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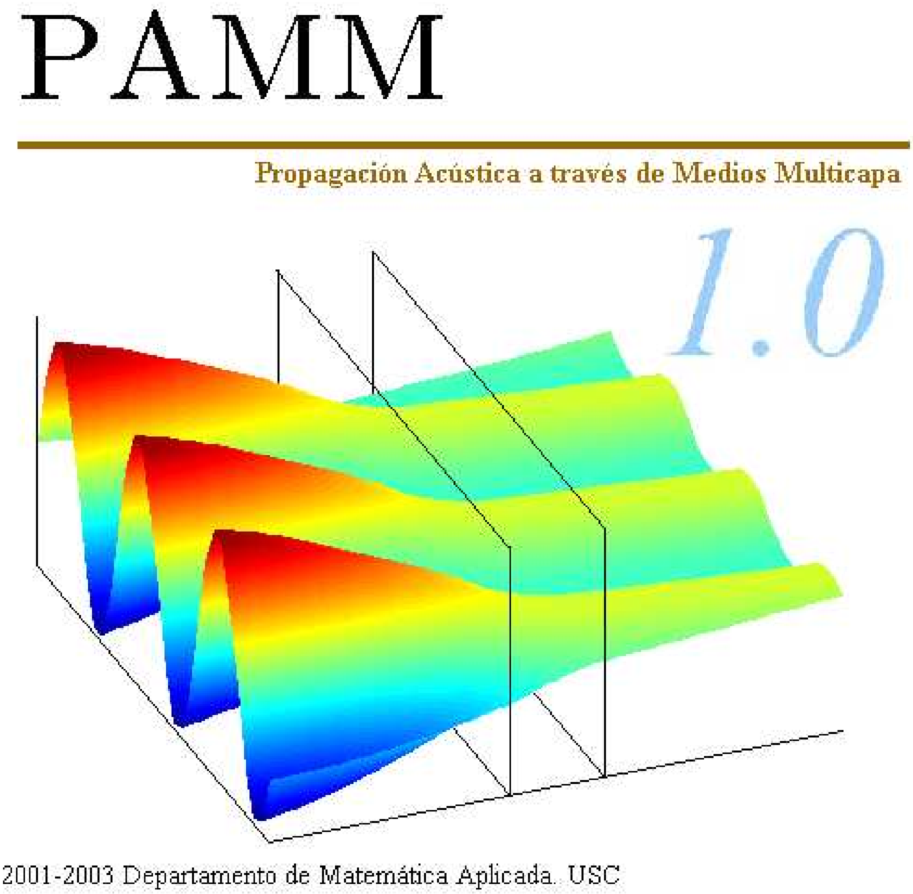
PAMM USER MANUAL



1. Introduction

Software PAMM (Propagation of Acoustic waves in Multilayered Media) developed in the Applied Mathematics department of the University of Santiago de Compostela, allows us to predict the pressure field in stratified media formed by materials of different acoustic characteristics. It is assumed that the pressure field is given by the sum of plane waves with oblique incidence in the multilayered media. So for each set of data, a one-dimensional problem is solved exactly without any discretization procedure.

With this software, the layered media can be made with multiple layers modelled as viscid compressible fluid, visco-elastic solid, rigid or elastic plates (with or without composite structure), porous media (rigid or elastic, with open or closed pores,...), wall impedances surfaces, porous veils, and so on.

The physical data set of each one of the materials, which form the multilayered media, are introduced in the code by using a intuitive graphic interface. The next step is running the exact solver for plane wave analysis that PAMM provides. Finally, it allows us to hand a wide variety of levels and coefficients for analyzing the acoustic behavior associated to the multilayered media: the sound pressure level, the transmission loss, the reflection coefficient, the absorption coefficient, the input impedance, and the output impedance.

Moreover, software PAMM writes an output table with the complex values of each one of the levels and coefficients detailed above, and represents two-dimensional contour plots with respect to any two physical magnitudes in the input data set that the PAMM user has chosen. Additionally, the solution of the acoustic propagation problem in the multilayered media can be visualize by using an animation in the time-domain.

