eco Changes **for a greener tomorrow**

MITSUBISHI ELECTRIC
Changes for the Better

FACTORY AUTOMATION

Lithium Ion Battery Production Line Solution Catalog

e-F@ctory

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.

Maximizing productivity and reducing costs across the entire enterprise

e-F@ctory is the Mitsubishi Electric solution for improving the performance of any manufacturing enterprise by enhancing productivity, and reducing the maintenance and operations costs together with seamless information flow throughout the plant. e-F@ctory uses a combination of factory automation and IT technologies, offering solutions to reduce the total cost of development, production, and maintenance by supporting advanced *Monozukuri**.

e-F@ctory helps to reduce overall costs and is achieved in the following four areas:

* Monozukuri is an initiative started in Japan for promoting its unique manufacturing style for continuous improvement in production processes and operations. The word is derived by combining the words "*mono*", the thing that is manufactured, and "*zukuri*", the process of manufacturing

Reduce energy costs

e&eco-F@ctory (energy saving solution)

Modern manufacturing depends much on reducing energy costs as a way to realize an efficient manufacturing enterprise. e-F@ctory supports this by allowing visualization of real-time energy usage, helping to reduce the overall energy consumption.

Reduce development, production, and maintenance costs

iQ Platform

The iQ Platform minimizes costs at all phases of the automation life cycle by improving development times, enhancing productivity, reducing maintenance costs, and making information more easily accessible. Integration is at the heart of the iQ Platform, with a highly intelligent controller platform as the core, combined with a seamless communication network and an integrated engineering environment.

iQ Platform

Integrate FA and IT systems at low cost

### Connecting enterprise with the shop floor

e-F@ctory solutions provide direct connectivity from the shop floor to enterprise, such as Manufacturing Execution System (MES) without requiring a gateway computer. This enables leaner operations, improved yield, and efficient management of the supply chain.

Reduce setup and maintenance costs

iQ Sensor Solution

Easily setup and maintain various types of sensors. Maintenance and design costs can be reduced as compatible iQSS partner sensors can be managed together.

iQSS
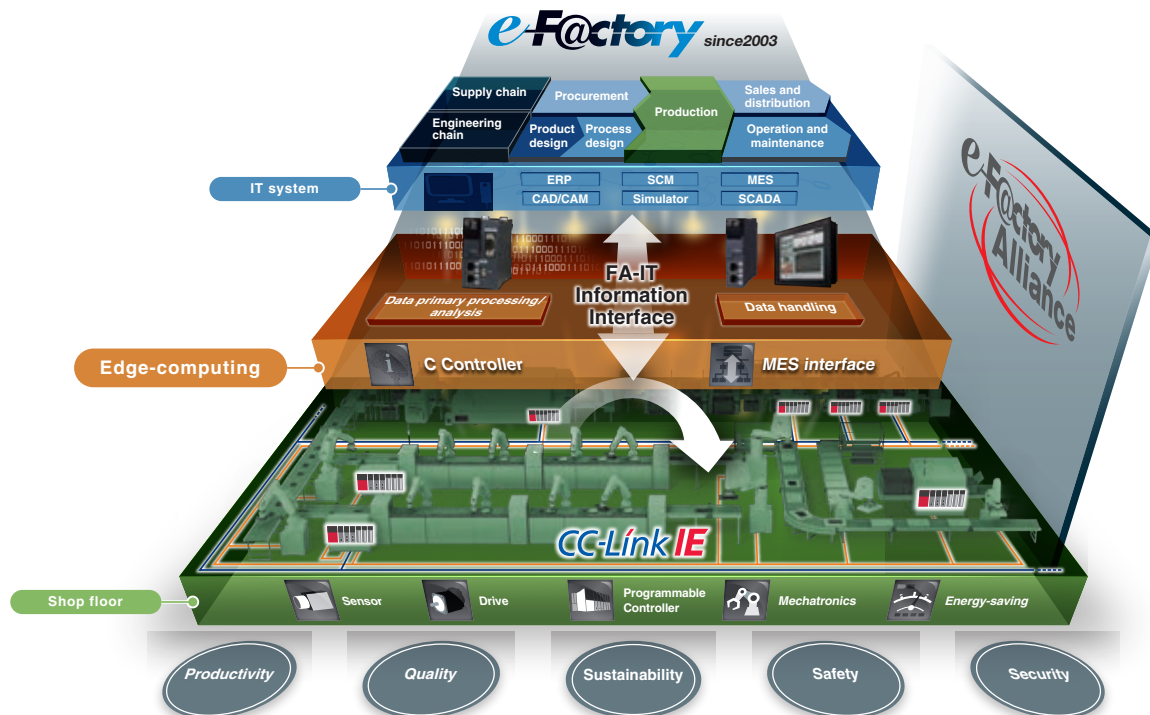
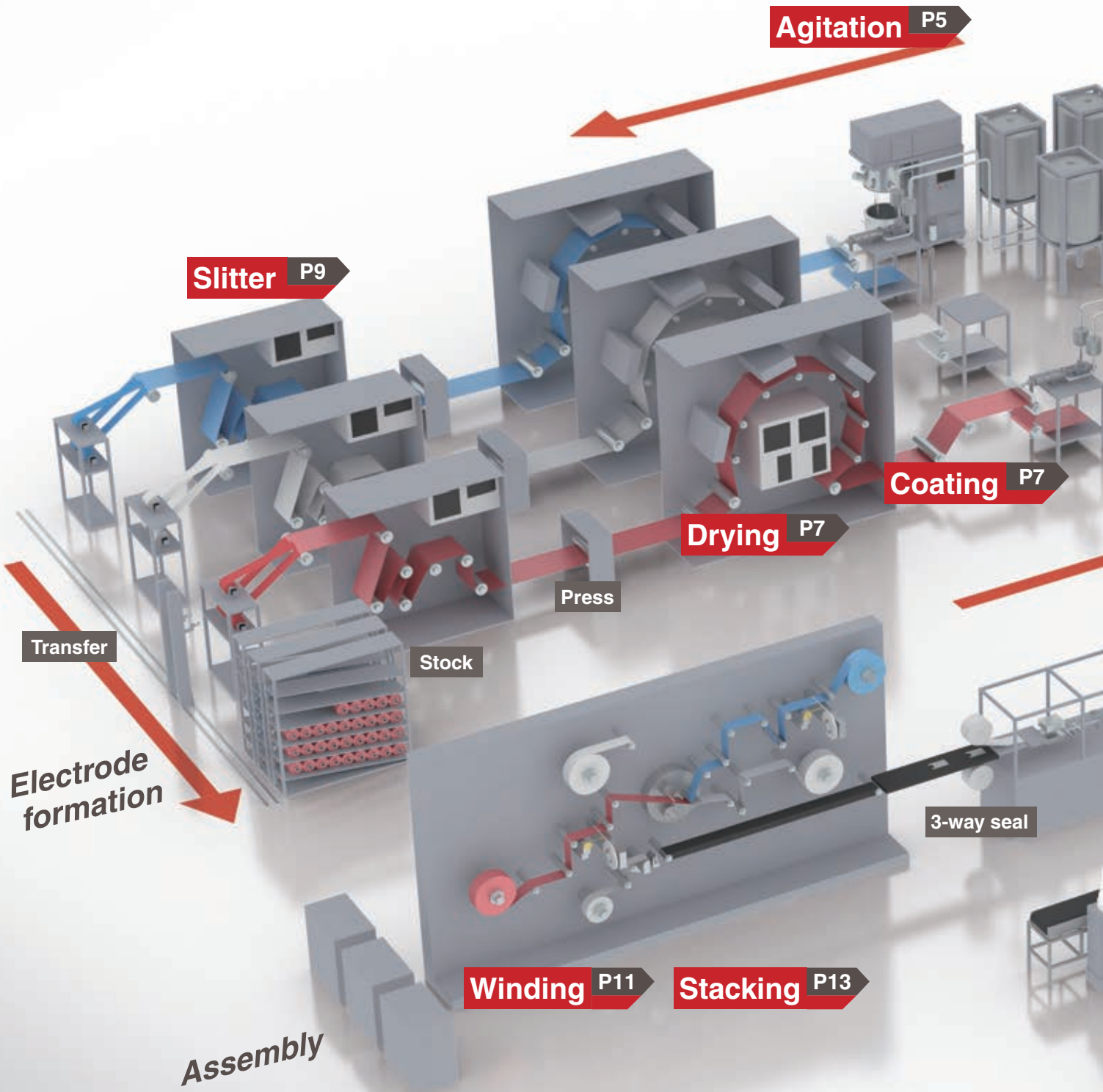## Best-in-class solutions across the ecosystem

