Virtual Protection Relay: Myth or Reality?

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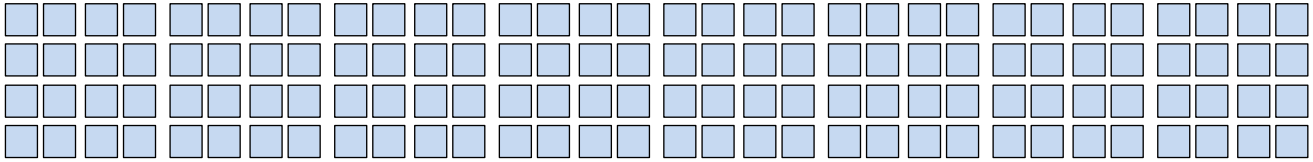
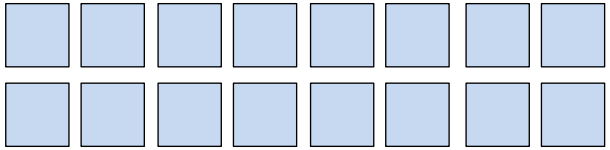
Introduction to Virtual Protection

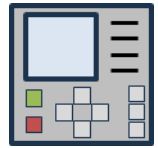
Fuses



Electromechanical Relays

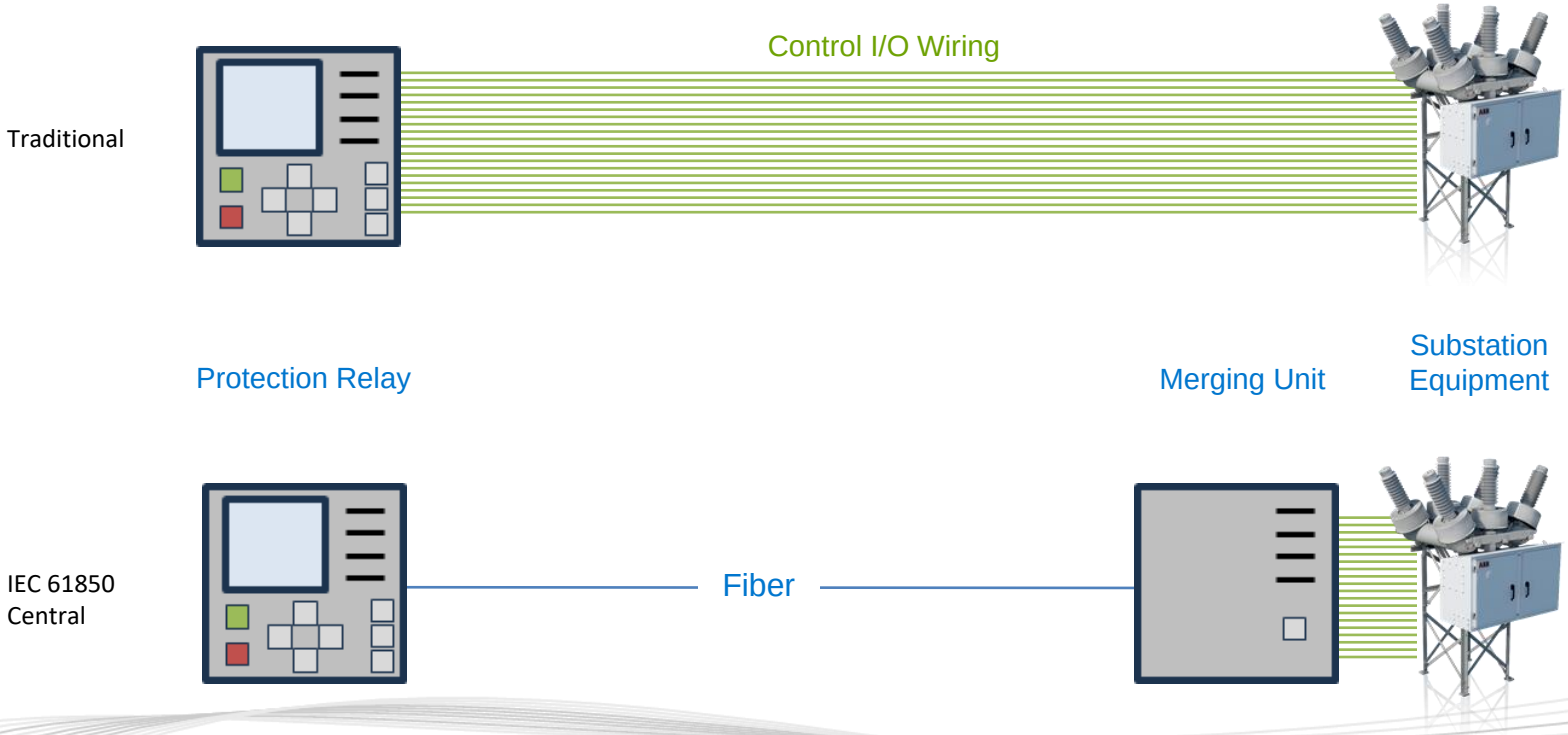
Microprocessor Based Relays





2023: Virtual Protection Relays

Introduction to Virtual Protection



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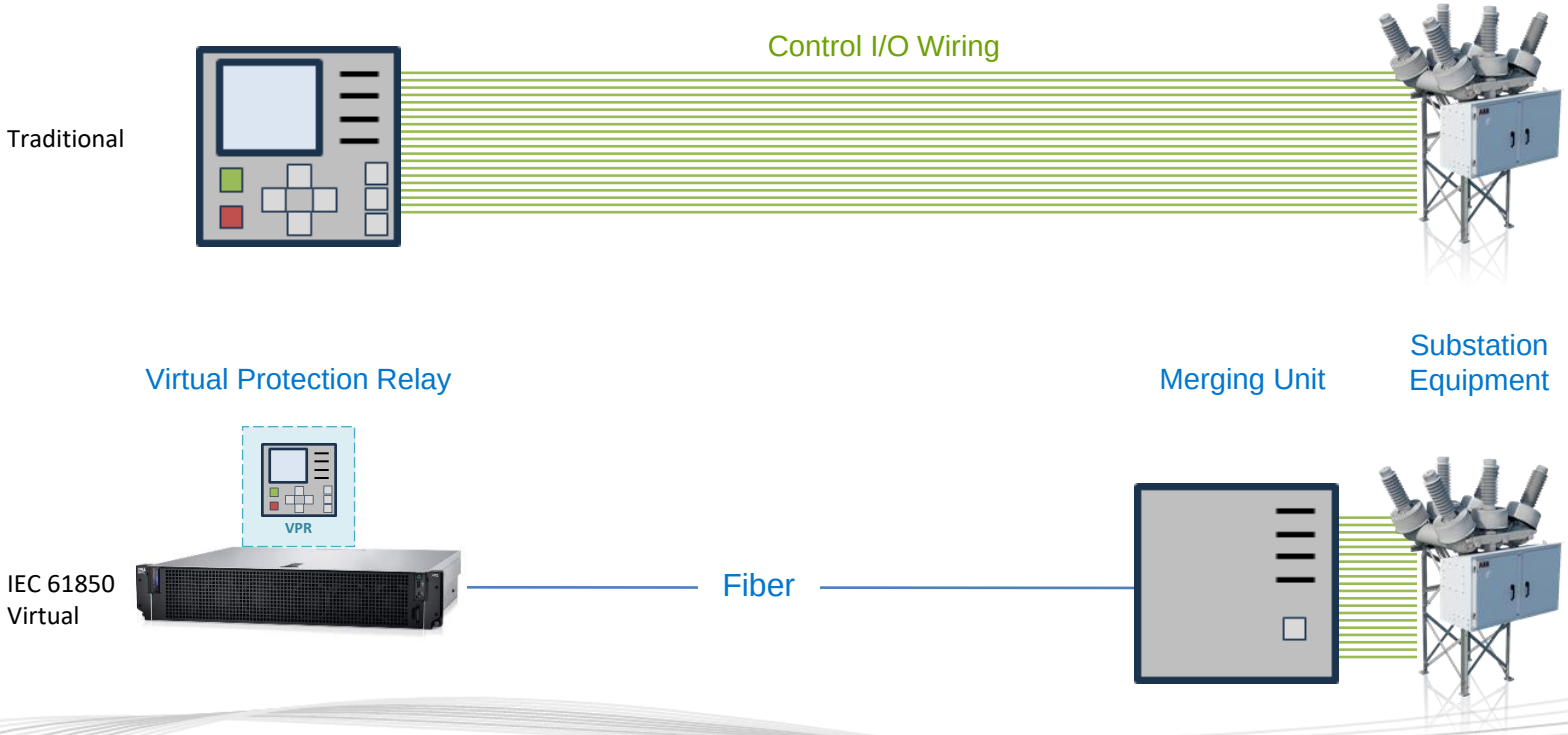

