Solutions to Common Distribution Protection Challenges

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Common Distribution Protection Problems

- Unnecessary operations on fast curve due to inrush
- Long protection times as multiple devices coordinate
- Operation of feeder relay caused by conductor slap
- Closure into faults in loop schemes from lack of communication

Distribution System Protection

Challenges

- Zones of protection are large and diverse
- Selectivity is classically established using time
- Topology is dynamic
- Maximum load conditions can be close to minimum fault conditions

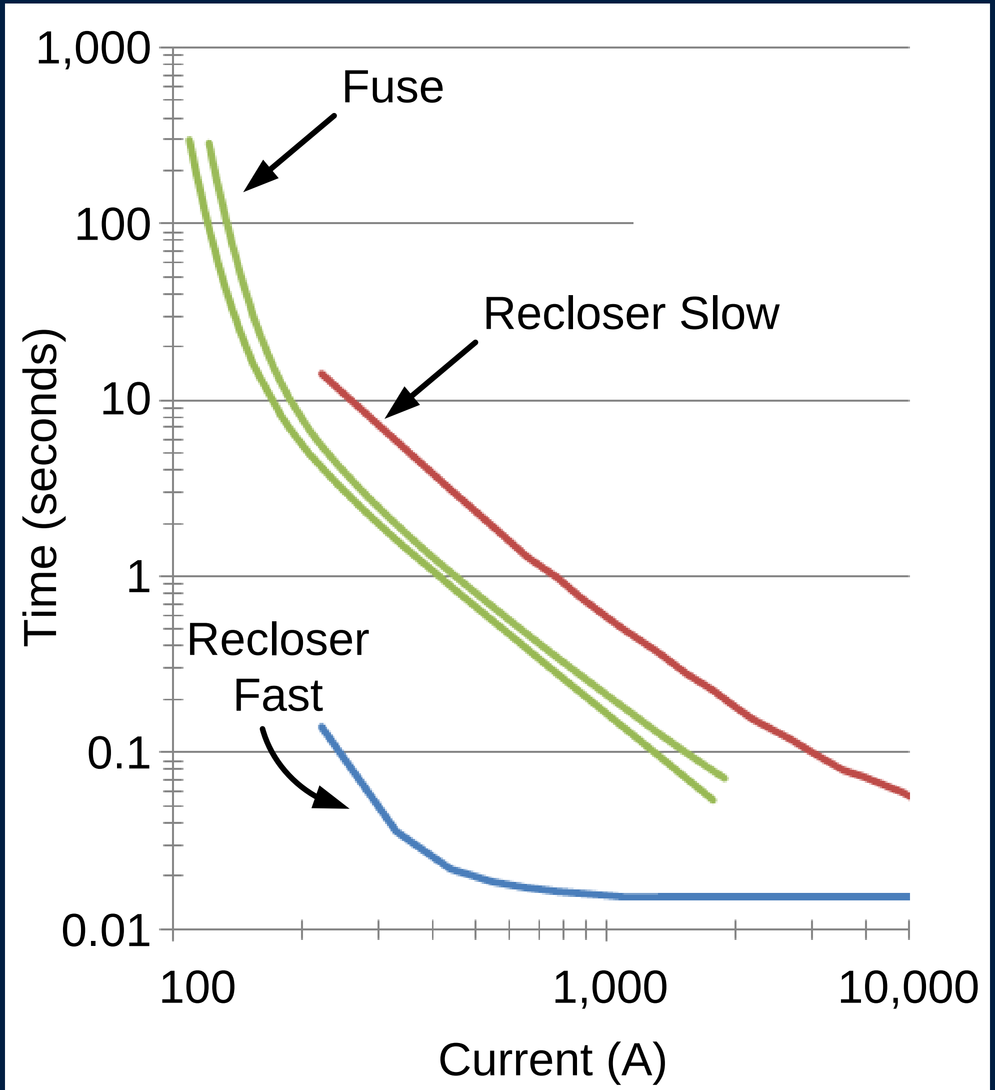
Distribution System Protection

Advantages

- Multiple shots of reclosing
- Measurements distributed across the protected system
- Advanced feeder relays and recloser controls
  - Event records
  - Historical data
  - Multiple protection elements
  - Custom logic

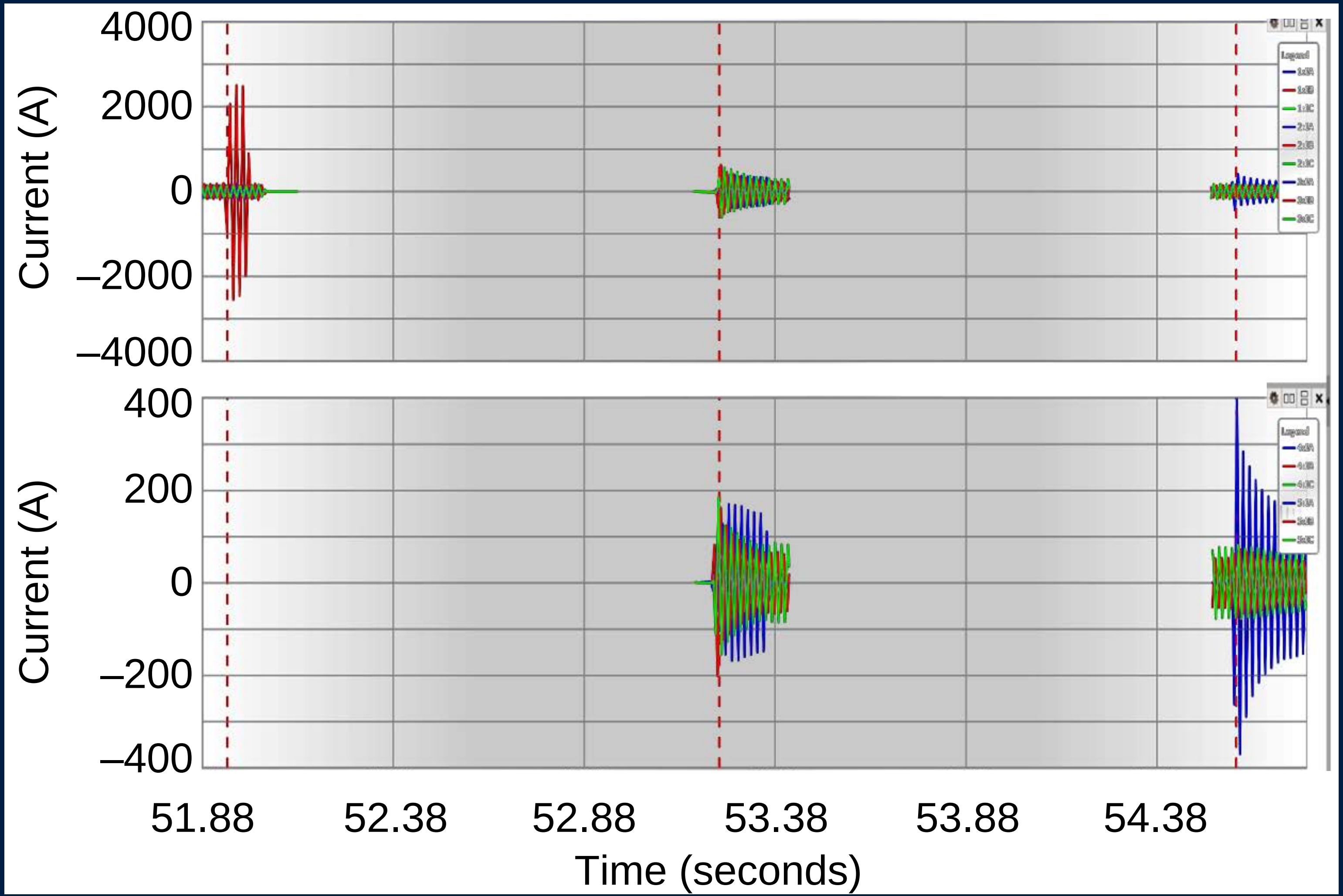
Eliminate Unnecessary Fast-Curve Operations
Problem

