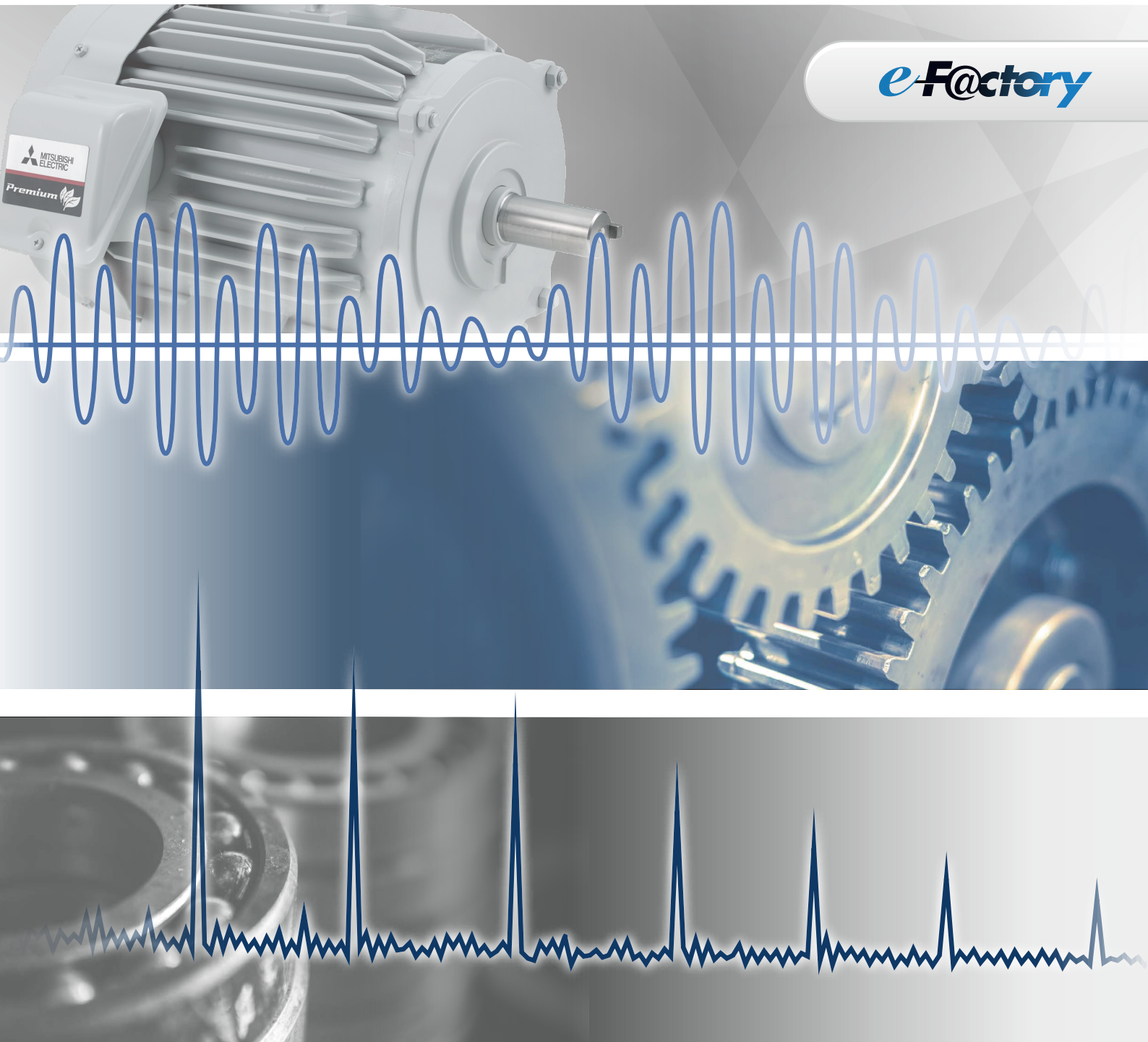


# FA Application Package

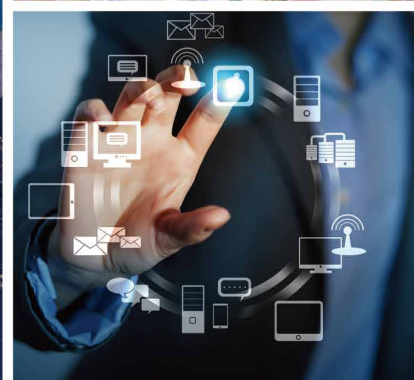
## iQ Monozukuri Rotary Machine Vibration Diagnosis



**e-Factory**

- Easy to introduce a diagnosis system
- Presume the faulty area according to the accurate diagnosis
- Easy to detect anomalies by using the MT method

# 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**

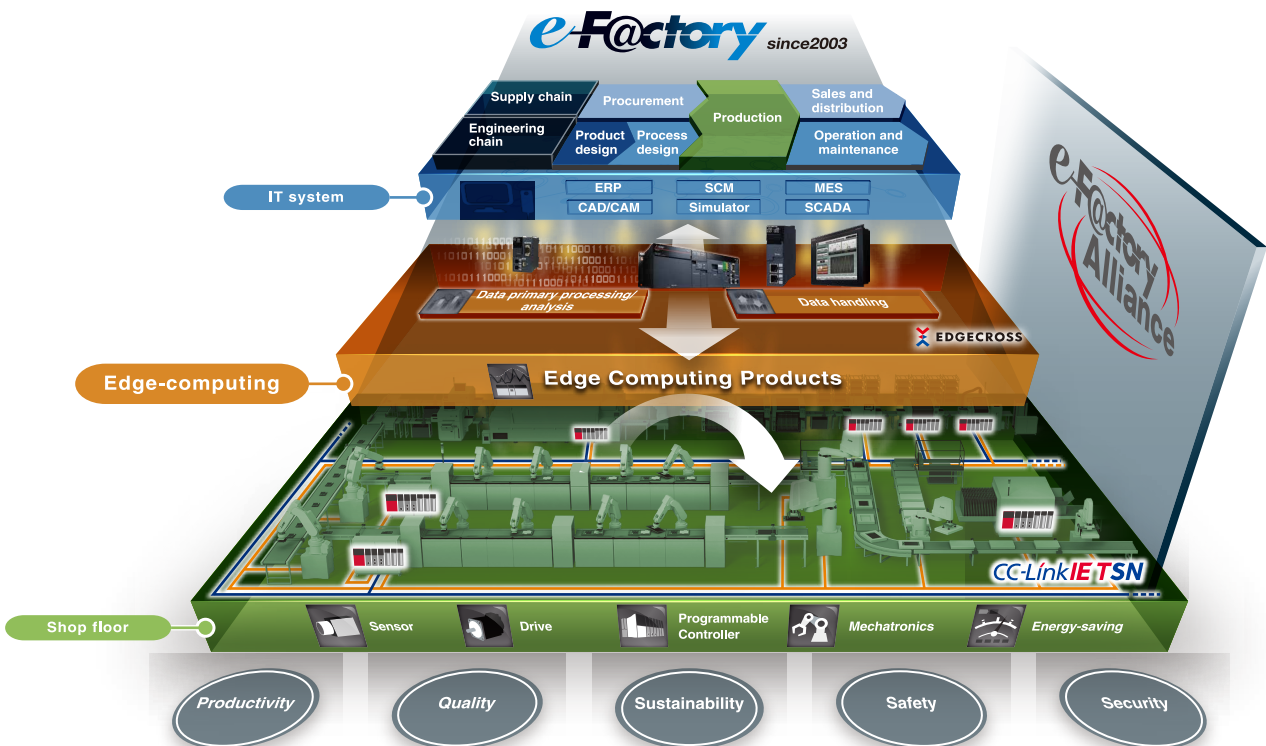
Commercial and consumer-centric equipment, products and systems.

### **Industrial Automation Systems**

Maximizing productivity and efficiency with cutting-edge automation technology.

# e-F@ctory

e-F@ctory is a concept for a further step on "Monozukuri", which reduces the total cost for development, production, and maintenance, and continuously supports improvement activities of the customer by utilizing the FA technology and IT technology.



In the increasingly complex manufacturing sites, coordination between "Man" and "Machine" through the best use of information from the production site is a key concept.

Productivity and quality can be improved not only with the information obtained from the devices at the production site, but the improvement triggered by on-site notice and flexible human actions. Similarly, automatic adjustment of equipment based on the information recognized by human is indispensable for the promotion of automation.

We have realized the "Next-generation manufacturing" through the use of the "e-F@ctory" information proposed by Mitsubishi Electric, the effective and flexible manufacturing realized through the coordination between man and machine, and the optimization of the production site, and the entire supply chain and engineering chain.





## " iQ Monozukuri " is a step toward achieving e-F@ctory.

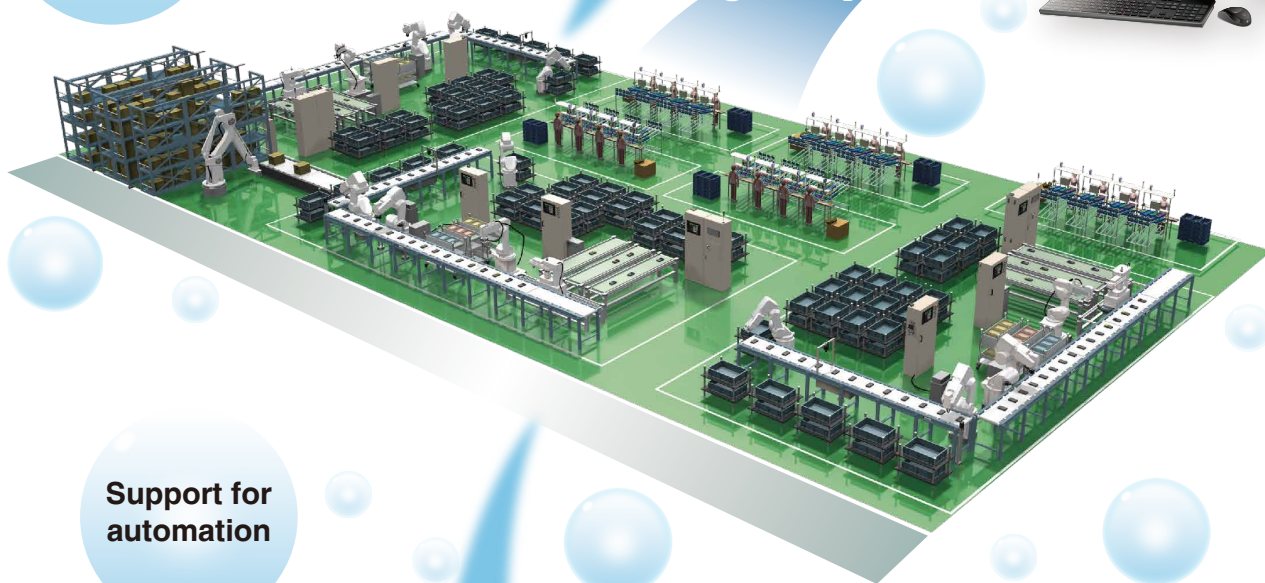
The FA application package "iQ Monozukuri" is a product that has been optimized through the accumulation of knowhow, which supports various problem solutions of the customer during manufacturing, and enables effective system installation, expansion, and operation/maintenance.