Finally, we must remark that the code of software PAMM has been developed in MATLAB.

2. Software description

The multilayered media can be composed by different materials: acoustic fluids, visco-elastic solids, rigid or elastic plates, rigid porous media or poroelastic materials. We also have a wide variety of dissipative interfaces: coupling interfaces, wall impedances, porous veils or rigid walls.

The software PAMM, developed integrally in MATLAB has a friendly graphic user interface that allow us to introduce the physical data of each layer of the stratified media. The code can be divided in different steps that are summarizing in the flux diagram (see Figure 1).

Now, we are going to describe the different steps that we have to do for introducing the physical data of the acoustic problem of propagation and which are output graphical results that software PAMM provides.

- **Step #1.**
  The initial introduction of the physical data can be done by creating a new data file (`File-New`) or opening a data file that has already been written in other session. (`File-Open...`).

- **Step #2.**
  In this step we have chosen a file that has been written in a previous session. In

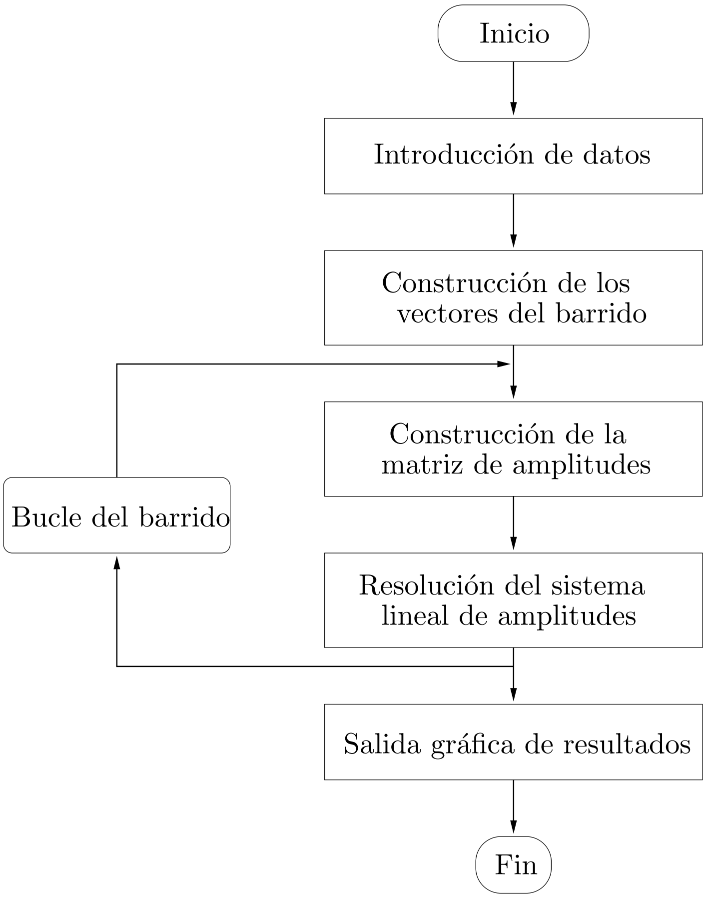


Figura 1: Flux diagraman of software PAMM.

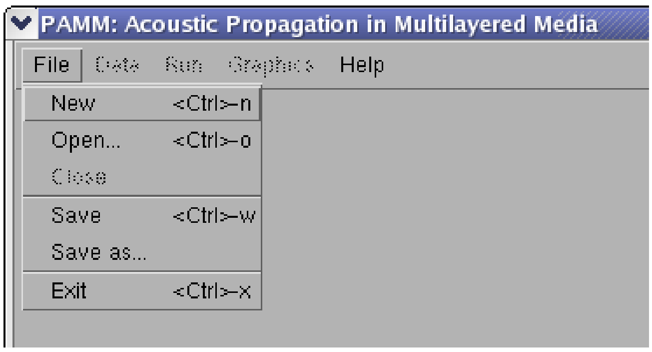


Figura 2: File menu.

menu `Data`, we see the different sub-menu that we have to fill with the physical information of each one of the materials of the multilayer medium.

