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INTRODUCTION  
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This application calculates the theoretical acoustical impedance, SPL response, electrical impedance, diaphragm displacement, phase response and group delay versus frequency characteristics of finite and infinite horn loaded loudspeakers.

Finite horns radiating into free space, half space, quarter space or eighth space can be analysed ( $4 \times \text{Pi}$ ,  $2 \times \text{Pi}$ ,  $\text{Pi}$  or  $\text{Pi} / 2$  steradians solid angle).

Horn systems can have an oblate spheroidal waveguide, a single Le Cléac'h, tractrix, radius, spherical wave or Salmon's family hyperbolic-exponential flare segment, or up to four conical, exponential and/or parabolic flare segments connected in series, coupled to a throat chamber, loudspeaker driver and acoustically lined or vented rear chamber. Horns with multiple drivers and arrays of multiple loudspeakers can be modelled.

Horn segment parameter values can be reset to zero by entering a blank for the throat area, mouth area, axial length, flare cutoff frequency, flare parameter or throat entry half-angle.

For multiple-segment horns, the more that the value of  $\text{Cir}$  (mouth circumference in flare cutoff frequency wavelengths) exceeds 1 for any horn segment, the less accurate the calculated throat acoustical impedance and other results become.

The application assumes that the velocity of sound in air is 344 metres per second, and that the density of air is 1.205 kilograms per cubic metre.

The driver diaphragm is modelled as a rigid plane circular piston. No allowance is made for frequency-dependent directional characteristics due to driver cone angle or cone material, or for changes in moving mass, acoustical impedance or radiated power caused by diaphragm resonance modes. Also, horn flare directional characteristics are not taken into account when calculating the constant directivity SPL response. This means that the actual upper frequency rolloff for a cone type drive unit coupled to a straight-axis horn can in some cases be more than one octave higher than the predicted value.

No provision is made for horn transmission losses.

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INPUT PARAMETERS WINDOW  
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Moving the mouse pointer over an object or message on the input parameters window displays a context-sensitive explanatory note in the status bar panel at the bottom of the window.

After calculating results by pressing F5 or Calculate, press F2 to move to the next window, Shift+F2 to move to the previous window or Esc or F5 to return to the input parameters window from any result window.

To enter a length, area or volume value in Imperial inch or foot units, press F6 in edit mode when the relevant input parameter has the focus.

Radiation, Amplifier and Mouth Parameters

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Ang Solid radiation angle (steradians).  
Enter 4, 2, 1 or 0.5 for finite horn, 0 for infinite horn, or  
double-click the angle parameter.

Eg Amplifier open circuit root-mean-square voltage (volts).  
Enter 0 for driver diaphragm constant rms velocity of 10 centimetres  
per second.

Rg Amplifier output resistance (ohms).

Cir Free space normalised horn mouth circumference in flare cutoff  
frequency wavelengths.

Fta Horn mouth flare tangent angle (degrees).

Horn Parameters  
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S1 Horn segment 1 throat area (sq cm).

S2 Horn segment 1 mouth area and horn segment 2 throat area (sq cm).

L12 Horn segment 1 axial length (cm).  
To select Con, Exp or Par flare in edit mode, press C, E or P when  
the relevant horn segment length parameter has the focus or double-  
click the length label. The length value must be non-zero to  
preserve the flare setting. To select Hyp, Lec, Obl, Rad, Sph or Tra  
flare in edit mode, press H, L, O, R, S or T when the L12 length  
parameter has the focus.

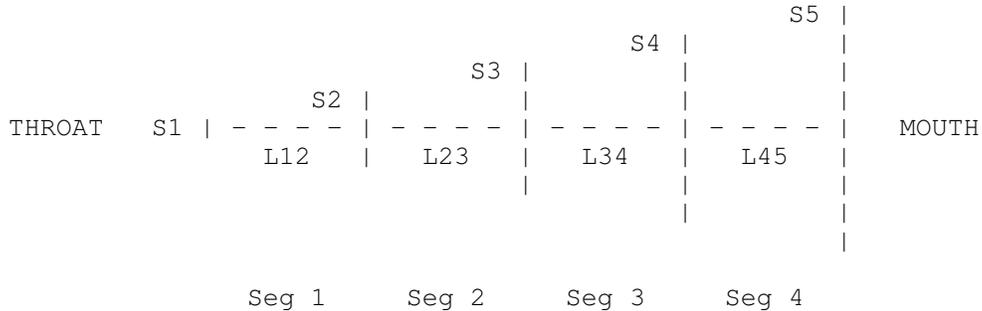
F12 Horn segment 1 flare cutoff frequency (hertz).

