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TECHNICAL REPORT

Communication networks and systems for power utility automation – Part 90-1: Use of IEC 61850 for the communication between substations

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CONTENTS

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-1: Use of IEC 61850 for the communication between substations

FOREWORD

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IEC 61850-90-1, which is a technical report, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
57/992/DTR	57/1021/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61850 series, under the general title: *Communication networks and systems for power utility automation*, can be found on the IEC website.

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

When IEC 61850 was prepared, it was intended for use in information exchange between devices of a substation automation system. In the mean time, the concepts are now used as well in other application domains of the power utility system. Therefore, IEC 61850 is on the way to becoming the foundation for a globally standardized utility communication network.

With existing and new applications in the field of power system operation and protection, the requirement to exchange standardized information directly between substations is increasing. IEC 61850 shall be the basis for this information exchange.

IEC 61850 provides the basic features to be used for that information exchange, however, some extensions to IEC 61850 may be required. This technical report provides a comprehensive overview of the different aspects that need to be considered when using IEC 61850 for information exchange between substations. Areas that require extension of specific parts of the existing IEC 61850 standard will later be incorporated in future editions of the affected part of IEC 61850.

A similar report discussing the use of IEC 61850 for communication between substations and control centres is under preparation as IEC 61850-90-2[1)]. Further, a similar report discussing the use of IEC 61850 for wide-area RAS (remedial action schemes) is being contemplated; this will likely be IEC 61850-90-3[1)].

The scope of IEC 61850 is no longer limited to substations. This is reflected in the changed title of the series. New domain specific parts have been added to the series. Working Group 10 of Technical Committee 57 is currently preparing the second edition of the basic parts of IEC 61850.

1) Under consideration.

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-1: Use of IEC 61850 for the communication between substations

1 Scope

This part of IEC 61850 provides a comprehensive overview on the different aspects that need to be considered while using IEC 61850 for information exchange between substations. In particular, this technical report

- defines use cases that require an information exchange between substations;
- describes the communication requirements;
- gives guidelines for the communication services and communication architecture to be used;
- defines data as a prerequisite for interoperable applications;
- does not define implementations which guarantee interoperability between different IEDs;
- describes the usage and enhancements of the configuration language SCL.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60044 (all parts), *Instrument transformers*

IEC 60834-1:1999, *Teleprotection equipment of power systems – Performance and testing – Part 1: Command systems*

IEC 60834-2:1993, *Performance and testing of teleprotection equipment of power systems – Part 2: Analogue comparison systems*

IEC 60870-4, *Telecontrol equipment and systems – Part 4: performance requirements*

IEC/TS 61850-2, *Communication networks and systems in substations – Part 2: Glossary*

IEC 61850 (all parts), C*ommunication networks and systems for power utility automation*

IEC 61850-3, *Communication networks and systems in substations – Part 3: General requirements*

IEC 61850-5:2003, *Communication networks and systems in substations – Part 5: Communication requirements for functions and device models*

IEC 61850-6:2009, *Communication networks and systems for power utility automation – Part 6: Configuration description language for communication in electrical substations related to IEDs*

IEC 61850-7-2:2010, *Communication networks and systems for power utility automation – Part 7-2: Basic communication structure – Abstract communication service interface (ACSI)*

IEC 61850-7-4:2010, *Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes*

IEC 61850-8-1,___ *Communication networks and systems for power utility automation – Part 8-1: Specific Communication Service Mapping (SCSM) - Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3*[2)]

IEC 61850-9-2,___ *Communication networks and systems in substations – Part 9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3*[2)]

IEC 62053-22, *Electricity metering equipment (a.c.) – Particular requirements – Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)*

IEC/TS 62351-6, *Power systems management and associated information exchange – Data and communication security – Part 6: Security for IEC 61850*

IEC 62439, *High availability automation networks*

ANSI/IEEE 1588, *Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems / revision of ANSI/IEEE 1588-2002 / Approved 2008-09-10*

IEEE 802.1Q, *Local and metropolitan area networks – Virtual bridged local area networks*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61850-2 and IEC 61850-7-2 apply.

