Application Considerations for Protecting Transformers With Dual Breaker Terminals

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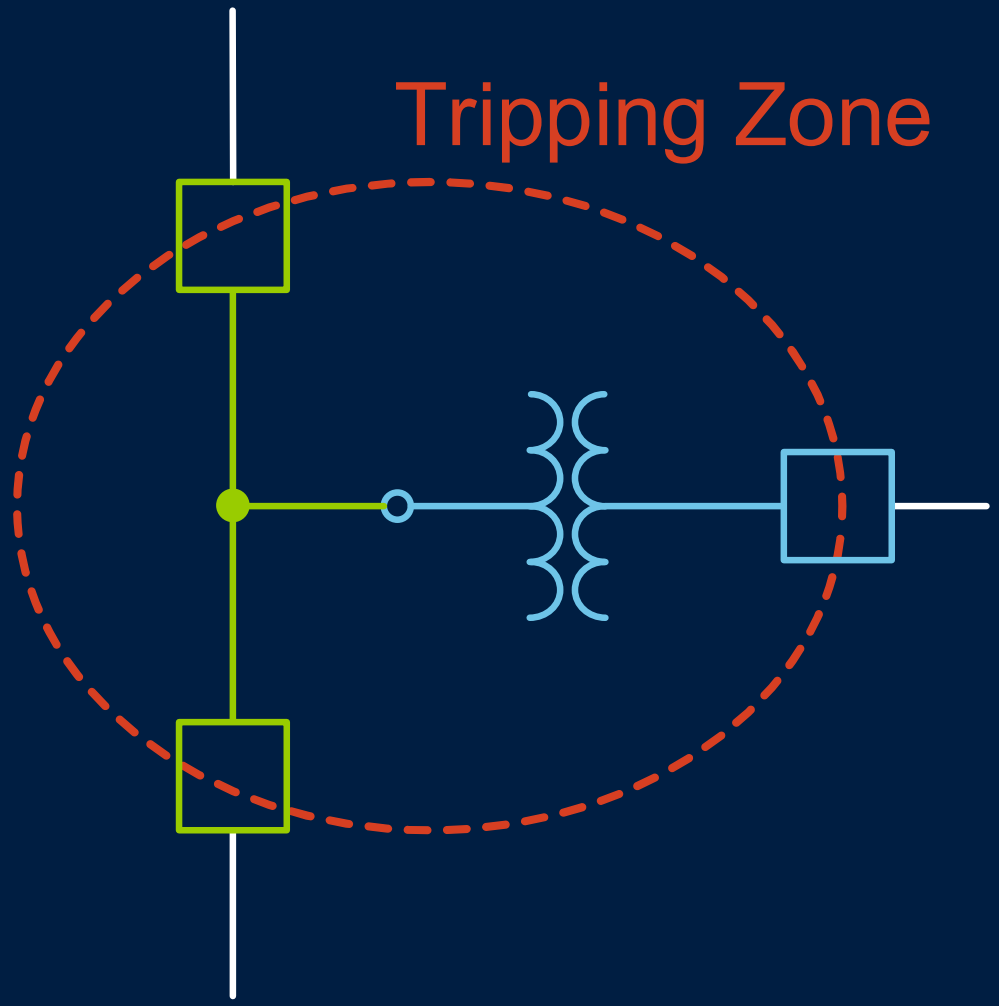
Key Concepts of Paper

- Transformers in dual breaker buses
  - Conflicting requirements
  - Tradeoffs using an overall differential zone
- Scheme design choices
- Setting concepts
  - CTR selection
  - Key relay settings
- Solutions for legacy installations

