PLCopen PC2 Technical Paper

Specification of Requirements for a Standard IEC 61131-3 Training Course

Version 2.1

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Table of Contents

History

This document has been:

- Created in January 1997 (Version 0.1)
- Reviewed by the task force of PC2 in February 1997 (Version 0.2)
- Submitted to the PC2 members for final comments in March 1997 (Version 0.3)
- Submitted to the PLCopen organization as a final draft in March 1997 (Version 0.4)
- Released as official version 1.0 in July 1998
- Updated in 2004 by PLCopen, and released for comments to the PLCopen members on Sept. 20, 2004
- Released as official version 2.0 in November 2004
- Updated in 2006 by PLCopen to include training logo, and released as version 2.1 on Sept. 19, 2006

1 Scope

PLCopen, a worldwide organization, does not provide hands-on training courses on IEC 61131-3 due to possible conflicting interests with its members. In order to guide potential users to relevant IEC 61131-3 courses, including the concepts and languages, PLCopen with its members defined these guidelines, together with a set of slides. The present document (including the relevant slides) specifies the basic requirements for a PLCopen certified training course on IEC 61131-3.
The full list of training certified PLCopen members can be found on the PLCopen website www.plcopen.org under 'Training'.

2 General requirements

2.1. Objectives of the training

After completion of the training, the attendee will:
- Be able to create a program according to IEC 61131-3
- Be able to understand practical advantages of the standard (i.e. documentation and program structure)
- Be able to read and understand an IEC program
- Know which language features are IEC compliant and which are vendor specific
- Have a basic understanding of the activities of PLCopen

2.2. General Contents

A standard training course consists of two main parts, and (optional) provider specific additions.
The main parts are:
- An overview, supplied by PLCopen (contents explained hereinafter) which needs to be used during the training;
- The main training course, of which the requirements are explained hereinafter

Additions are allowed, provided they are described as vendor specific, for the following areas:
- Examples making use of a particular programming system;
- Demonstrations of any particular programming software.

2.3. Training course files

The training course file, as provided by the training center, must include all information that is explained and used during the course. In addition, it must provide as Annex the following information in printed form:
- A document confirming that the training complies with the PLCopen training requirements;
- The PLCopen training requirements.

2.4. Additional requirements

Within this document there are no requirements specified for either didactical aspects or a specific sequence. For example, the declaration, scope and standard data types of a variable should be explained. On the other hand, neither the time that will be devoted to these various items, nor the order of their presentation mandatory. Each training provider can define the position of a chapter in the training sequence.
However it is recommended to start with the common elements of the IEC 61131-3 standard, and then continue with the programming languages (IL, ST, LD, and FBD).

3 The overview

3.1. Objectives

An overview of the IEC 61131-3 standard has to be presented, as well as the means of compliance with the standard. Also the role of PLCopen in the evaluation of programming tools has to be explained.

3.2. Contents

The common part of the training consists of the following elements:

- Advantages of IEC 61131-3
- International language standardization
- The seven parts of the IEC 61131 standard
- The IEC 61131-3 Software model
- The IEC 61131-3 Common Elements
  - Data types and Variables
  - Program Organization Units
  - Sequential Function Chart
  - Configuration elements
- The textual languages
- The graphical languages
- PLCopen mission
- The essence of compliance and the PLCopen compliance levels
- PLCopen address
- Literature reference

3.3. Recommendations

Additional information is allowed for slide no.10 «IEC 61131-3 - Part 5 Communication».
PLCopen provides a complete English version that training centers may translate into any local language.
There are no requirements for the training provider concerning the presentation format (header and footer) of the common part but the presentation content is fixed as supplied by PLCopen.

4 The main training course

The following chapters define which IEC 61131-3 concepts and languages must be explained in the training course, as well as the PLCopen certification procedure for such a course.
The requirements within the next chapters have to be met according to the following baselines:

1. All the common elements of IEC 61131-3 have to be dealt with throughout the whole course; in «Common elements» all the features described in chapter 2 of the Standard must be included, i.e.:
   - Use of printed characters
   - External representation of data
   - Data types
   - Variables
   - Program Organization Units
   - Sequential Function Chart
   - Configuration elements

2. The Programming Languages – both the textual and graphical languages

Each chapter may include recommended programming practices.

