OMRON

technology&trends magazine

SYSMAC

always in control

The evolution of the PLC

A new class industrial controller, performing like last generation computer, keeping the endurance and reliability on the existing level.

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Sysmac Studio
Designed for machine creators

Develop faster, with less mistakes and managing the asset throughout the development. A software based on the latest Microsoft technology.

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It just works!

Speed, accuracy and reliability: the QUALITY MIX!

More on page 24

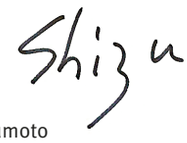
SPECIAL EDITION

realizing

Shizuto Yukumoto
Executive Officer of Omron,
and CEO of Omron Europe BV

From Cooperation to Co-creation

We listened, we learned and we created Sysmac automation platform. From a loud and clear voice of you – our loyal customers – we understood that the buyer-supplier and even cooperation in its widest meaning is not enough in this fast moving age. Therefore we designed a platform that is open, scalable, flexible and above all focused on the need of fast and flexible machines in order to offer a co-creation platform. An environment where operators are turned into creators and your people and our people work towards one goal: creating the best machines. We also understood from your voice that automation solutions must be in synchronisation with automation services and this has to meet the same high standard world-wide. We are still listening and still learning and trust us this is only the beginning of a long journey...

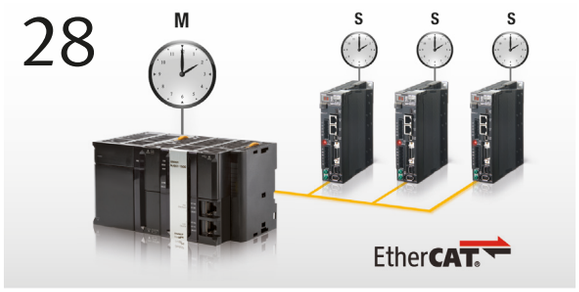


Shizuto Yukumoto

Cover:

We automate machines!

Technology & Trends introduces the Sysmac Automation Platform – Omron's vision for the coming decade.



FIRST CHOICE partner, FIRST CLASS automation

Shizuto Yukumoto
Executive Officer of Omron,
and CEO of Omron Europe BV

In June 2011 Mr Yoshihito Yamada became the new corporate president and CEO of Omron Corporation and his first action was to kick off a 10 year plan called "Value Generation 2020". The latter stresses that value generation for the customer should be at the heart and start of every activity. Globally, Omron intends to achieve a Global Number One status in machine control.

As a consequence of this, Omron Europe launched the "FIRST CHOICE" program in order to become the first choice partner in selected industries and with selected trend setter customers. We have set ourselves a tough challenge that needs a first class organization and first class automation.

First choice program

The first choice program is aimed at building a true partnership with selected customers in strategic industries. It goes beyond a sell-buy process and a problem solver partner. Our aim is to reach a "co-create" relationship that includes solution providing, automation services and future technologies in sensing and control. Omron is the only automation player that covers both sensing and control comprehensively and we will work towards integrating these two control disciplines for the benefit of our customers.

First class organization "TATE-YOKO"

Human capital is at the heart of Omron's expansion over the next 10 years. Our organisational model is the key to keeping and developing talents within the organization. TATE (vertical specialization) combined with YOKO (horizontal cross linkage) has always been the back-bone of our organizational strategy. Over the last few years we have specialized our sales force into two sales divisions: (1) Integrated Automation division and (2) Sensing & Components divisions. This gave us the focus and the clarity needed to achieve the first choice program. We have also invested in people, demonstration tools, Customer Relationship Management (CRM) systems and a first class intranet site to encourage borderless communication and free information flow.

First class automation

Our investment in people and the organization is only one dimension in our aim to become first choice for our customers. Technology and services are the second and 3rd dimensions in our program. The new Sysmac platform is designed to meet machine automation needs for the coming 10



years. It is truly open and information/communication (IC) ready, it is fast, accurate, deterministic and uses open standards for communication and software. It also carries Omron's ethical values in terms of quality and respect for environment.

First class services

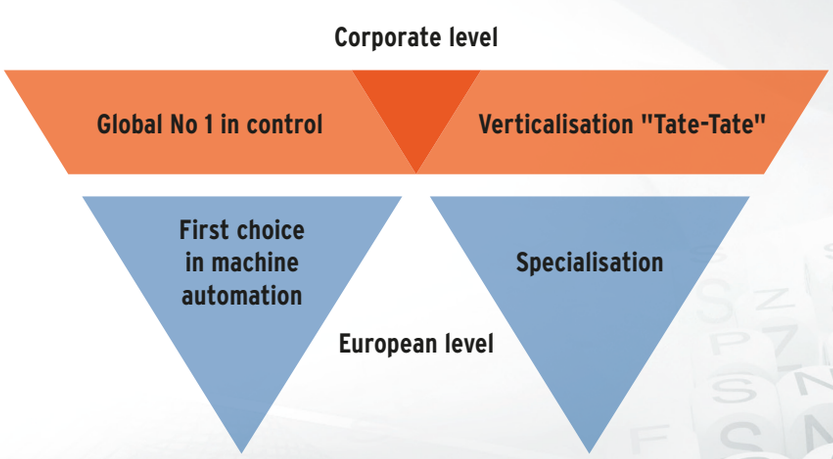
One would think that a presence of 40 years in Europe and an infrastructure of 50 technical offices, one manufacturing site and three development centers would be sufficient for us to claim first class service. Not us! Our next challenge is to harness this infrastructure for maximum value generation to our customers. Clear, no-fuss global commercial services and global automation service centers are currently a work in progress.

"Our people are in a way Omron's business card in the market."

The first step to this has been achieved with the Tsunagi (networking) laboratory, which was opened on September 14th in Omron's Den Bosch site (The Netherlands). The Tsunagi laboratory Europe follows the one opened in Kusatsu (Japan) and Shanghai (China) and is a part of a global network of support centers for open network communication.

First class people

I believe that beyond technology, services and strategies it is the quality of the people that we put in front of you, our customers, that matters most. Our people are in a way Omron's business card in the market. "Learn from the customer" is the first and most important thing we tell our people because it means: listen, understand, help and above all stay humble and respectful. Investing further in our people is one of the major things that Omron will set out to achieve over the next ten years.



Goal and organisatorial structure from top down

Shinya Yamasaki
Executive Officer
Senior General Manager,
Automation Systems
Division Headquarters Japan
Omron Industrial Automation
Company

Presently head of the Automation Systems Division and the driving force behind the development of the new Sysmac platform, Shinya Yamasaki knows Europe very well. Shinya was Marketing Director from 2000 to 2005 and was impressed by the diversity and the innovative power of the European market. In his return to Japan he took charge of the Automation Systems Division and set out to create a new automation platform that allies the cultural openness and diversity of Europe with the thoroughness of Japan. In his interview he elaborates on the birth of this child of two rich cultures, the challenges and the ambitions of Omron in the world of machine automation.

It is about PRIDE! "Sysmac is the first step of a 10 year journey". Can you elaborate on this journey and the goal behind it?

Mr. Shinya Yamasaki: As industrial automation matures, the rules of the game change. With our 10 year plan, Omron is in a leading position to impact this change, rather than just adapting to it. Over the next 10 years we will focus on our core competence – "Machine Automation". Our intention is to be the first choice supplier of automation solutions in this field.

Do you perceive the next 10 years as a process of Evolution or REvolution?

Mr. Shinya Yamasaki: It's more about Re-Evolution, or accelerated evolution. We will accelerate our ONE automation platform concept by leveraging our other competences like sensing, vision, safety, regulation etc., while investing heavily in developing our people and our services.
We also believe that we have to reach out to global competences and a wider global network of strategic partners. Microsoft, Intel, Hitachi, Panasonic and Yamaha are already valuable Omron partners.

"One machine control" is the concept of the new Sysmac Automation platform, how do you define it and where does it end?

Mr. Shinya Yamasaki: Simply "one software and one connection" for all the intelligent devices in the machine. We like simplicity...
We need to understand that integrated control evolved into integrated machines and now we have integrated cells where robots, safety, motion and vision will eventually meet. Customers are asking for ONE machine control and Omron intend to provide it.

A first step in a 10 years journey

Mr Shinya Yamasaki about Omron's new Sysmac Automation Platform

What were the technical challenges to achieve this ONE machine control?

Mr. Shinya Yamasaki: Our challenge was to exploit the huge technological advances in the PC world, while keeping the robustness and quality of Omron industrial control. Our failure rate is measured in terms of pieces per million while in the PC world it is pieces per thousand – it's a completely different world!
The other challenge was to develop a software platform that supports the next 10 years by integrating seamlessly today and tomorrow's devices and technologies.
For instance we integrated 3D simulation because we foresee that automation tomorrow will start from a 3D drawing.

Are there other challenges that you foresee?

Mr. Shinya Yamasaki: Skills, skills and skills in front of the customer. To meet our goals we need to have around 3000 machine automation engineers by 2020. The next challenge will be to obtain operational excellence worldwide. We have already started building global automation centres as a hub for our automation services. At the heart of those global automation centres lies the Tsunagi laboratory. Tsunagi, in Japanese, means "connectivity" and these centres will offer the highest expertise to our customers in networking and software, which are the nerves and brain of present and future automation technology.

Would you qualify the Sysmac NJ controller as a revolution in machine automation?

Mr. Shinya Yamasaki: We prefer to leave this appreciation up to the customer. We serve the machine automation market and at the heart of it are the machine builders who face increasing challenges to digest new technologies, integrate more functionality and deliver a safe, reliable and cost effective machine. The Sysmac platform is aimed at offering automation engineers a real automation solution, where modern programming doesn't affect predictability, performance doesn't affect robustness, size doesn't affect reliability, system integration doesn't impact simplicity and innovation does not infringe on reliability.

Any concrete examples?

Mr. Shinya Yamasaki: We developed the complete Sysmac Studio software in-house and made sure that everything was synchronized and integrated. With this we can have full visibility about what is happening within the CPU engine. For example, in both runtime and simulation it is possible to get a complete overview of how the tasks are running. Full transparency down to program task level is very important for reliable and robust machine programming and tuning. We also insisted that customers don't get any surprises as their axis count increases. Sub-millisecond cycle time is ensured up to 32 axis.

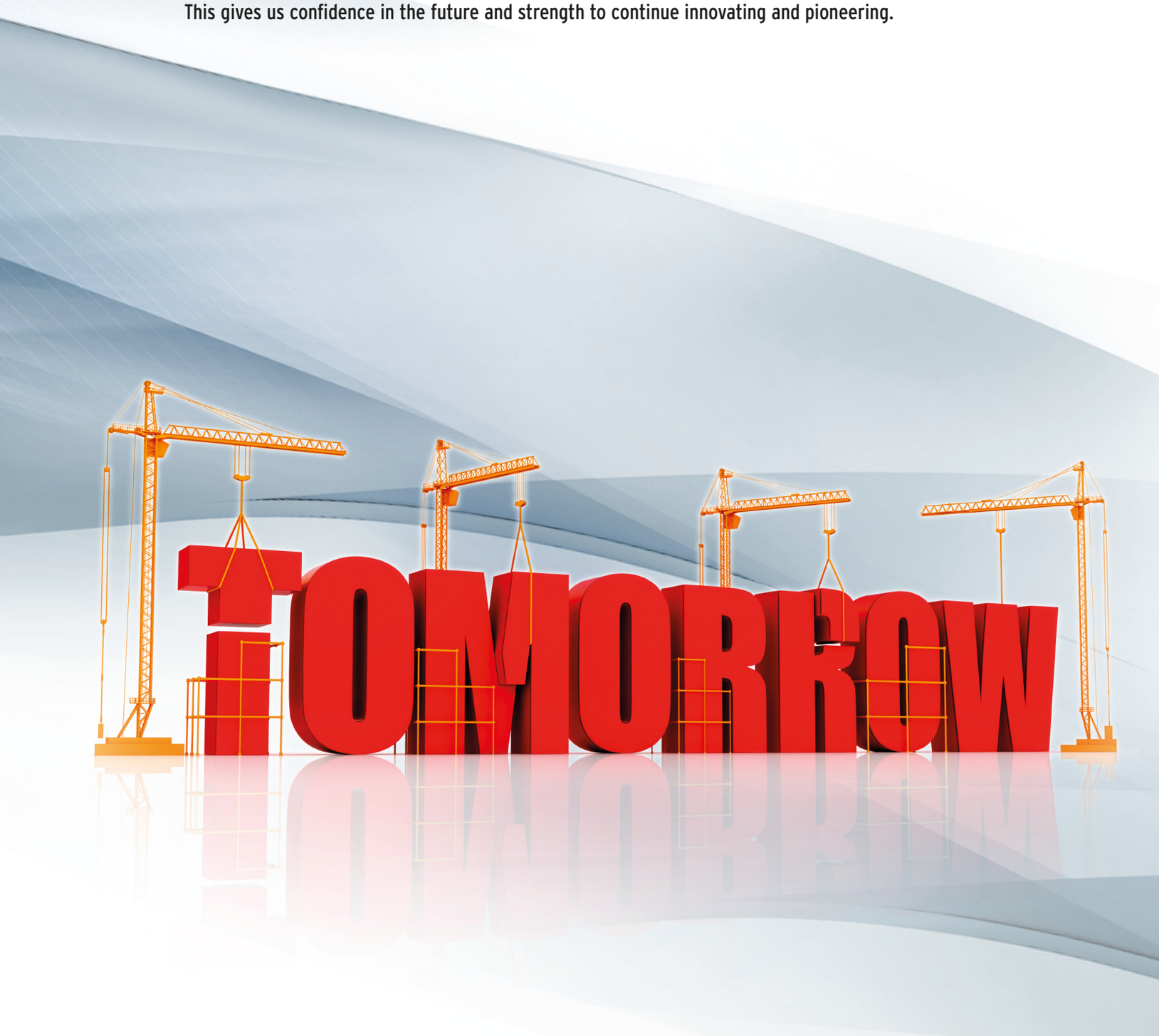
Your final words...

Mr. Shinya Yamasaki: My final word has to be my sincere gratitude to all the Omron employees and customers who have contributed to the development of Sysmac.

The Sysmac family

Proud of our history, confident in our future

Sysmac stands for System for Machine Automation Control and has been a trade name for our Programmable Logic Controllers since their launch in the early seventies. Since then Omron has shipped more than 10 million units world-wide. From now on the Sysmac name stands for a complete machine automation platform. It covers controller, network, software, servo drives, inverters and even vision systems. From a performance stand point we believe that this is the fastest and most robust machine control platform in the market. This gives us confidence in the future and strength to continue innovating and pioneering.



