



for a greener tomorrow



**MITSUBISHI
ELECTRIC**

Changes for the Better

FACTORY AUTOMATION

Mitsubishi Electric Roll to Roll Control Devices Selection Guide



The first step to selecting a Roll to Roll control device!



GLOBAL IMPACT OF MITSUBISHI ELECTRIC



Through Mitsubishi Electric's vision, "Changes for the Better" are possible for a brighter future.

Changes for the Better

We bring together the best minds to create the best technologies. At Mitsubishi Electric, we understand that technology is the driving force of change in our lives. By bringing greater comfort to daily life, maximizing the efficiency of businesses and keeping things running across society, we integrate technology and innovation to bring changes for the better.

Mitsubishi Electric is involved in many areas including the following:

Energy and Electric Systems

A wide range of power and electrical products from generators to large-scale displays.

Electronic Devices

A wide portfolio of cutting-edge semiconductor devices for systems and products.

Home Appliance

Dependable consumer products like air conditioners and home entertainment systems.

Information and Communication Systems

Commercial and consumer-centric equipment, products and systems.

Industrial Automation Systems

Maximizing productivity and efficiency with cutting-edge automation technology.

OVERVIEW

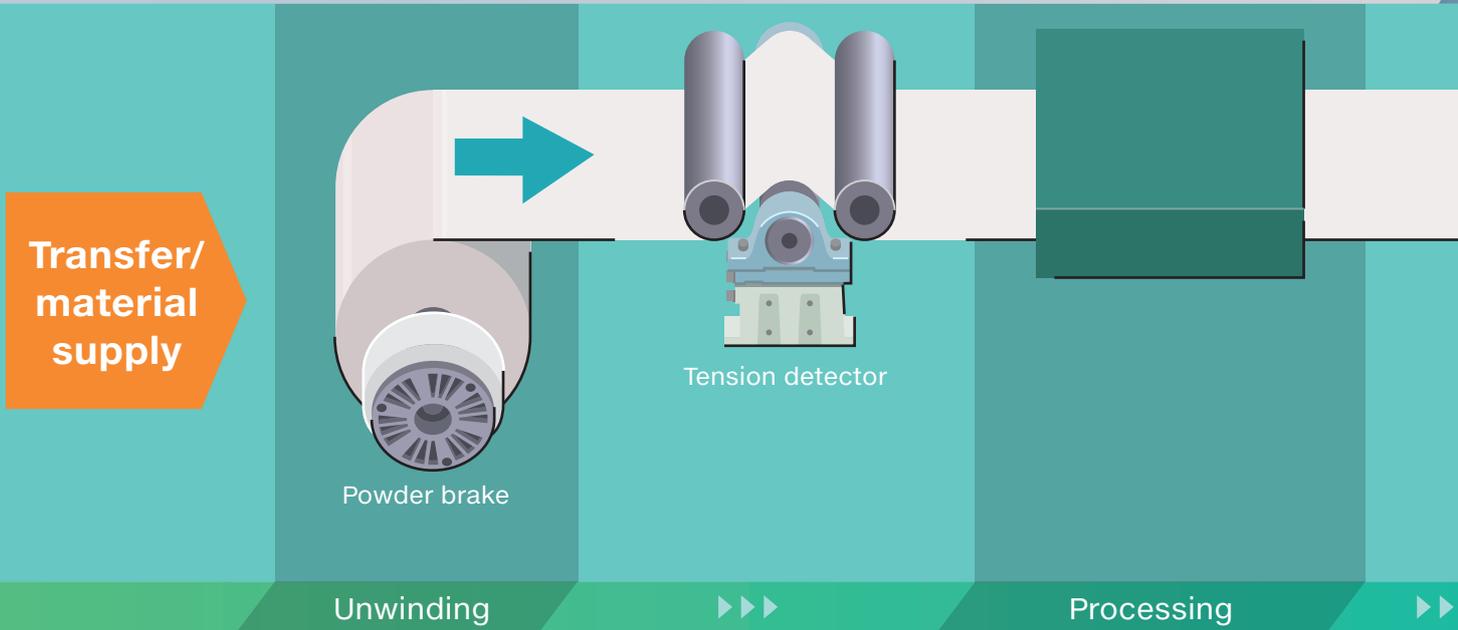
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Roll to Roll Collection



The Roll to Roll control devices proposed by Mitsubishi Electric can be combined with FA equipment group of simple and highly efficient devices that further enhance the possibility of tension control.

Each product improves the productivity in each field, and the configured network environment promotes line visualization. Mitsubishi Electric FA equipment comprehensively manages the production and processing of various long products, such as films, fibers, and printable electronics, so that the advantages can be maximized.



Drive system



Powder clutch and brake, tension controller, and tension detector



MITSUBISHI SERVO AMPLIFIERS & MOTORS
MELSERVO

AC servo



A800 A800 Plus

Inverter



Films



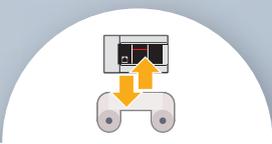
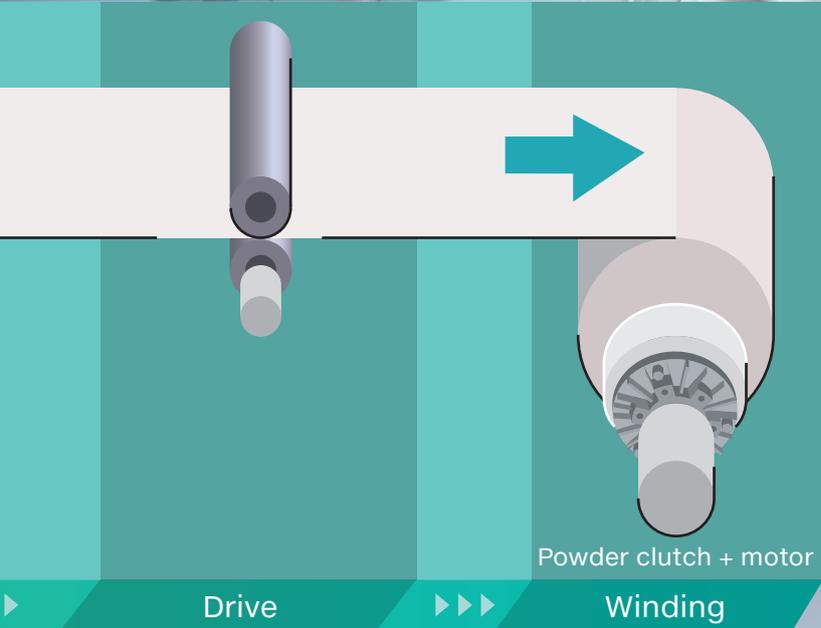
Printing



Paper and plastic



Electronic device materials



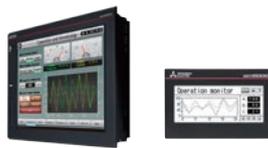
Control system



MELSEC iQ-R series



MELSEC iQ-F series



GOT2000
Graphic Operation Terminal

PLC

Human-Machine Interfaces (HMIs)-GOT



Data management



MELIPC



MELSEC iQ-R series



MELSEC iQ-F series

Industrial PC/PLC

Mitsubishi Electric Roll to Roll Applications

Various types of Mitsubishi Electric FA equipment are used in manufacturing processes, such as for printing, vapor deposition, and coating, where long materials, including high-performance films, sheets, and tapes, are treated using the Roll to Roll system. These devices are compatible with various FA networks and can be smoothly linked with the host controller.

