INSTRUCTION MANUAL

Accelerometer

PV Series

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Organization of This Manual

This manual describes the features and operation of Rion accelerometers.

This manual contains the following sections.

Accelerometer Selection

Gives information on how to select an accelerometer, based on factors such as acceleration and frequency, mass of the vibrating object, temperature, length of connection cable, etc.

Usage

Gives information on accelerometer mounting methods and frequency response.

Explanation and Precautions Regarding Specification Items

Gives information on sensitivity calibration, sensitivity temperature characteristics, frequency range, transverse sensitivity, temperature transient sensitivity, base strain sensitivity, and acoustic sensitivity.

Precautions

Be sure to observe the following precautions, to ensure safe use and prevent the risk of injury or damage.

- Never drop the accelerometer. The shock of a fall can fatally damage a piezoelectric accelerometer, or lead to serious performance degradation. Scratches or other damage on the mounting surface can degrade frequency response.
- Never connect a regulated voltage source to an accelerometer with an integrated constant-current input amplifier. If a voltage is applied, the built-in amplifier will be destroyed.
- Do not exceed the specified usage temperature range. Pay special attention to high temperatures. Otherwise the accelerometer may be fatally damaged.
- Piezoelectric accelerometer other than waterproof types are not hermetically sealed. Do not place such accelerometers in water or leave them exposed to humidity over 85% for an extended period. Otherwise moisture may enter the accelerometer and lead to reduced insulation and performance degradation.
- If you suspect that there is a problem with the unit, contact your supplier.

Contents

Accelerometer Selection

Acceleration and Frequency of Vibrating Object

The selection of a suitable accelerometer will be mainly based on the sensitivity required for the magnitude of acceleration developed by the vibrating object. Another major factor is the frequency of vibration. For objects vibrating at a low frequency, a high-sensitivity accelerometer will be required. For objects vibrating at a high frequency, a compact, lightweight accelerometer with frequency response that extends into the high frequency region should be selected.

For accelerometers, the higher the sensitivity (and therefore the suitability for measuring low-level acceleration), the more limited the high frequency response will be. Reversely, accelerometers with more extended frequency response will tend to have lower sensitivity (and therefore be more suitable for measuring high-level acceleration).

Mass of Vibrating Object

When the accelerometer is mounted to the vibrating object, the mass of the accelerometer will be added to that of the object, resulting in a change of vibration mode. If the ratio of object mass vs. accelerometer mass is 10 times or more, the change in resonance frequency of the vibrating object will be less than 5% and can be disregarded. For vibrating objects with a mass of 5 kg or more, any accelerometer can therefore be used. If the mass of the vibrating object is 1 kg or less, only compact and lightweight accelerometers should be used.

Temperature

If an accelerometer is used at a temperature that exceeds the permissible ambient temperature for use, as listed in its specifications, the accelerometer will be damaged.
Be sure to select a accelerometer that is rated for the entire temperature range expected for the vibrating object. When the temperature fluctuates, noise will be superimposed on the output waveform, due to thermal transient response. If considerable temperature fluctuation is expected for the vibrating object, select an accelerometer with low temperature transient sensitivity.

Cable Length

Charge output accelerometers are more susceptible to electromagnetic noise interference than accelerometers with a built-in amplifier. This phenomenon gets more pronounced the longer the cable run is. For installations where the cable length exceeds 5 meters, an accelerometer with built-in amplifier is recommended.

Usage

Accelerometer Mounting Methods and Frequency Response

Various mounting methods for accelerometers are shown in Figure 1. The same accelerometer will have a significantly different frequency response depending on the mounting method, as can be seen from Figure 2. The data in this graph are for the accelerometer type PV-85, but the same principle applies to other accelerometers as well. The rod attachment method is different from the other methods in so far as the accelerometer is only held by hand against the vibrating object.

