PLCopen

*for efficiency in automation*

# The PLCopen Motion Control Library : changing the landscape of industrial control

This world is not stable, resulting in changing requirements. These changes are very visible on the front line – the consumers. Changes in consumer behavior, combined with governmental rules, require changes at the suppliers in the food and beverage industry. By differentiation in packaging and in products the suppliers fight for market share and shelf space in the supermarket. These changes require smaller batches, needing more flexible production lines. Also, changing governmental rules, focused to protect the consumers by making the suppliers responsible and liable, requires producers to change their way of production. On top of this, they have to produce more efficiently, for instance to serve their shareholders or produce less waste.
The suppliers in the food & beverage (or even pharmaceutical sectors) transfer their requirements to their machine suppliers, which in turn transfer them to their control suppliers. The control plays a crucial role in fulfilling these new requirements. To be more specific: the application software is crucial. And to make that effective, standardization is needed.
This paper presents such a standard, being implemented across different technologies, and being well supported by a large representation of the industry, this software standardization will certainly change the landscape.

## CHANGING REQUIREMENTS IN FOOD PACKAGING

A typical example of the effect of consumer changes is visible in the packaging industry. Packaging comprises many aspects like bottling, weighing, bagging, cartonning, flow wrapping, form-fill-seal, labeling, palletizing, and includes a wide variety of application domains within a packaging plant. Each application provides a unique set of requirements specific to both industries and regions. Pharmaceutical plants must track products accurately through every stage of the manufacturing process. Food and beverage suppliers are also concerned about product tracking; however, the ability for a plant to respond to wide variability in container sizes and labeling is absolutely imperative today.
Overall, changes in consumer needs and/or wishes include customization, personalization, and convenience. These changes happen in the distribution and storage along the chain (for instance just-in-time, and additional selling places), as well as the food packaging industry. Consumer changes like these can make huge portions of the existing packaging equipment obsolete very quickly.

## ONE STEP BACK IN THE CHAIN: MACHINE BUILDERS

To cope with these consumer changes, the packaging industry is putting pressure on the leading packaging machine builders to better fulfill their needs in:

- Smaller footprints
- Faster startups
- Flat to lower cost per function completed
- Higher speeds
- Improved efficiency
- Faster changeovers
- Better quality package
- Reduced waste
- Improved reliability

Such requirements are not specific to the packaging industry. Overall one could say that the goal is: Faster, Better, Cheaper.

## ANOTHER STEP BACK – THE EFFECT ON CONTROL SUPPLIERS

All these changing requirements are heavily reflected in the control architecture. And motion control, especially servo-based, plays an ever increasing role in this.

A packaging control system deals with: Human Machine Interfaces, Logic and Sequencing Control Systems, Motion Control Systems including drive technologies, Network Architectures, incl. Business System Integration, Interface technologies to drives and other actuators and sensors.

All these aspects are controlled by software, playing an ever increasing role. Since these multiple environments need to be integrated, standards and open platforms are a pre-requisite. As the investment cost in the application software is ever increasing, an essential part is in the programming environment and structure to create, maintain, and operate the application software.

## EFFECT ON CONTROL SYSTEMS

To cope with these new requirements in packaging effectively, from a motion control point of view, a mechatronics design is needed. This means that mechanics in the machine are replaced by electronic solutions in the form of digital; motion control. For example a rigid CAMshaft is replaced by a combination of multiple drives/motors. The control software in these mechatronics solutions provide the flexibility here.
To solve this cost effectively, the packaging machinery must take advantage of the latest software, networking, and operating system technologies to enable machinery to be flexible enough for today's manufacturing requirements. Manufacturing plants need equipment that is less complex, more flexible, easier to maintain, and with smaller footprints. These requirements translate into substituting today's mechanical solutions with electronic and software based solutions. Motion control technology combined with industrial software is capable of vastly reducing the complexity and size of every domain of packaging machinery today.

## THE NAME OF THE GAME – SOFTWARE

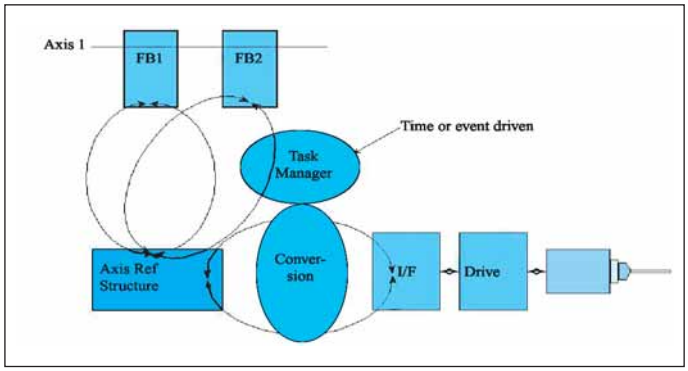
Motion integration issues have emerged to the forefront, along with maintainability and connectivity to automation solutions. Unfortunately, the motion control market is a very fragmented market, providing a wide variety of incompatible systems / solutions. In practice this means that the architecture and the software tools for development, installation and maintenance will differ widely. This incompatibility incur considerable costs: applying different implementations is confusing, engineering becomes difficult, and the software is not reusable across platforms. Overall, this means that there is too little standardization in this market.
Standardization for flexible solutions which are open to new developments. Meaning not only harmonizing the programming languages, like done within the worldwide IEC 61131-3 standard, but also the software interface towards different motion control solutions, like distributed versus integrated. In this way, the benefits of software standardization are clear:

- Less hardware dependence
- Higher level of reusable code
- Transparent programs
- Lower commissioning, installation and maintenance costs
- Wide industry acceptance
- And last but not least: reduction in training costs

## THE ROLE OF PLCopen

Motion control gets more and more integrated with the 'classical' PLC environment, creating a good basis for standardization. This vision was shared among many different suppliers as part of the organization PLCopen, and resulted in the definition of a PLCopen Motion Control Library.

