Apply a Wireless Line Sensor System to Enhance Distribution Protection Schemes

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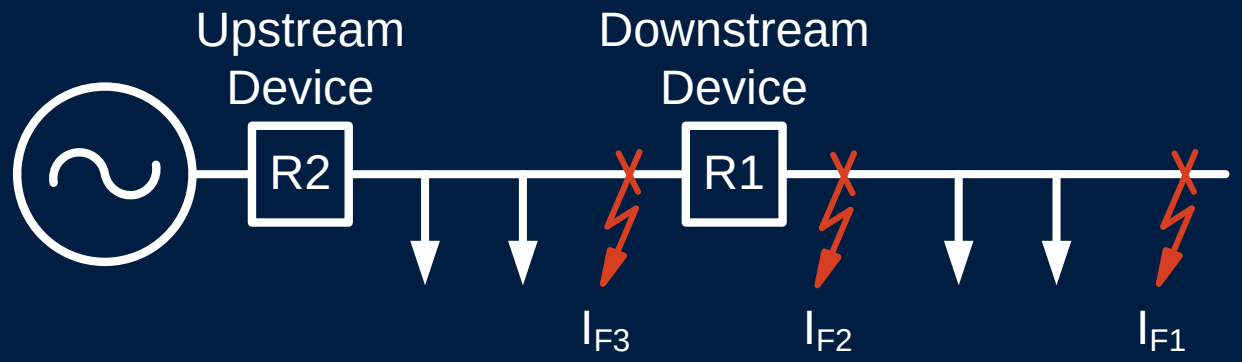
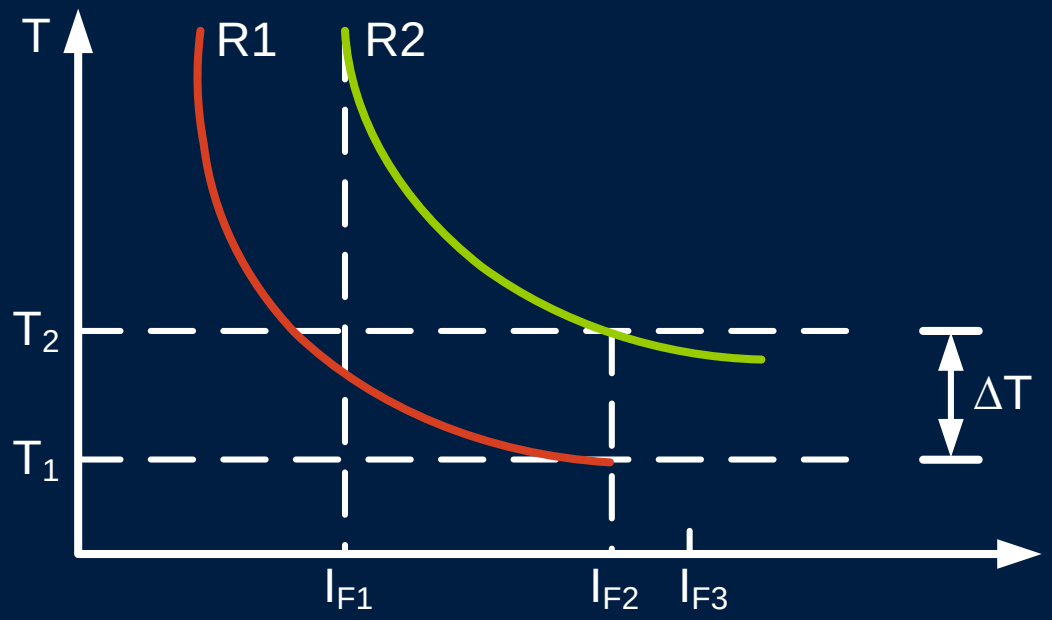
Distribution System

- Protection objectives
  - Minimize fault duration
  - Reduce number of affected customers
- Protection methods
  - Use inverse-time overcurrent elements
  - Coordinate devices to provide selectivity

