Improving Protection Applications for Modern Distribution Switchgear Systems

Benton Vandiver III, ABB ES

Nov 4, 2020

HITACHI ABB POWER GRIDS

Overview

Introduction

Challenge

Conventional P&C

Communication-based P&C

Integrated Multi-Object P&C

Conclusions

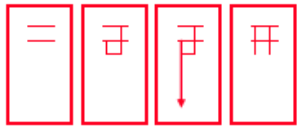
Introduction

- MV Switchgear both conventional and GIS are in high demand
- Switchgear are used in all distribution applications and configurations across all industries, utilities, commercial facilities, campuses, municipalities, etc.
- PAC systems applied to MV switchgear have remained philosophically unchanged
- New technology and trends have opened new possibilities:
  - MV switchgear has evolved more compact and modular
  - Non Conventional Instrument Transformer's have introduced new capabilities
  - Data & control demands have driven changes in communication requirements
  - Demands on grid operations and performance - require higher efficiencies
  - Mature industry standards drive product designs with new advantages

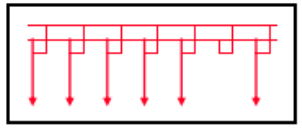
- Using a clean sheet approach and applying proven technology, a re-design reveals big improvements are easily possible over conventional philosophies.

Conventional P&C

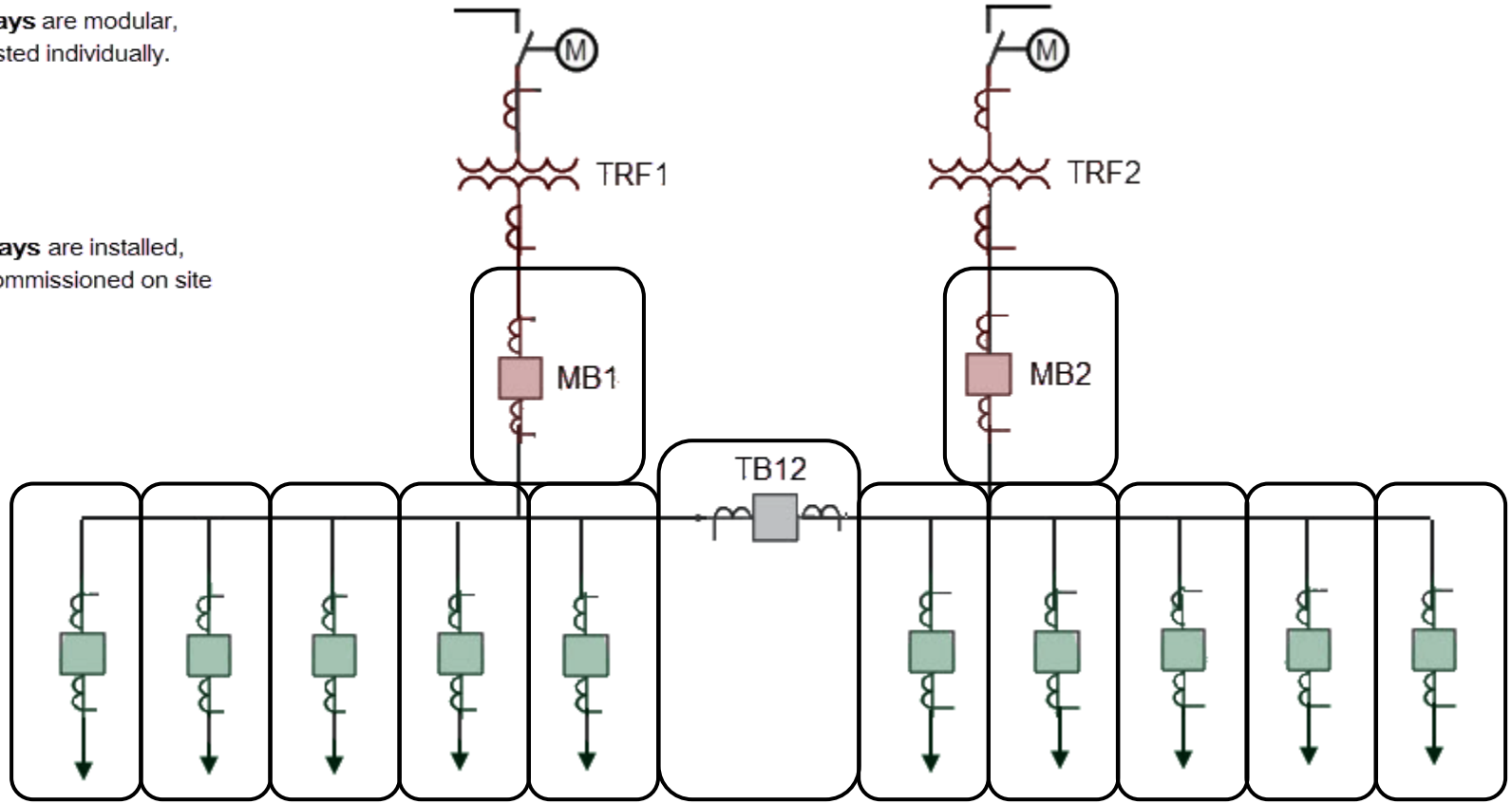
Typical Distribution Switchgear with dual Transformers/10 Feeders



Bays are modular, tested individually.