Faouzi Grebici
Sysmac Project Leader,
Europe and The Americas
Omron Automation Division

History

Omron introduced the first Sysmac PLC in 1971 and since then we have introduced a number of innovations. Communication, numerical control, back-plane less hardware and compact size have been just a few of our breakthroughs in the world of PLC's. However two intrinsic images that have characterised Omron's controllers throughout this long history are robustness and ease of use. This has inspired an appreciation and consequently a loyalty from small to medium-sized machine builders. Now that Sysmac has moved from a PLC to a total automation platform we are committed to keeping the same values.

Sysmac platform

The guiding values for the new Sysmac automation platform were simple yet challenging

- Designed specifically for machine control
- One connection, one software philosophy
- Open to global standards
- Omron quality

Created to automate the best machines

We decided to go develop the platform for high speed and high accuracy machine control. For this we opted for the lightest architecture and the fastest machine network in the market. To ensure scalability and control flexibility we decided to use an INTEL atom processor instead of traditional ASICs-based architecture and an industry proven real-time operating system (RTOS). Both were pre-tested for more than two years before adoption.

"It took almost two years of testing and investigation before the final validation of EtherCAT."

EtherCAT: the one machine network

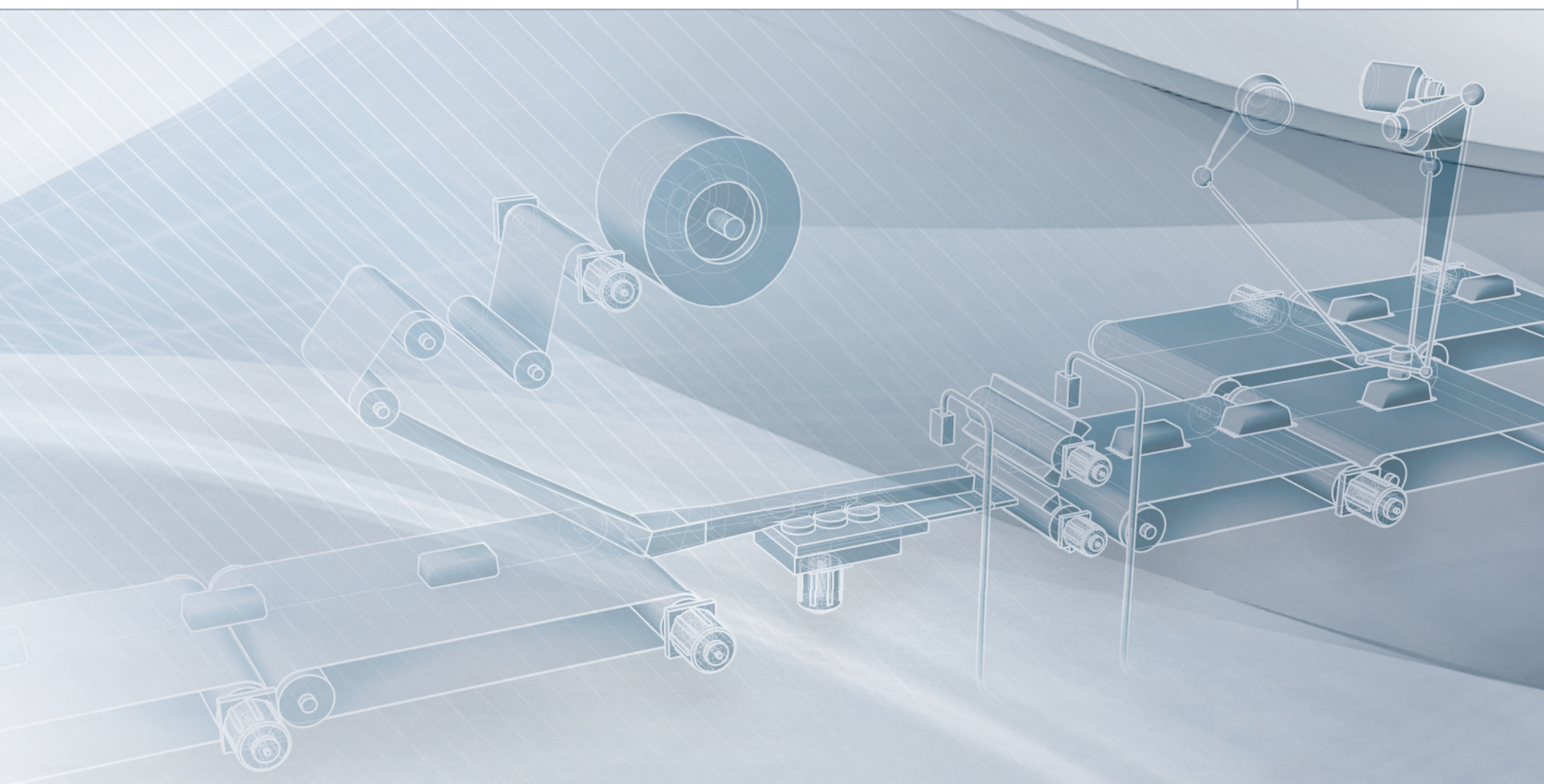
Another pillar of the new Sysmac automation platform is the adoption of EtherCAT as Omron's de-facto machine network. It took almost two years of testing and investigation before the final validation of EtherCAT. The latter is fast, simple and affordable, we had to work internally to make it robust and fit for the harshest industrial environments. EtherCAT will be embedded into all of our wide ranges of field devices.

Sysmac Studio: the one and complete software

Thanks to Omron's global development deployment we were able to use the software development centers in the UK and Spain to undertake the bulk of the development of the new Sysmac

"...we decided to include 3D motion simulation as a first step into the world of machine virtualization."

studio software. Since usability and ease of use are essential in today's modern tools we wanted the developers to work closely with the application specialists and Microsoft engineers. Due to differences in language and culture, this would have been much more difficult to achieve in Japan. Thanks to this team's closeness we came to understand that machine virtualization is the future and for this we decided to include 3D motion simulation as a first step into the world of machine virtualization.



Global players use global standards

It is no exaggeration to point out that Omron is one of the most open automation companies in the world. Therefore, adopting global programming standards such as IEC 61131-3 and PLCopen came naturally to us.

100% Omron quality

To ensure that the software, firmware and network were all perfectly integrated, we decided to have 100% control over the entire development. We went through a tough financial crisis and we could have cut corners by licensing software or using PC based hardware with patched-up tools instead. However, this would have compromised our commitment to our customers, to offer the best quality in the market. It is also important to state that published performances are never based on mere theoretical calculation but rather tested and proven in the most severe operating conditions. That is why it just WORKS!

Today and tomorrow

Today we are proud and pleased to introduce the first generation of the Sysmac automation platform. It covers flexible machine automation and provides an integrated platform with focus on speed and performance. The second generation will focus on flexible cell automation with fully integrated safety, kinematics and CNC basic functionality. We will also work towards more machine virtualization. We have worked hard to build a solid foundation for the future of automation, the rest is just a building block process.

"...tested and proven in the most severe operating conditions..."

Sysmac Studio
Designed for machine creators

Over the years the importance of software has gradually increased to the point now where software can literally differentiate a product in the market. The engineering time invested in the development of a machine becomes a critical asset. Omron therefore understand the importance of providing the best possible tools to the machine creator – to develop faster, with less mistakes and managing the asset throughout the development. This need created the opportunity for Omron to invent a brand new software solution using the latest technology from Microsoft.

From a strong pedigree

Omron has always been at the front when it comes to software technology. Back in the early 1990's Omron released one of the first Windows based programming packages for our PLCs, called SYSWIN. Developed in Europe at our Software Product Centre (in Southampton, UK), this product paved the way for a strong relationship between the development teams in Japan and Europe that continues today.

Around the year 2000 Omron became obsessed with integration, and following the introduction of CX-Programmer we combined all our software products into one: CX-One – "One software for the complete machine".
This greatly simplified the situation for our customers who since then can benefit from just one licence (including simulation), one DVD and a level of integration between the products such as symbol sharing.

Why Sysmac?

With the advances of software technology such as .NET and WPF, Omron took the opportunity to bring a new level of integration and user experience to the machine automation market. Integration of existing products always has limits; similar usability is not enough for Omron. Even if software follows a usability guideline, there will always be subtle differences in behaviour; different terms used that need to be learnt, or simply different short cut keys.

> "It is not simply a new skin on old technology, but literally a complete new development using the latest technology from Microsoft..."

Although built on this strong pedigree of software and integration, Sysmac Studio is a brand new software product, developed entirely by Omron.

It is not simply a new skin on old technology, but literally a complete new development using the latest technology from Microsoft: Windows Presentation Foundation (WPF).
This enables us to achieve a new user experience in factory automation.
By concentrating on the design flow of a machine builder and providing the tools he needs where and when he needs them, Omron have dramatically accelerated the development process for the machine builder.

Having developed this completely ourselves we are very proud to own the technology, and this is a great advantage for our customer: we are controlling the quality throughout the entire process. It also enables us to be in complete control of the future direction of the software, therefore harnessing the maximum value from integration.
We automate machines!

James Riley
IA Solution Marketing Manager
Omron Europe BV

‘Never make mistakes’ and ‘never repeat work’

Some of the guiding principles during the development of Sysmac Studio were the phrases ‘never make mistakes’ and ‘never repeat work’. Each requirement was tested against these principles to enhance the user experience in the software. The Sysmac platform is all about being fast, but simply developing fast is not enough. Doing things quickly often leads to mistakes and the later that mistakes are found the more expensive it is to correct them. For this reason features designed to speed up development were also tested against the principle ‘never make mistakes’.

Why we are passionate about “One Software”

The first benefit to the user of working in a truly integrated development environment like Sysmac Studio is the ability to not have to spend time learning different software products. The behaviour of the tool is the same whether you are setting up the IO table, configuring the network or programming the ladder. There is a simple & consistent layout to the application with the project on the left hand side, the working area in the middle and any relevant tools on the right hand side. With a consistent menu and toolbar, the user quickly becomes familiar with the application and can find what he is looking for.

Sysmac Studio has been developed with IEC61131-3 at the core. This means not only the languages, but also tasks and data structures. Compliance to the standards has dominated this development to ensure that technology can be more easily transferred into this Sysmac environment. The motion instructions are also using PLCopen function blocks rather than any proprietary interfaces. The machine builder no longer programs his logic and motion separately; he makes one program using ladder or ST that is in complete control of his machine.

Having followed the standards of IEC61131 and PLCopen, even users not previously familiar with Omron software quickly feel comfortable working with Sysmac Studio.
To enhance the user experience even further, Omron added a level of flexibility within the programming of the device. Even to the most traditional ladder programmer, Structured Text (ST) is frequently used for simple parameter initialization, but to take the time to create a function block instance just to set some parameters is a waste of time.

Sysmac Studio allows ST to be embedded inline with ladder. Mixing the languages in this way allows each to be used flexibly based on its own strengths.

Background compilation

Sysmac Studio uses a method of background compilation to continually check the integrity of the project. As the user makes changes to the settings or programs the entire project is checked, when any conflicts between parameters or programs are detected, a small exclamation mark is show near that area. This unobtrusive icon does not stop the user working, but just provides the visual indication required to address the problem. When manually compiled a detailed output window highlights both warnings and errors. The user can click on any message and jump immediately to that line of the program. Parameters that are out of range are shown with a red highlight and the tooltip reminds the user of the maximum value so he doesn't need to constantly refer to the manual.

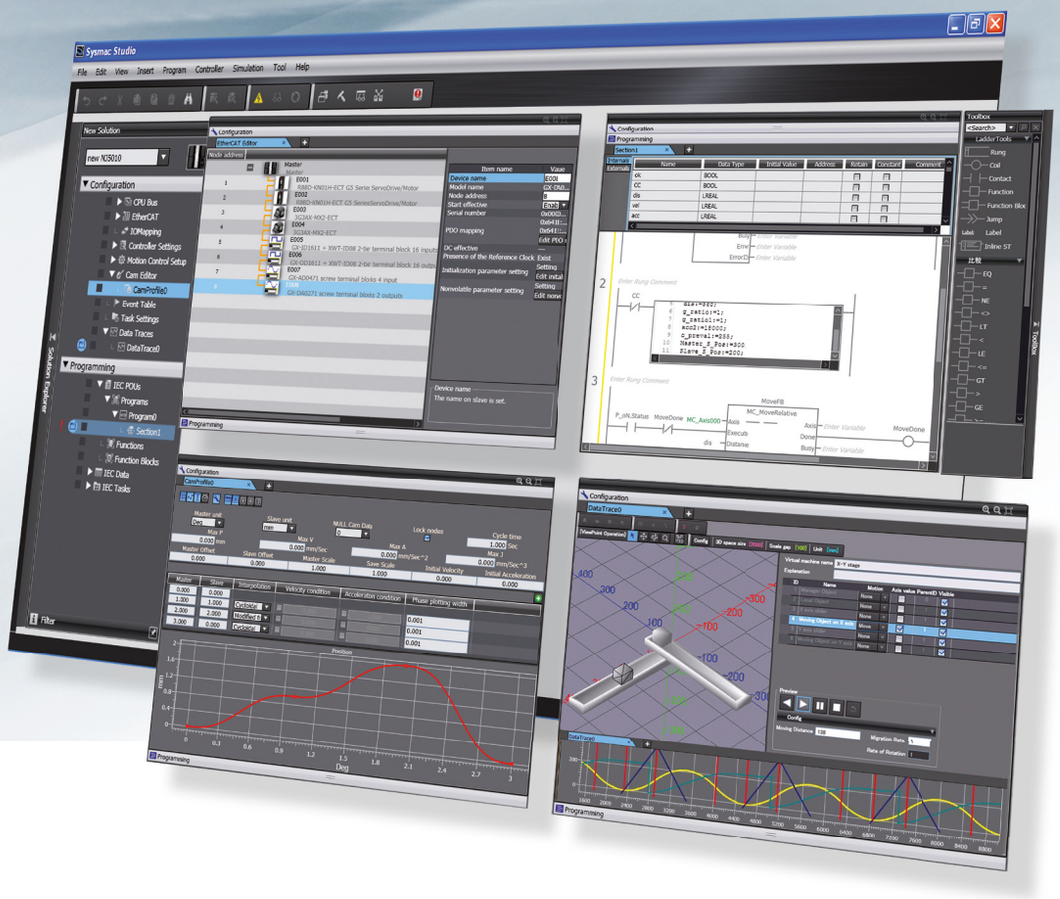
One of the most frustrating things when designing a machine is the need to repeat work. Sysmac Studio solves this in many ways: the most obvious example is the IO mapping & global variable table. This one table is used for the IO units, the EtherCAT devices and any other global variables defined in the development. This structured variable table has full support for IEC61131 structures, but also custom data types can be defined such as structures, unions or enumerations. Throughout the entire application, whenever a variable is required to be entered, as soon as the user starts typing a list is displayed of relevant variables from the table, including structured data types. Thus he never needs to repeat work, or keep a printed list of his IO.