T Hyperbolic-exponential and Le Cléac'h horn flare parameter.  
Enter 0 for catenoidal, < 1 for cosh, 1 for exponential, > 1 for sinh  
or 99999.99 for conical.

R Radius horn flare profile radius (cm).

AT Horn throat entry half-angle (degrees).

Multiple Segment Horn  
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Driver Parameters  
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Sd Driver diaphragm piston area (sq cm).

Bl Driver magnetic flux density x voice coil conductor length (tesla.m).  
 Cms Driver diaphragm suspension mechanical compliance (m/newton).  
 Rms Driver diaphragm suspension mechanical resistance (newton.sec/m).  
 Mmd Driver diaphragm and voice coil dynamic mechanical mass (gm).  
 Mmd equals Mms (total moving mass) minus air load.  
 Le Driver voice coil inductance (millihenrys).  
 Re Driver voice coil dc resistance (ohms).  
 Nd Number and position of drivers in loudspeaker.  
 Specify driver system configuration using the Driver Arrangement tool.

Chamber Parameters  
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Vrc Rear chamber volume (litres).  
 Lrc Rear chamber average length (cm).  
 Fr Rear chamber acoustical lining airflow resistivity (rayls/cm).  
 Tal Rear chamber acoustical lining thickness (cm).  
 Ap Rear chamber port cross-sectional area (sq cm).  
 Apl Throat chamber port or throat adaptor entry cross-sectional area (sq cm).  
 Lpt Chamber port tube or throat adaptor length (cm).  
 Vtc Throat chamber volume (cc).  
 Atc Throat chamber average cross-sectional area normal to axis (sq cm).

The rear chamber volume is the effective enclosed air volume behind the driver diaphragm, including any space occupied by acoustical lining material but excluding port tube, driver magnet and chassis assemblies.

The throat chamber volume is the effective air volume between the driver diaphragm and the throat chamber port, the throat adaptor entry or the horn throat.

The locations of the throat chamber and rear chamber are as shown in the schematic diagram.

Set relevant values to zero if no throat chamber, rear chamber, acoustical lining, port tube or throat adaptor.

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 DEFAULT RESULT WINDOWS  
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Schematic Diagram  
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Loudspeaker schematic diagram and system volume. The design is assumed to be axisymmetric. Use the mouse pointer to identify component parts and show scale.

#### Acoustical Impedance

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Horn throat acoustical resistance and reactance in normalised acoustical ohms versus frequency in hertz. The actual acoustical resistance and reactance can be determined by multiplying the chart values by the given scaling factor.

#### SPL Response

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Sound pressure produced at a point source normalised distance of one metre when the driver is supplied with a signal of a given voltage, versus frequency in hertz. The level is expressed in decibels relative to the standard reference sound pressure of 20 micropascals.

The default response assumes constant directivity. The constant directivity SPL response is also the acoustical power response.

The Directivity Response tool can be used to take into account the frequency dependent directional characteristics of finite single-segment horns.

#### Electrical Impedance

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Loudspeaker electrical input impedance magnitude in ohms versus frequency in hertz.

#### Diaphragm Displacement

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One-way maximum displacement of the driver diaphragm from its mean position in millimetres for a specified input signal, versus frequency in hertz. The actual displacement can be determined by dividing the chart value by the scaling factor, where given.

Behaviour at all input voltage levels is assumed to be linear. No allowance is made for low frequency high power amplitude compression.

Each diaphragm in a multiple driver configuration has the same displacement, as given by the calculated value.

#### Phase Response

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Phase-angle difference in degrees between voltage  $E_g$  and the output sound pressure of a loudspeaker system, versus frequency in hertz.

By default, the phase is corrected by adding a linear phase offset equivalent to the mean group delay across the -12 dB delimited SPL bandwidth. Use the Delay tool to specify a different offset correction value or to display standard wrapped phase.

