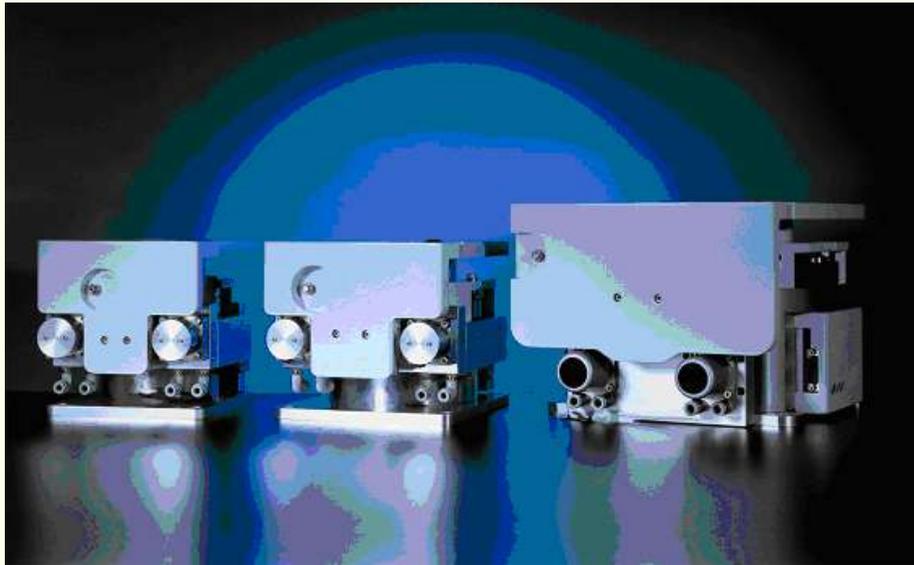


# Active Solution with a view to the future

Valuable Advanced Active Vibration isolation system



## Powerful

TI's (Texas Instruments') TMS320C6713®225 MHz, having high performances (1350 MFLOPS etc), is adopted on the DSP board in the VAAV controller.

In VAAV Series, there are 9 types. : VAAV-550, 1000, 2200, 4000, 7000, 10000, 30000 and 550L, 1000L. Concerning servo-valves, there are two types : standard type for normal use and big air flow quantity type for high speed response.

## Mature

Our active vibration isolation technology, cultivated for a long time has been utilized with the best completeness in the field of semiconductor production devices, LCD production devices, super precision metal cutting machine tools, electron microscopes, and other various needs.

## Elegant

16 bit A/D 19 channels and 24 bit D/A 10 channels converters, both having precisely synchronous sampling, are used in the controller.

Stage Feed-Forward (SFF) Control Technology is realized with the analogue signals, proportional to the acceleration and the position signals of customer's stage movements. For option, we can supply a Signal Generator for SFF Control.

## Harmony

For flexible use such as OEM, connectors are placed on the rear panel of the controller.

On the front panel of the controller, there are state indication LED's, a power switch, two control switches, a serial interface for adjustment, and two analogue outputs.

On the rear panel of the controller, connectors for input and output of four actuator units, connectors for analogue outputs, and connectors for digital input and output (16 bit) are placed.

# VAAV Standard Series are also suitable for moving stages



Having no resonance, VAAV has a big merit in the field of various equipment. Especially, in the case of a combination with a moving stage and a precision instrument, active vibration isolation is indispensable. VAAV Standard Series are most suitable for such usage. High-speed response valves of big air-flow quantity are prepared for large mass load movement, such as big type metal cutting machine tools and LCD production devices. So we can answer all needs of vibration isolation with these line-ups.

■ Dimension of VAAV Series Standard Unit

Types	load (for 1 system)	Dimension of 1 unit
V A A V - 5 5 0	270 ~ 900kg	215 (W) × 160 (D) × 170 (H) mm
V A A V - 1 0 0 0	500 ~ 1700kg	240 (W) × 180 (D) × 170 (H) mm
V A A V - 2 2 0 0	1100 ~ 3700kg	280 (W) × 240 (D) × 208 (H) mm
V A A V - 4 0 0 0	2100 ~ 7000kg	330 (W) × 270 (D) × 208 (H) mm
V A A V - 7 0 0 0	3600 ~ 12000kg	425 (W) × 345 (D) × 240 (H) mm
V A A V - 1 0 0 0 0	5000 ~ 17000kg	465 (W) × 400 (D) × 240 (H) mm
V A A V - 3 0 0 0 0	30000 ~ 50000kg	700 (W) × 700 (D) × 178 (H) mm
H A - 4 5 0 (Horizontal actuator)		480 (W) × 365 (D) × 405 (H) mm
Contoroller (SAC-05)	300 (W) × 300 (D) × 120 (H) mm	
Regulator unit (RGU-01)	250 (W) × 100 (D) × 200 (H) mm	

- A standard vibration isolation system consists with 4 units.
- HA-450 is a horizontal actuator used in conjunction with VAAV-30000.
- The maximum value in the above table is the one in case of equal load and no movement.

