SHOCK AND VIBRATION RESPONSE SPECTRA COURSE
Unit 26. Indirect Saturation Removal

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Introduction

As a review, 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. Unit 25 presented a highpass filtering method, which has some drawbacks.

The purpose of this Unit is to present an indirect filtering method for removing saturation effects from shock data. The indirect method tends to be superior to the other methods.

Example

Raw Data

An acceleration time history from a rocket vehicle frangible joint shock test is shown in Figure 1. This is the same time history that was considered in Unit 25. 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, recovery is attempted.

Recovery Scheme

The recovery scheme is the indirect filtering method outlined in Table 1.

Table 1. Indirect Filtering Method	
Step	Description
1	Lowpass filter the acceleration signal at 100 Hz.
2	Multiply the lowpass filtered signal by a scale factor, such as 0.95.
3	Subtract the scaled, lowpass filtered signal from the original signal.
4	Correct pre-shock.
5	Highpass filter the data at low frequency, < 20 Hz.
6	Calculate the shock response spectrum.
7	Calculate the velocity time history.

The purpose of the method is to retain some of the low frequency data that would otherwise be removed by a "brute force" highpass filtering method.

The method requires engineering judgment.

Note that some trial-and-error may be necessary to determine the optimum filtering values in steps 1 and 5, as well as the optimum scale factor in step 2.

Recovered Data via the Indirect Method

The indirect method is implemented via program indirect.exe. The input time history is the test data from Figure 1. The input parameters are shown in Table 2.

Table 2. Input Parameters for Program: indirect.exe
Description
Lowpass filter at 100 Hz.
Scale Factor = 0.95.
Correct pre-shock? yes
Highpass filter at 16 Hz

The acceleration time history obtained via the indirect method is shown in Figure 4. The signal oscillates about the zero baseline. The indirect method is successful thus far.

The shock response curves obtained from the resulting signal are shown in Figure 5. The spectral curves have a consistent slope across the entire frequency domain. Furthermore, the curves are nearly equal to one another over most of the domain.

The velocity time history is shown in Figure 6. Though imperfect, the velocity time history has a stable oscillation about the zero baseline.

Finally, a comparison of absolute spectral curves from three methods is shown in Figure 7. The indirect method results are compared with two highpass filtering methods. The indirect method curve has a more realistic slope than the other curves.

Conclusion

The indirect filtering method cannot recover the original acceleration signal with absolute certainty. Nevertheless, it is a useful tool for estimating the original signal. It yields a more realistic shock response spectrum than the brute force highpass filtering methods.

Homework

A sample acceleration time history from a linear shape charge test was given in the previous Unit as lsc.txt. The data format is: time (sec) and accel (G). Use this data to repeat the example in this text. Use program indirect.exe. Experiment with the input parameters.