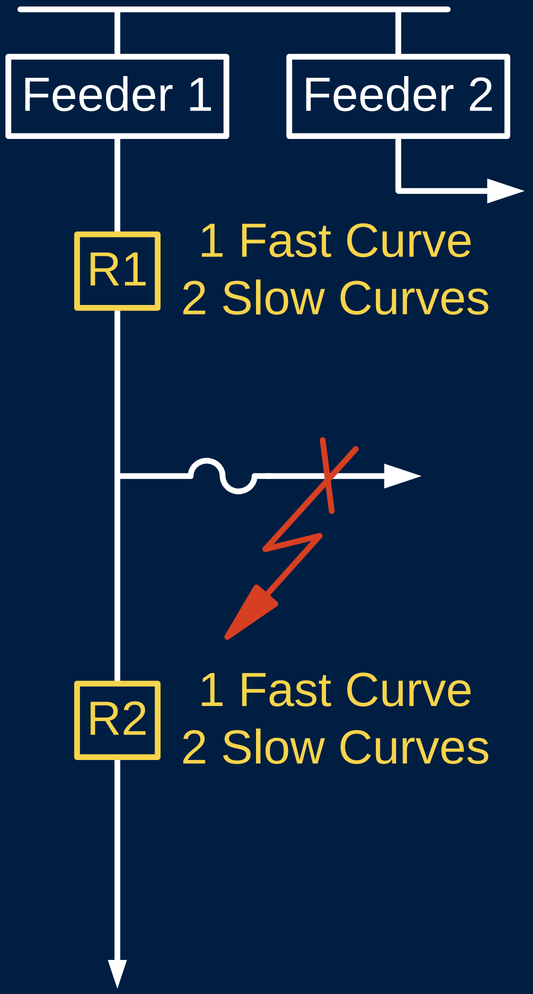
- High speed
- High sensitivity
- Low security during inrush
  - Magnetizing inrush
  - Load inrush
- Frequent exposure to inrush due to reclosing



Eliminate Unnecessary Fast-Curve Operations

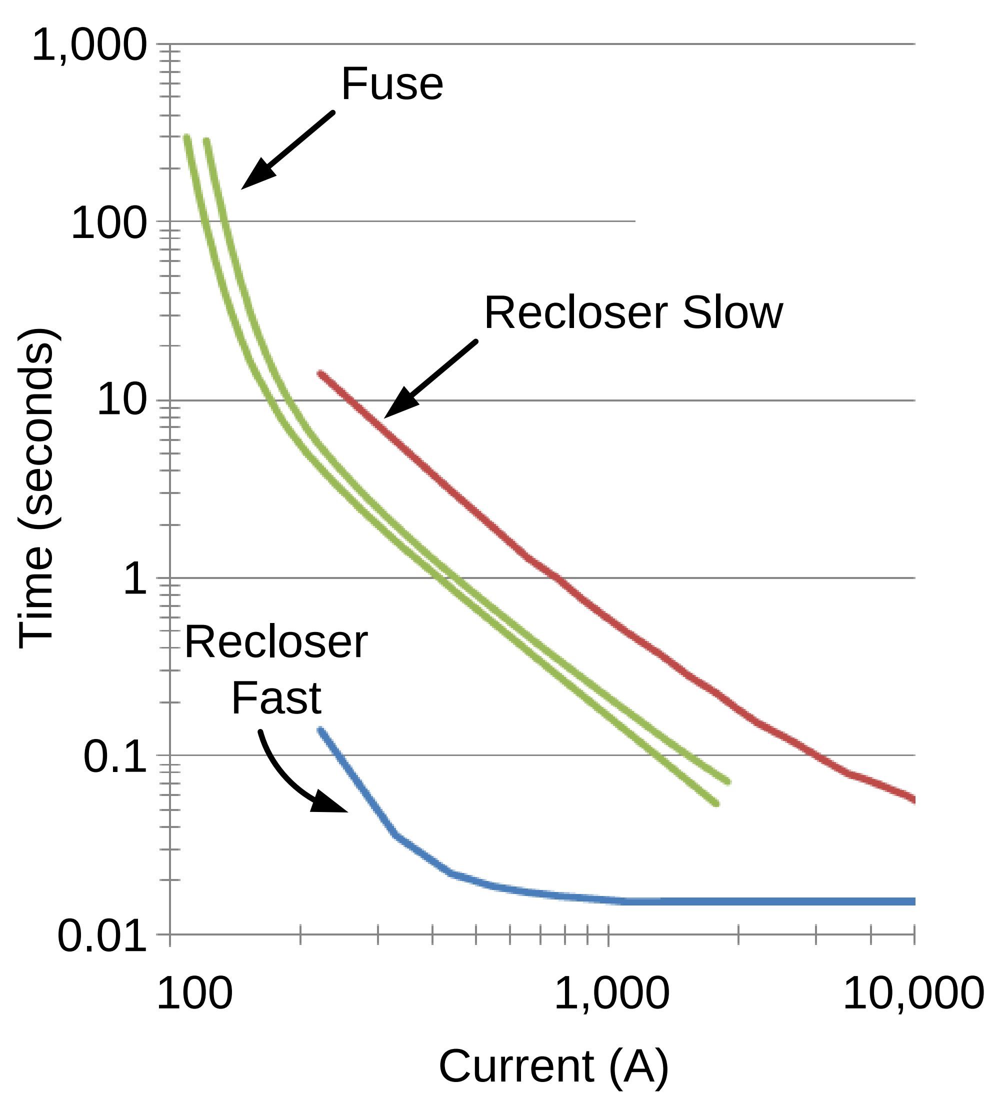
Example – R2 Trips on Inrush When R1 Recloses

