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MICROPROCESSOR RELAY DIRECTIONAL CHANGE DURING CURRENT REVERSAL

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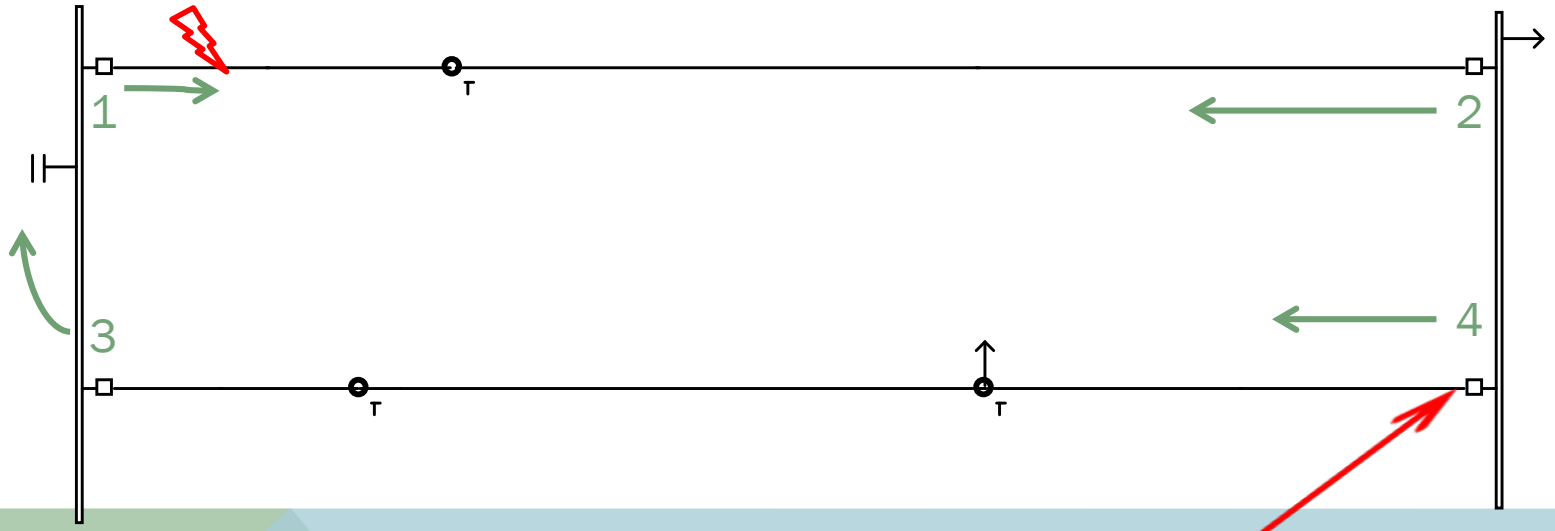
OVERVIEW OF EVENTS

- An SLG fault occurred on one transmission line of a parallel circuit
  - Fault duration was 83.33 ms (5 cyc at 60 Hz).
- After one end cleared, one terminal of a parallel line operated.
  - There was no fault on this parallel line.
  - A reverse fault appeared to be forward
  - Reverse fault current value was higher than the instantaneous overcurrent pickup value.

