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

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Questions

> What are we doing?
> Why are we doing it?
> How are we doing it?
Conventional Substation
Conventional Substations
Conventional IED

Protection IED

Waveform Recording

V, I, V0, I0, V2, I2

Protection Function Element

Process Interface Module

Analog Inputs Module

Data Bus

Event Report

Opto Inputs Module
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
Process Bus Definition

- Remote control (NCC)
- Technical services

SUBSTATION LEVEL FUNCTIONS

Bay Unit
- Control
- Metering
- Disturbance recorder
- Misc. Functions

Protection
- Protection
- Disturbance recorder

Instrumental transformers
TC38

Switchgear and transformer
TC14, TC17

Instrumental transformers
TC38

Switchgear and transformer
TC14, TC17
Process Bus Definition
IEC 61850 Interfaces
Merging Unit functionality

Merging Unit

Amplifiers, Filters
Analog circuit
Group Delay D1

Analog to
Digital
Converter

Digital Signal
Processing
Group Delay D2

Calibrator

Time Synchronization

IEC 61850 9-2
SAV
Stand Alone Merging Unit

- Protection IED
- Waveform Recording
- V, I, V0, I0, V2, I2
- Process Interface Module
- Protection Function Element
- Event Report

Merging Unit

- Opto Inputs Module
- IEC 61850 9-2 Data Bus
NCIT with low level analog output
NCIT with embedded MU

NCIT

IEC 61850 9-2

Data Bus

Protection IED

Waveform Recording

V, I, V0, I0, V2, I2

Process Interface Module

Protection Function Element

Opto Inputs Module

Event Report
ABB Combined NCIT Sensor
GE NCITs

[Images of various industrial components related to GE NCITs]
MV NCIT Based Switchgear

Protection relay with IEC 61850

Current sensor

Voltage sensor
# IEC 61869 standards

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<th>PRODUCT FAMILY STANDARDS</th>
<th>PRODUCT STANDARD IEC</th>
<th>PRODUCTS</th>
<th>OLD STANDARD IEC</th>
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<td>GENERAL REQUIREMENTS FOR INSTRUMENT TRANSFORMERS</td>
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<td>61869-6</td>
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MU data objects
## Digital output sampling rates

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

Remote iSAS HMI WP (MMS)

Communication equipment

To NCC of DSO (IEC 104)

To Sys. Op. (IEC 104)

ISAS HMI Panel computer (Control room)

ISAS HMI Panel computer (10 kV SG building)

Protection & Control server (Main)

Protection & Control server (BackUp)

Recorder

Metering & PQ

Control room Controller

10 kV SG Bld. Controller

Local SCADA

Station Bus (SBLAN)

Control room

Controller

10 kV SG Bld.

Controller

Line Differential equipment at opposite line terminal

Embedded in root switch GPS receiver

SW A

SW B

SW X

SW Y

SW X.1

SW Y.1

Process Bus (PBLAN)

SW X.2

SW X.2

16 PIDs SG 110 kV

40 PIDs SG 10 kV
Virtual MU

IEC 61850-9-2

Transmission Line (TL)

Logical Device CB1_PROT
  LPHD  LLN0  PTOC1

Logical Device TL_PROT
  LPHD  LLN0  PTOC1

Logical Device CB2_PROT
  LPHD  LLN0  PTOC1
Local Virtual Measurements

Synchrophasors

MU
- TCTR
- TVTR

MMXU

61850-9-1/2

virtualMU
- TCTR
- TVTR

MMXU
Redundant Interface
Transformer Differential Protection
Quality and Efficiency
Protection Testing

Diagram showing the interconnection of different modules and devices in a protection testing setup. The diagram includes:

- **Test Switch**
- **Test Device**
- **Analog Inputs Module**
- **Opto Inputs Module**
- **Waveform Recording**
- **V, I, V0, I0, V2, I2**
- **Distance Protection Module**
- **Relay Outputs Module**
- **Distance Protection Scheme**

The diagram illustrates the flow of data and signals between these components, indicating how they interact during a protection testing scenario.
Conventional Test Setup

Network Simulator

Waveform Record

COMTRADE file

Test Computer

Test Device

Test Switch

Multifunctional Protection IED

V

I

52a

Trip
Distance Protection Function

**IOU**
- XCBR1

**MU**
- TVTR1
- TCTR1

**Distance Protection IED**
- PTRC1
- PSCH1
- PDIS1
- PDIS2
- PDIS3

**Communication Device**
- PDIS2
Process Bus Test setup

IEC 61850 Based IED

Etherne

GOOSE

SV

IEC 61850 Based Test Device

Trip

Test Computer

Ethernet Switch
Process Bus Monitoring

- U/I sensors
- I sensors
- switch control
- I sensors
- actor
- I sensors
- switch control
- I sensors
- U/I sensors

Station bus with 8-1 and 9-2 traffic
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)

Sensor head with redundant fiber coils
Opto-electronics (3-phase)
Process bus to protection IEC61850-9-2LE
Other Benefits

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