



**Process Bus – overcoming the complexity of process bus adoption to drive down design, implementation and operation costs**

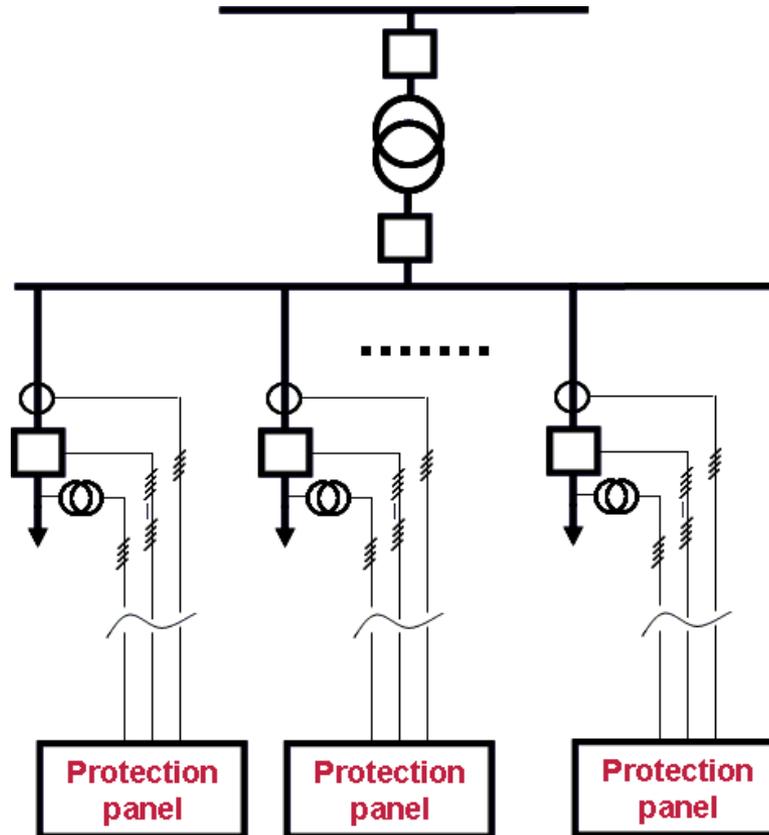
Alexander Apostolov

28 September 2017, Amsterdam, The Netherlands

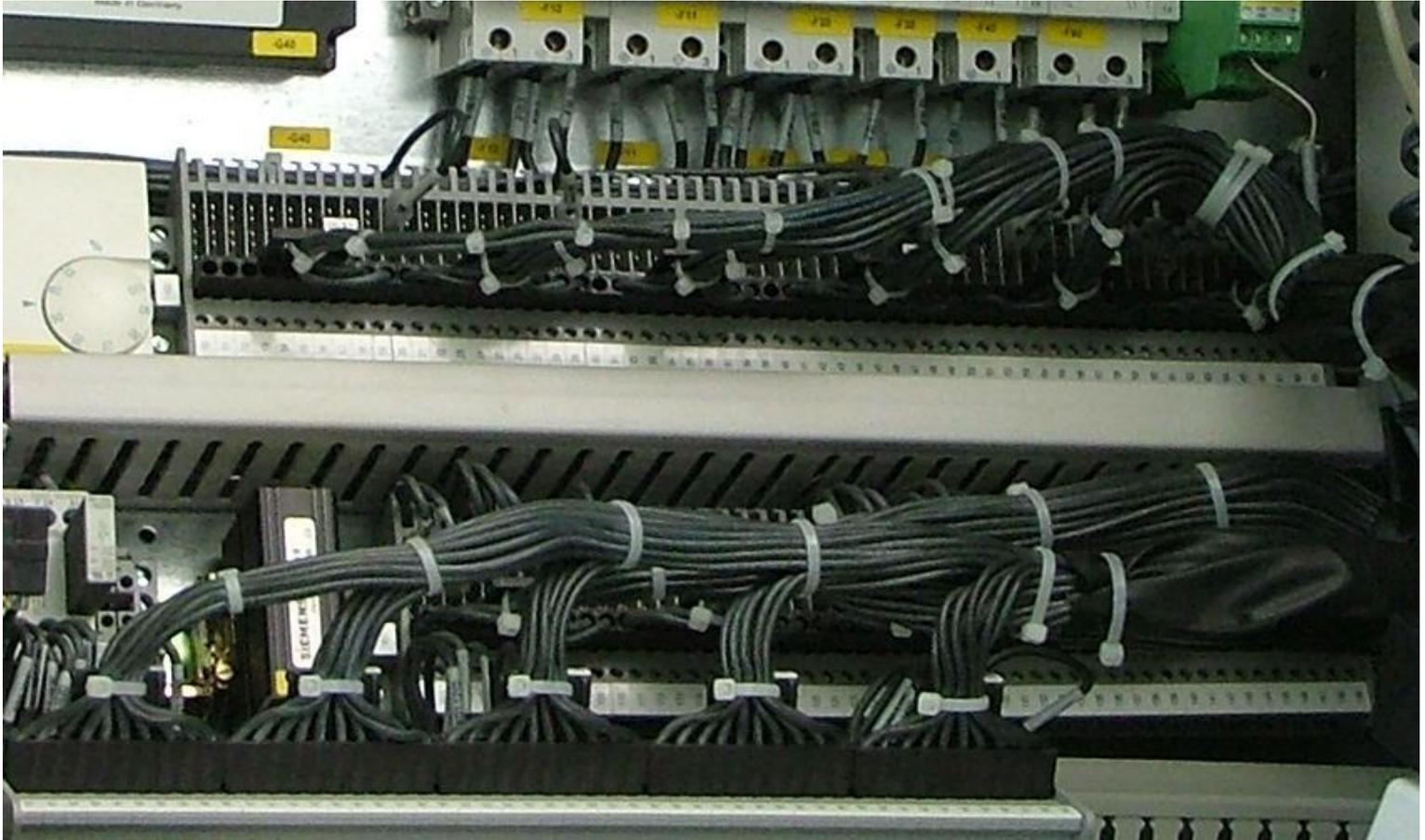
# Questions

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

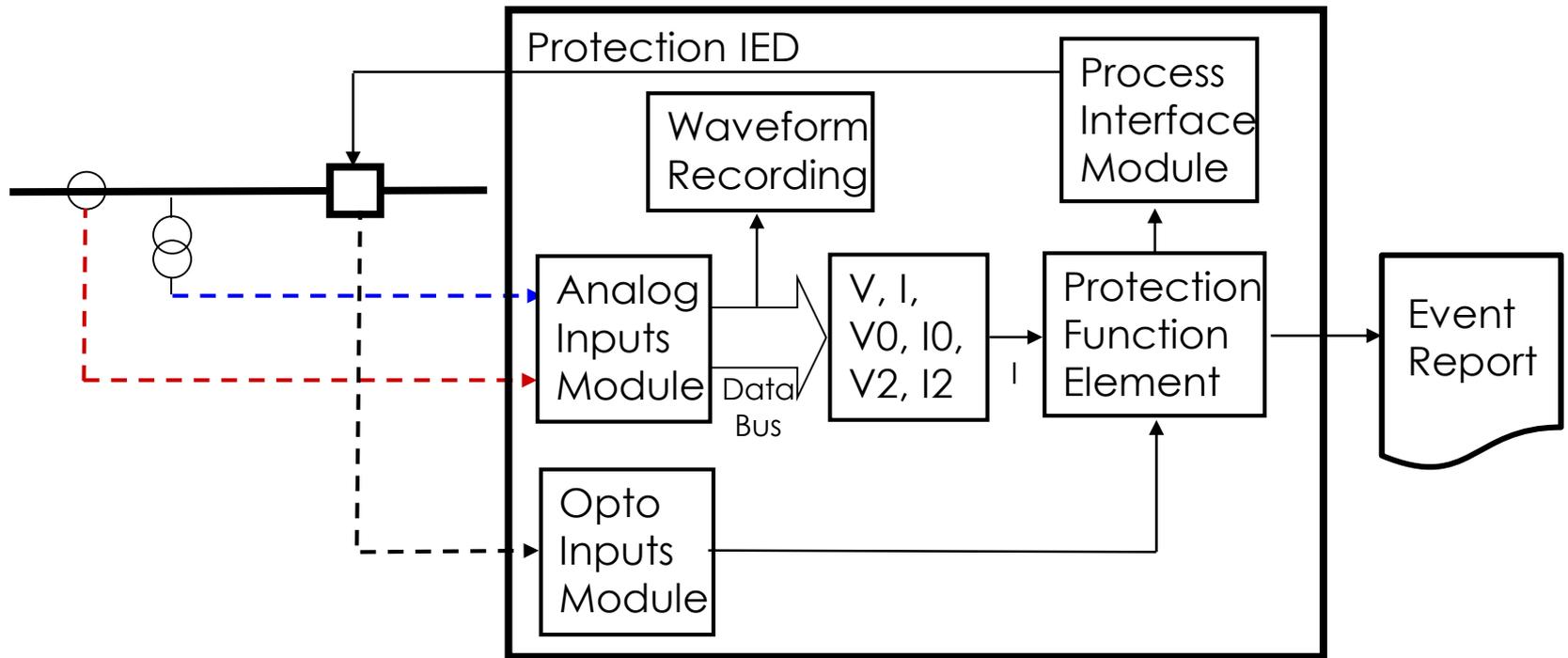
# Conventional Substation



# Conventional Substations



# Conventional IED



# Process Bus Definition

- > Process bus is the combination of all interfaces between the process and the SPACS communicating data and information that can be shared between the PIU and the SPACS functions.
- > The process can be divided in three major parts:
  - > The power process
  - > The auxiliary process
  - > Building/Substation process