Control system

PLC



MELSEC iQ-R SERIES
MELSEC iQ-F SERIES

GOT



GOT2000
Graphic Operation Terminal

Drive system

Low to high speed/large capacity

Inverter → **Motor**



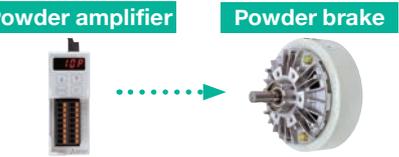
A800 *1*3
A800 Plus *3

Ultralow to low speed

Tension controller *2 → **Tension detector** → **Tension meter**



Powder amplifier → **Powder brake**



Unwinding process

High speed/multi-axis

Servo amplifier → **Motor**



MELSERVO-J5

Ultralow to high speed/large capacity

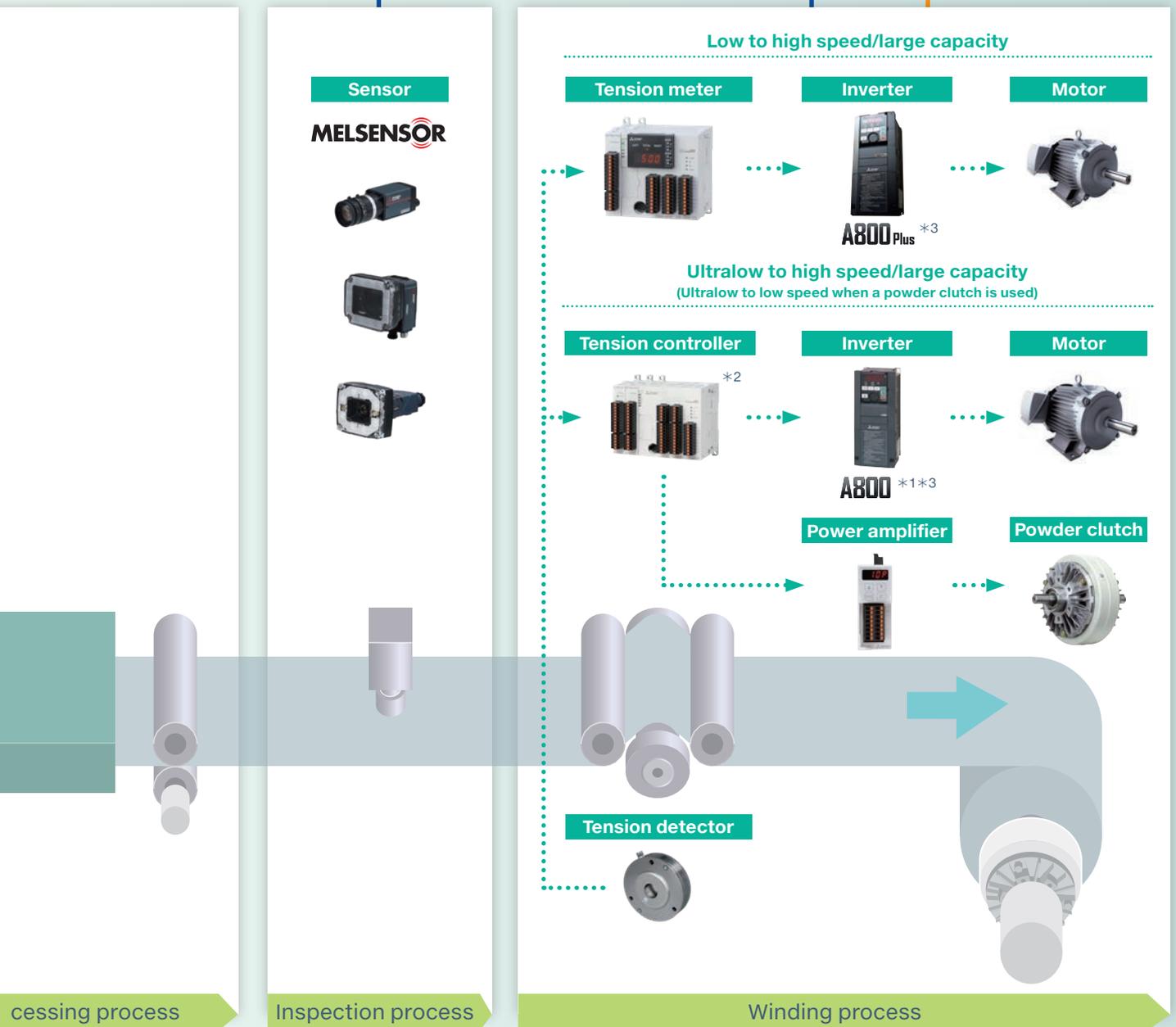
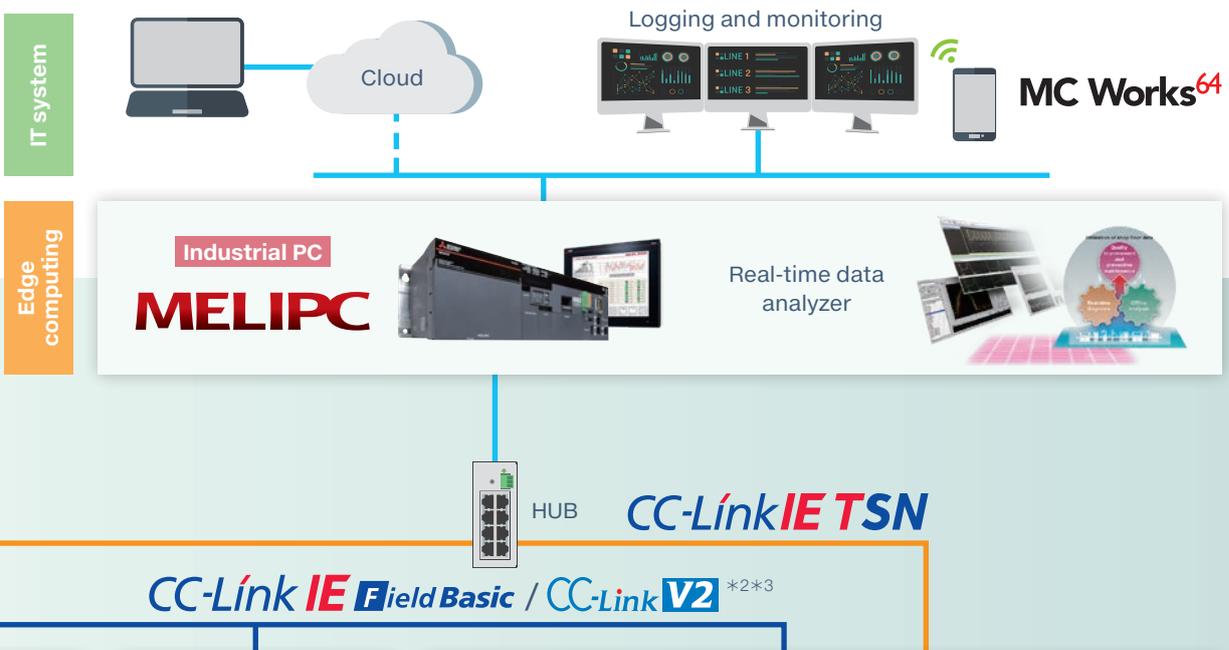
Inverter → **Motor**



A800 *1*3
A800 Plus *3

Intermediate shaft

Pro



*1: To connect to CC-Link IE TSN, A800 (standard) with an optional product (FR-A8NCG) is used.
 *2: LE-10WTA-CCL is not compatible with CC-Link IE Field Network Basic. Use CC-Link V2.
 *3: To connect through CC-Link IE Field Network Basic, the A800-E(-R2R) series is required. To connect through CC-Link V2, an optional product (FR-A8NC) is required.