4 Abbreviated terms

BER	Bit error ratio
Bkr	Circuit breaker
C/S	Client / Server
CE	Central equipment
DCB	Directional comparison blocking
DF	Directional relay to detect forward faults
EHV	Extreme high voltage
HV	High voltage
IF, I/F	Interface
I/F -R	Interface to receive data
I/F -S	Interface to send data
L2TP	Layer 2 tunnelling protocol
MV	Medium voltage
PDH	Plesiochronous digital hierarchy
PMU	Phasor measurement units
QA	Circuit breaker
QB	Line disconnector
QC	Earthing switch
QinQ	802.1Q in 802.1Q (VLAN stacking)
RAS	Remedial action schemes

[2)] To be published

RO	Overreaching distance zone
RT	Remote terminal
Rx	Receiver
SDH	Synchronous digital hierarchy
SIPS	System integrity protection scheme
SONET	Synchronous optical NETwork transport system
SS	Substation
TPI	Teleprotection interface
Tx	Transmitter
VoIP	Voice over IP (Internet protocol)
VPN	Virtual private network
WAN	Wide area network

NOTE Abbreviations used for the identification of the common data classes and as names of the attributes are specified in the specific clauses of this document and are not repeated here.

5 Use cases

5.1 General

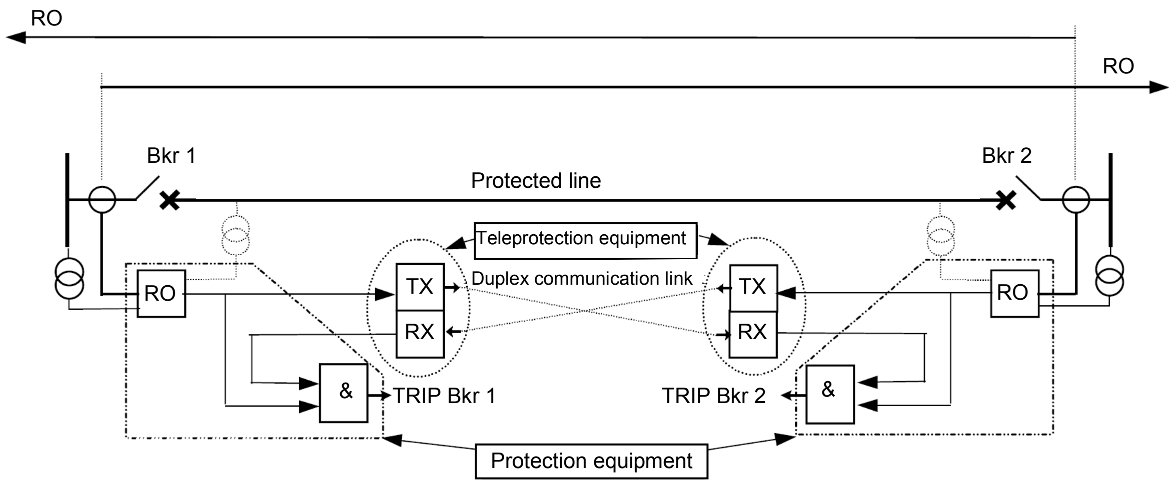
For the purpose of communication between substations, the following functions are considered.

Conventional CTs and VTs are assumed for input to relays in the following use cases. However, they could be replaced by newer technology, such as digital input based on process bus, without any significant change in the descriptions.

5.2 Distance line protection with permissive overreach tele-protection scheme

Summary:

When a distance relay detects a forward fault in the overreach zone, it sends a permissive signal to the remote end, see Figure 1. If that relay also receives a permissive signal (from the remote end), the relay sends a trip signal to the local CB.