### What iQ Monozukuri provides

- A wide range of applications prepared by "process", "usage", and "equipment"
- Know-hows and ideas about "Monozukuri" accumulated by Mitsubishi Electric and our partners over the years
- System consisting of highly reliable FA products manufactured by Mitsubishi Electric and partner companies

Support for  
human work

Edge computing



Support for  
automation

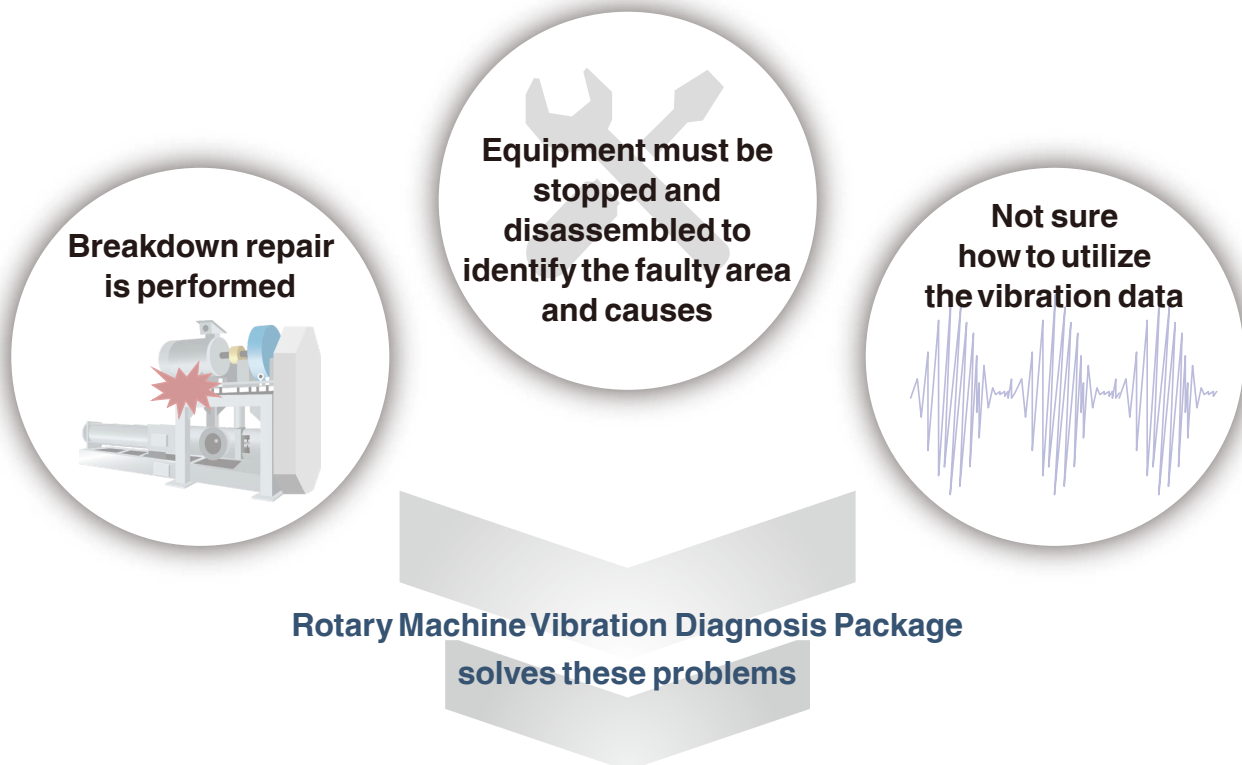
### FA products

Mitsubishi Electric has been making persistent technical innovations from small-batch production systems to the developed flexible production systems in order to comply with the needs of the customers. It offers a wide range of extremely diverse FA products from control devices, driving devices, energy-saving support devices, and power distribution control devices to industrial mechatronics. It plays an active part in every production site for the purpose of automation, energy-saving, and quality improvement.



# FA Application Package iQ Monozukuri Rotary Machine Vibration Diagnosis

"iQ Monozukuri Rotary Machine Vibration Diagnosis" is an application that helps to visualize the equipment condition and presume the faulty area by collecting, analyzing, and diagnosing vibration data from equipment with rotating machinery.



- Prevent a breakdown
- Reduce downtime
- Improve maintenance efficiency
- Extend periodic maintenance intervals
- Reduce maintenance costs
- Improve equipment reliability

No need to stop equipment to find and identify faults, which leads to further  
**"improvement of productivity and quality".**

# Application Example

By introducing "iQ Monozukuri Rotary Machine Vibration Diagnosis" to equipment with rotating machinery, it helps to solve problems at various production sites.

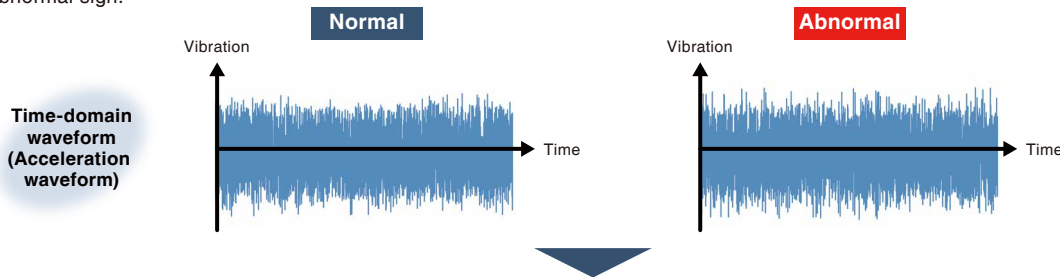
Examples of applicable equipment: Equipment with rotating machinery such as a motor, fan and blower, compressor, reduction and increase drive, conveyor, and converting machine

(Equipment that generates impact vibration, such as press machines, and equipment that generates vibration due to self-propelled operation, such as AGVs, are excluded.)

## Case 1 Detect an abnormal sign and perform maintenance before failure

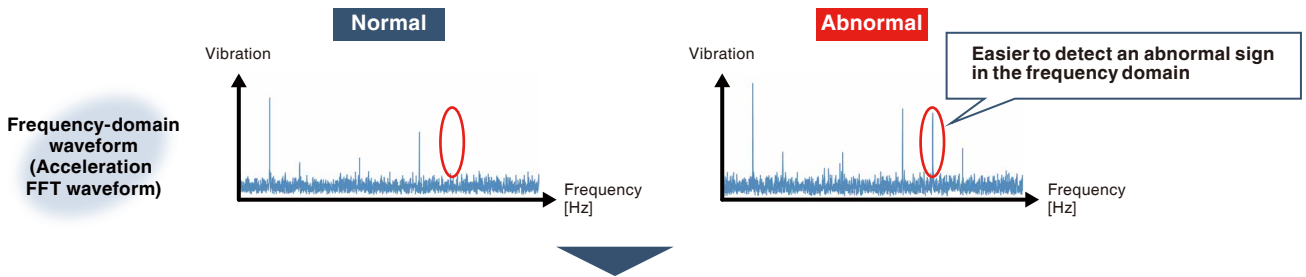
The changes in the equipment condition can be observed by monitoring the vibration from equipment.

However, the difference between the normal and abnormal waveforms is unclear in the time domain, making it difficult to detect an abnormal sign.



By using Rotary Machine Vibration Diagnosis...

### Detect an abnormal sign by converting the time-domain waveform to the frequency-domain waveform



### Presume the faulty area according to the simple diagnosis and accurate diagnosis

#### Simple diagnosis

helps determine if there is a fault in equipment

**There is a fault!**

ALM	Simple diagnosis item	State/Measurement value	
	Vibration severity		
	Velocity RMS value (mm/s)		
ALM	Simple diagnosis item	Setting value	
	Acceleration FFT Guard band monitoring width (%)	130	
	Acceleration FFT Guard band cont. excess pts. (points)	100	
ALM	Simple diagnosis item	Measurement value	Threshold value
OK	Acceleration waveform zero peak (m/s <sup>2</sup> )	155.30	129.25
	Acceleration waveform RMS (m/s <sup>2</sup> )	10.85	10.95
	Acceleration waveform Crest factor	14.31	23.67
	Acceleration FFT Overall (m/s <sup>2</sup> )	9.78	11.66
	Velocity FFT Overall (mm/s)	22.89	27.32

#### Accurate diagnosis<sup>\*1</sup> helps presume the faulty area

**A sign of inner race damage is detected**



ALM	Accurate diagnosis item	Measurement value	Amplitude (mm/s <sup>2</sup> )	Threshold value
	Unbalance/Misalignment	1.48	1.88	
	Misalignment(x2)	0.56	0.65	
	Misalignment(x3)	0.57	0.80	
OK	Inner race damage	0.65	0.63	
	Outer race damage	5.98	6.91	
	Rolling element damage	1.19	1.43	
	Cage damage	0.89	0.93	
	Gear teeth damage	0.42	0.59	
	Gear teeth damagex2	0.18	0.34	
	Fan damage	0.57	0.60	
	User setting1			
	User setting2			
	User setting3			
	User setting4			

\*1: Accurate diagnosis requires specification value information of the components.

Unplanned breakdowns can be prevented and downtime can be reduced by performing maintenance at the location with an abnormal sign

## Case 2 Detect a fault in equipment without knowledge of vibration diagnosis

Vibration analysis requires a certain level of expertise.

In addition, specification values and other data of components are also required to perform the accurate diagnosis and presume the faulty area.



By using Rotary Machine Vibration Diagnosis...

### Detect "unusual" conditions by MT method\*1 diagnosis

Generate **unit space** by collecting more than the required amount of vibration data under **normal** conditions before diagnosis.

	POA1 [m/s <sup>2</sup> ]	POA2 [m/s <sup>2</sup> ]	POA3 [m/s <sup>2</sup> ]
Sample 1	5.0	5.1	5.1
Sample 2	4.2	4.3	4.4
Sample 3	4.5	4.6	4.3
:	:	:	:

Normal data



Unit space

Quantify the amount of deviation from the unit space with a single index called **Mahalanobis distance** and determine if it is normal or abnormal.

Mahalanobis distance monitoring														
Acceleration FFT					Velocity FFT									
Management CH	Mahalanobis distance	Threshold (mg)	Minimum	Maximum	Collection	Management CH	Mahalanobis distance	Threshold (mm/s)	Minimum	Maximum	Collection			
1	13.84	10.00	30	47	1	17.28	10.00	30	47	1	17.28	10.00	30	47
2	2.30	10.00	30	100	2	3.50	10.00	30	100	2	3.50	10.00	30	100
3	5.10	10.00	30	52	3	6.00	10.00	30	52	3	6.00	10.00	30	52
4	8.50	10.00	30	100	4	8.70	10.00	30	60	4	8.70	10.00	30	60

Touch the management CH of each monitoring target to switch to the FFT monitoring screen.

Color of the number of collected samples: 100 (normal) / 100 (warning) / 100 (alarm)

Lamps indicate diagnosis results

\* Combined diagnosis is possible by combining data other than vibration such as temperature and current.

**Vibration diagnosis is possible without knowledge of vibration analysis!  
Not only can you determine if the data is normal or abnormal, but also  
you can recognize the severity of a fault and detect a sign**

\*1: The MT method (Mahalanobis-Taguchi Method) is a technique to generate a pattern (unit space) of normal data and detect the data that significantly deviates from the pattern (Mahalanobis distance) as an abnormal value.

# Diagnostic Procedure

The following describes the procedure to perform vibration diagnosis using this package.

## Easy installation Refer to page 9.

Just install a program!  
Vibration diagnosis system can be introduced easily and smoothly.



## Easy diagnosis

### Simple diagnosis Refer to page 11.

- Detect if there is a fault in equipment

### Acceleration FFT guard band monitoring Refer to page 11.

- Detect anomalies by guard band monitoring in the frequency-domain waveform

### Accurate diagnosis Refer to page 12.

- Presume the faulty area based on the part specifications

### MT method diagnosis Refer to page 14.

- Diagnosis is possible without knowledge of vibration analysis
- Combined diagnosis is possible by combining vibration data and other data (temperature, current, etc.)

# Other Useful Features

- Overall diagnostic view of the entire system ..... Refer to page 15.
- Trend graphs for trend monitoring of diagnosis results ..... Refer to page 16.
- Waveform graphs for vibration observation ..... Refer to page 17.
- Data saving as a CSV file ..... Refer to page 18.
- Simultaneous logging of vibration data for up to 4 CHs ..... Refer to page 18.
- Diagnosis results view on your personal computer ..... Refer to page 19.



# Features of the FA Application Package iQ Monozukuri Rotary Machine Vibration Diagnosis

There are two typical methods for vibration diagnosis: simple diagnosis, which is used to detect a fault, and accurate diagnosis, which is used to presume the fault area and causes.

