Transmission line protection for systems with high penetration of inverter-based resources

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Questions

- What are we doing?
- Why are we doing it?
- How are we doing it?

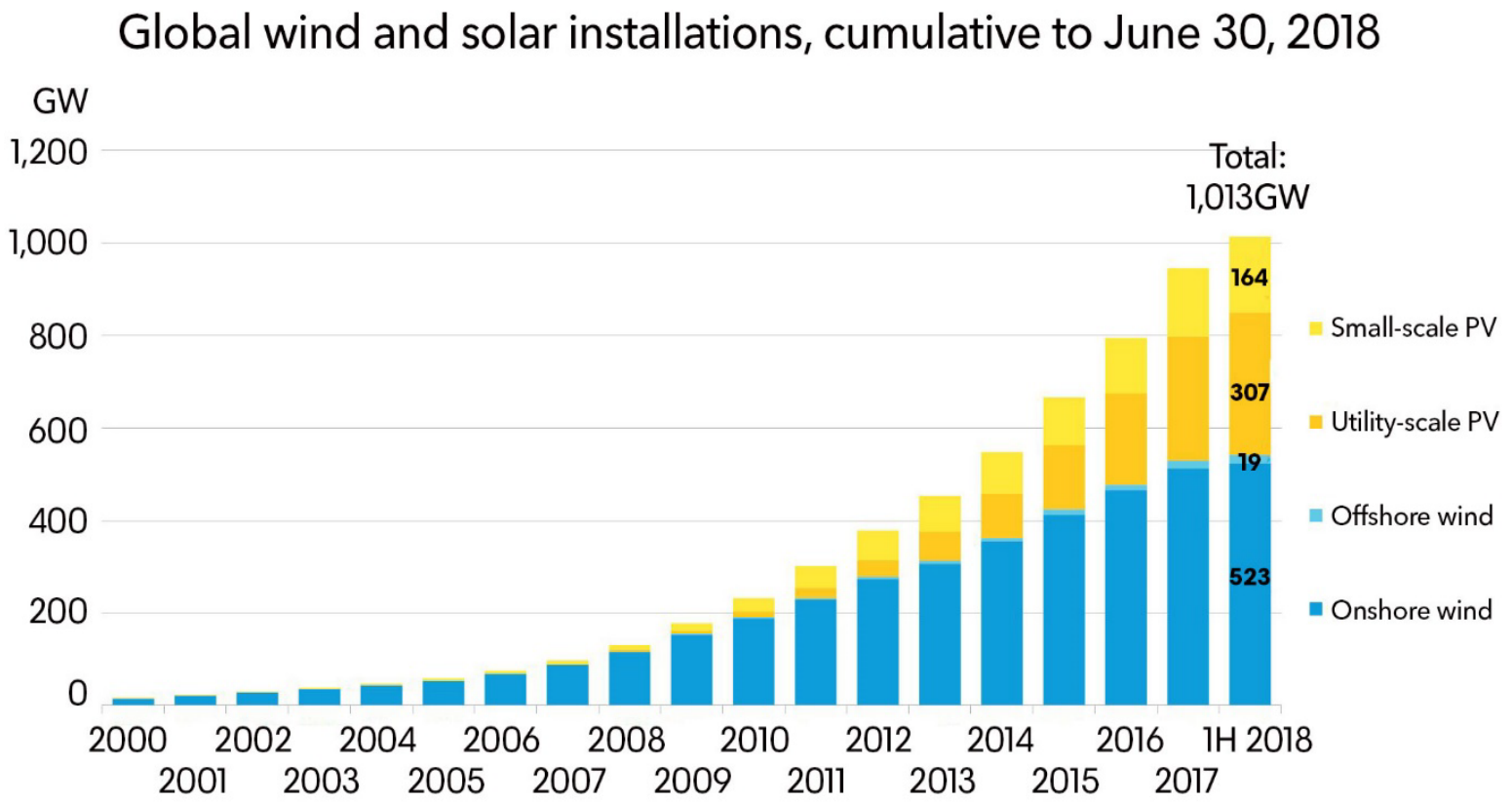
What are we doing?

- Reducing the fault clearing time for transmission lines in systems with high penetration of IBR

Why are we doing it?

