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LOUDSPEAKER MODELS

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|INTRODUCTION

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

Finite horns radiating into free space, half space, quarter space or eighth space can be analysed (4 x Pi, 2 x Pi, Pi or Pi / 2 steradians solid angle).

Horn systems can have an oblate spheroidal waveguide, a single Le Cléac'h, Bessel, 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.

A parabolic (Par) flare should be used when simulating a rectangular cross-sectional area horn segment having two parallel straight sides and two sloping straight sides, where the area varies linearly with axial length.

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.

By default, at the common boundary between two horn segments in a multiple-segment horn the cross-sectional areas are the same for each segment. The mouth area of the first segment is equal to the throat area of the second segment. Double-clicking on any segment area label in edit mode allows different cross-sectional areas to be specified at the common boundary. The mouth area of the first segment does not necessarily have to be the same as the throat area of the second segment. This will result in a step transition at the common boundary. All horn segment area labels are shown in red when stepped segments are specified.

When stepped segments are specified it is not possible to use the Multiple Entry Horn Wizard, export schematic diagram horn data, print the schematic diagram, export an AkAbak script or open the current record in the Wavefront Simulator.

For multiple-segment horns, the more that the value of 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.

Horn transmission losses are assumed to be zero, unless absorbent filling material is specified. Vented-box enclosure system losses are taken into account using the QL quality factor parameter.

|INPUT PARAMETERS WINDOW

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. If the mouse pointer is moved over the throat area or Sd label of a horn system then the compression ratio is also shown.

After calculating results by pressing F5 or clicking the Calculate button, 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.

Press the S key to instantly check the schematic diagram. Release the S key to immediately return to the previously displayed chart or input parameters 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.

Double-click on the Eg label in edit mode or press V or A when the Eg text box has the focus to select the Vel constant diaphragm velocity or Acc constant diaphragm acceleration option. Not applicable to ME1, ME2, BP4, BP6, BP8, BPA, BPB, BPC, DBR or ABC records. Double-click on the Acc label in edit mode or press E when the Vel or Acc text box has the focus to re-select the Eg constant amplifier open circuit voltage option. The Eg, Vel and Acc default values can be changed as required.

Double-click on the Cir or Fta label in edit mode to select the Clo closed horn mouth option. Not applicable to direct radiator loudspeakers, Ripole loudspeakers, tapped horns, paraflex horns, CH2 or CH3 compound horns, multiple entry horns or single segment horns other than Con, Exp or Par.

Double-click on the Le label in edit mode to select the lossy inductance option, and to more accurately simulate loudspeaker systems having drivers with large motors. Not applicable to ME1 and ME2 records. The lossy inductance model was derived empirically from experimental data and adjusts the value of Bl as necessary to achieve the desired result. The adjusted Bl value can be seen in the bottom status bar panel by moving the mouse pointer over the Bl label or text box. A red Le label indicates that the lossy inductance option has been selected.

Double-click on the Le text box in edit mode to select the Semi-Inductance Model. Not applicable to ME1 and ME2 records. A green Le label indicates that the semi-inductance model has been selected.

Double-click on the Cms label in edit mode to select the Frequency-Dependent Damping or FDD Model. Not applicable to ME1 and ME2 records. A green Cms label indicates that the FDD model has been selected.

Double-click on the Vrc label in edit mode to select the cubic centimetre unit option. Not applicable to ME1 or ME2 records. A red Vrc label indicates that the cubic centimetre unit option has been selected.

For tapped horns with a throat chamber port, double-click on the Lrc label in edit mode to specify a second throat port connected in series with the first. Throat port 2 can have a conical, cylindrical, exponential or parabolic flare. Selecting the zero flare cylindrical option enables throat port 2 to be stepped relative to throat port 1.

Press the F8 function key in edit mode to reset the current record filter parameters to their default values.

|Radiation, Source and Mouth Parameters

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

Eg Amplifier open circuit root-mean-square voltage (volts).

Vel Driver diaphragm constant rms velocity (m/sec).

Acc Driver diaphragm constant rms acceleration (m/sec^2).

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
~~~~~~~~~~~~~~~~

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 on the length label. The length value must be non-zero to preserve the flare setting. To select Bes, Hyp, Lec, Obl, Rad, Sph or Tra flare in edit mode, press B, H, L, O, R, S or T when the L12 length parameter has the focus.

F12 Horn segment 1 flare cutoff frequency (hertz).

m Bessel horn flaring index.
Enter 0 for cylindrical, 1 for parabolic, 2 for conical, 99999 for exponential or -2 for Gabriel's horn.

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.

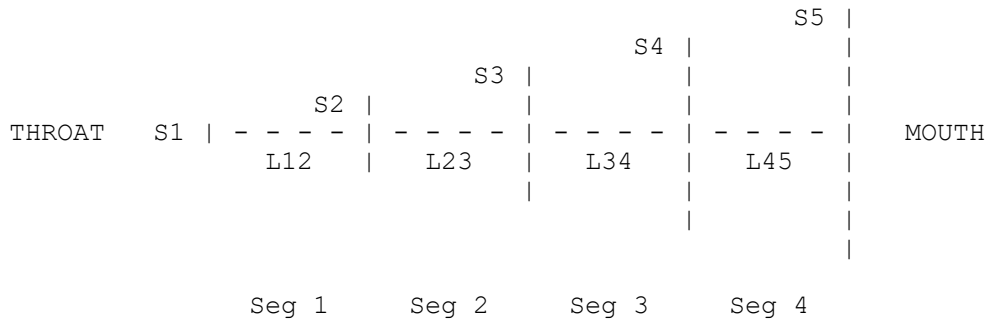
T Spherical wave horn flare parameter.
Enter 1 for spherical wave or 0.5 for exponential tractrix.

R Radius horn flare profile radius (cm).

AT Horn throat entry half-angle (degrees).

CA Oblate spheroidal waveguide coverage half-angle (degrees).

Multiple Segment Horn
~~~~~~~~~~~~~~~~~~~~~



|Traditional Driver Parameters
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

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   Loudspeaker system configuration and driver arrangement.
     Specify using the Loudspeaker Configuration tool.

fs   Driver free-air resonance frequency (hertz).

Vas Volume of air that provides a restoring force equal to that of the
     driver's mechanical compliance (litres).

Qes Driver resonant electrical Q at the driver resonance frequency, due
     solely to inherent electromagnetic damping.

Qms Driver resonant mechanical Q at the driver resonance frequency, due
     solely to internal mechanical damping.

Qts Driver total Q.

Pmax Driver rated thermal limited electrical input power (watts).

Xmax Driver diaphragm linear mean-to-peak displacement limit (mm).

For a dual voice coil driver with the two coils connected in series, specify Re = 2 x Re1, Le = 2 x Le1 and Bl = 2 x Bl1 where Re1, Le1 and Bl1 are the parameter values for one coil.

For a dual voice coil driver with the two coils connected in parallel, specify Re = Re1 / 2, Le = Le1 / 2 and Bl = Bl1 where Re1, Le1 and Bl1 are the parameter values for one coil.

For a dual voice coil driver with the two coils connected in either series or parallel, Qes = Qes1 / 2 where Qes1 is the parameter value for one coil.

|Advanced Driver Parameters For Semi-Inductance Model
~~~~~~

Re' Resistance (ohms).

Leb Free inductance (millihenrys).

Le   Bound inductance (millihenrys).

Ke   Semi-inductance (semi-henrys).

Rss Shunt resistance (ohms).

|Advanced Driver Parameters For Frequency-Dependent Damping or FDD Model
~~~~~~

Rms Mechanical resistance (newton.sec/m).

Ams Admittance (m/newton).

|Chamber Parameters

Vrc Rear chamber volume (litres or cc).

Lrc Rear chamber average length (cm).

Fr Rear chamber acoustical lining airflow resistivity (mks rayls/m).

Tal Rear chamber acoustical lining thickness (cm).

Fr1 Absorbent filling material airflow resistivity (mks rayls/m).

Tal1 Absorbent material filled length (cm and percent).

Ap Vented rear chamber port cross-sectional area (sq cm).
Offset flared port tube mouth cross-sectional area (sq cm).

Apt Offset flared port tube throat cross-sectional area (sq cm).

Lpt Vented rear chamber port tube length (cm).
Offset flared port tube length (cm).

Ap1 Throat port or throat adaptor entry cross-sectional area (sq cm).

Ap2 Throat port 2 or absorber chamber port cross-sectional area (sq cm).

Lp Throat or absorber chamber port or throat adaptor length (cm).

Vtc Throat chamber volume (cc).

Atc Throat chamber average cross-sectional area normal to axis (sq cm).

Sp1 Passive radiator diaphragm piston area (sq cm).
Sp1 = 1 passive radiator, Sp9 = 9 passive radiators.

Cmp Passive radiator suspension mechanical compliance (m/newton).

Rmp Passive radiator suspension mechanical resistance (newton.sec/m).

Mmp Passive radiator diaphragm dynamic mechanical mass (gm).

Mma Passive radiator diaphragm added mass (gm).

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 maximum allowable volume is 999999.9 cubic centimetres.

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.

An airflow resistivity value of 1 mks rayl per metre is equivalent to 1 pascal.second per square metre.

DEFAULT RESULT WINDOWS

Schematic Diagram

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

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

Acoustical Power

Constant directivity 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 acoustical power output producing the constant directivity sound pressure is assumed to radiate uniformly into the solid angle specified by the Ang input parameter.

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

Double-click anywhere on the Y-axis vertical SPL scale to switch from the default 5 dB increments to either 6 dB or 3 dB increments.

Electrical Impedance

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

Diaphragm Displacement

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 arrangement has the same displacement, as given by the calculated value.

Phase Response

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

The combined phase response is the vector sum of the phases of the two outputs. The distance between the outputs is not taken into account.

Standard wrapped phase is displayed by default. The Delay tool can be used to add a linear phase offset, or to remove an existing offset and restore standard wrapped phase. The default offset delay correction value is equivalent to the mean group delay across the -12 dB delimited SPL bandwidth.

The Unwrapped Phase tool can be used to display the unwrapped phase response in degrees versus frequency in hertz. Click on the chart to show the phase value at a specified frequency. The unwrapped results for systems with large phase shifts can become unreliable at high frequencies, due to phase aliasing caused by under sampling.

|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.

Press the L key to add a green 1/f limit guideline. Press the L key again to add a red Claus Futtrup limit guideline. Press the L key a third time to remove the 1/f limit guideline and press the L key a fourth time to remove the Claus Futtrup limit guideline.

The Claus Futtrup audible group delay threshold limit guideline in milliseconds is given by the expression:

GDlimit = 1000 * 1.1606 / (5.6413 * f ^ 0.81511 - f)

Where f is the frequency in hertz.

System group delay has two parts, a linear phase part which is a pure propagation time delay, and an excess group delay part which results from rapid phase shifts.

Because the limit guidelines apply to the excess group delay part of the system group delay only, the limit values shown on the group delay chart have the propagation time delay part added as an offset adjustment.

