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Coupling devices for power line carrier systems

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Groupes de couplage pour systèmes à courants porteurs sur lignes d'énergie

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Coupling devices for power line carrier systems

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CONTENTS

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COUPLING DEVICES FOR POWER LINE CARRIER 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 recommendations and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This recommendation has been prepared by IEC Technical Committee No. 57, Power Line Carrier Systems. It is based on a report of CIGRE Study Committee No. 14, dated May 1968.

Drafts were discussed at the meetings held in Zurich in 1971 and in Athens in 1972. As a result of this latter meeting, a new draft, document 57(Central Office)8, was submitted to the National Committees for approval under the Six Months' Rule in March 1973.

The following countries voted explicitly in favour of publication:

Australia
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Norway
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Romania
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Sweden
Switzerland
Turkey
Union of Soviet Socialist Republics
United Kingdom
United States of America

COUPLING DEVICES FOR POWER LINE CARRIER SYSTEMS

SECTION ONE — GENERAL

1. Scope

This recommendation applies to coupling devices for power line carrier (PLC) systems which are connected between the coupling capacitor(s) and the carrier-frequency connection to the PLC terminal (or to a similar coupling device, directly or via additional equipment, in the case of retransmission).

The coupling device, in conjunction with the coupling capacitor(s) ensures:

a) the efficient transmission of carrier-frequency signals between the carrier-frequency connection and the power line;

b) the safety of personnel and the protection of the low-voltage parts of the installation against the effects of the power-frequency voltage and transient overvoltages.

This recommendation also applies to coupling devices used in conjunction with PLC systems which are required to operate over power cables.

2. Object

The object of this recommendation is to establish definitions, requirements, methods of testing and rated values for coupling devices.

3. Service conditions

This recommendation gives detailed requirements for use under the following conditions.

3.1 *Standard conditions*

The standard conditions shall be those for outdoor service. Coupling devices shall be capable of their function whether exposed to sunshine, rain, fog, hail, frost, snow, ice, etc.

3.2 *Altitude*

The height above sea level shall not exceed 1 000 m.

3.3 *Ambient temperature*

Unless otherwise agreed between manufacturer and purchaser, the ambient temperature shall be between −25 °C and +40 °C and shall not exceed the following limits:

+30 °C for the daily average,

+20 °C for the annual average.

3.4 *Power frequency*

Power systems shall have a rated frequency between zero (d.c.) and 60 Hz inclusive.

3.5 *Operating voltage*

The rated operating voltage of the power line shall be not less than 1 000 V.

3.6 *Provision for unusual service conditions*

In all cases where the above conditions are not met and severe atmospheric conditions such as salt spray and industrial pollution are to be expected, special arrangements should be made between manufacturer and purchaser.

SECTION TWO — DEFINITIONS

For the purpose of this recommendation, the following definitions apply.

4. Methods of coupling

Coupling is usually effected to one or more phase conductors of the power line (poles in the case of a d.c. power line), phase-to-earth and phase-to-phase being the most common forms of coupling. Coupling to all three phases of a circuit may be required in certain cases. Coupling to one or more associated insulated earth-wire conductors is also employed.

4.1 *Phase-to-earth coupling*

Coupling to the power line effected between the conductor(s) of one phase of the line and earth (see Figures 1*a* and 2, pages 20 and 22).

4.2 *Phase-to-phase coupling*

Coupling to the power line effected between the conductor(s) of one phase and the conductor(s) of another phase of the same line (see Figures 1*b* and 1*c*, page 21). The two phases may belong to the same circuit or to different circuits of the power line (intercircuit coupling).

Note. — Coupling between individual conductors of a phase bundle is a special application.

5. Coupling device

An arrangement of elements which contribute to ensure, together with one or more associated coupling capacitors, the transmission, under prescribed conditions, of carrier-frequency signals between one or more conductors of the power line and the carrier-frequency connection (see Figures 1 and 2).

Note. — These elements, alone or together, contribute to all, or part of, the following functions:

- tuning, designed to compensate for the reactive component of the coupling capacitor(s) impedance, in order to promote the efficient transmission of carrier-frequency signals. This function may be performed by a *tuning device*,
- impedance matching between the power line and the carrier-frequency connection. This function may be performed by a *transformer* or *autotransformer*,
- galvanic isolation between primary and secondary terminals of the coupling device. This function may be performed by the above-mentioned transformer, if present,
- draining to earth of the power-frequency current derived by the coupling capacitor(s). This function may be performed by an inductance, termed *drain coil*, or by the *primary winding* of the previously mentioned transformer, if present,
- limitation of voltage surges coming from the power line, at the terminals of the coupling device. This function may be performed by *lightning arresters* suitably arranged in the coupling device,
- direct and efficient earthing, when necessary, of the primary terminal(s) of the coupling device. This function may be performed by an *earthing switch*.

5.1 *Earth terminal*

A terminal of the coupling device which is intended to be connected directly to the local station earth.

5.2 *Primary terminal*

A terminal of the coupling device which is intended to be connected to the low-voltage terminal of the coupling capacitor.

5.3 *Secondary terminal*

A terminal of the coupling device which is intended to be connected to the carrier-frequency connection.

6. Communication terms for coupling devices

6.1 *Nominal line-side impedance* (Z_1)

The impedance which the coupling device, together with the associated coupling capacitor(s), is designed to match on the line side, and to which the requirements refer (see Figure 3, page 22).

6.2 *Nominal equipment-side impedance* (Z_2)

The impedance which the coupling device is designed to match, on the equipment side, and to which the requirements refer (see Figure 3, page 22).

