Machine Control Network

Achieving "high-speed and high-precision" machine control through the world's highest level network solution

Perfectly suited to rapidly advancing machine control
EtherCAT provides high speed, expandability and flexibility

With the need to reduce takt times, improve yields and ensure traceability, the requirements for manufacturing systems are expanding. To respond to these requirements, devices in the system are increasingly connected with networks. However, for high-speed and high-precision applications such as motion control, it is necessary to adopt separate network in addition to the field networks.

EtherCAT, which can execute motion control in realtime, realizes high capacity communication required for field networks among a large number of nodes, while maintaining the high-speed synchronous-communication through its preeminent communication performance. As an inter-system network that eliminates the barrier between motion networks and field networks, EtherCAT will contribute not only to a reduction of design works but also to a shortening of takt times.

World highest level network
EtherCAT with its strength in high speed control is a next-generation network able to achieve preeminent performance in motion control.

An Ethernet-based network with realtime control capability
- 5-times faster Motion network communications speed over existing (MECHATROLINK-II) networks
- Synchronization performance between the slaves: 1 μs max.

High-speed and high-precision communications
- High speed Ethernet 100BASE-TX (100 Mbps)
- Adoption of the On-the-Fly method that enables realtime control

Global open network
- With over 1,300 member companies worldwide

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Note 1. EtherCAT is a registered trademark of Beckhoff Automation GmbH.

Note 2. CompoNet and EtherNet/IP are trademarks of ODVA.
Less network wiring

CompoNet
- For distribution of small number of I/Os

"Integrated Networks"
- A new era of networking in a system

All networks required for machine control are integrated under this preeminent network capability. Design, wiring and maintenance become simplified.

The world standard open network covers all layers including factory management levels, system levels and component levels. The EtherCAT realizes the world’s top-class performing network at each layer.

Best in class
Integrating field networks and motion networks
A new dimension to network in the system

Features of the EtherCAT
The EtherCAT is a high-performance field network able to connect drive devices, intelligent sensors and I/O devices using Ethernet technologies.

**Network specifications**
- Communication speed: 100 Mbps
- Communication standard: 100BASE-TX
- Communication media: cat.5, RJ45
- Distance between nodes: 100 m max.

High Performance

**High-speed communications**
- Preeminent high-speed communications
- Precise and smooth motion control achieved with the industry's fastest level communication cycle
- Over 5-times faster communications than other companies' motion networks

**Management of on-site device data**
- Message transmission can be handled while real-time control is executed. The operation of on-site devices can be monitored and parameters can be configured via the network.

Intelligence

**Open Network**
High Performance
Simple and Capable

EtherCAT Overview
Simple and Capable

- **Expanding applications, not limited for motion control**
  - The large-capacity communication among multiple axes and multiple nodes can be handled at a high-speed. The feature is favorable for large-scale systems, too.
  - The distance between nodes can be extended up to 100 m.
  - Flexible communication specification allows a wide variety of devices to join the same network. The connectable devices involve drive devices such as Servo Drives and Inverters, I/O devices, and other intelligent devices, including Vision Sensors.

Open Network

- **Global open network**
  - The EtherCAT Technology Group (ETG) is expanding the EtherCAT network on global scale. They are working in Germany where their headquarter is, and in Japan, the United States, China, and South Korea.
  - Over 1,300 member companies worldwide have joined this activity.
OMRON EtherCAT
Product Lineup

OMRON has ample product lineup for EtherCAT communications. It is now possible to build a system with one network, without using multiple networks and dealing with complicated wirings.

- Ample product lineup selectable
  - Industry’s top-class performance in positioning control contributes to a reduction of takt times.
    - 10-times faster speed over existing networks.
    - High-speed start-up of 0.15 - 0.4 ms per axis.
    - High-precision control achieved under the fastest control cycles of 0.5 ms.

Position Control Unit (2/4/8/16 axes)

CJ1W-NC 81

FZM1 Series
Vision sensor for positioning
System productivity improvement through industry’s top-class detection capabilities and a dedicated positioning menu
- Stable measurement under changing environment and workpiece conditions
- Built-in auto-calibration function
- High-speed camera for fast image capturing

OMNUG G5 Series
Servomotor / Servo Drive
Industry-fastest motion control servo system
- High-speed control through the high-speed EtherCAT motion network and the industry-best speed response frequency of 2 kHz.
- Damping control function to suppress system vibration.
- Safety function comes with standard functions

P12 - 13
P10 - 11
Fast positioning control and less wiring works.