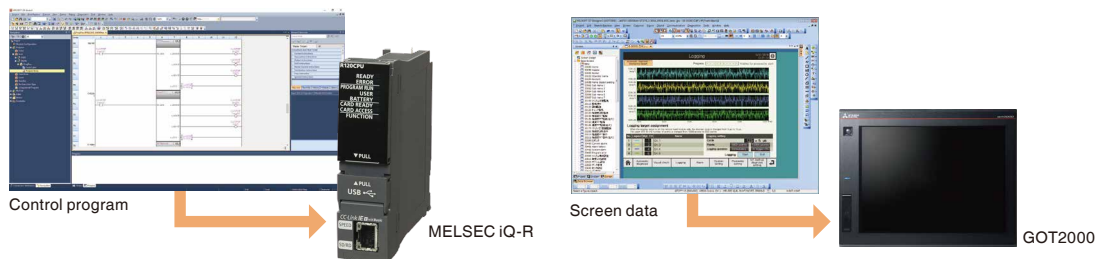
"iQ Monozukuri Rotary Machine Vibration Diagnosis" realizes predictive maintenance of equipment through MT method diagnosis using the MT method in addition to simple diagnosis and accurate diagnosis.

## Easy installation

### Easy to install a vibration diagnosis system

A vibration diagnosis system can be quickly constructed without specialized knowledge. All you need to do is install a program included in the package to the PLC (MELSEC iQ-R) and screen data to the GOT (GOT2000) and then specify the sensor sensitivity and equipment specification values on the GOT screen.

**Step1** Install the control program to the PLC.  
Install the screen data to the GOT.



**Step2** Turn on the power of the system to start up the PLC and GOT. \*1\*2



**Step3** Set the sensor sensitivity and equipment specification values on the GOT screen.



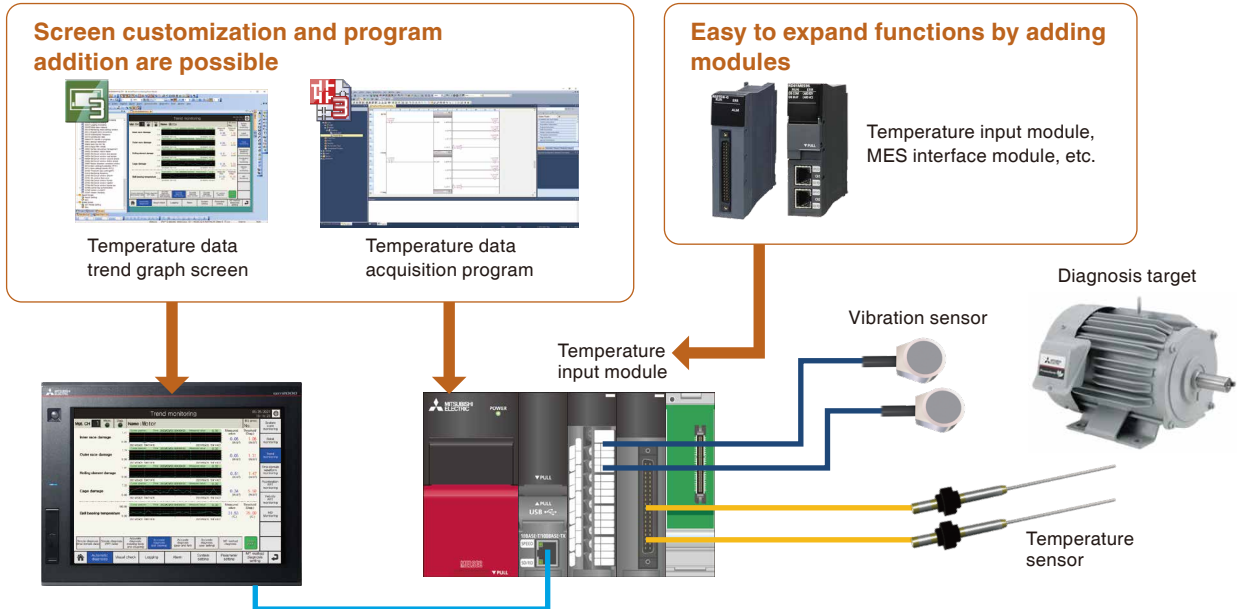
\*1: Complete wiring of necessary devices such as sensors in advance.  
\*2: Only for the first time, register a license key to the PLC CPU.



You can quickly diagnose  
the vibration of equipment

## Easy installation Flexible system expansion

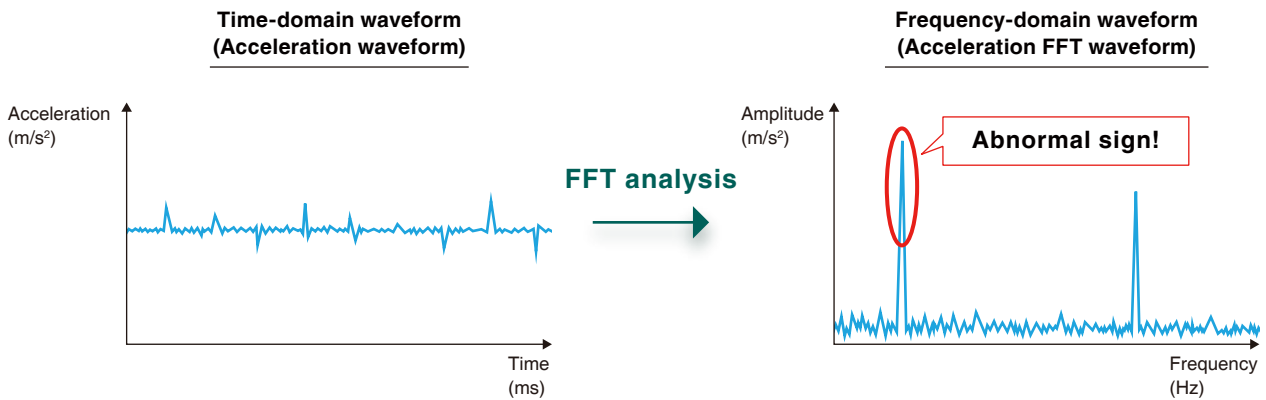
With the Mitsubishi FA devices and general-purpose vibration sensors, the system can be flexibly configured to meet customer needs. Optional control programs can be added and the GOT screen can be customized.\*1



\*1: Any malfunction or failure due to customization is out of guarantee.

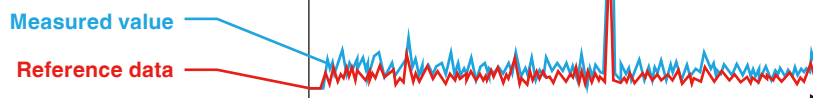
## Easy diagnosis (FFT analysis) Visualize the vibration through FFT analysis

The vibration can be visualized by converting vibration data into frequency-domain waveform through FFT analysis. The frequency-domain waveform makes it easier to check the vibration status and detect abnormal signs.



### <Overlaying the reference data>

By saving the normal waveform of equipment as reference data and overlaying it on the measured vibration data, you can recognize the differences in the vibration level at a glance!



## Easy diagnosis (Simple diagnosis) Fault detection by simple diagnosis

By comparing the measured value with the reference value, you can detect if there is a fault or its sign in equipment.

### Simple diagnosis (Absolute value judgment)

If the measured value (velocity RMS value) calculated from the vibration data exceeds the judgment reference value specified in ISO10816-1, it is judged as abnormal.

Vibration severity	ISO10816-1			
	Class I	Class II	Class III	Class IV <sup>*1</sup>
Velocity RMS value (effective value) (mm/s)				
0.28	A	A	A	A
0.45	A	A	A	A
0.71	A	A	A	A
1.12	B	B	B	A
1.8	B	B	B	A
2.8	C	C	B	B
4.5	C	C	C	B
7.1	D	C	C	C
11.2	D	D	D	C
18	D	D	D	D
28	D	D	D	D
45	D	D	D	D

A: Good    B: pass    C: Warning    D: Danger

**Vibration severity**  
An endurance reference for the vibration of rotary machines which is specified by the ISO. The judgment standard differs depending on the size and type of equipment.

- Class I : Small machine (such as motor with power of 15 kW or less)
- Class II : Medium machine (such as motor with power between 15 to 75 kW or machine with power of 300 kW)
- Class III : Large machine (when mounted on stiff and heave foundation)
- Class IV<sup>\*1</sup> : Large machine (when mounted on a soft foundation)

\* Conditions to apply the vibration severity  
Number of rotations: 600 to 12000 r/min  
Vibration measuring range: 10 to 1000 Hz

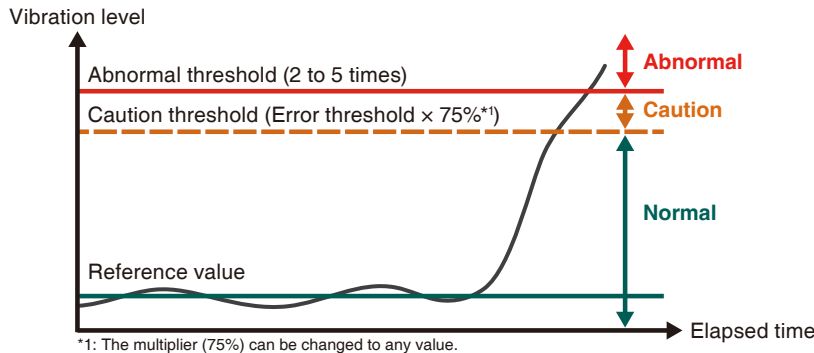
\*1: In iQ Monozukuri Rotary Machine Vibration Diagnosis, Class IV under ISO10816-1 is not supported because the class is determined according to the motor capacity.

**Note** The measured value may exceed the judgment reference value due to the installation status of the equipment or the influence of noise.

### Simple diagnosis (Relative value judgment)

Measure the vibration at the same location multiple times (10 times if possible) to obtain a value at the normal condition (reference value).

Compare the measured value with a threshold which is specified as 2 to 5 times the reference value to determine if it is normal.

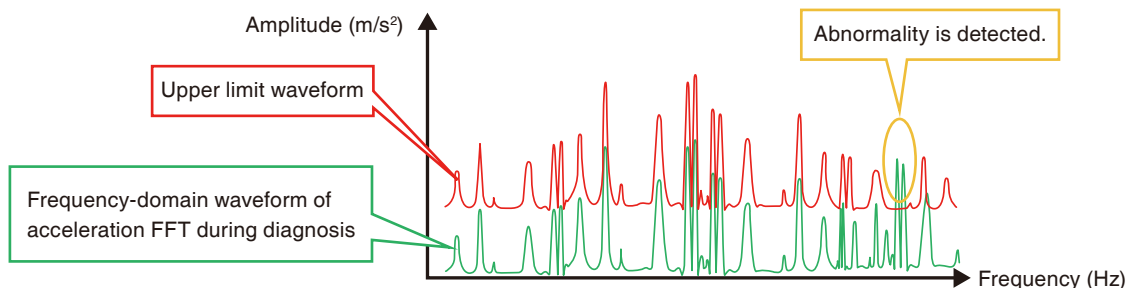


## Simple diagnosis (Acceleration FFT guard band monitoring) Fault detection by acceleration FFT guard band monitoring

By monitoring the guard band of the frequency-domain waveform of the acceleration FFT, a fault in equipment or its sign can be detected.

### Acceleration FFT guard band monitoring

If the frequency-domain waveform of the acceleration FFT exceeds the upper limit waveform (obtained by shifting up the frequency-domain waveform of the reference data by the guard band monitoring width) at the specified number of points, it is judged as abnormal.