5 The models

5.1. Software model

- Reference to Figure 1 of the standard
- Configurations
- Resources (provide support for all features requested for the program execution)
- Tasks
- Global variables
- Access paths
- Implementation dependant parameters

5.2. Communication model

- Reference to Figure 2 of the standard
- The various techniques available

5.3. Programming model

- Programs (collection of software elements, each of them written in one IEC language)
- Functions
- Function blocks:
- I/O parameters, internal variables and an algorithm;
- User derived functions and function blocks

5.4. Recommendations

- The models can be combined with the Common Elements section;
- To apply the software model to a real system;
- Each provider may issue specific actions depending on the used training tools (project creation, PLC configuration, etc.);
- Instantiation process (figure 3 of the standard) can be explained with practical examples during the course of the training.

6 Common elements

6.1. Objectives

- To gain an understanding of the IEC 61131-3 main concepts and to learn how software is organized before proceeding to the detailed study of each programming language;
- To show that IEC 61131-3 provides an extensive range of elements that can be used with any of the textual and graphical languages;
- To gain an understanding how elements such as variables and data types are used before start of programming using any of the IEC 61131-3 languages;
- To understand the software- and programming-model;
- To gain insight on the structuring methods as provided, specifically via Sequential Function Chart.

6.2. Use of printed characters

- Restricted characters set
- Rules used to build identifiers
- Language keywords, comments
- Implementation dependent parameters

6.3. External representation of data

- Numerical, character string and time literals

6.4. Data types

- Elementary, generic and derived data types
- Derived data types include declaration, initialization, and usage

6.5. Variables

- Symbolic and direct representation, initialization
- Declaration in the program organization units (keywords VAR, VAR_INPUT, ...)
- Declaration in the configuration or resource (Global variables)

6.5.1. Recommendations

It is useful to explain the concept of ‘scope’ when previous programming systems did not use it (i.e. systems using only direct represented variables, implicitly global).

6.6. Program Organization Units

The following three sections deal with the Program Organization Units, POU’s. The defined software model can be of help here.

6.7. Functions

6.7.1. Objectives

- To describe the standard functions in IEC 61131-3 and their behavior

- To explain how to create a user defined functions.

6.7.2. Contents

- Representation, execution control, and declaration
- Typing, overloading, and type conversions
- Standard functions (the different groups defined in IEC 61131-3)

6.7.3. Recommendations

Should be explained before the programming languages.
Function calls should be developed in the following chapters concerning the programming languages.

6.8. Function blocks

6.8.1. Objectives

- To describe the standard function blocks of IEC 61131-3 and their standard behavior
- To explain how to create a user defined function block.

6.8.2. Contents

- Representation, declaration (both textual and graphical; list of input/output variables, internal variables and body that describes the algorithm)
- Standard function blocks (the different groups defined in IEC 61131-3)

6.8.3. Recommendations

Should be explained before the programming languages. Function block instantiation should be developed in the following chapters concerning the programming languages. The good practice of FB (modular software) should be shown.

6.9. Programs

6.9.1. Objectives

- To describe the concept of Programs within the IEC 61131-3 standard
- To explain how to create programs

6.9.2. Contents

- Representation, declaration (both textual and graphical; list of input/output variables, internal variables and body that describes the algorithm)

6.9.3. Recommendations

Should be explained before the programming languages.

6.10. Sequential function charts (SFC)

6.10.1. Objectives

- To describe the context of SFC within the IEC 61131-3 standard and its language aspects.
- To show the modular design approach and the program flow.

6.10.2. Contents

- General
- Steps and step flags
- Transition conditions
- Action blocks (declaration, association with steps, action blocks, action qualifiers, action control)
- Rules of evolution

- SFC Compliance requirements

6.10.3. Recommendations

SFC will be generally explained in association with one of the four above-mentioned languages. The notion of safe SFC will be explained.

6.11. Configuration elements

6.11.1. Objectives

- To describe the configuration elements

6.11.2. Contents

- Configuration, resources, and access path
- Tasks

6.11.3. Recommendations

It is recommended to include the different models as defined in the IEC standard at this point, e.g.:

7 Textual programming languages

7.1. Objectives

- To define the instruction format, operators
- To define the expression format, operators and statements (assignment, selection and iteration)
- To define the basic language elements and their relationships. Another chapter is specially devoted to application design.

7.2. Common elements

Identify the common elements in the textual programming languages

7.3. Instruction List (IL)

- Instructions
- Operators, modifiers and operands
- Function and function blocks

7.3.1. Recommendations

Function invocation and function block instantiation should be mentioned in this chapter

7.4. Structured Text (ST) language

- Expressions
- Statements (assignment, function and function block statements, selection statements, iteration statements)

7.4.1. Recommendations

Function invocation and function block instantiation should be mentioned in this chapter.