Bays are installed, commissioned on site



Conventional P&C

Three Basic Protection Zones - Trf / Fdr / Bus

Transformer Protection
Feeder Protection
Hi-Z Bus Diff Protection

Requires dedicated matching CTs for Diff

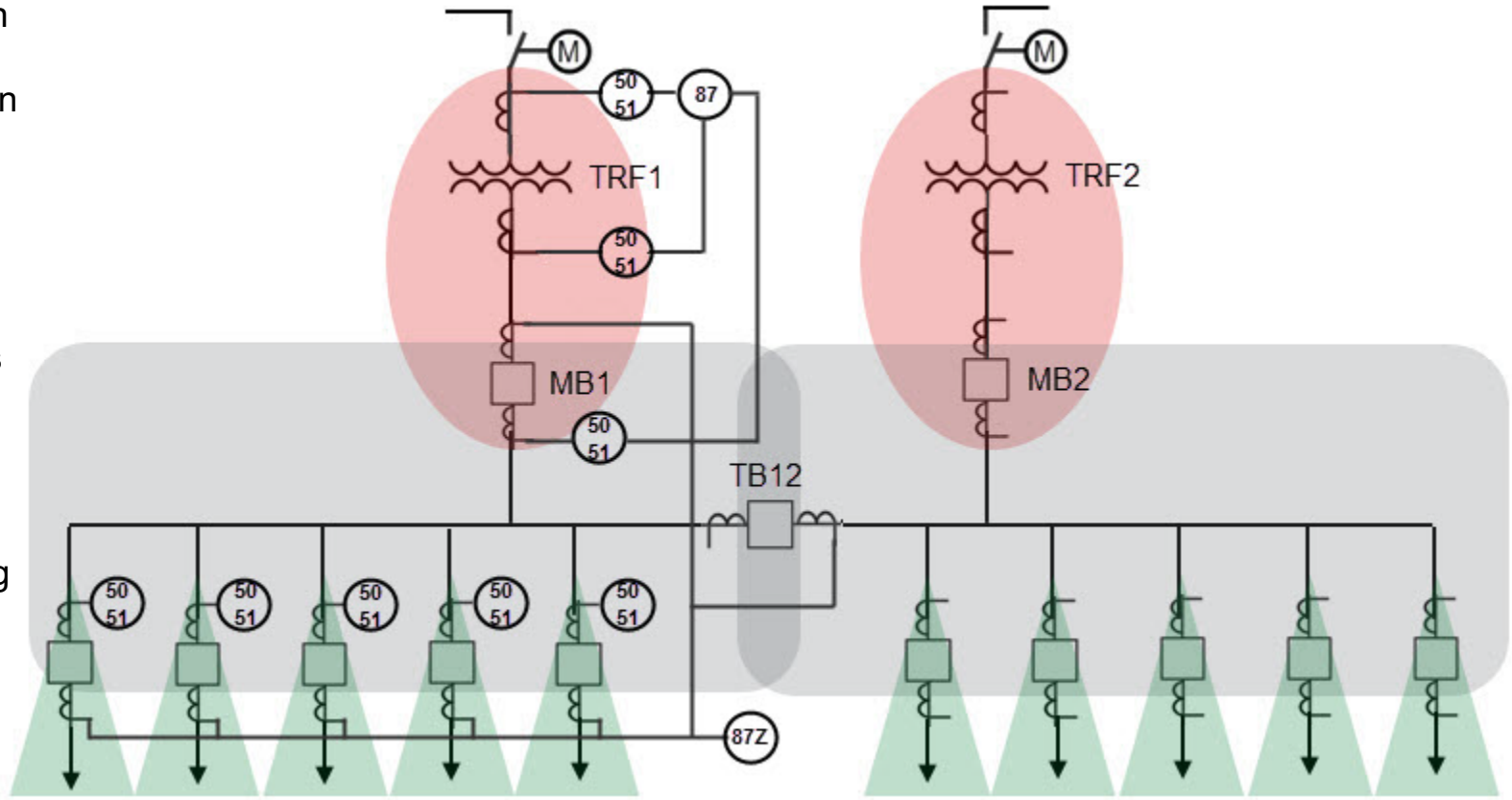
60+ Protection and Auxiliary relays for this topography

No communications

Hard-wired interlocking

No backup

Manual Safety Procedures



Communication-based P&C

Three Basic Protection Zones - Trf / Fdr / Bus

Transformer Protectior
Feeder Protection
Hi-Z Bus Diff Protectio

Requires dedicated matching CTs for Diff

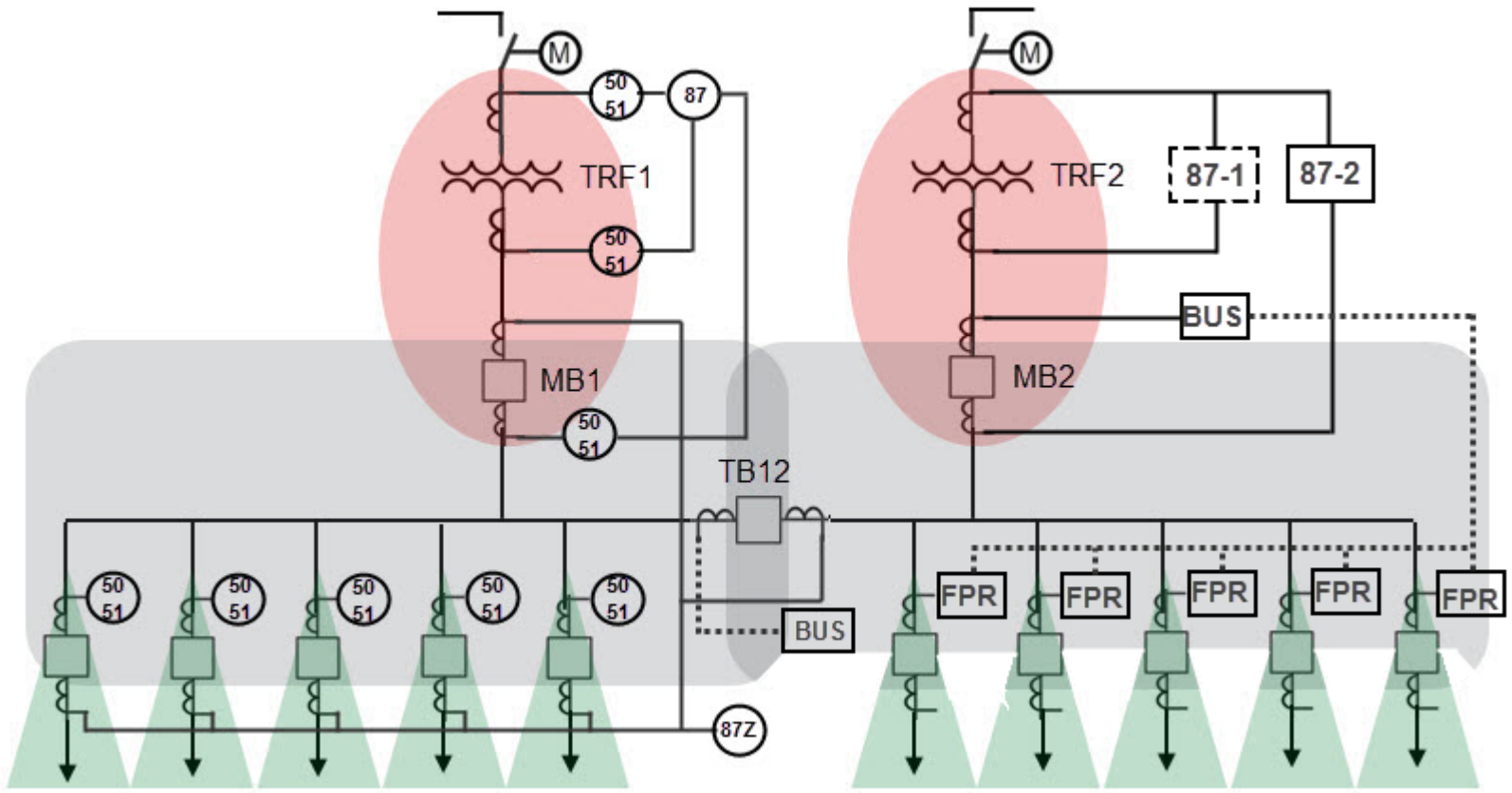
60+ Protection and Auxiliary relays for this topography

No communications

Hard-wired interlockin

No backup

Manual Safety Procedures



Transformer Protection (sometimes redundant)
Feeder Protection w/Bus Interlocking