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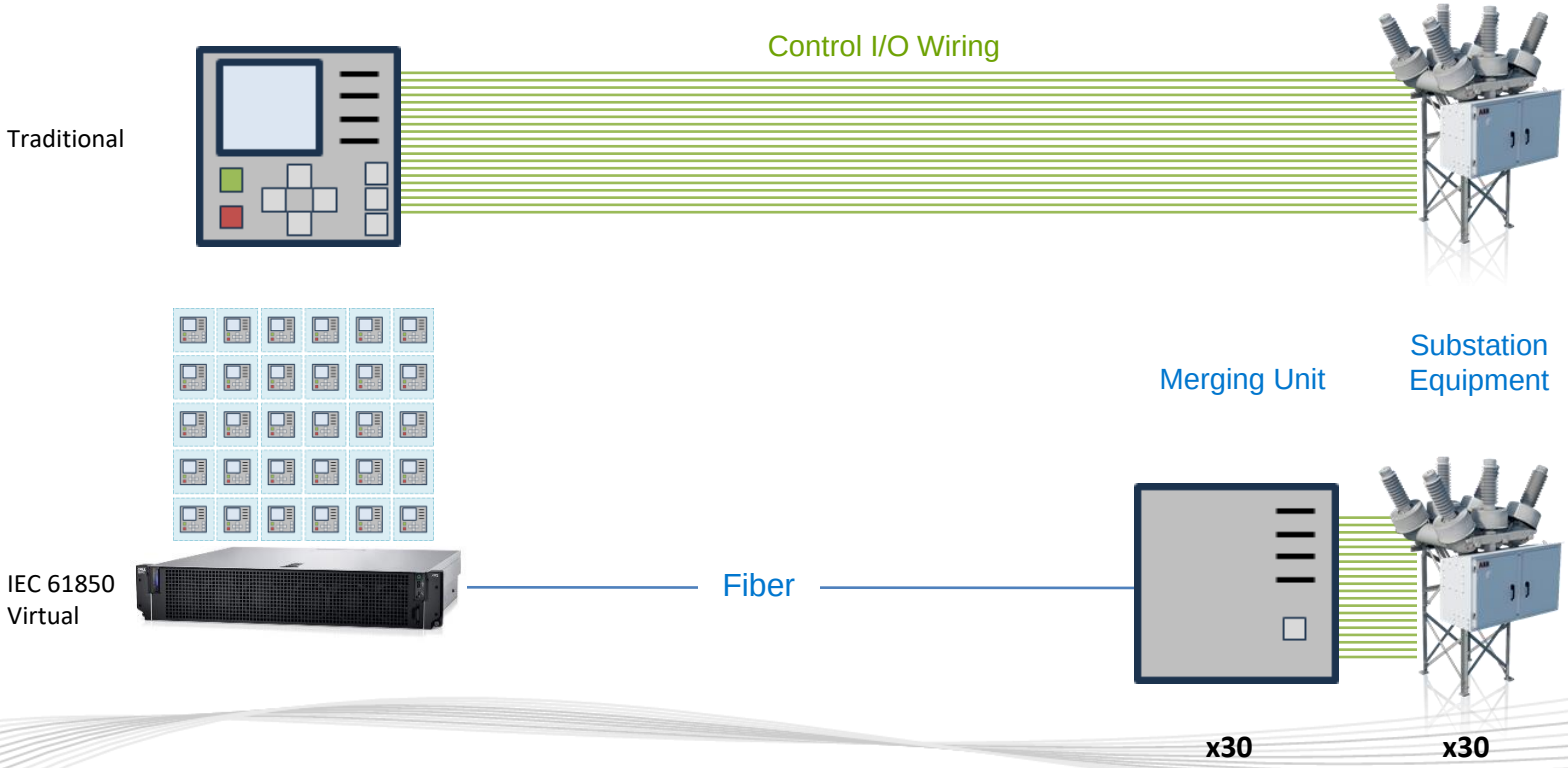
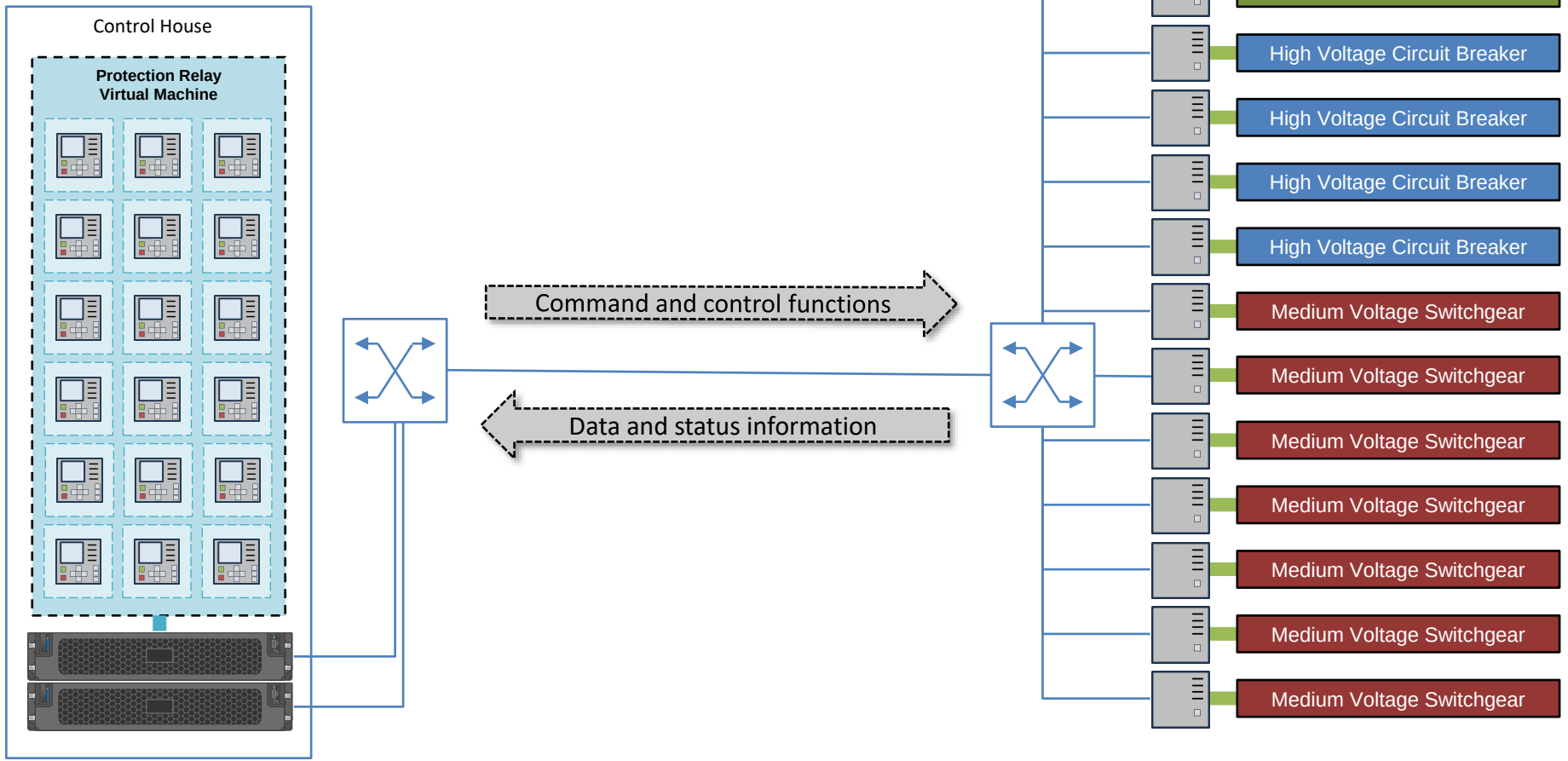