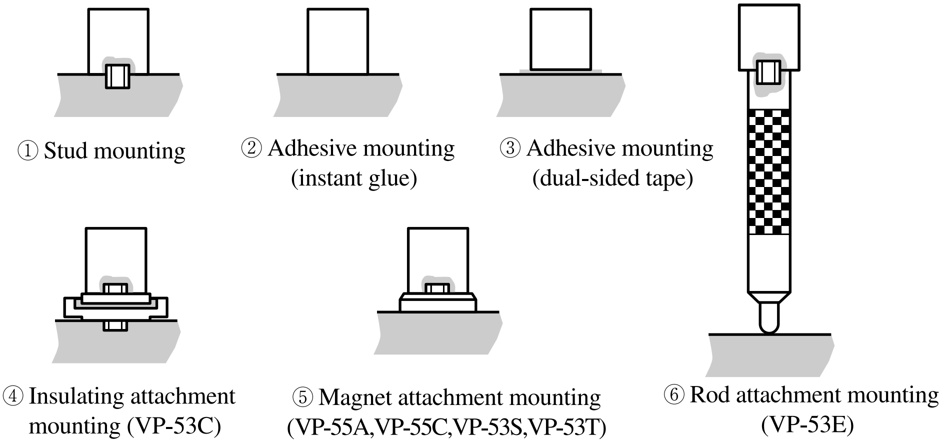

Fig. 1 Mounting methods of accelerometers

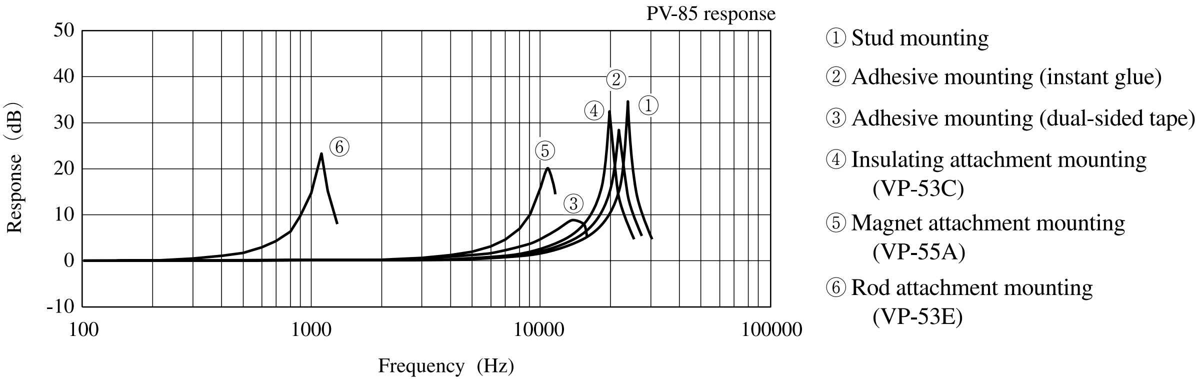

Fig. 2 Frequency response differences due to mounting method

Stud mounting

When mounted with a stud, such as the VP-53A, the range where the vibration frequency response of the accelerometer can be considered reasonably flat is the range listed in the specifications of the accelerometer. Before mounting the accelerometer, wipe off any dust and contamination from the mounting surface. Use a torque wrench to tighten the studs, so as to maintain the specified torque. If contamination or surface irregularities prevent the accelerometer from fitting tightly onto the mounting surface, or if the tightening torque of the studs is insufficient, high frequency response will be degraded and the accelerometer will not perform to the upper limit of its ratings. **Reversely, if the tightening torque of the studs is excessive, the studs will be damaged.**

Adhesive mounting (instant glue or dual-sided tape)

When properly installed using adhesive mounting, the range where the vibration frequency response of the accelerometer can be considered reasonably flat is close to the range listed in the specifications of the accelerometer. The mounting resonance frequency is approximately the same as for stud mounting, but the peak resonance level will be somewhat lower, due to the damping effect of the adhesive.

Before gluing the accelerometer to the mounting surface, clean the accelerometer and the mounting surface thoroughly using alcohol. Use cyanoacrylate based glue and take care that no glue is deposed on the connector section of the accelerometer.

Since adhesive mounting is less resistant against shock acceleration and temperature, the maximum measurable acceleration may be reduced for some accelerometers. Compared to stud mounting, the aging characteristics and temperature reliability will be inferior. This should be taken into consideration when choosing a mounting method.

To remove an accelerometer that has been attached using adhesive mounting, grip the hexagonal section of the accelerometer with a spanner or similar tool, and apply a rotational force to the accelerometer. **Never tap or knock on the accelerometer.**

When dual-sided tape is used, the sharp resonance peak in the upper frequency range will be attenuated, resulting in almost flat response. However, physical reliability with dual-sided tape is much worse than when using glue. This method should therefore only be used for temporary installations. With dual-sided tape, the maximum measurable acceleration will be reduced, and the temperature range will also be more narrow.

