Programmable controllers –
Part 4:
User guidelines
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FOREWORD</strong></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td><strong>INTRODUCTION</strong></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>General</td>
<td>8</td>
</tr>
<tr>
<td>1.1</td>
<td>Scope and object</td>
<td>8</td>
</tr>
<tr>
<td>1.2</td>
<td>Normative references</td>
<td>9</td>
</tr>
<tr>
<td>1.3</td>
<td>Use of this report</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>Terms and definitions</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>General recommendations for installation</td>
<td>11</td>
</tr>
<tr>
<td>3.1</td>
<td>Environmental conditions</td>
<td>11</td>
</tr>
<tr>
<td>3.2</td>
<td>Field wiring</td>
<td>11</td>
</tr>
<tr>
<td>3.3</td>
<td>Electromagnetic compatibility</td>
<td>12</td>
</tr>
<tr>
<td>3.4</td>
<td>User system markings</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>PLC in functional safety applications</td>
<td>13</td>
</tr>
<tr>
<td>4.1</td>
<td>Functional safety and safety-related-system concept</td>
<td>13</td>
</tr>
<tr>
<td>4.2</td>
<td>Using a PLC in a safety-related application</td>
<td>15</td>
</tr>
<tr>
<td>4.3</td>
<td>Requirements on PLCs in a safety-related system</td>
<td>16</td>
</tr>
<tr>
<td>4.4</td>
<td>Integration of PLC into a safety-related system</td>
<td>16</td>
</tr>
<tr>
<td><strong>Annex A (informative) Overview of normative parts of IEC 61131</strong></td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>A.1</td>
<td>Overview of IEC 61131-1</td>
<td>19</td>
</tr>
<tr>
<td>A.2</td>
<td>Overview of IEC 61131-2</td>
<td>26</td>
</tr>
<tr>
<td>A.3</td>
<td>Overview of IEC 61131-3</td>
<td>59</td>
</tr>
<tr>
<td>A.4</td>
<td>(blank)</td>
<td>88</td>
</tr>
<tr>
<td>A.5</td>
<td>Overview of IEC 61131-5</td>
<td>88</td>
</tr>
<tr>
<td>A.6</td>
<td>(blank)</td>
<td>100</td>
</tr>
<tr>
<td>A.7</td>
<td>Overview of IEC 61131-7</td>
<td>100</td>
</tr>
<tr>
<td>A.8</td>
<td>(blank)</td>
<td>107</td>
</tr>
<tr>
<td><strong>Annex B (informative) Conformity to IEC 61131 and product certification</strong></td>
<td></td>
<td>108</td>
</tr>
<tr>
<td>B.1</td>
<td>General</td>
<td>108</td>
</tr>
<tr>
<td>B.2</td>
<td>Conformity to standards</td>
<td>108</td>
</tr>
<tr>
<td>B.3</td>
<td>Declaration of conformity and certification</td>
<td>109</td>
</tr>
<tr>
<td>B.4</td>
<td>The inter-relation of standards to laws in European Community</td>
<td>109</td>
</tr>
<tr>
<td>B.5</td>
<td>CE-marking of PLCs in the European Union</td>
<td>111</td>
</tr>
<tr>
<td>B.6</td>
<td>Transition periods</td>
<td>113</td>
</tr>
<tr>
<td>B.7</td>
<td>Other jurisdictions</td>
<td>114</td>
</tr>
<tr>
<td>B.8</td>
<td>Reference documents</td>
<td>115</td>
</tr>
<tr>
<td><strong>Annex C (informative) Use of PLC programming languages and examples</strong></td>
<td></td>
<td>116</td>
</tr>
<tr>
<td>C.1</td>
<td>Preamble</td>
<td>116</td>
</tr>
<tr>
<td>C.2</td>
<td>Advance planning</td>
<td>116</td>
</tr>
<tr>
<td>C.3</td>
<td>Structure and organization</td>
<td>117</td>
</tr>
<tr>
<td>C.4</td>
<td>Use of PLC languages</td>
<td>120</td>
</tr>
</tbody>
</table>
C.5 User Defined Function Block (DFB) .................................................................127
C.6 Language implementation ..................................................................................130

