PLCopen:
changing the world of industrial automation
-
status, structuring tools, activities and libraries

Eelco van der Wal
Managing Director PLCopen
PLCopen Mission

We want to be the leading association resolving topics related to control programming to support the use of international standards in this field.
Programming in its environment

<table>
<thead>
<tr>
<th>Database Tools</th>
<th>Visualization / HMI</th>
<th>Project design Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Programming Tools</td>
<td>Debugging Tools</td>
</tr>
<tr>
<td>Networking Tools</td>
<td>Configuration Tools</td>
<td>Simulation Tools</td>
</tr>
</tbody>
</table>
Organization

General Meeting, BOM, MD

TC1  TC2  TC3  TC4  TC5  TC6  PC1  PC2  PC3  PC4

TECHNICAL  COMMITTEES  PROMOTIONAL
TC1: Standards

- IEC 61131-3 is enhanced with Corrigendum & Amendments
- Development of joint PLCopen position for IEC
- Communication of information from IEC to PLCopen
- Improvement proposals
- Focused to upcoming update: end of 2002
TC2: Functions

- Definition of Function Block libraries & calling conventions
- … for example…
- Motion Control Library: the integration of different technologies: logic and motion
- Safety Library – providing the basis for safety critical environments
**TC3 : Certification**

…without testing there is no standard…

- The IEC 61131 standard only gives basic rules for compliance
- Certification gives guidance for users towards real IEC 61131-3 programming systems (e.g. PLCopen certified list shows compliant products)
TC3: PLCopen Compliance Levels

Conformity Level & Reusability Level
Re-usability of Function (Block) libraries

Base Level
Portability of minimal systems
Compliance: Results

Datatypes supported: 26 of 26
TC3 - CL and RL for LD
TC3 - CL and RL for LD : status

- Next logical step: Conformity Level for LD
- Draft document as basis ready
- The kick off meeting will be held on May 7, 2003 at Matsushita, Holzkirchen, Germany
- Specification ready. Test software under development
First Certificates for CL and RL - ST
First Certificates for CL and RL - ST

- Matsushita Electric Works (Europe) with Control FPWIN Pro
- Schneider Electric with Concept
Compliance: Results and Status Base Level (Oct. ‘03)

- Accreditation installed: two institutes accredited
- Base Level definition ready for IL, ST, FBD, LD and SFC
- Test software ready for IL, ST, FBD and SFC. LD in preparation
- 22 software packages certified (see website for status)
**TC4: Communication**

- Communications interfaces
- Interfaces to add-on packages
- Application interchange format
- Mapping of Profibus has been done
- Mapping of CANopen has been done
**TC5: Safe software guidelines**

- Support for safe programming techniques
- Focus to IEC 61508 “Functional Safety of Safety Related systems”
- Guidelines for the use of the IEC standard
- Basis for easier commissioning
- In combination with the Function Blocks
- First results expected April 2004
TC6: XML

- Definition of XML schemes for all the IEC languages
- Representation of graphical information
- Interface to other tools
- Possible basis for distribution of Function Block libraries
- Work is under construction (members-only)
- Results will be made publicly available
PLCopen as a World-wide association

Main Office in Europe

Office in North America

Office in Japan
General Promotion

- PC1: General Promotion
- PC3: Promotion North America
- PC4: Promotion Japan
PC4 - Activities in Japan – Dec. 2002

- Fuji Electric,
- Matsushita Electric Works,
- Toshiba,
- Yokogawa Electric

(listed in alphabetical order)

have decided to resume the activities of PLCopen in the Japanese market.

As independent organization, Kanagawa Industrial Technology Research Institute joined this group.
PC4 - Activities in Japan

Objectives and planned activities:

- Introducing and promoting IEC 61131-3 and JISB3503
- Providing training for users with common needs
- Promoting standardization
- Promoting the utilization of user development resources through users groups
- Certification in Japan
PC4 - Activities in Japan

Mr. Kawashima / Fuji
Mr. Kanno / Yokogawa
Mr. Kitamura / MEW
Mr. Mitsuo / MEW
Mr. Kaneko / Yokogawa
Mr. Tomizawa / Fuji
Mr. Satoh / Toshiba
Dr. Miyazawa
Mr. Imai / Toshiba

Page 22 printed at 11/18/2003
www.plcopen-japan.jp
PLCopen China

Under construction …..
Acceptance and WW PLC market share

US: 23% share
- Languages: 1. LD 93%
  2. FBD
  3. ST

Europe: 45% share
- Languages: all 5 languages

Japan: 22% share
- Languages: 1. LD
  2. ST

Sources: • Frost & Sullivan
  • ARC
  • ZVEI
  • Matsushita
**PC2: Common training program**