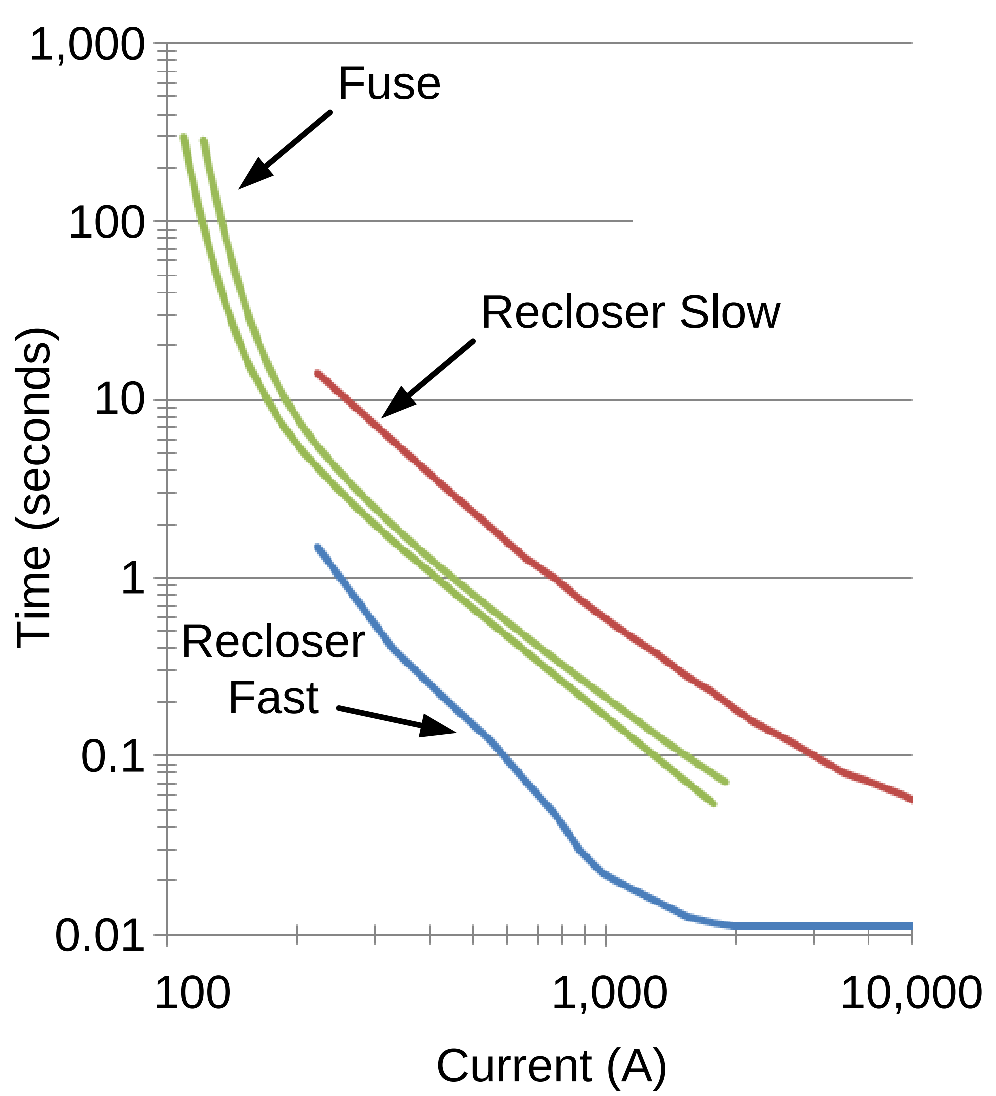




Eliminate Unnecessary Fast-Curve Operations

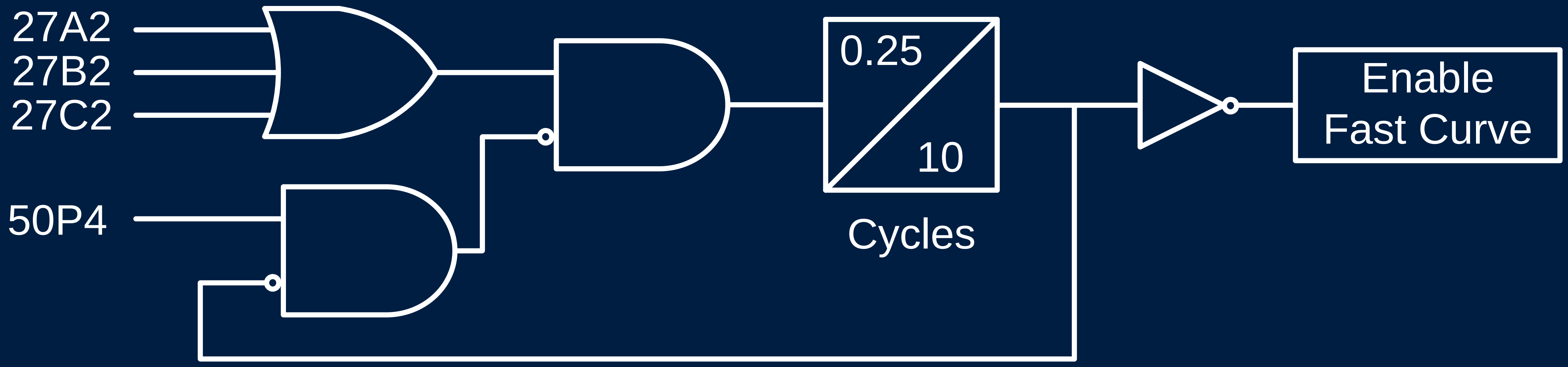
Solution 1 – Use Slower Fast Curve





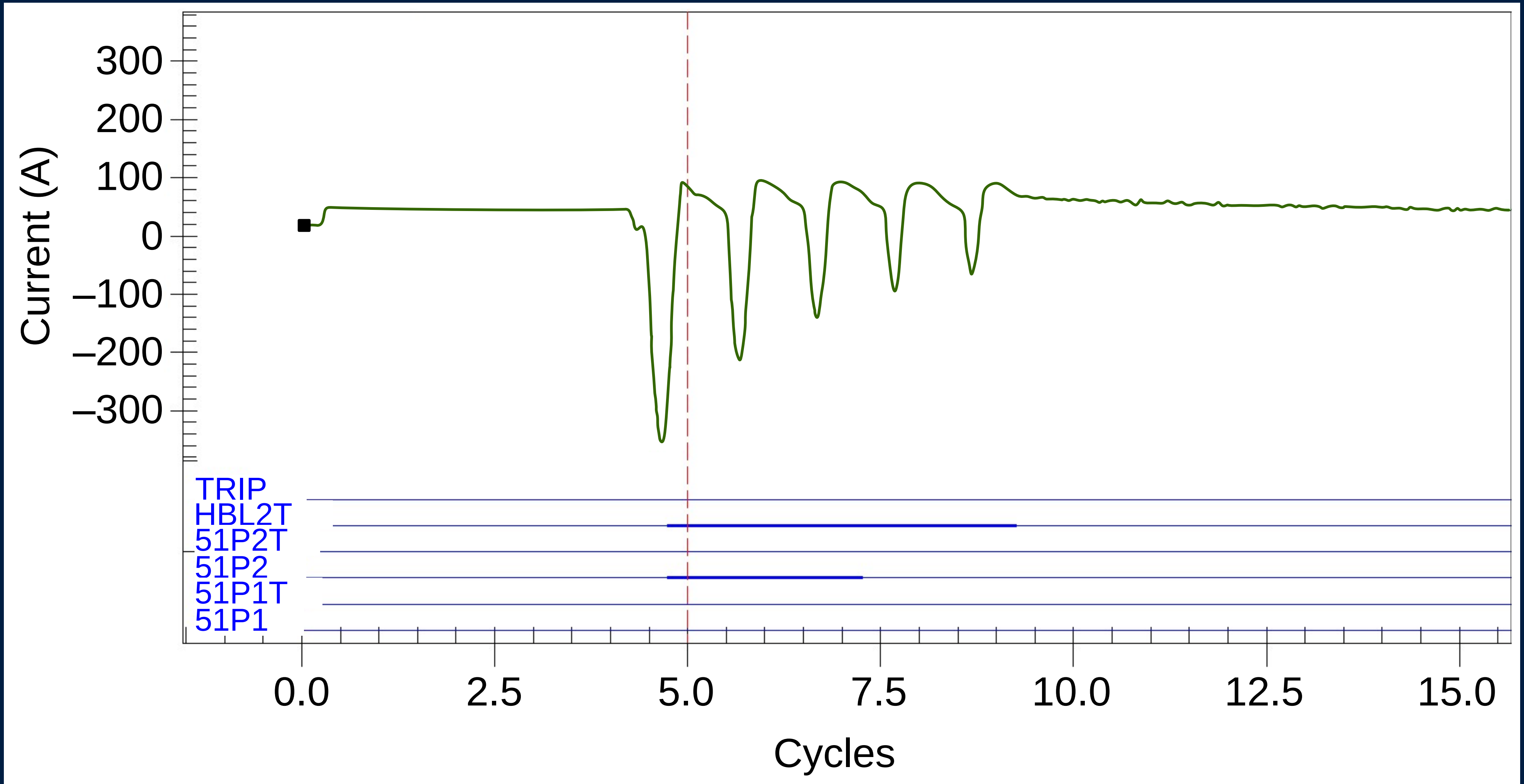
Eliminate Unnecessary Fast-Curve Operations

Solution 2 – Predict Inrush and Block Fast Curve



Eliminate Unnecessary Fast-Curve Operations

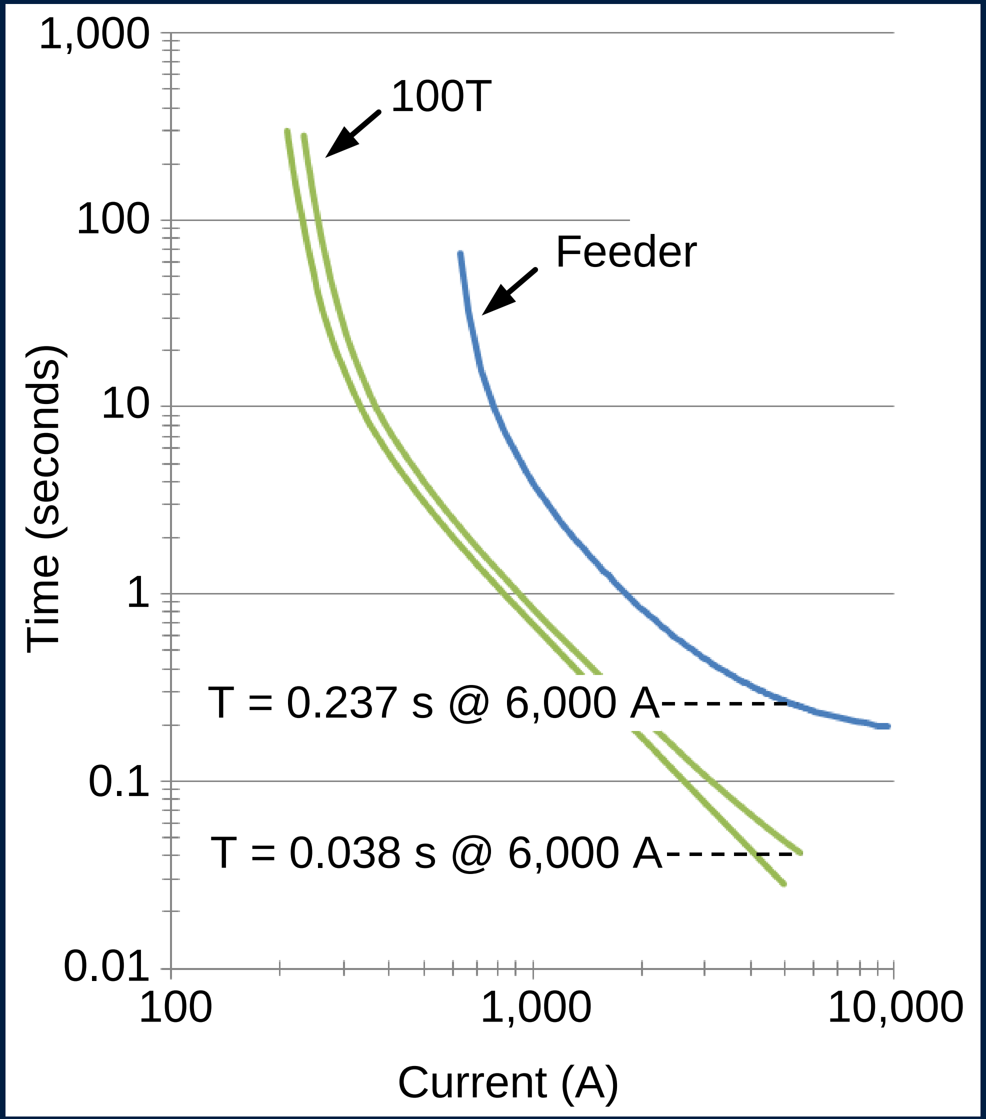
Solution 3 – Detect Inrush With Second Harmonic



