SHOCK AND VIBRATION RESPONSE SPECTRA COURSE
Unit 25. Direct Saturation Removal

By Tom Irvine
Email: tomirvine@aol.com

Introduction

Again, measured accelerometer data may offsets or trends. These effects are usually spurious. An offset could occur due to accelerometer saturation. Or an offset could occur due to some electrical drift inside the data acquisition system.

There are several methods for removing offsets and trends.

Unit 24 presented a polynomial trend removal method, which is suitable for simple offset cases.

Another candidate method is highpass filtering, which was discussed in Unit 18.

The purpose of this Unit is to determine whether highpass filtering is suitable for removing saturation effects from shock data.

Example

Raw Data

An acceleration time history from a rocket vehicle frangible joint shock test is shown in Figure 1. The signal clearly has a saturation effect, as evidenced by the offset. The accelerometer's own natural frequency may have been excited.

The shock response spectrum is shown in Figure 2. The spectral levels in the low frequency domain near 10 Hz are artificially high due to the saturation effect.

The corresponding velocity time history is shown in Figure 3. The velocity clearly diverges from the zero baseline.

Some experts would thus argue that the signal is invalid and that the data should be discarded. Nevertheless, data is precious. Thus, use highpass filtering to remove the saturation effects.

Filtered Data

A 50 Hz highpass filter is used in an attempt to recover the data. The highpass filtered acceleration time history is shown in Figure 4. The filtering effectively removes the offset. Nevertheless, it has the unwanted side effect of introducing a spurious trend prior to time zero.

The shock response spectrum of the filtered data is shown in Figure 5. The filtering is successful in that it brings the positive and negative curves together. Nevertheless, the initial slope of each curve is unrealistically sharp. The filtering operation has thus removed some of the “good data” at the low frequency domain.

Finally, the velocity time history of the filtered accelerometer data is shown in Figure 6.

Conclusion

Highpass filtering is somewhat successful for removing saturation effects from signals. It removes the saturation effects but also removes some of the “good data.” It is thus a brute force method.

A superior method will be introduced in Unit 26.

Homework

A sample acceleration time history from a linear shape charge test is given in lsc.txt. The data format is: time (sec) and accel (G). Use this data to repeat the example in this text. You may experiment with the highpass filtering frequency.

