Dytran by HBK
HOTTINGER BRÜEL & KJÆR

WHITE PAPER

4786A IPS Charge Amplifier

DYTRAN BY HBK'S VIBRATION MONITORING SOLUTIONS ENHANCE HELICOPTER SAFETY AND EFFICIENCY

In the world of helicopter manufacturing, safe and efficient operation of the aircraft is critical at all points in the design process as well as over the lifespan of the craft. To ensure that an aircraft is safe and is performing at peak efficiency, rigorous ground and flight testing is conducted by manufacturers. This testing phase is an essential part of the aircraft development process, allowing the manufacturer to identify and address any issues before the aircraft is put into service. The flight-testing phase includes extensive evaluation of the helicopter's flight controls, stability, and handling characteristics, as well as its performance under various conditions such as high speed, high altitudes, and adverse weather conditions.

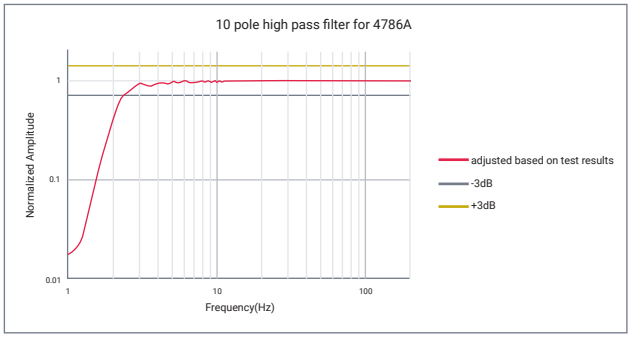
Due to the nature of rotary-wing aircraft, there are rotating components in a variety of locations such as the main rotor, tail rotor, turbine, and transmission components that are vital to the operation of the aircraft. Any imbalance in these rotating parts can cause an out of balance condition on that component, which can cause severe problems with the aircraft. Issues that can arise from an out of balance part include increased vibration, which will affect the comfort of occupants and put additional strain on components reducing the service life of the helicopter. Out of balance conditions also negatively impact the performance of the aircraft, reducing its speed, maneuverability, and fuel efficiency, which can all have an impact on the ability of the aircraft to complete its intended mission. For these reasons, it is imperative to monitor and maintain balance in these components for safe and efficient operation of the aircraft.

During ground and flight-testing, high-frequency accelerometers are mounted at key locations to monitor vibration caused by rotating components. Dytran by HBK has been supporting leading aerospace companies with their need for piezoelectric accelerometers for flight and ground testing for many years. Dytran piezoelectric and VC MEMS accelerometers are deployed by many manufacturers around the world for their testing and maintenance needs. The Dytran team has worked directly with industry leading helicopter manufacturers to design new parts or modify existing models to meet their specific testing needs.

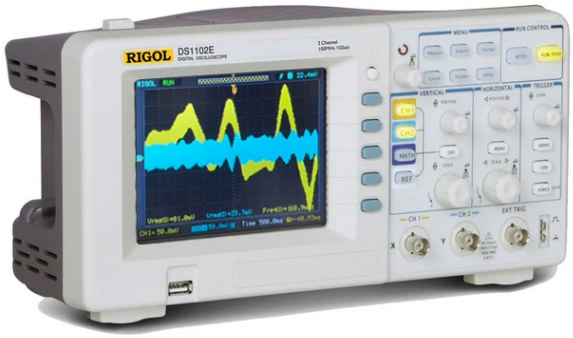
In support of recent requirements for a flight test, Dytran has worked closely with a manufacturer's flight test team to develop a new differential charge amplifier, model 4786A, and has already seen initial use in prototype aircraft testing.

The 4786A is a differential charge amplifier designed to be used with 20 pC/g and 50 pC/g charge accelerometers. There are several features that differentiate the 4786A from a typical charge amplifier such as integrated velocity output produced by built-in analog integrator, and a sensitivity selector that switches between 20 and 50 pC/g accelerometers to scale the velocity output accordingly. The velocity output was a key requirement for this application as velocity is commonly used in aerospace to monitor potential imbalances in rotating parts. The unit of measurement used for velocity is IPS or inches per second. Velocity is the rate of change of displacement with time, which allows engineers to detect components with high movement and correct imbalances using balancing techniques to reduce vibration and wear on those components.

The most important feature of the model 4786A is the extended low-frequency response of the integrator. Typically, it is industry standard to have the low-frequency response of a velocity output of an inline charge amplifier to be around 20 Hz. Some manufacturers push it down to 10 Hz. The customer has a specific requirement to push the response down to 3 Hz. This was a challenging requirement because extending the low frequency response that low would drastically affect the bias stability. Bias stability is determined by the low-frequency signal fluctuations produced by thermal effects, triboelectric effects, and/or base strain. These fluctuations, while very low in amplitude, are multiplied by the integrator exponentially with decrease in frequency. The bias instability may become quite severe and will have a negative impact on the RMS reading of the signal as well as decrease the dynamic range of the measurement setup. To solve the problem, a custom filter was introduced in the design to clean any low frequency fluctuations and assure bias stability.



The introduction of the 10 pole, high pass filter described above, allowed the reduction of the low frequency fluctuations to manageable levels as shown in the image below (yellow trace – no high pass 10 pole filter on the integrator input, blue trace – 10 pole, Butterworth, high pass filter with 2.5 Hz corner frequency.



The 10 pole high pass filter reduced the low frequency fluctuations to manageable levels

Another unique feature of the 4786A is the ability to be used with either 20 pC/g or 50 pC/g accelerometers while maintaining a fixed velocity output sensitivity. Our customer uses engine accelerometers of these two different sensitivities for their testing. Rather than having two different ranges of the 4786A made for each accelerometer sensitivity, Dytran designed the 4786A to operate at 100 mV/IPS for both sensitivities. This allows one amplifier to be used for both accelerometer sensitivities, which allows our customers to be more flexible in using the appropriate sensitivity for their specific test needs.

The 4786A has been successfully deployed on multiple flight tests and Dytran looks forward to future opportunities with this part, as we have seen great interest in the 4786A in rotorcraft and turbine applications. The 4786A differential charge amplifier is not just limited to the needs of helicopter flight testing. Other customers in the aerospace and other industries that require monitoring of rotating components can also benefit from using the 4786A. Its ability to provide both acceleration and velocity output, as well as its compatibility with both 20 pC/g and 50 pC/g accelerometers makes it a versatile solution for customers looking to monitor imbalances and reduce vibration in their test article. The 4786A has potential to be used in various industries such as automotive, industrial, and aerospace applications.

References

[1] https://www.acessystems.com/fundamentals-series-aviation-vibration/

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