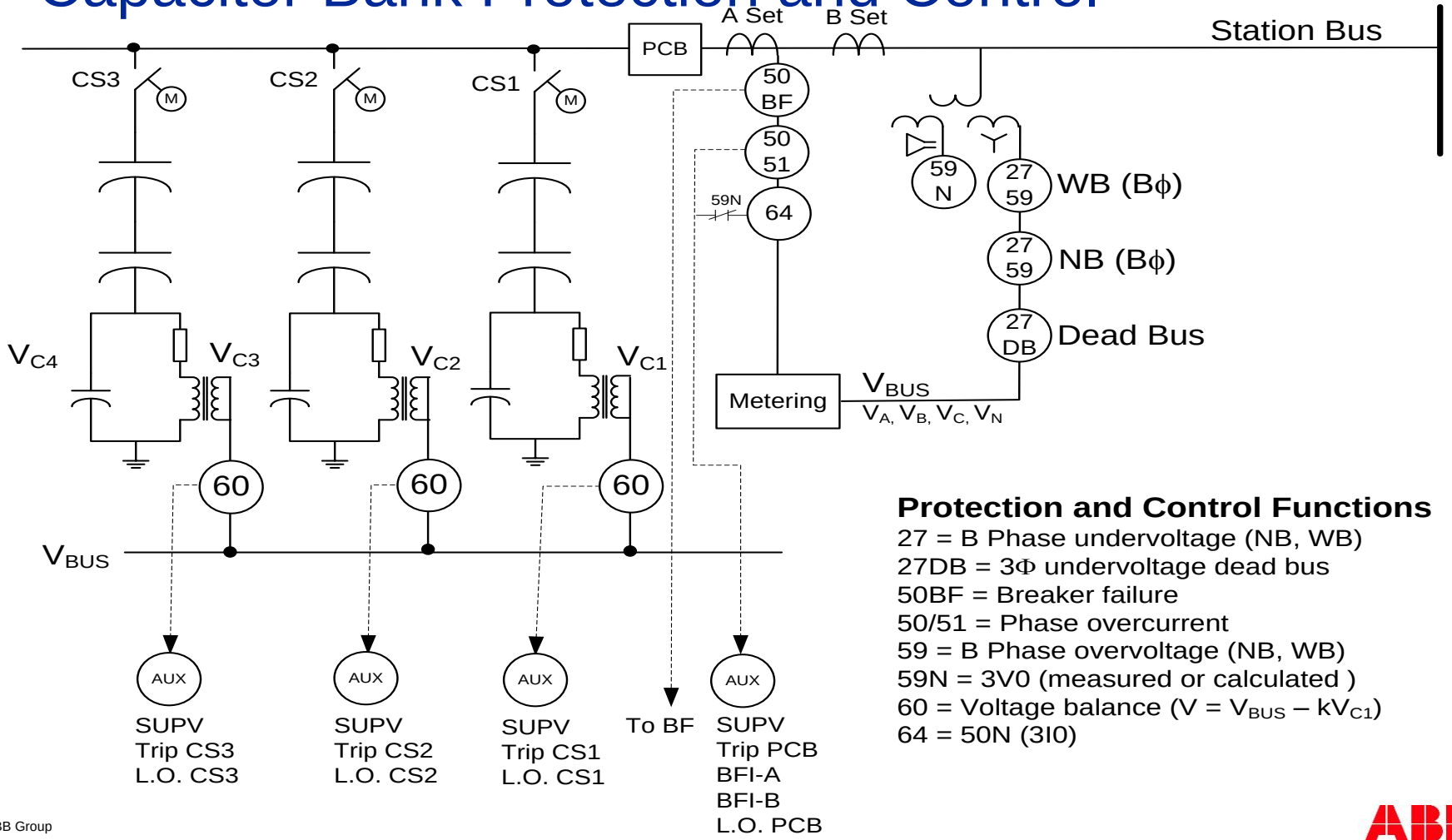


- This allows breaker to be controlled using the HMI screen on front of the relay.

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.
- This customer specific application shows some key control aspects from the Relion relay.

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)

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

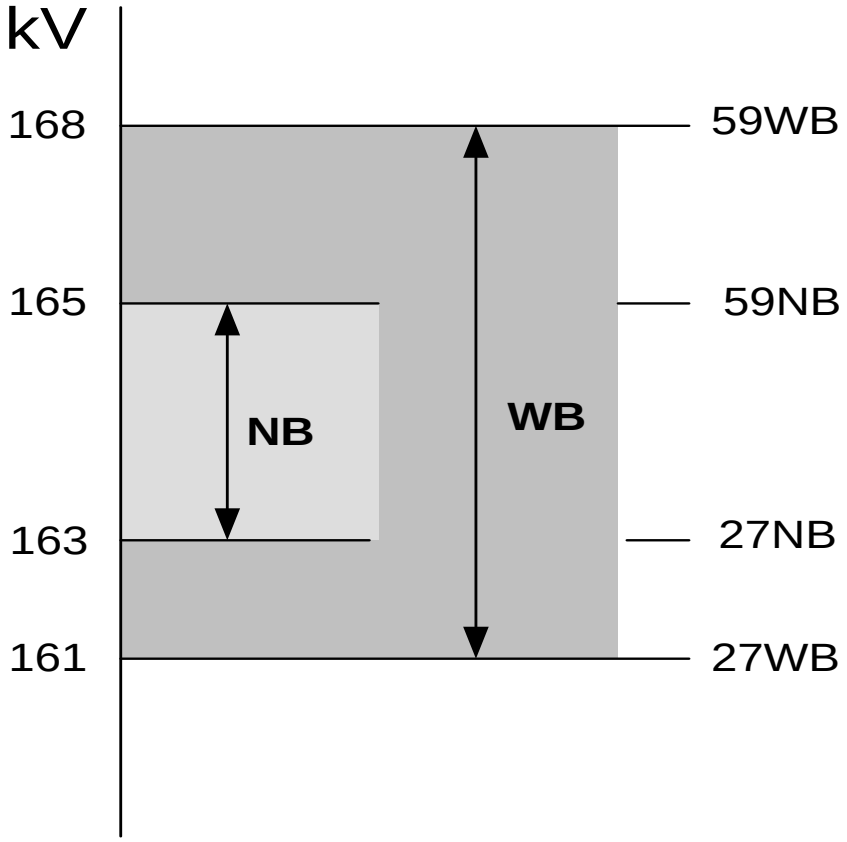
- Operate bank circuit switchers (CSW)
  - Local HMI graphic screen control
- Remote SCADA (IEC61850 or DNP 3.0)
  - Local or Remote “manual” switch operation equalization logic
  - Used to select the circuit switcher that was next in line to be operated
  - Very customer specific application.

Automatic Control

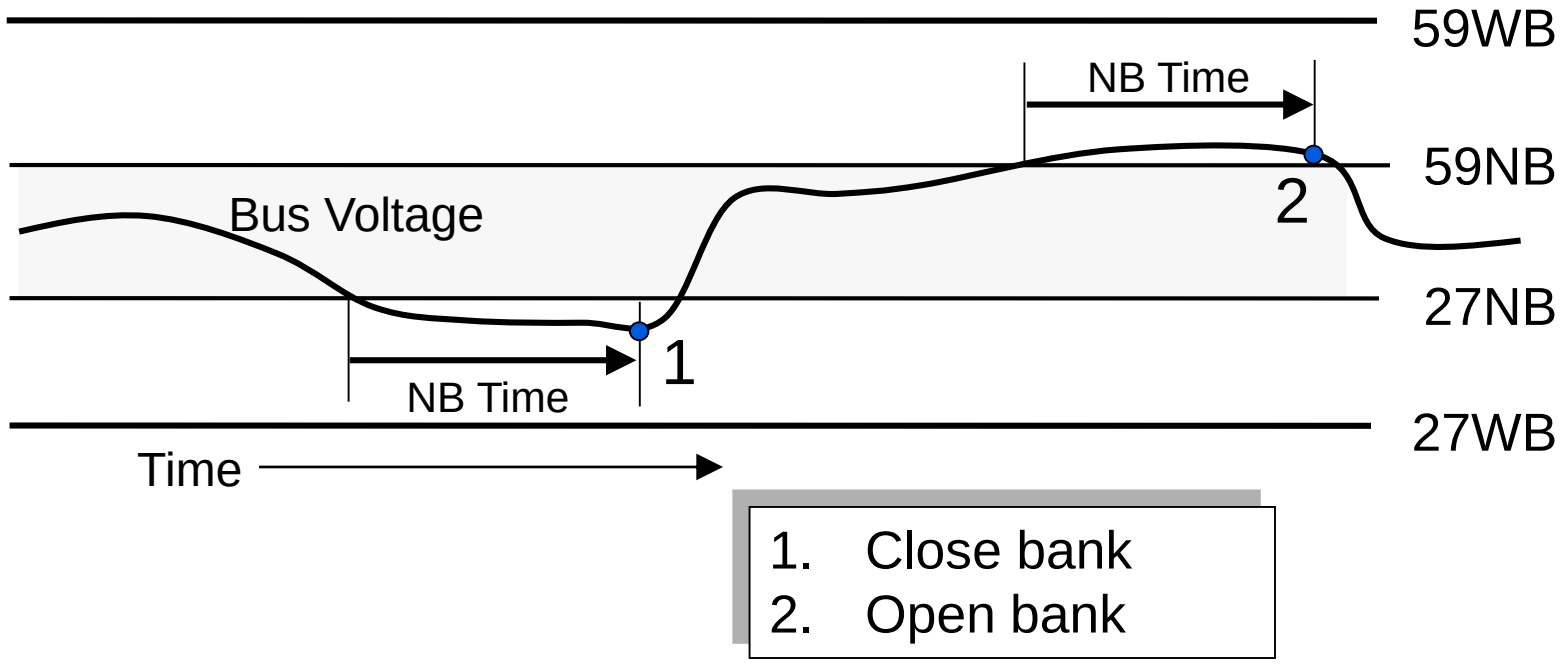
- NB or WB voltage regulation
- NB to WB transfer logic
- NB hunting and WB transfer logic
- WB hunting and manual control transfer logic
- Switch operation equalization logic

