SHOCK AND VIBRATION RESPONSE SPECTRA COURSE
Unit 24. Simple Trend Removal

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Introduction

Measured accelerometer data may offsets or trends. These effects are usually spurious, although an exception is considered as a homework problem.

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.

One method is to perform a highpass filter operation, using the method discussed in Unit 18.

Another is to perform a polynomial curve. The polynomial curve is then subtracted from the data. The purpose of this Unit is to present polynomial trend removal.

Theory

The polynomial coefficients are found via a least-squares method.

Typically, the polynomial order is less than or equal to 2. The coefficient calculation is prone to numerical instability for higher order polynomials.

Note that a second-order polynomial is a parabola. A first-order polynomial is a line with a slope. A zero-order polynomial is simply a constant.

The details of the least square calculation are found in standard numerical methods textbooks, such as Reference 1.

Example

The following example shows how trend removal can be used to refine a shock pulse.

The acceleration time history in Figure 1 is actual measured data from a rocket vehicle pyrotechnic shock test. The data quality appears to be good at first inspection.

Now assume the velocity time history is desired. Note that some models of shock damage are based on velocity rather than acceleration.

The velocity time history is shown in Figure 2. The velocity signal diverges severely from the zero baseline, indicating that the acceleration time history has a problem.

Now perform a simple first-order curve fit on the acceleration time history, by seeking a polynomial of the form

$$y(t) = a_0 + a_1 t \tag{1}$$

The curve-fit is performed using program trend1.exe. The program returns the following equation for the acceleration time history.

$$y(t) = 2.7635 + 3.1820 \ t \tag{2}$$

Equation (2) is shown in Figure 3.

Program trend1.exe also performs the trend removal. The resulting acceleration time history is shown in Figure 4.

The refined acceleration time history is then integrated. The resulting velocity time history is shown in Figure 5. It has a stable oscillation about the zero baseline.

The trend removal is thus successful.

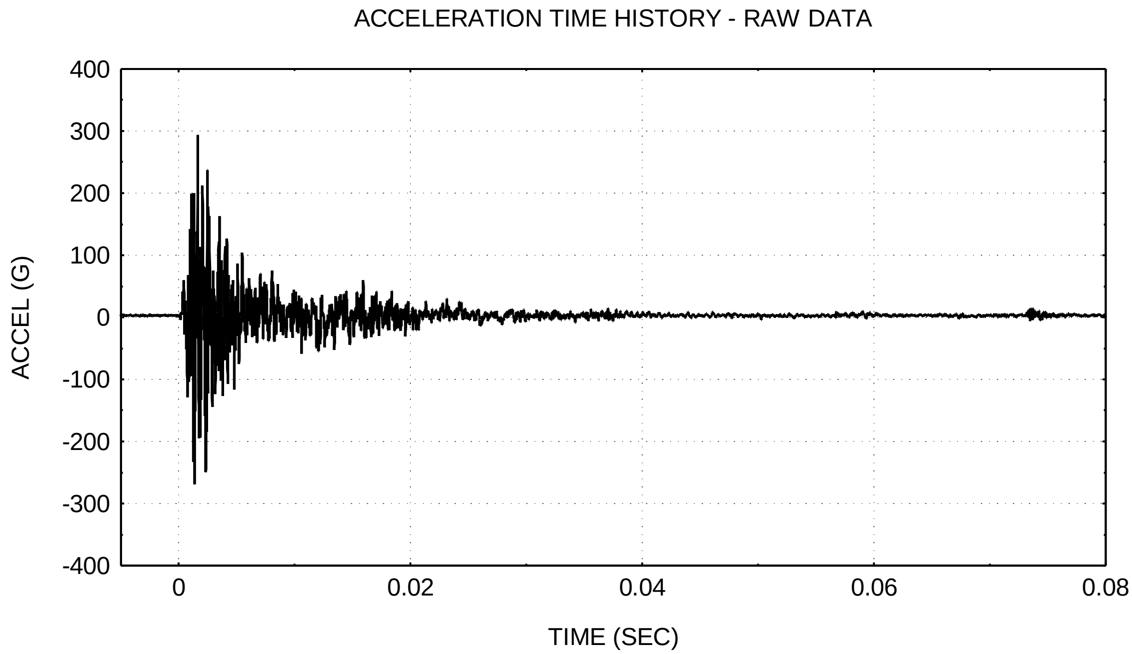

Figure 1.

