TECHNICAL REPORT

IEC TR 61131-4

Second edition
2004-07

Programmable controllers –

Part 4: User guidelines

Reference number
IEC/TR 61131-4:2004(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site (www.iec.ch)**

- **Catalogue of IEC publications**

  The on-line catalogue on the IEC web site (www.iec.ch/searchpub) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

  This summary of recently issued publications (www.iec.ch/online_news/ justpub) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

  If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

  Email: custserv@iec.ch
  Tel: +41 22 919 02 11
  Fax: +41 22 919 03 00

TECHNICAL REPORT

IEC TR 61131-4

Second edition
2004-07

Programmable controllers –

Part 4:
User guidelines

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE XF

For price, see current catalogue

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PROGRAMMABLE CONTROLLERS –

Part 4 – User guidelines

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

This part of the International Standard IEC 61131 has been prepared by subcommittee 65B: Devices, of IEC Technical Committee 65: Industrial-process measurement and control.

This second edition cancels and replaces the first edition published in 1995. It constitutes a technical revision.

This second edition of IEC 61131-4 differs extensively from the first edition. The first edition, IEC 61131-4:1995, initiated some twenty years ago, was mainly tutorial in nature. The present revision aims to provide an engineering overview of the IEC 61131 series for the end-user of PLC equipment who may not be expected to delve into the details of the extensive product standard that is IEC 61131.

The purpose of this revision is therefore to assist the end-users of PLCs to make efficient and effective use of the IEC 61131 series, and to realise the benefit of IEC standard compliant programmable controllers. This revised Technical Report serves as a quick reference and roadmap. Many of the IEC 61131 parts have gone through their maintenance cycle revisions. This revision of IEC 61131-4 is based on the latest revisions available.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
65B/508A/DTR	65B/527/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IEC 61131 consists of the following parts, under the general title: *Programmable controllers*

Part 1: General information

Part 2: Equipment requirements and tests

Part 3: Programming languages

Part 4: User guidelines

Part 5: Communications

Part 7: Fuzzy control programming

Part 8: Guidelines for the application and implementation of programming languages

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this Technical Report may be issued at a later date.

INTRODUCTION

This part of IEC 61131 constitutes the fourth part of a series of standards on programmable controllers and the associated peripherals and should be read in conjunction with the other parts of the series.

Where a conflict exists between this and other IEC standards (except basic safety standards), the provisions of this standard should be considered to govern in the area of programmable controllers and their associated peripherals.

Terms of general use are defined in IEC 61131-1. More specific terms are defined in each part.

PROGRAMMABLE CONTROLLERS –

Part 4: User guidelines

1 General

1.1 Scope and object

The object of this Technical report is to introduce the end-users of Programmable Controller (PLC) to the IEC 61131 series, and to assist the end-users in their selection and specification of their PLC equipment according to the IEC 61131 series. This user guideline has as its main audience PLC end-users.

PLCs, their application program and their associated peripherals are considered as components of a control system. Therefore, PLC users should take note that this standard does not deal with the automated system in which the PLC and PLC system is but one component. However, when applying this user guideline, an overall system architecture evaluation is recommended. Functional safety of the overall automated system is beyond the scope of this standard.

An objective of this user guideline is to facilitate communication between the PLC user and PLC supplier according to the specifications of the IEC 61131 series that applies to PLCs and their associated peripherals. This information exchange is illustrated in Figure 1.