10+ Protection and Auxiliary relays for this topography

Hard-wired interlocking w/ GOOSE Comms

Limited backup

Similar Manual Safety Procedures

Slower Bus fault detection

Integrated Multi-Object P&C

Multi-Zone Protection - Trf / Bus / Fdr

Transformer Protection
Hi Speed Bus Protection
Full Feeder Protection

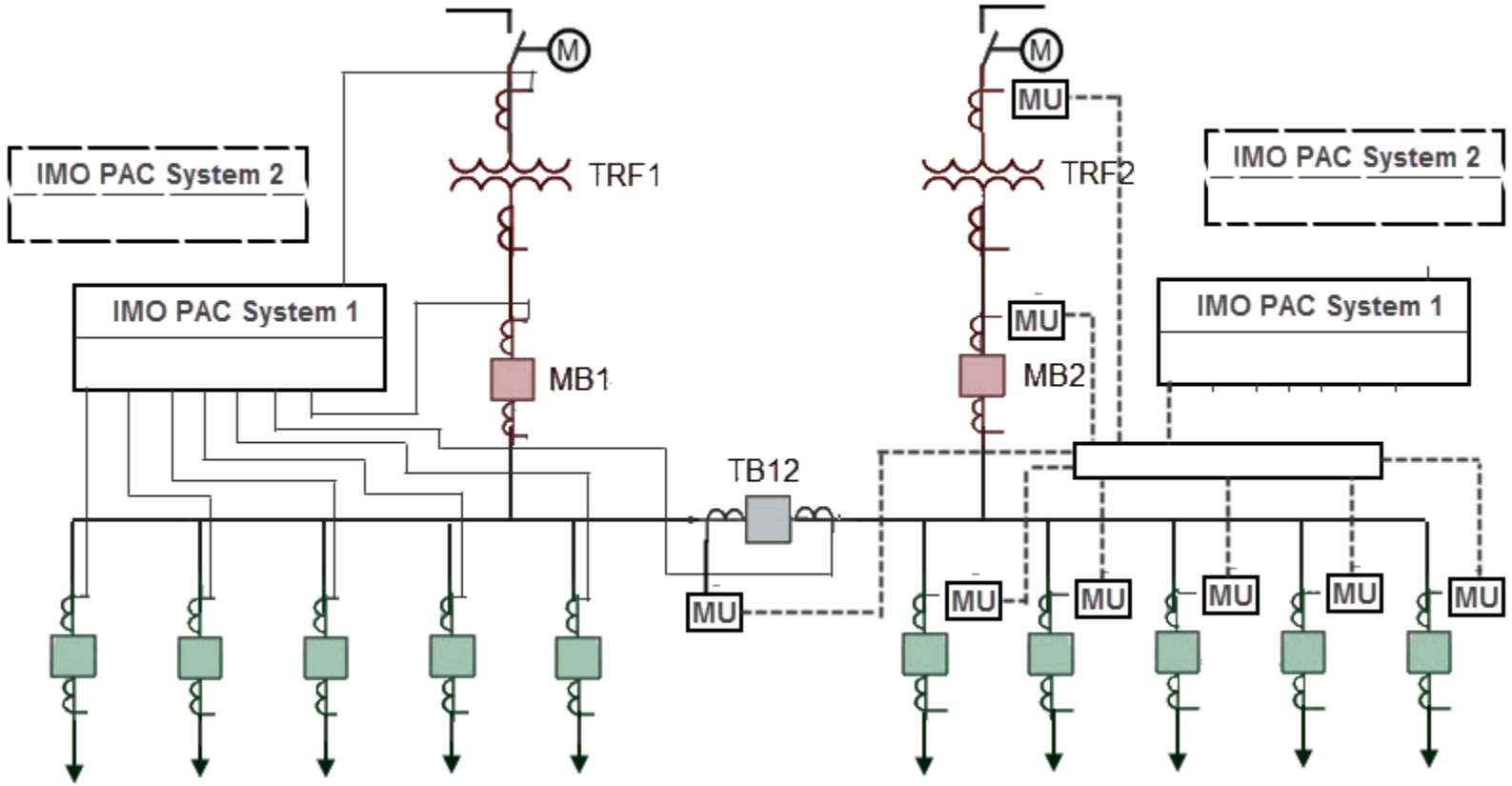
4 IMO Systems provide full redundancy for this topography

All interlocking is internal logic

Minimum GOOSE Comms required

Fully integrated Safety Procedures

Reduced fault times



HITACHI ABB POWER GRIDS

Integrated Multi-Object P&C

Multi-Zone Protection - Trf / Bus / Fdr

Transformer Protection
Hi Speed Bus Protection
Full Feeder Protection

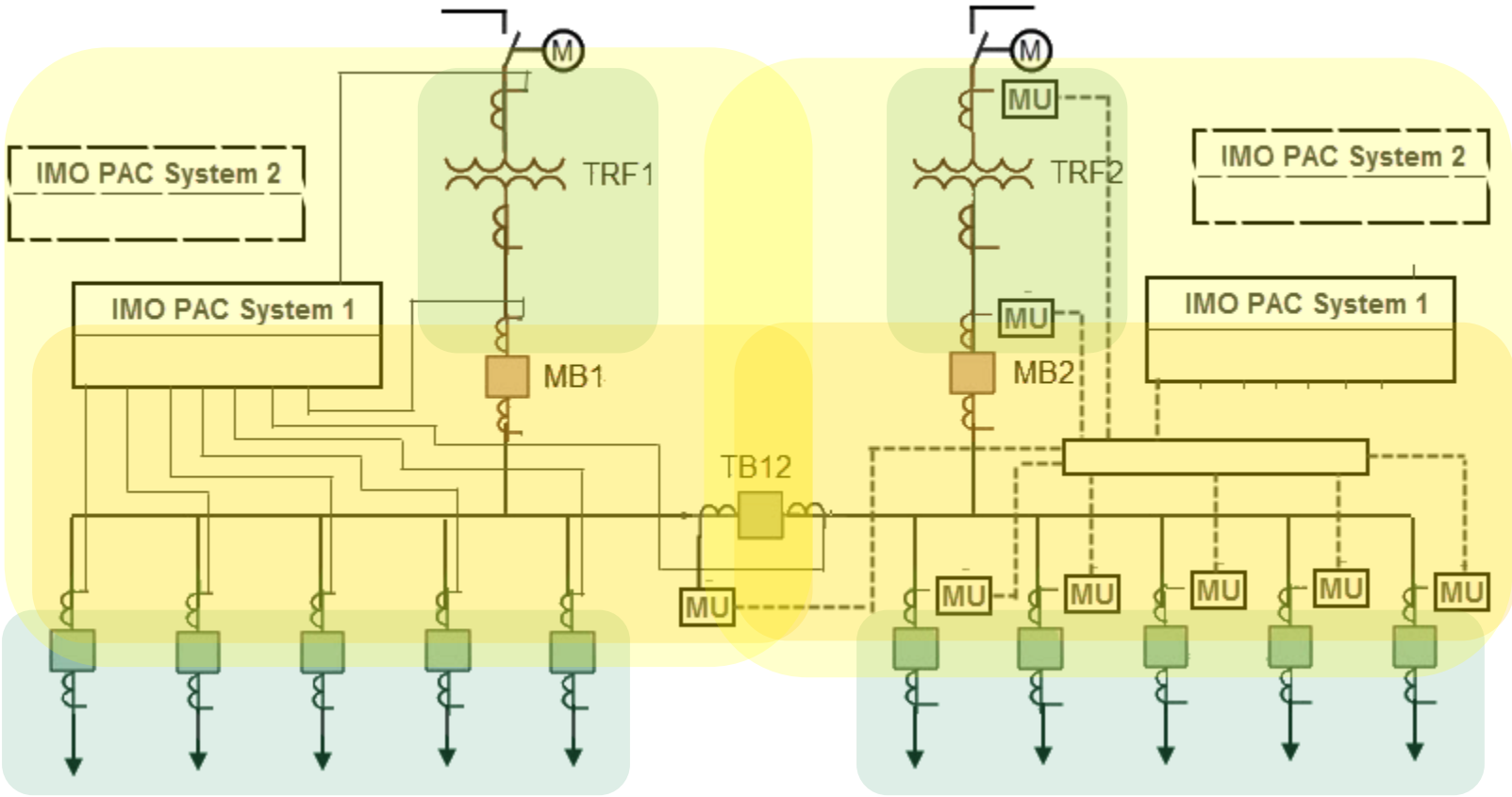
4 IMO Systems provide full redundancy for this topography