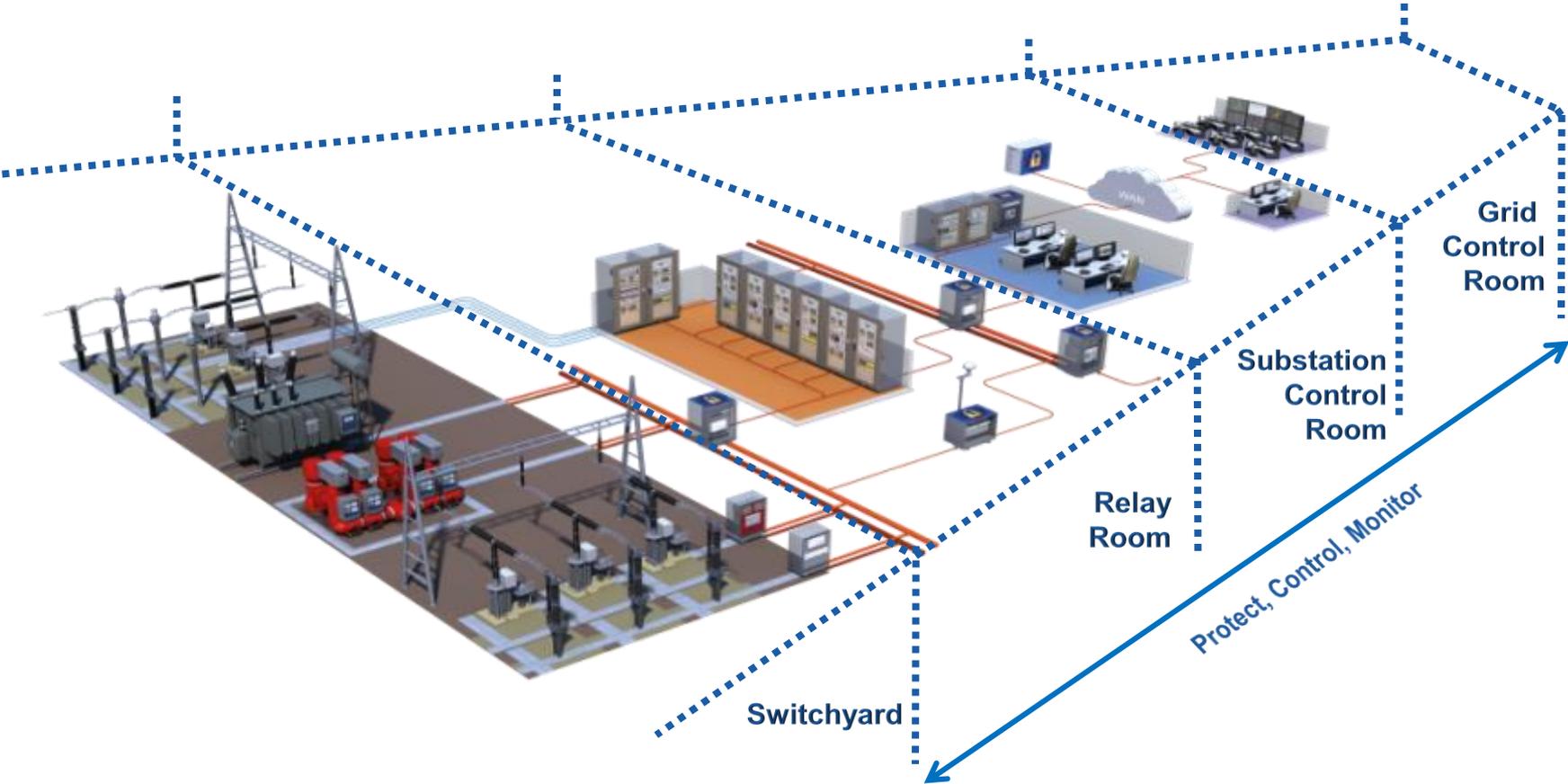
# Digital Substation



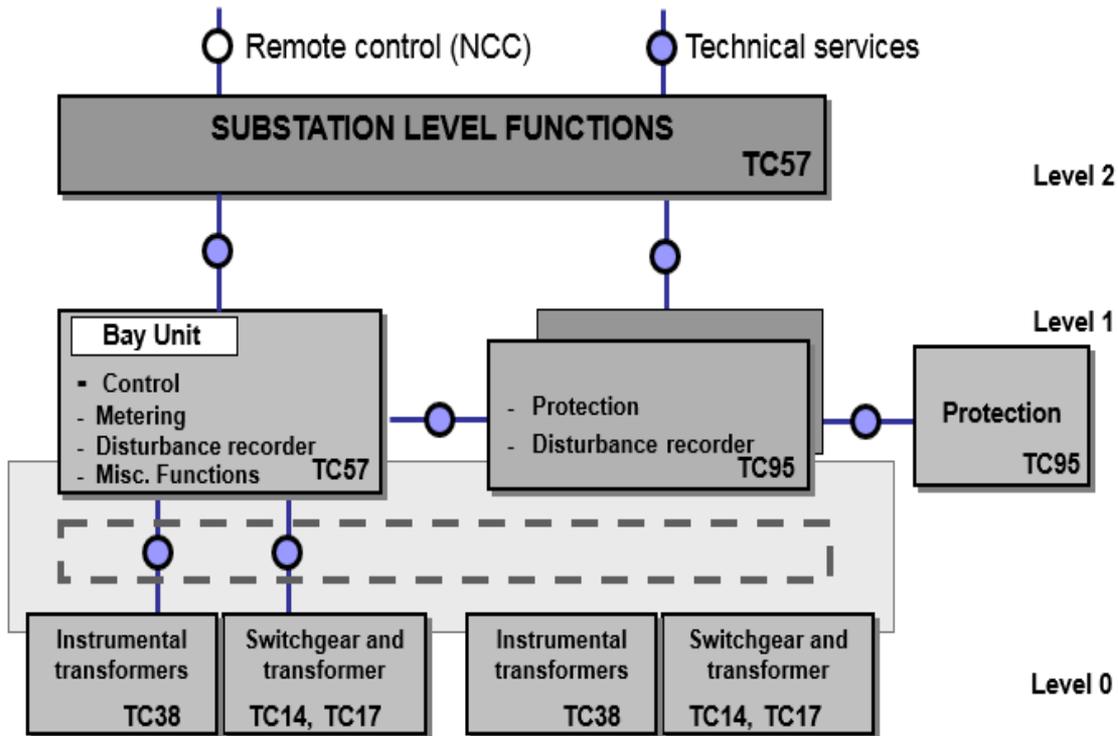
For Air Insulated Switchgear



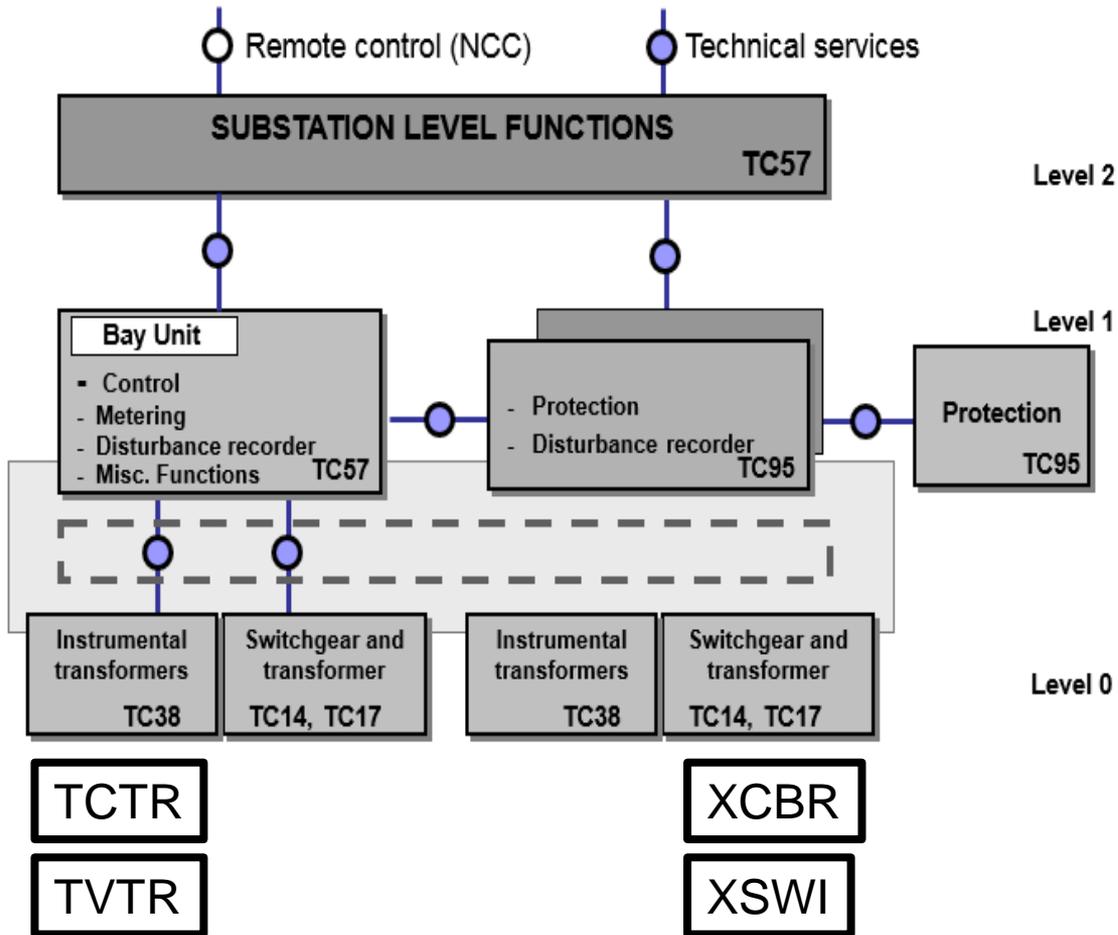
For Gas Insulated Switchgear



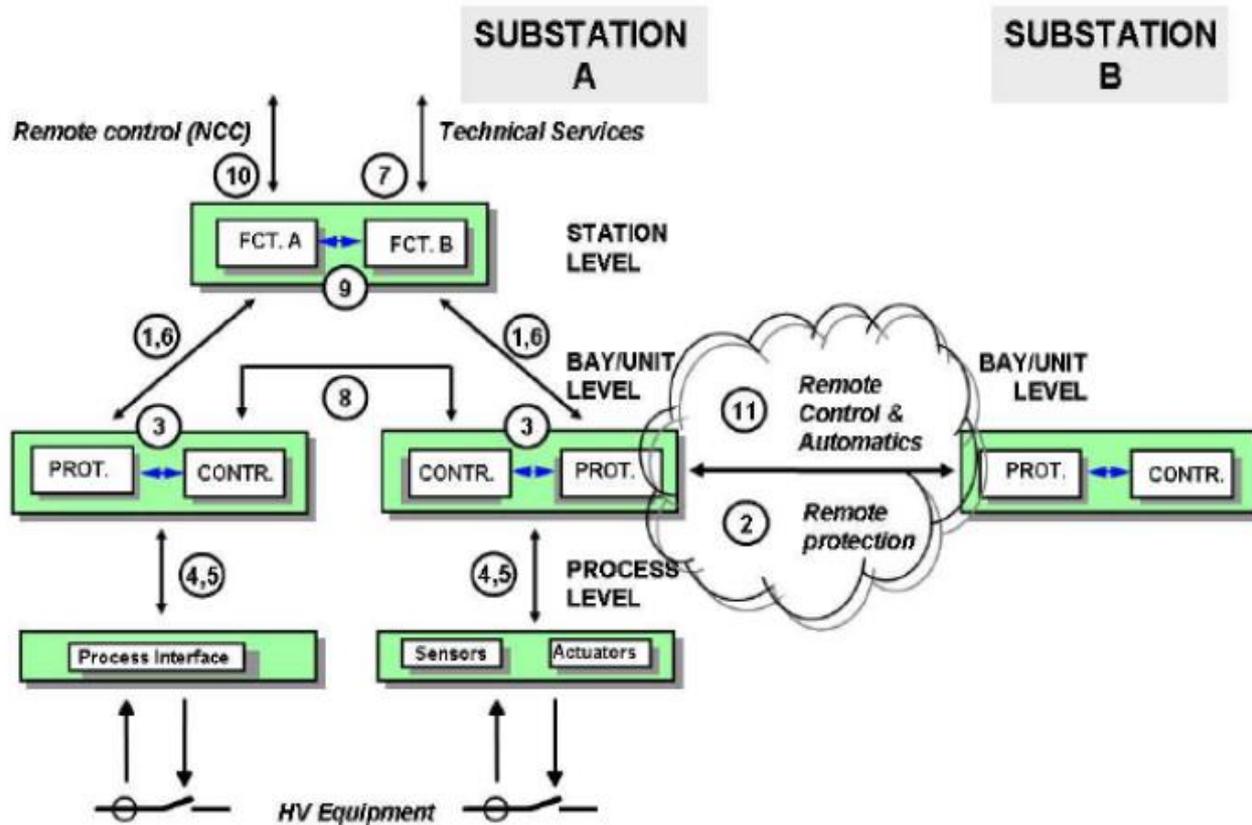
# Process Bus Definition



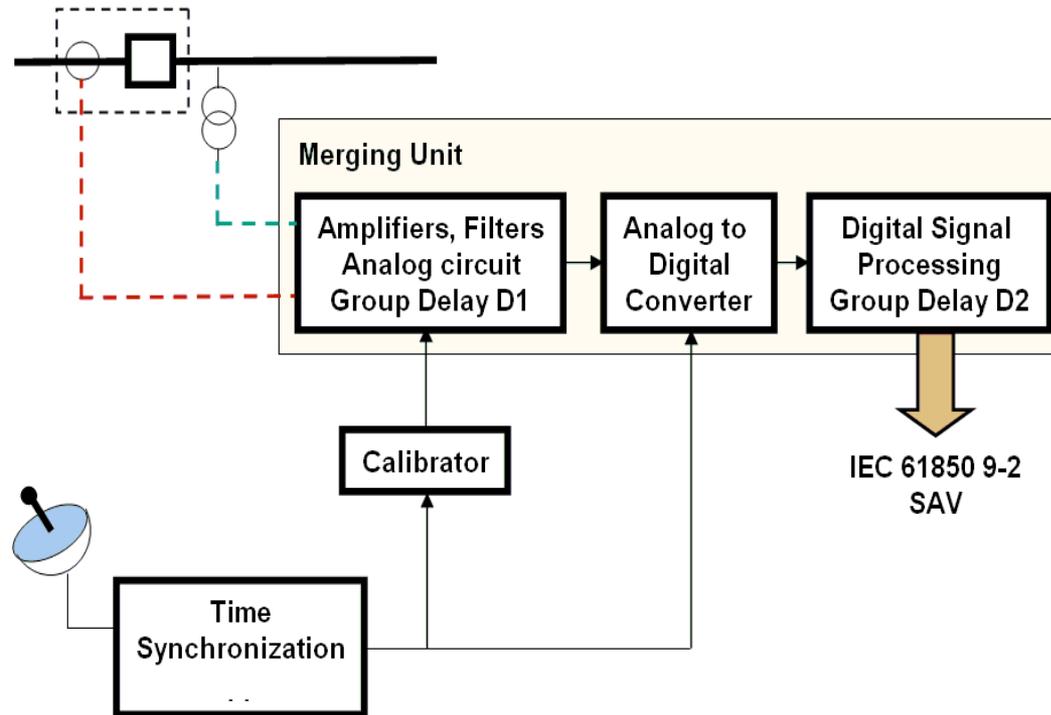
# Process Bus Definition



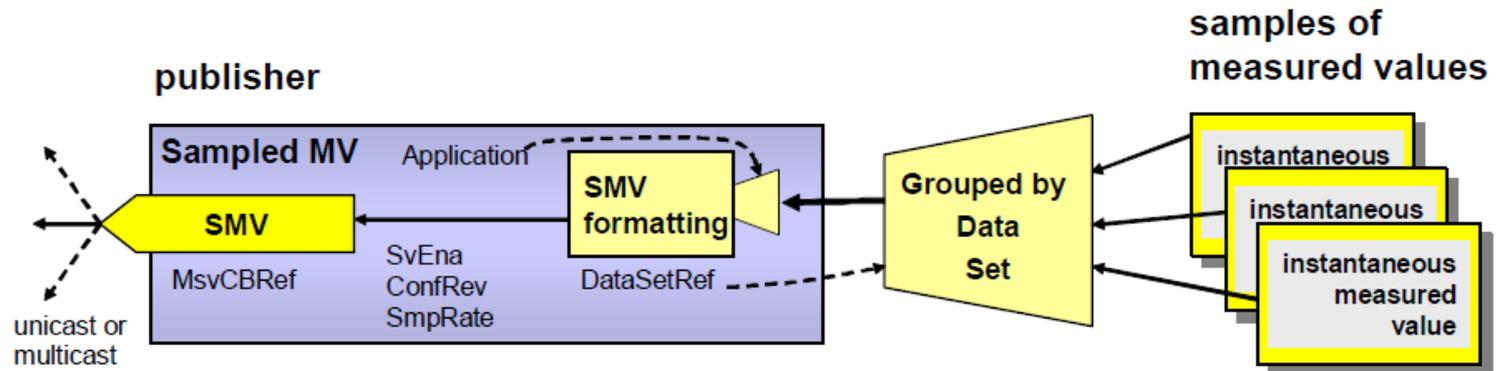
# IEC 61850 Interfaces



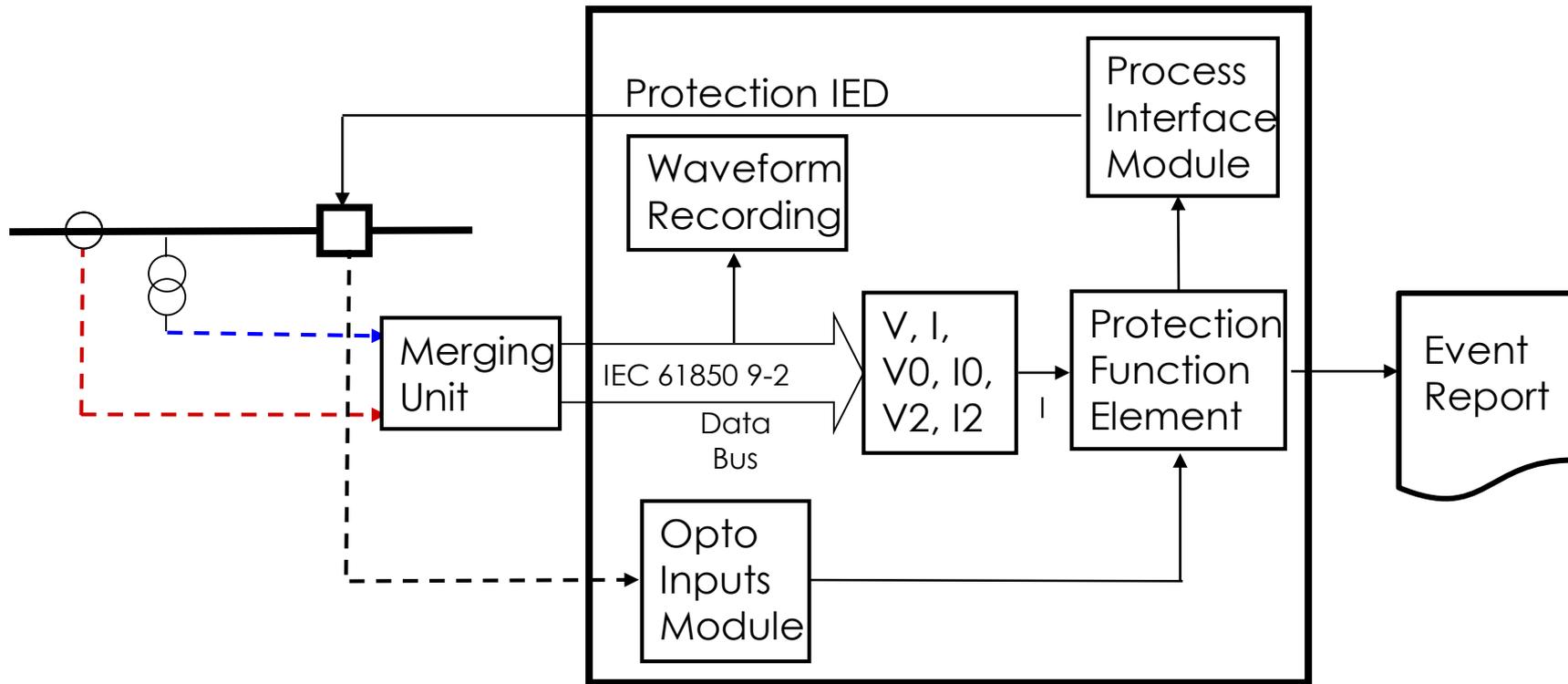
# Merging Unit functionality



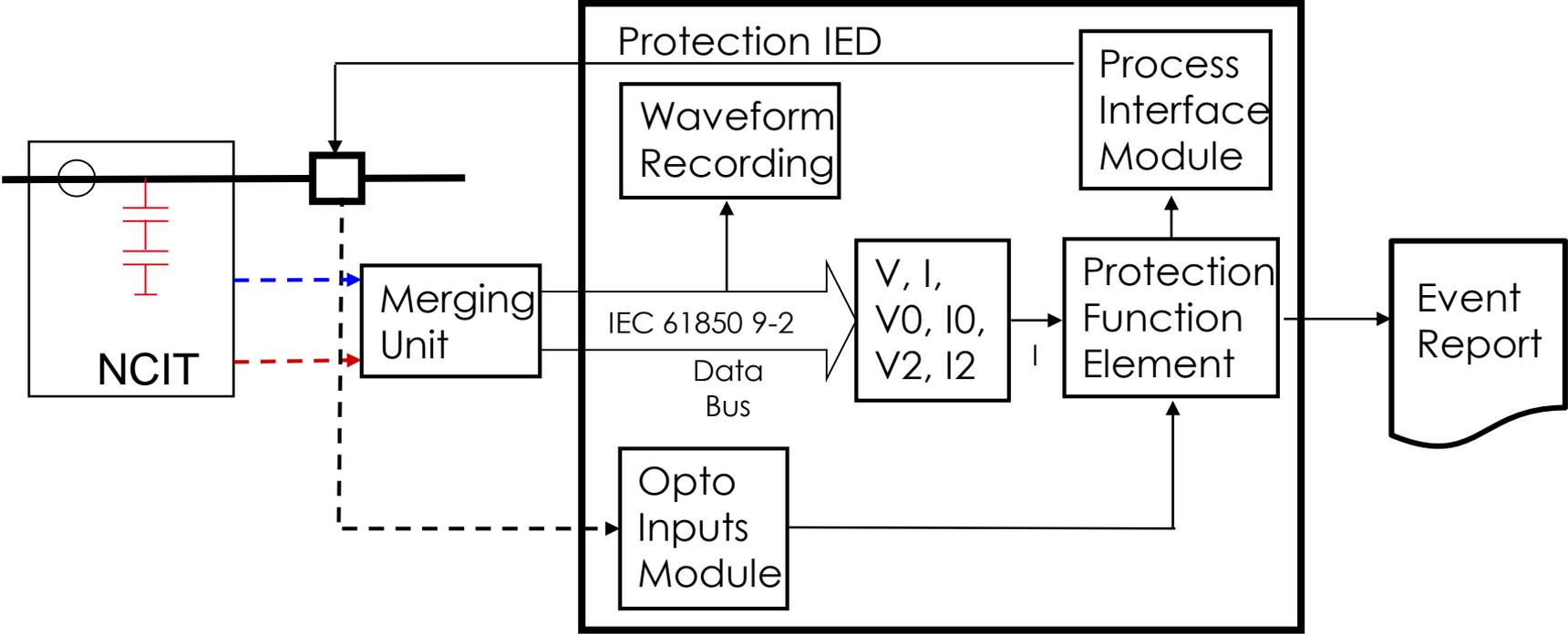
# SMV Publishing



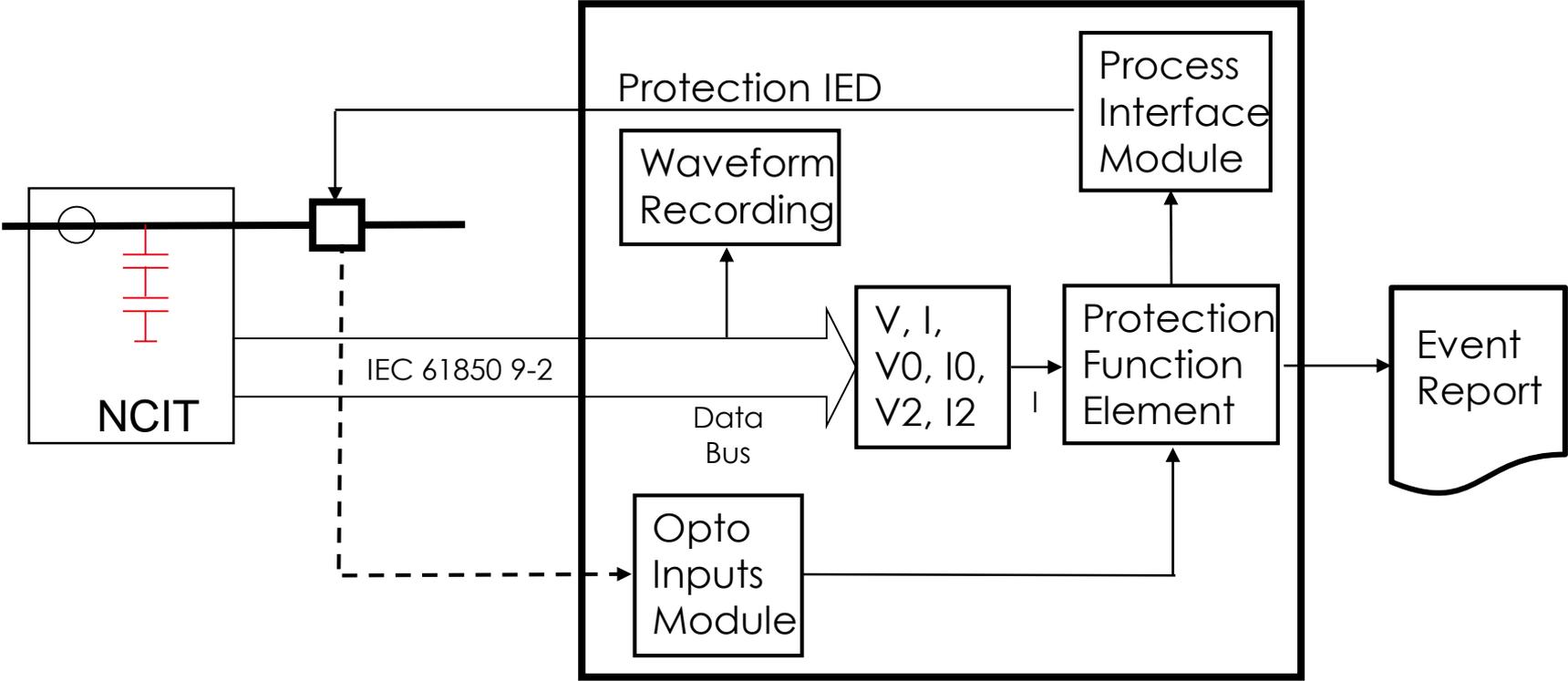
# Stand Alone Merging Unit



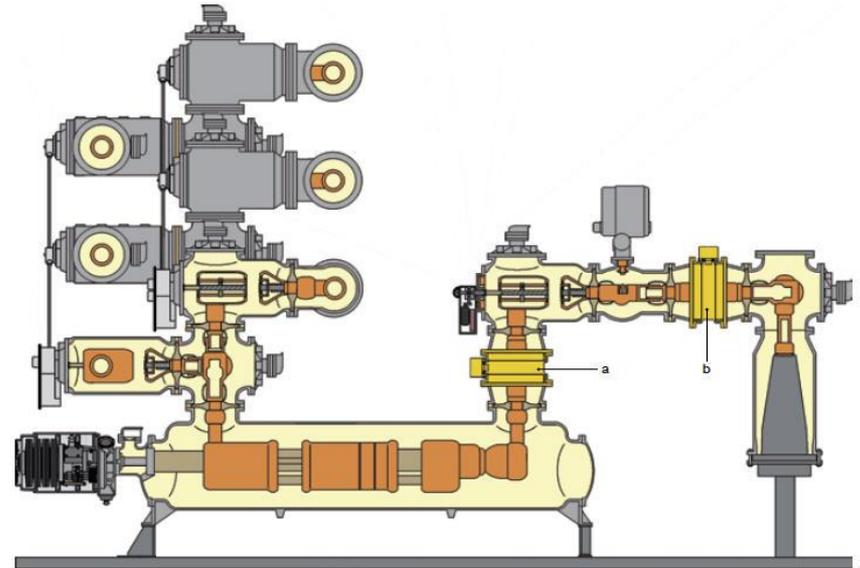
# NCIT with low level analog output



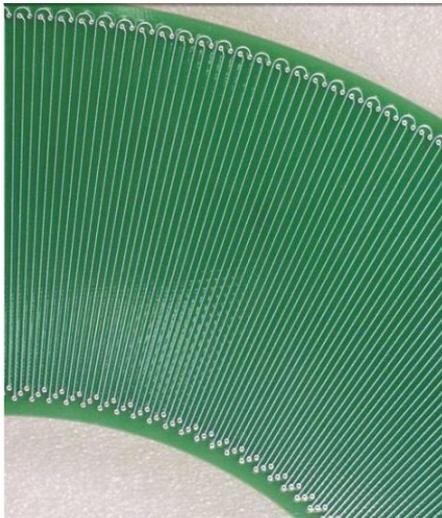
