

Considerations and Benefits of Using Five Zones for Distance Protection

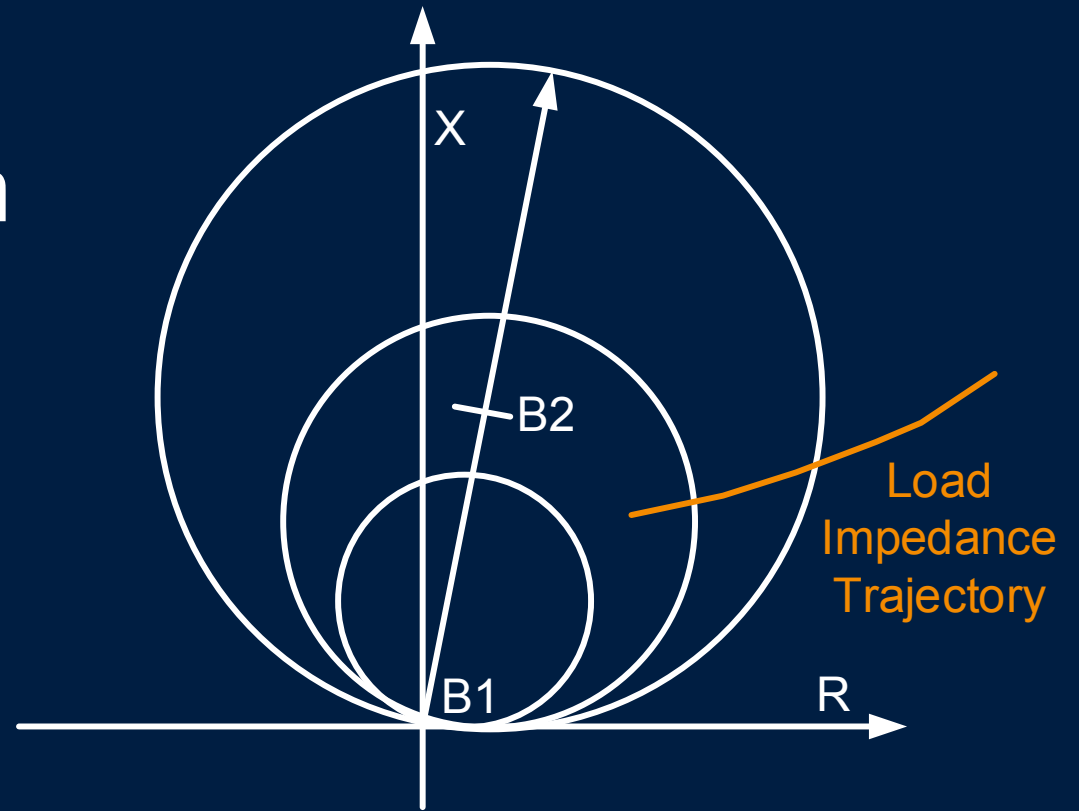
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Overview

- Review of pilot schemes
- Effects of
 - CT saturation
 - Mutually coupled lines
 - Series compensation
 - CCVT transients
- Guidelines for applying multiple zones

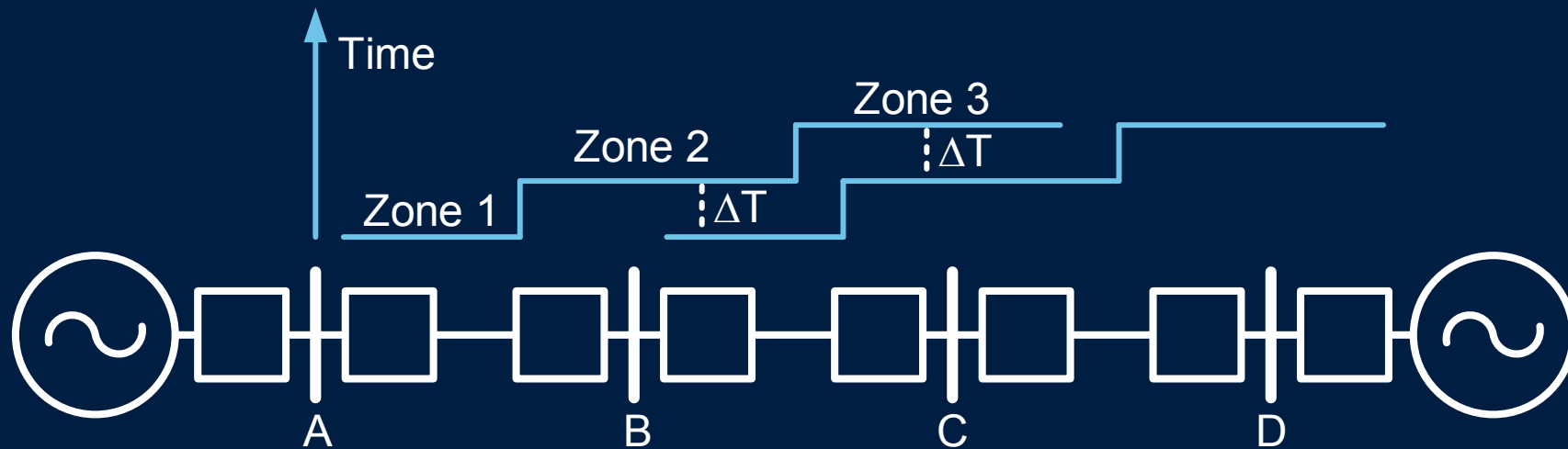
Introduction

- Distance element protection is widely used for transmission systems
- Overreaching zones set with long reaches can conflict with line loadability requirements