Distribution System Protection Schemes

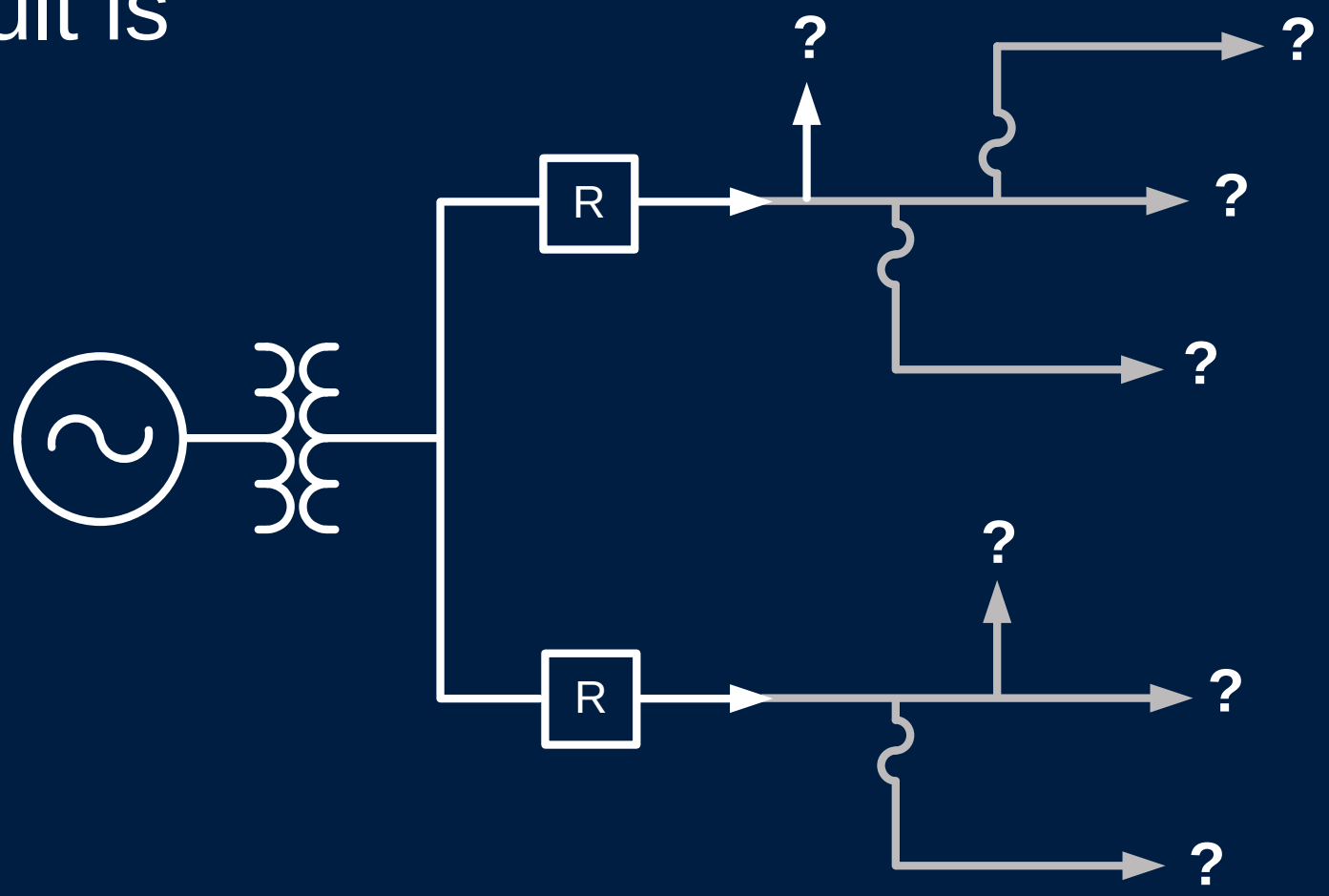
- Sacrifice speed for selectivity
- Can increase fault-clearing times for faults closer to source





Distribution System Protection Schemes

- Do not know where fault is
- Cannot differentiate fused sections from unfused sections
- Must wait for fuse coordination time margin before tripping