8 Graphical programming languages

8.1. Objectives

- To link elements in networks
- To design power flow, signal flow and execution control within networks
- To define the basic language elements and their relationships. Another chapter is specially devoted to application design.

8.2. Common elements

- Representation of line and blocks
- Direction of flow in networks
- Evaluation of networks
- Execution control elements

8.3. Ladder Diagram (LD) language

- Power rails
- Link elements and states
- Contacts
- Coils
- Functions and function blocks
- Order of network evaluation

8.3.1. Recommendations

Function invocation and function block instantiation should be mentioned in this chapter.

8.4. Function Block Diagram (FBD)

- General
- Combination of elements
- Order of network evaluation
- Functions and FBs control

8.4.1. Recommendations

Function invocation and function block instantiation should be mentioned in this chapter.

9 To make a full application

9.1. Objectives

- Wrap-up!
- To describe limits and risks

9.2. Contents

- CONFIGURATION and RESOURCE declarations
- Association with TASKS
- Use of SFC as a structuring part
- Passing parameters down the program structure
- Using multiple languages within the application, and using non-IEC languages («C» code for instance)
- The concept of reusable programs within the IEC context, as well as within the PLCopen context

9.3. Recommendations

This part could be devoted to recommendations on good programming practice, especially within the context of a full programming application example.

10 PLCopen Certification procedure

Based on the document `Specification of Requirements for a standard IEC 61131-3 training course`, dated September 20, 2004, the following rules apply to a legal entity to become a PLCopen certified training center.

1. The company has to be a member of PLCopen.
2. The company needs to comply with the existing specification, as specified by the PLCopen Promotional Committee 2 Training, and as published by PLCopen, and of which this statement is a part.
3. This compliance is done in written form. For this purpose the company provides PLCopen with the application form as included in this specification, clearly stating the applicable training course. By signing this form, the provider of the training course states that the course is compliant with these requirements. This form has to be returned to PLCopen.
4. A copy of the signed form and the specification of requirements must be included in the training material, in order to give each participant the possibility to check the compliance.
5. In case of non-fulfillment, to be decided by PLCopen, the company will receive a statement from PLCopen in writing. The company will have a one month period to either adopt their course in such a way that it complies, (by issuing a new compliance statement) or remove all reference to the specification, including the use of the logo, from all their specifications, be it technical or promotional material.
6. The certificate from PLCopen has to be used as it is - meaning the full definition. It may be altered in size as long as the original scale and color setting is kept. Space has been provided for the training institute to add their specific information.

10.1. Certificate for the attendee of the training

Certified training providers have the right to use the PLCopen certificate layout, including the art and graphics work, for generating or including into their company specific certificates. These certificates can be provided to each participant of a PLCopen certified training, who passed the training successfully. The training provider has the responsibility to keep track of the participants who received such a certificate, as well as of their personal results during the training. On request from PLCopen, these files have to be made available to PLCopen immediately. These files will be used for control of the procedures related to PLCopen certified training only, and will not be used for any other activities.

11 PLCopen Training Logo and its Use

For quick identification of certified training centres, PLCopen has developed a training logo:

This Training logo is owned and trademarked by PLCopen.

In order to use this logo free-of-charge, the relevant company has to fulfil all the following requirements:

1. the company has to be a member of PLCopen;
2. the company has to comply to the existing specification, as specified by the PLCopen Promotional Committee PC2, and as published by PLCopen, and of which this statement is a part;
3. this compliance is done in written form by the company to PLCopen, clearly stating the applicable software package and the supporting elements, as specified in the document itself;
4. in case of non-fulfilment, which has to be decided by PLCopen, the company will receive a statement on this from PLCopen in written form. The company will have a one month period to either adopt their software package in such a way that it complies, represented by the issuing of a new compliance statement, or remove all reference to the specification, including the use of the logo, from all their specification, be it technical or promotional material;
5. the logo has to be used as is - meaning the full logo. it may be altered in size as long as the original scale and color setting is kept.
6. the logo has to be used in the context of Training and IEC 61131-3.

12 Application form

for

PLCopen certified IEC 61131-3 Training Course

Herewith we state that our training course

.....<Name>

.....<Description / focus>

.....<Version>

Does comply with the requirements as specified in the PLCopen document `Specification of Requirements for a standard IEC 61131-3 training course`, Version 2.1 of September 19, 2006.

When returning this form to PLCopen, we will receive a certificate and our company name will be published in several commercial publications as a certified training provider. We are aware of the fact that costs will arise in connection with this certificate.

Name:

Email address:

Function:

Company:

Place:

Date: Tel. Nr. Central Contact:

Signature: