Piezo Vibration Sensors VS Series
Application Note

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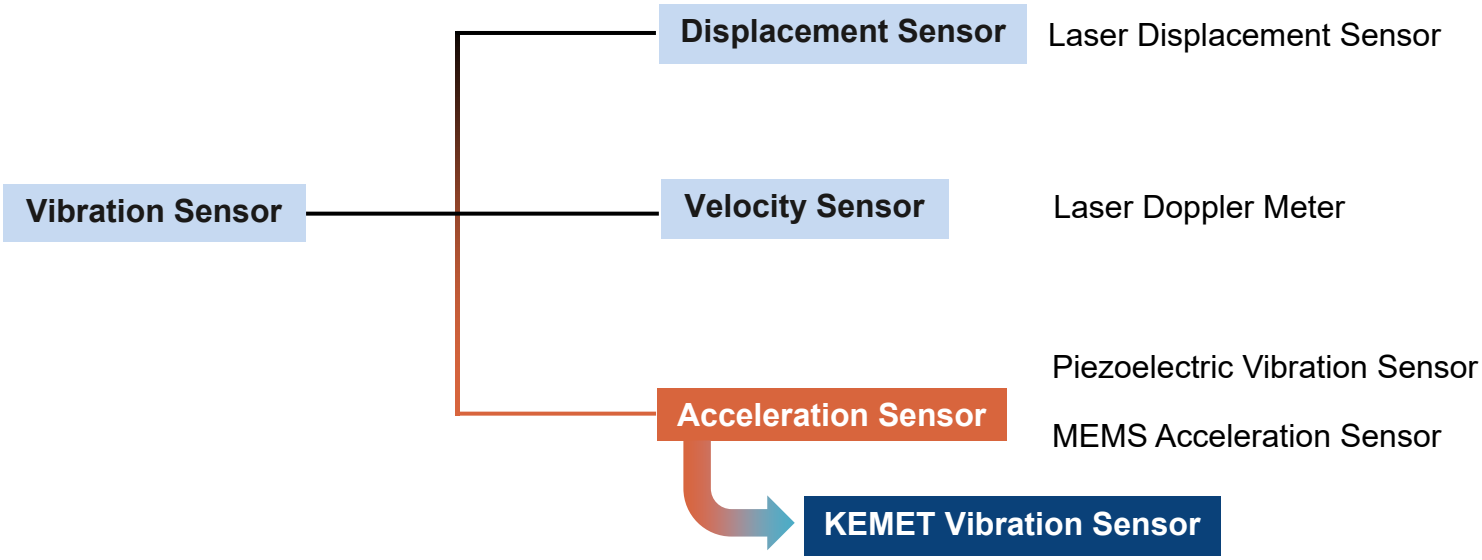
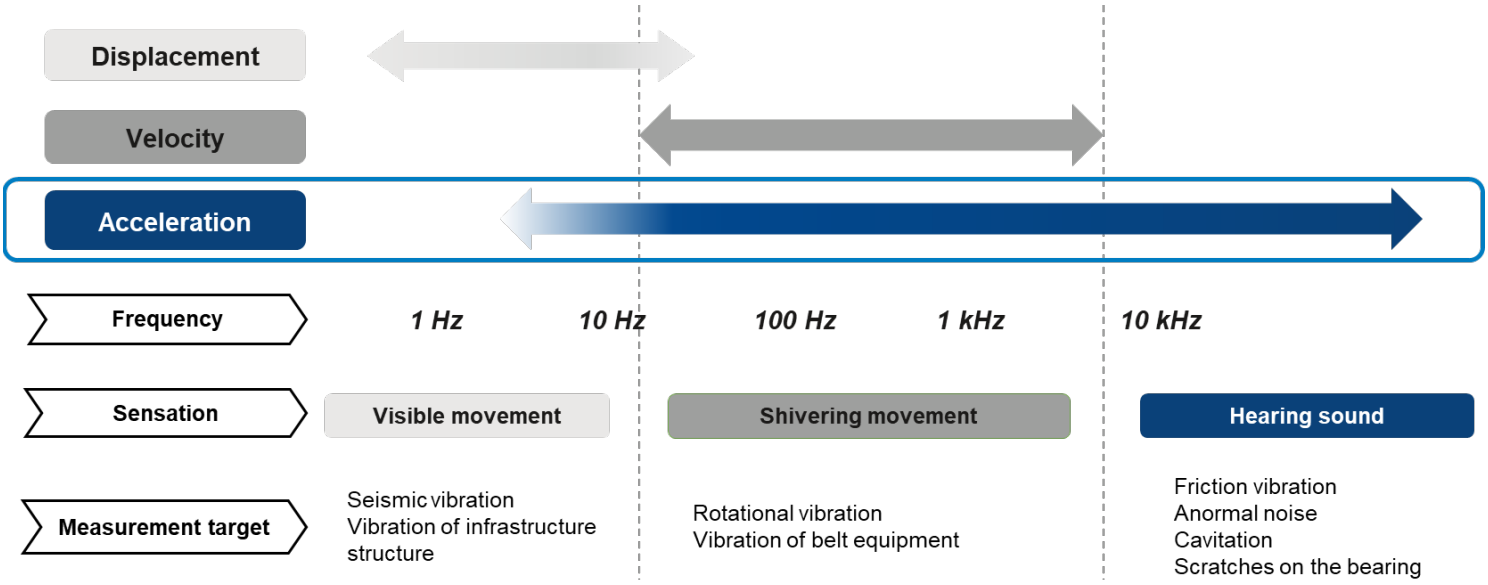
Classification of Vibration Sensors

- A vibration sensor is a sensor that measures the periodic movement of an object.
- Vibration sensors are roughly classified into three types: displacement sensor, velocity sensor, and acceleration sensor.



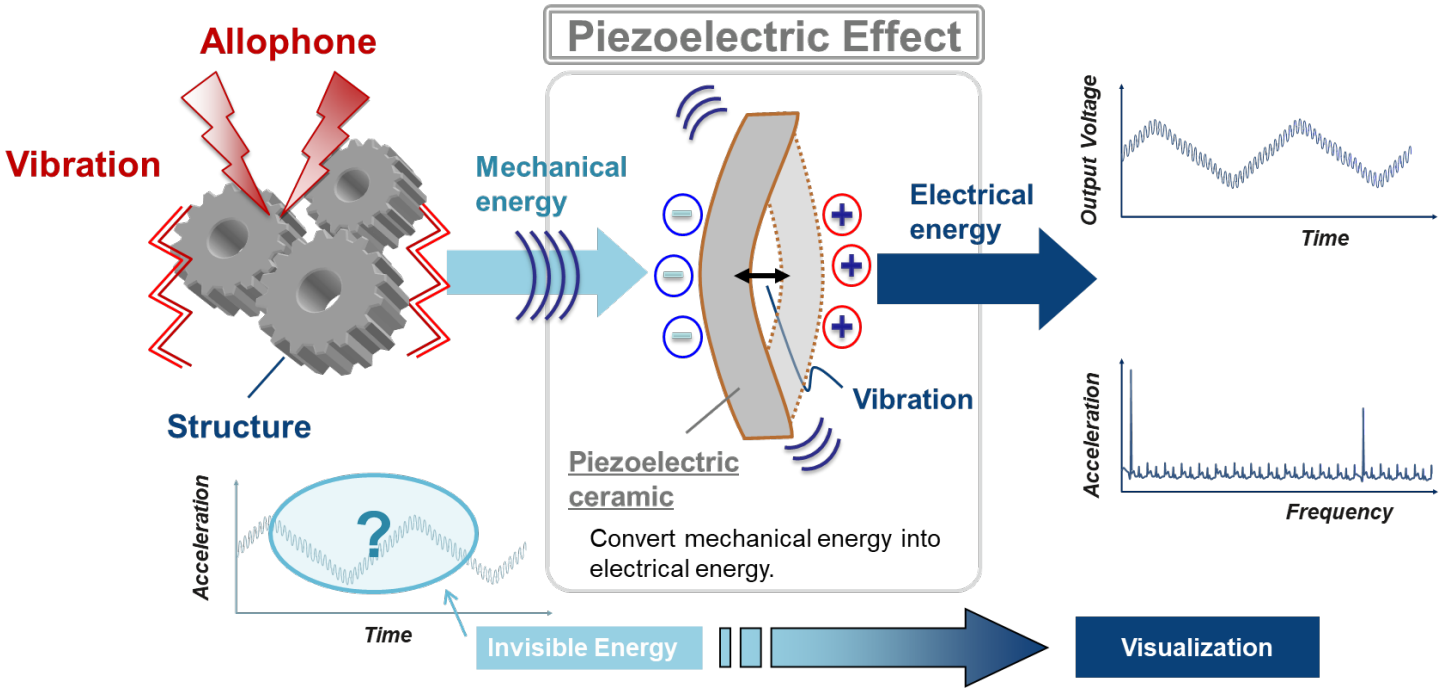
Frequency Range of Vibration Sensors

- Accelerometers are attracting attention, especially in the high frequency range, for monitoring mechanical vibrations.



