

Prevent False Tripping Due to Grounding Bank Backfeed

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Southern Pine Electric Cooperative



Outline



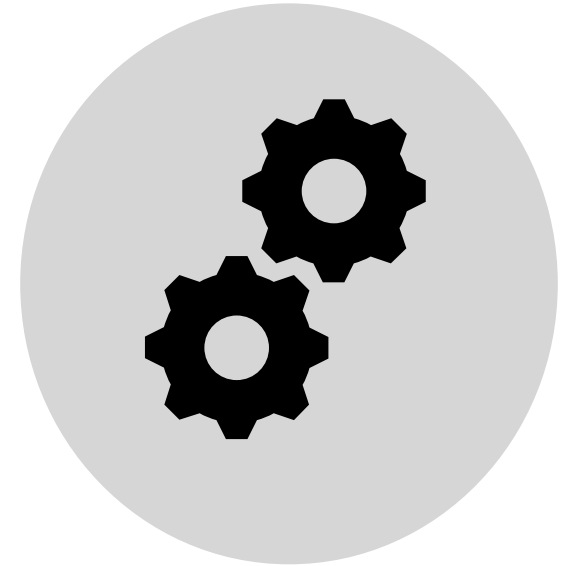
Southern Pine
Electric
Cooperative
Background



History of the
problem

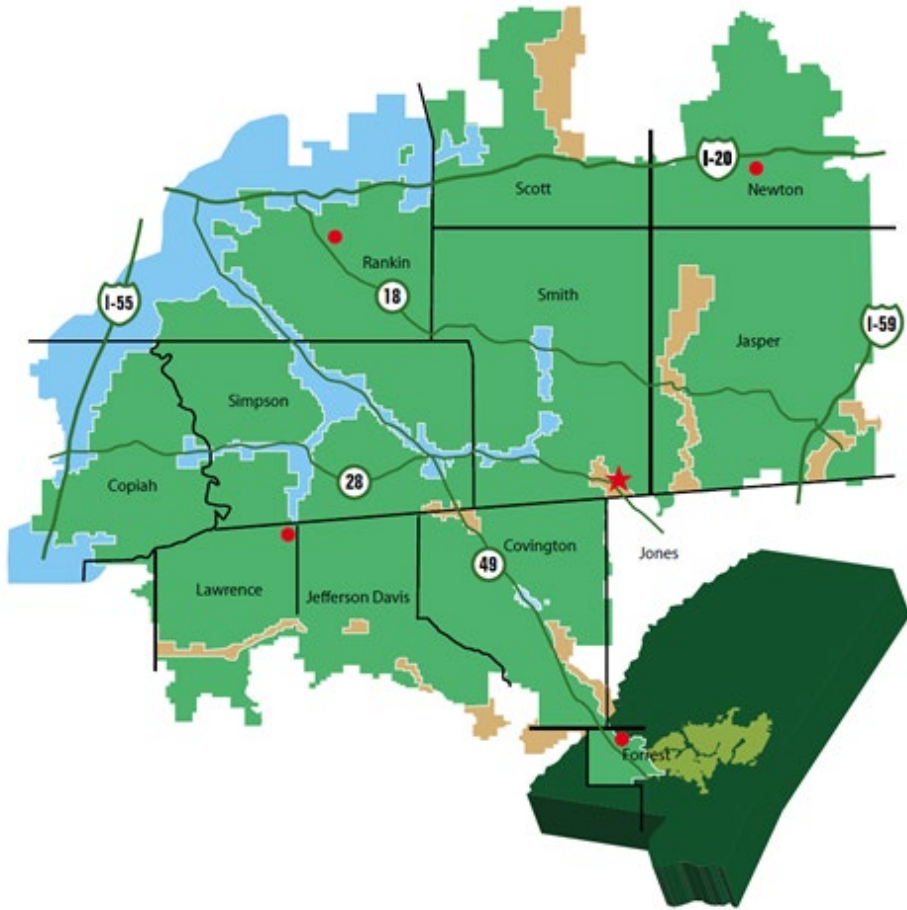


Analysis



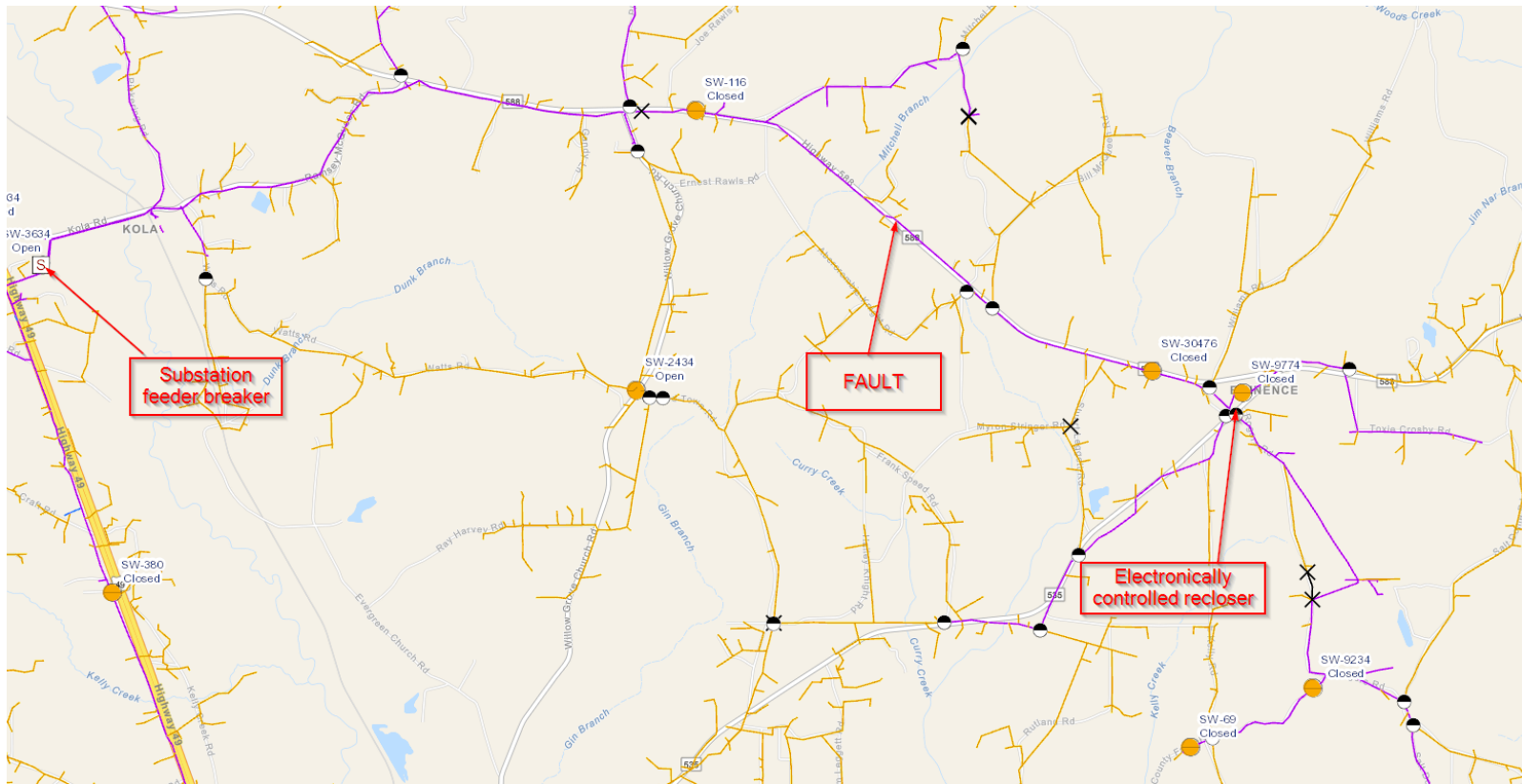
Solution

Southern Pine Electric Cooperative



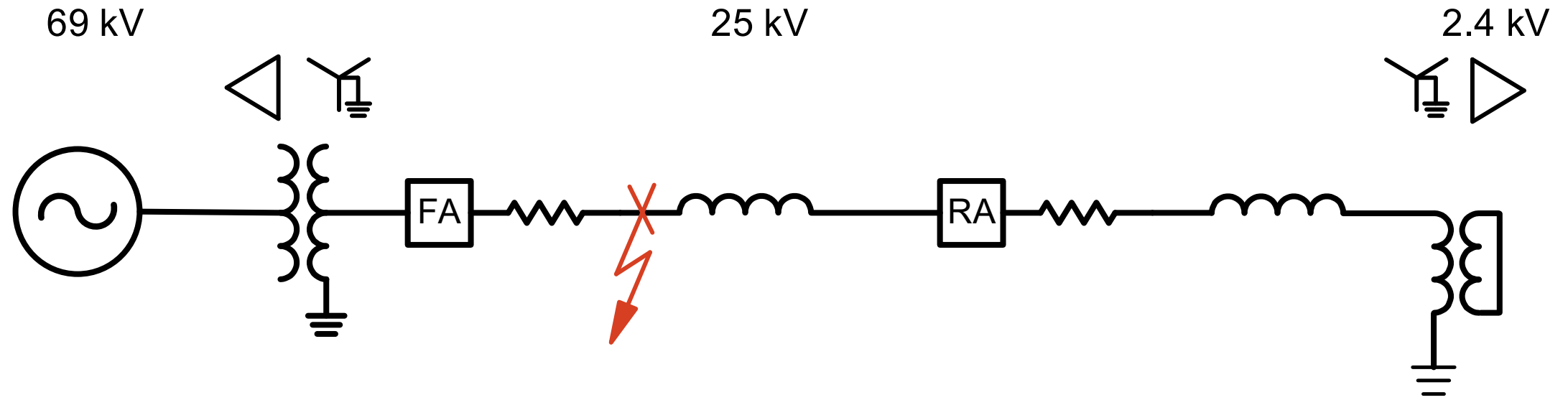
- Was chartered in March 1938 to serve 481 homes and farms
- Is one of the largest electric cooperatives in the country, with more than 10,000 miles of energized line serving more than 68,000 meters
- Serves 11-county service area encompassing 14.3% of total land mass of Mississippi