Subzones of Dual Breaker Transformer Zone

87B Zone

- High through fault
- High speed
- Low sensitivity



87T Zone

- High sensitivity
- Relatively high speed
- Low through fault

Conflicting CTR Requirements

- High enough to not limit loadability

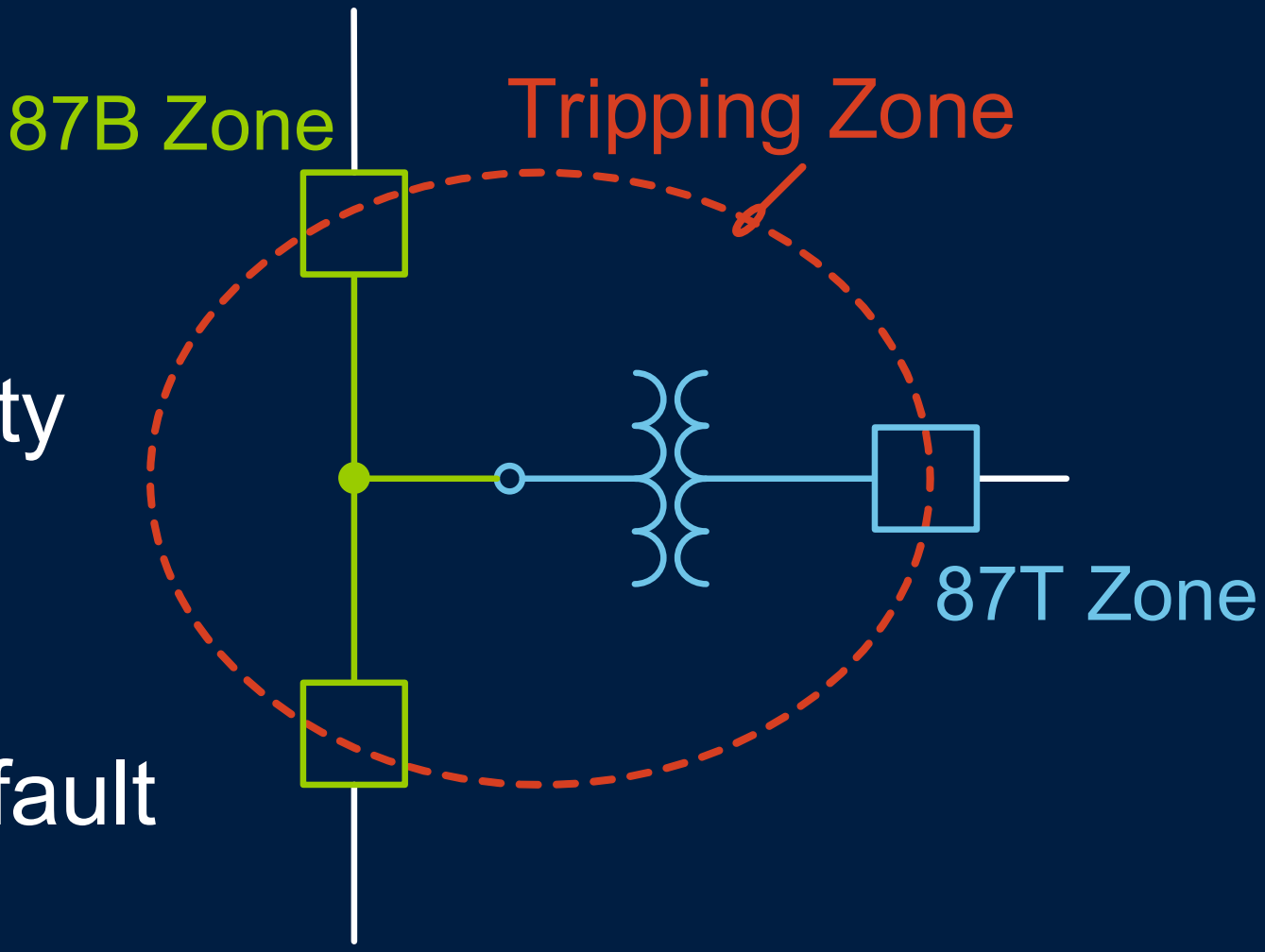
  Bus >> Transformer

- Low enough for sensitivity

  Transformer << Bus

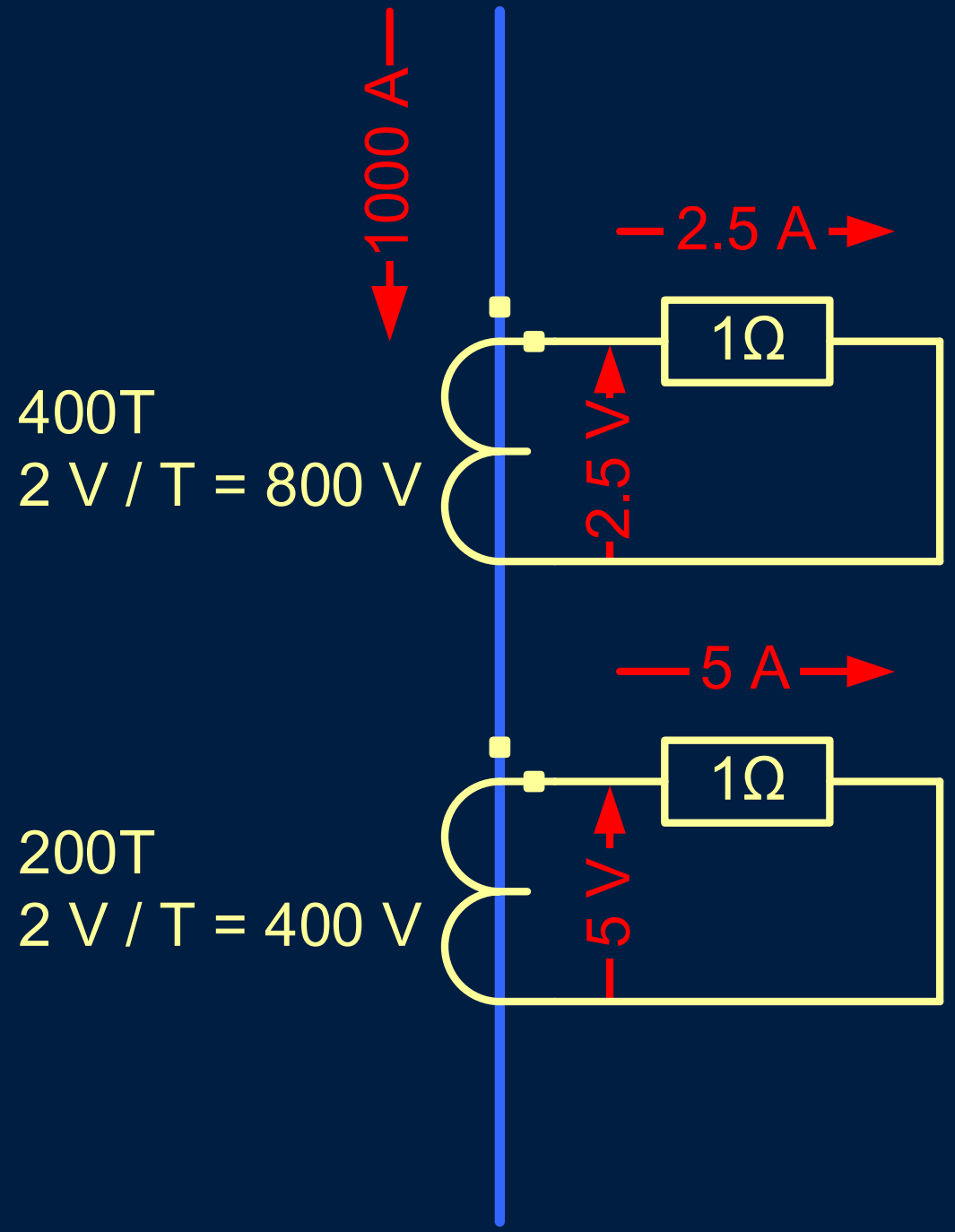
- High enough to not saturate during through fault

  Bus >> Transformer

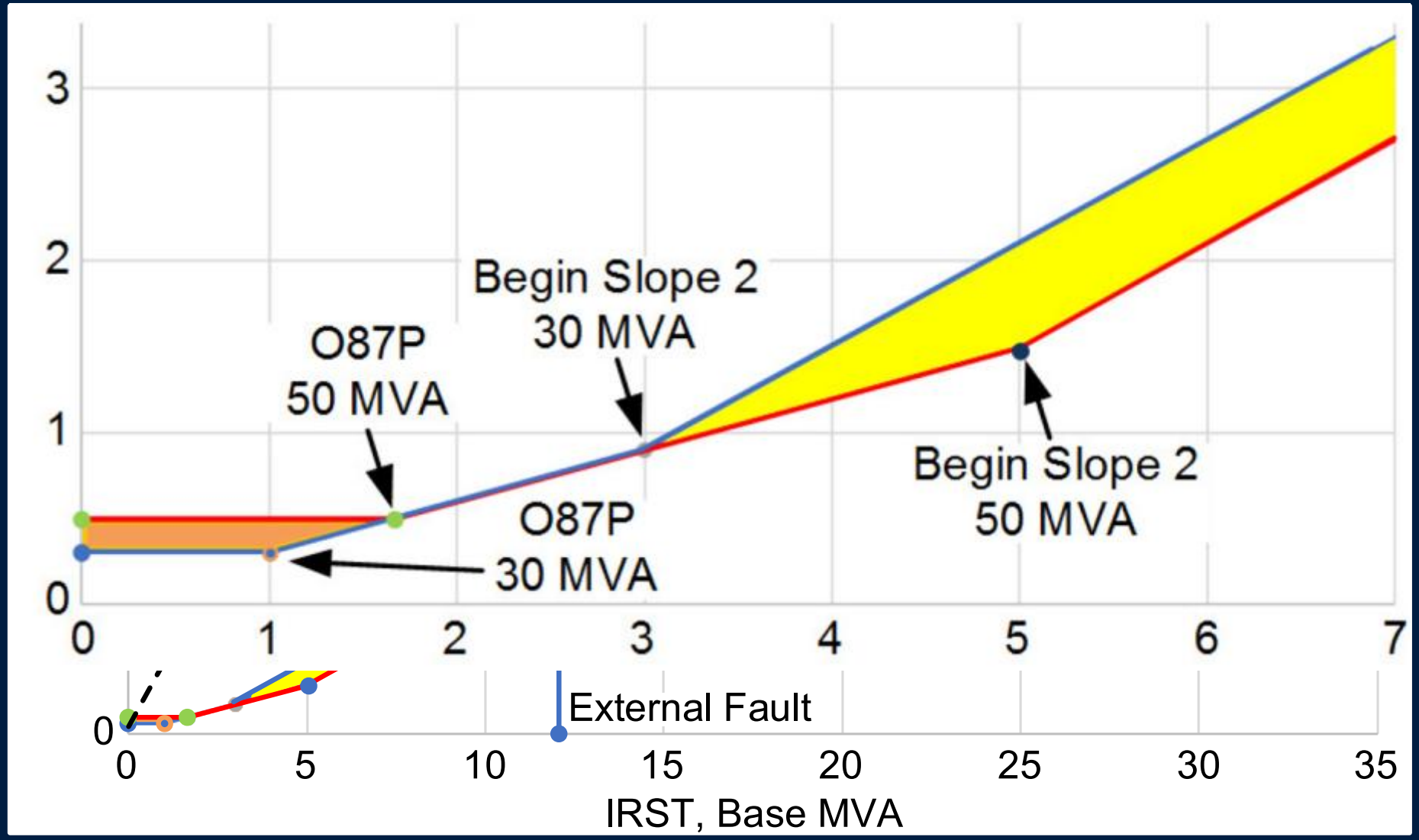


CT Performance

- Asymmetrical current drives saturation
- Core area drives volts / turn
- Square of turns drives performance
  - Fewer turns reduces voltage available
  - Fewer turns increases voltage required