# NCIT with embedded MU



# ABB Combined NCIT Sensor



# GE NCITs

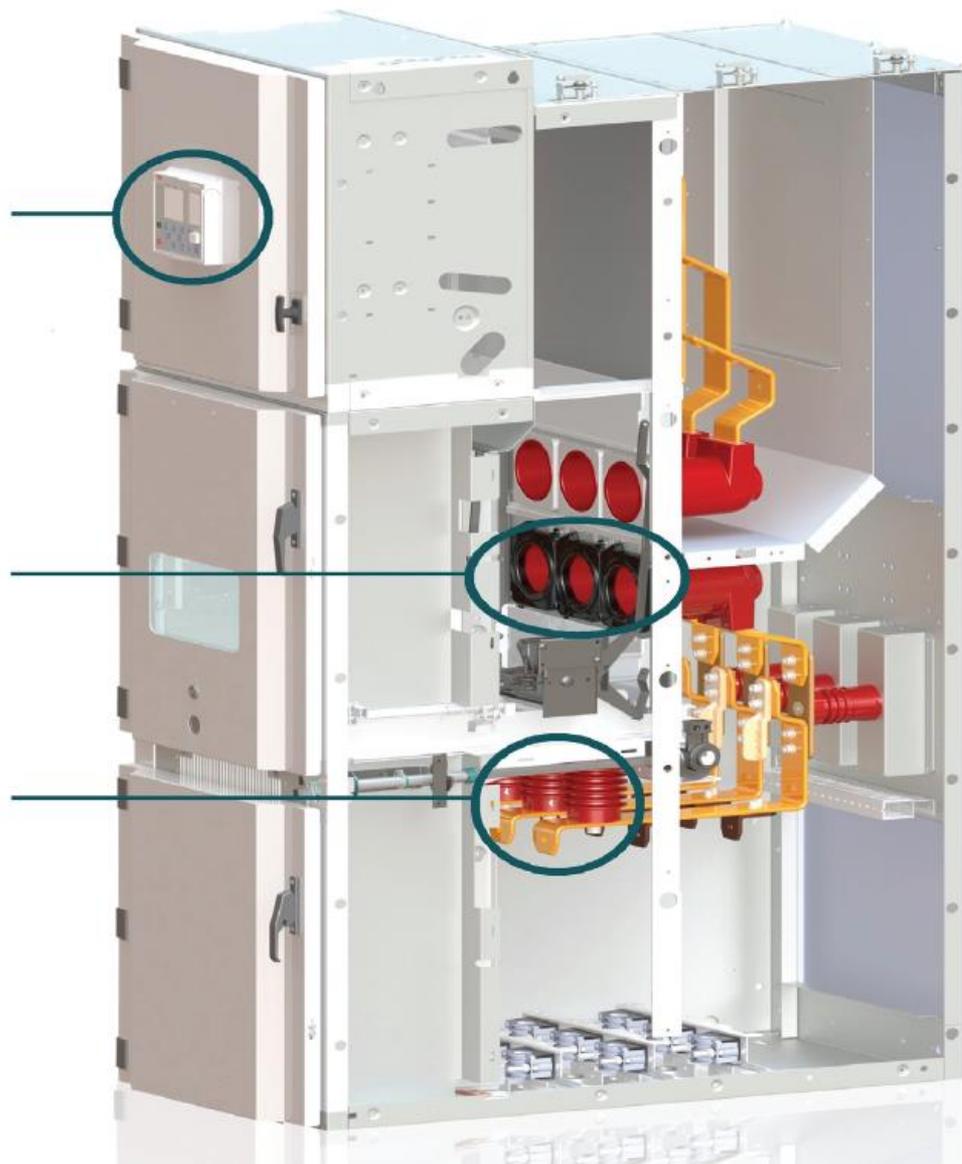


# MV NCIT Based Switchgear

Protection relay  
with IEC 61850

Current sensor

Voltage sensor



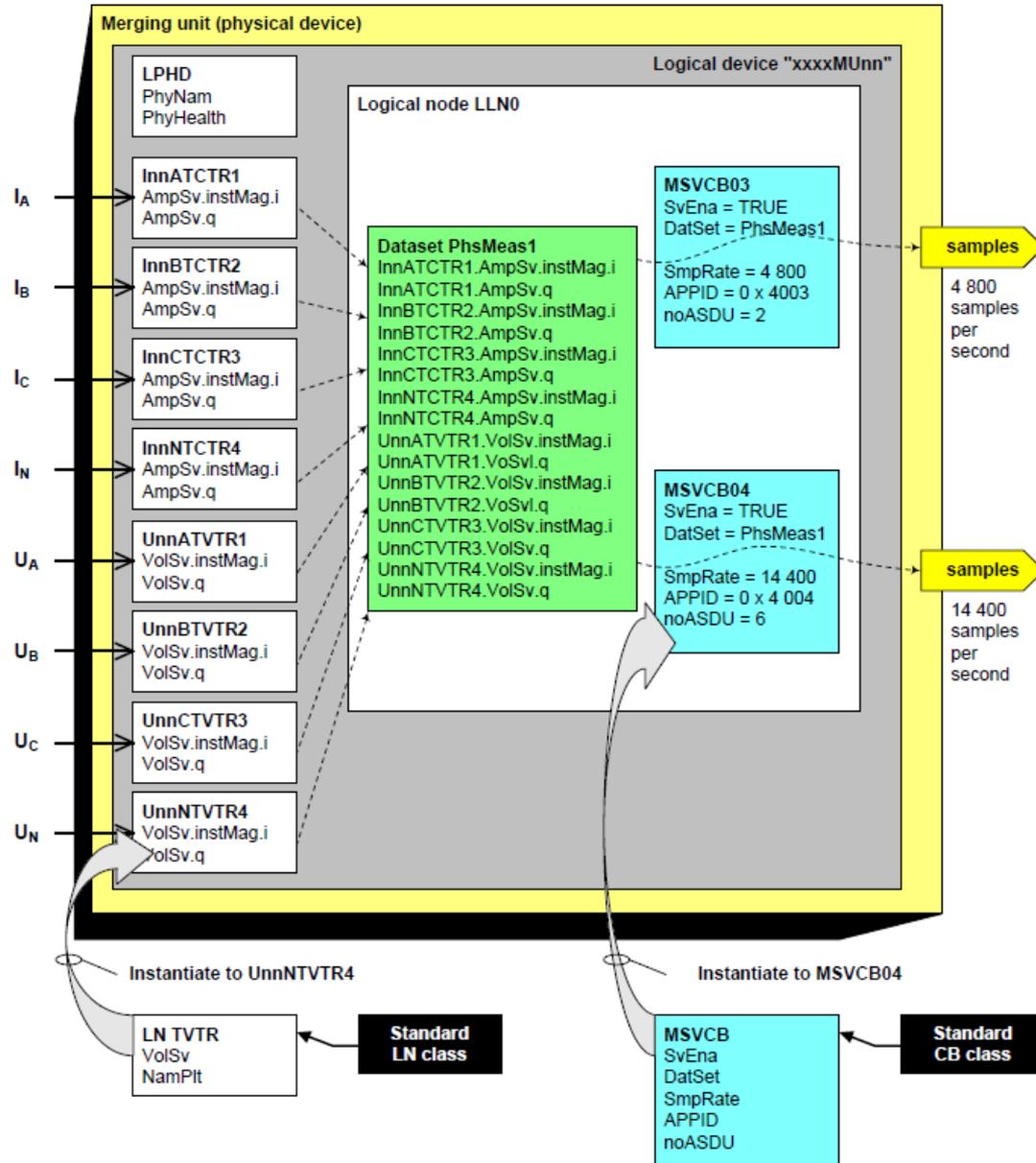
# MV NCITs



# IEC 61869 standards

PRODUCT FAMILY STANDARDS	PRODUCT STANDARD IEC	PRODUCTS	OLD STANDARD IEC	
<b>61869-1</b> GENERAL REQUIREMENTS FOR INSTRUMENT TRANSFORMERS	<b>61869-2</b>	ADDITIONAL REQUIREMENTS FOR CURRENT TRANSFORMERS	60044-1 60044-6	
	<b>61869-3</b>	ADDITIONAL REQUIREMENTS FOR INDUCTIVE VOLTAGE TRANSFORMERS	60044-2	
	<b>61869-4</b>	ADDITIONAL REQUIREMENTS FOR COMBINED TRANSFORMERS	60044-3	
	<b>61869-5</b>	ADDITIONAL REQUIREMENTS FOR CAPACITOR VOLTAGE TRANSFORMERS	60044-5	