✓ First requirement: Understanding tension control methods

How to use torque control and speed control properly

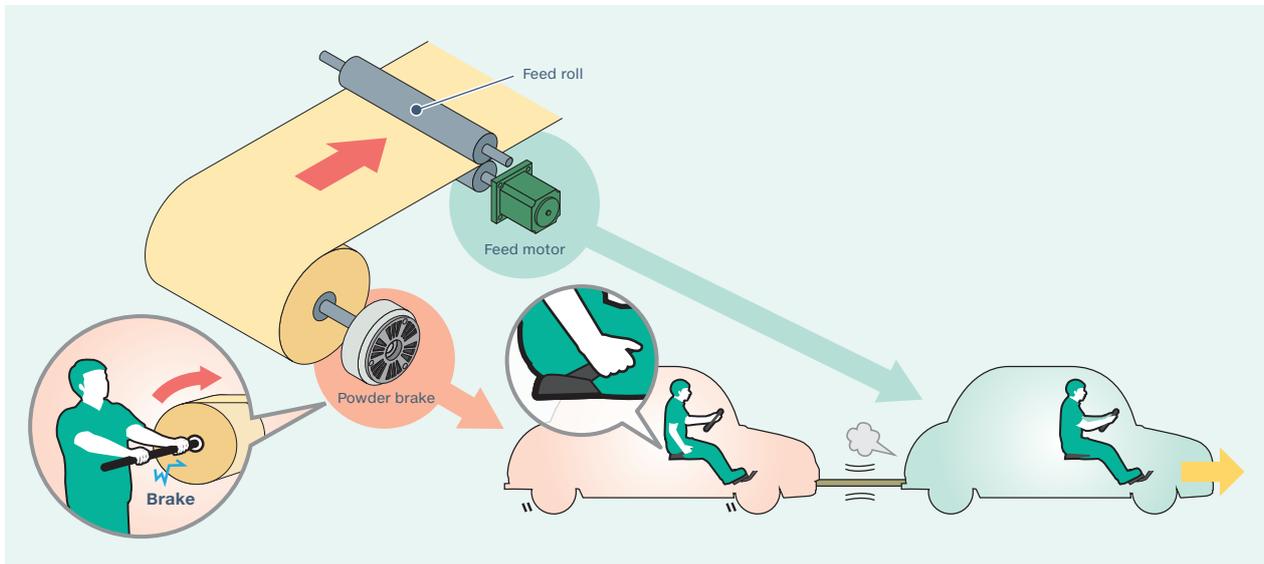
Two types of tension control, methods via torque control and speed control, are available. Each method has merits/demerits. Therefore, it is necessary to select a proper method in accordance with the actual usage conditions.

Usage conditions	Torque control Details P8, P9	Speed control Details P10, P11
<ul style="list-style-type: none"> • Tension accuracy • Low speed 	<p>✓</p> <p>The tension is determined by the torque generated by the actuator, and detailed control is possible.</p>	<p>✗</p> <p>The tension is determined by the weight attached to the dancer roll or the pressurization by the air cylinder. It is not possible to change only the torque used for controlling the tension even if the tension changes.</p>
<ul style="list-style-type: none"> • Availability of acceleration/deceleration • Considerable change in reel diameter • Low tension 	<p>✗</p> <p>Control is difficult because it is affected by the torque caused by changes in inertia and mechanical loss.</p>	<p>✓</p> <p>Because the tension is determined by the weight attached to the dancer roll or the pressurization by the air cylinder even if acceleration or deceleration is performed, the control is less affected by acceleration or deceleration. Because the reel shaft can be driven, the tension can be made low by positively feeding out the material.</p>

What is torque control?

The feed motor transfers the material at a constant speed, and the material is pulled by the winding shaft in the reverse direction to the material transfer direction, so as to generate tension. The tension can be controlled by adjusting the torque of the powder brake. The advantages of torque control are that the tension can be controlled with a high degree of accuracy in the case of feedback control and the configuration is so simple that the pass line can be shortened, allowing for the design of compact equipment.

The material feeding speed is determined by the rotation speed of the feed motor. The torque caused by inertia moment and mechanical loss must be corrected.

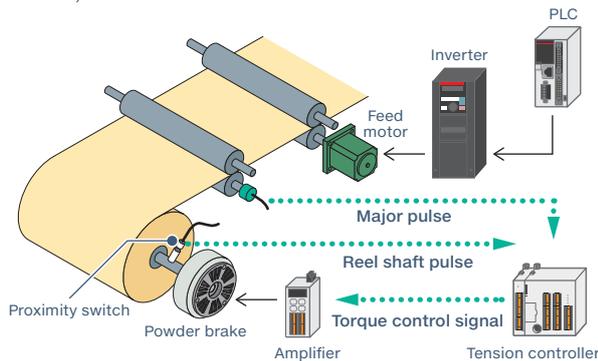


Examples of tension control methods by torque control

Representative control methods are open-loop control, with high stability, and feedback control, with high accuracy. "Feedforward-feedback composite control," which enables more-advanced tension control, can be realized by combining open-loop control and feedback control.

1 Open-loop control (reel diameter detection method)

The torque is controlled according to the change in the reel diameter calculated using the signal from the sensor, such that constant tension can be obtained.



Features

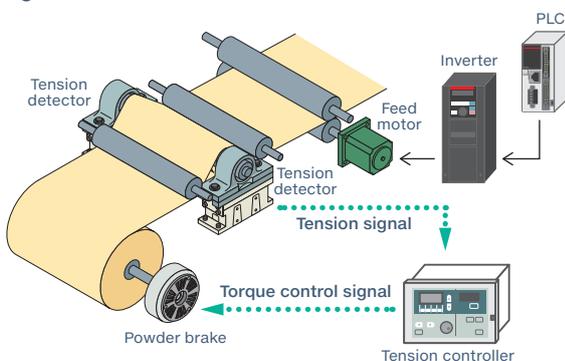
- **The initial cost of introduction is low (a tension detector is not required).**
- Stable control is realized (control is not sensitive to sudden disturbances).
- Taper control is easy.
- Applicable to equipment on which a tension detector cannot be used.

Cautions

- The actual material tension cannot be obtained.
- The control is affected by torque changes and the linearity of the actuator, as well as by mechanical loss.

2 Feedback control (also known as: closed-loop control)

The material tension is directly monitored by a tension detector and is controlled by feedback to obtain the target tension.



Features

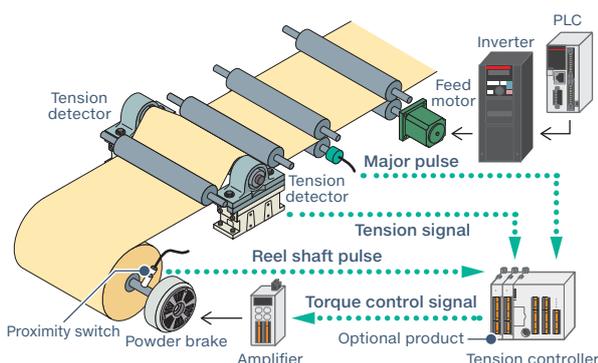
- **Tension accurately controlled according to the target value can be obtained.**
- The tension can be controlled without being affected by the torque characteristics (linearity and temperature characteristics) of the actuator.
- The actual material tension can be numerically obtained.

Cautions

- A tension detector is required.
- The control does not immediately follow sudden disturbances (changes in tension).
- It is necessary to coordinate the machine manipulation and control.

3 Feedforward-feedback composite control

Combination of highly stable open-loop control and highly accurate feedback control realizes more-advanced tension control.



Features

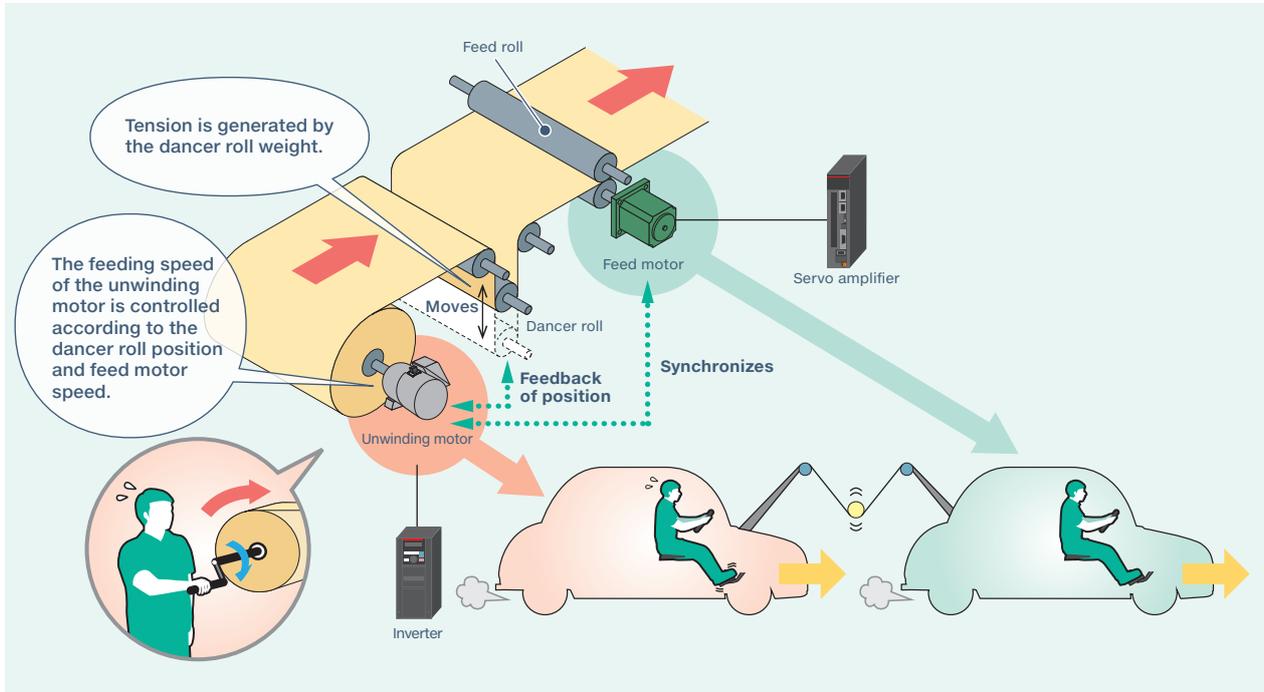
- **The disadvantage of feedback control, i.e., the influence of short-term disturbances, can be moderated.**
- The influence of inertia moment during acceleration and deceleration can be corrected.