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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.

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The Spherical option shows the loudspeaker radiating into a sphere, hemisphere or spherical sector. The radiation angle is given in degrees. The solid radiation angle can also be viewed in 3-D.

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

|Horn Segment Wizard
~~~~~~~~~~~~~~~~~~~

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. The coverage half-angle of an oblate spheroidal waveguide can also be calculated. Cir or Fta can be set to a specified value when the mouth area or flare cutoff frequency calculation option is selected. When used with an exponential, hyperbolic-exponential or oblate spheroidal waveguide segment, double-clicking on the Cir label changes the parameter from Cir to Fta.

The Tools menu command is enabled when the Ap1 throat adaptor parameter, the Ap2 absorber chamber port parameter or any horn segment parameter has the focus. The tool can also be selected by double-clicking on 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 on the segment volume.

|Hypex Approximator
~~~~~~~~~~~~~~~~~~

Approximates a specified hyperbolic-exponential horn using up to four conical, exponential or parabolic segments.

To change the flare of a horn segment, double-click on the label above the length slider control. If the label is double-clicked while the Ctrl key is pressed, all segments are set to the same flare.

To change the Auto / Manual setting of an area slider control, double-click on the label above the area slider.

To directly set an enabled slider control to a specified value, key in the value and then press Enter while the control has the focus.

The volume difference value is the sum of the segment volumes minus the volume of the specified hyperbolic-exponential horn. The value is positive when the sum of the segment volumes is greater than the hyperbolic-exponential horn volume. The value is negative when the sum of the segment volumes is less than the hyperbolic-exponential horn volume. Double-click on the schematic diagram caption to change the volume difference from litres to percentage.

The Tools menu command can be accessed when either S1, S2, L12 (Hyp) or T for a hyperbolic-exponential horn has the focus, and S2 is not greater than 99999.99.

|Calculate Parameter
~~~~~~~~~~~~~~~~~~~

Derives Bl, Cms, Rms, Mmd, Cmp, Rmp and Mmp values from relevant
~~~~~~~~~~~~~~~~~~~

Thiele-Small parameters, calculates Eg given the power delivered to a specified load and determines the Helmholtz resonance frequency given Lpt.

When selected from Sd, displays the driver Thiele-Small parameters Sd, Re, fs, Vas, Qes, Qms and Qts, and the electro-mechanical parameters Le, Pmax and Xmax. The values of all parameters shown can be edited, except for Qts.

When selected from Sp1 to Sp9, displays the passive radiator Thiele-Small parameters Sp, fs, Vas and Qms. The values of all parameters shown can be edited.

The Tools menu command is enabled when Eg, Sd, Bl, Cms, Rms, Mmd, Sp1 to Sp9, Cmp, Rmp, Mmp or Lpt has the focus. The tool can also be selected by double-clicking on the parameters in edit mode.

|Chamber Type
~~~~~~~~~~~~

Specifies a lined or vented rear chamber, a passive radiator, a ported throat chamber, a ported stub or a throat chamber coupled to the horn throat by a conical, cylindrical, exponential or parabolic adaptor.

The Tools menu command is enabled when the input parameters window is in edit mode. Not applicable to BP4, BP6, BP8, BPA, BPB, BPC, DBR or ABC records. The chamber configuration can also be selected by double-clicking on the Fr, Ap, Ap1, Ap2 or Sp1 label.

Press the Ctrl key and double-click on the Fr, Ap or Ap1 label to specify a passive radiator. Press the Ctrl key and double-click on the Sp1 label to specify multiple passive radiators. Double-click on the Sp1 to Sp9 or Cmp label to restore the default Fr label. Double-click on the Mmp label to specify the mass in grams to be added to each passive radiator diaphragm.

Double-click on the Lp label in edit mode or press C, E or P when the Lp text box has the focus to specify a conical, cylindrical, exponential or parabolic flare throat adaptor or absorber chamber port. The flare can also be specified by double-clicking on the label above the Lp slider control in the Loudspeaker Wizard tool.

|Loudspeaker Configuration
~~~~~~~~~~~~~~~~~~~~~~~~~

Specifies the loudspeaker system configuration and 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 (left side of slider) or parallel (right side of slider) isobaric arrangement.

The 'Multiple Driver Equivalent' option enables a given single driver to be replaced by a multiple driver array having the same performance.

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.

A normal horn, an offset driver horn, a tapped horn, a paraflex horn, a compound horn, a stubbed horn, a multiple entry horn, a 4th order, 6th order series, 6th order parallel, 8th order series, 8th order parallel, type A, type B or type C band pass enclosure, or a double bass reflex or an

aperiodic bi-chamber enclosure can be specified.

The tool can be selected by double-clicking on the Nd, OD, OD1, TH, TH1, PH1, PH2, PH3, PH4, CH, CH1, CH2, CH3, SH1, SH2, SH3, SH4, ME1, ME2, BP4, BP6, BP8, BPA, BPB, BPC, DBR or ABC disabled text box in edit mode.

Double-clicking on the input parameters window loudspeaker configuration label in edit mode steps through the Nd, OD, OD1, TH, TH1, PH1, PH2, PH3, PH4, CH, CH1, CH2, CH3, SH1, SH2, SH3, SH4 loudspeaker configuration options.

Pressing the Ctrl key and double-clicking on the input parameters window loudspeaker configuration label in edit mode steps through the ME1, ME2, BP4, BP6, BP8, BPA, BPB, BPC, DBR, ABC loudspeaker configuration options.

|System Design With Driver
~~~~~~~~~~~~~~~~~~~~~~~~~

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 on 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.

|TL Design
~~~~~~~~~

Determines the dimensions for a transmission line loudspeaker system given the driver parameter values and the required usable bandwidth or area taper or expansion ratio. The dimensions can be calculated using one of three methods, with the desired method being selected by double-clicking the method label.

The three available methods are:

Method MJK 2021

Described in Martin J. King's 2021 'Classic Transmission Line Enclosure Alignments' document. Inputs are driver parameter values and required area taper or expansion ratio. Double-click on the 'Area Taper Ratio' label to specify an expanding transmission line.

Available alignments are:

MJK 2021 A	SBB4 and BB4	QL = 15	Qts must be between 0.20 and 0.70
MJK 2021 B	QB3 and SQB3	QL = 15	Qts must be between 0.10 and 0.56
MJK 2021 C	SC4 and C4	QL = 15	Qts must be between 0.25 and 0.70

The desired alignment is selected by double-clicking the method label.

