Case Study: Inglewood Distribution Automation

April 5th, 2018 NWESS

Outline

- Introduction to Puget Sound Energy (PSE)
- Distribution Automation Overview
- Project Implementation
  - DA Scheme Example
    - Adaptive Setting Groups
    - Device Coordination
- Design Challenges
  - Standardizing Equipment
  - Special Considerations

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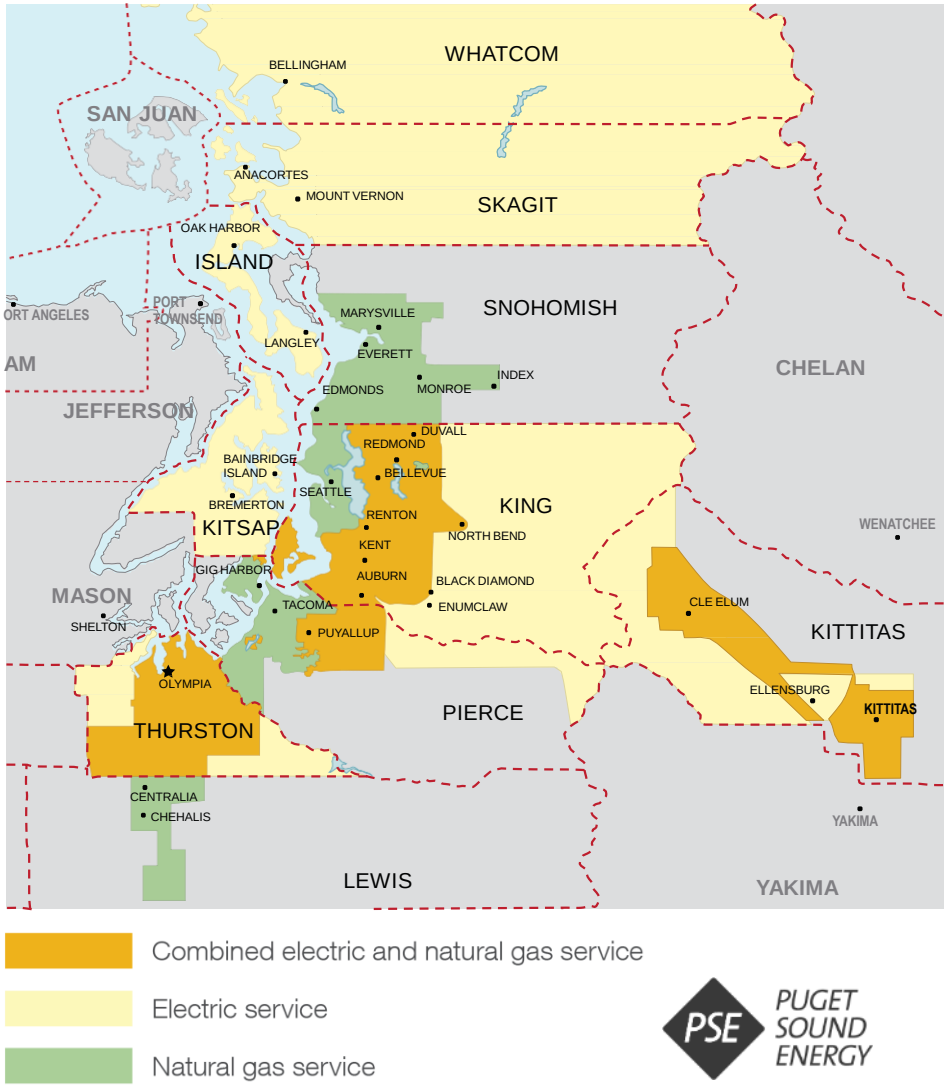
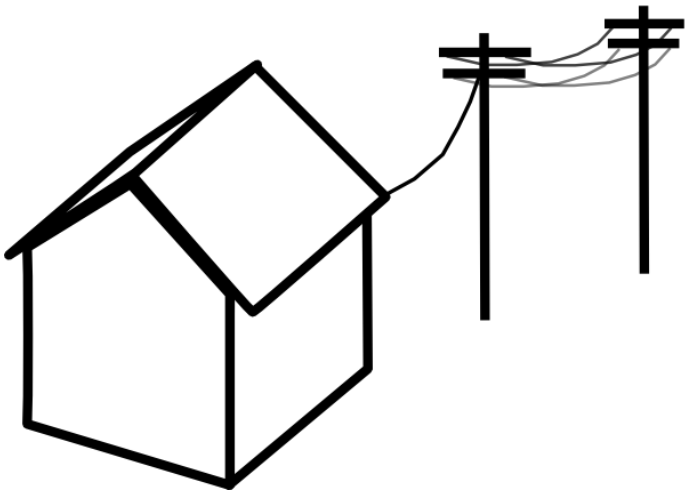
Puget Sound Energy (PSE)

- PSE is Washington State's oldest and largest utility
- Served the Puget Sound Region for over 135 years
- 1.1 million electric customers
- 400+ substations
  - 300+ distribution
- 1200+ substation feeder circuits
- Primarily a distribution focused electric utility



Distribution Automation Overview

- PSE Formed a task force in 2015 for vendor proposals
- Project benefits estimated at 20x their initial cost
- Per Project reliability benefits
  - 5,000 Customer Interruptions reduced
  - 700,000 Customer Minutes of Interruption reduced



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Approaches to Distribution Automation

- Several Different Approaches to DA
  - Fault Targeting Only Switches
    - Exposes Entire Feeder to momentary outages
    - Little to no coordination study
  - High Speed Communications
    - GOOSE
    - Cost Prohibitive
    - Requires new equipment
  - PSE's Hybrid Approach
    - Designing the DA scheme around protection requirements and fundamentals

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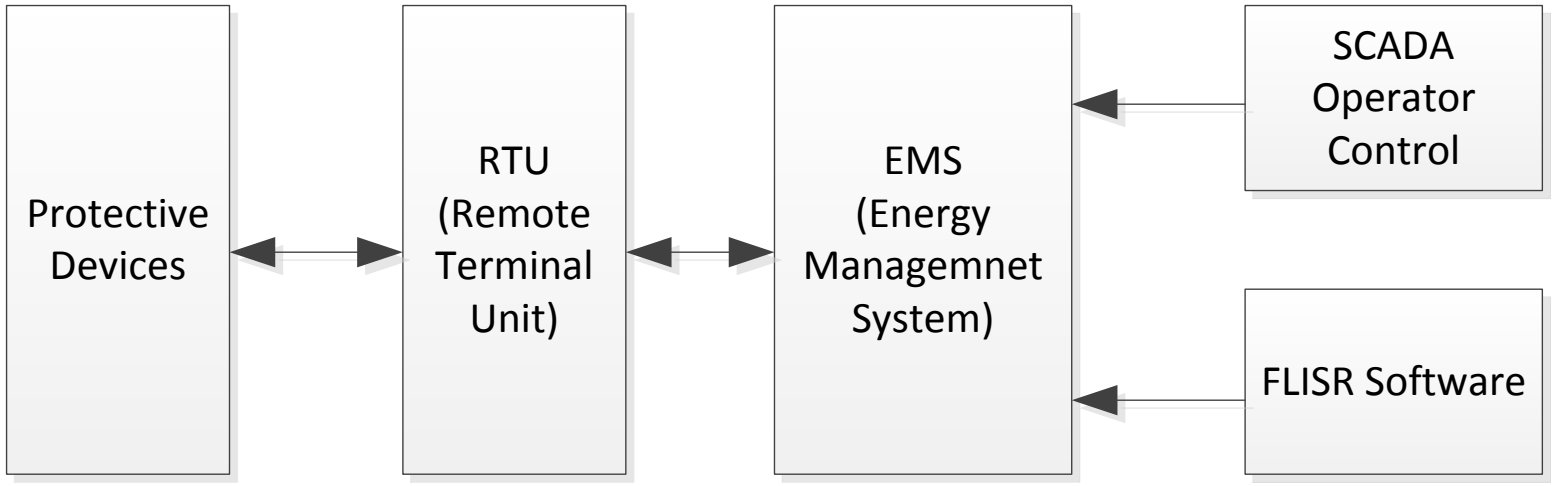
FLISR Installation @ PSE



