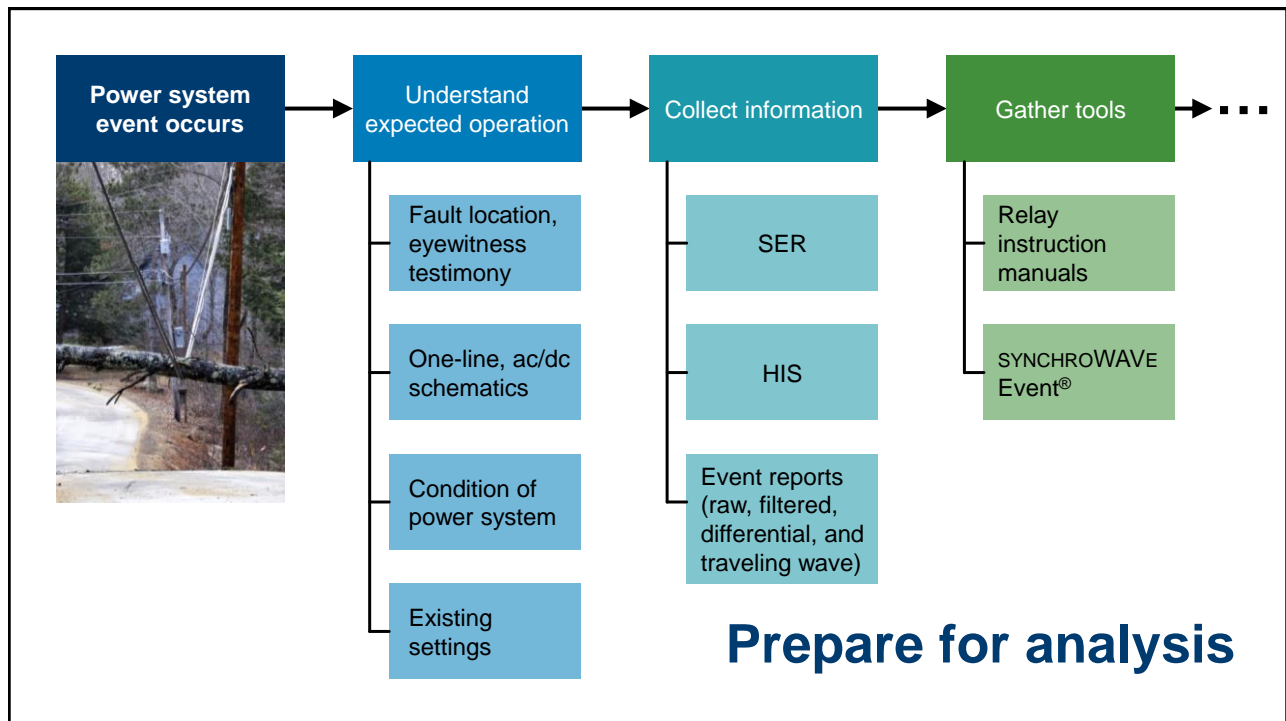




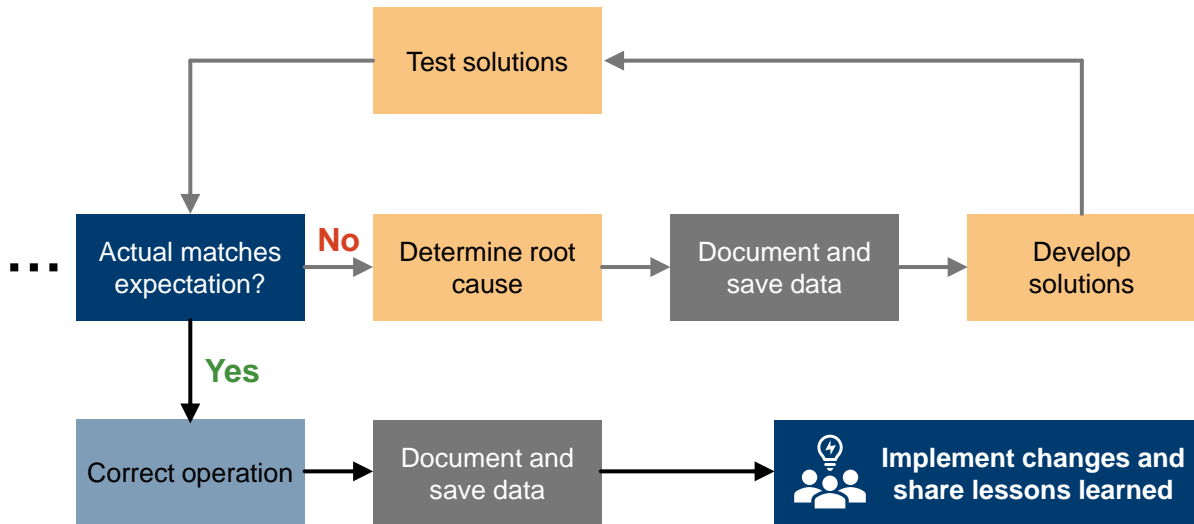
Analysis of Transmission Line Events (Advanced)