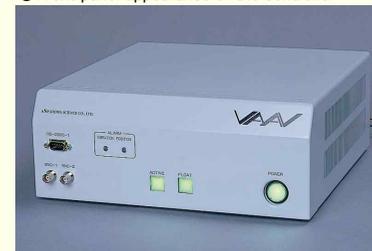
## ■ VAAV Series Technical Specification

- freedom 3 axes, 6 freedoms
- Transmission characteristic refer to technology data
- position accuracy  $\pm 10 \mu m$
- primary air supply 0.6 MPa (dry clean air)
- Air consumption standard valve ; 60 Nl/min  
high speed response valve 250 Nl/min
- Electric power AC single phase 100~240 V 100W

## ● VAAV-30000 actuator unit



## ● Front panel appearance of the controller



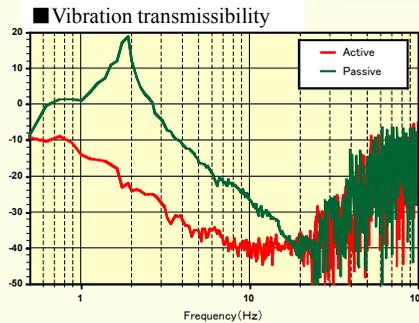
## ● Rear panel appearance of the controller



# For more vibration sensitive precision instruments



**VAAV**  
Series **L**



Specially, sensitive precision measuring machine devices, such as electron microscopes, scanning tunneling microscopes, atomic force microscopes, as well as optics measuring equipment, need corresponding careful countermeasures. VAAV L Series support these equipment softly with special air spring actuators, having low natural frequencies, and lowers the control frequency range.

■ The dimensional specification of VAAV Lseries

(Other technical specifications concerning air supply etc. are same with the one for standard VAAV)

Type	Load (for 1 system)	Dimension of 1 unit
VAAV-550L	270 ~ 900kg	225 (W) × 160 (D) × 240 (H) mm
VAAV-1000L	500 ~ 1700kg	240 (W) × 180 (D) × 240 (H) mm

- A standard vibration isolation system consists with 4 units.
- The maximum value in the above table is the one in case of equal load and no movement.

## Soft

The air spring actuators, each having a low natural frequency with a built-in pendulum, have good passive vibration isolation characteristics, which will be the base of control. That makes it possible to lower the frequency range necessary for control, and support the load softly with a good vibration isolation characteristic.

## Optimal

For individual equipment load, the best vibration isolation characteristic can be made with suitable combination of acceleration feedback, position feedback, and floor feed forward. This system is especially suitable for the vibration isolation countermeasures for the precision devices whose vibration isolation characteristics are most important.

# Active Vibration Isolation (Technical Documentation)

## 1. The limits of passive vibration isolation system

Passive vibration isolation system is the system that holds mass with springs and suppresses vibration with dampers. This is a simple but a good suppressing effect on vibration isolation. Above all, the air spring type vibration isolation systems have low natural frequencies. In addition, low level changes can be expected with these systems, with automatic level control valves. So we are using these types of vibration isolation system in various fields.

But there are cases when these air spring-type vibration isolation systems cannot solve troubles.

There is a resonance phenomenon in a passive vibration isolation system. In this frequency range, the vibration of the load becomes larger than the floor vibration. That makes the vibration isolation effect negative.

Generally, "Floor vibration is very small in the low frequency range." With this reason, bad influence of this resonance phenomenon can be made small, using air springs having low natural frequencies. But, there may be troubles even in this case.

Low natural frequencies can be achieved by making spring constants small. This shows that the large deviation of the load can be generated with small outer force. Moreover, the decrement time of the vibration becomes large. In the case of moving load action, such as moving stages, there may be the case that the system does not stop vibration, or the case that the vibration deviation becomes over the permission displacement of the air springs and another kind of vibration may occur.