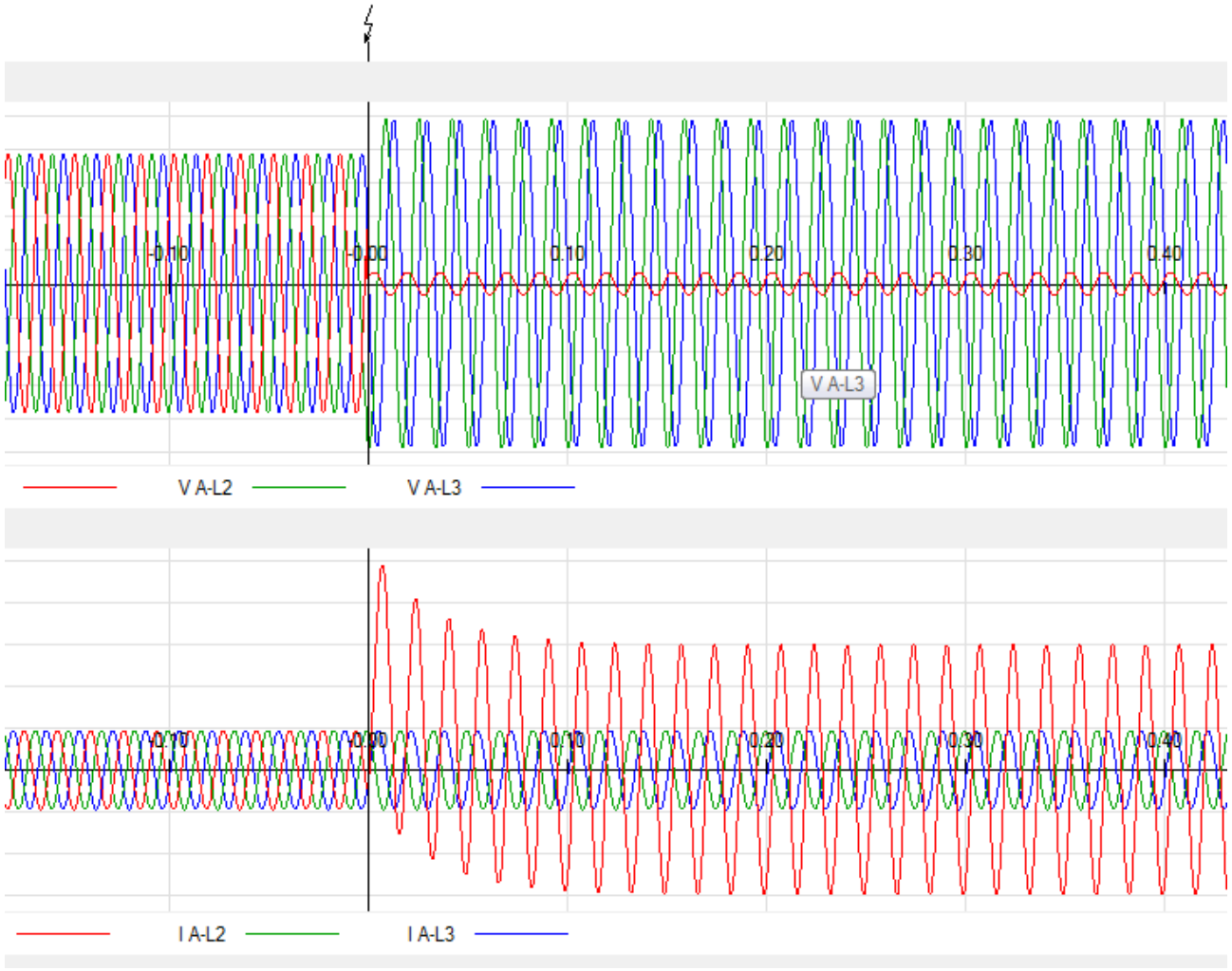
- Changes in the electric power grid
- Reduced fault currents contribution
- To limit the loss of DERs during short circuit faults