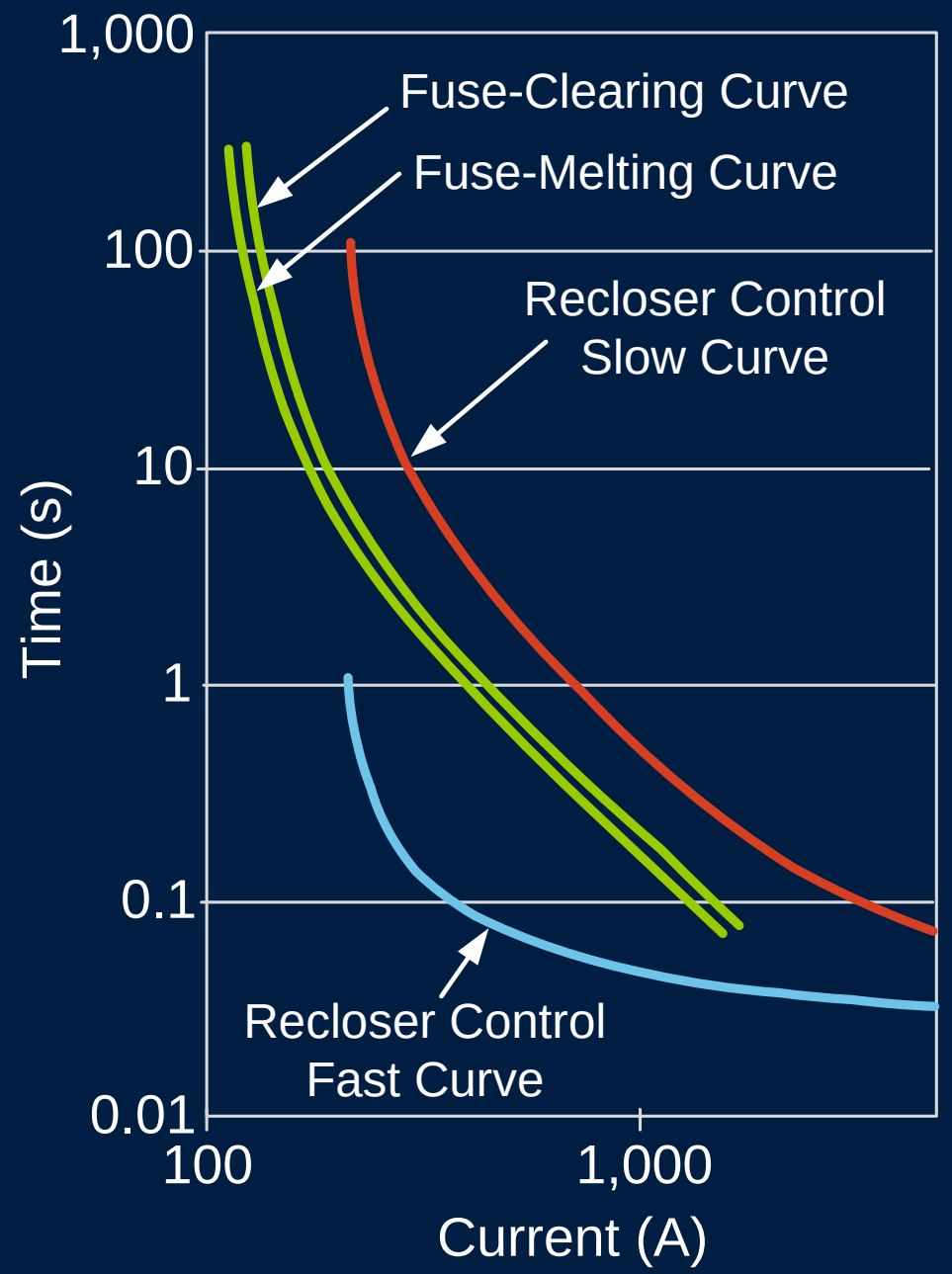


Speed Matters

- Public safety – fire ignition and property damage
- Equipment life – damaged components, cable connections, and jumpers
- Power quality
  - Different requirements and expectations
  - CBEMA curve – acceptable voltage

Fuse-Saving Schemes

- Recloser arms fast-curve for first trip and slow-curve after reclosing
- Recloser trips on fast-curve for any fault
- Fuses clear permanent downstream faults after reclosing
- Recloser clears temporary or permanent faults



Fuse-Saving Scheme Advantages

- Minimizes customer outages
- Reduces maintenance costs by minimizing fuse replacements
- Improves System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI)
- Restores services after temporary fault

Fuse-Saving Scheme Disadvantages

- Is difficult to coordinate
- Leads to frequent temporary interruptions
- Increases Momentary Average Interruption Frequency Index (MAIFI)

Fuse-Blowing Schemes
“Trip-Saving” Scheme

- Fuse clears downstream faults
- Recloser trips for main line section or unfused section faults

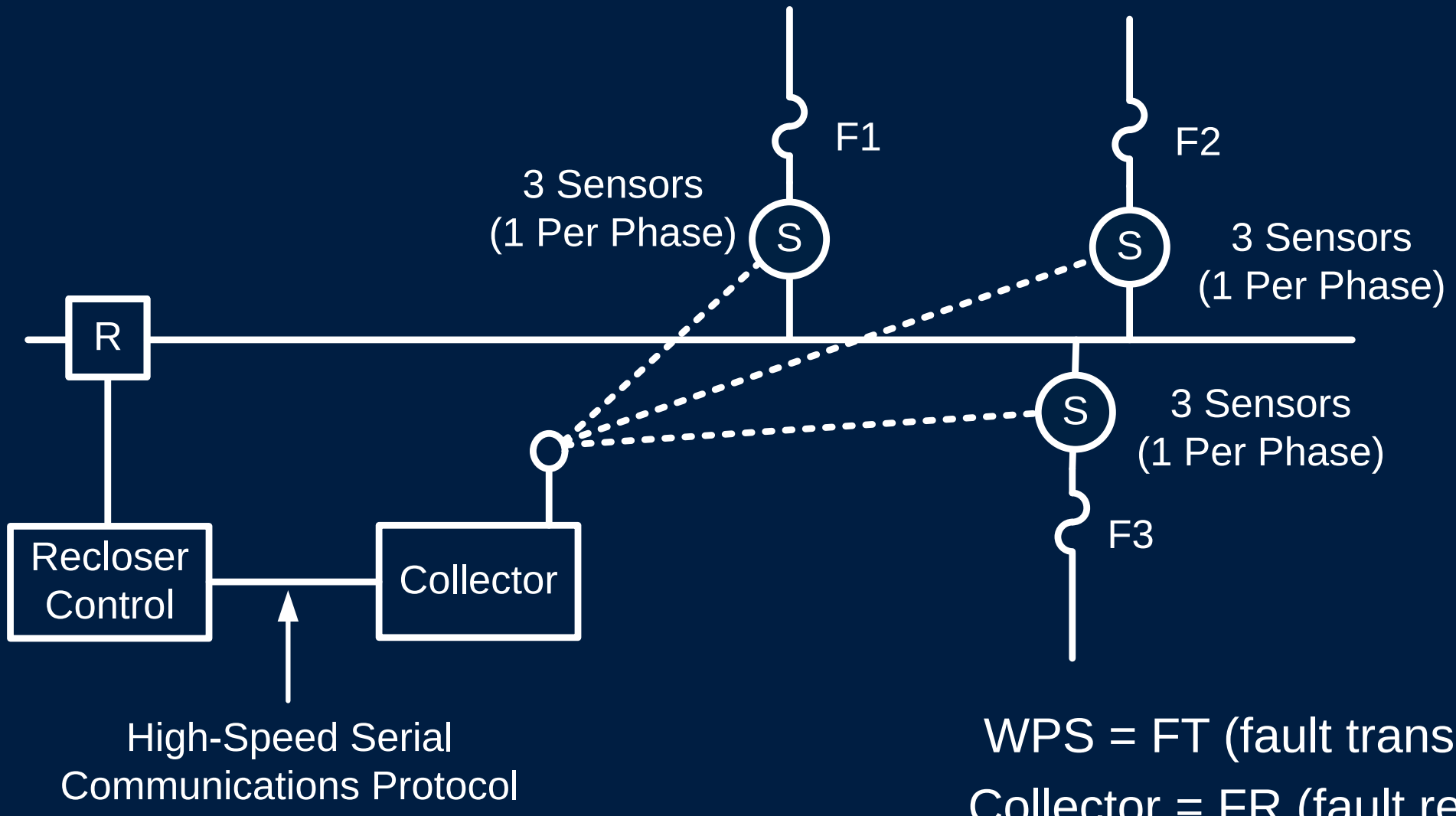
Fuse-Blowing Scheme Advantages

- Improved power quality on unfaulted line sections
- Easy coordination
- Reduced MAIFI