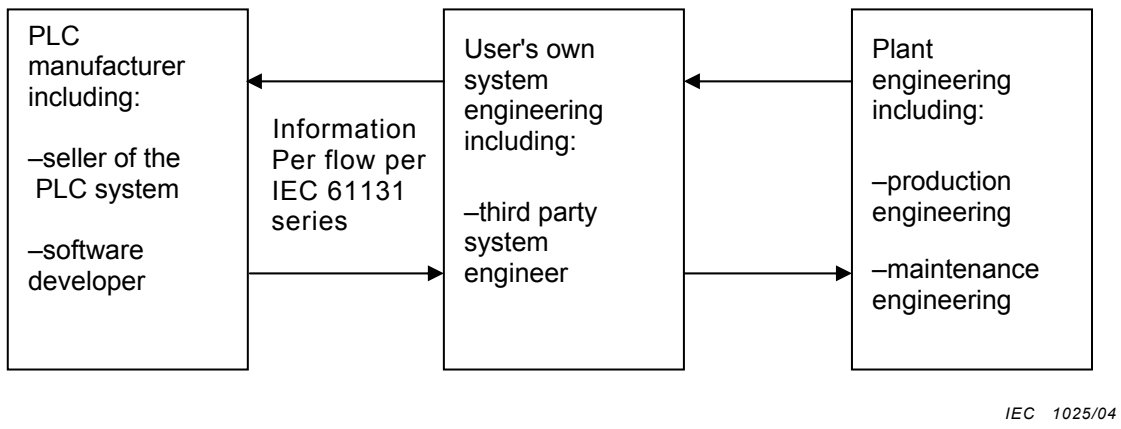

Figure 1 – Object of user guidelines

As depicted in Figure 1, the users consist of system integrators and end-users. The manufacturer of PLC is required by the IEC 61131 series to furnish appropriate product information to the user. Optionally, the user supplies operational requirements and specifications to the manufacturer in order to receive suitable products and services from the manufacturer. One objective of this Technical Report is therefore to assist in this communication, especially from the end-user's perspective. Accordingly, this Technical Report does not detail all the requirements of each and every part of the IEC 61131 series, such as conformance tests. The user should refer to the individual parts of the standard when needed.

1.2 Normative references

The following referenced documents are indispensable for the application 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 61131-1: *Programmable controllers – Part 1: General information*

IEC 61131-2: *Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61131-3: *Programmable controllers – Part 3: Programming languages*

IEC 61131-5: *Programmable controllers – Part 5: Communications*

IEC 61131-7: *Programmable controllers – Part 7: Fuzzy control programming*

IEC 61131-8: *Programmable controllers – Part 8: Guidelines for the application and implementation of programming languages*

1.3 Use of this report

A PLC application starts with the user's system analysis and specification. Inquiries and discussions (and suggestions/recommendations) with the manufacturer necessitate the use of a mutually agreed language for interactive information exchange as in Figure 1. The user can use this report as a basis and/or to supplement any in-house system design rules. The user can then specify the equipment and software requirements according to the relevant parts in the IEC 61131 series. In this user guideline, introductions and briefings of various parts of the IEC 61131 series are presented in Annex A according to the divisions in the IEC 61131 series. For example, Clause A.1 covers IEC 61131-1, Clause A.2 covers IEC 61131-2, etc.

This Technical Report presents only those specifications for which the user may have an immediate need for reference. It is not a complete summary of the whole IEC 61131 series.

2 Terms and definitions

For the purposes of this part of IEC 61131, the following terms and definitions, as well as those given in IEC 61131-1, apply.

2.1
application program (user program)
logical assembly of all the programming language elements and constructs necessary for the intended signal processing required for the control of a machine or process by a PLC system

2.2
automated system
control system beyond the scope of IEC 61131 in which PLC systems are incorporated by or for the user, but which also contains other components including their application programs

2.3
operator (human)
person commanding and monitoring a machine or process through an HMI connected to the PLC. The operator does not change the PLC hardware configuration, software or the application program. A PLC is not intended for use by untrained personnel. The operator is assumed to be aware of the general hazards in an industrial environment.

2.4
programmable controller
digitally operating electronic system, designed for use in an industrial environment, which uses a programmable memory for the internal storage of user-oriented instructions to implement specific functions (such as logic, sequencing, timing, counting and arithmetic) to control, through digital or analogue inputs and outputs, various types of machines or processes.

NOTE In the first edition of the IEC 61131 series, the acronym "PC" was used for Programmable Controller. However, usage of the earlier acronym PLC has been persisted with the majority of industries. After consultation, IEC Subcommittee 65B WG7 recommended that the more widely accepted acronym PLC be used, starting with all new editions of the IEC 61131 standard.