- The effect of training is often underestimated.
- Standardization can be very useful and provide a better interface between study and reality.
- PC2 defined common basics for training.
- .. for instance: a IEC 61131-3 training guideline is published.
- Training facilities fulfilling basic requirements can be certified and listed / referenced to (see website for listing).
IEC 61131-3

Harmonizing the way people look to control

the future is here
The 7 parts of the IEC 61131 Standard

- 1 General overview, definitions
- 2 Hardware
- 3 Programming Languages
- 4 User Guidelines
- 5 Messaging Service Specification
- 7 Fuzzy Logic
- 8 Technical Report

IS = International Standard
IEC 1131 versus IEC 61131

- The good news is – there is no difference
- It is an international harmonization of all the IEC standards and the localized versions
- ... however, there are second editions for parts of the IEC 61131 standards
IEC 61131-3 Programming languages / Industrial Control Programming

The interface between the programmer and the control system
IEC 61131-3 Programming languages / Industrial Control Programming

...with support for people with different backgrounds
The IEC 61131-3 Standard

Common Elements

Programming Languages
IEC 61131-3 : Common Elements
Variables & Data Types

What is this?

01010101 10101010

Historically

• Reference to a physical memory location

• Reference to a physical Input
IEC 61131-3: Common Elements
Variables & Data types

Temperature_Sensor_1 : Integer

- Symbolic representation via labels
- Restricted area for I/O mapping
- Hardware independent code
- Higher transparency & readability
- Less errors
IEC 61131-3 : Common Elements

Software Model

• Configuration
• Resources
• Tasks
IEC 61131-3 Software Model

Configuration

Resource

Task

Program

FB

FB

Variable access path

Function Block

Variable

Global and direct variables

Execution control path

Access path

Communication Function
IEC 61131-3 vs conventional PLC

- Configuration
- Resource
- Task
- Program
- FB
- Function Block
- Variable

- Global and direct variables
- Execution control path
- Access path
- Communication Function

Variable access path
Conventional PLC vs IEC 61131-3

Endless Loop:
- Read inputs
- Do Calculations
- Set Outputs

Task 1
- Time based

Task 2
- Events based

Task 3
- Events based

Task 4
- Time based

Program

Resource

Task
Common Elements: Tasks

- PLCs
- Embedded
- DCS
- IEC 61131-3
- Drives
- PC based Control
- SoftLogic
- LON nodes
Common Elements: Tasks & Datatypes

Multi-functional Operator Panel

- Windows CE 3.0
- IEC 61131-3 tasks
- SCADA & HMI tasks
- I/O Communication tasks
- OPC

I/O Communication bus
IEC 61131-3: Common Elements

COMMON ELEMENTS

- Data Types & Variables
- Configuration, Resources, Tasks

Programming Organization Units

* Functions
* Function Blocks
* Programs
Functions ..... 

* Standard functions

ADD, SQRT, SIN, COS, GT, MIN, MAX, AND, OR, etc.

* Your own defined functions:

FUNCTION SIMPLE_FUN : REAL
VAR_INPUT
  A, B : REAL;
  C : REAL := 1.0;
END_VAR
SIMPLE_FUN := A*B/C;
END FUNCTION
.... & Function Blocks

- Standard Function Blocks
- Additional supplied Function Blocks
- Your own defined Function Blocks
- All FBs are highly re-usable in same program, different programs or project
FUNCTION_BLOCK HYSTERESIS
VAR_INPUT
  XIN1, XIN2 : REAL;
  EPS : REAL; (* Hysterisis band *)
END_VAR
VAR_OUTPUT
  Q : BOOL := 0
END_VAR
IF Q THEN
  IF XIN1 < (XIN2-EPS) THEN
    Q := 0 (* XIN1 decreasing *)
  END_IF;
  ELSIF XIN1 > (XIN2 + EPS) THEN
    Q := 1; (* XIN1 increasing *)
  END_IF;
END_FUNCTION_BLOCK
Programs: hierarchical design

Start : BOOL;
Emergency : BOOL;
Limit : INT;

Automation application
Advantages POU’s

- Create own Function Block Libraries (per application area)
- FBs are tested and documented
- Make libraries (world wide) accessible
- Re-use as much as possible
- Change programming to creating networks of FBs
- Save 40% on next project
Sequential Function Chart, SFC

- Powerful graphical technique for describing the sequential behaviour of a control program
- Used to partition a control problem
- Shows overview, also suitable for rapid diagnostics
- The basic elements are STEPS with ACTION BLOCKS and TRANSITIONS
- Support for alternative and parallel sequences
SFC: alternative sequences

- Step 1
  - Transition 1a
  - Step 2a
    - Transition 2a
  - Step 2b
    - Transition 2b
- Step 3
- Step 1
  - Transition 1b

N | FILL
The IEC 61131-3 Standard

Common Elements

Programming Languages
The IEC 61131-3 Programming Languages

Instruction List

<table>
<thead>
<tr>
<th>LD</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANDN</td>
<td>B</td>
</tr>
<tr>
<td>ST</td>
<td>C</td>
</tr>
</tbody>
</table>

