NUMERICAL SIMULATIONS OF THE SPECIAL ISOLATION DEVICES AGAINST VIBRATORY ACTIONS

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ABSTRACT

In this paper the author use the physical and mathematical models for the antiseismic and antivibrational elastic systems and describe the dynamic behaviour of this systems, for the few types of the vital equipment - elastic systems - building ensemble configuration. Thus, it was put into the evidence the advantages of the moduling construction, which enable the best adaptation between the elastic sustain and insulate system configuration, and the real available conditions. The structure of the elastic system was imagined thus that, together with the rubber incorporated elements, it enable to obtain the higher values for the static and dynamic deformations and the small values for the eigen frequencies of the system. In this way, it was obtained the values for the isolation degree over the 90 ... 95%. The presented elastic insulation systems was developed by the Research Institute for Construction Equipment and Technologies - ICECON SA.

1. Introduction

During the researches, the author was proposed and developed the few types for elastic insulated systems, but the basic configuration it was consider the polygonal shape with six elastic rubber elements (Fig. 1).

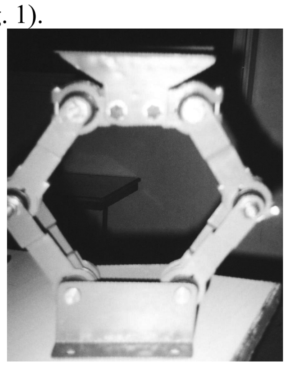

Figure 1. Antiseismic isolation device with six elastic elements

This basic device can be use singular, for antiseismic and antivibrational isolation of the light weight machines, and it can be use to build up the complex isolation systems for the big machines insulation. One of this kind of antiseismic isolators, composed by four polygonal devices with six rubber elements per system, are presented in Fig. 2.

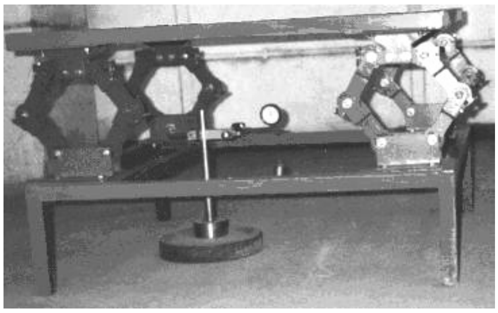

Figure 2. Antiseimic isolation system with four poligonal devices

For the basic system with six elastic nodes, the simplified physical model for dynamic behaviour numerical simulation is presented in Fig. 3.

For the complex system behaviour analysis was made using a 2D physical model (see Fig. 4), because this device working into the longitudinal plane that contain the disturbing forces. Thus, the model contain only two pairs from all four devices, that composed the entire elastic system.

All the sides of these models have the same geometric and mass properties that the real rigid elements that composed the real systems, although the shapes of the model sides was simplified comparative with the real system.

Also, on the model nodes, it was used the rotational elastic elements (rotational spring with or without rotational damper) with the same rigidity coeficient that the cassettes (torsion element) from the nodes of the real systems.

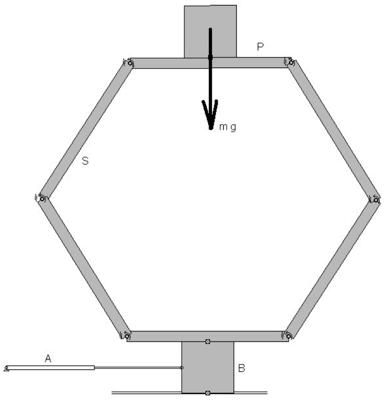

Figure 3. Basic device model

For kinematic and dynamic behaviour analysis of this elastic insulated systems with polygonal shape it was used the Working Model© software package.

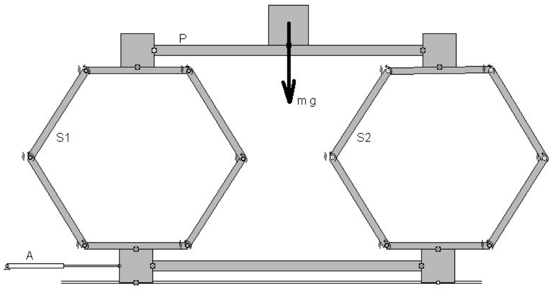

Figure 4. 2D model for complex isolation system

The influence of the seismic wave was simulated through the actuators with the next moving laws:

- for the horizontal direction movement:

$$F_x = F_{ox} \cos(2\pi \ f\, t) \qquad (1a)$$

- for the vertical direction movement:

$$F_y = F_{oy} \cos(2\pi \ f\, t) \qquad (1b)$$

where the F_{ox} respectively F_{oy} are the magnitudes of the movement and which have the constant values (time independent values) for vibrational type of distorsions (Fig. 5a), and which have the time dependent values for the seismic wave type of distorsions (Fig. 5b).