History



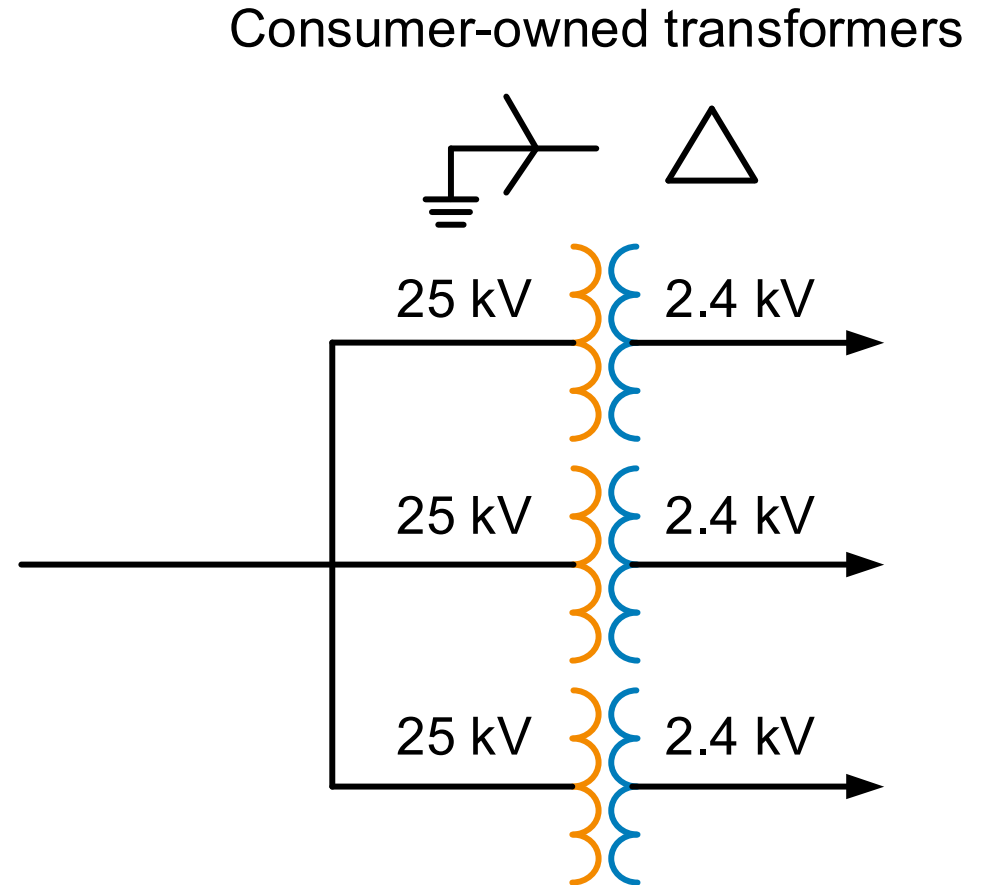
- Fault between feeder breaker and recloser
- Feeder breaker tripped to lockout
- Recloser also tripped to lockout

One-line diagram



Consumer site

- Consumer owns multiple wye-delta transformers
- Motors are mostly 2,400 V
- Loads are all 3 W, so requested 3 W service



Effect

- Feeder lockout required personnel to open and clear feeder breaker to find and repair feeder fault
- After fault was found and repaired, personnel returned to substation and put feeder breaker back into service
- After power was restored to only part of feeder, personnel **then** drove ten miles to the recloser to close it and restore service to remaining consumers

Sequential Event Recorders

Feeder

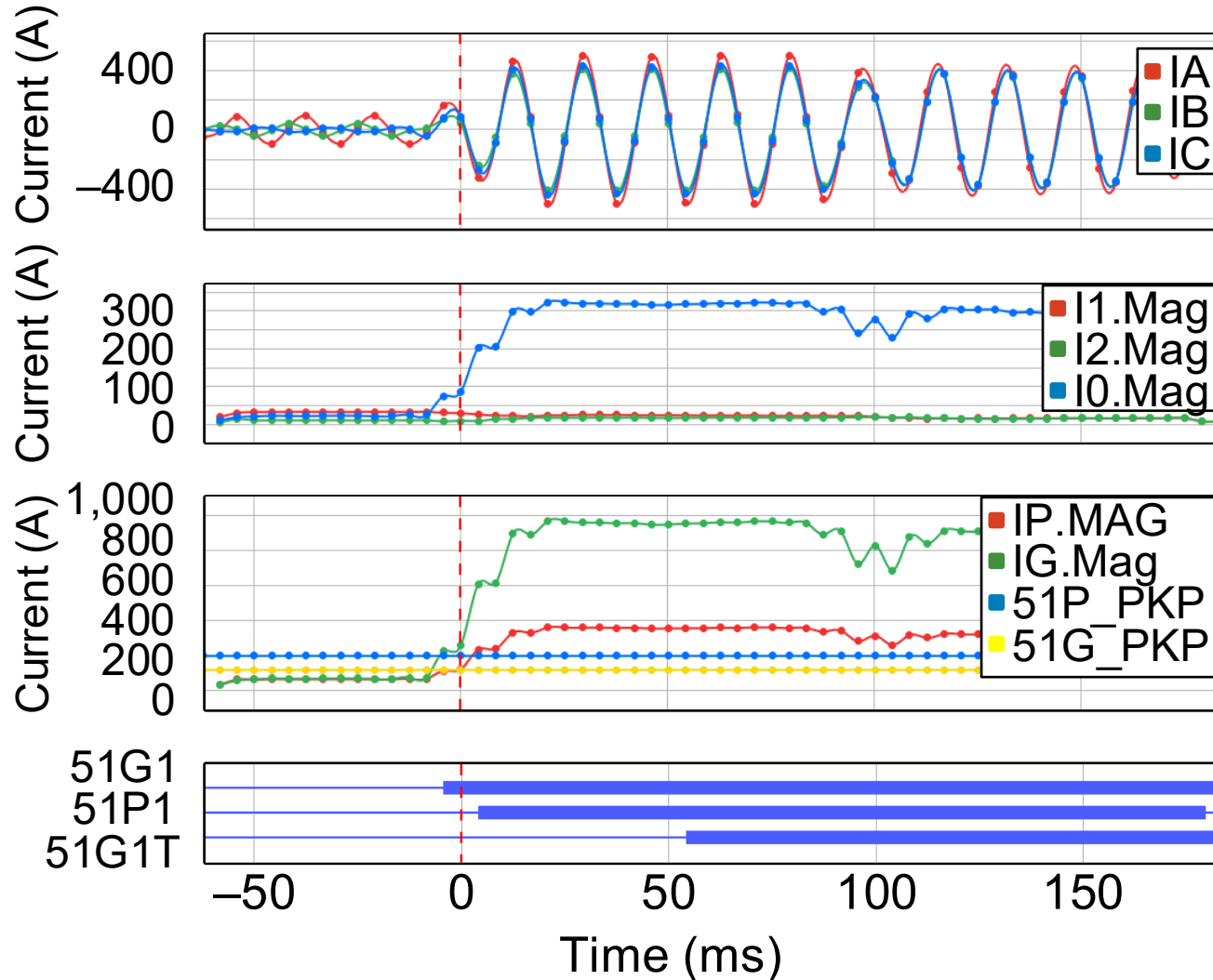
636	12/21/20	08:03:36.980	51P1	Asserted
635	12/21/20	08:03:36.980	OUT103	Asserted
634	12/21/20	08:03:37.018	51N1	Deasserted
633	12/21/20	08:03:37.022	51P1	Deasserted
632	12/21/20	08:03:37.026	OUT103	Deasserted
631	12/24/20	01:05:17.658	51P1	Asserted
630	12/24/20	01:05:17.662	51N1	Asserted
629	12/24/20	01:05:17.662	OUT103	Asserted
628	12/24/20	01:05:18.579	51N1	Deasserted
627	12/24/20	01:05:18.808	51P1T	Asserted
626	12/24/20	01:05:18.808	79CY	Asserted
625	12/24/20	01:05:18.808	79RS	Deasserted
624	12/24/20	01:05:18.808	OUT101	Asserted
623	12/24/20	01:05:18.808	OUT104	Asserted
622	12/24/20	01:05:18.808	TRIP	Asserted
621	12/24/20	01:05:18.825	IN105	Deasserted

Recloser

302	12/21/20	08:04:17.033	SH1	Deasserted
301	12/21/20	08:04:17.033	SH0	Asserted
300	12/24/20	01:05:17.740	51G1T	Asserted
299	12/24/20	01:05:17.740	79CY	Asserted
298	12/24/20	01:05:17.740	79RS	Deasserted
297	12/24/20	01:05:17.740	TRIP	Asserted
296	12/24/20	01:05:17.819	52A	Deasserted
295	12/24/20	01:05:17.828	51G1T	Deasserted
294	12/24/20	01:05:17.849	59A1	Deasserted



Event record



- Once inception of fault occurs, purely zero-sequence current is present
- This zero-sequence current causes the 51G elements to pickup and then initiate a TRIP
- Currents can be high enough to pick up 51P elements as well

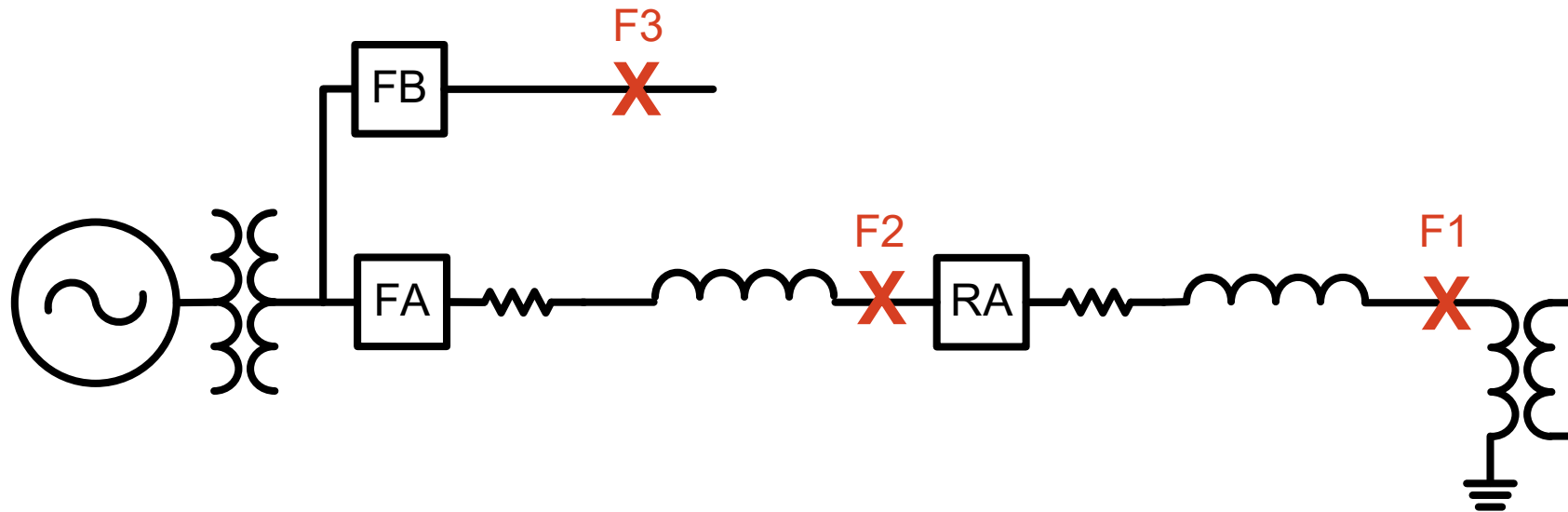
Why...Wye (grounded) – delta transformer?