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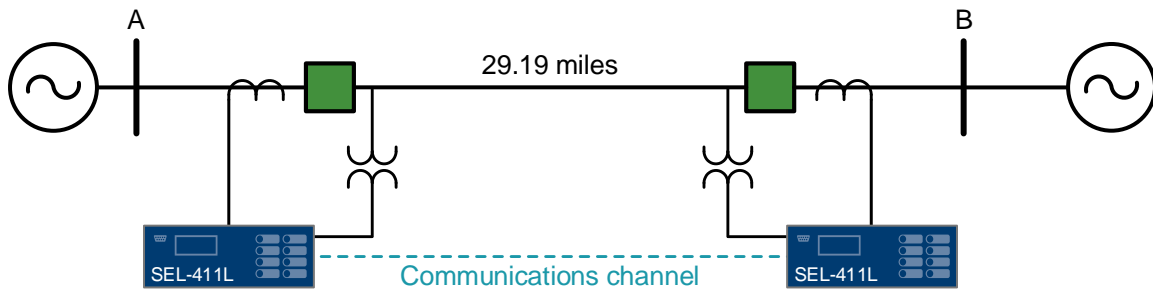


Find root cause



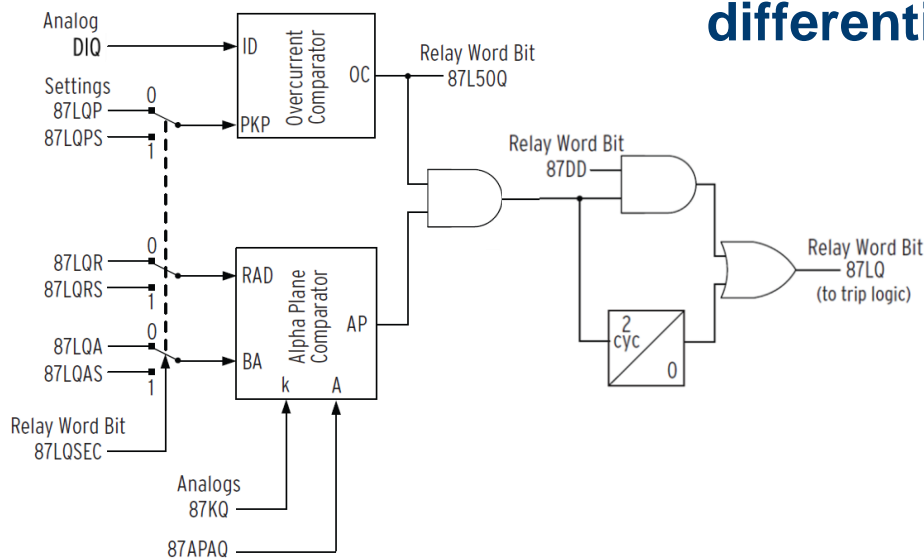