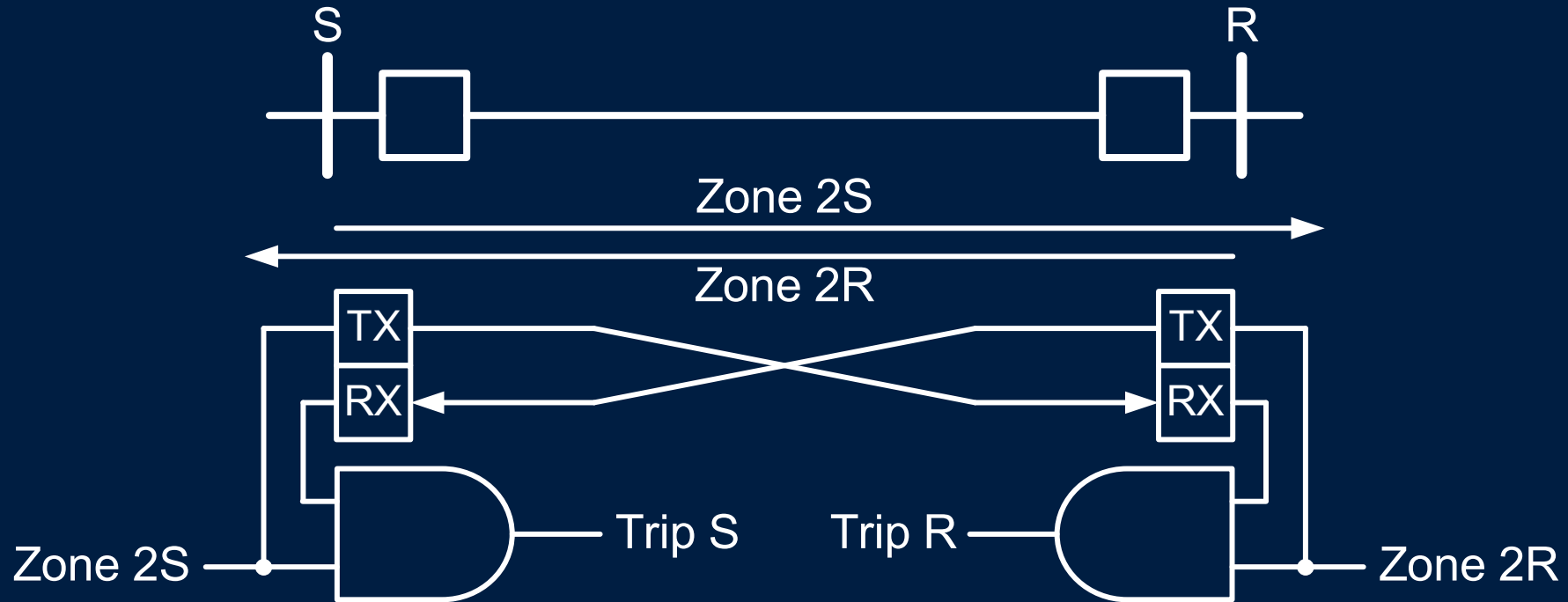
Zones of Protection

- Electromechanical relays had limited number of protection zones
- More zones improves overall dependability and security



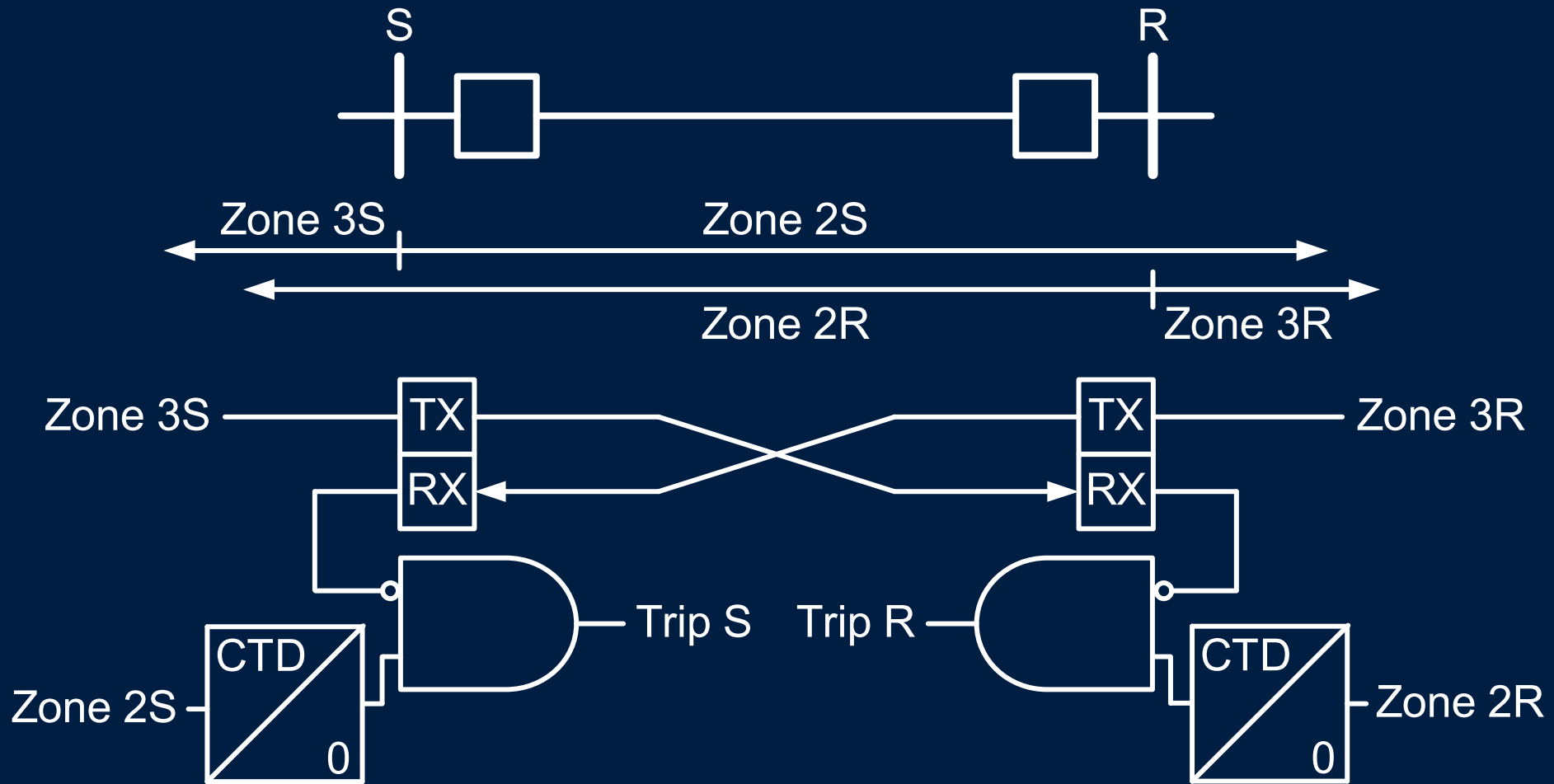
Review of Pilot Schemes

Permissive Overreaching Transfer Trip (POTT)