Cautions

- A tension detector and a sensor (proximity switch or rotary encoder) for reel diameter calculation are required.

What is speed control?

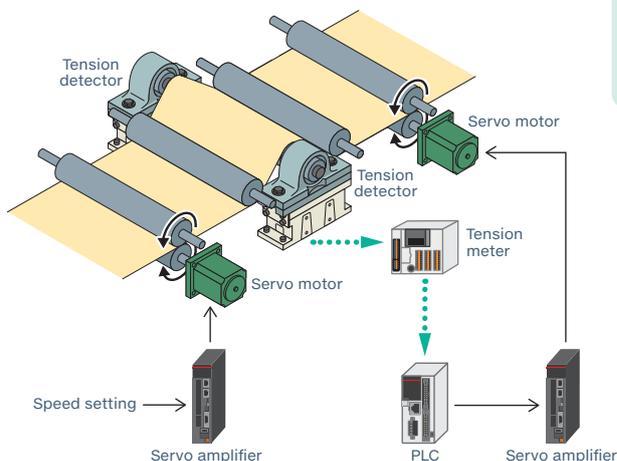
Speed control is a control method that stabilizes the tension by controlling the feeding speed of a material. The tension is adjusted by controlling the pressure on the dancer roll or via control based on the difference in the material-feeding speed (draw control). In the case of speed control using the dancer roll, the dancer roll absorbs machine vibration and speed fluctuation, thereby allowing a stable speed transfer and tension control.



Examples of tension control methods by speed control

1 Method using the tension detector

- The difference between the tension detected by a tension detector and the set tension is detected so as to control the difference in motor speed.
- The principle of this method is the same as that of draw control because tension is generated via the difference in rotation speed between the front and rear rolls.

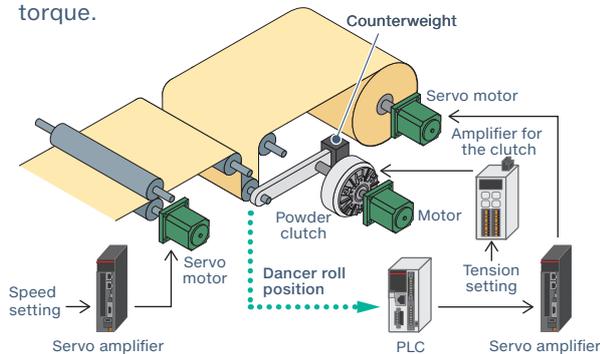


Features of speed control using the tension detector

- Speed control can be performed using a simple configuration.
- The tension accuracy is higher than the dancer roll method.
- The tension stability is rather low.
- The controllability considerably changes in accordance with the characteristics of the material.

2 Method using the dancer roll (pressurization by powder clutch)

- The pressure on the dancer roll is adjusted by using a powder clutch.
- The tension setting can be changed by applying pressure to the dancer roll via the powder clutch torque.

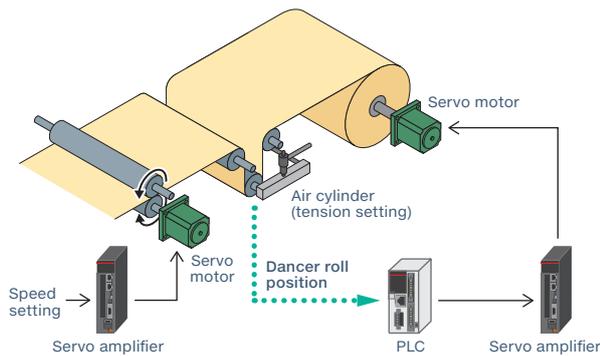


Features of speed control using the powder clutch

- The tension can be changed by the torque of the powder clutch.
- The dancer roll position depends on the difference between the input speed and the output speed.
- Synchronization can be easily achieved even if the path is long.
- The dancer roll position does not affect the tension.

3 Method using the dancer roll (pressurization by air cylinder)

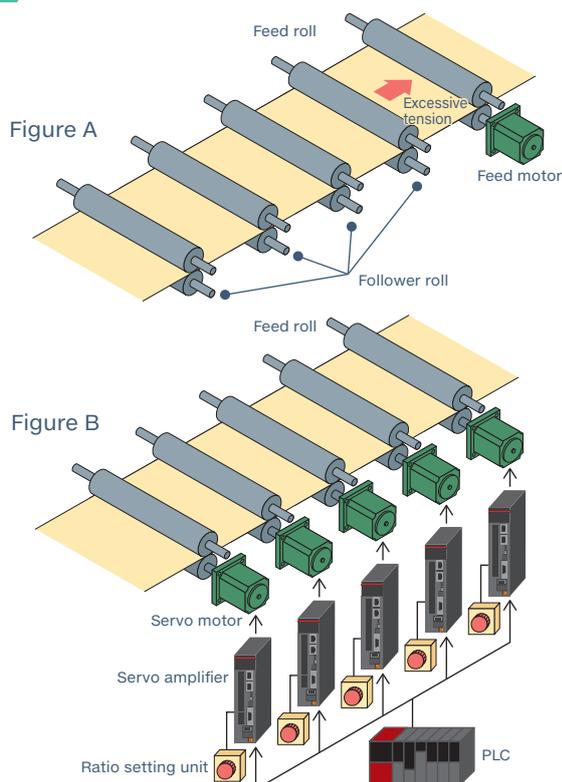
- An air cylinder is used to adjust the pressure on the dancer roll.
- The tension setting can be changed by applying pressure to the dancer roll via the pneumatic pressure of the air cylinder.



Features of speed control using the dancer roll

- The tension stability is high even with acceleration or deceleration.
- Synchronization can be easily achieved even if the path is long.
- The dancer roll absorbs shock.
- The tension accuracy depends on the air pressure and machine mechanism.

