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TECHNICAL REPORT

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

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Communication networks and systems for power utility automation –
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CONTENTS

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-21: Travelling Wave Fault Location

FOREWORD

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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- withdrawn, or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)*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

4 Types of travelling wave fault location

The types of travelling wave fault location are described as follows:

Type A TWFL – Fault distance is calculated based on the time difference between the first arrival of the surge and the surge reflected by the fault or by the opposite end. Also known as single-ended travelling wave fault location.

Type B TWFL – Fault distance is calculated by the difference in the time of arrival of fault surge detected by the devices located at both ends of the line. One of the devices transmit timing signal to opposite end after detecting surge to synchronize them.

Type C TWFL – Fault locator transmits and receives an impulse signal on the line and measures a propagation time from transmitting an impulse till receiving an echo signal to calculate a fault distance.

Type D TWFL – Fault distance is calculated by the difference in the time of arrival of fault surge detected by the devices located at both ends of the line. These two devices are time-synchronized by the same resources such as GNSS. Also known as double-ended travelling wave fault location.

Type E_s TWFL (single-ended) – Fault locator picks-up the transients generated when a line is re-energized by circuit breaker. It is applicable to permanent faults.

Type E_d TWFL (double-ended) – Almost the same as B type, except fault locator transmits timing signals repeatedly.

Type F/K TWFL – Type F fault locator transmits and receives equal interval impulse signals repeatedly on the line and measures a reciprocating time from transmitting an impulse till receiving an echo signal to measure a fault distance. Type K fault locator is almost the same as type F, except sweep trigger of oscilloscope is synchronized with interval of impulse signals.

Type FMCW TWFL – Fault locator transmits and receives a FMCW (frequency modulated continuous wave), and measures beat frequency by mixed wave of transmitted and received FMCWs. Fault distance is calculated by beat frequency.

Type W TWFL – Type W traveling wave fault location makes use of traveling wave data from various substations across the monitored transmission network to achieve reliable fault location even in the case that a detection device installed at a substation fails and/or that such a device is not installed. This method uses information exchange between devices located at the nodes of the network with a central station which determines the location of the fault based on the network topology and the information received. This is also known as wide-area fault location. This approach can also be employed by other applications using travelling waves.

5 Requirements and use cases

5.1 General

The objective of this clause is to go down to the general high-level requirements of the information exchange for travelling wave fault location systems. This is the starting point for proposing new logical nodes (LNs), the extension of the existing LNs, new communication services, communication profiles and configuration methods. This approach can also be employed to other applications using travelling waves.

The following use cases for travelling wave fault location do require the definition of new LNs and extension of the existing LNs as follows:

- **Single ended fault location** – To locate the fault position of a transmission line based on travelling wave signals measured at one end of the line only.
- **Double-ended fault location through communications** between two devices – To locate the position of the fault on a transmission line based on the travelling wave signals measured at both ends of the line. This method uses information exchange between the devices located at the line ends to achieve fault location.
- **Double-ended fault location through communications with a master station** – To locate the position of the fault on a transmission line based on the travelling wave signals measured at both ends of the line. This method uses information exchange between the devices located at the line ends with a master station. The master station determines the location of the fault using the information received.
- **Wide area fault location** – To locate the position of a fault on a transmission network, based on the travelling wave signals measured on various nodes of the network. This method uses information exchange between devices located at the nodes of a network with a master station. The master station determines the location of the fault using the information received.
- **Pulse radar echo method** – To locate the fault position on a transmission line based on time difference between transmitted and echo pulse. This method injects a pulse or burst of some probe waveform into transmission line.
- **Substation integration with other fault location and disturbance recoding functions** – to integrate travelling wave fault location device with other devices in the substation to achieve more intelligent and comprehensive fault location.
- **Testing and calibration** – To test and to calibrate the travelling wave fault location system by commands and info exchange through communications. E.g., commands can be sent by the master station to the devices to simulate a fault so as to check the integrity of the system. Line length calibration typically requires line energisation and single-ended analysis to determine the actual line length.

Travelling wave signals contain both voltage and current components. Acquisition of the travelling wave signals can be done through instrument voltage or current transformers with the suitable frequency response. For high voltage transmission systems with capacitive voltage transformers, or for HVDC systems, the signal can also be captured with current transformers located at the earth path, which captures the capacitance currents to earth.

5.2 Use case 1: Single-ended fault location (Type A)

5.2.1 Use case 1A: Single-ended fault location (Type A) – phase segregated

5.2.1.1 Description of the use case

5.2.1.1.1 Name of use case

Use case identification		
ID	**Domain(s)**	**Name of use case**
	Travelling wave fault location	Single-ended fault location

5.2.1.1.2 Version management

Version management						
Version management changes / Version	**Date**		**Domain expert**	**Area of expertise / Domain / Role**	**Title**	**Approval status** **draft, for comments, for voting, final**

5.2.1.1.3 Scope and objective of use case

Scope and objectives of use case	
Related business case	None
Scope	Travelling wave fault location by a single device at one end of the line
Objective	Achieve fault location by analysis of the records acquired at one end.