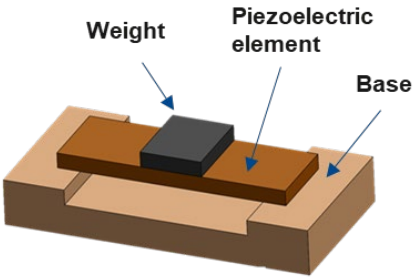
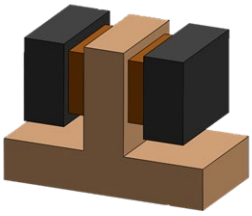
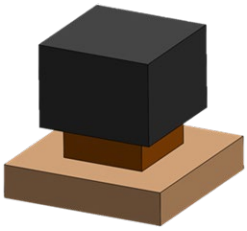
Principle of Piezoelectric Vibration Sensors

- The piezoelectric effect is a phenomenon in which an electric field is generated when mechanical energy is applied to ceramics.



Types of Piezoelectric Vibration Sensors

- Piezoelectric vibration sensors are roughly divided into three types of structures.
- Each has its own characteristics and can be used according to the purpose.
- KEMET uses a bending type.

Bending Type	Share Type	Compressed Type
		
• Small size • High sensitivity • Simple structure	• Small effect of external noise	• High strength • High resonance frequency and high sensitivity
• Low resonance frequency	• Complex structure • Difficult to reduce height	• Susceptible to external noise

Features of KEMET Vibration Sensors

- Vibration in a wide frequency band can be collected in real time with high sensitivity.

Proprietary Technology

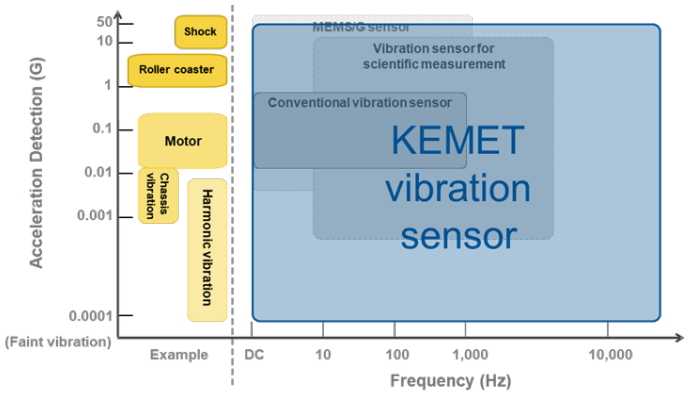
- Composition optimization of ceramic materials
- Mechanism to increase vibration

Features

- High sensitivity and wide frequency band
- Voltage output through the built-in amplifier
- Small size and low profile

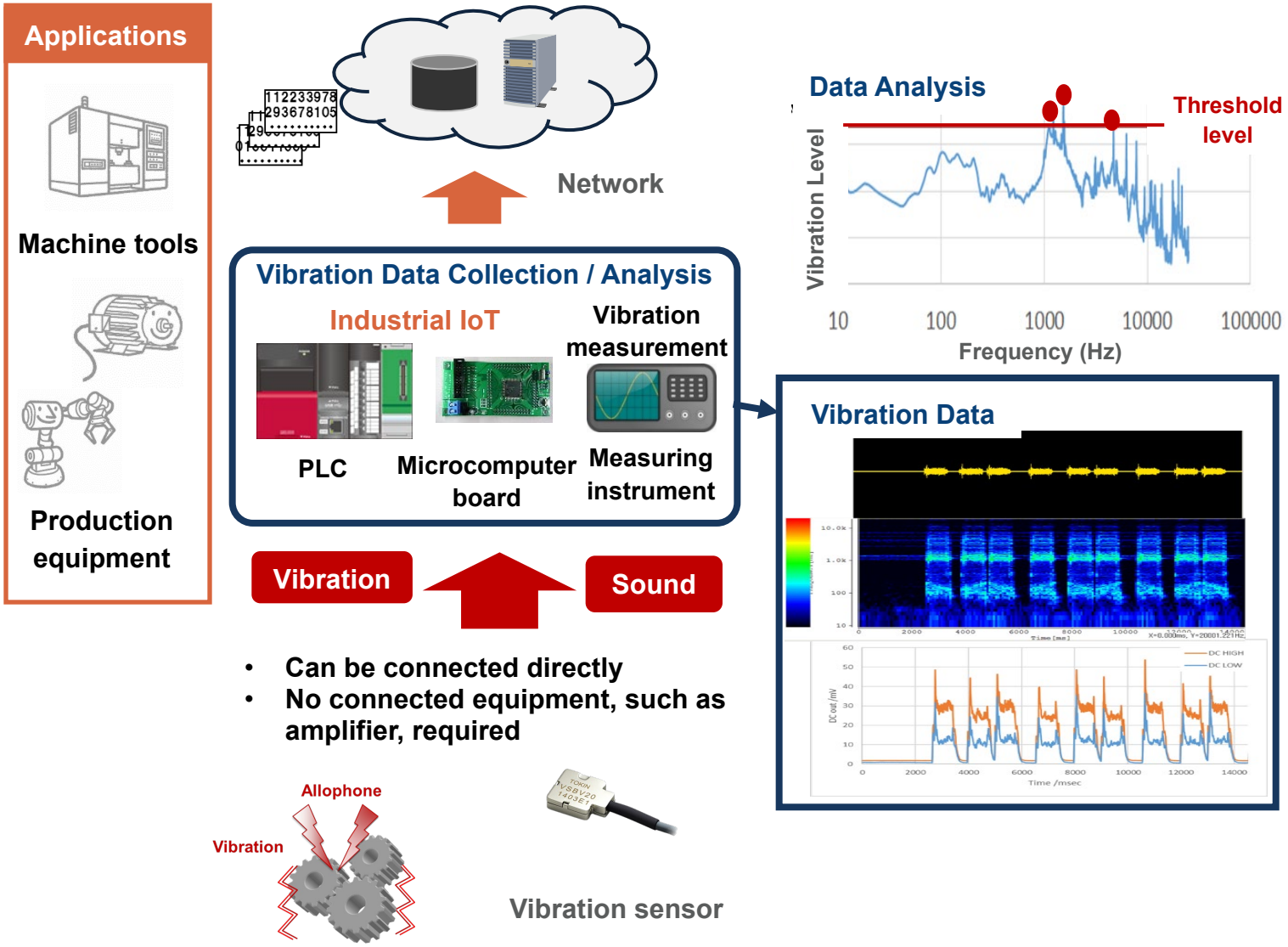
Achieves high sensitivity and wide frequency band

Detection Acceleration Area



Example of Measurement Environment

- Monitor the status of FA equipment and structures on the network and perform "visualization".

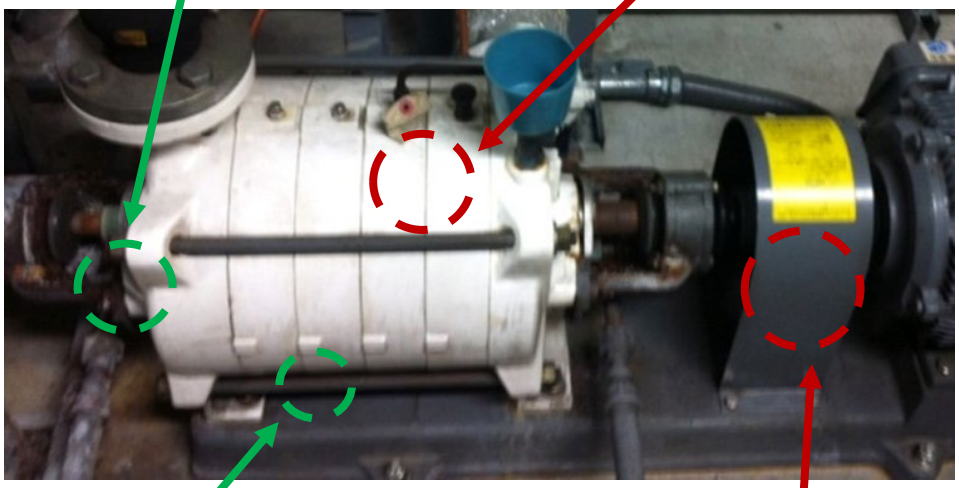


- **Can be connected directly**
- **No connected equipment, such as amplifier, required**

Sensor Mounting Location

- The frequency performance of the sensor is highly dependent on the method of installation.

