# IEC TR 61850-90-21

Edition 1.0 2025-02

# TECHNICAL REPORT

## Communication networks and systems for power utility automation – Part 90-21: Travelling Wave Fault Location

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.200

ISBN 978-2-8327-0163-8

**Warning! Make sure that you obtained this publication from an authorized distributor.**

® Registered trademark of the International Electrotechnical Commission

# CONTENTS

FOREWORD ..... 5
INTRODUCTION ..... 7
1 Scope ..... 8
1.1 Scope of work ..... 8
1.2 Published versions of the standard and related namespace names ..... 8
1.3 Namespace name and version ..... 8
1.4 Published versions of the standard and related namespace names ..... 8
1.5 Code Component distribution ..... 9
2 Normative references ..... 10
3 Terms and definitions ..... 10
4 Types of travelling wave fault location ..... 10
5 Requirements and use cases ..... 11
5.1 General ..... 11
5.2 Use case 1: Single-ended fault location (Type A) ..... 12
5.2.1 Use case 1A: Single-ended fault location (Type A) – phase segregated ..... 12
5.2.2 Use case 1B: Single-ended fault location (Type A) – 3-phase lines with modes at different speeds ..... 18
5.3 Use case 2: Double-ended fault location (Type D) through communications between two devices ..... 23
5.3.1 Description of the use case ..... 23
5.3.2 Diagram of the use case ..... 25
5.3.3 Technical details ..... 26
5.3.4 Step by step analysis of the use case ..... 27
5.3.5 Information exchanged ..... 29
5.4 Use case 3: Double-ended fault location (Type D) through communications with a master station ..... 29
5.4.1 Description of the use case ..... 29
5.4.2 Diagram of the use case ..... 31
5.4.3 Technical details ..... 32
5.4.4 Step by step analysis of the use case ..... 33
5.4.5 Information exchanged ..... 35
5.5 Use case 4: Wide area fault location (Type W) ..... 35
5.5.1 Description of the use case ..... 35
5.5.2 Diagram of the use case ..... 37
5.5.3 Technical details ..... 39
5.5.4 Step by step analysis of the use case ..... 40
5.5.5 Information exchanged ..... 43
5.6 Use case 5: Pulse radar echo method (Type C and Type FMCW) ..... 43
5.6.1 Description of the use case ..... 43
5.6.2 Diagram of the use case ..... 45
5.6.3 Technical details ..... 47
5.6.4 Step by step analysis of the use case ..... 48
5.6.5 Information exchanged ..... 50
5.7 Use case 6: Integration with other fault location and disturbance recording functions in a substation ..... 50
5.7.1 Description of the use case ..... 50
5.7.2 Diagram of the use case ..... 51

5.7.3 Technical details ..... 52
5.7.4 Step by step analysis of the use case ..... 53
5.7.5 Information exchanged ..... 55
5.8 Use case 7: Testing and calibration ..... 55
5.8.1 Use case 7a: Wave velocity calibration ..... 55
5.8.2 Use case 7b: Simulation testing by remote commands ..... 60
5.8.3 Use case 7c: Calibration for the pulse radar echo method ..... 64
5.9 Use case 8: Fault location for hybrid lines ..... 68
6 Information models ..... 69
6.1.1 Mapping of the requirements of use case 1 ..... 69
6.1.2 Mapping of the requirements of use case 2 ..... 70
6.1.3 Mapping of the requirements of use case 3 ..... 71
6.1.4 Mapping of the requirements of use case 4 ..... 72
6.1.5 Mapping of the requirements of use case 5 ..... 73
6.1.6 Mapping of the requirements of use case 6 ..... 74
6.1.7 Mapping of the requirements of use case 7a ..... 75
6.1.8 Mapping of the requirements of use case 7b ..... 76
6.1.9 Mapping of the requirements of use case 7c ..... 77
7 Logical node classes and data objects modelling ..... 78
7.1 General ..... 78
7.2 Abbreviated terms used in data object names ..... 78
7.3 Logical node classes ..... 78
7.3.1 General ..... 78
7.3.2 Classes list ..... 79
7.3.3 Logical nodes for protection related functions of 90-21 (LNGroupR) ..... 79
7.3.4 Logical nodes for further power system equipment of 90-21 (LNGroupZ) ..... 86
7.4 Data object name semantics ..... 91
8 System configuration ..... 92
8.1 General ..... 92
8.2 Double-circuit line ..... 92
8.3 Topology for single line with aerial mode and zero mode ..... 94
Annex A (normative) Conditions for element presence ..... 95
Annex B (informative) Explanation of percentage full scale ..... 97
Bibliography ..... 98

Figure 1 – Wide-area travelling wave fault location system ..... 36
Figure 2 – Class diagram LogicalNodes_90_21:LogicalNodes_90_21 ..... 79
Figure 3 – Class diagram LNGroupR::LNGroupRext ..... 80
Figure 4 – Class diagram LNGroupZ:LNGroupZext ..... 86

Table 1 – Published versions of the namespace ..... 8
Table 2 – Attributes of (Tr)IEC 61850-90-21:2022A namespace ..... 9
Table 3 – Single-ended fault location use case requirement mapping over LNs ..... 70
Table 4 – Double-ended fault location through communications between two devices use case requirement mapping over LNs ..... 71
Table 5 – Double-ended fault location through master station communications use case requirement mapping over LNs ..... 71