PROTECTION ELEMENTS

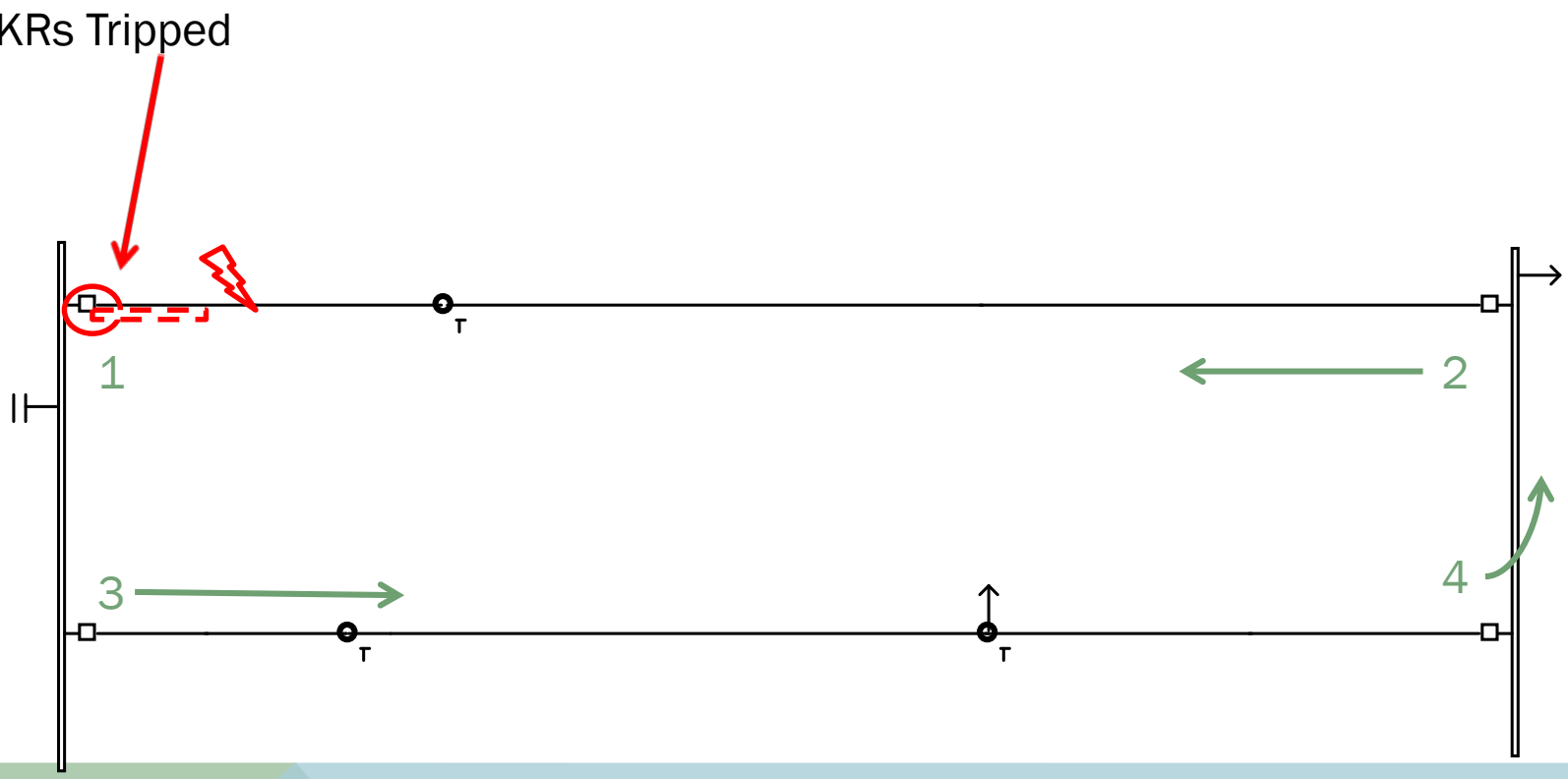
- The relays used communication schemes and non-communication tripping schemes
- The element that misoperated was a directional ground instantaneous overcurrent element
  - This is a non-communication element meant to under-reach and trip with no intentional time delay
  - 67G1 requires a high pickup value for the current and an established forward direction.
  - The relay uses other elements to establish the direction