Structured Text

C := A AND NOT B

Function Block Diagram

A \rightarrow \text{AND} \rightarrow C

Ladder Diagram

A \rightarrow B \rightarrow C
-\rightarrow-\rightarrow\rightarrow\rightarrow( )
The IEC 61131-3 Standard

Common Elements

Programming Languages

Top Down

Bottom Up
IEC Programming Environments

Many of them offer:

- graphical programming screens
- support for multiple windows
- mouse operation
- pull-down menus
- built-in hypertext help function
- software verification during design
Recap … TC2: Functions

- Definition of Function Block libraries & calling conventions
- … for example…
- Motion Control Library: the integration of different technologies: logic and motion
- Safety Library – providing the basis for safety critical environments
Revolutionizing the industry
The Rationale of a Motion Control Library
Let us look at the Packaging Industry for food and beverage...
Example of a changing landscape: Packaging for the Food & Beverage (F&B) Industry

- Retail Food and Foodservices = 11% of US economy
- Shipment of Packaging Machinery = 10% of retail food
- Packaging Machines sales volume in 1999: $4.85 bio.
No Technology push – but market trends

- Changes in consumer behavior
- Changes with suppliers towards F&B consumers
- Forced changes with packaging machine suppliers
- … enforcing changes with control suppliers
Changes in consumer behavior…?

- How about looking at your own behavior?
  - So here is looking at you!

Hi,
I am a pack of coffee

So am I!
The suppliers compete for market share...

(... still looking at you!)

.... by providing different varieties in different packages

..... requiring more flexible packaging equipment
Changing packaging requirements

...are pushed backwards in the supply chain:

the packaging industry is putting pressure

on the leading packaging machine builders

...to better fulfill their needs
Changing needs in..

- Smaller footprints
- Faster startups
- Higher speeds
- Improved efficiency
- Faster changeovers
- Better quality package
- Reduced waste in production
- Improved reliability of equipment
How to cope with this?

..machine mechanics do not help anymore...
How to cope with this?

by replacing mechanical and electrical solutions by electronic solutions

=> Mechatronic Solutions:

Examples:

- Camming
- Gearing
Camming

Multiple movements mechanically coupled to a master axis
Electronic Camming

Control

Drive

Motor

Master Axis

Drive

Motor

Slave Axis

Drive

Motor

Slave Axis
Electronic Gearing
Real – life Advantages

Targets for a new design:

- ‘Zero’ maintenance
- Sanitation design

Solution

◆ Aim for a 50% mechanical parts reduction
Traditional Mechanical Design

Over 350 parts
Multi Axis Servo Drive

Major part count reduction

- Pulleys - 45 to 0
- Belts - 15 to 0
- Drive sprockets - 15 to 0
- Spline shafts - 2 to 0
- Gearboxes - 16 to 10
- Motors - 1 to 10
- Bearings - 18 to 3
- Line shafts - 6 to 0

Total - 118 to 23 (81% reduction)
Push on control suppliers

- Control get into the heart of the machine
- in a strategic role
- to match (and beyond) the new requirements
- via added mechatronics functionality
- Requiring tight control between ‘PLC’ and Motion functionality
Control needs software

The world is not just about physical mechanics anymore…

The name of the game is….

Software
Software needs standardization

To increase acceptance and usage

As well as ease of application

......

There are sufficient examples in the marketplace ......
Standardization means:

- Hardware independent Software Development

Example: Machine Industry

Used for High End Result (showing Capabilities)

Software Development
Standardization means:

- Hardware independent Software Development

Example: Machine Industry
Standardization means:

- Hardware independent Software Development

Example: Machine Industry

...for Low End Result (Low Cost)
Standardization means:

- Hardware independent Software Development
- Consistent Development Environment
- Consistent Installation and Maintenance Interface

*Same ‘Look and Feel’*
How can we fulfil this?

- Standardized Programming Tools
- Standardized Programming Languages
- Standardized access to drive / motion specifics
  - centralized or distributed control

IEC 61131-3 provides the only platform for this!
The PLCopen Task Force Motion Control

- Initiated by Users to fulfil their requirements

**Goal:**

To harmonize the access for Motion Control across different platforms during development, installation and maintenance based on the IEC 61131-3 environment
HW Independence via Function Blocks

Software View

Encapsulation / Information Hiding

Hardware View

Inputs

Outputs
Example of a Function Block

**MoveAbsolute**

- **Axis**
  - BOOL Execute
  - REAL Position
  - REAL Velocity
  - REAL Acceleration
  - REAL Deceleration
  - REAL Jerk
  - REAL MC_Direction
  - REAL Direction