e-F@ctory Alliance

The e-F@ctory Alliance is an ecosystem offering best-in-class solutions by combining products between Mitsubishi Electric and its various partners. Close collaboration with such partners broaden the choices for the customer and realize the best solution possible.
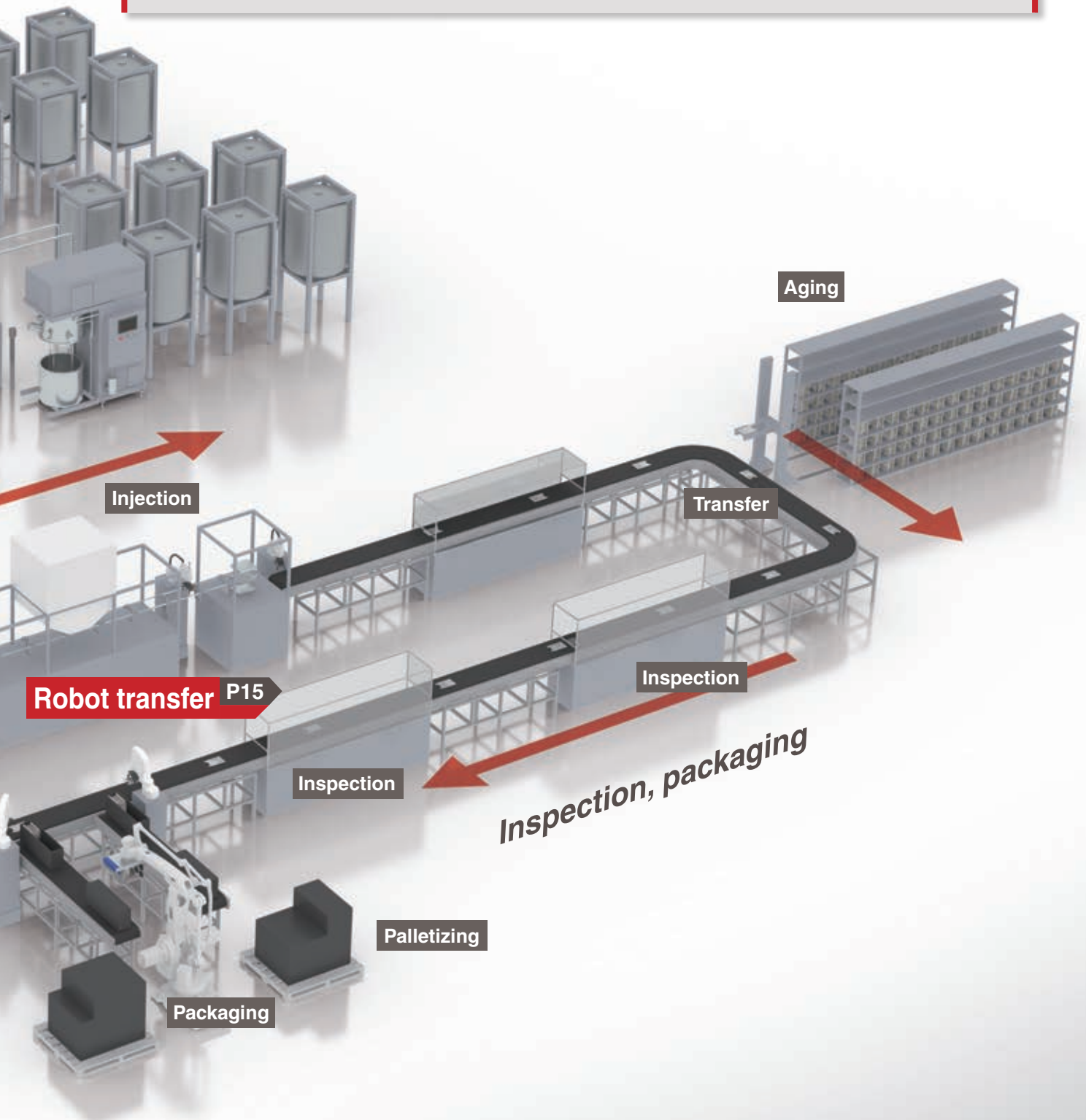
Lithium Ion Battery Production Line

Lithium ion batteries are manufactured on a large-scale production line consisting of electrode formation, stacking, inspection, packaging, and shipping processes.

Devices used in each process incorporate the technology of Mitsubishi Electric FA devices, including tension control, drive control, synchronous control, robots, and IT collaboration (e-F@ctory). This technology enables efficient production of high-quality lithium ion batteries.

Agitation P5

Slitter P9

Coating P7

Drying P7

Press

Transfer

Stock

Electrode formation

3-way seal

Winding P11

Stacking P13

Assembly

- The diverse lineup of devices supports various scales of production facilities.
- The high-speed, high-accuracy positioning achieved with the AC servo and the multi-axis synchronous control improves productivity.
- Stable system operation and high productivity are realized with the inverter's high-performance speed control and torque control.
- An unwinding and winding system is easily structured with the tension detector and tension controller.
- The lightweight robot body and compact arm help to save space.
- The Mitsubishi Electric FA Network contributes to stronger operation control and quality assurance system throughout the factory.

Aging

Injection

Transfer

Robot transfer P15

Inspection

Inspection

Inspection, packaging

Palletizing

Packaging

Agitator

The agitator mixes the battery materials coated onto the lithium ion battery's electrodes.

Have you ever faced these challenges?

Challenge 1 **Eliminating unevenness in battery materials**

Challenge 2 **Mixing with a suitable viscosity**

Challenge 3 **Easily moving the device according to the type of battery**
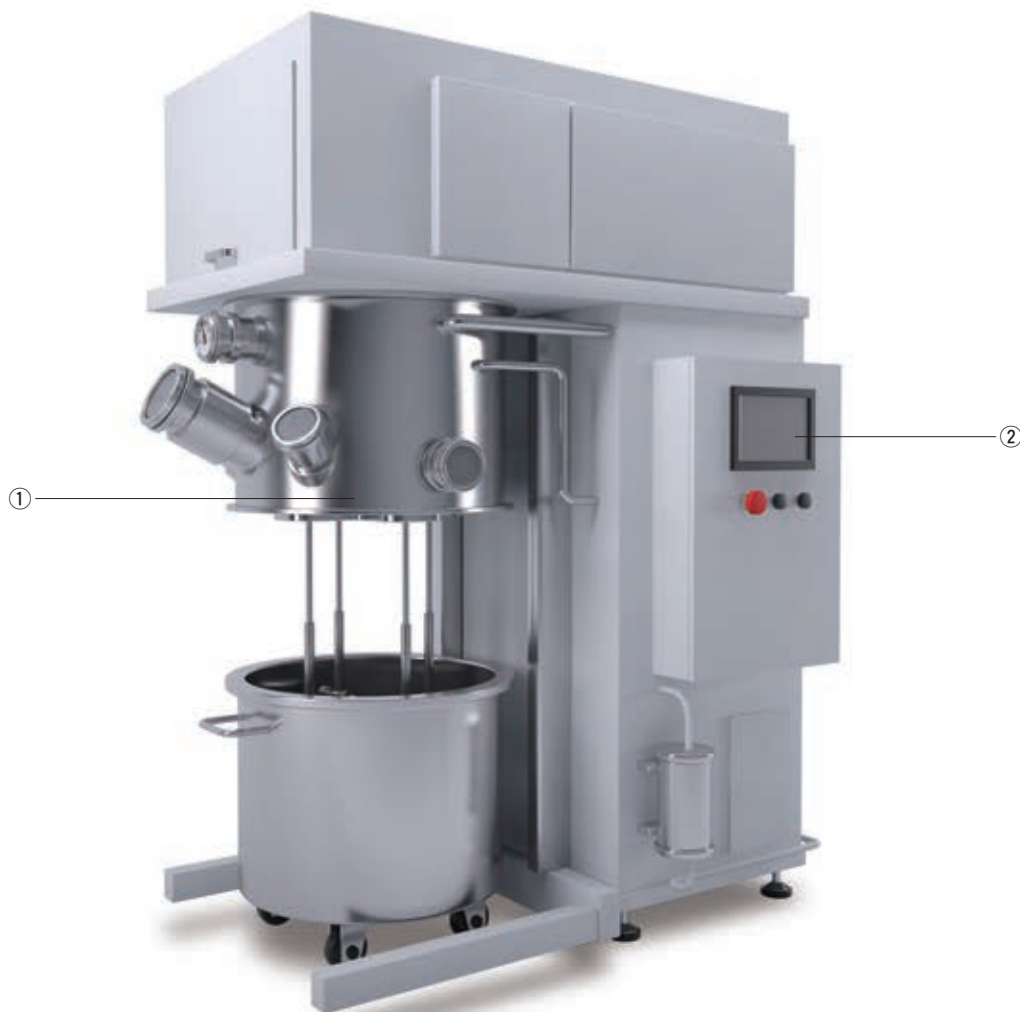
①**Agitator section**
The battery material is mixed so it is uniform.

②**Operation section**
The device is operated with the display (GOT) screen.
The operation status can also be displayed.
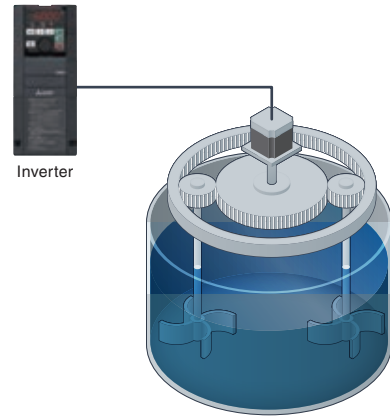
Solution 1

Stable speed control

The inverter enables speed control that is not affected by the quality or amount of battery material.

● The speed fluctuation rate is low, thereby ensuring operation with a stable speed.

Inverter

Speed fluctuation rate

Advanced flux vector control	1%
Real sensor-less vector control	0.5%
Vector control	0.01%

Point!!
» Motors of other brands can be driven with offline automatic tuning.
» Large capacity inverters are also available to support large-scale devices.