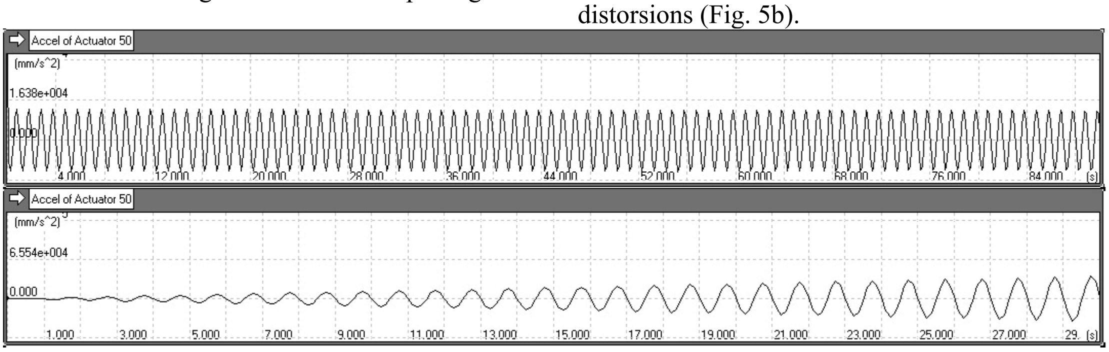

Figure 5. The evolution of seismic distorsion wave (acceleration)