Reduce Time-Overcurrent Protection Times

Problem

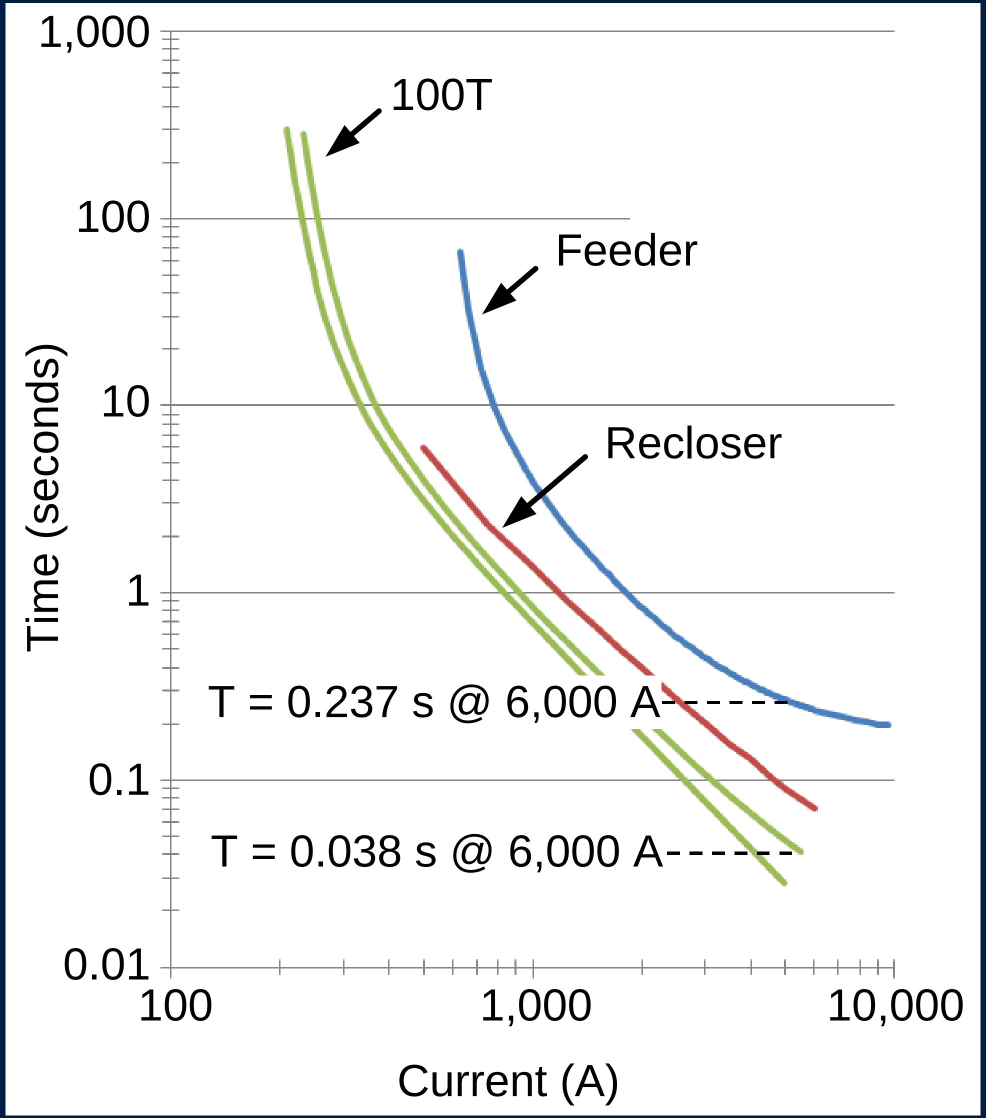
- Typical coordination interval is ~ 0.2 second
- Fuse size (100T) may be limited by downstream load
- Feeder curve may be limited by upstream overcurrent protection or damage curves



Reduce Time-Overcurrent Protection Times

Example

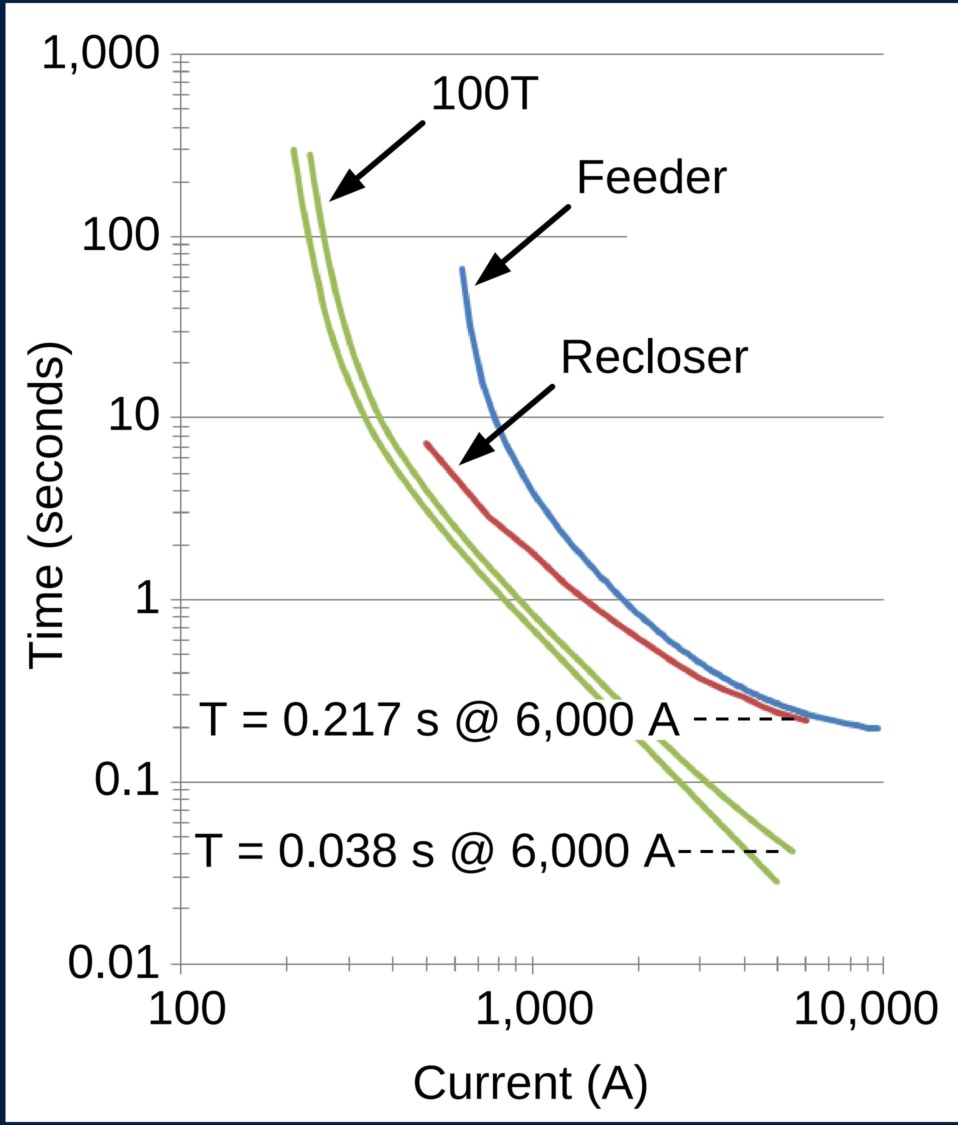
- Recloser installed between feeder and 100T fuse is meant to improve feeder sectionalization
- Coordination interval does not allow for it