## 2. The principal of active vibration isolation system

In the case of active vibration isolation system, vibration sensors and position sensors are set, and actuators operate so as to decrease vibration and position deviation. This vibration isolation control method is called Feed-Back Control (FB Control). So, there is no resonance phenomenon which occurs necessarily in the passive vibration isolation system. (Refer to Fig.2)

You can decrease the vibration, added from outside, in short time. Moreover, you can also decrease drastically the torsion load applied to the surface plate by balanced output of the actuators.

Furthermore, you can decrease the vibration induced on the surface plate of the system, if you operate the actuators to deduct the output signals from the sensors, set on the floor.

We call this kind of vibration isolation control method Floor Feed-Forward Control (FFF Control). Together with FB Control and FFF Control, you can decrease the vibration induced on the surface plate still more. (Refer to Fig. 2)

On the surface plate of the vibration isolation system, a moving machine, such as a X-Y stage, will often be set.

With the movement of a mass, the rotational moment is generated proportional to the product of the mass and deviation. And force is generated proportional to the product of the mass and acceleration. If you can measure the position and the acceleration of the moving mass, you can drastically reduce the influence of the moving mass, generating the reversible force, proportional to the value. This type of control is Stage Feed Forward Control (SFF Control). With our VAAV active vibration isolation system, you can operate these 3 kinds of control at the same time.

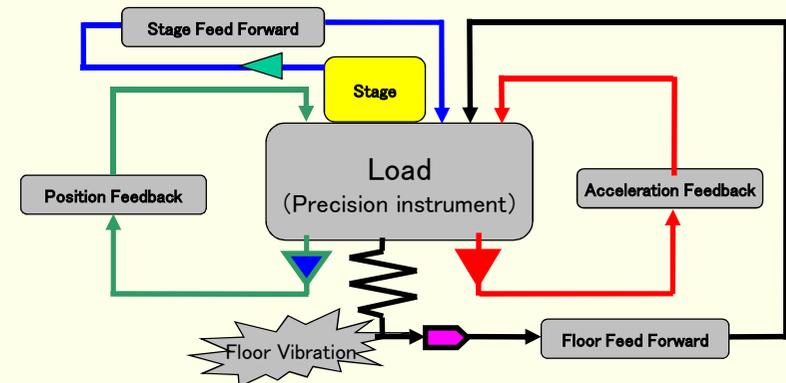


Fig.1 The principal of active vibration isolation system

### 3. Merits of VAAV

In our VAAV systems, air springs and air servo-valves are adopted for their actuators. With the combination of them, you can produce large force which is the merit of this system. Different from linear motor type systems, you need not care overheat or electromagnetic field troubles, and you can use same controller from VAAV-550 to VAAV-30000.

In the case that high speed response is necessary, you can also use the same controller with big air flow valves.

With our high performance controller, you can combine various combinations of these 3 types of control methods, FB, FFF and SFF, according to your needs.

### 4. VAAV vibration isolation effect (Vibration Transmissibility)

Figure 2 shows the vibration transmissibility, explaining the effect of our vibration isolation system. VAAV standard series are adopting high spring constant air springs, and the natural frequency of the system being about 5 Hz

This has the effect of suppressing big displacement on the surface plate, influenced from the moving stage. In the case of Position FB Control only, the vibration transfunction of this system is almost equivalent to the one of the passive vibration isolation system, having 5 Hz resonant frequency.

In the case of Acceleration FB Control, the system shows a high performance characteristic of active vibration isolation system. It has no resonance.

For this reason, a good vibration isolation characteristic will be obtained, even if you adopt a slightly high natural frequency.

Adding this, big decrement effect can be expected, if you adopt FFF Control.

In the case of VAAV L Series, low natural frequencies of air springs are adopted, so the vibration isolation ratio in the low frequency region will be decreased. VAAV L Series are specially suitable for precision instruments, having sensitive vibration characteristics.