- Grounding bank for DER
 - Limits overvoltage on unfaulted phases
 - Allows DER to use impedance grounding
 - Alternatively, a zigzag grounding bank may be applied in parallel with DER service; any grounding bank has the same effect
- Provide four-wire delta service
- Provide customer with three-wire, three-phase service
 - Consumer insists on ungrounded connection
 - Better to provide four-wire, three-phase service



Fault analysis with grounding bank

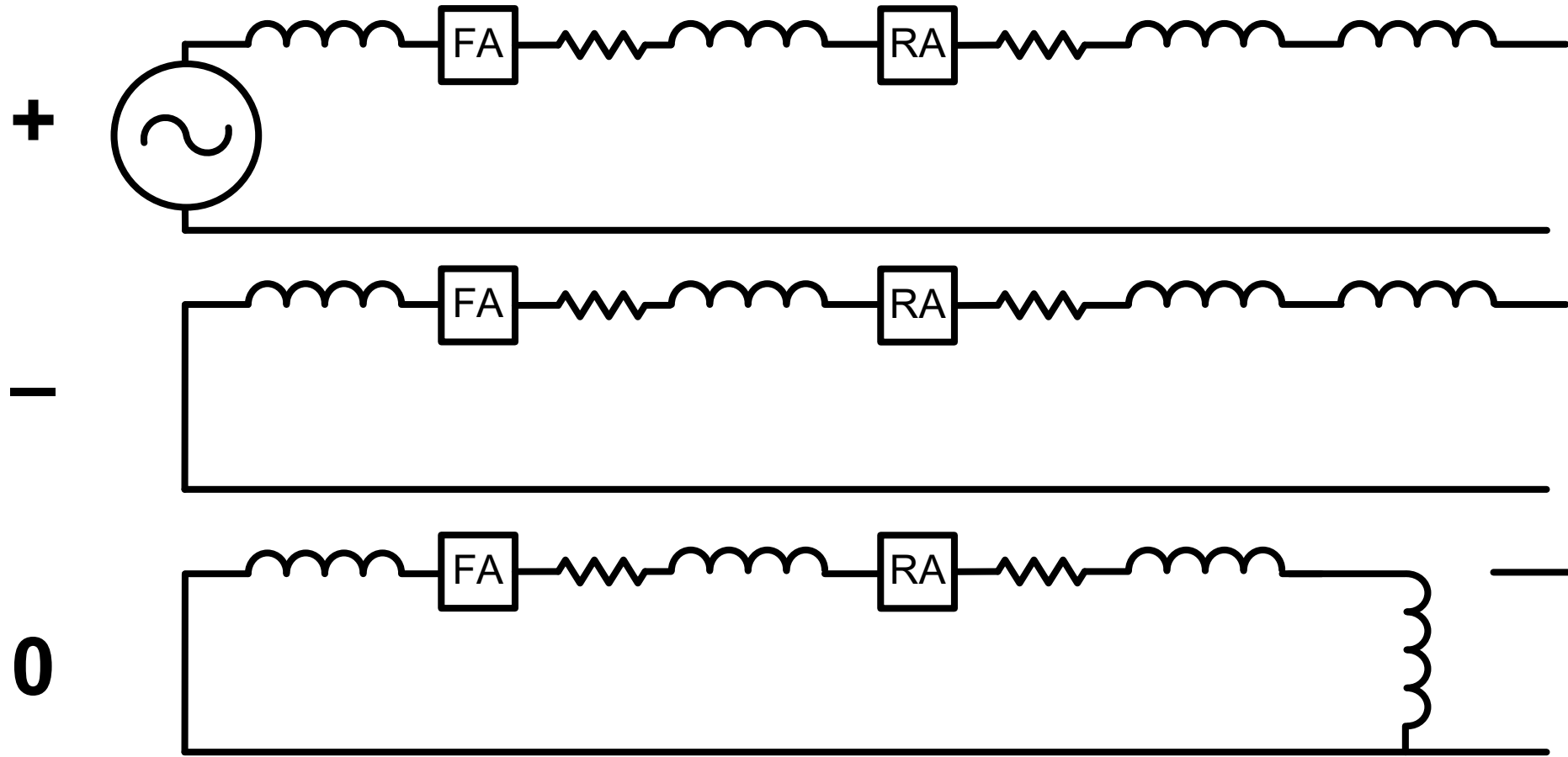
Example feeder with grounding bank



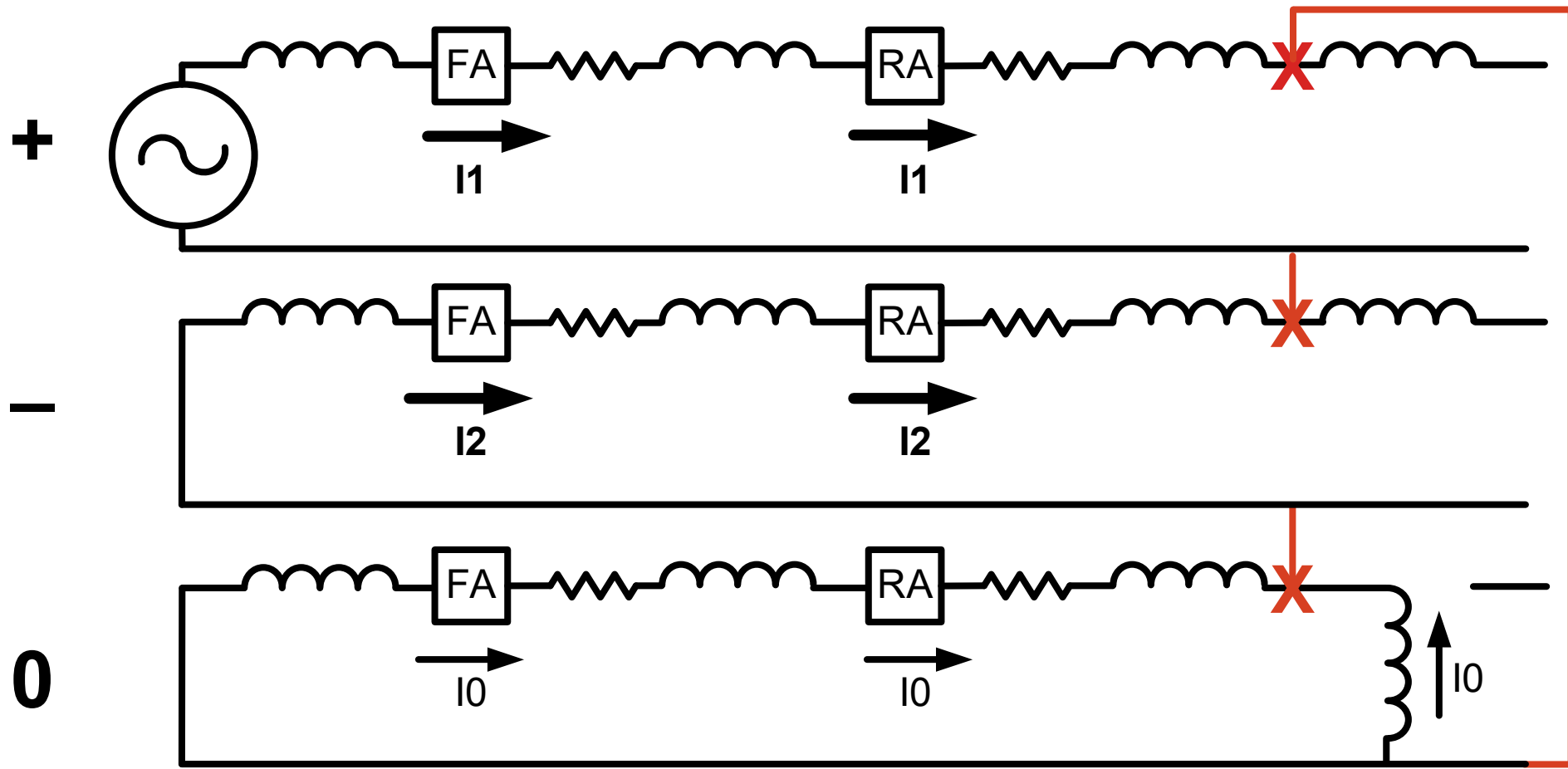
	RA	FA	FB
F1	TRIP	TRIP (backup)	—
F2	—	TRIP	—
F3	—	—	TRIP