TOPOLOGY OF AREA – FAULT CURRENT DIRECTION



Relay with the unintended operated

TOPOLOGY OF AREA – CURRENT REVERSAL

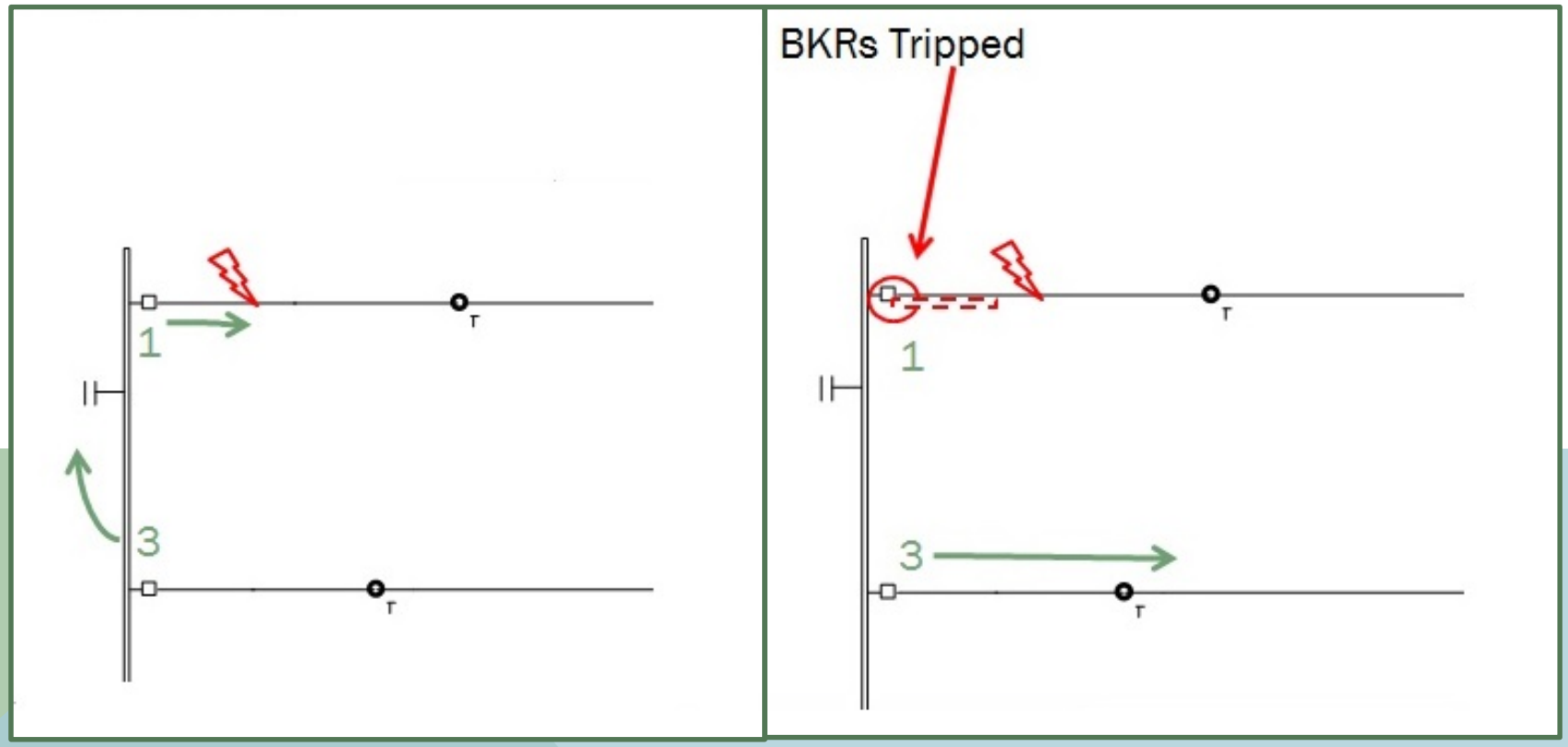


CONTRIBUTING FACTORS

- This event involved a combination of contributing factors
  - Parallel Lines
  - Location and clearing of the fault
  - Relative strength of the fault current sources
  - Relay philosophy update was needed to account for manufacturer relay logic change

PARALLEL LINES

- There's a current reversal on the parallel line after an end has cleared
- This is more likely to happen on parallel lines



LOCATION OF FAULT – FAULT CLEARING

- Since the fault was located near a terminal, that relay operated quickly to send a trip
- This led to one of the parallel lines being single-ended