Fuse-Blowing Scheme Disadvantages

- All faults become permanent outages
- Personnel must replace fuses after every event
- Fault duration on main feeder or unfused sections is increased

Wireless Protection Sensor (WPS) System

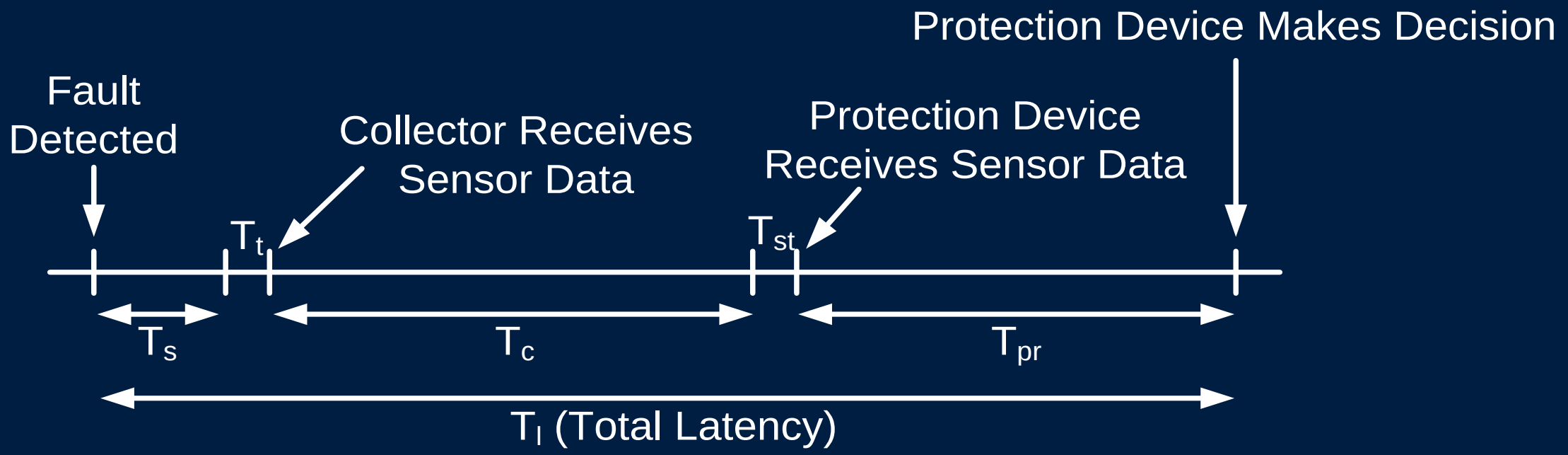


WPS = FT (fault transmitter)

Collector = FR (fault receiver)

