IEC 61850 Testing - Equipment Requirements and Tools

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Questions

• Why are we testing?
• What are we testing?
• What should be tested?
• How it should be tested?
Quality Process

- Development (EN ISO 9001)
  - System test
    - Prototype series
      - Type test
  - Verification *
    - Customer x
  - Conformance Test

- Market approval
  - Customer 1
- Delivery and putting online
  - Project 1
  - Project x
  - Project n

- Routine test of products
- FAT * of system equipment

- Site commissioning
  - Site acceptance test
    - Trial operation *
      - Warranty
        - Service maintenance support
          - Decommissioning

*I optional
IEC 61850 Testing
Requires good understanding of:

- The functional hierarchy of the IEC 61850 system
- The local and distributed functions
- Existing testing tools
- The purpose of the test:
  - Conformance
  - Type
  - Acceptance
  - Commissioning
  - Maintenance
Conformance Test Process

Start

Static Conformance Review

Selection and Parameterisation

Dynamic Tests

- Basic Interconnection testing
- Capability Testing

Analysis of Results

Final Conformance Review
Synthesis and Conclusion
Test Report Production

Control Flow

End
Distance Protection

- Analog Inputs Module
- Opto Inputs Module
- Waveform Recording
- V, I, V0, I0, V2, I2
- Distance Protection Module
- Relay Outputs Module
- Distance Protection Scheme
Conventional Substations
Distance Protection
Testing

Test Device

Distance Protection
Waveform Recording
V, I, V0, I0, V2, I2
Relay Outputs Module
Distance Protection Scheme
Distance Protection Module
V, I, V0, I0, V2, I2
Data Bus
Analog Inputs Module
Opto Inputs Module
Conventional Solutions

- Analog Sensor
- Function Module
- Outputs Module
- Multifunctional IED
- Process Control

Event Start: $t_{SM} \rightarrow t_{FM} \rightarrow t_{OM} \rightarrow t_{PC}$
Event End: $t_{EVT}$
IEC 61850 Environment
Process Bus Based Hybrid Solutions

- Analog Sensor
  - Sensor Module
  - Interface Module
  - Input Module
  - Interface Module
  - Input/Output Unit

- Status Sensor
  - Process

- Merging Unit
  - LAN Switch

- Protection IED
  - Interface Module
  - Function Module
  - Outputs Module
  - Process Control
  - Process

Event Start
- $t_{SM}$
- $t_{IM1}$
- $t_{LAN}$
- $t_{IM2}$
- $t_{PM}$
- $t_{OM}$
- $t_{PC}$

Event End
- $t_{EVT}$
Station Bus Test Setup

IEC 61850

Based IED

V

I

Ethernet

GOOSE

or GSSE

Laptop

Computer

IEC 61850

Based Test

Device

GOOSE

or GSSE

Ethernet

Trip
GOOSE Subscription
Functional Testing
Process Bus Based Solutions

Process Bus Based Solutions

- Analog Sensor Module
- Interface Module
- LAN Switch
- Interface Module
- Function Module
- Sensor Module
- Merging Unit
- Protection IED
- Status Sensor Module
- Outputs Module
- Control Interface Unit
- Process Control
- Event Start
- Event End

- $t_{SM}$
- $t_{IM1}$
- $t_{LAN1}$
- $t_{IM2}$
- $t_{FM}$
- $t_{IM3}$
- $t_{LAN2}$
- $t_{IM4}$
- $t_{OM}$
- $t_{PC}$
- $t_{EVT}$
Process Bus Based Relay
Distance Protection Function Modeling
Distance Protection Functions
Distribution

Distance Protection IED

XCBR1
PTRC1
TVTR1
PDIS1
PDIS2
PDIS3
TCTR1
PSCH1
Distance Protection Functions
Distribution

Distance Protection IED

IOU
XCBR1

MU
TVTR1
TCTR1

PDIS1
PDIS2
PDIS3

PTRC1
PSCH1
Distance Protection Functions Distribution
Process and Station Bus Test Setup

IEC 61850 Based IED

Ethernet Switch

Laptop Computer

IEC 61850 Based MU
IEC 61850 Based IED

IEC 61850 Based Test Device

GOOSE

Ethernet

GOOSE and SV

Trip
Test Scheme

Laptop Computer — Ethernet Switch — GOOSE

IEC 61850 Based IED

IEC 61850 Based Test Device

GOOSE

Sending IED

Receiving IED

Ethernet
GOOSE and SV Test setup

Laptop Computer

Ethernet Switch

IEC 61850 Based IED

GOOSE

SV

IEC 61850 Based Test Device

Trip
Merging Unit Test Setup

- Laptop Computer
- Ethernet Switch
- IEC 61850 Based MU
- IEC 61850 Based Test Device

Connections:
- SV to Ethernet
- V and I from MU to Test Device
SV Comparison Test Setup

IEC 61850 Based IED

Ethernet Switch

Ethernet

Laptop Computer

GOOSE and SV

IEC 61850 Based Test Device

IEC 61850 Based IED

Trip

V

I

GOOSE and SV

Ethernet
Test With Filtering
Top-down System Testing

Configuration

Settings

Control

System Boundary

Inputs

Outputs

Reports

Logs
Bottom-up Testing

Configuration → Settings → Control

Function Boundary

SF_M

FE_1 → FE_i → FE_K

Inputs → Outputs → Reports → Logs
Black-box Testing

Test System

Control

Reports

Outputs
White-box Testing

![Diagram showing the relationship between SF_M, FE_1, FE_i, and FE_K in a test system.](Image)

- **SF_M**: Control node
- **FE_1**, **FE_i**, **FE_K**: Functional elements
- **Reports** and **Outputs** paths

Diagram illustrates the flow and interaction within the test system.
Distributed Testing
Distributed Testing
The IEC 61850 Test Configuration

- ICD File
- ICD File
- IEC 61850 Standard System Configuration Tool
- Network System Simulator
- Scheme Testing Tool
- Other Test Modules
- IED Simulator
- MU Simulator
- Test Device