Solution 2

# Torque control during agitation

Even if the viscosity cannot be directly measured, the materials can be mixed to a suitable viscosity by monitoring the motor torque.

● The viscosity can be controlled with the motor torque that estimates using real sensor-less vector control and vector control.

● The load characteristic measurement function can monitor the load state, and quickly detect errors such as breakage of the agitator's shaft.

Load characteristic measurement function

Torque

Torque5

<Overload range>
Clogged filter
Clogged pipe, etc.

Torque4
Error detection width
Error detection width

Torque3
Torque2
Torque1

<Light load range>
Blade damage
Dry run, etc.

Output frequency

Min. frequency | 1/4 frequency range | 1/2 frequency range | 3/4 frequency range | Max. frequency

Point!!
» Real sensor-less vector control doesn't need an encoder.
» Perform preventive maintenance with the load characteristics measurement function.
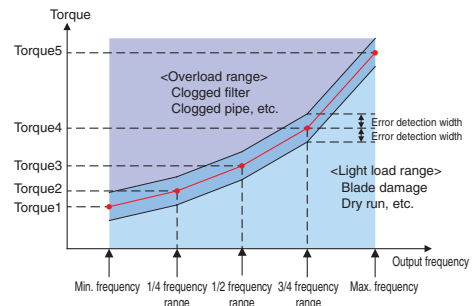
## Solution 3

Easily complete settings for setup

Easily set the blending ratio with the high-speed data logger unit.

● Recipe files are stored on the SD memory card using the FTP server function.

● The recipe file corresponding to the battery type is read out, and the blending ratio of materials to be added is controlled.

Material A 30% | Material B 30% | Material C 40%

Material A 40% | Material B 40% | Material C 20%

Blending ratio data is changed

Product 01 production

Product 02 production

	Recipe 01	Recipe 02
Material A	30%	40%
Material B	30%	40%
Material C	40%	20%

1 Recipe file with blending ratio data registered is stored

2 Blending ratio data is read out (Recipe 02 data is read out)

Point!!
» Using the MES interface, recipe data in the database can be imported at anytime.
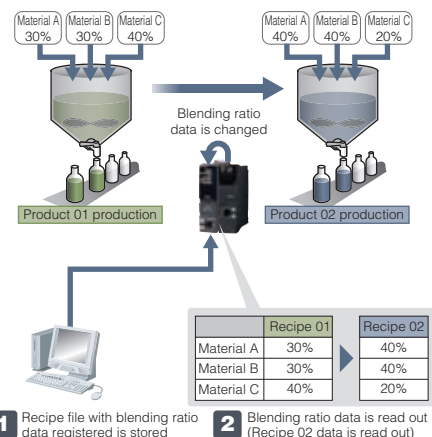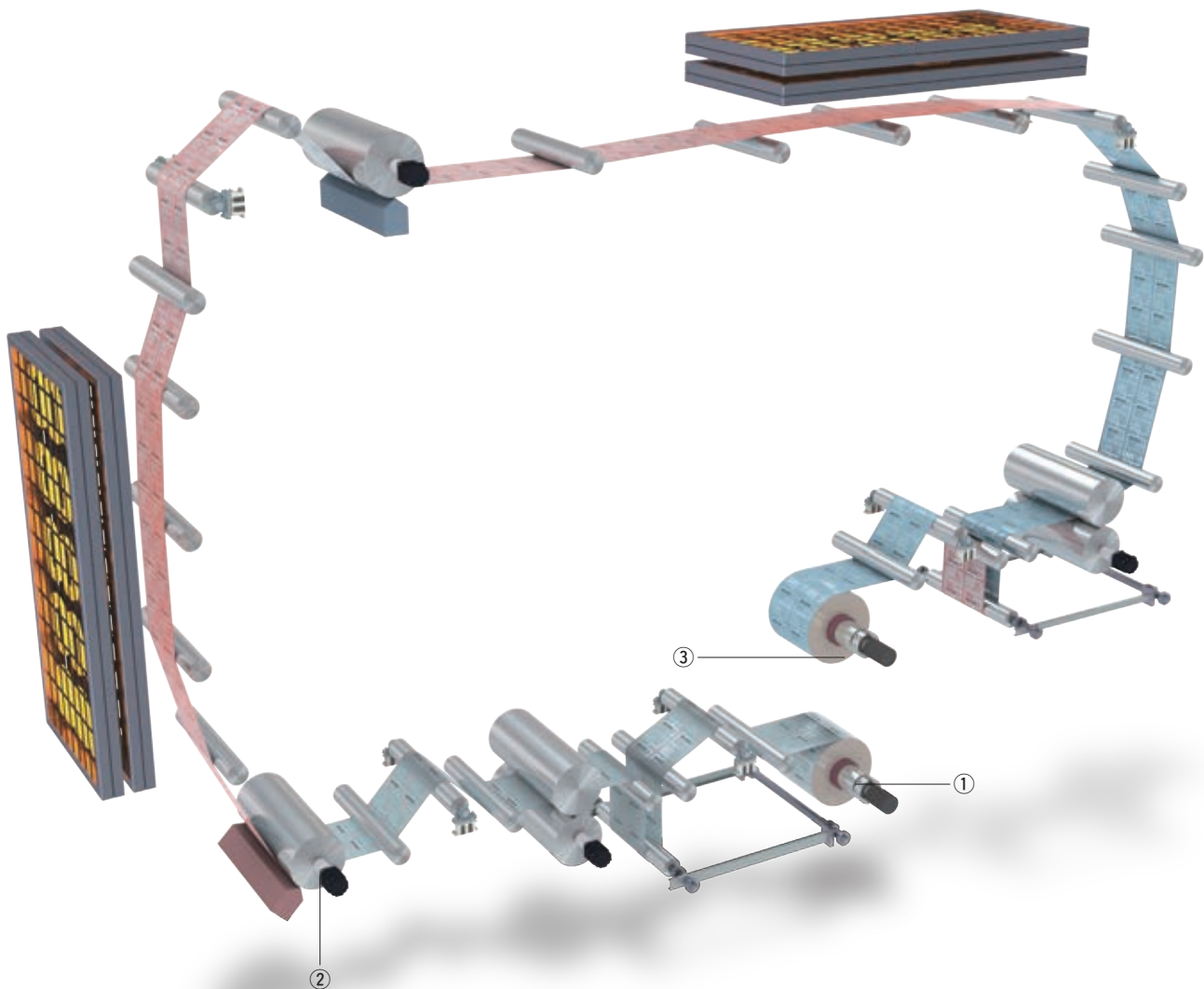
Coater

The coater applies aluminum foil oxide on the cathode, carbon coated copper foil on the anode, and a heat-resistant protective layer on the separator.

Have you ever faced these challenges?

Challenge 1 Suppressing tension fluctuation, and applying a uniform coat

Challenge 2 Performing stable tension control even when unwinding and winding the metal foil

Challenge 3 Realizing drive that is synchronized with a continuous processing interval using the same device

① **Unwinding of long material**
The tension is controlled to prevent unevenness in the coating material. Feedback control realizes highly precise tension control.

② **Coating section**
When the distance from coating to winding is long, the elasticity of the material can cause it to flap, so the tension is controlled at the center.

③ **Winding of long material**
If the maximum diameter and minimum diameter winding ratio is large, the winding finish can be improved by controlling the taper tension as necessary.
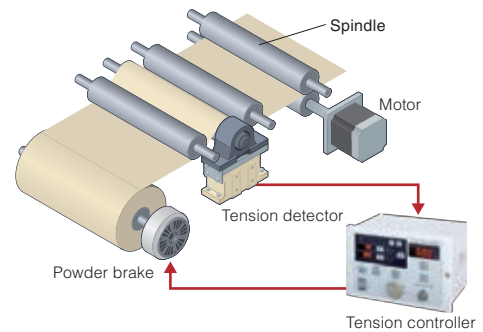
Simple tension control

Easily realize stable and highly accurate tension control using the tension controller.

● Highly accurate tension control is possible just by setting the parameters.

● Powder clutch and brakes, AC servo, and inverter (vector inverter) torque control is supported.

Point!!

» With the powder clutch, the tension can be controlled from an almost stopped line speed.

» The material's moment of inertia and line speed are calculated to suppress tension fluctuation during acceleration and deceleration.

Spindle

Motor

Tension detector

Powder brake

Tension controller

Stable speed control

Stable tension control at the reel shaft is possible by using the inverter (vector inverter).

● The speed control is stable since the motor load inertia ratio can be suppressed even for heavy reel shaft materials.

● By raising the rotation speed to the rated output range during use, the motor capacity can be reduced up to 40% compared to when using in only the constant torque range.

Point!!

» Easily control the speed even for reels of metal foil, etc., which have a large moment of inertia.

Inverter (vector inverter)
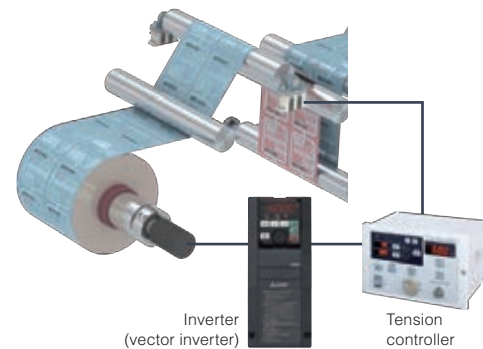
Tension controller

Highly accurate synchronous control

The MELSEC iQ-R series and servo system controller enable highly accurate motion control of multiple axes.