NB or WB Voltage Regulation

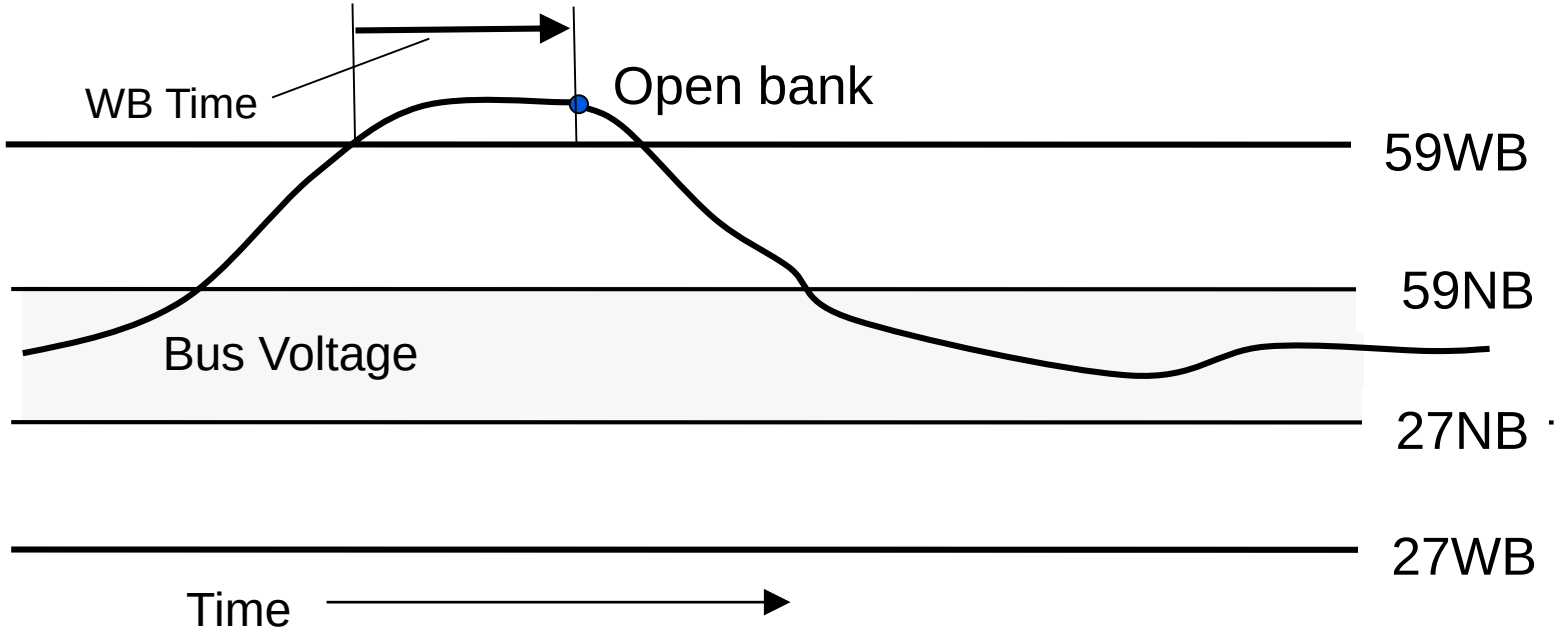
- Example: Add or subtract system KVAR to regulate 161 kV substation bus voltage
  - Load level
  - Amount of load switched
  - System kVAR



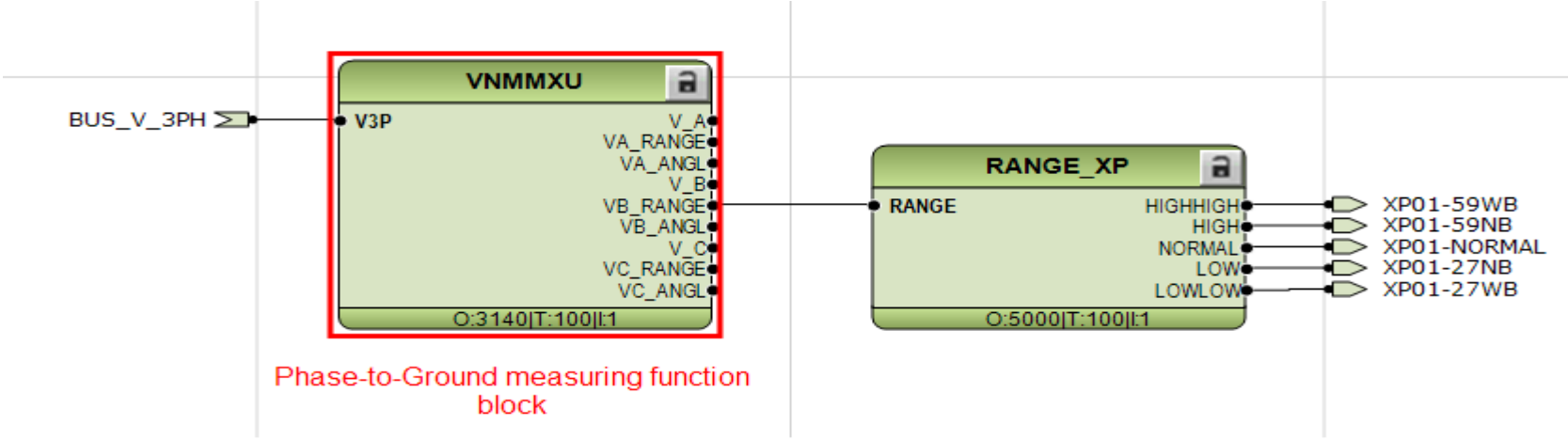
Narrowband Operation



Wideband Operation



NB or WB Voltage Regulation – How is it done?



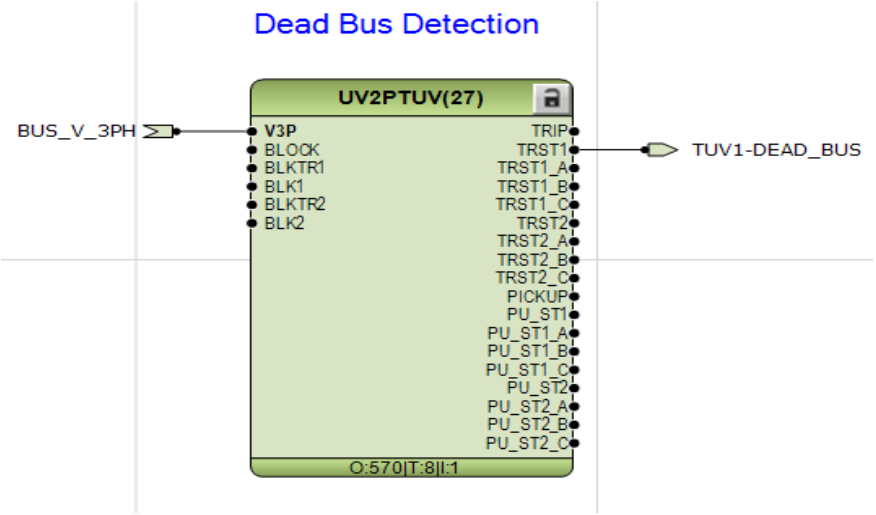
- "VNMMXU" measures phase-to-ground voltages
  - VB_RANGE has associated settings for output to an "RANGE_XP" for binary outputs.
  - 59WB and 59NB drive an "Overvoltage" condition, and 27NB and 27WB drive an "Undervoltage" condition.

NB or WB Voltage Regulation – How is it done?

UL2 Amplitude					
General					
VB_DbRepInt		1	Type	1	300
VB_ZeroDb		0	m%	0	100000
VB_HiHiLim		96995.000	V	0.000	10000000000.(
VB_HiLim		95263.000	V	0.000	10000000000.(
VB_LowLim		94108.000	V	0.000	10000000000.(
VB_LowLowLim		92953.000	V	0.000	10000000000.(
VB_Min		85000.000	V	0.000	10000000000.(
VB_Max		100000.000	V	0.000	10000000000.(
VB_RepTyp		Cyclic			
VB_LimHys		0.100	%	0.000	100.000