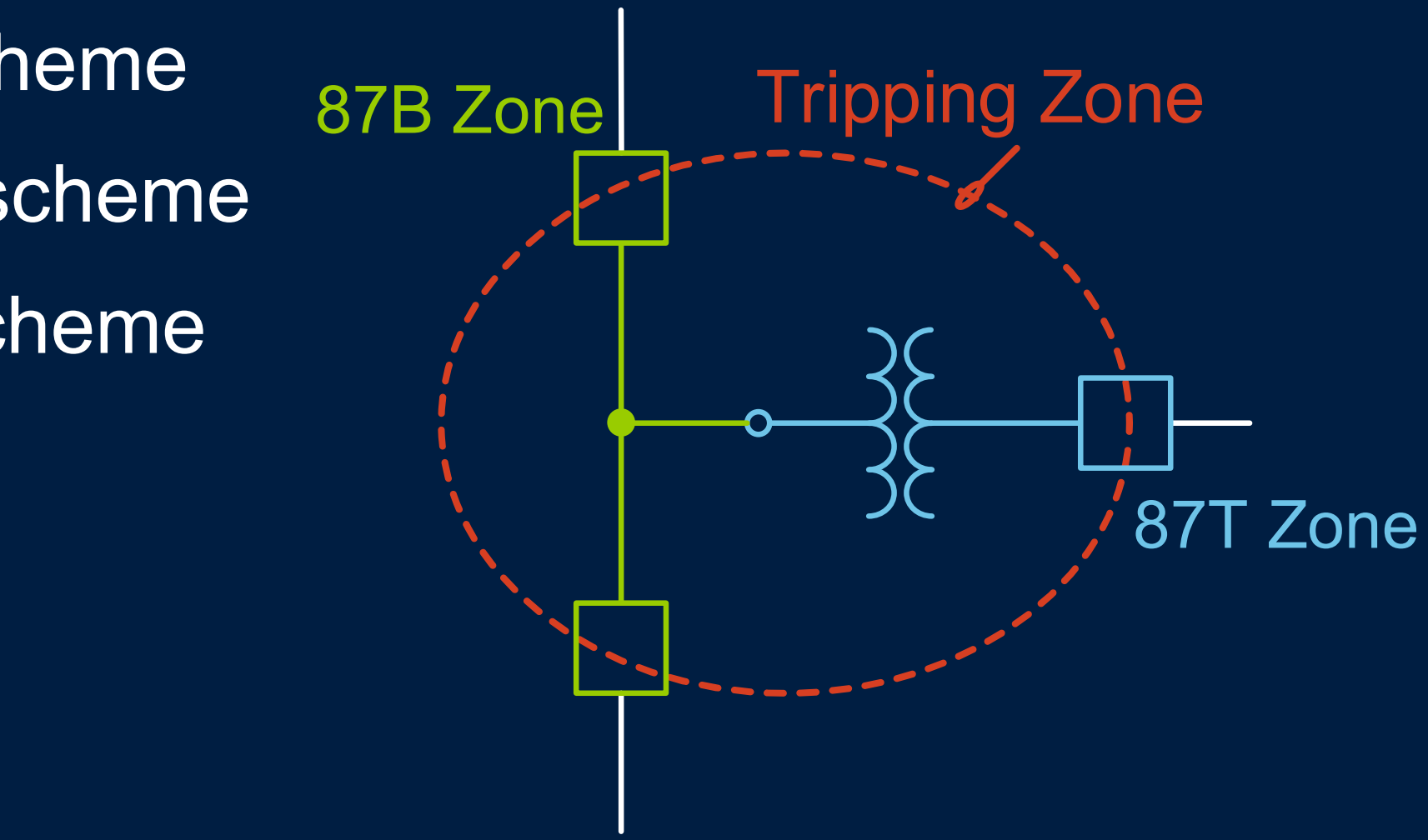


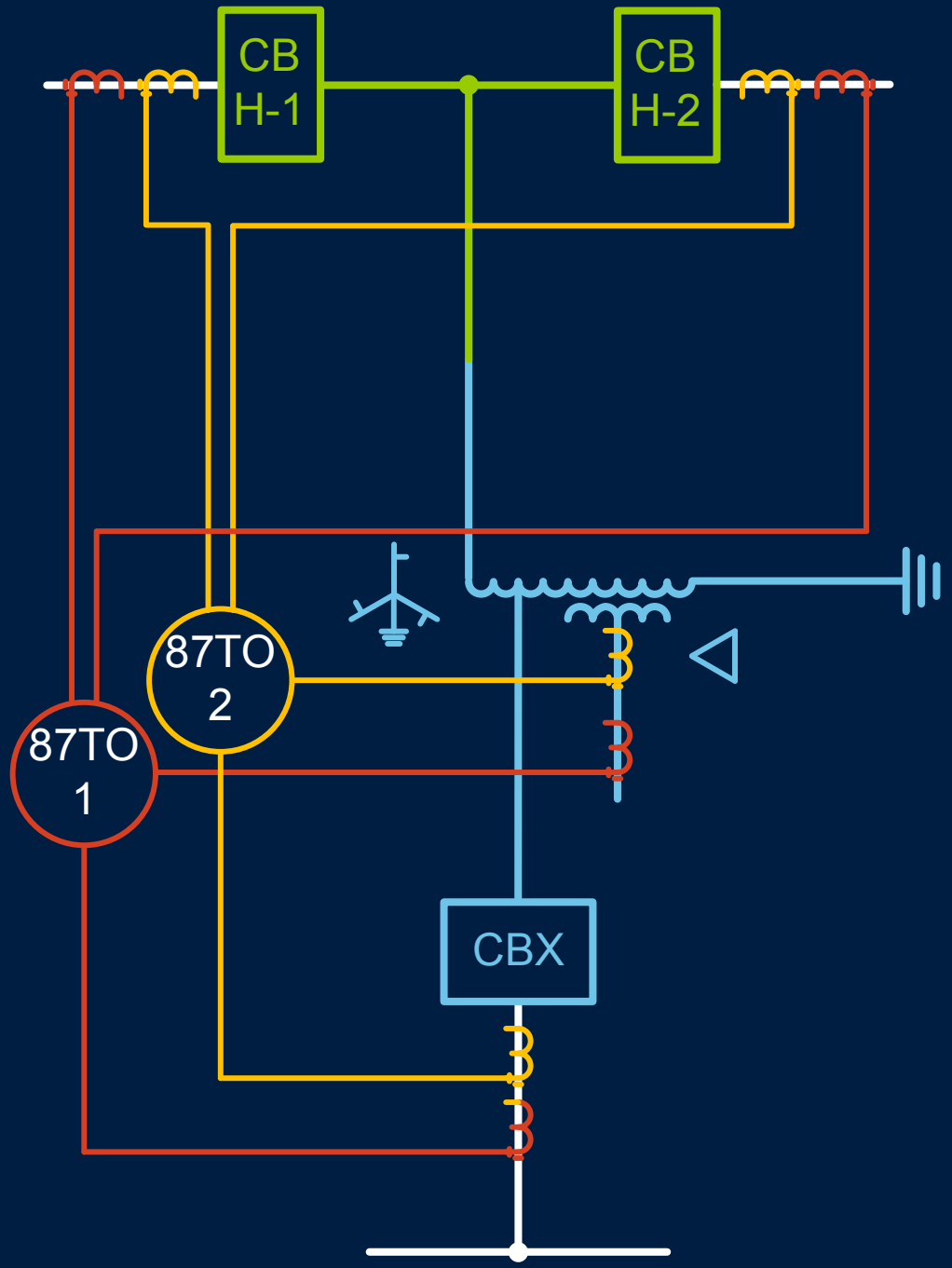
Effect of MVA Setting on 87T



Three Options for System Design

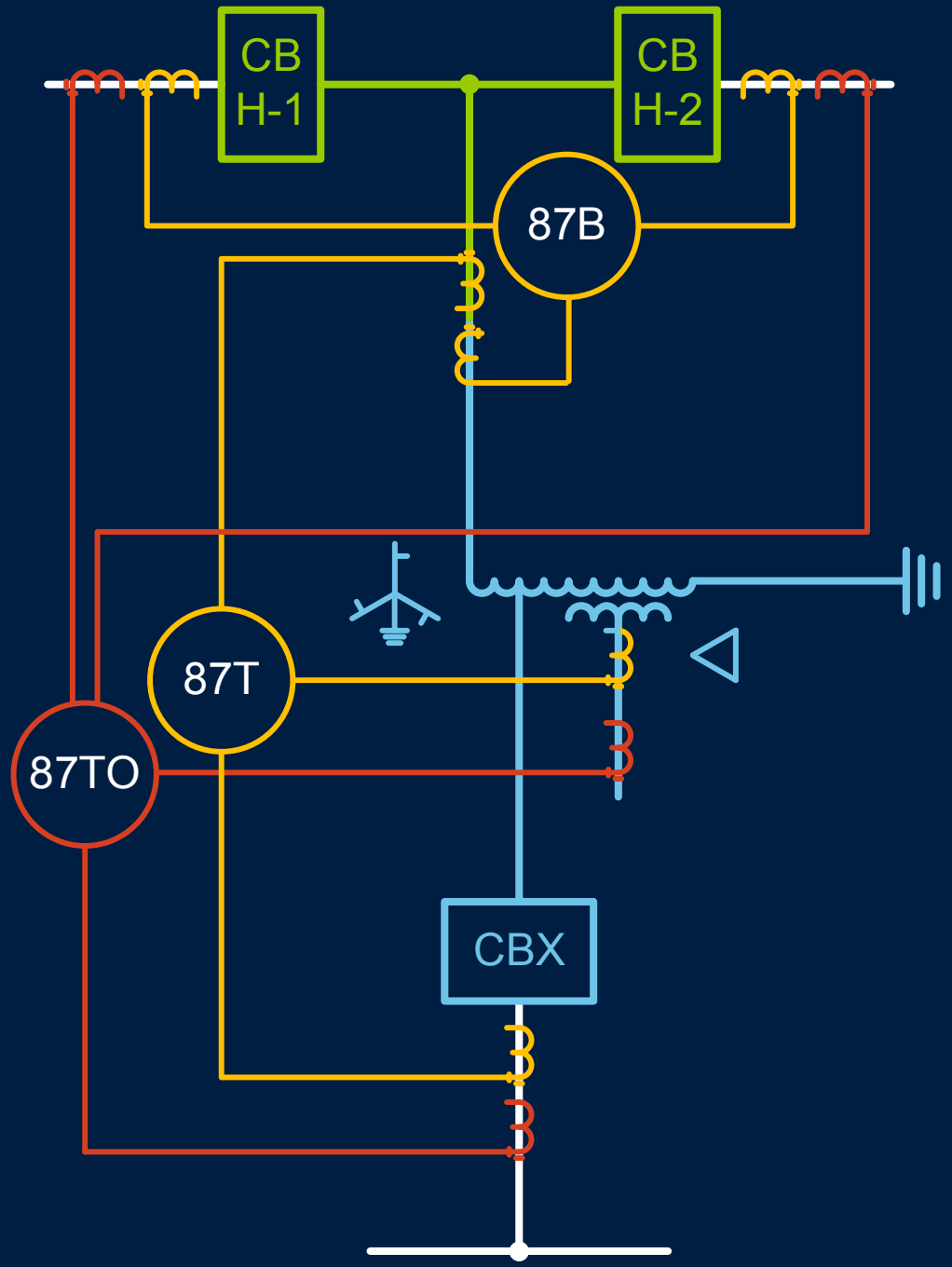
- Two-relay scheme
- Three-relay scheme
- Four-relay scheme





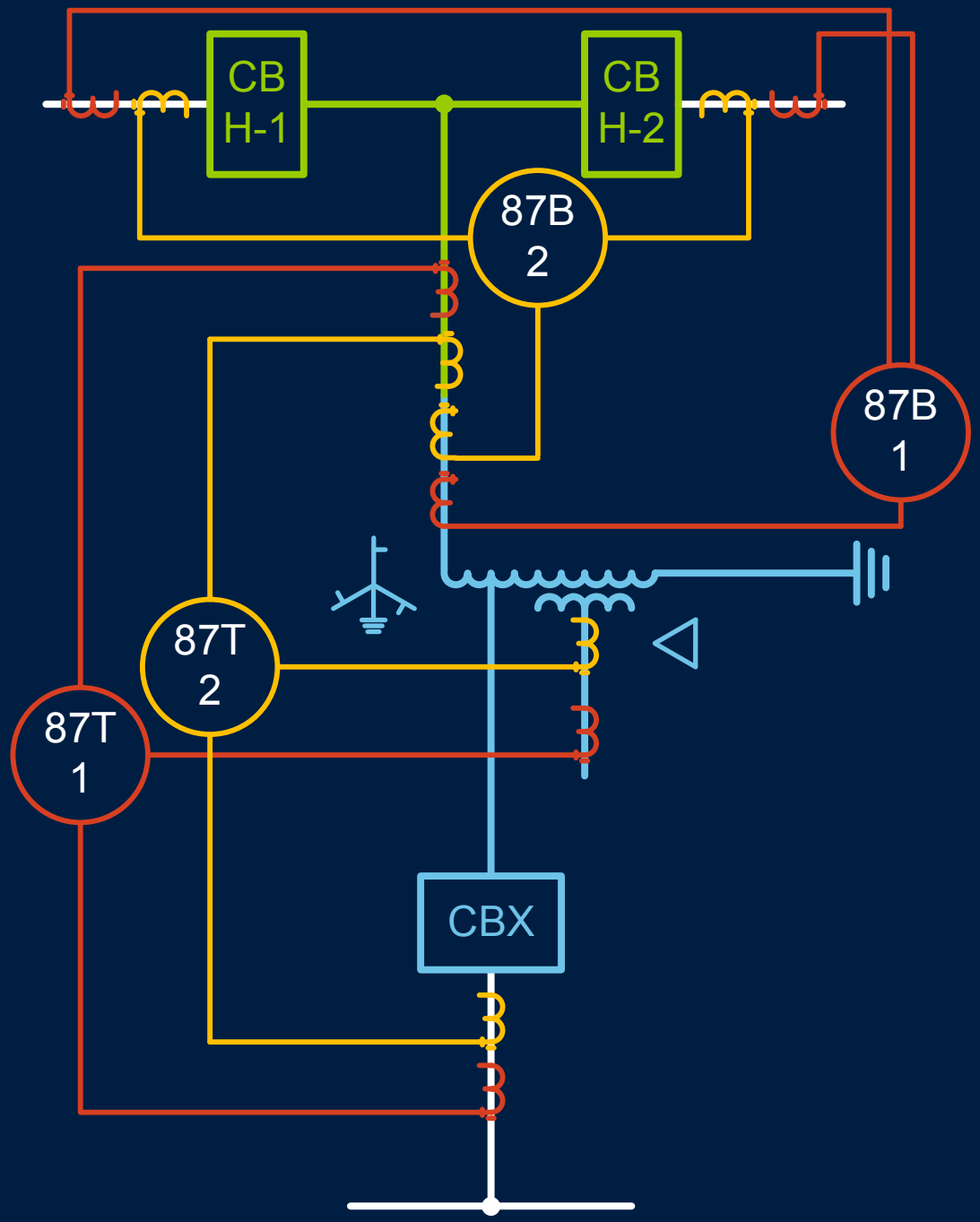
Two-Relay Scheme

- Benefits
  - Low cost – only two relays
  - Moderate setting complexity
  - Least panel space and wiring
- Drawbacks
  - Tradeoff
    - Sensitivity of 87T zone
    - Loadability and security of 87B zone
  - Reduced speed of 87B zone
  - Ambiguous fault location