Method MJK 2006

Described in Martin J. King's 2006 'Classic Transmission Line Enclosure
~~~~~~~~~

Alignment Tables' document. Inputs are driver parameter values and required area taper or expansion ratio. Double-click on the 'Area Taper Ratio' label to specify an expanding transmission line.

fs must be between 20 Hz and 70 Hz and Qts must be between 0.20 and 0.70.

Superseded by Method MJK 2021 above.

Method BS 2022

Developed by Brian Steele in 2022. Inputs are driver parameter values and required usable bandwidth.

The TL design tool is enabled when the input parameters window is in edit mode. The closed end cross-sectional area, open end cross-sectional area, transmission line length and driver offset are calculated. A parabolic profile is assumed.

|Resize Wizard

Scales the size of a specified loudspeaker system, including driver parameter values.

The degree to which a loudspeaker system can be re-scaled is specified by a resize factor, or by entering a value for driver diaphragm piston area Sd. Double-clicking on the 'Resize factor' label selects the Sd option. The value for driver voice coil dc resistance Re can also be specified.

The response of a specified loudspeaker system can be shifted up or down in frequency without changing the curve shape, by decreasing or increasing the system size.

The tool is enabled when the input parameters window is in Edit mode. Not applicable to ME1 or ME2 records, or when the driver has lossy inductance, semi-inductance or frequency-dependent damping specified.

|Loudspeaker Wizard

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

The Combined output option calculates the total system power response. The Combined 1 output option also calculates the total response but in addition shows the individual acoustical power outputs that make up the total response.

In addition to the standard power response chart, when the wizard is used with an unbaffled direct radiator, a direct radiator in a flat open baffle, a direct radiator in a H-frame open baffle or a direct radiator in a U-frame open baffle, the pressure response at a specified off-axis angle, and the polar directivity pattern at a given frequency, are also calculated. The results indicated by the lighter-coloured portion of the acoustical pressure chart trace are approximate only, and become progressively less accurate as the frequency increases. This is because the dipole point source model used in the calculations starts to break down

as the frequency rises and the sources increase in size compared to the wavelength. The pressure results take into account the combined radiation from both sides of the system. Pressure results can be exported in a similar way to the power results. Click on the polar directivity pattern to show the pressure level and the directivity index at a specified angle. The arrow keys can be used to change the selected angle. The value of ka (wave-number k = 2 * Pi * f / c multiplied by piston radius a) is also given.

When the wizard is used with an unbaffled direct radiator, a direct radiator in a flat open baffle, a direct radiator in a H-frame open baffle or a direct radiator in a U-frame open baffle, double-clicking on the schematic diagram shows the positions of the dipole acoustic centres. Pressing the Esc key hides the acoustic centres.

When the wizard is used with a direct radiator in a U-frame open baffle, the Fr and Tal values required to achieve cardioid directivity in a resistive system can be automatically calculated by selecting the Filling option and then double-clicking on the Manual label below the Fr1 and Tal1 slider controls. Double-clicking on the default Rs parameter label changes the displayed filling material parameter from specific acoustical resistance Rs in mks rayls, to acoustical resistance Ra in mks acoustic ohms.

A green marker line indicating the fundamental resonance frequency can be added to all charts by double-clicking on any chart. The marker can be removed by pressing the Esc key. Moving the mouse pointer over the marker line shows the resonance frequency value.

Double-click anywhere on the power chart Y-axis vertical SPL scale to switch from the default 5 dB increments to either 3 dB or 6 dB increments.

Press the Ctrl key and double-click anywhere on the group delay chart to switch to the group delay per period chart. Press the Ctrl key and double-click anywhere on the group delay per period chart to switch back to the group delay chart.

Double-click anywhere on the group delay per period chart Y-axis vertical scale to switch the chart range from the default 1 cycle to either 2 cycles, 5 cycles, 10 cycles or 20 cycles.

With the group delay or group delay per period chart displayed, press the L key to add a green 1/f limit guideline. Press the L key again to add a red Claus Futtrup limit guideline. Press the L key a third time to remove the 1/f limit guideline and press the L key a fourth time to remove the Claus Futtrup limit guideline.

The Claus Futtrup audible group delay threshold limit guideline in milliseconds is given by the expression:

GDlimit = 1000 * 1.1606 / (5.6413 * f ^ 0.81511 - f)

Where f is the frequency in hertz.

System group delay has two parts, a linear phase part which is a pure propagation time delay, and an excess group delay part which results from rapid phase shifts.

Because the limit guidelines apply to the excess group delay part of the system group delay only, the limit values shown on the group delay and

group delay per period charts have the propagation time delay part added as an offset adjustment.

For direct radiator closed-box systems, the value of total quality factor Qtc is displayed when the Chamber input parameters option is selected.

For passive radiator systems, double-click on the Sp1 slider control label when the Chamber input parameters option is selected to specify up to 9 passive radiators. Double-click on the Mmp slider label to specify the mass in grams to be added to each passive radiator diaphragm. Double-click on the Added Mass slider label to return to the Mmp slider.

Absorbent filling material can be included in the horn segments of a Loudspeaker Wizard system by selecting the Filling option. The chart captions change from black to pink when absorbent filling material is specified.

The airflow resistivity of the absorbent filling material in each segment is specified in mks rayls/m using the Fr1 slider controls. If a Fr1 slider value is changed while the Ctrl key is pressed, all segments are set to the same resistivity value.

The Tal1 sliders can be used to partially fill segments with absorbent material. The first half of the slider fills the segment from the throat end, and the second half fills the segment from the mouth end. For horn 2 in a compound horn system, the first half of the slider fills the segment from the mouth end, and the second half fills the segment from the throat end. If a Tal11 slider value is changed while the Ctrl key is pressed, all segments are filled to the same percentage value.

When the Schematic and Filling options are selected, the total volume of filling material in the system is shown in litres. If all airflow resistivity values are less than 1000 mks rayls/m then the total weight of Polyfill absorbent material in kilograms required to achieve the specified resistivity is also shown. Double-clicking on the Filling label switches between total and segment values.

Absorbent filling material settings can be switched on or off by pressing the F key. The chart caption changes from black to pink when the settings are on.

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 temporarily stored and recalled while the wizard is open by clicking the appropriate memory button or pressing the equivalent function key.

Pressing Ctrl+C when the power or pressure response chart is displayed captures the current results. Pressing Ctrl+V shows or hides previously captured results. Not applicable when room gain is included.

Press the V key to instantly check the schematic diagram. Release the V key to immediately return to the previously displayed chart.

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.

If stepped segments are specified and all area sliders are set to Manual, double-clicking on a segment Con label changes the segment flare to Cyl (cylindrical). When the zero flare cylindrical option is selected the

segment cross-sectional area can be adjusted using either the segment throat or mouth slider. Double-clicking on a segment Con label while the Ctrl key is pressed sets all segment flares to Cyl.

To change the flare of a throat adaptor or absorber chamber port, double-click on the label above the Lp slider control.

To change the Eg, Vel or Acc option, double-click on the label above the slider control.

To change the Thiele-Small parameter displayed on the Driver window, double-click on the label below the Re slider control.

To change the frequency range, double-click on the chart frequency label. The 100 to 20000 hertz range is not applicable when absorbent filling material is included.

To directly set a slider control to a specified value, key in the value and then press Enter while the control has the focus. For the Tal1 slider, a directly entered positive percentage value will fill the currently selected segment with absorbent material from the throat end, and a directly entered negative percentage value will fill the segment from the mouth end. For horn 2 in a compound horn system, a directly entered Tal1 positive percentage value will fill the currently selected segment with absorbent material from the mouth end, and a directly entered negative percentage value will fill the segment from the throat end.

To quickly move through a slider control value range, press and hold the Home or End key while the slider 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.

Imported room gain data can be included in the Loudspeaker Wizard acoustical power results by either clicking the Include Gain button in the Memory & Width window or by pressing the F7 function key. Not applicable when the chart frequency range is set to 1 to 2000 hertz.

Data exported from a Boxplan workbook can be imported into the Loudspeaker Wizard by either clicking the Import Data button in the Memory & Width window or by pressing the F6 function key when the wizard has the focus. If the Ctrl key is also pressed, the Boxplan driver parameter values are not imported.

The active or parametric equaliser filter option in the Filter Wizard tool can be selected from the Loudspeaker Wizard by either clicking the Filter Wizard button in the Memory & Width window or by pressing the F8 function key. Not applicable when the Pmax and Xmax slider controls are enabled.

SPL magnitude and phase values can be saved to a tab-delimited text (.txt) or frequency response data (.frd) file for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory & Width window or by pressing the F9 function key with the Power output option selected. Frequency values increase logarithmically. The export frequency range is limited to a maximum of 2000 hertz when absorbent filling material is included.

Electrical impedance magnitude and phase values can be saved to a

tab-delimited text (.txt) or impedance response data (.zma) file for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory & Width window or by pressing the F9 function key with the Impedance output option selected. Frequency values increase logarithmically.

Diaphragm displacement values can be saved to a tab-delimited text (.txt) or comma separated values (.csv) file by either clicking the Export Data button in the Memory & Width window or by pressing the F9 function key with the Displacement output option selected. Frequency values increase logarithmically.

The constant width dimension of a direct radiator enclosure or rectangular horn having two parallel sides can be altered while leaving the cross-sectional height dimensions unchanged, by using the Width slider control in the Memory & Width window.

Specify the initial width dimension using the Width slider and then double-click on the Width label to switch the slider to the width adjustment mode. Adjust the slider to vary the horn or enclosure width from the initial value. Double-click on the label to reset to the initial width.

Select the Lossy Le check box on the schematic diagram window to more accurately simulate the power response and diaphragm displacement of systems having drivers with large motors. The lossy inductance model was derived empirically from experimental data.

Select the Semi-Inductance Model check box on the schematic diagram window to use the semi-inductance model.

Select the FDD Model check box on the schematic diagram window to use the frequency-dependent damping model.

The loudspeaker is modelled as shown in the schematic and system model diagrams.

System Model Element Codes:

AC = Absorber Chamber	P1 = Port 1
AP = Absorber Chamber Port	RC = Rear Chamber
C1 = Chamber 1	RP = Rear Chamber Port
D = Driver	S = Stub
H1 = Horn Segment 1	TA = Throat Adaptor
PR = Passive Radiator	TC = Throat Chamber
PT = Offset Port Tube	TP = Throat Chamber Port

|Multiple Entry Horn Wizard

Automatically re-calculates the results for a specified two-way or three-way multiple entry horn loudspeaker system in real time, as input parameter values are changed.

CoEntrant, Unity and Synergy loudspeakers are examples of multiple entry horn systems.

The wizard cannot be used if stepped segments have been specified.

A Nd record is used to specify the horn system and HF driver at the horn

throat. A ME1 record is used to specify the MF drivers at the first offset entry point and a ME2 record is used to specify the LF drivers at the second offset entry point.

A three-way system requires the Nd record to have at least three segments, and both a ME1 and a ME2 record to be activated.

A two-way system requires the Nd record to have at least two segments, and a ME1 record to be activated. If a ME2 record is also activated it will be disregarded if only two segments are specified in the Nd record.

The Tools menu command is enabled when the input parameters window for a Nd record is in edit mode and at least two horn segments have been specified, and a ME1 record has been previously activated.

Double-click anywhere on the power chart Y-axis vertical SPL scale to switch from the default 5 dB increments to either 3 dB or 6 dB increments.

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 temporarily stored and recalled while the wizard is open by clicking the appropriate memory button or pressing the equivalent function key.

Pressing Ctrl+C when a power response chart is displayed captures the current results. Pressing Ctrl+V shows or hides previously captured results.

Press the V key to instantly check the schematic diagram. Release the V key to immediately return to the previously displayed chart.

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 specify absorbent filling material in a ME1 or ME2 throat port tube, set the Fr slider control to the airflow resistivity value and the Tal slider to zero.

Pressing the Ctrl key while adjusting an Amplifier Eg or Rg slider control sets the other Eg or Rg sliders to the same value.

The Amplifier delay slider control enables the offset ME1 and ME2 drivers to be time-delayed (positive delay slider value) or time-advanced (negative delay slider value) relative to the HF driver at the horn throat. By default the delay is expressed as an equivalent distance in centimetres. Double-clicking on the delay caption automatically sets the slider to the actual physical path length difference. Double-clicking on the delay value changes distance to time, in milliseconds.

To change the alignment type of a band pass 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 switch a band pass filter on or off, double-click on the On / Off label for that filter.

To switch a parametric equaliser filter band on or off, double-click on the On / Off label for that band. To select either a peaking EQ filter, a low shelving filter, a high shelving filter, a low pass filter or a high pass filter for a given band, double-click on the filter label for that band.

Press the Esc key to hide the green frequency marker.

Press the F5 function key to restore all band pass and parametric equaliser filter slider controls to their initial default settings.

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 quickly move through a slider control value range, press and hold the Home or End key while the slider 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.

Select the Schematic option to display the schematic diagram of the specified two-way or three-way multiple entry horn loudspeaker system.

Select the Power 1 option to display the horn mouth acoustical power output of the driver assembly located at the horn throat. The baseline shows the total horn mouth acoustical power output.

Select the Power 2 option to display the horn mouth acoustical power output of the driver assembly located at the first offset entry point. The baseline shows the total horn mouth acoustical power output.

Select the Power 3 option to display the horn mouth acoustical power output of the driver assembly located at the second offset entry point. The baseline shows the total horn mouth acoustical power output.

Select the Total Power option to display the acoustical power output of the complete system.

Select the Impedance 1 option to display the magnitude of the electrical input impedance of the driver assembly located at the horn throat.

Select the Impedance 2 option to display the magnitude of the electrical input impedance of the driver assembly located at the first offset entry point.

Select the Impedance 3 option to display the magnitude of the electrical input impedance of the driver assembly located at the second offset entry point.

Select the Displacement 1 option to display the driver diaphragm displacement of the driver assembly located at the horn throat.

Select the Displacement 2 option to display the driver diaphragm displacement of the driver assembly located at the first offset entry point.

Select the Displacement 3 option to display the driver diaphragm displacement of the driver assembly located at the second offset entry point.

SPL magnitude and phase values can be saved to a tab-delimited text (.txt) or frequency response data (.frd) file for use with other loudspeaker

design software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key with any of the Power output options selected. Frequency values increase logarithmically from 10 to 20000 hertz, or from 1 to 2000 hertz.

Electrical impedance magnitude and phase values can be saved to a tab-delimited text (.txt) or impedance response data (.zma) file for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key with any of the Impedance output options selected. Frequency values increase logarithmically from 10 to 20000 hertz, or from 1 to 2000 hertz.

Diaphragm displacement values can be saved to a tab-delimited text (.txt) or comma separated values (.csv) file by either clicking the Export Data button in the Memory window or by pressing the F9 function key with any of the Displacement output options selected. Frequency values increase logarithmically from 10 to 20000 hertz, or from 1 to 2000 hertz.

|Driver Front Volume
~~~~~~~~~~~~~~~~~~~

A stand-alone tool that calculates the effective air volume between the driver diaphragm and the front plane of the driver, given D1 the inside diameter of the mounting sealing strip, D2 the inside diameter of the diaphragm suspension, D3 the diameter of the dust cap, H1 the thickness of the sealing strip, H2 the perpendicular distance from the front plane to the edge of the dust cap, and H3 the perpendicular distance from the front plane to the centre of the dust cap.