2.5
programmable controller system
user-assembled configuration, consisting of a programmable controller and associated peripherals that is necessary for the intended automated system. It consists of units interconnected by cables or plug-in connections for permanent installation and by cables or other means for portable and transportable peripherals.

2.6
service personnel
person changing or repairing the PLC hardware configuration or the application programme.

The service person may also install software updates provided by the manufacturer. They are assumed to be trained in the programming and operation of the PLC equipment and its use.

They are persons having the appropriate technical training and experience necessary to be aware of hazards – in particular, electrical hazards – to which they are exposed in performing a task and of measures to minimize danger to themselves or to other persons or to the equipment.

3 General recommendations for installation

The installation procedure should fulfil the requirements given by documents, which are prepared during the system selection/engineering/application phase. Not all site conditions can be recognized at the PLC selection phase. During installation, it is important to update all engineering and application documents according to how the PLC equipment is assembled or modified on site.

3.1 Environmental conditions

The user should ensure that care is taken concerning temperature, contaminants, shock, vibration and electromagnetic influence. Refer to IEC 61131-2 for specific environmental requirements. Table 1 describes environmental conditions to be evaluated during installation.

Table 1 – Environmental conditions

Criteria	Comments and considerations
Temperature	Check for possible influence of steady or temporary heat sources: - space heater - solar heat - hot goods passing by
Contaminants	Moisture, corrosive gases, liquids and conductive dust can affect the function of a PLC system. Therefore, check: - use of adequate enclosures in compliance with international/national codes - compliance with manufacturer's installation instructions - degradation of thermal efficiency caused by dust
Shock and vibration	Check for possible effects on site: - engines - compressors - transfer lines - presses, hammers - vehicles
Electromagnetic interference	Check electromagnetic interference from various sources on site: - motors - switch gears, thyristors - radio-controlled equipment - welding equipment - electrical arcs - switched power supplies - power converters/inverters

3.2 Field wiring

Proper field wiring practices are of prime importance to the application of PLCs. The installer needs to follow the manufacturer's wiring instructions and applicable local regulations.

Two earthing/grounding requirements need to be fulfilled during installation: protective earth (safety grounding) and functional earth (signal ground reference).

Protective earthing requires the solid connection (e.g., low impedance connection, including star washers, welding, soldering, etc.) of inactive metal parts to an equipotential metallic grid (frames, chassis, cabinets). The grid needs to be connected to protective earth in accordance with local and national codes.

Functional earthing needs to be installed as the low impedance network of signal ground reference lines. It should be a network separate from protective earthing.

Protective and functional earth networks may be interconnected via wires or other low impedance paths. Such interconnections or lack thereof may be required by applicable local/national codes, or due to noise reduction requirements, depending on the type of controlled process/equipment. Table 2 describes installation rules of earthing measures.

Table 2 – Installation rules: earthing measures

Criteria	Reference	Comments and considerations
Protective earthing		- Provide sufficient conductor cross-section for connections to earth. - Doors should have electrical connections according to local and national codes. - Verify connections are tight and resistant to vibration and corrosion.
Functional earthing		- Usually functional ground reference is connected only at a single point to earth. When more than one connection to earth is made, care should be taken to avoid ground loop interference. Such multipoint earth connections must be made to an equipotential grid. - Protective earth conductors may be suitable for functional grounding. Such practice can be determined on site by measurement at 50 Hz/60 Hz and at frequencies above signal frequency. Such quality may be improved by specially installed electrodes or, possibly, earthed conductive building structures. - If a direct connection of the signal ground reference conductor of the PLC to earth is not possible, the connection may be made via a suitable capacitor. The capacitor should correspond to the rated insulation voltage of the PLC circuit, and should have good high-frequency properties. Static charging can be prevented by the use of a high ohm value resistor for discharge. - There should be no discontinuities on ground circuits, such as could be introduced by terminals and sockets.
Caution – protective earthing is intended to reduce the risk of electric shock hazard. Under no circumstances should the protective earth be disconnected from the PLC. Functional earth connections may be temporarily disconnected for servicing and/or maintenance as required.		