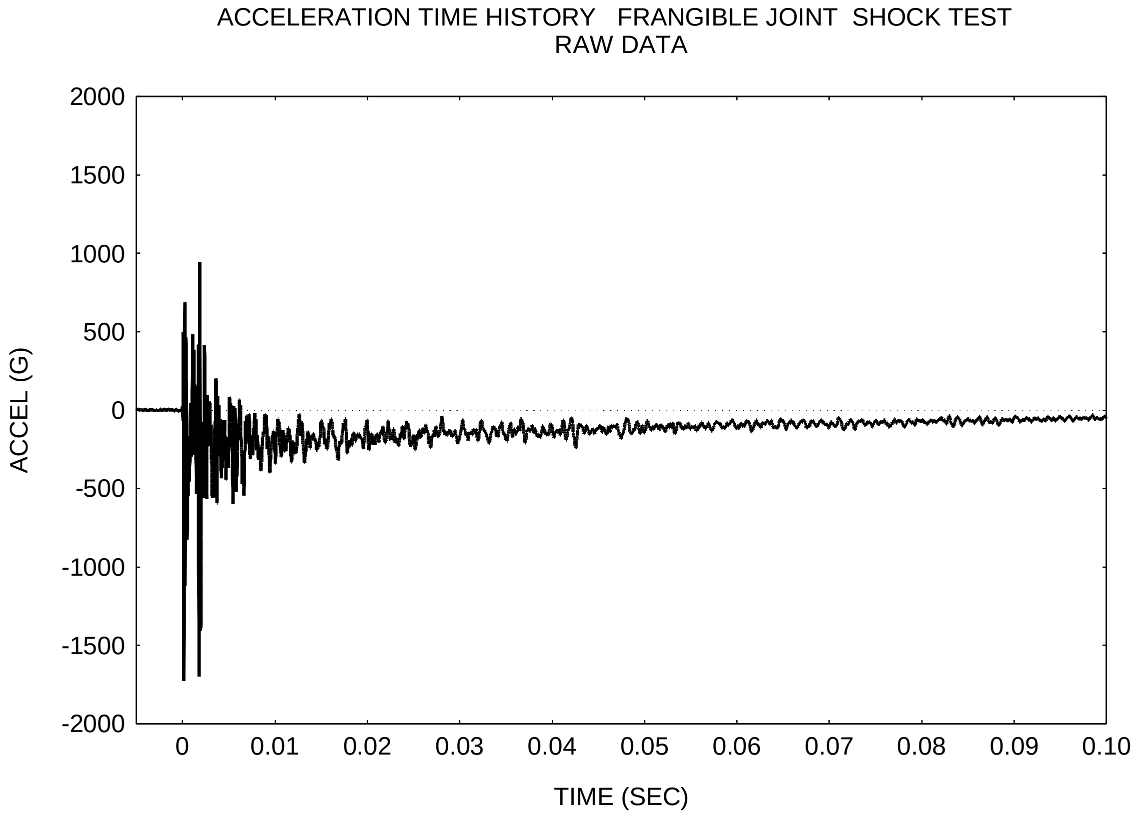

Figure 1. Acceleration Time History, Raw Data

Ideally, the signal would oscillate about the zero baseline. An offset is clearly present, however.