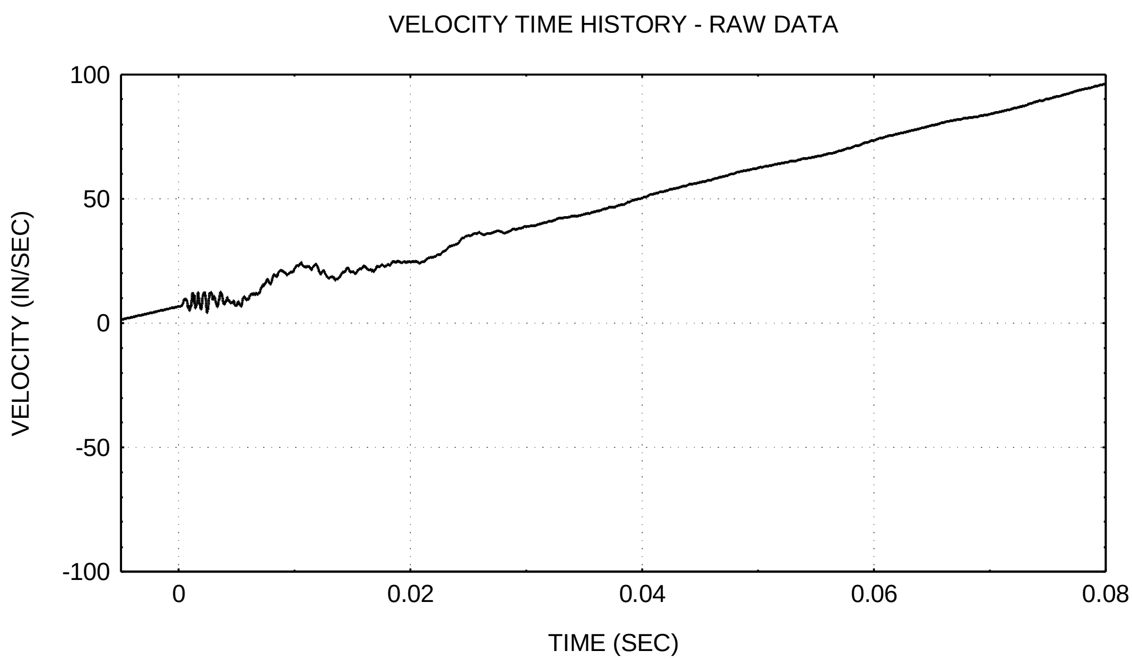

Figure 2.

