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Negative-Stiffness Vibration Isolation Supports Advanced Genomic Sequencing

By Jim McMahon

In its continuing efforts to revolutionize discovery-based research into understanding the most complex biological systems, Pacific Biosciences has released its next generation of automated, long-read genomic sequencer with Single-Molecule, Real-Time (SMRT*) sequencing technology — the Sequel™ system.

"The sequel system is very multifaceted in operation," says Kevin Lin, mechanical engineer at Pacific Biosciences. "It encompasses robotics, chemical and biological processing and photonics." Since the system was to be used in diverse R&D settings, excessive ambient vibrations could influence the data.

"We needed to implement a vibration isolation component that would not only isolate the sensitive components from vibrations, but also that would be sufficiently small, compact and integrative," he says.

Vibration can be caused by a multitude of factors, both internal and external to the building in which the system resides, including vibrations from heating and ventilation systems, fans, pumps, elevators, adjacent road traffic, nearby construction, overhead aircraft, and even wind and weather conditions. These influences cause vibrations as low as 2 Hz and can create strong disturbances in sensitive equipment.

Pacific Biosciences needed a vibration isolator that would be compact enough to fit into its Sequel system, which is much smaller than its prior sequencer -- about 60 percent smaller.

Negative-Stiffness Vibration Isolation

During the design of the Sequel system, we did considerable research into various vibration isolation options including active isolation systems and smaller modified air tables," says Lin. "The option we decided on was the performance that negative-stiffness isolation provides."

Developed by Minus K Technology, negative-stiffness isolators employ a unique and completely mechanical concept in Low-frequency vibration isolation. They do not require electricity or compressed air. There are no motors, pumps or chambers and no maintenance, because there is nothing to wear out. They operate purely in a passive mechanical mode.

Because of their high vibration isolation efficiencies, particularly at low frequencies, negative-stiffness vibration isolation systems enable vibration-sensitive instruments, such as the Sequel system, to operate in severe low-vibration environments that would not be practical with top-performance air tables and other vibration-mitigation technologies.

"In negative-stiffness vibration isolation, vertical-motion isolation is provided by a stiff spring that supports a weight load, combined with a negative-stiffness mechanism," explains Dr. David Platus, president and founder

of Minus K and inventor of negative-stiffness isolators, "The net vertical stiffness is made very low without affecting the static load-supporting capability of the spring. Beam-columns connected in series with the vertical-motion isolator provide horizontal-motion isolation. A beam-column behaves as a spring combined with a negative-stiffness mechanism. The result is a compact passive isolator capable of very low vertical and horizontal natural frequencies and very high internal structural frequencies."

Prior to founding Minus K, Platus worked in the nuclear, aerospace and defense industries conducting and directing analysis and design projects in structural-mechanical systems. He holds more than 20 patents related to shock and vibration isolation.

A key factor for selection of negative-stiffness was the elimination of hysteresis of the isolator, a critical function in the operation of the system. The isolator is mounted to the main frame of the Sequel instrument and physically interacts with the internal robot, causing some initial movement of the isolator after each interaction.

The speed and repeatability at which the vibration isolator can return back and cancel out this movement is critical to the operation of the system. In this regard, the negative-stiffness isolator outperforms the pneumatic isolators.

Pacific Biosciences of California develops sequencing systems to help scientists resolve genetically complex problems. With a strong history of collaboration and a focus on creating high-value and high-quality technology. PacBio has revolutionized methods used by scientists to resolve complex genetic challenges. Based on its SMRT technology, the company's sequencing systems, including consumables and software, provide a simple, fast, end-to-end workflow for SMRT sequencing.

"We were attracted to negative-stiffness because of the high vibration cancellation performance of the isolator and its favorable hysteresis," says Lin. "We were also attracted to its simplicity of operation." Nothing is needed to supply and control air and there is no need for electrical connections. It is also lightweight and compact making it easy to fit into the smaller footprint of the Sequel system. "We wanted to reduce the size and cost of the Sequel System to make it more affordable and attractive to a wider audience," concludes Lin "The negative-stiffness vibration isolator supports this initiative."

Contact Minus K Technology, Inc.; 460 Hindry Ave., Unit C, Inglewood, CA 90301;
Phone 310-348-9656; E-mail: sales@minusk.com; Web: www.minusk.com.