Ares' Rigid Rectangular Element

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Ares is an acoustical design tool from MAE. One of its components is an acoustical modeler composed of elements that can be connected together to form acoustical circuits. The *rigid rectangular* element in the module is useful for estimating the microphone response on the front or back of a thin rectangular object such as a cell phone or table. This brief document describes using the element.

Rigid Rectangle Element

A *rigid rectangle* element simulates the presence of a thin rigid body in space that's being excited by a point source above the rectangle. This largely simulates a talker using a cell phone or a tablet, where the rectangle is the cell phone or tablet, and the point source is the talker. The element allows for multiple sensing points which simulate microphone ports.

The solution is only a numerical approximation and not an exact solution. Keep this in mind when interpreting the results.

The rectangle is in the xy plane at z=0. The width is in the x direction and the height in the y direction, with the center of the rectangle at x=0, y=0. The xy locations of the sensing ports are specified. They can be either to be on the surface of the rigid rectangle, either front or back surface, where the front is the side where the point source is located.
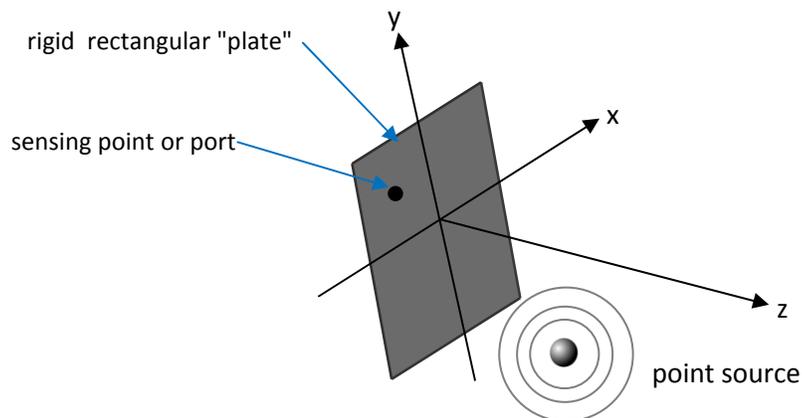
Being able to predict the microphone pressure on the front and back of a cell phone or tablet is useful in determining microphone locations.

Four sensing locations are presently supported.

width   the width of the rigid rectangle in the x axis direction
height the height of the rigid rectangle in the y axis direction
Psrc   the pressure of the point source as measured at a distance of
        1 inch or 25.4mm. This is the common mouth reference position (MRP)
        for a head and torso simulator (HATS) artificial mouth.
Xsrc   the x coordinate of the point source Psrc
Ysrc   the y coordinate of the point source Psrc
Zsrc   the z coordinate of the point source Psrc. this needs to be a positive value.
X1,Y1   the x,y location of the first sensing port on the rectangle surface
   the front or back location is set by the drop down box below these values

X2,Y2, etc.   repeat of X1,Y1 but for the other sending port locations.

Example of using a Rigid Rectangle element

Create a new Modeler module from the *New Module* menu.

Pull the *Acoustical* menu down and select *rigid rectangle* about one third way down the menu and place it in the Ares window.

Create a graph element from the Miscellaneous menu and connect it to the first node on the rigid rectangle as shown below.
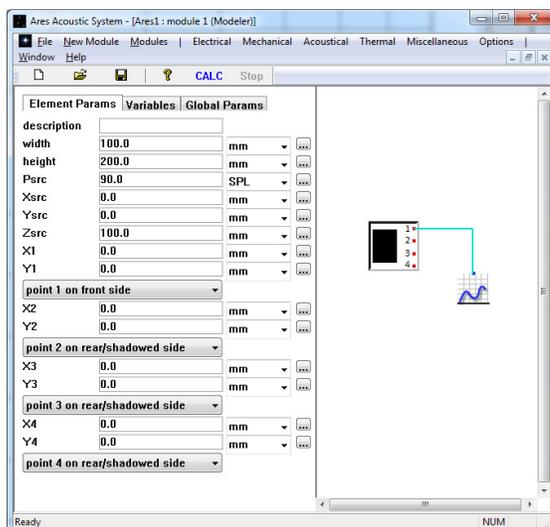
The rigid rectangle element doesn't require any additional elements to predict the sound pressure on the surface of the rectangle. Before we run the solver, let's make sure that the frequency range is from 50 to 10000 Hz. Select the *Global Params* tab and set the Fmin, Fmax and num points to those shown below.

Reselect the *Element Params* tab so we can see the element parameters again.

By default the *rigid rectangle* element has a height and width the size of a 7 inch tablet. The four sensing points are all at the origins 0,0 with the first one on the front and the rest on the back.

Let's move the last two to 1 cm from the edge. Set the Y3 and X4 parameters to the values shown below so the third point will be 1 cm from the top and the fourth point will be 1 cm from the right edge.

Now run the solve by either pressing the CALC button or pressing F5. The solve will rapidly run through the low frequencies, but take a longer and longer time as the frequency increases.