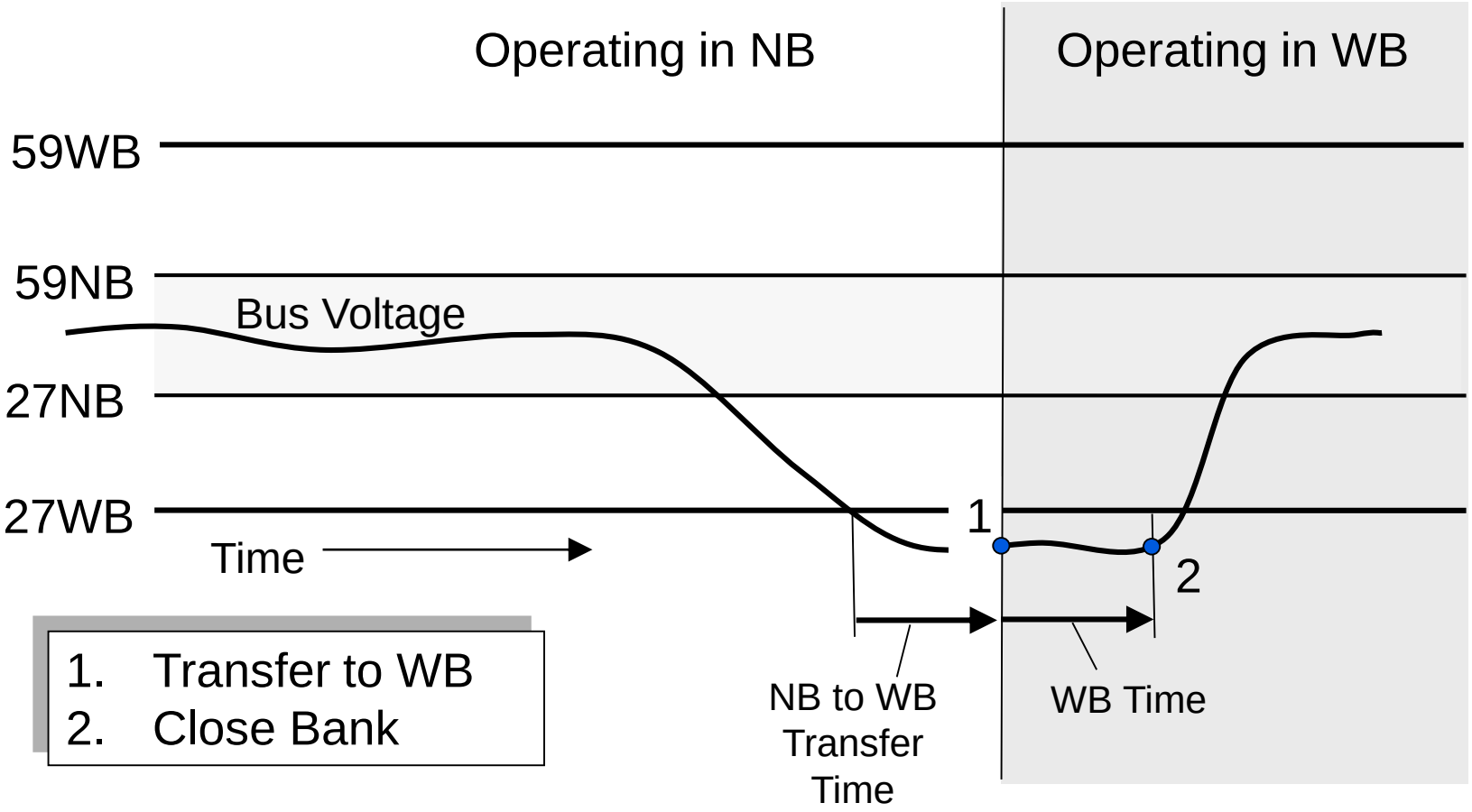
- Settings for the VNMMXU function block
- When the voltage exceeds 96995 volts, the 59WB will be asserted. When the voltage is 95263 volts, the 27WB is asserted.

Dead Bus Detection – How is it done?

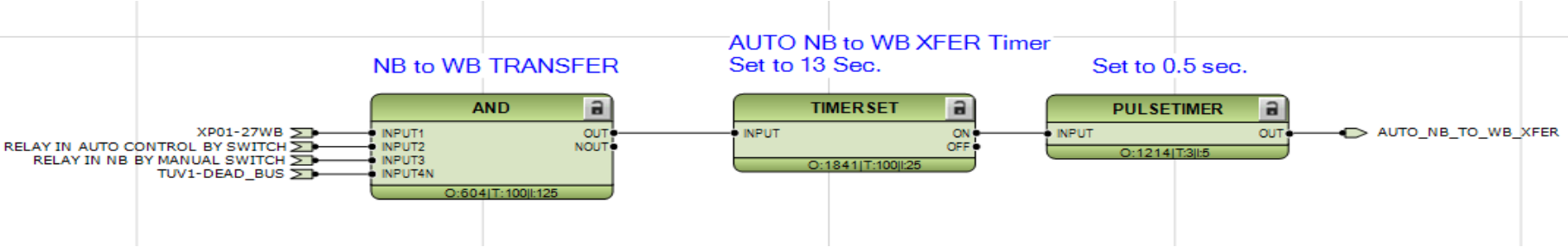


- Supervises the 27WB function
- Needed for capacitor banks on radial lines
  - Prevents automatic operation of capacitor banks

NB to WB Transfer

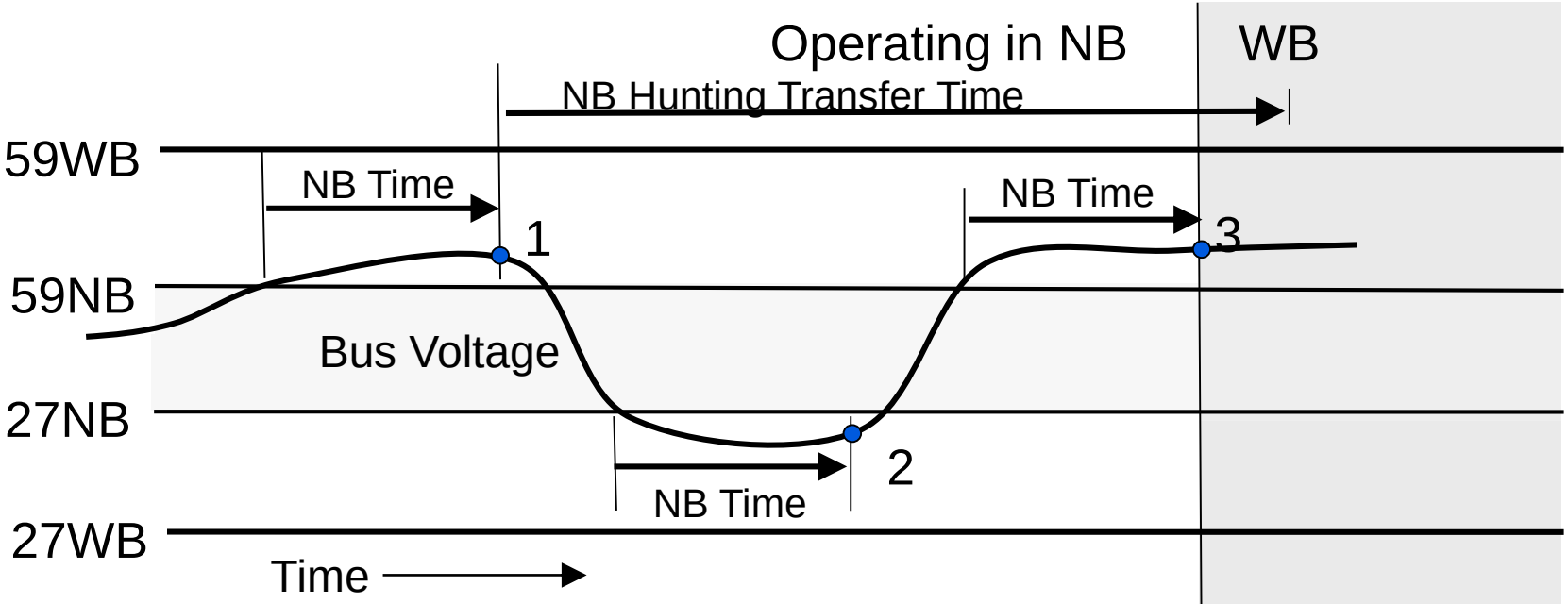


NB to WB Transfer – How is it done?



Logic needed to make “Narrow Band” to “Wide Band” decision.