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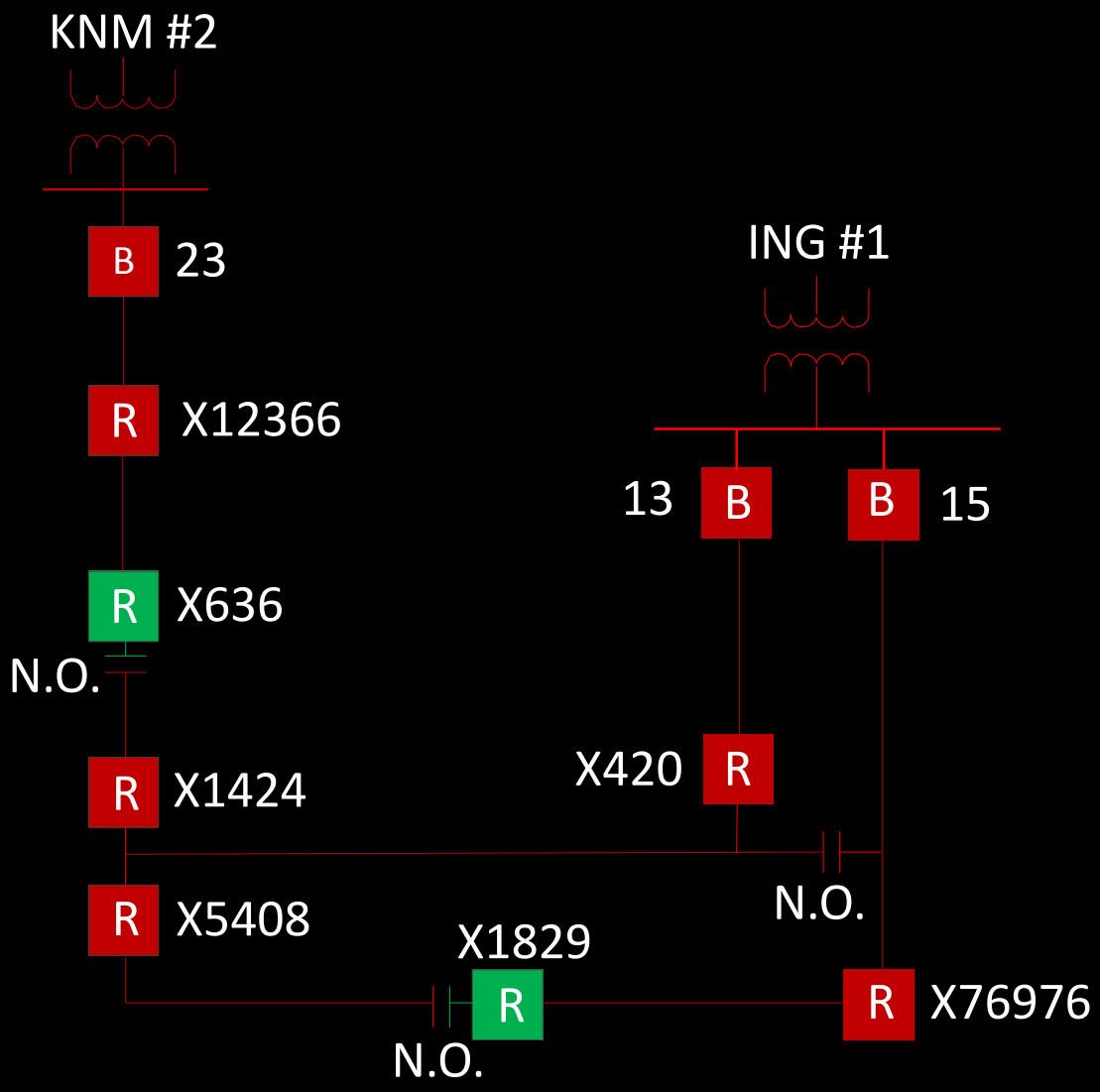
System One Line



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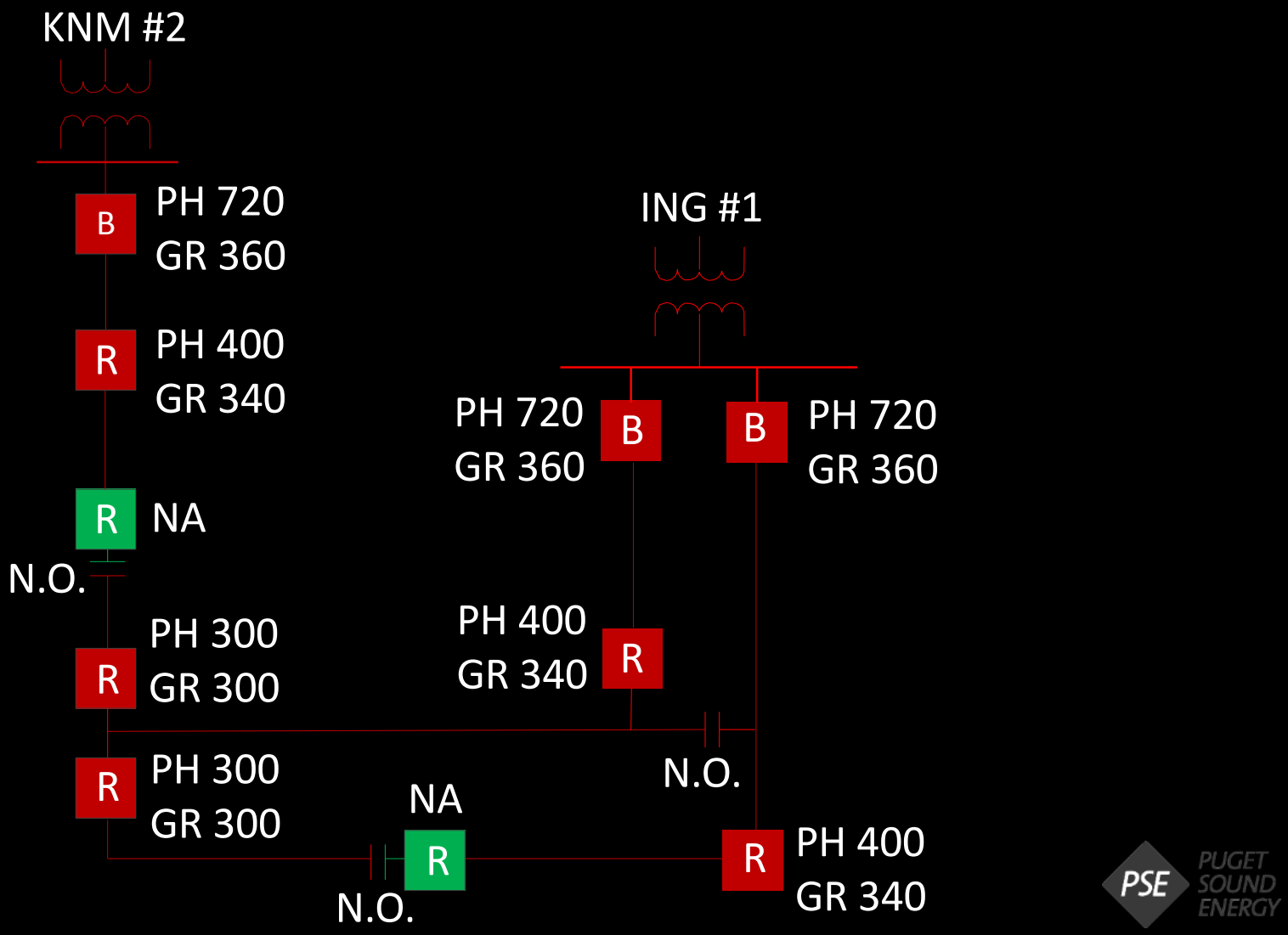
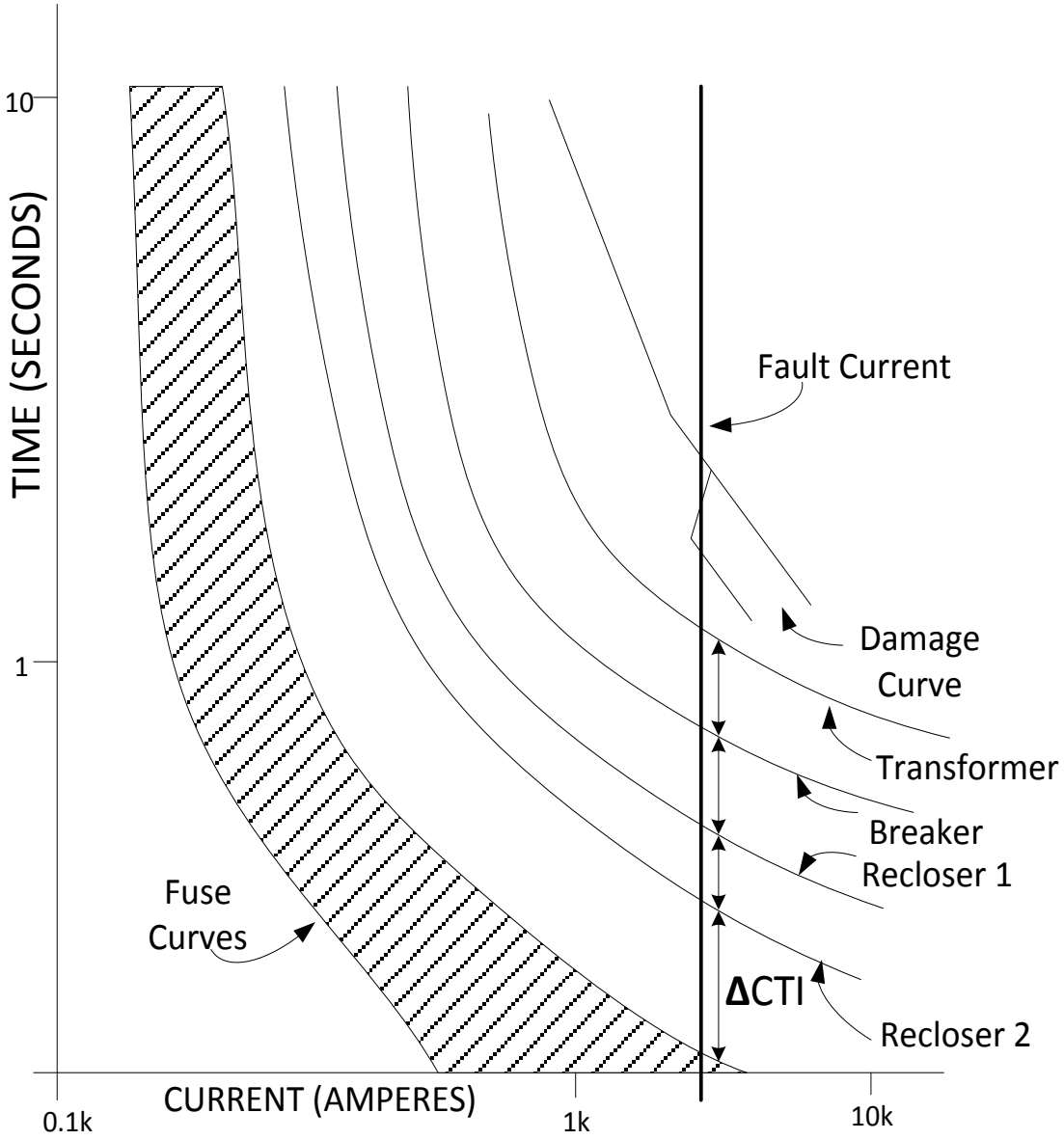
51P/51G PU Levels