Review of Pilot Schemes

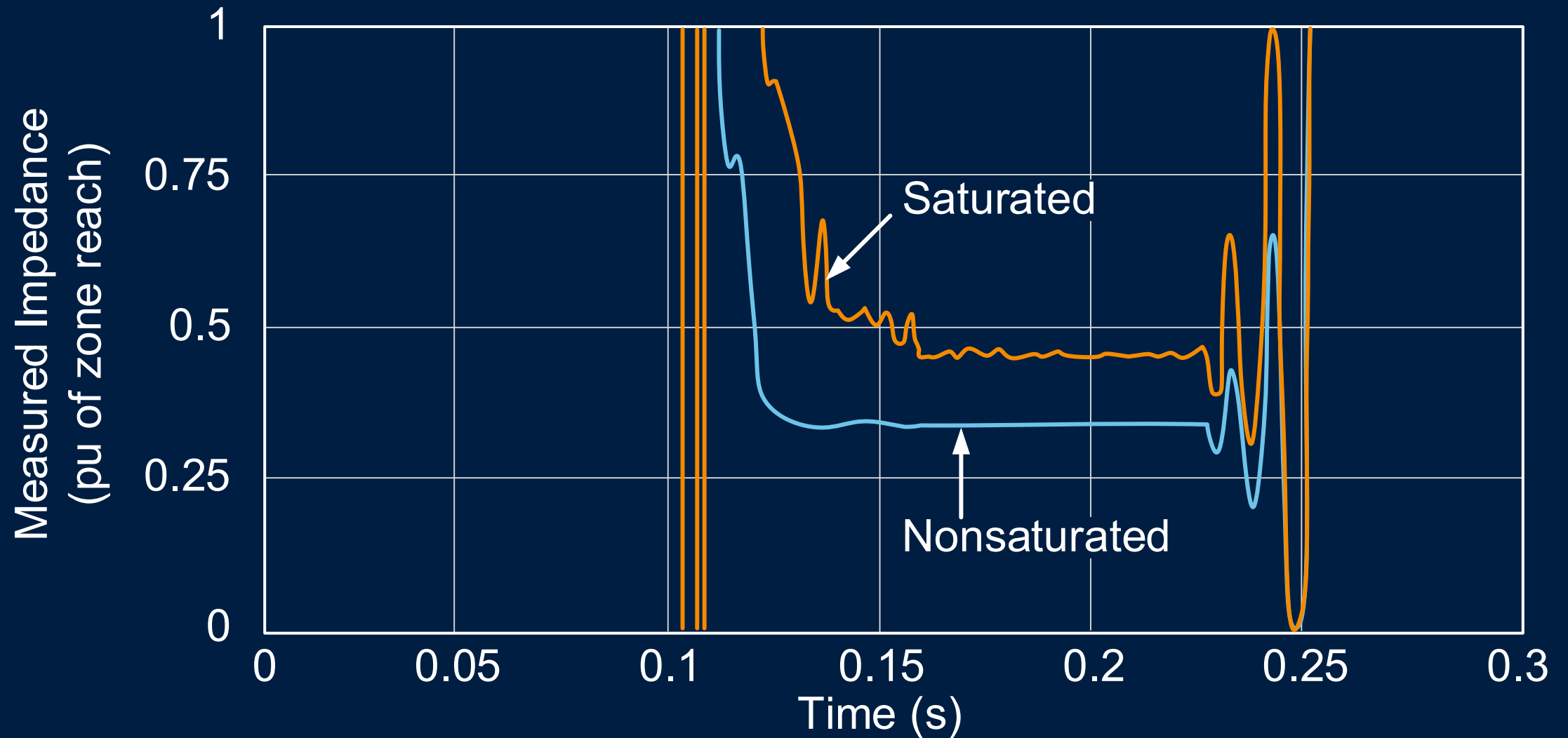
Directional Comparison Blocking (DCB)



Guidelines for Applying DCB Scheme With Extended Reverse Zone Reach

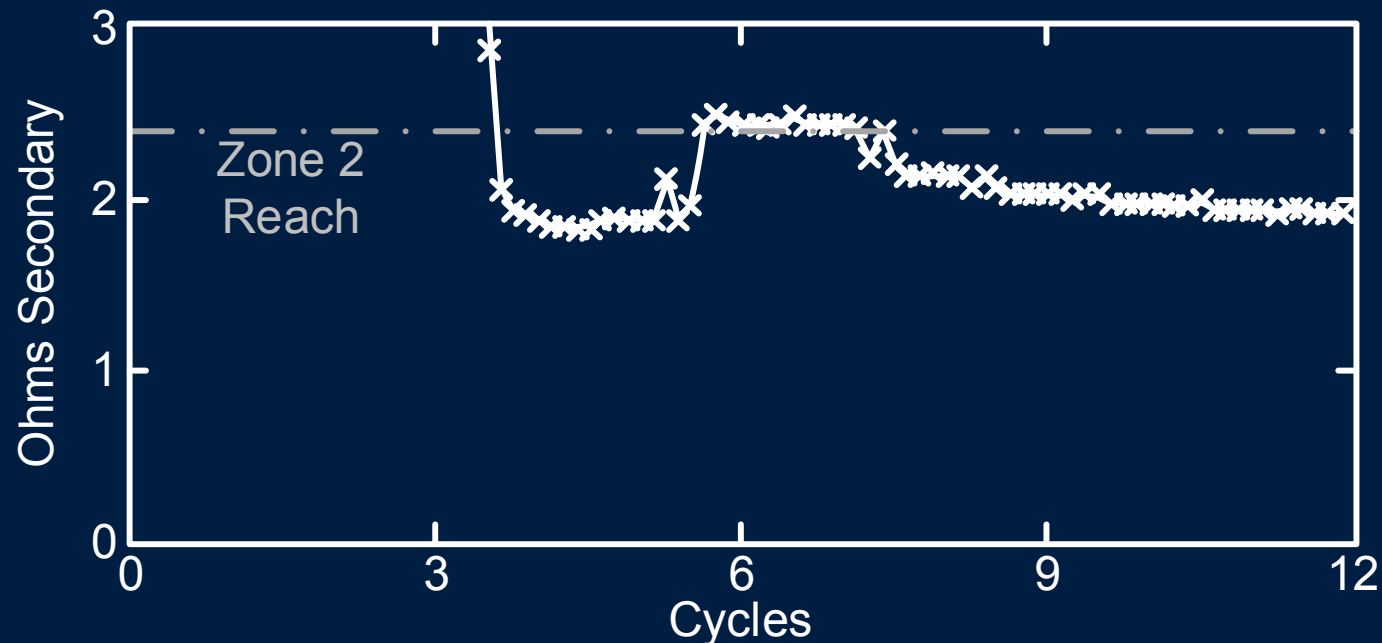
- Remote overreaching zone must not reach beyond reverse zone of local relay
- To minimize CTD, reverse zone must be set to longer reach to ensure block asserts as quickly as possible
- Setting of $1.5 \cdot (\text{overreaching DCB zone}) - Z1L$ is recommended