The driver front volume calculated by the tool must be manually added to Vtc, it is not added automatically.

Double-click on the front volume value to show front cross-sectional area.

The Tools menu command is enabled when the input parameters window is in edit mode. The tool can also be selected by double-clicking on the Vtc or Atc label or text box in edit mode.

|View Schematic
~~~~~~~~~~~~~~~

Displays the loudspeaker schematic diagram and system volume.

|3-D Wireframe View
~~~~~~~~~~~~~~~~~~

Displays a single segment horn as a three-dimensional wireframe image. Click and drag the mouse to rotate the wireframe. Double-click to reset to the default position.

The Up, Down, Left, Right, Page Up, Page Down, Home and End navigation keys can also be used to rotate the wireframe.

Select from the schematic diagram window.

|Frequency Range
~~~~~~~~~~~~~~~

Changes the chart frequency range from the default setting of 10 to 20000 hertz to 1 to 2000 hertz.

|Sample
~~~~~~~

The Sample menu command can be selected from any default chart window, or by pressing F3 or double-clicking on the chart.

Single-clicking a chart will provide abbreviated data at the frequency given by the mouse pointer location. The sampling frequency can be changed by dragging the red marker line, or by using the Up, Down, Left, Right, Home and End navigation keys. Press the Esc key to release a set frequency point.

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, or between 0.1 and 2000 hertz.

Acoustical power chart ~ Calculates the constant directivity sound pressure level, electrical input power, acoustical output power, power conversion efficiency, horn throat peak sound pressure and horn throat peak particle velocity at any given frequency between 1 and 20000 hertz, or between 0.1 and 2000 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. When the power compression response is sampled the thermal power compression is also shown, expressed in decibels.

Electrical impedance chart ~ Calculates the driver electrical input impedance magnitude and phase at any given frequency between 1 and 20000 hertz, or between 0.1 and 2000 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, or between 0.1 and 2000 hertz.

Phase response chart ~ Calculates the system standard wrapped phase shift or the system corrected phase shift at any given frequency between 1 and 20000 hertz, or between 0.1 and 2000 hertz. When the phase response is sampled by single-clicking the chart, the unwrapped phase shift is also shown.

Group delay chart ~ Calculates the system group delay, equivalent distance travelled and equivalent wavelengths at any given frequency between 1 and 20000 hertz, or between 0.1 and 2000 hertz.

Beam width chart ~ Calculates the directivity pattern -6 dB beam width at any given frequency between 1 and 20000 hertz, or between 0.1 and 2000 hertz.

|Compare
~~~~~~~~

Displays the current and previous or captured acoustical impedance, acoustical power, acoustical pressure, 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.

|Output
~~~~~~~

Calculates the acoustical power output from the front side of the driver, the acoustical power output from the rear side of the driver, or the combined front and rear acoustical power outputs. The chosen output option is retained until changed by the user, or until a different record is selected, at which time the default output option is restored. The default option calculates the combined acoustical power output.

For a direct radiator in a vented-box enclosure loudspeaker system, the Combined output option combines the direct radiator acoustical power output with the port acoustical power output.

The path length from the rear side of the driver diaphragm to the port outlet is assumed to be equal to Lrc plus Lpt, as shown in the schematic diagram.

The distance between the radiating side of the driver diaphragm and the port outlet is specified using the acoustic path length parameter. The acoustic path length is the length of the shortest acoustic path between the two outputs (assumed to be point sources).

For a system with an offset driver and offset port or passive radiator, the acoustic path length is calculated automatically by default. The default value can be manually changed if required by switching the path length slider control option from Auto to Manual.

Press the F9 function key to permanently save the entered path length value.

For a finite damped transmission line enclosure loudspeaker system, the Combined output option combines the transmission line acoustical power output with the direct radiator acoustical power output.

For a finite front-loaded horn loudspeaker system with no rear chamber, the Combined output option combines the horn acoustical power output with the direct radiator acoustical power output.

For a finite back-loaded horn loudspeaker system, the Combined output option combines the horn acoustical power output with the direct radiator acoustical power output. The direct radiator cannot be located inside the horn mouth.

For a finite horn-loaded vented-box enclosure loudspeaker system, the Combined output option combines the horn acoustical power output with the port acoustical power output.

For a finite offset driver horn loudspeaker system, the Combined output option combines the horn acoustical power output with the direct radiator acoustical power output or the port acoustical power output.

For a finite compound horn loudspeaker system, the Combined output option combines the horn 1 acoustical power output with the horn 2 acoustical power output.
~~~~~~~

|Directivity Response
~~~~~~~~~~~~~~~~~~~~

Displays the far-field acoustical pressure at a specified off-axis angle, taking into account the frequency-dependent directional characteristics of the radiating system.

Select from the acoustical power or acoustical pressure chart window. Applicable to direct radiating single drivers, single passive radiators, finite single-segment non-negative flare horns with no throat adaptor, and non-negative flare ports.

|Directivity Pattern
~~~~~~~~~~~~~~~~~~~~

For a specified frequency, displays 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 -6 dB beam width angle is also given. Click on the directivity pattern to show the pressure level and the directivity index at a specified angle. The arrow keys can be used to change the selected angle. For a direct radiating single driver, the value of ka (wave-number k = 2 * Pi * f / c multiplied by piston radius a) is also given.

The directivity pattern can be displayed using either polar or rectangular coordinates.

Select from the acoustical power or acoustical pressure chart window. Applicable to direct radiating single drivers, single passive radiators, finite single-segment non-negative flare horns with no throat adaptor, and non-negative flare ports.

|Directivity Index
~~~~~~~~~~~~~~~~~~

Displays the directivity index in decibels versus frequency in hertz for a specified off-axis angle in degrees. The directivity index is 10 times the logarithm to the base 10 of the directivity factor. The directivity factor is the ratio of the intensity on a designated axis of a sound radiator at a given distance, to the intensity that would be produced at the same position by a point source if it were radiating the same total acoustic power as the radiator.

Click on the chart to show the directivity index value at a specified frequency. The arrow keys can be used to change the selected sample frequency.

Select from the acoustical power or acoustical pressure chart window. Applicable to direct radiating single drivers, single passive radiators, finite single-segment non-negative flare horns with no throat adaptor, and non-negative flare ports.

|Directivity Beam Width
~~~~~~~~~~~~~~~~~~~~~~

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 acoustical power or acoustical pressure chart window. Applicable to direct radiating single drivers, single passive radiators, finite single-segment non-negative flare horns with no throat adaptor, and non-negative flare ports.

|Directivity Polar Map
~~~~~~~~~~~~~~~~~~~~~

Displays the far-field sound pressure at a fixed distance as a function of the off-axis angle in degrees, versus frequency in hertz. Select 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 acoustical power or acoustical pressure chart window. Applicable to direct radiating single drivers, single passive radiators, finite single-segment non-negative flare horns with no throat adaptor, and non-negative flare ports.

|Impulse Response
~~~~~~~~~~~~~~~~~

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 acoustical power or acoustical pressure chart window.

Click the Export button to save the impulse response data values to either a 16-bit integer or 32-bit floating point PCM wave sound file. The 16-bit export file sets the minimum or maximum peak to the maximum value allowed for a 16-bit signed integer, maximising the resolution. The 32-bit export file preserves the magnitude, enabling more meaningful comparisons. Double-click on the dB Offset label to change the value from default rms to peak.

Click the Compare or Clear button or press F4 to show or hide the comparison with the previous result.

|Impulse Spectrogram
~~~~~~~~~~~~~~~~~~~~

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

The spectrogram frequency range is 40 to 10000 hertz when the main chart range setting is 10 to 20000 hertz, and is 4 to 1000 hertz when the main chart range setting is 1 to 2000 hertz.

Select from the acoustical power or acoustical pressure chart window.

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.
~~~~~~~~~~~~~~~~~~~~

|Room Gain Excluded
~~~~~~~~~~~~~~~~~~

Displays the power response with imported room gain data excluded. Not applicable when the 1 to 2000 hertz chart frequency range is selected.

|Room Gain Included
~~~~~~~~~~~~~~~~~~

Displays the power response with imported room gain data included. Not applicable when the 1 to 2000 hertz chart frequency range is selected.

|Room Gain Profile
~~~~~~~~~~~~~~~~~~

Displays the room gain data only. Not applicable when the 1 to 2000 hertz chart frequency range is selected.

|Maximum SPL
~~~~~~~~~~~~

Displays the maximum sound pressure level in decibels that can be achieved at 1 metre without exceeding the amplifier maximum output power Pamp, the amplifier maximum output voltage Vamp, the amplifier maximum output current Iamp, the driver rated thermal limited electrical input power Pmax, or the diaphragm linear mean-to-peak displacement limit Xmax, versus frequency in hertz. One or more of the above input parameter options can be selected by double-clicking on the On / Off labels.

Press the F9 function key to permanently save the entered Pamp, Vamp, Iamp, Pmax and Xmax values.

|Power Compression
~~~~~~~~~~~~~~~~~~

Displays the thermal power compression response for a given driver input voltage and voice coil temperature, taking into account the increase in voice coil resistance due to the coil being heated above the standard reference value of 20 degrees Celsius.

The value of the increased voice coil resistance due to heating is displayed in the status bar panel at the bottom of the input parameters window when the mouse pointer is moved over the Re text box.

The design maximum voice coil temperature for a driver is typically about 200 degrees Celsius. The Re input parameter value is assumed to be the resistance of the voice coil at 20 deg C.