Typical Distribution Time Current Curves



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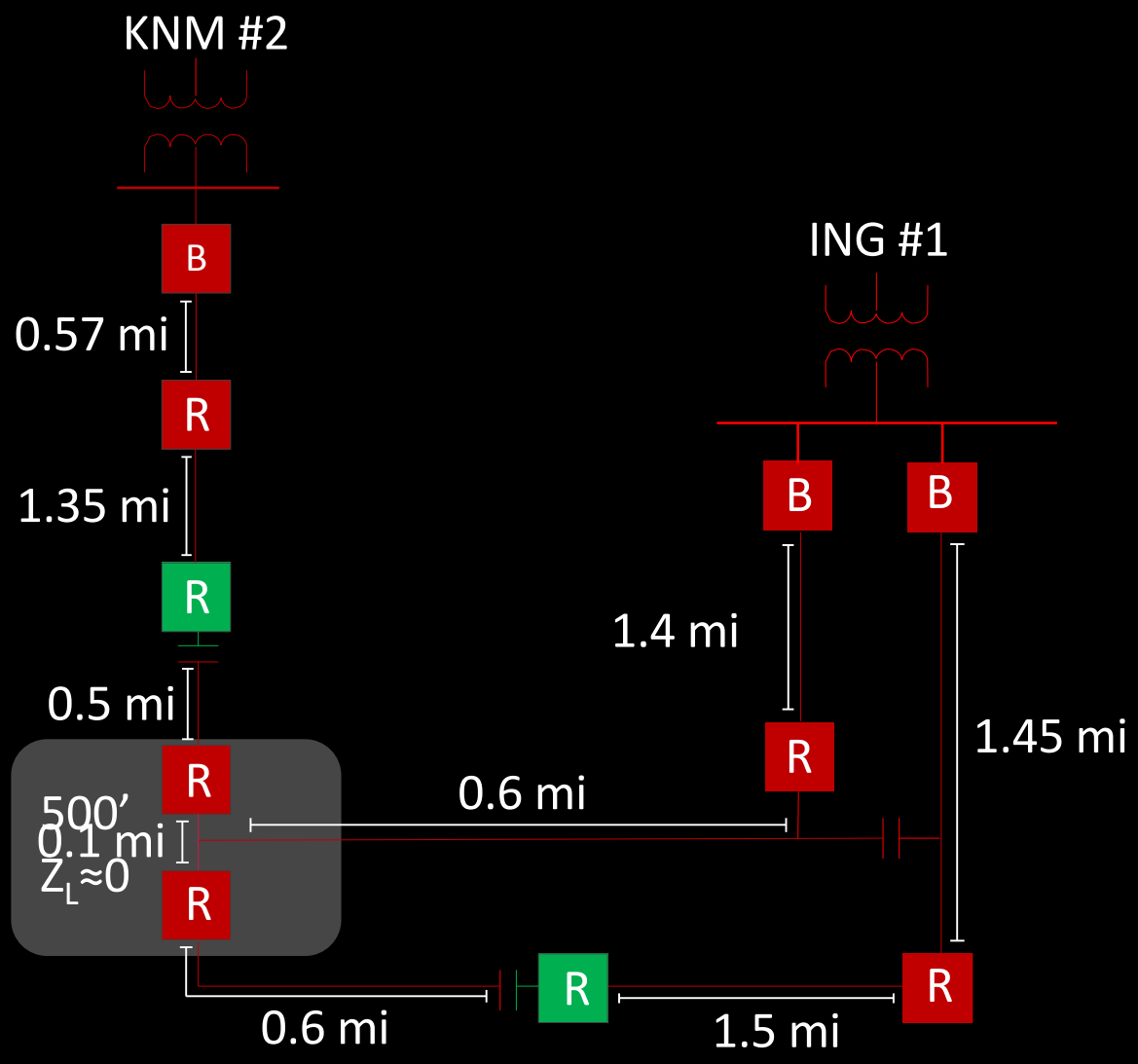
Line Lengths



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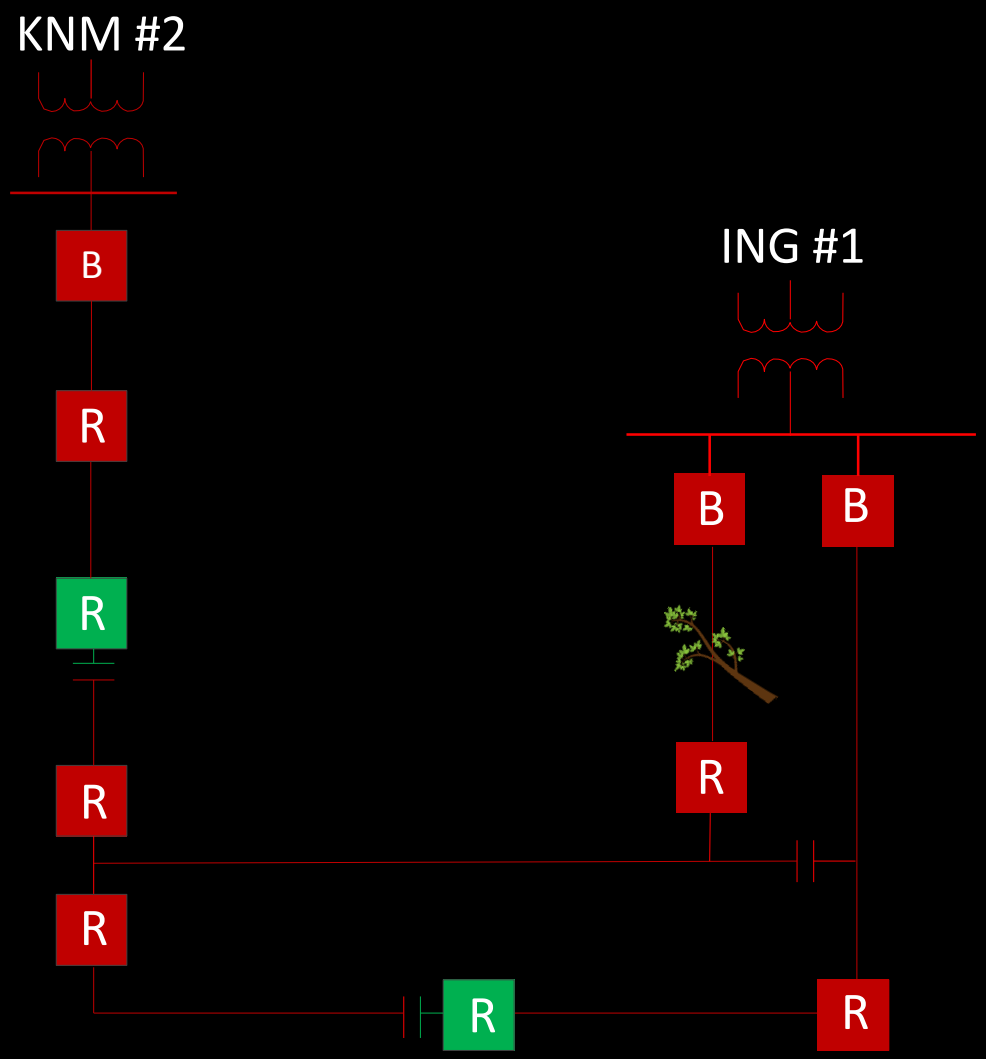
Adaptive Setting Group Example - Fault