	<b>61869-6</b> ADDITIONAL GENERAL REQUIREMENTS FOR LOW POWER INSTRUMENT TRANSFORMERS	<b>61869-7</b>	ADDITIONAL REQUIREMENTS FOR ELECTRONIC VOLTAGE TRANSFORMERS	60044-7
		<b>61869-8</b>	ADDITIONAL REQUIREMENTS FOR ELECTRONIC CURRENT TRANSFORMERS	60044-8
		<b>61869-9</b>	DIGITAL INTERFACE FOR INSTRUMENT TRANSFORMERS	
		<b>61869-10</b>	ADDITIONAL REQUIREMENTS FOR LOW POWER PASSIVE CURRENT TRANSFORMERS	
		<b>61869-11</b>	ADDITIONAL REQUIREMENTS FOR LOW POWER VOLTAGE TRANSFORMERS	60044-7
		<b>61869-12</b>	ADDITIONAL REQUIREMENTS FOR COMBINED ELECTRONIC INSTRUMENT TRANSFORMERS AND COMBINED STAND ALONE INSTRUMENT TRANSFORMERS	
		<b>61869-13</b>	STAND ALONE MERGING UNIT	
		<b>61869-14</b>	ADDITIONAL REQUIREMENTS FOR DC CURRENT TRANSFORMERS	
		<b>61869-15</b>	ADDITIONAL REQUIREMENTS FOR DC VOLTAGE TRANSFORMERS FOR DC APPLICATIONS	