Table 6 – Wide Area fault location use case requirement mapping over LNs ..... 72
Table 7 – Pulse radar echo method use case requirement mapping over LNs ..... 73
Table 8 – Integration with other equipment use case requirement mapping over LNs ..... 74
Table 9 – Line calibration use case requirement mapping over LNs ..... 75
Table 10 – Testing by remote commands use case requirement mapping over LNs ..... 76
Table 11 – Calibration for the pulse radar echo method – use case requirement mapping over LNs ..... 77
Table 12 – Normative abbreviations for data object names ..... 78
Table 13 – List of classes defined in LogicalNodes_90_21 package ..... 79
Table 14 – List of classes defined in LNGroupR package ..... 80
Table 15 – Data objects of RTWD ..... 81
Table 16 – Data objects of RTWI ..... 83
Table 17 – Data objects of RTWL ..... 84
Table 18 – List of classes defined in LNGroupZ package ..... 86
Table 19 – Data objects of ZCABExt ..... 87
Table 20 – Data objects of ZLINExt ..... 89
Table 21 – Attributes defined on classes of LogicalNodes_90_21 package ..... 91
Table A.1 – Conditions for presence of elements within a context ..... 95

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

# COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

## Part 90-21: Travelling Wave Fault Location

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC TR 61850-90-21 has been prepared by IEC technical committee 57: Power systems management and associated information exchange. It is a Technical Report.

The text of this Technical Report is based on the following documents:

| Draft | Report on voting |
|---|---|
| 57/2718A/DTR | 57/2738/RVDTR |

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

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

# INTRODUCTION

The travelling wave technique for locating faults in transmission, distribution and cable network system has been maturing in recent years due to the advancement in technology. The technique is potentially more accurate and has a much wider application scope when compared with the traditional impedance-based method. However, the technique and its associated information exchange have not yet been fully modelled in IEC 61850. There is a need to do this so that the equipment can be integrated with other IEC 61850 compliant equipment, both in the substation level and in the network level.

# COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

# Part 90-21: Travelling Wave Fault Location

## 1 Scope

### 1.1 Scope of work

This part of IEC 61850, which is a Technical Report, aims to provide background information, use cases, data models and guidance on the application of such a technique.

This document will

1) describe the principles of fault location based on travelling waves aided by communications;
2) specify use cases for this method under the following application scenarios:
   a) Single-ended fault location,
   b) Double-ended fault location through communications between two devices,
   c) Double-ended fault location with communications to a master station,
   d) Wide area fault location applications,
   e) Pulse radar echo method,
   f) Substation integration with other fault location and disturbance recording functions,
   g) Testing and calibration;
3) describe the information model for each use case;
4) give guidance on scheme configuration.

### 1.2 Published versions of the standard and related namespace names

The table below provides a reference between all published editions, amendments or corrigenda of this document and the full name of the namespace.

**Table 1 – Published versions of the namespace**

| Edition | Publication date | Webstore | Namespace |
|---|---|---|---|
| Edition 1.0 | 2024-10 | IEC 61850-90-21:2024 | (Tr)IEC 61850-90-21:2022A2 |

### 1.3 Namespace name and version

The parameters which identify this new release of this namespace are as follows:

### 1.4 Published versions of the standard and related namespace names

shows all attributes of (Tr)IEC 61850-90-21:2022A namespace.

**Table 2 – Attributes of (Tr)IEC 61850-90-21:2022A namespace**

| Attribute | Content |
|---|---|
| **Namespace nameplate** | |
| Namespace Identifier | (Tr)IEC 61850-90-21 |
| Version | 2022 |
| Revision | A |
| Release | 2 |
| Full Namespace Name | (Tr)IEC 61850-90-21:2022A2 |
| Full Code Component Name | IEC_TR_61850-90-21.NSD.2022A2.Full |
| Light Code Component Name | IEC_TR_61850-90-21.NSD.2022A2.Light |
| Namespace Type | transitional |
| **Namespace dependencies** | |
| extends | IEC 61850-7-4:2007B version:2007 revision:B |
| **Namespace transitional status** | |
| Future handling of namespace content | The name space (Tr)IEC 61850-90-21:2022A is considered as "transitional" since the models are expected to be included in further editions IEC 61850-7-4xx. Potential extensions/modifications may happen if/when the models are moved to the International Standard status. |

## 1.5 Code Component distribution

Each Code Component is a ZIP package containing the electronic representation of the Code Component itself, with a file describing the content of the package (IECManifest.xml).

The life cycle of a code component is not restricted to the life cycle of the related publication. The publication life cycle goes through two stages, Version (corresponding to an edition) and Revision (corresponding to an amendment). A third publication stage (Release) allows publication of Code Component in case of urgent fixes of InterOp Tissues, thus without need to publish an amendment.

Consequently new release(s) of the Code Component may be released, which supersede(s) the previous release, and will be distributed through the IEC TC57 web site at: http://www.iec.ch/tc57/supportdocuments.

The code component associated to this TR is an nsd file. It is available as a full version and a light version. The light version is freely accessible on the IEC website for download at: http://www.iec.ch/tc57/supportdocuments, but the usage remains under the licensing conditions.

The latest version/release of the document will be found by selecting the file for the code component with the highest value for VersionStateInfo e.g. *IEC_TR_61850-90-21.NSD.{VersionStateInfo}.Light*

In case of any differences between the downloadable code component and the IEC pdf published content, the downloadable code component is the valid one; it may be subject to updates. See included history files.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 TS 61850-2, *Communication networks and systems for power utility automation – Part 2: Glossary*

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