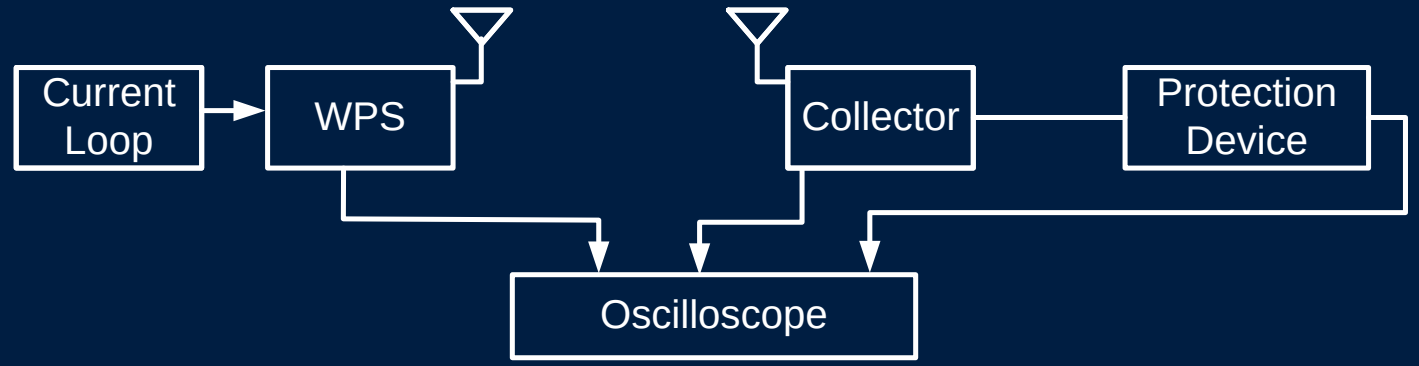
WPS Latencies

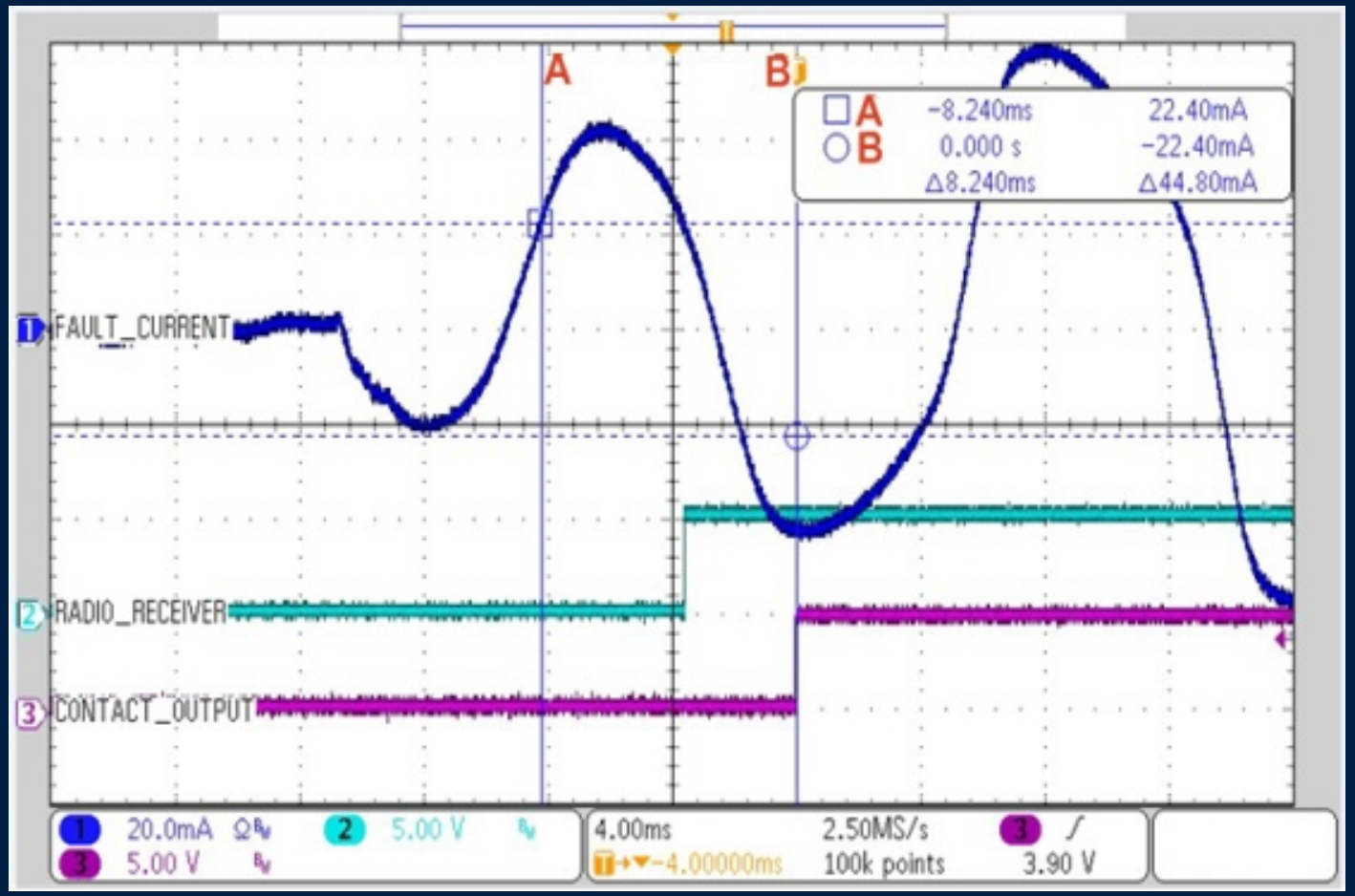
WPS Information Available in <1 Cycle



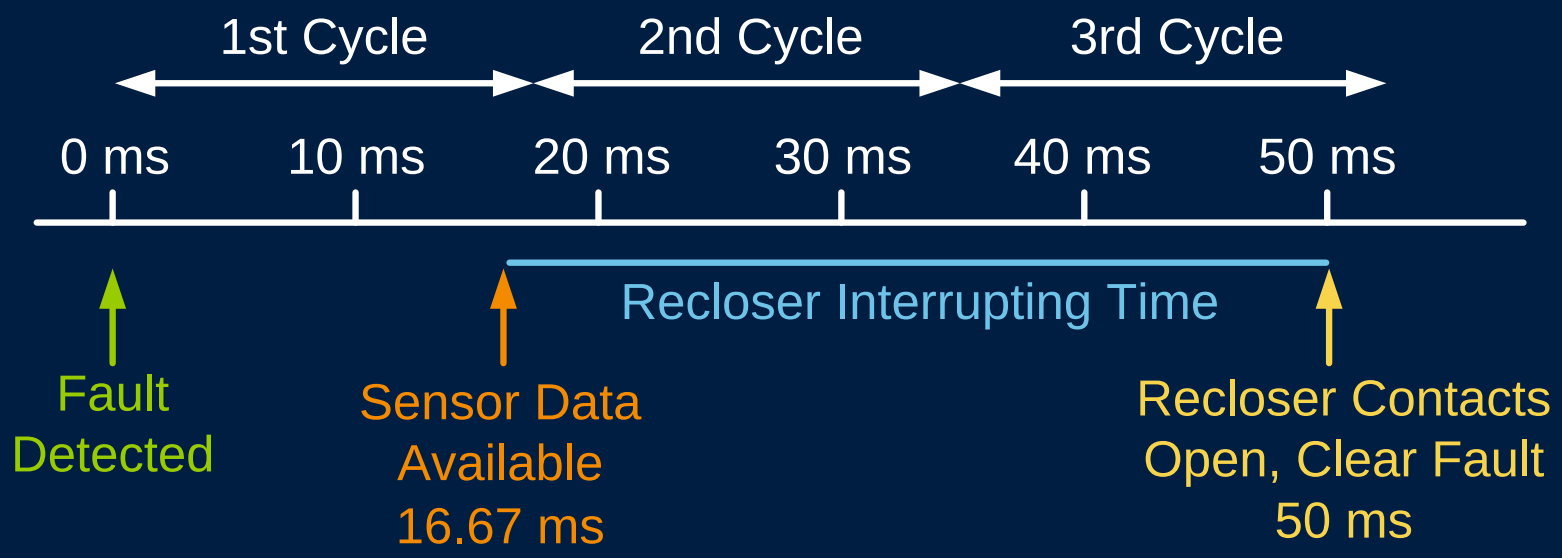
WPS Latencies

WPS System Test Results





Latency Requirements
Fuse-Saving Scheme



Maximum Coordination Current for Type T-Tin Fuses

Fuse Size	Maximum Coordination Current
15T	570 A
40T	1,500 A
65T	2,500 A
100T	3,800 A
140T	5,850 A