#### Group Delay

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Negative derivative in milliseconds of the loudspeaker system phase response, versus frequency in hertz.

Group delay is a measure of the rate of change of phase with respect to frequency, and is positive when the phase slope is negative.

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TOOLS MENU  
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Radiation Angle  
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Specifies the placement of the loudspeaker, and the solid angle into which the loudspeaker radiates. The solid angle is measured in steradians. Set the value to zero to specify an infinite horn.

The Tools menu command is enabled when Ang has the focus. The tool can also be selected by double-clicking the parameter in edit mode.

Horn Segment Wizard  
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Calculates either the throat area, mouth area, axial length, flare cutoff frequency, flare parameter, throat entry half-angle, mouth circumference in cutoff frequency wavelengths or mouth flare tangent angle, given the other relevant horn segment parameters. Cir or Fta can be set to a specified value when the mouth area or flare cutoff frequency calculation option is selected.

The Tools menu command is enabled when any horn segment parameter or the Apl throat adaptor parameter has the focus. The tool can also be selected by double-clicking the parameters in edit mode. The mouth area calculation option can be used to determine the cross-sectional area at any point along the axial length of a horn segment. For system volume, double-click segment volume.

Calculate Parameter  
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Derives Bl, Cms, Rms and Mmd values from relevant Thiele-Small parameters, calculates Eg given the power delivered to a specified load and determines Lpt given the Helmholtz resonance frequency. When selected from Sd, displays the driver Thiele-Small parameters.

The Tools menu command is enabled when Eg, Sd, Bl, Cms, Rms, Mmd or Lpt has the focus. The tool can also be selected by double-clicking the parameters in edit mode.

Chamber  
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Specifies a lined or vented rear chamber, a ported throat chamber or a throat chamber coupled to the horn throat by a conical adaptor.

The Tools menu command is enabled when the input parameters window is in edit mode. The chamber configuration can also be selected by double-clicking the Fr, Tal, Ap, Apl or Lpt label.

## Driver Arrangement

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Specifies the number and position of driver modules connected electrically in series and/or parallel. A driver module can contain a single driver, or up to 9 drivers connected in a series or parallel isobaric configuration.

Multiple drivers share the horn system, throat chamber and rear chamber as defined by the input parameter values and as shown in the schematic diagram. An offset driver horn, a tapped horn or a compound horn can be specified.

Select the tool by double-clicking the Nd, OD, TH, TH1 or CH disabled text box in edit mode.

## System Design With Driver

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Determines the optimum design for a hyperbolic-exponential horn loudspeaker given the driver parameter values and the required operating frequency range. Horn flare parameter T can be entered as an optional input by double-clicking the upper rolloff corner frequency label. The tool is enabled when the input parameters window is in edit mode.

## System Design From Specifications

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Determines the optimum design for a hyperbolic-exponential horn loudspeaker given the system parameter values and the required operating frequency range.

## Loudspeaker Wizard

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Automatically re-calculates the results for a specified loudspeaker system in real time, as input parameter values are changed. The tool is applicable to single segment conical and parabolic horns, and all multiple segment horns.

The initial slider control settings and chart results are saved as a reference baseline when the tool is selected. Up to four sets of values can be stored and recalled by clicking the appropriate memory button or pressing the equivalent function key.

Press the S key to instantly check the schematic diagram.

To change the flare of a horn segment, double-click on the label above the length slider control. To change the Manual / Auto setting of an area slider control, double-click on the label above the area slider. To change the frequency range, double-click on the chart frequency label. To directly set a slider control to a specified value, key in the value and then press Enter while the control has the focus.

To reset a slider control to its baseline value, press B while the control has the focus. To reset all slider controls to their baseline values, press Alt+B. To save a new baseline with the current slider control settings and chart results, press Ctrl+Alt+B.

## View Schematic

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Displays the loudspeaker schematic diagram and system volume.

Sample  
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The Sample menu command can be selected from any chart window, or by pressing F3 or double-clicking the chart. Single-clicking a chart will provide abbreviated data at the frequency given by the mouse pointer location.

Acoustical impedance chart ~ Calculates the normalised throat acoustical resistance and reactance and the actual throat acoustical resistance and reactance at any given frequency between 1 and 20000 hertz.