All interlocking is internal logic

Minimum GOOSE Comms required

Fully integrated Safety Procedures

Reduced fault times



Transformer Protection
Hi Speed Bus Protection
Full Feeder Protection

4 IMO Systems provide full redundancy for this topography

All interlocking is internal logic

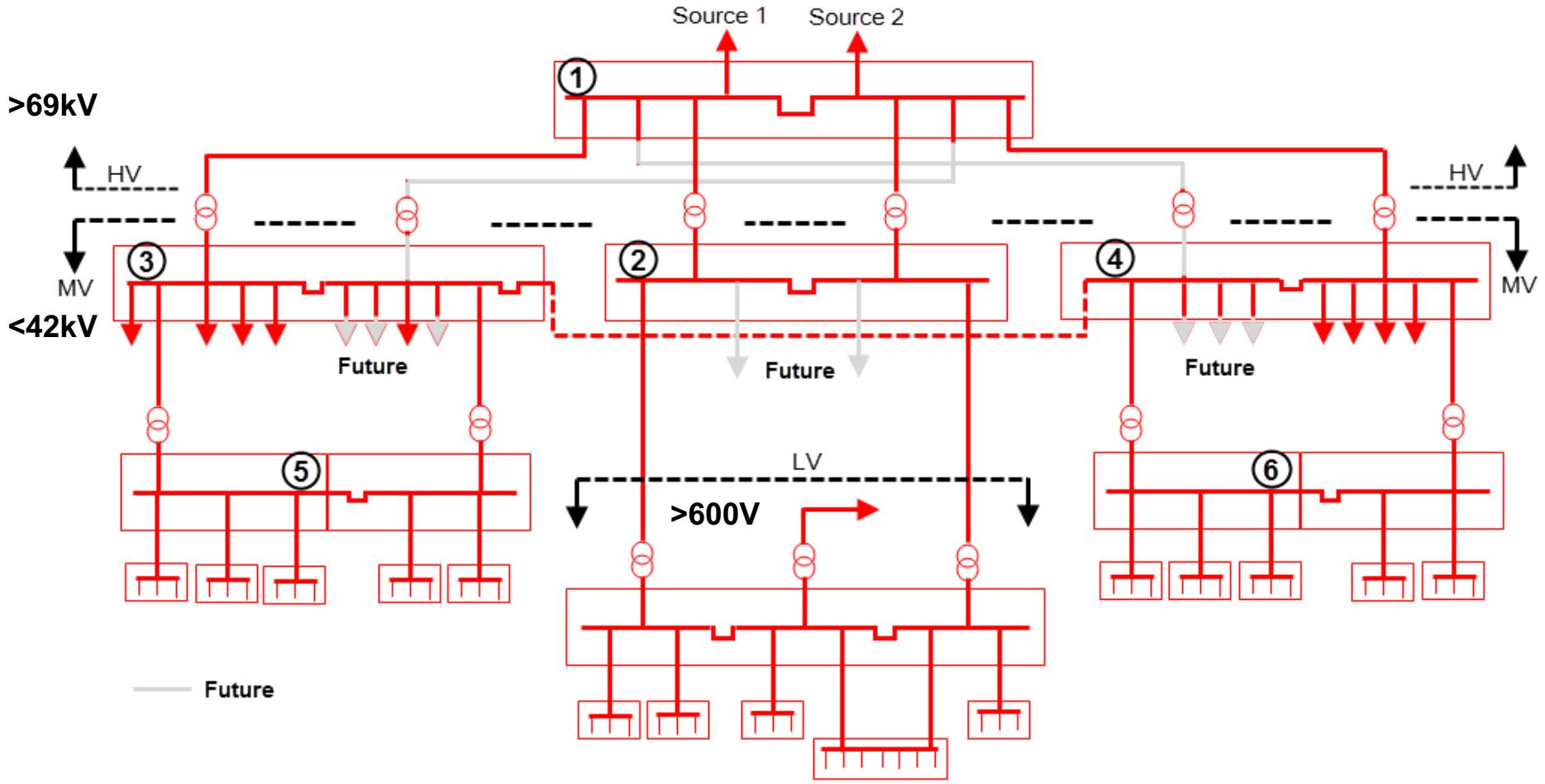
Identical Configuration w/Merging Units adding a Process Bus Ethernet Switch w/ GOOSE Control

Key Benefits - Reduce Costs / Simplify Engineering

- ✓ **Reduced** the number of protection devices a minimum of 6 to 1
- ✓ **Reduce** Installation time and footprint
- ✓ **Standardize** the P&C Scheme
- ✓ **Eliminate** complex zone interlocking schemes and their coordination.
- ✓ **Minimize** testing /commissioning
- ✓ **Improved** protection speed and zone coverage for all operational scenarios
- ✓ **Optimize** sensor data
- ✓ **Enhanced security** for operators and field personnel with proper interlocks and automatic fast OC protection during switching/maintenance.
- ✓ **Simplify** fault study coordination / with 100% Bus Zone coverage.
- ✓ **Simplify** Trouble-shooting events / DFR analysis / reporting
- ✓ **Simplify** SCADA / DCS integration with a single dataset definition.
- ✓ **Simplified** migration plan from analog to communication-based system.
- ✓ **Simplified** Hybrid solution, leverage the transition into Brownfield facilities with a single scheme
- ✓ **Simplified** IEC 61850 engineering solution
- ✓ **Future proof** - transition to full IEC 61850 with Merging Units utilizes the same configuration.

