

SHOCK AND VIBRATION RESPONSE SPECTRA COURSE

Unit 11. Vibration Response Spectrum - General Method

By Tom Irvine

Introduction

The previous unit presented the Miles equation for determining the response of a single-degree-of-freedom system subjected to base excitation, where the excitation is in the form of a power spectral density.

Again, the Miles equation assumes that the base input is white noise, with a frequency content from 0 to infinity Hertz.

Measured power spectral density functions, however, often contain distinct spectral peaks superimposed on broadband random noise. The Miles equation can produce erroneous results for these functions.

This obstacle is overcome by the "general method." The general method allows the base input power spectral density to vary with frequency. It then calculates the response at each frequency. The overall response is then calculated from the responses at the individual frequencies.

The general method thus gives a more accurate response value than the Miles equation.

A drawback of the general method is that it is too cumbersome for hand calculation. Fortunately, it can be performed via a software calculation.

Text

The main text for this unit is given in the following tutorial papers:

"An Introduction to the Vibration Response Spectrum."

"Enveloping Data via the Vibration Response Spectrum."

Please read these papers before performing the homework problems.

Homework

No hand calculations are needed for these problems. Use the software programs as noted.

1. An actual power spectral density measured on a suborbital rocket vehicle during flight is given in file mflight.psd. This level is regarded as the base input level to certain avionics components. Plot this function.
2. Calculate the overall GRMS value using program psdint.exe.

3.

- a) Calculate the vibration response spectrum of mflight.psd using program vrs.exe. Assume $Q = 10$. The output file is: vrs.grp. The dimensions of vrs.grp are: response acceleration (GRMS) versus natural frequency (Hz).
- b) Rename vrs.grp as flight.grp.
- c) Plot flight.grp

4.

Assume that a simplified power spectral density envelope of mflight.psd is required. The enveloping is to be performed in terms of vibration response spectra.

The power spectral envelope is permitted to clip the peaks of mflight.psd. Clipping is desired to minimize the overall level of the envelope. Assume that the envelope will be defined by four breakpoints. Furthermore, the middle segment will be flat. The breakpoints are partially defined as shown in Table 1.

| Table 1. Power Spectral Density Envelope | |
|--|-------------------------------|
| Frequency (Hz) | Accel (G ² /Hz) |
| 10 | 0.0005 |
| 1600 | A |
| 1800 | A |
| 2000 | 0.008 |

The task is to perform a trial-and-error calculation to choose the value of the "A" amplitude. Again, there are two goals. The primary goal is that the vibration response spectrum of the envelope power spectral density must envelop that of the flight power spectral density. The secondary goal is to minimize the A value in Table 1.

The frequency range of interest is 10 Hz to 2000 Hz.

The task is carried out using program vrs.exe.

- a) Choose an A trial value.
- b) Run program vrs.exe using the breakpoints in Table 1 and an amplification factor of $Q=10$.
- c) Plot the resulting vrs.grp file against the flight.grp file from problem 3c.
- d) Perform steps a through c until the trial value A yields a vrs.grp function which just barely envelops the flight.grp curve.
- e) The value A in Table 1 is now chosen. Calculate the overall level of Table 1.
- f) Plot the Table 1 power spectral density against the mflight.psd level.

- g) The mflight.psd curve has a distinct peak at 1710 Hz. The Table 1 envelope curve should clip this peak by a substantial margin. What is the margin in dB? Use program dBoct.exe.
- h) The Table 1 envelope curve should have a higher overall GRMS value than the mflight.psd curve. What is the difference in dB? Use program dBoct.exe with the SRS option.