In most cases the specified driver voice coil temperature will be an estimate only, due to the difficulty in determining the actual precise temperature. The response results should therefore be taken as indicative and not exact.

|Multiple Speakers
~~~~~~~~~~~~~~~~~~

Displays the acoustical power output response of a given multiple loudspeaker array connected to a single amplifier.

|Filter Wizard

Automatically re-calculates the results for a specified filter system in real time, as input parameter values are changed. The Le Cléac'h high pass passive filter option provides for two-stage impedance equalisation and high frequency uplift.

The tool can be accessed from the acoustical power, electrical impedance, diaphragm displacement, phase response or group delay window.

Click the On button to include the current active and parametric equaliser, passive, or Le Cléac'h filter settings when calculating results. Click the Off button to exclude the filter settings.

The Filter Wizard is not applicable when the Vel constant diaphragm velocity or Acc constant diaphragm acceleration option is selected, when the Maximum SPL tool is being used, or when a room gain profile is displayed.

Select the Schematic option to display the network schematic diagram of the specified passive filter.

Select the Power or Pressure option to display the acoustical power or acoustical pressure of the specified passive or active filter and loudspeaker system.

Double-click anywhere on the power or pressure chart Y-axis vertical SPL scale to switch from the default 5 dB increments to either 3 dB or 6 dB increments.

Select the Impedance option to display the magnitude of the electrical input impedance of the specified passive filter and loudspeaker system.

Select the Displacement option to display the driver diaphragm displacement of the specified passive or active filter and loudspeaker system.

Select the Phase option to display the phase response of the specified passive or active filter and loudspeaker system.

Select the Delay option to display the group delay or group delay per period of the specified filter and loudspeaker system.

Double-click anywhere on the group delay chart to switch to the group delay per period chart. Double-click anywhere on the group delay per period chart to switch back to the group delay chart.

Double-click anywhere on the group delay per period chart Y-axis vertical scale to switch the chart range from the default 1 cycle to either 2 cycles, 5 cycles, 10 cycles or 20 cycles.

With the group delay or group delay per period chart displayed, press the L key to add a green 1/f limit guideline. Press the L key again to add a red Claus Futtrup limit guideline. Press the L key a third time to remove the 1/f limit guideline and press the L key a fourth time to remove the Claus Futtrup limit guideline.

The Claus Futtrup audible group delay threshold limit guideline in milliseconds is given by the expression:

GDlimit = 1000 * 1.1606 / (5.6413 * f ^ 0.81511 - f)

Where f is the frequency in hertz.

System group delay has two parts, a linear phase part which is a pure propagation time delay, and an excess group delay part which results from rapid phase shifts.

Because the limit guidelines apply to the excess group delay part of the system group delay only, the limit values shown on the group delay and group delay per period charts have the propagation time delay part added as an offset adjustment.

Select the Impulse option to display the impulse response of the specified filter and loudspeaker system. Not applicable when the Filter Wizard is activated from the Loudspeaker Wizard, or when room gain is included.

When the Filter Wizard is activated from the Loudspeaker Wizard, select the Port Velocity option to display the particle velocity at the outlet end of the port tube in a bass-reflex system, or the Mouth Velocity option to display the particle velocity at the mouth end of a horn or transmission line system.

Select the Filter Gain option to display the gain response of the specified filter.

Select the Filter Phase option to display the phase response of the specified filter.

Select the Filter Delay option to display the group delay of the specified filter.

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

Pressing Ctrl+C when the power or pressure response chart is displayed captures the current results. Pressing Ctrl+V shows or hides previously captured results.

Press the V key to instantly check the passive or Le Cléac'h filter network schematic diagram. Release the V key to immediately return to the previously displayed chart.

To change the components in the branch of a standard 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 switch a parametric equaliser filter band on or off, double-click on the On / Off label for that band. To select either a peaking EQ filter, a low shelving filter, a high shelving filter, a low pass filter or a high pass filter for a given band, double-click on the filter label for that band. Press the Esc key to hide the green frequency marker.

In some parametric equaliser software packages the shelving filter 'Q Factor' is actually S, a "shelf slope" parameter. The relationship between Q and S is given by the expression:

S = 1 / (((1 / Q) ^ 2 - 2) / (10 ^ (G / 40) + 1 / (10 ^ (G / 40))) + 1)

Where:

S = shelf slope parameter
Q = Q factor
G = gain

If the Active or Equaliser filter option is selected, current active and parametric equaliser filter settings (but not passive or Le Cléac'h settings) can be saved to the permanent data record by clicking the Save button in the Memory window, or by pressing the F8 function key.

If the Passive or Le Cléac'h filter option is selected, current active, passive and Le Cléac'h filter settings (but not parametric equaliser settings) can be saved to the permanent data record by clicking the Save button in the Memory window, or by pressing the F8 function key.

To change the frequency range, double-click on the chart frequency label. Not applicable when absorbent filling material is included in the loudspeaker system.

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 quickly move through a slider control value range, press and hold the Home or End key while the slider 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. Current slider control settings and chart results for the currently selected filter can be saved as a new baseline by pressing Ctrl+Alt+B.

Click the Reset button in the Memory window or press the Ctrl+F8 function keys to reset current settings back to the saved settings. Press the F5 function key to restore all slider controls to their initial default settings.

When the Filter Wizard is activated from the Loudspeaker Wizard, SPL magnitude and phase values can be saved to a tab-delimited text (.txt) or frequency response data (.frd) file for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key with the Power output option selected. Frequency values increase logarithmically.

When the Filter Wizard is activated from the Loudspeaker Wizard, Diaphragm displacement values can be saved to a tab-delimited text (.txt) or comma separated values (.csv) file by either clicking the Export Data button in the Memory window or by pressing the F9 function key with the Displacement output option selected. Frequency values increase logarithmically.

|Efficiency
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Displays the acoustical output power divided by the electrical input power, or power conversion efficiency, in percent versus frequency in hertz. Does not include the effect of filters. Click on the chart to show the efficiency value at a specified frequency.
~~~~~~~~~~

Select from the acoustical power 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.

|Driver Power
~~~~~~~~~~~~

Displays the driver electrical input power in watts versus frequency in hertz. Click on the chart to show the power value at a specified frequency. In a multiple speaker and/or multiple driver system the power delivered to each driver is shown, rather than the total power delivered to all drivers.

Select from the acoustical power 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
~~~~~~~~~~~~~~

Displays the peak sound pressure at the horn throat, horn mouth, port inlet, port outlet or direct radiator in pascals versus frequency in hertz. For a multiple-segment Nd or CH horn without stepped segments the peak sound pressure is also shown at the point of minimum cross-sectional area, and for a CH2 horn without stepped segments it is also shown at S4 in Horn 2.

Click on the chart to show the sound pressure value at a specified frequency. The throat of an OD offset driver or tapped horn is at S2. The throat of an OD1 offset driver horn is at S3.

For an offset driver or tapped horn, the throat sound pressure is calculated at the S2 or S3 throat when there is no throat chamber, at the horn side of the throat chamber when there is a throat chamber but no throat port, and at the horn end of the throat port when there is a throat chamber and a throat port.

Select from the acoustical power chart window. Not applicable to combined outputs.

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
~~~~~~~~~~~~~~~~~

Displays the peak particle velocity at the horn throat, horn mouth, port inlet, port outlet or direct radiator in metres per second versus frequency
~~~~~~~~~~~~~~~~~

in hertz. For a multiple-segment Nd or CH horn without stepped segments the peak particle velocity is also shown at the point of minimum cross-sectional area, and for a CH2 horn without stepped segments it is also shown at S4 in Horn 2.

Click on the chart to show the particle velocity value at a specified frequency. The throat of an OD offset driver or tapped horn is at S2. The throat of an OD1 offset driver horn is at S3.

For an offset driver or tapped horn, the throat particle velocity is calculated at the S2 or S3 throat when there is no throat chamber, at the horn side of the throat chamber when there is a throat chamber but no throat port, and at the horn end of the throat port when there is a throat chamber and a throat port.

Select from the acoustical power chart window. Not applicable to combined outputs.

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
~~~~~~

When selected from the acoustical impedance chart window, sets the acoustical impedance chart range.

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.

|Impedance Phase
~~~~~~~~~~~~~~~~

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

Select from the electrical impedance 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.

|Diaphragm Pressure
~~~~~~~~~~~~~~~~~~

Displays the peak sound pressure at the driver diaphragm in pascals versus frequency in hertz. Click on the chart to show the pressure and force at a specified frequency. Total pressure is the difference between the pressures on the front and rear sides of the diaphragm with phase taken into account.
~~~~~~~~~~~~~~~~~~

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
~~~~~~~~~

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.

|Unwrapped Phase
~~~~~~~~~~~~~~~~

Displays the unwrapped phase response in degrees versus frequency in hertz. Click on the chart to show the phase value at a specified frequency. The unwrapped results for systems with large phase shifts can become unreliable at high frequencies, due to phase aliasing caused by under sampling.

Select from the phase 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.

|Throat Adaptor Designer
~~~~~~~~~~~~~~~~~~~~~~

A stand-alone tool that displays the flare profile of a horn throat adaptor transition element, given D1 the entry diameter, D2 the exit diameter, A1 the entry flare tangent angle and A2 the exit flare tangent angle. The minimum length element is calculated. The profile data can be exported.

|Wavefront Simulator
~~~~~~~~~~~~~~~~~~~

Models sound wave propagation in horn loudspeakers. Isophase wavefronts are shown. A warning message is displayed if the specified resolution, frequency, element size and window size slider settings would generate inaccurate results due to aliasing effects.

The current record cannot be opened in the wavefront simulator if stepped segments have been specified.

To add or delete walls, click or drag the mouse with the 'Mouse = Edit System' option selected, or click the mouse then use the Up, Down, Left and Right navigation keys.

To specify a straight wall, Shift+click the mouse at the line end points.

To specify a rectangular walled box enclosure, Ctrl+click the mouse at the diagonal corners.

To specify a standard point source, Alt+click the mouse twice at the same location.

To specify a reverse polarity point source, a time-delayed point source, or the acoustical output power of a point source relative to the default value, Alt+click the mouse at the proposed source location, select the reverse polarity check box, set the power and delay slider controls to the desired values, and then Alt+click the mouse again at the proposed source location. Moving the mouse pointer over a point source displays the selected polarity, power and delay settings in the caption bar at the top of the tool. Default settings are not shown.

To delete a point source, click the mouse over the source.

To specify a standard driver source, Alt+click the mouse at the diaphragm end points.

To specify a reverse polarity driver source, a time-delayed driver source, or the acoustical output power of a driver source relative to the default value, Alt+click the mouse at the diaphragm first end point, select the reverse polarity check box, set the power and delay slider controls to the desired values, and then Alt+click the mouse at the diaphragm second end point. Moving the mouse pointer over a driver source displays the selected polarity, power and delay settings in the caption bar at the top of the tool. Default settings are not shown.

To delete a driver source, click and drag the mouse over the source.

By default the delay slider control is calibrated in delay distance in grid elements. To change the calibration scale of the delay slider,

double-click on the delay value to select delay time in milliseconds, delay distance in centimetres or delay phase angle in degrees.

For custom designs, double-click on the element size slider label to switch to window size.

Custom designs can be permanently saved by selecting the 'Save Current Design' option. Saved designs can be opened by selecting the 'Open Saved Design' option.

Custom and imported designs are retained when the resolution slider setting is changed. Systems can be drawn using one resolution and analysed using another. The window size is re-scaled automatically.

|Options
~~~~~~~~

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

~~~~~~
|FILE MENU
~~~~~~

|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.

|Undo
~~~~~

Rolls back changes made to current record input parameters window values and settings, with the exception of changes generated using the Multiple Entry Horn Wizard.

|Redo
~~~~~

Rolls forward previously undone changes made to current record input parameters window values and settings.

|Copy Driver
~~~~~~~~~~~~

Copies driver parameter values from the current record to the Clipboard.

|Paste Driver

~~~~~~

~~~~~~~~~~~~~~

Pastes driver parameter values from the Clipboard to the current record.

The File menu command is enabled when the input parameters window is in edit mode.

|Copy Driver to Database
~~~~~~~~~~~~~~~~~~~~~~~~

Copies driver parameter values from the current record to the driver database.

Not applicable to the default record.

|Paste Driver from Database
~~~~~~~~~~~~~~~~~~~~~~~~~~~

Pastes driver parameter values from the driver database to the current record.