345 kV line trip during lightning strike

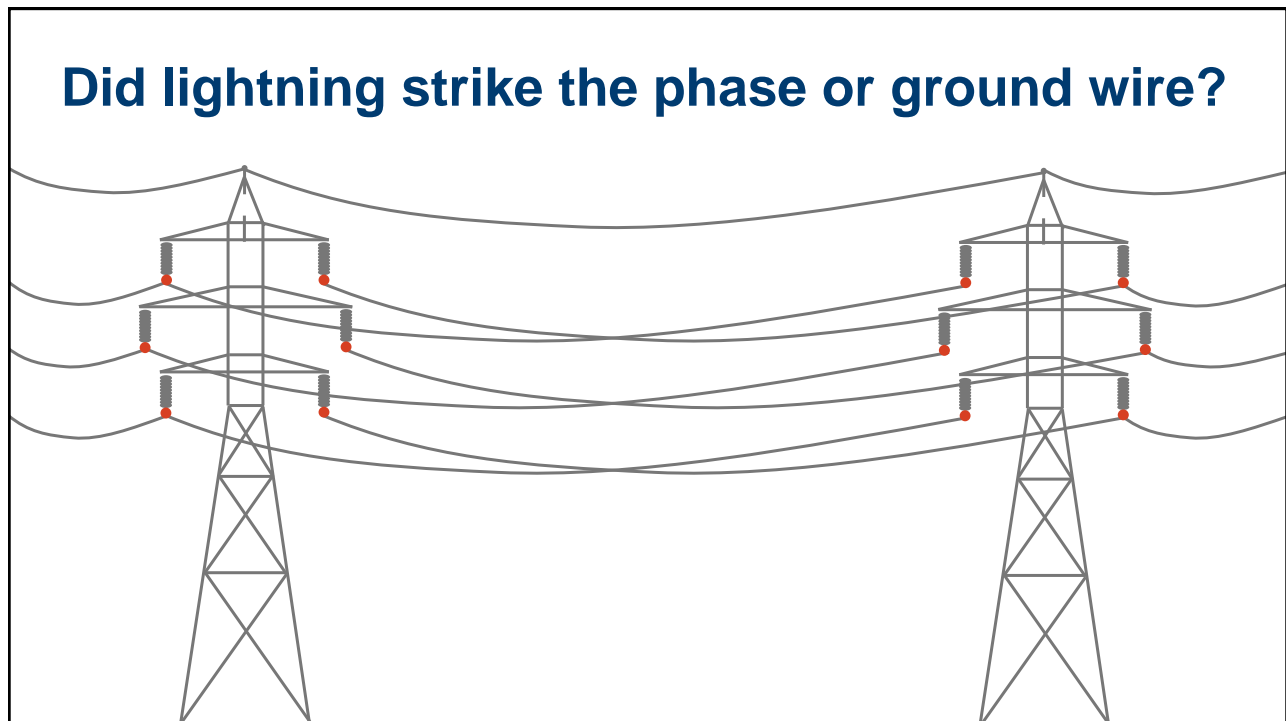
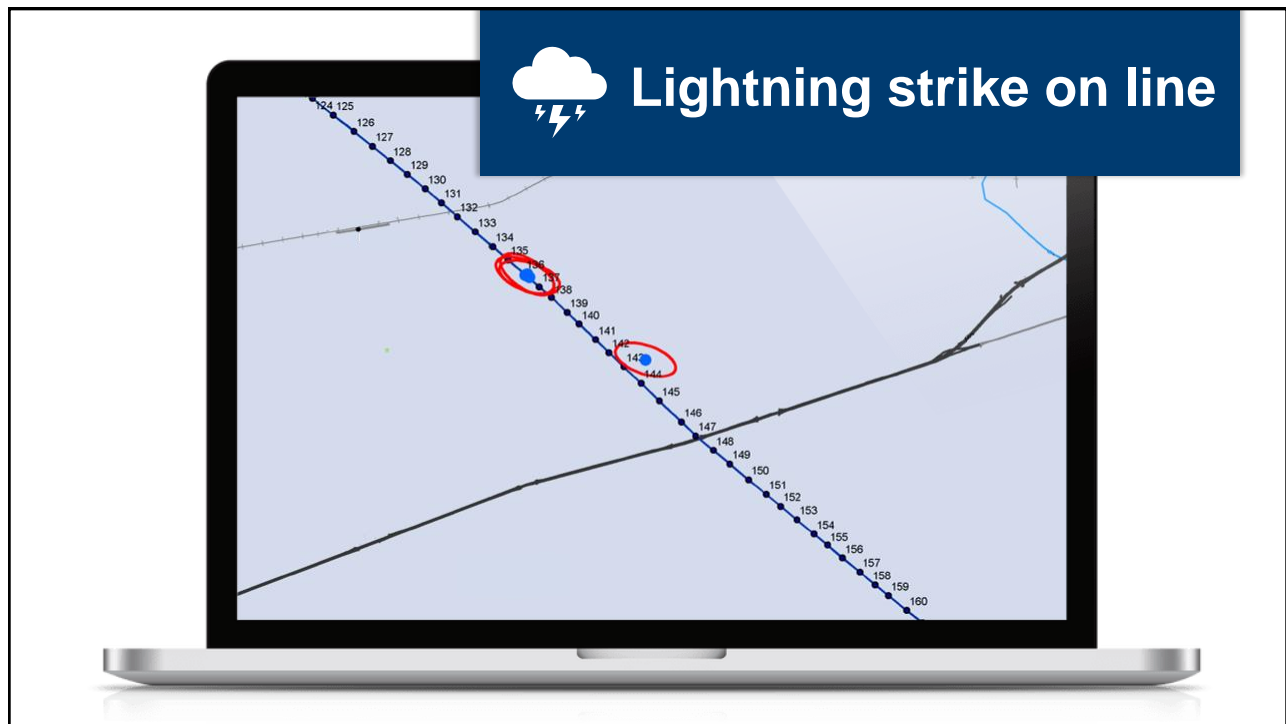
Example 1