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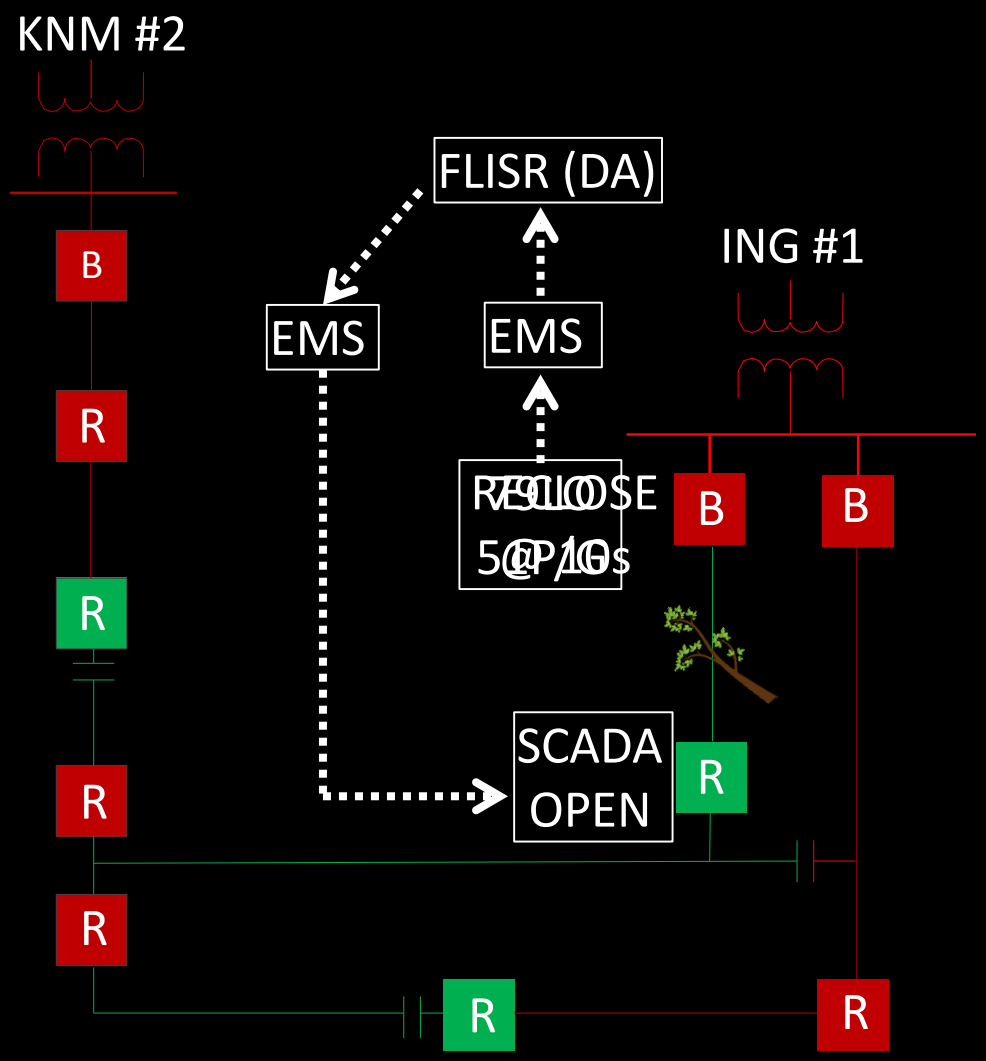
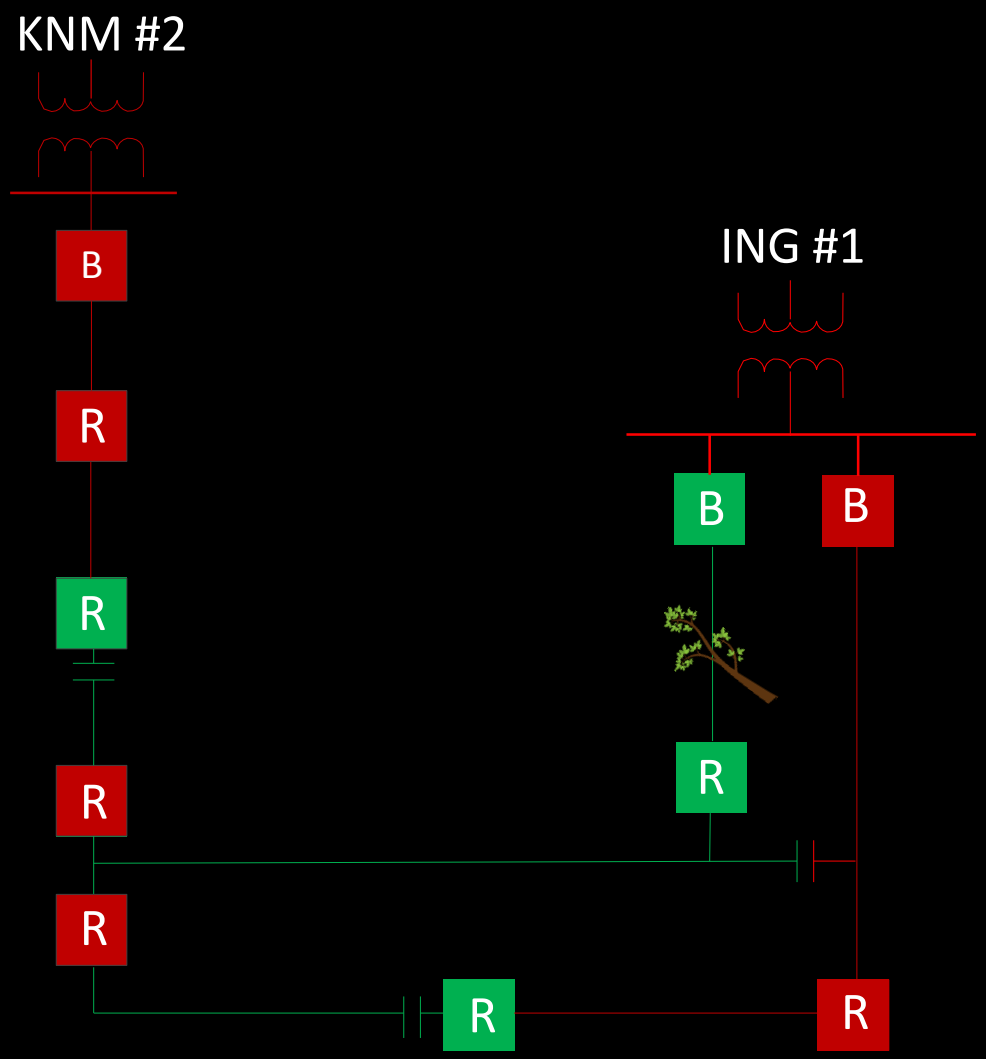
Adaptive Setting Group Example - Fault



