Improvement of the penetrator seismometer for extending the frequency response and application to future planetary explorations

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A short-period passive seismometer onboard the former Japanese LUNAR-A penetrator is modified as two different types of long-period active sensors; one is a so-called PID-controlled feedback type sensor, and the other newly equips a pair of position-sensitive capacitor plates in the interior. The former has a broader frequency range in velocity output, compared with the original short-period sensor, by an additional installation of integrator/compensator circuits. The latter adopts both displacement and velocity feedback system in a closed loop and has a higher sensitivity in a broad frequency range.

The original short-period seismometer is a conventional electro-magnetic type one with velocity output consisted of signal coils as a pendulum mass suspended by a pair of diaphragm springs and magnetic circuits fixed to the reference frame. As a space-qualified instrument, this seismometer is a type of a very compact size, light-weight and low-power consumption, including a gimbals mechanism that is used to orient to the desired direction after deployment on the moon's surface.

Because it was developed for the application to the hard-landing penetrator probe, it has the shock-durability up to 10,000G at a high-speed impact process and it demonstrates to work well even under low temperature condition, which is assumed on the Moon's surface layer.

When several little modifications are made for this short-period seismometer, the sensor performance in the frequency ranges of 10 to 20 seconds is considerably improved and appropriate for detection of the longer body waves and possible surface waves on any other terrestrial planets. However, the present lunar penetrator can not install both the active-type seismometers for a long-lived observation, because of the strict limitation of power consumption. If some more electrical power is supplied, we will be able to apply either of these improved versions for lunar soft-lander, post-Kaguya and beyond. And also, if the possible Martian penetrator with an after-body structure would be continuously operated by the solar power battery, we could do just the same.

In this paper, we present some results of laboratory and field tests and compare them with the original short-period sensor, and then we describe the future prospects for application on the lunar and planetary explorations.