Cases with red dash are at risk of incorrect trip

Example feeder: sequence networks

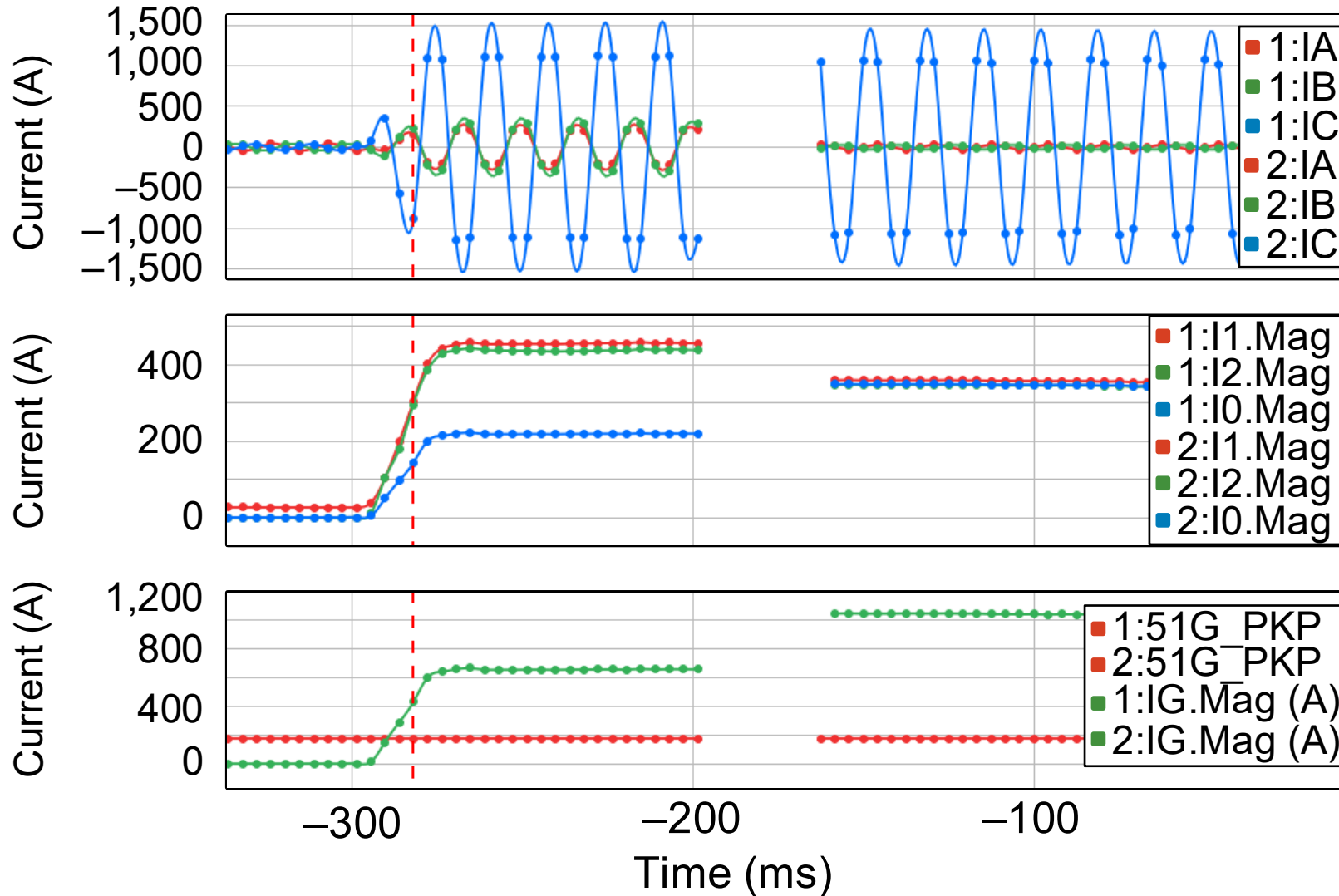


Example feeder: Fault F1



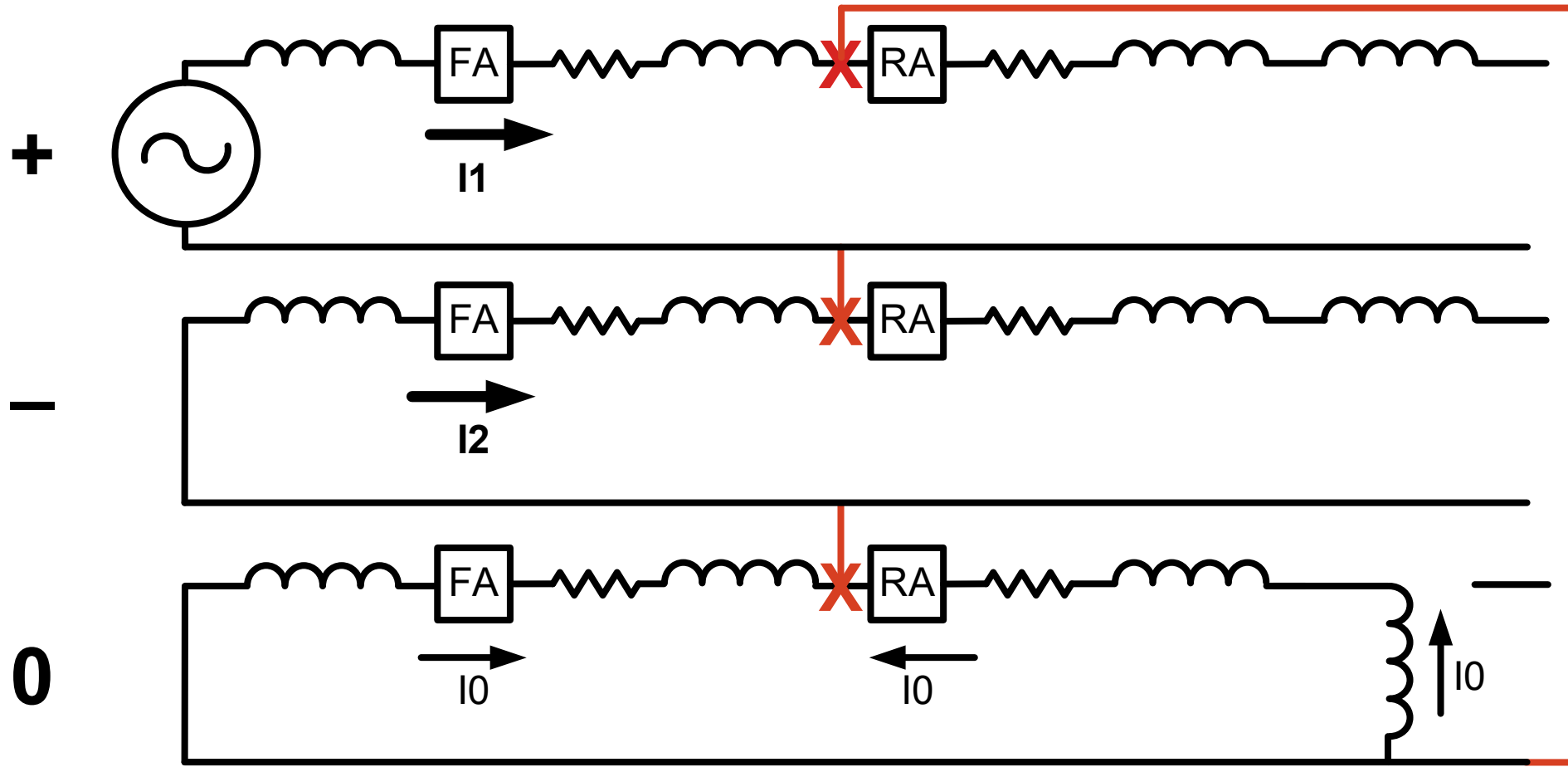
Fault F1 seen by recloser

Grounding
bank in
service

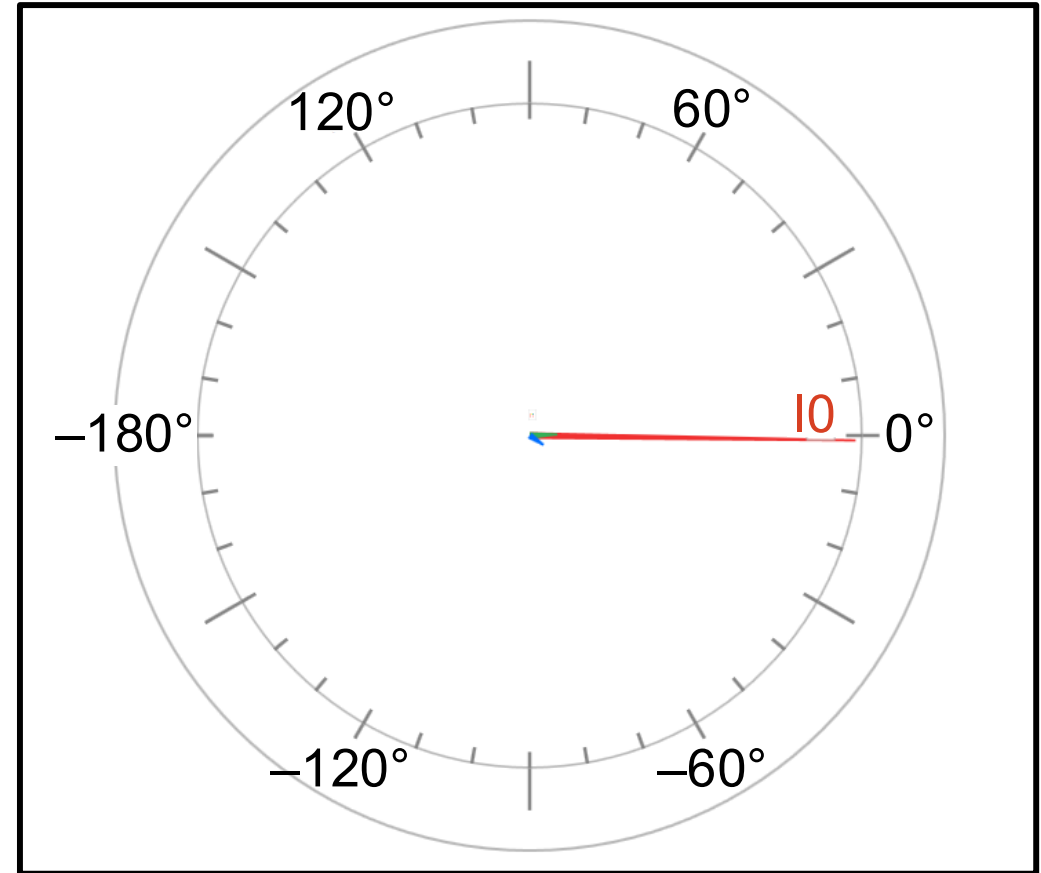
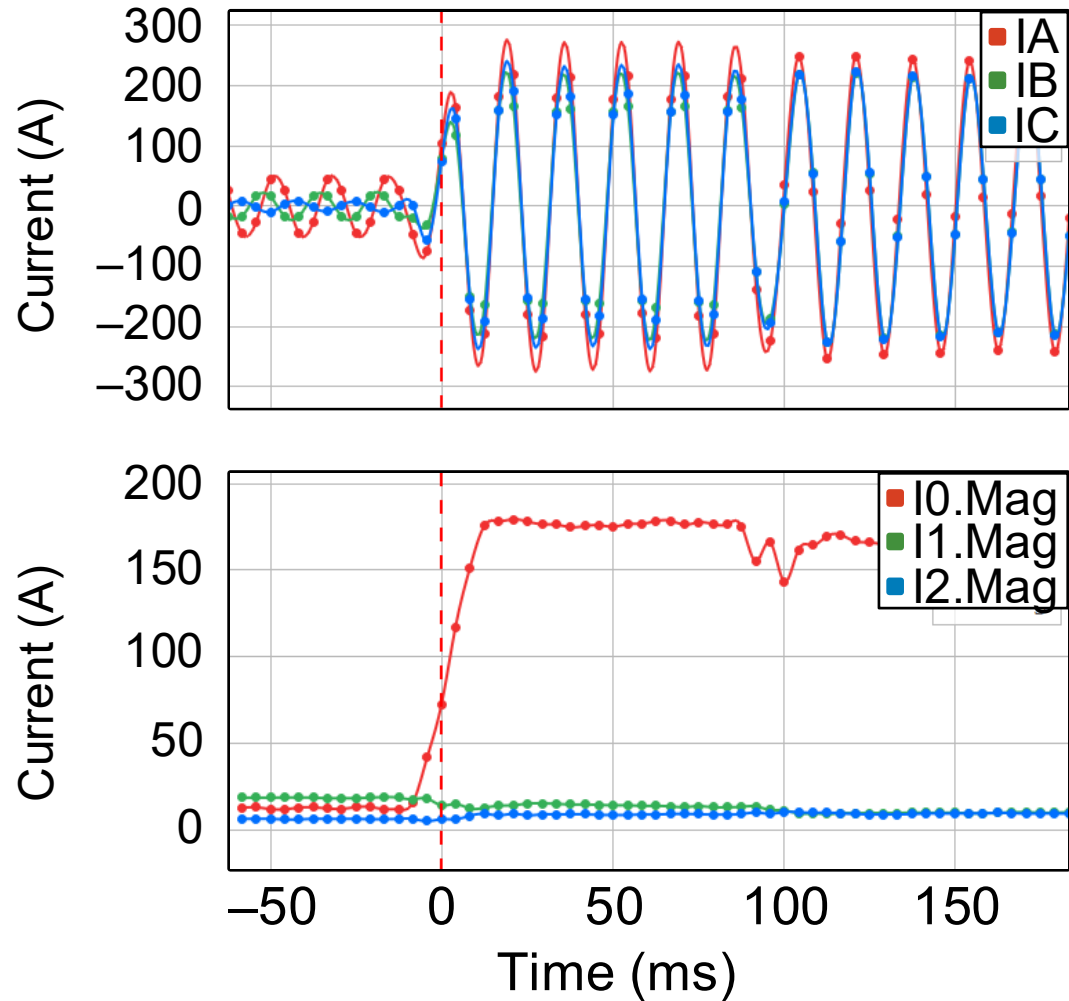