Figure 1 – Object of user guidelines ........................................................................8
Figure 2 – SRS in risk reduction concept .................................................................14
Figure 3 – Event tree analysis for deployment of SRS ..............................................18
Figure A.1 – Basic functional structure of a PLC system .........................................21
Figure A.2 – PLC hardware model ..........................................................................22
Figure A.3 – Typical interface/port diagram of a PLC system ..................................23
Figure A.4 – Type test EUT configuration ................................................................32
Figure A.5 – Digital I/O parameters .........................................................................35
Figure A.6 – Immunity zones ....................................................................................46
Figure A.7 – Programmable Controller System (PLC system).................................59
Figure A.8 – Software model ...................................................................................62
Figure A.9 – Combination of programmable controller language elements ..........64
Figure A.10 – Examples of function usage ...............................................................69
Figure A.11 – Function block instantiation examples ..............................................70
Figure A.12 – Sequential function chart ..................................................................71
Figure A.13 – Function block and program declarations for configuration example ....79
Figure A.14 – The four programming languages .....................................................82
Figure A.15 – Boolean OR examples .......................................................................86
Figure A.16 – Programming elements of Function Block Diagram language ..........87
Figure A.17 – Top-down and bottom-up programming ............................................88
Figure A.18 – Scope of IEC 61131-5 ....................................................................88
Figure A.19 – Relationship of the communication model to IEC 61131-2 and IEC 61131-3 90
Figure A.20 – Programmable controller communication model .........................91
Figure A.21 – Example of communication control in FBD language ...................99
Figure A.22 – Example of a fuzzy control in FBD program ..................................101
Figure A.23 – Example of ramp curve membership functions .............................102
Figure A.24 – Defuzzification program block .........................................................102
Figure A.25 – Example of singleton terms ..............................................................102
Figure C.1 – Program structure overview ...............................................................118
Figure C.2 – Program structure with detail ..............................................................119
Figure C.3 – The structured program plan for brewing process automation with various languages ...............................................................121
Figure C.4 – Example of a program in IL language ...............................................122
Figure C.5 – Example of a program in ST language ..............................................123
Figure C.6 – Example of a control program in LD language ...................................124
Figure C.7 – An example of a control program in FBD language .........................125
Figure C.8 – A control program in SFC .................................................................126
Figure C.9 – A DFB for valve control .................................................................127
Figure C.10 – DFB for valve actuation ..............................................................128
Figure C.11 – DFB for alarm actuation ..............................................................129
Table 1 – Environmental conditions ......................................................................................11
Table 2 – Installation rules: earthing measures ........................................................................12
Table 3 – Installation rules: EMC ..........................................................................................12
Table 4 – SIL of demand mode safety functions .................................................................14
Table 5 – SIL of continuous mode safety functions ...............................................................14
Table A.1 – Summary of programmable functions .................................................................24
Table A.2 – General conditions for tests ...............................................................................32
Table A.3 – Operating ambient air temperature of PLC systems ...........................................33
Table A.4 – Emission limits ...................................................................................................45
Table A.5 – Criteria to prove the performance of a PLC-system against EMC disturbances .................................................................47
Table A.6 – Voltage drops and interruptions ........................................................................47
Table A.7 – Shock protection requirements for open and enclosed equipment ......................50
Table A.8 – Temperature limits ............................................................................................52
Table A.9 – Data type declaration features ...........................................................................67
Table A.10 – Location and size prefix features for directly represented variables ...............67
Table A.11 – Variable usage ................................................................................................68
Table A.12 – Examples of function block I/O variable usage .................................................70
Table A.13 – Step features ..................................................................................................72
Table A.14 – Transition and transition conditions ................................................................73
Table A.15 – Declaration of action ........................................................................................75
Table A.16 – Step/action association ....................................................................................77
Table A.17 – Action block features ......................................................................................78
Table A.18 – Configuration and resource declaration features ..............................................79
Table A.19 – Examples of configuration and resource declaration features .........................80
Table A.20 – Operators of Instruction List language ............................................................83
Table A.21 – Operators of the ST language ........................................................................84
Table A.22 – ST language statements: ................................................................................84
Table A.23 – Status presenting entities .................................................................................92
Table A.24 – PLC summary status .......................................................................................93
Table A.25 – Status of I/O subsystem ....................................................................................94
Table A.26 – Status of processing unit ..................................................................................94
Table A.27 – PLC application functions ..............................................................................95
Table A.28 – Meaning of value of I/O state .........................................................................97
Table A.29 – List of communication function blocks ..............................................................98
Table A.30 – Semantic of communication function block parameters ................................98
Table A.31 – Defuzzification methods .................................................................................103
Table A.32 – Priority of rule block operators .......................................................................103
Table A.33 – Fuzzy logic control basic level language elements ........................................105
Table A.34 – Fuzzy logic control extension level language elements (optional) ..................105
Table A.35 – Fuzzy logic control data check list ..................................................................106
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 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.

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:

<table>
<thead>
<tr>
<th>Enquiry draft</th>
<th>Report on voting</th>
</tr>
</thead>
<tbody>
<tr>
<td>65B/508A/DTR</td>
<td>65B/527/RVC</td>
</tr>
</tbody>
</table>

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.
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.

![Diagram of information flow per IEC 61131 series](image-url)

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