



INTERNATIONAL TELECOMMUNICATION UNION

CCITT

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

DIRECTIVES

concerning the protection of telecommunication lines
against harmful effects from electric power
and electrified railway lines

VOLUME VIII

PROTECTIVE DEVICES

Geneva 1989



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ISBN 92-61-04091-8

PREFACE

The rapid development of new technologies in telecommunications, electric power transmission and distribution, and electric railway systems has made the earlier issue of the Directives (1960 edition) out-of-date and this former issue is therefore being replaced completely.

The present Directives (1988 edition) have been established by the International Telegraph and Telephone Consultative Committee (CCITT) to give clear advice on how adverse electromagnetic effects on telecommunications lines from nearby electric power or electric railway installations may be minimized. The Directives have been based on the latest information that is available.

The new Directives have been prepared in close cooperation with the following international organizations :

- the International Union of Railways (UIC)
- the International Conference on Large High Voltage Electric Systems (CIGRE).

Representatives from these organizations have participated in preparation of the text of the Directives.

The two organizations support the underlying principles from which these texts have been derived, and the guidelines in the Directives which have been given. Such guidelines normally relate to general cases which are described. It is left to national organizations to establish more detailed regulations which apply to particular cases.

The new Directives are divided into a series of separate volumes, each dealing with a particular part of the complete subject. Each volume can be used independently. Modern calculation methods which are suitable for computer techniques have been incorporated.

Numerical values are used to define desirable limits which should be followed when the recommended technical measures are taken. In general, it should not be necessary to exceed these limits, although some special cases may arise where it is either uneconomical or impractical to do so (e.g. in narrow valleys). In such cases, mutual agreement based on the principles set out in the Directives should be reached.

Guidance on administration, economic and particularly legislation matters have been omitted deliberately since they are considered to be outside the technical scope of the advice given in the new Directives. In consequence, the rules of procedure which should be followed by telecommunications operators, and electric power and electric railway authorities have not been covered.

Nevertheless, the three international organizations which have worked together to produce the new Directives, CCITT, UIC and CIGRE, recommend that :

“Telecommunications, electric power and electric railway authorities should work together closely and follow the new Directives when seeking solutions to mutual problems. The solutions chosen should be those most acceptable and economical overall, and should not confer undue advantages to any participant.

We, the undersigned, representing the three organizations, CCITT, UIC and CIGRE, support the work done jointly on behalf of our organizations in producing these Directives. We recommend these Directives to members of CCITT, UIC and CIGRE who seek solutions to mutual disturbance problems.”

Th. IRMER
Director of the CCITT

J. BOULEY
*Secretary-General
of UIC*

G. LEROY
*Secretary-General
of CIGRE*

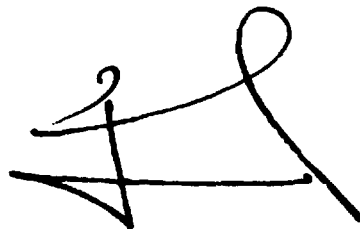




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CHAPTER 1

INTRODUCTION

1.1 Aim and scope of the Directives

The present Directives supersede the 1963 edition approved by the 2nd Plenary Assembly of CCITT in New Delhi 1960. The 1963 Directives were amended in 1965, 1974, 1978 and 1982. They provided a comprehensive description of electromagnetic effects due to the close proximity of telecommunication lines to power and electrified railway systems, containing regularly updated findings in this field and reflecting the current state of the art.

Analyses have shown, however, that in spite of these advantages, the 1963 Directives are not used as widely as expected. The main reasons for this are believed to be that the 1963 Directives form a very bulky book which is hard to handle and in which theoretical considerations tend to prevail over practical advice. Calculation methods and the related models were developed before modern computer technology was available. Since the 1963 Directives reflected the principal arrangements which appeared in the original first issue in 1925, many cross-references became necessary as new clauses were added. In consequence, the VIIth Plenary Assembly of CCITT in Geneva 1980 decided to revise the 1963 Directives completely and entrusted Study Group V with the task of producing new Directives for publication in 1988.