Simplified one-line diagram

87LQ negative-sequence differential element





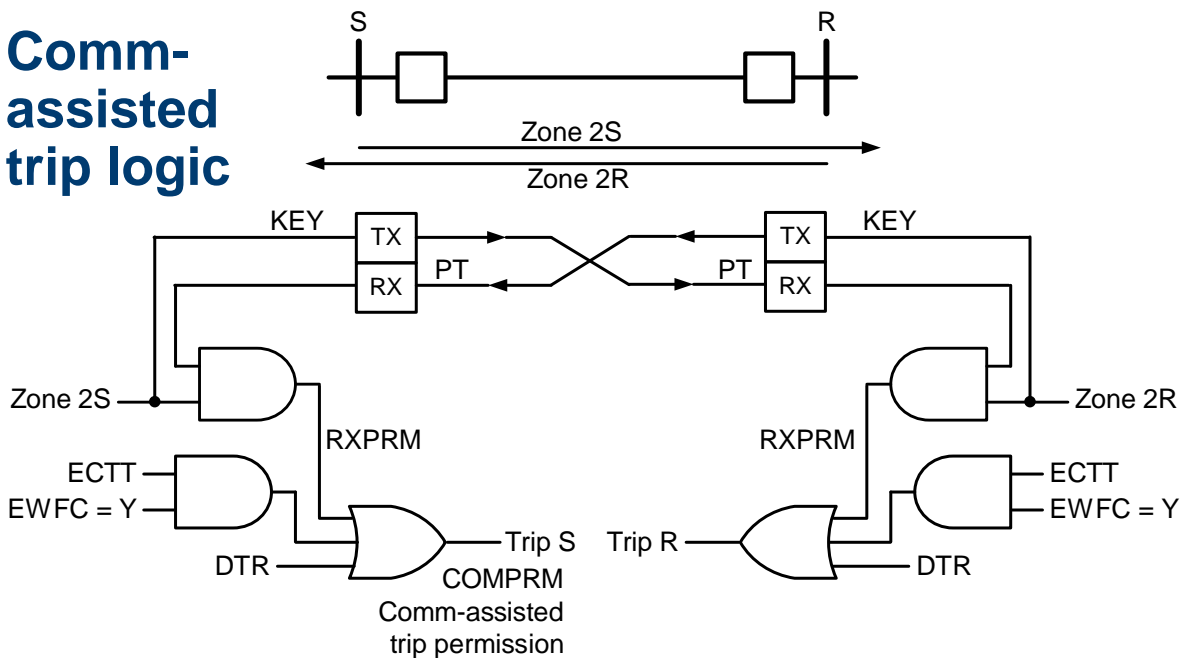
Line trip during fault

Example 2

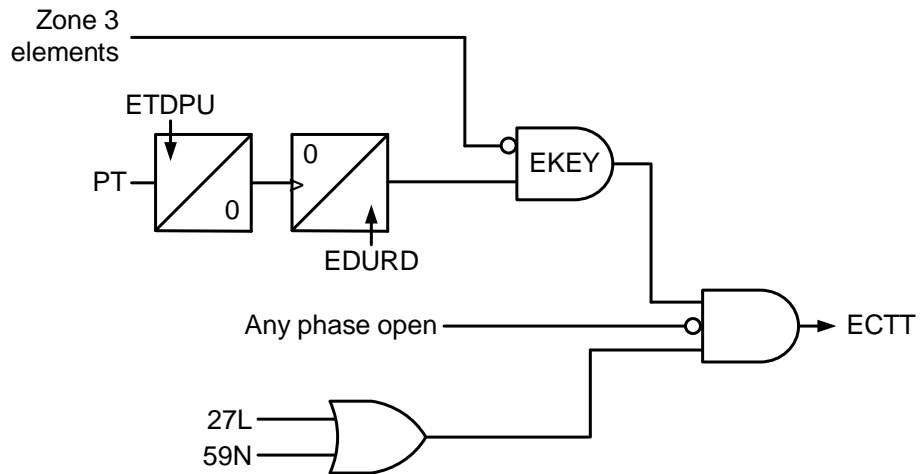


Simplified one-line diagram

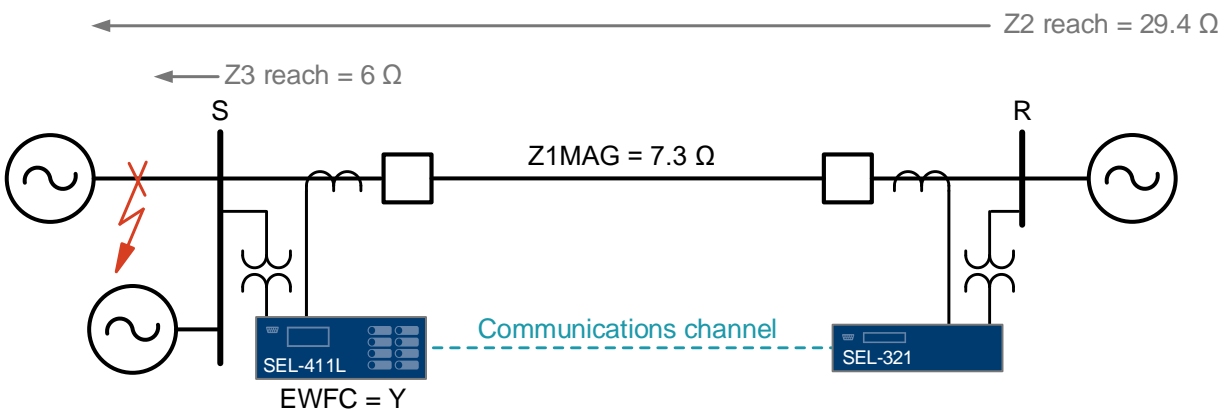
Comm-assisted trip logic



Weak infeed logic

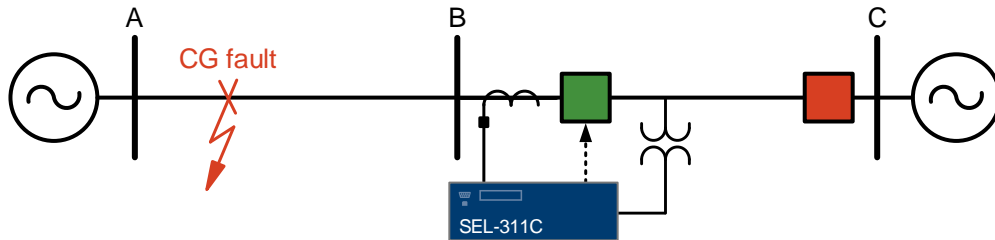


Summary of operation

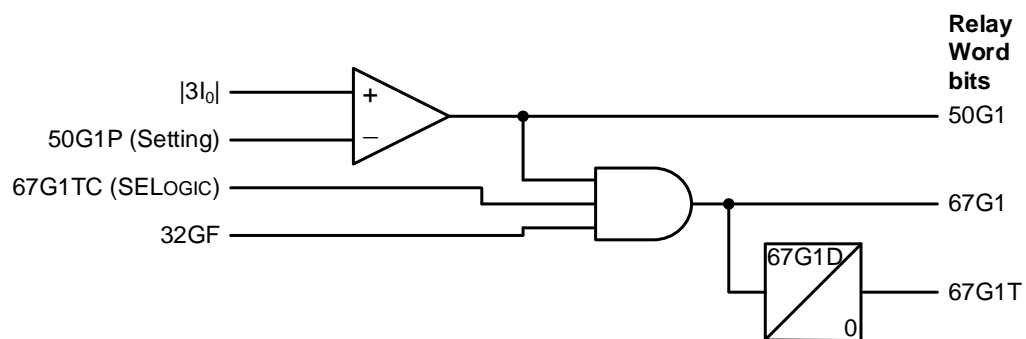


Relay trips for reverse fault

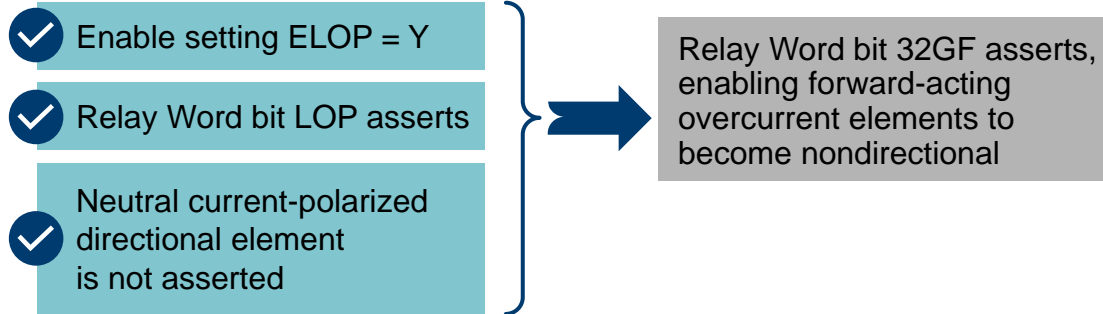
Example 3



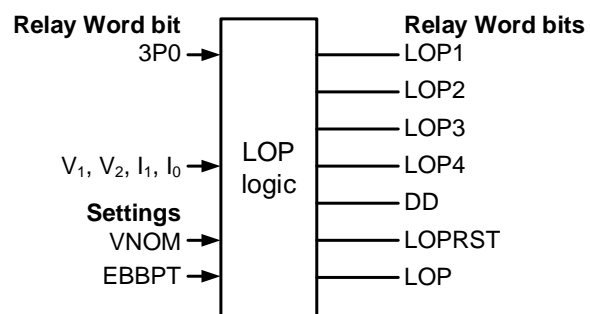