## Easy diagnosis (Accurate diagnosis)

### Presume the faulty area according to the accurate diagnosis

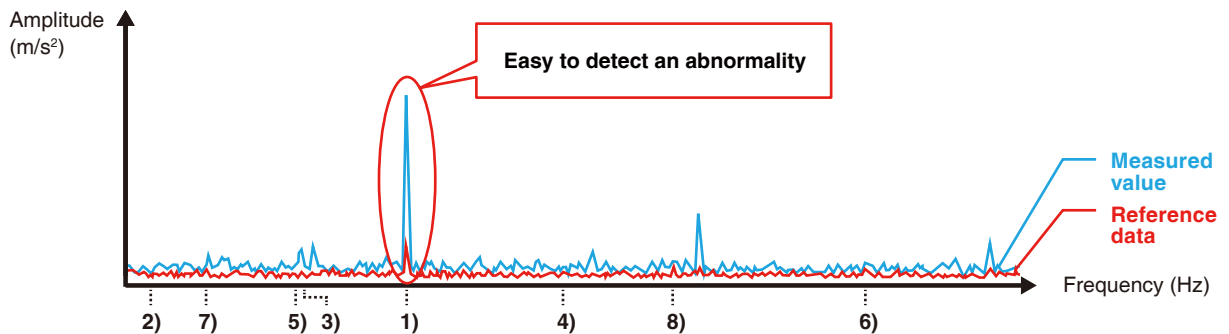
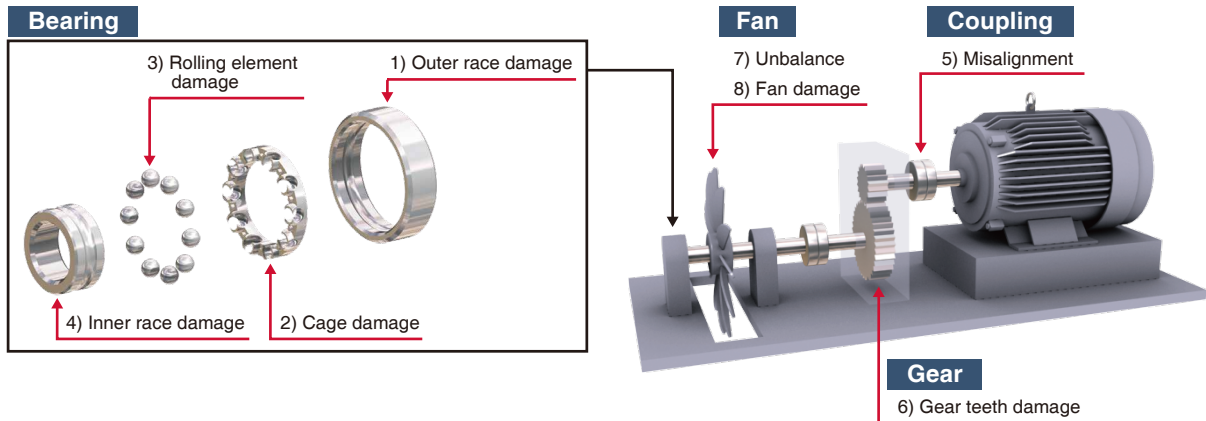
By monitoring the amplitude of the characteristic frequency calculated from the rotary speed and the specification values of components, the faulty area can be presumed and a fault can be found at an early stage. The threshold value should be set between 2 and 5 times of the reference value which is the value at the normal condition obtained by measuring the vibration from equipment multiple times (10 times if possible).

This threshold value is compared with the measured value to perform pass / fail judgment.

\* During accurate diagnosis, rotational speed and loads must be constant.

### Accurate diagnosis

Perform the FFT analysis on the vibration data to presume the faulty area based on the change in amplitudes of characteristic frequencies.



## List of accurate diagnosis results

The lamps indicate the results of accurate diagnosis, allowing users to recognize faults and conditions at a glance.

Detail monitoring				05/13/2021 13:02:08		
Mgt. CH	1	Moni.	Diag.	Name : Motor	BG proc. No.	System state monitoring
ALM	Simple diagnosis item	State/Measured value	ALM	Accurate diagnosis item	Amplitude (m/s <sup>2</sup> )	
	Vibration severity			Unbalance/Misalignment	Measured value	Threshold (Diag.)
	Velocity RMS value (mm/s)			Misalignment(x2)	0.56	0.85
				Misalignment(x3)	0.57	0.80
ALM	Simple diagnosis item	Setting value		Inner race damage	0.65	0.63
	Acceleration FFT Guard band monitoring width (%)	130		Outer race damage	5.98	6.91
	Acceleration FFT Guard band cont. excess pts. (points)	100		Rolling element damage	1.19	1.43
ALM	Simple diagnosis item	Measured value	Threshold (Diag.)	Cage damage	0.89	0.93
	Acceleration waveform Zero peak (m/s <sup>2</sup> )	155.30	129.25	Gear teeth damage	0.42	0.59
	Acceleration waveform RMS (m/s <sup>2</sup> )	10.85	10.95	Gear teeth damage(x2)	0.18	0.34
	Acceleration waveform Crest factor	14.31	23.67	Fan damage	0.57	0.80
	Acceleration FFT Overall (m/s <sup>2</sup> )	9.78	11.66	User setting1		
	Velocity FFT Overall (mm/s)	22.89	27.32	User setting2		
				User setting3		
ALM	MT method diagnosis item	Measured value	Threshold (Diag.)	User setting4		
	Acceleration FFT Mahalanobis distance	13.84	10.00	User setting5		
	Velocity FFT Mahalanobis distance	17.26	10.00	User setting6		

## Quick setting of ball bearing specification values

Specification values are automatically filled in by choosing the following contents: model of Mitsubishi three-phase motor, ball bearing manufacturer, and bearing number (equivalent to the model).

### Automatic setting of specification values by specifying the model of the Mitsubishi three-phase motor

Specification value setting

06/03/2021 10:48:59

Mgt. CH 1 | Name: Motor

Basic setting(necessary)

Rotation speed at vibration measure 1500 r/min

Setting of the failure diagnosis for the ball bearing

Manufacturer - Bearing number -

Pitch diameter D 36.50 mm

Ball diameter d 7.940 mm

Number of balls Z 8 balls

Contact angle  $\alpha$  0.0 deg.

Setting of the failure diagnosis for the reduction/increase drive gear

Number of motor side gear teeth 2 T

Setting of the failure diagnosis for the fan or blower

Number of fan blades 3 blades

When the rotation speed is other than 600 to 12000 r/min, the motor capacity selection for vibration severity setting is set to [Invalid].

Back Next

Automatic diagnosis | Visual check | Logging | Alarm | System setting | Parameter setting | MT method diagnosis setting

**Specification value automatic input (Mitsubishi three-phase motor specification)**

Specify the basic specification items of the Mitsubishi three-phase motor and input specification values automatically. Touch the [i] switch to check the Mitsubishi three-phase motors for which specification values can be automatically input.

Mitsubishi three-phase motor

Model SF-PR(-\*)

Output 0.75 kW

Number of poles 2P

Ball bearing Pulley side / Opposite pulley side

After setting the basic specification items in order from the top, touch the [DB check] switch and check the bearing number of the ball bearing.

**Specify the model, output, number of poles, and ball bearing (pulley side / opposite pulley side) of the Mitsubishi three-phase motor**

Default value setting | Back | Confirm

Supported Mitsubishi three-phase motor : Super Line Premium Series (SF-PR series)

### Automatic setting of specification values by specifying the ball bearing manufacturer and bearing number

Specification value setting

06/03/2021 10:48:59

Mgt. CH 1 | Name: Motor

Basic setting(necessary)

Rotation speed at vibration measure 1500 r/min

Setting of the failure diagnosis for the ball bearing

Manufacturer - Bearing number -

Pitch diameter D 36.50 mm

Ball diameter d 7.940 mm

Number of balls Z 8 balls

Contact angle  $\alpha$  0.0 deg.

Setting of the failure diagnosis for the reduction/increase drive gear

Number of motor side gear teeth 2 T

Setting of the failure diagnosis for the fan or blower

Number of fan blades 3 blades

When the rotation speed is other than 600 to 12000 r/min, the motor capacity selection for vibration severity setting is set to [Invalid].

Back Next

Automatic diagnosis | Visual check | Logging | Alarm | System setting | Parameter setting | MT method diagnosis setting

**Specification value automatic input (ball bearing specification)**

Specify the ball bearing manufacturer and bearing number to automatically input the specification value. Specification values can be input only for single-row deep groove ball bearings and single-row combined angular contact ball bearings. (except for ball bearings with a prefix in the bearing number)

Ball bearing

Manufacturer NTN

Bearing number 6000

Default value setting | Back | Confirm

**Specify the manufacturer and bearing number of the ball bearing**

Supported ball bearings:

- Single-row deep groove ball bearing
- Single-row angular ball bearing
- Duplex-row angular ball bearing

**Note**

When specifying the ball bearing manufacturer to automatically fill in the ball bearing specification values, please agree to the terms of use for the technical calculation tool on the relevant manufacturer's website before using the tool.

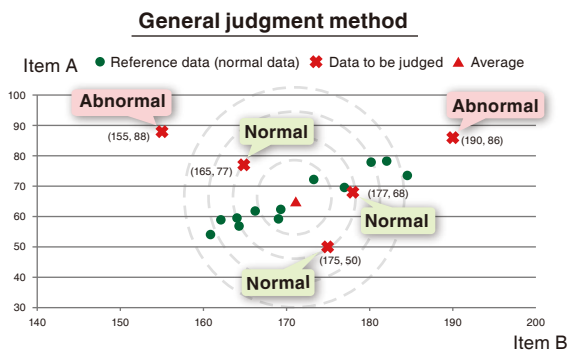
For details of the Mitsubishi three-phase motors and ball bearings available for automatic input of ball bearing specification values, refer to iQ Monozukuri Rotary Machine Vibration Diagnosis Announcement of new support service for automatic input of ball bearing specification value "Technical Bulletin BCN-E2113-0038".

# Easy diagnosis (MT method diagnosis) Easy to detect anomalies by using the MT method

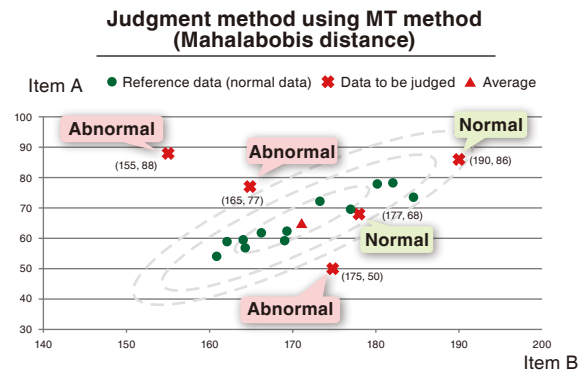
By applying the MT method (quality engineering method) to vibration analysis, anomalies can be easily detected even without knowledge about vibration analysis or specification value information of the components. Moreover, composite diagnosis is possible by combining vibration data with data other than vibration such as temperature and current.

## MT method diagnosis

A group of reference data called unit space is generated from normal data (equipment data when operation is started, stable, or steady) and the deviation from normal condition can be quantified using a single index called Mahalanobis distance. This helps to not only determine if it is normal or abnormal but also recognize the severity of a fault and detect its sign.



Data is determined as normal or abnormal according to the distance from the average value, ignoring the variance of data.



Since variance is considered, data can be determined as normal or abnormal in a suitable manner for the equipment.

## List of MT method diagnosis results

The lamps indicate the results of MT method diagnosis, allowing users to see if there is a fault.

Mahalanobis distance monitoring										05/13/2021 11:26:58	
Management CH during processing 0 Progress										Waiting for processing start	
Mgt. CH	Acceleration FFT					Velocity FFT					System state monitoring
	ALM	Mahalanobis distance	Threshold (Disp.)	Minimum	Number of samples	ALM	Mahalanobis distance	Threshold (Disp.)	Minimum	Number of samples	
1	○	13.84	10.00	30	47	○	17.26	10.00	30	47	Trend monitoring
2	○	2.30	10.00	30	100	○	3.50	10.00	30	100	Time-domain waveform monitoring
3	○	5.10	10.00	30	52	○	6.00	10.00	30	52	Acceleration FFT monitoring
4	○	8.50	10.00	30	100	○	8.70	10.00	30	60	Velocity FFT monitoring
5	●					●					MD Monitoring
6	●					●					
7	●					●					
8	●					●					
9	●					●					
10	●					●					
11	●					●					
12	●					●					
13	●					●					
14	●					●					
15	●					●					
16	●					●					

Touch the management CH of each monitoring target to switch to the FFT monitoring screen.