4 Draw control

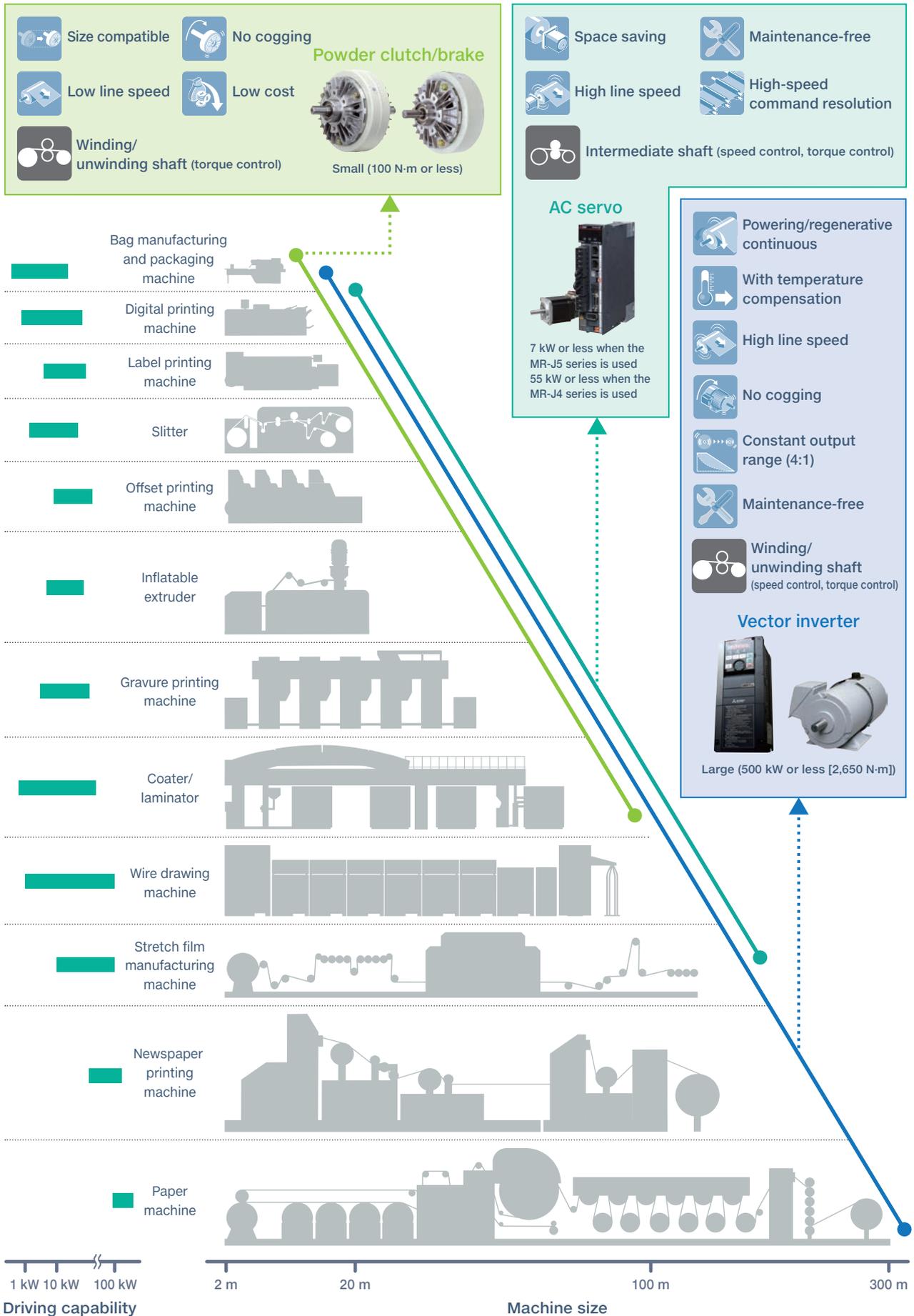


When many follower rolls are driven by the traveling material as shown in Figure A, the tension may become excessive toward the head area due to the effect of mechanical loss in the follower rolls. For driving each follower roll to prevent excessive tension, it is necessary to control the speed in accordance with the elongation and shrinkage of the material.

It is possible to drive each roll using the servo motors, and to drive the servo motors in the rear area at a higher speed than the servo motors in the front area using the ratio setting units as shown in Figure B. The elongation percentage is approximately 0.1 to 5%.

The method of driving rolls in the rear area at a higher speed in this way is called draw control. The operation tension is determined by the elongation percentage property of the material.

✓ Device map for solutions/comparison of actuators



✓ Effect of introducing tension control

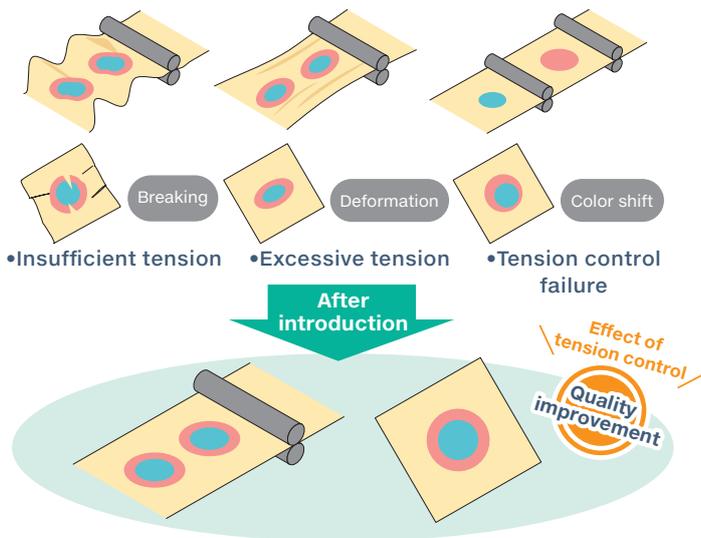
Introducing tension control improves the quality of the continuous processing of the material.

Improving the printing quality

Maintenance of proper tension

Before introduction

If tension is low, wrinkles are formed, and the printed pattern is broken. If tension is too high, the material stretches, and, when tension is lost, it shrinks. As the result of this, the printed pattern is distorted. If tension is not uniform or fluctuates in the printing units, colors could overflow or bleed, and the printed pattern could become deformed.

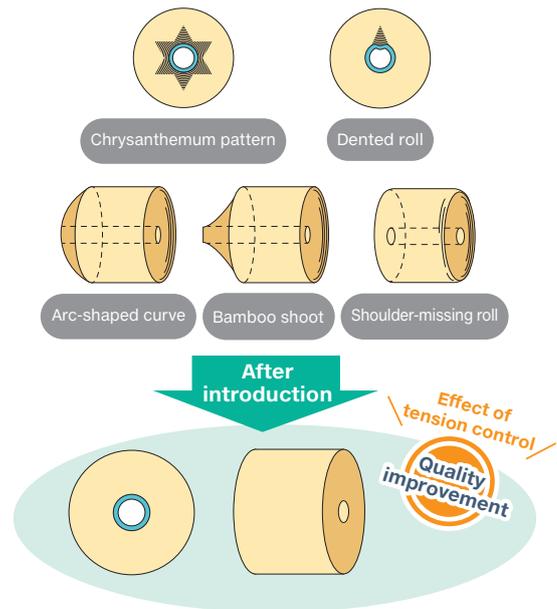


Improvement of roll form quality

Accurate measurement of reel diameter

Before introduction

In the material processing and winding stages, if tension is not controlled properly, the following problems could occur:

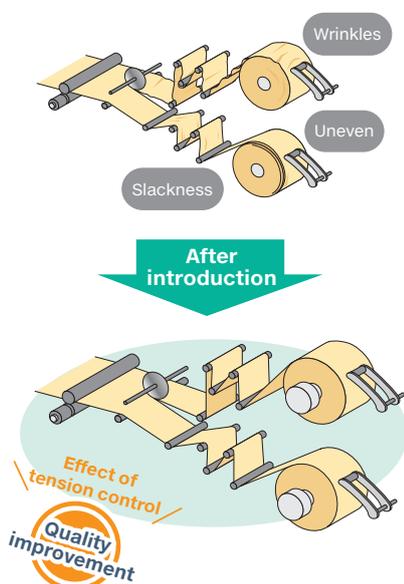


Improvement of cutting width accuracy

Improvement of both processing accuracy and capacity

Before introduction

If materials on the upper and lower rolls differ in tension, the width could become uneven, and wrinkles and slackness could occur.

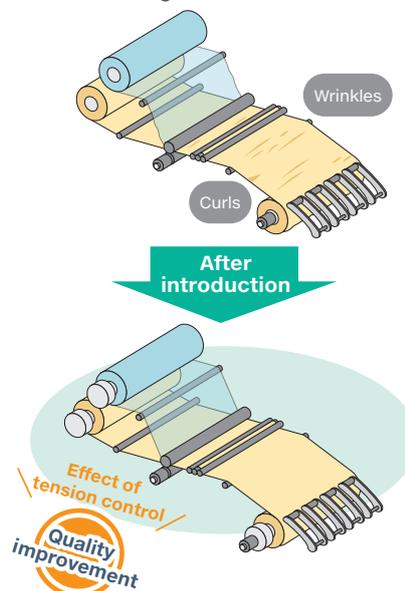


Improvement of lamination quality

Uniform tension of materials to be laminated

Before introduction

If the tension is not controlled properly between the upper area and the lower area, wrinkles and curls may form due to elongation and shrinkage of the material.

