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TECHNICAL REPORT

colour inside

Guidelines for parameters measurement of HVDC transmission line

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GUIDELINES FOR PARAMETERS MEASUREMENT OF HVDC TRANSMISSION LINE

FOREWORD

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IEC TR 63502 has been prepared by IEC technical committee TC 115: High Voltage Direct Current (HVDC) transmission for DC voltages above 100 kV. It is a Technical Report.

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

Draft	Report on voting
115/374/DTR	115/386/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.

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- withdrawn, or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.

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INTRODUCTION

The development of global clean energy exacerbates uneven distributions of electrical energy, which intensifies the demand for HVDC transmission techniques as a high-efficiency long-distance transmission solution of the energy. Parameters of DC lines (e.g. overhead lines, cables, or their combination) are essential in modelling transmission lines in computations, of which the accuracy greatly affects the analysis results of the DC transmission system and the correctness of determining operating strategies. However, the parameters of DC lines are sensitive to the geological structures, weather characteristics along the transmission corridors, earthing modes and other uncertainties, which make the theoretical values of parameters invalid. Thus, on-site measurement is important.

The parameter testing of DC lines is generally carried out after the construction or renovation of DC projects. The measured parameters of DC transmission lines are important for several applications, mainly including DC transmission system steady-state calculation, transient calculation, fault analysis, electromagnetic environment calculation, construction quality assessment after newly launched HVDC project or renovation, etc. The test results of line parameters can be used to verify whether the actual parameters meet the requirements of engineering design. In steady-state calculation, DC resistance is generally used for power flow computation, voltage drop computation, and resistance loss computation under different operating modes. In transient calculation, the resistance, capacitance, inductance of the DC line in per-unit length and its frequency characteristics are essential in performing the over-voltage calculations under lightning strike, operation, fault, and other working conditions. In electromagnetic environment calculation, the capacitance analysis of the DC line is the prerequisite for the calculations of the surface electric field for the wire, the nominal electric field and ion flow electric field generated by the DC line in the surrounding space, which further give the important performance data of the DC line, including audible noise, radio interference, corona loss, etc.

Based on the accurate descriptions of DC line parameters, considering the actual needs of the above applications, the main DC line parameters described in this document are the DC resistance and frequency characteristics. Frequency characteristics refer to the response of line resistance per unit length, inductance, and capacitance as well as the necessary coupling capacitance and inductance under different frequencies.

This document introduces measurement specification, including measurement conditions, safety precautions, measurement instruments, measurement methods, etc., in order to measure the parameters of HVDC overhead transmission line and cable with a DC voltage level above 100 kV.

GUIDELINES FOR PARAMETERS MEASUREMENT OF HVDC TRANSMISSION LINE

1 Scope

This document gives information relevant to the on-site HVDC transmission line parameter measurement. HVDC transmission line can be overhead lines, land or submarine cables, or hybrid lines with overhead line section(s) and cable section(s) (or any combination of these).

This document is also relevant to line parameter measurement of earth electrode lines in HVDC power transmission systems.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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

3.1
source terminal
terminal of a transmission line, at which a power source is applied for the parameter measurement

[SOURCE: IEC TR 63042-303:2021, 3.2]

3.2
ending terminal
terminal opposite to the source terminal of a transmission line

[SOURCE: IEC TR 63042-303:2021, 3.3]

3.3
parameter in unit length
resistance, inductance, and capacitance per unit length of HVDC transmission line. A length of 1 km is adopted as the unit length of a transmission line

3.4
frequency characteristics
parameters in unit length changing with different signal frequencies

3.5
induced voltage
voltage caused by electromagnetic or electrostatic effect of adjacent energized lines or equipment

[SOURCE: IEC TR 63042-303:2021, 3.7]

3.6
induced current
electric current resulting from the displacement of charge carriers due to an induced voltage

[SOURCE: IEC 60050-121:2008, 121-11-29]

3.7
differential mode measurement
applying two-phase signals with equal amplitude and opposite phase into bipolar line to measure the parameters of HVDC transmission line

3.8
common mode measurement
applying single-phase signal into bipolar line to measure the parameters of HVDC transmission line

3.9
differential mode short-circuit impedance
input complex impedance of the measured line with the ending terminal short-circuited in differential mode measurement

3.10
differential mode open-circuit impedance
input complex impedance of the measured line with ending terminal open-circuited in differential mode measurement

3.11
common mode short-circuit impedance
input complex impedance of the measured line with the ending terminal short-circuited in common mode measurement

3.12
common mode open-circuit impedance
input complex impedance of the measured line with the ending terminal open-circuited in common mode measurement

3.13
signal connecting line
test wire connecting the measured line with test equipment and earthing devices

4 General

4.1 Background

The theoretical parameters of DC transmission lines can be invalidated by the varieties of soil resistivity and tower configurations caused by various terrains that DC transmission lines pass through, including mountains, rivers, plains, etc. Therefore, it is essential to obtain accurate parameters of DC lines through on-site measurement. To ensure the smooth progress of on-site measurement works and the accuracy of measurement results, this document has been prepared to clearly introduce the measuring items, measuring methods, measuring tools, measuring processes, and safety precautions.

4.2 Measurement items

– Induced voltage and induced current

– Insulation resistance

– Polarity verification

– DC resistance

– Frequency characteristics

4.3 Measurement conditions

1) Dismantle all temporary earthing wires along the line.

2) Nobody works on the line.

3) Isolate the line from the reactors, capacitors, voltage dividers and other equipment.

4) The parameters of overhead line and cable are measured separately in case of hybrid transmission line.

5) Earthing grid of the converter station is available to offer the earthing point for the measurement. The earthing device can be artificially set to provide a potential reference point for measurements when the test is done remotely.

6) Technically eliminate the effect of the resistance of the signal connecting line from the measured result when measuring the DC resistance.

7) Record the earthing status of adjacent transmission lines, as they can affect the result of the measurement.

4.4 Safety precautions

1) It is important to take anti-interference measures to reduce the induced voltage or induced current, thus improving the safety of personnel or equipment. See Annex A for details.

2) Keep the line earthed when dismantling or assembling the test wires and use the earthing switch to short-circuit the ending terminal of the line.

3) Reliably connect the signal line, earthing wire and other wires. Keep the test wires sufficiently insulated to withstand test voltage and induced voltage.

4) Postpone the measurement if there are unfavourable weather conditions, such as thunderstorm, rain, snow, etc. Environmental data, such as temperature, humidity, and atmospheric pressure, also need to be recorded.

5) To protect the personnel and equipment from the lightning strike imposed on the measured line during the measurement, a safety spark gap is used between the signal line and earthing wire.

6) Use insulating gloves, insulating boots, insulating mat and other protective equipment to protect test personnel.

4.5 Measurement instruments

1) Before the measurement, the induced voltage and current can be estimated by the simulation calculation, in order to help select a suitable range of the voltmeters and ammeters.

2) The resistance-capacitance divider is used when testing the induced voltage.

3) A megohmmeter with a source voltage of higher than 5 kV is used in testing the insulation resistance.

4) The uncertainty of the DC resistance device is 0,5 % or lower, which can be determined based on the method of IEC Guide 115:2023.

5) The frequency range of the test power supply used for measuring the frequency characteristics covers the interval of 30 Hz to 2 500 Hz. In order to improve measurement accuracy, the measurement frequency points can avoid the inherent resonant frequency of the measured line. The voltage output of the test power supply is not less than 300 V and the current output is not less than 3 A.