Mechanical Measurements I

Using A DSO To Measure Vibration Using Accelerometers

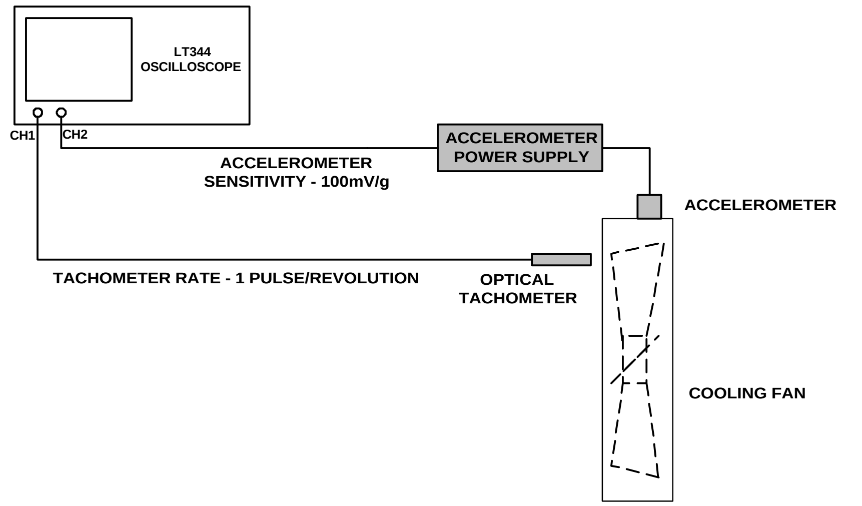

Figure 1 - Block diagram of a test setup to measure mechanical vibration using an accelerometer as a transducer

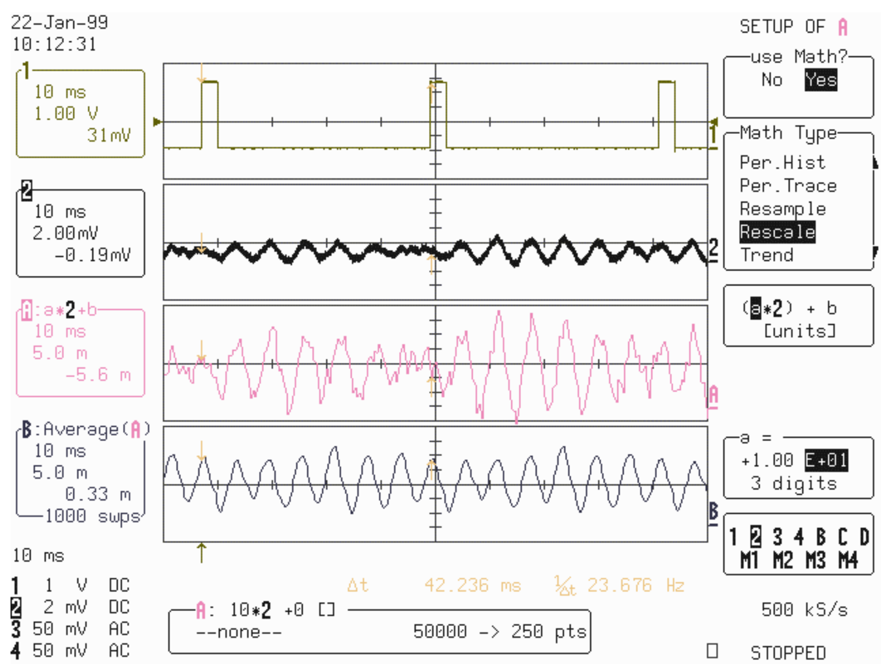

Figure 2 – LT 344L Oscilloscope setup for measuring and scaling vibration data from a 100 mV/g accelerometer

LeCroy oscilloscopes, such as the Waverunner™ series, are ideal for measuring and analyzing mechanical vibration and related phenomena. Long acquisition memory, SmartTriggers™, and extensive math and analysis functions are well suited for the demands of mechanical measurements.

Figure 1 illustrates the a typical vibration measurement setup. The device under test is a 7 blade cooling fan. The frame is instrumented using an accelerometer. An optical tachometer is used to derive a trigger signal once per revolution. The accelerometer is powered by an external, battery power supply and has a calibrated output sensitivity of 100 mV/g.