Color of the number of collected samples: 100 Collecting (minimum number: unreachd) 100 Collecting (minimum number: reached) 100 Not collected

## Other useful features (Diagnostic status list display) Overall diagnostic view of the entire system

The entire system status can be checked at a glance because the diagnosis status and results of all 16 channels can be displayed in a list.

### List of diagnosis statuses and results for all 16 CHs

The lamps indicate the diagnosis status and results of all 16 channels.  
Touching a status lamp displays the diagnosis results of the corresponding channel at once.

\* A series of processing from collecting to diagnosing vibration data is sequentially carried out for each channel.

**Status lamp**

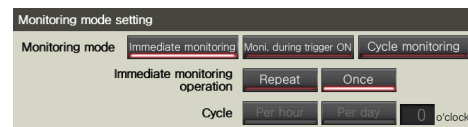
Mgt. CH	Moni.	Diag.	Name	Diag. date and time	State	Monitoring mode	Detail	Monitoring
1	●	●	Motor	05/13 11:50:44	Error	Immediate monitoring	Once	Start End
2	●	●	Bearing	05/13 11:32:44	Normal	Immediate monitoring	Once	Start End
3	●	●	Gear	05/13 11:44:23	Normal	Immediate monitoring	Once	Start End
4	●	●	Fan	05/13 11:51:23	Caution	Immediate monitoring	Once	Start End
5	●	●						
6	●	●						

**Diagnosis status**                      **Diagnosis result**

### <Automatic diagnosis can be performed at any timing>

Monitoring timing of automatic diagnosis can be selected from the following.

- Immediate monitoring: Data is collected when the monitoring start switch is touched.
- Moni. during trigger ON: Data is continuously collected while a specified device is on.
- Cycle monitoring: Data is periodically collected.



### Overall view of diagnosis results for a specific CH

The lamps indicate the results of simple diagnosis, acceleration FFT guard band monitoring, accurate diagnosis, and MT method diagnosis of the specified channel.

05/13/2021 13:02:08

#### Detail monitoring

Mgt. CH **1**    Moni. ●    Diag. ●    Name : Motor    BG proc. No.    System state monitoring

ALM	Simple diagnosis item	State/Measured value		ALM	Accurate diagnosis item	Amplitude (m/s <sup>2</sup> )	
		Measured value	Threshold (Diag.)			Measured value	Threshold (Diag.)
●	Vibration severity			●	Unbalance/Misalignment	1.48	1.88
●	Velocity RMS value (mm/s)			●	Misalignment(x2)	0.56	0.85
●	Acceleration FFT			●	Misalignment(x3)	0.57	0.80
●	Guard band monitoring width (%)	130		●	Inner race damage	0.65	0.63
●	Acceleration FFT			●	Outer race damage	5.98	6.91
●	Guard band cont. excess pts. (points)	100		●	Rolling element damage	1.19	1.43
●	Simple diagnosis item	Measured value	Threshold (Diag.)	●	Cage damage	0.89	0.93
●	Acceleration waveform	155.30	129.25	●	Gear teeth damage	0.42	0.59
●	Zero peak (m/s <sup>2</sup> )			●	Gear teeth damage(x2)	0.18	0.34
●	Acceleration waveform RMS (m/s <sup>2</sup> )	10.85	10.95	●	Plan damage	0.57	0.80
●	Acceleration waveform Crest factor	14.31	23.67	●	User setting1		
●	Acceleration FFT Overall (m/s <sup>2</sup> )	9.78	11.66	●	User setting2		
●	Velocity FFT Overall (mm/s)	22.89	27.32	●	User setting3		
●	MT method diagnosis item	Measured value	Threshold (Diag.)	●	User setting4		
●	Acceleration FFT			●	User setting5		
●	Mahalanobis distance	13.84	10.00	●	User setting6		
●	Velocity FFT						
●	Mahalanobis distance	17.26	10.00				

Home Automatic diagnosis Visual check Logging Alarm System setting Parameter setting MT method diagnosis setting

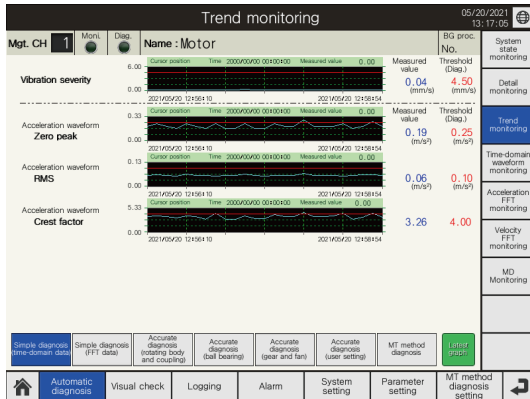
## Other useful features (Trend monitoring)

# Trend graphs for trend monitoring of diagnosis results

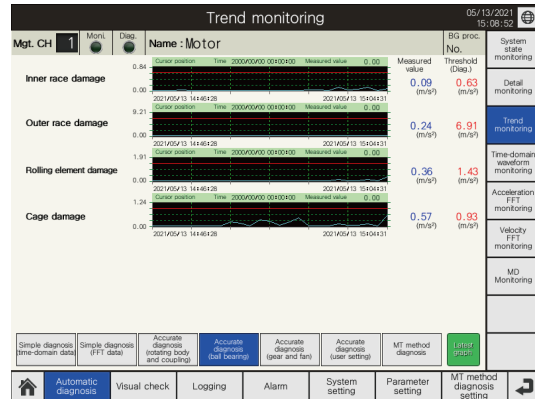
Trend graphs which show the results of diagnosis at regular intervals, such as daily or hourly, enable trend monitoring of the diagnosis results and allow users to detect an abnormal sign.

## Trend display of diagnosis results of a specific CH

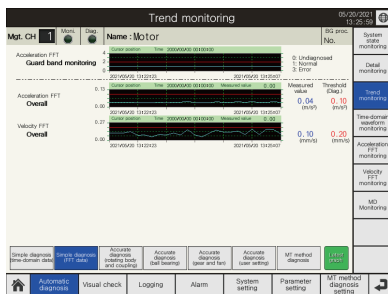
Trend graphs show the trends of diagnosis results of simple diagnosis, acceleration FFT guard band monitoring, accurate diagnosis, and MT method diagnosis of the specified channel.



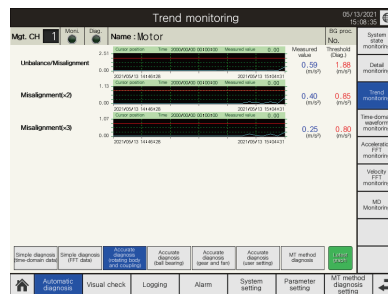
Simple diagnosis (Time-domain data)



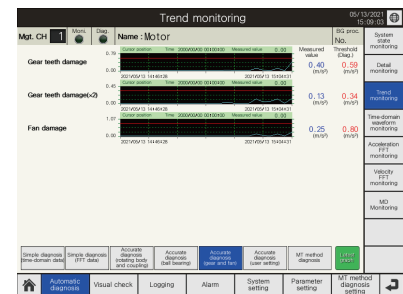
Accurate diagnosis (Ball bearing)



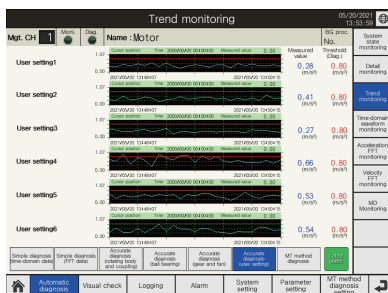
Simple diagnosis (Frequency-domain data)



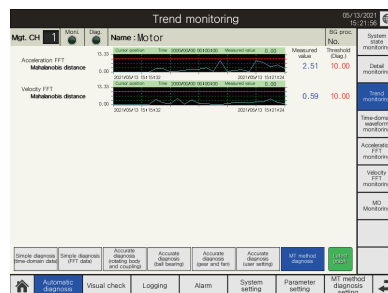
Accurate diagnosis (Rotating body and coupling)



Accurate diagnosis (Gear and fan)



Accurate diagnosis (User setting)



MT method diagnosis

### <Horizontal scaling and scrolling with gestures>

Horizontal axis can be scaled by pinch in/out gestures.

In addition, by saving the trend data in the SD memory card inserted in the GOT, the past diagnosis results can be horizontally scrolled by flicking.

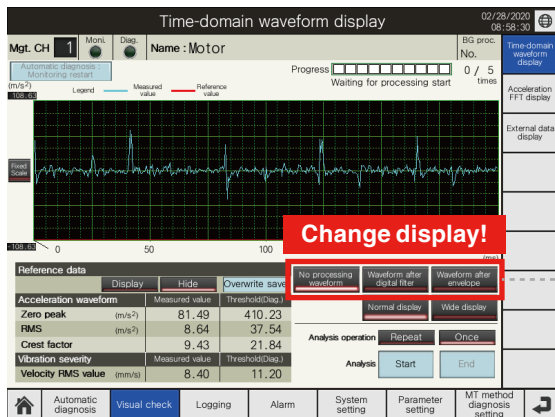


## Other useful features (Visual check) Waveform graphs for vibration observation

Vibration can be viewed in the time-domain waveform and frequency-domain waveform.

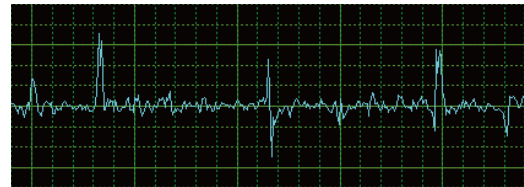
### Time-domain waveform for vibration observation

The vibration condition can be checked with three types of time-domain waveform (No processing waveform / Waveform after digital filter / Waveform after envelope).



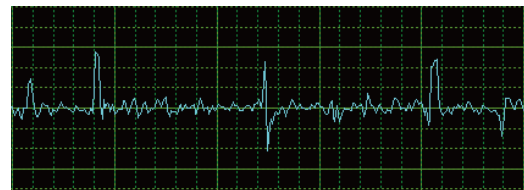
#### No processing waveform

This is the original waveform obtained by scaling the signal (vibration data) from the vibration sensor.



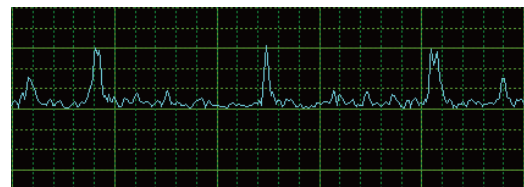
#### Waveform after digital filter

A digital filter is applied to eliminate noise superimposed by vibration sensors and cables.



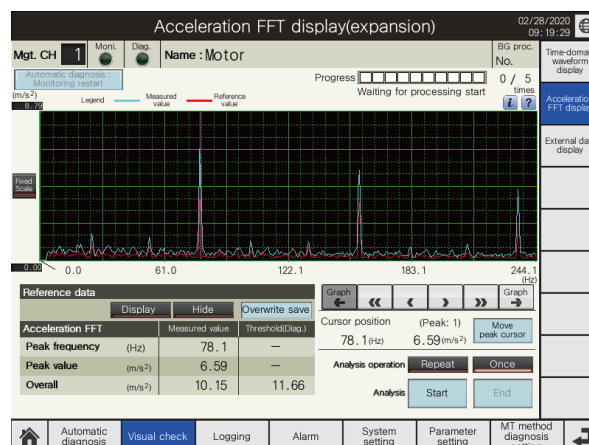
#### Waveform after envelope

The change in amplitude can be clearly observed by extracting the outline of amplitude absolute values (envelope processing).