When an axis is defined in the project, immediately an axis variable is added to the global variables of a special axis structured data type. This allows access to all the attributes of the axis, and can be passed to any of the PLCopen function blocks that are supported. The user does not waste time or have to remember several steps; the software does it automatically for him, accelerating his development.

> "Sysmac Studio: a brand new software product developed by Omron."

3D simulation

The real breakthrough in fast development comes from being able to build confidence that the solution is right, that the project will work as you expect and when you expect. Sysmac Studio includes some fantastic tools to test & debug your project. All the basic features are included such as watch windows, data traces and power-flow monitoring, but



in addition Omron have introduced 3D simulation. This gives the user the ability to see at a glance the behaviour of the axes in the project. Whilst a data trace is accurate, it can be quite difficult to interpret exactly how the axes relate to each other, but when visualized in 3D it immediately becomes obvious if the program is working in the way it was intended.

A new user experience

Sysmac Studio has achieved bringing all the functionality from the range of tools previously required directly inside one framework – an integrated development environment. That includes:

- Configuring IO's and Axis
- Configuration of EtherCAT devices
- Preparation of CAM Profiles
- Programming for Logic & Motion
- Monitoring
- 3D Simulation

With all this functionality within the one software product, the software is aware of the total machine solution. This enables it to constantly check the integrity of the project highlighting any problems or errors and warning the user as appropriate. All the data is stored in one project, so the user does not need to worry or care about exactly what files he puts in his backup storage.

Thus we say we offer a new experience to the machine builder thanks to the flexibility of WPF and the true integration between Logic, Motion and the rest of the machine!

Sysmac NJ 501: The evolution of the PLC

Sysmac NJ Series is a new class industrial controller, capable to perform like last generation computer, but keeping the endurance and reliability of a hard proven Omron PLC.

Traditionally, Omron's PLC's based on ASIC (Application-Specific Integrated Circuits), are incredibly reliable. Due to the on purpose developed hardware, they are exempt from inherent reliability problems common in other control systems. However our experience shows that developing ASIC circuits can take up to two years, followed by the necessary tests as a part of the PLC, so this introduces an undesired lag between our customer requirements and our product release.

Additionally, new PC technology adoption is growing because of it's flexibility (Office PC's, Home PC's, Multimedia PC, etc.) using powerful MPU's.

Open versus closed

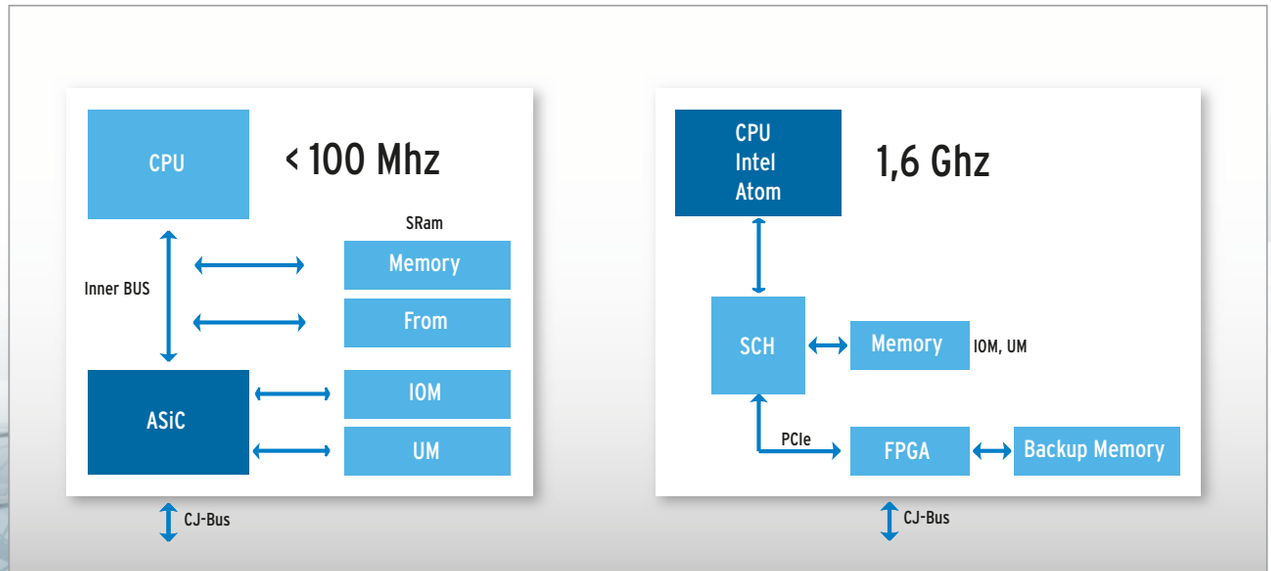
It would be great to use this type of technology for Industrial Control applications, unfortunately it is well known, that conventional PC technology cannot achieve the required performance/durability ratio required for most of the control applications. This is the eternal dilemma of the Quality of a closed system versus the Flexibility of an Open System.

Our challenge was to find a solution for this dilemma and therefore we targeted to develop an Automation Controller, with the same reliability level as it's CJ Series PLC and the flexibility and computational power of modern PCs.

It has been a real challenge. The development has challenged the minds of hundreds of Omron R&D engineers, in order to achieve a very unique piece of hardware, designed for heavy duty operation, 24 hours per day, 365 days per year, year after year.

The result is the Sysmac NJ-501, a Hard Real Time Controller with an embedded Intel MPU.

The graph shows evolution of a traditional PLC Architecture to a Machine Controller.



Josep M. Lario
Motion Specialist
Omron Europe BV

Comparison table PLC's and Machine Controller

	Conventional PLC	Machine Controller	PC Based PLC
Purpose	Control Machine I/O Sequence	Control Machine I/O Sequence, Motion, Vision, Information, Safety, etc...	Control Machine I/O, Sequence, Motion, Vision, Information, Safety, etc...
			Other Non Realtime Purposes
Architecture	Dedicated Hardware	Dedicated Hardware with Embedded MPU	(PC) Conventional Hardware
			(IPC) Improved Conventional Hardware
Control Algorithms	ASIC specific and Firmware	Hardware specific and Embedded MPU firmware	PC Software
Operating System	RTOS	Hard Real Time OS*1	Windows Based RTO*2
Flexibility	Limited	High	Very High
Hard Real Time behaviour	Very High	Very High	Windows Based RTO*2 (Limited)
			True RTOs*3 (Hardware constrains)
Non Real Time Processes	–	–	Executed in Idle time of RTO processes*2*3
Expected Life Time	Unattended for years	Unattended for years	Limited by PC technology
Processing Speed	High	Very High	Very High
Industrial Grade	Yes	Yes	No (PC)
			Yes*4 (IPC)
Malware	No	No	Real threat

**1 Hard Real Time OS, is designed to exhibit truly fail-safe behaviour, this kind of O.S. is normally used in fields where reliability is a must: aerospace, defense, medical, etc...*
**2 Windows is not a Hard Real Time OS (Windows CE is aiming real-time capabilities). Microsoft admits Windows is not intended for Hard Real Time Applications. There are inventions based on Windows that offer an approach to real-time, however an non Hard RTOS, don't exhibit real-time behaviour when stress tests are applied.*
**3 Conventional PC electronics are not designed for Hard Real Time purposes, hence some inherent architectural limitations exist.*
**4 IPC (Industrial PC), is an Industrial Grade PC. In Omron it means that electronic circuits have been redesigned with enough margin of electronic parameters, and components have been specially qualified to pass severe Factory Automation/ Industrial Products tests: Endurance, Vibration, Stress, Electric Shock, EMC, etc...*

NJ Software Architecture

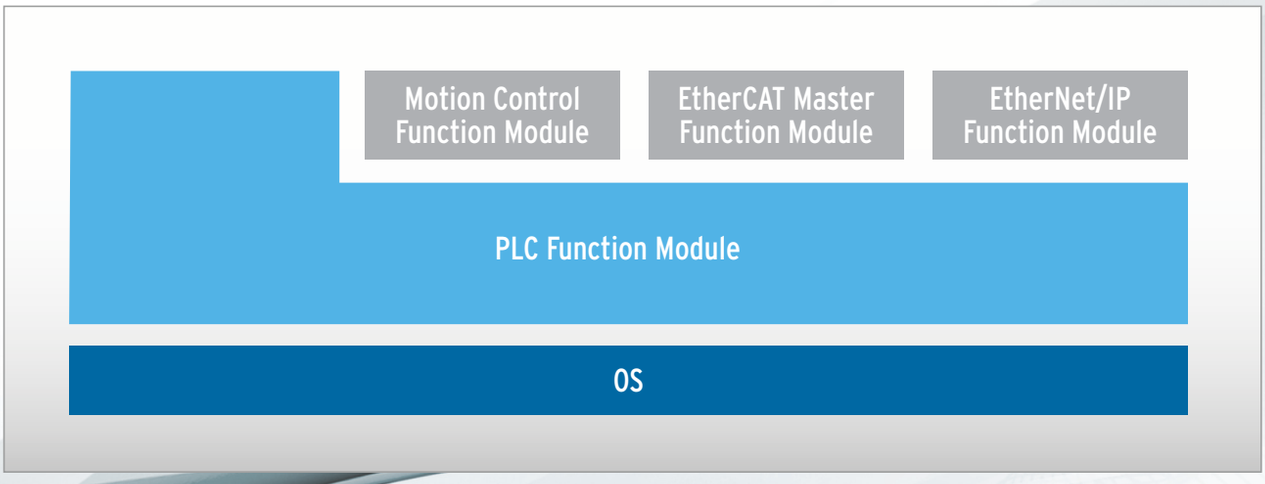
Software Architecture is an evolution of the proven Omron PLC concept.

The internal Hard Real Time OS has close interaction with specific Omron developed Hardware. This genuine hardware is the result of combining decades of Omron experience in developing PLC hardware with the versatility and computational power of an Intel MPU. In fact, the Intel MPU is relieved of some specific functions, managed at the hardware level by sub-processors and FPGAs. The result is reflected in outstanding stability and reliability, with a minimal temperature increment which is a critical factor to ensure electronic system longevity.

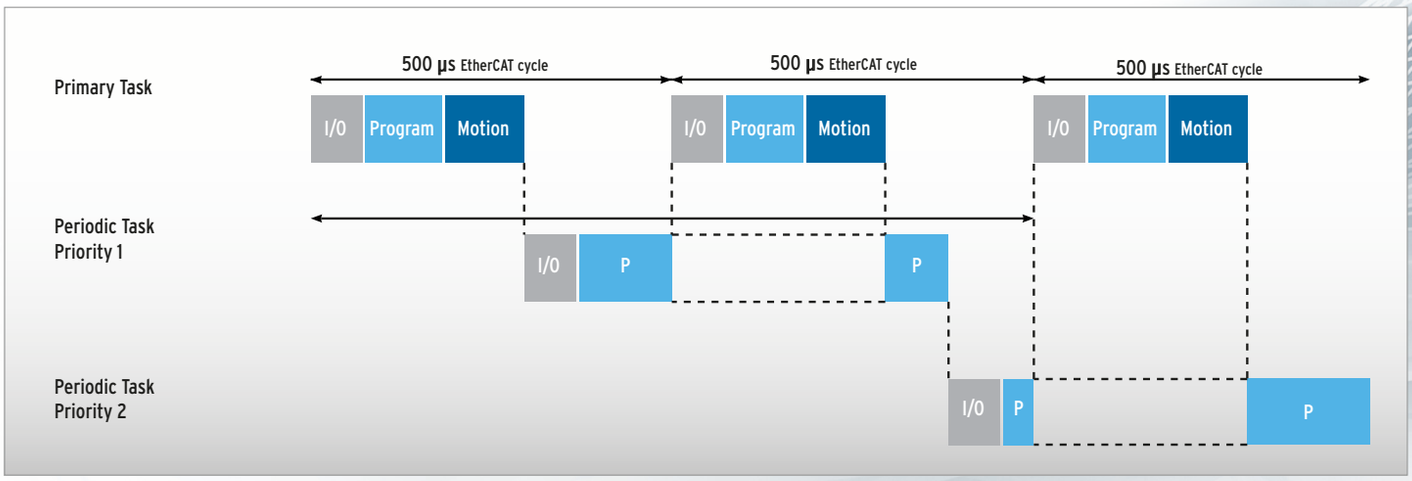
Function modules

- The PLC function module controls overall scheduling, executes the user program, interfaces the CJ-series units, sends commands to the other function modules, and interfaces the USB connector and SD Memory Card.
- The Motion Control Module executes motion processing based on target values (such as the position or velocity target value) from the motion control instructions in the user program. It outputs command values, controls status, and obtains information through the EtherCAT Master Function Module. This function module outputs command values for Servo Drives.
- The EtherCAT Master function module communicates with the EtherCAT slaves as the EtherCAT.
- The EtherNet/IP Function Module communicates with the EtherNet/IP Network.

All modules are scheduled In Tasks, these tasks are strictly synchronized, the NJ executes the PLC Primary Task and Motion Control Function Module within the EtherCAT Refresh Time, exhibiting True Hard Real Time performance.



The new OMRON IEC-61131-3 PLC Function Module runs on Top of the OS.



IEC-61331-3 Task Execution

The NJ system, completely executes the Primary Task (PLC +Motion) within the EtherCAT loop.

In addition, up to 3 Additional Periodic Task can be executed with different priorities.

Periodic Tasks are executed in the remaining time of the Primary task.

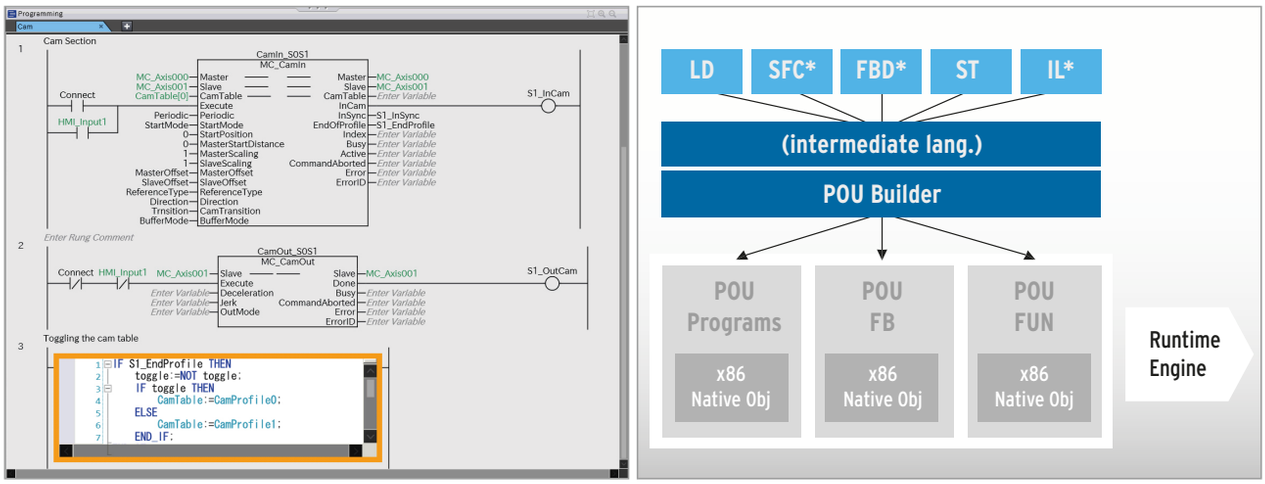
Each Task can hold up to 128 Programs.