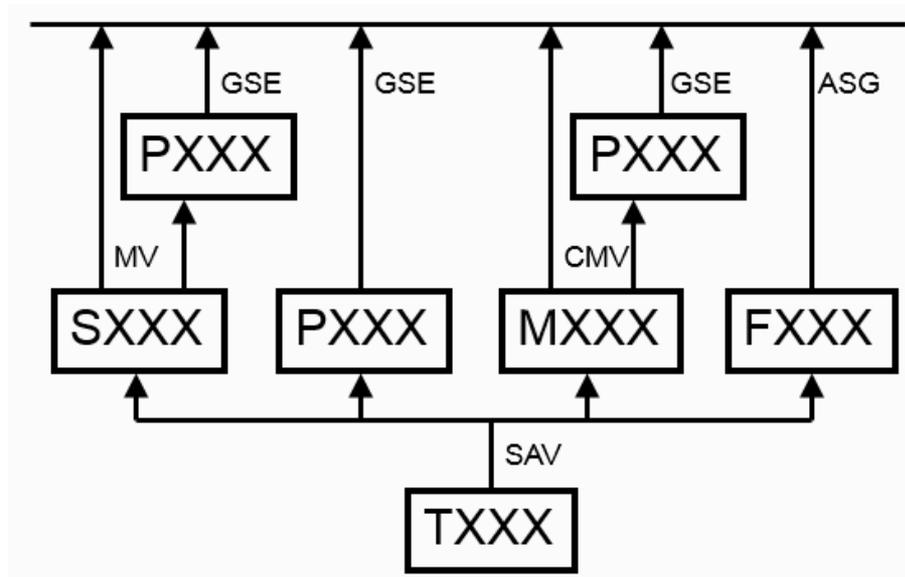
# MU data objects



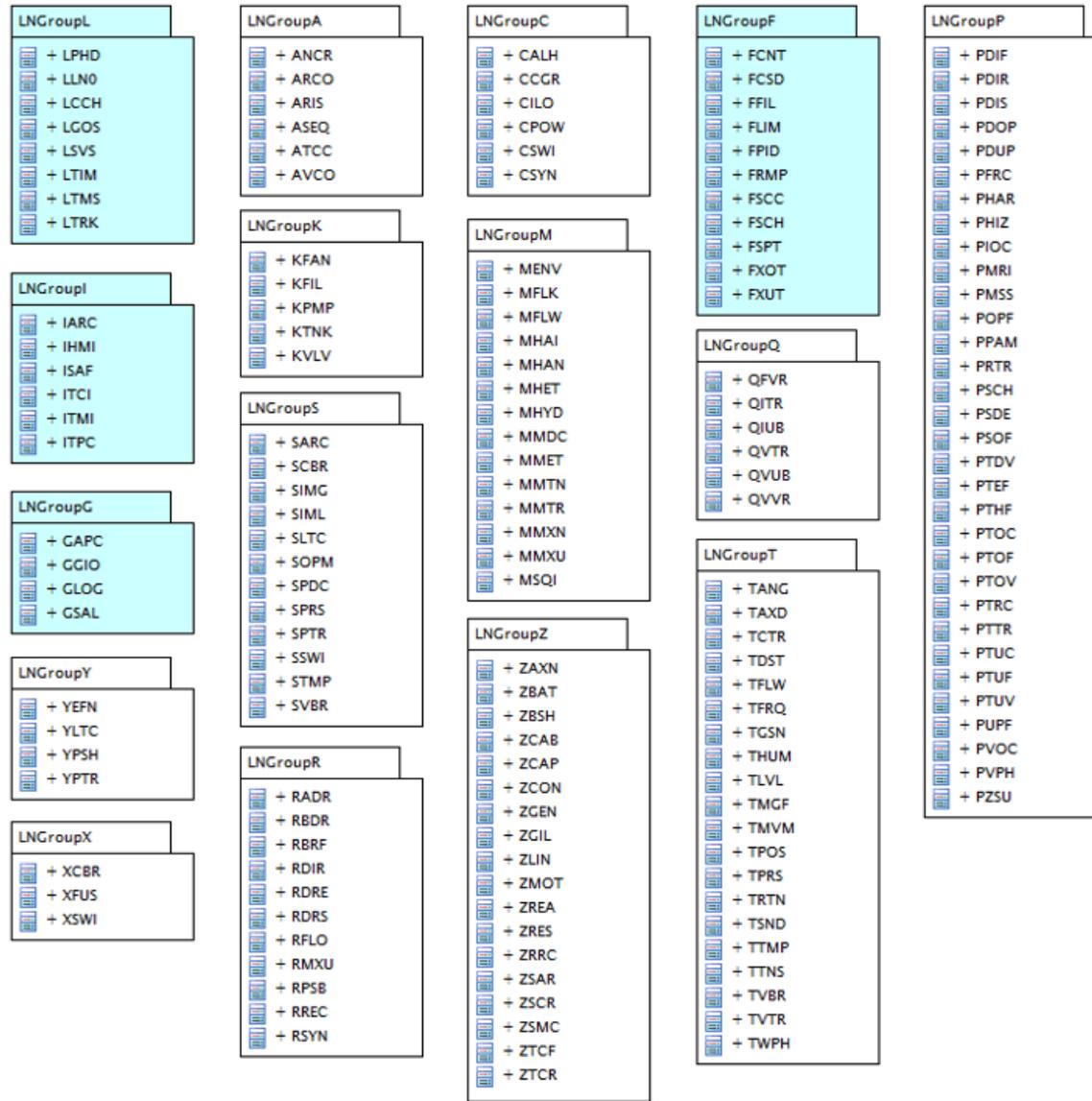
## Digital output sampling rates

Digital output sample rates Hz	Number of ASDUs per frame	Digital output publishing rate frames/s	Remarks
4 000	1	4 000	For use on 50 Hz systems backward compatible with 9-2LE guideline.
4 800	1	4 800	For use on 60 Hz systems backward compatible with 9-2LE guideline, or 50 Hz systems backward compatible with 96 samples per nominal system frequency cycle.
4 800	2	2 400	Preferred rate for general measuring and protective applications, regardless of the power system frequency.
5 760	1	5 760	For applications on 60 Hz systems backward compatible with 96 samples per nominal system frequency cycle.
12 800	8	1 600	Deprecated, only for use on 50 Hz systems.
14 400	6	2 400	Preferred rate for quality metering applications, regardless of the power system frequency including instrument transformers for time critical low bandwidth d.c. control applications.
15 360	8	1 920	Deprecated, only for use on 60 Hz systems.
96 000	1	96 000	Preferred rate for instrument transformers for high bandwidth d.c. control applications.

# Abstract Functional Decomposition



# Class diagram LNs::LN Groups



## Sensors LNs

- Angle sensor Name: TANG
- Axial displacement sensor Name: TAXD
- Current transformer Name: TCTR
- Distance sensor Name: TDST
- Liquid flow sensor Name: TFLW
- Frequency sensor Name: TFRQ
- Generic sensor Name: TGSN
- Humidity sensor Name: THUM

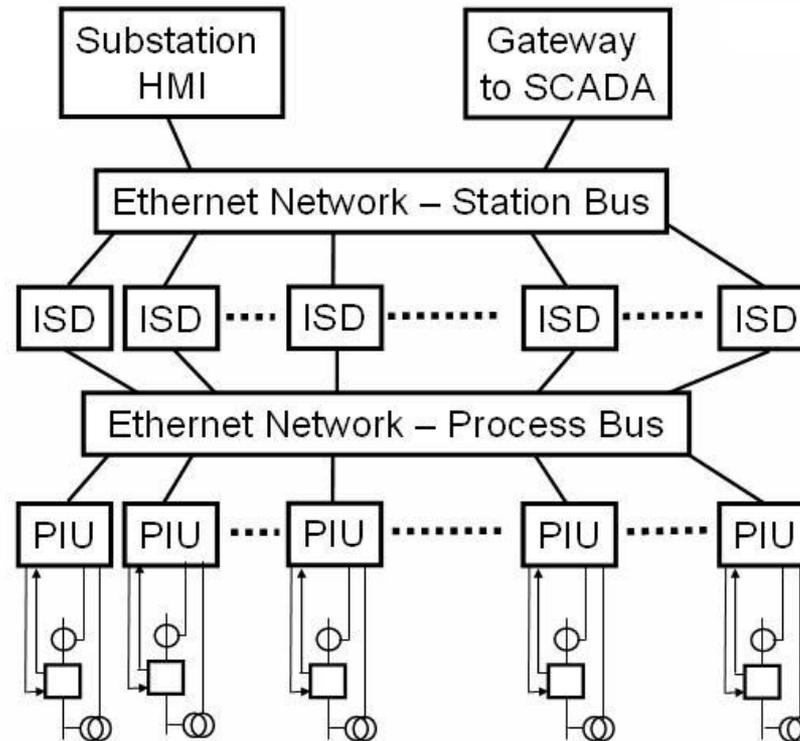
## Sensors LNs

- Humidity sensor Name: THUM
- Media level sensor Name: TLVL
- Magnetic field sensor Name: TMGF
- Movement sensor Name: TMVM
- Position indicator Name: TPOS
- Pressure sensor Name: TPRS
- Rotation transmitter Name: TRTN
- Sound pressure sensor Name: TSND

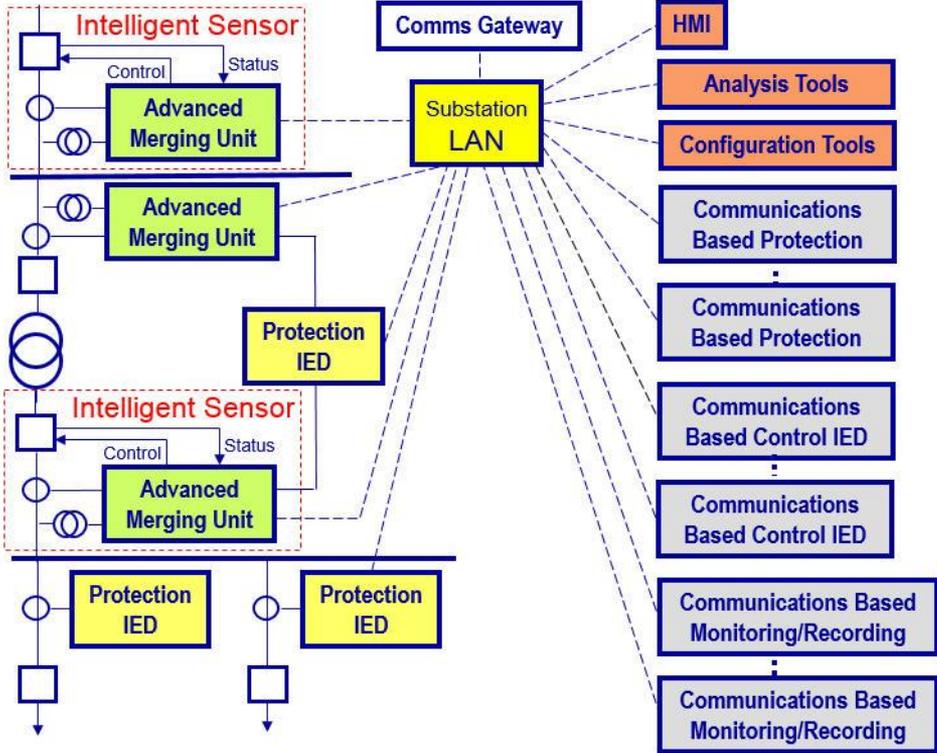
## Sensors LNs

- Sound pressure sensor Name: TSND
- Temperature sensor Name: TTMP
- Mechanical tension / stress sensor Name: TTNS
- Vibration sensor Name: TVBR
- Voltage transformer Name: TVTR
- Water acidity sensor Name: TWPH