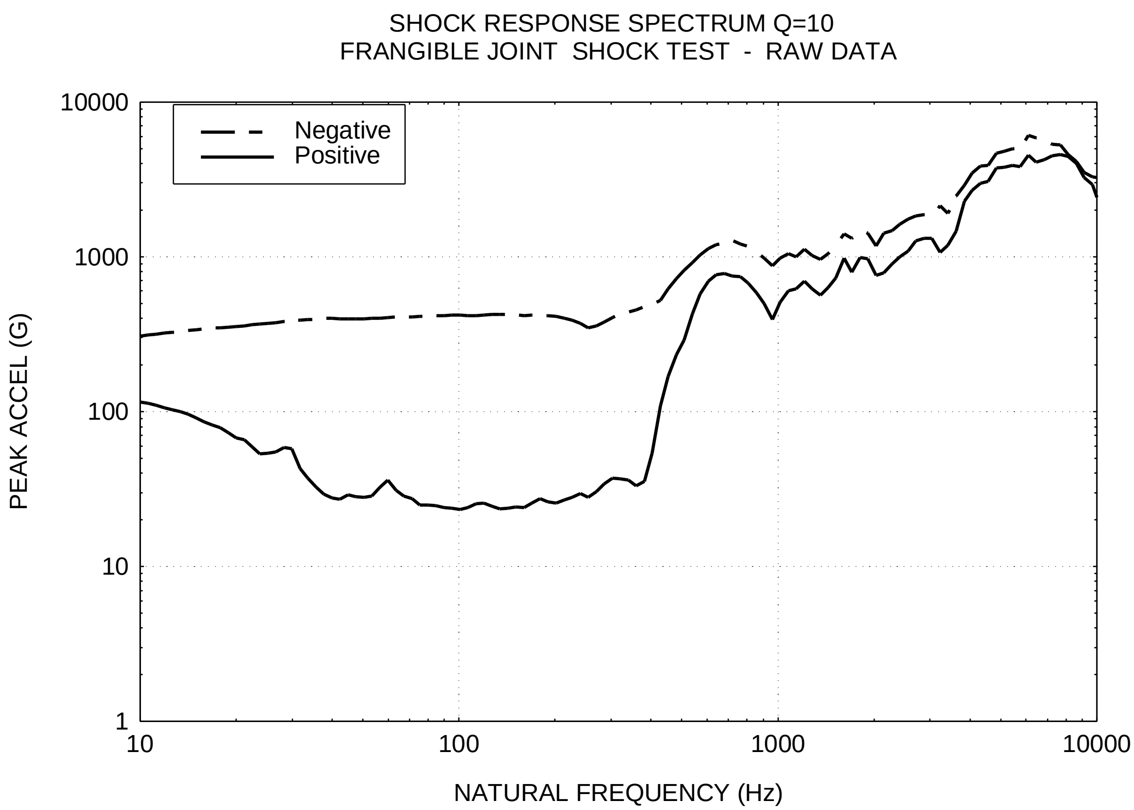

Figure 2. Shock Response Spectrum of Raw Data

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.