- **Axis**
  - BOOL CommandAborted
  - BOOL Done
  - BOOL Error
  - WORD ErrorID

- **AXIS_REF**
  - BOOL

---

**Execution Parameters**

- Execute
- Position
- Velocity
- Acceleration
- Deceleration
- Jerk
- MC_Direction
- Direction
Axis_Ref as Var_In_Out

<table>
<thead>
<tr>
<th>AXIS_REF</th>
<th>MoveAbsolute</th>
<th>Axis</th>
<th>AXIS_REF</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOOL</td>
<td>Execute</td>
<td></td>
<td>BOOL</td>
</tr>
<tr>
<td>REAL</td>
<td>Position</td>
<td></td>
<td>Done</td>
</tr>
<tr>
<td>REAL</td>
<td>Velocity</td>
<td>CommandAborted</td>
<td>BOOL</td>
</tr>
<tr>
<td>REAL</td>
<td>Acceleration</td>
<td>Error</td>
<td>ErrorID</td>
</tr>
<tr>
<td>REAL</td>
<td>Deceleration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REAL</td>
<td>Jerk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC_Direction</td>
<td>Direction</td>
<td></td>
<td>WORD</td>
</tr>
</tbody>
</table>
Axis_Ref as Var_In_Out
Axis_Ref with 1 FB

Time or event driven
Axis_Ref with 2 FBs
Error Handling

Error - Rising edge – error during execution of the FB

ErrorID - Error identification
Conclusion

- IEC 61131-3 provides a good framework for Motion Apps
- PLCopen Motion Control Library provides an independent user interface
- Support for single axis and multiple axes / motion control
- IEC 6113-1-3 with PLCopen MC provides mechatronic solutions
- User derived FBs and data structures, and multi-tasking are crucial
Status and Future

- Part 1 of the PLCopen Motion Control Library released Nov. 2001
- Is implemented now by several suppliers (see website)
- Part 2 deals with extensions – release date Dec. 2003
- Part 3 will deal with user guidelines
- Part 4 deals with Homing Functionality
- Part 5 deals with Stacked Commands
Revolutionizing the industry
PLCopen TC2
Function Blocks for Safety

- Definition of a set of Function Blocks for safety related applications
- Under TC2 – Function Blocks
TF - Safety : Goal

Allow the user to achieve the functional safety at the plant and machine level
TF - Safety : What does this mean ?

- Reference Standards –IEC 61508 and IEC 61511
- Additional standards - IEC 62061, EN 954, ISO 13849
- Operating mode

- Stop functionality
  - Emergency Stop (‘Not-aus’)
  - Safe operation stop (MC related)
  - Time-delay Stop
  - Safety door monitoring

- Safe reduce speed (MC related)

- Two-hand Control

- Safety door interlocking

- Testable Safety sensors

- Muting (for light barriers) – controlled by-passing of the safety functionality

- Redundant inputs (Q?: is this the right level of functionality)

- Safe Communication
TF - Safety: additional Safety aspects for software development

- Merge of logic, motion and safety functions
- A reduction in the syntax of the languages used is an item
- Support in software tools for safety environments
TF - Safety : Time frame

First draft planned for

April 2004
PLCopen TC6 – XML

Opening up the development environments by specifying XML formats for IEC 61131-3
TC6 - XML

Producer of graphical and logical information

Other Development tool

Development tool

Consumer of graphical and logical information

Other Development tool

XML

XML

XML
What is included

In principle all.....

- Textual Programming Languages – IL and ST
- Graphical Programming Languages – LD, FBD
- Structural Language – SFC
- ...continued....
What is included

- Graphical Information, like ...
  - Place and position
  - Routing of connections
- Comments
- ...continued....
What is included

- Program Organization Units – (User Derived) Functions and Function Blocks, Programms
- (User Derived) Datatypes
- Project information (layered structure)
- Mapping information
What is included

- The exported file contains ‘everything’
- Including supplier specific information
- The intelligence is in the parsing function during input
TC6 – XML : status

- First ‘release for comments’ planned for November 2003
- Available on public website www.plcopen.org
- Comments will be merged into final version for publication
- Will also be available on www.plcopen.org
What are the benefits?
Benefits

- Reduced waste of human resources (in training, debugging, maintenance and consultancy)
- Creating a focus to problem solving via software reusability (reduced application investment and supplier dependency)
- Reduced misunderstandings and errors
- Programming techniques usable in more environments (general industrial control)
- Combining harmoniously different components from different locations, companies or countries, or projects
- Increased connectivity (investment protection)
The association PLCopen

Together we can make it happen:

Standardization in Industrial Control Programming

WE NEED YOUR SUPPORT FOR THIS!

Join the organization PLCopen
More Information...

www.plcopen.org

- Free-of-Charge electronic Newsletter ‘PLCopening’ (in english)

email: evdwal@plcopen.org
Thanks !