Sysmac:

- Allows local I/O, EtherCAT and EtherNet/IP data to be refreshed at different rates by assigning individual variable update to tasks.

- Includes an exclusive control to prevent variables from changing by another tasks at unexpected timing.

"Software Architecture is an evolution of the proven Omron PLC concept."



Editor & Compiler
**SFC, FBD and IL are not supported in Version 1.0*

Compiled versus Interpreted code

The Classic PLC approach correspond to an interpreted code, however the NJ Series executes a compiled code.

- The user develops PLC program in IEC-61131-3 language.
- The builder converts IEC-61131-3 program to (Common Intermediate Language).
- The POU builder generates the optimized compiler code to be executed by the MPU.

As a consequence:

- The PLC Execution is faster than the Interpreted PLC (Code is optimized for the MPU).
- Programs in all languages generate equivalent optimized code.

Based on the previous techniques, the NJ Includes exclusive InlineST feature.

The InlineST block is a pure ST code written directly in a Ladder Block. This ST block is part of the program code (not an instance to ST FB!), so has direct access to the local program variables.

The combination of Ladder and ST elements in the same program enhances the programming experience by combining the benefits of ladder programming with the convenient expression of ST language.

Online Edit is another common feature to Omron PLC's that has also been included in the NJ Sysmac, by means of Online Edit, a program can be modified while the PLC and Motion Control Module are in execution.

NJ Performance Benchmarks

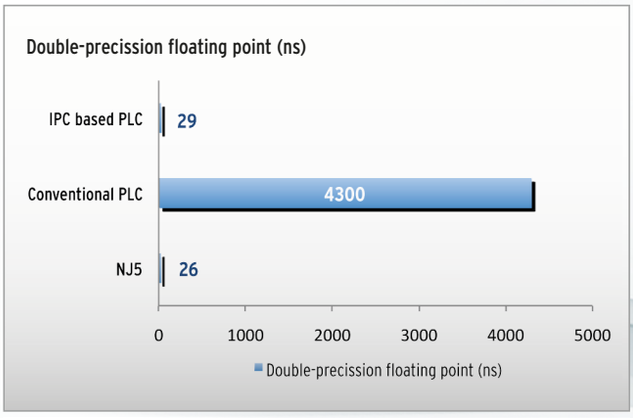
It is easy to say that the NJ is an outstanding product, however an objective comparison with other products is a more quantifiable way to explain the difference.

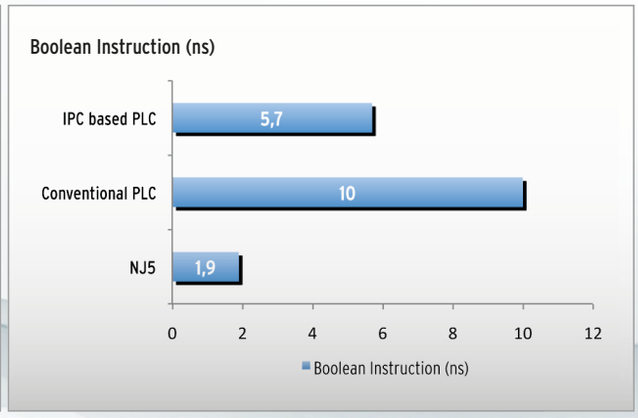
The following Benchmarking compares the NJ5 Controller series with Conventional and IPC based PLCs.

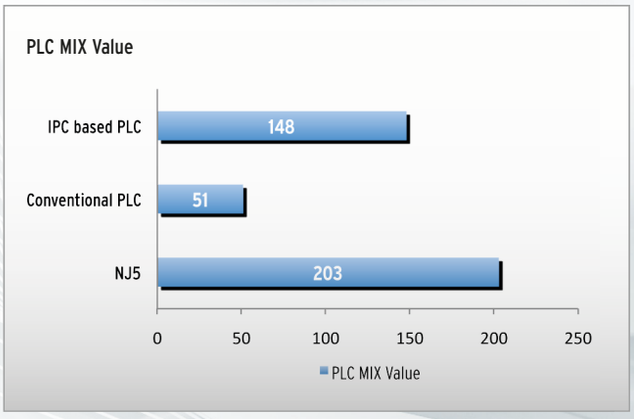
PLC MIX index is a PLC benchmarking standard introduced by JEMA (Japan Electrical Manufacturer's Association), aiming to provide a non biased comparison between different PLC vendors, a high value in the PLC MIX index indicates a high performance in instruction processing.

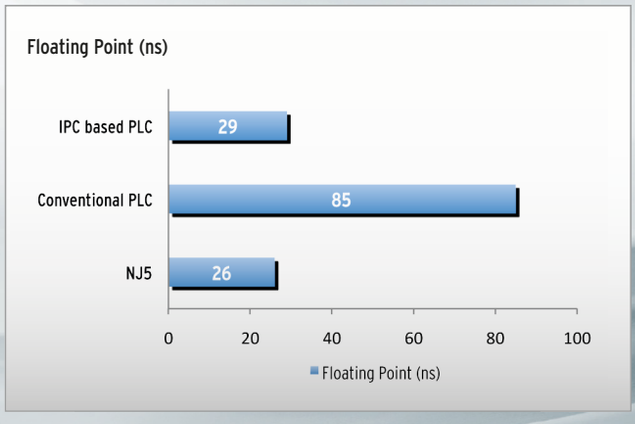
jema-net.or.jp/Japanese/standard/plcmix.html

Note: The IPC used for this test is using the same range MPU.









Conclusion

The Sysmac NJ-501 is an outstanding Machine Controller, with outstanding performance thanks to the combination of the Intel MPU embedded in Omron Electronics, and the proven reliability of Omron's CJ PLCs.

This is clearly a very unique and exquisite combination of Quality and Performance, that is setting the standards for future Machine Controllers.

sysmac
always in control

Josep Marti
Motion Product Manager
Omron Europe BV

Reading about standards can often be a time-consuming and difficult experience for many of us. In order that you keep reading, I promise to only focus on why IEC 61131-3 and PLCopen are needed and why the new Sysmac NJ5 machine controller fully complies with them.

IEC 61131-3 and PLCopen: Omron's commitment to openness

The languages in Industrial Automation

Within industrial automation there are "mainly two" types of controllers that have driven the creation of IEC 61131-3, the PLC and the motion controller. For PLCs, Ladder Diagram or simply "Ladder" was imposed immediately as the "de facto programming language". It was easily adopted due to the similarity with the electric schematics that allowed engineers to move easily from traditional wired control systems to “programmed” controllers. Later, when motion controllers were placed inside the machine, programming language options became much more heterogeneous, with alternatives from Basic, C, C++, ST and Ladder up to different Visual Block diagrams. Today, far from being reduced, the variety of programming language is confronted with a merge of disciplines inside the machines like CNC, robotics, Safety or Vision that bring people with different language backgrounds and new needs into the machine controller scene.

In reality we are also confronted with “language dialects”. Taking Ladder as an example, we can see that “in fact” each PLC vendor has had its own language and the differences between them can be quite significant. These vendor specific dialects are the consequence of the technology evolution pushed by each vendor independently. Arriving at this point, the needs for standarisation start to become obvious but languages are not alone here.

The controller architecture

Linked to the programming language, we have the controller architecture (I/O, memory, network, tasks, programs etc.) that has played a critical role in defining the specific vendor dialect. The most important consequence is that a program created for one controller requires a large investment in engineering time before it can be moved to a different controller. When the controller is a PLC, the change of vendor or family will require some effort, but if the controller is a motion controller then, the change is much more painful and in some cases not feasible. The reason behind this is that the diversity in motion controller architectures, functionality and performance is extremely wide.

IEC 61131-3

Now that we have looked at the effect of not having standards, it is time to look into the IEC 61131-3 and PLCopen standards. There are many ways to describe them, but as promised I will take the simplest option.

IEC 61131-3 is the third part of the open international standard IEC 61131. This part 3, **defines the programming languages** for programmable controllers, these are; Ladder diagram (LD), Structured text (ST), Function block diagram (FBD) Instruction list (IL) and Sequential function chart (SFC). However, IEC 61131-3 does not simply define the languages, it also **covers several common elements** that together create a virtual model of the controller, the defined common elements include; Data Types, Variables, Configuration, Resources, Tasks, Functions, Function Blocks and of course Programs.
As a result, when a controller is developed following the IEC 61131-3 standard, the engineering investments in the controller application, its programs, its structures and also the dedicated learning time will have a very high re-usability.

PLCopen

PLCopen is a vendor independent association, whose core activity is focused around IEC 61131-3. PLCopen defines extensions for IEC 61131-3 such as the Motion Control Library or Safety among others. Omron is one of the companies participating in the PLCopen committees and is actively contributing to the creation of the specification expansions.

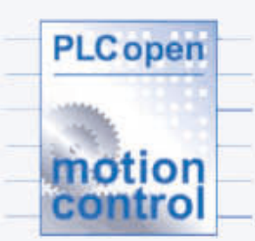
Omron and the standards

Omron has been progressively adopting the IEC 61131-3 standards since the nineties in its CJ PLC family and now, **we are introducing the new Sysmac NJ machine controller that has been developed to fully comply with IEC and PLCopen standards.**
The Sysmac NJ5 machine controller complies with IEC 61131-3, PLCopen motion control parts 1 and 2 (V2.0) and also Part 4 that is focused on coordinated multi-axes control in a 3D-space (Omron is the second company in the world to obtain a certification for Part 4). Omron's commitment is to continue following the standards closely while expanding the controller functionality and the products belonging to the Sysmac family.

for those aspects in the system that go beyond the defined areas in the standard, **Omron carefully checked each detail in order to provide a system that has high usability, is predictable and offers total transparency to the user.**

Omron has also been pushing forward the standard in areas where it is not providing enough flexibility to the user. A good example is the possibility within the Sysmac NJ5 to combine ST programs directly inside Ladder programs. We are convinced that our 78 years of experience in industrial automation will enable us to influence and thereby improve future versions of these standards.

In line with Omron's compliance with standards, the Sysmac NJ5 includes, within the controller, the accepted industrial communication networks EtherCAT and EtherNet/IP. The topic of industrial networks, however, deserves a dedicated article.



PLCopen Motion control

The Sysmac NJ501 is certified for PLCopen Motion control Version 2.0 (merge of Part 1 and Part 2) and Part 4 that is focused on coordinated multi-axes control in a 3D space.

Part 1 – Basics and Part 2 – Extensions
Part 4 – Coordinated Motion

"...the second company in the world obtaining the PLCopen motion control certification for part 4"

As a machine controller, the Sysmac NJ5 includes, in one controller, the functionality that had traditionally sat in separate controllers. It includes PLC, Motion, Robot and Vision control and we will continue to expand on this. One challenge in merging these disciplines was how to make the controller easy to program, commission and maintain. The use of IEC 61131-3 and PLCopen has helped to ensure that the programming environment will be appreciated and understood by users with different backgrounds and skills. Additionally,

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Sysmac Project Leader,
Europe and The Americas
Omron Automation Division

Jan-Willem Vogelaar
European Quality & Environment
Operations Manager
Omron Europe BV

Why it JUST WORKS!

50,000 machine builders, over 50 years of industrial automation and over 15 million controllers sold around the world tell us that QUALITY should always be at the heart of our core business.

Speed, accuracy and reliability: the QUALITY MIX!

Speed, accuracy and flexibility without compromising on reliability form the core requirement of the quality for the new Sysmac NJ controller. While most PC based controllers claim to meet the performance criteria set by the NJ, few will measure up on comparison when it comes to the robustness and ruggedness that is required from a true industrial controller, from a true global automation supplier.

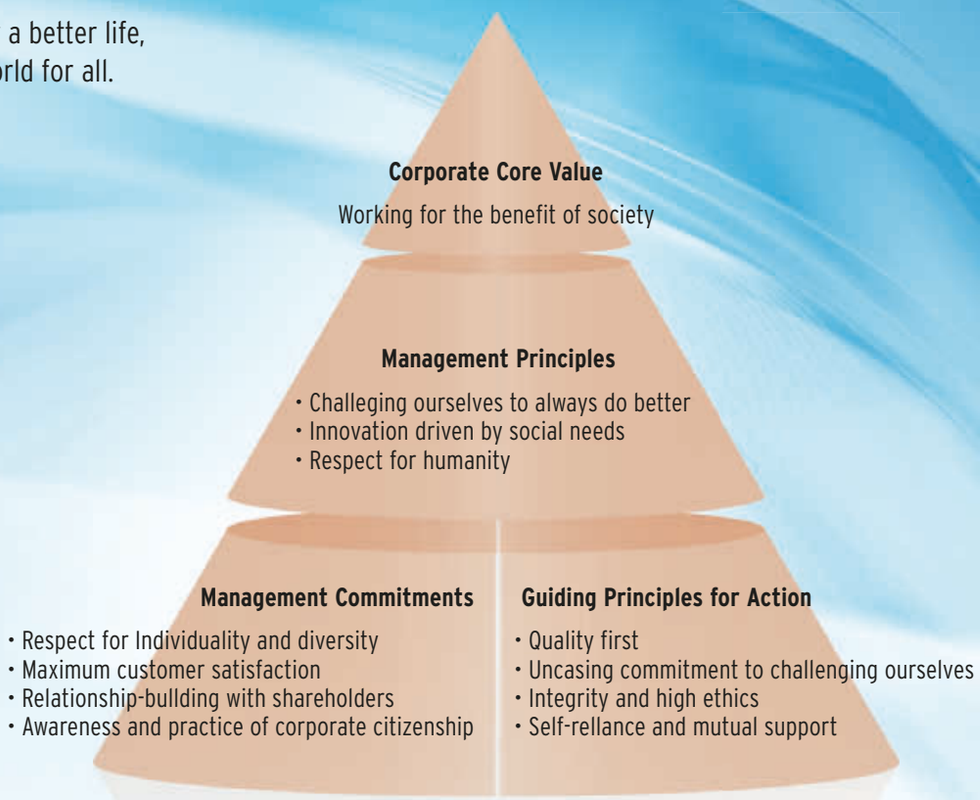
Quality FIRST! Is not just a LOGO!