The new Directives are intended to meet a number of requirements, particularly those sought by engineers in the field. Nevertheless, the valuable background advice contained in the 1963 Directives is retained and even expanded wherever relevant. As a result, the new Directives should be useful:

- to practising engineers who seek guidelines on how to deal with danger and disturbance problems;
- to scientists and researchers who need a reference book with the most recent findings;
- to students who require a textbook with which to become acquainted with electromagnetic coupling phenomena;
- to Administrations which need to have a basis to form national regulations and standards.

The new Directives have been prepared as a result of close collaboration between many members of CCITT, CIGRE and the UIC. They therefore describe technical methods for solving mutual problems which are recognized by these international organizations and which should facilitate coordination between member organizations in user countries.

The principal object of the new Directives is to describe ways in which adverse effects from power transmission and distribution lines or from electrified railway lines onto telecommunication lines can be reduced or avoided. Such effects may result in danger to personnel, damage to telecommunication equipment, deterioration of telecommunication transmission quality or to disturbance of signalling.

Although the advice given in the new Directives has been described for public telecommunication networks, the basic principles have a more general application, and owners of other networks should decide whether they can be adapted to their own needs.

1.2 Structure of the Directives

1.2.1 Content of individual volumes

The new Directives are divided into 9 volumes, each dealing with a separate part of the overall subject matter. The series is made up as follows:

- | | |
|-------------|--|
| Volume I | "Design, construction and operational principles of telecommunication, power and electrified railway facilities" describes these systems and shows why conditions for their mutual coexistence must be established. |
| Volume II | "Calculating induced voltages and currents in practical cases" describes the methods for evaluating voltages and currents resulting from capacitive, inductive and conductive coupling in a variety of commonly-encountered situations. |
| Volume III | "Capacitive, inductive and conductive coupling: physical theory and calculation methods" gives an account of the physical laws governing the relevant phenomena together with mathematical models, and introduces a precise calculation method to evaluate voltages and currents resulting from couplings. |
| Volume IV | "Inducing currents and voltages in electrified railway systems" describes traction systems using d.c. and a.c. at various frequencies (16 2/3 Hz, 50 Hz, 60 Hz etc.) in normal operation and under fault conditions. |
| Volume V | "Inducing currents and voltages in power transmission and distribution systems" describes unbalanced and balanced power systems in normal operation and under fault conditions. |
| Volume VI | "Danger and disturbance" considers the risk to both equipment and people. |
| Volume VII | "Protective measures and safety precautions" describes methods which are commonly used to ensure satisfactory working and operating conditions. |
| Volume VIII | "Protective devices" gives the latest information on devices which may be used to improve safety standards or reduce disturbance of telecommunication systems. |
| Volume IX | "Testing methods and measuring apparatus" describes the methods and apparatus used to determine parameters required for coupling calculations, and to verify the satisfactory operation of protective measures. In addition it deals with testing methods taking into account modern practices in other fields of electromagnetic compatibility (e.g. lightning, high frequency disturbances). |

The volumes overlap to some extent deliberately. This limits the need to consult several volumes simultaneously when resolving practical problems.

Calculation methods for evaluating voltages and currents induced into lines are given in both Volumes II and III. In Volume II simplified formulae are given for each type of coupling with graphs and data for step-by-step calculation. The method covers the usual cases which arise in practice and requires access only to calculators or small computers. It is useful to those seeking a simple procedure where some approximations have to be made.

In Volume III, a rigorous calculation method is given, strictly associated with the theory of coupling which is also treated in the volume. The method deals with a wide range of situations and assumes that access is available to adequate computing facilities. The volume is intended to be used by those who require a precise evaluation of the coupling results.

1.2.2 *Use of the Directives*

1.2.2.1 *When studying coupling processes in general*

- For a broad understanding of telecommunication, power and electrified railway facilities and their mutual coupling effects, consult Volume I.
- For further information on inducing installations in power or electrified railway systems, consult Volume IV (railway systems) or Volume V (power systems).
- For detailed study of coupling phenomena and calculation methods, consult Volumes II and III.
- To understand the effects of induced voltages and currents, i.e. danger and disturbance, and the limiting values which are recommended, consult Volume VI.
- For advice on protective components or complex protective devices, consult Volume VIII.
- For information on relevant testing and measuring techniques, consult Volume IX.