Principles for Applying WPSs

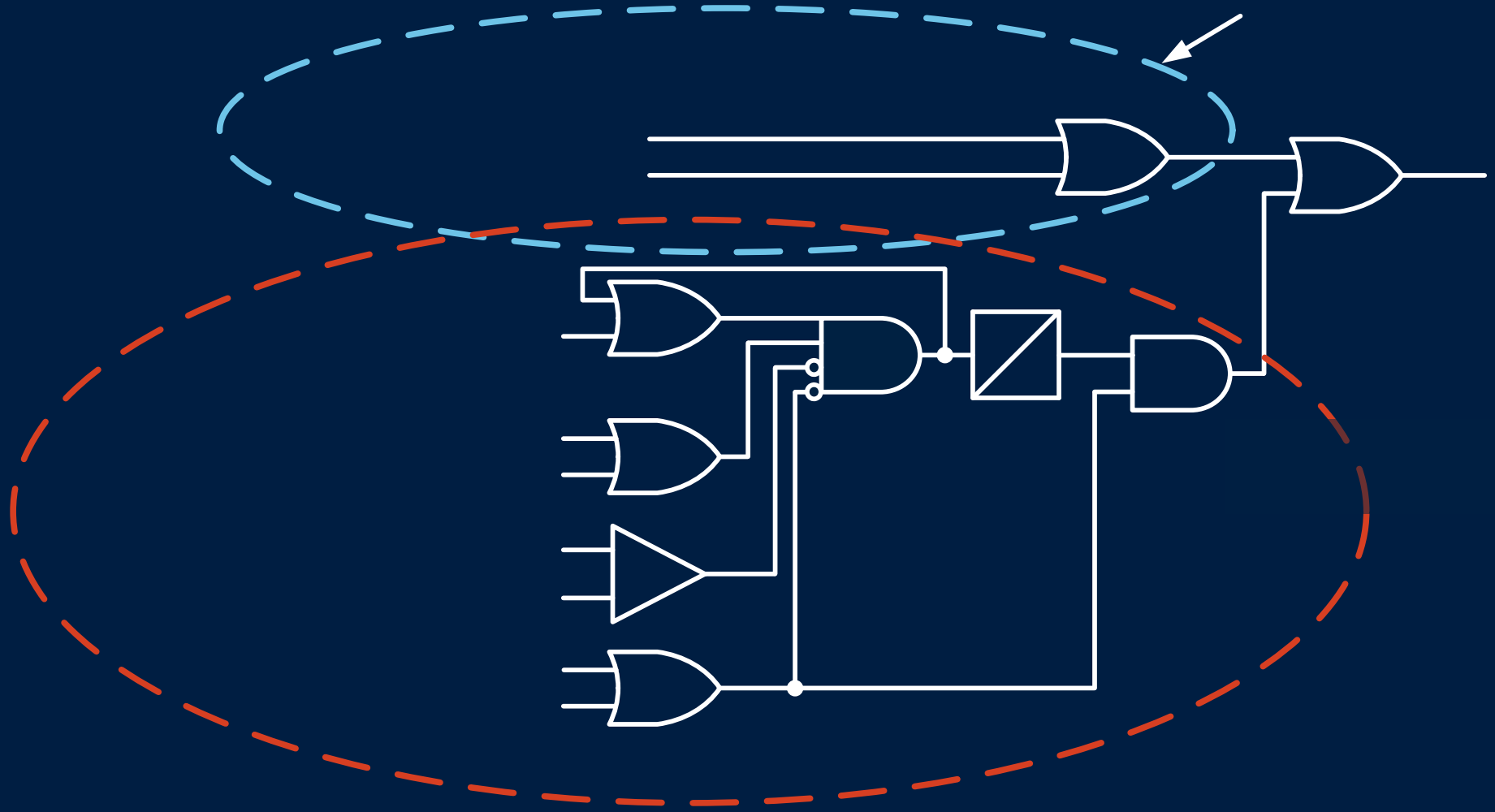
1. Protection devices should not make protection decisions based solely on fault data from WPSs
2. Protection devices should fall back to backup scheme in absence of sensor data
3. Protection devices should use sensor fault information to enhance / augment / optimize existing schemes

Application #1

Switchover on the Fly From Fuse-Blowing to Fuse-Saving Scheme (Permissive)

- Specific (candidate) line section(s)
  - Fuse-blowing always active
  - Fuse-saving only enabled under certain conditions
- Other line sections – fuse-blowing works as usual

Switchover on the Fly From Fuse-Blowing to Fuse-Saving Scheme (Permissive)

