Enhancing Dynamic Pressure Transducer Performance

Adam Hurst and Steve Carter, Kulite Semiconductor Products, Inc., discuss the recently developed KSC-2 signal conditioner

Supersonic transport will be a growing area of research in the coming decades. The development of such high-speed transport vehicles is predicated on aerodynamic testing in high-speed wind tunnels. These test facilities tend to be of somewhat limited dimensions necessitating the utilisation of sub-scale test articles. Since dynamic pressure measurement bandwidth scales inversely with the model geometry, faithful representation of true flight pressures rely on the accurate measurement of dynamic pressure amplitudes to frequencies of 100kHz and higher during wind tunnel testing.

When high sensitivity pressure transducers with low full-scale operating pressures are employed for these measurements, data of interest often occur near the transducer resonant frequency. Complicating this need for increased transducer bandwidth are turbulent boundary layers that continuously excite the seismic (chip) resonance of high-speed pressure sensors exposed to supersonic flow conditions. The excitation of the sensor's seismic resonance makes it difficult to accurately assess the turbulent boundary layer. To overcome this challenge, engineers often select a pressure transducer with a higher operating pressure and resonance in the MHz regime. The higher operating full-scale pressure range comes at the cost of lower sensitivity. Turbulent boundary layers typically exhibit low-level dynamic pressures and such a sensor compromise severely limits the characterisation of turbulent boundary layers. Measuring turbulent boundary layers is seen as a critical need to the supersonic and hypersonic communities as it results in significant heating and additional viscous drag.

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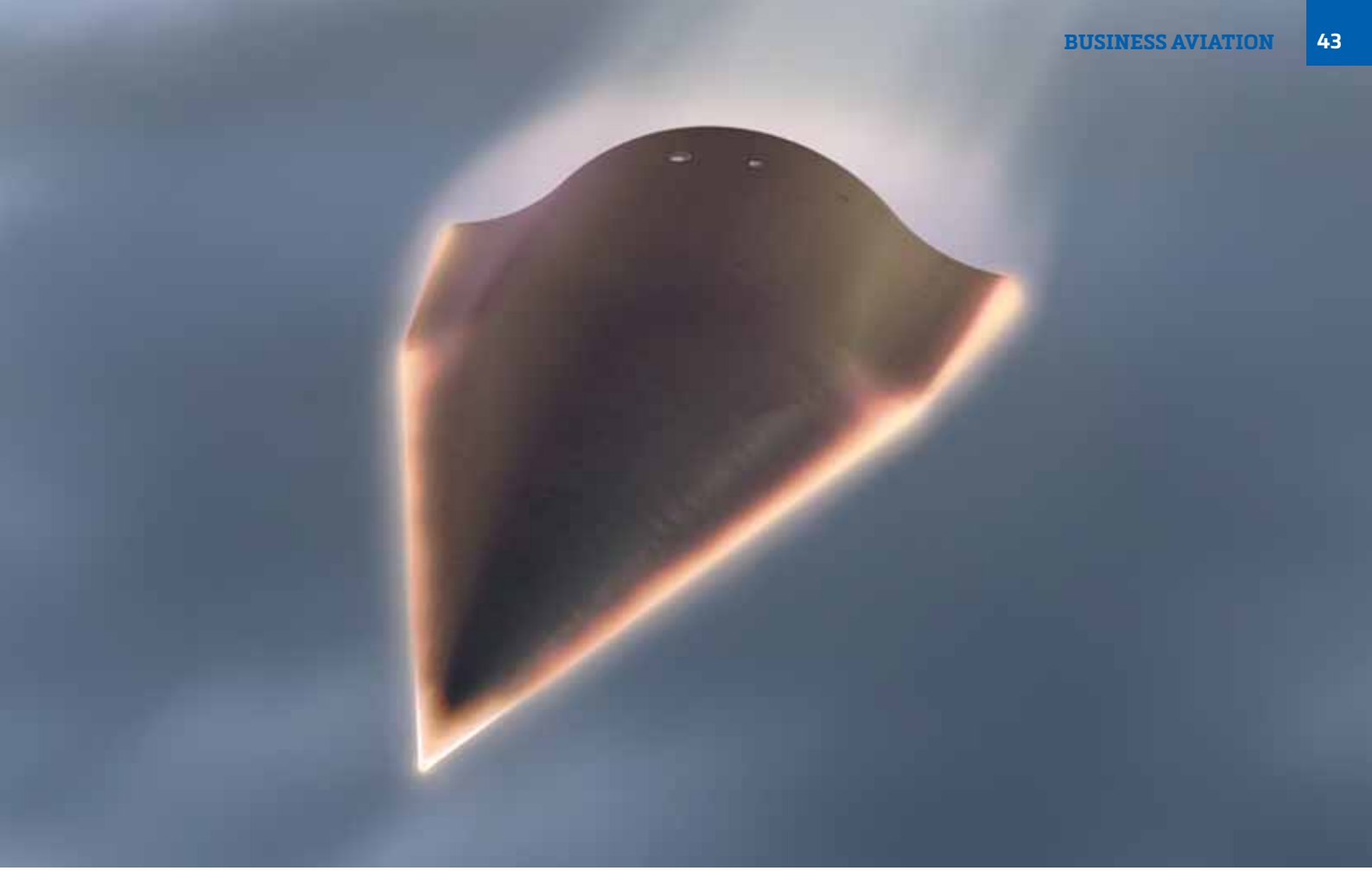
KSC-2 Signal Conditioner/Amplifier Front Panel