1.2.2.2 *When establishing standards or similar regulations*

- For limiting values of induced voltages and currents, consult Volume VI.
- For estimating induced voltages and currents using simplified calculations, consult Volume II.
- For precise calculation of induced voltages and currents, consult Volume III.
- To select appropriate protective measures, consult Volume VII.

1.2.2.3 *When dealing with danger and disturbance problems in practice*

- Identify the telecommunication, power and electrified railway lines involved and ensure they are described in adequate detail.
- Compare the operational and fault conditions in the inducing systems with the actual inducing voltages and currents by consulting Volume IV (railway systems) or Volume V (power systems).
- Determine the electrical and geometrical parameters needed for calculations in Volume II or Volume III using numerical values that are known.
- To measure parameters which are not known, consult Volume IX.
- To estimate the induced voltages or currents using simple calculation methods, consult Volume II.
- To calculate induced voltages and currents precisely, consult Volume III.
- To decide whether the predicted induced voltages and currents are acceptable, consult Volume VI.
- To select suitable protective measures, consult Volume VII.

These steps are illustrated in the flowchart in Figure 1/1.

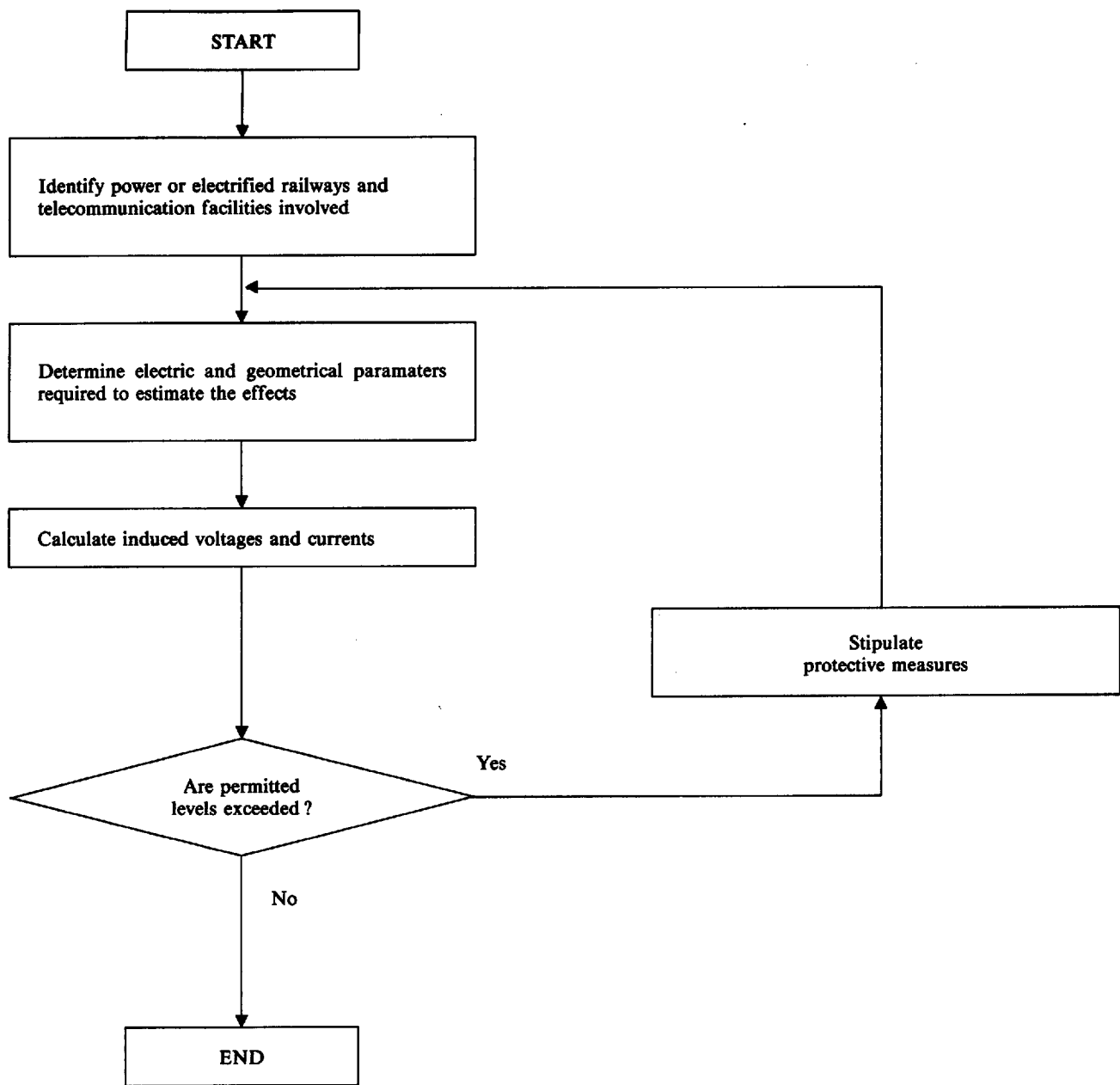


FIGURE 1/1

Flowchart to be followed when dealing with danger and disturbance problems in practice

FIGURE 1/1

Flowchart to be followed when dealing with danger and disturbance problems in practice

1.3 Purpose of the volume

This volume is a catalogue of protective devices whose use and method of operation is described elsewhere in the Directives. It gives details of the range of their characteristics and indicates those which are most important when choosing a device for a particular protective purpose. Dimensioned drawings (in mm) or general descriptions give approximate indications of the size of the devices since this is often of practical importance. Descriptions of the internal functioning of devices and of the ways in which they provide protection are usually brief. For more detailed information reference should be made to Volume VII or the other sources listed under individual devices.