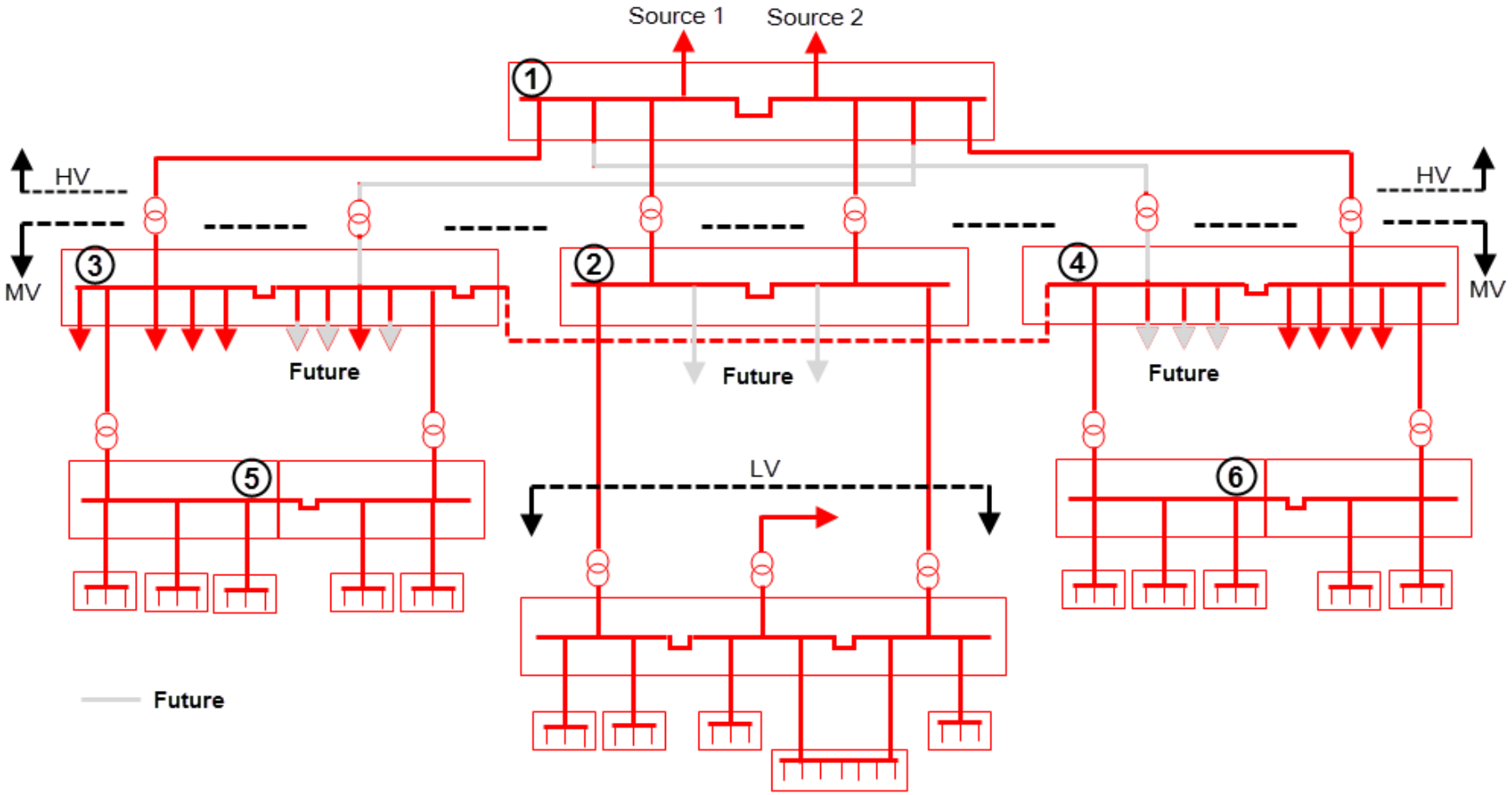
Challenge - Conventional P&C

Typical Industrial power system one-line with redundant hierarchical switchgear



Challenge - Conventional P&C

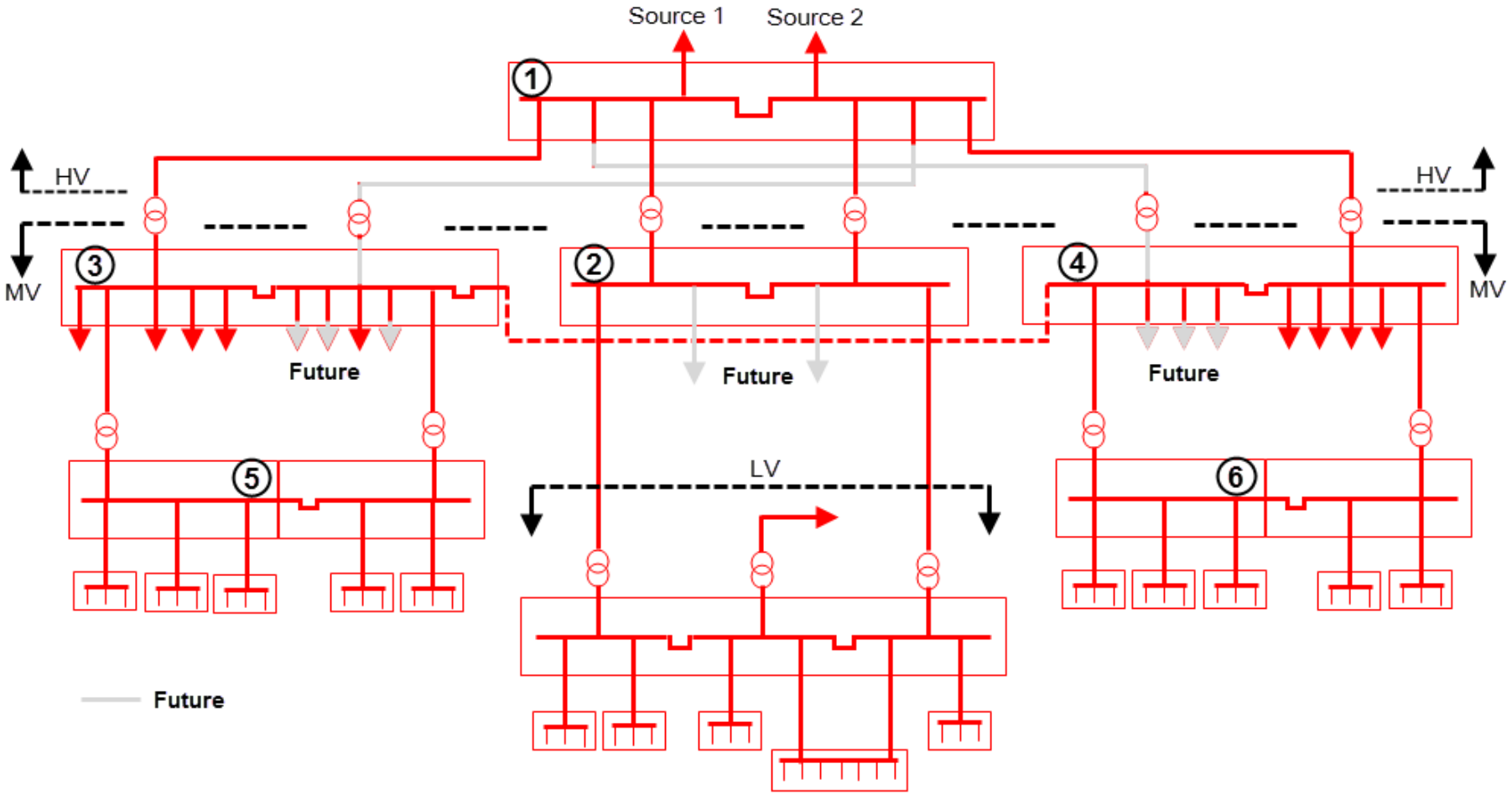
Switchgears 1-6 require over 70+ protection devices excluding SCADA