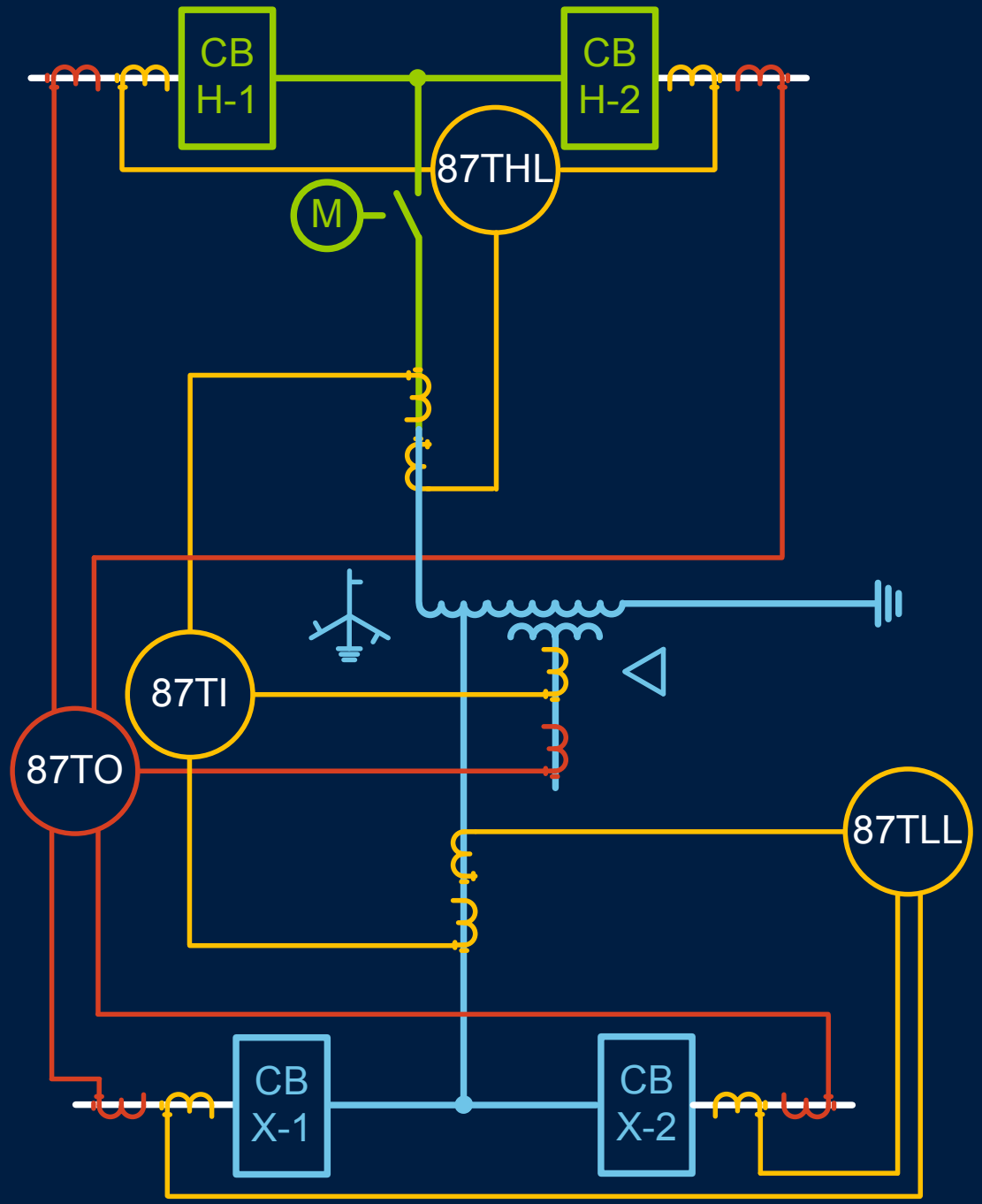
Three-Relay Scheme

- Benefits
  - Balance cost and performance
  - High sensitivity and security
  - Moderate panel space and wiring
  - Accurate fault location
- Drawbacks
  - Most complex settings
  - Loss of performance if 87T or 87B out of service



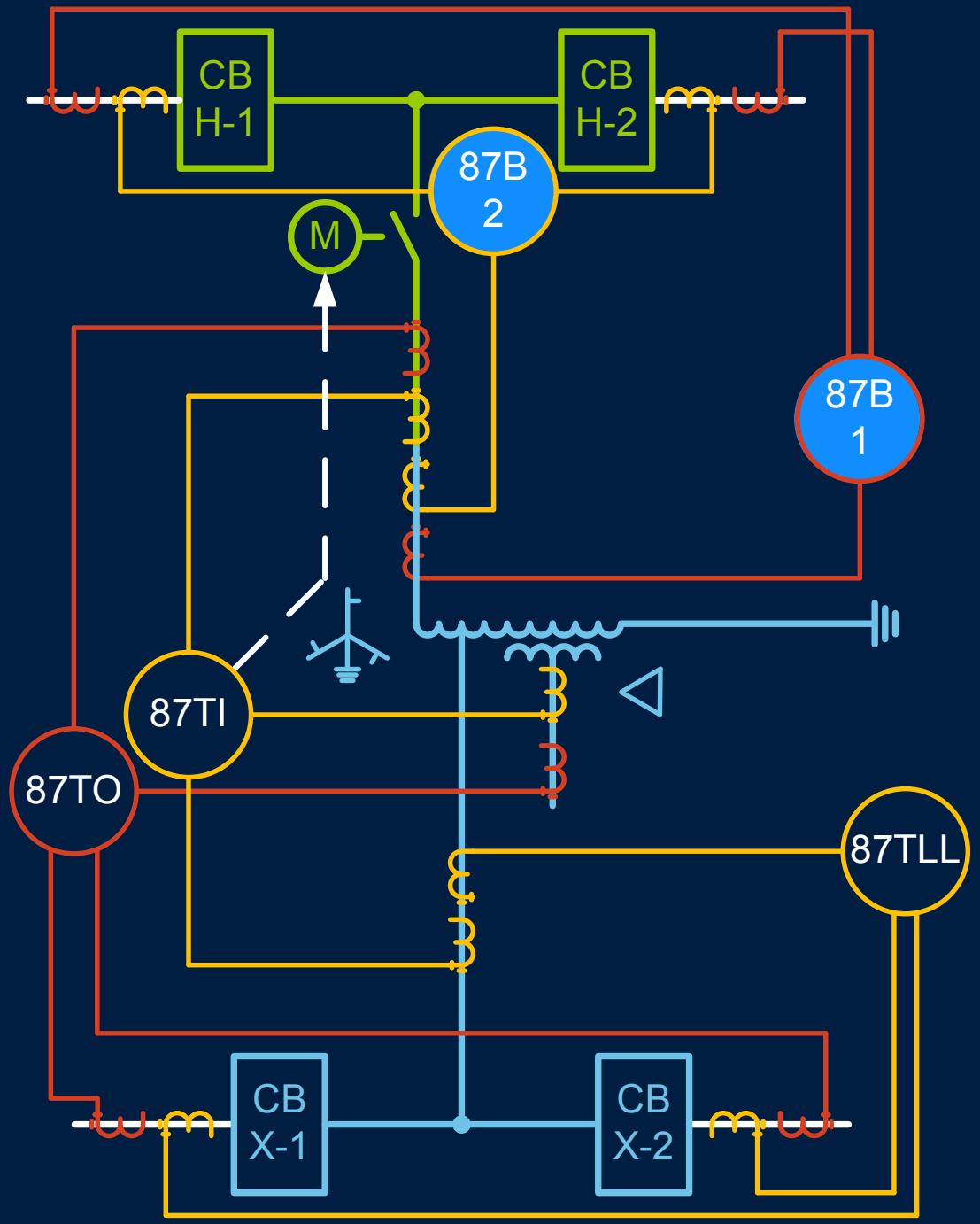
Four-Relay Scheme

- Benefits
  - Best performance
  - Least complex settings
- Drawbacks
  - Most relays
  - Most panel space
  - Most wiring



AEP Standard

- Dual breaker terminals on both the high side and low side of the transformer
- Protection redundancy and hardware diversity
- Dual slope percent restraint for bus and transformer zones with unique settings for the manufacturers' relays