Object to be Measured: Motor



NOT OK

Curved surface

Uneven surface

Foreign matter pinched

＊In this case, it may affect the frequency characteristics.

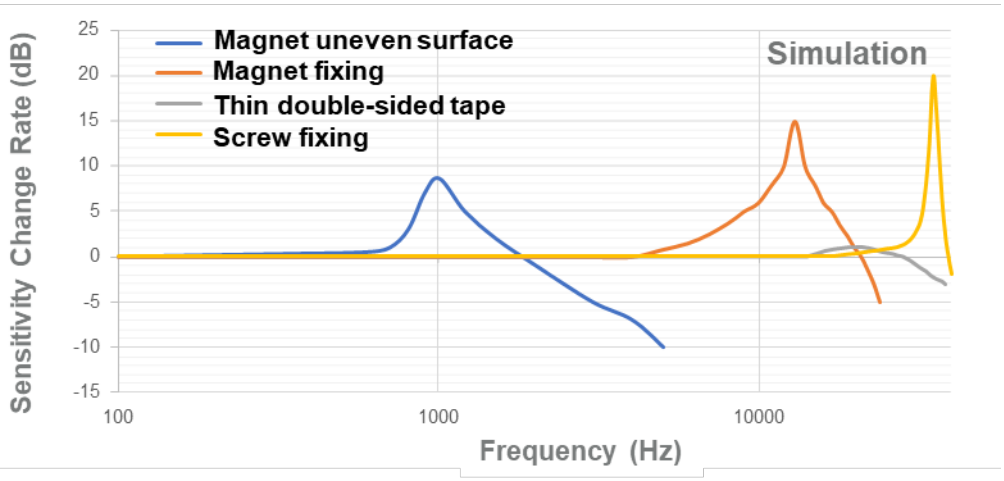
OK

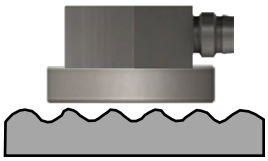
Flat surface

How to Attach the Sensor?

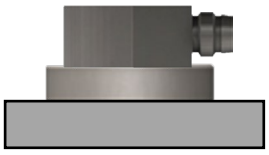
- The frequency performance of the sensor is highly dependent on the method of installation.
  - Select the fixing method according to the measurement frequency.

Fixing Method and Frequency Characteristics





Magnet on uneven surface

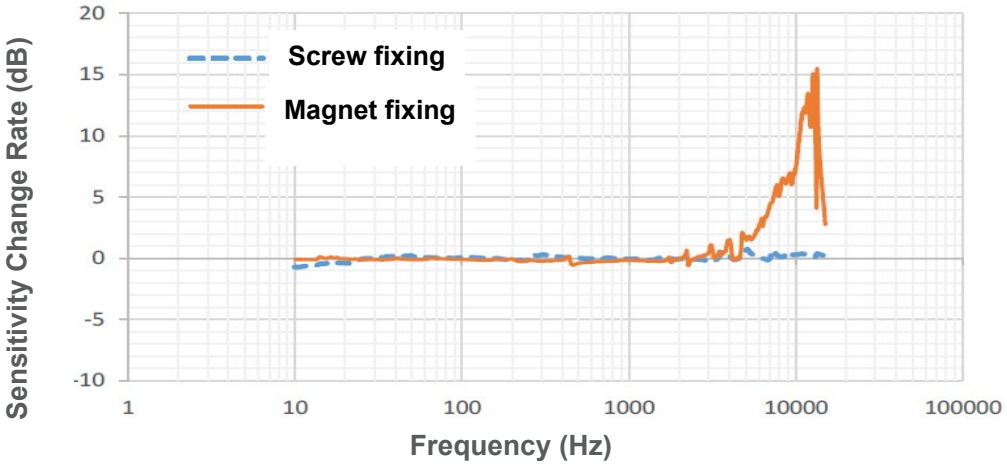


Magnet on flat surface

Thin double-sided tape

Screw fixing

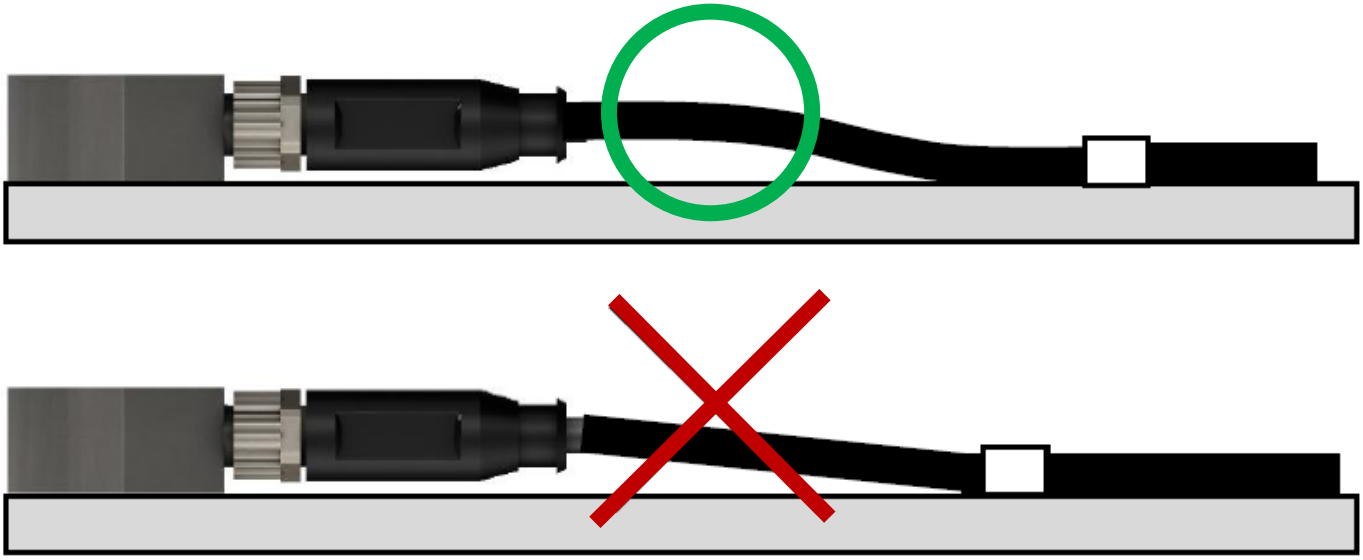
Measured Value (VS-JV10A)



If you need to measure up to high frequency, we recommend fixing with screws.

How to Wire Cables?

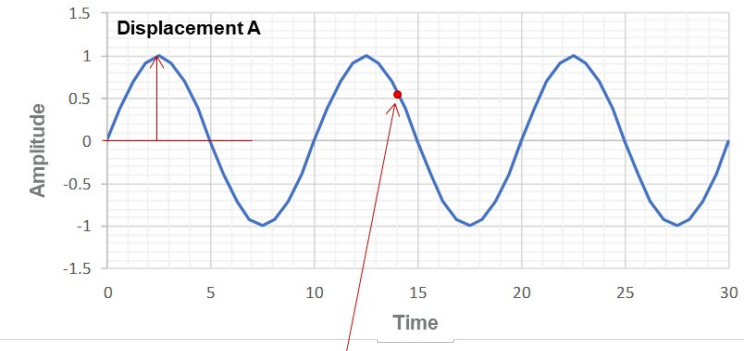
- Please use the following with caution in order to obtain correct measurement and stable data.
  - Secure the cables at appropriate intervals to minimize cable vibration.
  - Select the cable layout and fixing so that tension is not applied.
  - Do not bend the cable more than necessary (keep the minimum bending radius).



Displacement, Velocity and Acceleration

- The relationship between displacement, velocity and acceleration changes with frequency.
  - The higher the frequency, the easier it is to measure because the same displacement produces higher velocities and accelerations.
  - Acceleration sensor is suitable for high frequency measurement such as motor.

Displacement



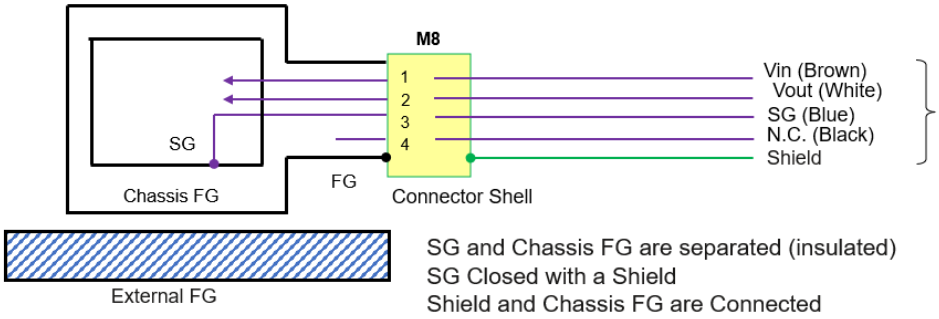
Let [x] be the displacement at a certain time [t].

