FSA 5800 MEASUREMENTS AT HIGH FREQUENCIES SIMULATED BURST GENERATOR AND PULSED LASER DIODE

APPLICATION NOTE LDV-010 (A4)

Laser Doppler Velocimetry and Doppler Bursts

Laser Doppler Velocimetry (LDV) and Phase Doppler Particle Analysis (PDPA) require a frequency processor in order to analyze and correctly determine the frequency of light signals scattered by tracer particles passing through an interference fringe pattern generated by intersecting laser beams. The frequency of the scattered signal is proportional to the velocity of the tracer particle.

For high velocities (>500 m/s), the frequencies generated can easily reach hundreds of megahertz; therefore, it is important to have a signal processor that can handle very high frequencies.

The application note describes several tests conducted with the FSA 5800 in order to assess the suitability of this processor for high-speed flows. The first set of tests involved introducing a known signal with added noise into the processor in order to assess the uncertainty in the measurement. The second test was performed by feeding in light signal from a diode at a known frequency in order to test not only the signal processor, but also the photodetector module and the entire system's ability to measure high-frequency signals.

Experimental Setup – Simulated Burst Generator

The TSI® model FSA 5800 was tested at a range of high frequencies generated by a simulated LDV burst generator in order to test the suitability of the processor for measuring high-speed flows.

Noise was added to the simulated signal in order to closely mimic the sort of signal that would be encountered in real-world measurements in a noisy environment. The amplitude of the noise was approximately 50% of the signal. A line-trace of the simulated signal with a burst and showing the noise can be seen in Fig. 1. Two real bursts can be seen in the figure.

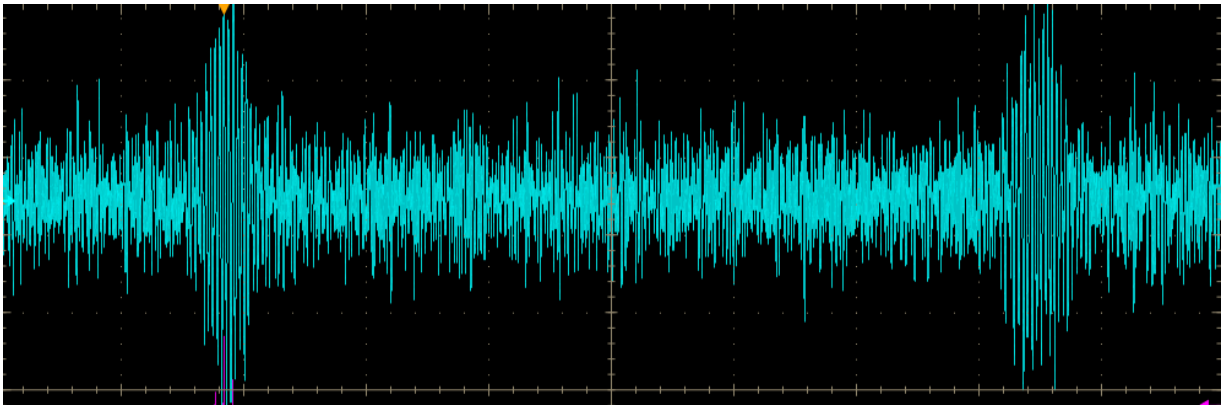

Figure 1. A line-trace showing the signal amplitude and noise. Two bursts are present in this figure.

The simulated bursts signals were generated at 300 kHz at a range of high frequencies spanning from 55 MHz to 210 MHz, and the data was recorded using TSI®'s FSA BurstPro™ Flow and Particle Analysis software.

Results

The results of the tests can be seen in Figure 2. The input frequency is shown in the blue columns (left). The measured frequencies are shown in the yellow columns (right), along with the difference between the input and measured frequencies (%) and Frequency TI (%). The burst efficiency was 95% or greater for the measurements.