Adaptive Setting Group Example - Restoration



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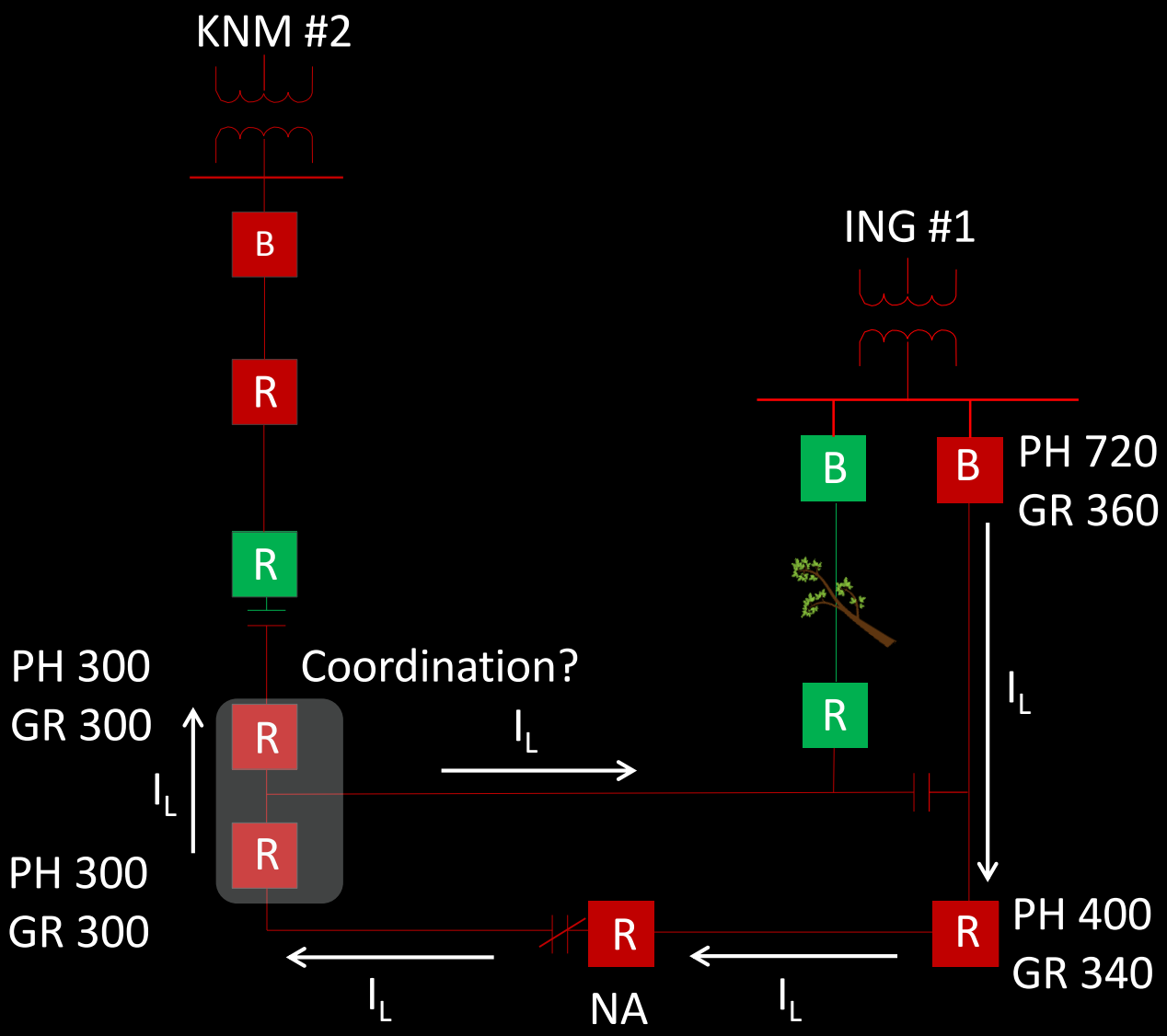
Adaptive Setting Group Example - Restoration



Coordination Options

- Let the devices miscoordinate
  - DA software can detect this
  - Event analysis and troubleshooting
  - What happens if DA scheme is off?
- High Speed Communications
  - GOOSE
  - Existing infrastructure does not support GOOSE
  - Expensive to implement
- Turn all devices into “smart” switches
  - Exposes all customers to fault
  - No ability to sectionalize system if DA scheme is off

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PSE's Hybrid Approach to DA schemes

- Design protection system as normal
- Any devices that cannot be coordinated are turned into automated fault targeting switches
- Take each feeder contingency separately
- Fault Tripping Off Mode
  - Program separate setting groups into reclosers
  - Setting the 51P and 51G elements
  - Removing the 51P1T and 51G1T elements from the trip equation
  - DA system enables setting group during feeder reconfiguration
  - Greater Flexibility in choosing which devices operate for faults
- Directionality can still be used for separate feeder pickups in the forward or reverse direction (requires voltage sensing)

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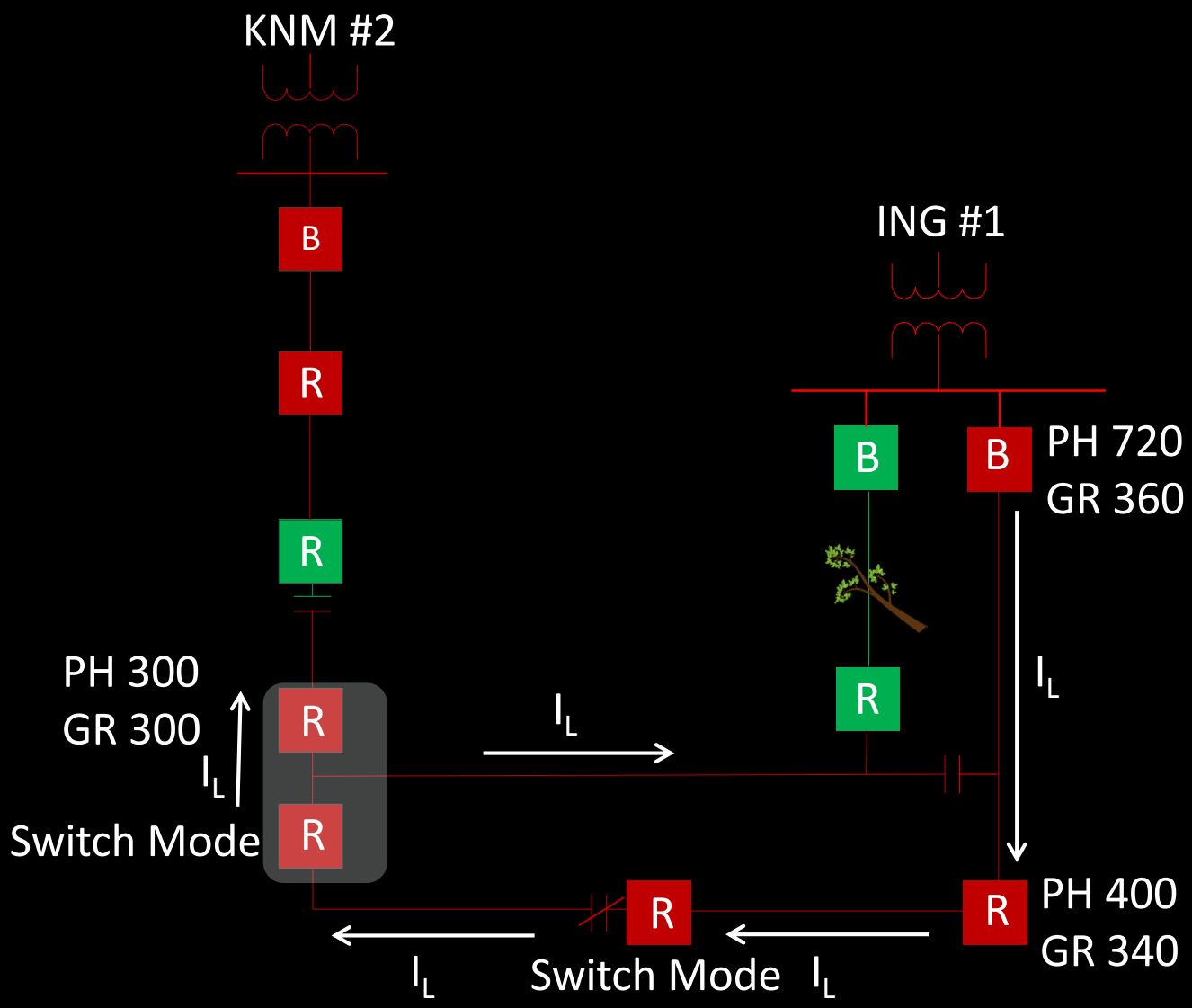
Adaptive Setting Group Example – SG2