Increasing Penetration of DERs

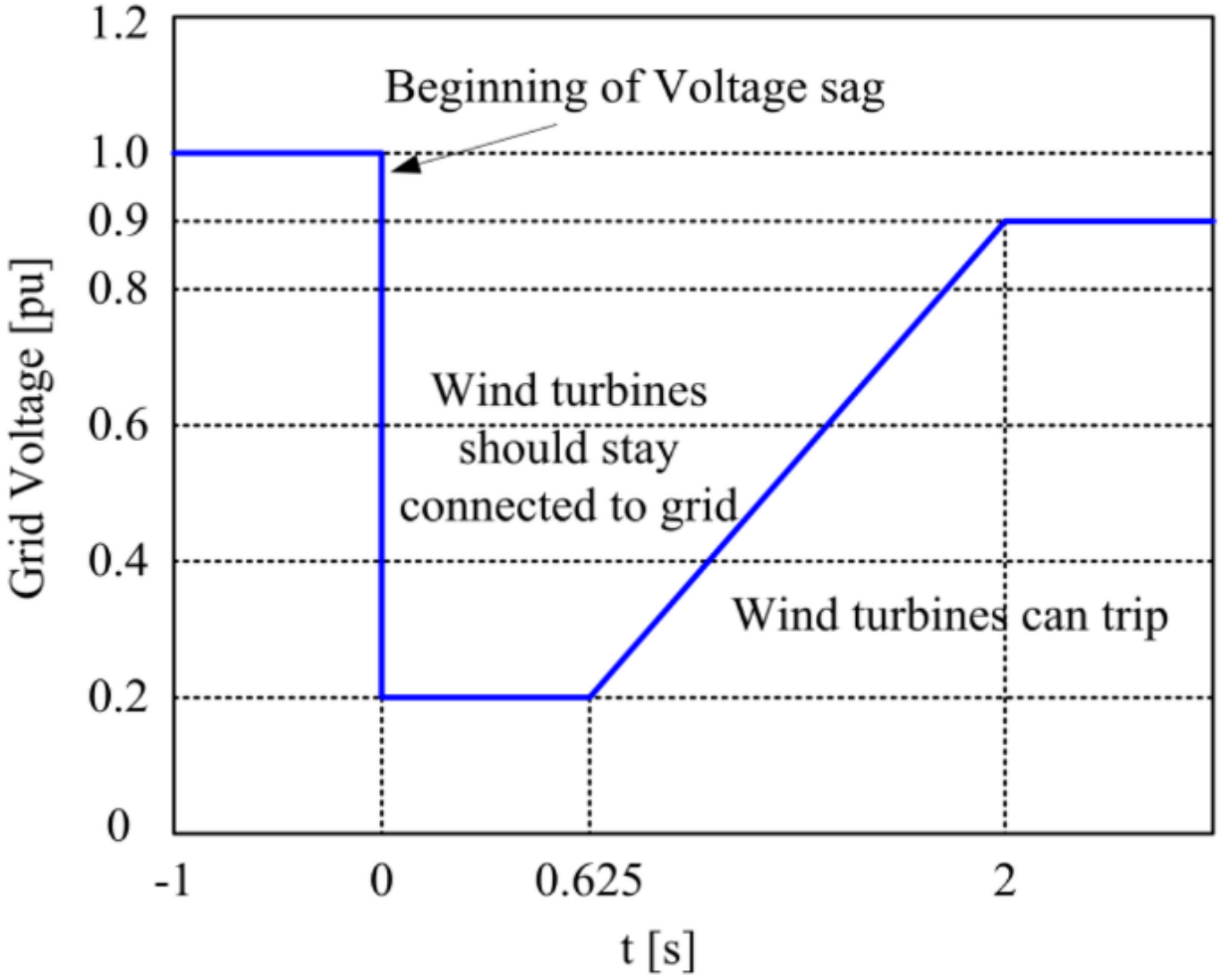


Source: Bloomberg NEF. Note: 1H 2018 figures for onshore wind are based on a conservative estimate; the true figure will be higher. BNEF tyipcally does not publish mid-year installation numbers.