6.3 *Composite loss*

The composite loss (see I.E.V. 55-05-175) brought about by the quadripole made up of the coupling device and associated coupling capacitor(s) having the specified capacitance and assumed to have no loss, terminated by the nominal line-side and equipment-side impedance.

6.4 *Return loss*

The return loss (see I.E.V. 55-05-195) of the quadripole made up of the coupling device and associated coupling capacitor(s) having the specified capacitance and assumed to have no loss, respectively terminated by the nominal line-side and equipment-side impedance.

6.5 *Available bandwidth*

The frequency band within which the composite loss does not exceed, and the return losses do not fall short of the specified values.

6.6 *Carrier-frequency working range*

The range of carrier frequencies within which the available bandwidth of a coupling device can be set.

6.7 *Nominal peak-envelope power*

The peak-envelope power for which the coupling device has been designed compatible with the requirements for intermodulation.

SECTION THREE — REQUIREMENTS

7. Safety and protection requirements of the coupling device

7.1 *General*

The coupling device shall meet the following requirements irrespective of whether or not the protective devices of an associated coupling capacitor or capacitor voltage transformer contribute to the safety and protection of the coupling device. The design of the coupling device shall be such as to prevent the occurrence of dangerous potentials on the carrier-frequency connection due to the service voltage or transient overvoltages which may occur on the power line.

Note. — There are two types of transient overvoltages to be taken into account:

a) Overvoltages due chiefly to the operation of switchgear. Such overvoltages may have amplitudes of the same order of magnitude as the service voltage and be transferred to the low-voltage side of the coupling capacitor because of the steep-fronted or high-frequency nature of the transients.

b) Atmospheric overvoltages which are also transferred to the low-voltage side of the coupling capacitor for the same reason.

The coupling device shall be designed and built to ensure that a fault on the power line shall not in general cause a permanent interruption in the functioning of the coupling device. If, under abnormal power-system conditions, the values specified in Sub-clauses 7.5, 8.1 and 8.2 are exceeded, this shall be a matter for special agreement between manufacturer and purchaser.

7.2 *Earthing of the primary terminal*

The coupling device shall be so designed that the impedance at power frequency between the primary terminal and the earth terminal is as low as possible and in no case in excess of 20 Ω. This low impedance shall be ensured by a device such as a drain coil or matching transformer winding as specified in Sub-clause 7.3.

7.3 *Drain coil or matching transformer winding*

The drain coil or matching transformer winding shall:

a) offer a maximum guarantee of continuity of connection to the earth terminal;

b) withstand any of the above-mentioned overvoltages which may occur on the power line, taking into account the effect of the main arrester (Sub-clause 7.5).

7.4 *Earthing switch*

An earthing switch shall be provided for making a temporary direct connection between the primary and earth terminals. The requirements of Sub-clause 7.3 also apply to this device.

The method of operating the earthing switch shall take due regard of national requirements for safety.

It is recommended that an indication of "on" and "off" positions of the earthing switch be clearly visible.

7.5 *Main arrester*

A lightning arrester shall be connected as directly as possible between the primary and earth terminals and shall be capable of protecting the coupling device and the carrier-frequency connection.

Notes 1. — For this purpose, at present, either arresters of the air-gap type or those of the non-linear resistor type are used.
If an air-gap type arrester is used, it must be robust and allow easy maintenance; moreover, it is recommended that its power-frequency sparkover voltage be of the order of 2 kV r.m.s. and that it be able to sustain an impulse discharge current of wave shape 8/20 µs of at least 5 kA. It is desirable that the arrester be capable of sustaining a power-frequency current of at least 5 kA r.m.s. for a period of 0.2 s while ensuring, even if damaged, that the other parts of the coupling device remain adequately protected.
If a non-linear resistor type arrester is employed, it is recommended that its rated voltage be of the order of 1 kV (corresponding to an impulse sparkover voltage of about 4 kV) and that it be able to sustain an impulse discharge current of wave shape 8/20 µs of at least 5 kA. See IEC Publication 60, High-voltage Test Techniques, and IEC Publication 99-1, Lightning Arresters, Part 1: Non-linear Resistor Type Arresters for A.C. Systems, 2nd edition).

2. — Where the coupling capacitor is remote from the coupling device, it may be necessary to provide, at the coupling capacitor, an additional arrester, similar to the main arrester.

3. — It may be advisable, both for the protection of the carrier-frequency connection and the PLC terminal, to provide an arrester which will limit the voltage across the secondary terminals of the coupling device to a value compatible with the withstand voltage of the carrier-frequency connection and that of the protection device, if any, at the other end of the carrier-frequency connection. Gas-type arresters, having a power-frequency sparkover voltage of the order of a few hundred volts are generally suitable.

8. Insulation requirements

8.1 *Power-frequency level*

If isolation between primary and secondary terminals of the coupling device is required by local operating conditions, then the tests described in Sub-clause 12.6 shall be applied using a power-frequency voltage of 5 kV r.m.s.

8.2 *Impulse level*

The coupling device shall be so designed as to be able to withstand a 1.2/50 µs impulse voltage whose peak value is equal to twice the value of the impulse sparkover voltage of the main arrester as applied in accordance with the method indicated in Sub-clause 12.4.

9. Carrier-frequency requirements

9.1 *Composite loss*

The composite loss shall be the least possible compatible with the bandwidth and design requirements called for by safety considerations and shall be not greater than 2 dB over the whole of the available bandwidth of the coupling device.

9.2 *Return loss*

The line-side and equipment-side return losses shall preferably be not less than 12 dB over the whole of the available bandwidth of the coupling device. In certain cases, values less than 12 dB may require to be accepted, subject to agreement between manufacturer and purchaser.