Grounding
bank out
of service

Example feeder: Fault F2



Fault F2 seen by recloser



Solutions

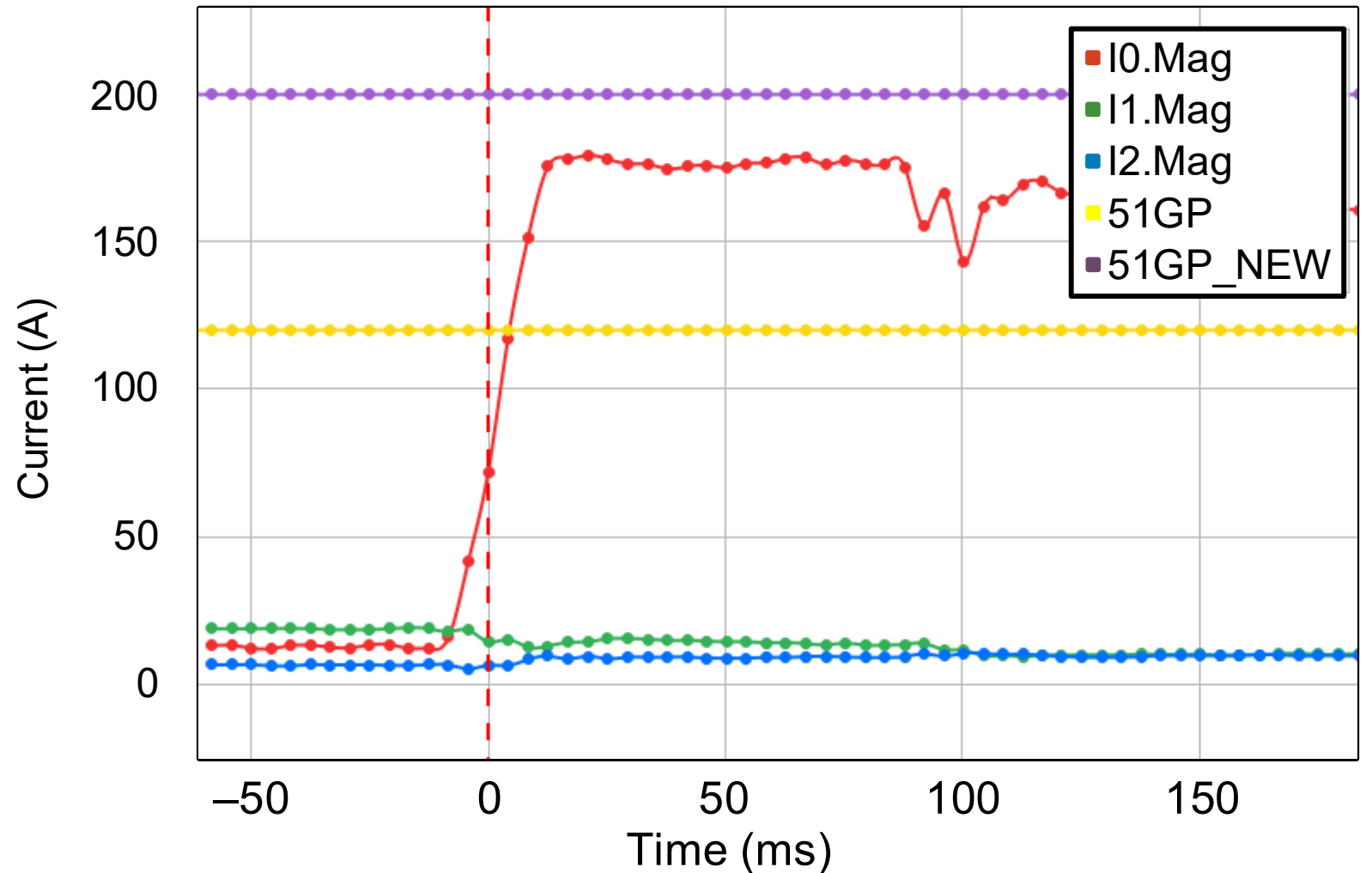
- Desensitize 51G
 - Reduces dependability for ground faults
 - May be acceptable for small grounding banks
- Use directional overcurrent
 - Is secure and dependable
 - Requires three-phase voltage measurement
- Use 50Q supervision
 - Is secure and dependable
 - Is easy to set
 - Needs only current measurements
 - Can be applied in legacy electronic recloser installations

Desensitize 51G

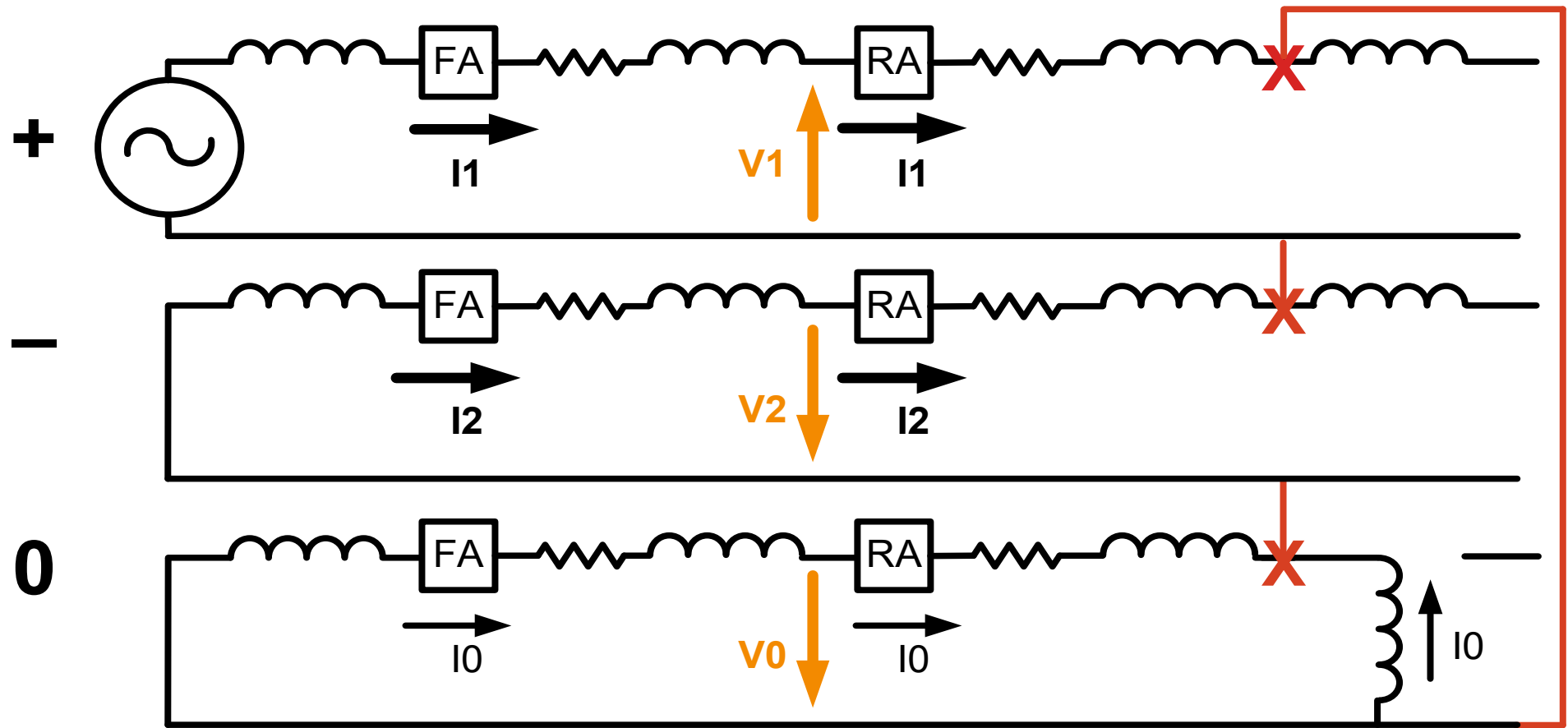
$$R_f \leq \frac{7,200 \text{ V}}{200 \text{ A}}$$

$$R_f \leq 36 \Omega$$

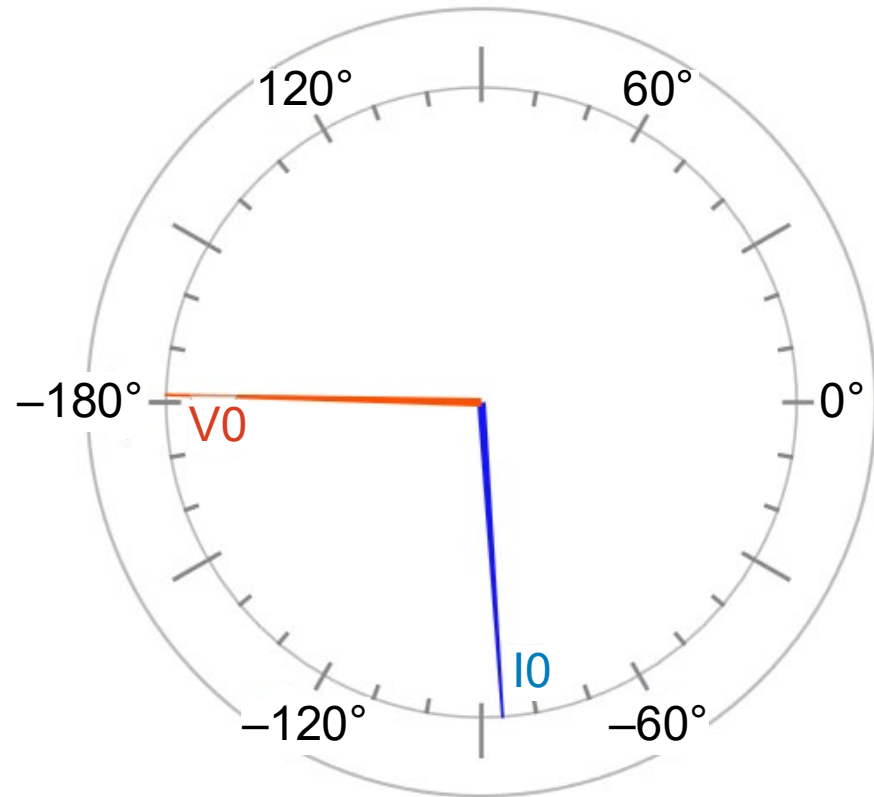
- Is this adequate resistive coverage?
- Is this a worst-case event?