AEP Standard

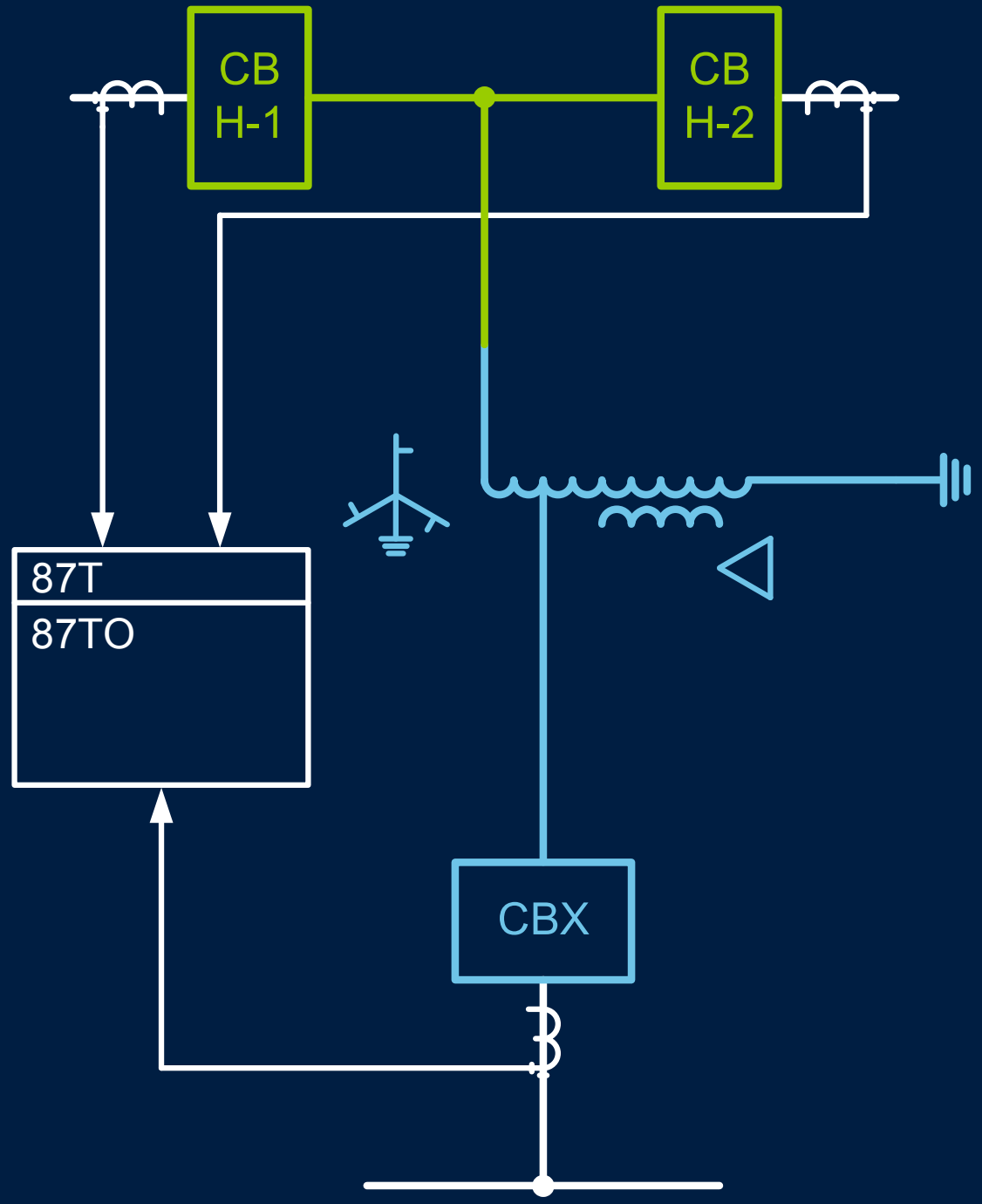
- High system reliability requires high-side bus restoration
- Guidance on through-path loadability and automatic restoration of a high-side bus

Summary of Settings Considerations

Application With Restraint Type	Slope 1	Slope 2
Transformer Differential		
Maximum	35	75
Sum of magnitudes	22	48
Bus Differential		
Maximum	35	75
Sum of magnitudes	22	50

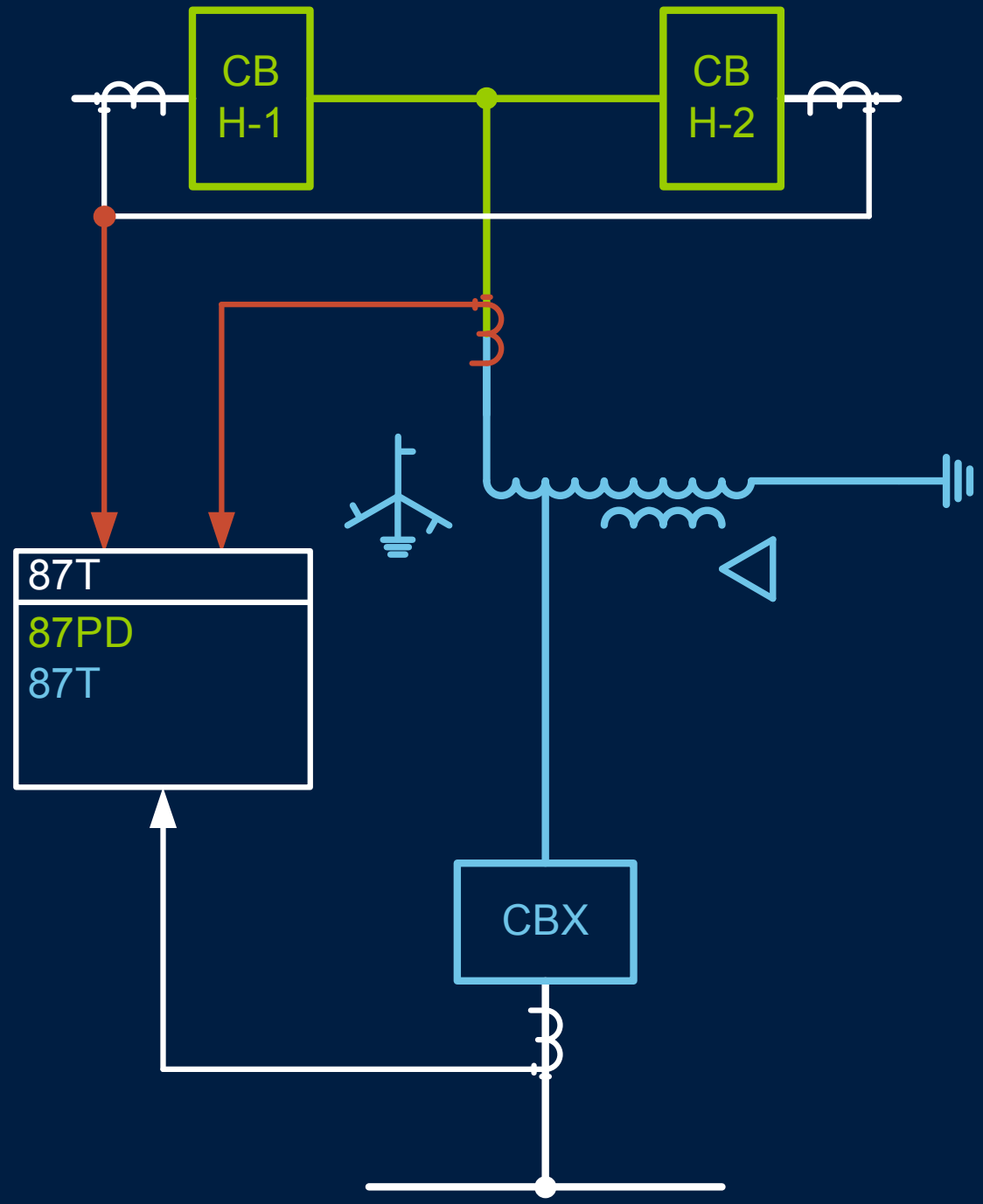
Legacy Applications
Compromises to Look For