SPL response chart ~ Calculates the sound pressure level, electrical input power, acoustical output power, system efficiency, horn throat peak sound pressure and horn throat peak particle velocity at any given frequency between 1 and 20000 hertz. When a single-segment horn is sampled the second-harmonic distortion is also calculated. When the maximum SPL response is sampled the acoustical output is shown as either power or displacement limited, and the input voltage and Pmax diaphragm displacement are given.

Electrical impedance chart ~ Calculates the driver electrical input impedance magnitude and phase at any given frequency between 1 and 20000 hertz.

Diaphragm displacement chart ~ Calculates the driver diaphragm mean-to-peak displacement, peak velocity and peak acceleration at any given frequency between 1 and 20000 hertz. When the maximum SPL tool has been selected the sampled displacement is shown as either power or displacement limited. When displacement limited, the Pmax displacement value is also given.

Phase response chart ~ Calculates the system corrected phase shift or the system standard wrapped phase shift at any given frequency between 1 and 20000 hertz.

Group delay chart ~ Calculates the system group delay, equivalent distance travelled and equivalent wavelengths at any given frequency between 1 and 20000 hertz.

Beam width chart ~ Calculates the directivity pattern -6 dB beam width at any given frequency between 1 and 20000 hertz.

Compare  
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Displays the current and previous or captured acoustical impedance, SPL response, electrical impedance, diaphragm displacement, phase response, group delay or beam width results on the same chart.

Previous results are used in comparisons by default. Press Ctrl+C to capture the current results or Ctrl+R to release captured results. Results can also be captured or released by right-clicking on any chart.

Press F4 to show or hide the previous or captured results.

Directivity Response

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Displays the SPL response of a finite single-segment non-negative flare horn at a specified off-axis angle, taking into account the frequency-dependent directional characteristics of the horn.

Select from the SPL response chart window.

Directivity Pattern

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Displays the directional characteristics of a finite single-segment horn at a specified frequency. The polar diagram shows the far-field sound pressure at a fixed distance as a function of the off-axis angle, expressed relative to the on-axis pressure with the maximum value normalised to 1. The sound pressure ratio can be indicated directly or in decibels. The on-axis directivity index and -6 dB beam width are also given. Click on the polar diagram to show the pressure level at a specified angle.

Select from the SPL response or beam width chart windows.

Directivity Beam Width

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Displays the angular distance in degrees between the two points on either side of the principal axis of the directivity pattern where the sound pressure level is down 6 decibels from its value on axis, versus frequency in hertz.

Select from the SPL response chart window. Only applicable to finite single-segment horns.

Directivity Polar Map

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Displays the far-field sound pressure at a fixed distance as a function of the off-axis angle in degrees, versus frequency in hertz. Click the check box to show the results normalised to the on-axis response.

Results can be sampled by moving the mouse pointer over the chart window. A specific point can be selected by clicking or dragging on the window, and by using the Up, Down, Left and Right navigation keys. Press the Esc key to release a set point.

Select from the SPL response or beam width chart windows. Only applicable to finite single-segment horns.

Impulse Response

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Displays the impulse pressure versus time response of a loudspeaker system. The maximum positive or negative amplitude value is normalised to 0.9 and the maximum peak is positioned by default at the 0 msec reference point.

Select from the SPL response chart window.

Click the Export button to save the impulse response data values to a wave sound file. Click the Compare or Clear button or press F4 to show or hide the comparison with the previous result.

### Impulse Spectrogram

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Displays the impulse spectral density, or normalised amplitude in decibels as a function of frequency, versus time in milliseconds.

Results can be sampled by moving the mouse pointer over the chart window. A specific point can be selected by clicking or dragging on the window, and by using the Up, Down, Left and Right navigation keys. Press the Esc key to release a set point.

### Maximum SPL

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Displays the maximum sound pressure level in decibels that can be achieved at 1 metre without exceeding the driver rated thermal limited electrical input power  $P_{max}$  or the diaphragm linear mean-to-peak displacement limit  $X_{max}$ , versus frequency in hertz.

Black indicates power limited, red indicates displacement limited.

Press Ctrl+S to permanently save the entered  $P_{max}$  and  $X_{max}$  values.