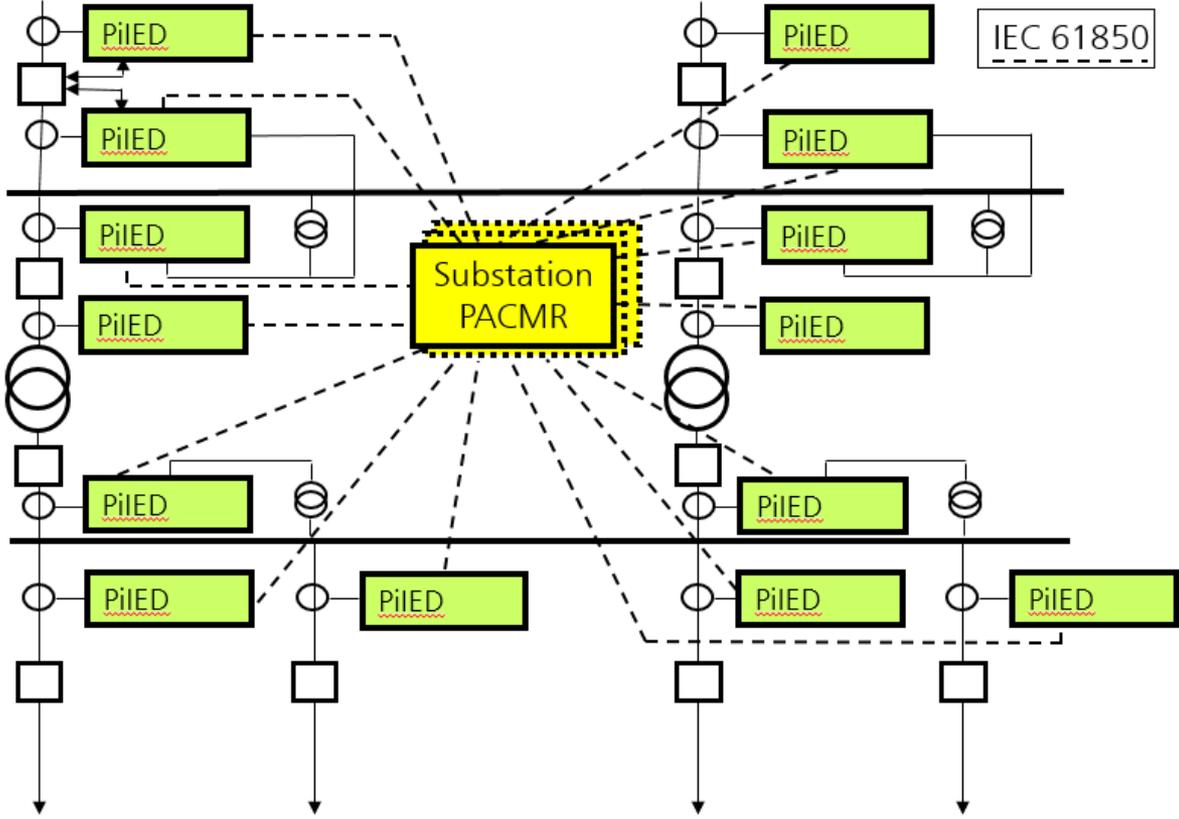
# System Architecture



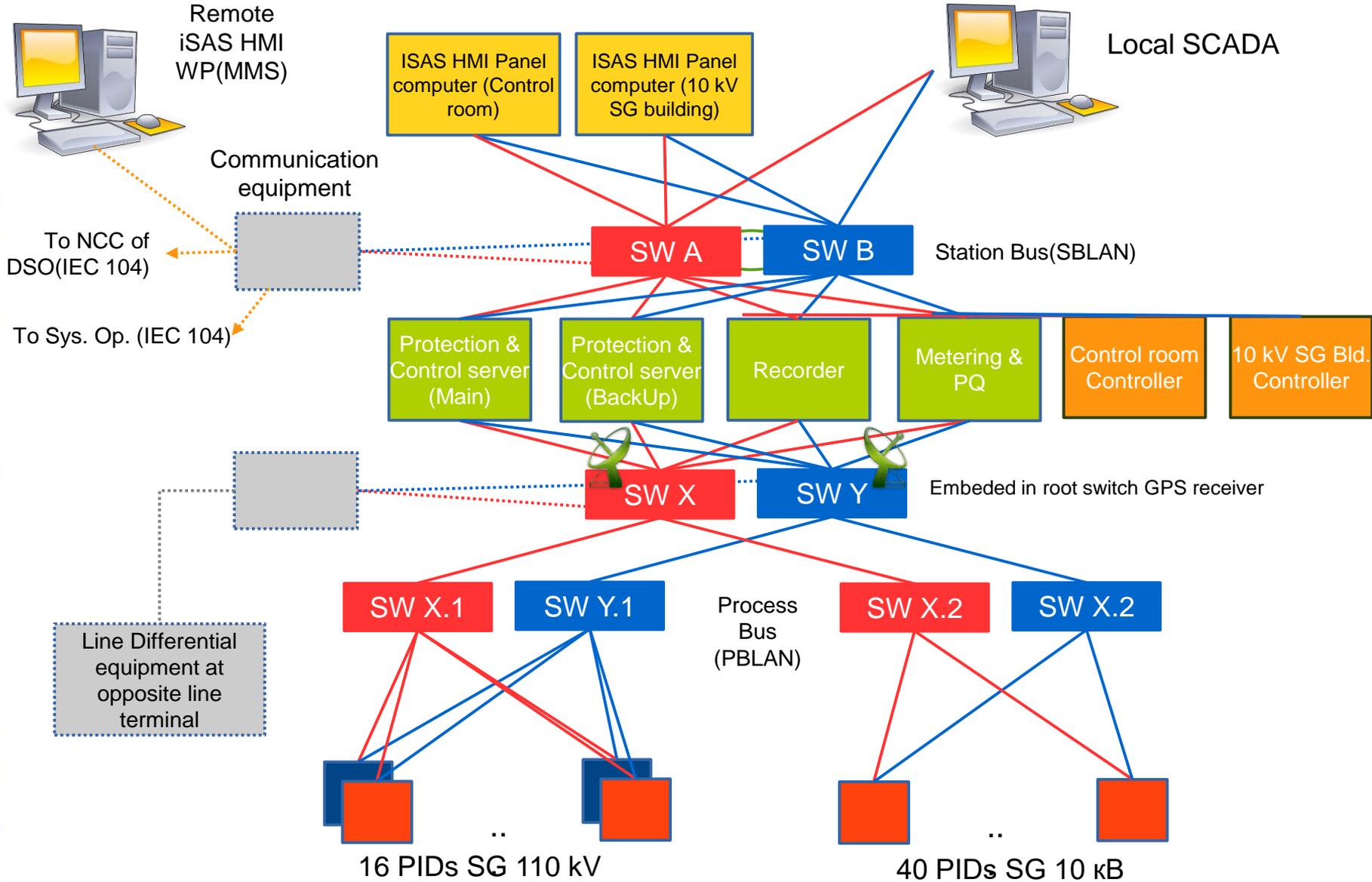
# Distributed Substation Design



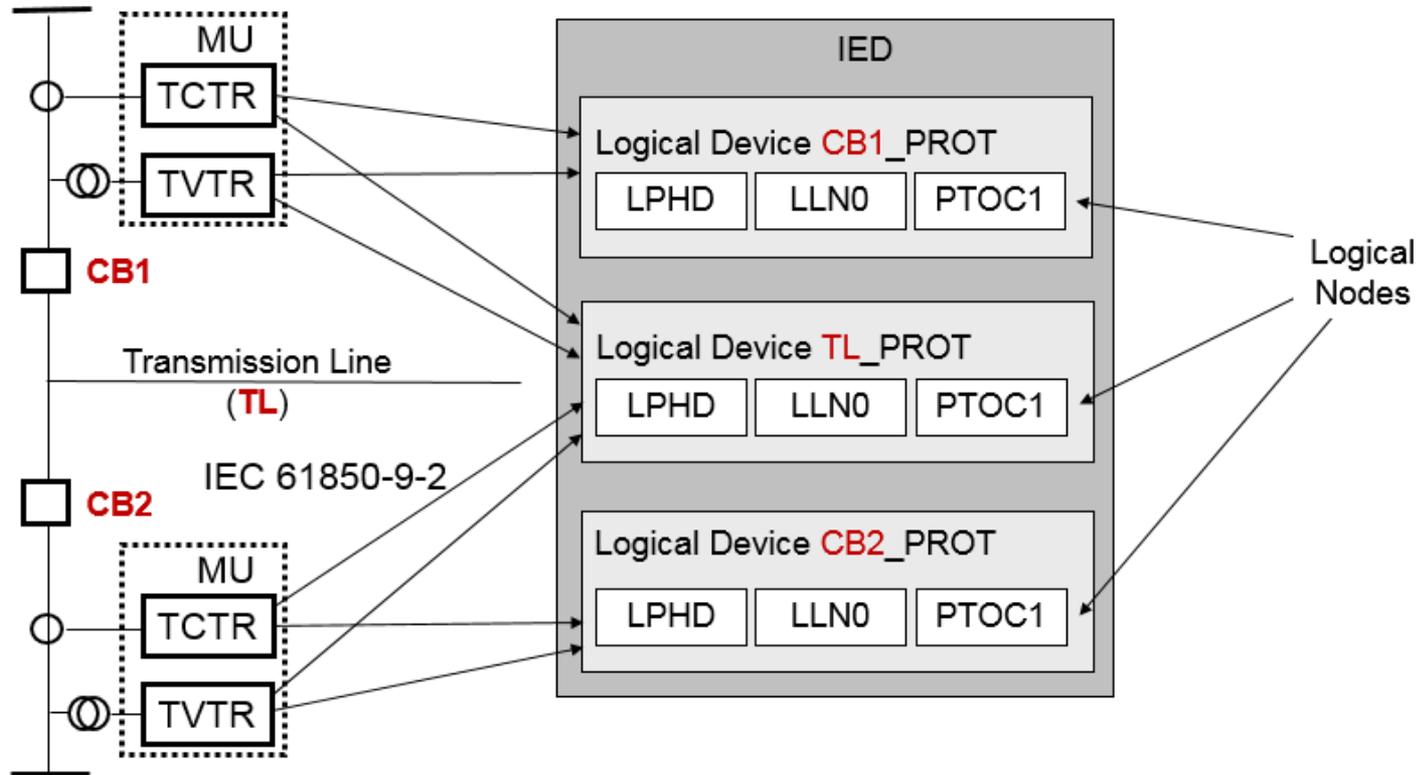
# Centralized Substation Design



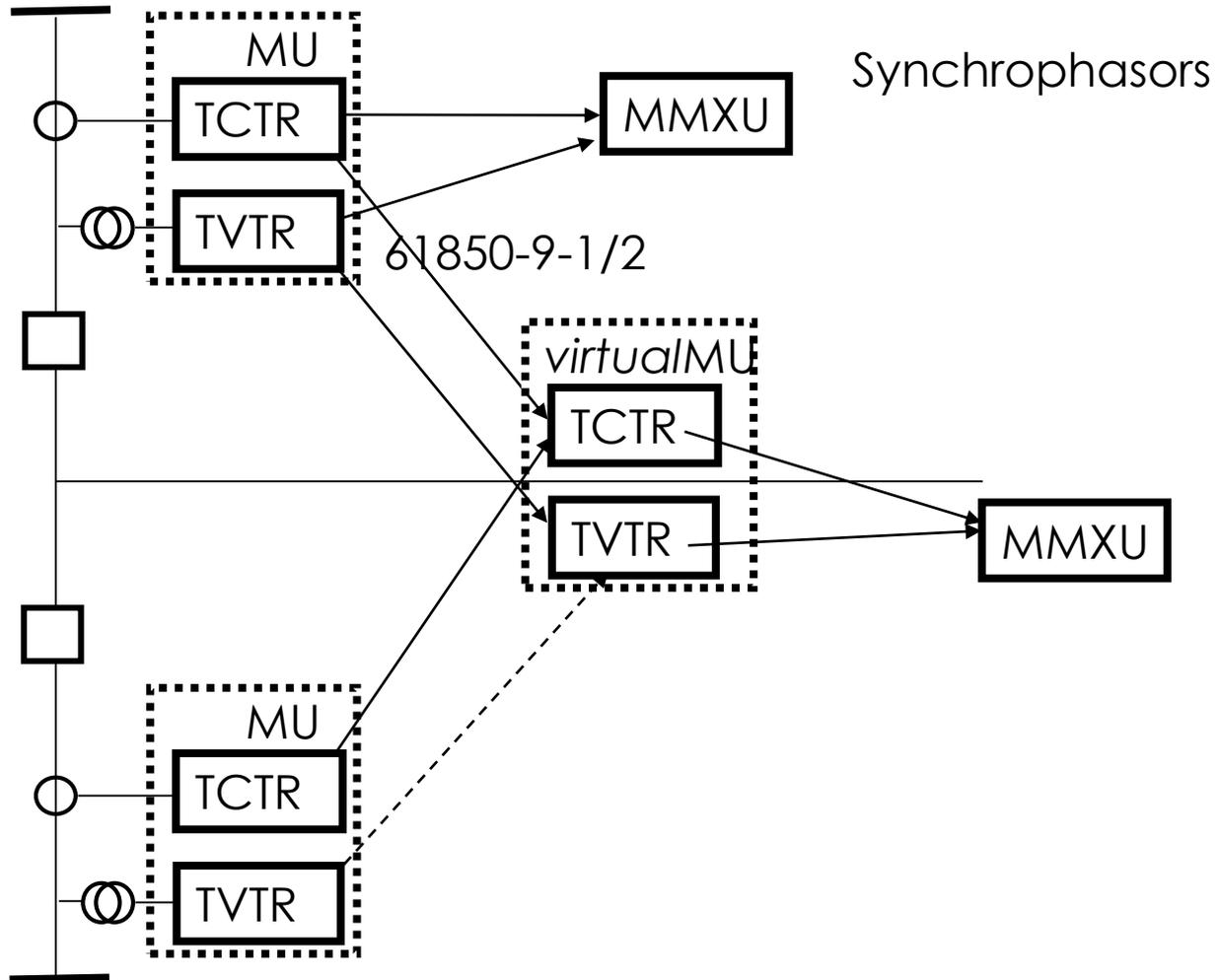
# PAC System physical structure



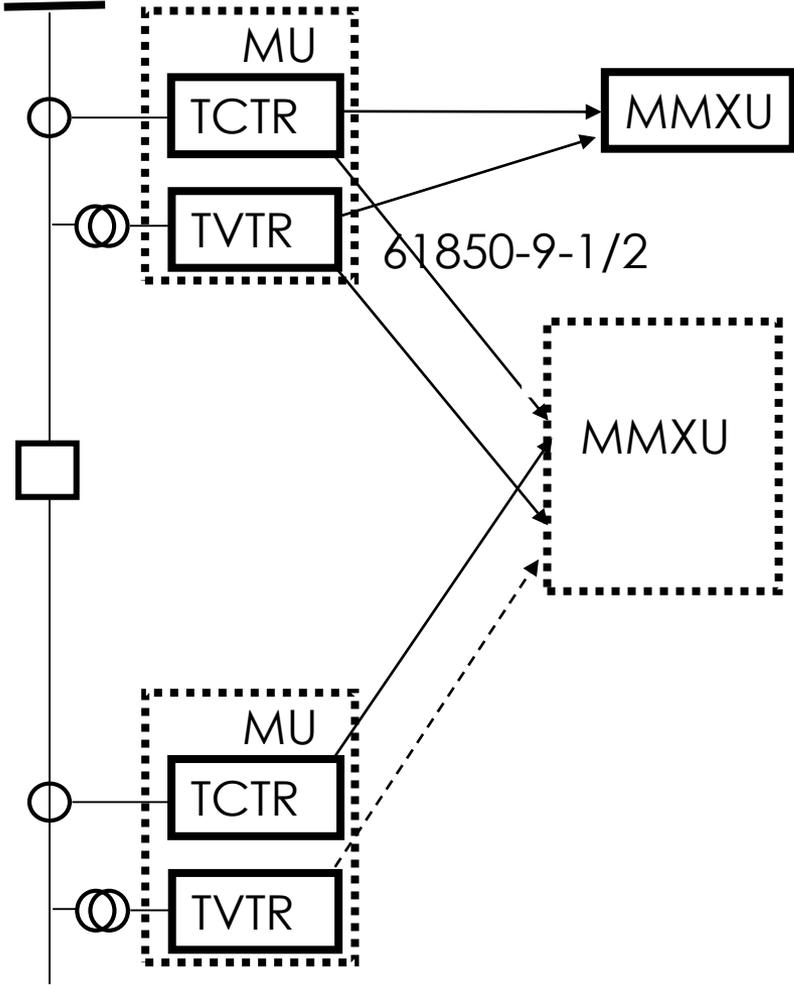
# Virtual MU



# Local Virtual Measurements



# Redundant Interface

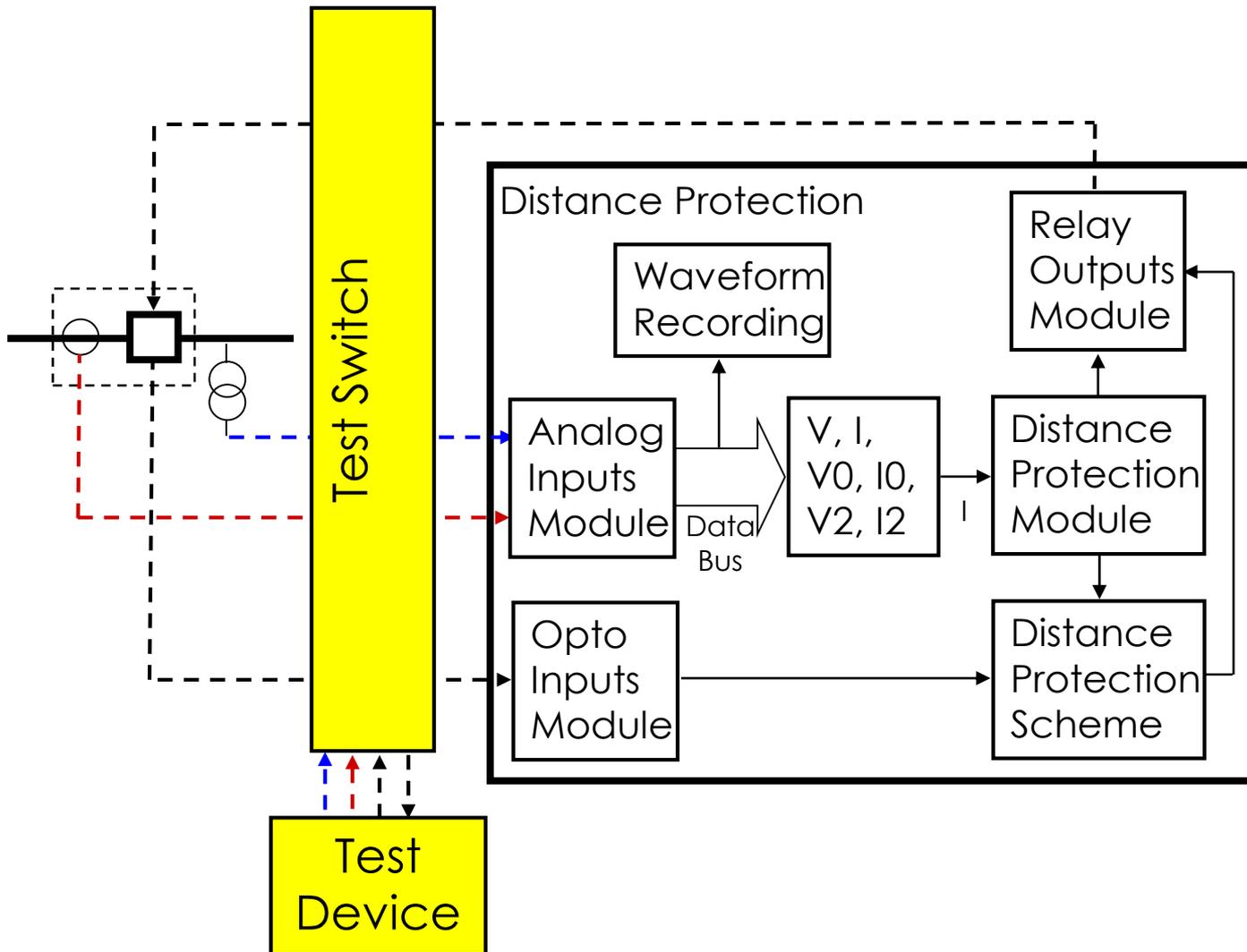




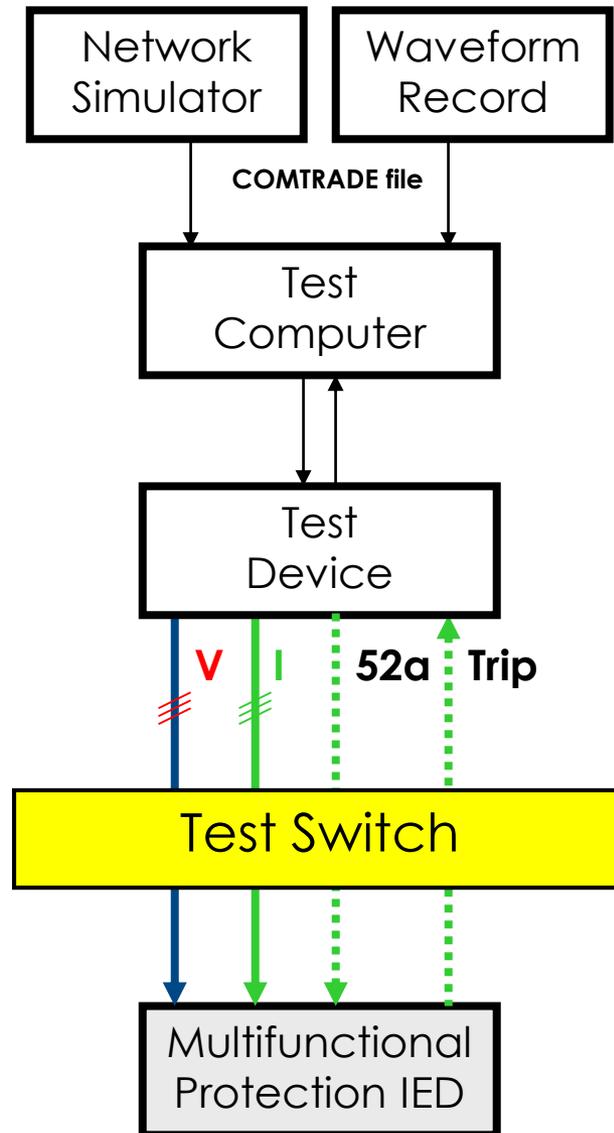
# Quality and Efficiency



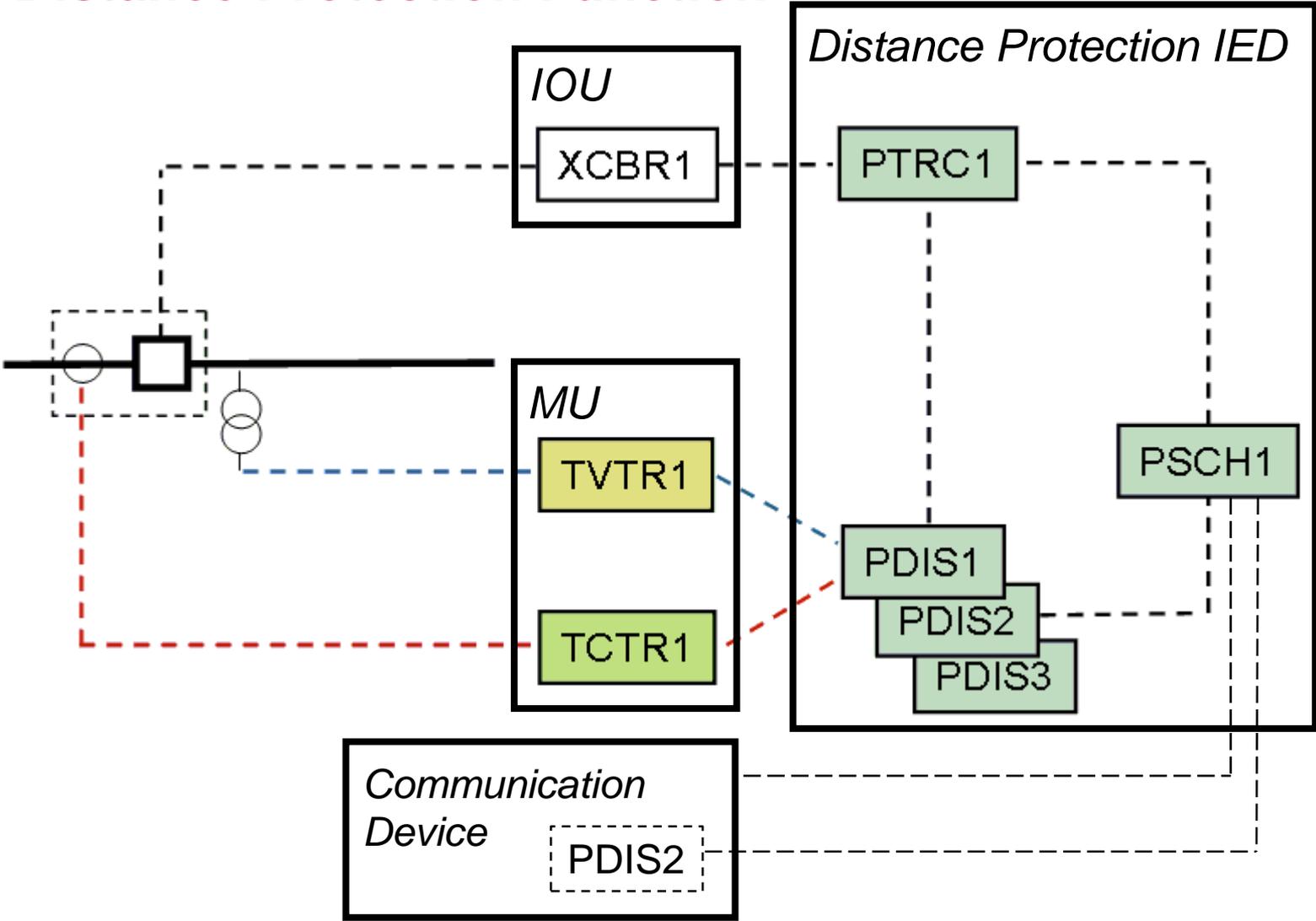
# Protection Testing



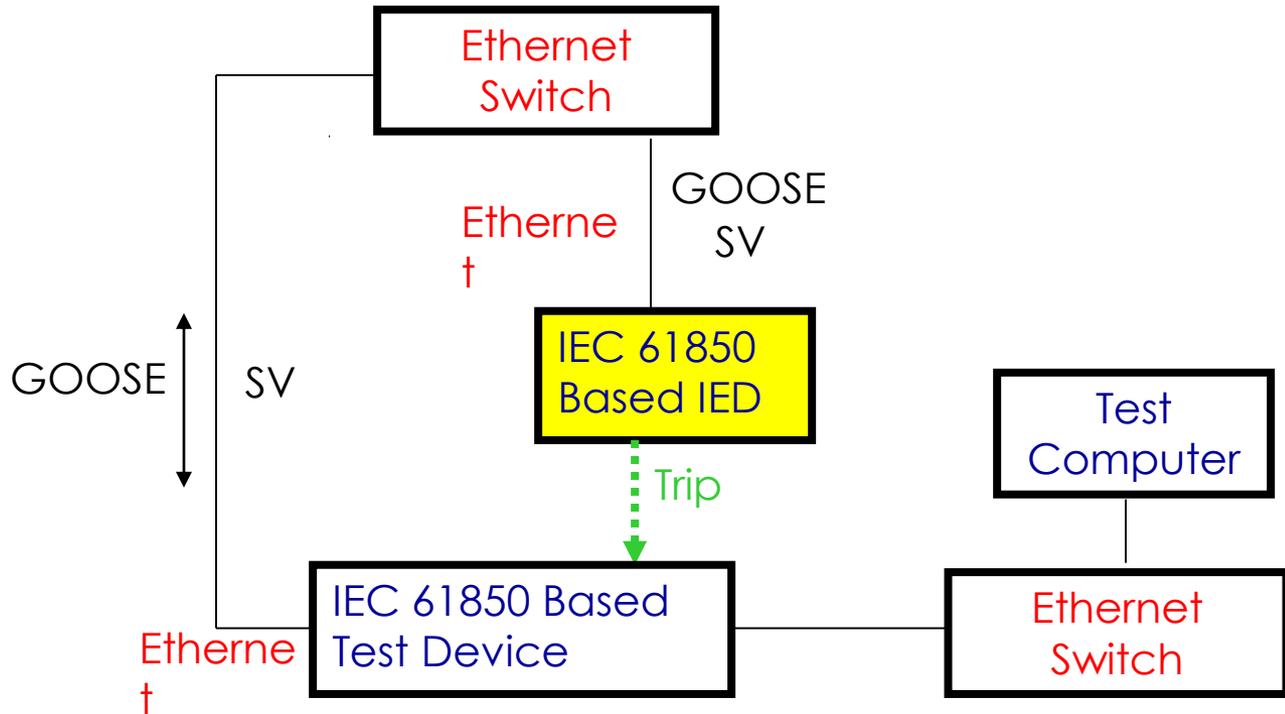
# Conventional Test Setup



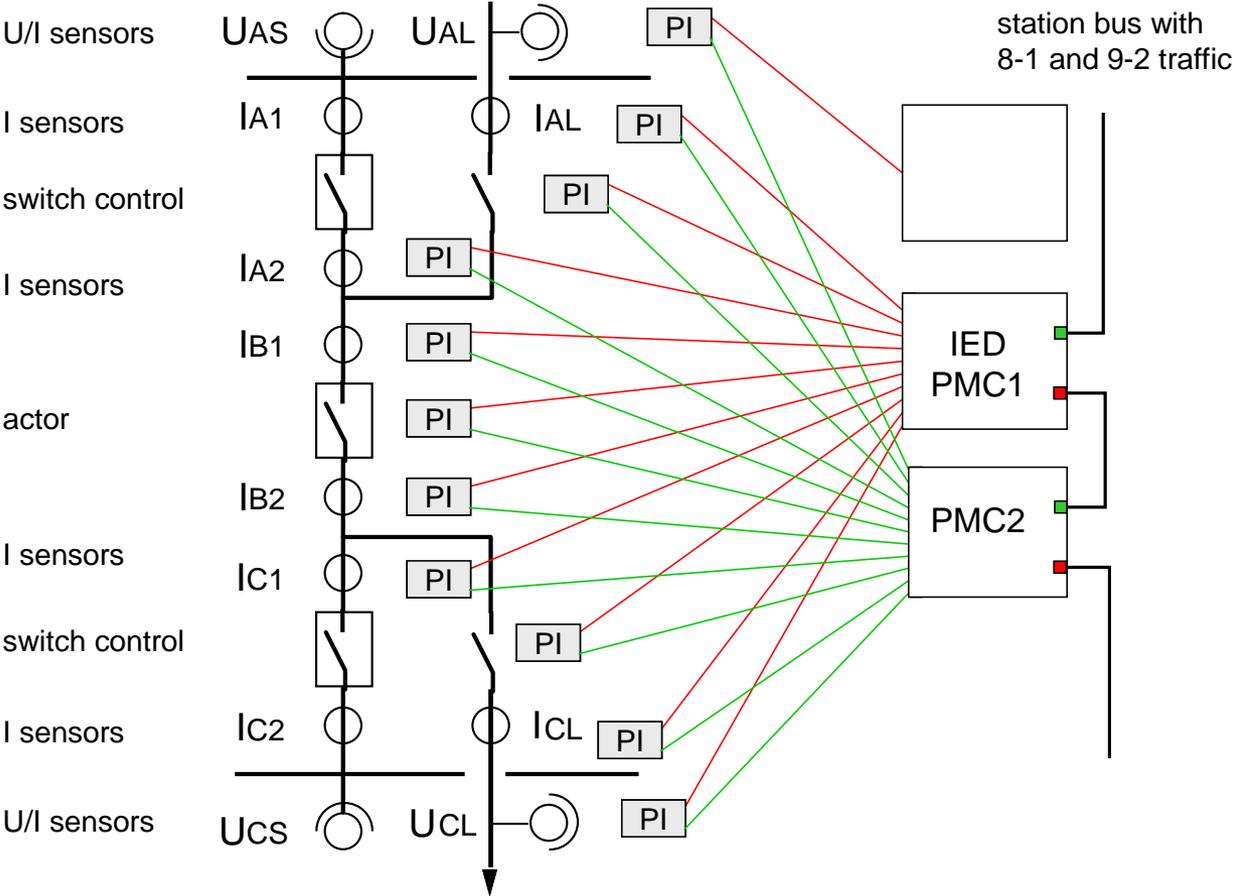
