TN-30

What’s Wrong With My Piezoelectric Accelerometer?

Written By
Mike Lindstrom

INTRODUCTION

A frequently asked question about measurements made with piezoelectric (PE) vibration sensors is related to the measurement parameters. After completing a test and evaluating data, test engineers may observe obvious signs of problems within the data that was collected. Many factors can affect the data from a PE accelerometer including measurement range, the measurand input amplitude, the measurand input frequency content, and the data acquisition sample rate. For example, input amplitude levels that are greater than the sensor's measurement range will saturate the amplifier. Input frequency content at or near the sensor's resonant frequency may also saturate the amplifier. The high Q-factor at resonance will cause the sensor to enter an overload recovery state and no meaningful data can be acquired (even with post-process filtering in your DAQ). Data of a saturated amplifier will appear as illustrated in Figure 1 and Figure 2, (note exponential decay).

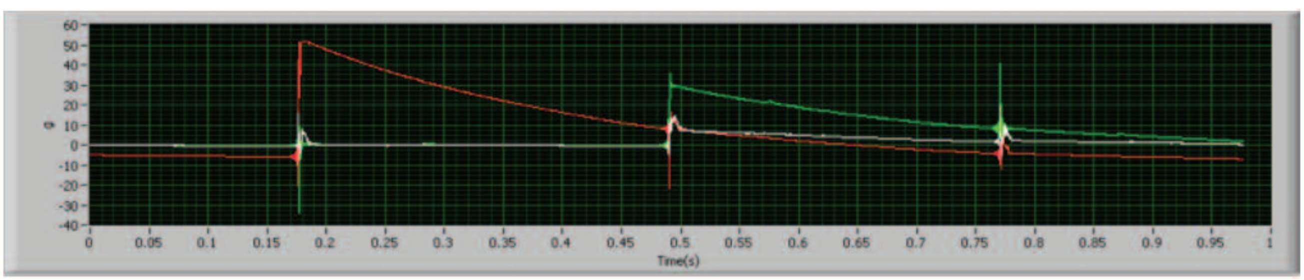

Figure 1 – Saturated amplifier example #1

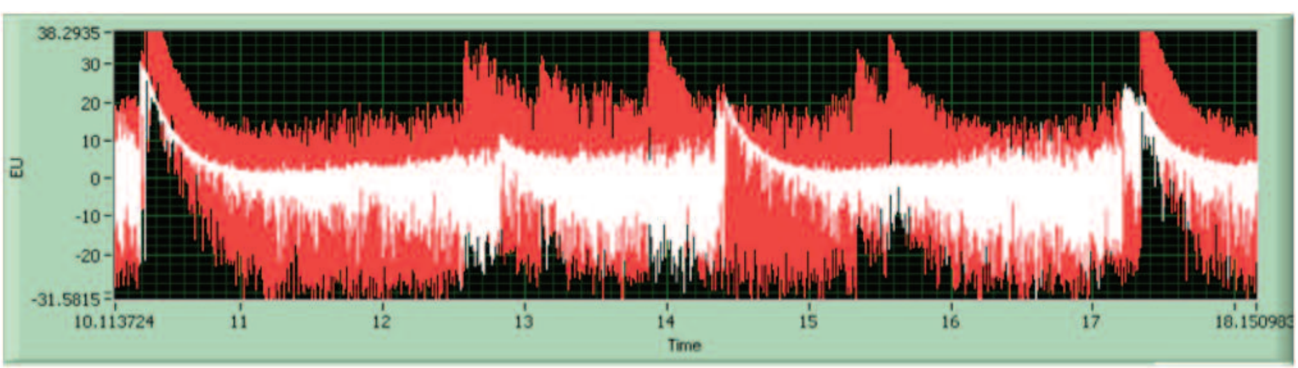

Figure 2 – Saturated amplifier example #2

Sensors with single or two-pole low pass filters will decrease the chance of amplifier saturation and increase the useable frequency range. Low pass filters will attenuate (suppress) signal generation at or near the resonant frequency of the sensor. This counteracts the gain (high-Q) factor caused by the sensor's mechanical resonance. See figure 3.