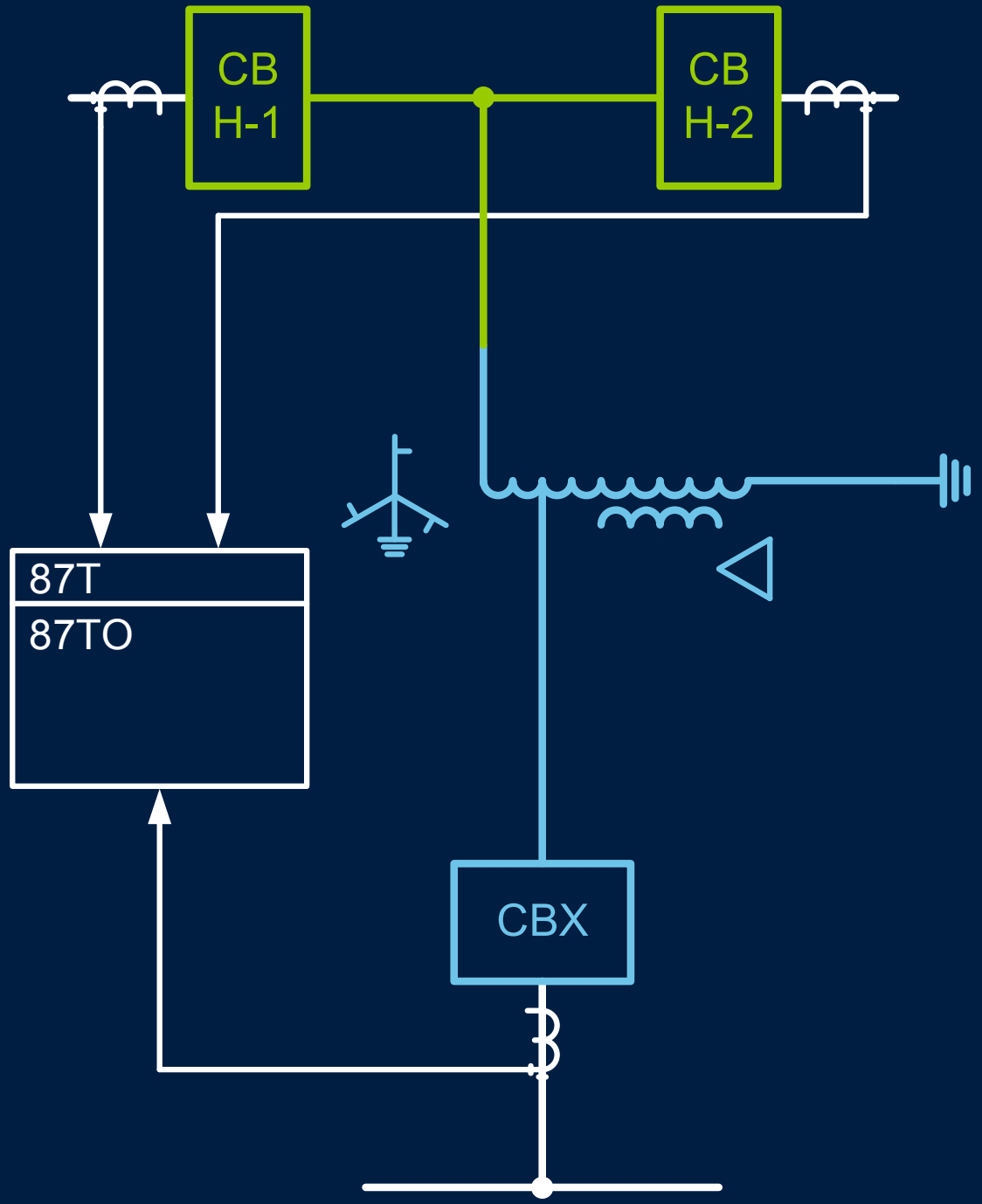
- Inadequate security for through fault not limited by transformer impedance
- Inadequate bus loadability
- Inadequate transformer protection sensitivity

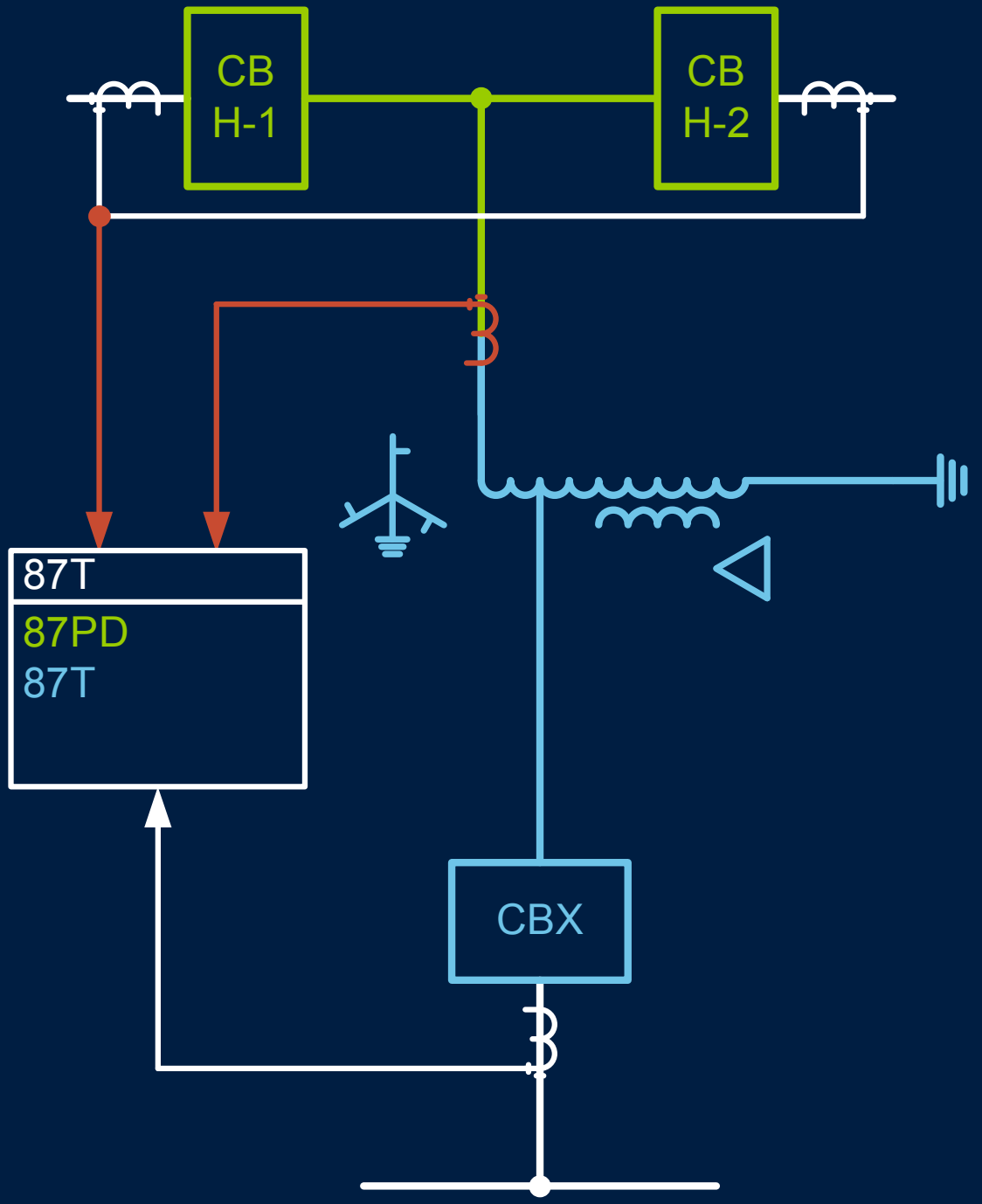


Possible Solutions
Partial Differential

- 87PD zone
- 50P and 87U considerations
  - Above inrush
  - Above BUS X fault
  - Above spurious differential current
  - Below internal bus fault