Forward ground fault

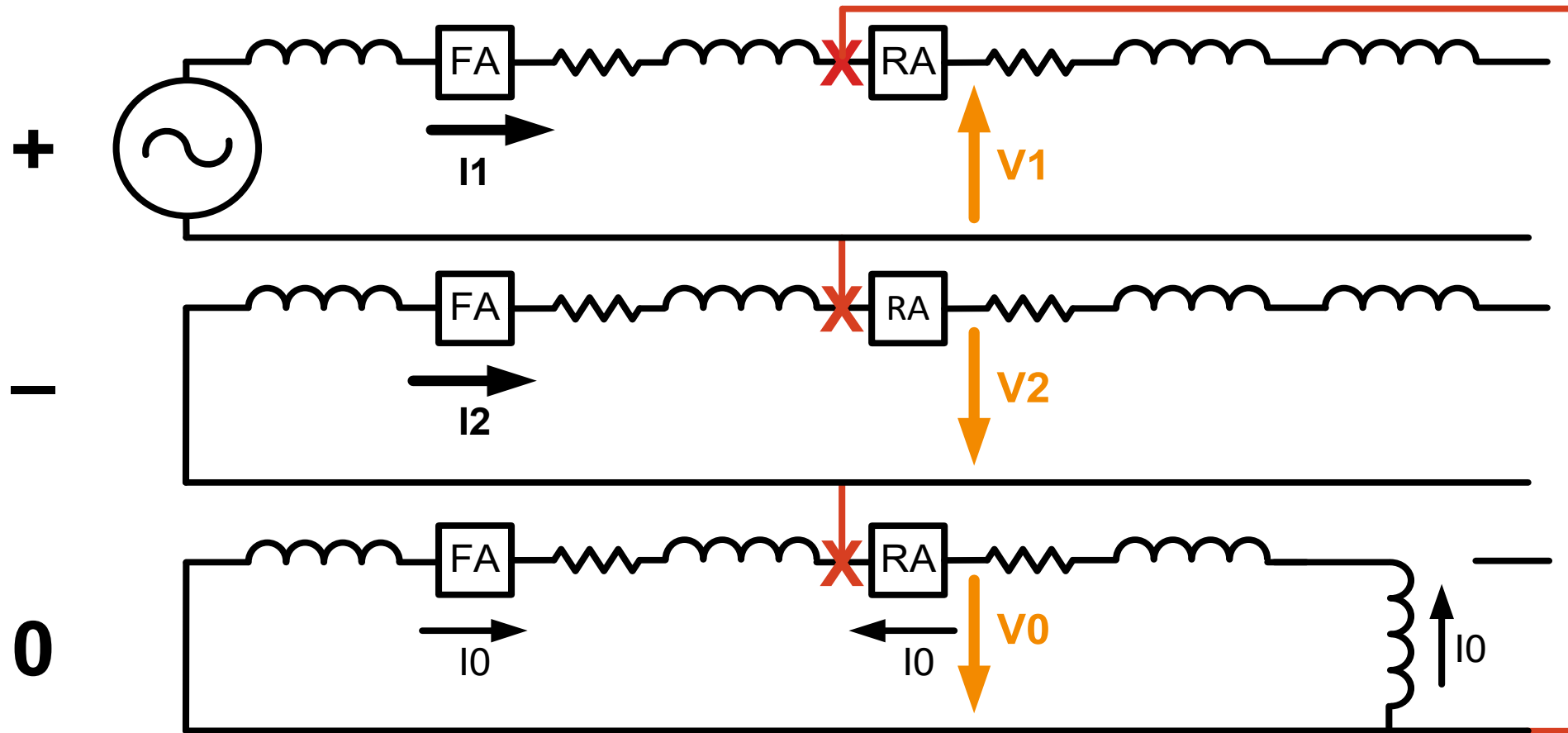


Forward ground fault phasors

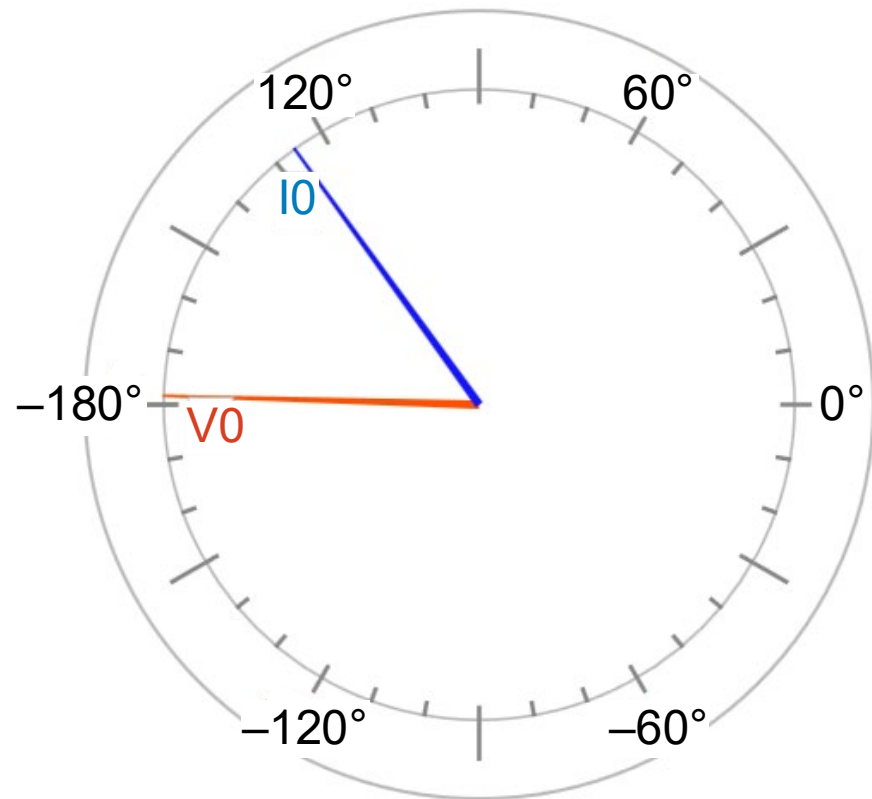


Color	Name	Mag	Angle
Orange	V0	0.53775 kV	177.66°
Blue	I0	219.763 A	-87.36°

Reverse ground fault



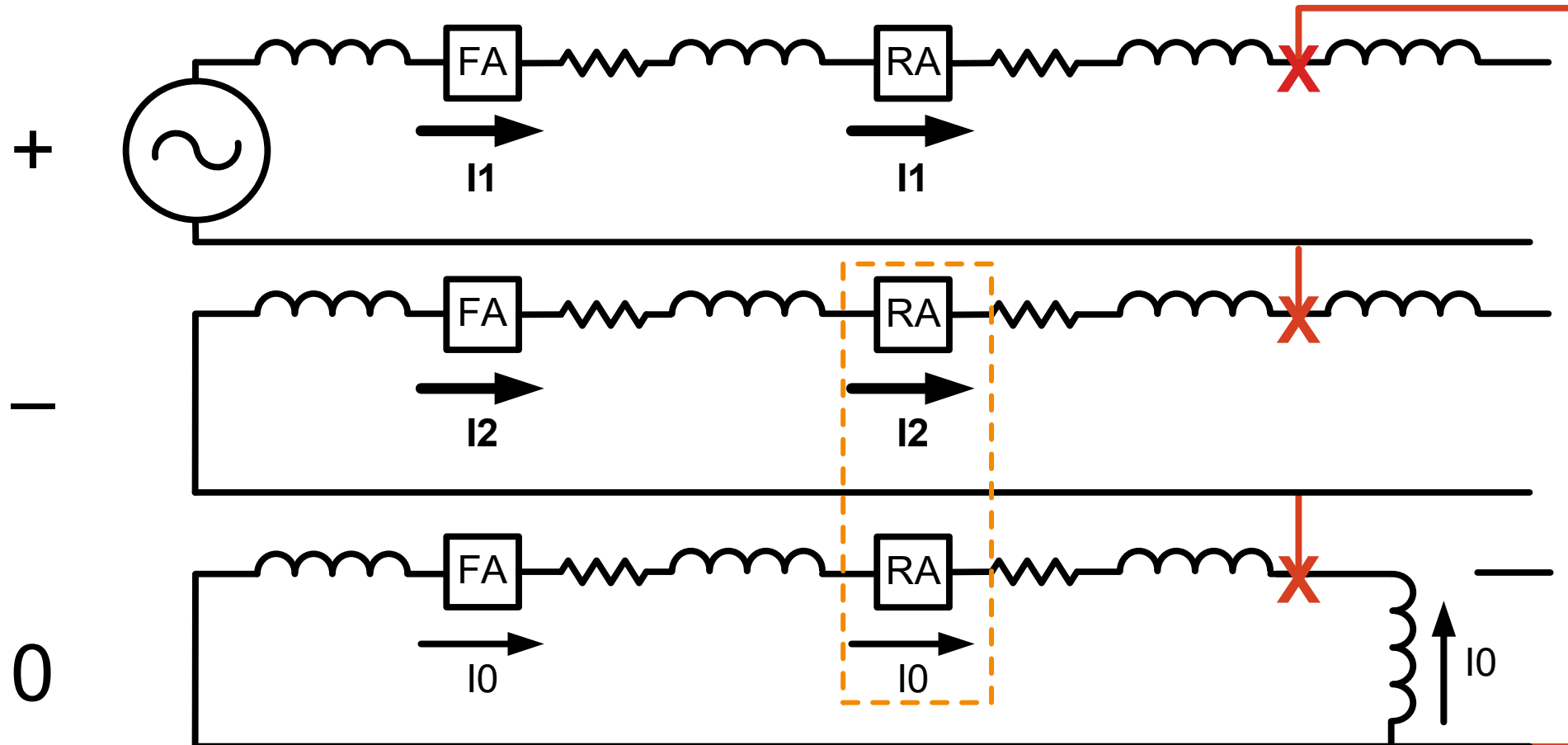
Reverse ground fault phasors



Color	Name	Mag	Angle
■	V0	1.09079 kV	178.39°
■	I0	176.768 A	125.8°

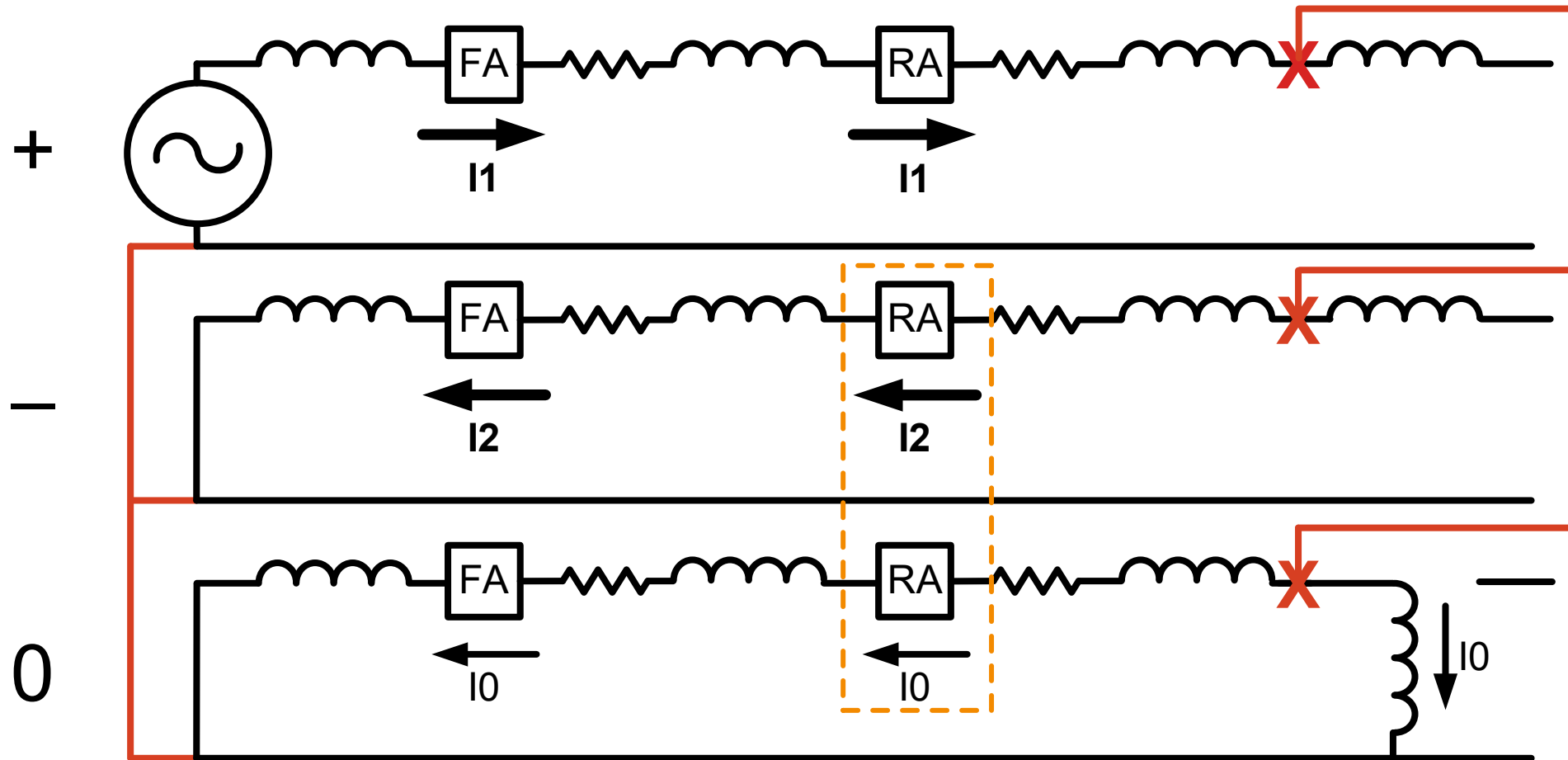
50Q supervision

$I_2 \geq I_0$ in forward single-line-to-ground fault



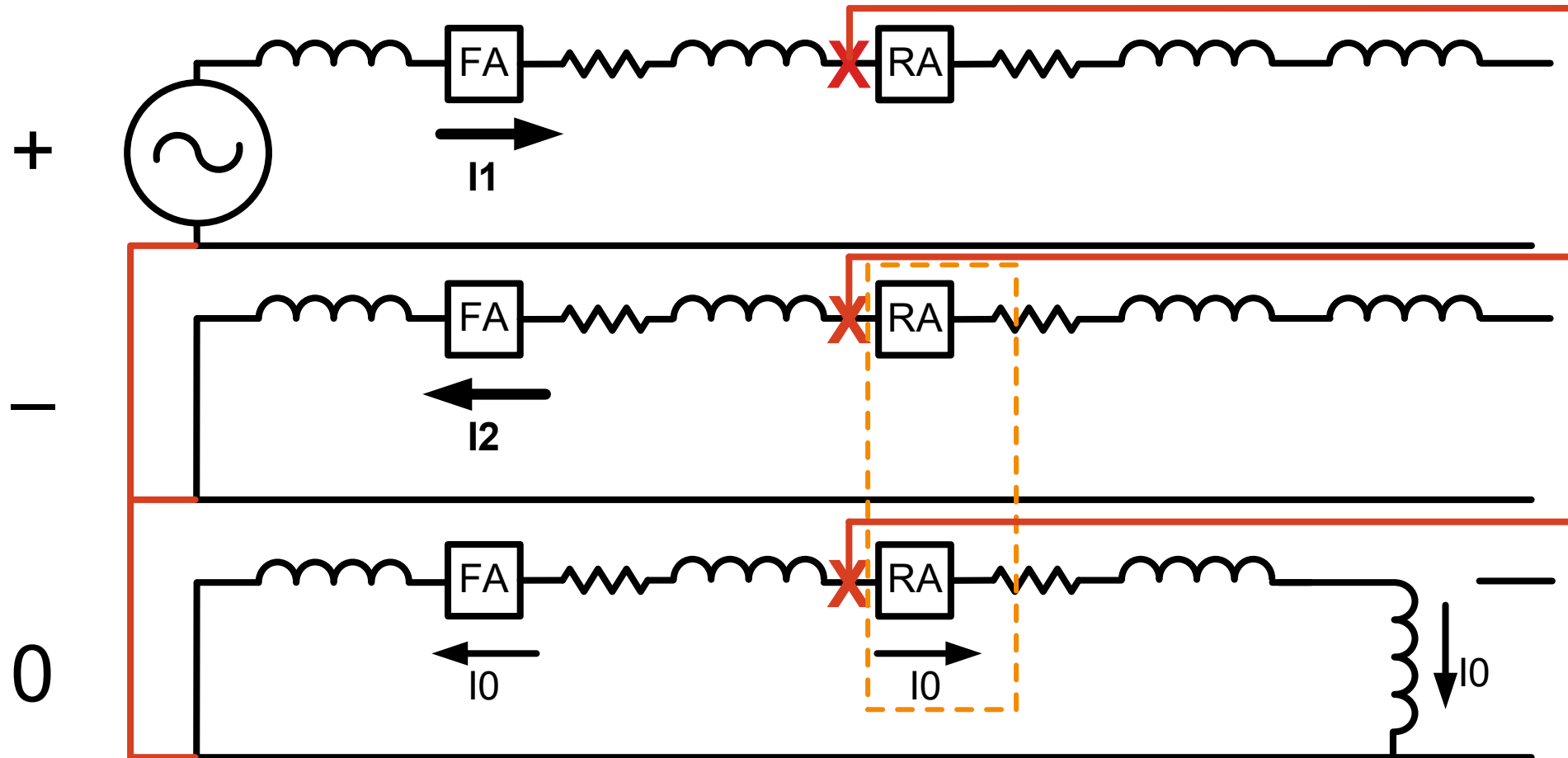
50Q supervision