SOURCE STRENGTH

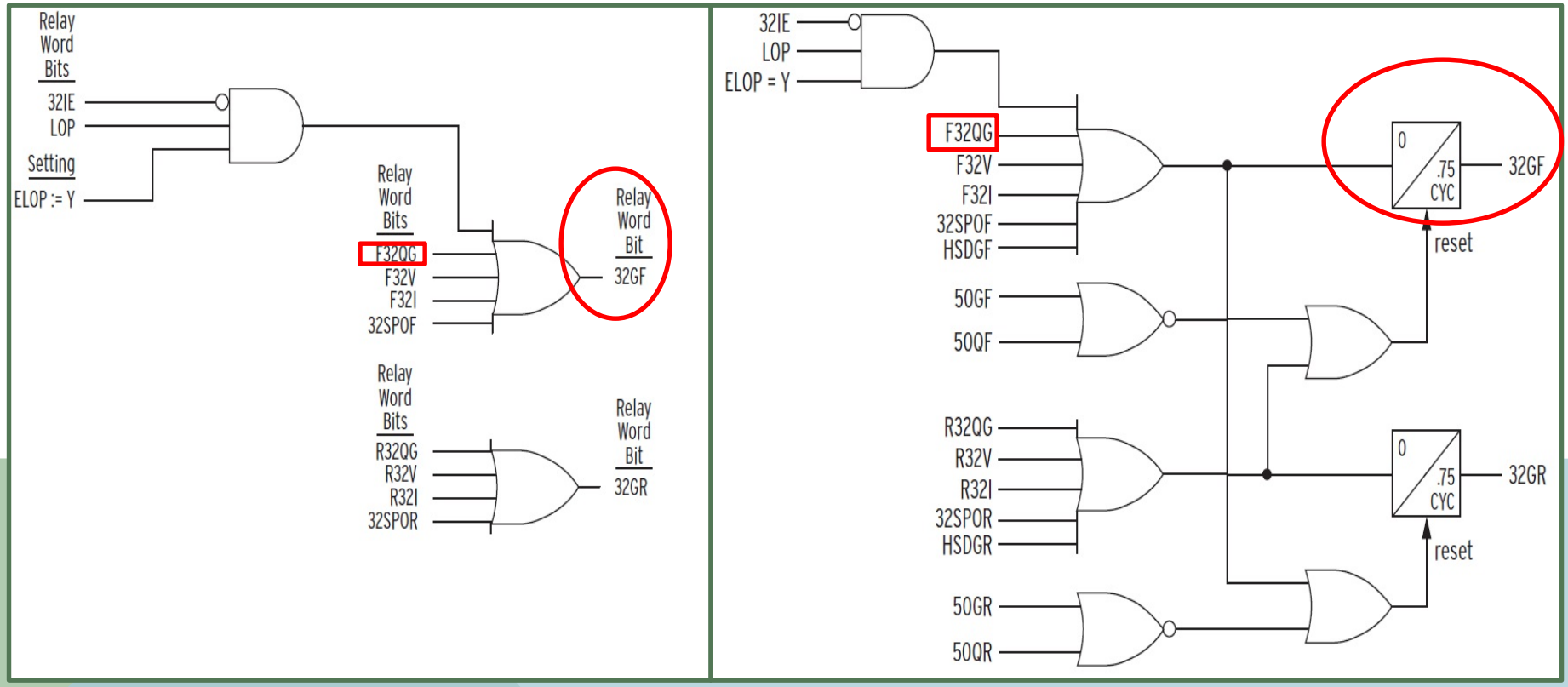
- One end of the line had a much stronger source
- When the current was reversed due to the end opening, most of the fault contribution came from the stronger source
  - This fault current went through the line where the relay misoperated
- This also led to the fault current being above the instantaneous ground overcurrent pickup

