VELOCITY MEASUREMENTS IN A SPEAKER CAVITY

APPLICATION NOTE LDV-009

Oscillating flows are found in many areas, in both nature and in industrial processes. Audio speakers are oscillating devices, and achieving good sound quality across the full audio spectrum depends on good design of the electronics, the driver, and the speaker enclosure. Speakers can be found in very large sizes, but for the consumer, a smaller size is often preferred. Careful design is thus required to achieve good audio characteristics from a compact size enclosure. Analyzing the internal speaker flow can help achieve good audio capabilities by optimizing the flow patterns. As a non-intrusive technique, laser Doppler velocimetry (LDV) is a good choice because with a transceiver probe, we only need optical access on one side – even a single small window (e.g., <20mm diameter) can suffice. TSI's 15 mm diameter TLN 10 series transceiver probe could even be fixed inside the flow, owing to its sealed corrosion-proof stainless steel construction.

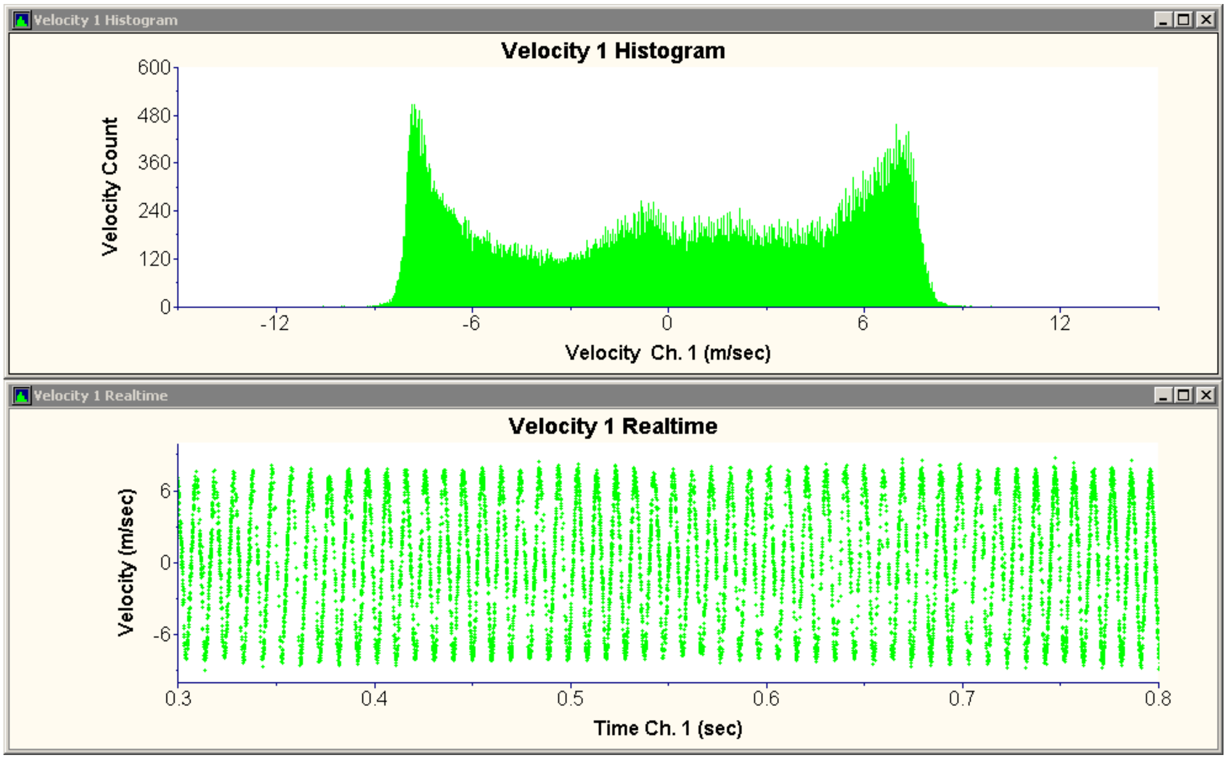

Figure 1: Velocity histogram and real-time plot of channel 1 velocity for the flow inside a speaker enclosure.