Introduction to Virtual Protection

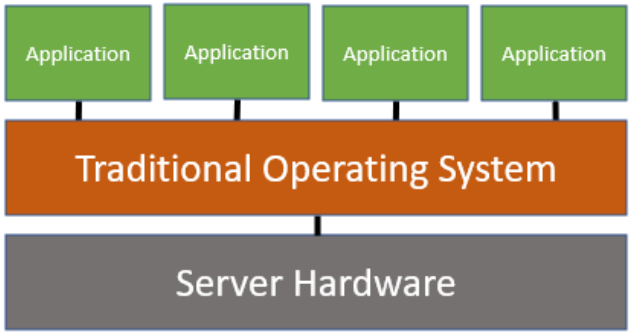


Virtual Protection Relay Hardware Requirements

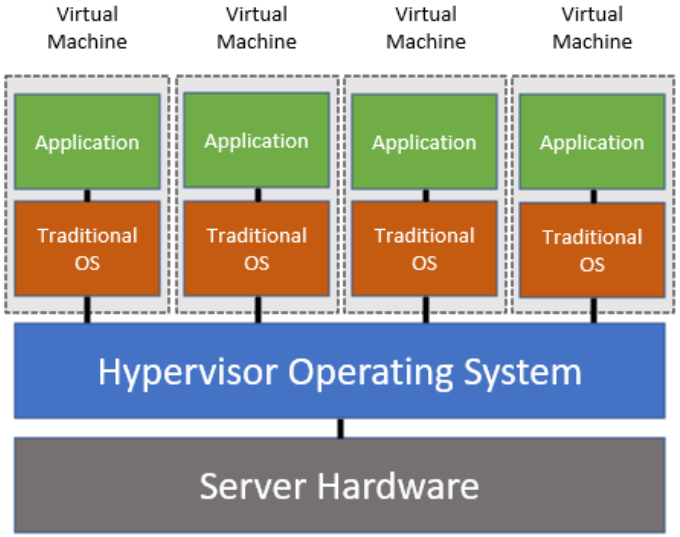
IEC 61850-3 Compliant
Server

Key Specifications	Minimum Recommendation
CPU	- 8 cores or greater - Virtualization-enabled (Intel VT-x or AMD-V) - 2.2 GHz Clock (varies by specific application)
Memory	- 64 GB or greater - Error Correction Code (ECC) support
Networking	- Parallel Redundancy Protocol (PRP) support - Precision Timing Protocol (PTP) support
Environmental	- 10° C - +55° C or better - N+1 fan redundancy
Power	- Redundant AC or DC
Hypervisor	- Real-time capable - Support for clustering of multiple servers for redundancy

Traditional vs VPR Architecture



Traditional Architecture



Virtualized Architecture

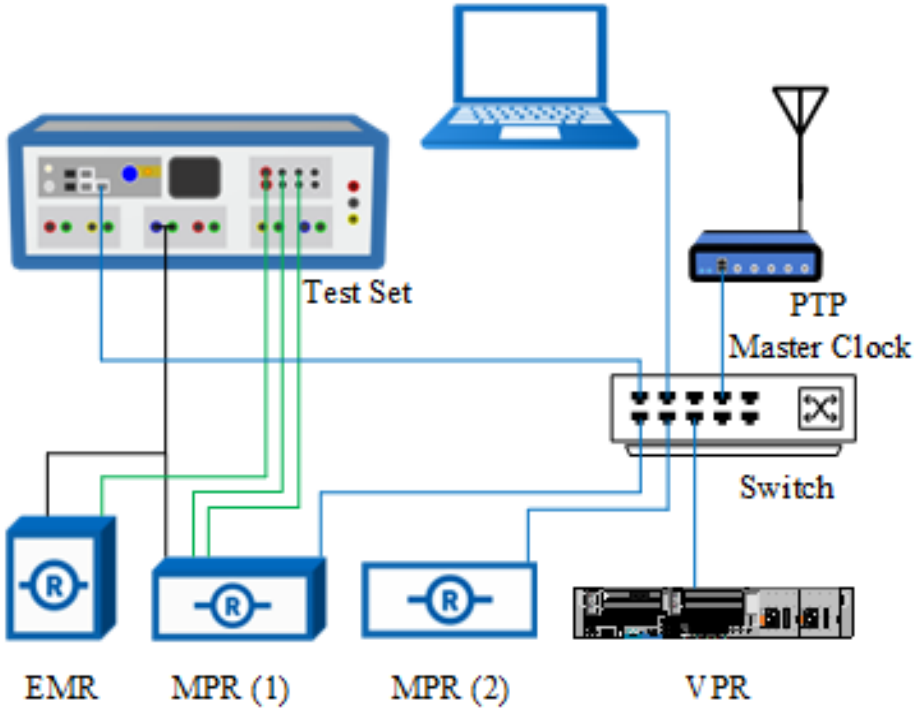
Virtual Protection Relay First Impressions

