Mass Measurement for Outer Space Experiments

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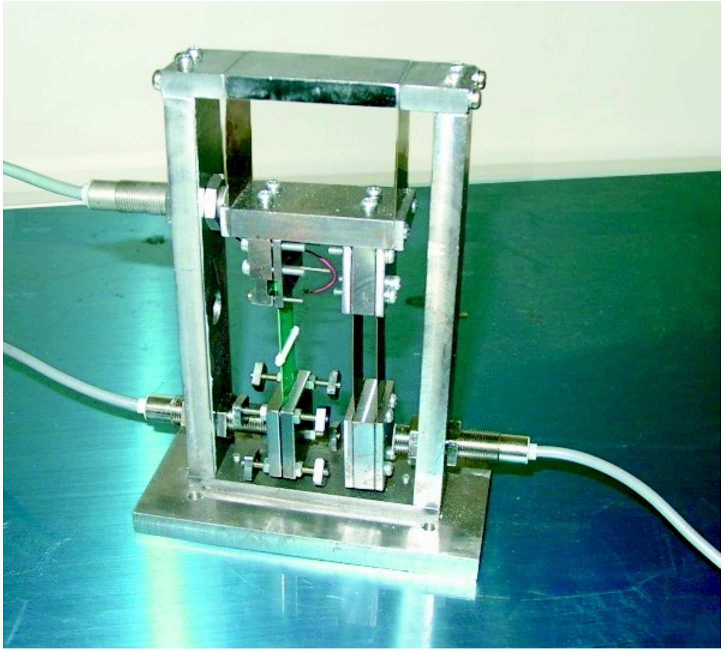
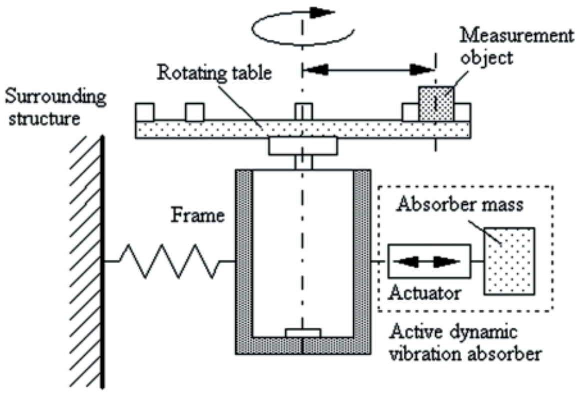
- Solution to perform mass measurement in outer space
- Two measurement systems available
- Experiment hard- and software by dSPACE
- Development system based on dSPACE ACE Kit 1102

How to perform mass measurement under weightlessness or low-gravity conditions has become a vital issue for experiments in outer space. The Department of Mechanical Engineering of Saitama University has developed a laboratory environment for conducting such experiments. The core element is the dSPACE DS1102 DSP Controller Board (part of the dSPACE ACE Kit) for measurement and controlling.



Vibration type system with bimorphic piezoelectric actuator.

As we all know, there is no natural acceleration present in space, which is required for mass determination. Hence, a mass measurement experiment must generate this acceleration to provide measurable forces, for example, by a device emitting vibrations. However, when it comes to applications in outer space, the surrounding structures are usually quite flexible, which is why any transmission must be suppressed. To cope with this challenge, the system must perform mass measurement as well as vibration control.



Centrifugal-type mass measurement system.

Two concepts

The developed system is capable of carrying out mass measurement by applying two different concepts: the centrifugal and vibration type. For example, with the centrifugal type, a sample object is attached to a rotating table at a fixed distance from the longitudinal axis. Since the object unbalances the rotor, a centrifugal force with an amplitude proportional to the mass and distance is generated during rotation. This force makes the supporting frame vibrate. To restrain these vibrations, an active absorber is attached to the frame. The active absorber features a controller, which insulates the excitation force and prevents the frame from moving. Or to put it more clearly: the absorber vibrates in such a way that the product of the absorber mass and the amplitude of its vibration is equal to the amount of unbalance. This correlates with the product of the mass to be measured and its distance from the axis. Therefore, the mass of the sample object can be derived from the vibration amplitude of the absorber mass.

However, there is a disadvantage when the sample object has a complex shape: the distance to the axis must be known exactly to achieve accurate results. One so-

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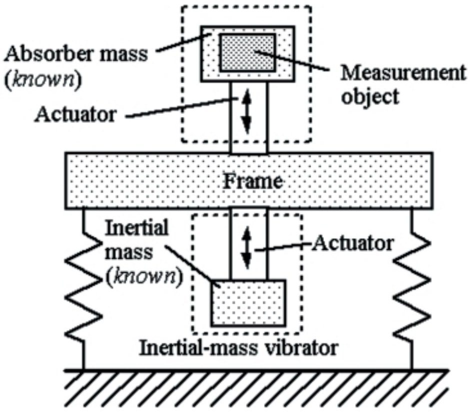

Vibration-type mass measurement system.

lution to this problem is to attach the sample object to the absorber mass. The harmonic excitation is generated by an inertial mass vibrator instead of a rotating unbalance. This vibrator consists of an inertial mass and an actuator, hence very similar to the active absorber. Since the absorber features the suppression of the force stressing the frame, the product of the absorber mass and the amplitude of its vibration equals the inertial mass and the related vibration. Therefore, the mass of the sample object can be determined via the vibration ratio of the absorber and inertial mass.

Experiment setup with dSPACE

We implemented the corresponding control algorithms very easily on the dSPACE DS1102 DSP Controller Board. The entire programming was performed graphically within MATLAB/Simulink. The configuration of the A/D and D/A channels was equally convenient, since dSPACE Real-Time Interface (RTI) provides the corresponding Simulink blocks. Subsequently the Simulink blocks were downloaded to the hardware. For experiment control, such as data acquisition or variable display, dSPACE's ControlDesk was used, which allows continuous monitoring of control signals or excitation signals.

The accuracy of the system which can be achieved is around 0.5 percent, and without vibrations occurring on the surrounding structures.

Prof. Mizuno
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Japan

MISCELLANEOUS

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