Displacement	$x = A\sin(\omega t)$
Speed	$v = x' = A \cdot 2\pi f \cdot \cos(\omega t)$
Acceleration	$v = x'' = -A \cdot (2\pi f)^2 \cdot \sin(\omega t)$

ω = angular frequency (Hz) = $2\pi f$

f = vibration frequency (Hz)

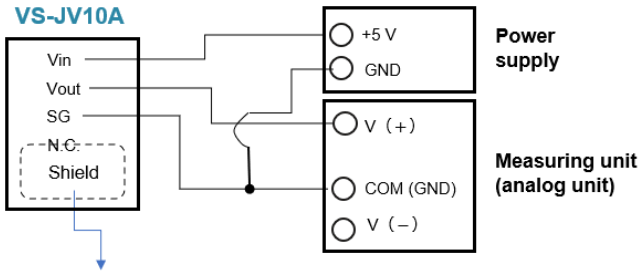
Connection Example with VS-JV Type



Cable
VSC-***PURS4-M8D-01
Chassis Material: PUR
The shield is connected to the connector shell.

SG and Chassis FG are separated (insulated)
SG Closed with a Shield
Shield and Chassis FG are Connected

Connection Example



- Connect to SG when FG and SG separation is not required.
- When separating FG and SG, open or connect to FG.
- When separating, please consider noise when connecting.

When Measuring Vibrations?

① Is offset voltage (~1.5 V) present?

・In normal conditions you should see 1.5V output.

・Tap the area around the sensor and you should see AC waveform representing mechanical stimulus.

② If no offset voltage present?

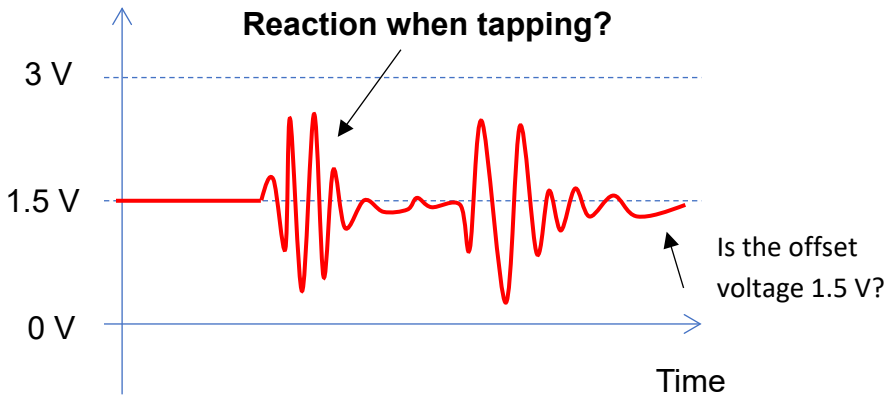
・ Tap the area around the sensor, expect to see AC waveform representing mechanical input stimulus.
・ If no AC waveform present, check data logger and connector (confirm good connection).
・ If AC waveform present but no DC offset, check settings of data logger.

③ Is there any power supply noise?

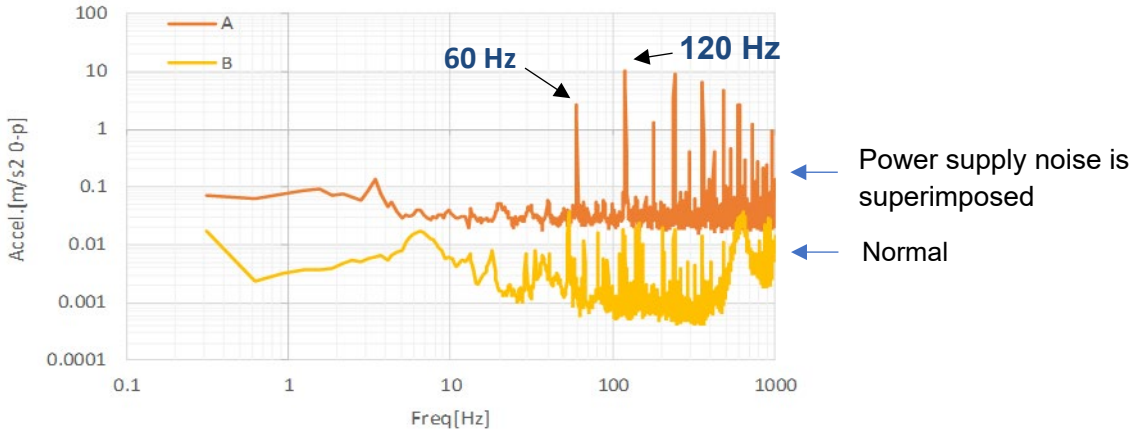
・ If a large output is generated at 0/60 Hz during connection, it is considered that power supply noise is superimposed.
・ Noise varies greatly depending on the operating environment, so consider ground connection in advance.

・ The connection of the shielded wire has a large effect, so check it carefully (SG, FG, floating, etc.).

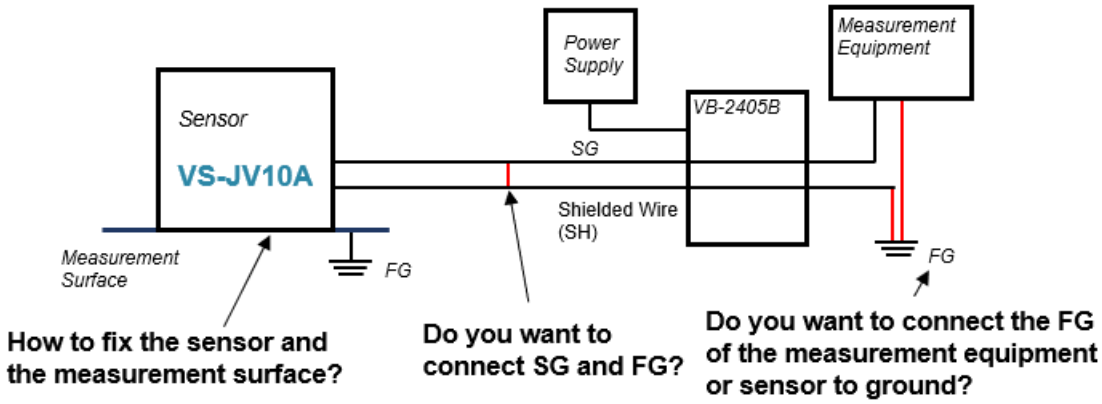
Waveform Checkpoint



FFT Example of Vibration Sensor



Connection Checkpoint



Temperature Characteristics

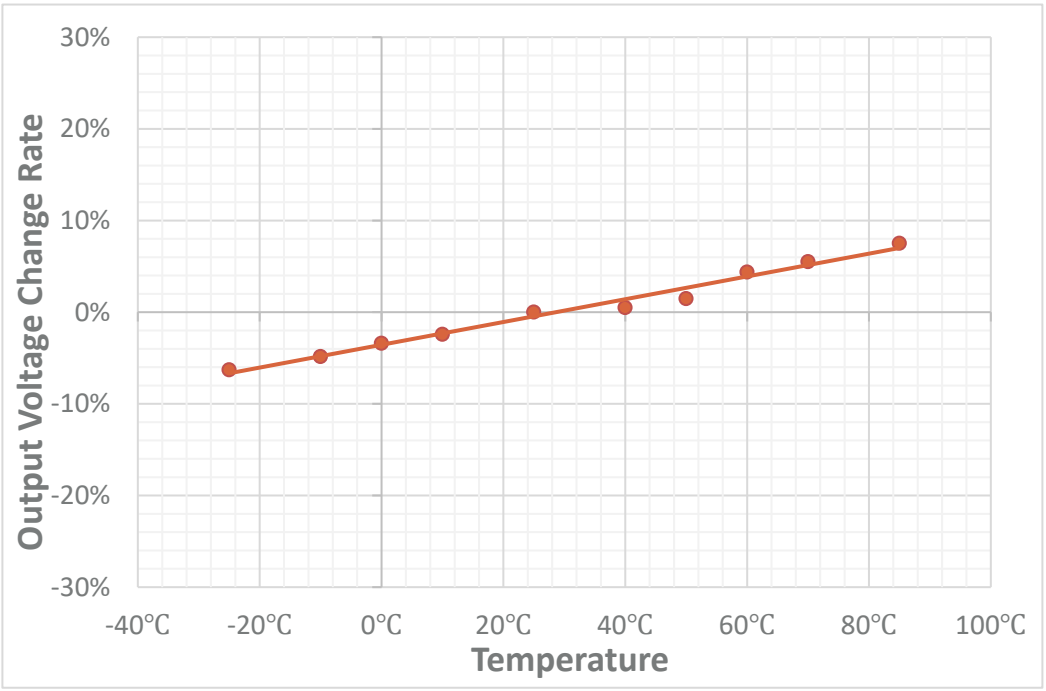
Vibration Sensor *VS-JV10A*

Applied waveform:

Sin 1 kHz / 0.1 V

Measuring instrument:

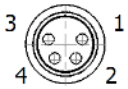
DS2000 / onosokki



Typical example

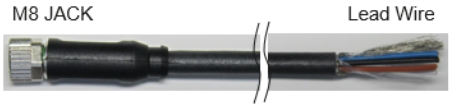
Connection Diagram for VS-JV10A

Sensor



Connector
(Mating view)

Cable



Standard PN: **VSC-030PURS4-M8D-01**

Lead Wire

Vin
Vout
SG (Signal Ground)
FG (Frame Ground)
N.C.