DIRECTIONALITY

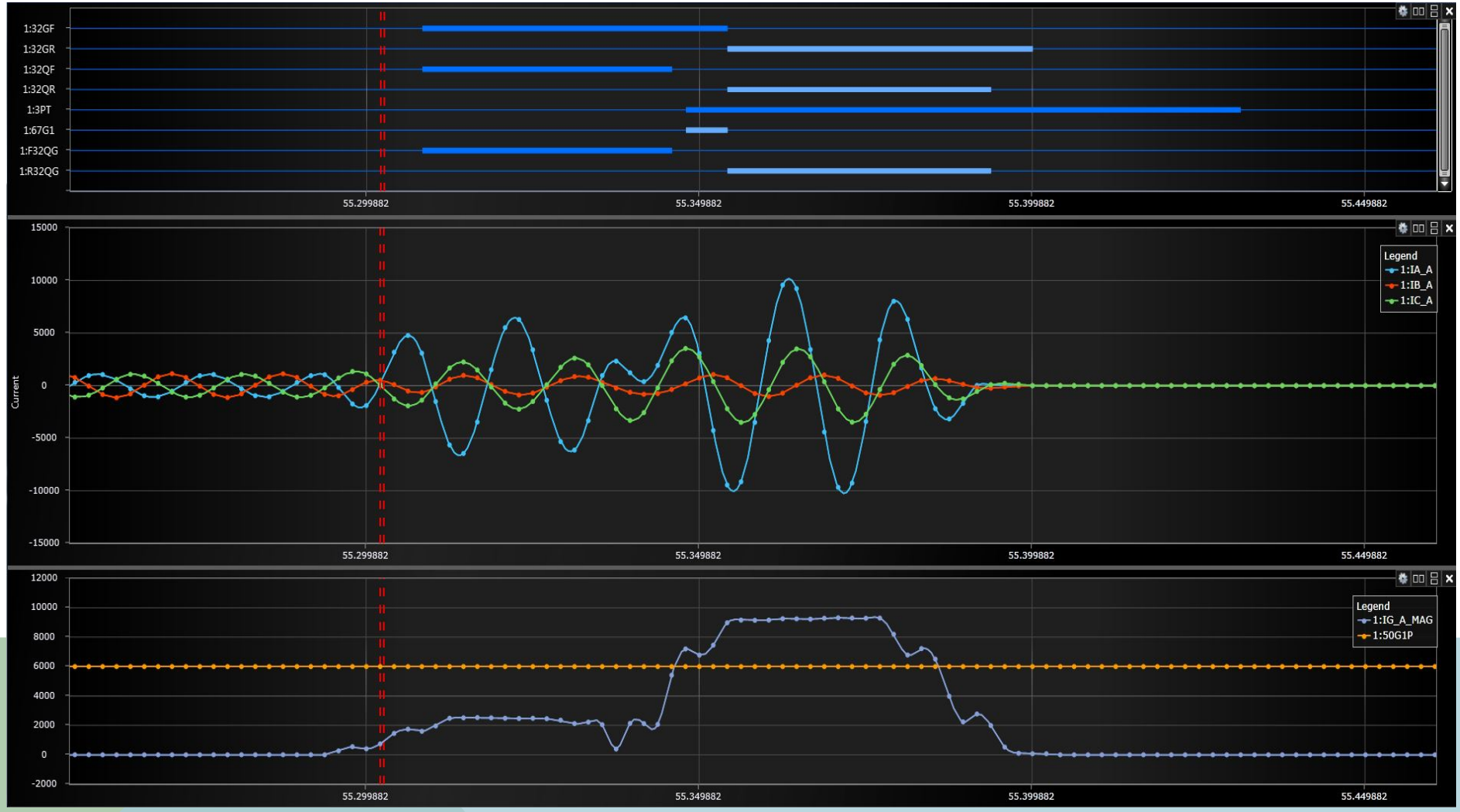
- It was also realized that the relay settings didn't account for a change in the directionality logic
- A directional element dropout timer led to the relay still seeing a forward fault when other directional elements dropped out
- This forward decision and the high reverse current led to the ground instantaneous overcurrent element operating