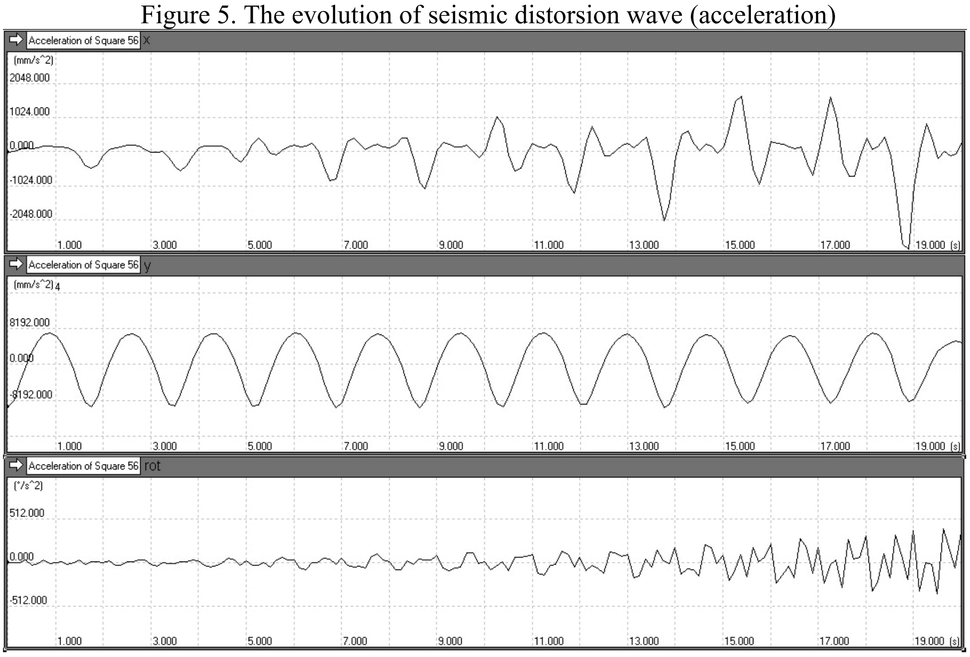

Figure 6. The evolution of basic device acceleration

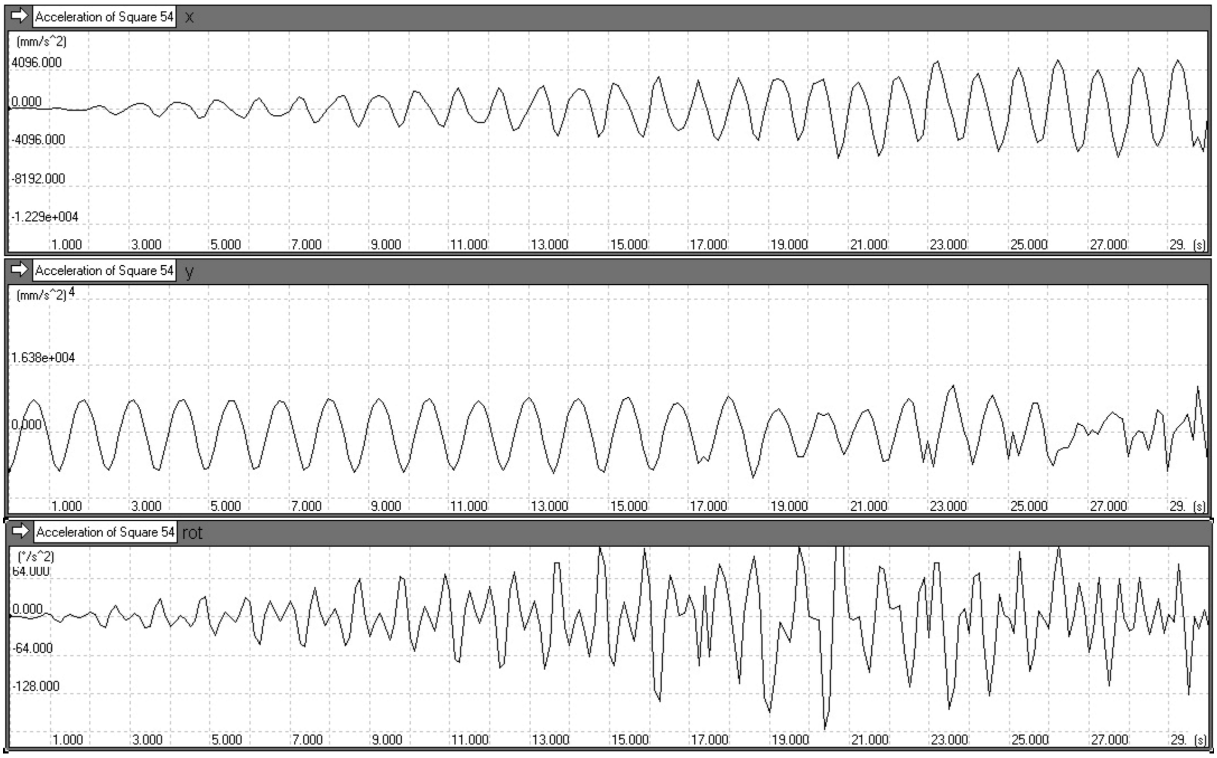

Figure 7. The evolution of system acceleration (variable distorsion amplitude)