Effects of CT Saturation on Distance Element Performance



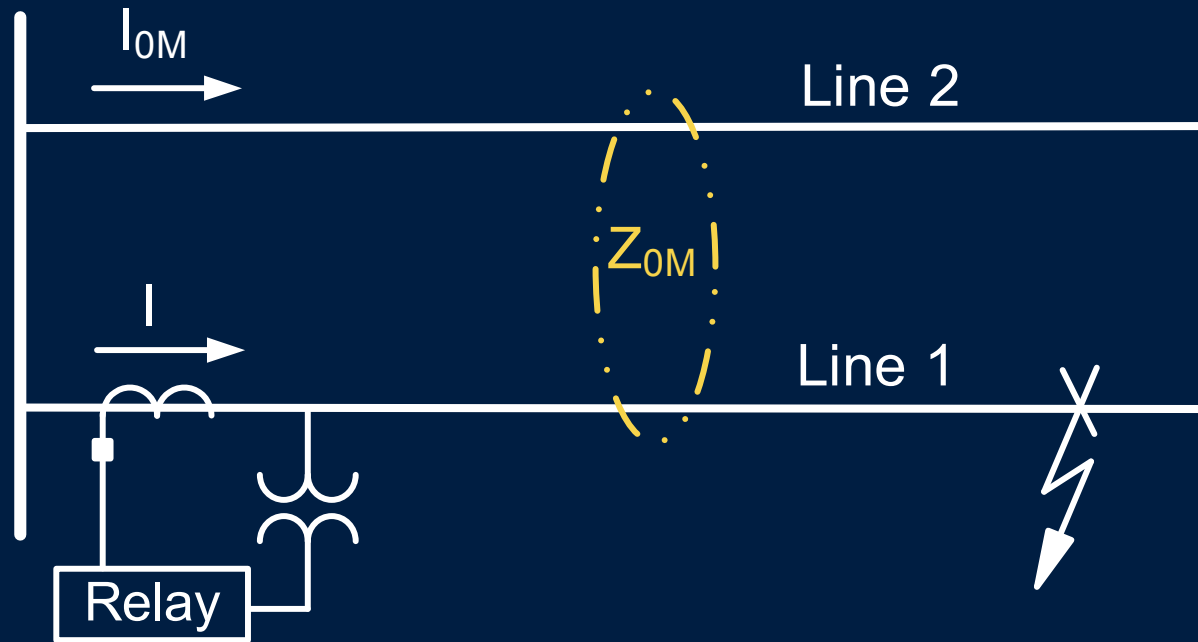
Effects of CT Saturation on Distance Element Performance

- CT saturation can cause calculated impedance to momentarily fall outside the reach
- One solution to this is to extend the reach



Mutually Coupled Lines

- Nearby lines can have zero-sequence mutual coupling
- Coupling can affect impedance measurement



Mutually Coupled Lines

- To ensure pilot protection has sufficient coverage, typical settings need to be much greater than 125%
- Using the same zone for pilot and step-distance schemes can cause coordination problems
- Separate zones for pilot and step-distance protection are required to achieve maximum selectivity and speed

Lines of Different Lengths

- In past, Relay 1 overreaching zone reached no farther than Relay 2 instantaneous zone
- In pilot protection, it may extend to 200% to ensure reliable speed

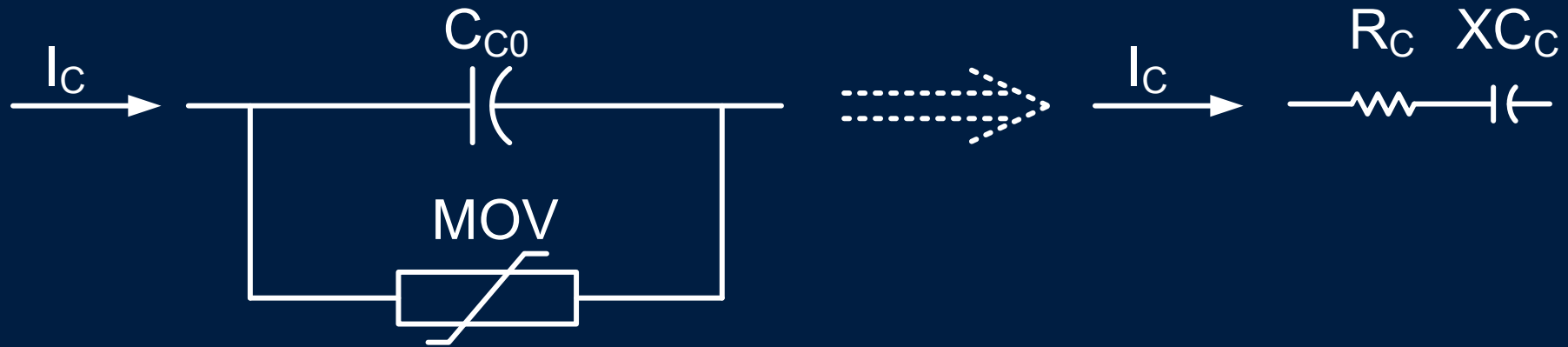


Lines of Different Lengths

- A zone can be set to extend the reach of pilot protection for speed (e.g., 200%)
- A separate step-distance zone can be set to not overreach the Relay 2 instantaneous zone
- If adjacent line is really short, step-distance zone may not be capable of reach coordination, only time coordination