- Same performance in positioning control as NC81
- Connection of 64 slaves, in addition to the connection with Servo Drives

**CJ1W-NC82**

- Connection to EtherCAT becomes possible by attaching an optional communication device
- Sensorless vector control for powerful operation of 0.5 Hz/200% starting torque
- Shorter control cycle times
- Feedback pulse input for speed or position

**SYSDRIVE MX2 Series**

- Control of multiple inverters under a single high-speed network

**GX Series**

- Ample I/O terminal lineup for high-speed communications
  - Digital I/O: 2-tier, 3-tier, and e-CON connector
  - Analog I/O: Open collector input, Line drive input

For each application, see pages P6-9, P14-15, P16-17.
**Product Information**

**High Speed**

The CJ1W-NC82 allows connection to the EtherCAT-compatible slaves up to 64 nodes besides the servo axes. Even when controlling multiple servo systems plus remote I/O terminals through the single EtherCAT network, the CJ1W-NC82 maintains as much performance as when controlling the servo systems only.*

*Even when connecting the PLC with 4-axis servo systems and GX Series (352 I/O points), the control cycle of 0.4 ms for each servo axis can be maintained at 1.0 ms. (A CJ1W-NC482 with 4-axis servo systems connected to a 16 I/O points type remote I/O terminal is used.)

**High-speed startup**

Fastest time of 0.4 ms* achieved from start command sending by the PLC to startup of the servo system (transmission time included).

High-speed startup, previously thought as only being possible using pulse train methods, is realized on a performance level that exceeds the pulse train method.

* CJ2H CPU Unit with unit version 1.3 or CJ2M CPU Unit used.

**High-speed processing**

Shortest control cycle of 0.5 ms achieved for a position control unit. By shortening the command cycle to the servo drives, smoother control of the servo drives becomes possible as well as high-speed startup.

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EtherCAT-compatible Position Control Unit

**SYSMAC CJ Series**

- CJ1W-NC81 (2 axes)
- CJ1W-NC481 (4 axes)
- CJ1W-NC881 (8 axes)
- CJ1W-NC981 (16 axes)
- CJ1W-NC842 (4 axes + 30 communications with 64 slaves)
- CJ1W-NC882 (8 axes + 70 communications with 64 slaves)

<table>
<thead>
<tr>
<th>Features</th>
<th>CJ1W-NC81</th>
<th>CJ1W-NC481</th>
<th>CJ1W-NC881</th>
<th>CJ1W-NC981</th>
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</table>

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**Control cycle**

- 1 ms
- 1 ms
- 2 ms

**I/O points**

- 16 I/O points
- 32 I/O points
- 64 I/O points

**Minimum master CoE compatible (no information service for SDO)**
Achieving a simplified system by integrating motion and field networks

Integrated network
In addition to servo drives, the SYMAC CJ Series supports various other EtherCAT-compatible slaves such as inverters, vision sensors and I/O terminals. This has enabled the construction of integrated networks connected only by Ethernet cable from an EtherCAT-compatible position control unit, thus simplifying the entire system and reducing cost.

Common programming with the pulse train position control unit (high-speed model)
The EtherCAT-compatible position control unit shares its positioning functions and interface when programming with the pulse train position control unit (high-speed model). This allows for easy selection of position control units according to the intended use.

Supporting direct operation and memory operation
The PLC ladder program supports both direct operation that controls positioning and memory operation that executes positioning in the position control unit. Built-in memory operation functions such as repeat and JUMP commands enable high-speed control independent of the ladder program and the PLC’s scan time.
High-speed response

EtherCAT communication-capable models of the industry’s top class G5 Series Servo Drive is added to the product lineup.

By combining the G5 Series response speed frequency of 2 kHz with a faster data update cycle of 250 μs (four times faster than the previous OMRON product at 1 ms), positioning control takt times can be further reduced.