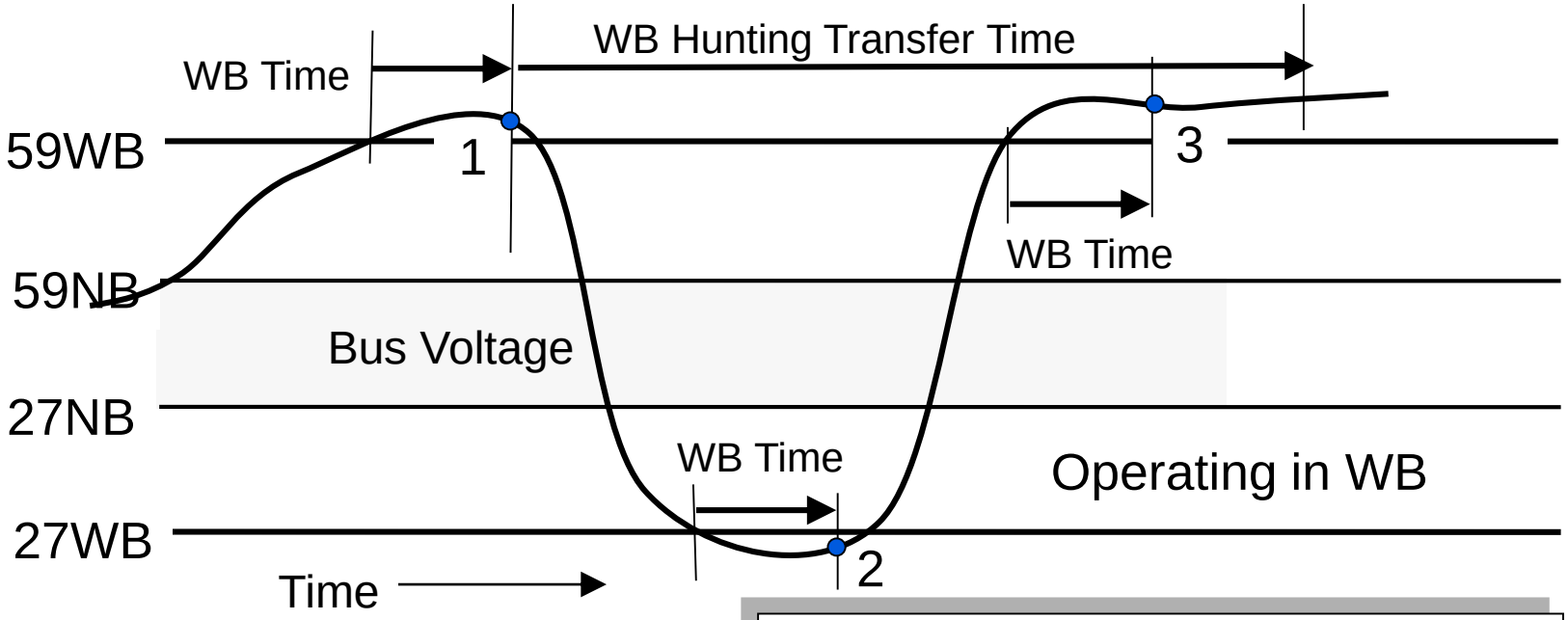
NB Hunting and WB Transfer



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

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

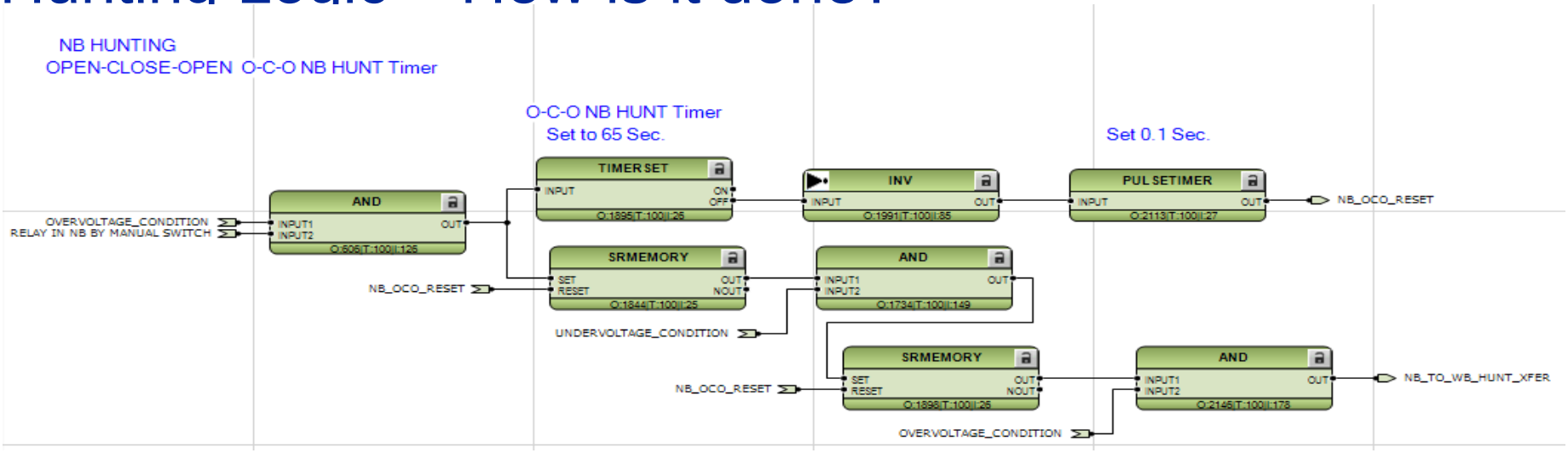
WB Hunting and MANUAL Transfer



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

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

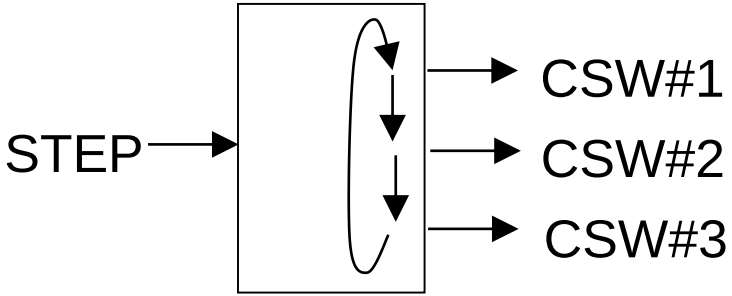
Hunting Logic – How is it done?



Shown is Narrow Band Hunting, Open – Close – Open, under 65 seconds.

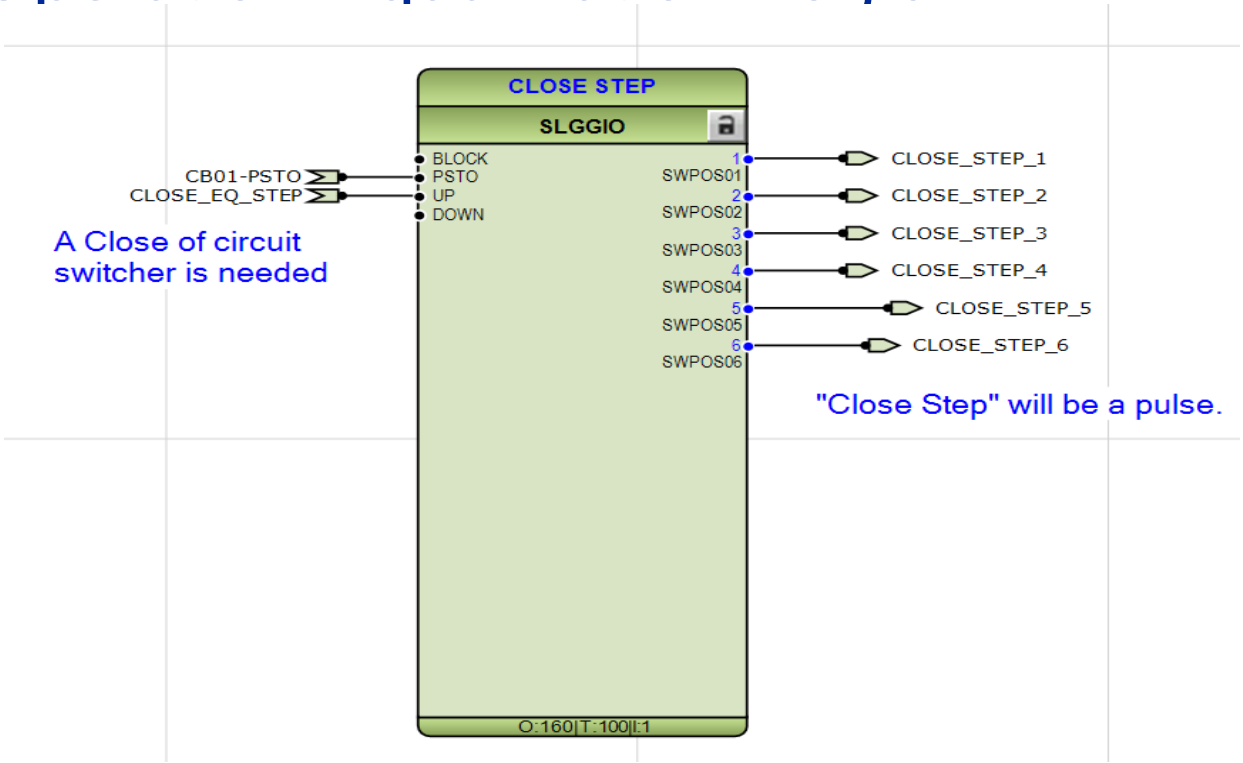
Same logic philosophy can be used for NB Hunting COC, WB Hunting COC and OCO.

Switch Operation Equalization Logic



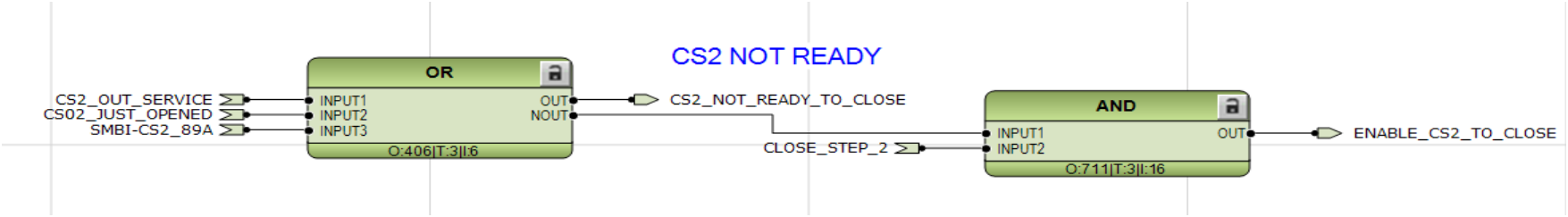
- Switch open and close operations are handled independently
- Only one switch is enabled to open [close] on next open a switch command [close a . . .]
- On operation command, if selected switch to open [close] is not ready (e.g. out of service, switch already open [closed]) a STEP is issued
- A STEP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

Switch Operation Equalization Logic



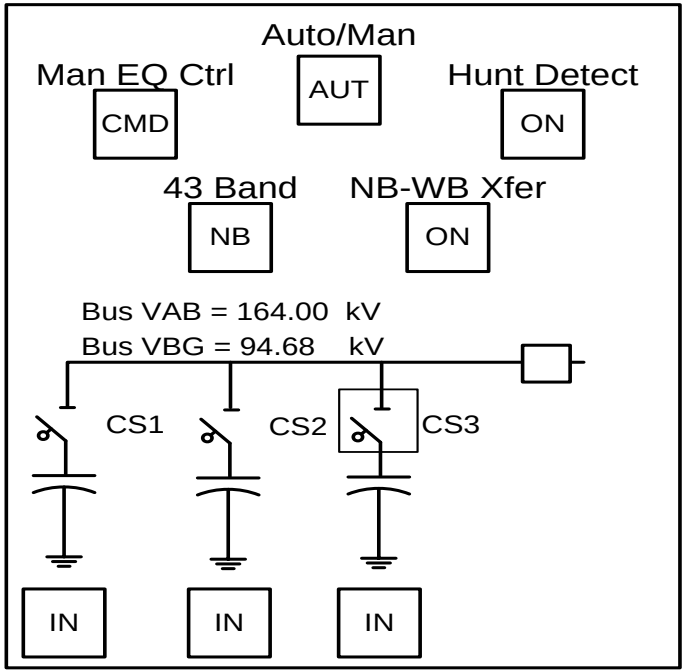
- "CLOSE_EQ_STEP" is picked up based on the "Undervoltage" condition.
  - For example, a "CLOSE_STEP_2" has been issued…

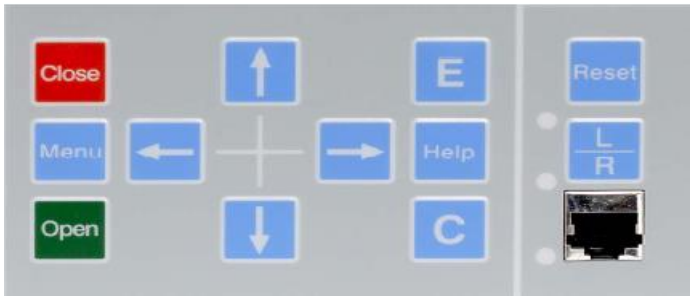
Switch Operation Equalization Logic



- Circuit Switcher number 2 will only close if the “OR” gate is not asserted.