HITACHI ABB POWER GRIDS

Challenge - Conventional P&C

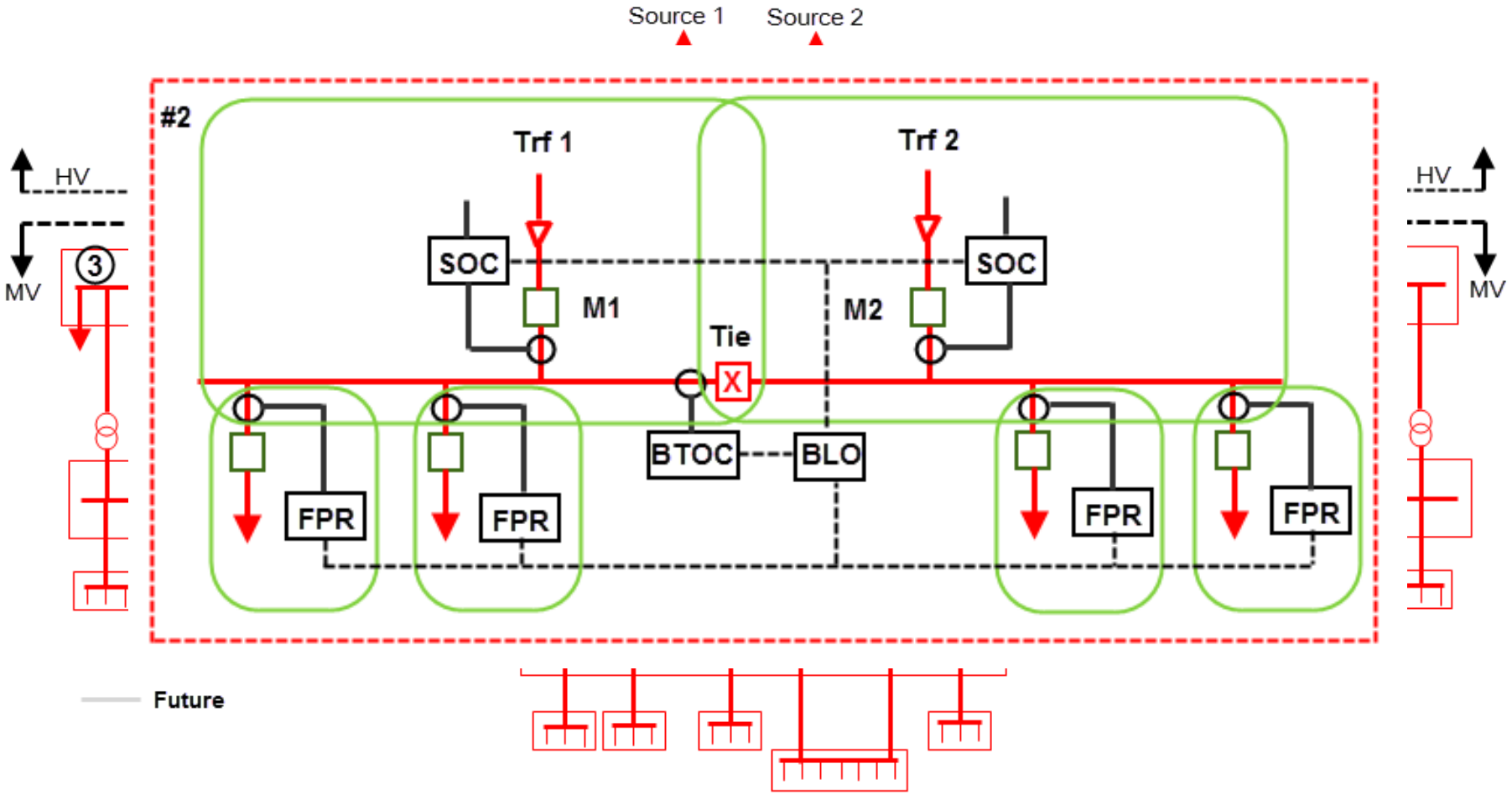
Switchgears 1-6 are never tested/commissioned as a complete P&C system