# Distance Protection Function



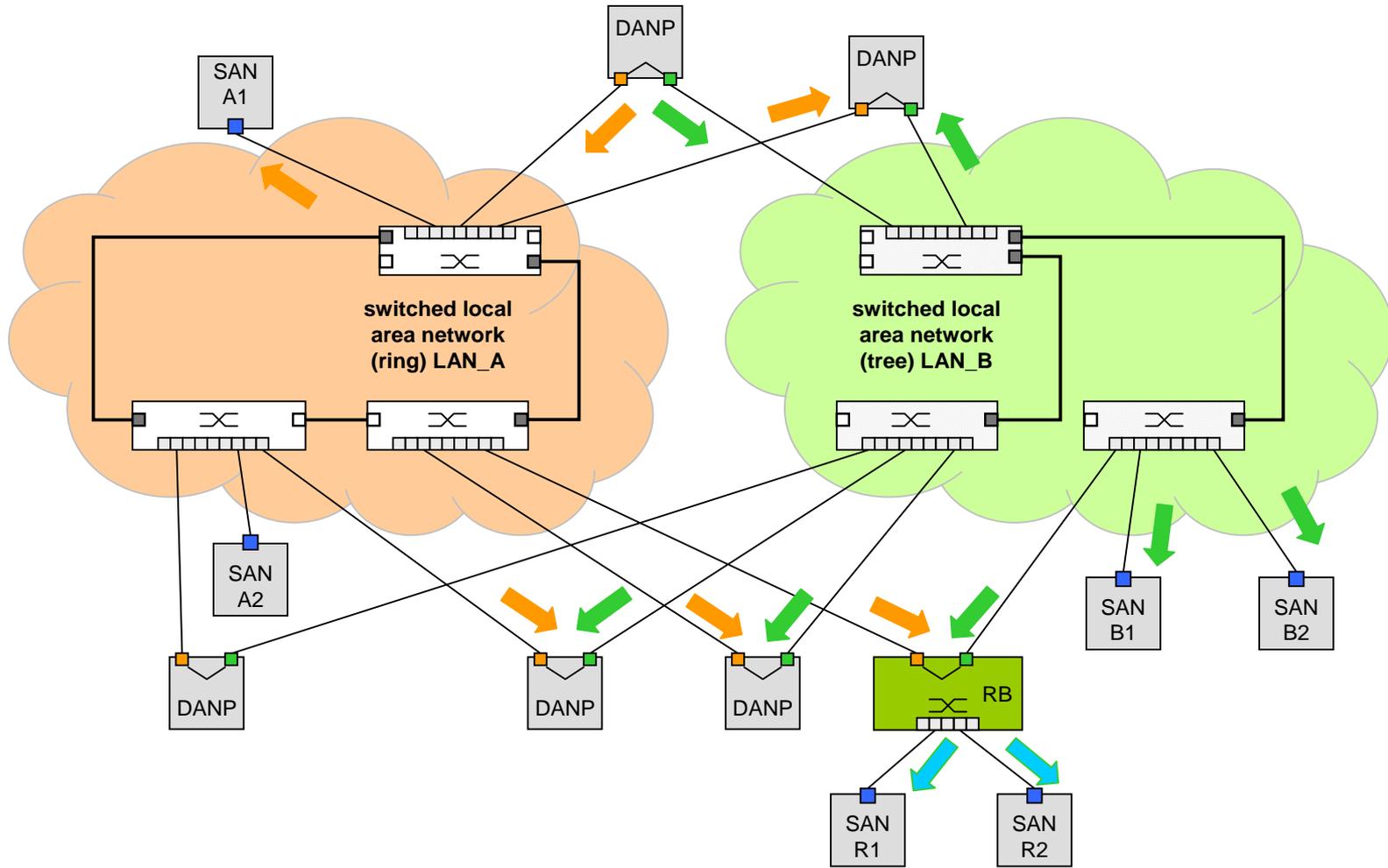
# Process Bus Test setup



# Process Bus Monitoring



# Monitoring vs. Testing



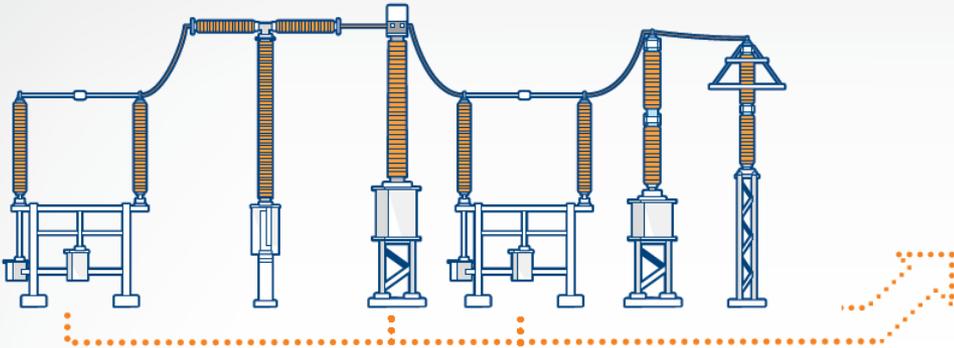
SAN - Singly Attached Nodes  
DAN - Doubly Attached Nodes

# Reduced Installation Costs

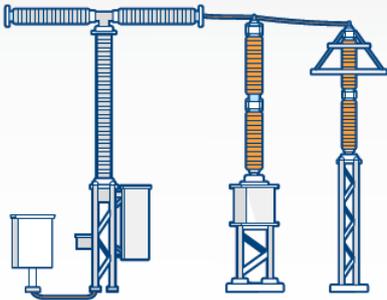
- Reduced costs due to the replacement of hundreds or even thousands control cables with a limited number of fiber optic cables
- Reduced costs due to the replacement of the wiring of hundreds of copper wires to the panels' terminal blocks and then from the terminal blocks to the relay terminals with the plugging in of a few pairs of fiber cables