Copy all for positions to the A-D graph buffers by
- connecting the graph to rigid rectangle's node 1
- press the A button on the graph controls to copy the node data into that buffer
- select the check box to the left of the A button
- type "1" into the comment for the A buffer

Repeat this for node 2, 3 and 4 so the graph element's parameters are as shown below.

Element Params | Variables | Global Params

description

Connector node

☑

Plotting buffers

☑ A 1
☑ B 2
☑ C 3
☑ D 4
☐ E

Finally, enter "50" for the *x axis range (min max)* field to force the graph to start at 50 Hz. The graph element's graph will now appear as shown below.

Graph window for element #2

Pressure (SPL)

Frequency (Hz)

Note that the first point, which is the only one on the front of the rectangle, has the highest pressure which roughly has a 6 dB increase at higher frequencies.

Points 2,3, and 4 have their pressures drop off at higher frequencies as the rectangle is shadowing those sensing points.

At low frequencies, the curves are all approaching the same values which result from the wavelengths being so long that the rectangles size being too small to significantly effect the sound wave. Note that the 3rd point (light blue curve) is curving down as the frequency approaches 50 Hz. This is an artifact of the approximate solution used and not physically meaningful.

The iteration feature can be used to show how the pressure changes across the back of the rectangle. To do this, we'll iterate across the y axis from the center of the rectangle at y=0 mm to the top at y=100mm.

First go to the *Global Params* tab and set the iteration parameters to those shown below.

Iteration parameter range		
min iteration	0	%
max iteration	100.0	%
num	10.0	

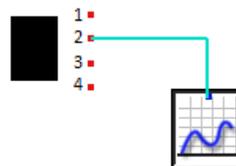Going from 0% to 100% will cause the parameter to go from zero (0%) to its current value (100%).

Now select *Element Params* tab, select the rigid rectangle element, and change the X2 and Y2 parameters to 0 100mm respectively.

| X2	0.0	mm
Y2	100	mm
point 2 on rear/shadowed side		

Now press the iterate button to the left of Y2. This will run the solve 11 times, which will take a while.

To plot the values for just the second point, connect the graph element to node 2 and uncheck buffers A-D for plotting as shown below.

Element Params Variables Global Params

description

Connector node
☑

Plotting buffers
☐ A 1
☐ B 2
☐ C 3
☐ D 4
☐ E
☐ F

The result should be the graph shown below. Little effect at low frequencies, with a lot of activity at the high frequencies.