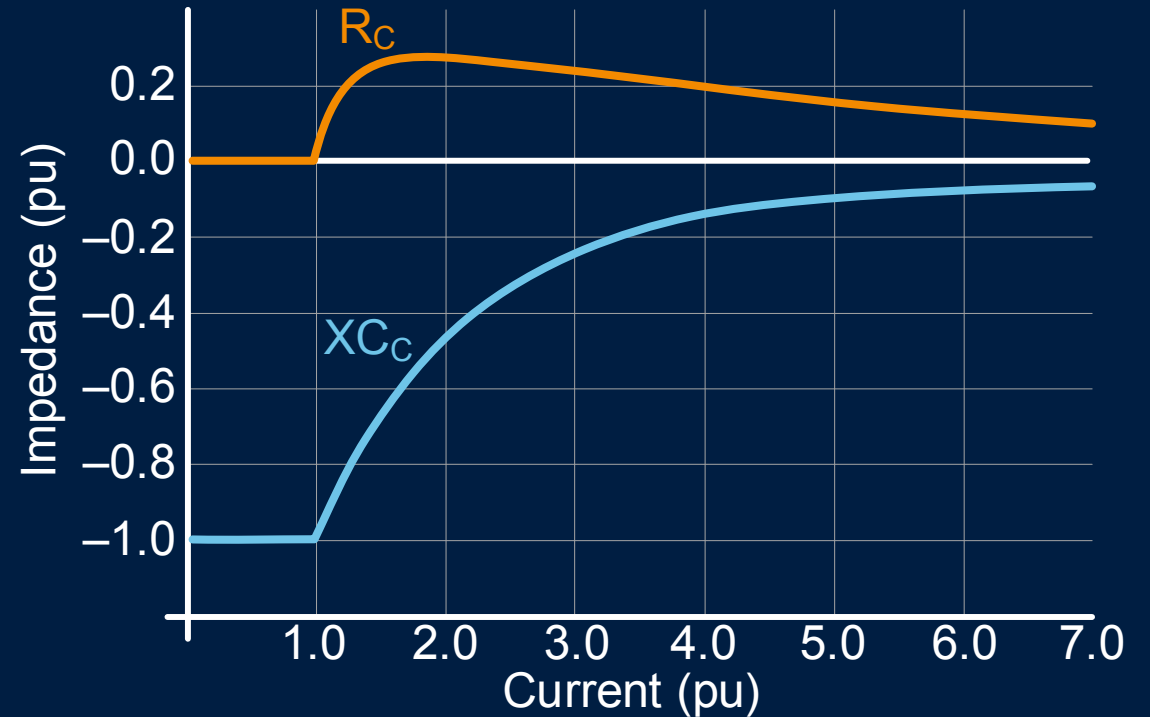
Series-Compensated Lines

MOV Resistance Changes, Capacitance Changes



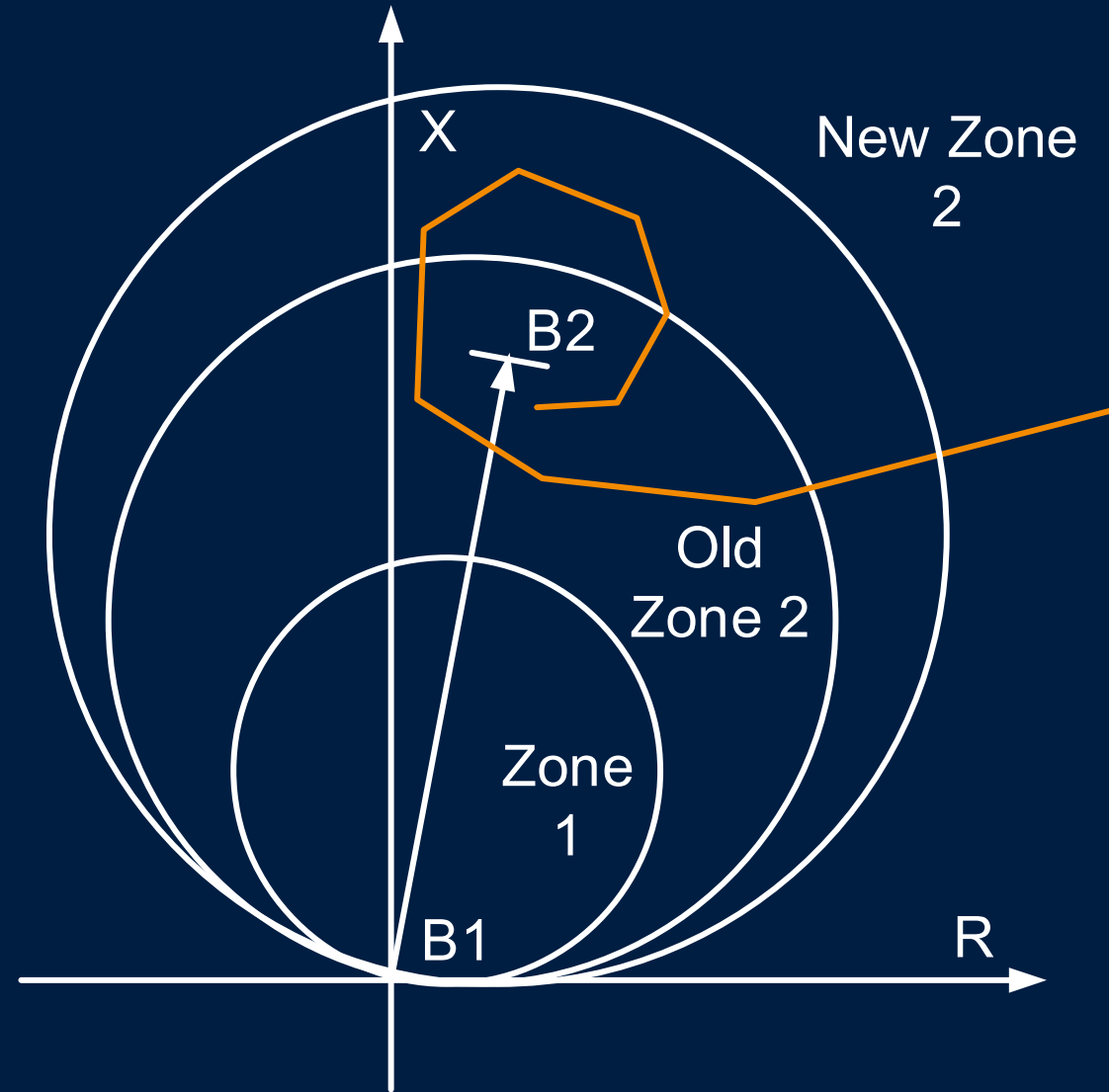
Series-Compensated Lines

- R_C and XC_C depend on through current of series capacitor
- Variation in R_C and XC_C change impedance measured by the relay