Reduce Time-Overcurrent Protection Times

Solution 1 – Faster Curve on Reclose

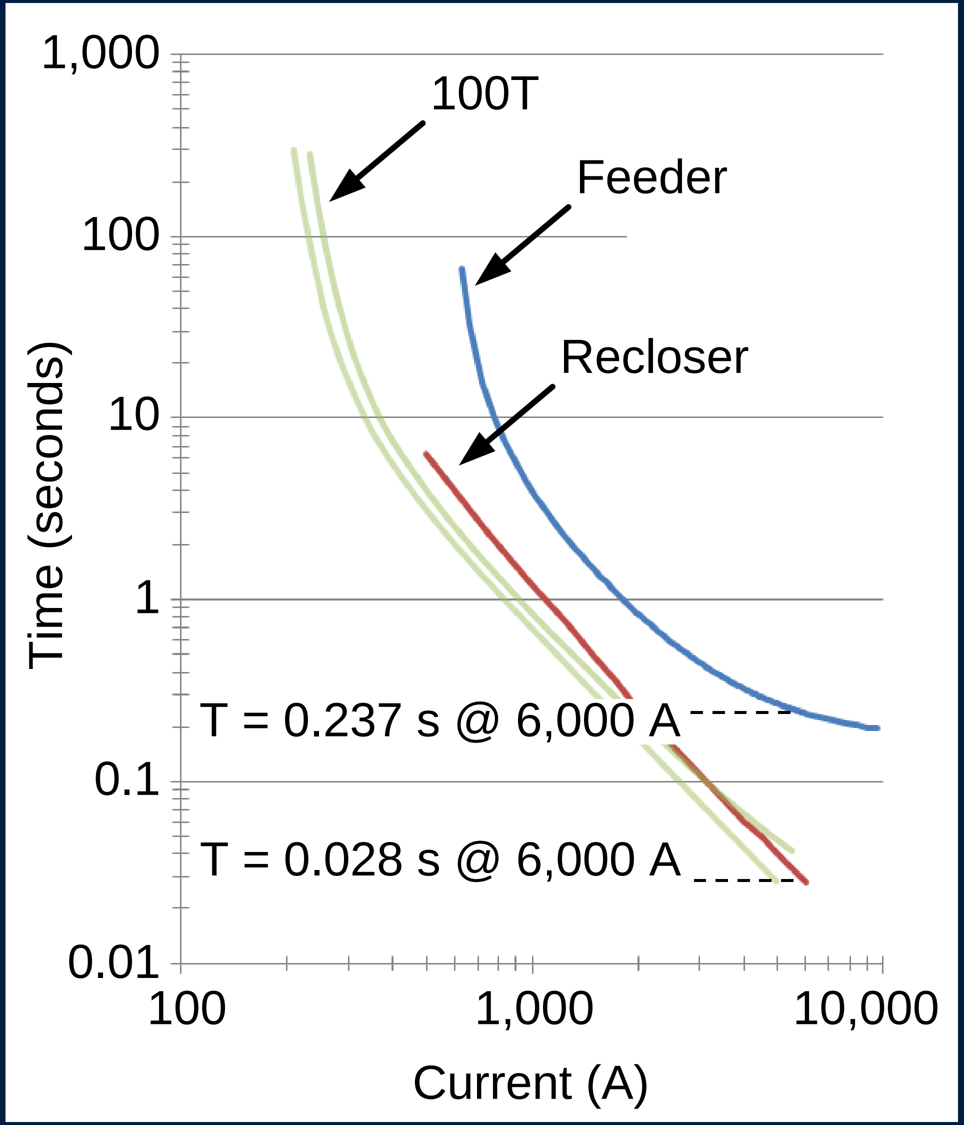
- Allow feeder and recloser to miscoordinate on first time-overcurrent trip



Reduce Time-Overcurrent Protection Times

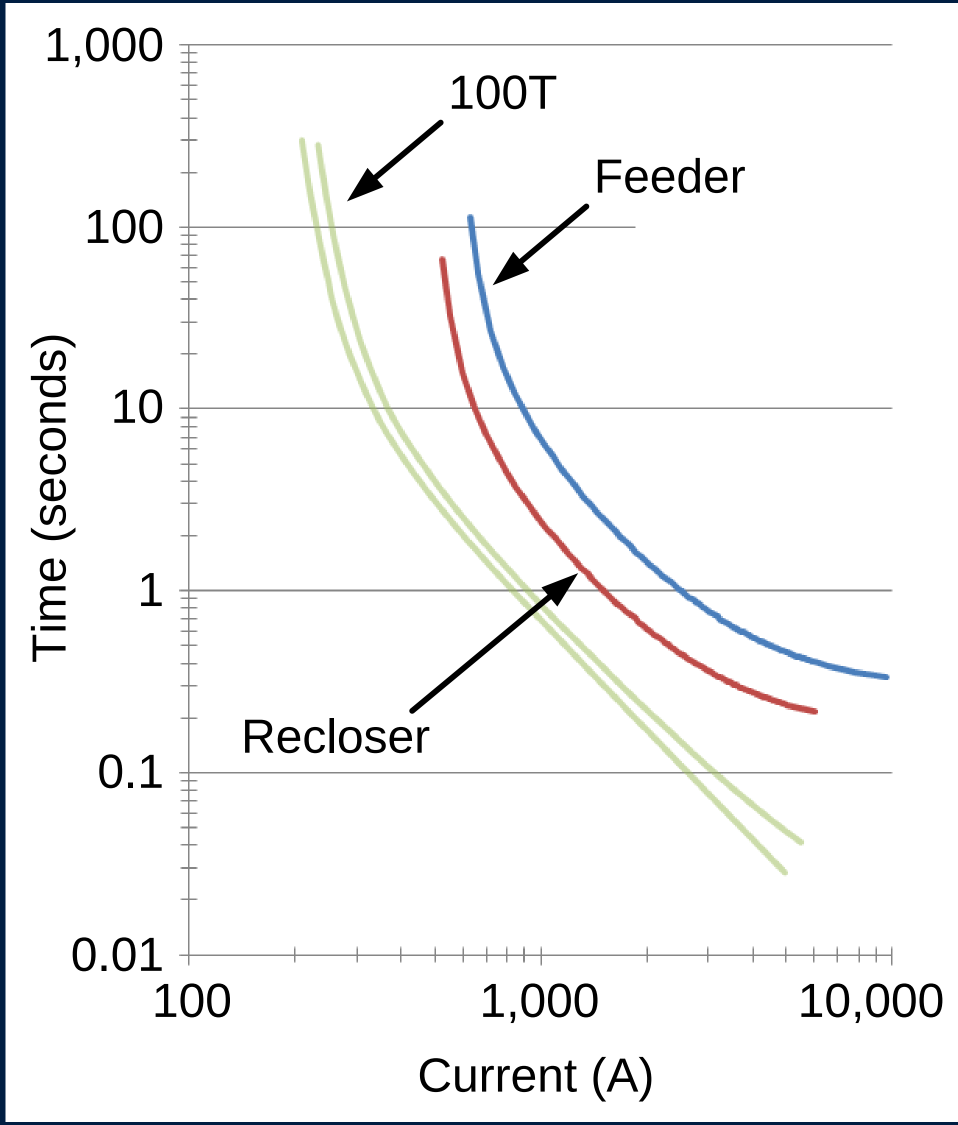
Solution 1 – Faster Curve on Reclose

- Allow feeder and recloser to miscoordinate on first time-overcurrent trip
- Use faster curve on recloser for subsequent time-overcurrent trips



Reduce Time-Overcurrent Protection Times
Solution 2 – Even Faster Curve on Reclose