DC Power Supply 5 V

- Stabilized power supply, etc.
- Current consumption: approx. 0.35 mA.
- If the power supply is unstable, please insert a smoothing.
- Capacitor (about 100 µF) between Vin and GND.

Measuring Equipment

- FFT, oscilloscope, A/D (→PC), etc.
  ※or terminate with 100 kΩ or more

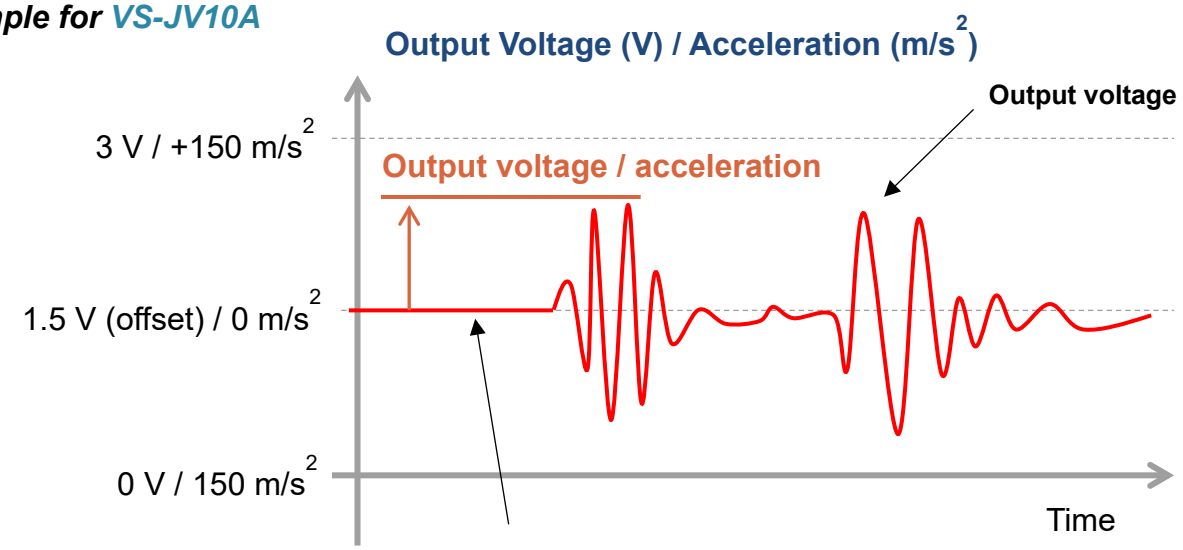
Pin Assignment

Pin Assignement	Symbol	Function
1	V_{IN}	Power input
2	V_{OUT}	Sensor output
3	SG	Signal ground
4	N.C.	N/A

Connection

Pin Assignement	Wire Color	Symbol	Function[1]
1	Brown	V_{IN}	Power input
2	White	V_{OUT}	Sensor output
3	Blue	SG	Signal ground
4	Black	N.C.	N/A
Other conductor	Shield	FG	Frame ground

Output Example for VS-JV10A



(over 100 m/s² is not guaranteed)

- When the vibration sensor receives vibration, it outputs a voltage proportional to the amount of vibration.
- The acceleration value is obtained based on the offset voltage.
  For example, if an instantaneous value is 2 V,

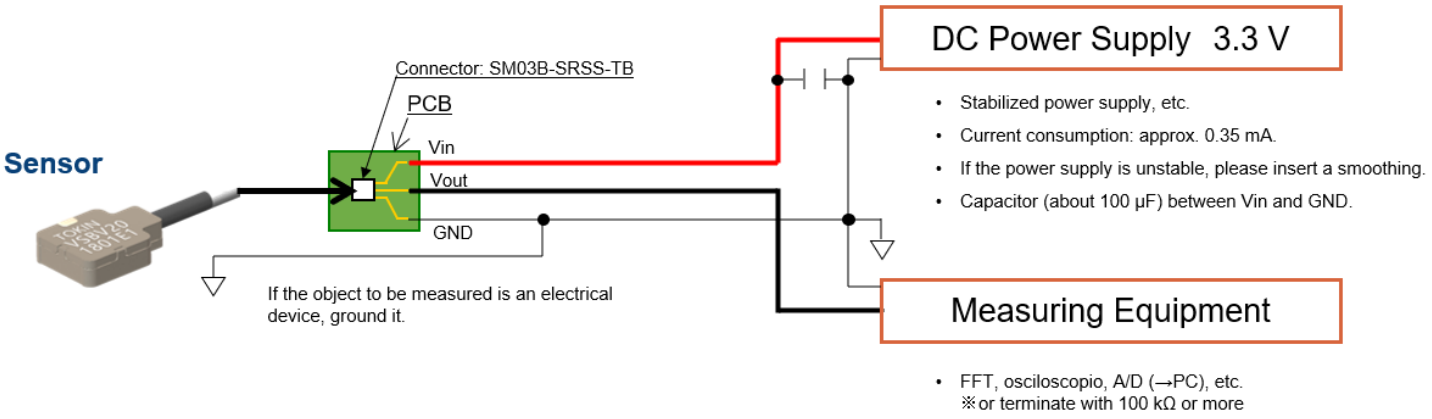
Output voltage: 2 - 1.5 = 0.5 (V)

Multiplying that value by the sensitivity gives the resulting acceleration.

Acceleration: 0.5 / 0.01 = 50 (m/s²)

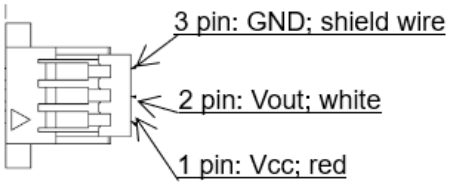
Sensitivity: 10 mV (mV/m/s²)

Connection Diagram for VS-BV203-B



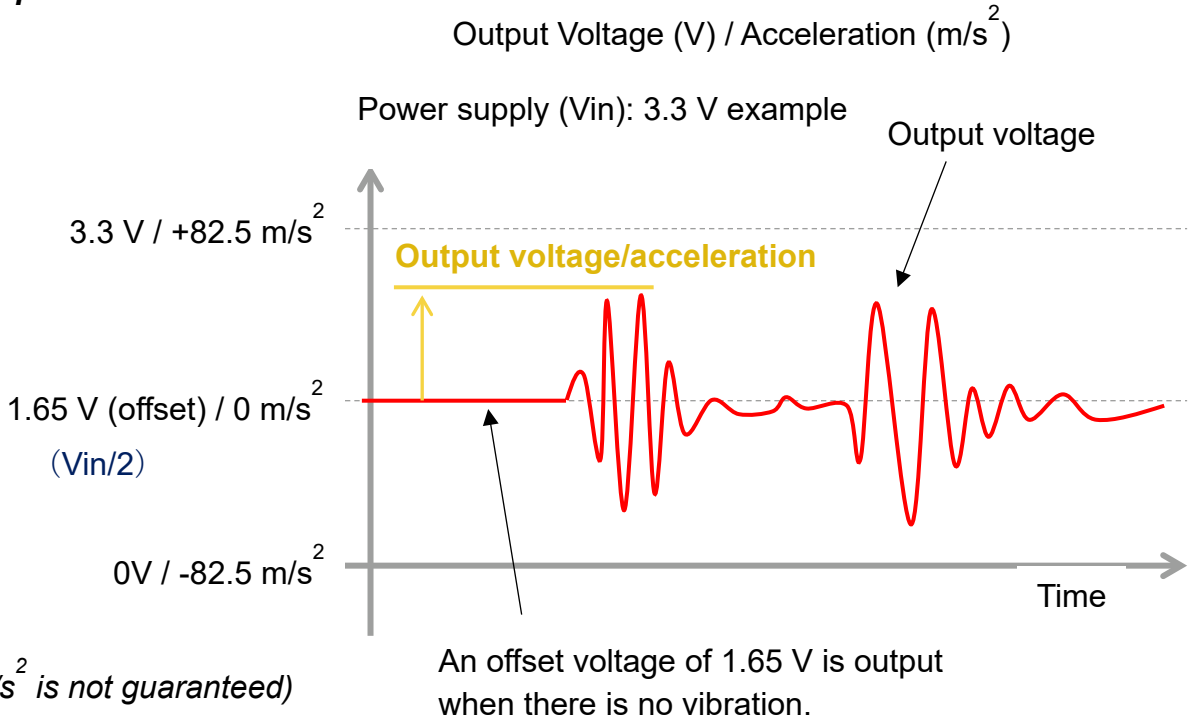
Pin Assignment

Connection; line color



※ Connector: **SHR-03V-S-B**

Output Example for VS-BV203-B



(over 50 m/s² is not guaranteed)