In (`Configuration...`) we introduce the number of media which compose the multilayer, the angular frequency, the angle of incidence and the amplitude of the plane wave, which is the acoustic excitation of the propagation problem. Moreover, we also can chose if the acoustic problem includes an actuator in order to simulate a active

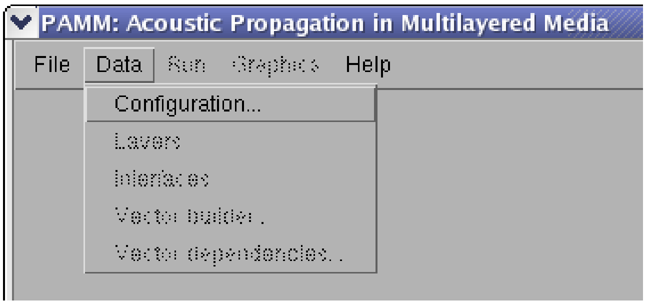


Figura 3: Data menu.

control of noise. The actuator consists in a rigid piston supported in a interface of the multilayer medium.

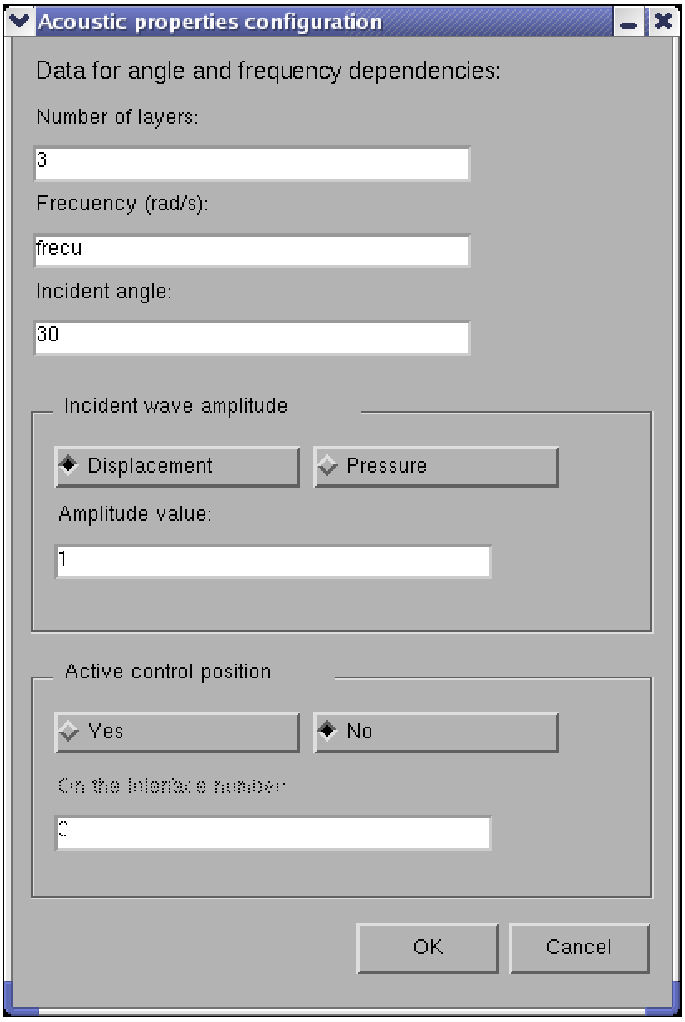


Figura 4: Configuration window.

In (`Layers...`) menu we have to chose the medium type of each one of the layers of the stratified medium. The type of media that we can chose are: acoustic fluids, visco-elastic materials, rigid plates, simple or composite elastic plates, micro-perforated plates, rigid porous materials using the Darcy's like model or the Allard-Champoux model, and poroelastic materials for open or close pores.