Using various attachments

The use of an attachment will reduce the efficiency with which vibrations are transmitted to the accelerometer, resulting in a drop in high frequency response. Except for the insulating attachment, mounting strength will be reduced, and the maximum measurable acceleration will be reduced.

The insulating attachment VP-53C causes only a slight drop in resonance frequency compared to stud mounting, which keeps response deterioration in the specified frequency range low.

The magnet attachment VP-55A, VP-55C, VP-53S or VP-53T will reduce both high frequency response and maximum measurable acceleration.

The rod attachment VP-53E will further reduce the resonance peak, so that the range of flat response extends only to several hundred Hz. Because the accelerometer is simply held against the vibrating object by hand, the maximum measurable acceleration also decreases.

Floor placement

Floor vibrations where acceleration is less than 9.8 m/s^2 and vibration frequency is low can be measured by simply placing an accelerometer on the floor. However, because the accelerometer can be moved easily, measurement reliability will be low, so that this method is not recommended except in special cases.

Connection to Vibration Meter

Charge output type

When using the PV-85 or another charge output type accelerometer, a vibration meter with built-in charge amplifier is required. Use the specified cable (VP-51A etc.) to connect the accelerometer to the vibration meter. Adjust the charge sensitivity of the vibration meter to match the input sensitivity listed in the calibration chart of the accelerometer. For more information on how to set the sensitivity of the vibration meter, please refer to its documentation.

Note
For vibration meters where input sensitivity is given in gravity acceleration pC/G, multiply the value listed in the calibration chart by 9.8 to determine the gravity acceleration sensitivity.

Integrated amplifier type

For accelerometers with built-in amplifier such as the PV-41, a vibration meter capable of supplying a 2-mA regulated current is required. Use the specified cable (VP-51A etc.) to connect the accelerometer to the vibration meter. (For accelerometers with permanently connected cable, a separate connection cable is not necessary.) Adjust the voltage sensitivity of the vibration meter to match the input sensitivity listed in the calibration chart of the accelerometer. For more information on how to set the sensitivity of the vibration meter, please refer to its documentation.

Note
For vibration meters where input sensitivity is given in gravity acceleration mV/G, multiply the value listed in the calibration chart by 9.8 to determine the gravity acceleration sensitivity. **Never connect a regulated voltage source to acceleration accelerometers with integrated constant-current input amplifier. If a voltage is applied, the built-in amplifier will be destroyed.**

Accelerometers with integrated amplifier are less susceptible to electrical noise caused by cable friction and to externally induced electromagnetic noise than charge output type accelerometers.

Cable Handling

When routing the connection cable, attention must be paid to vibrations. If the cable is allowed to vibrate, the insulation sheath of the cable may become charged due to friction, leading to noise interference. In extreme cases, resonances may lead to cable breaks. The cable should therefore be routed so that it is not subject to vibrations and resonances and does not affect the vibration of the vibrating object.

When bending the cable, the curve radius should be at least 20 mm. At a lower curve radius, the cable may break.

Cable stress tends to be most severe at the connector base, leading to cable break in this area. Always handle the cable with care and especially avoid subjecting this section to a bending force etc. Take special care when connecting or disconnecting the cable and accelerometer.

Both with charge output type accelerometers and integrated amplifier type accelerometers, the length of the connecting cable does not affect sensitivity or frequency response. However, long cable runs will result in increased susceptibility to externally induced electromagnetic noise interference. This factor is especially relevant when measuring low vibration levels.

When using an accelerometer rated for high temperatures in a high-temperature environment, be sure to use a heat-resistant cable (VP-51B).

Explanation and Precautions Regarding Specification Items

Sensitivity Calibration

The sensitivity of an accelerometer is expressed in pC /(m/s^2) for charge output types and in mV/ (m/s^2) for integrated amplifier types. Accelerometer sensitivity is measured by comparing the accelerometer to the reference accelerometer PV-03 that has been absolutely calibrated using laser interferometry according to ISO 5347. The frequency used for calibration is 80 Hz.

Sensitivity Temperature Characteristics

The sensitivity of a piezoelectric acceleration accelerometer will differ slightly according to temperature. For charge output types, sensitivity increases by approximately +0.1%/°C. Conversely, the sensitivity of integrated amplifier type accelerometers decreases by about the same ratio. Figure 3 shows the temperature dependent sensitivity change for charge output and integrated amplifier type accelerometers.