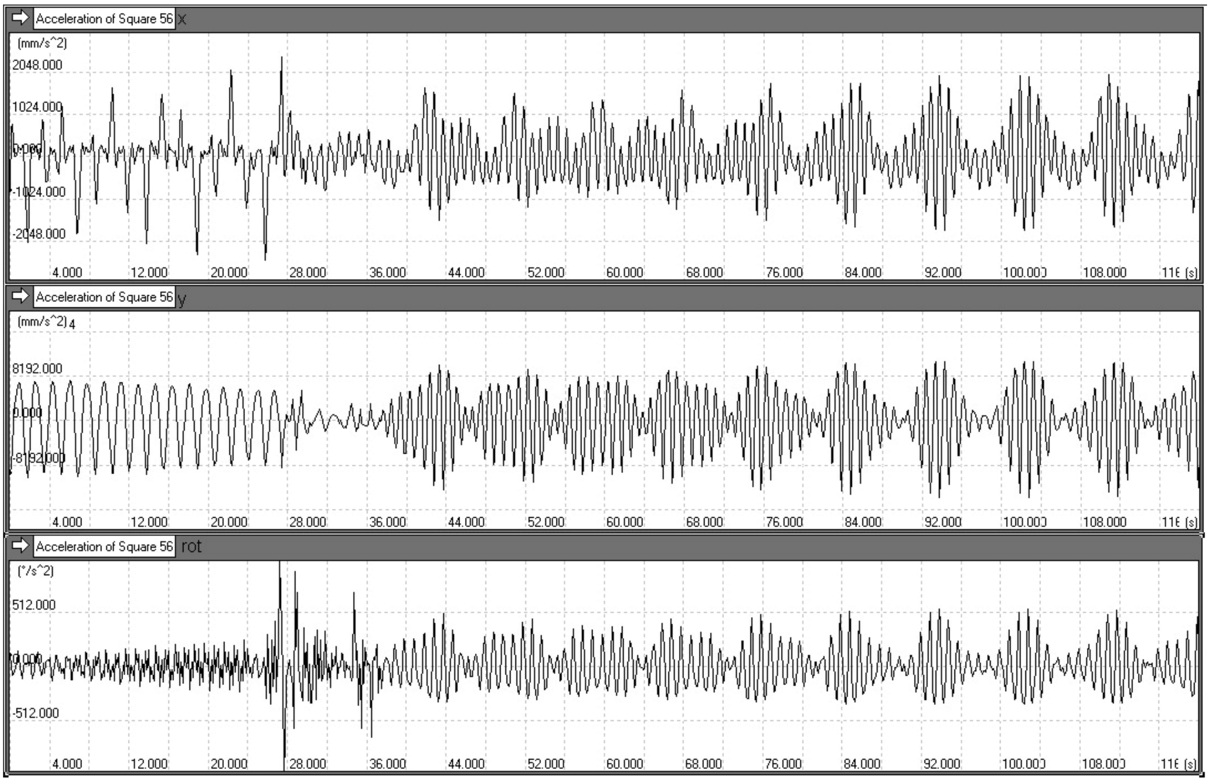

Figure 8. The evolution of system acceleration (constant distorsion amplitude)

2. Simulation results and analysis

For the models presented in Fig. 3 (singular device) and Fig. 4 (system with four elastic elements), where the seismic wave it was considered as an actuator action only on horizontal direction, the acceleration diagrams are presented in Fig. 6 and, respectively, in Fig. 7. In both situations, the numerical simulations was made in the case of time dependent magnitudes of distorsion (Fig. 5b).

The previous three diagrams sets have the next purport: the first diagram in the set is the evolution of the horizontal acceleration of the insulated mass; the second diagram is the evolution of the vertical acceleration and the last diagram of the set is the rotational acceleration also of the insulated mass.

The total time length for the first simulation (Fig. 6) was 20 sec. and for the second (Fig. 7) was 30 sec. For both numerical simulation the time length was about 120 sec, but the models became unstable over the 50 ... 60 sec from the beginning.

For the device presented in Fig. 3 (basic device) it was also considered the case of constant amplitude of the actuator movement. The results it can be seeing in the next set of diagrams (Fig. 8). In this case, the movement of the system (movement of the insulated mass) became stable after about 30...40 sec from the motion beginning.

To analyse the more realistic behaviour of the model, for this kind of elastic antisesimic isolator, it must be consider the two types of distorsions: on the horizontal and on the vertical direction. This case was presented in the Fig. 10 - for variable distorsion amplitude, and in Fig.11 - for constant distorsion amplitude.