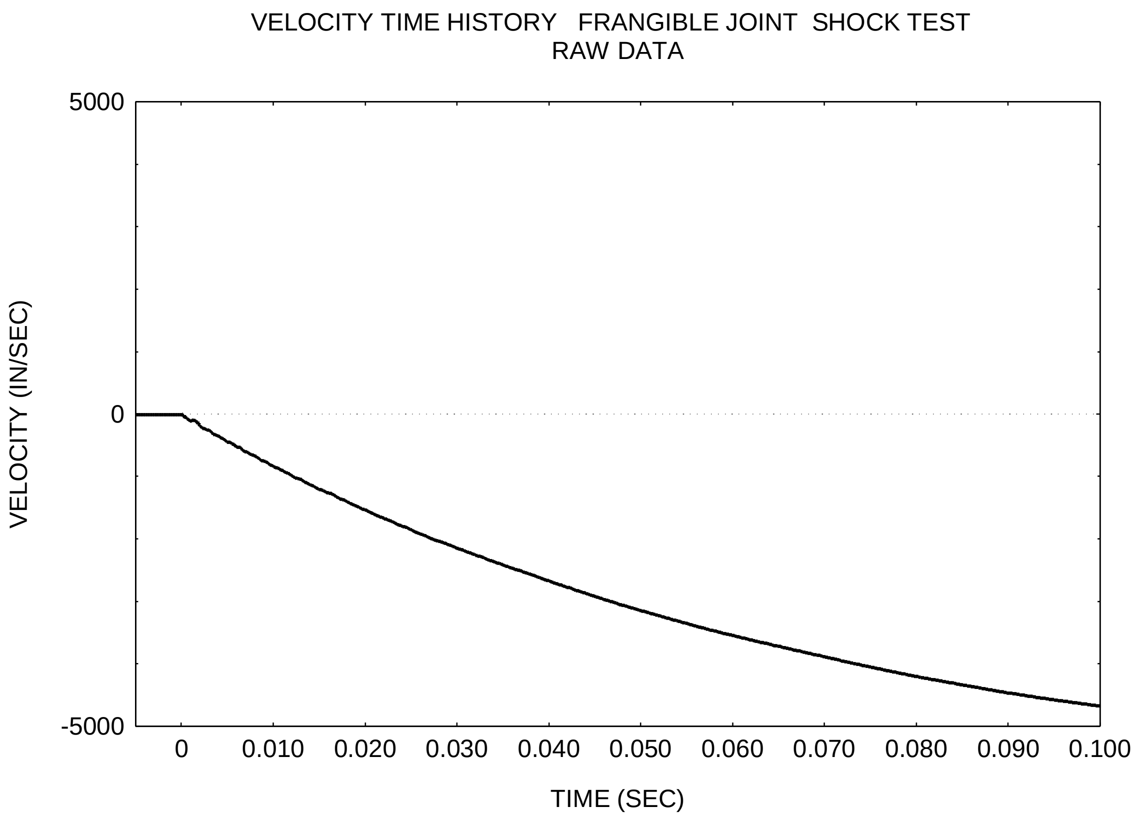

Figure 3. Velocity Time History, Raw Data

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

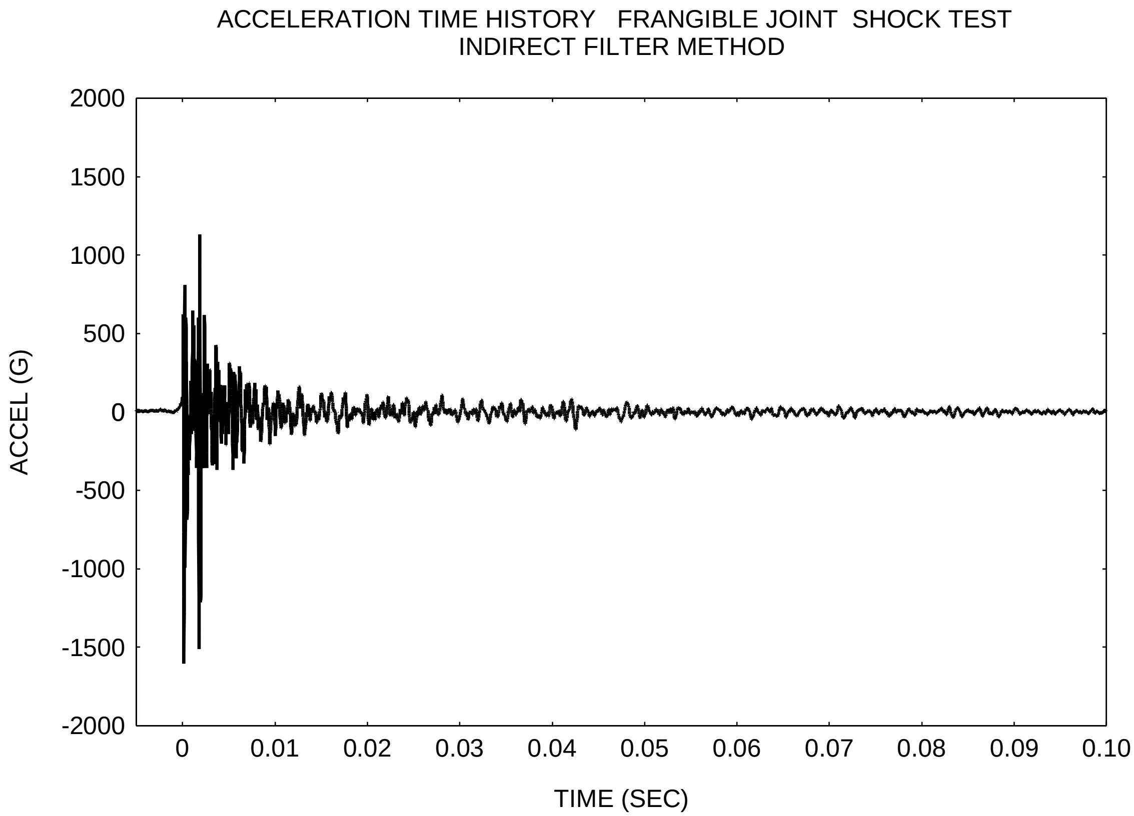

Figure 4. Acceleration Time History, Processed via the Indirect Filter Method.

The processed acceleration time history oscillates about the zero baseline.