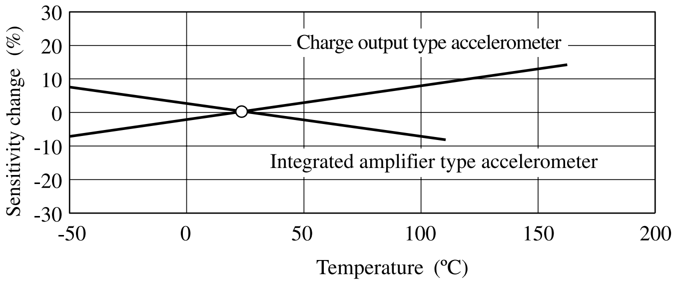

Fig. 3 Temperature dependent sensitivity change of accelerometers

Frequency Range

The vibration frequency range of a accelerometer is defined as the range where response differs by no more than ±1 dB from the response at 80 Hz, when the accelerometer is mounted with the specified studs. It is determined by a comparative measurement, using the reference accelerometer PV-03 or similar. As can be seen in Figures 4 and 5, every type of accelerometer has a sharp resonance peak in the area of about 3 times above its upper frequency range limit. The exact location of the peak will differ slightly, depending on the mounting method and individual accelerometer tolerances.

Therefore it is not possible to achieve flat response by using a compensation filter with reverse characteristics.

The response of the general-use accelerometer PV-85 is flat to about 7 kHz, but there is a resonance peak at about 24 kHz. The smaller and lighter the accelerometer, the higher will the resonance peak be. The frequency range for such accelerometers is also correspondingly wider, extending further towards high frequencies. Note that frequency response will change drastically at high frequencies, depending on the mounting method. The lower limit of the frequency range is essentially not affected by the mounting method.

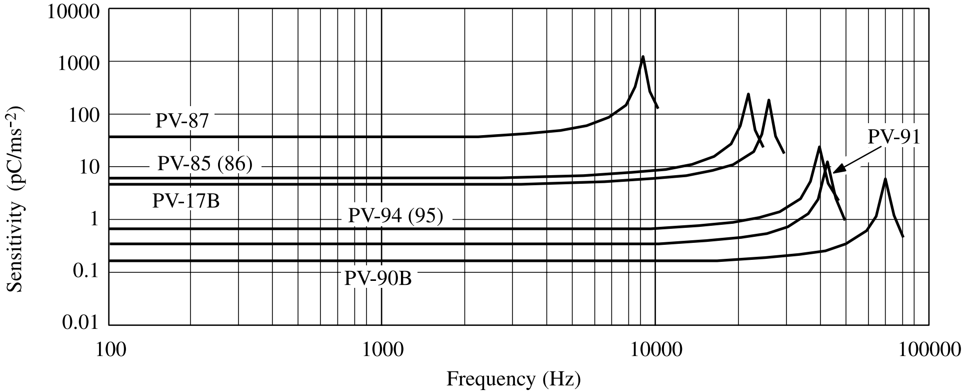

Fig. 4 Representative frequency ranges of accelerometers (charge output type)

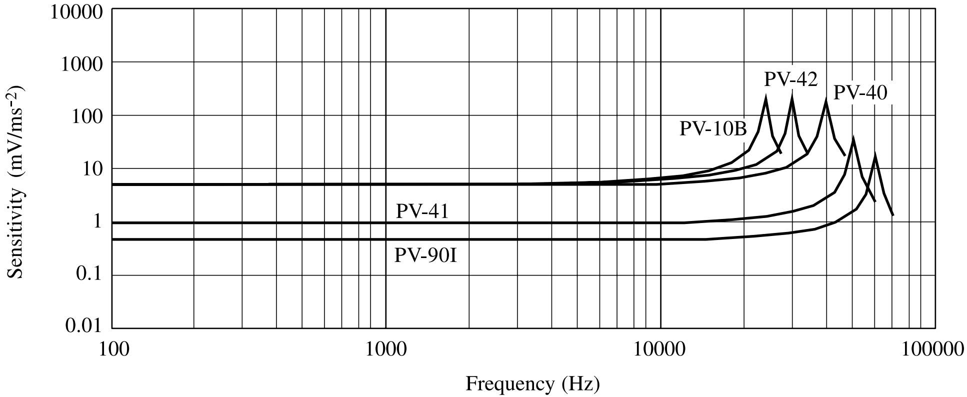

Fig. 5 Representative frequency ranges of accelerometers (integrated amplifier type)

Transverse Sensitivity

The transverse sensitivity is the ratio of sensitivity on a plane at a right angle to the reference axis sensitivity. Slight shifts in the reference axis angle during accelerometer assembly give rise to the transverse sensitivity.