$I_2 \geq I_0$ in forward double-line-to-ground fault



50Q supervision

$I_2 \ll I_0$ in reverse double-line-to-ground fault

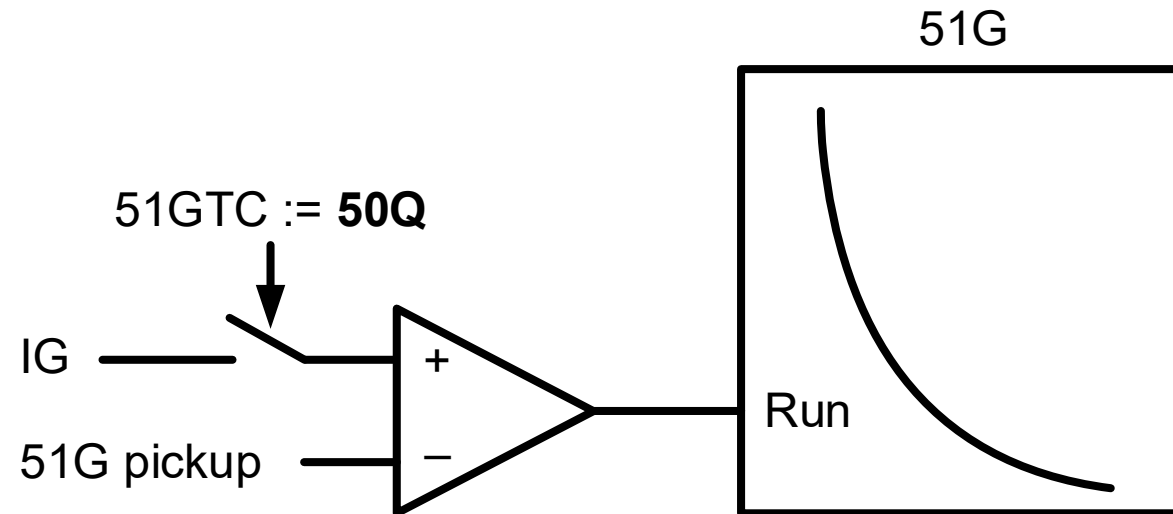


50Q supervision

How to set

51G supervision

1. Set 50Q pickup = 51G pickup
2. Run when 50Q = 1



50Q supervision

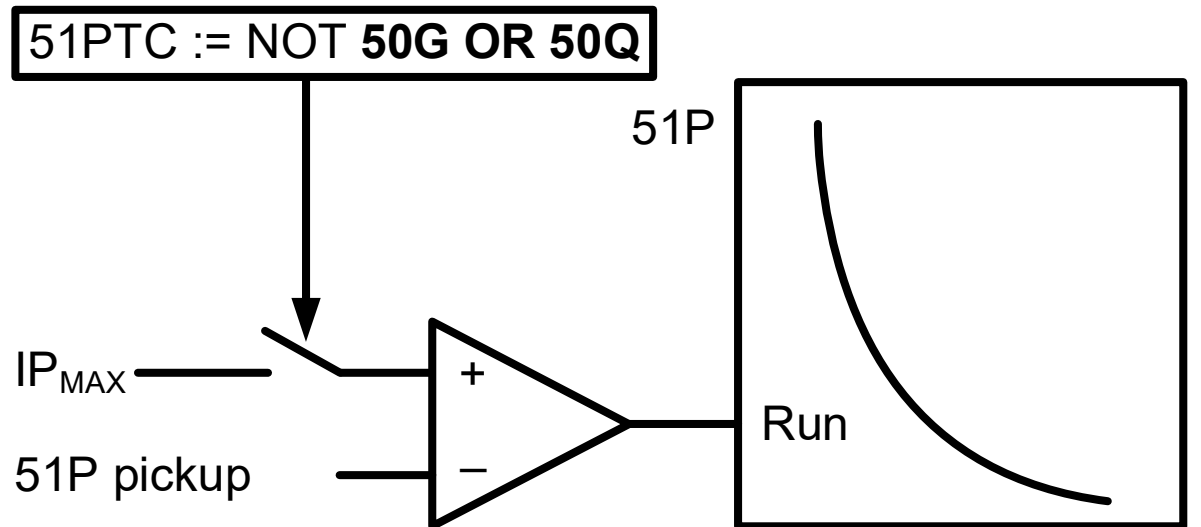
How to set

51P supervision

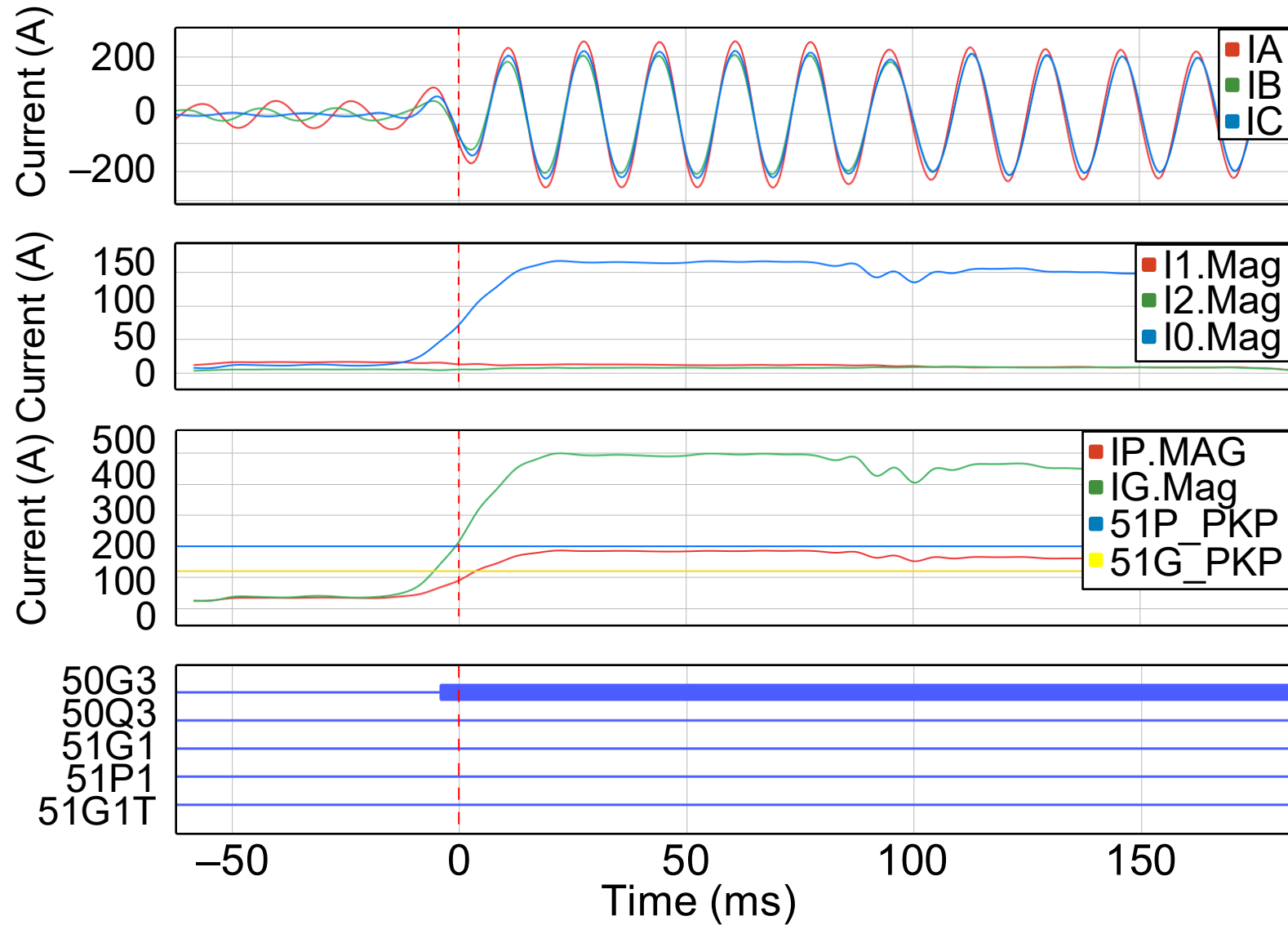
1. Set 50Q pickup = 51G pickup
2. Set 50G pickup = 51G pickup

Run when

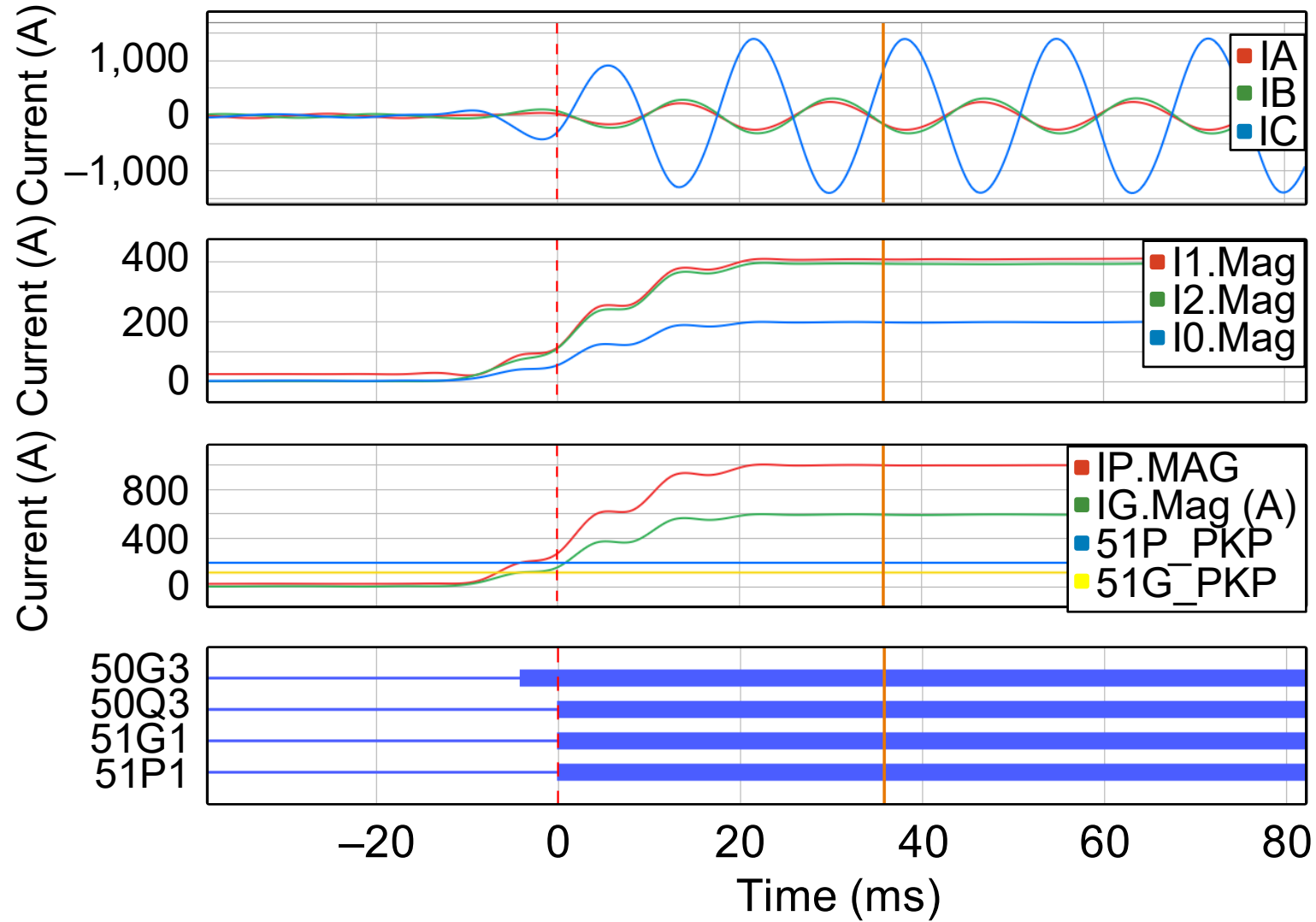
1. $50G = 0$ (not a ground fault)
2. $50Q = 1$ (forward unbalanced fault)
3. $\text{NOT}(50G \text{ OR } 50Q) = 1$
(three-phase fault)
4. Simplifies to $(\text{NOT } 50G \text{ OR } 50Q)$



F2 with 50Q supervision



F1 with 50Q supervision



Conclusion

- Grounded-wye delta transformers threaten security of traditional radial distribution protection
- Classical solutions require voltage measurements not available with some legacy reclosers
- 50Q supervised solution secures traditional protection schemes without equipment upgrades
- 50Q supervised solution works on radial systems or systems with only one strong source

Questions?