The File menu command is enabled when the input parameters window is in edit mode. The menu command can also be selected by right-clicking any driver parameter label in edit mode.

|Find
~~~~~

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
~~~~~

Sorts records in comment-ascending alphanumeric order.

|Import Hornresp Record
~~~~~~~~~~~~~~~~~~~~~~

Loads input parameter data values from an exported record file.

|Import Room Gain Profile
~~~~~~~~~~~~~~~~~~~~~~~~

Loads room gain profile data values from a text (.txt) or frequency response data (.frd) file.

The file must not contain any header or footer comment records.

File data records must be listed sequentially in order of increasing frequency, with the first field in each record being the frequency value, and the second field being the room gain value. Additional record fields, and any records outside the frequency range 10 to 20000 hertz, are disregarded. Room gain values must be relative to a zero decibel reference point.

Fields in a record can be space or tab delimited, and field values can have either a period or a comma as the decimal separator.
~~~~~~~~~~~~~~~~~~~~~~~~

|Export Hornresp Record
~~~~~~~~~~~~~~~~~~~~~~

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

Currently saved filter settings are exported.

|Export AkAbak Script
~~~~~~~~~~~~~~~~~~~~

Saves current record input parameter data values to an AkAbak Version 2.1 script file. Record must be valid. Select from the input parameters window.

Scripts cannot be exported for stepped segment, open baffle, PH1, PH2, PH3, PH4, ME1, ME2, BP4, BP6, BP8, BPA, BPB, BPC, DBR or ABC records.

|Export Horn Data
~~~~~~~~~~~~~~~~

Saves schematic diagram data values to a tab-delimited text (.txt) or comma separated values (.csv) file. Select from the schematic diagram window.

Horn data cannot be exported if stepped segments have been specified.

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.

Click the Preview button to show the diameter profile for an axisymmetric horn, the width and height profiles for a rectangular horn, and the petal profile for a petal horn.

Width Flare Con ~ Rectangular cross-section horn segment width changes linearly with axial length. The height at any point equals the cross-sectional area divided by the width at that point.

Width Flare Exp ~ Rectangular cross-section horn segment width changes exponentially with axial length. The height at any point equals the cross-sectional area divided by the width at that point.

Width Flare Uni ~ Rectangular cross-section horn segment cross-sectional area aspect ratio changes uniformly with axial length.

Width Flare can be changed to Height Flare by double-clicking on the flare label.

The flat profile of the left and right side walls of a rectangular cross-section horn can be determined by plotting the schematic diagram exported Height / 2 half-height 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 half-width 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 previewed and exported if required by selecting the Exact Profile option.

For a compound horn, only the horn 1 data can be previewed and exported.

|Export All Chart Data
~~~~~~~~~~~~~~~~~~~~~

Saves data values for all calculated charts to a tab-delimited text (.txt) or comma separated values (.csv) file. Frequency values increase logarithmically from 10 to 20000 hertz, or from 1 to 2000 hertz. Select from any chart window. In a multiple speaker and/or multiple driver system, Pin is the total electrical input power delivered to all drivers.

|Export Za + Phase
~~~~~~~~~~~~~~~~~~

Saves horn throat acoustical impedance magnitude and phase values to a tab-delimited text (.txt) or comma separated values (.csv) file for use with other loudspeaker design software tools. Frequency values increase logarithmically from 10 to 20000 hertz, or from 1 to 2000 hertz. Select from the acoustical impedance window.

|Export SPL + Phase
~~~~~~~~~~~~~~~~~~~

Saves SPL magnitude and phase values to a tab-delimited text (.txt) or frequency response data (.frd) file for use with other loudspeaker design software tools. Frequency values increase logarithmically from 10 to 20000 hertz, or from 1 to 2000 hertz. Select from the acoustical power or acoustical pressure window.

|Export Ze + Phase
~~~~~~~~~~~~~~~~~~

Saves electrical impedance magnitude and phase values to a tab-delimited text (.txt) or impedance response data (.zma) file for use with other loudspeaker design software tools. Frequency values increase logarithmically from 10 to 20000 hertz, or from 1 to 2000 hertz. Select from the electrical impedance window.

|Print
~~~~~~

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

The schematic diagram cannot be printed if stepped segments have been specified.

|Exit
~~~~~

Closes the Hornresp application.

~~~~~~
|HELP MENU

~~~~~~

~~~~~~

|Hornresp Help
~~~~~~~~~~~~~~

Hornresp help file. Can be selected from any window by pressing the F1 function key and if required can be converted to a text file by renaming the .hlp extension as .txt.

|Input Wizard
~~~~~~~~~~~~~

Enables a loudspeaker system to be specified by selecting from a set of context-sensitive options, and for the input parameter values of a representative example of the specified loudspeaker to be automatically generated. The design template produced by the wizard can be customised as required, by the user.

Press the Home key to return to the first page of the wizard. The wizard can be selected from the input parameters window by pressing the F7 function key.

|About Hornresp
~~~~~~~~~~~~~~~

Hornresp version and product number, and licence and copyright details.

~~~~~~
|LOUDSPEAKER MODELS
~~~~~~

|Unbaffled Direct Radiator
~~~~~~~~~~~~~~~~~~~~~~~~~~

Set S1 = Sd x number of drivers and S2 to L45 = 0.

By default, the combined diaphragm side 1 plus diaphragm side 2 acoustical power output is calculated. The Output tool can be used to determine the diaphragm side 1 output or the diaphragm side 2 output.

The acoustic path length is calculated automatically, and is the length of the shortest acoustic path between the two acoustic centres of the dipole system. The acoustic centres are assumed to be point sources.

|Direct Radiator in an Infinite Baffle
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Set Ang = 2 x Pi, S1 to L45 = 0 and Vrc and/or Lrc = 0.

|Direct Radiator in a Flat Open Baffle
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Set S1 = baffle area and S2 to L45 = 0.

By default, the combined diaphragm side 1 plus diaphragm side 2 acoustical power output is calculated. The Output tool can be used to determine the diaphragm side 1 output or the diaphragm side 2 output.

The acoustic path length is calculated automatically, and is the length of
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

the shortest acoustic path between the two acoustic centres of the dipole system. The acoustic centres are assumed to be point sources.

|Direct Radiator in a H-Frame or U-Frame Open Baffle

Select the CH loudspeaker configuration option and set S1 = S2 = S5 = S6, Vrc and/or Lrc = 0 and Vtc and/or Atc = 0.

To specify a U-frame system set either L12 or L56 = 0.1.

To specify a direct radiator in a flat open baffle set L12 and L56 = 0.1.

To specify an unbaffled direct radiator set L12 and L56 = 0.1 and S1, S2, S5 and S6 = Sd x number of drivers.

By default, the combined diaphragm side 1 plus diaphragm side 2 acoustical power output is calculated. The Output tool can be used to determine the diaphragm side 1 output or the diaphragm side 2 output.

The acoustic path length is calculated automatically, and is the length of the shortest acoustic path between the two acoustic centres of the dipole system. The acoustic centres are assumed to be point sources.

|Ripole Folded Open Baffle

Select the Offset Driver OD2 option from the Loudspeaker Configuration tool.

The default acoustic path length is calculated automatically, and is the length of the shortest acoustic path between the two acoustic centres of the dipole system. The acoustic centres are assumed to be point sources.

The acoustic path length can also be set manually to any other value if required.

|Closed-Box With Inline Driver

Select the Normal Nd option from the Loudspeaker Configuration tool and the Rear Lined option from the Chamber Type tool. Set S1 to L45 = 0 and Vrc and Lrc > 0.

To specify acoustical lining material in the enclosure set Fr and Tal > 0.

|Closed-Box With Inline Driver and Passive Radiator

Select the Normal Nd option from the Loudspeaker Configuration tool and the Passive Radiator option from the Chamber Type tool. Set S1 to L45 = 0 and Vrc and Lrc > 0.

By default, the combined direct radiator plus passive radiator acoustical power output is calculated. The Output tool can be used to determine the direct radiator output or the passive radiator output.

Double-click on the Mmp label to specify the mass in grams to be added to each passive radiator diaphragm in the system. The Loudspeaker Wizard tool can also be used to specify added mass.

The input parameters window Mmp label changes to red when mass is added, and the value of the mass added to each passive radiator diaphragm can be seen in the bottom status bar panel by moving the mouse pointer over the Mmp label or text box.

|Closed-Box With Offset Driver
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Select the Offset Driver OD option from the Loudspeaker Configuration tool. Specify two segments and double-click on the Cir or Fta label in edit mode to select the Clo closed horn mouth option. Set Vrc, Lrc, Vtc and Atc = 0.

Use the Loudspeaker Wizard to add absorbent filling material to horn segments as required.

Set L12 = 0.01 cm if the driver is not offset.

|Closed-Box With Offset Driver and Stub
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Select the Offset Driver OD option from the Loudspeaker Configuration tool and specify at least three segments, or select the Offset Driver OD1 option and specify four segments. Double-click on the Cir or Fta label in edit mode to select the Clo closed horn mouth option. Set Vrc, Lrc, Vtc and Atc = 0. Specify the stub using Ap1 and Lp.

Double-click on the Loudspeaker Wizard L34 slider value to prevent it from changing when the L23 slider is adjusted. Double-click on the value again to restore normal operation. Applicable to three segment systems only.

|Closed-Box With Offset Driver and Passive Radiator
~~~~~~

Select the Offset Driver OD option from the Loudspeaker Configuration tool and the Passive Radiator option from the Chamber Type tool. Specify at least three segments and double-click on the Cir or Fta label in edit mode to select the Clo closed horn mouth option. Set Vrc and Lrc = 0.

Double-click on the Loudspeaker Wizard L34 slider value to prevent it from changing when the L23 slider is adjusted. Double-click on the value again to restore normal operation. Applicable to three segment systems only.