3.3 Electromagnetic compatibility

A number of common installation practices have been found to minimise EMC related problems. Some of these are listed in Table 3

Table 3 – Installation rules: EMC

Criteria	Reference	Comments and considerations
Mains		- Mains conductors should be separately installed from other PLC wiring, i.e., cable spacings of 10 cm or more from signal cables. - Unavoidable crossing should be at right angles. - Use of mains' filters on the cabinet feed-ins may be required. - Transient suppressor at mains' entrance may be required.
Input/output		- Separation of the field wiring from internal I/O cabling and from bus lines. - Care must be taken not to compromise isolation of circuits (e.g., by optical separation) between I/O field wiring and internal PLC system. - Filtering of susceptible I/O cables may be required. - Use of shielded cables with low inductance cable shields (low-level signals). - Earthing measurement in each individual case must be determined on site. - Shield may be connected to functional ground or protective earth. - Electrical contacts in series with inductive loads require special attention for voltage surge and stored energy.
Noise sources		Noise damping at emission sources with noise suppressers such as: - Separate cables for input, outputs, and power circuits. - Minimise the total length of wiring. - Use of manufacturer recommended cables and leads.
Analogue and other noise-sensitive circuits		- Use of shielded wires. - Use of twisted-pair wiring.
Routing		Interference voltage or current noise can enter PLCs where connections are made, as well as the power supply connections. The wiring which extends between the PLC and these control devices should be properly routed to minimize induced noise on these wires.

3.4 User system markings

User system markings of components (sensors, actuators, cables, distribution-boards, enclosures, modules, etc.) should be done in accordance with the installation drawings and applicable codes.

Special care needs to be taken on markings of wiring. Each and every field wire should be identified with a marking corresponding to drawing. Alteration from the drawing should be noted on the same drawing immediately.

Care needs to be taken to ensure the following:

– markings need to be indelible;
– adequate sizes of letters and signs;
– fuse location, type, rating need to be clearly marked;
– visibility of markings; and
– conformity with installation drawings according to revision of final documents.

4 PLC in functional safety applications

When PLCs are required to perform safety functions, it is necessary that special measures be taken to avoid and limit dangerous failures of the functional-safety-related system. Detailed requirements for Safety-Related System (SRS) are contained in IEC 61508 and in emerging sector implementation standards such as the IEC 61511 series. The purpose of this Clause is to provide an overview of some of the functional safety issues that will need to be addressed. It is not intended to provide definitive or detailed guidance for implementation.

4.1 Functional safety and safety-related-system concept

Functional safety, as defined in IEC 61508, refers to the ability of a SRS to carry out the functions necessary to achieve a safe state for the Equipment Under Control (EUC) or to maintain a safe state for the EUC. In this definition, the main subject is focused on the ability of a safety-related system to do what it is required to do.

“Safety” refers to freedom from unacceptable risk. It follows that there are acceptable risks. The level of risks may be categorized as “broadly acceptable”, “tolerable” where further risk reduction is impracticable (the As Low As Reasonably Practical, ALARP, principle) and, the “intolerable” where risks cannot be justified, except in extraordinary circumstances. Risk level is assessed as a combination of “Consequence of hazardous event” and “Frequency of hazardous event”.

The task of a SRS is to reduce the risk to a tolerable level or lower as prescribed by the control system designer. This risk-reduction model is depicted in Figure 2.

NOTE 1 The IEC 61131 series does not deal with the functional safety or other safety aspects of the overall automated system. Safety considerations for the overall automated system are beyond the scope of this standard.

NOTE 2 The IEC 61131 series does not contain a part on functional safety. At the preparation of this part of IEC 61131, a sector standard for PLC and similar equipment is under consideration.

NOTE 3 Safety, as covered in IEC 61131-2, refers to prevention of electric shock and fire hazards.