HITACHI ABB POWER GRIDS

Challenge - Conventional P&C

Switchgear #2 typical P&C zones

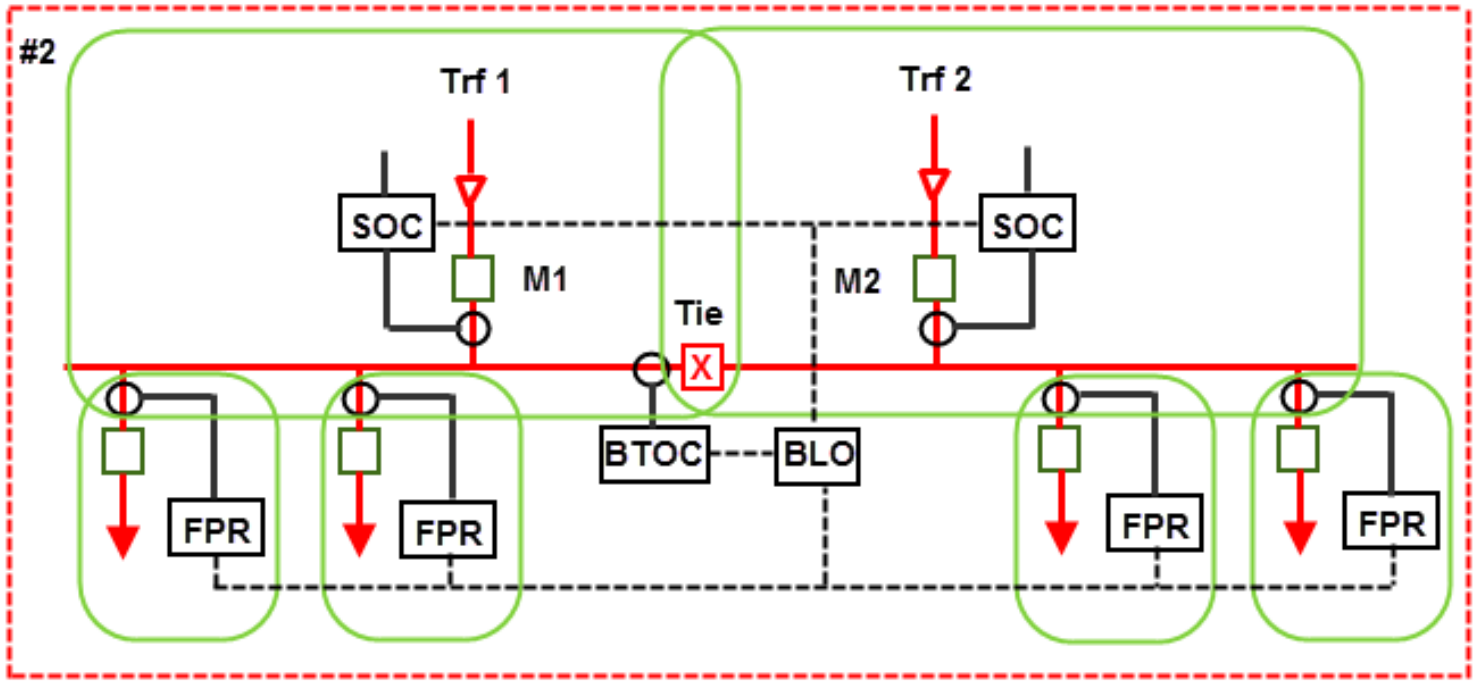


HITACHI ABB POWER GRIDS

Conventional P&C

Issues:

- Individual P&C devices setup/testing
- Difficult to system test /commission in isolation
- Relatively slow internal fault protection (>150mS)
- Settings / sensitivity issues affect operations
- SCADA/DCS integration
- Operations / Safety Protocols are incomplete
- Trouble-shooting events requires concerted effort
- DFR analysis / reporting is not optimized and requires considerable effort



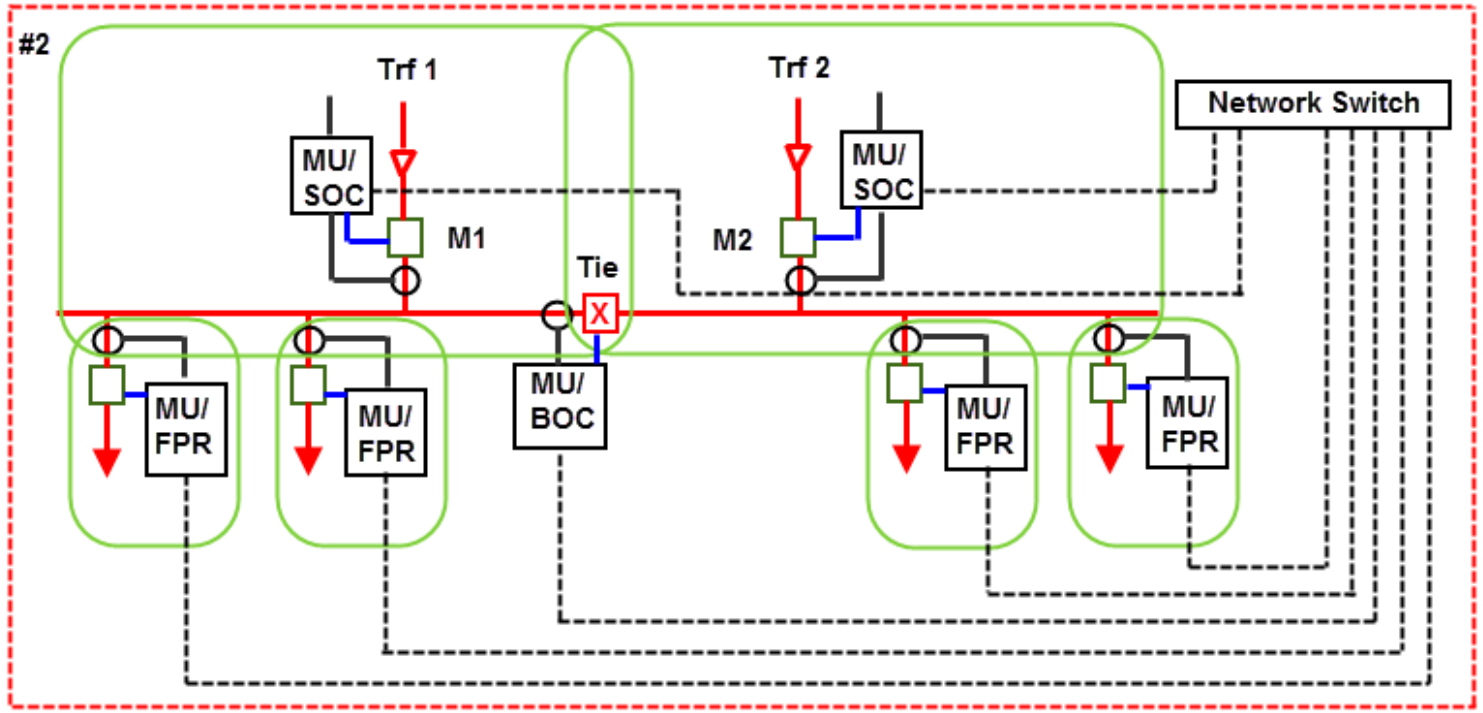
Communication-based P&C

Some benefits

- Minimizing copper wiring by using fiber and a substation network at the station level
- Maintain protection zone coverage and some operational flexibility

Challenges

- Optimize sensor data and share it everywhere it is logically needed.
- Communications can be a challenge / testing / trouble-shooting
- Proving interlock extensions to other Swgr and multi-vendor integration
- Keeping performance targets
- Providing upstream/downstream data and controls