Control Configuration

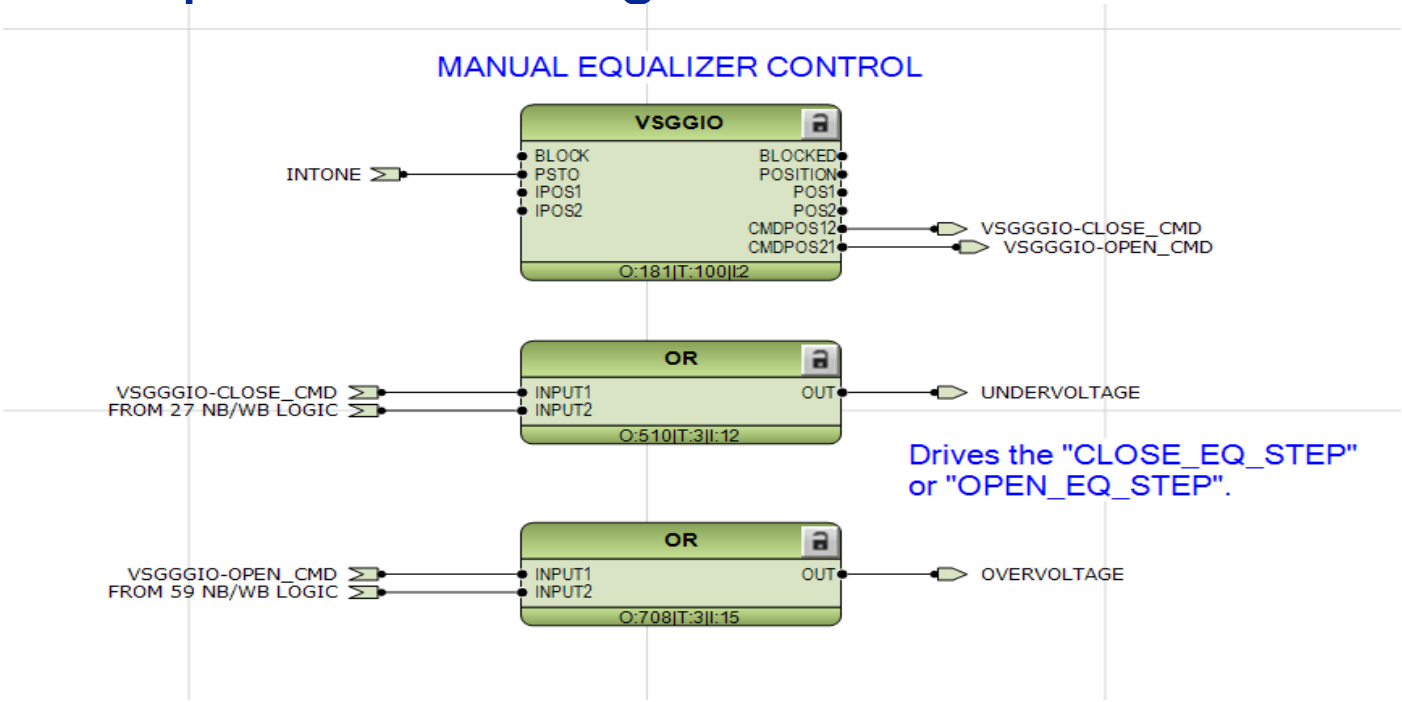




Switch	Pos	Operation
Auto/Man	MAN	Permits manual operation of the circuit breaker and capacitor bank circuit switches from the HMI graphic controller.
	AUT	Puts the control of capacitor bank circuit switchers in the automatic mode and blocks manual operation.
Man EQ Ctrl	CMD	Provides switch operation equalization while 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.

- We will take a look at the “MAN EQ CTRL” switch.

Manual Equalization Logic

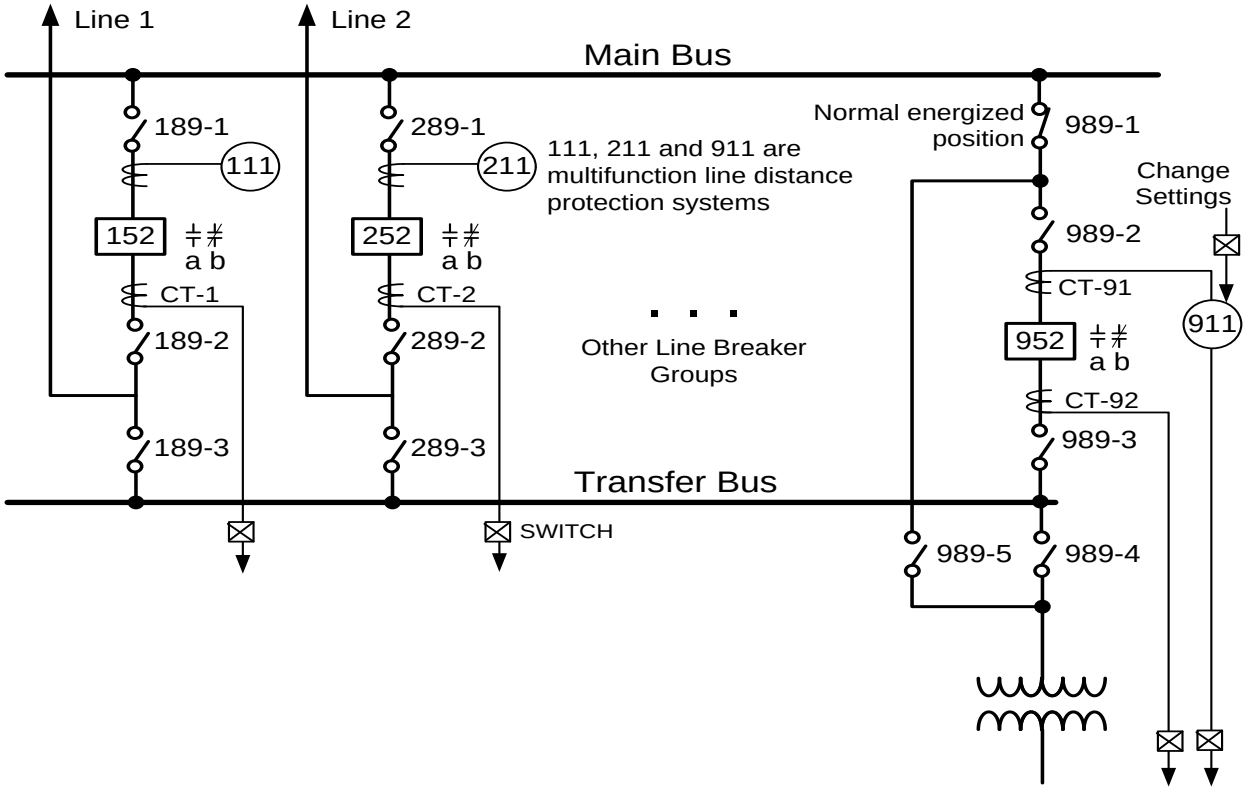


- By asserting a close or open command, the next circuit in sequence will operate.

Line Breaker Bypass scheme – Case Study

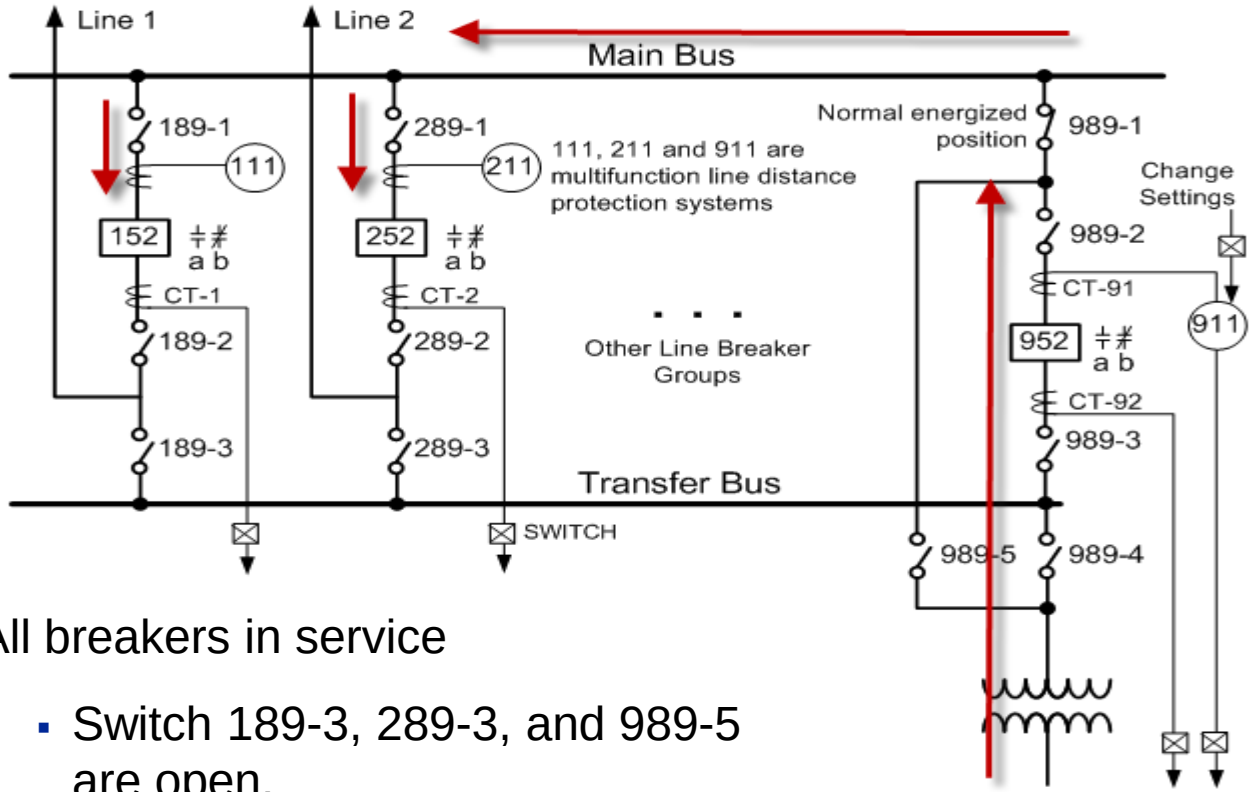
- The transformer bank differential and the bus bar differential protection is effected by which breaker is bypassed.
- Benefit of this substation layout is that any breaker can be bypassed at anytime.
- Drawback – Complex current switching scheme is needed. Protection settings must me interlocked with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