- Reduced costs due to the requirements for testing of all hard wired interfaces versus the testing of the GOOSE messages based on advanced software tools

# DCB with FOCS

CONVENTIONAL AIR-INSULATED SWITCHGEAR BAY

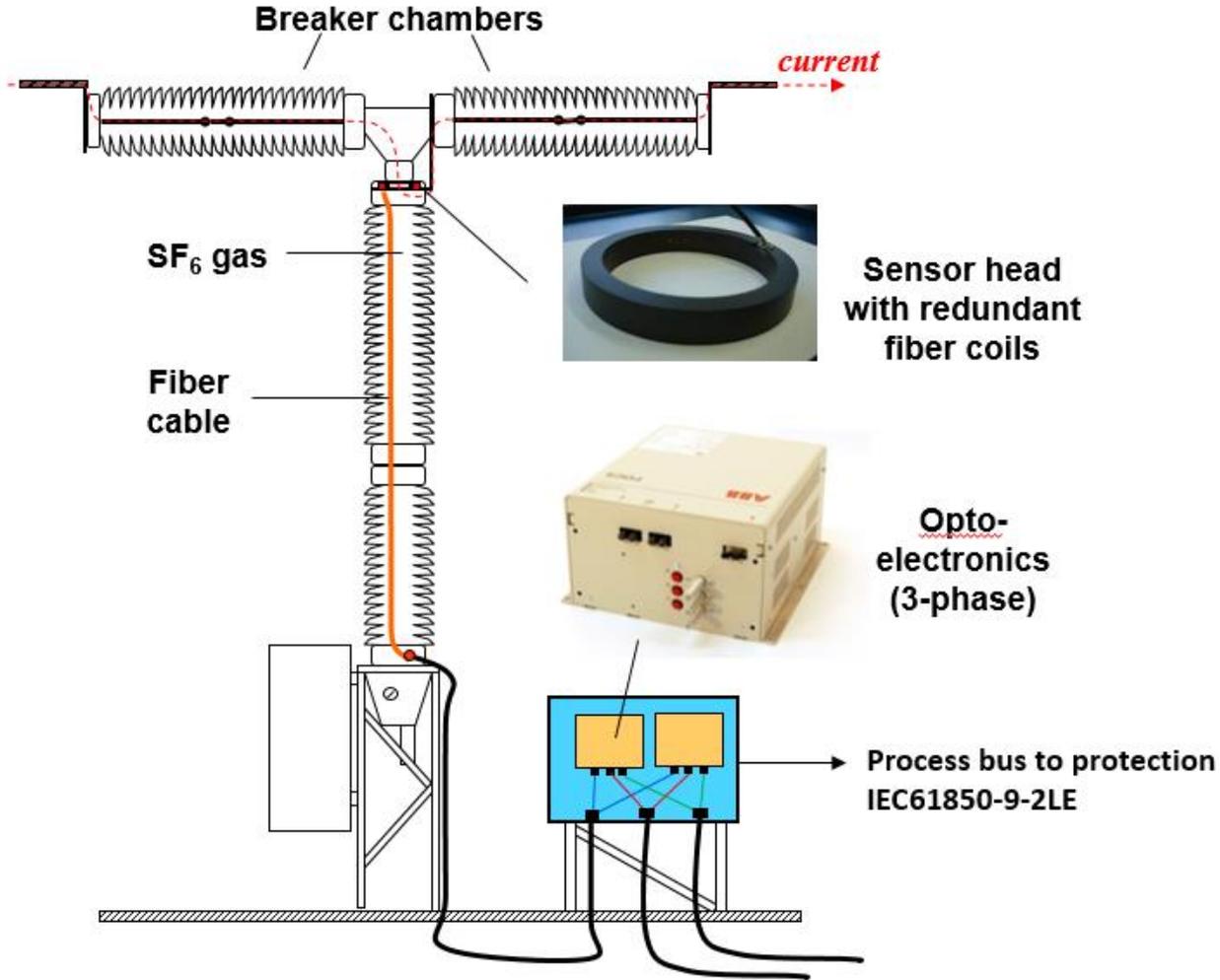


INTEGRATED SWITCHGEAR BAY



DCB with FOCS  
(Disconnecting Circuit  
Breaker with Fiber Optic  
Current Sensor)

# DCB with FOCS



Fiber Optic Sensor (FOCS in DCB)

## Other Benefits

- Improved safety
- Reduced probability for CT saturation
- Improved flexibility
- Reduced maintenance
- Improved interoperability
- Improved reliability
- Remote testing

# Remote Testing