The acoustic path length is calculated automatically by default, and is the length of the shortest acoustic path between the two acoustic centres of the dipole system. The acoustic centres are assumed to be point sources. The default value can be manually changed if required by switching the path length slider control option from Auto to Manual.

|Closed-Box With Closed Rear Chamber and Offset Driver and Passive Radiator
~~~~~~

Select the Offset Driver OD option from the Loudspeaker Configuration tool and the Passive Radiator option from the Chamber Type tool. Specify at least three segments and double-click on the Cir or Fta label in edit mode to select the Clo closed horn mouth option. Specify the closed rear chamber using Vrc and Lrc.

Double-click on the Loudspeaker Wizard L34 slider value to prevent it from changing when the L23 slider is adjusted. Double-click on the value again

to restore normal operation. Applicable to three segment systems only.

|Vented-Box With Inline Driver and Port

Select the Normal Nd option from the Loudspeaker Configuration tool and the Rear Vented option from the Chamber Type tool. Set S1 to L45 = 0 and Vrc, Lrc, Ap and Lpt > 0.

By default, the combined direct radiator plus port acoustical power output is calculated. The Output tool can be used to determine the direct radiator output or the port output.

An inner end correction is added to the Lpt rear chamber port tube length where appropriate. If an end correction is added the Helmholtz resonance frequency of the specified system can be seen in the bottom status bar panel by moving the mouse pointer over the Ap label or text box. The port tube air mass and end correction length can be seen by moving the mouse pointer over the Lpt label or text box.

Vented-box enclosure system losses are taken into account using the QL quality factor parameter. The default value is 7 but the value can be adjusted between 1 and 99 by double-clicking on the input parameters window QL or Lossless label in edit mode. The value can also be adjusted using the QL slider control in the Chamber section of the Loudspeaker Wizard. If the Loudspeaker Wizard slider is set to the maximum position, the true lossless model is selected. If the slider QL label is double-clicked, the control is reset to the default value of 7. The QL parameter reverts to the default value of 7 when a different record is selected or a new record is added.

|Vented-Box With Offset Driver and Port

Select the Offset Driver OD option from the Loudspeaker Configuration tool and specify at least three segments, or select the Offset Driver OD1 option and specify four segments. Double-click on the Cir or Fta label in edit mode to select the Clo closed horn mouth option. Set Vtc = 0. Specify the offset port using Ap and Lpt.

An inner end correction is added to the Lpt offset port tube length. The port tube air mass and end correction length can be seen by moving the mouse pointer over the Lpt label or text box.

Double-click on the Lpt label in edit mode to specify a flared port tube. Ap is the tube mouth cross-sectional area, Apt is the tube throat cross-sectional area and Lpt is the tube length.

Double-click on the Loudspeaker Wizard L34 slider value to prevent it from changing when the L23 slider is adjusted. Double-click on the value again to restore normal operation. Applicable to three segment systems only.

The acoustic path length is calculated automatically by default, and is the length of the shortest acoustic path between the two acoustic centres of the dipole system. The acoustic centres are assumed to be point sources. The default value can be manually changed if required by switching the path length slider control option from Auto to Manual.

Vented-box enclosure system losses are taken into account using the QL quality factor parameter. Refer to the Vented-Box With Inline Driver and

Port section for further information on the QL parameter.

|Vented-Box With Closed Rear Chamber and Offset Driver and Port
~~~~~~

Select the Offset Driver OD option from the Loudspeaker Configuration tool and specify at least three segments, or select the Offset Driver OD1 option and specify four segments. Double-click on the Cir or Fta label in edit mode to select the Clo closed horn mouth option. Set Vtc = 0. Specify the offset port using Ap and Lpt and the closed rear chamber using Vrc and Lrc.

An inner end correction is added to the Lpt offset port tube length. The port tube air mass and end correction length can be seen by moving the mouse pointer over the Lpt label or text box.

Double-click on the Lpt label in edit mode to specify a flared port tube. Ap is the tube mouth cross-sectional area, Apt is the tube throat cross-sectional area and Lpt is the tube length.

Double-click on the Loudspeaker Wizard L34 slider value to prevent it from changing when the L23 slider is adjusted. Double-click on the value again to restore normal operation. Applicable to three segment systems only.

|Fourth Order Band Pass Enclosure
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Select the BP4 option from the Loudspeaker Configuration tool or press the Ctrl key and double-click on the ME2 label in edit mode to set the BP4 flag.

Press the Ctrl key and double-click on the Fr label to specify a passive radiator. Press the Ctrl key and double-click on the Sp1 label to specify multiple passive radiators. Double-click on the Sp1 to Sp9 label to restore the default Fr label.

Double-click on the Mmp label to specify the mass in grams to be added to each passive radiator diaphragm.

To replace an externally-vented port tube with a specified passive radiator, double-click on the Ap1, Ap2 or Ap3 label for that port. The label name changes to PR and the unused port tube text boxes are disabled.

To select the alternative externally-vented port in a BP6P, BPA, BPC or ABC system, double-click on the Ap label for that other port.

To select the internal port in a BPB, BPC or DBR system, double-click on the Ap1 label.

To remove a passive radiator and restore the port tube, double-click on the PR label in edit mode.

Press F5 or click the Wizard button to open the Loudspeaker Wizard. Set the chamber, port, amplifier and filter slider control values by moving the sliders or by directly keying in the value and then pressing Enter while the control has the focus.

Sliders Lo1 and Lo2 specify the position of an offset driver. The default Manual option enables the offset in each chamber to be adjusted separately. Double-clicking on the Manual option selects the Auto option. If the Auto option is selected, setting the value of one offset slider automatically

sets the other to the same value.

System dimensions for a given passband ripple and sensitivity can be automatically calculated by selecting the Other input option, double-clicking the Auto Off label and specifying the desired ripple magnitude and sensitivity.

Acoustical power, electrical impedance and driver diaphragm displacement values can be exported for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key, while the relevant chart is displayed.

The enclosure is modelled as shown in the schematic and system model diagrams. Refer to the Loudspeaker Wizard section for details of the system model element codes.

|Sixth Order Series or Parallel Band Pass Enclosure

Select the BP6S (series) or BP6P (parallel) option from the Loudspeaker Configuration tool or press the Ctrl key and double-click on the BP4 label in edit mode to set the BP6 flag.

Refer to the Fourth Order Band Pass Enclosure section for information on how to specify a passive radiator in a BP6 system.

A series band pass enclosure is specified by default. Double-click on the red 'Series band pass' label in edit mode to change to a parallel band pass enclosure.

Press F5 or click the Wizard button to open the Loudspeaker Wizard. Set the chamber, port, amplifier and filter slider control values by moving the sliders or by directly keying in the value and then pressing Enter while the control has the focus.

Double-click on the 'Series' or 'Parallel' label just below the port sliders to change the enclosure type. Not applicable when port 2 has been specified as a passive radiator in a parallel band pass enclosure.

Set the Ap2 slider to zero to remove port tube 2 and simplify the enclosure to a BP4 alignment. Not applicable when a passive radiator is specified.

Double-click on the Lp2 slider in a BP6S enclosure to specify port tube 2 unflanged at both ends.

Sliders Lo1 and Lo2 specify the position of an offset driver. The default Manual option enables the offset in each chamber to be adjusted separately. Double-clicking on the Manual option selects the Auto option. If the Auto option is selected, setting the value of one offset slider automatically sets the other to the same value.

When calculating the combined power response of a BP6P system, the outputs from port 1 and port 2 are assumed to be point sources, separated by the specified acoustic Path length.

Acoustical power (BP6S), total acoustical power (BP6P), electrical impedance and driver diaphragm displacement values can be exported for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key, while the relevant chart is displayed.

The enclosure is modelled as shown in the schematic and system model diagrams. Refer to the Loudspeaker Wizard section for details of the system model element codes.

|Eighth Order Series or Parallel Band Pass Enclosure
~~~~~~

Select the BP8S (series) or BP8P (parallel) option from the Loudspeaker Configuration tool or press the Ctrl key and double-click on the BP6 label in edit mode to set the BP8 flag.

Refer to the Fourth Order Band Pass Enclosure section for information on how to specify a passive radiator in a BP8 system.

A series band pass enclosure is specified by default. Double-click on the red 'Series band pass' label in edit mode to change to a parallel band pass enclosure.

Press F5 or click the Wizard button to open the Loudspeaker Wizard. Set the chamber, port, amplifier and filter slider control values by moving the sliders or by directly keying in the value and then pressing Enter while the control has the focus.

Double-click on the 'Series' or 'Parallel' label just below the port sliders to change the enclosure type.

Double-click on the Lp2 slider in a BP8S enclosure to specify port tube 2 unflanged at both ends.

Acoustical power, electrical impedance and driver diaphragm displacement values can be exported for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key, while the relevant chart is displayed.

The enclosure is modelled as shown in the schematic and system model diagrams. Refer to the Loudspeaker Wizard section for details of the system model element codes.

|Type A Band Pass Enclosure
~~~~~~~~~~~~~~~~~~~~~~~~~

Select the BPA option from the Loudspeaker Configuration tool or press the Ctrl key and double-click on the BP8 label in edit mode to set the BPA flag.

Refer to the Fourth Order Band Pass Enclosure section for information on how to specify a passive radiator in a BPA system.

Press F5 or click the Wizard button to open the Loudspeaker Wizard. Set the chamber, port, amplifier and filter slider control values by moving the sliders or by directly keying in the value and then pressing Enter while the control has the focus.

When calculating the combined power response, the outputs from port 1 and port 2 are assumed to be point sources, separated by the specified acoustic Path length.

Total acoustical power, electrical impedance and driver diaphragm displacement values can be exported for use with other loudspeaker design

software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key, while the relevant chart is displayed.

The enclosure is modelled as shown in the schematic and system model diagrams. Refer to the Loudspeaker Wizard section for details of the system model element codes.

|Type B Band Pass Enclosure

Select the BPB option from the Loudspeaker Configuration tool or press the Ctrl key and double-click on the BPA label in edit mode to set the BPB flag.

Refer to the Fourth Order Band Pass Enclosure section for information on how to specify a passive radiator in a BPB system.

Press F5 or click the Wizard button to open the Loudspeaker Wizard. Set the chamber, port, amplifier and filter slider control values by moving the sliders or by directly keying in the value and then pressing Enter while the control has the focus.

Acoustical power, electrical impedance and driver diaphragm displacement values can be exported for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key, while the relevant chart is displayed.

The enclosure is modelled as shown in the schematic and system model diagrams. Refer to the Loudspeaker Wizard section for details of the system model element codes.

|Type C Band Pass Enclosure

Select the BPC option from the Loudspeaker Configuration tool or press the Ctrl key and double-click on the BPB label in edit mode to set the BPC flag.

Refer to the Fourth Order Band Pass Enclosure section for information on how to specify a passive radiator in a BPC system.

Press F5 or click the Wizard button to open the Loudspeaker Wizard. Set the chamber, port, amplifier and filter slider control values by moving the sliders or by directly keying in the value and then pressing Enter while the control has the focus.

When calculating the combined power response, the outputs from port 2 and port 3 are assumed to be point sources, separated by the specified acoustic Path length.

Total acoustical power, electrical impedance and driver diaphragm displacement values can be exported for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key, while the relevant chart is displayed.

The enclosure is modelled as shown in the schematic and system model diagrams. Refer to the Loudspeaker Wizard section for details of the system model element codes.

|Double Bass Reflex Enclosure

Select the DBR option from the Loudspeaker Configuration tool or press the Ctrl key and double-click on the BPC label in edit mode to set the DBR flag.

Refer to the Fourth Order Band Pass Enclosure section for information on how to specify a passive radiator in a DBR system.

Press F5 or click the Wizard button to open the Loudspeaker Wizard. Set the chamber, port, amplifier and filter slider control values by moving the sliders or by directly keying in the value and then pressing Enter while the control has the focus.

When calculating the combined power response, the outputs from the direct radiating side of the driver diaphragm and port 2 are assumed to be point sources, separated by the specified acoustic Path length.