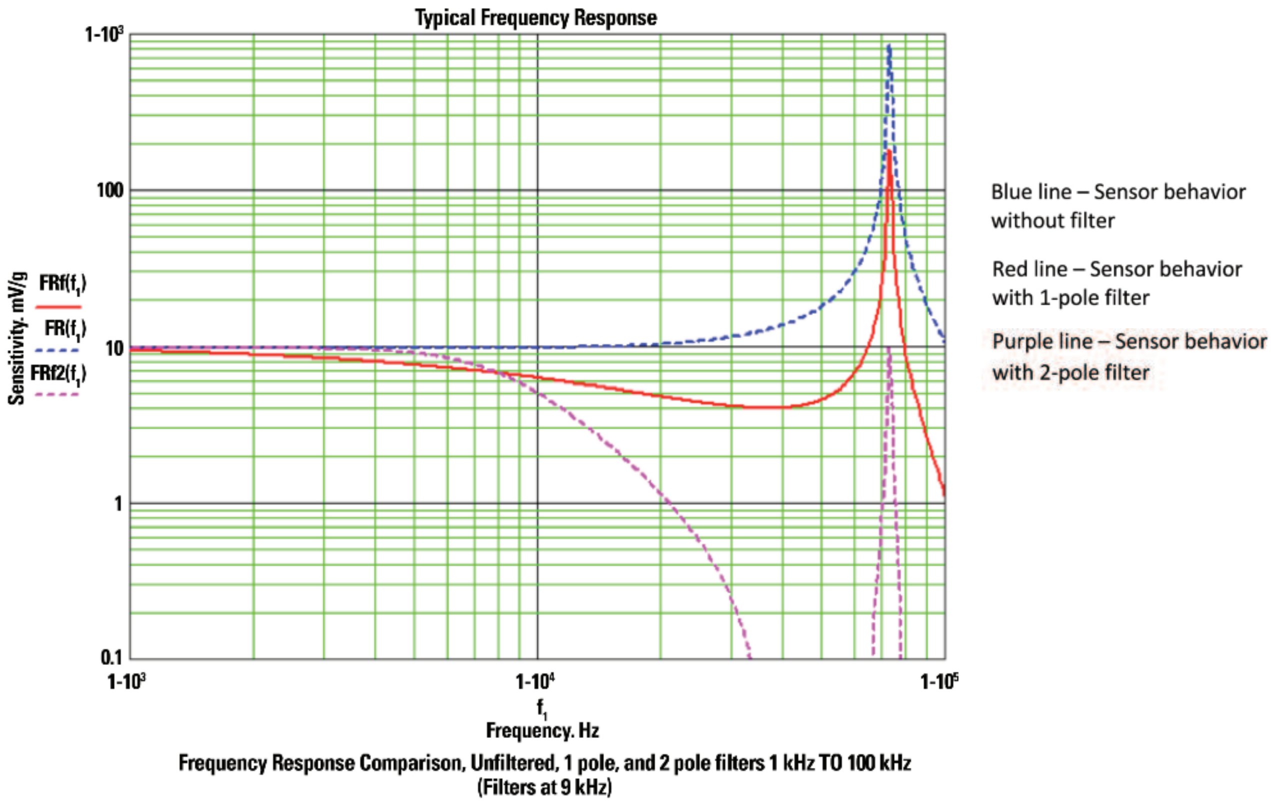

Figure 3 – Unfiltered and Filtered Sensor Response

Testing was performed at PCB Piezotronics to highlight the importance of selecting the right sample rate and sensor measurement range to obtain proper results in any application

TEST BACKGROUND

PCB model 352C18 (10 mV/g, 2-gram accelerometer) and PCB model 352C65 (100 mV/g, 2-gram accelerometer) were mounted to the end of a cantilever beam as show in Figure 4. The end of the cantilever beam was impacted with a hammer to provide a step input. The outputs of each accelerometer were connected to a digital oscilloscope set at a sample rate of 2 kHz. Model 352C18 was also connected to a second oscilloscope set at a sample rate of 2 MHz.