### Combined Response

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For a finite back-loaded horn loudspeaker system, combines the direct radiator output with the default displayed horn SPL response. The direct radiator cannot be located inside the horn mouth.

For a finite horn-loaded vented-box loudspeaker system, combines the port output with the default displayed horn SPL response. The port outlet cannot be located inside the horn mouth.

For a direct radiator vented-box loudspeaker system, combines the port output with the default displayed direct radiator SPL response.

The path length from the rear side of the driver diaphragm to the port outlet is assumed to be equal to  $L_{rc}$  plus  $L_{pt}$ , as shown in the schematic diagram.

The distance from the port outlet to the listener can be adjusted if necessary using the path length difference parameter. A positive value for path length difference increases the listener distance.

Destructive interference nulls are often not as deep as predicted, due to the directional characteristics of the front and rear radiated sound.

### Multiple Speakers

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Displays the normalised far-field SPL response of a given multiple loudspeaker array connected to a single amplifier. Not applicable to infinite horns.

### Filter Wizard

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Automatically re-calculates the results for a specified filter system in real time, as input parameter values are changed.

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The electrical impedance chart shows the passive filter electrical input impedance magnitude when connected to a specified loudspeaker.

The initial slider control settings and chart results are saved as reference baselines when the tool is selected. Up to four sets of passive filter values can be stored and recalled by clicking the appropriate memory button or pressing the equivalent function key.

Press the S key to instantly check the schematic diagram.

To change the components in the branch of a passive filter from series to parallel configuration, double-click on the label below the relevant slider group. To change the alignment type of an active filter, double-click on the alignment label. To change the slope units from dB per octave to dB per decade, double-click on the slope label. To change the frequency range, double-click on the chart frequency label. To directly set a slider control to a specified value, key in the value and then press Enter while the control has the focus. Press F5 to reset all passive filter slider values to zero.

To reset a slider control to its baseline value, press B while the control has the focus. To reset all slider controls for a filter to their baseline values, press Alt+B. To save a new baseline for a filter with the current slider control settings and chart results, press Ctrl+Alt+B.

System Efficiency  
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Displays the system efficiency in percent versus frequency in hertz. Click on the chart to show the efficiency value at a specified frequency.

Select from the SPL response chart window.

Previous results are used in comparisons by default. Press Ctrl+C to capture the current results or Ctrl+R to release captured results. Results can also be captured or released by right-clicking on the chart.

Press F4 to show or hide the previous or captured results.

Sound Pressure  
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Displays the peak sound pressure at the horn throat in pascals versus frequency in hertz. Click on the chart to show the sound pressure value at a specified frequency. The throat of an offset driver or tapped horn is at S2.

Select from the SPL response chart window.

Previous results are used in comparisons by default. Press Ctrl+C to capture the current results or Ctrl+R to release captured results. Results can also be captured or released by right-clicking on the chart.

Press F4 to show or hide the previous or captured results.

Particle Velocity  
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Displays the peak particle velocity at the horn throat in metres per second

versus frequency in hertz. Click on the chart to show the particle velocity value at a specified frequency. The throat of an offset driver or tapped horn is at S2.

Select from the SPL response chart window.

Previous results are used in comparisons by default. Press Ctrl+C to capture the current results or Ctrl+R to release captured results. Results can also be captured or released by right-clicking on the chart.

Press F4 to show or hide the previous or captured results.

Range  
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When selected from the electrical impedance chart window, sets the electrical impedance chart range. Select Zoom to optimise the scale for the resonance peak.

When selected from the group delay chart window, sets the group delay chart range.

Phase  
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Displays the electrical impedance phase in degrees versus frequency in hertz. Click on the chart to show the phase value at a specified frequency.

Previous results are used in comparisons by default. Press Ctrl+C to capture the current results or Ctrl+R to release captured results. Results can also be captured or released by right-clicking on the chart.

Press F4 to show or hide the previous or captured results.

Pressure  
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Displays the peak sound pressure at the driver diaphragm in pascals versus frequency in hertz. Click on the chart to show the pressure value at a specified frequency.

Select from the diaphragm displacement chart window.

Previous results are used in comparisons by default. Press Ctrl+C to capture the current results or Ctrl+R to release captured results. Results can also be captured or released by right-clicking on the chart.