● The multiple drive axes in a system containing both servos and inverters can be synchronously controlled with a high accuracy by using a high-speed network.

Synchronization between modules

Multi-CPU

High-speed data communication

CC-Link **IE**

CC-Link **IE**

SSCNETIII/H

Point!!

» The AC servomotor is suitable for intermediate shaft control having a relatively small moment of inertia and high level of multi-axis synchronous control.
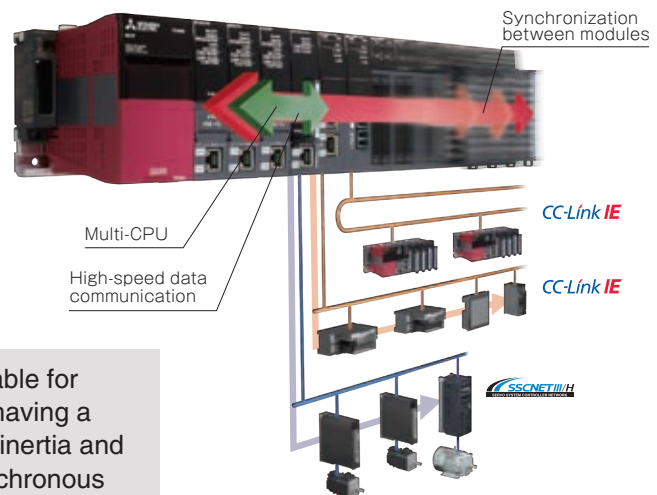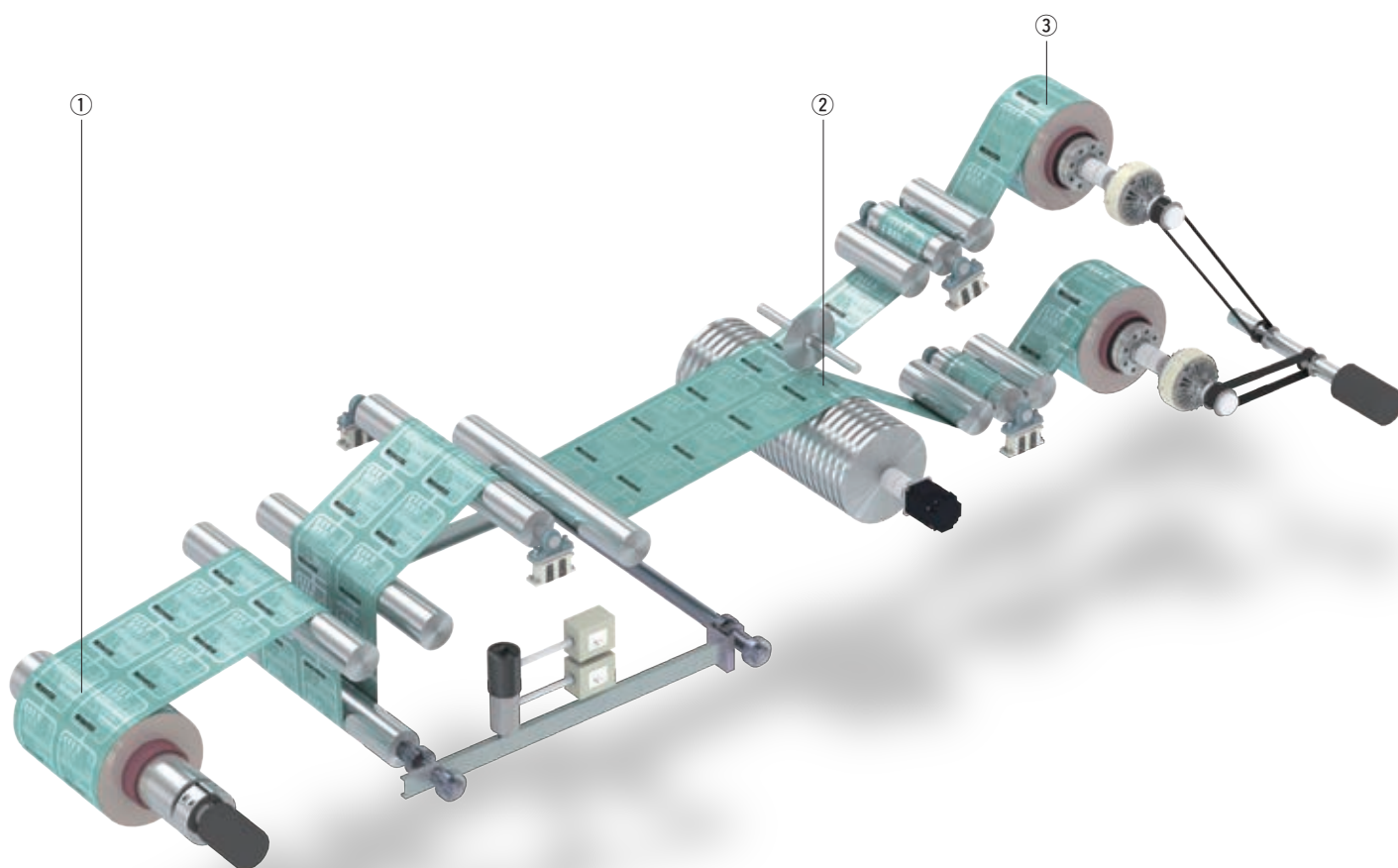
Slitter

The cathode, anode, and separator, which have been coated and dried, are each slit to a constant width using a cutter knife.

Have you ever faced these challenges?

Challenge 1 Easily realizing tension control

Challenge 2 Suppressing winding deviation or tightening

Challenge 3 Integrating the drive control for the entire system

①Unwinding of long material
The tension is controlled to keep the unwinding tension constant.

②Cutter knife section
A constant speed is maintained to ensure that the electrode material is cut to a uniform width.

③Winding of long material
If the maximum diameter and minimum diameter winding ratio is large, the winding finish can be improved by controlling the taper tension as necessary.

Simple wiring, and high accuracy tension control

With the powder clutch, high accuracy tension control can be realized inexpensively using a simple machine configuration and simple wiring.

● Multiple axes can be controlled with a single take-up motor.

● Low-cost and stable torque control characteristics can be realized.

Powder clutch

Tension detector

Power amplifier

Inverter

Motor

Tension controller
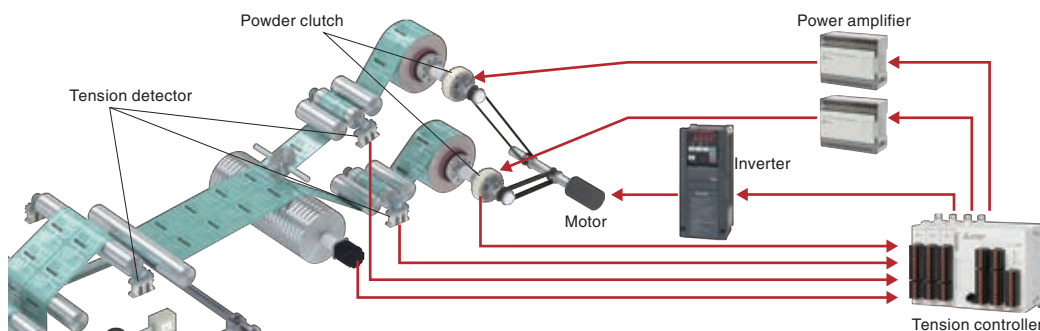
Point!! » The hollow shaft type powder clutch can be mounted on the take-up shaft, by that simplifying the machine configuration.

Simple taper tension control using just parameter settings

**The inertia compensation calculation, mechanical loss compensation calculation, and taper tension control can be realized easily just by setting the parameters for the tension controller.**

● The Roll to Roll dedicated inverter is equipped with functions for tension feedback control, dancer feedback control, and reel diameter calculation, etc.

Point!! » Taper tension control is also important because the line speed of the slitter is relatively fast, and winding can easily deviate if air gets into the material being wound.

Control tension(N)

Taper ratio

Taper tension control

Min. diameter

Reel diameter(mmϕ)

Max. diameter
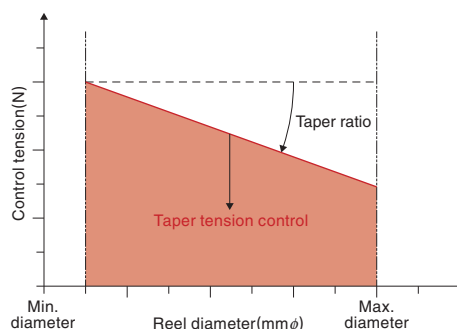
Simple synchronous control with a single unit

Synchronous control can be started easily just by setting the synchronous control parameters and turning the synchronous control start signal ON.

● Synchronous control including the servo amplifier and inverter is possible.

**Point!!** » Complicated programs are not needed.

Winder

The cathode, anode, and separator are stacked and wound into a cylindrical or rectangular shape to manufacture the battery cell.

Have you ever faced these challenges?