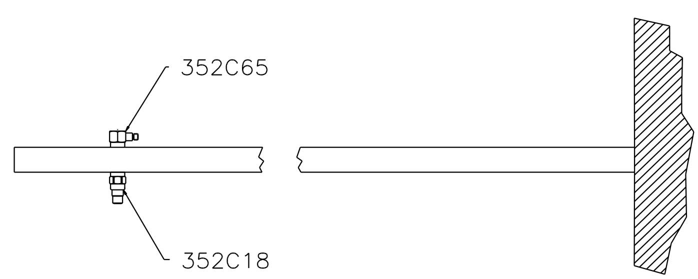

Figure 4. Test Setup

TEST RESULTS

The output of each accelerometer is shown in Figure 5 and Figure 6. Figure 5 is the output over a two second period. Figure 6 shows the same signal in a .10 second time span. Figure 5 shows that the 352C65 signal peaks/saturates and then exponentially decays the baseline voltage back to zero. This type of behavior indicates that the input exceeded the accelerometer's measurement range (50 g-pk) and saturated the internal amplifier. The erroneous peak output from the 352C65 indicates the peak level was 150 g-pk and the 352C18 output indicates a peak level of 325 g-pk. The lower than actual peak level measured by the 352C65 is the result of the internal amplifier saturating and limiting its maximum output (which was well outside the typical ±5.0 Volt linear range). The 325 g-pk from the 352C18 accelerometer was well within the (±5.0 Volt linear output) specified measurement range of 500 g-pk.