When the vibration sensor receives vibration, it outputs a voltage proportional to the amount of vibration.
The acceleration value is obtained based on the offset voltage.
For example, if an instantaneous value is 2V,

Output voltage: 2 - 1.65 = 0.35 (V)

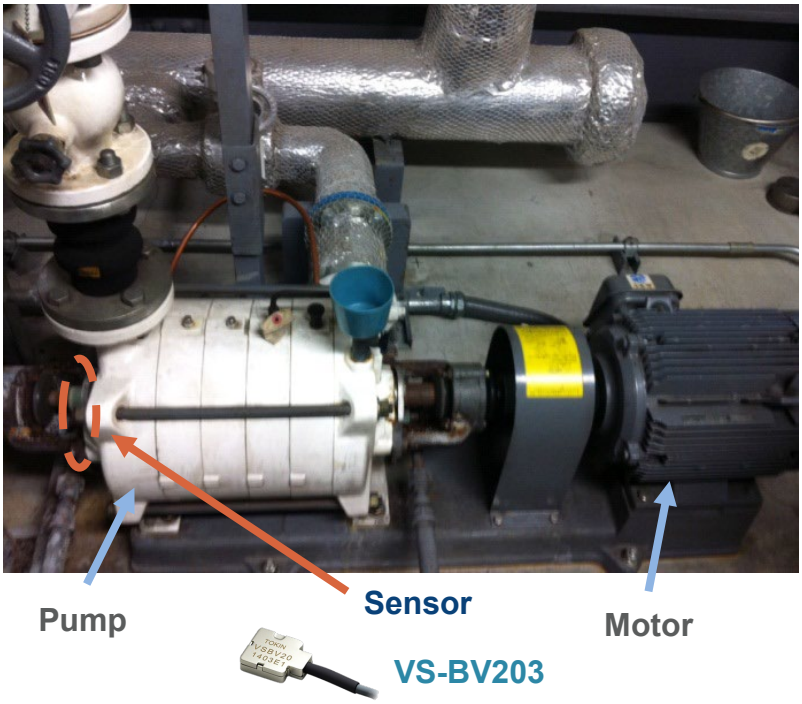
Multiplying that value by the sensitivity gives the resulting acceleration.

Acceleration: 0.35 / 0.02 = 17.5 (m/s²)

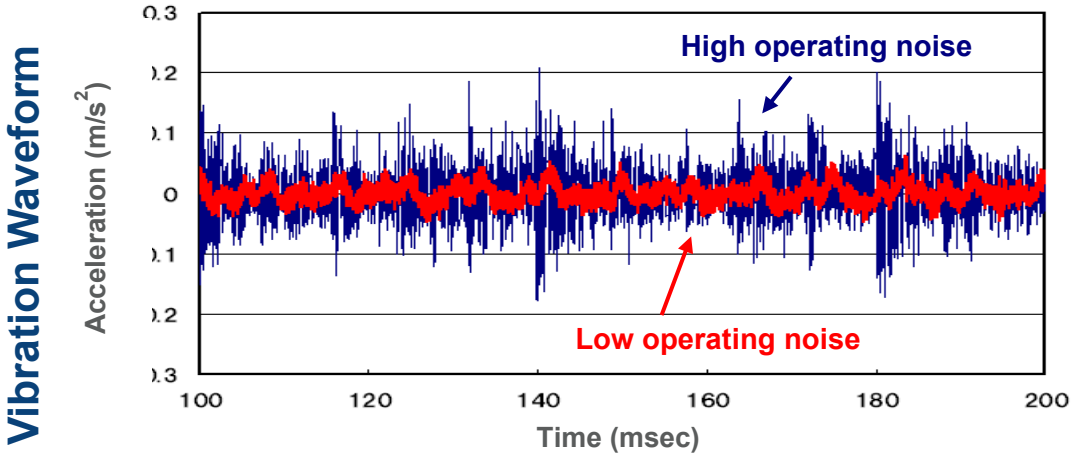
Sensitivity: 20 mV (mV/m/s²)

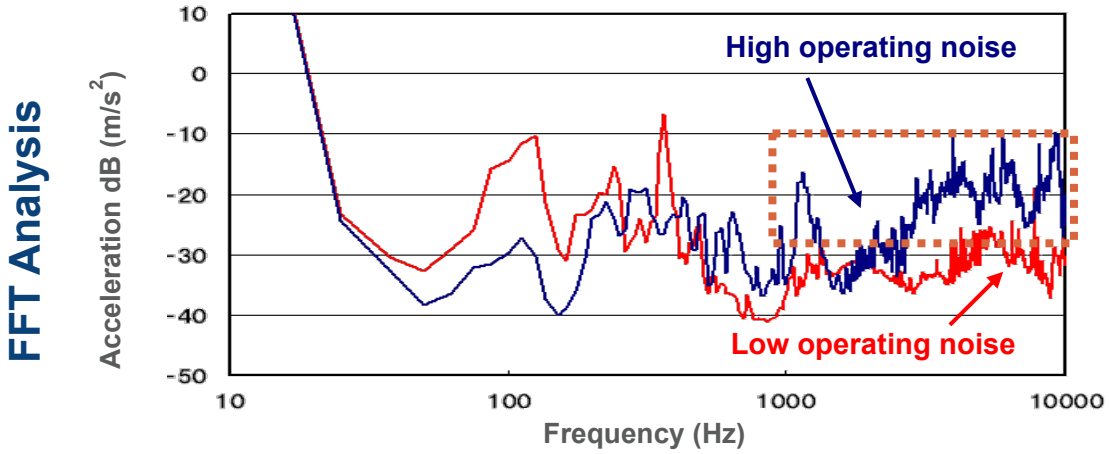
***Measurement Example* ① Pump**

- We measured the vibration waveforms of two pumps with different operating sounds.
- A difference was found in the vibration waveform between the two pumps.
- Since vibration is large at high frequencies, the worn part of the bearing may have deteriorated.



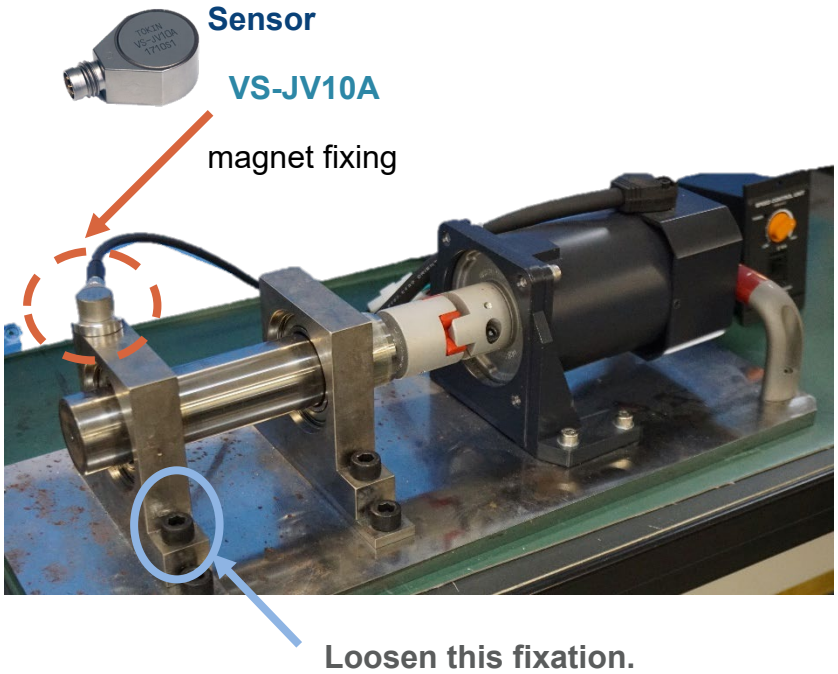
- Measure two pumps with different operating sounds.