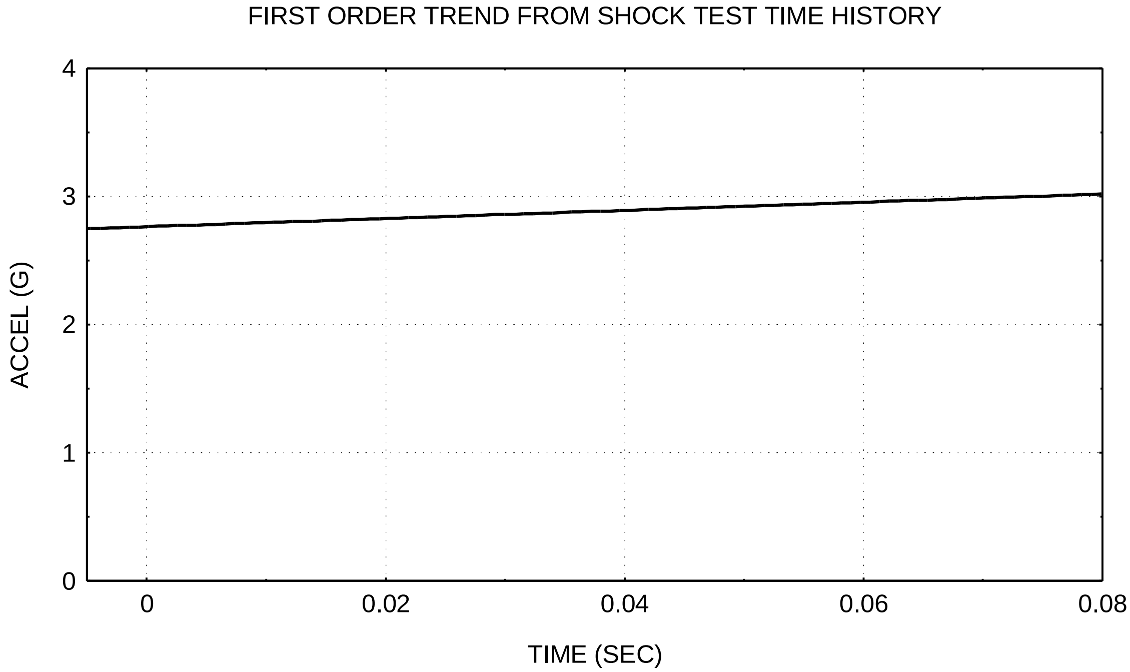
FIRST ORDER TREND FROM SHOCK TEST TIME HISTORY
4
3
2
1
0
ACCEL (G)
0
0.02
0.04
0.06
0.08
TIME (SEC)

Figure 3.

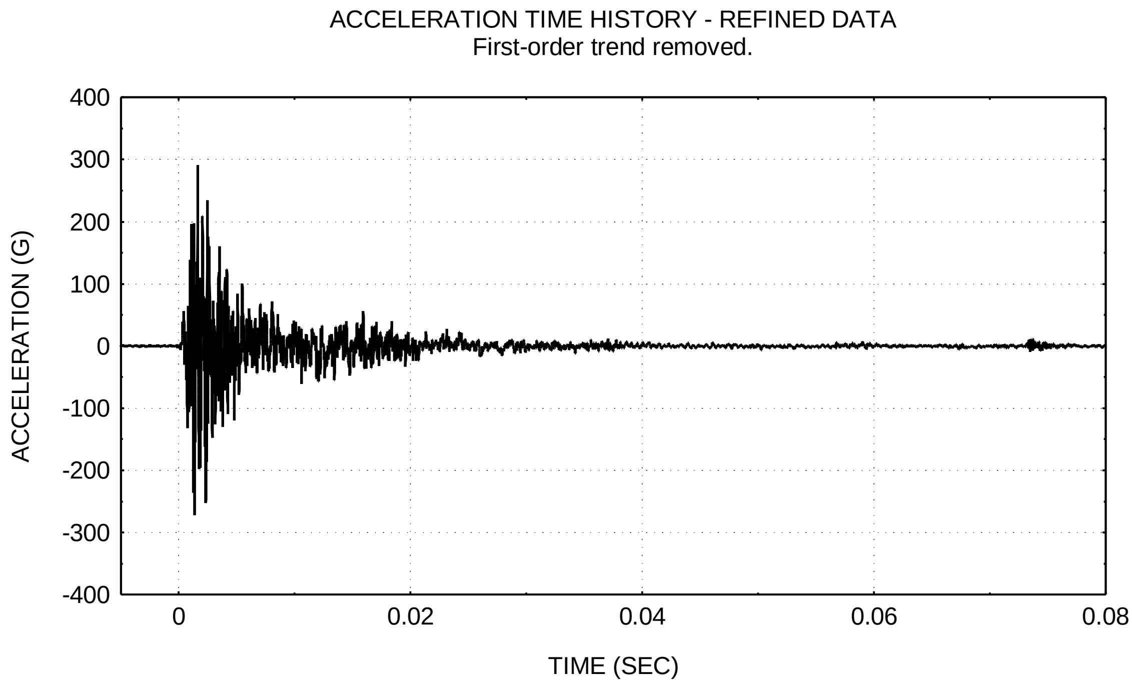

Figure 4.