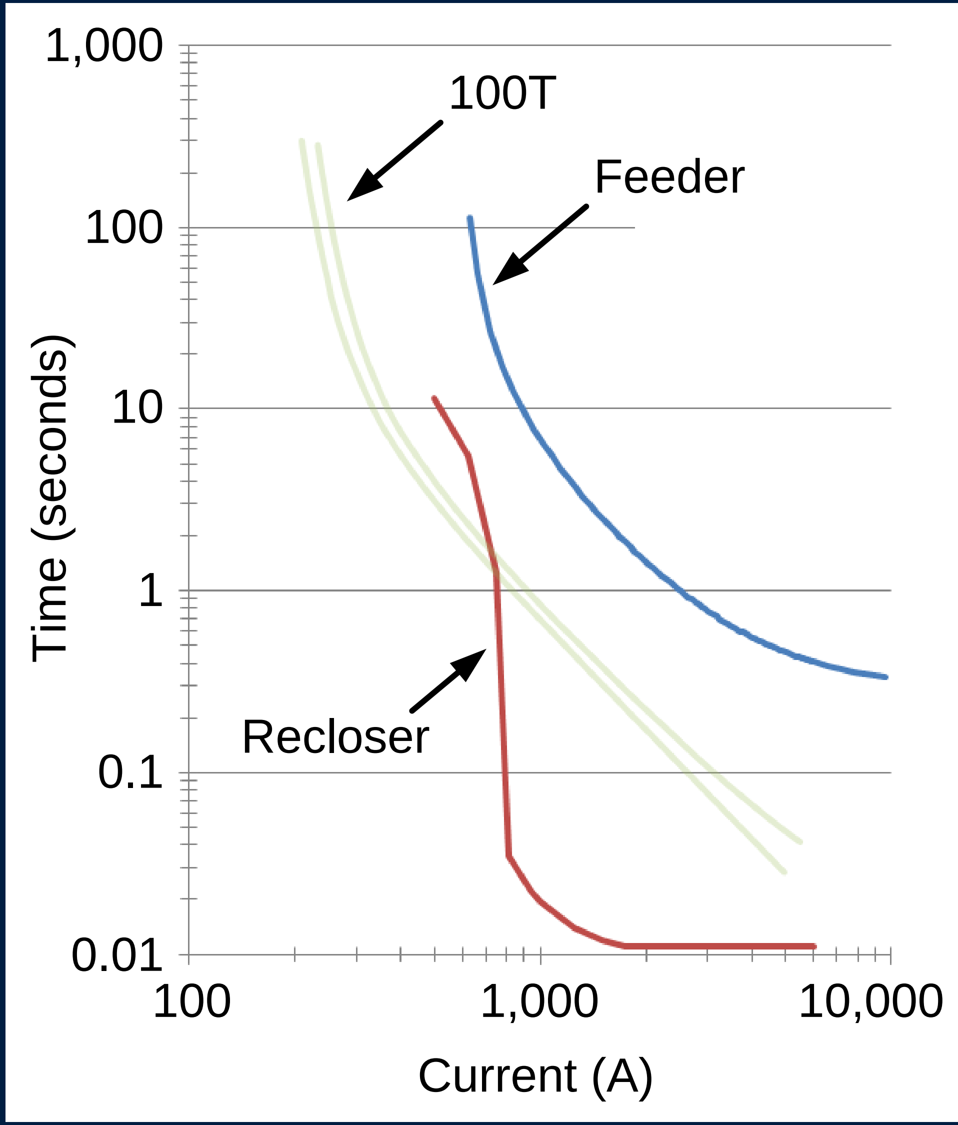
- Allow feeder and recloser to miscoordinate on first time-overcurrent trip



Reduce Time-Overcurrent Protection Times

Solution 2 – Even Faster Curve on Reclose

- Allow feeder and recloser to miscoordinate on first time-overcurrent trip
- Use instantaneous or short time-delay overcurrent to reduce through-fault energy



Prevent Feeder Lockout Due to Conductor Slap

Problem

Fault develops
downstream of recloser

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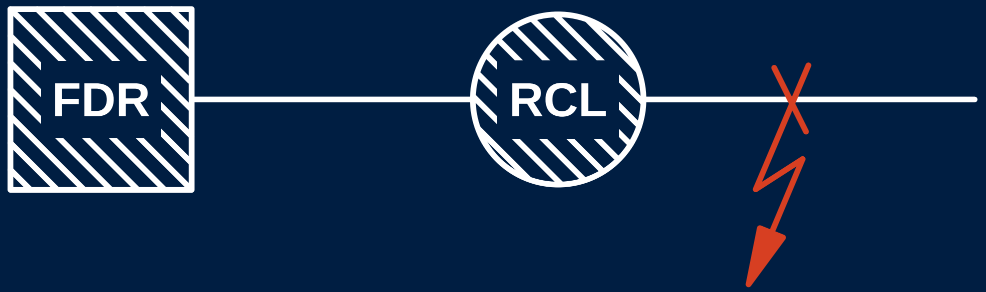
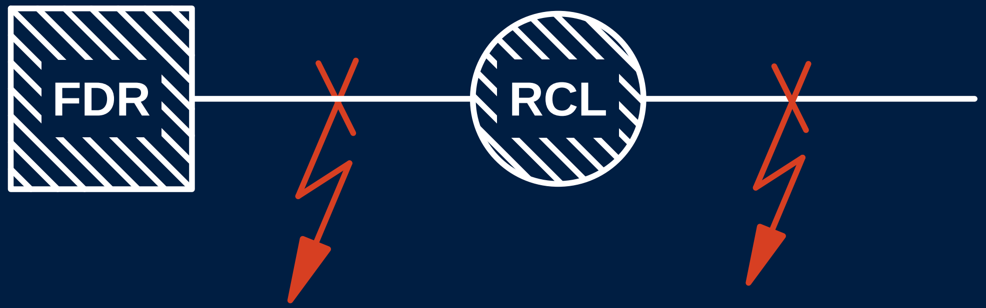
Fault develops downstream of recloser



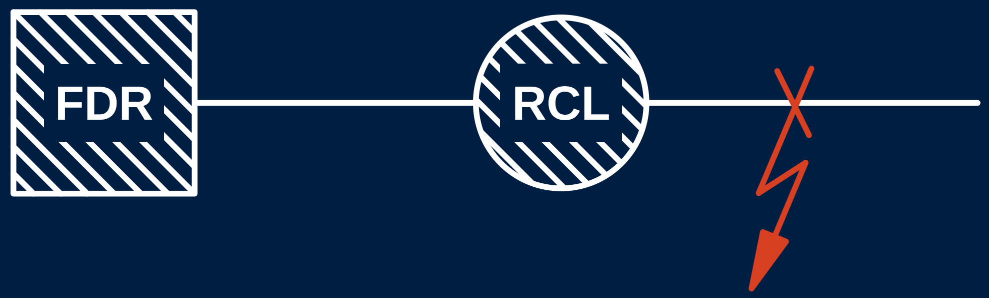
Magnetic field from fault current causes upstream conductors to contact



Prevent Feeder Lockout Due to Conductor Slap

Problem

Fault develops downstream of recloser



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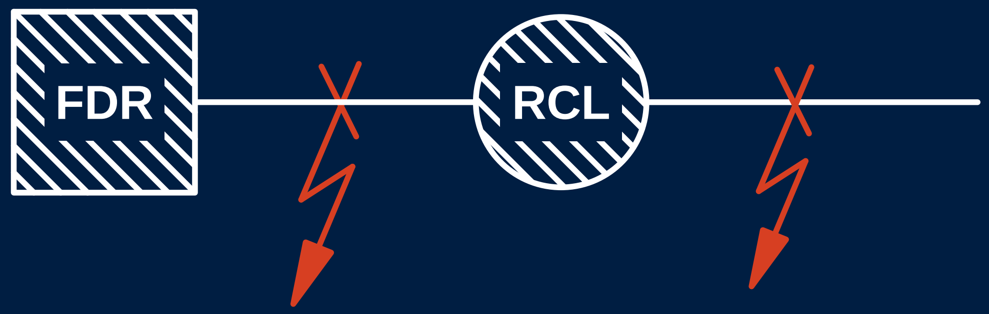