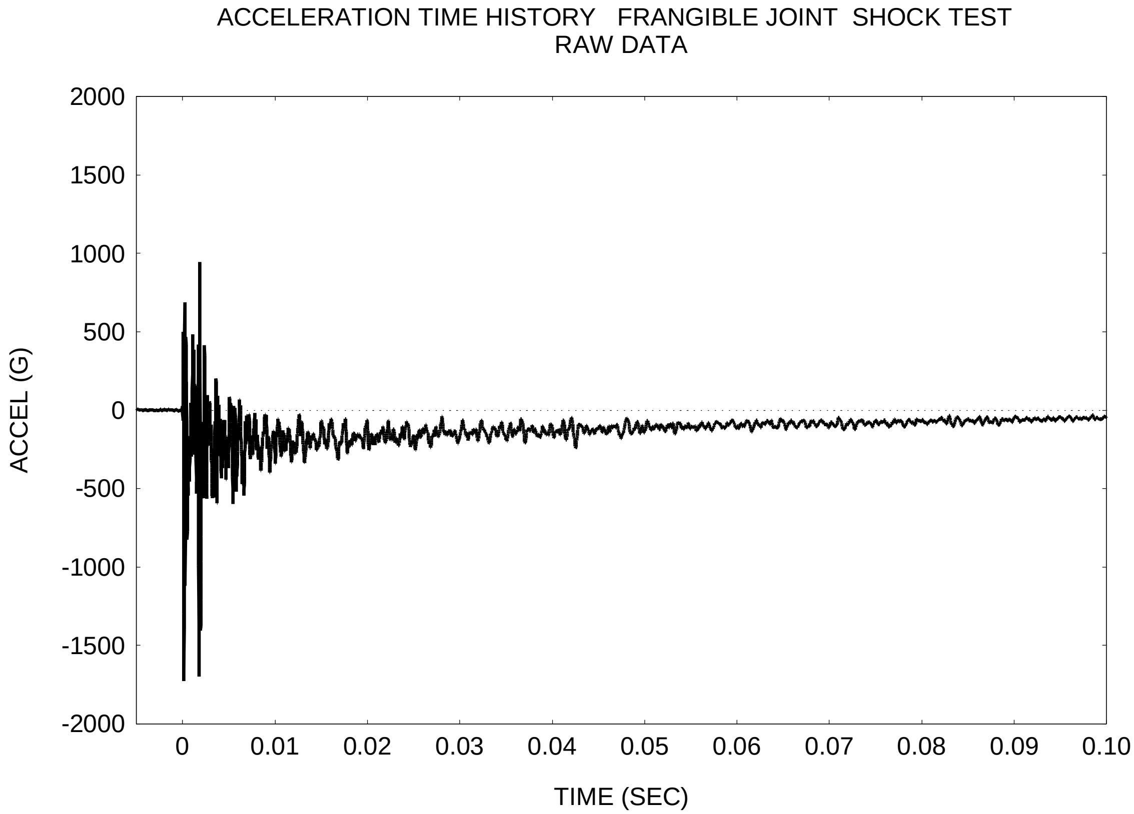

Figure 1. Acceleration Time History, Raw Data

Ideally, the signal would oscillate about the zero baseline. An offset is clearly present, however. The offset is beyond the scope of simple polynomial trend removal. Highpass filtering will be attempted as an alternative.

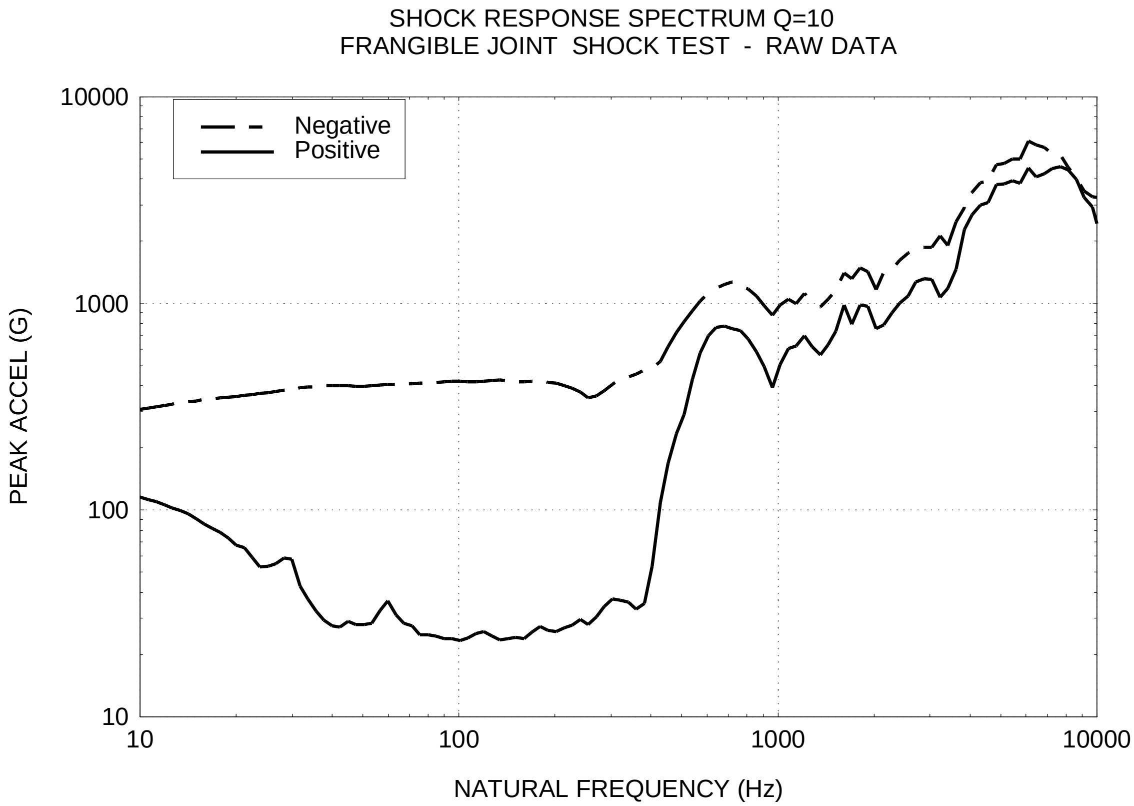

Figure 2. Shock Response Spectrum of Raw Data

The negative and positive spectral curves clearly diverge from one another, particularly below 500 Hz. Furthermore, each curve is unrealistically high in the low frequency domain near 10 Hz. These characteristics are further evidence of saturation.