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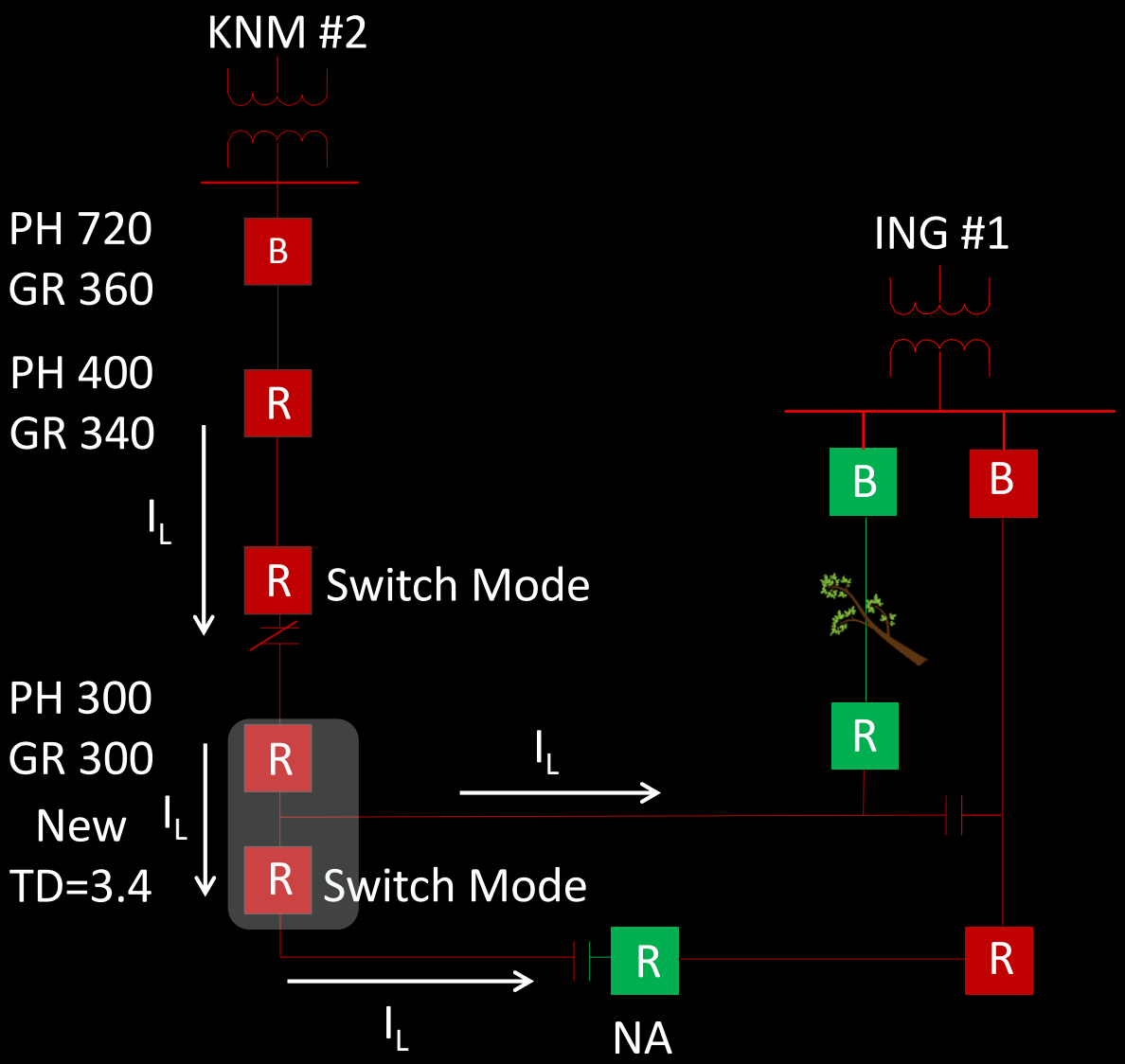
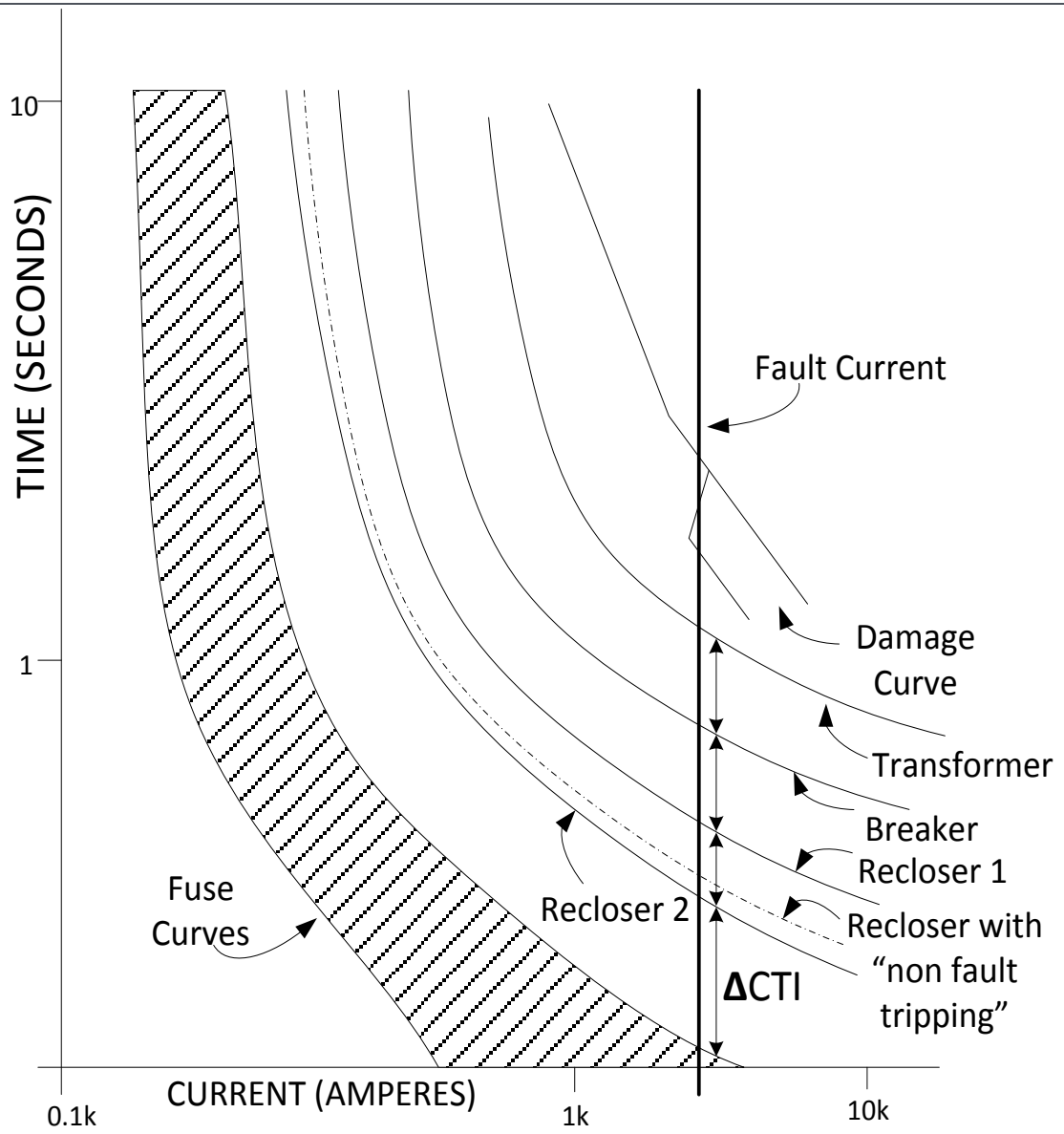
Alternate Feed – Distinct PU/TD



“Non Fault Tripping” Mode



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Design Challenges

- Integrating DA scheme into existing infrastructure
- Documentation
- Maintaining Protection Standards
  - Proper CTI Margins Between Devices
  - Ensure EOL clearing criteria is met
  - Increased load limits, while maintaining sensitivity
- Standardizing Future Equipment
  - Minimum requirements for device to be included in DA
    - 51T, 52A, Amps, HLWS
    - Recloser Controllers

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Microprocessor Based Feeder Breaker

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Can you automate this please?