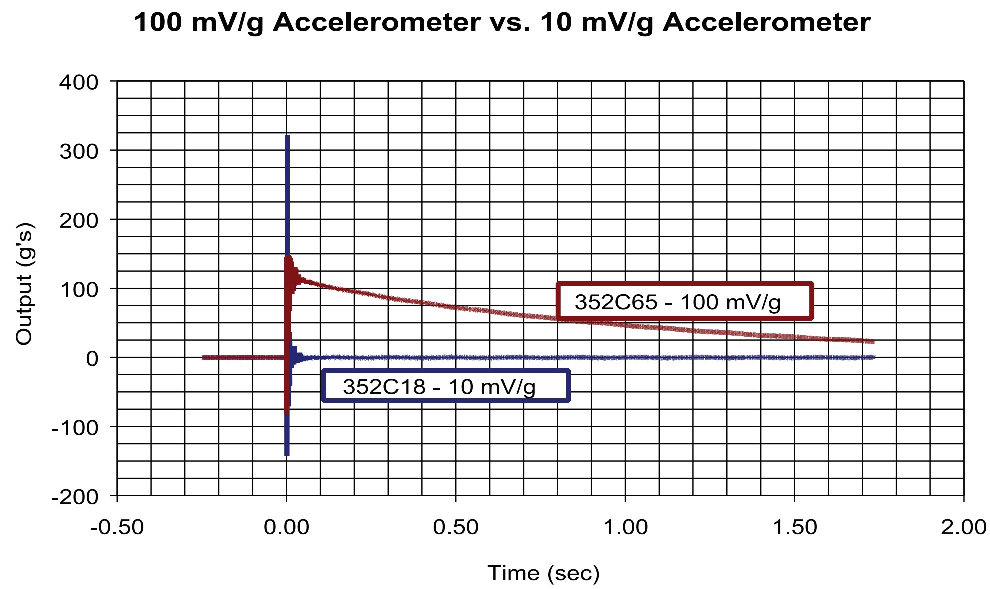

Figure 5. Accelerometer Output Signals

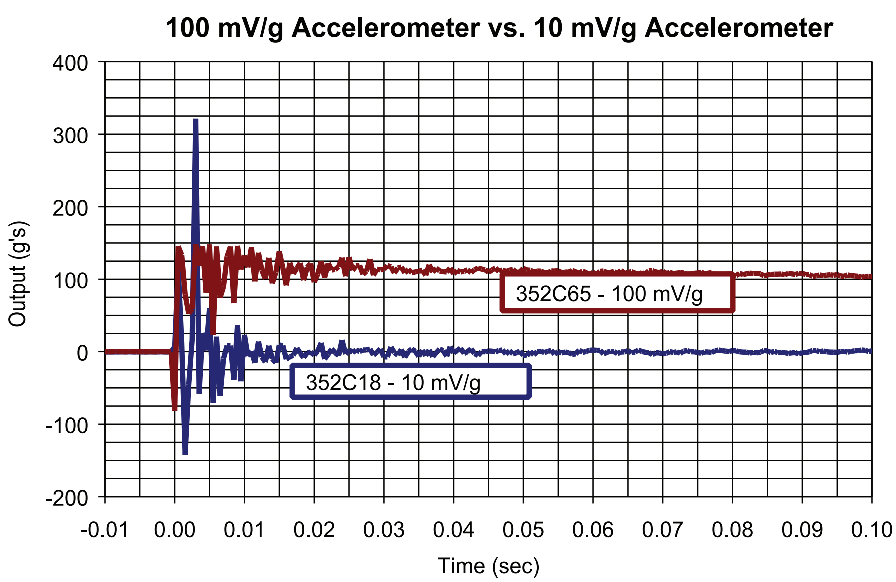

Figure 6. Accelerometer Output Signals - Expanded

The shorter time span plot is shown to illustrate how the levels from the 352C65 differ from the 352C18 as the signal exceeds the 50 g-pk measurement range. The signal from model 352C65 in Figure 6 could be confused with a malfunction of the accelerometer. Even worse – It could go completely unnoticed if only looking at frequency domain data.

Figure 7 is a plot of the 352C18 and 352C65 at a sample rate of 2 kHz. The 352C18 is also sampled at a rate of 2 MHz. The 2 MHz data shows a very high frequency signal resulting from the metal to metal impact of the hammer to steel beam. The lower 2 kHz sample rate acts as a filter on the original data and attenuates the high frequency content of the measured output levels. The 2 MHz data has a peak output of over 200 g's where the maximum output of the 2 kHz data is just over 100 g's in the same time frame.

CONCLUSION

Erroneous data can lead a test engineer to believe that there is a problem with the measurement instrumentation. It might not always be a sensor issue, however. The importance of measurement parameters should not be overlooked when attempting to make an accurate measurement. Two key parameters are the DAQ sample rate and sensor measurement range. A key indicator of amplifier saturation is exponential decay of the baseline voltage to zero. It is important to remember that the sample rate can act as a filter to attenuate the frequency content and observed peak levels. It can also mask amplifier saturation if it is occurring in a measurement.

The data presented was measured with integrated circuit piezoelectric (ICP®) accelerometers, but saturation can also occur within the external amplifiers used with measurements involving charge output (PE) accelerometers.

If you are experiencing amplifier saturation during your measurement please feel free to contact PCB® to discuss either sensors with an increased measurement range or sensors with built in low pass filters.

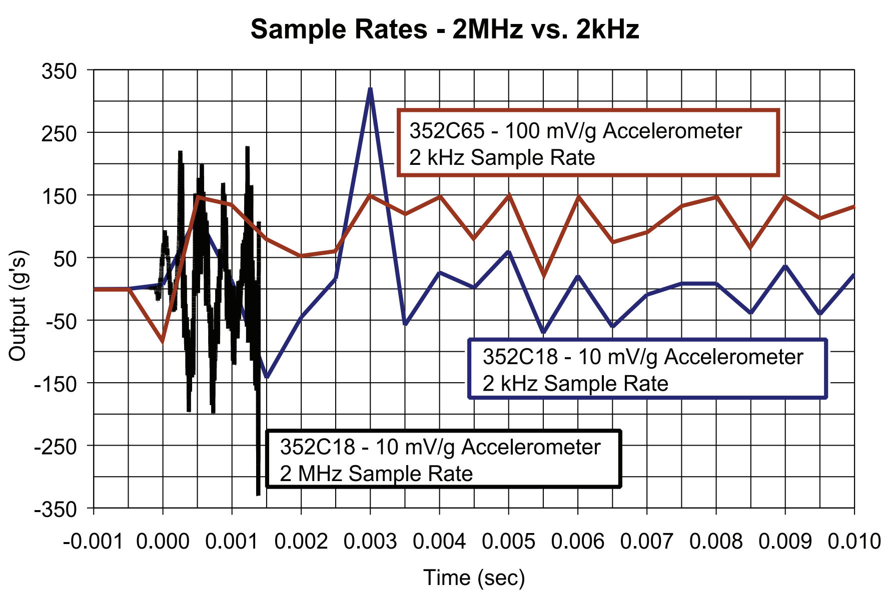

Figure 7. Sample Rate

PCB PIEZOTRONICS
AN AMPHENOL COMPANY

3425 Walden Avenue, Depew, NY 14043 USA

pcb.com | info@pcb.com | 800 828 8840 | +1 716 684 0001

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