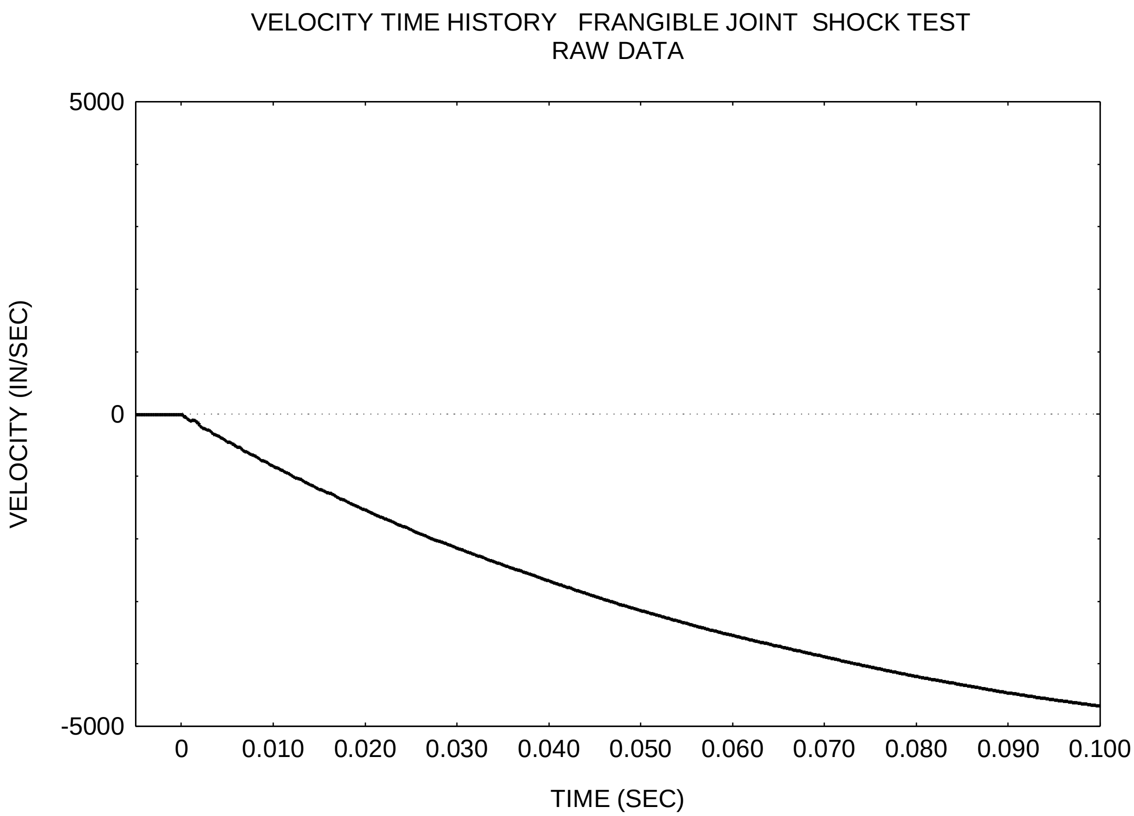

Figure 3. Velocity Time History, Raw Data

The integrated signal reaches nearly 5000 in/sec, which is very unrealistic. This is another manifestation of the saturation effect.