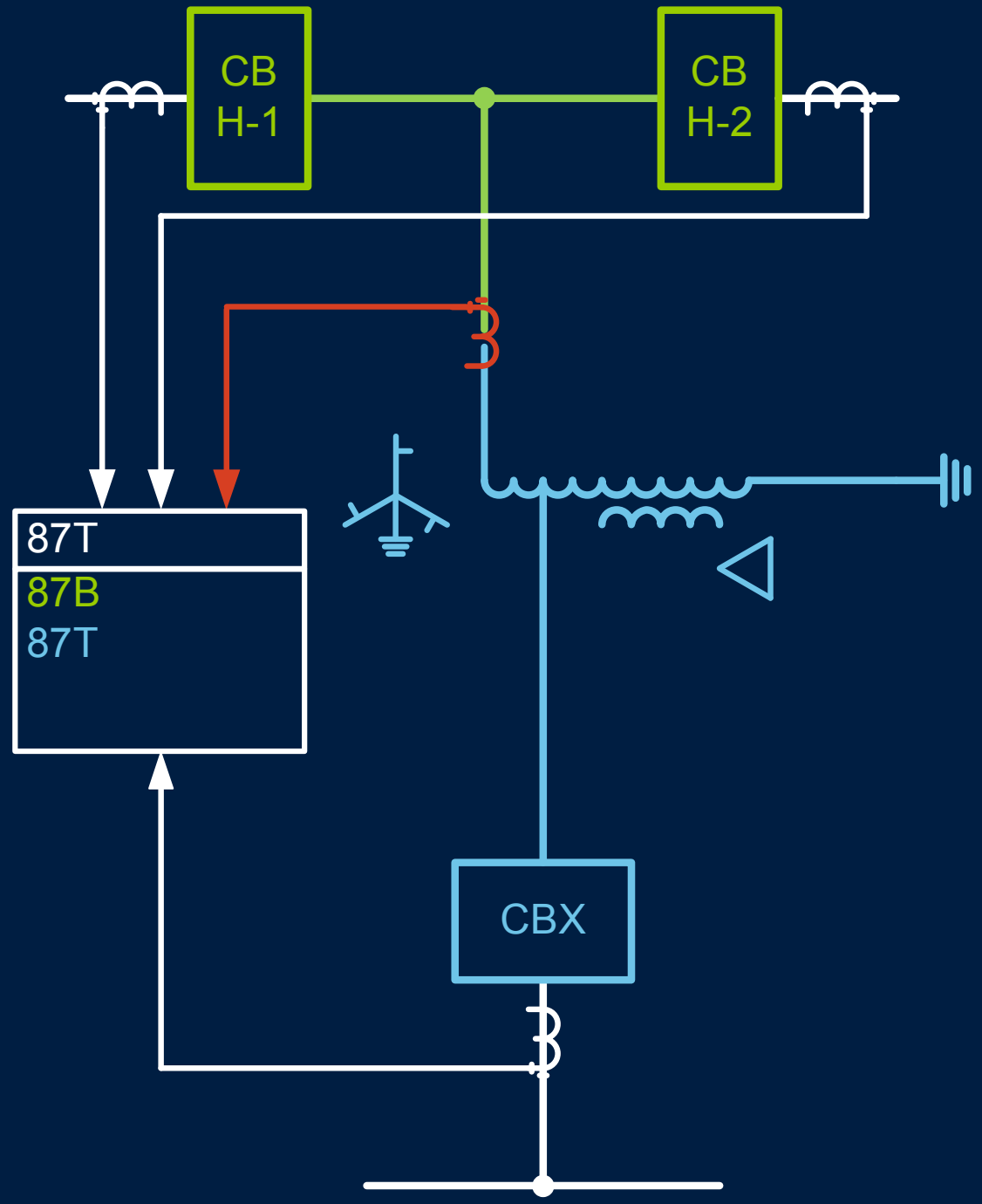



CB
H-1
CB
H-2
87T
87TO
CBX


CB
H-1
CB
H-2
87T
87PD
87T
CBX

Possible Solutions
87B in Protection Logic

- Partial differential elements cannot be used
- Implement simple bus differential elements in protection logic

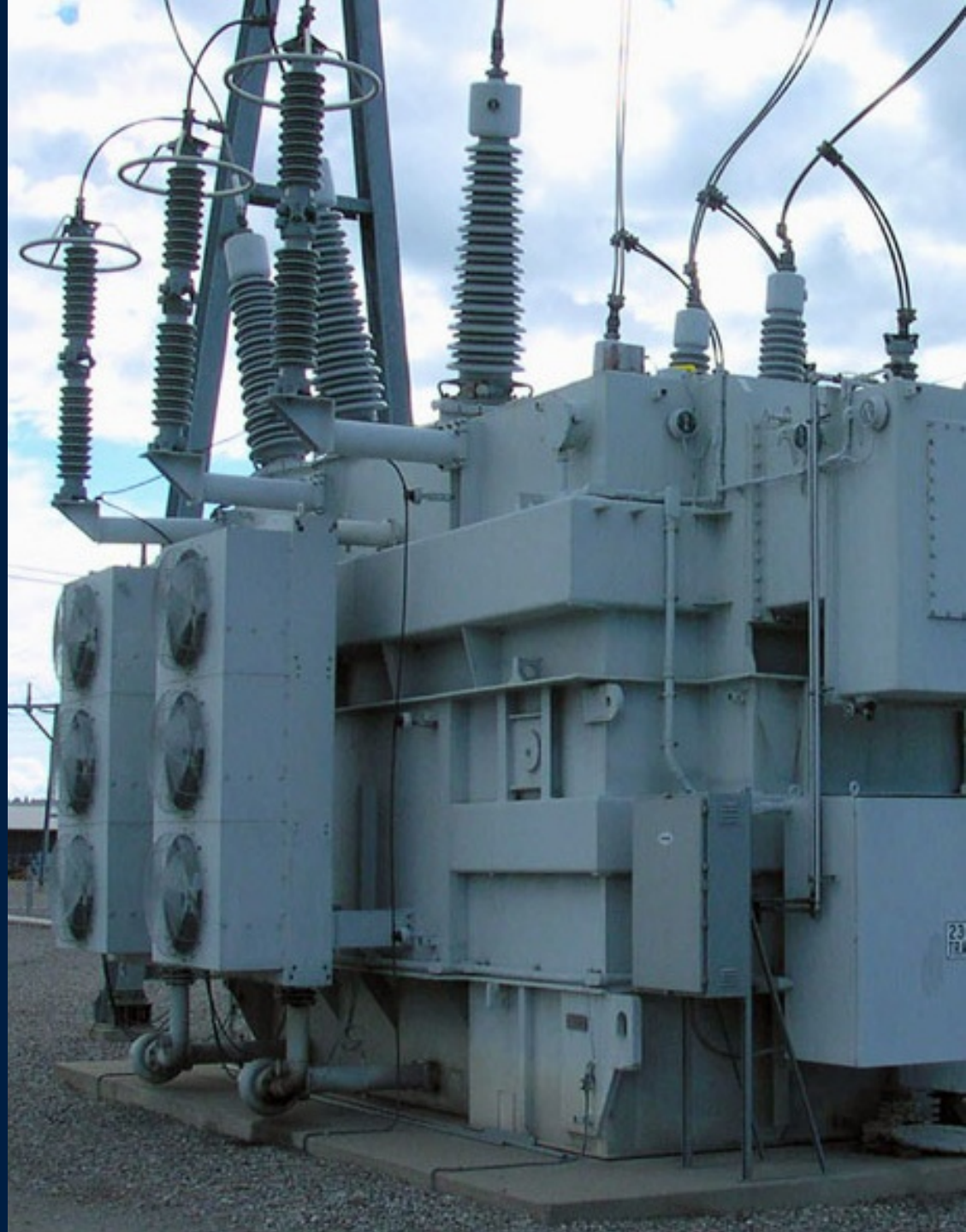


Summary

- Transformer and bus differential zones have inherently different performance and reliability requirements
- A single overall differential relay covering both zones can result in significant compromises
- Use of separate differential subzones is recommended
- A case study with detailed calculations helps solidify the concepts

Summary of Recommendations

- Evaluate if you have compromised protection
- Evaluate presented alternatives
- Use recommended guidelines to select CTRs
- Use base MVA for selecting tap factors



Questions