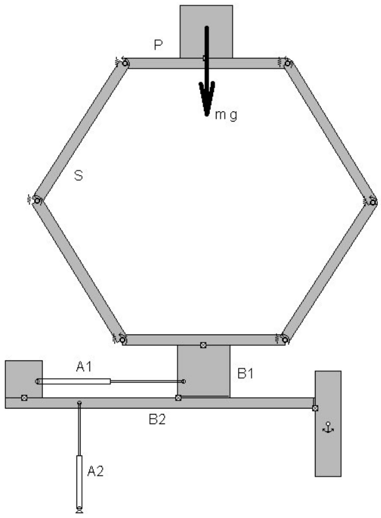

Figure 9. Basic device model with two direction distorsion

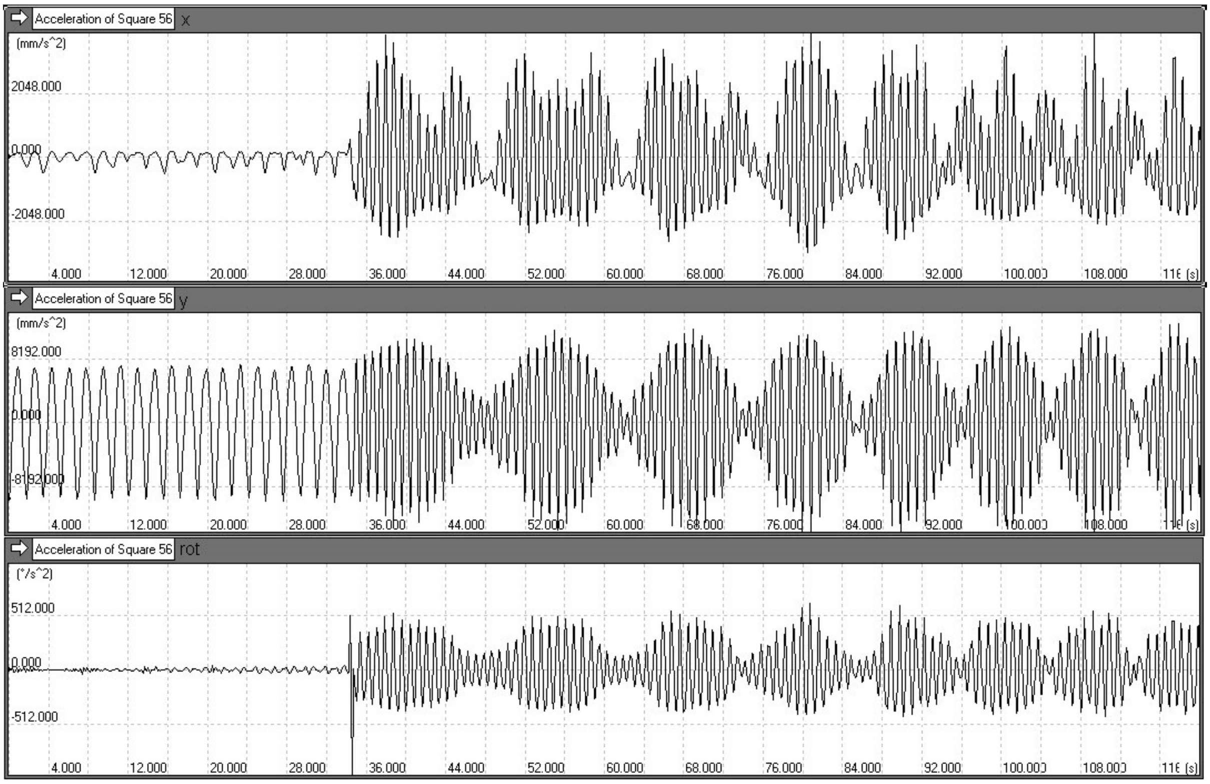

Figure 10. The evolution of system acceleration (variable distorsion amplitude)

The model used for this simulation are also presented in Fig. 9. For simulates the seismical actions it was used two actuators with independent laws of movement, but with the same values for frequency and with the same phase. The ratio beetween the horizontal and the vertical magnitudes awas 5:1.

4. Concluding Remarks

For all the distorsions the frequency was 1 Hz. The value of the insulated mass was 4,00 kg and the mass for the device structure was (6 x 0,2) kg. The weight of the other part of the model was neglected. The system was started from another certain state than the stable. This fact produced two consequences: the first can be observed on the previous diagrams - the existence of the initial transitory state; this was observed in the numerical simulation of the system movement - the system was self-corrected and, after the transitory state, acquire the stable state of the movement.

In case of using of the variable amplitude of the distorsion, the system became unstable because the model was not able to limit the increasing of the amplitude value. For the very realistic modelling of the elastic antiseismic isolation systems, it is necessary to consider both the increasing and the decreasing process of the seismic wave amplitude, and the time variation of the frequency of this wave, to obtain an accurate shape of the disturbing forces.