CHANGE IN RELAY LOGIC

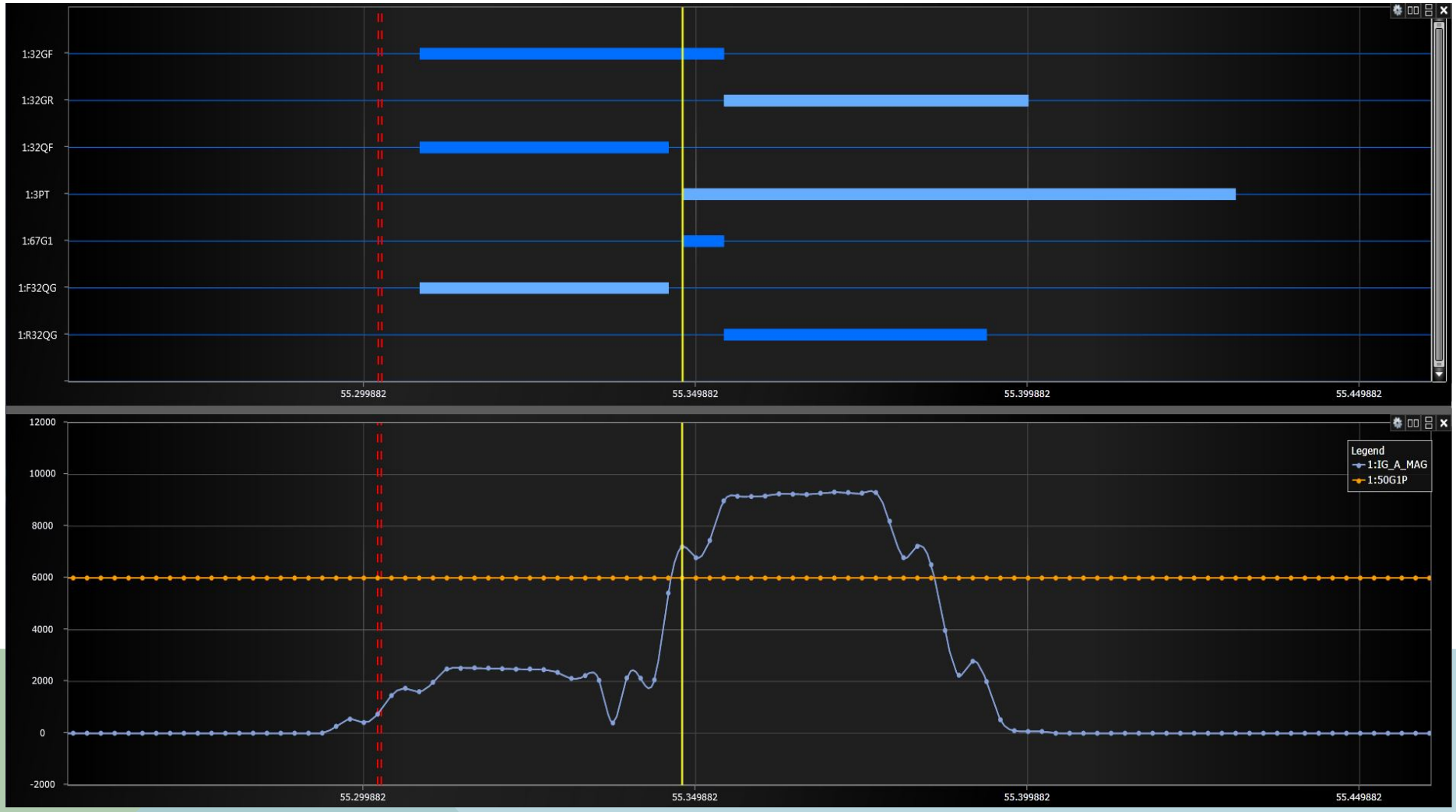
- There was a dropout timer added to the relay's directionality logic for ground directional elements



RELAY OSCILLOGRAPHY - OVERVIEW



RELAY DIGITAL ELEMENTS



NOTES

- Initially, the torque control was set to 1 since there was no dropout time delay between F32QG and 32GF in the original logic
  - 32GF used to establish forward direction for the ground instantaneous overcurrent tripping element
  - An adjustment can be made by torque controlling with the F32QG element
- The forward ground instantaneous element picking up for a reverse fault would have been difficult to test since studies are usually done to test the forward pickup

LESSONS LEARNED

- Relays and their logic can be updated after the initial company practice is established
- As relays are updated, it’s important to track changes in relay logic and other updates
- There could be logic changes that would change current relaying philosophy

REFERENCES

1. Schweitzer Engineering Laboratories SEL-421 Instruction Manual

QUESTIONS/ COMMENTS?