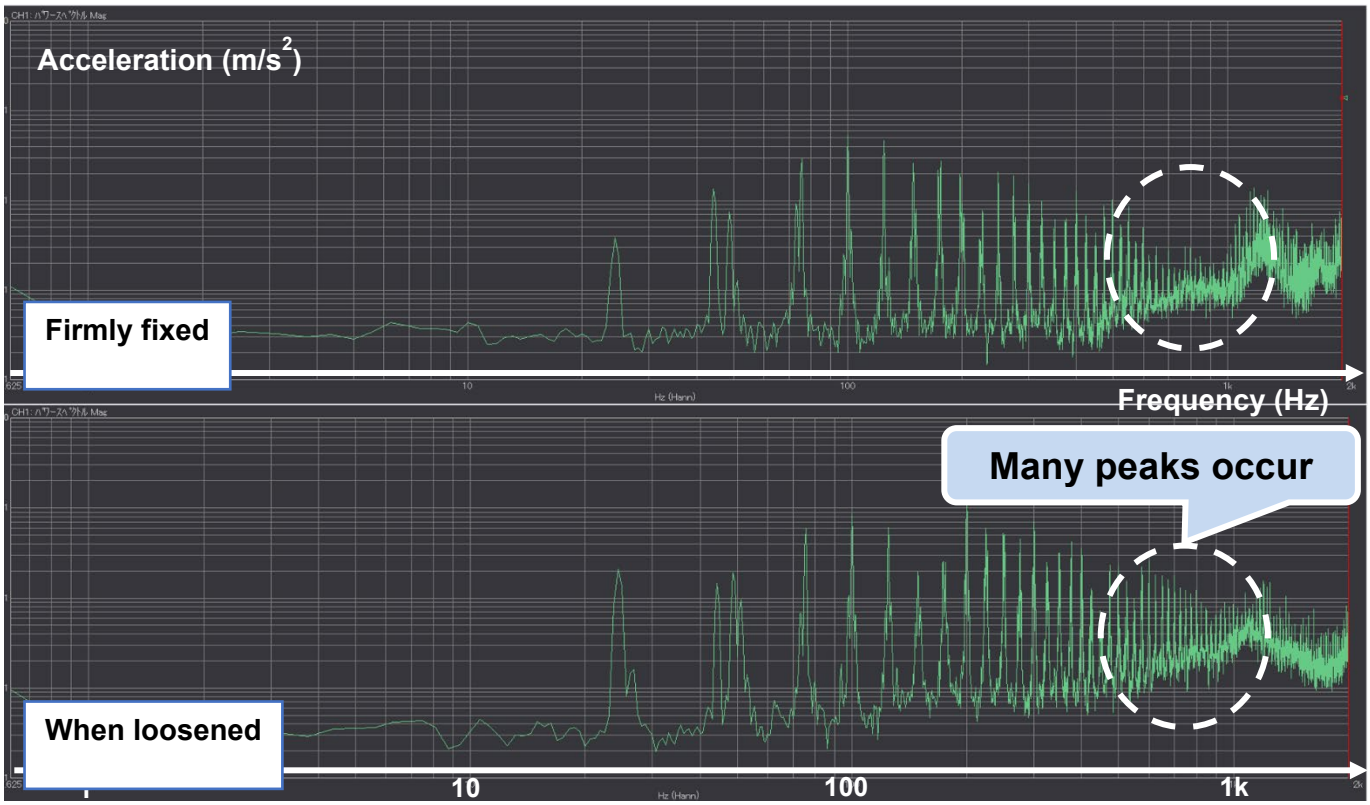


Measurement Example ② **Motor**

- While driving the motor, loosen the fixed part of the bearing.
- Many peaks occur around 500 Hz to 1 kHz.
- There was a difference in the vibration level in a specific frequency band.



FFT Analysis



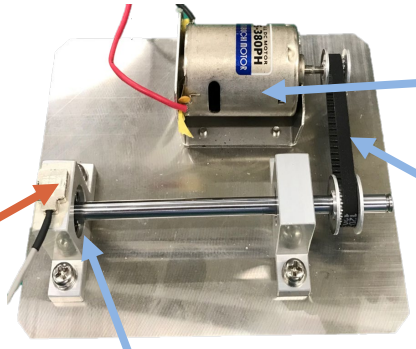
Measurement Example ③ **Bearing**

- Comparison of waveforms with and without bearing ball damage.

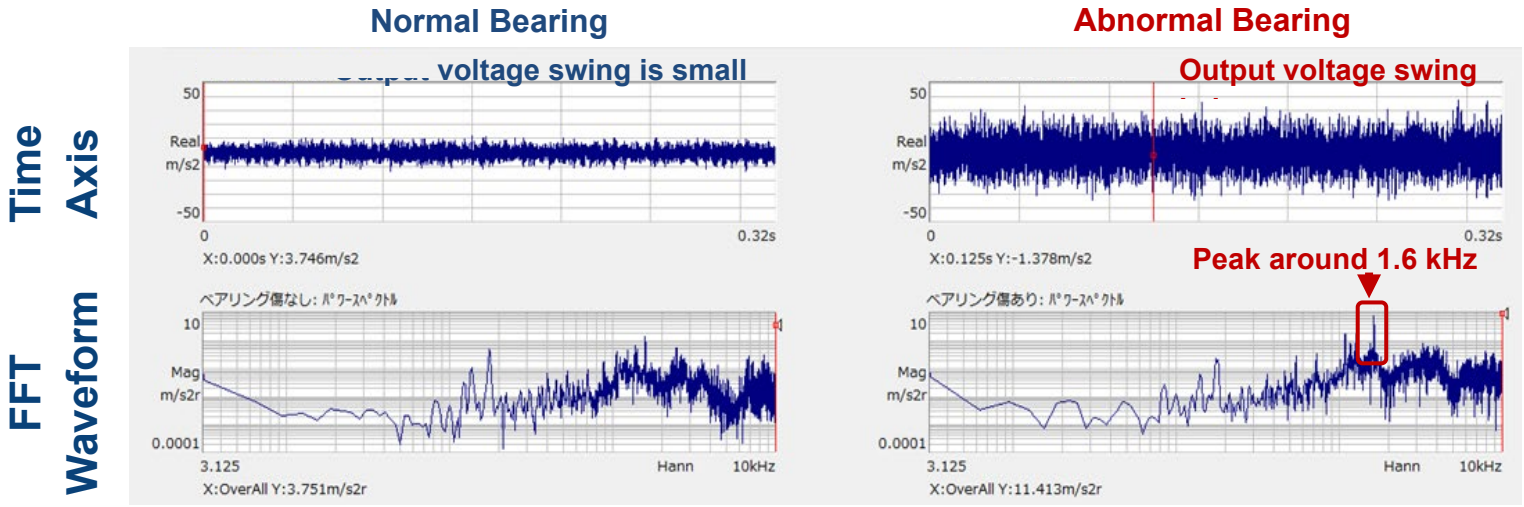
Sensor

VS-BV203

double-sided tape fixing



The general usage is to set the threshold value based on the output difference between normal and abnormal equipment.



Measurement Example ④ **Fan**

- The vibration of the air supply / exhaust fan was measured for half a year.
- By using VB-2405B, it is possible to measure even at a low sampling frequency.