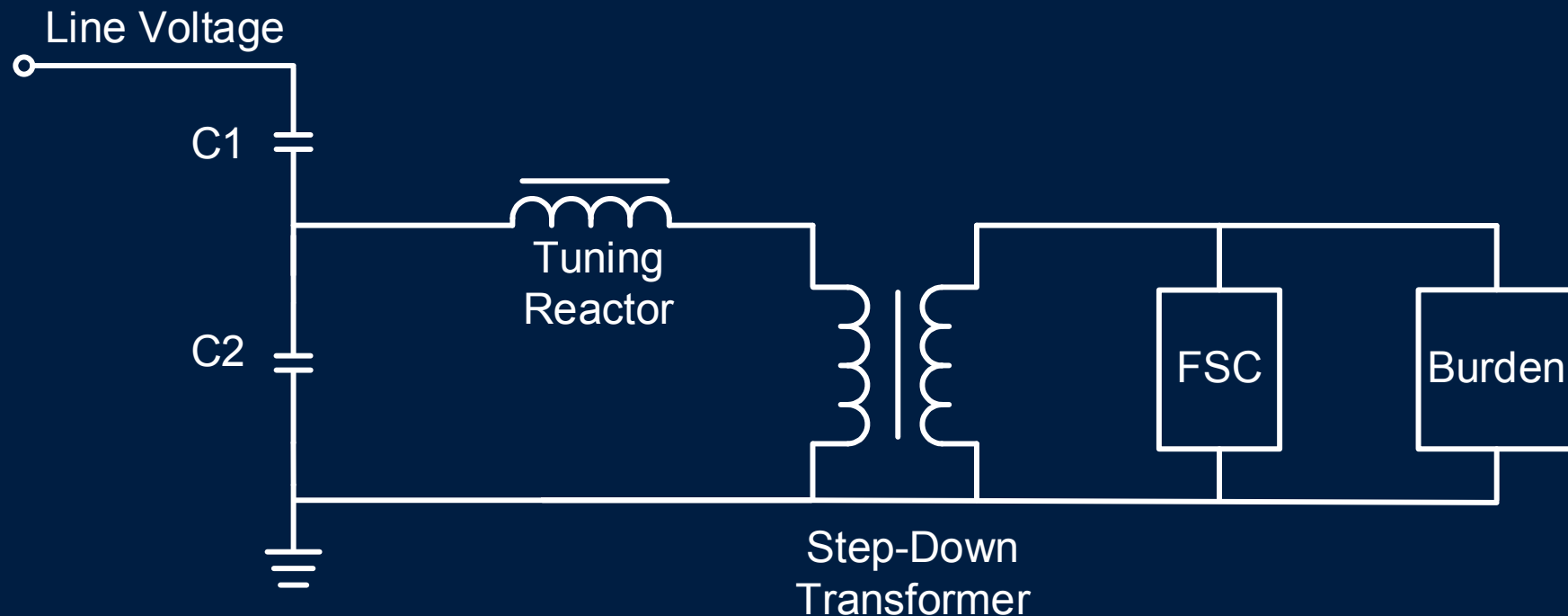
Series-Compensated Lines

- Reduce underreaching zones
- Extend overreaching zones
- Separate zones for step-distance and pilot protection



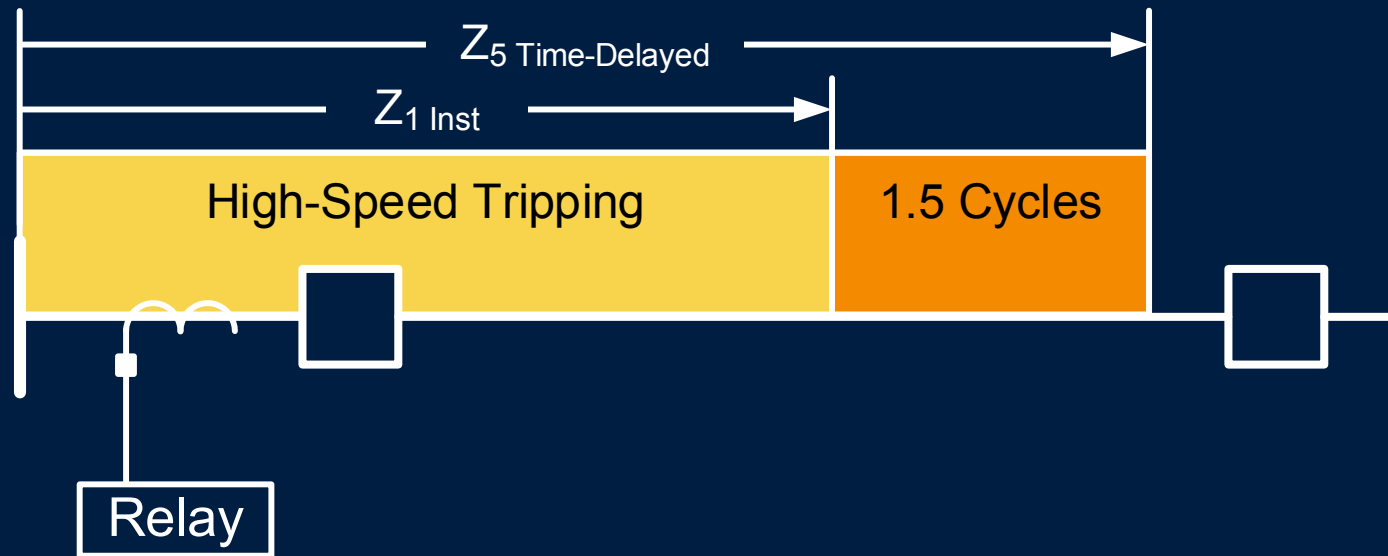
CCVT Transients

- CCVT transient response can last up to 1.5 cycles
- Severity depends on voltage point on wave (inception angle), active or passive FSC, and system SIR