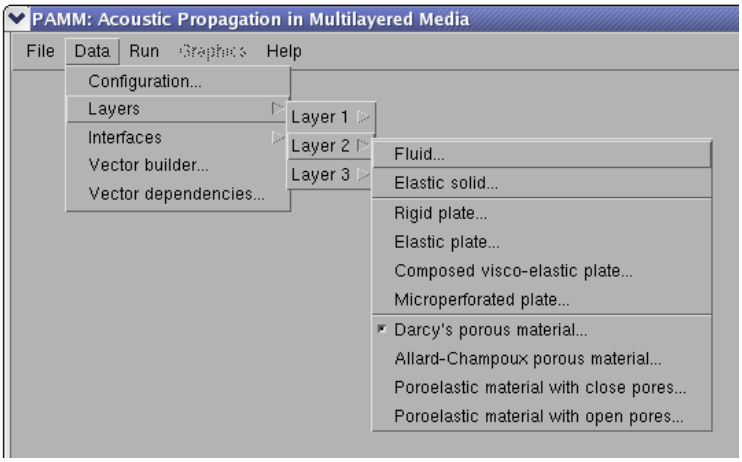


Figura 5: Layers menu.

Attending to each medium, there is a simple window to introduce the input parameters with the physical data corresponding with the model used. In the example showed below, we have chosen a rigid porous medium modelled with the Darcy's like model. Under this choice, a window, as that showed in Figure 6 arises.

In (`Interfaces...`) the PAMM user choose the coupling interfaces conditions on the interfaces between two media of the multilayer, i.e., the boundary conditions that joint the different materials. The coupling interfaces that PAMM is actually supporting are (see Figure 7):

- Contact: it preserves the continuity of the pressure and displacement fields.
- Wall-like impedance: this type of boundary condition only preserves the continuity of the pressure field.
- Porous veil: this type of boundary condition only preserves the continuity of the displacement field.
- Rigid wall: a null displacement condition is assumed on the interface.

In the present example, we have chosen all the interfaces of `Contact` type. In the case of contact interfaces or rigid walls, we do not have to introduce more data. However, if we want to work with other type of interfaces, then we need to define more input data in a new window to specify the impedance associated to the absorbing interface.

Finally, we define the vectors that we have introduced as input data in the previous windows. We are going to illustrate the use of the `vector builder` in the present example.

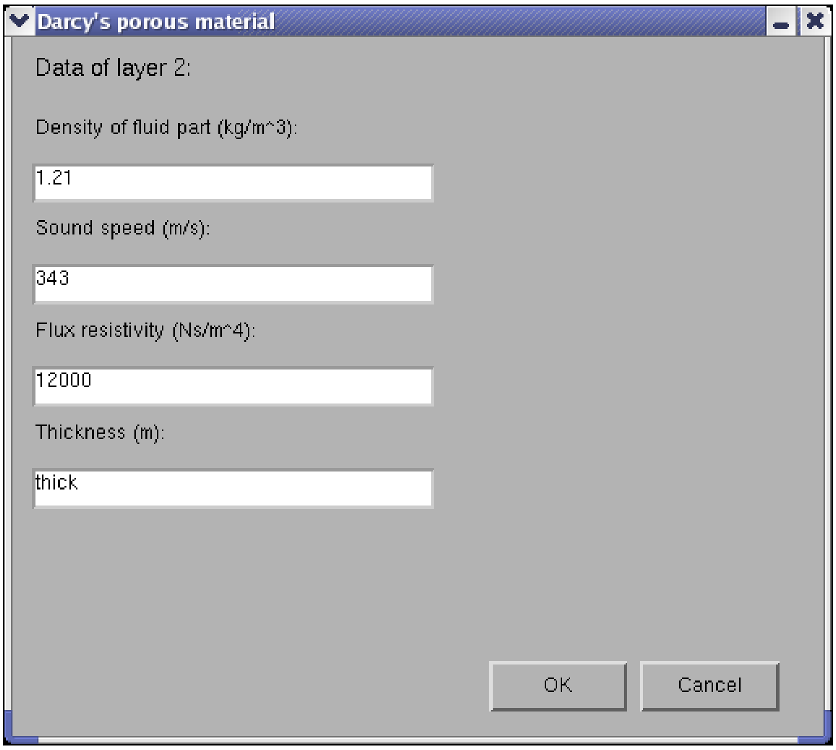


Figura 6: Darcy's like model window.