Challenge 1 Difficulty creating a cam for flat winding

Challenge 2 Suppressing the positional deviation between the cell and separator

Challenge 3 Difficulty adjusting the gain for tension control

① ② ③
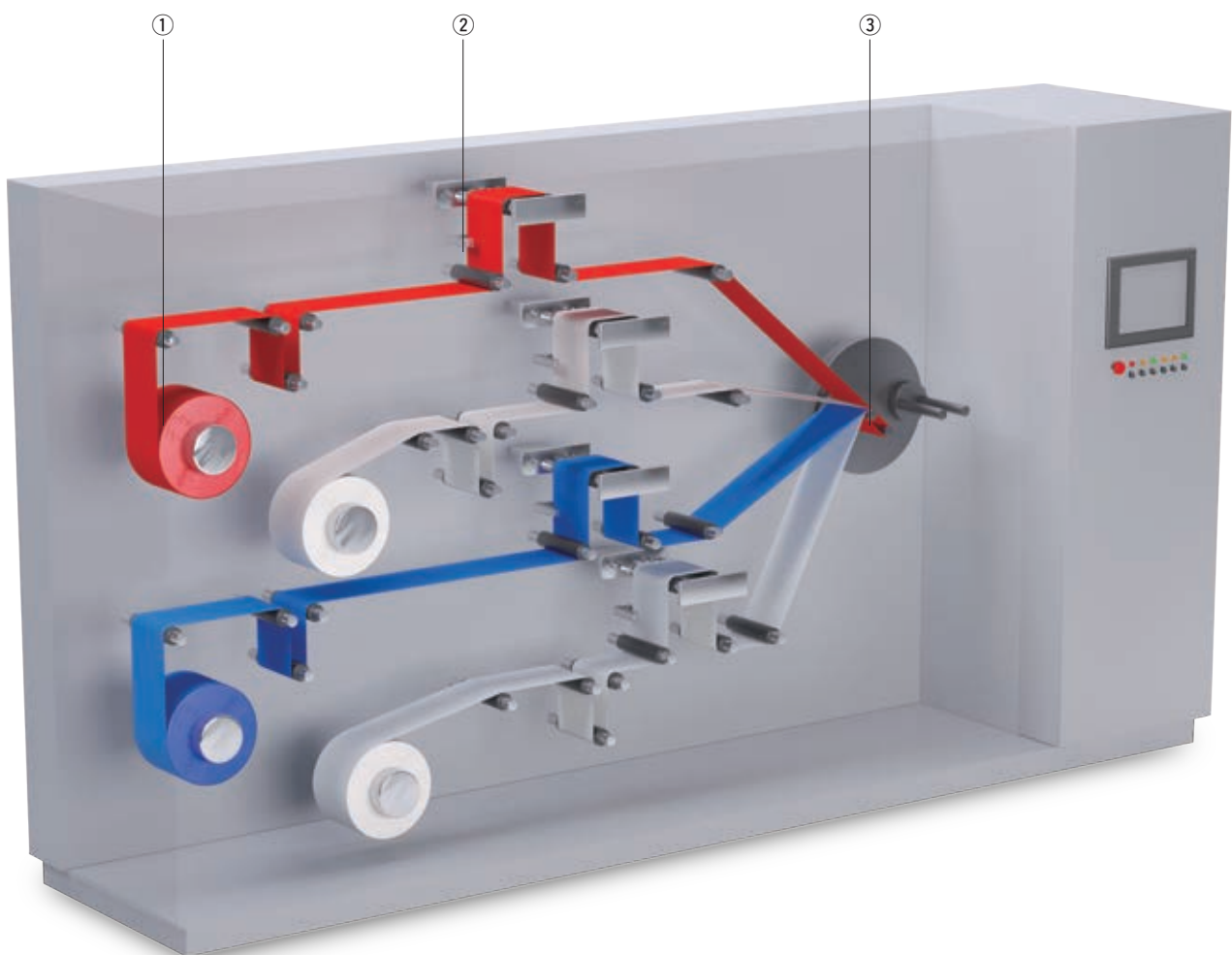
①Unwinding of long material
The tension fluctuation is suppressed while unwinding the electrode and separator.

②Meandering compensation
The edge sensor suppresses meandering, and keeps the edges of the wound material flat.

③Winding of electrode and separator
The electrode and separator are wound up while suppressing the tension fluctuation.
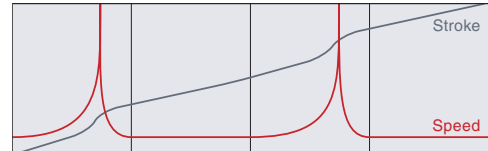
Solution 1 — Automatic generation of cam for flat winding

The cam pattern can be automatically generated so that the material feed rate is constant.

● By operating with an automatically generated cam, the material can be wound while suppressing the tension fluctuation.
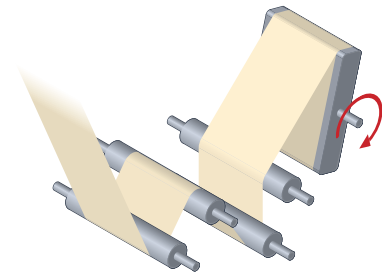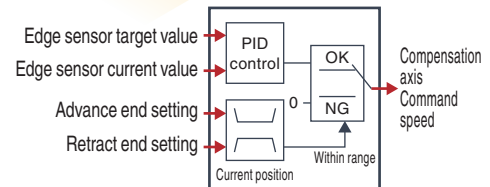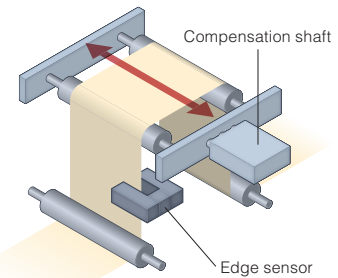
Cam pattern for flat roll

Stroke

Speed

Point!! » Cam is automatically generated so there's no need for difficult calculations.

Solution 2 — Meandering compensation function

An edge sensor is installed and the position is compensated with PID control so that the winding finish is neat.

● The work edge is compensated to the value measured by the edge sensor.

Compensation shaft

Edge sensor

Edge sensor target value → PID control → OK
Edge sensor current value →
Advance end setting → 0 → NG
Retract end setting → Within range
Current position → Compensation axis Command speed

Point!! » Compensation shaft's command is automatically output.

Solution 3 — Tension control automatic adjustment function

The appropriate gain for tension control is automatically adjusted so that the tension stays constant.

● The PI gain for tension and dancer feedback control is easily and automatically adjusted with one-touch operations.

Before adjustment — Dancer position — Time

After adjustment — Dancer position — Time
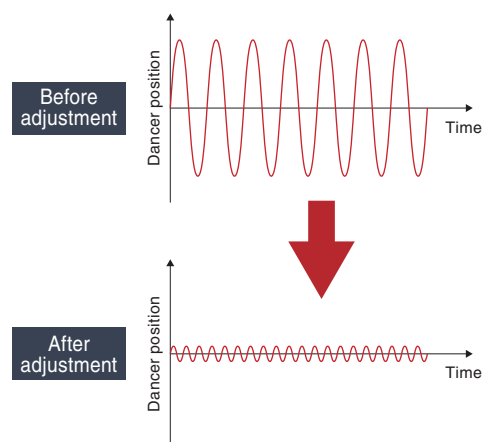
Point!! » The gain for tension control can also be adjusted easily.

The above function can be realized easily with the FA Application Package "iQ Monozukuri CONVERTING". Contact Mitsubishi Electric for details.

iQ Monozukuri

Stacking

The cathode, anode, and separator are stacked to create the battery cell.

Have you ever faced these challenges?

Challenge 1 Finding optimum methods for controlling the tension for the manufacturing process

Challenge 2 Keeping the arm from vibrating when setting the electrodes

Challenge 3 Increasing the device performance

①Removing and stacking the electrodes
The electrodes are removed from the stocker, and stacked in the order of cathode, separator, anode, and separator.

②Winding of separator
The tension is kept constant while unwinding so that that wrinkles do not form when the separator is zigzag folded. A tension detector may be used, or a dancer roll may be used.
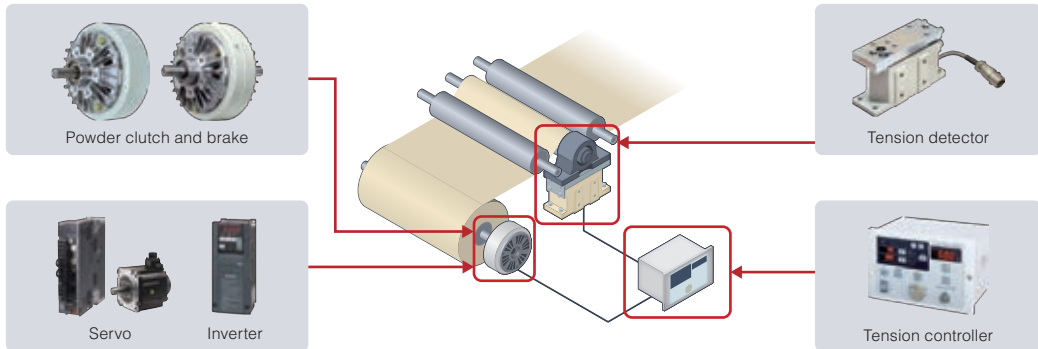
Solution 1

Realize tension control with various devices

A variety of solutions for tension control are available such as methods to change the unwinding speed using a tension detector, and methods to directly control the torque of the unwinding shaft motor.

● The optimum device can be selected according to the system.

