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Line traps for a.c. power systems

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Circuits-bouchons pour réseaux alternatifs

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Line traps for a.c. power systems

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LINE TRAPS FOR A.C. POWER SYSTEMS

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by IEC Technical Committee No. 57: Telecontrol, teleprotection and associated telecommunications for electric power systems.

It forms the second edition of IEC Publication 353 and replaces the first edition, 1971.

The text of this standard is based on the following documents:

Six Months' Rule	Report on Voting	Two Months' Procedure	Report on Voting
57(CO)23	57(CO)28	57(CO)43	57(CO)48

Full information on the voting for the approval of this standard can be found in the Voting Reports indicated in the above table.

The following publications are quoted in this standard:

Publication Nos. 50:	International Electrotechnical Vocabulary (IEV).
71-1 (1976):	Insulation co-ordination, Part 1: Terms, definitions, principles and rules.
76-2 (1976):	Power transformers, Part 2: Temperature rise.
85 (1957):	Thermal evaluation and classification of electrical insulation.
99:	Lightning arresters.
99-1 (1970):	Part 1: Non-linear resistor type arresters for a.c. systems.
129 (1975):	Alternating current disconnectors (isolators) and earthing switches.
270 (1981):	Partial discharge measurements.
353 (1971):	Line traps.
383 (1976):	Tests on insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1 000 V.
518 (1975):	Dimensional standardization of terminals for high-voltage switchgear and controlgear.

LINE TRAPS FOR A.C. POWER SYSTEMS

SECTION ONE - GENERAL

1. Scope

This standard applies to line traps inserted into high voltage a.c. transmission lines to prevent undue loss of carrier signal power, typically in the range 30 kHz to 500 kHz, under all power system conditions and to minimize interference from carrier signalling systems on adjacent transmission lines. It does not apply to inductors which are connected to high voltage transmission lines for other purposes.

Line traps associated with a.c./d.c. converter stations require to operate under power system conditions which are not defined in this standard.

The information which has been provided in Appendix B to assist in the specification of such line traps is of an advisory nature only and does not form part of this standard.

2. Object

The object of this standard is to establish definitions, requirements, methods of testing and ratings for line traps.

3. Symbols used in this standard

Please note that the symbols used only in the appendixes are not included.

α	=	temperature coefficient
A_t	=	tapping loss
A_{tR}	=	tapping loss based on blocking resistance
C_r	=	self-capacitance
Δf_1, Δf_2	=	bandwidth based on blocking impedance
Δf_{1R}, Δf_{2R}	=	bandwidth based on blocking resistance
f_c	=	centre frequency
f_{cR}	=	centre frequency based on blocking resistance
f_{pN}	=	rated power frequency
I_N	=	continuous rated current
I_{km}	=	asymmetrical peak value of first half cycle of short-circuit currents
I_{kN}	=	steady state component of short-circuit currents

J = short-circuit current density

L_p = power-frequency inductance of the main coil

L_t = true inductance of the main coil

L_{tN} = rated inductance of the main coil

R_b = blocking resistance

T = inverse of temperature coefficient

U = voltage developed across the line trap at rated power frequency by the rated short-time current

U_m = maximum system voltage

Z_b = blocking impedance

θ = temperature

4. Service conditions

4.1 *Standard conditions*

The standard conditions shall be those for outdoor service. A line trap shall be capable of carrying out its required function whether exposed to sunshine, rain, fog, frost, snow, ice, etc. Cases arising from severe atmospheric conditions such as salt spray, industrial pollution, etc., shall be covered by special agreement between manufacturer and purchaser.

4.2 *Altitude*

A line trap shall not be used at an altitude greater than 1 000 m above sea-level without special agreement with the manufacturer and measure being taken to ensure its suitability.

4.3 *Ambient temperature*

Unless otherwise agreed between manufacturer and purchaser, a line trap shall not be used beyond an air temperature range of -40 °C to +40 °C.

4.4 *Power frequency*

This standard applies only to power system frequencies between 15 Hz and 60 Hz inclusive.

4.5 *Wave shape*

For the purpose of this standard, power-frequency currents and voltages shall be considered to have wave shapes which are approximately sinusoidal.

4.6 *Unusual service conditions*

In the event that the requirements of Sub-clauses 4.2 and 4.3 cannot be met, reference should be made to Clause 8 and Sub-clause 10.3.

SECTION TWO - DEFINITIONS

For the purpose of this standard, the following definitions shall apply. Other terms used have the meanings attributed to them in IEC Publication 50, unless otherwise stated.

5. General

A line trap, consisting of a main coil in the form of an inductor, a tuning device and a protective device, is intended for insertion in a high voltage power transmission line between the point of connection of carrier-frequency signals and adjacent power system elements such as busbars, transformers, etc. The tuning device connected across the main coil ensures, with proper adjustment, that the line trap presents a relatively high impedance at one or more carrier frequencies or carrier-frequency bands, whereas the impedance of the line trap at power frequencies is negligible. A line trap may also be used to limit the loss of carrier-frequency at a power system tee point.