Quality FIRST! Is one of our corporate guiding principles as shown in figure 1. Every product with an Omron logo represents Omron's business ethics. It means that you can rely on it as a product and on us as a partner. The product is guaranteed to perform within and beyond the specifications published on the datasheet. Beyond a selling or buying process it represents the building-together of experience between customers and Omron.

Corporate Motto

At work for a better life,
a better world for all.

The Omron Principles



Quality FIRST! Engraved in our corporate principles

PPM not PPT!

Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR) are commonly employed and requested by customers to check on the reliability level of a supplier. Beyond the fact that it is difficult to verify, those two items at best indicate how well you, as a supplier, select your parts and how quickly you react to a field failure. We prefer to use field failure return measured in piece per million (PPM). Here we insist on the difference with the PC based automation world where failure rate is usually quantified in piece per thousand (PPT) if any. The target PPM rate for the NJ is 50. This target is well below the best in class products on the market and even lower than Omron's CJ PLC series that rates around 75PPM.

Defect prevention methodology

An effective failure prevention process is a complete and integrated Total Quality Management discipline. It includes five major stages that must be implemented within a rigorous quality and environment assurance system.

1. Prevent creating defects at development and planning stage

2. Prevent importing defects at procurement

3. Prevent manufacturing defects during production

4. Prevent exporting defects when shipping

5. Prevent repeating defects during return and repairs

1

Prevent creating defects

To ensure that “we do the right things” before “we do the things right” we establish a balanced approach to any product development project. From one side we have the pure project development process, owned by the product manager and on the other side the total quality management process, lead by the quality assurance manager, who acts as a watchdog regarding Omron’s ethics and quality criteria.

There are 4 major (design) review milestones (DRs) after each Product Life-Cycle phase.

DR1 – Product Planning Review

This phase reviews the business plan and its marketing and commercial impact. At this stage the total quality management plan with roles, responsibility and strategy is fixed. The development project starts when DR1 is passed.

DR2 – Product Development Review

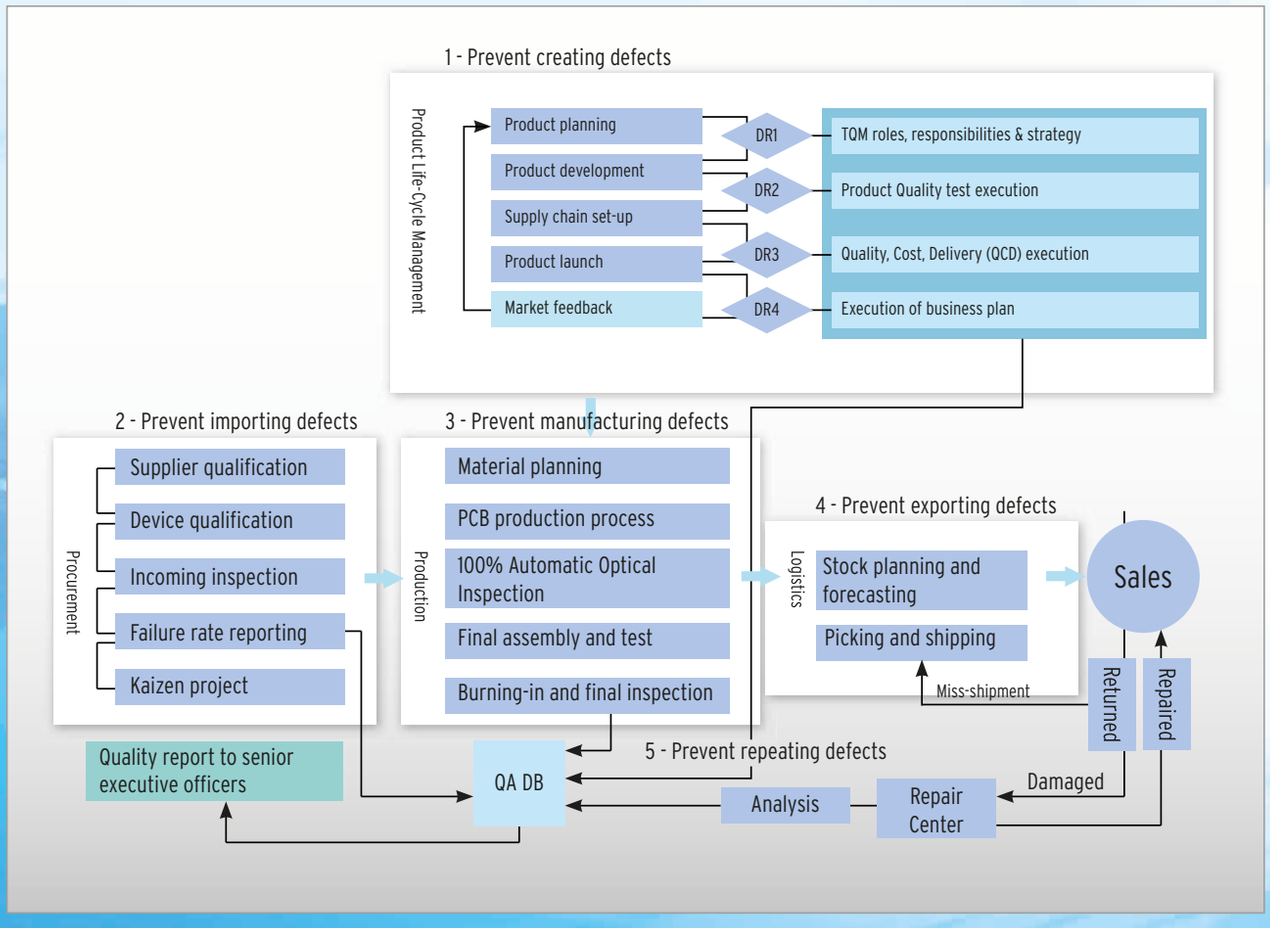
This phase deals with the product development and quality tests execution and validation. Mass production starts only when DR2 is passed.

DR3 – Supply Chain Setup Review

This phase prepares the product for market release. The supply chain from production to customer is established. This consists of (1) product registration, (2) price set-up, (3) initial stock, (4) documentation, (5) promotion material and (6) training.

DR4 – Business Case Review

This takes place between 6 to 12 months after release. It consists of monitoring the sales performance against the plan as well as carefully recording the initial feedback from the market. This is fed back to development for possible improvement or mostly as preparation for the next generation products.



Total Quality Management process

2 

Prevent importing defects

Making repeatedly excellent products is not an accident; it is a culture and a discipline. This is what we look for when we evaluate a supplier. Once we have a culture match, the product will follow. We insist that all devices have to be of industrial ruggedness and fit into our stringent design tolerances. We perform our own incoming inspection tests in spite of the added costs for new devices within the 1st year in order to prevent any infant failure. We work closely with our suppliers towards the same quality assurance platform and together we aim at reaching class A supply. To ensure a reliable and shock-free supply we share with them yearly estimations and six months rolling forecasts. Order handling is fully paper-less through EDI.

3 

Prevent manufacturing defects

We strictly control the manufacture of PCBs. For this we produce critical PCB's in house. After the solder paste application all the PCB's undertake a 100% automatic optical inspection from an Omron original AOI unit. They then pass to the reflow oven to be optically inspected again. The final assembly is performed within an intelligent man-machine assembly unit. Omron is the pioneer of manufacturing and assembly technologies, such as U-shaped, standing position assembly lines where man and machine work in harmony to get the most efficient, quick and flexible assembly system. All products undergo 100% functional testing before leaving the factory.

4 

Logistics

Total quality also means zero miss-shipments. Our European Distribution Center (EDC) operates with the same ERP system as sales and manufacturing. Therefore sales forecasts are immediately reflected in factory planning. The EDC is fully automated and uses a modern pick-to-voice system aiming to eliminate operator picking errors.

5 

Prevent repeating defects

Product return: Returned goods are dispatched to the repair center. Any failure is identified, repaired – at component level – and returned within 5 days. The failure records are recorded within the quality assurance database. Recurrent failures – or upon customer request – are deeply analysed by the quality assurance section. The quality assurance laboratory is equipped with the latest and most sophisticated equipment such as Shimadzu 3D non-destructive Microfocus X-Ray and scanning electron microscopes.

Traceability: all units have a unique serial number from where the production lot and even the component parts which make up the product can be traced. A monthly quality report is submitted to senior executive officers. Serious defects must be reported immediately to the same body.

QUALITY will always be the guiding light towards our future. It's more than a process or a guideline, it's simply a CULTURE.

EtherCAT: One Machine Network

EtherCAT is becoming the most popular machine protocol. Why? Unmatching performance, the highest precision and real openness make the difference with other Ethernet industrial protocols.

EtherCAT is the acronym for Ethernet for Control Automation Technology. It is an Ethernet (IEEE 802.3) compliant BUS, developed to be used in an industrial environment.

In recent times, the use of Ethernet industrial protocols has become more and more popular: EtherNet/IP, EtherCAT, and others are common terms that have been added to our vocabulary. All these protocols have a common physical media: Ethernet.

The most common Standard Ethernet is the 100-Base-TX + RJ45 connector:

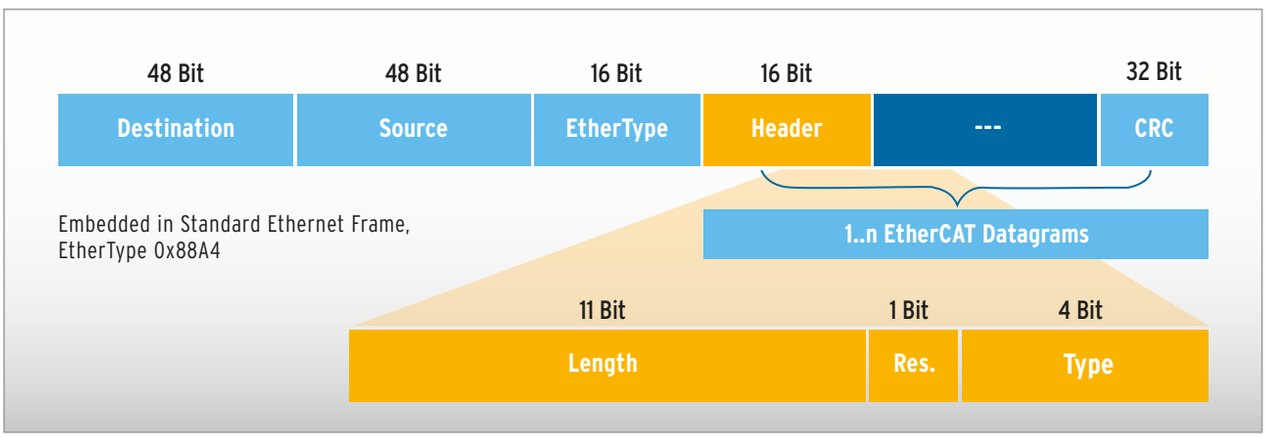
- Proven technology
- Up to 100 meters between devices
- Good noise immunity (Industrial Cable)
- Affordable/cost-effective cables
- Easy to manipulate, crimp, etc.

There are thousands of kilometers of Ethernet cables, in offices, homes and public infrastructures. It is possible to purchase cables of a reasonably quality, in every computer shop. However, in factory application it is recommended to use industrial cable versions (CAT 5 or higher), in addition to industrial class connectors.

The right Network for the right purpose

Common sense and good manners, recommends us to better use a spoon rather than a fork when eating soup, this is because a spoon has a better design for handling liquids. A similar approach can be taken for Industrial Ethernet Protocols, as not all protocols exhibit the same performance and features.

- *Ethernet/IP* is an excellent network for controller to controller applications with a natural integration in Company Corporative Networks. Using standard Ethernet hardware, EtherNet/IP is the perfect Factory Automation Network where the data size exchanged by node is high.



Josep M. Lario
Motion Specialist
Omron Europe BV

• *EtherCAT* exhibits outstanding performance with devices that exchange few amount of bytes but require a very deterministic and fast communication cycles. In addition due to the 'on the fly' data exchange EtherCAT is hardly affected by the number of nodes, it is the perfect Machine Network.

Both networks, Ethernet/IP and EtherCAT are open networks, represented in the ODVA and EtherCAT Technology Group
odva.org, ethercat.org

This article, will highlight some aspects that make EtherCAT a very special Machine Network, and Omron's defacto standard for Machine Automation.