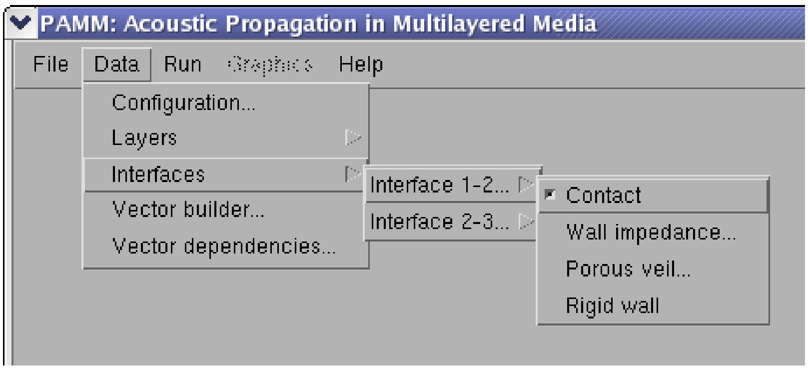


Figura 7: Interfaces menu.

For instance, we have introduced a vector named *frecu* in the frequency field of the configuration window and the vector *thick* in the field of the rigid porous medium window. To define the components of these two vectors, we use the menú `Data-Vector Builder` which is showed in Figure 8.

In this window we introduce the name of the vector, the upper and lower bound, and the distance between each one of its components. Let us remark that all the vectors defined in the `Vector Builder` have its components linearly distributed.

If in the numerical simulation we need to include linear dependencies between

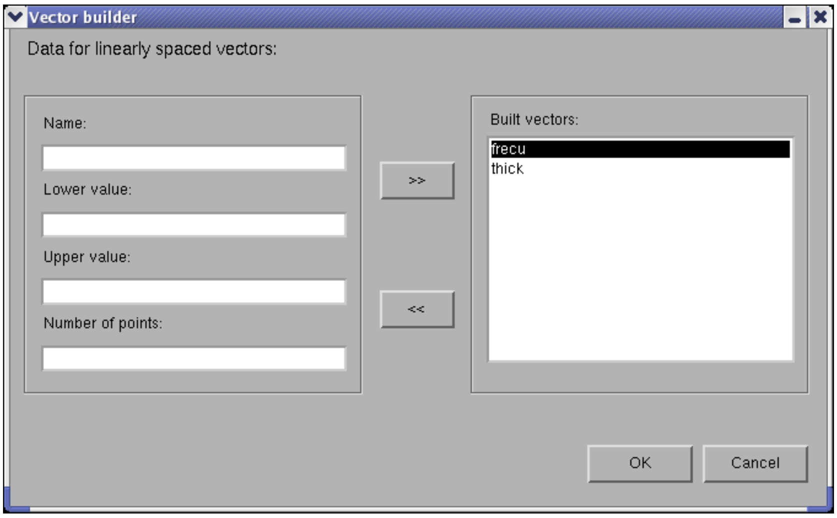


Figura 8: Vector builder window.

different variables, for instance, if we want to study the properties of the multilayer with respect to the frequency when we change the thickness and the flow resistivity at the same time, we should define this dependency in the window `Data-Vector dependencies` as it is showed in Figure 9. In the present example, since there are only two vectors, they are independent.