- Older Electromechanical based design
- PSE has over 1,260 Feeder Breaker relay Set
  - 10% Modern Day microprocessor based relay sets
  - 20% First Generation Microprocessor based relay sets
  - 70% Electromechanical relay packages

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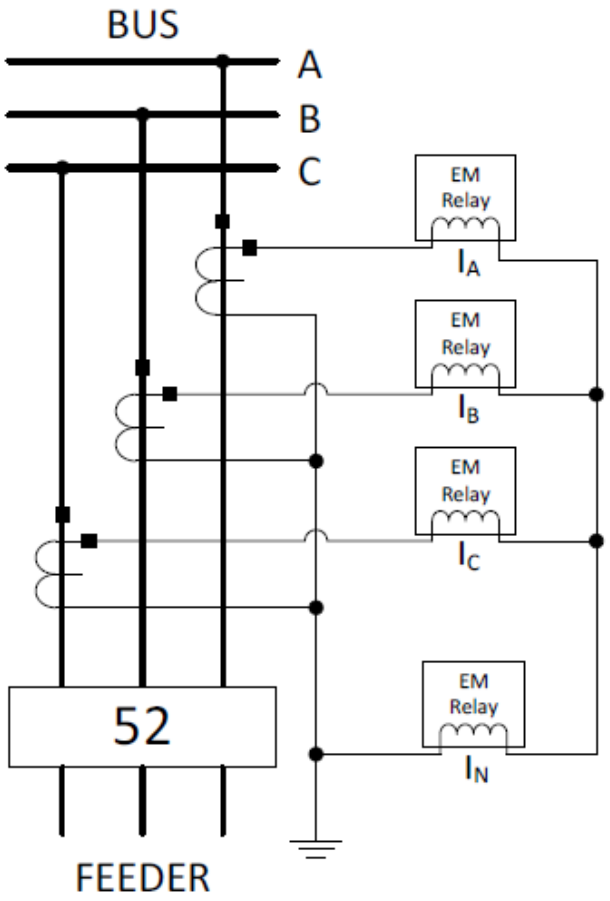
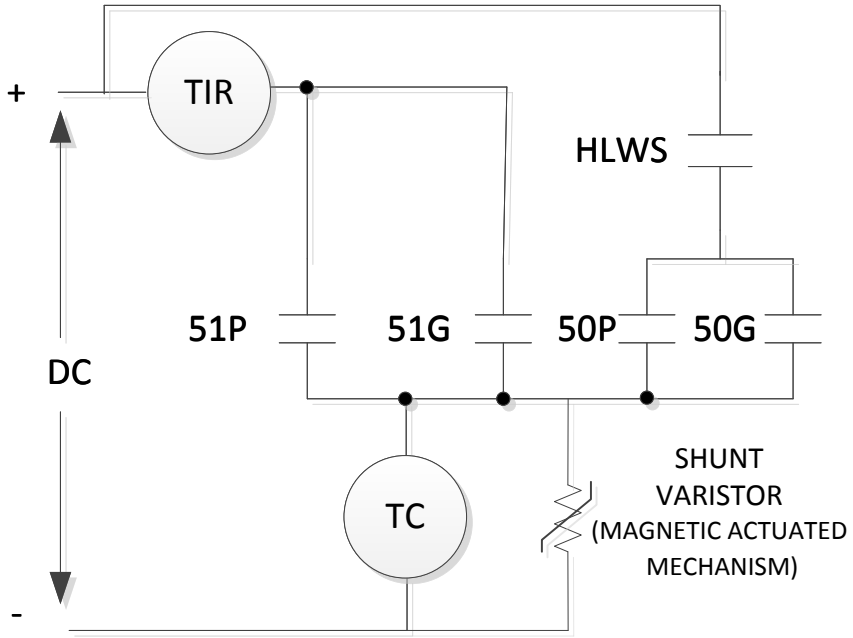
Trip Indication Relays





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Trip Indication Relays

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Documentation

- Standardize on minimum requirement for relay to be integrated into DA Scheme
  - Device Type
  - Generation of Device
  - Voltage Sensing
- What DNP points were available
- How were these points going to be mapped into the SCADA/EMS system
- Setting group documentation for planners and operators

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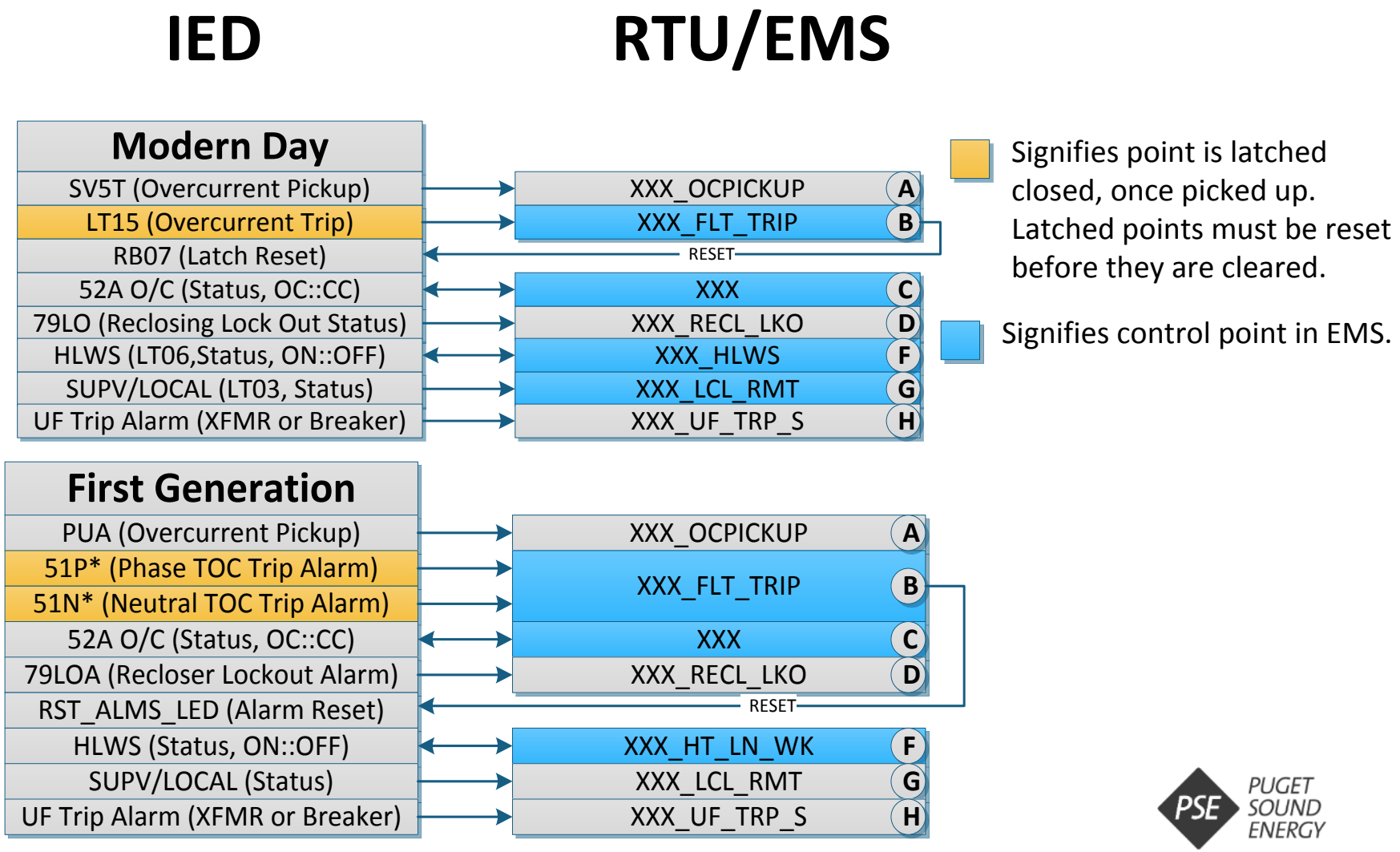
IED-EMS Maps for DA



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Setting Group Tables for Reconfiguration

NAME	IED	LOAD LIMIT (A)	SETTING GROUP FOR RECONFIGURATION		
			KNM-23	ING-13	ING-15
KNM-23 X636	XXX	###	2	2	2
ING-13 X1424	XXX	###	1	1	1
ING-13 X5408	XXX	###	2	1	2
ING-15 X1829	XXX	###	2	2	2
ING-15 X420	XXX	###	2	1	2
ING-15 X76976	XXX	###	2	2	1
ING-13	EM	###	-	-	-
ING-15	EM	###	-	-	-
KNM-23	EM	###	-	-	-
SETTING GROUP 1 – RECLOSER WILL TRIP FOR FAULTS DOWNSTREAM SETTING GROUP 2 – RECLOSER WILL SIGNAL AND TARGET ONLY FOR FAULTS DOWNSTREAM					