Effectively this standardization is done by defining libraries of reusable components. In this way the programming is less hardware dependent, the reusability of the application software increased, the cost involved in training and support reduced, and the application becomes scalable across different levels of control. As such it is based on IEC 61131-3 Function Blocks, creating application programs which are commonly understandable and reusable across platforms. Due to the data hiding and encapsulation, it is usable on different architectures, like from centralized to distributed control. And as such it is open to existing and future technologies. Overall, this standardization is expected to cover around 80% of the motion control market.
The definition, consisting nowadays of multiple parts, has been done via the definition of the state machine and a basic set of Function Blocks for single axis motion and a set of multi-axes Function Blocks.
To the user, the Function Blocks are crucial. These are the software equivalent of electronic chips. They contain inputs and outputs, with the associated names and data types. Each Function Block contains code (like a small program) to give it its functionality (like the components in a chip), and map it to the corresponding (motion control) environment. The user only sees the interface, being the inputs and outputs. The code itself is hidden – this is called data encapsulation and hiding, and is crucial to separate the different levels of programming and maintenance. Below is a small example of two Function Blocks operating on the same axis. Access to the axis itself is via Axis_Ref. This is a data-structure describing the drive itself. All Function Blocks have access to this reference. In this way the internals of the drive or architecture are hidden to the user, providing hardware independence: distributed, integrated, or centralized controls, for the user all architectures are accessed in the same way.




**Overview of the defined Function Blocks**
Without going into details, the following table gives an overview of the defined function blocks in Part 1 and 2 of the set of specifications, divided in administrative (not driving motion) and motion related sets.

| *Administrative* | | *Motion* | |
|---|---|---|---|
| ***Single Axis*** | ***Multiple Axis*** | ***Single Axis*** | ***Multiple Axis*** |
| Power | CamTableSelect | MoveAbsolute | CamIn |
| ReadStatus | | MoveRelative | CamOut |
| ReadAxisError | | MoveAdditive | GearIn |
| ReadParameter | | MoveSuperimposed | GearInPos |
| ReadBoolParameter | | MoveVelocity | GearOut |
| ReadDigitalInput | | Home | Phasing |
| ReadDigitalOutput | | Stop | |
| ReadActualPosition | | Halt | |
| ReadActualVelocity | | PositionProfile | |
| ReadActualTorque | | VelocityProfile | |
| WriteParameter | | AccelerationProfile | |
| WriteBoolParameter | | TorqueControl | |
| WriteDigitalOutput | | MoveContinuous | |
| SetPosition | | | |
| SetOverride | | | |
| DigitalCamSwitch | | | |
| TouchProbe | | | |
| AbortTrigger | | | |
| Reset | | | |

**Example: the same Function block instance controls different motions of an axis**
The figures below show an example where the function block FB1 is used to control "AxisX" with three different values of Velocity. In a Sequential Function Chart (SFC) the velocity 10, 20, and 0 is assigned to V. To trigger the Execute input with a rising edge the variable E is stepwise set and reset.

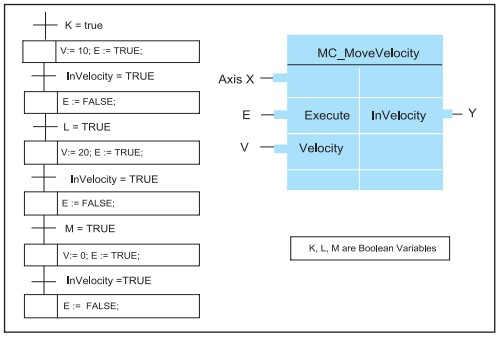



**Figure 1: Single FB usage with a SFC**

The following timing diagram explains how it will work.

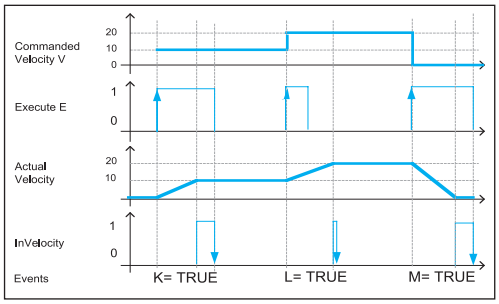



**Figure 2: Timing diagram for a usage of a single FB**

**Certification**
Included in the document are the rules for compliance and certification. Basically this is a self-certification, from which the results per supplier are published on the PLCopen website www.plcopen.org. Certified companies are allowed to use the PLCopen Motion Control logo, with additional number, date and number of supported compliant function blocks:

**CONCLUSION**
Changing needs at consumers put a high pressure on the consumer related industry, as well as on their suppliers. Fulfilling these needs requires moving from mechanical solutions to mechatronics solutions. This makes the role of software extremely important, combined with motion control.
Standardization in the fragmented motion control market is crucial. And such a standard is available: the PLCopen Function Blocks for Motion Control. As such it is changing the face of industrial control. The specification is freely available on the website www.plcopen.org as downloadable file (in pdf format).
Overall, the PLCopen Motion Control Specification nowadays consists of 5 parts:

- Part 1 - Basics
- Part 2 - Extensions
- Part 3 - User Guidelines
- Part 4 - Interpolation
- Part 5 - Homing procedures

Through the independent organization PLCopen a wide user acceptance is realized, and many implementations are already available. Also, cooperation with other organizations and workgroups, like the OMAC Motion Control for Packaging, is continued on an on-going basis.
With many implementations available this specification will be widely used in the industry.