Powder clutch and brake

Servo   Inverter

Tension detector

Tension controller

**Point!!** » Diverse lineup of products to realize tension control.

Solution 2

Suppress vibration with vibration suppression control

With the servo amplifier's advanced vibration suppression control II, the two types of vibration generated at the end of the arm and at the device body can be suppressed simultaneously.

● This function is effective for suppressing relatively low vibration of 100Hz or less.

No vibration suppression control

Advanced vibration suppression control II

Residual pulse
Torque
Speed command
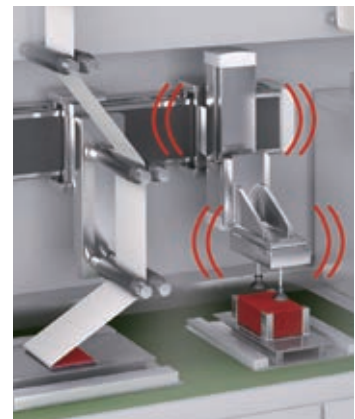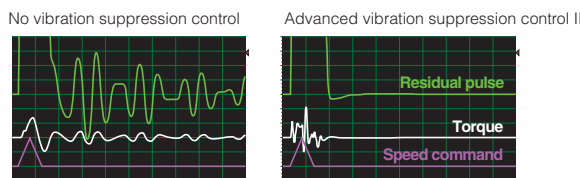
Point!! » The settling time can be reduced by suppressing the residual vibration.

Solution 3

Shorten cycle time with electronic cam

When the electrode pick & place operation and the separator folding operation are set with the servo system controller's electronic cam, the cycle time can be shortened compared to when executing the operation only with positioning control.

● Each arm will not interfere if the cam curves do not intersect.

Cathode arm horizontal position
Separator horizontal position
Anode arm horizontal position

Position
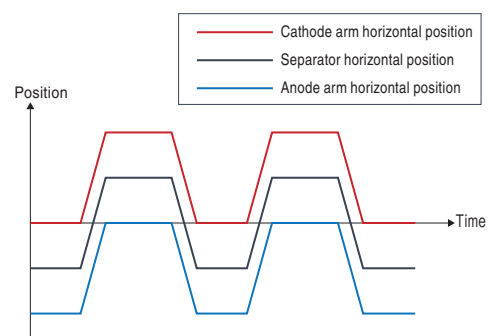
Time

Point!! » The cycle time can be shortened further by using advanced synchronous control.

ROBOT
Robot transfer

By using a robot to transfer workpiece between processes, the freedom of device layout increases, and man-hours for design, system startup, and adjustment can be reduced.
Robots can also flexibly handle multi-product production.

Have you ever faced these challenges?

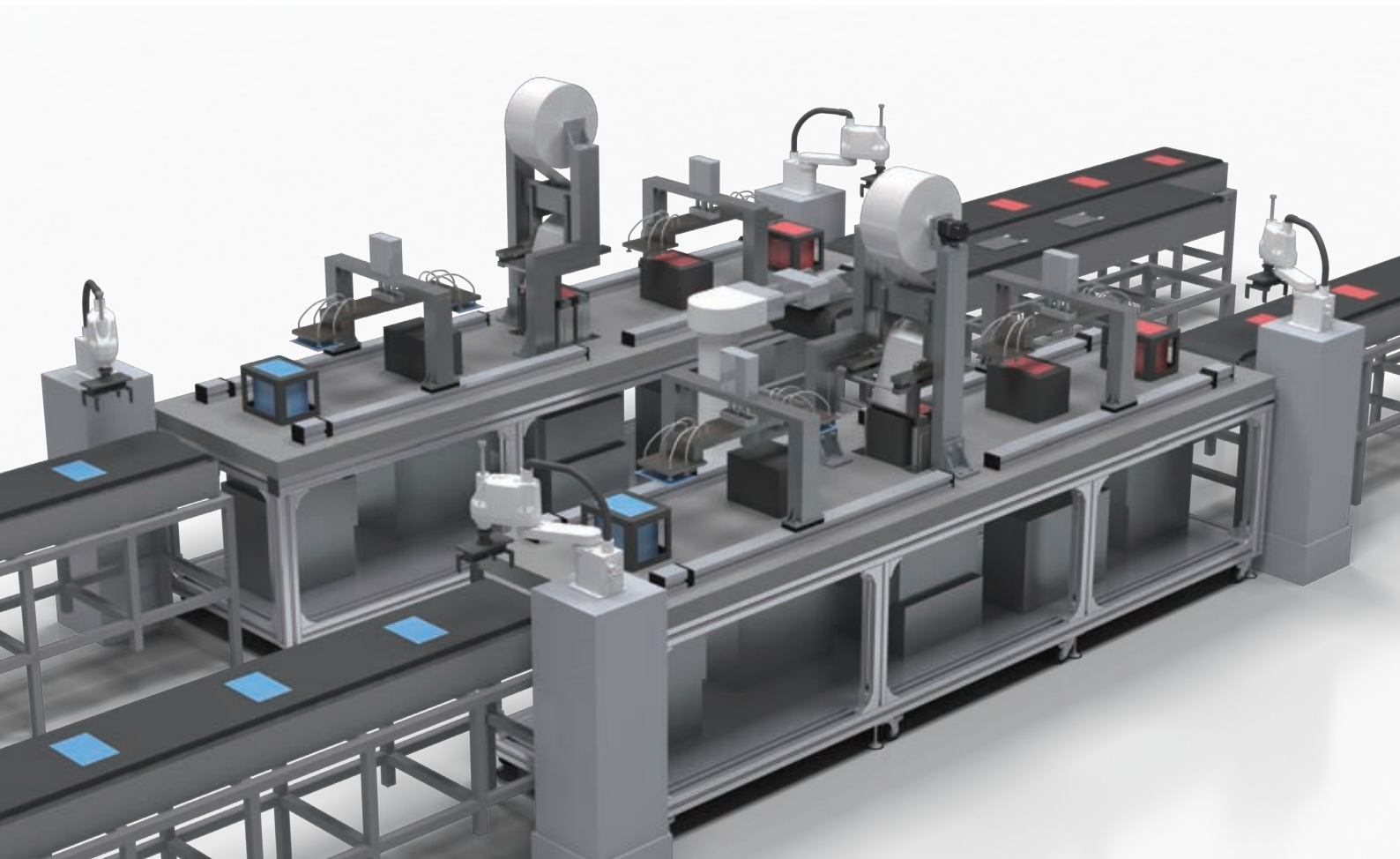**Challenge 1** Suppressing the robot vibration while achieving high-speed transfer

Challenge 2 Easily realizing coordination between the vision system and robot

Challenge 3 Preventing workpiece damage when robot collides

Space-saving compact arm
Space required for J3(Z) axis section 512mm/560mm (3CH/6CH body)

Lightweight robot body
14kg/17kg/18kg (3CH/6CH6020/6CH7020 body)

High-speed movements for high productivity
Cycle time: 0.44s/0.41s/0.43s (3CH/6CH6020/6CH7020)

Parallel input/output interface as standard
No. of I/O points: 32 input points/32 output points

Specifications with bellows and high weight capacity (RH-3CH) available
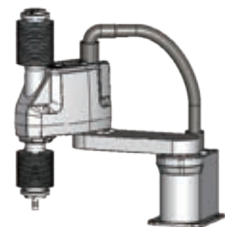
Bellows specifications

Specifications

			RH-3CH4018	RH-6CH6020	RH-6CH7020
Weight capacity		kg	Max. 3 (rating 1)	Max. 6 (rating 2)	
Arm length	No. 1	mm	225	325	425
	No. 2	mm	175	275	
Max. reach point	Reach	mm	400	600	700

Solution 1 — Functions to improve robot capabilities

Optimum motor control tuning can be set automatically with the operation mode setting function.

- ● The high-speed positioning/path priority/vibration suppression control modes can be set in the program.
- ● Optimum motor control matching to the robot's motion position, posture, and load conditions can be set.

Point!! » Optimum for linear movements and sealing work that require accuracy.
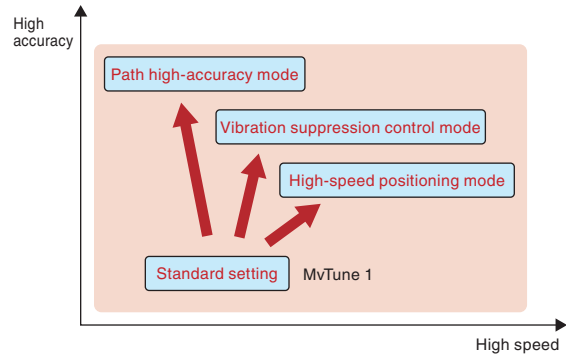

High accuracy

- Path high-accuracy mode
- Vibration suppression control mode
- High-speed positioning mode
- Standard setting   MvTune 1

High speed

Solution 2 — Simple vision setting

The vision system can be started up in a short time using the 2D calibration function.

- ● Calibration of various vision system brands can be set. The camera's calibration data is calculated with RT-TooBox3, and the results are stored in the robot controller.
- ● Programming can be completed easily using the sample program for vision alignment.

Point!! » Calibration can be set for all vision system makers.

Solution 3 — Reduce workpiece and robot damage

**The collision detection function can suppress workpiece damage caused when the workpiece and target interfere.**

- ● Collision of the robot arm is detected during teaching or operation, and damage to the robot unit or hand is reduced.
- ● The detection level can be changed according to the protection target.