67G1 logic diagram



Impact of LOP on protection

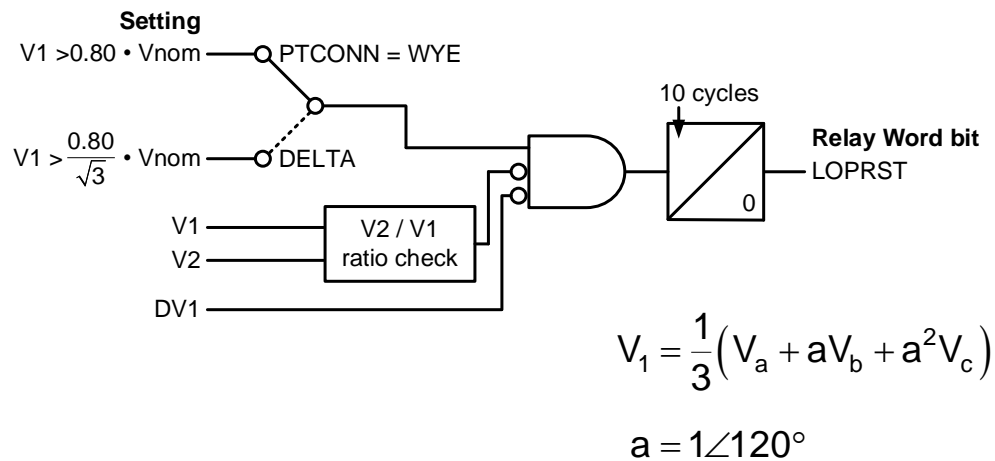


LOP logic outputs



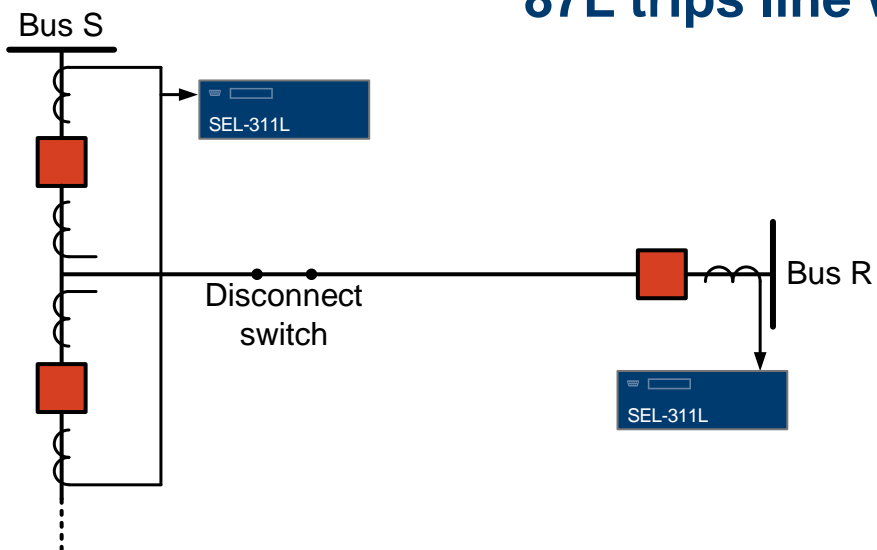
Relay Word bits	Description
LOP	LOP status; output is always available, regardless of ELOP setting
LOP1	Breaker closing LOP logic asserted; only available when EBBPT = N
LOP2	Voltage drop without change in current LOP logic asserted
LOP3	LOP latched
LOP4	Busbar PT LOP logic asserted; only available when EBBPT = Y
LOPRST	LOP reset condition based on detection of healthy voltages