Line Breaker Bypass scheme



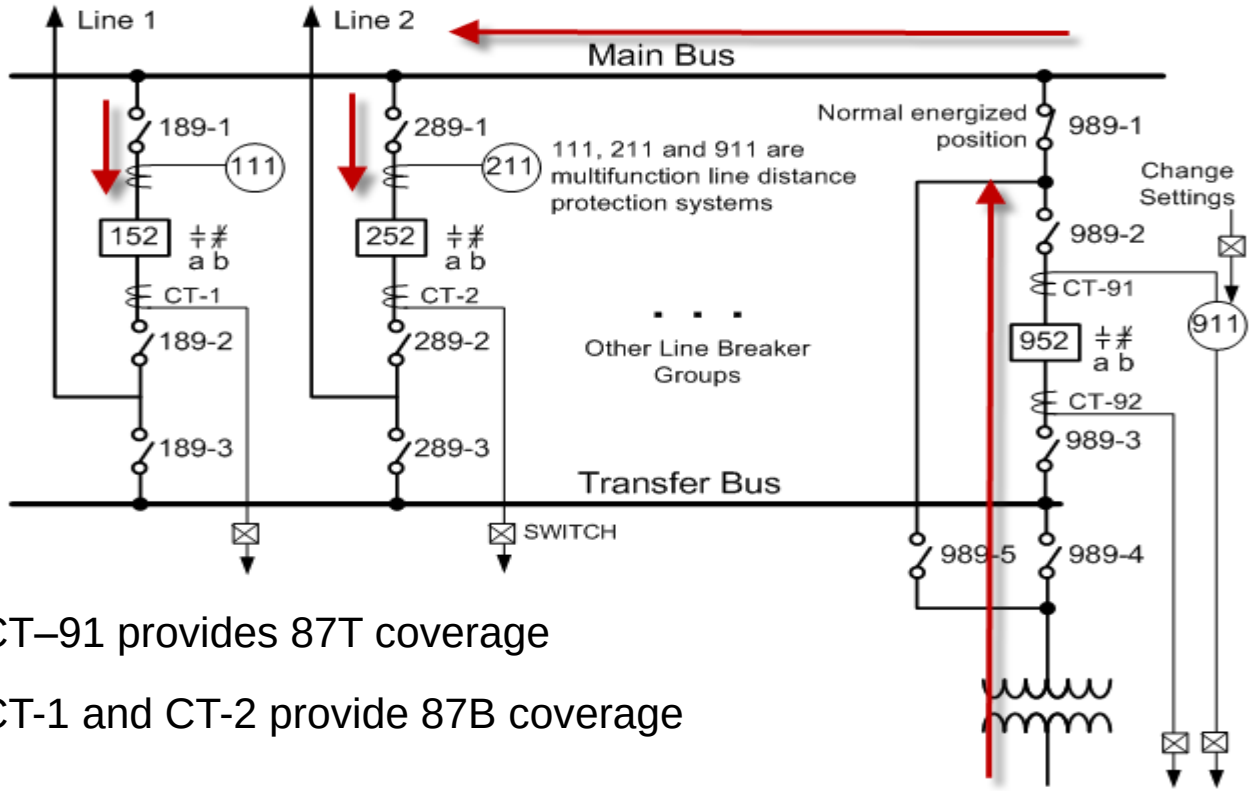
Substation Layout

Line Breaker Bypass scheme - Normal



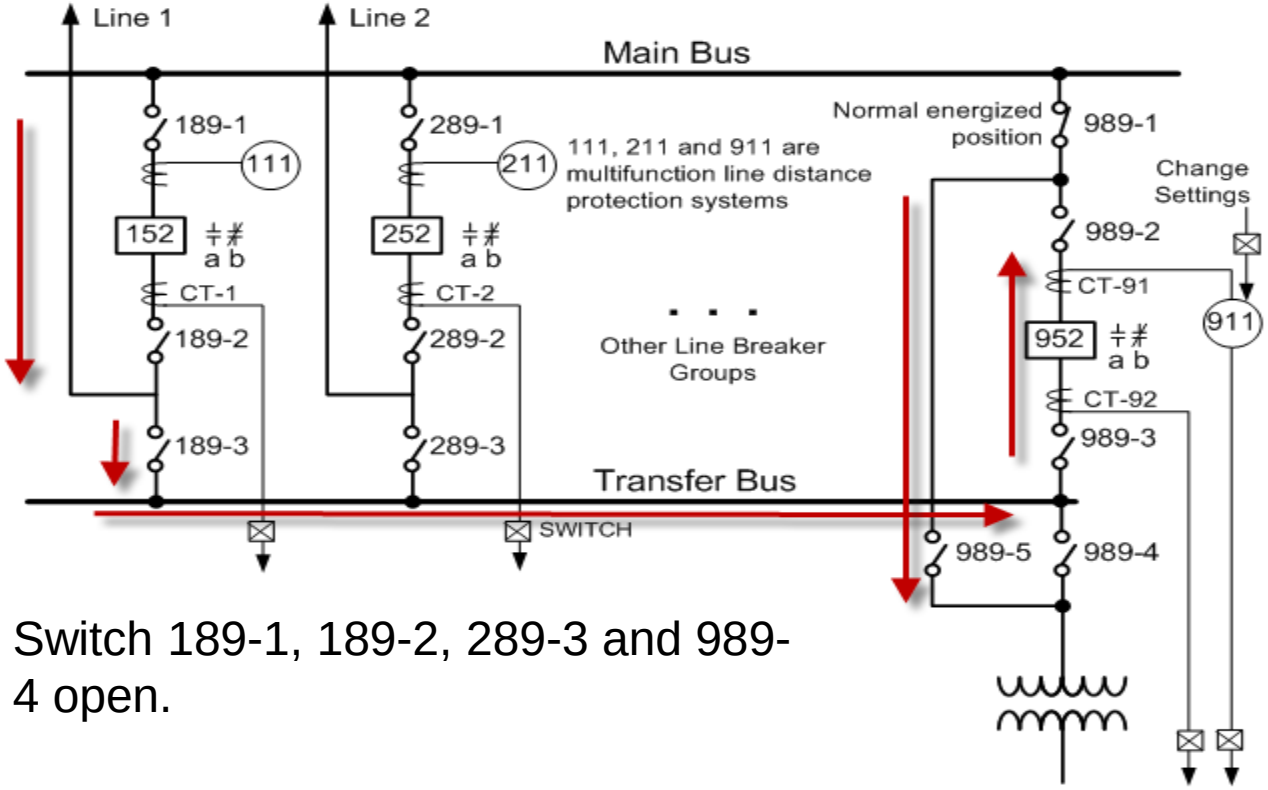
- All breakers in service
  - Switch 189-3, 289-3, and 989-5 are open.

Line Breaker Bypass scheme - Normal



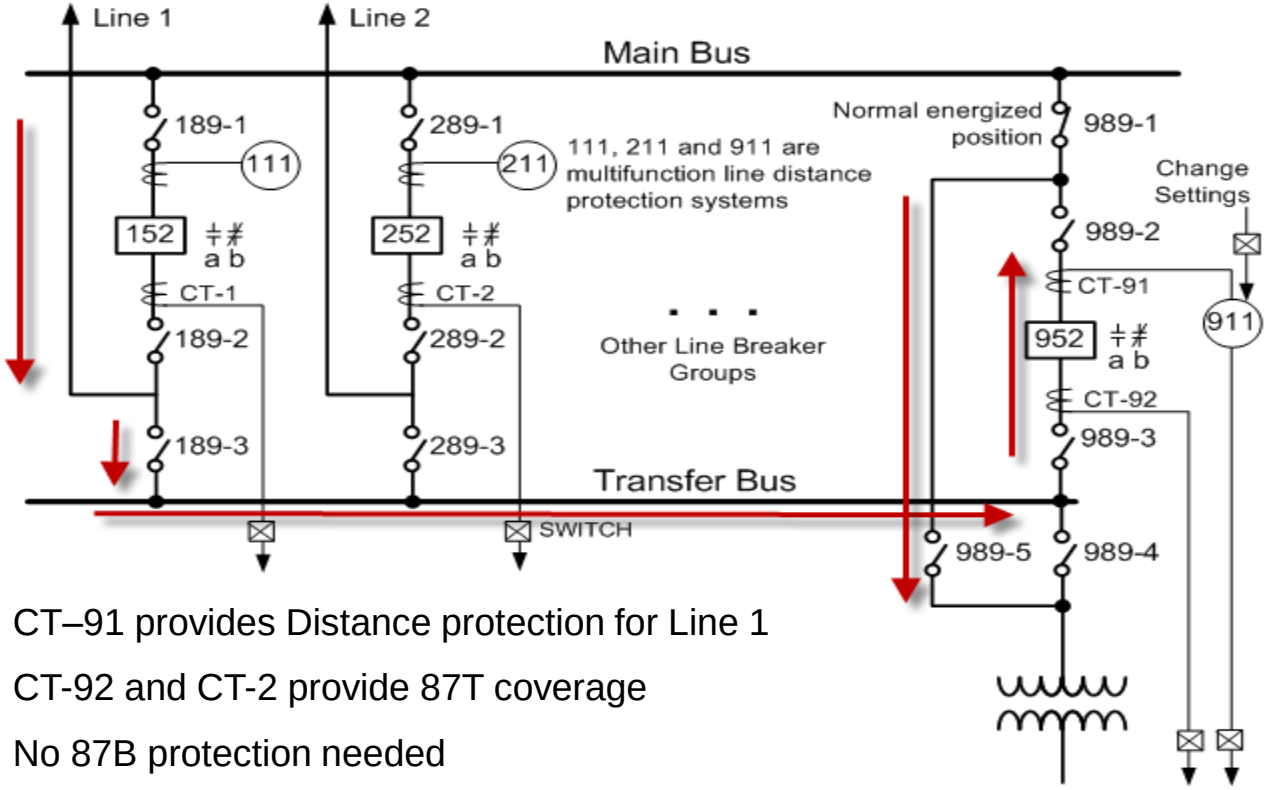
- CT–91 provides 87T coverage
- CT-1 and CT-2 provide 87B coverage