RO Overreaching trip function, must be set to reach beyond remote end teminal

IEC 503/10

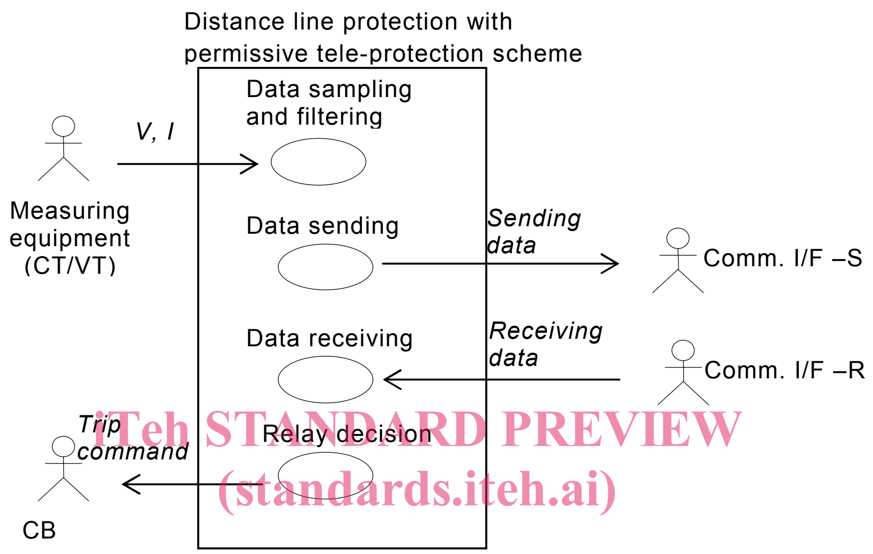
Figure 1 – Distance line protection with permissive overreach tele-protection scheme [1][3)]

3) Figures in square brackets refer to the Bibliography.

Constraints / Assumptions / Design considerations:

- The permissive signal needs a minimum of 1 bit. If it is a phase segregated signal, it needs 3 bits. If it is a phase segregated, and phase-to-phase and phase-to-earth are independent, the signal needs 6 bits. Directional earth fault detection may need another 1 bit.
- Data is sent only when a forward fault is detected.
- For communication channel failure, alternative actions must be considered.
- For fast tripping, the propagation, delay shall be small (e.g.: less than 5 ms).
- A high reliability is needed (e.g. BER less than 10^{-6}, alternative route, duplicated).

Use case diagram:



Actor(s):

Name	**Role description**
Measuring equipment	Measures current and voltage from protected line
Comm. I/F –S	Receives data from the local relay and sends the data to the remote end
Comm. I/F –R	Receives data from the remote end and gives the data to the local relay
CB	Disconnects the protected line from other system (Circuit breaker)

Use case(s):

Name	**Services or information provided**
Data sampling and filtering	Samples current and voltage data from measuring equipment and filters them
Data sending	Calculates a distance to the fault using filtered data. When a distance protection detects a forward fault, the distance protection sends the permissive signal to Comm. I/F –S (the remote end)
Data receiving	Receives the permissive signal from Comm. I/F –R (the remote end)
Relay decision	When the distance protection detects the forward faults and receives permissive signal from remote end, the distance protection issues a trip command to the CB

Basic flow:

Data sampling and filtering

Use case step	Description
Step 1	Current and voltage are given to distance protection by measuring equipment
Step 2	Distance protection samples an analogue value and converts it to digital data
Step 3	Distance protection removes any unwanted frequency components from the sampled data using a digital filter

Data sending

Use case step	Description
Step 1	Distance protection stores the filtered instantaneous data
Step 2	Distance protection calculates a distance to the fault using filtered data
Step 3	When a distance protection detects a forward fault to a pre-determined distance, a distance protection sends the permissive signal to Comm. I/F –S (in order to send the data to a remote end relay)
Step 4	Comm. I/F –S send the information to remote end

Data receiving

Use case step	Description
Step 1	Comm. I/F –R receives the data from the remote end
Step 2	Comm. I/F –R gives the received data to distance protection
Step 3	Distance protection receives the data

Relay decision

Use case step	Description
Step 1	When the distance protection detects the forward faults in a predetermined zone, and receives a permissive signal from the remote end, the distance protection issues a trip command to the CB

Exceptions / Alternate flow:

N.A.