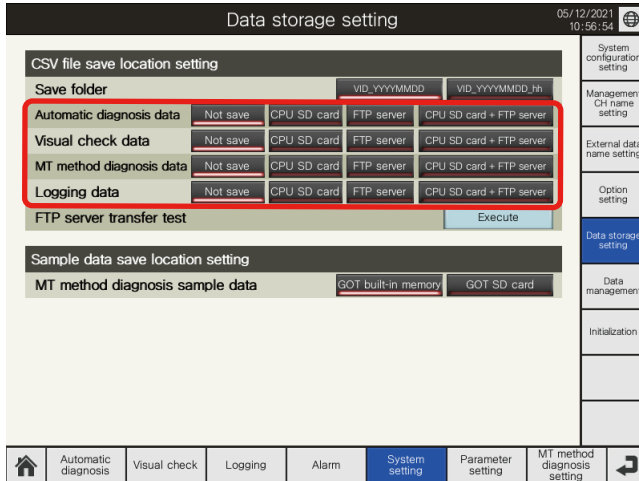
### Frequency-domain waveform for vibration observation

Through FFT analysis of vibration data, the vibration can be viewed in the frequency-domain waveform.



## Other useful features (Data management) Data saving as a CSV file

Automatic diagnosis data, visual check data, logging data, and MT method diagnosis data can be saved as a CSV file. CSV files can be saved in an SD memory card or FTP server.



### <CSV file contents>

#### • Automatic diagnosis data / Visual check data

- (1) Vibration data  
Time (s), acceleration waveform (m/s<sup>2</sup>), frequency (Hz), acceleration FFT (m/s<sup>2</sup>), velocity FFT (mm/s)
- (2) FFT setting value  
Cycle (μs), number of points (points), average method, average count (times), etc.
- (3) Diagnosis result  
Measured value, threshold value, diagnosis result of the simple diagnosis item  
Monitoring frequency, measured value, threshold value, diagnosis result of the accurate diagnosis item  
Measured value, threshold value, diagnosis result of the MT method diagnosis item

#### • Logging data

Time (s), Acceleration waveform (m/s<sup>2</sup>)

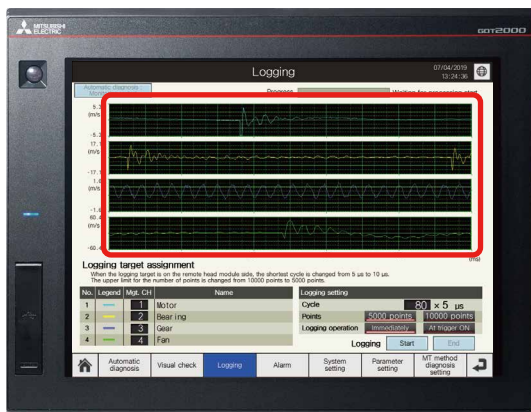
#### • MT method diagnosis data

Acceleration MD value (measurement value), acceleration MD value (threshold value), number of acceleration items, velocity MD value (measurement value), velocity MD value (threshold value), number of velocity items, etc.

## Other useful features (Logging)

### Simultaneous logging of vibration data for up to 4 CHs

Vibration data for up to 4 channels can be simultaneously logged and saved as a CSV file. CSV files can be used for detailed analysis of the vibration data on the personal computer. Vibration data cannot be read from a CSV file to the GOT screen for analysis and diagnosis.



CSV file



## Other useful features (Graph display tool) Diagnosis results view on your personal computer

By importing a CSV file of diagnosis results into the graph display tool (Microsoft® Excel®), diagnosis results can be checked in waveform display, list display, and trend display on the personal computer.

\*The graph display tool is not included in the product since it is a sample tool.

For information on how to obtain the tool, please consult your local Mitsubishi representative.

### Waveform display

The vibration status can be checked in time-domain waveforms and frequency-domain waveforms.

**Specifying CSV file**  
Up to 8 files can be specified to display waveforms overlapped.

**Switching waveform display**  
Display or hide the waveform by turning on/off the switch.

**Changing scale of waveform**  
The scale of the vertical axis in the graph can be changed as desired.

### List display

The CSV file overview, FFT setting during diagnosis, and diagnosis results of simple diagnosis / accurate diagnosis / MT method diagnosis can be checked in each list.

**CSV file overview**  
(File name, data collection time, management CH name)

**Simple diagnosis item**

**Accurate diagnosis item**

**FFT setting**

**MT method diagnosis item**

\*The diagnosis results of the acceleration FFT guard band monitoring are included in the simple diagnosis item.

### Trend display

The changes in the diagnosis result of each diagnosis item in the simple diagnosis / accurate diagnosis / MT method diagnosis can be checked in trend graphs.

**Displays each diagnosis item in a trend graph (up to 8 points)**

**Acceleration waveform Zero peak**

**Acceleration waveform RMS**

# Product Contents

This product consists of software and documents. It is necessary to prepare hardware and engineering software separately. For details, refer to "Necessary Software & Device List (P.22)".

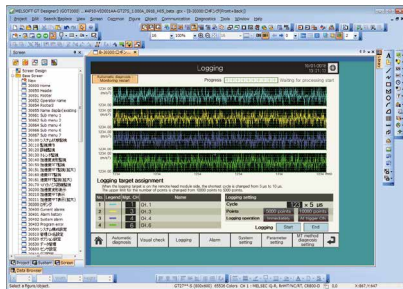
## Software



### Screen data (GT Designer3 project file<sup>1)</sup>

<sup>1</sup>: MELSOFT GT Designer3 is required.

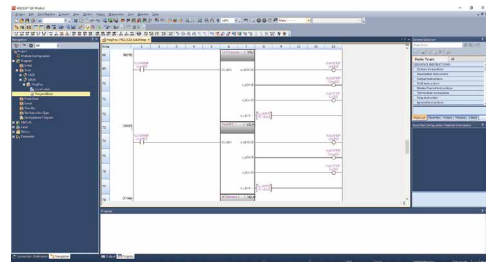
Screen data of GOT2000 for the rotary machine vibration diagnosis



### Control program (GX Works3 project file<sup>2)</sup>

<sup>2</sup>: MELSOFT GX Works3 is required.

Sequence control program for the rotary machine vibration diagnosis



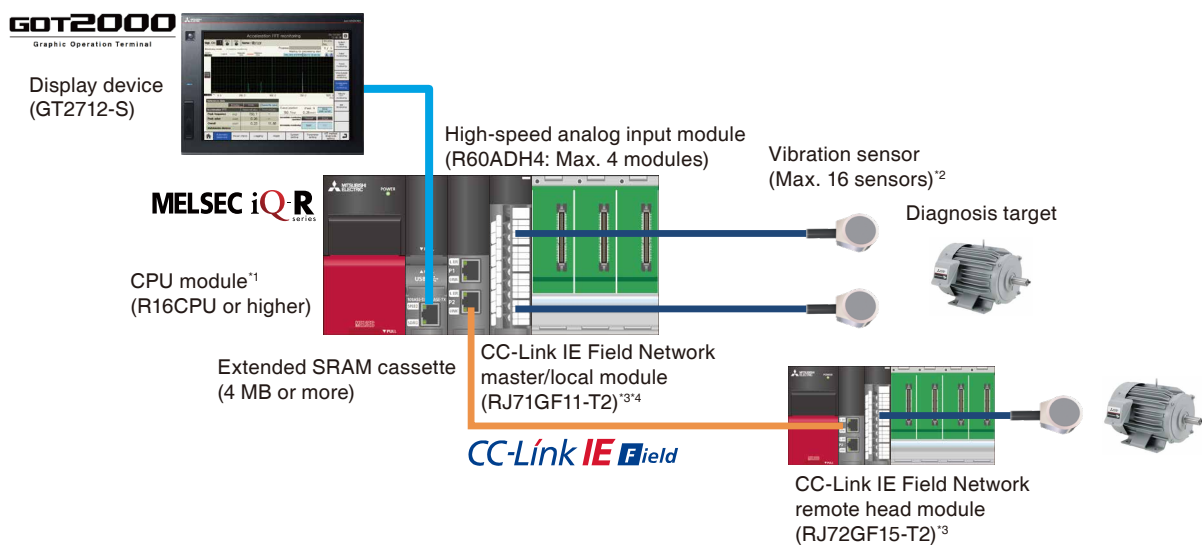
## Documents



### Manual (PDF file)

Instruction manual

# System Configuration Diagram



- \*1: When used with customer's device control programs, the rotary machine vibration diagnosis programs increase the scan time and affect the device control. In this case, use the multiple CPU configuration.
- \*2: Up to 16 vibration sensors can be used in a system. (Including sensors connected via networks)
- \*3: It is used when the diagnosis target is more than one or far away from the PLC CPU. Up to four MELSEC iQ-R series CC-Link IE Field Network remote head modules can be connected.
- \*4: The following modules can be used as the master station of CC-Link IE Field Network.
  - R\*\*ENCPU (\*\* is 16 or later.)
  - RJ71EN71

# Specifications

## System Specifications

Item		Description
Number of vibration sensor connections		Max. 16 sensors (Vibration sensors used for vibration detection in acceleration)
Input range	Voltage	-10 to 10 V DC
	Current	0 to 20 mA DC
Number of MELSEC iQ-R series CC-Link IE Field Network remote head module stations		Max. 4 stations
Sampling function	Cycle (Frequency range)	10 $\mu$ s (40 kHz), 20 $\mu$ s (20 kHz), 25 $\mu$ s (16 kHz), 50 $\mu$ s (8 kHz), 100 $\mu$ s (4 kHz), 400 $\mu$ s (1 kHz)
	Points	1024 points, 2048 points, 4096 points, 8192 points <sup>*1</sup>
FFT function	Spectrum format	Half amplitude
	Window function	Rectangle, Hanning, Hamming, Blackman
	Digital filter	None, Low-pass, High-pass, Band-pass
Diagnosis function	Simple diagnosis	Velocity RMS value (for vibration severity), Acceleration waveform (RMS, Zero peak, Crest factor), Acceleration FFT (Overall), Velocity FFT (Overall)
	Acceleration FFT guard band monitoring	Frequency-domain waveform of acceleration FFT
	Accurate diagnosis	Unbalance, Misalignment, Inner race damage, Outer race damage, Rolling element damage, Cage damage, Gear teeth damage, and Fan damage
	MT method diagnosis	Acceleration FFT (Partial overall), Velocity FFT (Partial overall), External data
Waveform display function		Time-domain waveform (No processing waveform / Waveform after digital filter / Waveform after envelope), Frequency-domain waveform (Acceleration FFT, Velocity FFT)
Trend display function		Trend graph display of the results of simple diagnosis, acceleration FFT guard band monitoring, accurate diagnosis, and MT method diagnosis
Diagnosis result display function		Normal / Caution / Error display
Alarm display function		Detail display, Current Alarm display, Alarm History display
Logging function	Cycle	1 to 80 (x5 $\mu$ s) <sup>*1</sup>
	Points	5000 points, 10000 points <sup>*1</sup>
File save function		The CSV files of diagnosis results are saved to the SD memory card inserted in the PLC CPU or the FTP server. The CSV files of the captured images of the GOT, MT method diagnosis sample data groups, and trend data are saved to the SD memory card inserted in the GOT.

\*1: When the high-speed analog input module installation position is the remote head module side, the upper limit for the number of sampling points is 4096 points, the shortest logging cycle is 10  $\mu$ s, and the upper limit for the number of logging points is 5000 points.

## Operating Environment

Item	Description	Remarks
Operation guaranteed OS	Microsoft® Windows® 10 (Home, Pro, Enterprise)	-
	Microsoft® Windows® 7 (Professional, Ultimate, Enterprise)	-
CPU	64-bit OS: 1 GHz or more / 32-bit OS: 1 GHz or more	-
Memory	64-bit OS: 2 GB or more / 32-bit OS: 1 GB or more	-
Free disk space	64-bit OS: 20 GB or more / 32-bit OS: 16 GB or more	-
Disk drive	DVD drive	Installation DVD-ROM
Interface	USB (USB1.1 or later)	For connection with the PLC CPU and GOT
Application	MELSOFT GX Works3	For editing or writing the control program
	MELSOFT GT Designer3 (GOT2000)	For editing or writing the screen data

# Necessary Software & Device List

## FA Application Package

Product name	Manufacturer	Model	Number of licenses <sup>*1</sup>
FA Application Package iQ Monozukuri Rotary Machine Vibration Diagnosis	Mitsubishi Electric Corporation	AP10-VID001AA-MA	1
		AP10-VID001AA-MB	5
		AP10-VID001AA-MC	10
		AP10-VID001AA-MD	15
		AP10-VID001AA-ME	20
		AP10-VID001AA-MF	25

\*1: One license is required per system.