High-speed rotation

The G5 Series Servo Motor supports rotational speeds of up to 6000 r/min (1.2 times faster than the previous OMRON model). In combination with the high-speed startup enabled by EtherCAT, positioning time can be further shortened.
Easy adjustment on startup and easier safety implementation with STO as standard function

Easy gain tuning

Real-time autotuning has doubled the application range allowing for more accurate estimation of a machine’s load inertia ratio. By widening the rigidity range from both high-end to low-end, the applicable range for the system can be increased. Furthermore, the settings can be made via EtherCAT.

Easy tuning of resonance suppression filter

The filter is automatically set to the resonance frequency while multiple adaptive filters reduce vibration. With an even wider frequency range, vibration can be reduced from drive shafts with low rigidity such as conveyor belts, to drive shafts with high rigidity. Also, the settings can be made via EtherCAT.

Conforms to the latest international standards

The OMRON G5 is the first to acquire international standard IEC 61800-5-2 (STO) for motion control in the industry within Japan. It also conforms to the European Directives ISO 13849-1 (Plc.d) and EN 61508 (SIL2). Safety control circuits can be constructed with the Servo Drive, delivering both safety and productivity.
Vision Sensors for Pick and Place

FZM1 Series

Selectable dedicated processing items

Existing models were ill-equipped in dealing with changes and deformation in the measurement object. To address this problem, the FZM1 Series is equipped with a dedicated positioning image-processing algorithm, highly capable of dealing with such changes or deformation. Just by selecting the menu for the target object, positioning detection is executed without calculations or complicated settings.

Positioning with alignment marks

The FZM1 precisely detects alignment marks which are commonly used in manufacturing of LCD panels and PCBs. The FZM1 accurately detects the marks, even if some dirt adheses to the marks or the mark is partly hidden.

Positioning with corner detection

Positioning can be performed by detecting a corner of the measurement object. Now, stable detection is possible even for rounded corners or when the edge is broken. This is ideal for LCD glass substrates and other objects on which alignment marks cannot be printed.

Positioning by shape of object

When picking electronic components or food items, unclear printing or dirt can make stable inspections impossible. FZM1 uses the ECM search processing method and can identify the position and angle of objects from their shapes. The use of ECM search processing enables precise position and attitude measurements without being affected by surface conditions.

Superior performance under severe conditions

Edge Code (EC) image processing technique

(Patent number: 11-550303)

Conventional search operation and pattern matching detect objects based on density differences or feature points registered on model images. This may cause unstable detection when the measurement object was changed or the shape was not consistent. With EC image processing, the workpiece is recognized as a geometric shape to minimize the effect of light interference or dirt. This achieves stable, accurate position detection without being affected by the surface of the workpiece.

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High precision position control with stable detection and easy operation

Easy

Simple auto calibration
The Vision Sensor provides a coordinate conversion function for each stage and robots. Coordinates can be converted for the Vision Sensor and output device without complex calculations.

Adaptable stages and robots
- Robot control: X, Y, Z, XY, XZ, YZ
- Stage control: X, Y, Z, XY, XZ, YZ

Flexible camera installation
There are no Camera installation restrictions even with alignment systems that use two Cameras. Differences between Camera angles and fields of vision can be calculated and coordinates converted without performing complex calculations in a PLC or other external device.

Easy setup and configuration by an Application Wizard
Calibration between the Cameras and stage or robot can be easily set up using a wizard. Simply select the type of inspection to easily generate the calibration parameters. Sampling data can be automatically input from an external device via EtherCAT to eliminate mistakes that occur through manual input. Fine tuning can also be quickly and accurately performed for production changes or adjustments of the setup as required on-site.

Less Wiring with Ethernet Cables
All trigger inputs and result outputs are connected using only an Ethernet cable. This eliminates excess wiring work and helps prevent wiring mistakes when launching the system. Additionally, with EtherCAT, wiring for up to 100 m can be made without a repeater allowing for easier installation of Vision Sensors and Servo Drives.
The EtherCAT communication unit is used to connect the MX2 Series to EtherCAT.

Multi-function Compact Inverter
SYSDRIVE MX2 Series

3G3AX-MX2-ECT EtherCAT Communication Unit
The EtherCAT communication unit is used to connect the MX2 Series to EtherCAT.

High-speed positioning and speed control
The SYSDRIVE MX2 Series inverter with EtherCAT interface provides high-speed position and speed control. By connecting servo drives, inverters and remote I/O terminals to the position control unit, overall system performance will be improved.