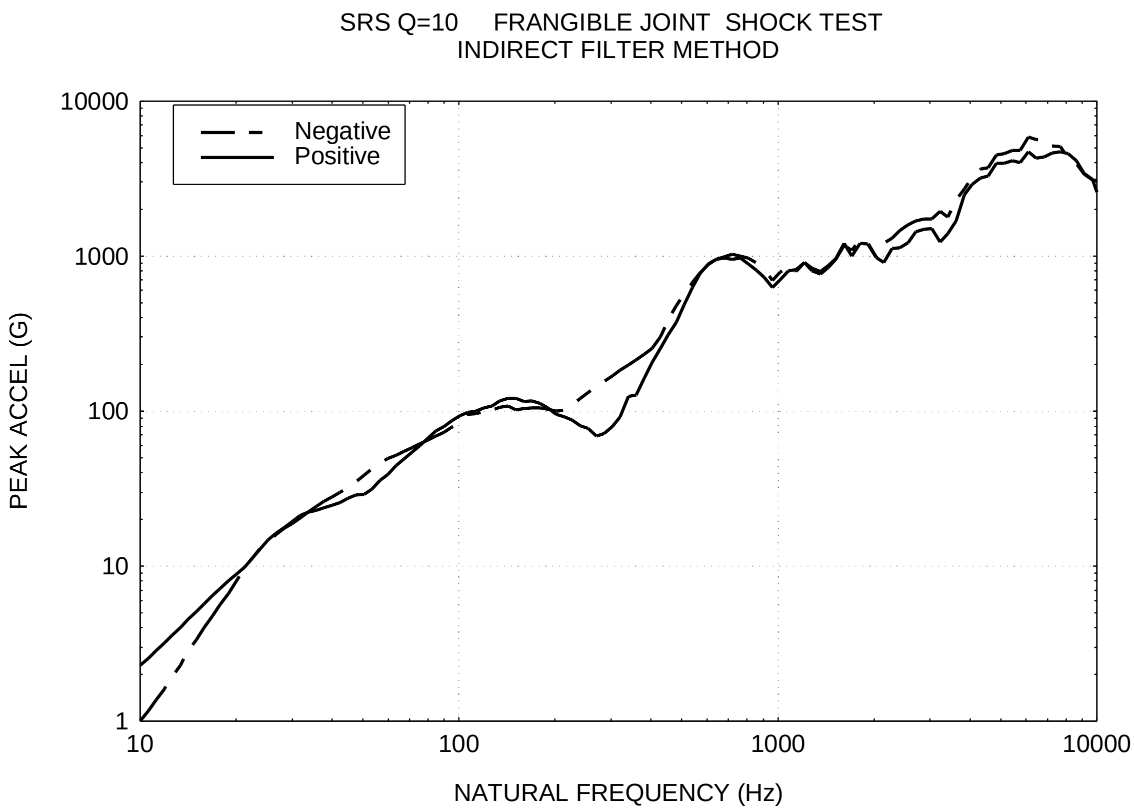

Figure 5. Shock Response Spectrum of Indirectly Filtered Data

The shock response spectra curves are approximately equal over most of the frequency domain. The overall slope appears realistic. The indirect filter method has thus proven successful, pending verification of the velocity time history.

