Mechanical Measurements II

Using A DSO To Measure Basic Rotating Machine Dynamics

LeCroy oscilloscopes, such as the Waverunner™ series, are ideal for measuring and studying basic dynamics on rotating machines. Long acquisition memory and specialized math and analysis functions make these measurements quick and easy

Figure 1 illustrates the a typical machine measurement setup. The device under test is a 7 blade cooling fan. The frame is instrumented using an accelerometer to measure vibration. An optical tachometer is used to derive a once per revolution trigger signal.

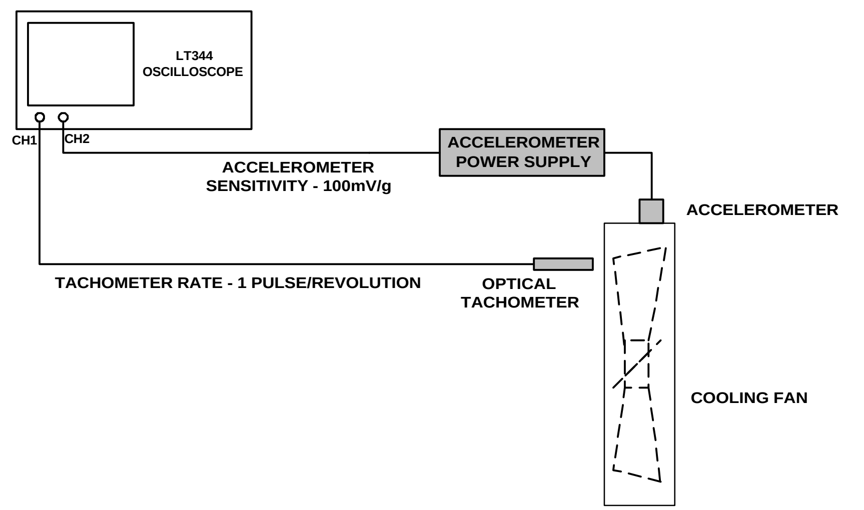

Figure 1 - Block diagram of a test setup to measure mechanical vibration and rotating machinery dynamics

The oscilloscope is setup to trigger on the once per revolution signal coming from the optical tachometer shown in the top trace (Channel 1) of figure 2. LeCroy's optional Jitter and Timing Analysis (JTA) math package is used to measure the frequency of the tachometer signal on a cycle by cycle basis. This analysis, for a run up from 0 to maximum rotational speed, is displayed in trace A. This represents the instantaneous frequency of the tachometer signal in units of frequency (cycle per second or Hertz). Trace B performs the rescaling, multiplying the measured frequency of trace A by 60. This rescales the data from cycles or revolution per second to revolutions per minute. The math setup menu shows that all values in trace A are multiplied by 60. The frequency of the trigger signal, read using the minimum and maximum

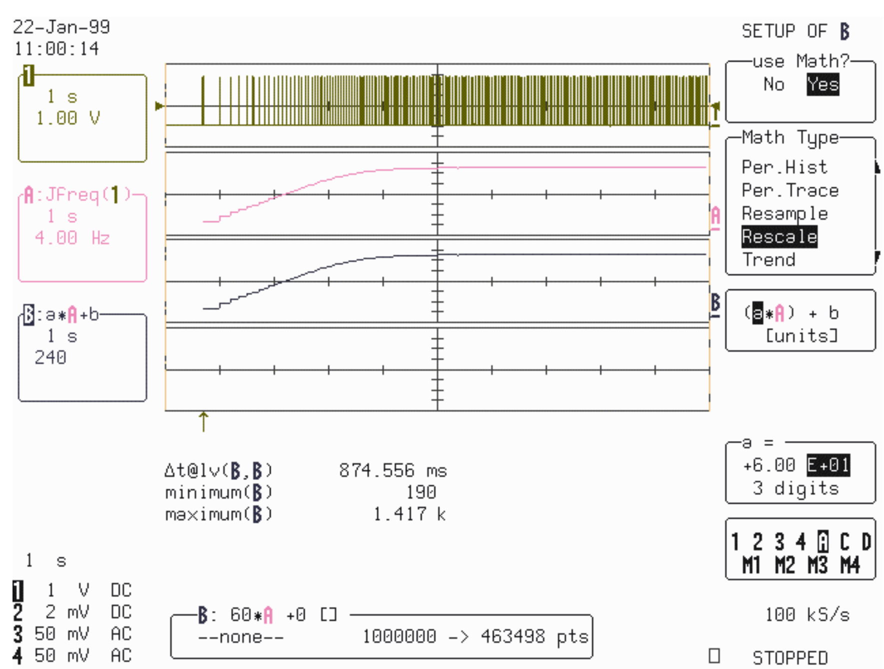

Figure 2 – LT 344L Oscilloscope setup for measuring and scaling angular velocity in rpm

parameters varies from 190 to 1417 rpm. Since we are triggering on the tachometer signal the initial increase in rotational speed wasn't measured while we waited for the once per revolution signal. This could be been eliminated by starting with the sensor at the very beginning of motion. A more practical alternative would be to use an optical encoder with multiple pulses per revolution.