LOP reset logic diagram

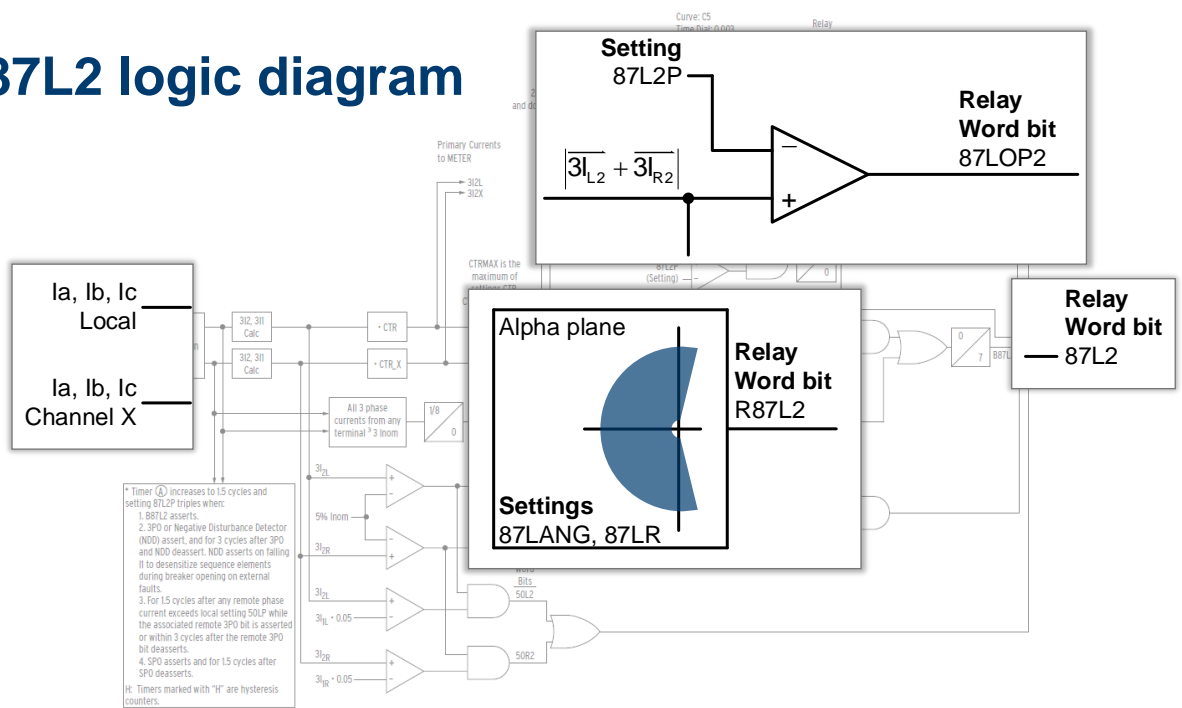


87L trips line with no fault

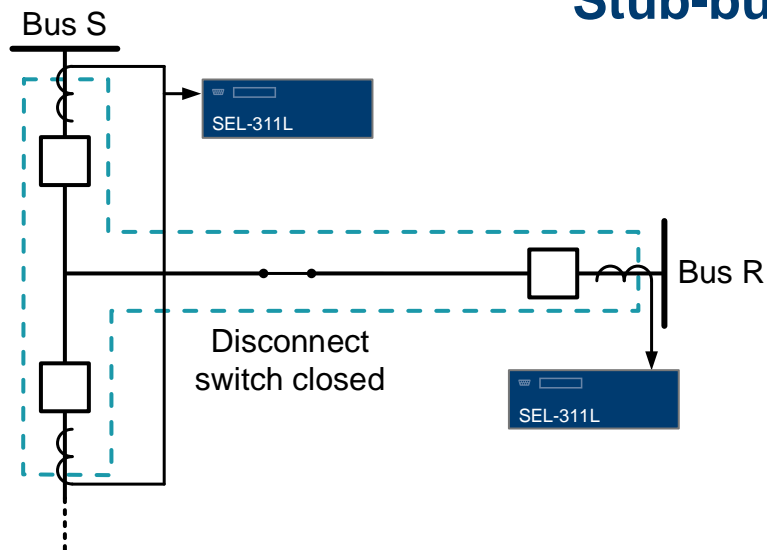
Example 4



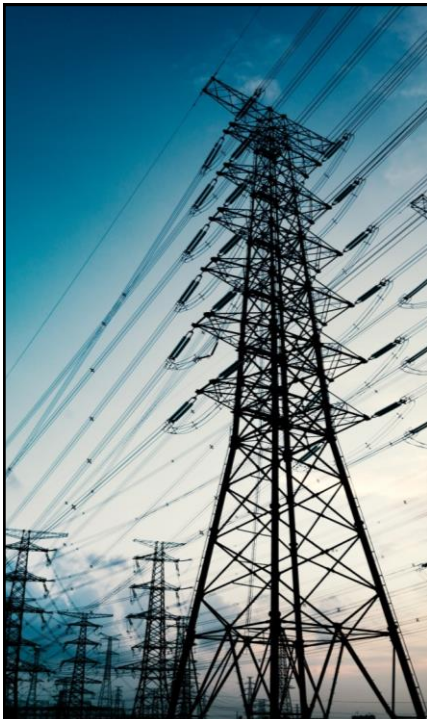
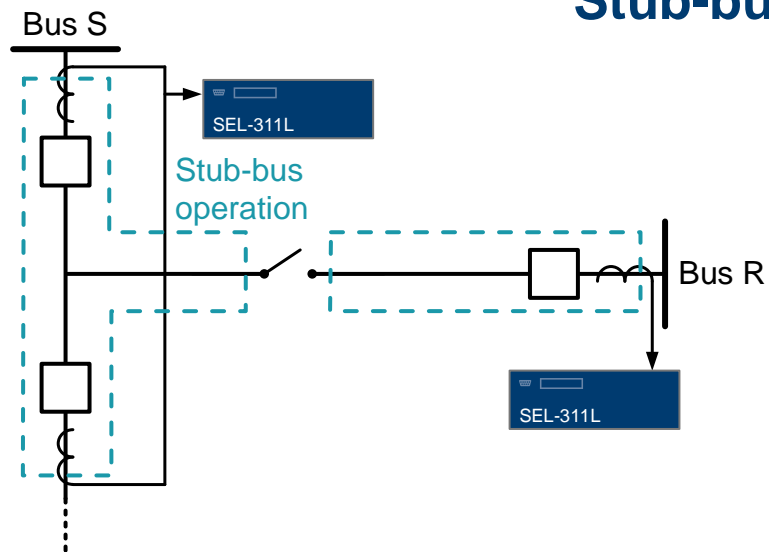
87L2 logic diagram



