SDLD101 - Simple oscillator under excitation random

Summary:

An oscillator simple, made up of a mass connected to a support by a spring and a shock absorber, is subjected to a random excitation transmitted by the support, of standard imposed acceleration.

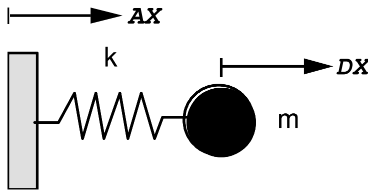
This test uses the features of the stochastic analysis and calculates the spectral concentration of power (DSP) of the movement of the mass starting from the excitation of the type also white vibration data by its DSP.

The movement is calculated according to various options: relative, absolute, differential movement.

One calculates then the statistical properties of the answer while passing in all the options of the post - random dynamic treatment.

1 Problem of reference

1.1 Geometry



The excitation is a seismic movement of standard imposed acceleration AX applied to the support in the direction DX.

One is interested in the movement of the mass m.

1.2 Material properties

Specific mass:	$m=100\,kg$
Elastic spring:	$k=10^6\,N/m$
Modal damping:	$\xi_0=0.05$

1.3 Boundary conditions and loadings

The problem is unidimensional in the direction x, and to 1 degree of freedom: the displacement of the mass m.

The excitation is a spectral concentration of power (DSP), of constant acceleration enters $0.$ and $100\,Hz$.

It is applied to the support.

2 Reference solution

2.1 Method of calculating used for the reference solution

The reference solution is analytical [bib1]. The own pulsation of the oscillator is $\sqrt{\frac{k}{m}}$,

that is to say $\omega_0=\sqrt{\frac{k}{m}}=100\,rad/s$, and $f_o=15{,}9155\,Hz$.

Moving absolute, the DSP of the answer in noted acceleration $G_{\ddot{R}\ddot{R}}(\omega)$ is connected to the DSP of the excitation $G_{\ddot{E}\ddot{E}}$ in acceleration also by:

$$G_{\ddot{R}\ddot{R}}(\omega)=\frac{\omega_0^4+4\xi_0^2\omega_0^2\omega^2}{(\omega_0^2-\omega^2)^2+4\xi_0^2\omega_0^2\omega^2}G_{\ddot{E}\ddot{E}}(\omega)$$

Moving relative, one a:

$$G_{\ddot{R}\ddot{R}}(\omega)=\left|\left(\frac{\omega^2}{\omega_0^2-\omega^2+2j\xi_0\omega_0\omega}\right)\right|^2 G_{\ddot{E}\ddot{E}}(\omega)$$

Moving differential, one a:

$$G_{\ddot{R}\ddot{R}}(\omega)=G_{\ddot{E}\ddot{E}}(\omega)$$

2.2 Results of reference

One tests the DSP of the answer for $0,5,10,15,20\,Hz$ in the three cases of movement: absolute, relative and differential.

2.3 Uncertainty on the solution

Analytical solution.

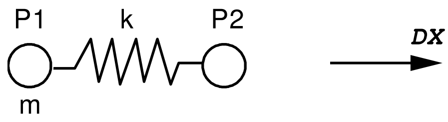
2.4 Bibliographical references

1 C. DUVAL “Dynamic response under random excitation in *Code_Aster* : theoretical principles and examples of use” - Notes HP-61/92.148

3 Modeling A

3.1 Characteristics of modeling

Discrete element in translation of the type DIS_T



Characteristics of the elements:

With the nodes $P1$ and $P2$: matrices of masses of the type M_T_D_N with $m=100\,kg$.
Enter $P1$ and $P2$: a matrix of rigidity of the type K_T_D_L with $K_x=10^6\,N/m$

Boundary conditions:

All the degrees of freedom are blocked except the degree of freedom DX node $P2$.

3.2 Characteristics of the grid

Many nodes: 2

Many meshs and types: 1 SEG2, 2 POI1

3.3 Sizes tested and results

Random dynamic response

Identification	Reference
ABSOLUTE: $F=5.Hz$	1.2307
ABSOLUTE: $F=10.Hz$	2.7116
ABSOLUTE: $F=15.Hz$	47.2154
ABSOLUTE: $F=20.Hz$	2.8924
ABSOLUTE: $F=25.Hz$	0.47047
RELATIVE: $F=5.Hz$	0.01197
RELATIVE: $F=10.Hz$	0.04209
RELATIVE: $F=15.Hz$	36.9225
RELATIVE: $F=20.Hz$	7.1006
RELATIVE: $F=25.Hz$	2.7953
DIFFERENTIAL: $F=5.Hz$	1.0
DIFFERENTIAL: $F=10.Hz$	1.0
DIFFERENTIAL: $F=15.Hz$	1.0
DIFFERENTIAL: $F=20.Hz$	1.0
DIFFERENTIAL: $F=25.Hz$	1.0

Postprocessing on the answer in absolute displacement: spectral moments and statistical parameters

Identification	*Reference*	% Tolerance
Spectral moment n°0	505.70832	0.1%
Spectral moment n°1	$49047.8\ 10^{4}$	0.1%
Spectral moment n°2	$5.025066\ 10^{6}$	0.1%
Spectral moment n°3	$5.52943\ 10^{8}$	0.1%
Spectral moment n°4	$7.2059956\ 10^{10}$	0.1%
Standard deviation	22.49	0.1%
Factor of irregularity	0.8324	0.1%
Frequency connects (Hz)	15.86	0.1%
Median number of passages by zero a second	31.73	0.1%
Spectral moment n°6	$4.186992\ 10^{15}$	0.1%
Spectral moment n°7	$1.7826555\ 10^{18}$	0.1%
Spectral moment n°10	$2.468734\ 10^{26}$	0.1%

4 Summary of the results

It is not astonishing that the results expected for the random dynamic response are got with a precision of 0% . Indeed the DSP of the answers do not result from an iterative process of resolution, but from an analytical expression bringing into play the modal transfer transfer functions. This analytical expression coincides with the reference solution for this problem.

For postprocessing, there is no reference solution.