Press F4 to show or hide the previous or captured results.

Velocity  
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Displays the driver diaphragm peak velocity in metres per second versus frequency in hertz. Click on the chart to show the velocity value at a specified frequency.

Select from the diaphragm displacement chart window.

Previous results are used in comparisons by default. Press Ctrl+C to

capture the current results or Ctrl+R to release captured results. Results can also be captured or released by right-clicking on the chart.

Press F4 to show or hide the previous or captured results.

#### Acceleration ~~~~~

Displays the driver diaphragm peak acceleration in metres per second per second versus frequency in hertz. Click on the chart to show the acceleration value at a specified frequency.

Select from the diaphragm displacement chart window.

Previous results are used in comparisons by default. Press Ctrl+C to capture the current results or Ctrl+R to release captured results. Results can also be captured or released by right-clicking on the chart.

Press F4 to show or hide the previous or captured results.

#### Delay ~~~~~

Sets the phase response chart offset delay correction. Move the slider control to minimum to show standard wrapped phase. Select from the phase response window.

#### Wavefront Simulator ~~~~~

Models sound wave propagation in horn loudspeakers. Isophase wavefronts are shown.

#### Options ~~~~~

Sets the throat chamber and rear chamber resonance masking and default result window options.

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FILE MENU  
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#### New ~~~

Creates a new data file.

#### Open ~~~~

Opens an existing data file.

#### Editor ~~~~~

Moves or copies records from one data file to another, or deletes records from a data file.

#### Copy Driver

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Copies the current record driver parameter values.

Paste Driver  
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Pastes previously copied driver parameter values to the current record.

Find  
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Searches for records that match the given comment text and filter.

The Page Up, Page Down, Home, End and Enter keys can also be used to move from one record to another, when the input parameters window is displayed.

Sort  
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Sorts records in comment-ascending alphanumeric order.

Import Hornresp Record  
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Loads input parameter data values from an exported record file.

Export AkAbak Script  
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Saves current record input parameter data values to an AkAbak script file. Record must be valid. Select from the input parameters window.

Export Hornresp Record  
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Saves current record input parameter data values to a Hornresp export record file. Record must be valid. Select from the input parameters window.

Export Horn Data  
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Saves schematic diagram data values to a tab-delimited text or comma separated values file. Select from the schematic diagram window.

Axial length values for each horn segment increase linearly from zero to the segment length. The length increment for each segment can be set to a specified value in centimetres.

The flat profile of the left and right side walls of a square or rectangular cross-section horn can be determined by plotting the schematic diagram exported Height / 2 values against Side Len as the X-axis centre line. The flat profile of the top and bottom horn walls can be determined by plotting Width / 2 values against Top Len as the X-axis centre line.

The flat profile of a petal horn side wall can be determined by plotting Width / 2 values against Side Len as the X-axis centre line.

The 2007 flare profile used in the Le Cléac'h horn simulation model becomes

slightly inaccurate near the horn mouth. The error is not large enough to make any practical difference to predicted results, however for construction purposes the exact axisymmetric profile can be exported if required by selecting the appropriate option when prompted.

Export All Chart Data  
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Saves data values for all calculated charts to a tab-delimited text or comma separated values file. Frequency values increase logarithmically from 10 to 20000 hertz. Select from any chart window.

Export SPL + Phase  
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Saves SPL magnitude and phase values to a tab-delimited text file for use with other loudspeaker design software tools. Frequency values increase logarithmically from 10 to 20000 hertz. Select from the SPL response window.

Export Ze + Phase  
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Saves electrical impedance magnitude and phase values to a tab-delimited text file for use with other loudspeaker design software tools. Frequency values increase logarithmically from 10 to 20000 hertz. Select from the electrical impedance window.

Print  
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Prints the input parameter values and displayed schematic diagram or chart.

Exit  
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Closes the Hornresp application.

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LOUDSPEAKER MODELS  
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Direct Radiator in an Infinite Baffle  
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Set Ang =  $2 \times \text{Pi}$ , S1 to L45 = 0 and Vrc and/or Lrc = 0.