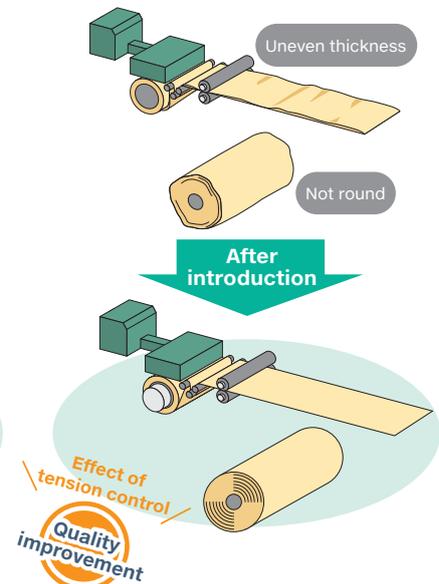


Uniform coated film thickness

Stable material tension and speed

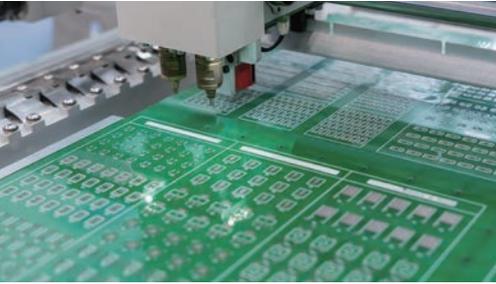
Before introduction

If the tension is uneven between before coating and after coating, the material thickness may become uneven and the product quality may deteriorate.



✓ Products for controlling Roll to Roll

Various types of equipment are available, such as tension controllers, tension detectors, and tension meters required for tension control, so that they can be selected according to the application and the content of control.



LE-10WTA-CCL



LD-10WTB-CCL



LE-30CTN

Tension controller

• Feedback-system tension controller

The material tension is directly measured by using a tension detector and is controlled by feedback so as to obtain the target unwinding and winding tension. Via this method, the tension can be accurately controlled according to the target value.

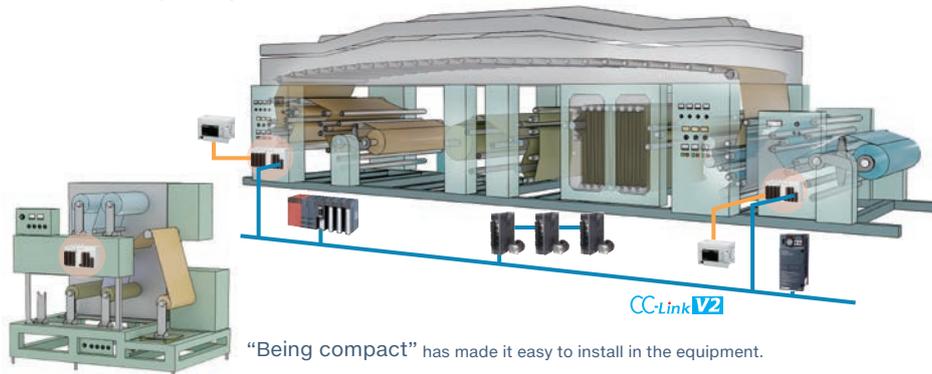
- Features ▶
- Simple startup
 - Small and light
 - Various communication methods
 - High accuracy

• Open-loop tension controller

The reel diameter is detected by a sensor, and the unwinding and winding torque is controlled. This method is not sensitive to sudden disturbances and ensures stable tension control.

- Features ▶
- Simple startup
 - Small and light
 - Various communication methods
 - High accuracy

“Network adaptability” allows incorporation into the line.



Highly advanced tension control

Enable tension control for up to 2 shafts

Diversified communication functions

Enable manipulation and display of settings from the panel using the graphic operation terminal.

Improved support for motor control

GT2104-P

Display main body



Connection cable





LM-10WA-CCL*

Tension meter

The tension meter is a unit that displays the material tension detected by the tension detector and that outputs the signals to external devices. The tension meter is applicable to multi-axis systems and capable of digitally displaying the tension for monitoring.

Features ▶ Simple startup Small and light High accuracy

*: Applicable to CC-Link V2.



ZKB-BN Powder clutch



ZKB-XN Powder brake

Powder clutch/brake

These devices use powder (magnetic iron powder) for transmitting torque and have advantages, such as smoothness of a fluid clutch and high efficiency obtained by connecting a friction plate type clutch. They are suitable as actuators for winding and unwinding long materials or overload safety devices (torque limiters).

Features ▶ Control in wide range Continuous slip operation
Stable torque Large heat capacity



LD-10PAU-B

Amplifier for the clutch

This amplifier for the clutch is used to control the exciting current for the powder clutch/brake by using external signals or external volumes.

Features ▶ Simple startup Small and light High accuracy



LX7-F



LX-TD

Tension detector

The tension sensor is capable of outputting the material tension as an electric signal. The material tension can be displayed and controlled via connection with a tension controller or a tension meter.

The LX-TD/LX7-F tension detector uses a differential transformer resistant to electrical noise, temperature changes, and humidity changes, and can detect tension with high accuracy.

Features ▶ Small and light High accuracy

AC Servo System MELSERVO-J5

Innovate Together

Create new value with MELSERVO-J5.
Unlock performance with a total drive solution.

MITSUBISHI ELECTRIC SERVO SYSTEM
MELSERVO-J5



CC-Link I^E TSN

MELSEC iQ-R series Motion module



RD78GH



RD78G

Various motions, such as positioning, synchronization, cam, speed, torque, and linear interpolation, can be easily controlled only by starting PLCopen® Motion Control FB. The maximum number of controlled axes is 64 (RD78G64) or 256 (RD78GHW).



MR-J5-G



MR-J5W-G

CC-Link I^E TSN

Servo amplifiers MELSERVO-J5 series

Combination with the motion module realizes accurate synchronous drive. The quick-tuning function, which can suppress vibration and overshoot in 0.3 sec, realizes stable positioning during automatic operation. Various predictive maintenance and preventive maintenance functions are provided and can reduce maintenance times.



HK-KT13W



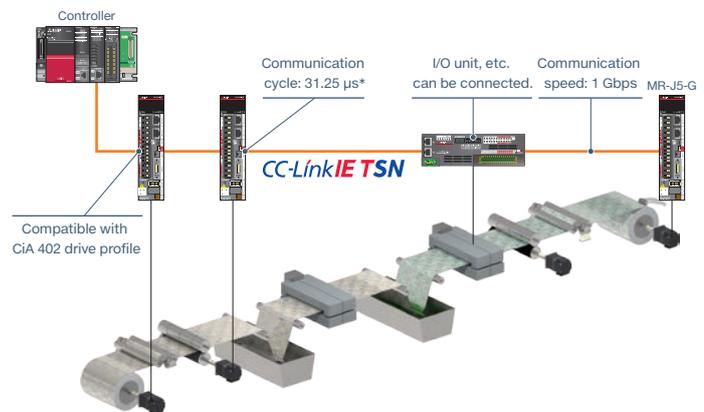
HK-ST102W

Rotary servo motor HK series

The motor is provided with a battery-less absolute position encoder with a resolution of 26 bits as standard. A battery is not required for retaining absolute position data. The motor power cable, encoder cable, and electromagnetic brake cable can be connected as one cable. The use of one-touch locks improves wiring work efficiency because the locks need not be screwed on.

Establishment of a high-speed and high-accuracy system applicable to CC-Link IE TSN

The servo amplifiers drive the servo motors by receiving commands (position/velocity/torque) at regular intervals in synchronous communication with the CC-Link IE TSN-compatible controller. Combination with the motion module ensures high speed and precise temporal coincidence, and realizes accurate synchronization between axes and machines.