CCVT Transients

- Traditionally, instantaneous zone was reduced to 20% of line impedance
- Could use marginally delayed zone to cover rest of line



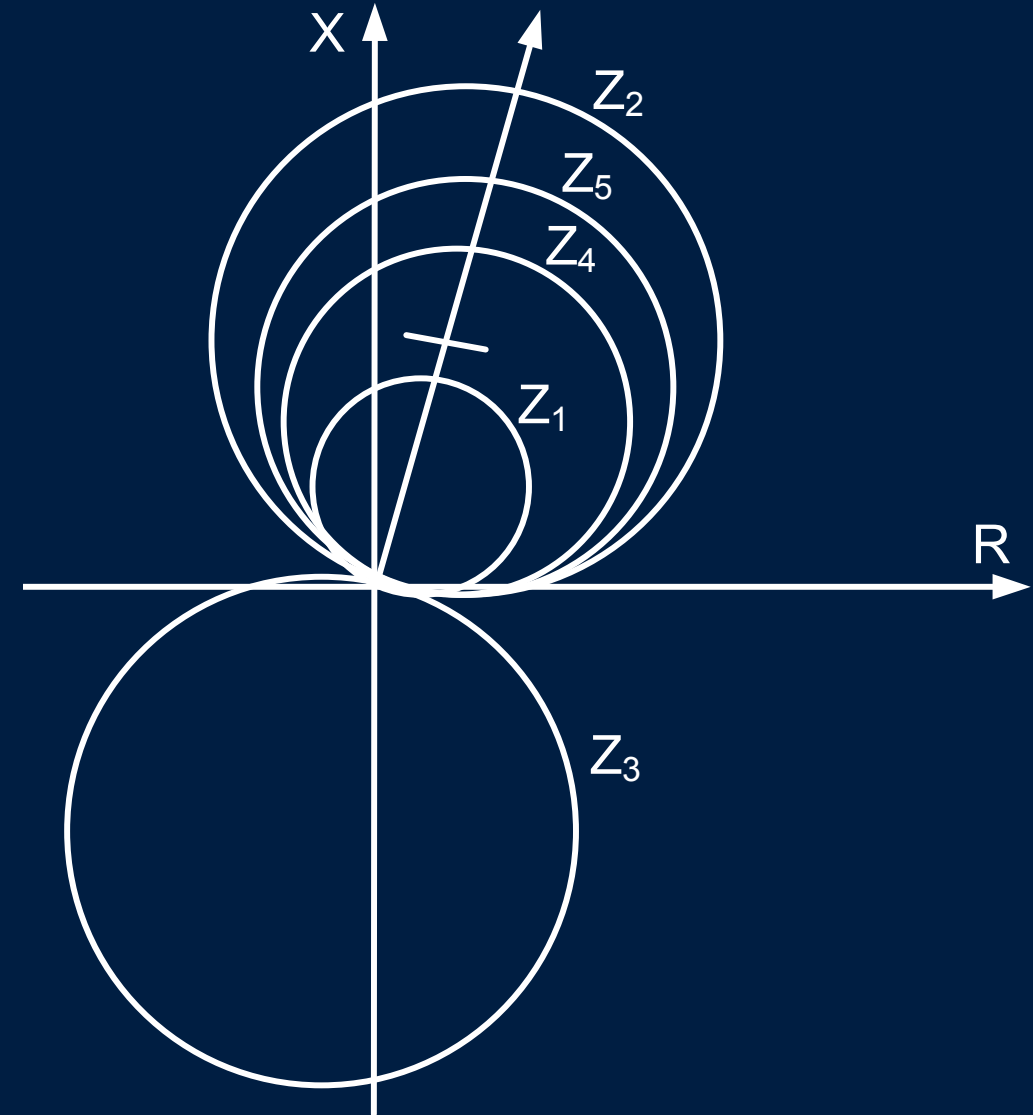
General Guidelines for Applying Multiple Zones

Examples

- Zones 1, 2, and 3
 - High-speed distance elements
 - Instantaneous zones in step-distance and pilot schemes
- Zones 4 and 5
 - Conventional distance elements
 - Time-delayed overreaching zones

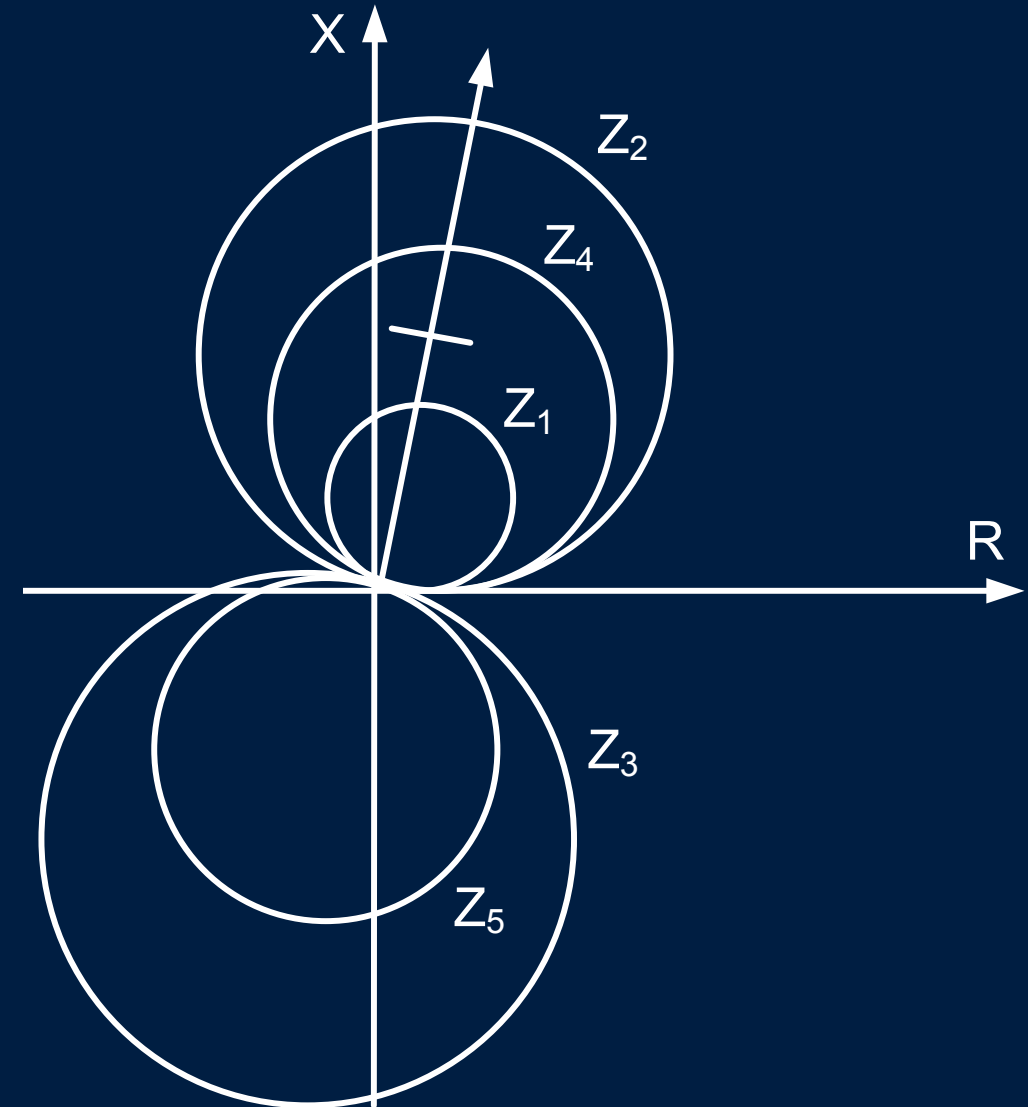
General Guidelines for Applying Multiple Zones