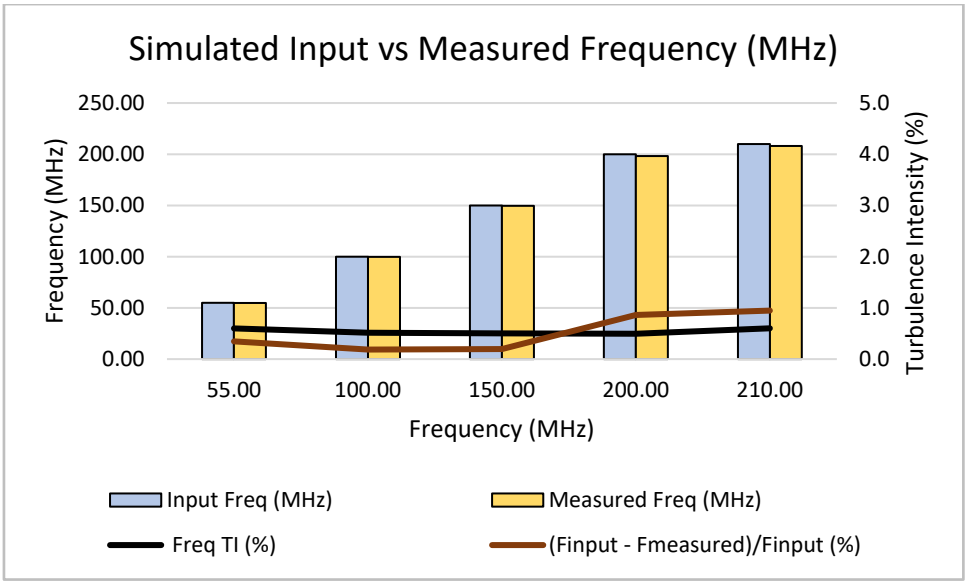

Figure 2. Input frequency, measured frequency, difference, and turbulence intensity for the simulated burst tests with added noise.

The results show an uncertainty of less than 1% across all measured frequencies. In addition, the RMS was less than 1% as well.

The results of the simulated frequency signal tests demonstrate the superb measurement capability of the FSA 5800 for high-frequency LDV measurements.

Experimental Setup – Laser Diode

The FSA 5800 was also tested using a pulsed laser diode input directly into the light port of the photo-multiplier tubes in the photo-detector portion of the FSA 5800. The diode had the capability of pulsing at a frequency of greater than 215 MHz. Diode bursts were introduced to the PMTs at a data-rate of 100 kHz with varying frequencies from 55 MHz to 210 MHz.

Results

The results of the tests can be seen in Figure 3. The input frequency is shown in the blue columns (left). The measured frequencies are shown in the yellow columns (right), along with the difference between the input and measured frequencies (%) and Frequency TI (%). The burst efficiency was 98% or greater for the measurements.

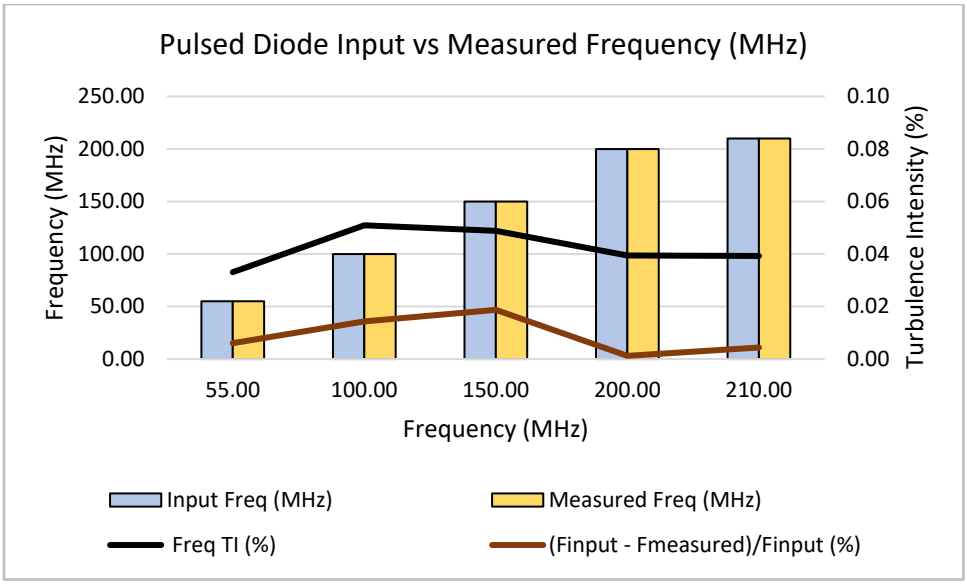

Figure 3. Laser Diode input frequency, measured frequency, difference (%), and turbulence intensity (%) for the simulated burst tests with added noise.

The results show an uncertainty of less than 0.02% across all measured frequencies. In addition, the RMS was less than 0.05% as well.

The results of the laser diode frequency signal tests demonstrate the measurement capability of the FSA 5800 for high-velocity LDV measurements which includes both the light signal collection portion of the processor and the signal processing itself.

Conclusion

Several experiments were conducted in order to ascertain the capabilities of the FSA 5800 for taking measurements in high speed flows. Both simulated bursts with noise and a pulsed laser diode signal were measured. The results show excellent frequency processing and extraction of the FSA 5800 at very high frequencies up to 210 MHz.

A frequency of 210 MHz can correspond to a velocity of over 2500 m/s with appropriate LDV optics, making the FSA 5800 an excellent choice for high speed velocity measurements.

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