Untuned line traps are sometimes used where there is a requirement for a wideband coupling. However, attention is drawn in Sub-clause 5.4 to the possibility of series resonance occurring under certain power system conditions, leading to an unacceptable shunting effect of the carrier-frequency signal path.

Figures 1a and 1b show the circuit diagrams of typical line traps.

5.1 *Main coil*

An inductor which carries the power-frequency current of the high voltage transmission line.

5.1.1 *Apparent inductance*

The reactance of the main coil divided by the angular frequency at which the reactance was determined, uncompensated for the effect of self-capacitance.

5.1.2 *Power-frequency inductance*

The inductance L_p at power-frequency.

5.1.3 *True inductance*

The self-inductance L_t of the main coil at a specified frequency compensated for the effect of self-capacitance.

5.1.4 *Rated inductance*

The value of true inductance L_{tN} at 100 kHz.

5.1.5 *Self-capacitance*

The capacitance C_r which, together with the true inductance, causes the main coil to resonate at self-resonant frequency. The self-capacitance is a function of the design of the main coil.

5.1.6 *Self-resonant frequency*

The frequency at which the combination of true inductance and self-capacitance becomes resonant.

5.1.7 *Resistance of main coil*

The value of resistance at d.c. current.

5.1.8 *Temperature coefficient*

The ratio α of the change in resistivity due to a change in temperature of 1 °C relative to the resistivity at 0 °C.

5.1.9 *Rated power frequency*

The frequency f_{pN} of the high voltage power transmission system to which the line trap is connected.

5.2 *Tuning device*

The combination of capacitors, inductors and resistors connected across the main coil. All of these components may not be present at any one time, depending on the carrier-frequency requirements of the line trap.

5.3 *Protective device*

The device connected across the main coil and tuning device which prevents the line trap from being damaged by transient overvoltages which may occur across it. Additional protective devices may be fitted to protect individual components of the tuning device.

5.4 *Carrier-frequency characteristics*

Power system elements such as transformers, busbars, lines, etc., represent an impedance connected beyond the line trap between line and earth. This impedance, in series with the impedance of the line trap, may shunt the carrier-frequency signal path. The loss in signal power resulting from this shunt depends upon the vectorial sum of the two impedances.

In the most unfavourable case, the reactive components of the two impedances may neutralise each other thus reducing the total shunt impedance to an unacceptably low value.

In order to eliminate this possibility and the further possibility of varying shunting effects arising out of power system switching, the blocking impedance of the line trap should always include a resistive component. The line trap performance can therefore be assessed in terms of its resistive component only.

5.4.1 *Blocking impedance*

The complex impedance Z_b of the complete line trap within a specified carrier-frequency range.

5.4.2 *Blocking resistance*

The resistive component R_b of the blocking impedance.

5.4.3 *Tapping loss*

The loss A_t sustained by a carrier-frequency signal due to the finite blocking ability of the line trap. It is defined in terms of the ratio of the signal voltages across an impedance equal to the characteristic impedance of the transmission line with and without the shunt connection of the line trap and is expressed in decibels.

5.4.4 *Tapping loss based on blocking resistance*

The loss A_{tR}, expressed in decibels, sustained by a carrier-frequency signal due to the shunt connection of the resistive component of the line trap impedance.

5.4.5 *Bandwidth based on blocking impedance*

The carrier-frequency bandwidth Δf_1 or Δf_2 within which the module of the blocking impedance does not fall below a specified value or the tapping loss A_t does not exceed a specified value (see Figures 2a and 2b).

5.4.6 *Bandwidth based on blocking resistance*

The bandwidth Δf_{1R} and Δf_{2R} based on the resistive component expressed in terms of the blocking resistance (see Figures 2a and 2b).

5.4.7 *Centre frequency*

The geometric mean frequency f_c of the bandwidth limit frequencies.

5.4.8 *Centre frequency based on blocking resistance*

The geometric mean frequency f_{cR} derived from the bandwidth limit frequencies based on blocking resistance. For band-tuned line traps f_c is equivalent to f_{cR}.

5.4.9 *Q factor*

The ratio of reactance to resistive component of the main coil at a specified frequency.

5.5 *Currents*

5.5.1 *Continuous rated current*

The maximum r.m.s. value of the current I_N flowing continuously through the main coil at specified power frequency which does not cause the specified temperature rise limits to be exceeded.

5.5.2 *Rated short-time current*

The r.m.s. value of the steady state component of the short-circuit current I_{kN} flowing through the main coil for a specified time without causing thermal or mechanical damage. The asymmetrical peak value I_{km} of the first half-cycle of the short-circuit current shall be assumed to be 2.55 times the r.m.s. value.

5.5.3 *Emergency overload current*

The amount of current which the main coil can sustain for a specified period without suffering permanent damage or a significant reduction in useful life.

SECTION THREE - REQUIREMENTS

6. General requirements

6.1 *Main coil*

The rated inductance of the main coil shall be chosen from the recommended values given in Clause 20 and shall not be less than 90% of the stated value.

Where there is a requirement for interchangeability, a suitable upper limit shall be agreed between manufacturer and purchaser. Otherwise, an upper limit does not require to be specified.

Note.- For calculations of blocking resistance or bandwidth based on blocking resistance, the lower tolerance should be used.