Line Breaker Bypass scheme –PCB 152 Bypassed



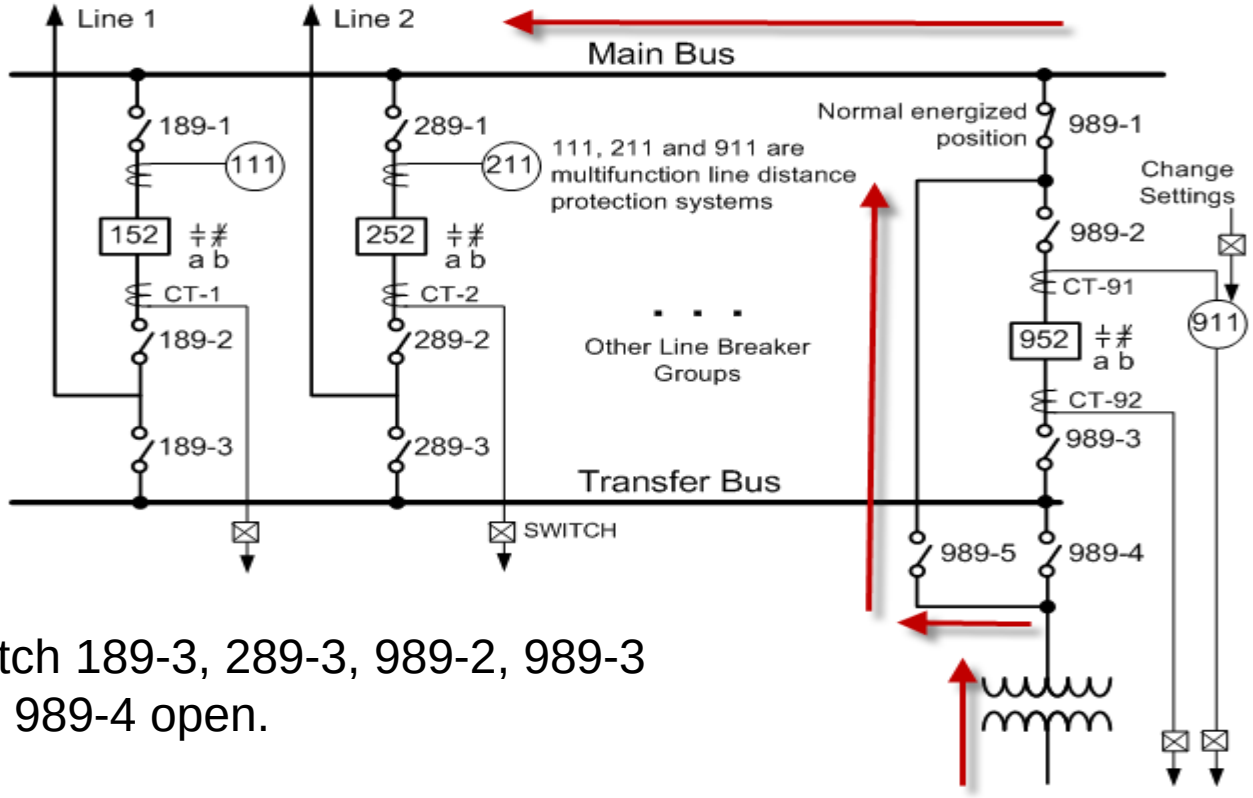
- Switch 189-1, 189-2, 289-3 and 989-4 open.

Line Breaker Bypass scheme –PCB 152 Bypassed



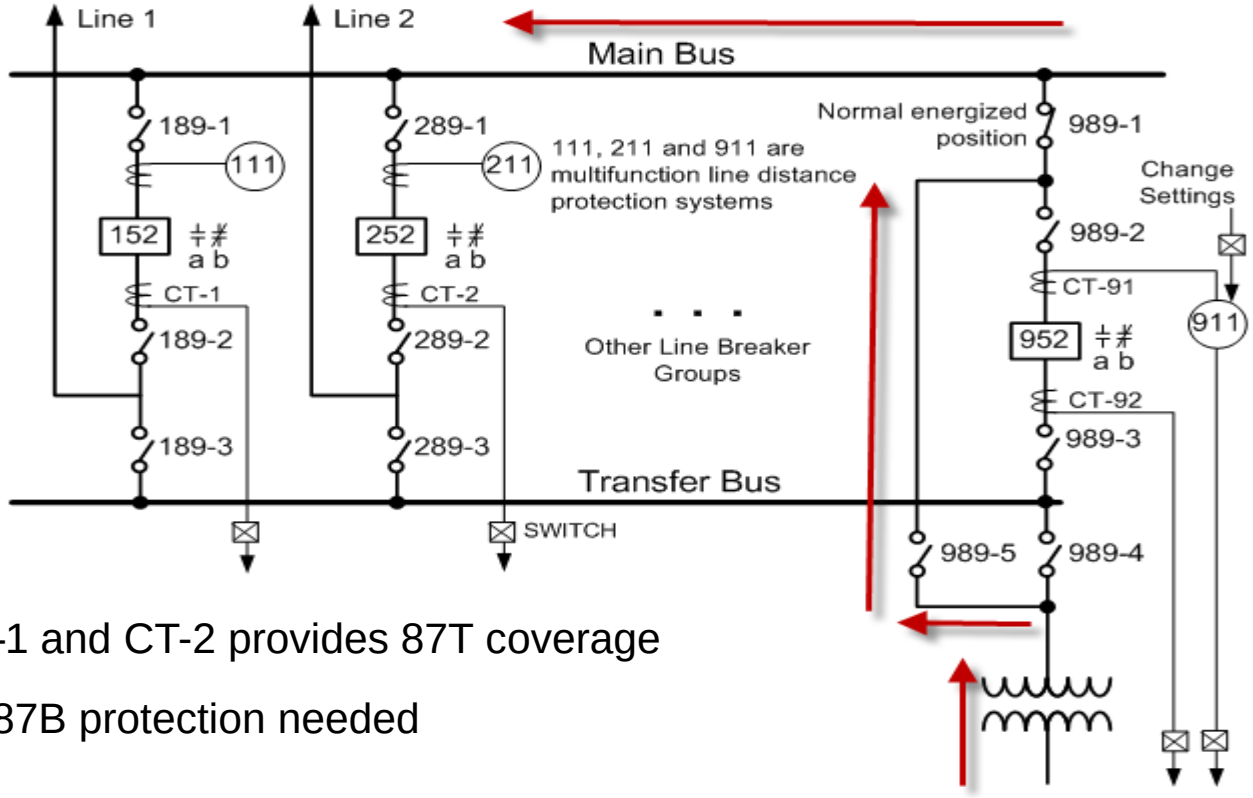
- CT–91 provides Distance protection for Line 1
- CT-92 and CT-2 provide 87T coverage
- No 87B protection needed

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

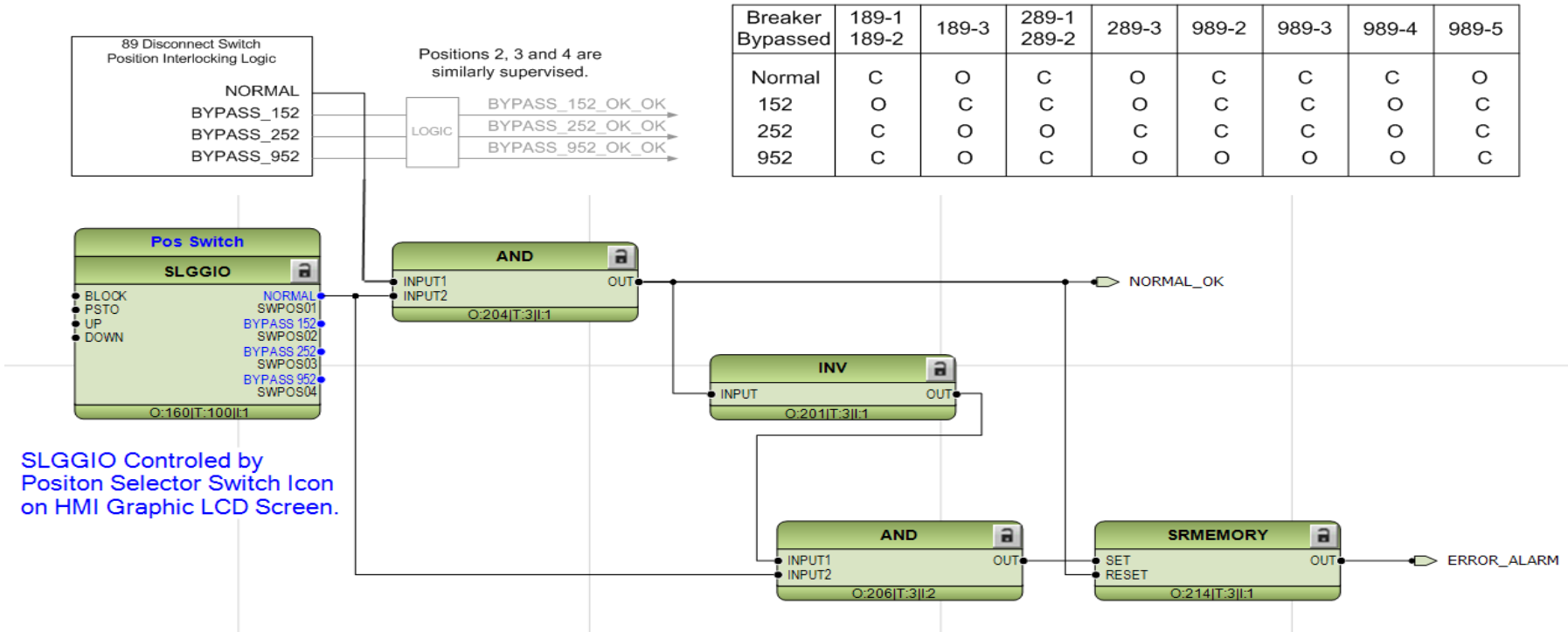
- Switching is done manually with a stacked (multiple contacts) position selector switch.
  - In this case the positions are Normal, Bypass 152, Bypass 252 and Bypass 952
  - This includes switching the CTs to the correct protection zone, changing the 911 settings [usually through contact input] when 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