Total acoustical power, electrical impedance and driver diaphragm displacement values can be exported for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key, while the relevant chart is displayed.

The enclosure is modelled as shown in the schematic and system model diagrams. Refer to the Loudspeaker Wizard section for details of the system model element codes.

|Aperiodic Bi-Chamber Enclosure

Select the ABC option from the Loudspeaker Configuration tool or press the Ctrl key and double-click on the DBR label in edit mode to set the ABC flag.

Refer to the Fourth Order Band Pass Enclosure section for information on how to specify a passive radiator in an ABC system.

Press F5 or click the Wizard button to open the Loudspeaker Wizard. Set the chamber, port, amplifier and filter slider control values by moving the sliders or by directly keying in the value and then pressing Enter while the control has the focus.

Double-click on the Path slider label to change from the default setting of D - P1P2 to either P1 - DP2 or P2 - DP1.

D - P1P2 ~ Shortest distance from the direct radiating side of the driver diaphragm to the co-located outputs of port 1 and port 2. When calculating the combined power response, the driver diaphragm output and combined port 1 and port 2 output are assumed to be two point sources, separated by the specified acoustic Path length.

P1 - DP2 ~ Shortest distance from the output of port 1 to the co-located outputs of the direct radiating side of the driver diaphragm and port 2. When calculating the combined power response, the port 1 output and combined driver diaphragm and port 2 output are assumed to be two point sources, separated by the specified acoustic Path length.

P2 - DP1 ~ Shortest distance from the output of port 2 to the co-located outputs of the direct radiating side of the driver diaphragm and port 1. When calculating the combined power response, the port 2 output and combined driver diaphragm and port 1 output are assumed to be two point sources, separated by the specified acoustic Path length.

Total acoustical power, electrical impedance and driver diaphragm displacement values can be exported for use with other loudspeaker design software tools by either clicking the Export Data button in the Memory window or by pressing the F9 function key, while the relevant chart is displayed.

The enclosure is modelled as shown in the schematic and system model diagrams. Refer to the Loudspeaker Wizard section for details of the system model element codes.

|Damped Transmission Line Enclosure
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Select the OD or OD1 offset driver option and use the Loudspeaker Wizard to add absorbent filling material to horn segments as required.

Set L12 = 0.01 cm if the driver is not offset.

By default, the combined transmission line plus direct radiator acoustical power output is calculated. The Output tool can be used to determine the transmission line output or the direct radiator output.

|Damped Transmission Line Enclosure With Mass Loading
~~~~~~

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).

|Damped Transmission Line Enclosure With Offset Port
~~~~~~

Specify at least three segments, select the OD offset driver option and double-click on the Cir or Fta label in edit mode to select the Clo closed horn mouth option. Set Vrc, Lrc, Vtc and Atc = 0. Specify the port using Ap and Lpt.

Double-click on the Loudspeaker Wizard L34 slider value to prevent it from changing when the L23 slider is adjusted. Double-click on the value again to restore normal operation. Applicable to three segment systems only.

|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 Type 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 Type tool and set Ap1, Lp, Vtc and Atc > 0. Double-click on the Lp label in edit mode or press C, E or P when the Lp text box has the focus to specify a conical,

cylindrical, exponential or parabolic flare throat adaptor.

By default, if no rear chamber is specified, the combined horn plus direct radiator acoustical power output is calculated. The Output tool can be used to determine the horn output or the direct radiator output.

|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 Type tool and set Ap1, Lp, Vtc and Atc > 0. Double-click on the Lp label in edit mode or press C, E or P when the Lp text box has the focus to specify a conical, cylindrical, exponential or parabolic flare throat adaptor.

By default, the combined horn plus direct radiator acoustical power output is calculated. The Output tool can be used to determine the horn output or the direct radiator output.

|Horn-Loaded Vented-Box Enclosure With Port Exit Located Outside Horn Mouth
~~~~~~

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

By default, the combined horn plus port acoustical power output is calculated. The Output tool can be used to determine the horn output or the port output. An end correction is added to the Lpt rear chamber port tube length where appropriate.

|Horn-Loaded Vented-Box Enclosure With Port Exit Located Inside Horn Mouth
~~~~~~

Select the tapped horn option and set Vrc, Lrc, Ap and Lpt > 0.

Set L12 = 0.01 cm if the driver is not offset.

|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
~~~~~~~~~~~~~~~~~~~

Position the driver entry point at S2 by specifying at least two conical, exponential and/or parabolic flare segments connected in series, and selecting the OD offset driver option from the Loudspeaker Configuration tool or double-clicking on the Nd label in edit mode to set the OD flag.

Position the driver entry point at S3 by specifying at least three conical, exponential and/or parabolic flare segments connected in series, and selecting the OD1 offset driver option from the Loudspeaker Configuration tool or double-clicking on the OD label in edit mode to set the OD1 flag.
~~~~~~~~~~~~~~~~~~~

Vtc and Atc can be used to specify a chamber between the driver diaphragm and the throat entry point. Ap1 and Lp 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 Atc).

By default, if no closed rear chamber is specified, the combined horn plus direct radiator or port acoustical power output is calculated. The Output tool can be used to determine the horn output or the direct radiator or port output. An end correction is added to the Lpt rear chamber port tube length where appropriate.

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

|Offset Horn and Offset Flared Port Tube
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Select the CH1 offset driver compound horn option and specify four segments. Double-click on the Cir or Fta label in edit mode to select the Clo closed horn mouth option. Double-click on the Ap1 label to specify the offset port using Ap and Lpt. An inner end correction is added to the Lpt port tube length.

Double-click on the Lpt label in edit mode to specify a flared port tube. Ap is the tube mouth cross-sectional area, Apt is the tube throat cross-sectional area and Lpt is the tube length.

|Two-Way or Three-Way Multiple Entry Horn
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

CoEntrant, Unity and Synergy loudspeakers are examples of multiple entry horn systems.

Specify the horn system, horn throat driver assembly, associated chambers, amplifier and filter using a Nd record.

Specify the first offset driver assembly, associated chambers, amplifier and filter using a ME1 record. The ME1 drivers in a two-way system can have a vented rear chamber. If a vented rear chamber is specified for the ME1 drivers in a three-way system, the port tube is disregarded and a closed rear chamber is assumed. The ME1 values of Vrc, Ap, Ap1, Ap2, Vtc and Atc are the sum totals of the chamber volumes and areas for all the ME1 drivers.

Specify the second offset driver assembly, associated chambers, amplifier and filter using a ME2 record. The ME2 drivers can have a vented rear chamber. The ME2 values of Vrc, Ap, Ap1, Ap2, Vtc and Atc are the sum totals of the chamber volumes and areas for all the ME2 drivers.

To specify absorbent filling material in a ME1 or ME2 throat port tube, set Fr to the airflow resistivity value and Tal to zero.

Select the ME1 option from the Loudspeaker Configuration tool or press the Ctrl key and double-click on the Nd label in edit mode to set the ME1 flag.

Select the ME2 option from the Loudspeaker Configuration tool or press the Ctrl key and double-click on the ME1 label in edit mode to set the ME2 flag.

A ME1 or ME2 record can be activated or deactivated by clicking on the

designated button. Activating a ME1 record deactivates any previously activated ME1 record. Activating a ME2 record deactivates any previously activated ME2 record.

The Multiple Entry Horn Wizard command is included on the input parameters window Tools menu list when a Nd record with at least two segments is selected, and a ME1 record is active.

The lossy inductance, semi-inductance and frequency-dependent damping models are not applicable to multiple entry horn systems.

|Tapped Horn
~~~~~~~~~~~~

Specify three or four conical, exponential and/or parabolic flare segments connected in series, set Vrc and/or Lrc = 0 and select the TH or TH1 tapped horn option from the Loudspeaker Configuration tool or double-click on the OD1 label in edit mode to set the TH flag. Double-click on the TH label to set the optional TH1 flag.

Driver entry points are at S2 and S3 for a three segment TH horn, S2 and S4 for a four segment TH horn, and S2 and S3 for a four segment TH1 horn.

Vtc and Atc can be used to specify a chamber between the driver diaphragm and the throat entry point. Ap1 and Lp can be used to specify a port opening between the throat chamber and the horn (not required if the cross-sectional area of the opening is equal to Atc).

With a throat chamber port specified, double-clicking on the Lrc label will add a second throat port connected in series with the first. Throat port 2 can have a conical, cylindrical, exponential or parabolic flare. Selecting the zero flare cylindrical option enables throat port 2 to be stepped relative to throat port 1.

Vrc and Lrc can be used to specify a chamber between the driver diaphragm and the mouth entry point. Ap and Lpt can be used to specify a port opening between the mouth chamber and the horn (not required if the cross-sectional area of the opening is equal to Vrc / Lrc).

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

|Paraflex Horn
~~~~~~~~~~~~~~

Select the PH1, PH2, PH3 or PH4 paraflex horn option from the Loudspeaker Configuration tool or double-click on the TH1 label in edit mode to set the PH1 flag. Double-click again to select the PH2, PH3 or PH4 flag.

The loudspeaker is modelled as shown in the schematic and Loudspeaker Wizard system model diagrams. Refer to the Loudspeaker Wizard section for details of the system model element codes.

Absorbent filling material can be added to segments 5, 6 and 7 but the Fr1 airflow resistivity settings cannot be saved to the permanent data record and the Tal1 filled length values are fixed at 100 percent.

|Stubbed Horn
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Select the SH1, SH2, SH3 or SH4 stubbed horn option from the Loudspeaker Configuration tool or double-click on the CH3 label in edit mode to set the SH1 flag. Double-click again to select the SH2, SH3 or SH4 flag.

A stubbed horn system can have up to three segments, with the stub or absorber chamber being specified using segment 4 and the absorber chamber input port being specified using Ap2 and Lp. Double-click on the Lp label in edit mode or press C, E or P when the Lp text box has the focus to specify a conical, cylindrical, exponential or parabolic absorber chamber port.

Select SH1 to position the stub or absorber chamber at S1. Select SH2 for position S2, SH3 for position S3 (at least 2 segments required) and S4 for position S4 (3 segments required).

|Compound Horn

Select the CH, CH1, CH2 or CH3 compound horn option from the Loudspeaker Configuration tool or double-click on the PH4 label in edit mode to set the CH flag. Double-click again to select the CH1, CH2 or CH3 flag.

CH
Horn 1 has one, two or three segments with normal entry.
Horn 2 has segment 4 with normal entry.

CH1
Horn 1 has two or three segments with offset entry at S2.
Horn 2 has segment 4 with normal entry.

CH2
Horn 1 has two segments with offset entry.
Horn 2 has segments 3 and 4 with normal entry.

CH3
Horn 1 has two segments with offset entry.
Horn 2 has segments 3 and 4 with offset entry.

By default, the combined horn 1 plus horn 2 acoustical power output is calculated. The Output tool can be used to determine the horn 1 output or the horn 2 output.