Stub-bus operation

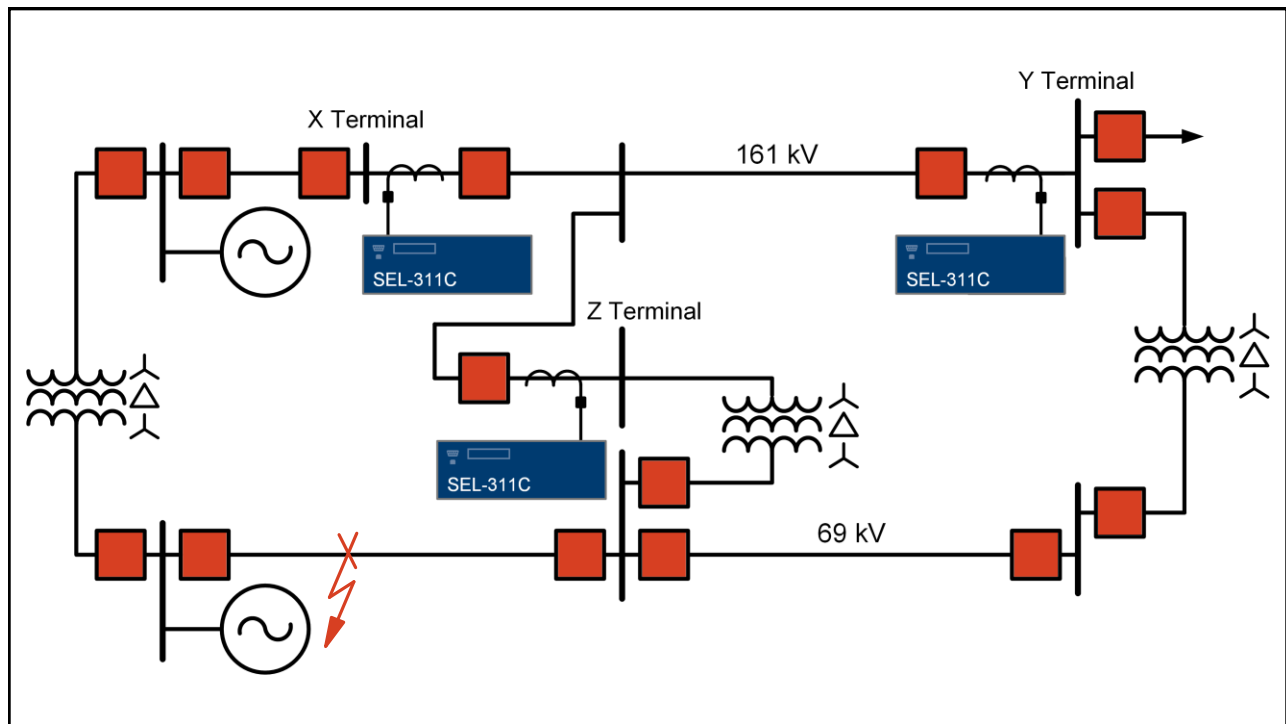


Stub-bus operation



**161 kV line using
DCB scheme trips
for out-of-section fault**

Example 5



Application Guide Volume V AG2016-01

Using Custom Calculations in SYNCHROWAVE[®] Event 2015 to Analyze Directional Elements

Ariana Hargrave, Brad Heilman, and Matt Watkins

Inputs

- Filtered event report from SEL-351 or SEL-421
- Relay settings

Outputs

- Mimics directional elements (32Q, 32P, 32V, and 32I)
- Plots operating quantity as well as forward and reverse thresholds for each element

Using AG2016-01 custom calculations

1. Open event report from SEL-351 or SEL-421
2. Copy code from **AG2016-01-351.txt** or **AG2016-01-421.txt** file and paste into **Custom Calculations** window
3. Edit settings at top to match settings in event report
4. Define **Z_Limit** to scale graph
5. Plot resulting signals (**Z2LIM**, **Z2FTLIM**, **Z2RTLIM**)