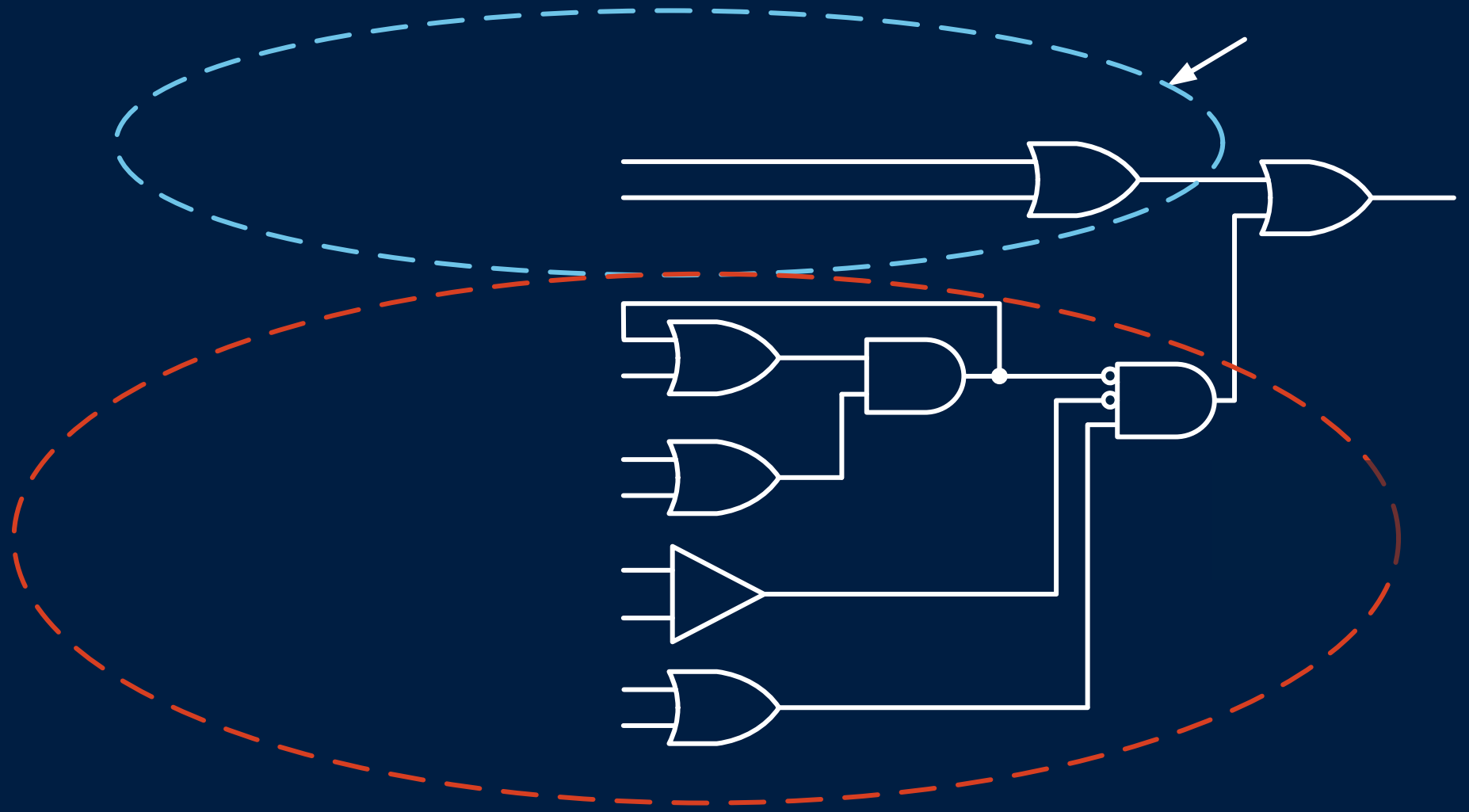


Application #2

Switchover on the Fly From Fuse-Saving to Fuse-Blowing Scheme (Blocking)

- Specific (candidate) line section(s)
  - Fuse-blowing always active
  - Fuse-saving blocked under certain conditions
- Other line sections – fuse-saving works as usual

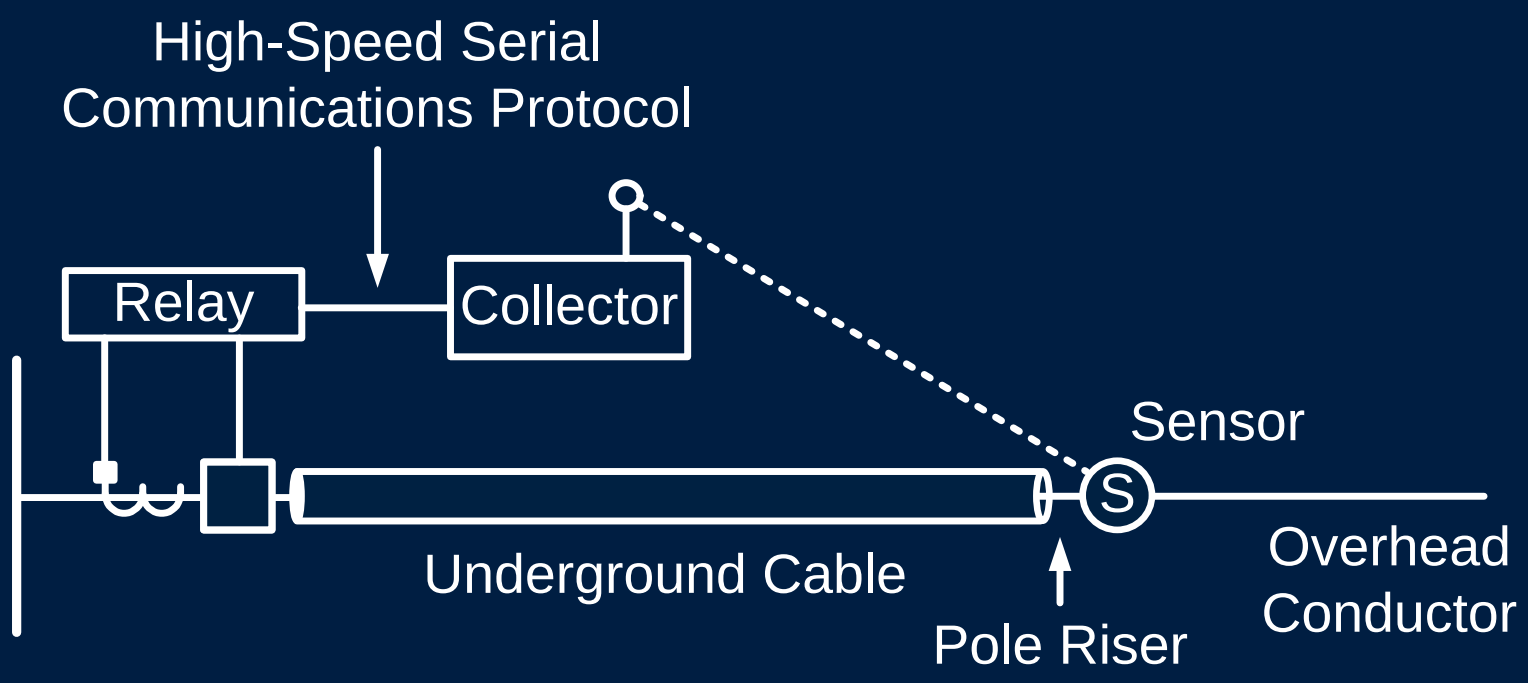
Switchover on the Fly From Fuse-Saving to Fuse-Blowing Scheme (Blocking)