## Software

Product name	Quantity	Manufacturer	Model	Remarks
PLC Engineering Software MELSOFT GX Works3	1	Mitsubishi Electric Corporation	SW1DND-GXW3-E	Version 1.072A or later
GOT Screen Design Software MELSOFT GT Works3 <sup>*1</sup>	1	Mitsubishi Electric Corporation	SW1DND-GTWK3-E	Version 1.250L or later

\*1: MELSOFT GT Designer3 is included in MELSOFT GT Works3.

## Device

Device name	Quantity	Manufacturer	Model	Remarks	
GOT	1	Mitsubishi Electric Corporation	GT2712-STBA/D	Screen size: 12.1-inch SVGA	Any of the models on the left
			GT2712-STWA/D	Screen size: 12.1-inch SVGA	
Power supply module <sup>*1</sup>	1 to 5	Mitsubishi Electric Corporation	R61P R62P R63P R64P	-	
Main base unit <sup>*1</sup>	1 to 5	Mitsubishi Electric Corporation	R33B R35B R38B R312B	-	
CPU module	1	Mitsubishi Electric Corporation	R16CPU R32CPU R120CPU R16ENCPU R32ENCPU R120ENCPU	Use the product with the firmware version "40" or later.	Any of the models on the left
Extended SRAM cassette <sup>*2</sup>	1	Mitsubishi Electric Corporation	NZ2MC-4MBS	Extended SRAM cassette 4MB	Any of the models on the left
			NZ2MC-8MBS	Extended SRAM cassette 8MB	
High-speed analog input module <sup>*3</sup>	1 to 4	Mitsubishi Electric Corporation	R60ADH4	Use the product with the firmware version "04" or later.	
SD memory card <sup>*4</sup>	0 to 2	Mitsubishi Electric Corporation	NZ1MEM-2GBSD	SD memory card 2 GB	Any of the models on the left
			NZ1MEM-4GBSD	SDHC memory card 4 GB	
			NZ1MEM-8GBSD	SDHC memory card 8 GB	
			NZ1MEM-16GBSD	SDHC memory card 16 GB	

Device name	Quantity	Manufacturer	Model	Remarks
Vibration sensor (acceleration sensor) <sup>5</sup>	1 to 16	TOKIN Corporation	VS-JV10A	Any of the models on the left
		Shinkawa Electric Co., Ltd.	CA-L02	
		ifm electronic gmbh	VSA004	
		PCB Piezotronics, Inc.	607M83	
		TE Connectivity Ltd.	805M4	
		Fuji Ceramics Corporation.	AF12C-5V	

- \*1: Use two modules for the stand-alone configuration, and two to five modules for the network support configuration.
- \*2: When five or more management channels are used, an extended SRAM cassette (model: NZ2MC-8MBS) is required.
- \*3: Up to four vibration sensors (acceleration sensors) can be connected per this module.
- \*4: It must be installed in the PLC CPU to save the vibration data in the CSV file.  
It must be inserted to the GOT to save the CSV files of the captured images of the GOT, sample data groups of MT method diagnosis, and trend data.
- \*5: One of the sensors that are tested by Mitsubishi Electric are described.  
For details refer to iQ Monozukuri Rotary Machine Vibration Diagnosis Tested Device Information "Technical News BCN-E2113-0034".

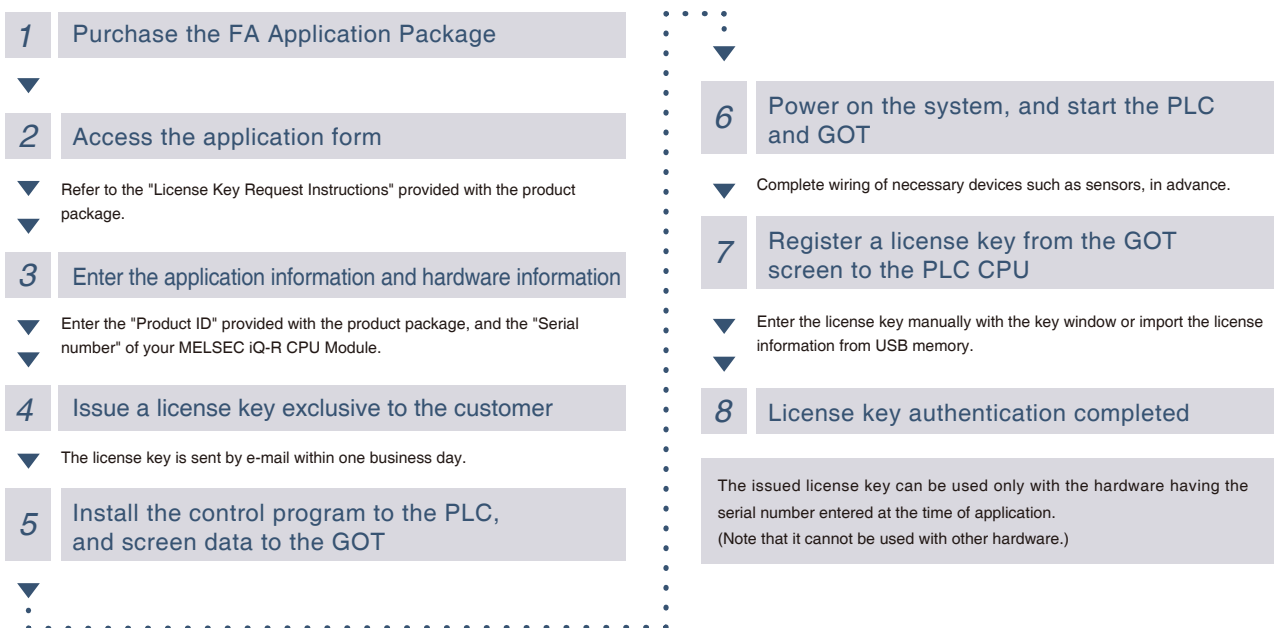
## Optional Devices<sup>\*1</sup>

Device name	Quantity	Manufacturer	Model	Remarks
CC-Link IE Field Network master/local module <sup>2</sup>	1	Mitsubishi Electric Corporation	RJ71GF11-T2	Any of the models on the left
Ethernet module <sup>2,3</sup>	1	Mitsubishi Electric Corporation	RJ71EN71	
CC-Link IE Field Network remote head module <sup>2</sup>	1 to 4	Mitsubishi Electric Corporation	RJ72GF15-T2	Up to four MELSEC iQ-R series CC-Link IE Field Network remote head modules can be connected.

- \*1: For other supported devices, contact your local Mitsubishi Electric representative.
- \*2: It is used when the diagnosis target is multiple devices or away from the PLC CPU.
- \*3: Use this module as the CC-Link IE Field Network master module.

# Procedure of License Key Authentication

FA application package "iQ Monozukuri Rotary Machine Vibration Diagnosis" requires license key authentication. The procedure of obtaining and authenticating the license key is as follows:

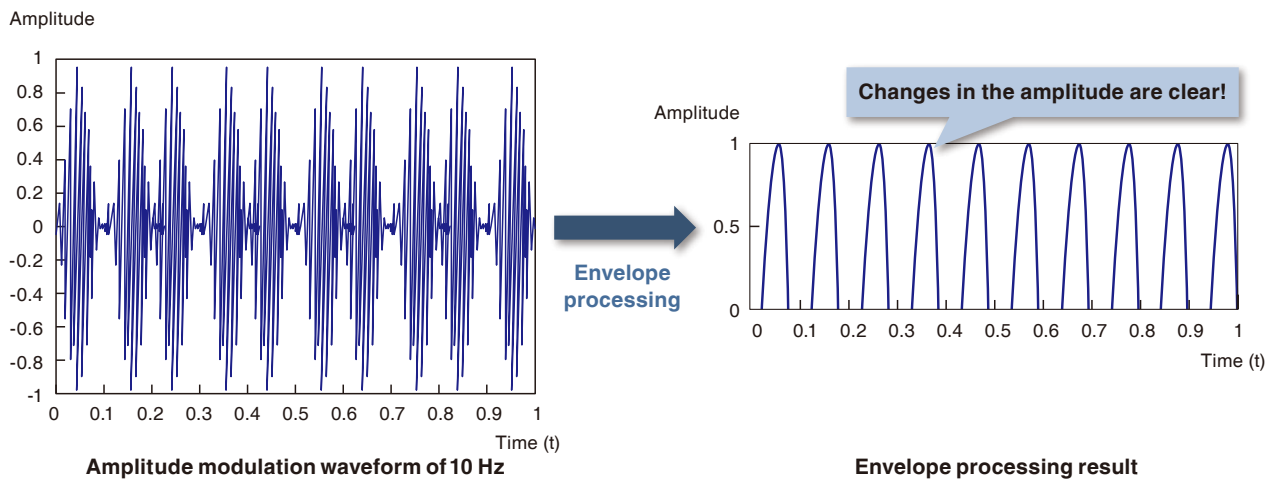


# Glossary

## Terminology for the vibration analysis

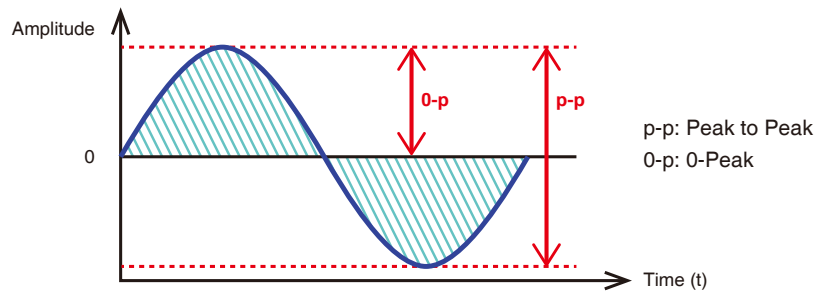
### Envelope

Envelope processing is a process to extract the outline of absolute amplitude values. It is used to examine the periodicity of impact vibration, such as the vibration caused by damage to the bearing.



### Peak value

The maximum value of amplitude in a waveform for a certain period. The peak value is represented as Peak to Peak and 0-Peak. It is used for evaluating the impact vibration and vibration waveform with small variations.

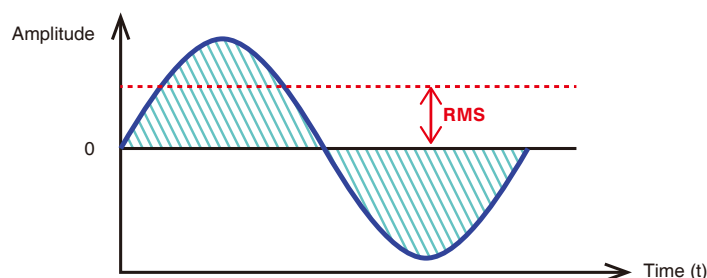


### RMS (effective value)

The square root of mean square for each instantaneous value within a certain period in the time-domain waveform. It indicates the average amplitude of the time-domain waveform.

It is used for evaluating the vibration waveform with few impact vibrations.

The velocity RMS is used for total judgment of the equipment condition. The acceleration RMS is used for calculation of crest factor.