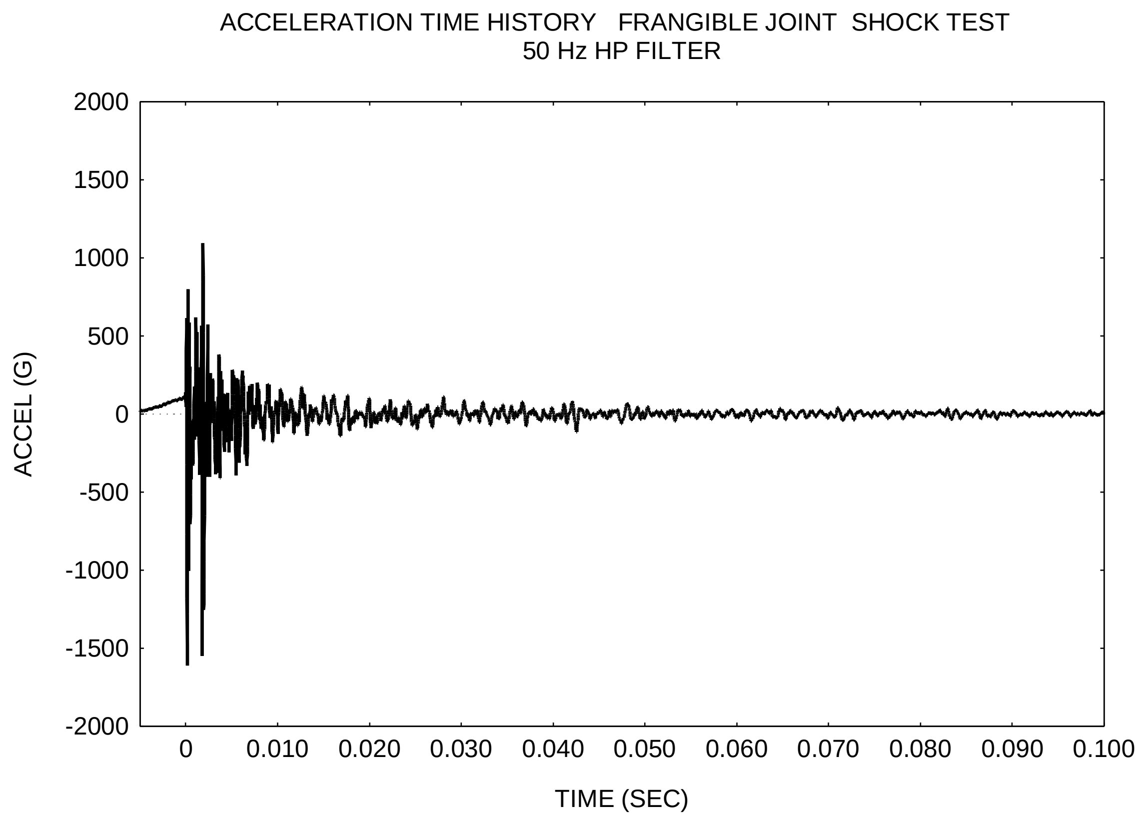

Figure 4. Signal Highpass Filtered at 50 Hz

The highpass filter operation removes the baseline shift effect. The filtered signal oscillates about the zero baseline. On the other hand, the filtering introduces a spurious trend leading up to time zero. This trend could be removed by diving the signal into segments prior to and after time zero. Then the polynomial trend could be removed from the pre-zero segment. Then, the segments could be reassembled.