Pre-conditions:

N.A.

Post-conditions:

N.A.

References:

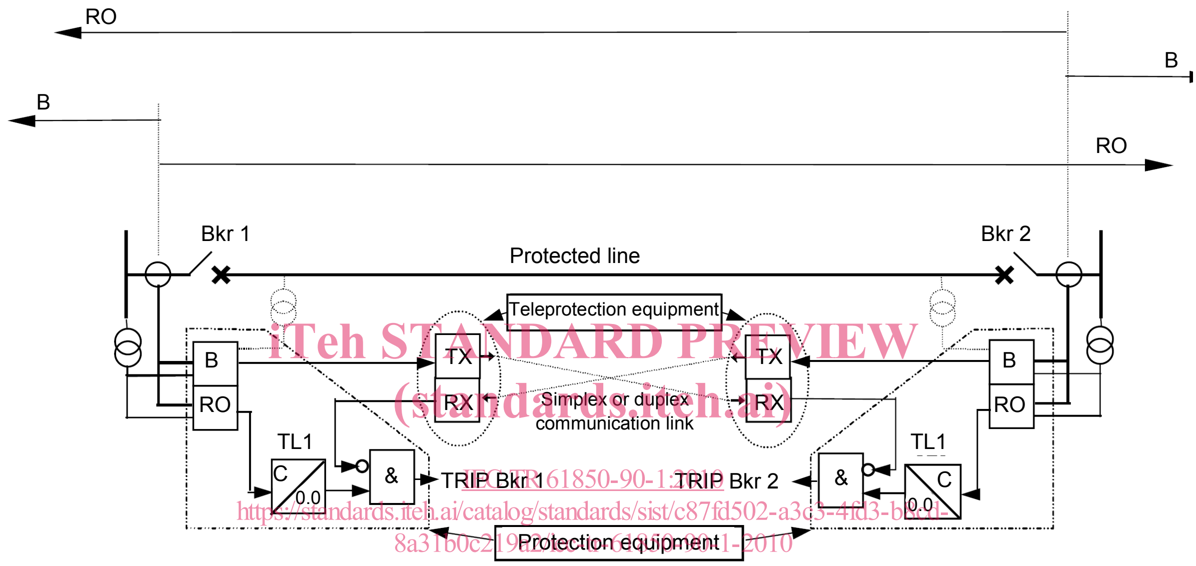
[1] Protection Using Telecommunication

5.3 Distance line protection with blocking tele-protection scheme

Summary:

When a distance relay detects reverse faults, it sends a blocking signal to the remote end. If the relay detects a forward fault and does not receive the blocking signal, the relay sends a trip signal to the local CB, see Figure 2.

A variant involves the directional comparison blocking (DCB) using a non-directional element to send a blocking signal for any fault (other wording: “starts the carrier”). The operation of the forward element removes the blocking signal (“stops the carrier”) and sends a trip signal to the local CB.



RO Overreaching trip function, must be set to reach beyond remote end of line
B Blocking function, must be set to reach beyond overreaching trip function at remote end of line
C Coordinating time, required to allow time for blocking signal to be received (set equal to channel time plus propogation time plus margin)

IEC 504/10

Figure 2 – Distance line protection with blocking tele-protection scheme [1]

Constraints / Assumptions / Design considerations:

- The blocking signal is a minimum of 1 bit. If it is phase segregated signal, it needs 3 bits. If it is phase segregated, and phase-to-phase and phase-to-earth are independent, the signal needs 6 bits. Directional earth fault detection may need another 1 bit.
- Data is sent when a reverse fault is detected or as a variant, when any fault is detected. In that variant, the blocking signal is removed when the fault direction is detected as forward.
- For communication channel failure, the blocking signal is typically removed.
- For fast tripping, the propagation delay shall be small (e.g.: less than 5 ms).
- A high reliability is needed (e.g. BER less than 10^{-6}, alternative route, duplicated).