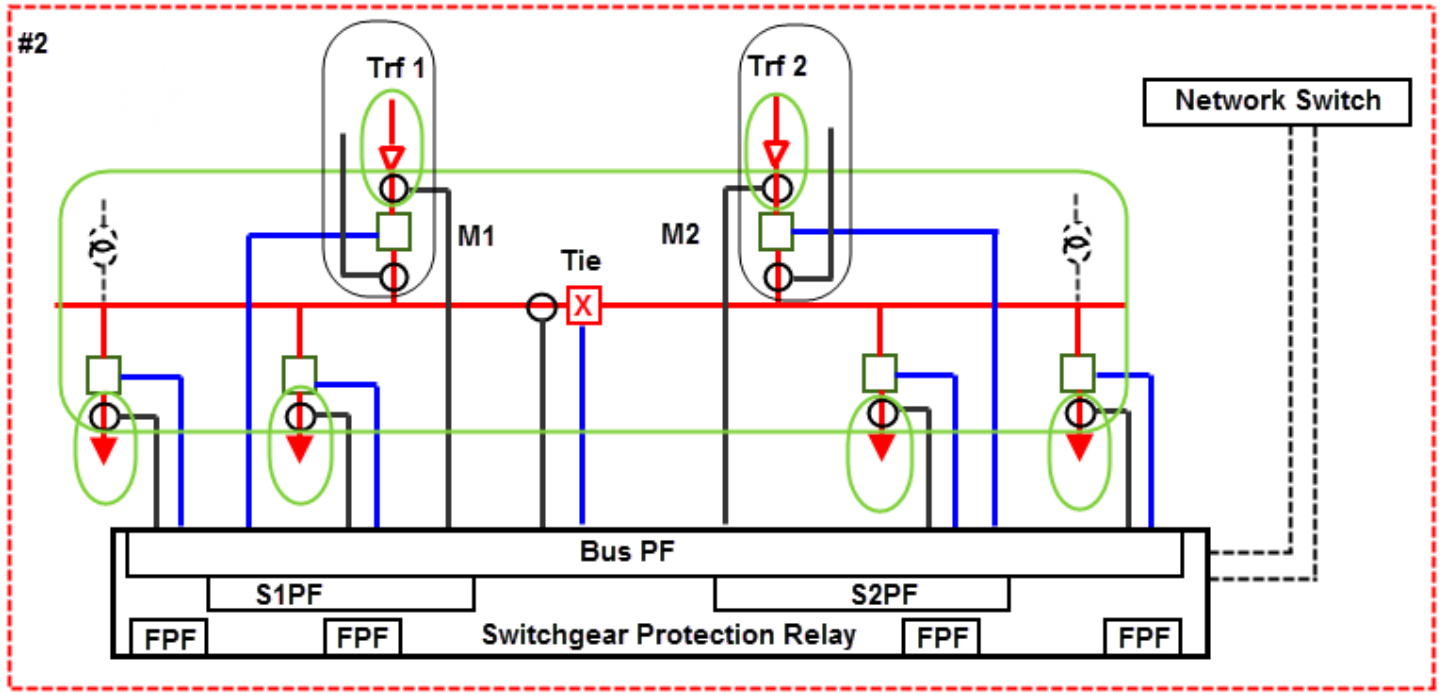


HITACHI ABB POWER GRIDS

Integrated Multi-object P&C

Key benefits from this centralized application focused in one high performance device are:

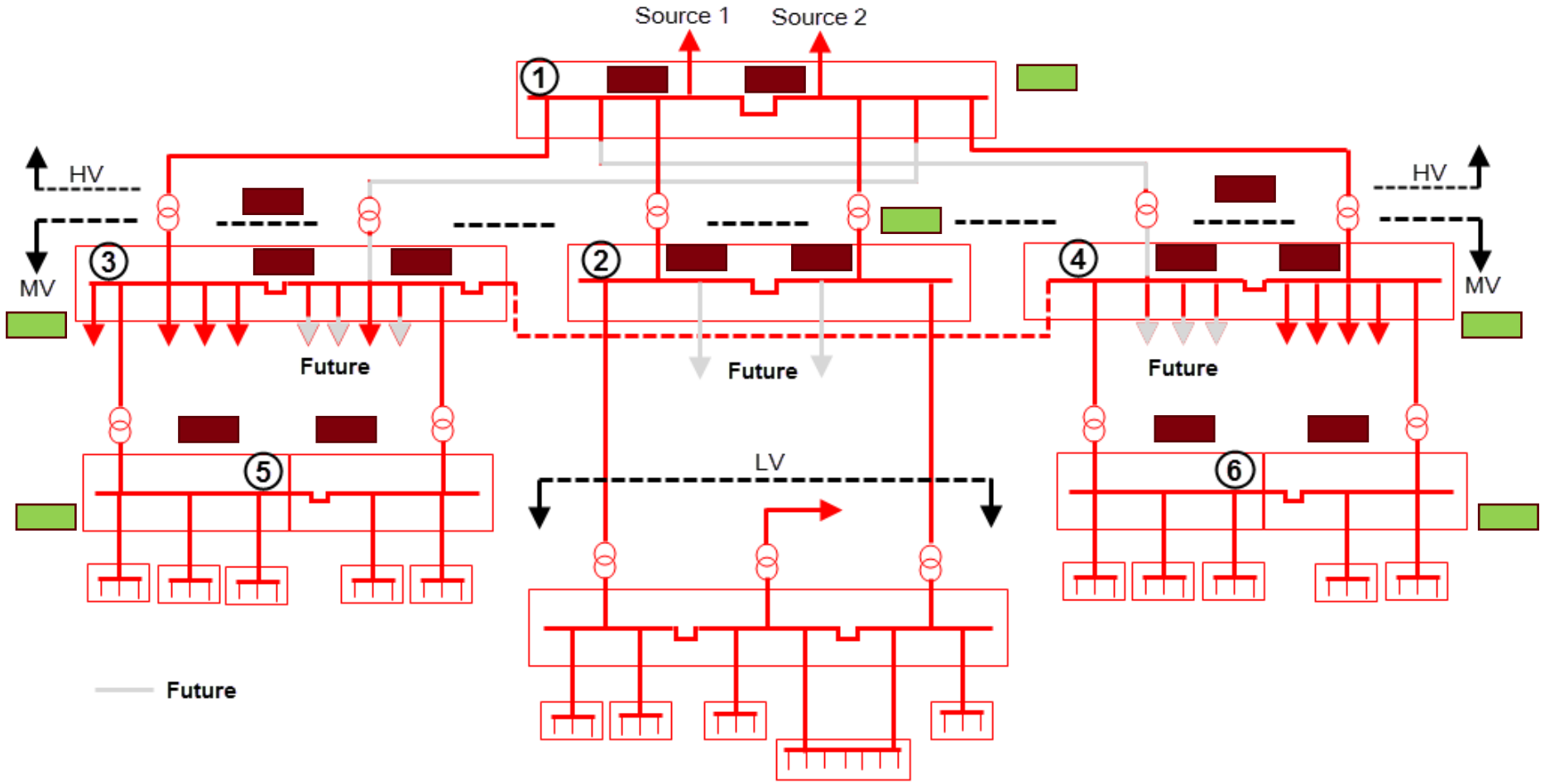
- **Reduced** the number of protection devices a minimum of 7 to 1 (reduce installation time, maintenance, testing, and cost with better protection)
- **Eliminate** complex zone interlocking schemes and their coordination.
- Perform complete FAT/SAT of the entire PAC system as designed.
- **Simplify** fault study requirements with improved coordination/operation.
- **Enhanced security** for operators and field personnel with proper interlocks and automatic fast OC protection during switching/maintenance.



- **Vastly improved arc-flash protection (10x)** for apparatus and personnel safety
- **Standardized** integrated Switchgear P&C scheme (eliminates wiring and settings errors, one device configuration, one firmware to manage if needed, one consolidated alarm/reporting SOE picture)

Centralized P&C Advantage

Switchgears 1-6 now require only 14 P&C devices including SCADA, (+6 ETH Switches)



HITACHI ABB POWER GRIDS

Conclusions

Due to the flexibility of IEC 61850 architecture there are many possible solutions to such applications and implementation philosophies. Modern high performance IED's using this distributed architecture provide unique multi-object integration advantages. As the industry continues to evolve and leverage the capabilities provided by this technology even more benefits can be realized.

Some will counter that this "all your eggs in one basket" approach is not feasible, but I would counter that if simplification, safety, repeatability, and ROI are of value, then the existing schemes and implementations have proven the real risk. Redundancy can be added in many ways with this technology, even full redundancy is worth trading devices at 7 for 2 when the engineering, installation, testing, and operations costs are significantly reduced. Today's modern power grid apparatus are expected to perform at a high level, and our system protection designs should too.

Any Questions?