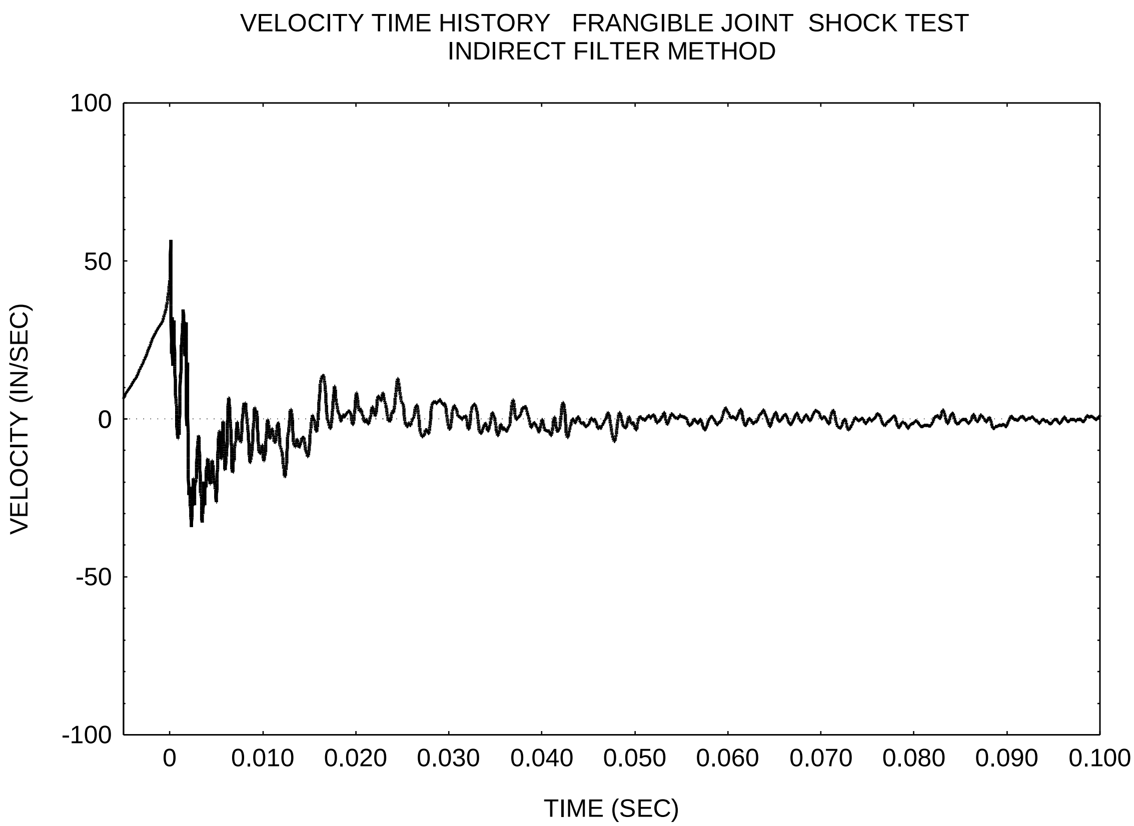

Figure 6. Velocity Time History of Indirectly Filtered Data

The velocity time history now oscillates about the zero baseline. The velocity prior to time zero has a spurious ramp. Nevertheless, the overall character of the velocity time history is satisfactory.

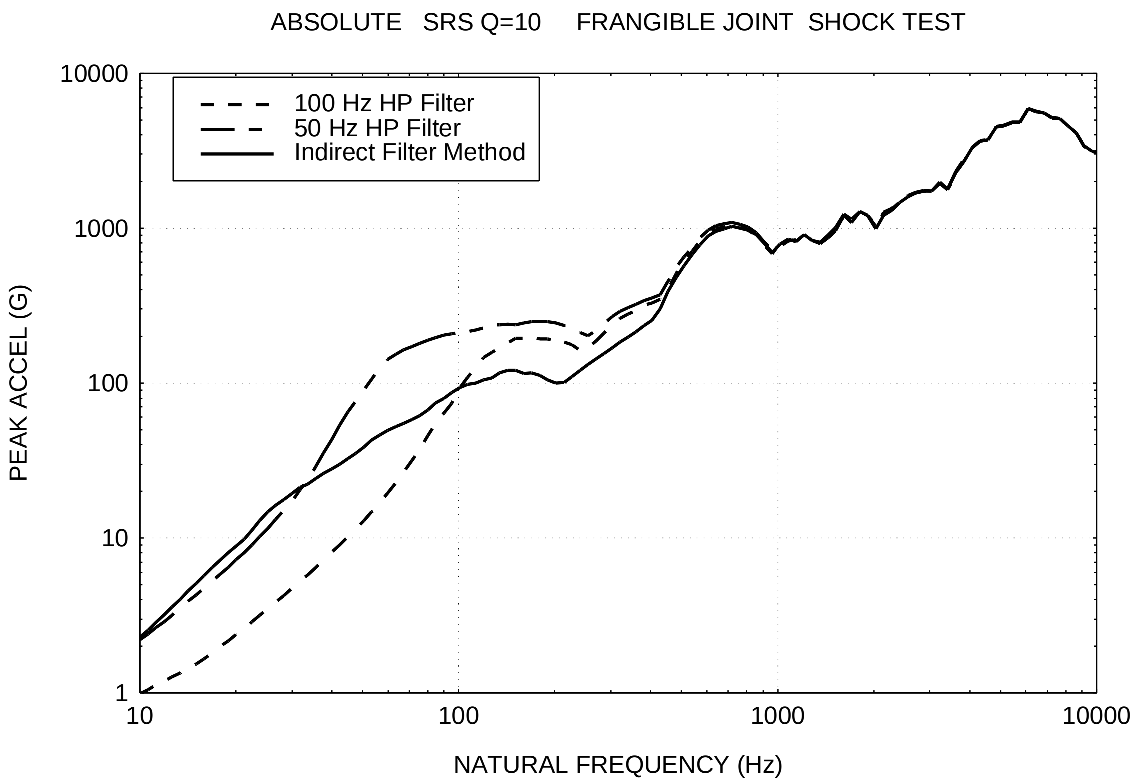

Figure 7. Three Processing Methods

Three processing methods are shown in Figure 7.

Both of the highpass filtering methods yield spectral curves with unrealistically steep slopes below 100 Hz.

The indirect method, however, yields a spectral curve with a slope consistent across the entire frequency domain.