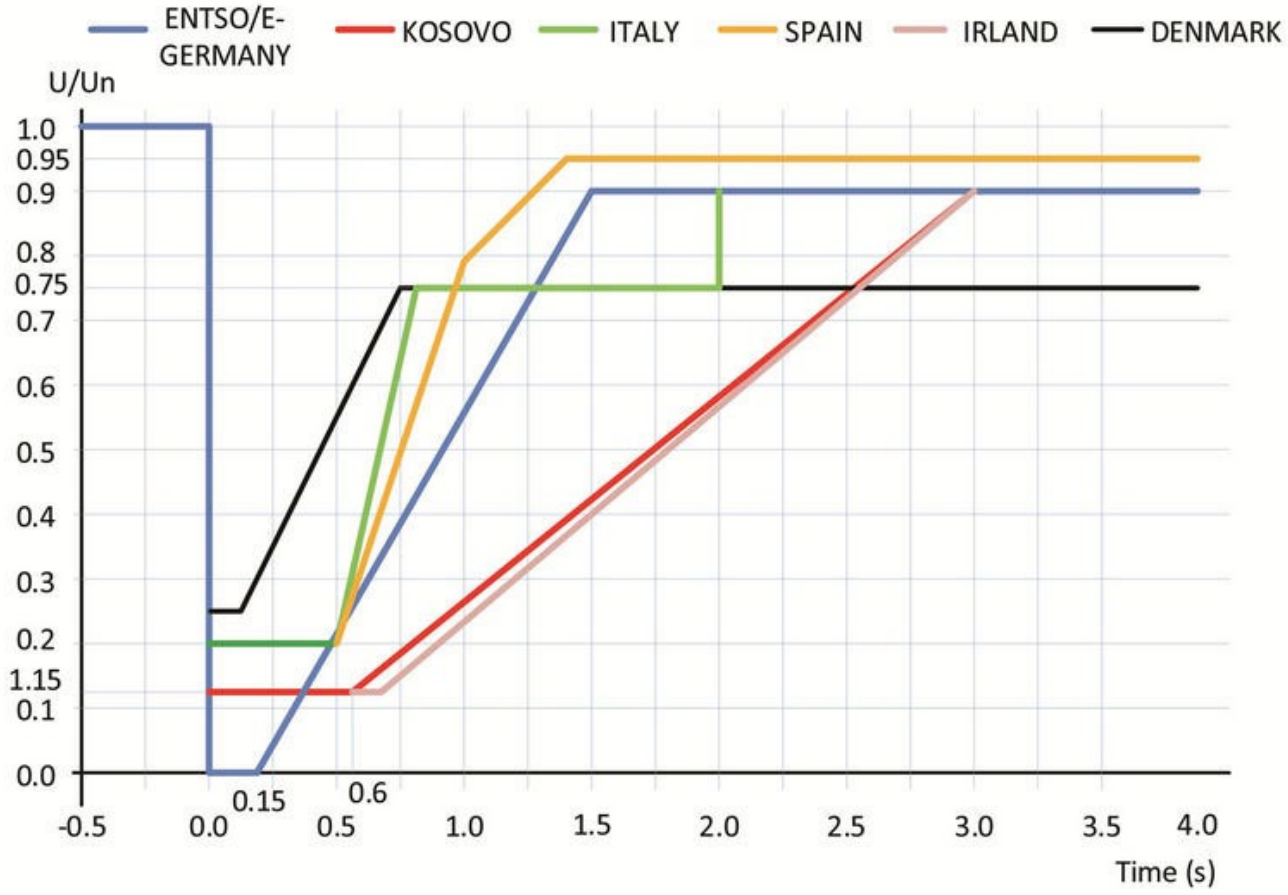
Effect of Short Circuit Fault



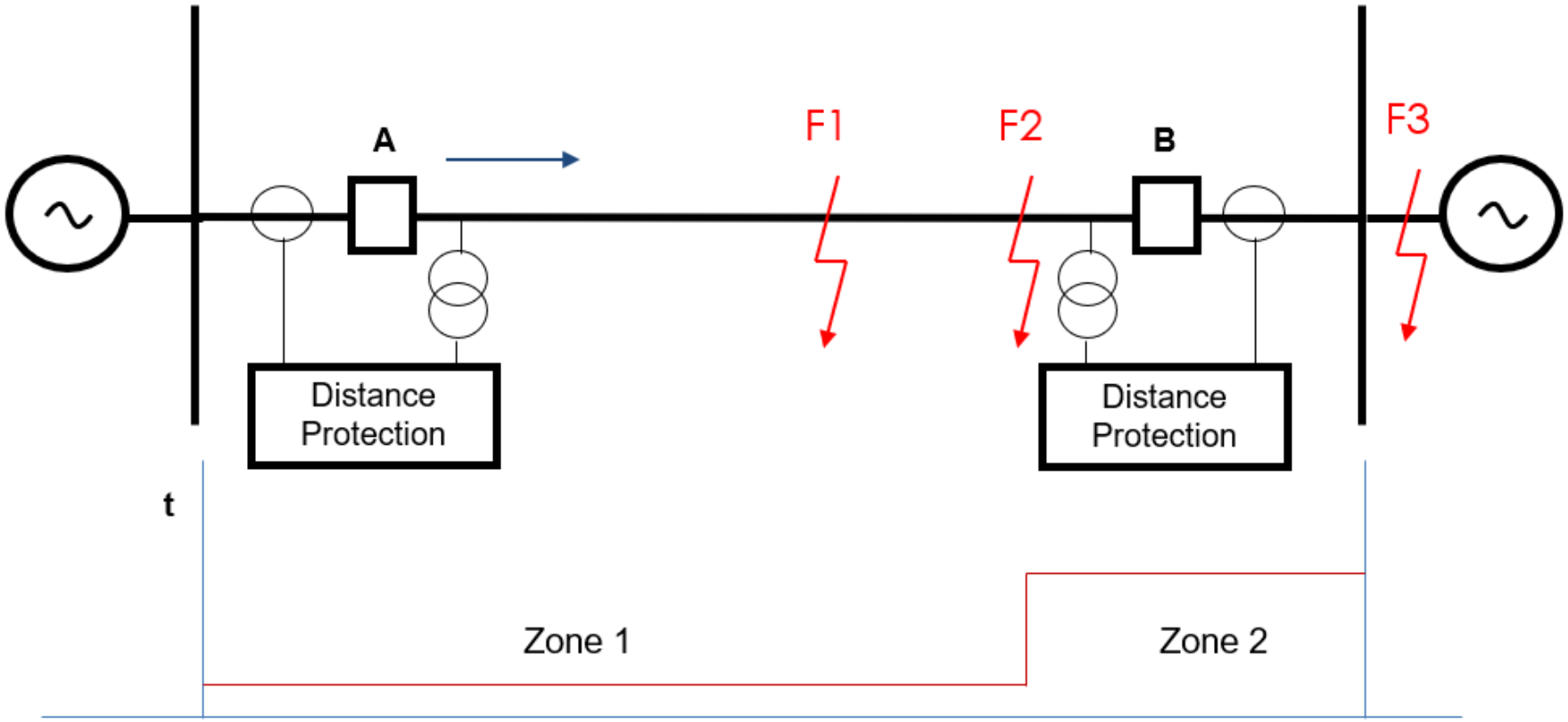
Ride-Through Characteristic



Ride-Through Capability



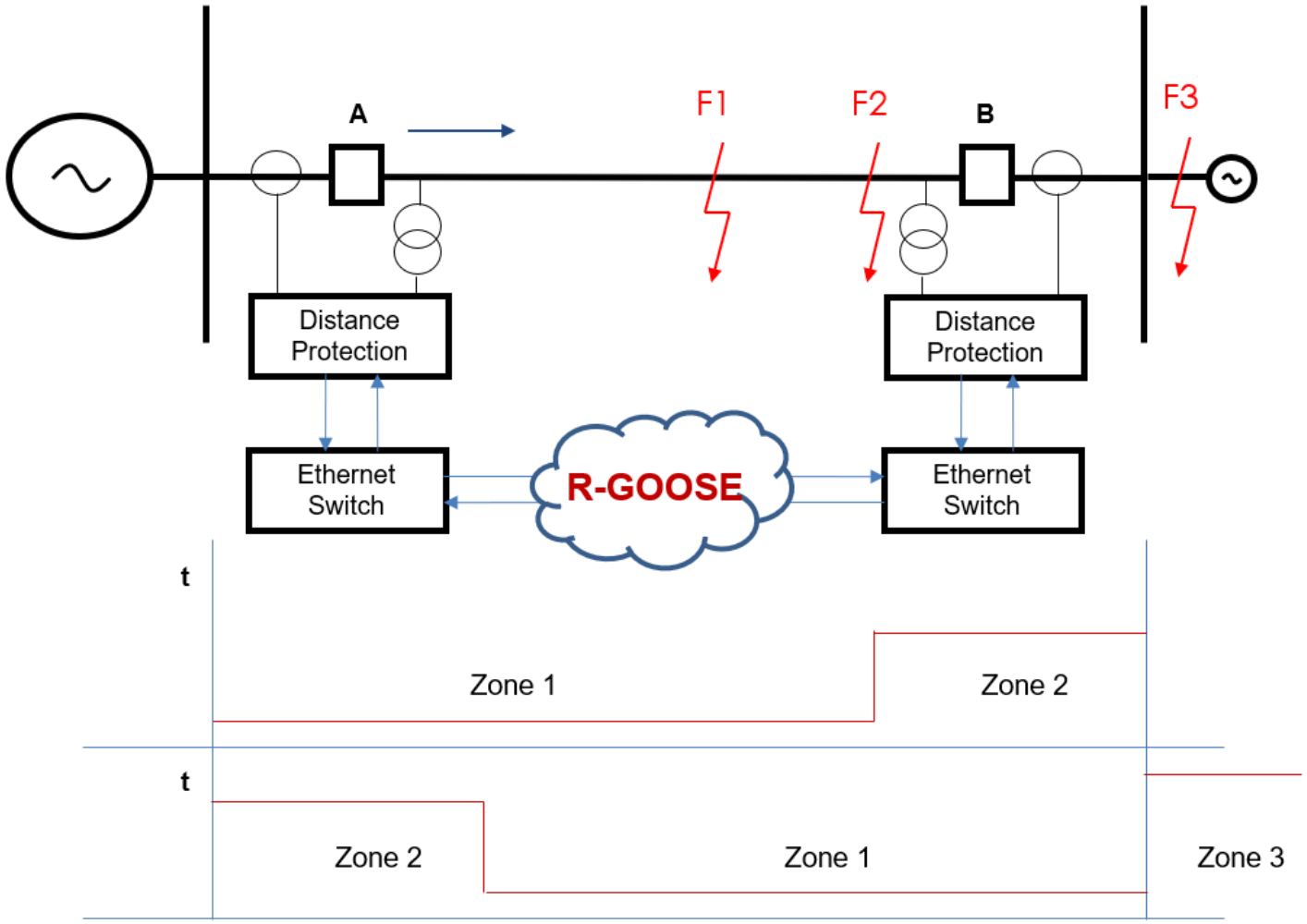
Distance protection