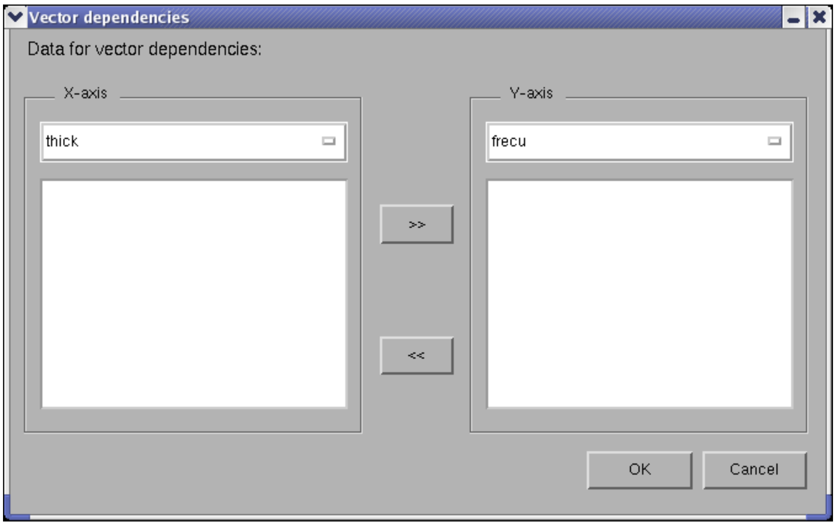


Figura 9: Vector dependencies window.

- **Step #3.**
  Now, when the input data have been introduced, we are in a position to simulate the acoustic propagation through the multilayer medium. We compute the solution of the acoustic problem using the `Run` menu. In this menu, we can choose different types of control in the multilayer: passive control and active control of noise with three types of implementation (null reflection, impedance matching or pressure release).

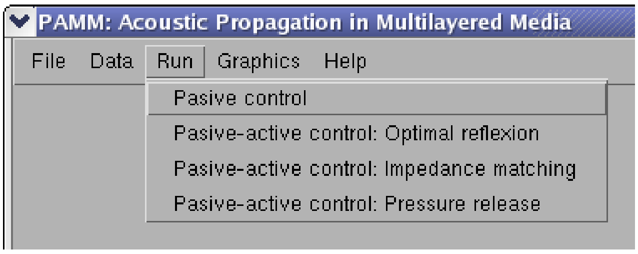


Figura 10: Run menu.

- **Step #4.**
  The plot of the numerical results is the last step of the simulation. For this last step, we use the `Graphics` menu, where we can choose the numerical results that are going to be plotted.

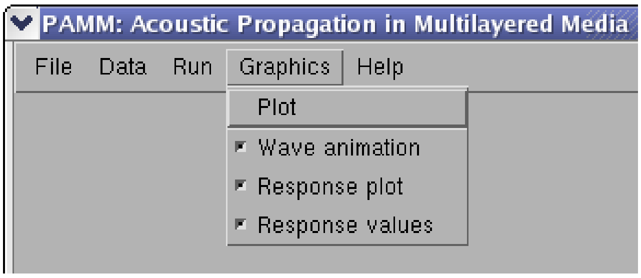


Figura 11: Graphics menu.

In the present example, we have chosen as graphic output all the possibilities that PAMM provides to the user. Indeed, if we select the action `Plot`, we obtain the window showed in Figure 12.

If we have selected the option `Graphics-Response plot`, if we press the right button of the mouse on the response plot (placed on the bottom of the output window), a context menu emerges where the user can choose which is the level or coefficient that is plotted in the response plot. The variables that PAMM is supporting are the following: the loss transmission, the sound pressure level, the reflection and absorption coefficients, and the real and imaginary parts of the input and output impedance to the multilayer.

Moreover, if we press the left button of the mouse on the response plot, we can obtain the exact value of the variable at the point of the plot where the mouse is situated. This value is highlighting in the two list of the right side of the output window. Finally, if a point has been selected in the response plot, then we can see the animation of the solution of the propagation problem by pressing the right button of the mouse on the animation plot placed in the upper part of the output window and choose the action `Animation`.