High-speed network greatly improves multi-axis control performance
In comparison to the conventional DeviceNet, response time for single-axis startup (from PLC startup to inverter current output) has been reduced by half.

The difference of response time for single-axis control and 24-axis control is only 3ms in an EtherCAT network. The EtherCAT is advantageous in multi-axis control applications.
EtherCAT provides high-speed control with multi-function MX2 Series

Easy operation after network allocation
In the initial setup of the EtherCAT communication unit, the inverter parameters are allocated to the CIO area in the PLC as shown on the right tables. The allocation can be understood and operated as easily as the inverter terminal block. It is not necessary to issue command or deal with complex communication handling. There are no troublesome processes such as in the handling of communications or in issuing commands.

Multi-function

Simple Position Control Function
The MX2 Series is equipped with simple position control function as standard.

Cost Saving
Encoder signals can be directly input to an inverter without using accessories such as a high-speed counter.

Simple Adjustment
Positioning can be performed with a target value. Conventional sensor adjustment for positioning is not necessary.

No Additional Programming
Positioning can be controlled by rewriting the target positions or the target values at 8 points in the inverter via EtherCAT without additional programming.

Shortening deceleration time with over-excitation control during deceleration (AVR function)
By using the over-excitation control during deceleration (AVR function) of the MX2 Series, deceleration times can be shortened without the use of braking options.

Various functions such as torque control and torque limit are also supported.
The MX2 Series sensorless vector control provides torque control and torque limit function, thus enabling simple contact stopping control and press control. Other functions including brake control, energy saving control and PID control are also provided.

* Encoder signals can be directly input to an inverter without using accessories such as a high-speed counter.
* Positioning can be performed with a target value. Conventional sensor adjustment for positioning is not necessary.
* No Additional Programming
  - Positioning can be controlled by rewriting the target positions or the target values at 8 points in the inverter via EtherCAT without additional programming.
* Shortening deceleration time with over-excitation control during deceleration (AVR function)
  - By using the over-excitation control during deceleration (AVR function) of the MX2 Series, deceleration times can be shortened without the use of braking options.
* Various functions such as torque control and torque limit are also supported.
  - The MX2 Series sensorless vector control provides torque control and torque limit function, thus enabling simple contact stopping control and press control. Other functions including brake control, energy saving control and PID control are also provided.

* When changing a torque reference value or torque limit value via EtherCAT communications, directly change the parameter that sets the reference command value.
## Wide selection of products

An extensive lineup of digital I/O terminals, analog I/O terminals and encoder input terminal are available for EtherCAT. The wiring type of the digital I/O terminal can be selected from either a unit with a screw terminal block or with an e-CON connector.

<table>
<thead>
<tr>
<th></th>
<th>2-tier screw terminal block type</th>
<th>3-tier screw terminal block type</th>
<th>e-CON connector type</th>
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</thead>
<tbody>
<tr>
<td>Digital input</td>
<td>16 points</td>
<td>32 points</td>
<td>8 points</td>
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<tr>
<td>Digital output</td>
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<tr>
<td>Encoder input</td>
<td>2 points</td>
<td>4 points</td>
<td>8 points</td>
</tr>
</tbody>
</table>

- 8 points can be allocated with an e-CON connector and a 2-tier screw terminal block is used.
- Common terminals can be connected to each terminal block.
- High-speed pulse counting can be made with a 4 MHz clock.
- Open collector input: 500 kHz
- Line drive input: 4 MHz

### Easy startup

**Simple setup**

In the fixed allocation mode of CJ1W-NC/32, the remote I/O system settings can be made by simply setting the node address.

- Node addresses can be easily set with a simple rotary switch using decimal numbers.
- The allocation area of the remote I/O terminal is automatically decided by simply setting the node address.

**Easy wiring**

EtherCAT connects the master and remote I/O terminal with an Ethernet cable. One-touch wiring is possible using an RJ45 connector.
High-speed communications

EtherCAT supports high-speed communications at a speed of 100 Mbps. The communication cycle is largely shortened by overwhelming EtherCAT communication performance. The communication cycle of EtherCAT network with CJ1W-NC□82 which executes position control and remote I/O control is shorter than that of DeviceNet.