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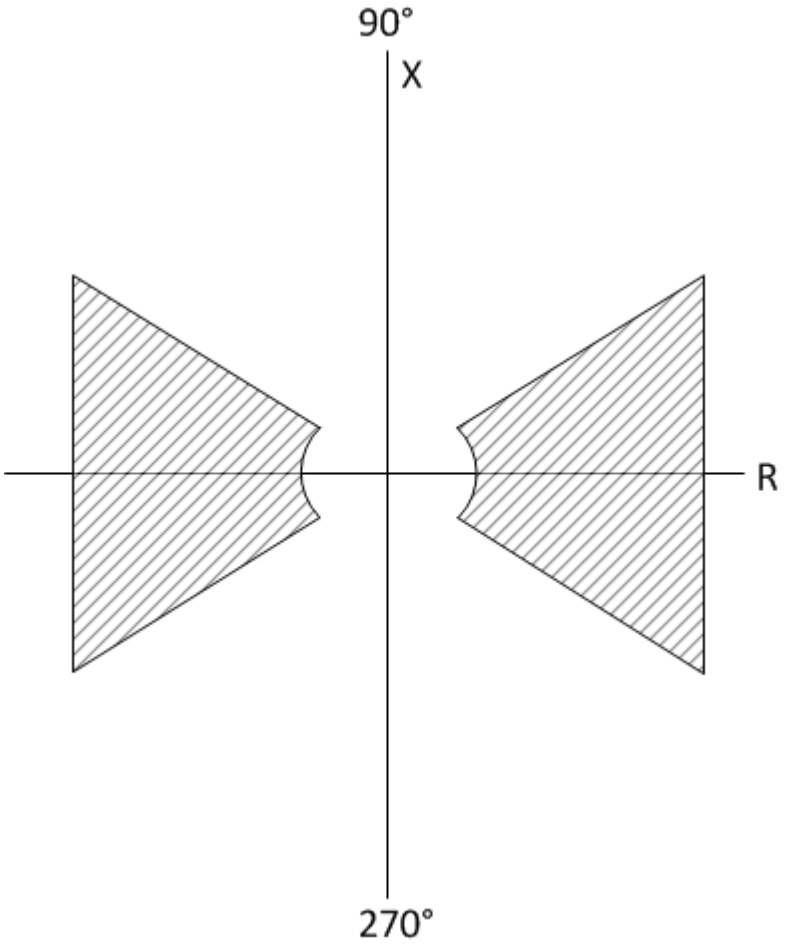
Load Encroachment on non-directional elements

- PSE has a protection design standard of ensuring bolted end of line (EOL) faults cover 150% of the phase and ground pickups
- Maintains standard pickup values for reclosers down the feeder
- Allows higher load limit of circuit than 51P set point



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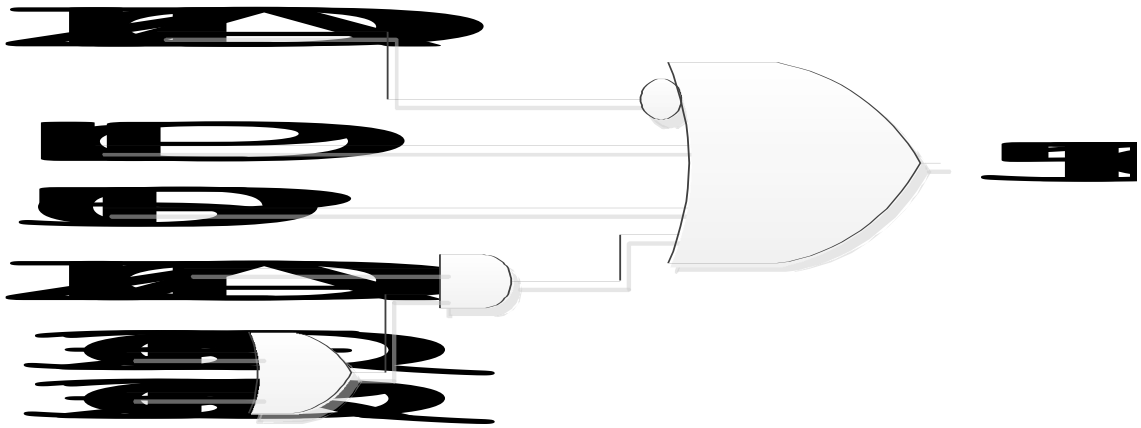
Load Encroachment on a non-directional element

- Proper Supervision is required
  - Operates purely off Positive Sequence
  - Susceptible to assertion during unbalanced faults
  - Unbalanced faults contain all three sequence components
  - 32QR & 32QF – set above highest normal imbalance of the system
  - 50P – set higher than load limit, absolutely a fault



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Future Topics and Discussions

- Distributed Generation applications in DA schemes
- Sectionalizer mode for reclosers
- Event Analysis
- DMS system integration
- Staffing Support

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Questions?

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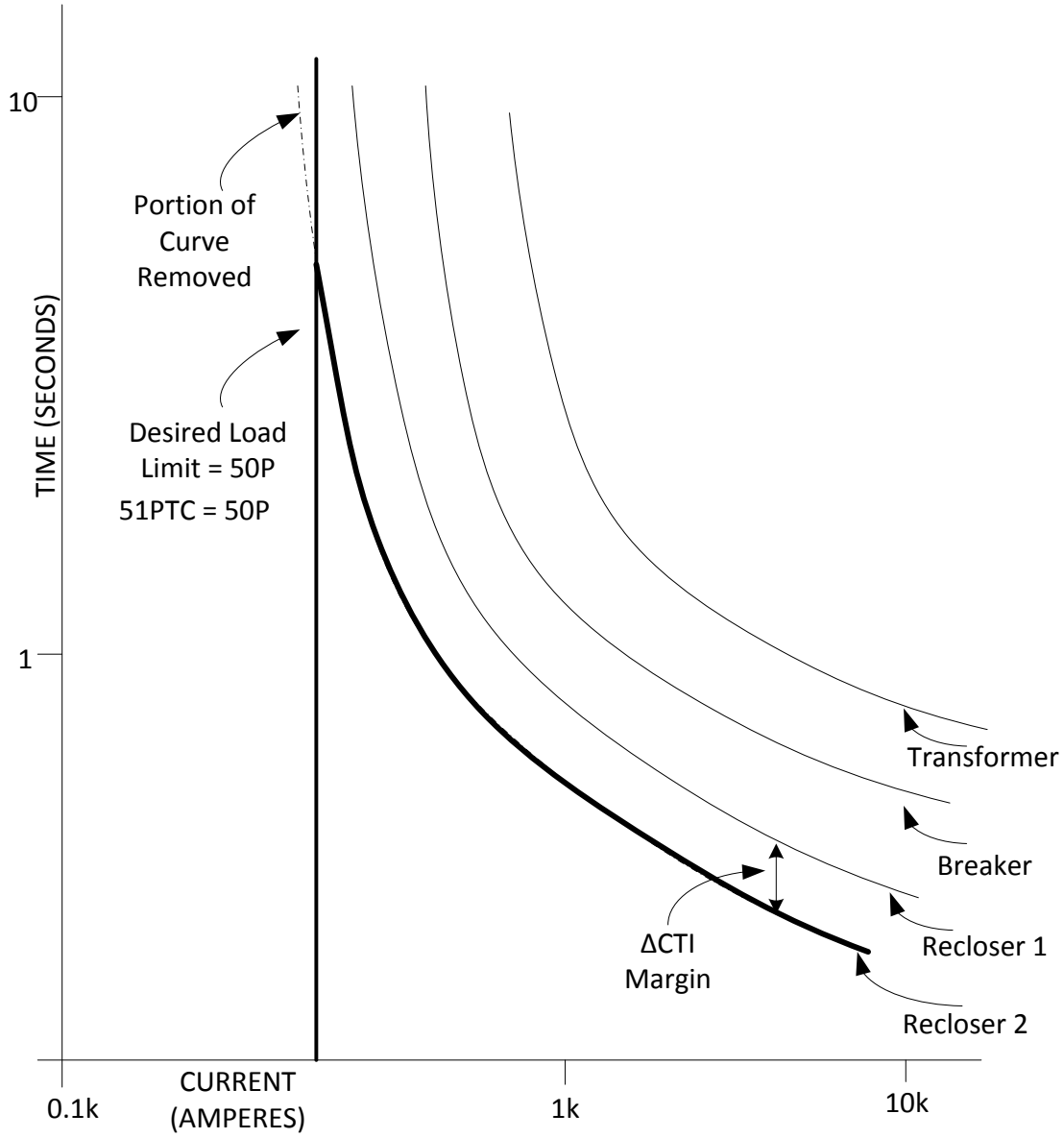
Extra Slides – Curve Shaving



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