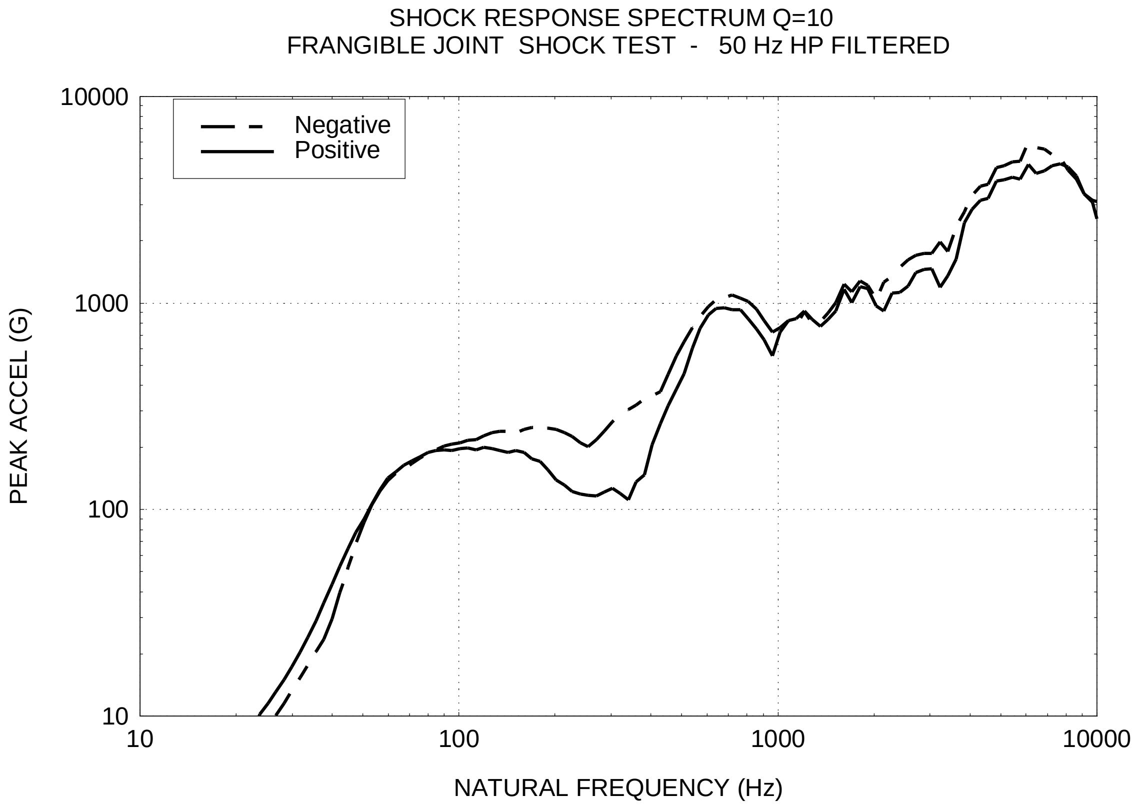

Figure 5. Shock Response Spectrum of Filtered Data

The data was highpass filtered at 50 Hz prior to the shock response spectrum calculation. The filtering brings the positive and negative curves closer together, yet it also causes an unrealistically sharp slope below 50 Hz.

Note that the effect of the highpass filtering diminishes above 1000 Hz. The curves in Figure 5 are nearly the same as those of the raw data in Figure 2 above 1000 Hz.

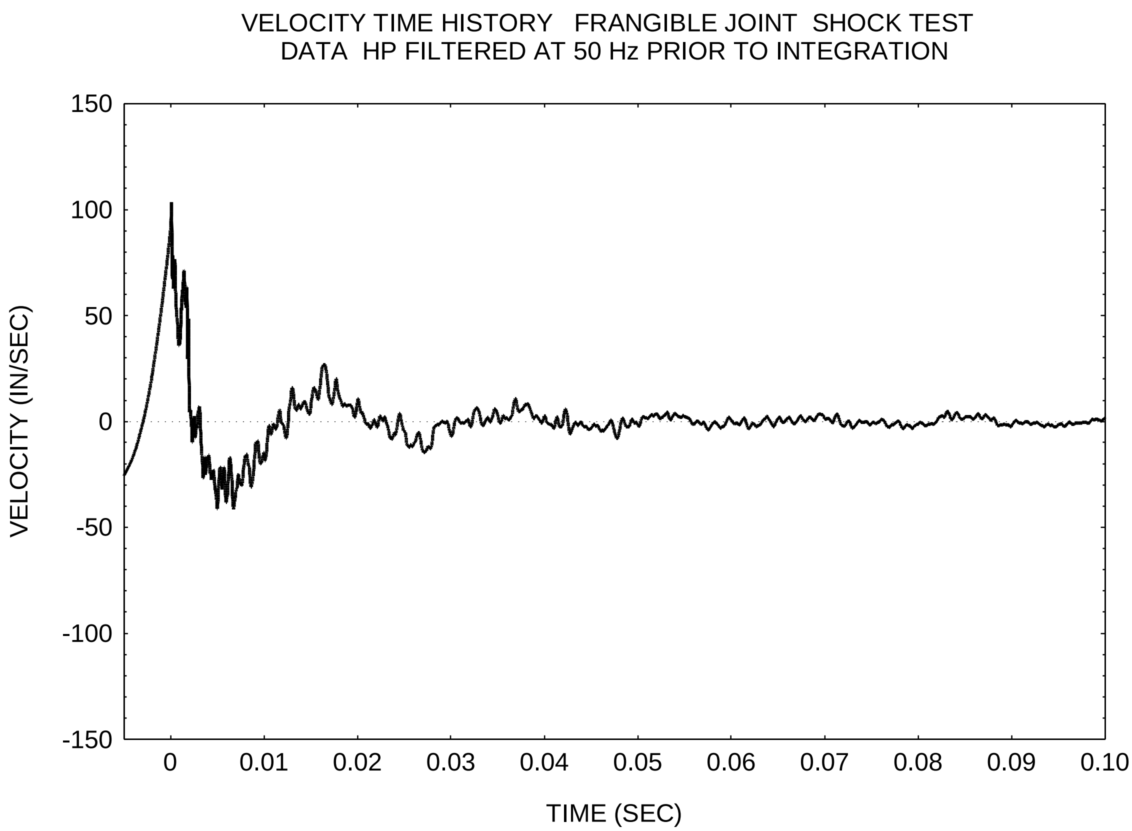

Figure 6. Velocity Time History of Filtered Data

The velocity time history now oscillates about the zero baseline. The initial velocity, however, incorrectly appears as a non-zero value. The filtering process thus has benefits, but also some limitations.