Air Supply / Exhaust Fan

Measurement Condition

Measurement interval: 2 hrs

Sampling: 0.441 ms

One measurement time: about 3.5s

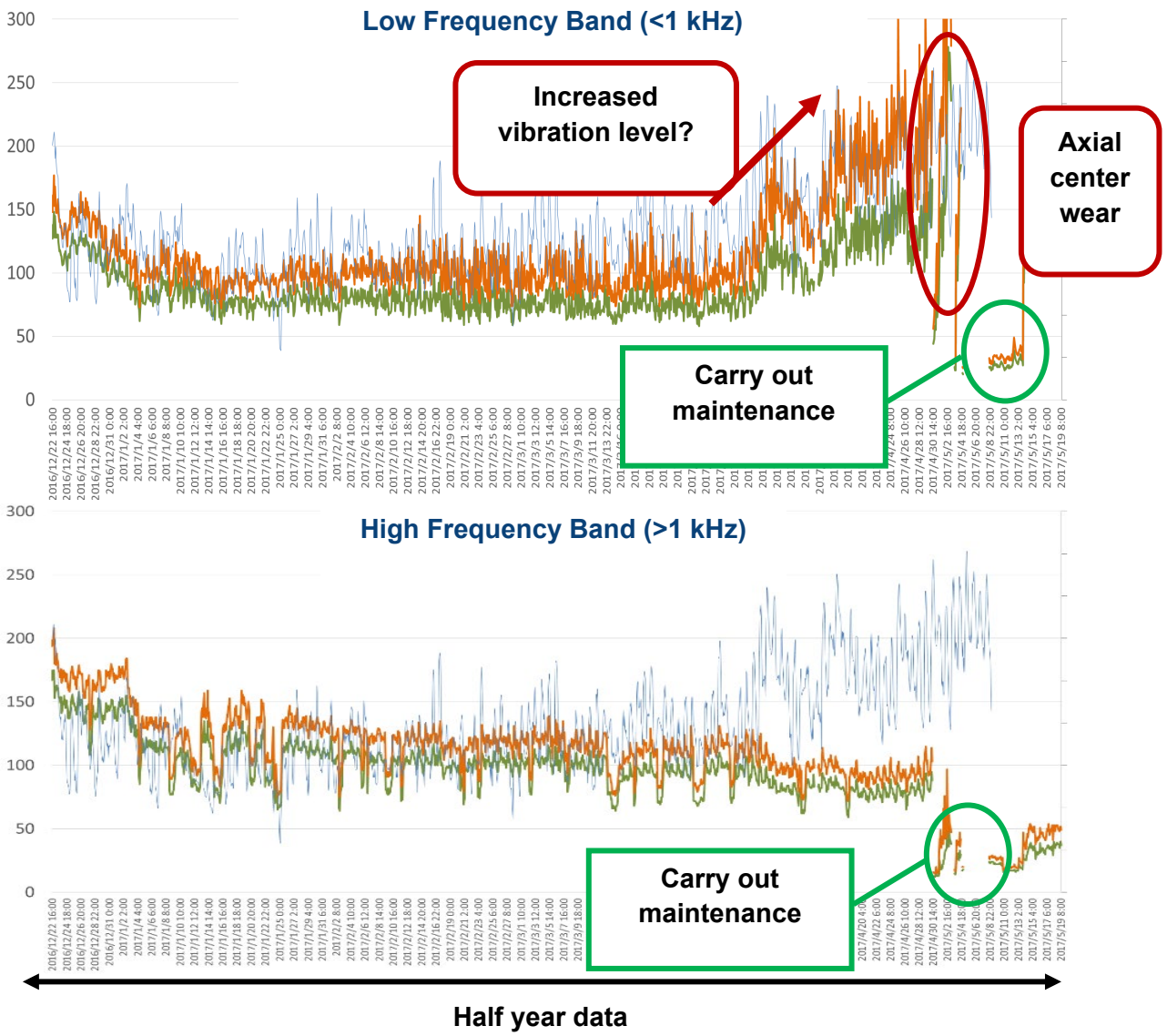
Constitution

Sensor — **Connection unit** — **Sequencer**

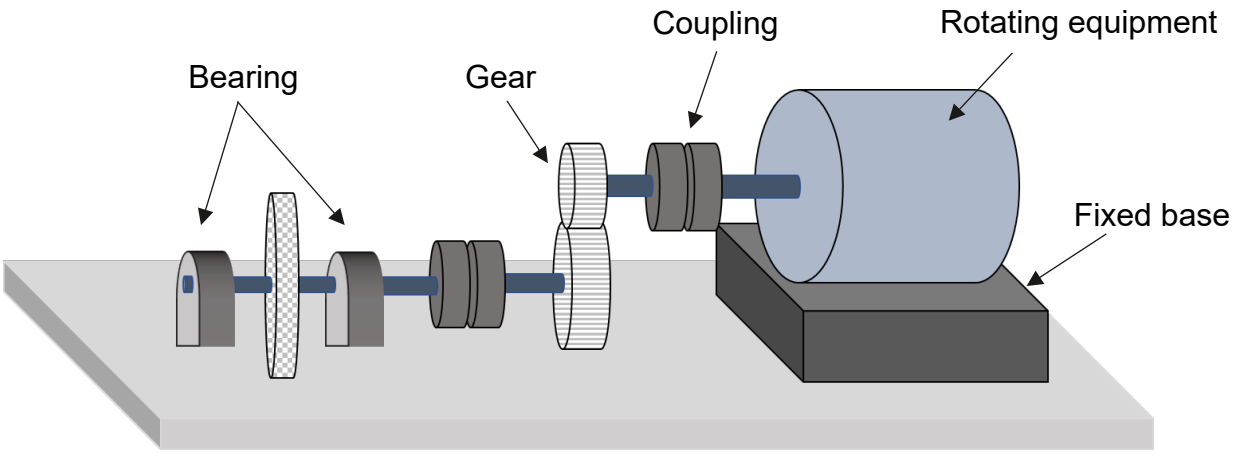
Magnet fixing

Equipment Used

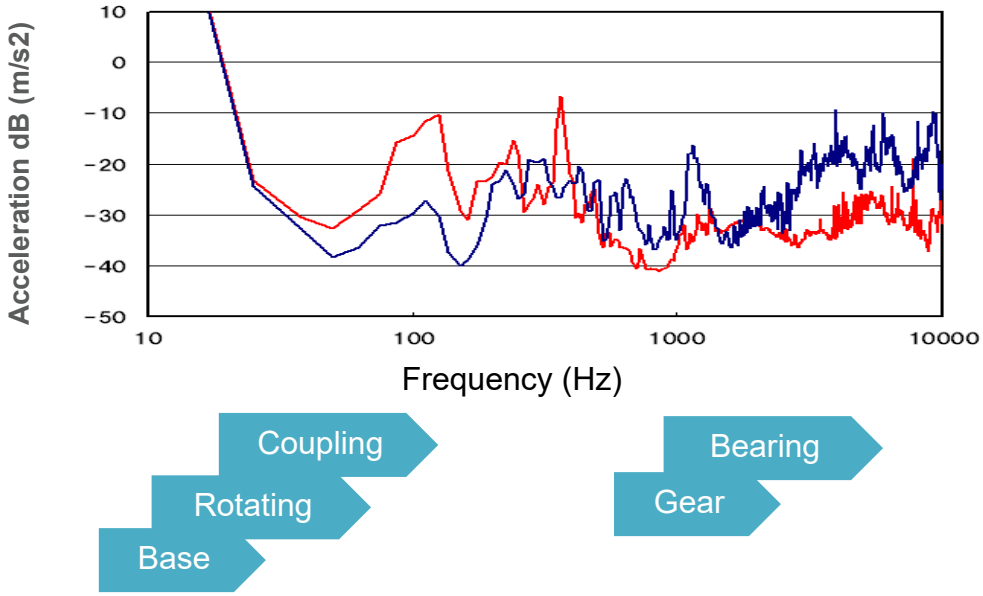
Sensor	**VS-JV10A**
Magnet	VM-03
Cable	VSC-100PURS4-M8D-01
Connection unit	VB-2405B
Sequencer analog unit	FX Series



Examples of Damage to Rotating Machines



Fast Fourier Transform (FFT) Output



Frequency Band (Hz)	Damaged Part	Damage Details	Detection Sensor
3k~10k	Bearing	Abrasion, burnout	**Vibration**, acoustic sound, heat
1k~5k	Gear	Missing tooth, gears do not mesh	**Vibration**, acoustic
50~200	Coupling	Misalignment	**Vibration**, heat
30~100	Rotating equipment	Unbalance	**Vibration**
10~50	Fixed base	Rattle, loose fixing bolt	**Vibration**

Product Lineup

Part Number	Acceleration Measuring Range
VS-JV10A 	±100 m/s^2 maximum 10 mV/m/s^2 sensitivity
VS-JV02A 	±500 m/s^2 maximum 2 mV/m/s^2 sensitivity
VS-BV203-B *with cable integrated* 	±50 m/s^2 maximum 20 mV/m/s^2 sensitivity

Accessories

- Cable VSC-100PURS4-M8D-01

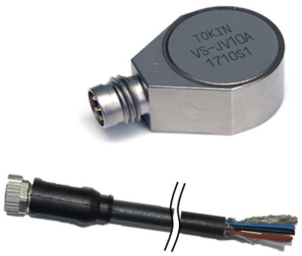
- Magnet base VM-03

- Attachment VA-01

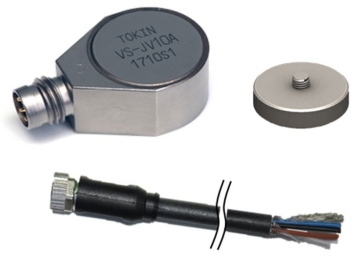
VS-JV Evaluation Kits

VS-JV02A-K01
or
VS-JV10A-K01

VS-JV02A-K02
or
VS-JV10A-K02



VS-JV02A-K03
or
VS-JV10A-K03



VS-JV02A-K04
or
VS-JV10A-K04