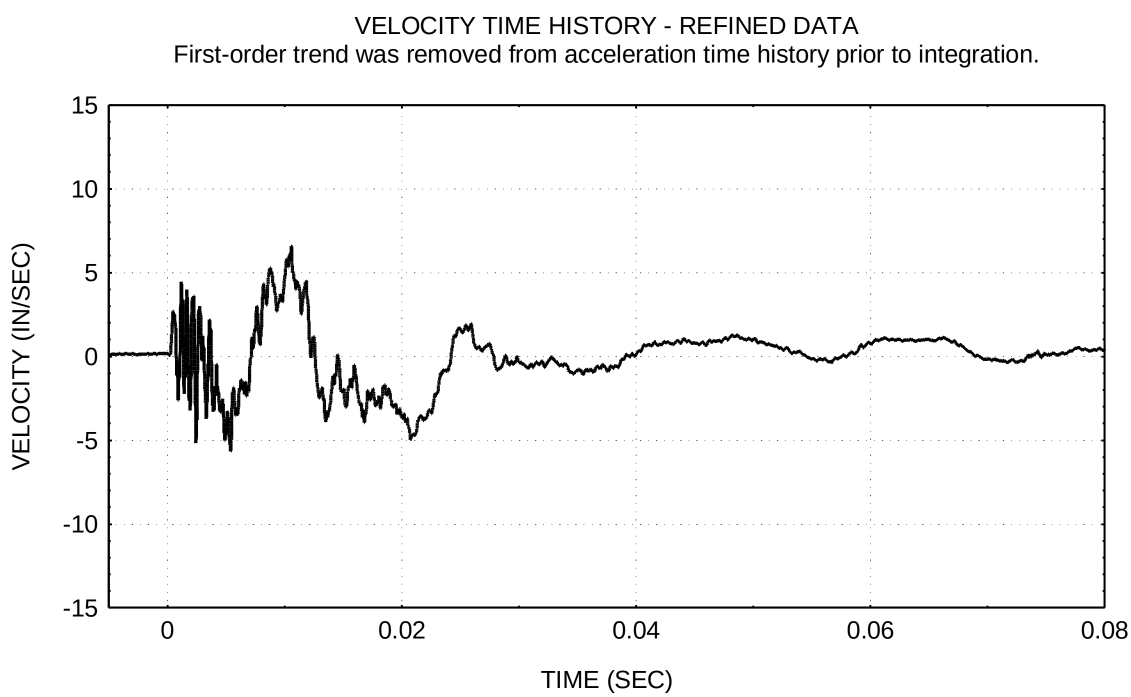

Figure 5.

Reference

1. R. Hornbeck, Numerical Methods, Prentice-Hall, New Jersey, 1975.

Homework

File fairing.txt is an acceleration time history measured during the fairing separation event of a rocket vehicle. The fairing separation occurred during powered flight. The dimensions are: time(sec) and accel (G). The accelerometer was a variable capacitance model which had the ability to measure frequencies down to zero. Thus the accelerometer could measure rigid-body acceleration as well as elastic-body acceleration. Note that Rigid-body acceleration is typically characterized by polynomial trends. On the other hand, elastic-body acceleration is characterized by oscillation. The fairing.txt file has both effects.

Use program trend1.exe to remove the rigid-body trend from the acceleration time history. Plot the acceleration time history both before and after the trend removal. Also, integrate the acceleration time history to obtain velocity, using program integ.exe. Convert the amplitude to either m/sec or in/sec. Plot the resulting velocity time history.