- Target LEDs and push buttons
  - Available in specific hardware versions and not in common servers
  - Virtual target LEDs are available in a web page accessed via a web browser
- Hardware readiness
  - It depends if this has been set up by a third party
- Relay settings
  - Similar to MPRs, they are available via a computer software or web browser
- Testing equipment
  - No need for special equipment if it supports GOOSE and SV

First Steps on Setting up a VPR

1. Server set up
   - Disk formatting and preferred redundancy configuration
   - Ethernet ports MAC address availability
2. Hypervisor OS installation
3. VPR application software installation

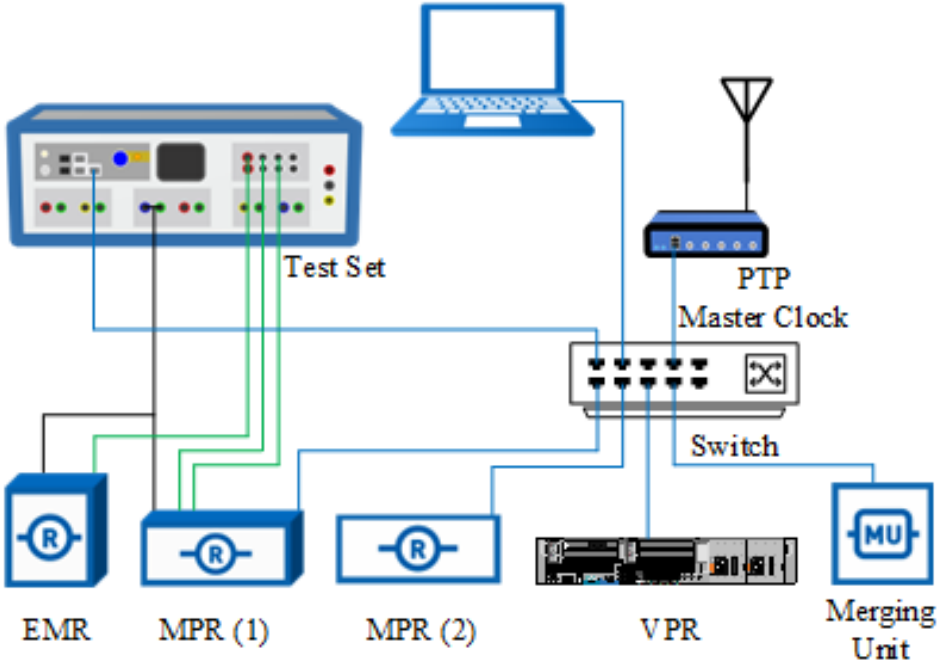
Overcurrent Protection Element Test Setup



Testing Scenarios

- Four testing scenarios were considered for this paper:
  1. Fault current 1% above the pickup value
  2. Fault current 10% above the pickup value
  3. Fault current 100% above the pickup value
  4. Fault current 10% above the pickup value with Ethernet traffic conditions in the switch

Fault current 10% above PU with Traffic



Testing Results Summary

Fault Above PU Setting	EMR	MPR (1) CO	MPR (1) HS CO	MPR (1) GOOSE	MPR (2) GOOSE	VPR GOOSE
1 %	71.2	26.2	23.6	24.7	36.4	19.9
10 %	38.1	23.6	21.0	22.3	22.3	16.6
100 %	14.9	16.0	13.4	14.9	9.2	10.3
10 % with traffic	40.2	25.0	22.4	23.6	22.5	16.6

Conclusion

- Similar to the initially-slow adoption of the microprocessor-based relay, virtual protection will likely face resistance to widespread adoption at the outset until successful use cases and institutional experience with the technology become available
- Paper results demonstrate that while the hardware and deployment of VPR may be different, the performance of it exceeds that of traditional mechanical and microprocessor-based relays protection
- Adopters of VPR technology may feel compelled to deploy VPR in limited pilot projects before widespread deployment
- Skills needed for the successful deployment of a VPR system require knowledge of both the IT and OT domains, converging the two technologies that have traditionally been managed separately

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Questions?