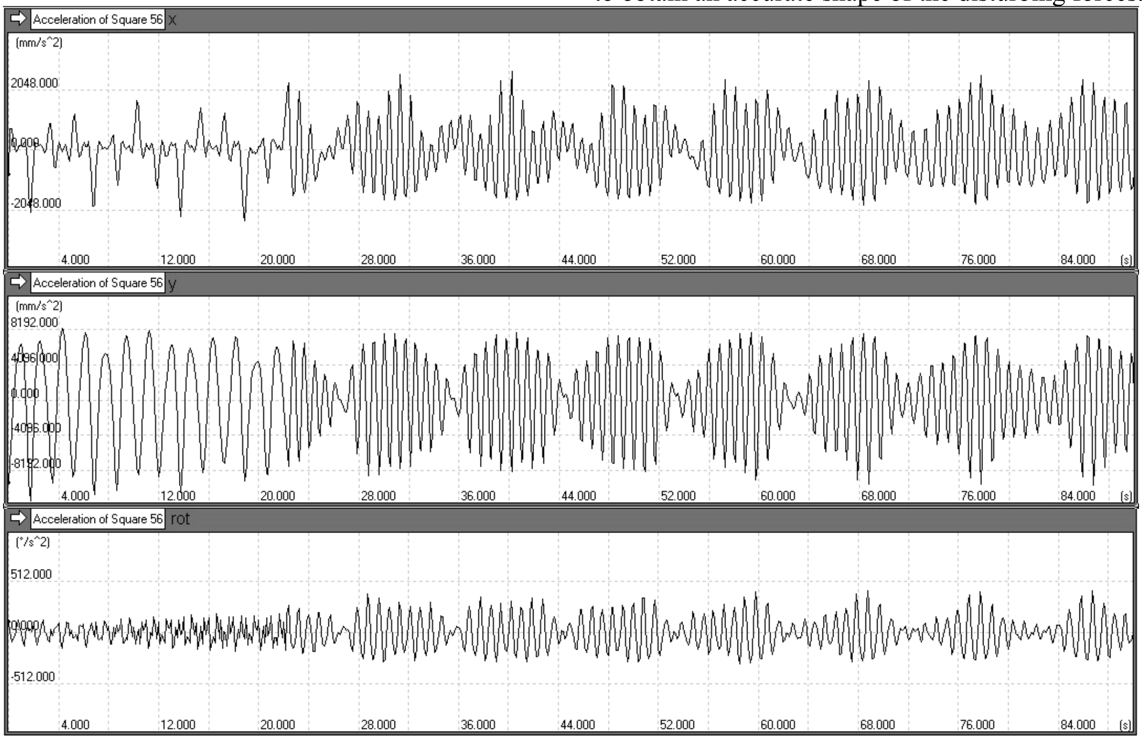

Figure 11. The evolution of system acceleration (constant distorsion amplitude)

In Fig. 12 it is depicted the acceleration of the basic system, with simple charge, on free movement. Like the previous diagrams, these graphs presents all three degree of freedom evolutions. This set of diagrams was presented only for comparison facilitate, between the unloaded and the loaded cases of analysis.

Acknowledgements

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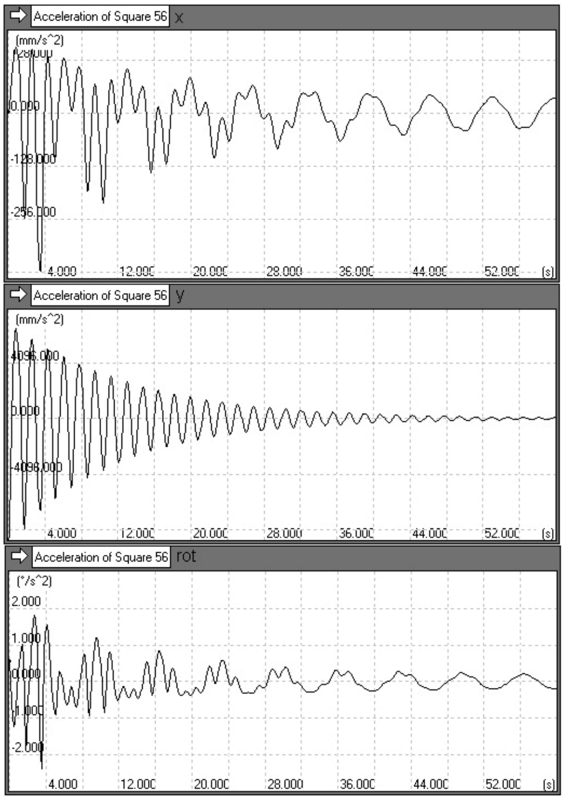

Figure 12. The free movement of the system

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