Point!! » Tooling costs and line stoppage time can be reduced.

Error

Collision
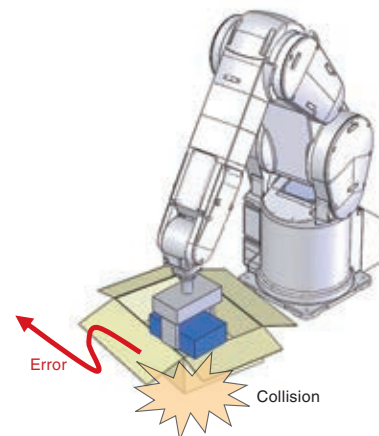
FA-IT Collaboration

Mitsubishi Electric, the expert in production sites, proposes the optimum system for lithium ion battery production lines.
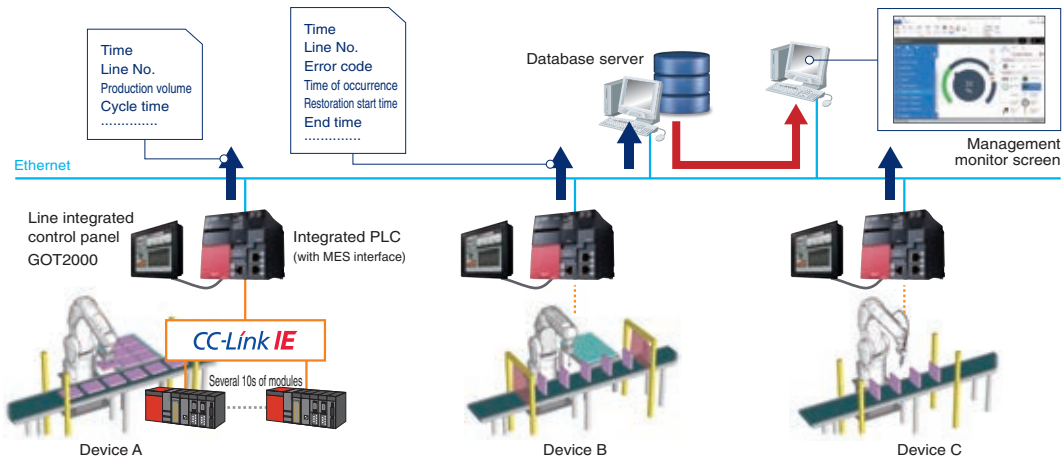
Operation results management system

Easily manage the production volume and cycle time operation results

This system manages each line's operation results (production volume, cycle time), and manages the error history.
The device information is all gathered in the integrated PLC via the network, and accumulated in the database server by the MES interface.

[Effect of introduction]

● Operation rate can be increased as devices are optimally operated with operation results management.
● With error history management, devices can be restored quickly when trouble occurs, and preventive maintenance can be performed.

Time
Line No.
Production volume
Cycle time
....

Time
Line No.
Error code
Time of occurrence
Restoration start time
End time
....

Database server

Management monitor screen

Ethernet

Line integrated control panel GOT2000

Integrated PLC (with MES interface)

CC-Link IE

Several 10s of modules

Device A

Device B

Device C

Quality control system (traceability, factor analysis)

Accumulate device numbers, operation history, and quality data

This traceability system can accumulate the facility number used in each production process, the operation history, and quality data.
Each time a workpiece (engine) passes through each process, the serial No., processing history, and inspection history, etc., are sent to the database.

[Effect of introduction]

● Faults can be handled swiftly using the traceability data
● The operation status and quality information can be managed in detail

Time
Serial No.
Facility No.
Tool status
Processing environment
Inspection results
....

Database server

Management monitor screen

Ethernet

SQL

Sent when process is passed

Sent when inspection is completed

Integrated PLC (with MES interface)

Process A

Process B

Inspection process
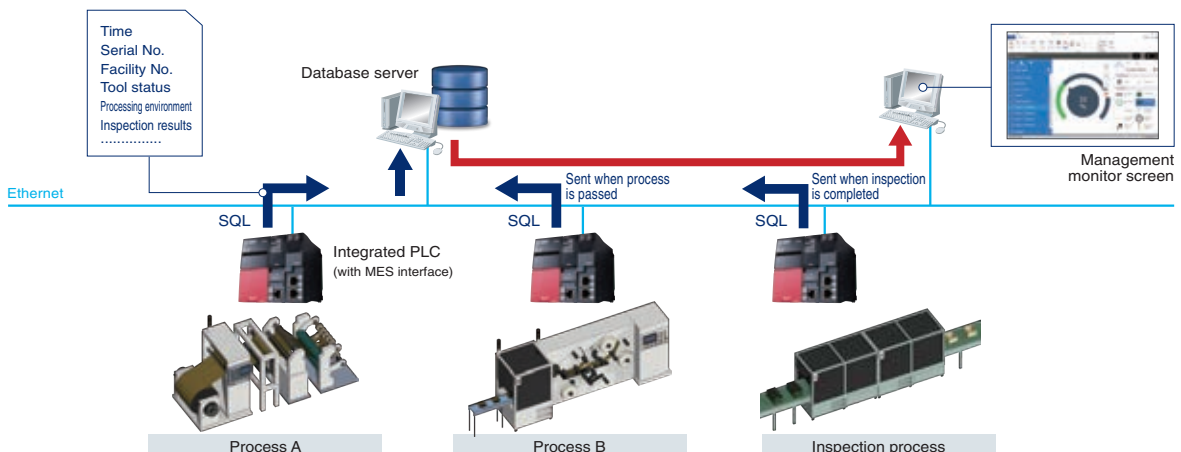
Alarm information management system

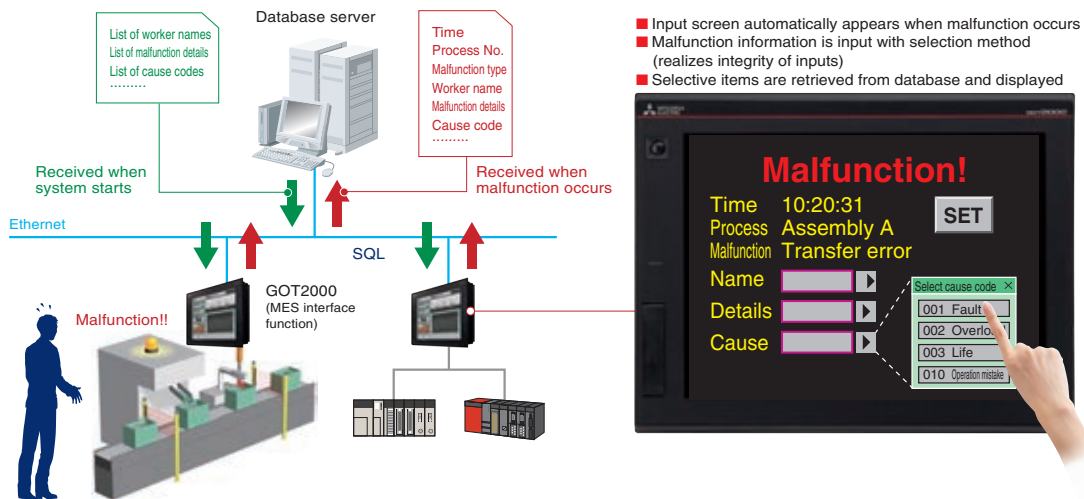**Information on malfunctions is stored, and input and sent from the display unit when a problem occurs.**

The alarm information management system stores information (process name, malfunction details, cause) of malfunctions that occur in the manufacturing line.

When the system is started up, the recipe information (worker name, malfunction details) are read in, and when a problem occurs, the detailed information can be input and sent from the display unit.

[Effect of introduction]

● Accurate and fast comprehension and recording with paper-less system

● Improved maintainability by managing selected items with server

List of worker names
List of malfunction details
List of cause codes
·········

Database server

Time
Process No.
Malfunction type
Worker name
Malfunction details
Cause code
·········

Received when system starts

Received when malfunction occurs

Ethernet

SQL

Malfunction!!

GOT2000
(MES interface function)

■ Input screen automatically appears when malfunction occurs
■ Malfunction information is input with selection method (realizes integrity of inputs)
■ Selective items are retrieved from database and displayed

Malfunction!
Time   10:20:31
Process   Assembly A
Malfunction Transfer error
Name
Details
Cause

SET

Select cause code ✕
001 Fault
002 Overlo
003 Life
010 Operation mistake

Mitsubishi Electric's
Roll to Roll Solutions

With Roll to Roll control, the tension, line speed, and tension controller methods required for the manufacturing system differ according to the material.
Mitsubishi Electric's FA device lineup has products to realize various required specifications and control methods.