Application #3

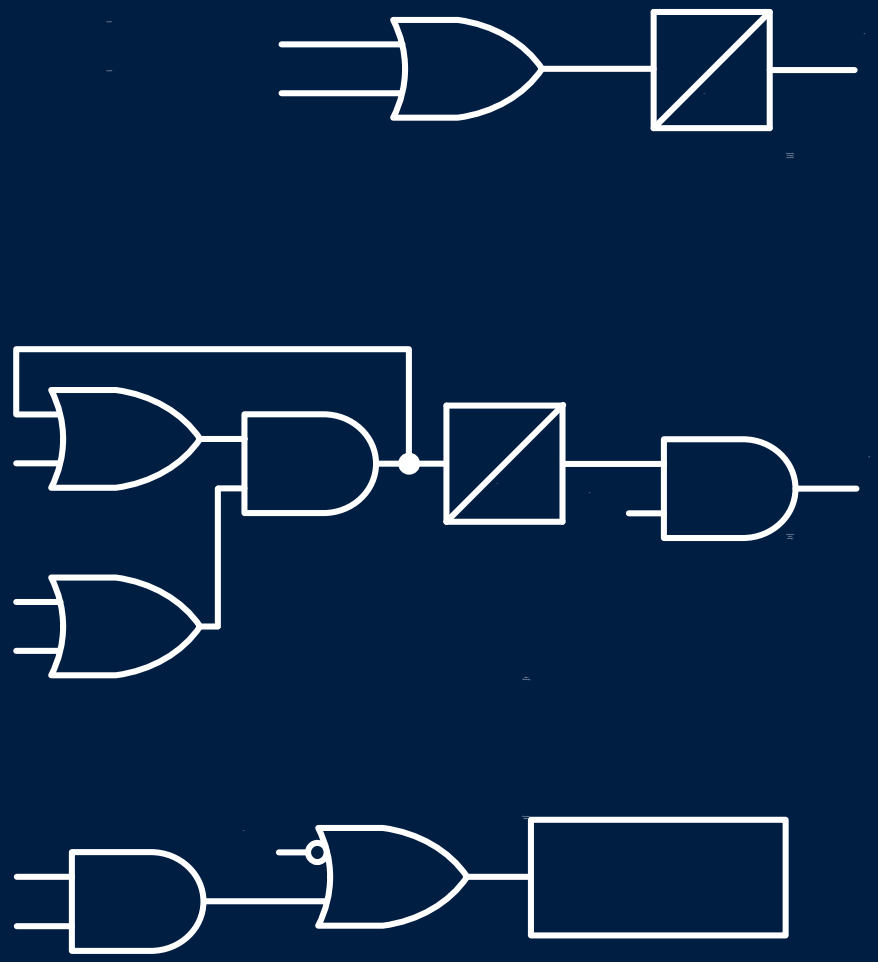
Switchover on the Fly Between Feeder Cable and First-Span Overhead Protection (Permissive)

- Blocks reclose for faults by default
- Dynamically enables reclosing for overhead faults



Switchover on the Fly Between Feeder Cable and First-Span Overhead Protection (Permissive)

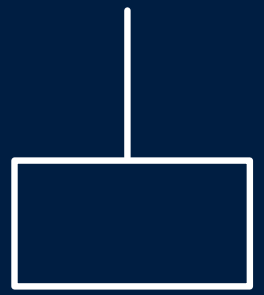
High-Set Element	Overhead Sensor	Action
No operation	No operation	Enable reclosing
No operation	Operation	Enable reclosing
Operation	Operation	Enable reclosing
Operation	No operation	Block reclosing



Application #4

Speed Up Tripping for Faults on Unfused Sections

- Eliminates delay for fuse to blow
- Speeds up trip response on unfused sections



Application #5

Speed Up Tripping for Faults by Discriminating Between Laterals for Fuse-Blowing Scheme

- Speeds up trip response
- Optimizes tripping time for multiple fuse sizes

Speed Up Tripping for Faults by Discriminating Between Laterals for Fuse-Blowing Scheme

Conclusion

- WPSs provide more visibility
- WPS information allows for speed without sacrificing selectivity
- Protection scheme operation is improved
  - Smarter schemes
  - Improved reclosing practices
  - Shorter coordination margins and fault duration

Questions?