32Q, 32V and 32I elements are modeled

Thresholds are dynamic

Forward threshold

If Z2F setting ≤ 0 ,

$$0.75 \cdot Z2F - 0.25 \cdot \left| \frac{V_2}{I_2} \right|$$

If Z2F setting > 0 ,

$$1.25 \cdot Z2F - 0.25 \cdot \left| \frac{V_2}{I_2} \right|$$

Reverse threshold

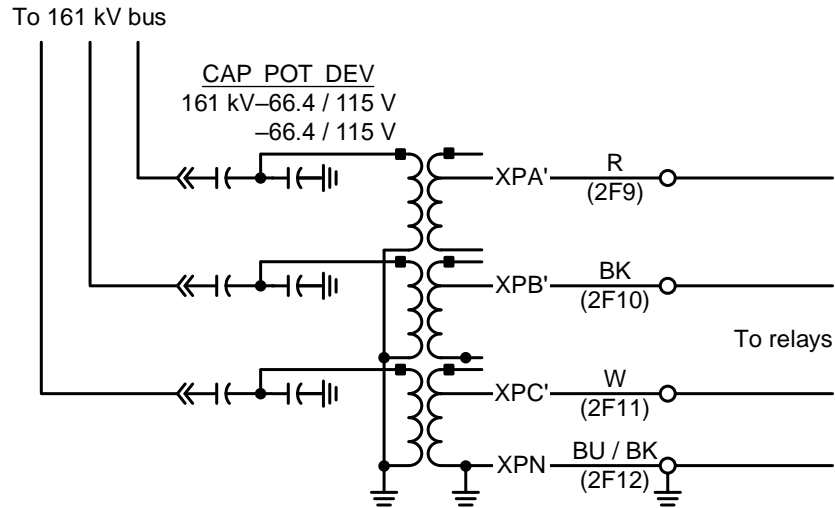
If Z2R setting ≥ 0 ,

$$0.75 \cdot Z2R - 0.25 \cdot \left| \frac{V_2}{I_2} \right|$$

If Z2R setting < 0 ,

$$1.25 \cdot Z2R - 0.25 \cdot \left| \frac{V_2}{I_2} \right|$$

Three-line diagram of VTs



Transmission line trips incorrectly

Investigation of past events

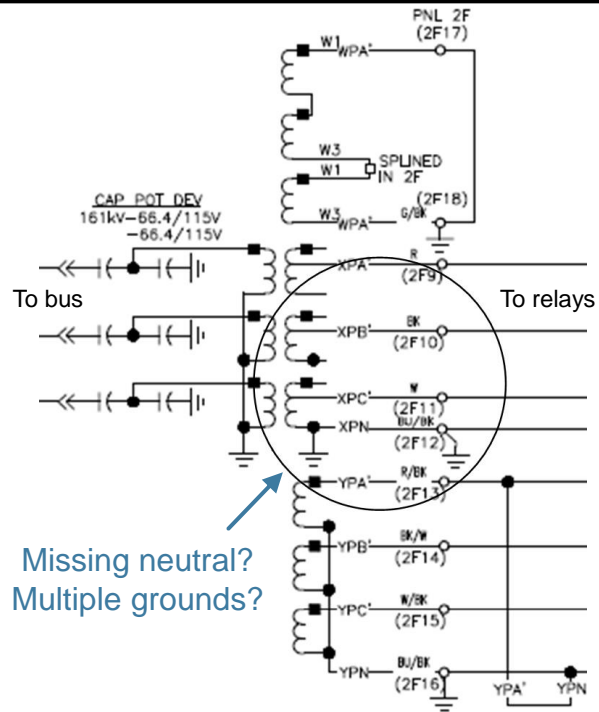
- A-phase VT had been replaced a few years earlier
- All recent undesired operations had occurred on A-phase-to-ground

Date and time	Faulted phase	Fault location	Targets
5 / 27 / 2018 10:20	AG T	-99.72	TRIP COMM ZONE2
6 / 28 / 2018 09:01	AG T	-85.27	TRIP ZONE1
7 / 17 / 2018 13:25	AG T	-160.39	TRIP COMM ZONE2
5 / 6 / 2019 02:18	AG T	-166.33	TRIP COMM ZONE2
6 / 21 / 2019 04:45	BG T	19.18	TRIP ZONE1
7 / 10 / 2019 13:05	AG T	-118.29	TRIP COMM ZONE2

Transmission line trips incorrectly

Possible errors in VT circuit

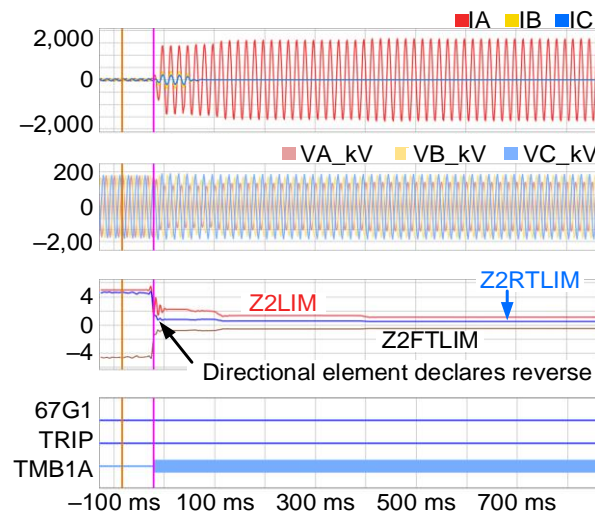
- Drawing and wiring errors were found
- Two, not three, secondary VT circuits were present (W was not present)
- Result is complete review of drawings and comprehensive test of ground connections in VT circuit



A few months later...reverse fault on 69 kV bus

Directional element declares reverse for reverse fault

- A-phase voltage drops as expected
- Z2LIM is now above reverse threshold, Z2RTLIM
- Relay correctly sends block signal
- 161 kV line, correctly, does not trip




A few months later...reverse fault on 69 kV bus

Directional element declares reverse for reverse fault

- A-phase voltage drops as expected
- Z2LIM is now above reverse threshold, Z2RTLIM
- Relay correctly sends block signal
- 161 kV line, correctly, does not trip

Pre-fault

Color	Name	Mag	Angle
	VA_kV.Phase	95.3032	0°

Fault

Color	Name	Mag	Angle
	VA_kV.Phase	66.3338	0°

Want more practice?

Lessons Learned Analyzing Transmission Faults

David Costello
Schweitzer Engineering Laboratories, Inc.




Event Analysis Tutorial Part 1: Problem Statements

Event reports have been an invaluable feature in microprocessor-based relays since the initial introduction of the technology. The days of unknown root cause for an operation, lengthy outages, or unexplained test results are largely over due to this tool and the ability of engineers and technicians to use it. We must practice to become proficient at analyzing event reports. This session provides real-world event examples, time to evaluate them, and solutions.

Author

• David Costello

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-  REFERENCE MATERIAL FOR WHITE PAPER LWP0009

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Author

• Karl Zimmerman

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