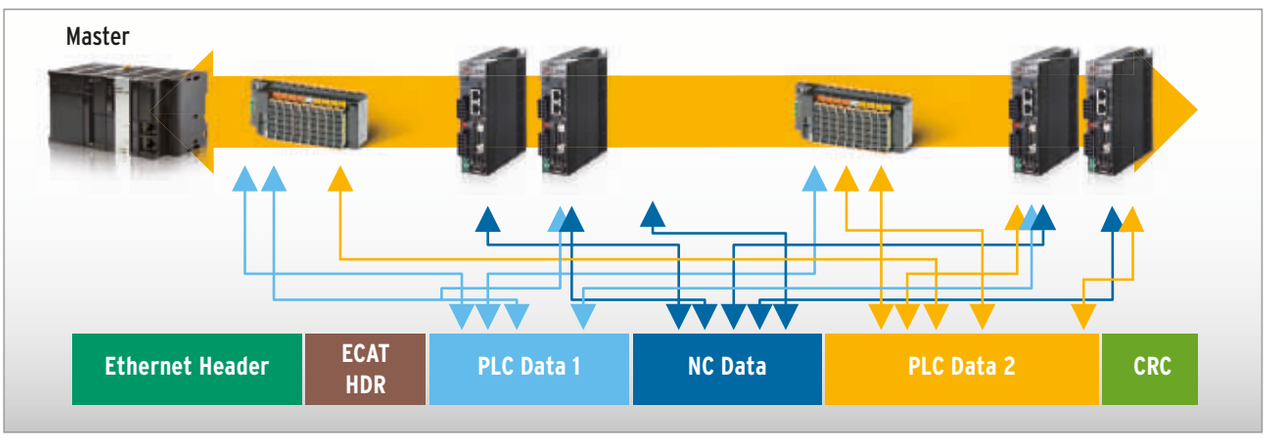
EtherCAT throughput

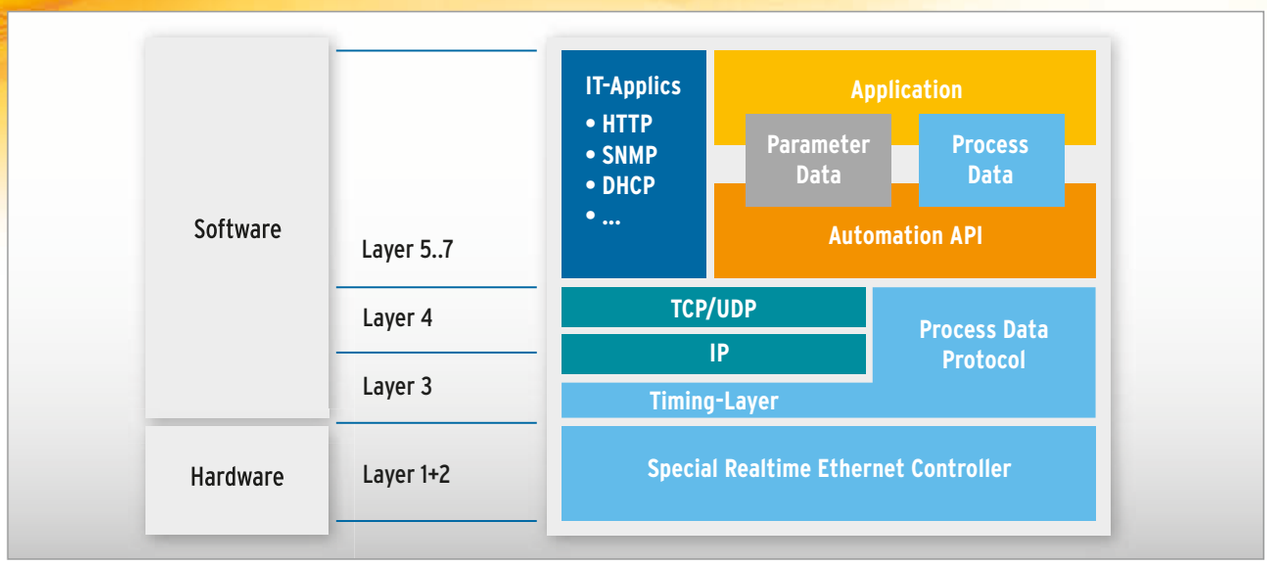
EtherCAT uses standard IEEE 802.3 Ethernet frames. The EtherCAT telegrams (EtherType 0x88A4) are encapsulated inside the standard Ethernet frame. The Ethernet frame was originally designed to handle large amount of data, and most of the Ethernet Industrial I/O protocols do not make efficient use of the Datagram space.

Imagine that the Ethernet Frame is a large school Bus with about 1500 seats (bytes). Only a few seats, can be occupied by a passenger and therefore in order to transport 1500 people a lot of school Buses will be required. A consequence of this will be that the highways (bandwidth) would be rapidly collapsed during rush hour.

It would be desirable to make a more efficient use of such a large school Bus (Datagram). If just one Bus was used, traffic jams on the highway (bandwidth usage) would be dramatically reduced.

As expected, this is exactly what EtherCAT does, by allocating data from several nodes in the same Ethernet Message, so that bandwidth usage is more efficient than other Industrial Ethernet networks.





Data exchange 'on the fly'

Thinking about the previous school Bus example – the Bus stops at each Bus station (node). It would be fantastic to have a method that allows passengers (data) to get In and Out of the Bus without need for stopping! However, as we know this is something that is impossible for a school Bus, it is, however, possible for EtherCAT.

EtherCAT Slave nodes exchange data 'on the fly'. In order to exchange data as quickly as possible this task is performed at hardware level, by means of specific EtherCAT Slave 'chip'.

There is a big difference in performance between Ethernet Networks that just use the Software layers of the OSI model (layers 3 to 7), and Ethernet Networks, like EtherCAT that have dedicated hardware, affecting OSI layers 1 and 2.

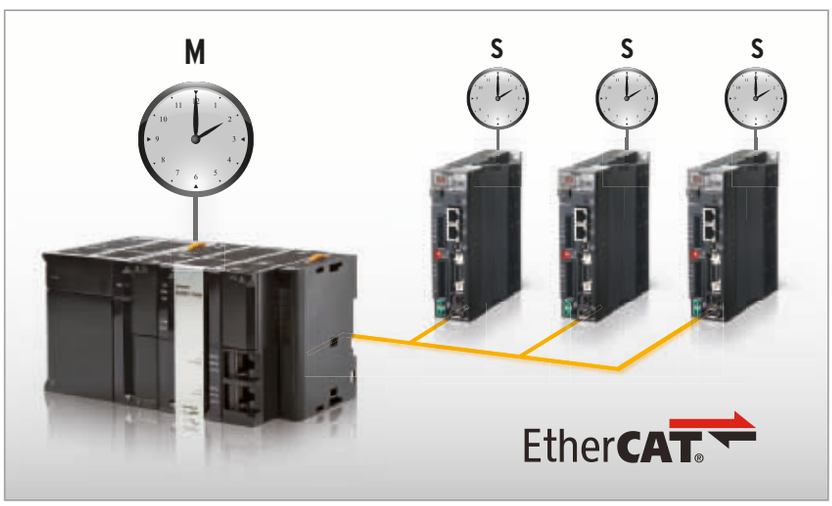
"Optimum performance of Omron EtherCAT Slaves in combination with Sysmac NJ Controller"

Throughput and precision: Distributed Clocks

The throughput of a network is a measure of the quantity of information that can be transmitted in a certain time. Throughput is determined by the bandwidth, but as explained before, the efficiency and the implementation of the protocol also makes a difference.

EtherCAT has a superb throughput, but 'brut force' without control is not always the best option.

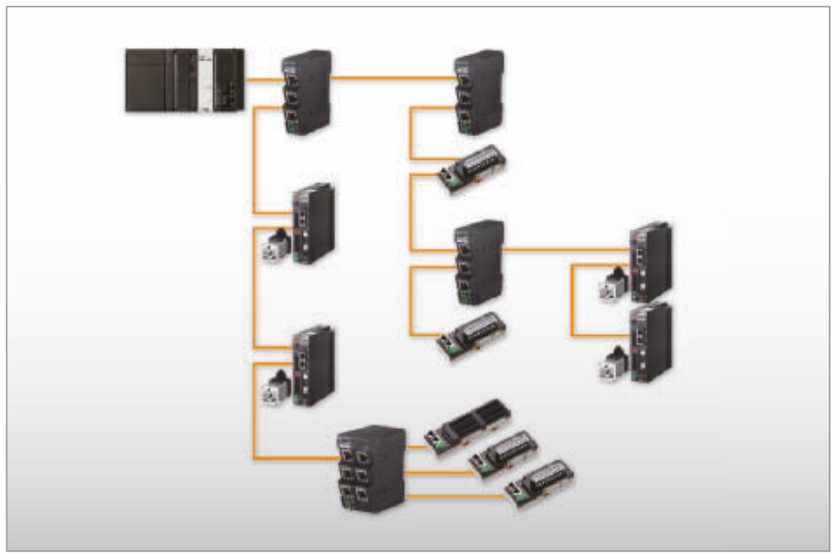
Precision is also a fundamental parameter to determine the health of a network.

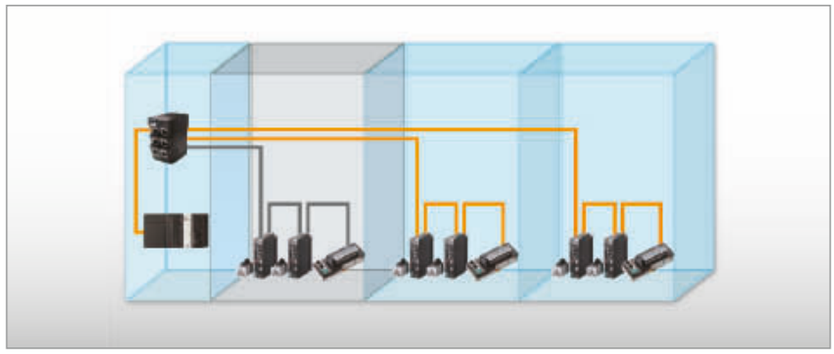


An ideal network will update data in a fixed period and with no fluctuation. Using the example of the school Bus, the Bus must exchange passengers at each Bus stop, day after day at the same time, e.g. 10:00 o'clock. When the Bus is advanced or delayed, let's say by +/- 5 minutes, this causes big problems for the passengers who are affected by this undesired random behaviour. This time fluctuation in a periodic transmission process is named jitter, the higher the jitter the worse the precision.

A network intended to be used for Motion Control applications must have a very low jitter or implement compensation mechanisms. EtherCAT has by design a very low jitter, efficient usage of the bandwidth and reliable data exchange is executed at hardware level. However this jitter is influenced by many factors, such as cable length, number of nodes, temperature etc.

The distributed clock mechanism, implemented in the EtherCAT is a compensation mechanism that reduces the already minimum jitter of the network to a negligible value of less than << 1 µs! This technique is based on implementing clocks in the different nodes of the network, these clocks are precisely synchronized and data transmission has a time print, therefore any potential jitter can be compensated by the slaves.





EtherCAT topology

One of the features that makes EtherCAT attractive as a device network, is that in contrast to many other Ethernet networks, a daisy-chain network can be established with no need for additional Ethernet switches. All EtherCAT slaves have at least an IN port and an OUT port so that the EtherCAT telegram easily flows though the network, with no need for additional hardware.

When the application requires different topologies: daisy-chain, tree or star, Omron's GX-JC branching units, can be used.

Branching units also allow a hot-swap of devices without affecting the performance of the other network segments.

EtherCAT: Open network

The EtherCAT Technology Group is the official standardization entity that defines the EtherCAT standards. EtherCAT follows international standards (IEC 61158, IEC 61784-2, IEC 61800-7, ISO 15745, E54 20 etc.)

EtherCAT includes more than 1750 members (August 2011), becoming the largest fieldbus organization in the world, with ETG offices in Germany, USA, Japan, China and Korea.

In particular, Omron masters and drives support CANopen over EtherCAT (CoE), with the CIA-402 Drive Profile, which qualifies the Sysmac system for demanding motion control applications.

Omron guarantees the optimum performance of Omron EtherCAT slaves in combination with Omron Sysmac NJ Controller, and because of the openness of EtherCAT, also 3rd party slaves (i.e pneumatic devices) can be integrated into the Sysmac system. For this purpose, Omron has established several certification laboratories worldwide, formally called “Tsunagi” laboratories, that will perform the required interoperability tests.

Product overview

Controller

PLCopen motion control

NJ-Series

- Integration of Logic and Motion in one Intel CPU
- Up to 64 axes motion control
- New PLC Logic and Motion cores, 100% Omron quality
- IEC 61131-3 programming languages
- EtherCAT and EtherNet/IP ports embedded
- Certified PLCopen Function Blocks for Motion Control
- Reuse with most of the CJ-series I/O units

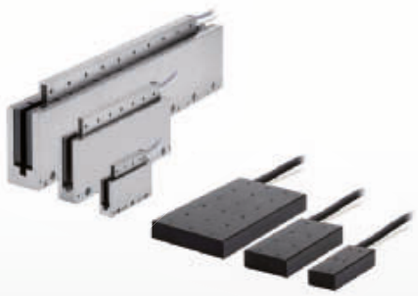
Servos

G5 servo motor

- Power range from 50 W to 15 kW
- IP67 protection
- Low cogging torque

G5 servo drive

- High-response frequency of 2 kHz
- Built-in safety conforming ISO13849-1 Performance Level d
- High accuracy provided by 20 bit encoder
- Advanced vibration suppression functions



Linear motor solutions

- Linear motor force range from 26.5 to 760 N
- Ironless and iron-core motor types available
- Highly dynamic and precise positioning

Conclusions

EtherCAT is an Ethernet open standard that is being adopted by more and more manufacturers. Our commitment to EtherCAT has resulted in an increasing number of products, including: Controllers, Rotary and Linear Drives, Inverters, I/O modules, Vision systems, EtherCAT Safety (coming soon) and more, qualifying EtherCAT as a real Machine Network.

For further information please order our Sysmac Brochure or visit our website industrial.omron.eu

Inverters

MX2

- Torque control in open loop
- 200% starting torque
- Double rating VT 120%/1 min and CT 150%/1 min

RX

- Power range up to 132 kW
- Sensor-less and vector closedloop control
- High starting torque in open-loop (200% at 0.3 Hz)
- Double rating VT120%/ 1 min and CT 150%/ 1 min
- Full torque at 0 Hz in closed-loop

Vision sensor

FQ-M series

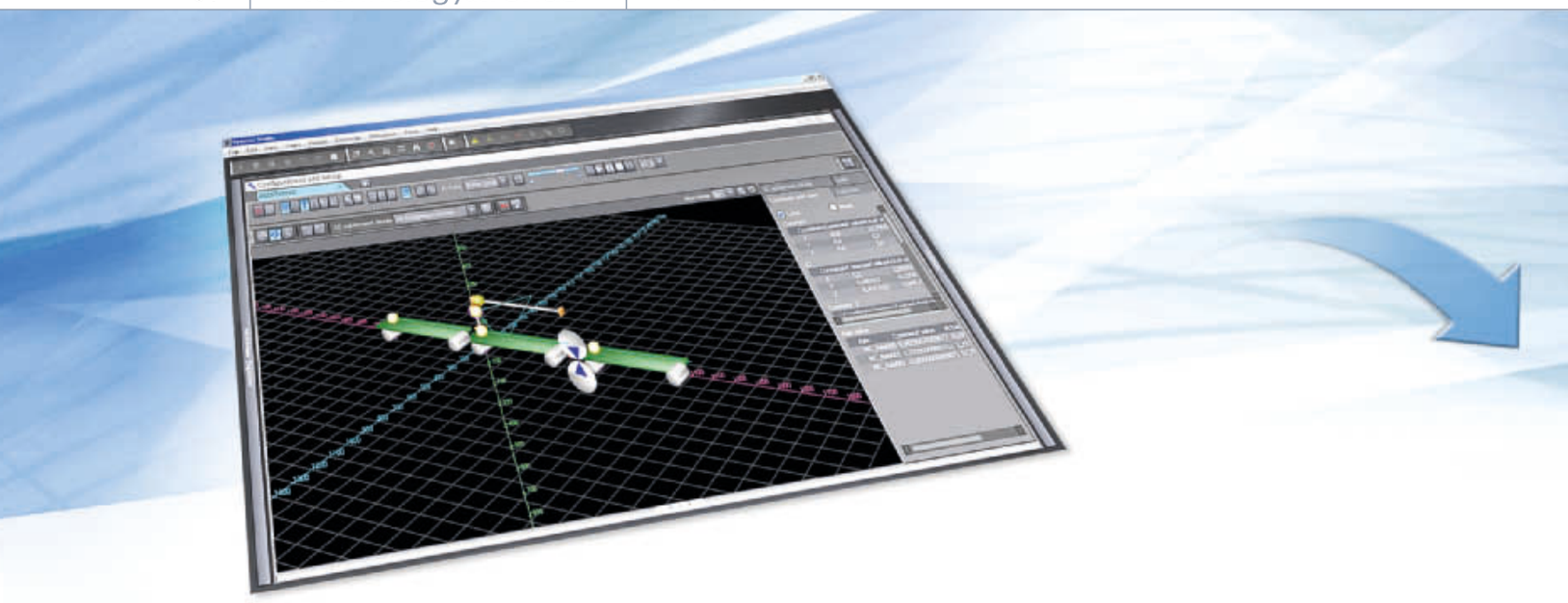
- Camera, vision and connectivity in one
- Compact vision sensor
- Designed for high speed Pick & Place
- Encoder tracking and smart calibration function
- Fast and powerful object recognition

Distributed I/O

GX series

GRT1-ECT

- Wide variety of lineup: digital, analogue and encoder I/O units
- High-speed input
- Removable I/O terminal for easy maintenance
- Easy set-up: automatic and manual address setting



Reinventing yourself is never easy. From a Ladder Logic programming standpoint, Omron have enjoyed great success with our previous software(s). Today's users demand the latest technology to push machine development and commissioning to a level of efficiency that was unimaginable just a few years ago. Reflecting on legacy programming tools such as LSS and Syswin, we have certainly evolved remarkably to now offer a revolutionary product known as Sysmac Studio.