The oscilloscope is setup to trigger on the once per revolution signal coming from the optical tachometer shown in the top trace (Channel 1). The data from the accelerometer is displayed in channel 2. This raw data has to be rescaled by dividing by the transducer sensitivity in order to readout directly in g's. Math trace A performs the rescaling, dividing the measured waveform by 100mV. The math setup menu shows that all values in channel 2 are multiplied by 10 (the reciprocal of 100 mV). The period of the trigger signal is 43.236 ms (23.676 Hz), read using cursors. This period indicates a rotational speed of about 1420 rpm.

Synchronous averaging is used to emphasize the vibration that is time synchronous with the fan rotation. This reduces vibration components, such as structural resonance, which are not synchronous with the fan blade rotation. By using the advanced triggering functions data can be gathered synchronously, over all or part of a revolution, or asynchronously.

In figure 3 the oscilloscope has been setup to analyze the data. The top trace shows the trigger signal. Beneath the trigger signal is the averaged vibration level calibrated in vertical units of g's. Traces C and D contain the FFT and averaged FFT of the vibration waveform. The menu shows the FFT setup.

Note that in the vibration signal shown in trace B there are 7 cycles occurring between each of the trigger pulses. This occurs throughout the entire waveform and is related to the number of blades. In other words the principal, synchronous vibration component is related to the fan blades passing supporting structures in the fan.

A measurement of the frequency of the highest peak in the frequency spectrum of the FFT, made using cursors, yields a vibration level of $7.5\ 10^{-3}$ g's at a frequency of 165 Hz. This is the

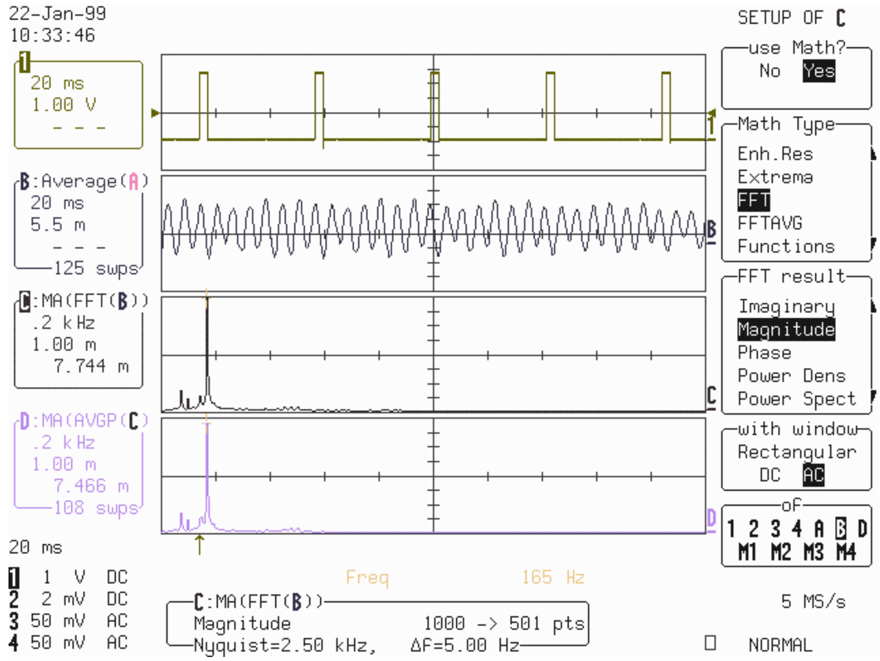

Figure 3 – Analyzing the vibration data using averaged data in both the time and frequency domain.

blade passing frequency (7 X 23.6 Hz = 165Hz).

Note that the peak amplitudes in the vibration signal in B occur at the same locations relative to the trigger signal. This represents specific effects due to individual fan blades. This type of effect can be related to factors including unbalance or structural defects. Further investigation of these effects is left for another application brief.

In addition to basic analysis in the time and frequency domain the oscilloscope can be used for extended analysis. If desired the vibration signal can be integrated and rescaled to readout in units of velocity (m/s, ft/s) or deflection (m, in).

Using the optional jitter and timing analysis math package rotational dynamics can be studied. These include run up, run down, braking and steady state rotational fluctuations.

The ability to perform these types of measurements is based on the LeCroy oscilloscopes key functional features: long acquisition memory, chained waveform math, and measurement tools such as cursors and parameters.