Sysmac NJ 501:
The evolution of the PLC

The Sysmac NJ Series is a new class industrial controller, capable of performing like a last generation computer, while retaining the endurance and reliability of an Omron PLC.

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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 decided 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.

This 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.

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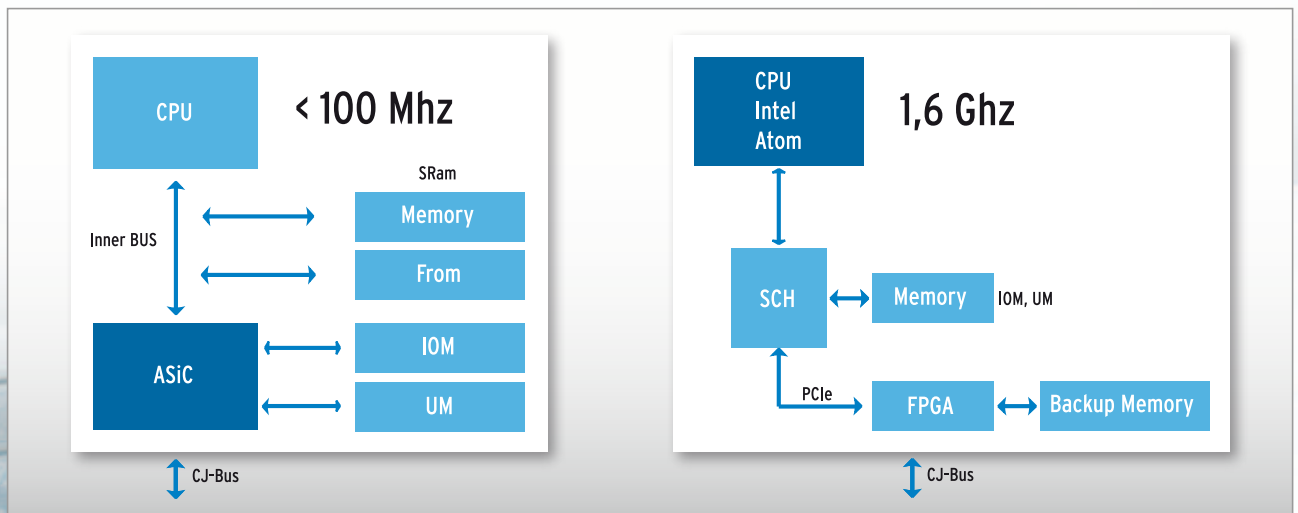
The graph shows evolution of a traditional PLC Architecture to a Machine Controller.

	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 Operating System, is designed to exhibit truly fail-safe behaviour, this kind of operating system is normally used in fields where reliability is a must: aerospace, defense, medical, etc...

*2 Windows is not a Hard Real Time Operating System (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 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...

relieved of some specific functions, managed at 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.
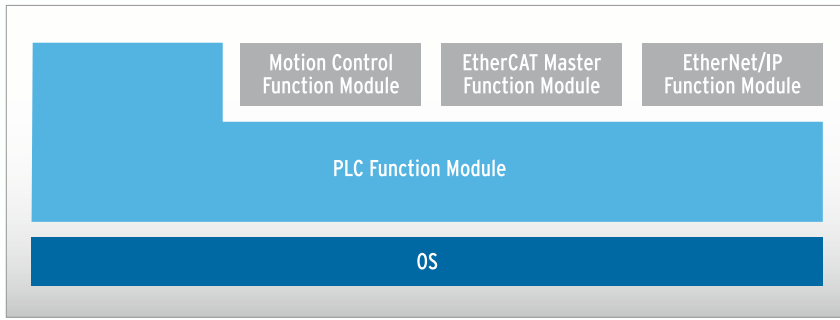
Function modules

- 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.

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 Tasks 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.

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

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 times.