KSC-2 Signal Conditioner/Amplifier Rear Panel

To overcome this measurement challenge, Kulite in partnership with Precision Filters of Ithaca, NY, developed the KSC-2 signal conditioner with an optional innovative feature called REZCOMP™. The KSC-2 is a compact, rugged dual-channel precision amplifier / filter optimised for conditioning Kulite pressure transducers and microphones to a typical static accuracy of ±0.1% of full scale. A user-friendly GUI controls one to eight KSC-2 units as a single system via USB 2.0. Configurations may be saved / recalled from the host computer. Settings may be



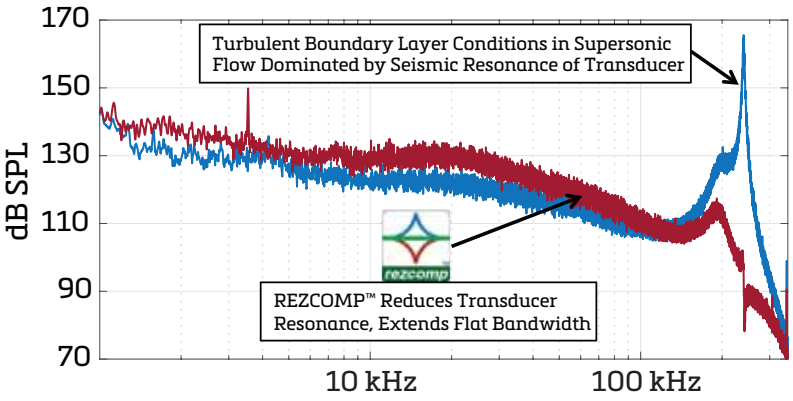


Figure 1: Application of REZCOMP™ in Supersonic Testing

saved to non-volatile memory for field deployment without a host computer.

REZCOMP™ (patent pending) is a technique to electrically compensate for any package or seismic resonances in real-time. REZCOMP™ allows users to extend the bandwidth of a standard transducer limited by a recessed installation, physical construction of the transducer or the physical response of the pressure chip by 2.5 times or more. Figure 1 illustrates REZCOMP™ compensating for the excitation of the seismic resonance of a low-pressure transducer in a supersonic wind tunnel test with a turbulent boundary layer thereby extending the flat-useable bandwidth.

The KSC-2 additionally offers fully programmable bipolar excitation, transducer zero balancing followed by precision pre-filter and post-filter amplification compatible with any high-speed analog-to-digital converter. Programmable 6-pole, low-pass filters support two response characteristics that are optimised for making time domain or frequency domain measurements ensure that only the bandwidth of interest is transmitted.

A recent Kulite user, Nick Tiliakos PhD, Innoveering, LLC., provided the following feedback following a successful test campaign: "The KSC-2 was critical to the success of our supersonic nozzle testing as it substantially improved the data quality, it mitigated noise through customer selected filtering coupled with a very low noise power supply and it enabled the detection of far lower dynamic pressures than previously achievable. Our team at Innoveering was very pleased with this sensor processing equipment, and we intend to purchase an additional KSC-2 unit for future work. Without the assistance of Kulite in characterising the natural resonance of the pressure chip and ability of the KSC-2 to selectively attenuate the resonance, obtaining useful dynamic pressure data to 100+ kHz and above would not have been possible."