A single-component LDV system was used to perform measurements at various locations in the speaker. The system was composed of a LA300 Argon ion laser, FBL-1 fiberlight™ beam generator, and TR160 transceiver probe. Signals were captured by the transceiver probes and sent to a PDM1000-1 detector module. Seeding was achieved by a Model 9306 atomizer and olive oil. An FSA™ 3500-1 signal processor with FLOWSIZER™ software was used to capture and analyze the data. The FSA™ signal processor's automatic selection of sampling rate ensures that each and every Doppler signal is analyzed at the highest possible resolution and accuracy. This is important for velocity measurement because uncertainty in velocity measurement can appear to be fluctuation in the flow, i.e. turbulence. Thus, we always want to be sure the signals are analyzed at the highest possible resolution and accuracy. Data rate is also key for many LDV measurements, especially those involving frequency analysis. The FSA™ signal processor's FFT-based burst detection system has the sensitivity required to extract Doppler bursts from the noisiest of signals, thus maximizing the data rate. A full description of the system components can be found in the Size and Velocity Measurement Systems brochure, available on www.tsi.com.

Figure 1 shows the velocity histogram and real-time plot of channel 1 velocity for the flow inside the speaker enclosure. The TSI LDV FLOWSIZER™ software package was used to display the data in many different ways, including scatter plots, line plots, and bar graphs. Data can also be cut and pasted to other applications like Excel® spreadsheet software for further analysis.

Figure 2 shows the power spectrum of other velocity measurements inside a speaker cavity, showing a primary resonance at ~50Hz, and several harmonics above that. FLOWSIZER™ software offers many options on its Power Spectrum Analysis Package, including the Slot or Even-time Analysis Methods, several windowing options, and so forth. The Power Spectrum Analysis is built into FLOWSIZER™ software – as is traverse control, graphics, sizing, and several ASCII export options.

This application note has shown that a TSI LDV system can be rapidly set up to measure the oscillating flow in a speaker enclosure. Various analysis techniques can be applied to the captured data, allowing the designer to refine the speaker's design to optimize sound quality.

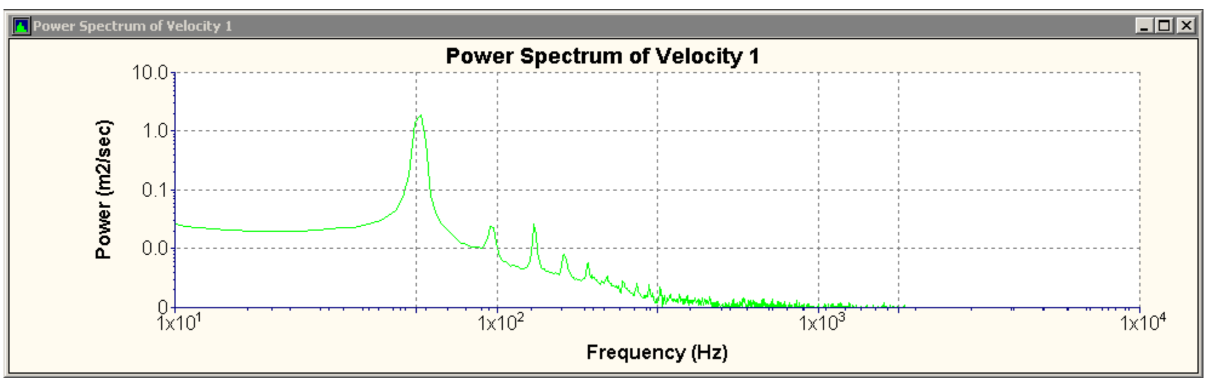

Figure 2: Power spectrum of the velocity data from a speaker cavity, showing a primary resonance at ~50Hz.

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