Compiled versus Interpreted code

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

- The user develops the 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 an 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 controller, by means of Online Edit, a program can be modified while the PLC and Motion Control Module are in execution.
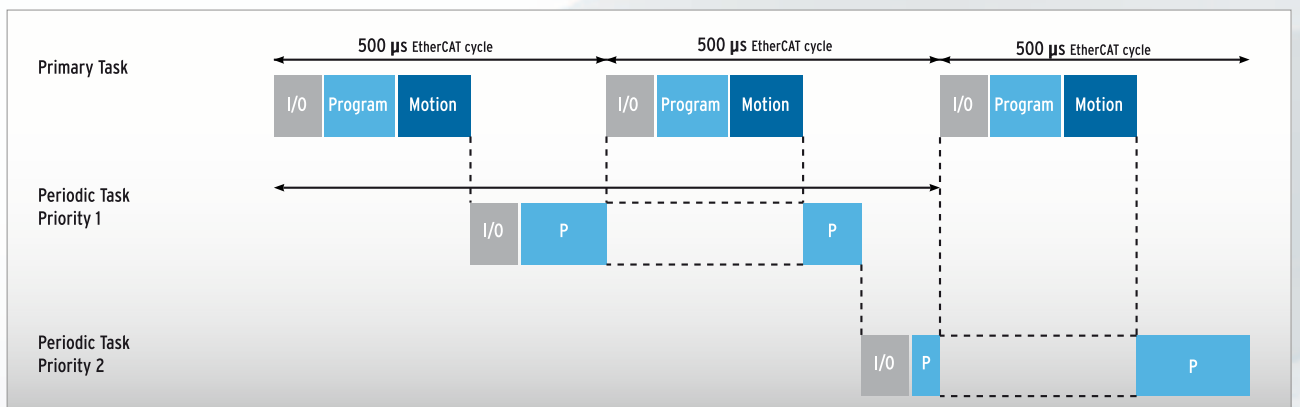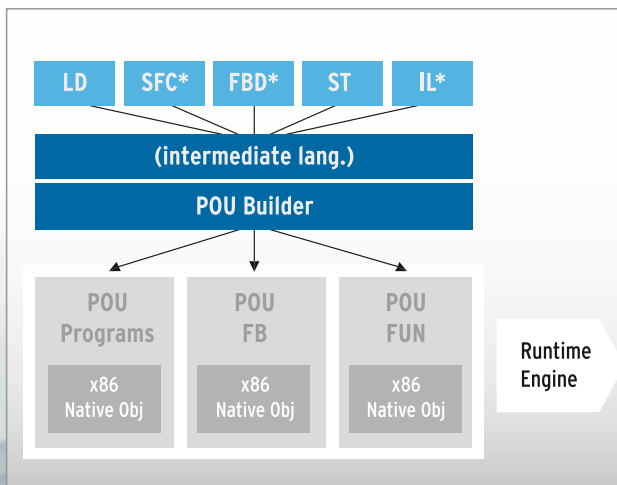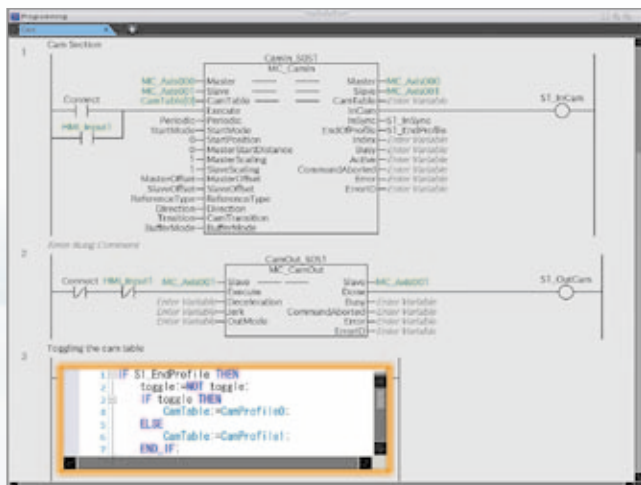
*Editor & Compiler *SFC, FBD and IL are not supported in Version 1.0*

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.
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.

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