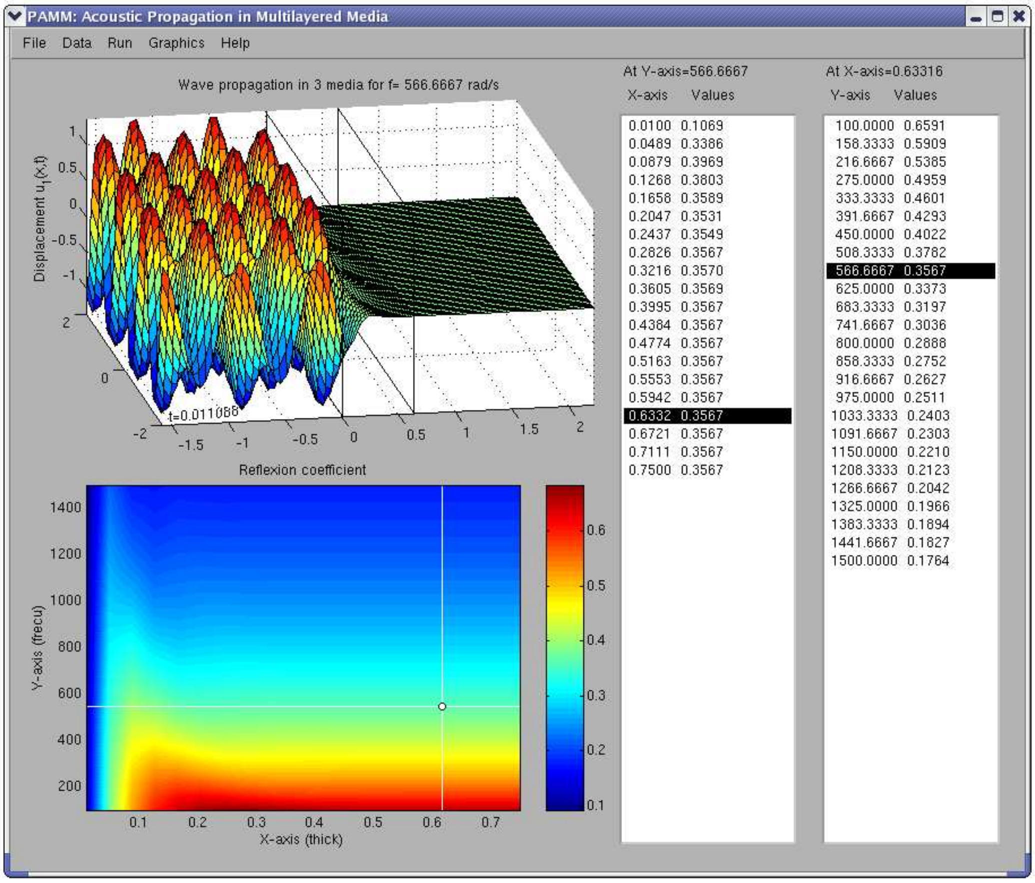


Figura 12: Graphic output window.

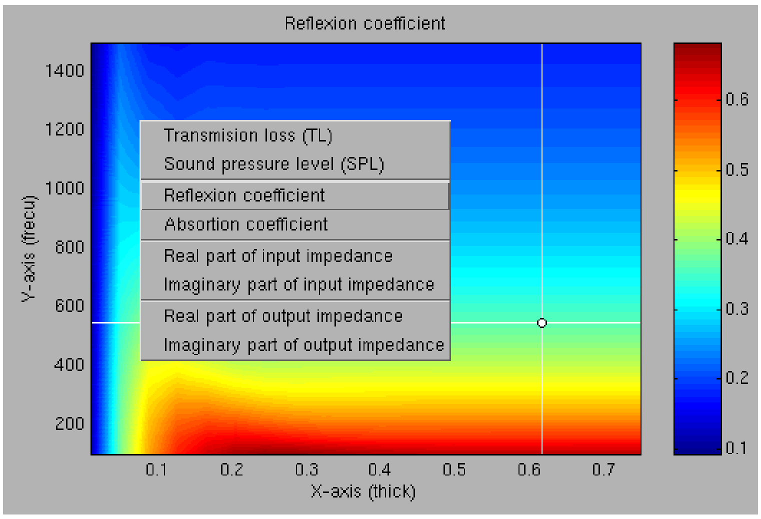


Figura 13: Context menu of the response plot.

To finish the simulation of the acoustic propagation in the multilayered medium, we have two possible choices. The first one is to save the input data, which we have introduced along the simulation, with the menu `File-Save as...`. The second choice is to close the simulation without saving the data. In this case, we use the menu `File-Close`. Finally, to quit we only need to choose `Exit` in the menu `File`.