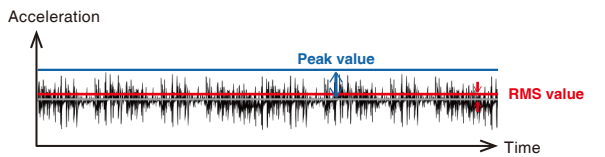
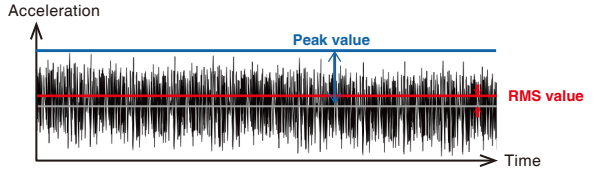
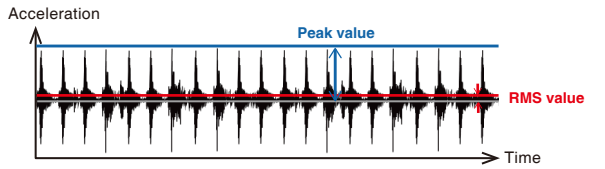




### □ Crest factor (CF)

A ratio of RMS value and peak value of time-domain waveform. (Crest factor = peak value/RMS value)

While the peak value and RMS value vary according to the rotation speed, the crest factor is less likely to vary but increases due to impact vibration. Therefore, the crest factor is used for detecting impact vibration such as damage on a bearing.

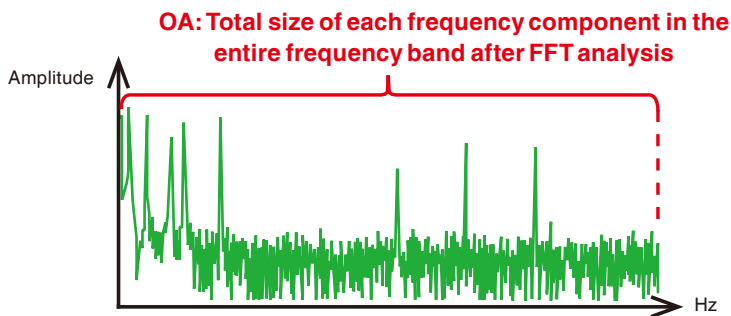
Vibration state	Time-domain waveform (Acceleration waveform)	Crest factor value (standard)
Normal		CF << 5
Motor load increased due to inadequate lubrication		CF ≈ 6
Impact vibration due to damage		CF >> 6

### □ Overall (OA)

The total size of each frequency component in the entire frequency band after FFT analysis.

Theoretically, OA equals to RMS value of the waveform before FFT analysis.

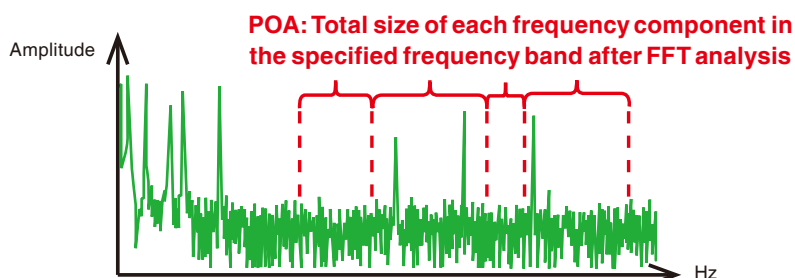
It is used to monitor the amplitude in the entire frequency band after FFT analysis.



### □ Partial overall (POA)

The total size of each frequency component in the specified frequency band after FFT analysis.

It is used to monitor the amplitude in the specified frequency band after FFT analysis.



### Terminology for the MT method

#### □ Item (Input field for MT method)

The characteristic value extracted from the source information (such as vibration) used to generate a unit space or calculate the Mahalanobis distance.

"iQ Monozukuri Rotary Machine Vibration Diagnosis" uses the POA value of vibration and other items.

If any unnecessary item is included in the unit space, it may affect the accuracy of error judgment.

#### □ Unit space

Reference data (normal data) group for calculating the Mahalanobis distance.

#### □ Sample

It refers to a set of data for each item measured under normal conditions, which is required to generate the unit space of the MT method. It is also called sample data.

#### □ Mahalanobis distance

An index that shows the amount of deviation from the reference data group.



# FA Application Package Lineup

## Processes and Usages

Packages in line with the status and purposes such as where to use or with what intention

### Process Remote Monitoring

Visualizing operation status and introducing IoT technologies to the shop floor to improve manufacturing process and productivity.



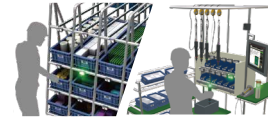
### ANDON

ANDON display improves productivity by sharing information between workers.



### Smart Work Navigator

Systems for supporting picking and assembly work can be easily developed and operated.



### Rotary Machine Vibration Diagnosis

Predictive maintenance can be realized for the facilities with rotary machines.



### Tool Wear Diagnosis for Machine Tools

Tool wear conditions are tracked by using IoT data to help optimize tool operation and improve processing quality.



### Processing Machine Loading

The setup and development of a processing machine loading/unloading system is supported.



### Force-sense Application

Various force sensing operations such as assembly, fitting, and inspection have been automated.



### Deburring/Polishing

Deburring and polishing can be automated just by rough teaching.



## Equipment

Packages realizing shortening of the system development time and easy development

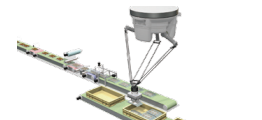
### CONVERTING

The development of a converting system that requires unwinding and winding control is supported.



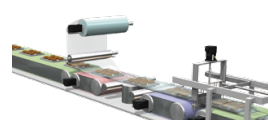
### HANDLING

The development of a conveyance mechanism that requires the calculation of coordinate conversion is supported.



### PACKAGING

The development of a packaging machine that requires cam control and position correction is supported.



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USA	MITSUBISHI ELECTRIC AUTOMATION, INC. 500 Corporate Woods Parkway, Vernon Hills, IL 60061, U.S.A.	Tel : +1-847-478-2100 Fax : +1-847-478-2253
Mexico	MITSUBISHI ELECTRIC AUTOMATION, INC. Mexico Branch Boulevard Miguel de Cervantes Saavedra 301, Torre Norte Piso 5, Ampliacion Granada, Miguel Hidalgo, Ciudad de Mexico, Mexico, C.P.115200	Tel : +52-55-3067-7512
Brazil	MITSUBISHI ELECTRIC DO BRASIL COMERCIO E SERVICOS LTDA. Avenida Adelino Cardana, 293, 21 andar, Bethaville, Barueri SP, Brasil	Tel : +55-11-4689-3000 Fax : +55-11-4689-3016
Germany	MITSUBISHI ELECTRIC EUROPE B.V. German Branch Mitsubishi-Electric-Platz 1, 40882 Ratingen, Germany	Tel : +49-2102-486-0 Fax : +49-2102-486-7780
UK	MITSUBISHI ELECTRIC EUROPE B.V. UK Branch Travellers Lane, UK-Hatfield, Hertfordshire, AL10 8XB, U.K.	Tel : +44-1707-28-8780 Fax : +44-1707-27-8695
Ireland	MITSUBISHI ELECTRIC EUROPE B.V. Irish Branch Westgate Business Park, Ballymount, Dublin 24, Ireland	Tel : +353-1-4198800 Fax : +353-1-4198890
Italy	MITSUBISHI ELECTRIC EUROPE B.V. Italian Branch Centro Direzionale Colleoni - Palazzo Sirio, Viale Colleoni 7, 20864 Agrate Brianza (MB), Italy	Tel : +39-039-60531 Fax : +39-039-6053-312
Spain	MITSUBISHI ELECTRIC EUROPE, B.V. Spanish Branch Carretera de Rubi, 76-80-Apdo. 420, E-08190 Sant Cugat del Valles (Barcelona), Spain	Tel : +34-935-65-3131 Fax : +34-935-89-1579
France	MITSUBISHI ELECTRIC EUROPE B.V. French Branch 25, Boulevard des Bouvets, 92741 Nanterre Cedex, France	Tel : +33-1-55-68-55-68 Fax : +33-1-55-68-57-57
Czech Republic	MITSUBISHI ELECTRIC EUROPE B.V. Czech Branch, Prague Office Pekarska 621/7, 155 00 Praha 5, Czech Republic	Tel : +420-255-719-200
Poland	MITSUBISHI ELECTRIC EUROPE B.V. Polish Branch ul. Krakowska 48, 32-083 Balice, Poland	Tel : +48-12-347-65-00
Sweden	MITSUBISHI ELECTRIC EUROPE B.V. (Scandinavia) Hedvig Mollersgata 6, 223 55 Lund, Sweden	Tel : +46-8-625-10-00 Fax : +46-46-39-70-18
Russia	MITSUBISHI ELECTRIC (RUSSIA) LLC St. Petersburg Branch Piskarevsky pr. 2, bld 2, lit "Sch", BC "Benua", office 720; 195027 St. Petersburg, Russia	Tel : +7-812-633-3497 Fax : +7-812-633-3499
Turkey	MITSUBISHI ELECTRIC TURKEY A.S Umraniye Branch Serifali Mahallesi Nutuk Sokak No:5, TR-34775 Umraniye/Istanbul, Turkey	Tel : +90-216-526-3990 Fax : +90-216-526-3995
UAE	MITSUBISHI ELECTRIC EUROPE B.V. Dubai Branch Dubai Silicon Oasis, P.O.BOX 341241, Dubai, U.A.E.	Tel : +971-4-3724716 Fax : +971-4-3724721
South Africa	ADROIT TECHNOLOGIES 20 Waterford Office Park, 189 Witkoppen Road, Fourways, South Africa	Tel : +27-11-658-8100 Fax : +27-11-658-8101
China	MITSUBISHI ELECTRIC AUTOMATION (CHINA) LTD. Mitsubishi Electric Automation Center, No.1386 Hongqiao Road, Shanghai, China	Tel : +86-21-2322-3030 Fax : +86-21-2322-3000
Taiwan	SETSUYO ENTERPRISE CO., LTD. 6F, No.105, Wugong 3rd Road, Wugu District, New Taipei City 24889, Taiwan	Tel : +886-2-2299-2499 Fax : +886-2-2299-2509
Korea	MITSUBISHI ELECTRIC AUTOMATION KOREA CO., LTD. 7F to 9F, Gangseo Hangang Xi-tower A, 401, Yangcheon-ro, Gangseo-Gu, Seoul 07528, Korea	Tel : +82-2-3660-9569 Fax : +82-2-3664-8372
Singapore	MITSUBISHI ELECTRIC ASIA PTE. LTD. 307 Alexandra Road, Mitsubishi Electric Building, Singapore 159943	Tel : +65-6473-2308 Fax : +65-6476-7439
Thailand	MITSUBISHI ELECTRIC FACTORY AUTOMATION (THAILAND) CO., LTD. 12th Floor, SV.City Building, Office Tower 1, No. 896/19 and 20 Rama 3 Road, Kwaeng Bangpongpan, Khet Yannawa, Bangkok 10120, Thailand	Tel : +66-2682-6522 Fax : +66-2682-6020
Vietnam	MITSUBISHI ELECTRIC VIETNAM COMPANY LIMITED Unit 01-04, 10th Floor, Vincom Center, 72 Le Thanh Ton Street, District 1, Ho Chi Minh City, Vietnam	Tel : +84-28-3910-5945 Fax : +84-28-3910-5947
Indonesia	PT. MITSUBISHI ELECTRIC INDONESIA Gedung Jaya 8th Floor, JL. MH. Thamrin No.12, Jakarta Pusat 10340, Indonesia	Tel : +62-21-31926461 Fax : +62-21-31923942
India	MITSUBISHI ELECTRIC INDIA PVT. LTD. Pune Branch Emerald House, EL-3, J Block, M.I.D.C., Bhosari, Pune-411026, Maharashtra, India	Tel : +91-20-2710-2000 Fax : +91-20-2710-2100
Australia	MITSUBISHI ELECTRIC AUSTRALIA PTY. LTD. 348 Victoria Road, P.O. Box 11, Rydalmere, N.S.W 2116, Australia	Tel : +61-2-9684-7777 Fax : +61-2-9684-7245

## MITSUBISHI ELECTRIC CORPORATION

HEAD OFFICE: TOKYO BLDG., 2-7-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN  
www.MitsubishiElectric.com