Powder clutch / powder brake

● High accuracy tension control of the winding shaft is possible easily at a low cost.
● Suitable for tension within the range of 50N to 1000N, and line speeds of 200m/min or less.
● The tension can be controlled from 0m/min by using the powder clutch and geared motor together.
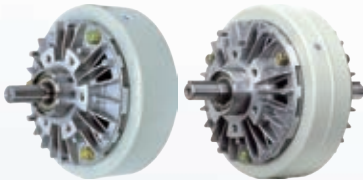
AC servo

● Winding and unwinding control is possible with speed control or torque control.
● A wind range of servo motor capacities from 0.1kW to 55kW is supported.
● The lineup includes the rotary type servomotor, linear servo motor, and direct drive motor.
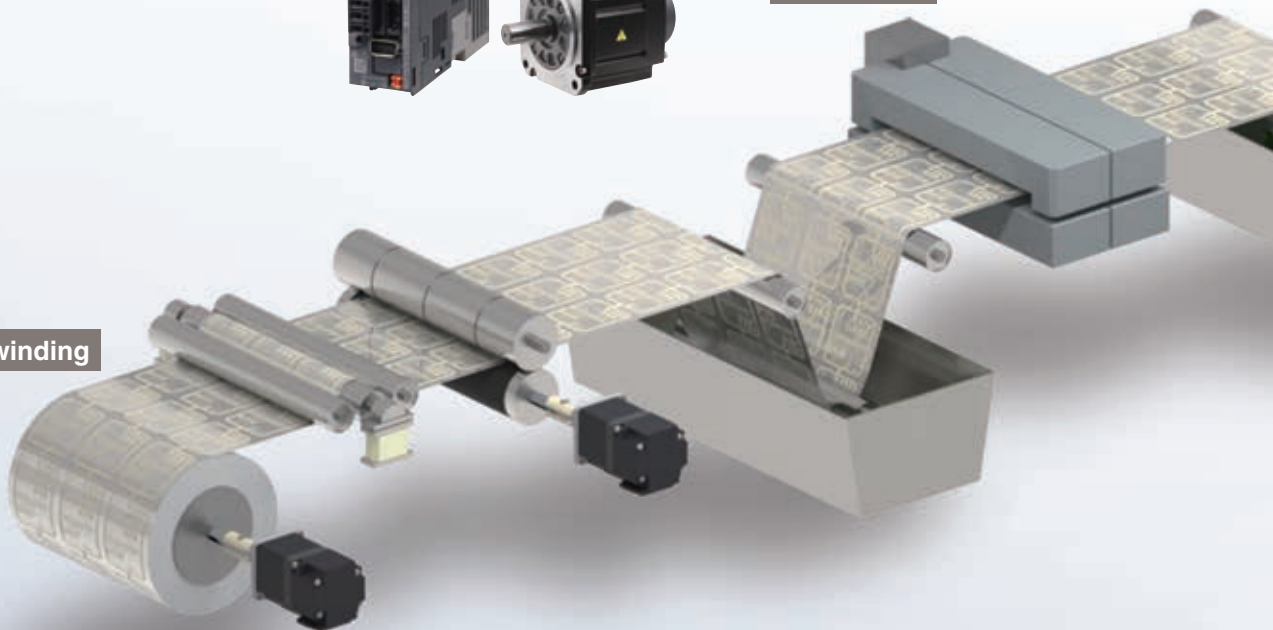
Inverter

● Both speed control and torque control are supported.
● Compatible with 0.4kW to 500kW capacities.
● Suitable for winding shaft control.

Processing

Unwinding

Programmable logic controller

- Feedback control with PID operation, and winding diameter calculation control using high-speed counter are flexibly supported.
- Control information can be communicated with host controller using diverse communication functions.

Servo system controller

- Each process can be synchronized with synchronous control.
- Advanced motion control, such as interpolation control and speed/torque control, is supported.
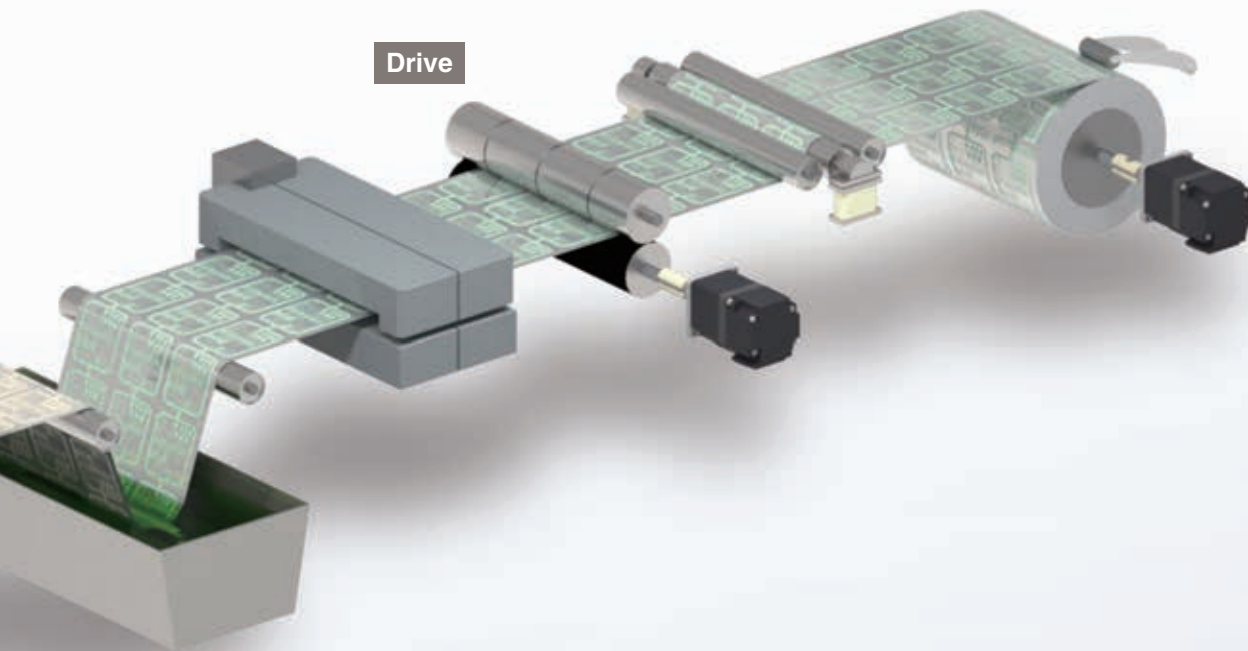
Tension controller

- Tension control can be realized easily just by setting the parameters.
- Communication function is supported.

Winding

Drive

Display unit (GOT)

- When connected with FA devices in the manufacturing system, devices can be monitored and changed.
- The facility can be monitored by displaying the system operation status and alarm occurrence state on the screen.

Tension meter

- The tension meter amplifies signals from the tension detector allowing simultaneous tension display and analog output.

Tension detector

- Supports rated loads of 50N to 2000N [1]
- Differential transformer type sensor with high mechanical shock and reliability is adopted

  [1]. Rated load of 50N to 500N is standard specification for flange-type tension detector lineup

Related materials

Catalogs for various FA devices required for lithium ion battery solutions are available.

■PLC, display, CC-Link IE

MELSEC iQ-R Series iQ Platform-compatible PAC	MELSEC iQ-F Series iQ Platform-compatible PLC	GOT2000 Series Mitsubishi Graphic Operation Terminal	Ethernet-based Open Network CC-Link IE Product Catalog
L(NA)08298	L(NA)08394	L(NA)08270	L(NA)08111

■Servo, inverter, robot

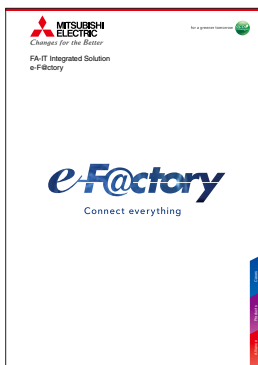|			
SERVO SYSTEM CONTROLLERS MELSEC iQ-R SERIES/MELSEC iQ-F SERIES	SERVO AMPLIFIERS & MOTORS MELSERVO-J4	INVERTER FR-A800	MITSUBISHI ELECTRIC INDUSTRIAL ROBOT FR Series
L(NA)03100	L(NA)03058	L(NA)06075	L(NA)09091

■e-F@ctory

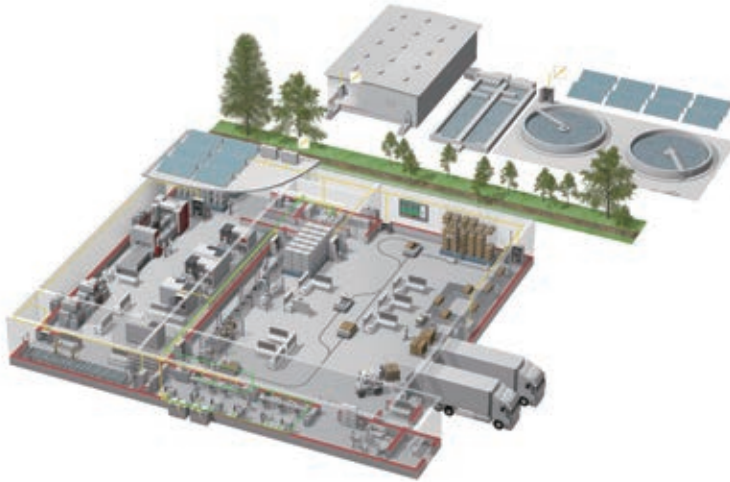FA-IT Integrated Solution e-F@ctory

L(NA)16012

Various materials such as catalogs, manuals, software, and CAD data, can be downloaded.

YOUR SOLUTION PARTNER

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

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)

Robots: SCARA, Articulated arm

Processing machines: EDM, Lasers, IDS

Transformers, Air conditioning, Photovoltaic systems

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.

* Not all products are available in all countries.

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