But what are we really offering?

Sysmac Studio

The Key Benefits for the Customer

Visualization of 3D machine simulation via DirectX

Sysmac Studio provides a new visualization feature to create 3D device models for machine run time simulation. This powerful tool allows programmers to test and evaluate motion applications such as robotics, conveyors and rotary motion at a much earlier stage in machine development. Sysmac Studio also offers offline debugging when you are not connected to a controller. To debug a control program, it is best to simulate the control program on the computer first to check the operation logic and parameter settings. These features allow control engineers to resolve issues much earlier in the design phase which translates to reduced time to market for a total solution.

The development challenge for 3D simulation in Sysmac Studio was to create a lightweight rendering engine that was appropriate for industrial applications. DirectX provides an ideal solution. DirectX technology has been used by the gaming industry for over 10 years to provide impressive visualization using high end graphics hardware accelerators. Today, 3D modeling is a reality using entry level graphics cards and software emulation. Instead of tracing a group of axes:

James Riley
IA Solution Marketing Manager
Omron Europe BV

like an X-Y table or Cartesian robot with all axis plotted against time, it is immediately more intuitive, and therefore more productive when these axes (X-Y-Z) are plotted against each other in a virtual 3D space showing the real motion control path. Zooming and panning provides the ideal viewing angle. Program variations can be simulated and re-run to assess the correct sequencing, optimum path control, minimum execution time and other critical operations. A data trace graph also provides information such as position vs. time which can be imported/ exported for later comparison of machine motion performance. Additionally, a video AVI file can be recorded of the 3D device model operation. And all this can be done offline, in the lab and tested, before the machine production has started.

"Simulation... a new level of confidence to the machine creator."

"Simulation offers a new level of confidence to the machine creator, he can see at a glance how the machine will operate and the axes interact."

These advanced development features not only speed the programming process, they give the user a new level of confidence before, during, and after the commissioning phase that translates to better machine performance from the beginning.

Windows Presentation Foundation (WPF) enhancing the user experience

An application's interface makes the first impression. Attractive and efficient interfaces generate a positive experience, and to the user, the experience *is* the application. Improving a user's experience with a better interface increases confidence, improves productivity and creates loyal customers. The main objective of Windows Presentation Foundation is to help developers create appealing and effective user interfaces without sacrificing functionality.

> “Windows Presentation Foundation… allows designers and developers to achieve their goals without compromise.”

When designing a new user interface, the goal was to improve the user's experience while implementing the software's new features and tools. But creating a whole new look and feel often requires more than just good software programming skills. Building a new user interface also means working with professional interface designers.

How can interface designers and software developers work together? This challenge has been a serious and limiting problem in the past. Typically, a designer submits graphics and images to achieve a specific look and feel for the application. These submissions establish vital usability factors such as screen layout, aesthetics and flow. But what if there is a misunderstanding or a technology limitation between the interface design and the implementation? Something that seems easy to create graphically may be impossible to reproduce by a developer. Windows Presentation Foundation offers a solution to this problem and allows designers and developers to achieve their goals without compromise. Sysmac Studio's excellent form and function can be attributed to the use of Windows Presentation Foundation and the benefits are realized throughout the software.

“The customer will be comfortable when they see that they can easily control all aspects of even the most complex systems without difficulties. In my opinion, this is high-level, manageable power!”

Seamless integration of the highest performance industrial network: EtherCAT

What is real-time control? The term “real-time” can be interpreted in many ways, but when a demanding application requires precision and speed, nanoseconds matter. High speed motion applications such as a linear flying cutoff or a rotary knife cannot afford data transfers at irregular intervals and together with speed, EtherCAT stands out from other industrial network protocols as a superior solution.

But a superior industrial control network is not just about speed. EtherCAT, together with the powerful Sysmac Studio software, allow control solutions from the highest level motion and vision applications down to the simple input/output device level. This virtually eliminates the need for multiple controllers and different networks, simplifying programming and maintenance – all with just one software tool.

"What I appreciate is one single environment to configure and program the sequencing and motion control. Moreover, I liked the easy interface with high standard functionality and information. That is a unique feature of Sysmac Studio."

Advanced EtherCAT network configuration features included in Sysmac Studio save valuable time and give the user a confidence that a system is performing at its very best. Diagnosis/Statistics Information for network performance can provide detail on metrics such as lost frames, transmission jitter, collision count and other critical traffic information. Such fine detail not only reduces downtime, it can completely prevent machine stoppage due to potential network issues. Packet Monitoring is another great feature that allows diagnosis of a network issue by directly capturing the problematic data sent over the EtherCAT network. Additionally, features like wiring checks and automatic creation of the network configuration encourage smooth commissioning and fast machine setup.

“...one single environment to configure and program the sequencing and motion control.”

Getting started with robotics

If you have recently visited a packaging fair, no matter where in the world, you would have seen that the use of robotics is increasing. After the expiration of the U.S.patent, the 3-axis Delta robot became a favorite solution for many machine builders. This parallel, "spider like" robot offers high speed and high flexibility.

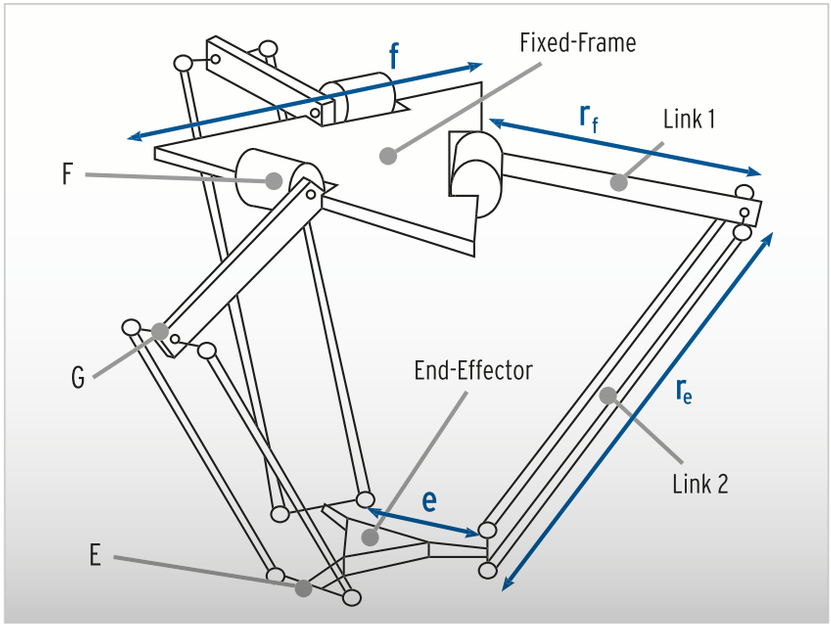
At the same time when Delta-3 "happened" to the industrial world, another technology had already started changing the concept of automation. The rapid speed of new Ethernet based communications, like EtherCAT, which made it possible to control complete machines from one system. Such systems are fast enough to satisfy even the highest requirements for motion control.

But how is this related to robots and Omron?

The new powerful control NJ501 series offers openness and performance for integrating functionality to satisfy any application, including robots. In the past, robots were controlled exclusively by dedicated robot controllers. A machine architect can now decide to control a robot in exactly the same way as all other parts, from one control system, by using one programming environment, the new Sysmac Studio software.

The NJ501 uses the fastest motion network in the world – EtherCAT. The control system calculates Delta-3 kinematics in a few microseconds and achieves top performance regarding the number of robot cycles and repeatability. Although we started by adding the Delta-3 functionality, support for robotics in the NJ501 will grow further in the future: both new functions for Delta-3 but also other robot types will broaden the appeal of this product.

This article provides you with basic information about Delta-3 robots and information about Omron's robotics team in Barcelona who are behind this development.



Mechanical Design and Configuration Parameters

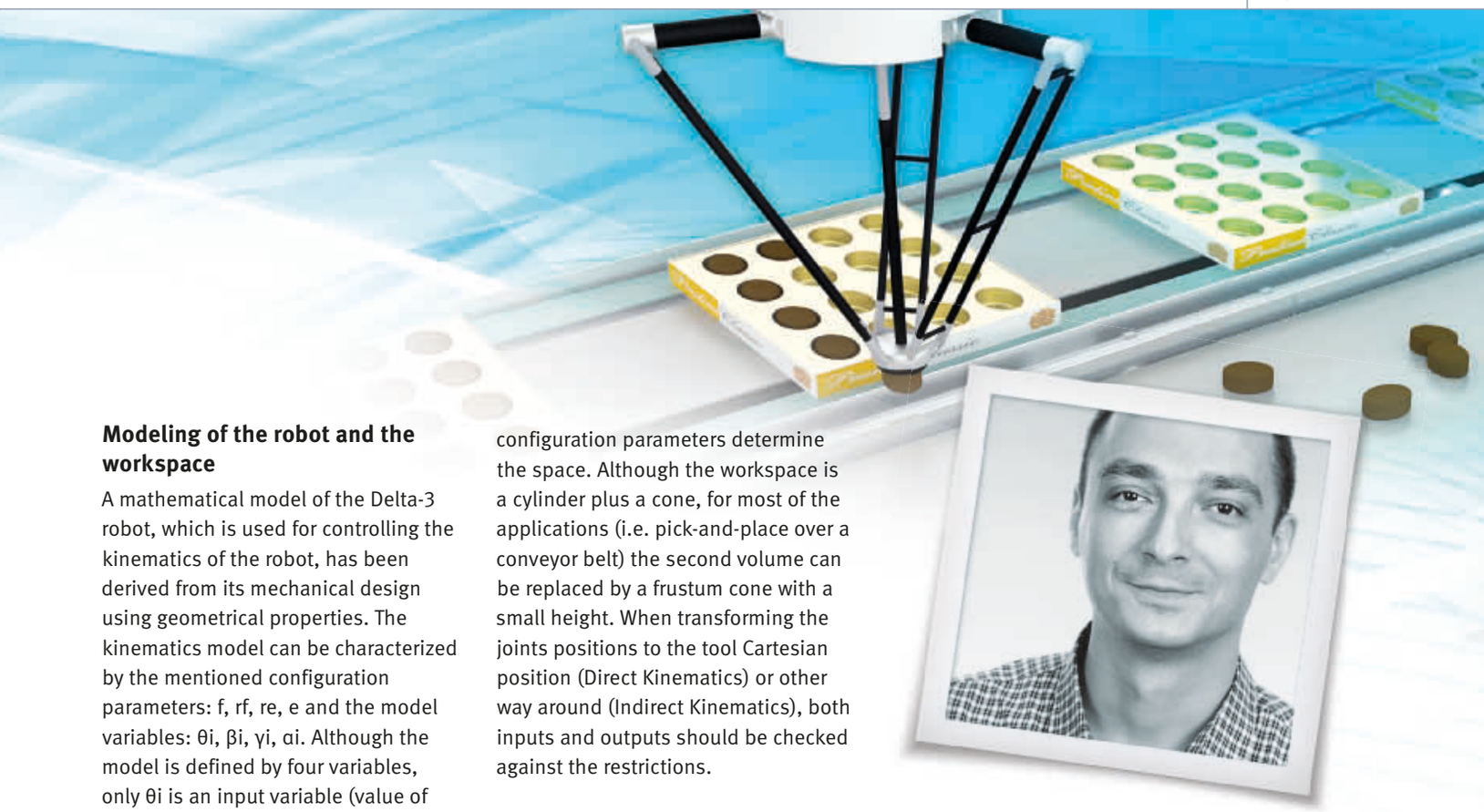
The Delta-3 robot translates the rotations of 3 actuated joints (F) into one movement of the robot tool, in a tree-dimensional workspace. Cartesian coordinates are commonly used to describe this movement.

The actuated joints (F) are identically placed on a circle and each pair is separated by 120 degrees. The robot legs are composed of two links (Link 1 and Link 2) and three joints (F, G, and E). The two other joints are passive ones (G, E).
The mechanical design determines the following configuration parameters, which are the inputs for the control algorithms:

- f : Side length of Fixed-Frame
- r_f : Length of Link 1, from hip (F) to knee (G)
- r_e : Length of Link 2, from knee (G) to ankle (E)
- e : Side length of End-Effector

Regarding robot singularity* as one of the major problems in the movement of robot manipulators, this could be solved by satisfying 4 simple rules. First is a control rule but others must be respected when the robot mechanics are built.

** "a condition caused by the collinear alignment of two or more robot axes resulting in unpredictable robot motion and velocities."*



Modeling of the robot and the workspace

A mathematical model of the Delta-3 robot, which is used for controlling the kinematics of the robot, has been derived from its mechanical design using geometrical properties. The kinematics model can be characterized by the mentioned configuration parameters: f, rf, re, e and the model variables: θi, βi, γi, αi. Although the model is defined by four variables, only θi is an input variable (value of the actuated joint) and others variables can be calculated using it and the configuration parameters. It is important to recognize that the range of θi depends also on the configuration parameters i.e. size of the fixed frame and the lengths of the links.

$$\left[-1\cdot\arccos\left(\frac{D}{r_e-rf}\right);180-\arccos\left(\frac{D}{r_f-r_e}\right)\right]$$

θimin and θimax calculations

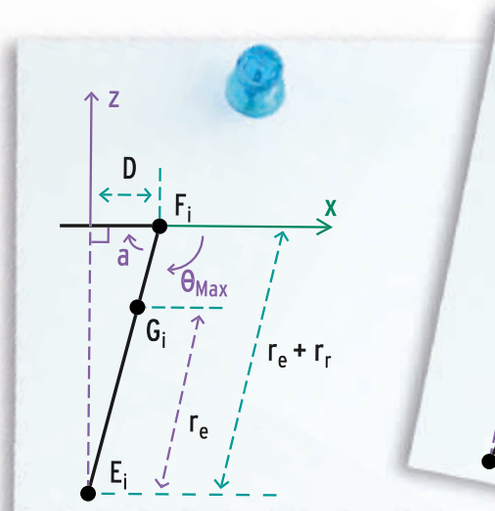
The workspace i.e. working area of the robot is reduced due to the mechanical design. Again the configuration parameters determine the space. Although the workspace is a cylinder plus a cone, for most of the applications (i.e. pick-and-place over a conveyor belt) the second volume can be replaced by a frustum cone with a small height. When transforming the joints positions to the tool Cartesian position (Direct Kinematics) or other way around (Indirect Kinematics), both inputs and outputs should be checked against the restrictions.