Many applications the dynamics of machine 'run up" and 'coast down' need to be measured. This is extremely important in intelligent motion systems, which need to accurately control angular displacement. While the fan is not generally used in these applications it serves as a readily available example as shown in figure 3.

In figure 3 the fan motor was started for 5 s, then allowed to coast down. As in the earlier example the rotational speed was rescaled to rpm as shown in trace B. Trace B shows that the rotational speed varies exponentially. In the same trace the measurement parameter Delta Time at Level (ΔT@LV) is used to measure how long it takes to accelerate from 400 to 800 rpm. The parameter readout indicates that it takes 926 ms for this transition for an average rate of change of 432 rpm/s.
In figure 4 the derivative math function is applied to the contents of trace b to derive the instantaneous angular acceleration. Parameters read the peak values of 648rpm/s and –674 rpm/s.

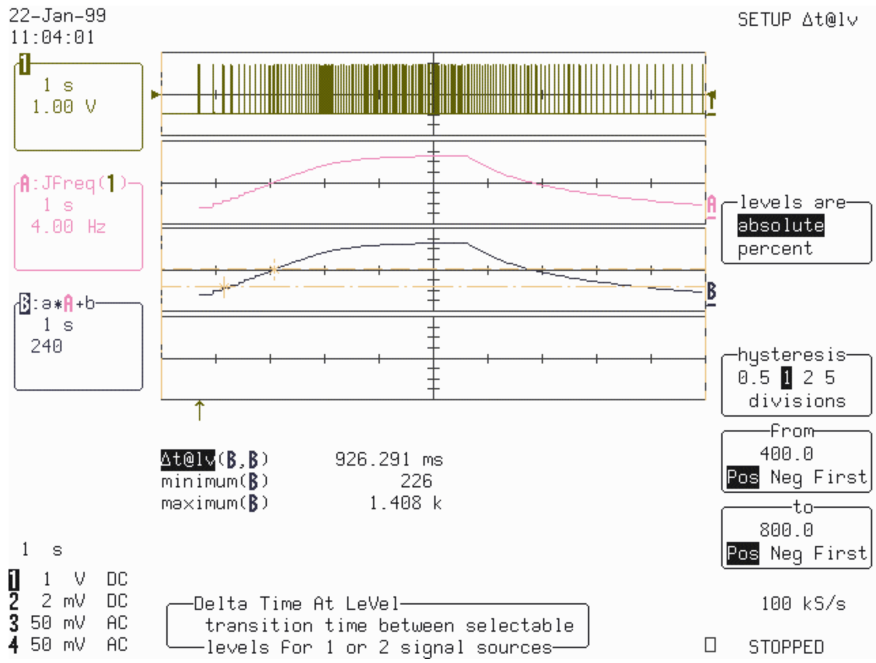

Figure 3 The measurement of a fan motor's angular acceleration during run up using the Delta time at level parameter.

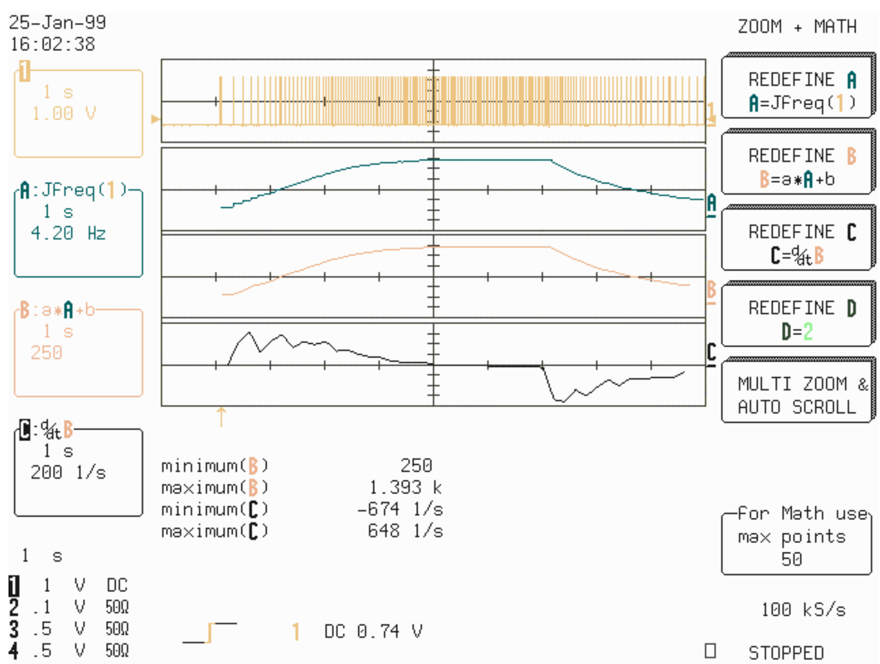

Figure 4 Using the derivative math function to compute instantaneous angular acceleration