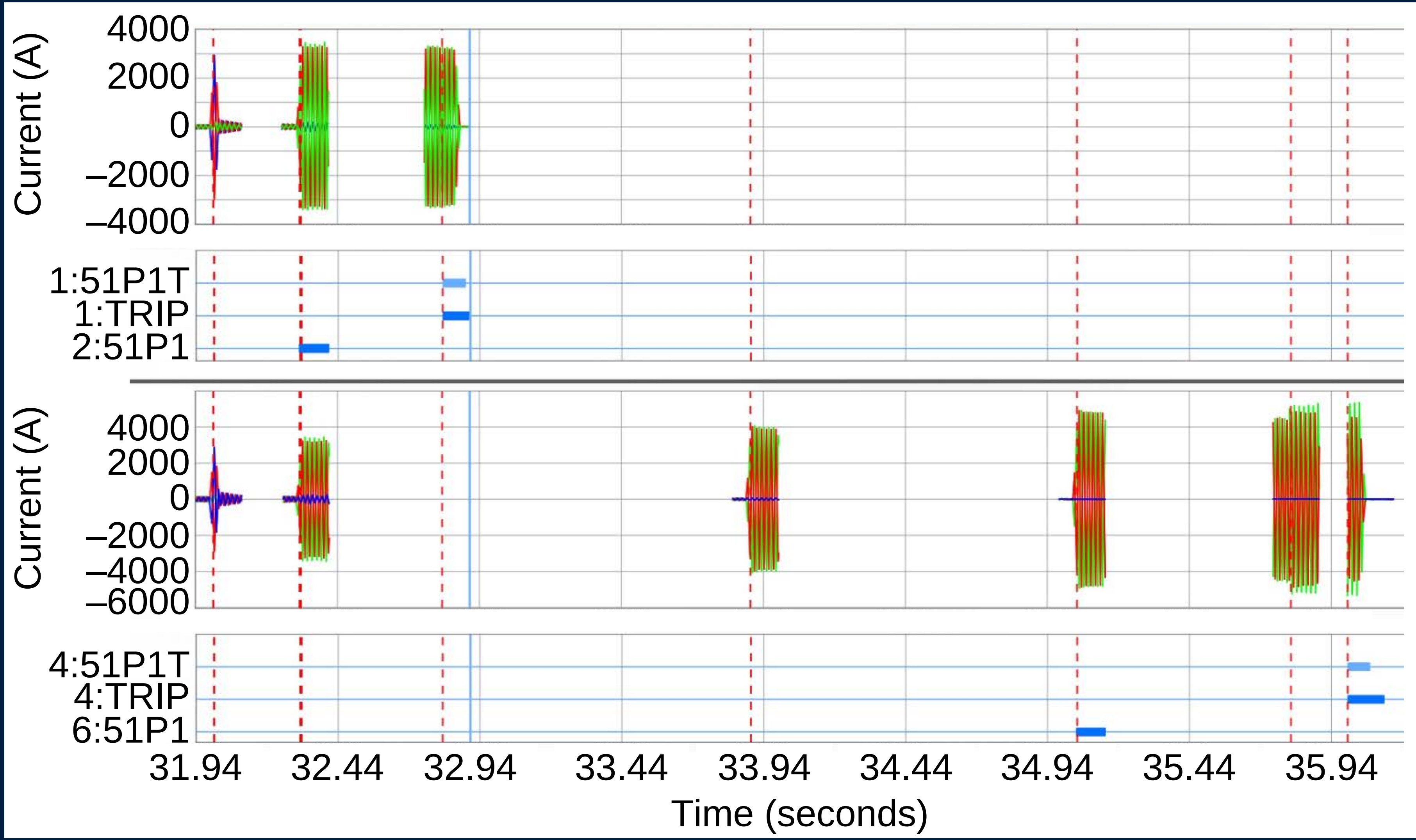
Feeder trips, but recloser may not trip

Prevent Feeder Lockout Due to Conductor Slap

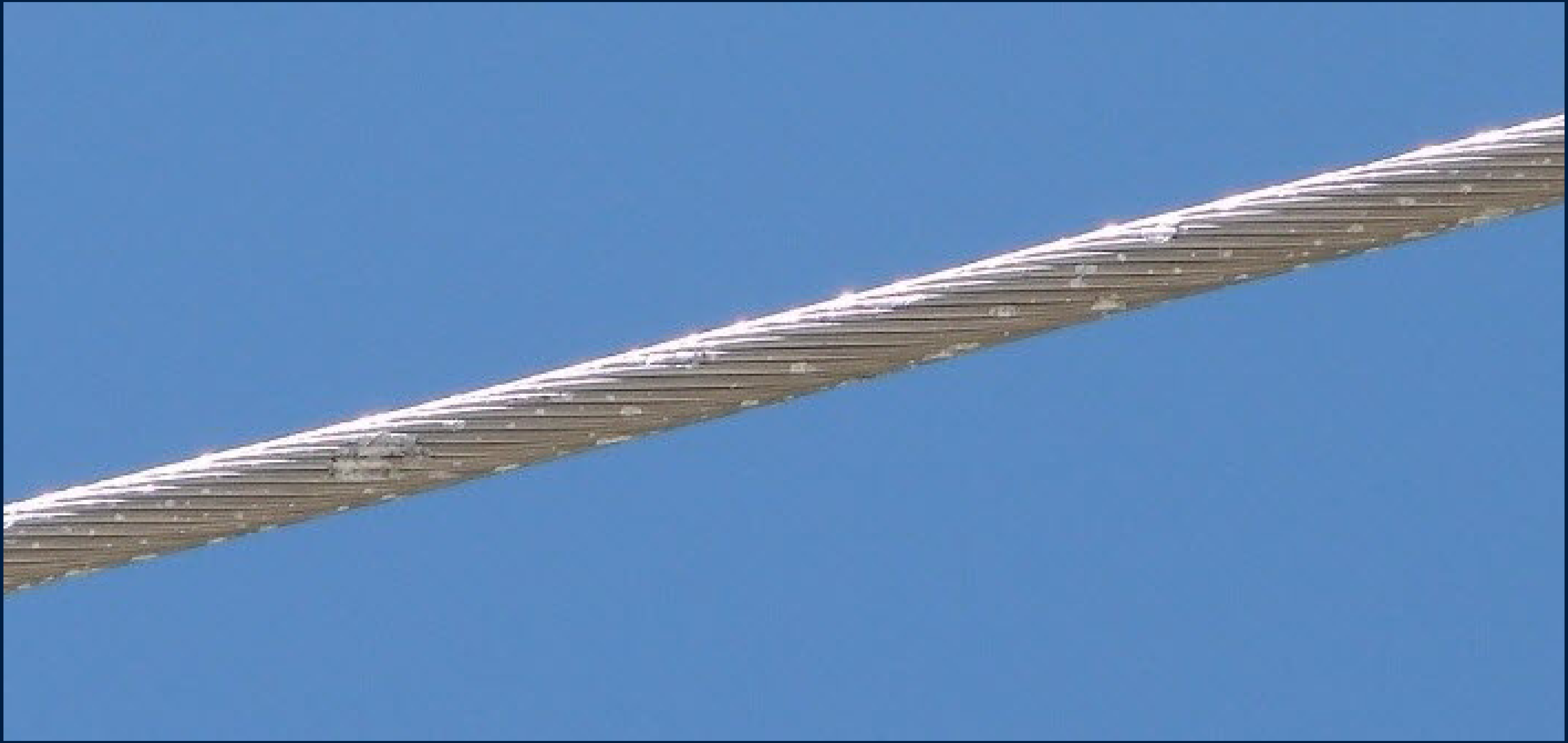
Example – Multiple Conductor Slaps After Fault Clears