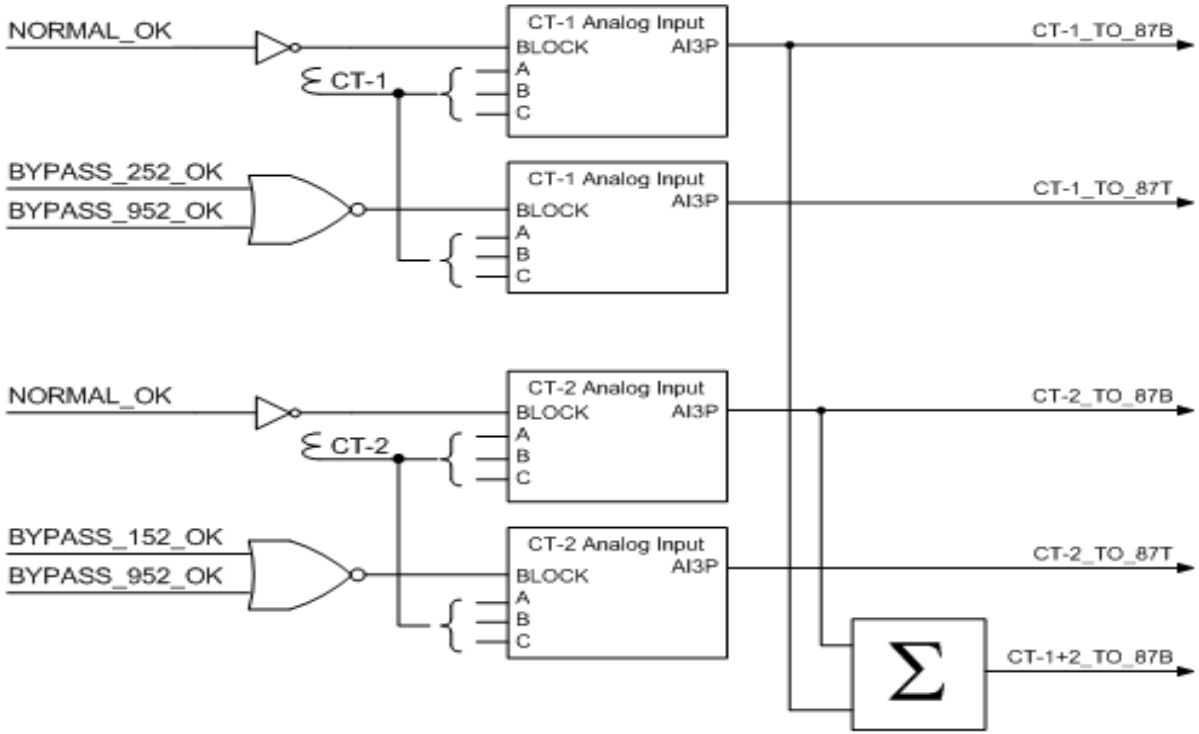
- Develop logic to determine what configuration the substation is in.
  - Use the substation disconnect switch positions to develop interlock logic
  - Supervise with a virtually selector switch on relay or station HMI

Line Breaker Bypass scheme – Relion Solution

Breaker Bypassed	189-1 189-2	189-3	289-1 289-2	289-3	989-2	989-3	989-4	989-5
Normal	C	O	C	O	C	C	C	O
152	O	C	C	O	C	C	O	C
252	C	O	O	C	C	C	O	C
952	C	O	C	O	O	O	O	C

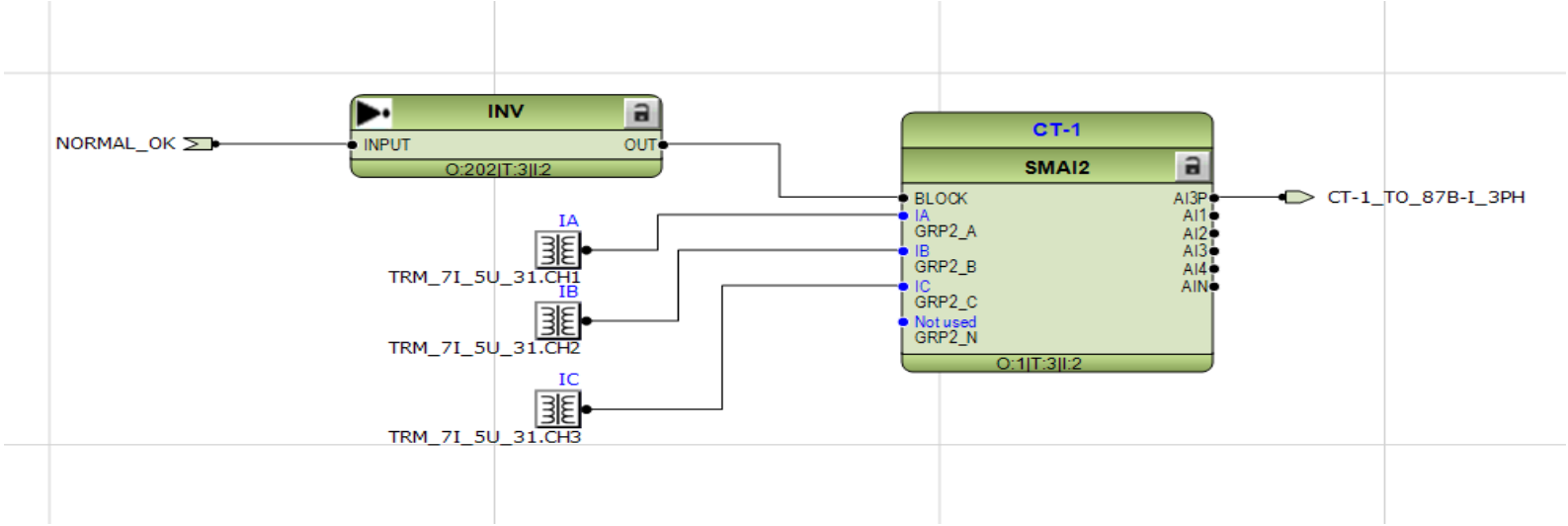


Line Breaker Bypass scheme – Virtual CT Switching



- 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.

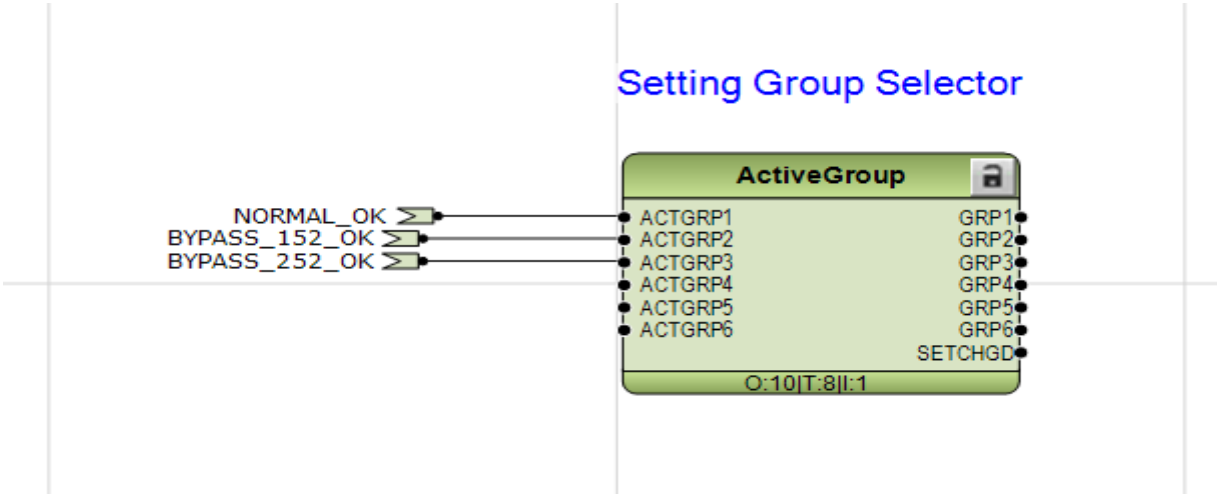
Line Breaker Bypass scheme – Virtual CT Switching



- Currents are virtually blocked when the system is not in the normal position.
- No need to physically open a current circuit.

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 these 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)

This webinar brought to you by:

ABB Power Systems Automation and Communication

- **Relion Series Relays** – Advanced flexible platform for protection and control
- **RTU 500 Series** – Proven, powerful and open architecture
- **MicroSCADA** - Advanced control and applications
- **Tropos** – Secure, robust, high speed wireless solutions

We combine innovative, flexible and open products with engineering and project services to help our customers address their challenges.

Thank you for your participation

Shortly, you will receive a link to an archive of this presentation.
To view a schedule of remaining webinars in this series, or for more information on ABB's protection and control solutions, visit:

www.abb.com/relion

Power and productivity
for a better world™