When vibrations are large from a certain direction and smaller vibrations from a direction at a right angle are to be measured, the transverse sensitivity must be taken into consideration.

As shown in the graph, the transverse sensitivity pattern when plotted on a 360-degree plane at a right angle to the reference axis takes the shape of a figure 8.

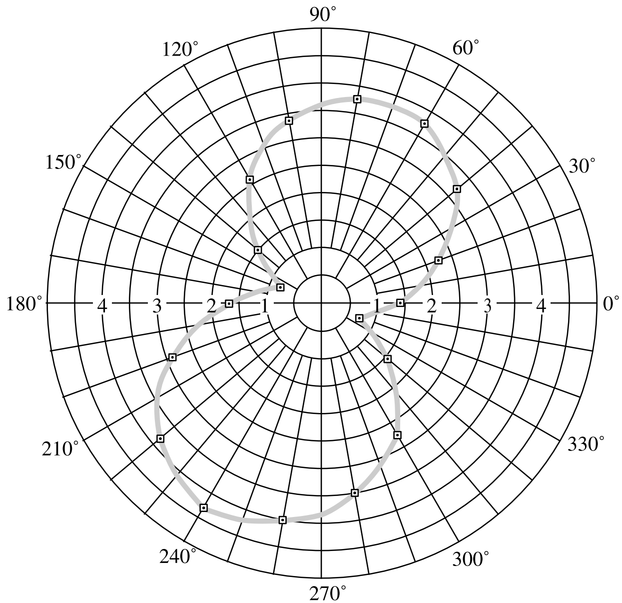

Fig. 6 Transverse sensitivity (%)

Temperature Transient Sensitivity

Temperature transient sensitivity refers to a change in output when the temperature of the accelerometer changes. Reasons for a this change are the pyroelectric effect (generation of an electrical charge due to temperature differences) and physical stresses acting on the piezo-electric element due to heat-induced expansion. Compared to shear-type accelerometers, compression-type accelerometers will have larger temperature transient sensitivity. The phenomenon of course is mainly related to temperature changes of the vibrating object to which the accelerometer is mounted, but changes in ambient temperature can also have an influence. A representative temperature transient sensitivity curve is shown in Figure 7. For installations where large temperature changes are expected, choose an accelerometer with low temperature transient sensitivity.

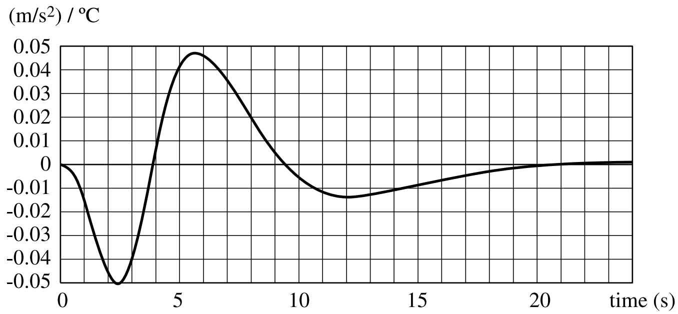

Fig. 7 PV-85 electrical output due to temperature transient sensitivity

Note
When changes in ambient temperature are expected, equipping the accelerometer with a cover may help to reduce the effect.

Base Strain Sensitivity

When the mounting base of a piezoelectric acceleration accelerometer is distorted, noise may occur and the sensitivity may change. The accelerometer should therefore be mounted on a sturdy, level surface. Base distortion mainly occurs in stud mounting installations.

Acoustic Sensitivity

An accelerometer is sensitive not only to vibrations of the vibrating object, but also to air-borne vibrations (sound). Normally, this sensitivity is low enough not to be a problem, but it can affect the measurement of low-level low-frequency ground or floor vibrations.

Note
In such cases the accelerometer should be provided with a cover.