All the devices listed are commercially available and are either in use or under active study by at least one telecommunications operating organization.

Organizations shown as users of the devices are able to indicate sources of supply and give further details.

CHAPTER 2

PARALLEL DEVICES FOR OVERVOLTAGE PROTECTION

Parallel devices are usually connected as shown in Figure 1/2 which shows a particular type of device but is applicable to all types. More complex arrangements are possible as indicated in K series Recommendations.

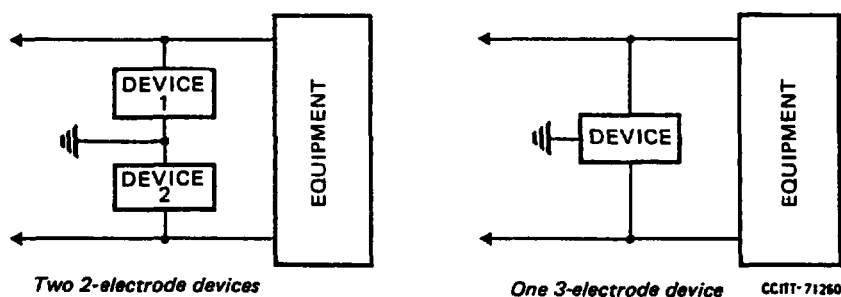


FIGURE 1/2

Connection of parallel devices

2.1 Spark-gap type devices

Spark-gap type devices include simple air gaps, carbons and gas discharge tubes. Their principle of operation is that at normal circuit voltage their impedance is high, of the same order as the circuit insulation, but at a certain voltage a spark or discharge occurs and the voltage across the device falls to a low value. The energy of the overvoltage is thus absorbed partly in the device but largely in the wiring of the line and is prevented from reaching the equipment.

Spark-gap type devices are usually small in relation to the currents they can carry because they can withstand high temperatures and the low spark voltage limits the power produced by the current.

2.1.1 Gas discharge tubes (GDTs)

GDTs have voltage-current characteristic as shown in Figure 2/2. Typical dimensions are shown in Figure 3/2.

GDTs are available with striking voltages from about 90 V upwards. For impulse voltages rising very rapidly (1 kV/μs), such as lightning surges, the striking voltage is higher e.g. 700-1000 V, regardless of the nominal d.c. striking voltage. Special GDTs are available for impulse voltages rising faster than 1 kV/μs.