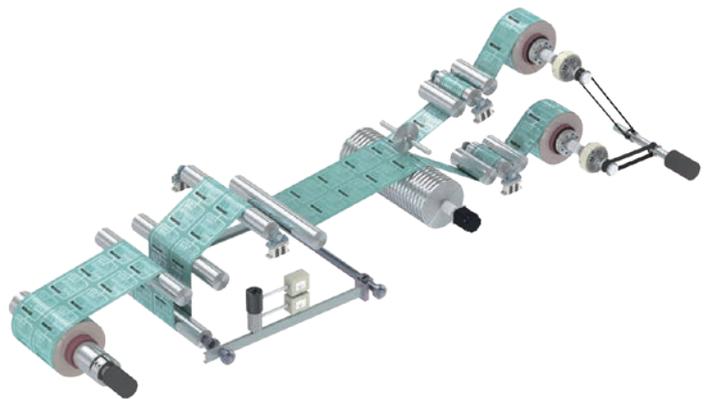
*: The communication cycle of 31.25 μs is obtained when the system is combined with the RD78GH.

Selection of an optimum adjustment method according to the required machine performance

At machine startup, noise sometimes occurs due to resonance. With the quick tuning function, tuning is performed at servo ON and such noise is minimized. In addition, the servo amplifiers offer various other types of servo adjustment functions that allow you to select the function that best suits your equipment.

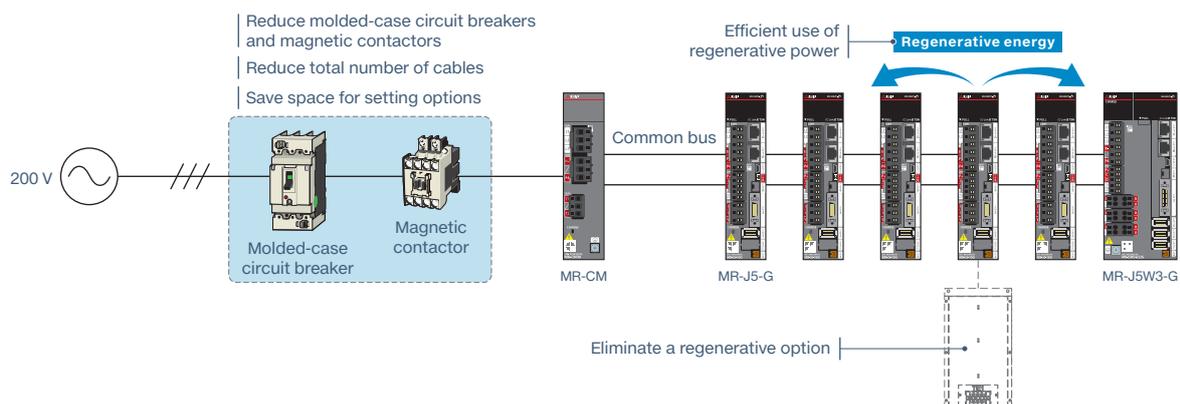
Servo adjustment function

- Quick tuning
- One-touch tuning
- Machine resonance suppression filter
- Advanced vibration suppression control II



The MR-CM simple converter realizes energy, space savings, and wiring savings

Utilizing a common bus connection conserves energy through the efficient use of regenerative power. Wiring can be simplified and installation space can be saved by reducing the number of molded-case circuit breakers and magnetic contactors. The MR-CM simple converter can connect to up to six compatible servo amplifiers having a total capacity of 3 kW or lower.





Inverter FR-A800 Plus*1

The optimum functions for Roll to Roll applications are added

• System simplification

The inverter is provided with various dedicated functions necessary for tension control, such as dancer roll control and reel diameter calculation. Stable winding and unwinding control can be realized only with the inverter.

• Easy startup and adjustment

Machine settings and adjustments appropriate to the purpose of use can be performed via parameters. System startup and adjustment work can be performed only with the inverter.

(Automatic adjustment function for tension PI gain)

• Wide range of applications

Four controls*2 ensure application to winding and unwinding on a wide range of systems, such as wire drawing machines and printing machines.



*1: The FR-A800-E-R2R offers connection with CC-Link IE Field Network Basic as standard. For connection with CC-Link, an optional product (the FR-A8NC) is required. For CC-Link IE Field Network communication, an optional product (FR-A8NCE) is required.
 *2: Dancer feedback speed control, tension sensor feedback speed control, tension sensor-less torque control, and tension sensor feedback torque control.

Winding diameter calculation

The present winding diameter for the winding/unwinding shaft is calculated from the actual line speed or the actual motor speed.

Line speed command input selection/actual line speed input selection

The line speed command and actual line speed required for calculating the winding diameter can be input through the analog input terminal or plug-in option.

Winding diameter calculation function selection

The winding diameter calculation method can be selected in order to improve the tension control performance.

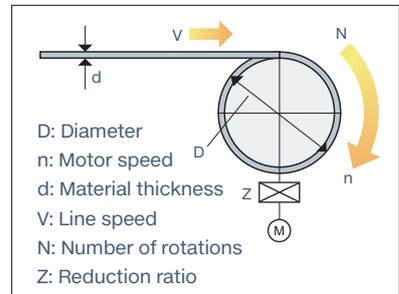
• Actual line speed calculation method

The winding diameter is calculated from the line speed and the main speed (actual motor speed).

$$D = \frac{V}{\pi \times n \times Z}$$

• Thickness calculation method

The material thickness is added up to find the overall winding diameter.
 $D = \text{Initial diameter} \pm 2 \times d \times N \times Z$



Dancer feedback speed control/tension sensor feedback speed control

PID control is performed using feedback of the detected dancer roll position or feedback from the tension sensor. Stable control can be achieved in combination with the winding diameter calculation.

Speed control proportional gain compensation

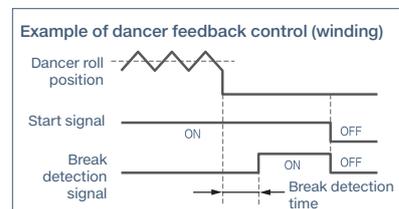
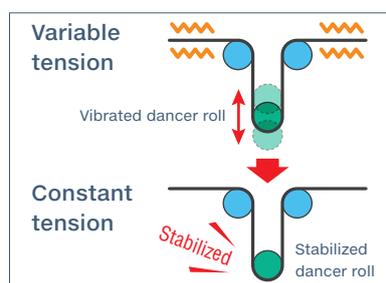
By adjusting the speed control proportional gain according to the winding diameter, the response level can be kept constant.

Tension PI gain tuning

By automatically adjusting the tension PI gain for PID control, time required for adjustment is significantly cut down. Anyone can start the system easily.

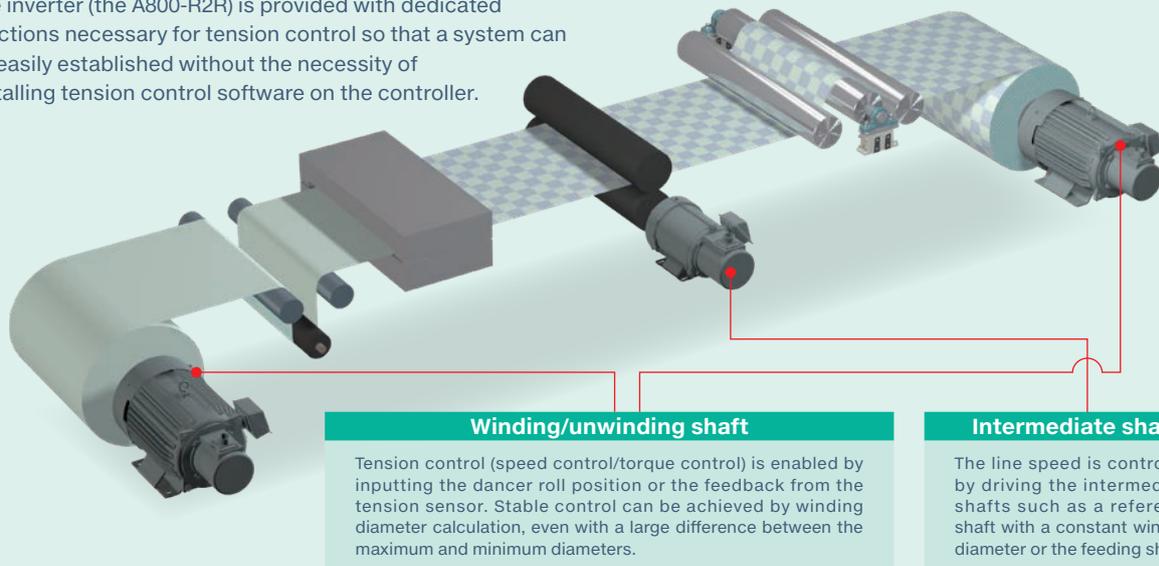
Dancer roll malposition detection

When material rupture (break) occurs and the sensor feedback value (dancer/tension feedback) is held at the upper/lower limit for a certain period of time, the break detection signal is output.