Recloser

Feeder

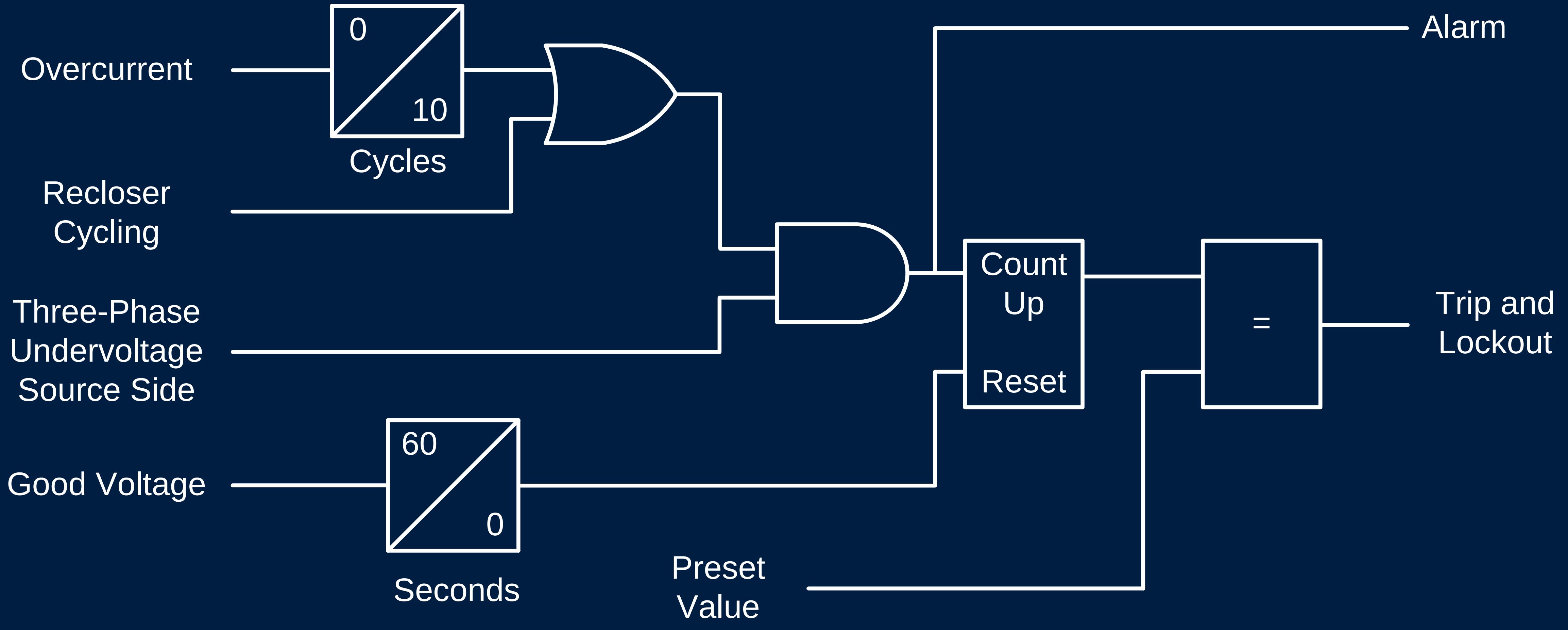


Pitting and Beading Due to Conductor Slap



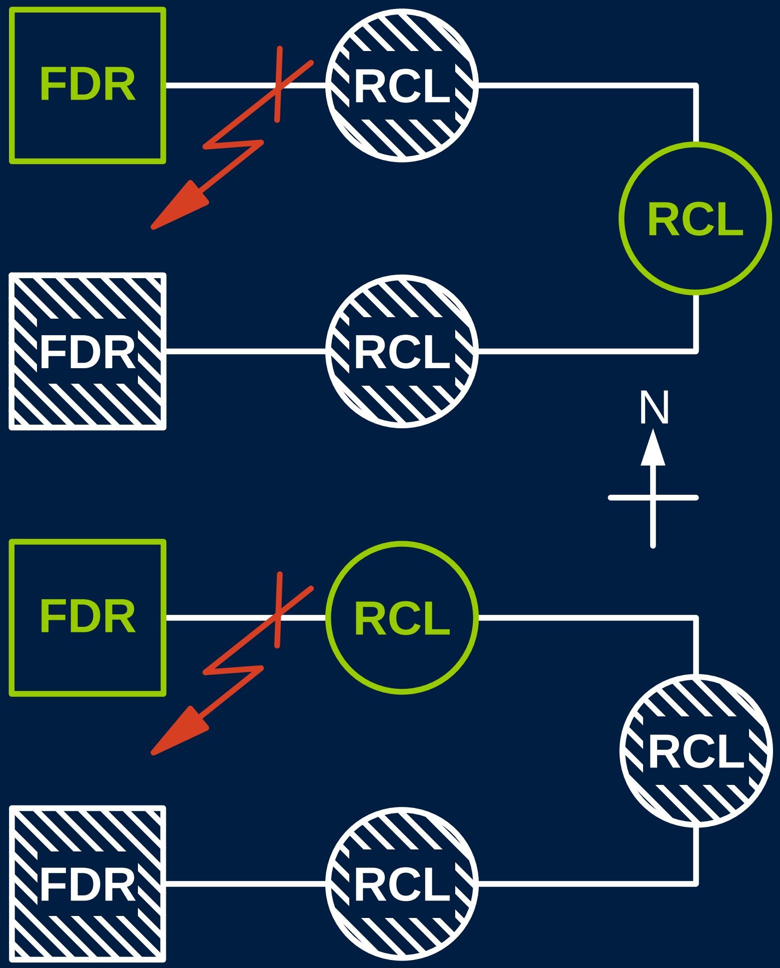
Prevent Feeder Lockout Due to Conductor Slap

Solution

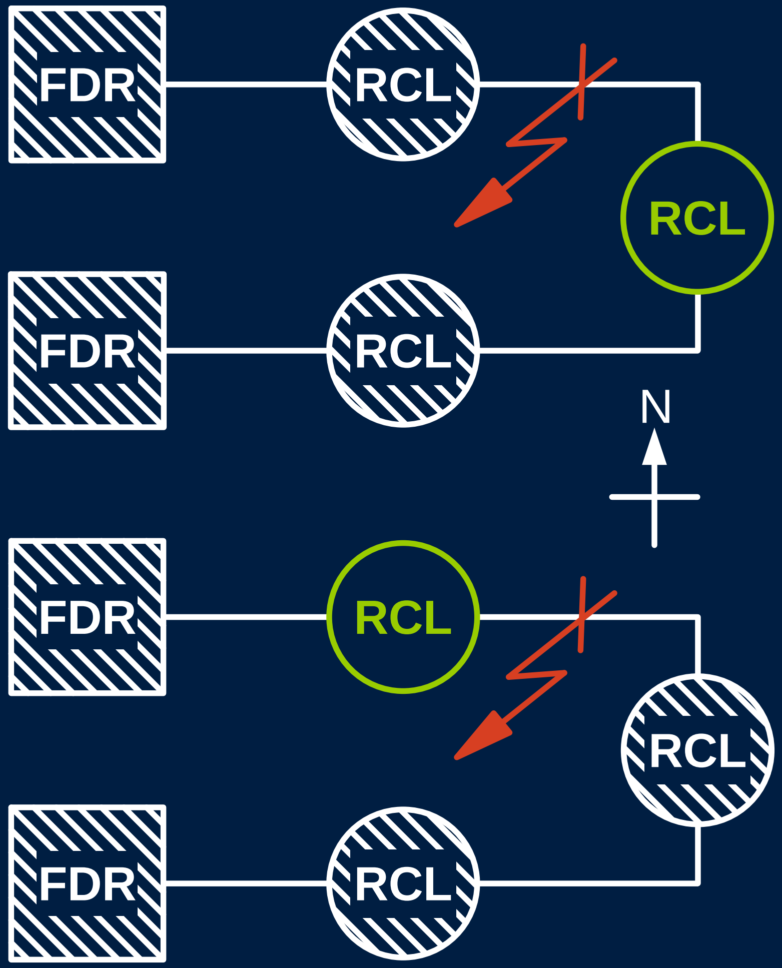


Prevent Restoration of Faulted Lines in Noncommunicating Loop Schemes

Problem

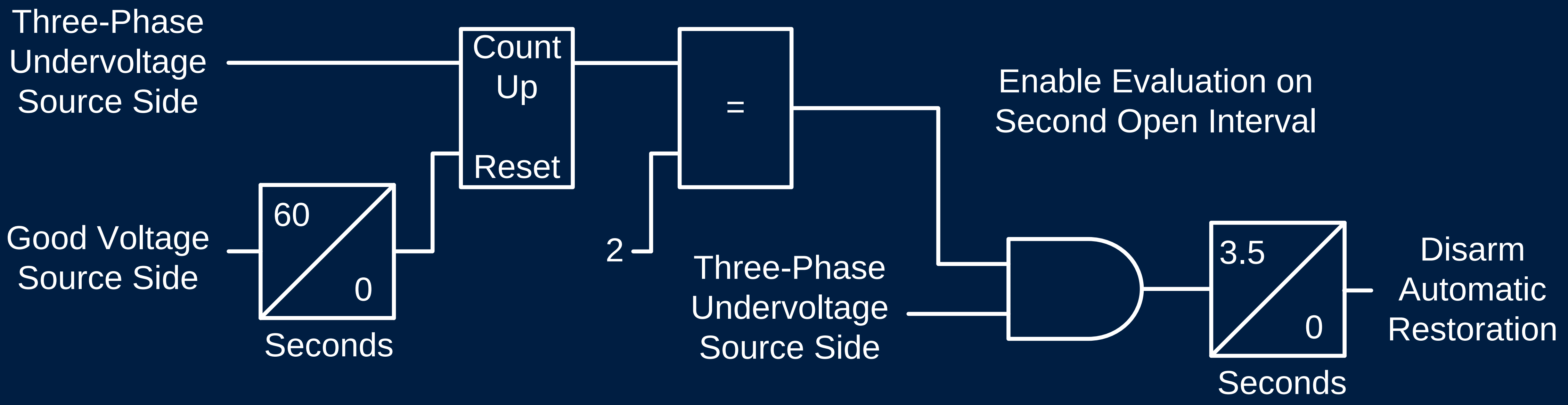


vs.



Prevent Restoration of Faulted Lines in Noncommunicating Loop Schemes

Solution



Feeder 2nd Open Interval
3 seconds

Recloser 2nd Open Interval
5 seconds

Conclusion

- Data from modern relays help explain complex distribution protection problems
- Multiple protection elements and custom logic can improve
  - Security of fuse-saving schemes
  - Selectivity of tightly coordinated feeders
  - Speed of overcurrent protection during reclose cycle
  - Security of feeders at risk of conductor slap
  - Selectivity of noncommunicating loop schemes

Questions?