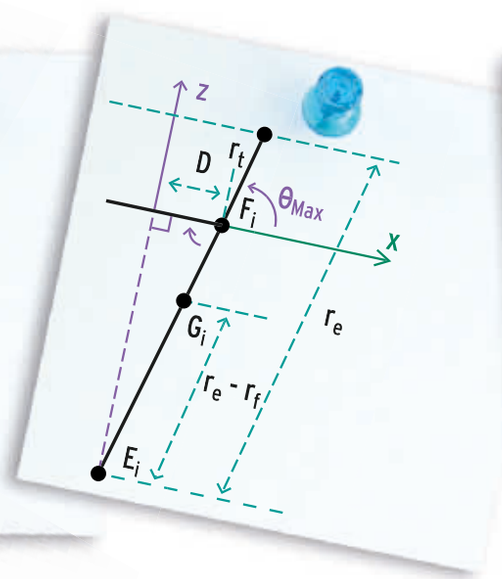
The text above would help you to understand the robot, but you don't need to dig deeper in the theory. By using an off-the-shelf Delta-3 robot and NJ501, you could just start programming robot movements for your machine in the Sysmac Studio software.

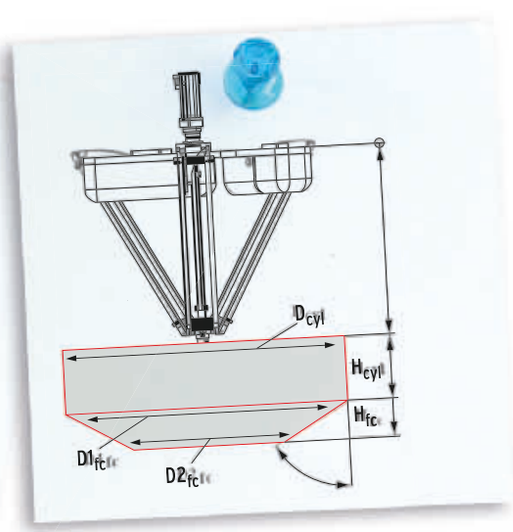
Igor Jovanovic
Development Team Leader
Omron Europe BV

Robotics team in Barcelona

The Omron team, "responsible" for providing Delta-3 controls for the NJ501, is located in Barcelona. This multifunctional team consists of development, test and application experts. All in one place, so that you can discuss robotics and together find solutions for your machines. The team will continue to expand the robotics roadmap in the NJ501, working closely with the NJ501 development team in Japan.







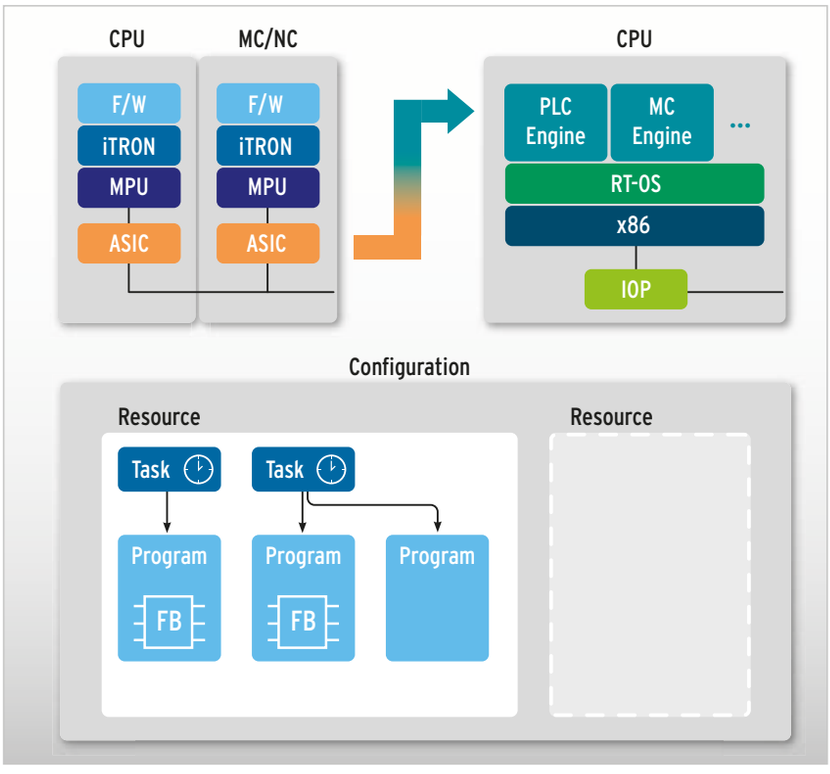
Sysmac platform and its customization

If you get ideas regarding the modification of existing and/or the creation of new functions in our products when designing your machine, then this article is for you. The following is all about Customization, especially about customizing a control system, such as the NJ501 series.

In the past, closed solutions, with own ASICs and not an open software platform, made the customization of control systems time-consuming and therefore expensive. Our products suffered the same problem. With the NJ501 series the situation is completely different.
This product is a high performance and easy extendable control platform. Although it has many functions, we don't expect that users won't need to add more.

The NJ501 series was developed in conjunction with our aim and top priority of "fast customer program execution". The result is great – instructions and programs made by customers run as fast as the Omron instructions. On top of that, the NJ501 is an extremely fast controller. This means that even for high-performance motion instructions, users could optimize the product themselves.
In short, if this product doesn't match your needs by 100%, go for the 100%, without compromising.
NJ501 uses the IEC61131-3 standard and its software model. The system consists of 4 elements: Configuration, Resource, Task and Run-time program. Functionalities are "organized" in the form of Program Organization Units (POUs). The IEC 61131-3 software model defines 3 types of POU: Programs, Function Blocks (FB) and Functions (FUN). Users can create any of these by using Ladder, Structured Text (ST) and in the near future Structured Flow Chart (SFC), by directly accessing the PLC and Motion core via its POU i.e. using Omron built-in instructions.

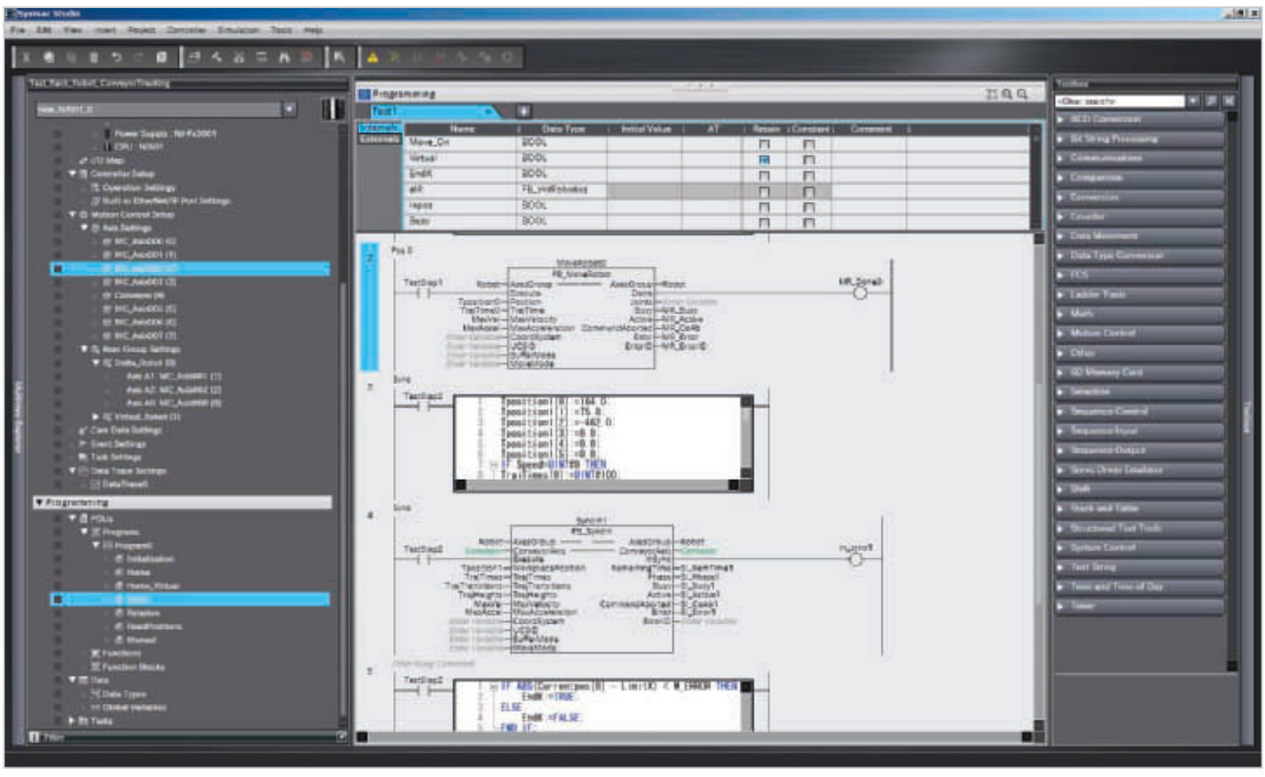
The Omron library is also built based on FBs and FUNs. The difference is that this library is offered as part of the product and it can access some special system functions that are not accessible from a user's POU. The library is easily extendable and this can be requested by customizing.



Igor Jovanovic
Development Team Leader
Omron Europe BV

To summarize, Omron customization of the NJ501 would mean adding a special functionality based on a customer request and delivering it with Omron's high quality. In this way, our customer's core knowledge about his/her production lines is combined with our knowledge of control systems.

In Europe, the Mechatronics Application Center can support such requests with its multidisciplinary team of developers and application engineers. As an example of customization completed by this team, located in Barcelona, is the development of functions to control Delta-3 robots.



Supporting Sysmac – with all of our resources

Omron Europe's extensive resources – in people, technology and service support – have benefited from intensive investment over recent years. This provides the bedrock which will enable customers to maximise the benefits of the revolutionary technology offered by the Sysmac platform.

Fernando Colás
Division Manager
Integrated Automation Division
Omron Europe BV

Klaus Okraffka
General Manager European Sales
Integrated Automation Division
Omron Europe BV

The Sysmac platform is Omron's vision for the future of machine automation, providing unprecedented connectivity. It's the result of massive investment in product development, involving tens of thousands of hours of engineering time by staff throughout Omron. At its core is the Omron philosophy that the only way to succeed in a high technology business is continually to develop new ideas and to expand them rapidly to the widest range of applications: there's simply no future in trying to protect existing technology.

Most of all, Sysmac technology is based firmly on what our customers told us they wanted: the freedom to develop machines that do precisely what they're intended to do. And from Omron's perspective, this requires an applications-orientated approach that's fully focused on the needs of the customer, one backed by project-related expertise and support.

The supplier of choice

Over the past few years, in parallel with the Sysmac development programme, Omron Europe has refocused its business so that it can provide this intensive support. Omron companies throughout Europe have always worked closely together, sharing information and expertise. However, the business has now been fully integrated into a single pan-European organisation that is genuinely borderless and structured around customer needs, with the aim of becoming the supplier of choice for users of industrial control and automation.

At the centre of this project is the clear understanding that technology without applications expertise is of little or no value to our customers. Our global network ensures that a machine-maker in, say, Italy has access to the knowhow and experience of an Omron applications engineer in Germany or Japan or the USA.

Massive investment in training

Alongside the business integration, we've made our biggest-ever investment in human capital, strengthening our team, not only by taking on more engineers but also by improving their knowledge through intensive training. Omron Europe now has more than 900 customer-facing engineers in almost 30 countries, offering both cutting-edge technology knowhow and extensive applications expertise. And this expertise is continually developed through regular training programmes and by sharing knowledge right across the business.

It's a strategy that will help to maximize the considerable benefits of the Sysmac platform. We're well aware of the complexity involved in migrating from traditional control-based solutions

to technology as revolutionary as Sysmac. This is particularly so when a combination of technologies provides the optimum solution, for example in an application calling for scalable machine automation. Omron Europe's pan-European applications expertise, available to every customer at a local level, provides the support and products to facilitate fast and smooth migration, from the initial design/concept through to field installation and beyond.

Staying close to customers

Our pan-European management, project teams, applications knowledge, engineering expertise, and field support are all devoted to developing these optimised solutions. Of course, one issue that all multi-national businesses have to address – and which some don't do particularly well – is the danger of becoming monolithic and faceless. It won't happen with Omron Europe, because we've retained our local focus and remained close to customers: physically close, with local people, support and facilities, and strategically close, with products, services and applications that fit precisely with the needs of each individual customer.

We're well aware that different parts of the global village have their individual preferences: as we like to say, we're a global company that refuses to be BIG. It's been a focus for Omron since the company was founded, and we intend to make sure it continues to be one of our main strengths. It is just our way of doing business.

New ways of thinking and working

Developing and manufacturing a new machine is only part of the story. Worldwide logistical support for installation and field service are essential requirements, because European machine-makers operate in a global market, exporting equipment to both emerging and mature markets worldwide. Omron Industrial Automation is a global business, with over 35,000 employees and extensive facilities in China, Southeast Asia, Japan and the Americas.

This ensures that the close relationships which are increasingly recognised and valued in Europe are maintained, no matter where the end-user operates.

With our support, customers can unleash the power of Sysmac, creating world-class machines and automation solutions. We can help make your vision a reality.

Colophon & Contact

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Global presence, local competence

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Over 2000 field engineers at work in almost 200 sites in 34 countries across the world.

Omron Industrial Automation
As part of the Omron Corporation, Omron Industrial Automation is a global manufacturer of technologically advanced products and a leading provider of application expertise. You'll find our Industrial Automation technologies in factories and machines all over the world.

Omron – a global company that refuses to be big
'A global company that refuses to be BIG' is the Omron culture that focuses on the idea of being close to the customer. We are global but never BIG, confirming that Omron will always be easy and flexible to deal with. Our field sales engineers and field application engineers work together to offer solutions and support.

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