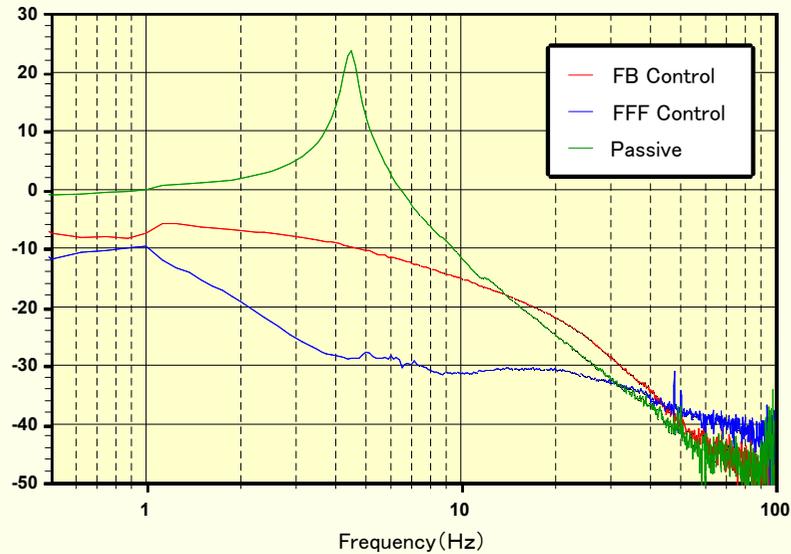


Fig.2 Vibration transmissibility of VAAV Standard System

### 5. VAAV Vibration Isolation Effects (Response of the Surface Plate versus Stage Movement)

Figures 3, 4 show the rotational displacement response curve and the rotational vibration response acceleration curve of the surface plate to the stage moving force, respectively. The effect is clear at a glance.

The moving load of the stage action is mainly divided into two parts. The first one is the rotational moment, proportional to the product of stage mass and stage position deviation.

The second one is the vibration force to the load, proportional to the stage mass and the stage acceleration.

If the stage mass and the stage position deviation, or the stage acceleration, are big, they generate large quantity of response deviation of the load.

In case of soft support with passive vibration isolation system, the swing may become large enough to over the permission value of the air springs.

The effect of the Acceleration FB Control is the decrease of vibration amplitude and vibration time.

For this reason, you can improve the accuracy and the settling time of the equipment.

(Refer to Fig. 4)

Adding this, if you connect the real time measured analogue outputs of the stage position deviation and acceleration to the controller, you can use our SFF Control.

You can see that the control force proportional to the stage rotational moment and the stage vibration force decrease drastically the moving stage response position deviation. (Refer to Fig. 3)

SFF Control with VAAV is theoretically simple, and reasonable. And big effect can be expected.

Up to 2 axes types moving stages, VAAV can be used with SFF Control.

Figures 5 and 6 show examples of the real time stage position deviation signal and stage acceleration signal, respectively.

One or two analogue signals within the range of  $\pm 10$  V must be transmitted. And the earth potential of the analogue signal generator and VAAV controller must be equal.

For option, we have the analogue signal generator, specified for these purposes. The signal generator will be used with the scale and the head, both specified in our specification.

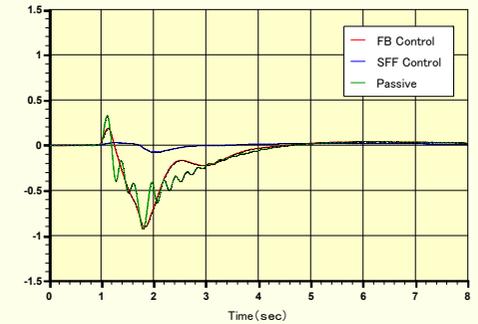


Fig.3 Rotational Displacement

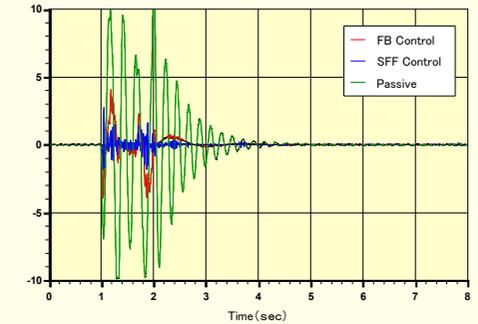


Fig.4 Rotational Acceleration



Fig.5 Position Signal of Stage

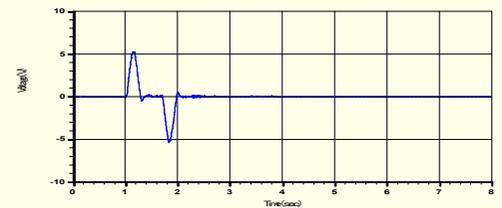


Fig.6 Acceleration Signal of Stage