Direct Radiator in a Closed-Box Enclosure  
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Select the 'Rear Lined' option from the Chamber tool and set S1 to L45 = 0 and Vrc and Lrc > 0. To specify acoustical lining material in the rear chamber set Fr and Tal > 0.

Direct Radiator in a Vented-Box Enclosure  
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Select the 'Rear Vented' option from the Chamber tool and set S1 to L45 = 0 and Vrc, Lrc, Ap and Lpt > 0.

By default, only the direct radiator output is calculated. The Combined Response tool can be used to determine the port output or the overall direct radiator plus port output SPL response. An end correction is added to the Lpt rear chamber port tube length where appropriate.

#### Front-Loaded Horn ~~~~~

Set Vrc and Lrc > 0.

To specify acoustical lining material in the rear chamber select the 'Rear Lined' option from the Chamber tool and set Fr and Tal > 0.

To specify a throat adaptor between the throat chamber and the horn throat select the 'Throat Adaptor' option from the Chamber tool and set Apl, Lpt, Vtc and Atc > 0.

#### Back-Loaded Horn ~~~~~

Set Vrc and/or Lrc = 0.

To specify a throat adaptor between the throat chamber and the horn throat select the 'Throat Adaptor' option from the Chamber tool and set Apl, Lpt, Vtc and Atc > 0.

By default, only the horn output is calculated. The Combined Response tool can be used to determine the direct radiator output or the overall horn plus direct radiator SPL response.

#### Horn-Loaded Vented-Box Enclosure ~~~~~

Select the 'Rear Vented' option from the Chamber tool and set Vrc, Lrc, Ap and Lpt > 0.

By default, only the horn output is calculated. The Combined Response tool can be used to determine the port output or the overall horn plus port output SPL response. An end correction is added to the Lpt rear chamber port tube length where appropriate.

#### Mass-Loaded Horn ~~~~~

Specify the mouth cover plate as a conical segment having negative flare (mouth area < throat area) and a length of 0.01 cm, and the mouth mass-loading port tube as a cylindrical exponential segment having zero flare (mouth area = throat area).

#### Offset Driver Horn ~~~~~

Specify at least two conical, exponential and/or parabolic flare segments connected in series, and select the offset driver option from the Driver Arrangement tool or double-click Nd, TH or CH in edit mode to set the OD flag.

The driver entry point is at S2. Vtc and Atc can be used to specify a chamber between the driver diaphragm and the throat entry point. Apl and Lpt can be used to specify a port opening between the chamber and the horn

(not required if the cross-sectional area of the opening is equal to  $A_{tc}$ ).

By default, with no rear chamber specified only the horn output is calculated. The Combined Response tool can be used to determine the rear output or the overall front plus rear SPL response. An end correction is added to the  $L_{pt}$  rear chamber port tube length where appropriate.

#### Tapped Horn

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Specify three or four conical, exponential and/or parabolic flare segments connected in series, set  $V_{rc}$  and/or  $L_{rc} = 0$  and select the tapped horn option from the Driver Arrangement tool or double-click  $N_d$ ,  $O_D$  or  $CH$  in edit mode to set the  $TH$  flag.  $TH$  can be double-clicked to set the optional  $TH1$  flag.

Driver entry points are at  $S_2$  and  $S_3$  for a three segment  $TH$  horn,  $S_2$  and  $S_4$  for a four segment  $TH$  horn, and  $S_2$  and  $S_3$  for a four segment  $TH1$  horn.  $V_{tc}$  and  $A_{tc}$  can be used to specify a chamber between the driver diaphragm and the throat entry point.  $A_{p1}$  and  $L_{pt}$  can be used to specify a port opening between the chamber and the horn (not required if the cross-sectional area of the opening is equal to  $A_{tc}$ ).

The Loudspeaker Wizard tool can be used to change the driver position without altering the horn length or flare.

#### Compound Horn

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Select the compound horn option from the Driver Arrangement tool or double-click  $N_d$ ,  $O_D$  or  $TH$  in edit mode to set the  $CH$  flag. Horn 1 is specified using segment 1 plus segments 2 and 3 if required. Horn 2 is specified using segment 4.

By default, only the horn 1 output is calculated. The Combined Response tool can be used to determine the horn 2 output or the overall horn 1 plus horn 2 SPL response.