Available input filter values are 0 ms, 0.5 ms, 1 ms (default), 2 ms, 4 ms, 8 ms, 16 ms and 32 ms.

High-speed input

The digital I/O terminals are equipped with high-speed input functionality (ON/OFF delay of 200 μs max.). Short communication cycle of EtherCAT and minimum wiring are highly advantageous for the applications that require high-speed signal input.

By increasing the digital input filter value for contacts where the status is unstable due to chattering or noise, malfunction can be prevented. Available input filter values are 0 ms, 0.5 ms, 1 ms (default), 2 ms, 4 ms, 8 ms, 16 ms and 32 ms.

Ample product line-up including digital I/O, analog I/O and encoder input
Case Study 1 for Higher Productivity

Oven furnace

Before implementation

- In the control system for an oven furnace where the speed control of taking in/out the workpieces and their feeding speed directly influence the product quality, the PLCs and multiple servo drives, inverters and remote I/Os are all connected in different networks. It makes it confusing to select components, since wiring and installation method are different in each network.
- It takes time to rewrite the inverter’s command speed settings, when the size of workpiece is changed.

After implementation

- To connect the PLCs, Servo Drives and Inverters with EtherCAT, only one Ethernet cable is required for detection of the workpiece, shatter control to take in/out the workpiece and conveyor speed control. Wiring can be carried out with simple construction directions.
- When a workpiece type is changed, the command speed settings of the inverter can be rewritten through EtherCAT. It reduces the time required for changing the settings.

Effect from implementing EtherCAT

- Reduces design, setup and startup work-hours
- Contributes to higher productivity and quality

The Solution

EtherCAT network covers the Servo Drives, Inverters, and Remote I/O Terminals. The assembly and wiring time is shortened and user can improve the system productivity through the operation.
Case Study 2 for Higher Productivity

Pick and Place System

Before implementation

- In the pick and place applications, same positioning operation is repeatedly executed at a high-speed. To handle the operation, pulse-train type position control unit and servo drives/servomotors are selected, though wiring will be increased.
- With the existing position control units, the PLC ladder program has to repeatedly control the actions of the system. The speed to startup the operation is dependent upon the PLC cycle time.

After implementation

- With the Position Control Unit and Servo Drives with EtherCAT communications, control speed as fast as that of conventional pulse-train type system can be achieved. The devices can be connected with one Ethernet cable.
- The Position Control Unit with EtherCAT interface has the memory operation function. It can handle the repeated operation without being affected by the cycle time of the PLC. It also enables startup, movement, and stopping at a high speed, which contributes to reduction of the takt time.

Effects from implementing EtherCAT
- Reduces cost
- Reduces design work-hours

The Solution

Position Control Unit and Servo Drives with EtherCAT communications ensure high-speed control from startup to stopping. The positioning time can be shortened, thus improving the productivity of the system. EtherCAT simplifies the wiring in the system, too.
Before implementation

- By connecting the PLC and vision sensors via EtherCAT, the communication settings are simplified. The vision sensor can handle the calculation of moving distance on the stage, thus reducing the programming work for PLC.
- The EtherCAT enables reduction of time taken for communication between the vision sensor and PLC. The Servo Drives with EtherCAT communications improve the takt time of position control by reducing the time required for executing startup - movement - stopping operation.

In the liquid crystal masking process, the positioning accuracy of the glass substrate directly influences the product quality. The PLC settings for communication with vision sensor and motion control programming to calculate the position coordinates on the stage are complicated.
- When repeating startup and stopping operation by detecting the alignment mark, the takt time is increased due to prolonged time taken for communication between the PLC and vision sensor and startup time of position control.

After implementation

The Solution

- By connecting the PLC and vision sensors via EtherCAT, the communication settings are simplified. The vision sensor can handle the calculation of moving distance on the stage, thus reducing the programming work for PLC.
- The EtherCAT enables reduction of time taken for communication between the vision sensor and PLC. The Servo Drives with EtherCAT communications improve the takt time of position control by reducing the time required for executing startup - movement - stopping operation.

FPD Liquid Crystal Masking System

Case Study 3 for Higher Productivity

Effects from implementing EtherCAT
- Increases productivity
- Reduces ladder design work

Case Studies for Higher Productivity

- Increases productivity
- Reduces ladder design work