- Zone 1 – 80%
- Zone 2 – 200%+
(forward pilot protection only)
- Zone 3 – 200%+
(reverse pilot protection only)
- Zone 4 – 118 to 150% to cover
end-of-line step-distance backup
- Zone 5 – set according to remote
backup requirements for **forward**
step-distance backup



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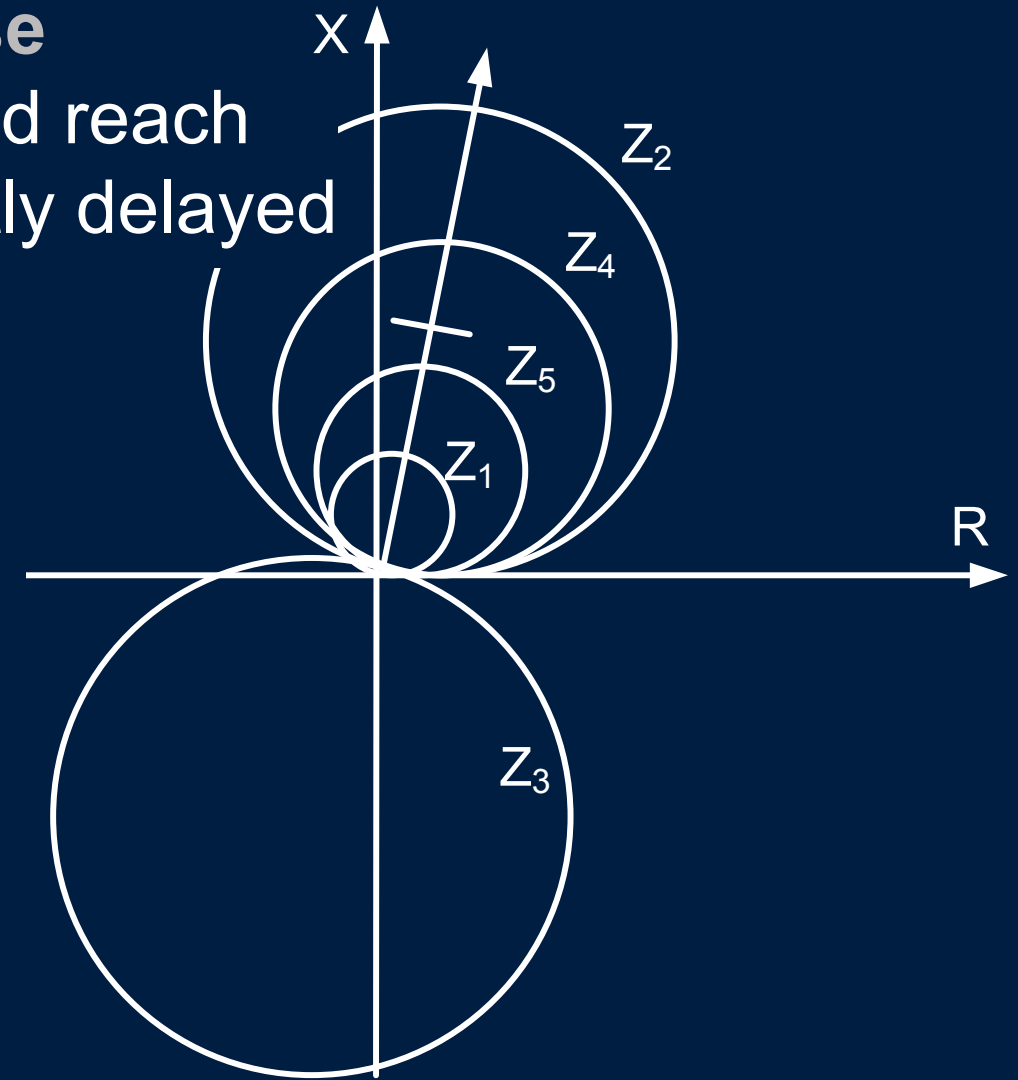
General Guidelines for Applying Multiple Zones

- Zone 1 – set according to maximum SIR
- Zone 2 – 200%+ (forward pilot protection only)
- Zone 3 – 200%+ (reverse pilot protection only)
- Zone 4 – 118 to 150% to cover end-of-line step-distance backup
- Zone 5 – 80% with 1.5-cycle delay

CCVT Case

Z1 is limited reach

Z5 is slightly delayed



Conclusions

- Requirements for pilot and step-distance schemes can contradict
- System components can affect requirements
- Using multiple zones optimizes selectivity, dependability, and speed

Questions?