Tension control realized by one inverter!

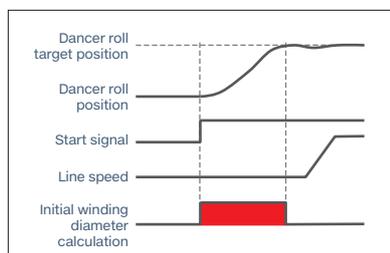
The inverter (the A800-R2R) is provided with dedicated functions necessary for tension control so that a system can be easily established without the necessity of installing tension control software on the controller.



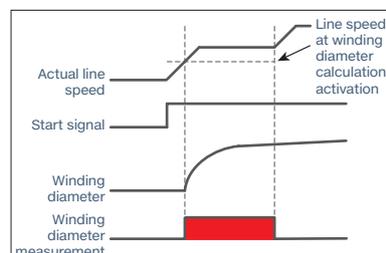
Initial winding diameter calculation

When the winding diameter changes after the material change or others, the present winding diameter is calculated in the following two ways.

The present winding diameter is calculated based on the dancer roll movement at a start from the lower limit position to the target position.



The present winding diameter is calculated from the line speed and the actual motor speed (The system must be started at low speed).



Winding diameter/winding length storage

The present value of winding diameter and winding/unwinding length can be stored. The winding diameter and winding length values are stored in the inverter even during power-OFF.

Tension sensorless torque control/tension sensor feedback torque control

The output torque of a motor is controlled so that the tension applied to a material is constant by calculating the winding diameter of a roll.

Mechanical loss compensation function

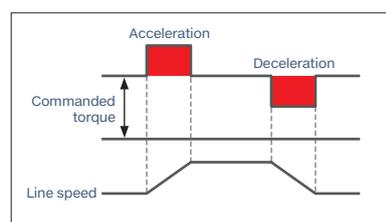
The tension applied to the material is maintained constant by raising a commanded torque to compensate mechanical loss caused by factors such as friction on the dancer roll or winding/unwinding shaft.

Tension command cushion time

The cushion time is set for the tension command to avoid sudden change in tension.

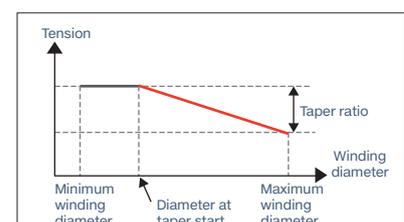
Inertia compensation function

During acceleration/deceleration, the tension applied to the material is maintained constant by adjusting the variable tension on the winding and unwinding sides.



Taper function

By adjusting the tension on the workpiece, it is possible to avoid imperfections such as wrinkles or deformation caused by the increase in diameter.



✓ Related devices

iQ Platform-compatible PLC

MELSEC iQ-R series

Bridging the next generation of automation



Core for next-generation automation environment

To succeed in highly competitive markets, it's important to build automation systems that ensure high productivity and consistent product quality. The MELSEC iQ-R series has been developed from the ground up based on common problems faced by customers. Mitsubishi Electric is taking a three-point approach to solving these problems: Reducing TCO, increasing Reliability and Reusability of existing assets.

iQ Platform-compatible PLC

MELSEC iQ-F series

The next level of industry



Function and cost performance required for small-scale/stand-alone control

Designed on the concepts of outstanding performance, superior drive control and user centric programming, Mitsubishi Electric's MELSEC-F series has been reborn as the MELSEC iQ-F series. From stand-alone use to networked system applications, MELSEC iQ-F series brings your business to the next level of industry.

Human-Machine Interfaces (HMIs)-GOT

GOT2000

Graphic Operation Terminal



A wide variety of lineup meets the needs of production sites

The GOT boasts advanced functionality, acts as a seamless gateway to other industrial automation devices, all while increasing productivity and efficiency.

GOT is the abbreviation of “Graphic Operation Terminal”. Switches and lamps had been conventionally attached to an operation panel as hardware. However, by using the screen design software, those can be created, and displayed and operated on the monitor screen of the GOT, the touch-panel HMI.

Industrial Computer

MELIPC



Industrial computer opens up new possibilities of manufacturing

Industrial computer has been developed maximizing highly reliable device control technology accumulated through development of the MELSEC series programmable controller. Mitsubishi Electric industrial computer MELIPC series offers new values for Edge computing, IT system coordination, and device control with its robust features and flexibility utilizing general purpose applications.

FA Sensor

MELSENSOR



Factory automation sensors MELSENSOR improve manufacturing productivity and product quality

Through seamless collection and management of measured production data, MELSENSOR helps implementation of Mitsubishi Electric’s e-F@ctory solution, further promoting IoT system configuration.

MEMO

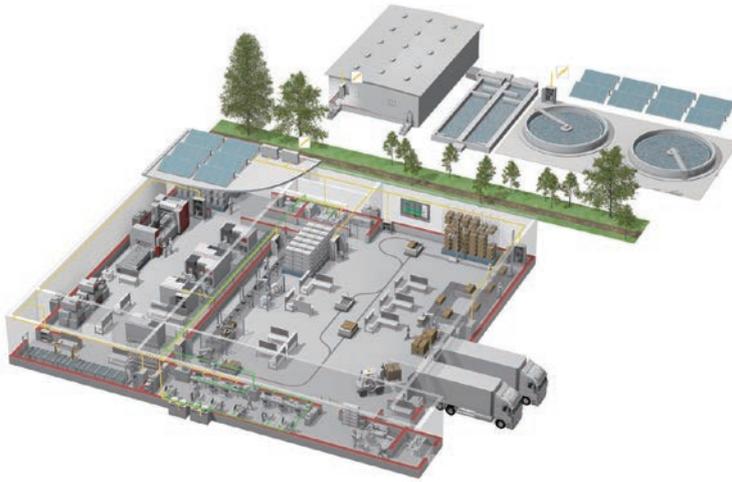
Safety Warning

· To ensure proper use of the products in this document, please be sure to read the instruction manual prior to use.

Registration

· The company names, system names and product names mentioned in this document are either registered trademarks or trademarks of their respective companies.
· In some cases, trademark symbols such as "™" or "®" are not specified in this document.

YOUR SOLUTION PARTNER



Mitsubishi Electric offers a wide range of automation equipment from PLCs and HMIs to CNC and EDM machines.

A NAME TO TRUST

Since its beginnings in 1870, some 45 companies use the Mitsubishi name, covering a spectrum of finance, commerce and industry.

The Mitsubishi brand name is recognized around the world as a symbol of premium quality.

Mitsubishi Electric Corporation is active in space development, transportation, semi-conductors, energy systems, communications and information processing, audio visual equipment and home electronics, building and energy management and automation systems, and has 237 factories and laboratories worldwide in over 121 countries.

This is why you can rely on Mitsubishi Electric automation solution - because we know first hand about the need for reliable, efficient, easy-to-use automation and control in our own factories.

As one of the world's leading companies with a global turnover of over 4 trillion Yen (over \$40 billion), employing over 100,000 people, Mitsubishi Electric has the resource and the commitment to deliver the ultimate in service and support as well as the best products.



Low voltage: MCCB, MCB, ACB



Medium voltage: VCB, VCC



Power monitoring, energy management



Compact and Modular Controllers



Inverters, Servos and Motors



Visualisation: HMIs



Numerical Control (NC)



Industrial / Collaborative Robots



Processing machines: EDM, Lasers, IDS



Transformers, Air conditioning, Photovoltaic systems

* Not all products are available in all countries.

Mitsubishi Electric Roll to Roll Control Devices Selection Guide

mitsubishi **ELECTRIC CORPORATION**

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