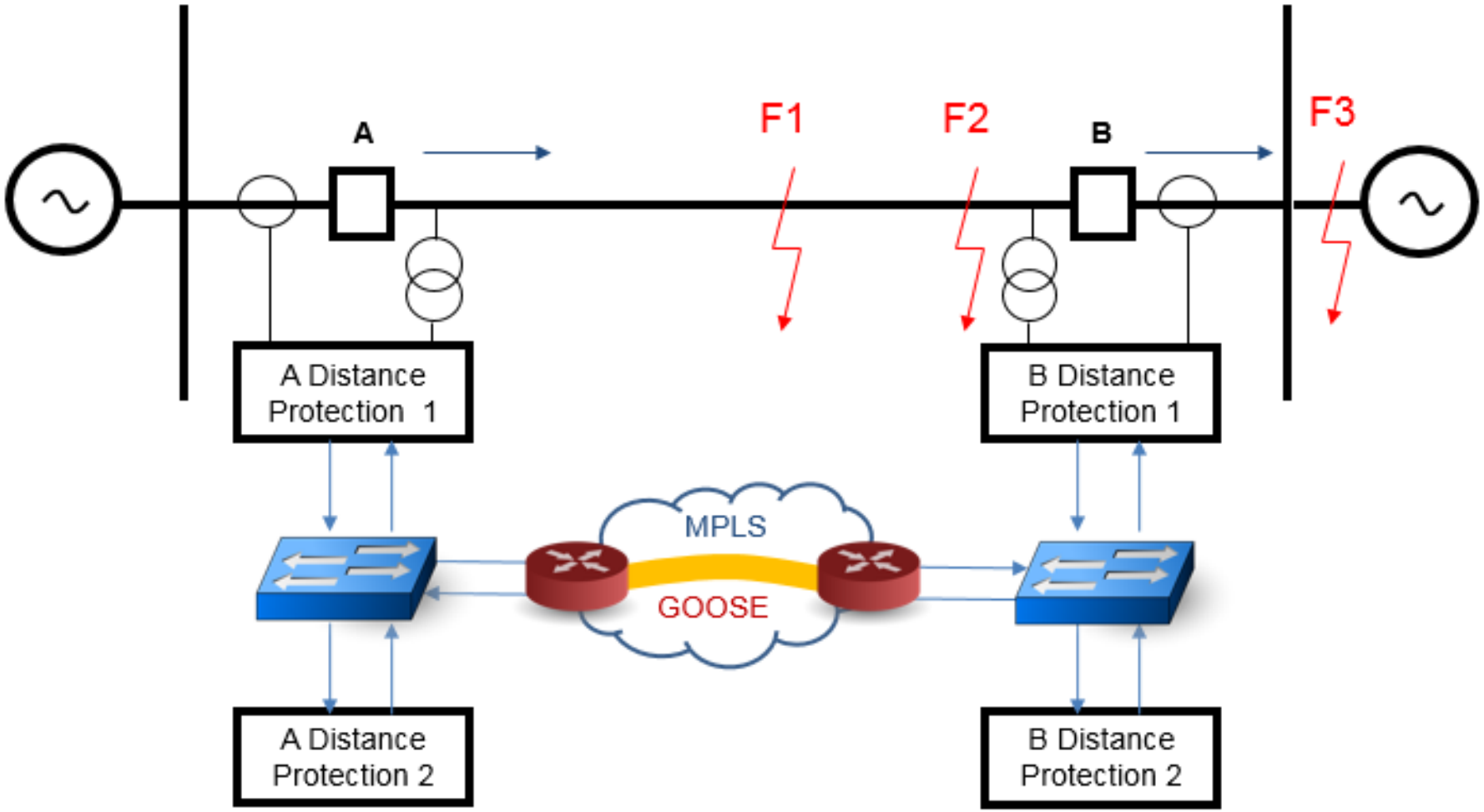
Communications based schemes

- Permissive schemes
- Blocking schemes
- Direct transfer trip schemes

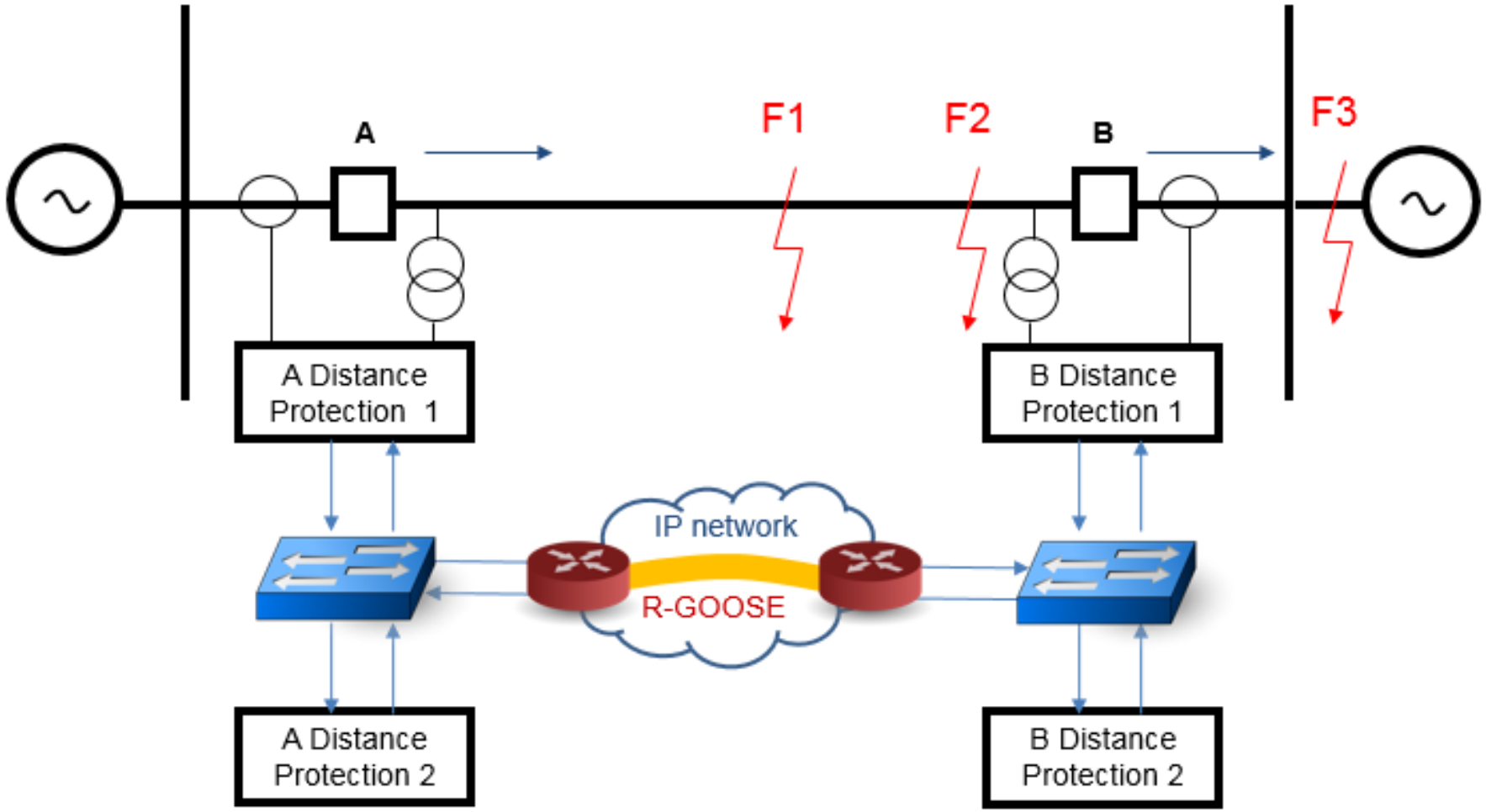
Week infeed logic



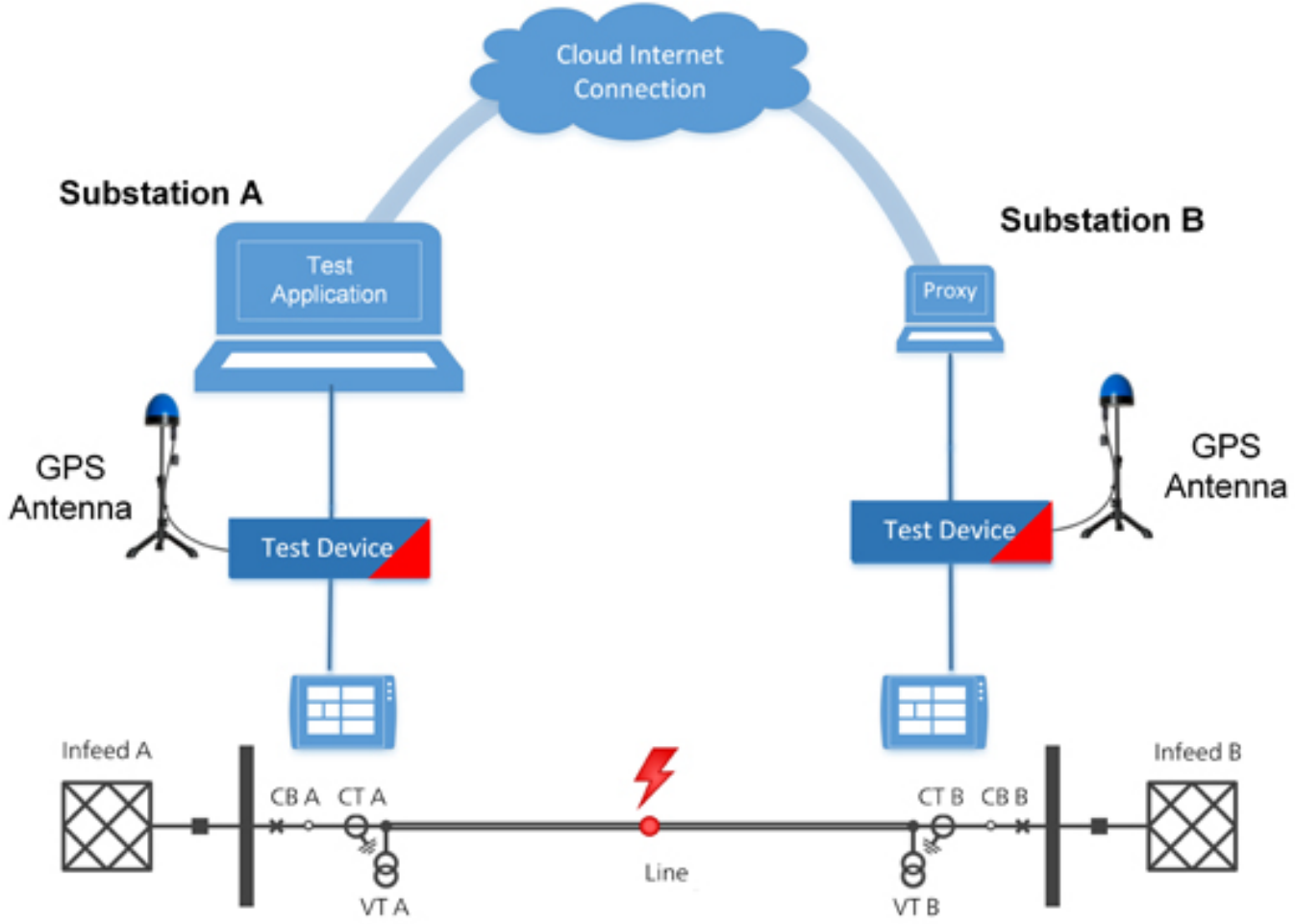
Wide area GOOSE



R-GOOSE


A
F1
F2
B
F3
A Distance Protection 1
B Distance Protection 1
IP network
R-GOOSE
A Distance Protection 2
B Distance Protection 2

Protection scheme testing



Conclusions

- The large penetration of DERs present significant challenges for protection schemes due to the low levels of fault currents
- At the same time the fault clearing times need to be reduced below 160 milliseconds in order to maintain the operation according to the ride through characteristics
- The most efficient solution to address these challenges is the POTT scheme with week infeed logic
- Routable GOOSE messages support their efficient implementation without significant investment