Graph window for element #2
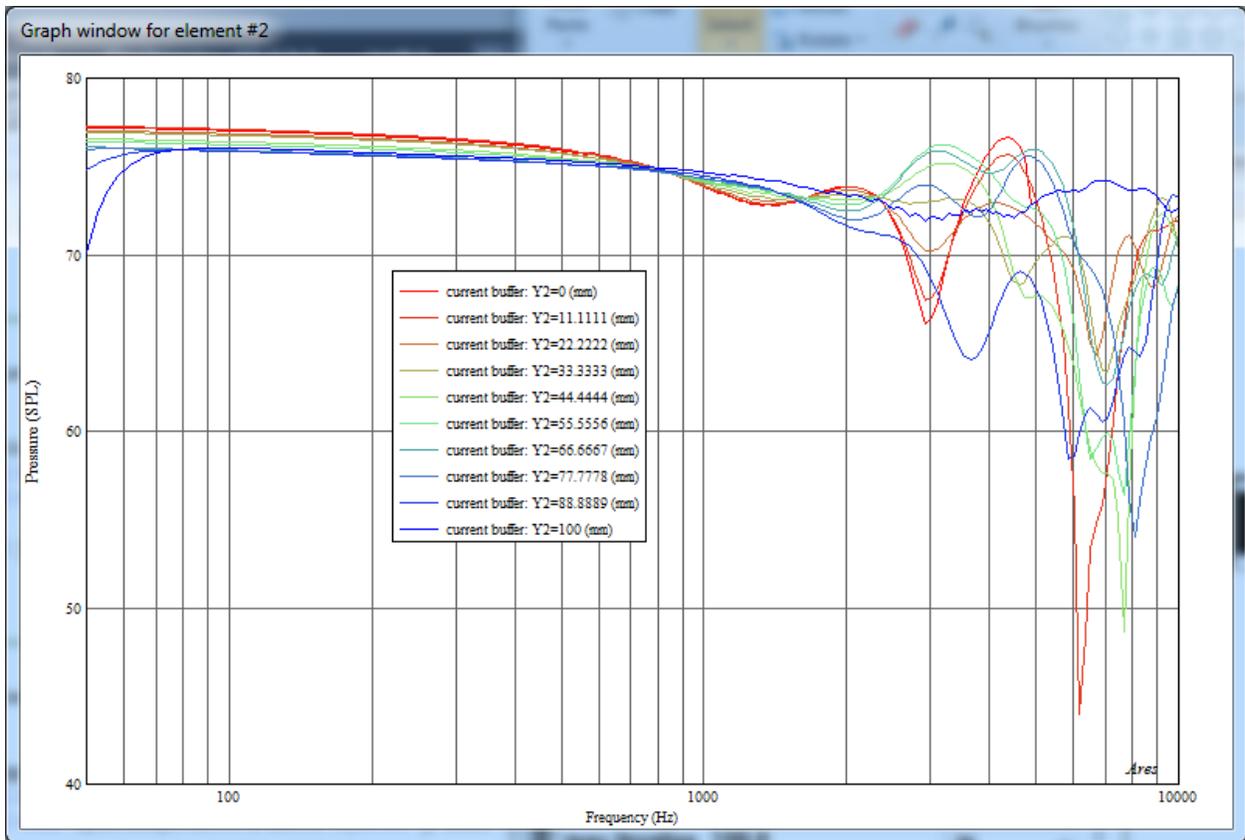
Cross sections of these iteration curves can be made by selecting the *vs iterator @* graph feature. Enter frequencies of 1000 4000 and 8000 for this parameter. Change the graph type from log x to linear, and clear the *x axis range (min max)* entry as shown below.
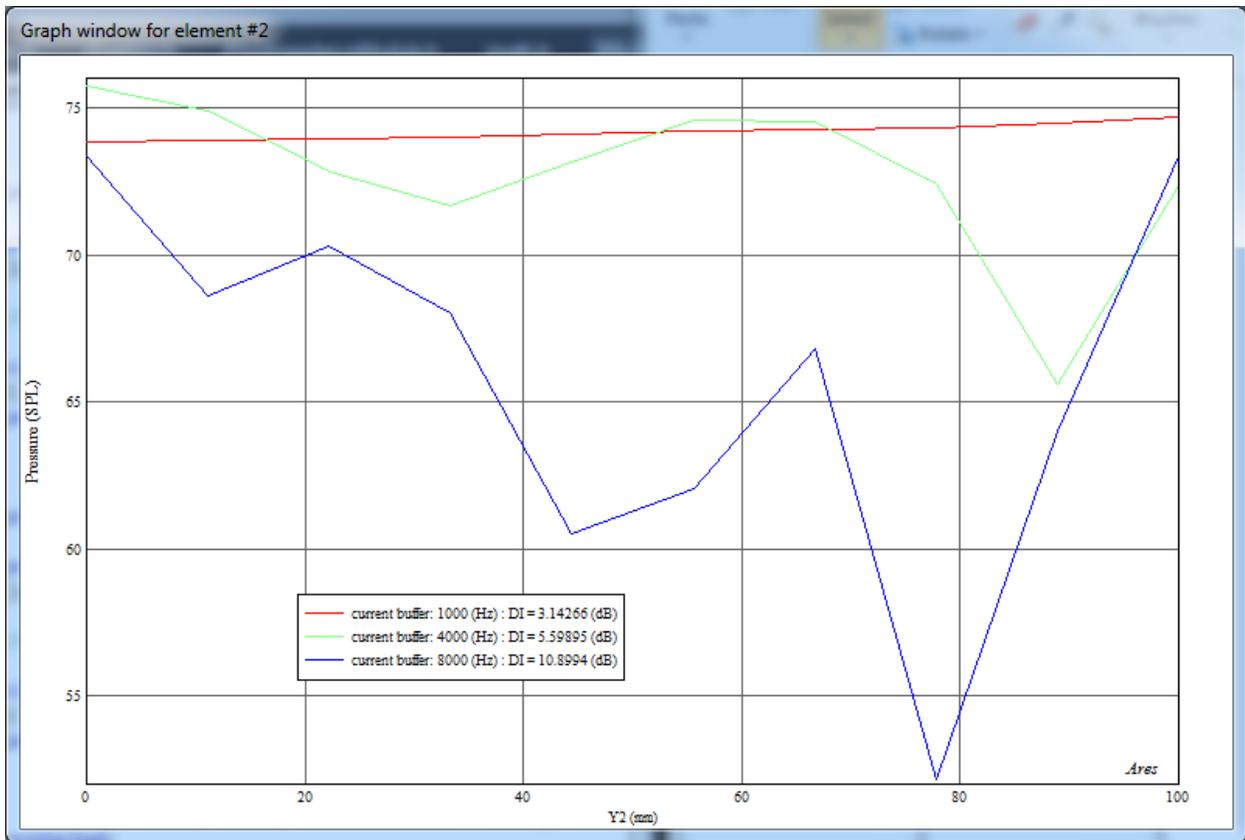

The result is the graph below which shows the pressure across the back of the rectangle, from the center at Y2=0 to the top at Y2=100mm for the three frequencies we entered.

Graph window for element #2

Legend:
- current buffer: 1000 (Hz) : DI = 3.14266 (dB)
- current buffer: 4000 (Hz) : DI = 5.59895 (dB)
- current buffer: 8000 (Hz) : DI = 10.8994 (dB)

Y-axis: Pressure (SPL)
X-axis: Y2 (mm)

There is little variation in the pressure across the back at 1 kHz, more at 4 kHz, and a great deal at 8 kHz, showing that the shadowing increases with increasing frequency.