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LDC7 Design Suite Operating Instructions

Generally, all of the loudspeaker design utilities for the LDC7 Design Suite function in the same manner in the Excel spreadsheets. Entering data is the same for all operations. Left click on the data entry field, type in the appropriate numbers, and hit the enter key. When all of the entry fields have been input, results are automatically displayed. The red corners in the text fields contain short explanations. To display these explanations and comments, move your mouse cursor over the text field (no clicking is required).

Driver Performance

The LDC7 Driver Performance calculator is a very simple, easy to use and powerful speaker design tool. To use the program, all you do is enter the parameter data that you have either measured using techniques described in Chapter 8 of LDC7, measured with an analyzer, or obtained from a woofer manufacturer's data sheet. This information is then entered by left clicking on the data "box" in each one of the Driver columns in the Input Parameters section, typing in the numbers, and then hitting the enter key. To complete this process you will only need the Sd (use the Speaker Sd utility in the Sd & Disp Vol section), Re (voice coil DC resistance), Fs, Qts, Qms, Vas, Xmax and Power handling in RMS Watts.

The last four rows allow you to play "what if" games with your woofer. Simply input a box volume for a sealed box and/or a vented box. For the sealed box you can also enter a percent of fiberglass fill material (a box lined on four sides and the back of the box with R19 6" thick fiberglass is typically 50% filled). For the vented box calculation all you need to do is enter a vent (port) diameter (this calculator is only for tube type vents). Since vent length is limited normally by box depth, you can keep changing the diameter until you find a length that will fit in the box with at least 0.5"-1" of rear clearance from the port end to the box wall.

Once the data is entered, the program will automatically give you the extended parameters (these cannot be changed), plus the sealed and vented box details (these also cannot be changed). There are six columns, so you can enter the same parameters for a single woofer six times and compare different box results, or enter six different woofers parameters and compare the sealed and vented box performance for each woofer.

The Driver Performance calculator will give you both power handling in RMS Watts and Maximum SPL in dB for each enclosure type. RMS power handling is based on excursion only, so may sometimes give what will look like excessively high power handling predictions. However, Max SPL is based on the thermal limit of the driver, and will give you a more realistic idea of the output capability of the woofer. The program will also give the box Alpha number that refers to the degree of rear loading on the woofer cone. An Alpha number higher than 3 means there is very little back pressure on the rear surface of the cone and the field will turn red as a caution. A number of 3 or higher could be compared to an infinite baffle, and would be like mounting a woofer through a wall in your home with the back side loading into another large room with no enclosure other than the room.

Sd and Displacement Volume

The Sd and Speaker Displacement Volume section of the LDC7 Design Suite has two very useful utilities. On the right side of the page is the Speaker Sd cone area calculator for producing T/S parameters and on the left side is the physical Speaker Volume Displacement calculator useful in generating enclosure dimensions.

Sd calculation in this utility is based upon AES Preprint #4082 titled Diaphragm Area and Mass Nonlinearities of Cone Loudspeakers by Olsen and Thorborg. This technique yields somewhat larger Sd results that the standard method of computing cone area from the cone diameter measured inclusive of 1/3 to 1/2 of the surround and is recommended. To use the Sd calculator, choose the row designated for the diameter of your driver in inches, then highlight the entry in the OD column, enter the diameter in centimeters measured from the outside edges of the surround and hit the enter key. Following this, highlight the entry in the RD column and enter the width of the surround in centimeters and hit the enter key. The true Sd for your driver will then automatically be calculated and will appear in green text in the Sd column.

The Speaker Volume Displacement calculator is useful for box dimension calculation. This data can be added to the net volume of your enclosure design to come up with a total gross volume that can then be used for creating the final dimensions of a box design. There are seven columns of required data that you can enter with the physical measurements of your driver using a ruler that is graduated in centimeters. To start, use the row that matches the diameter of your driver in inches. The seven data fields in the row are:

VD=diameter of the voice coil.
MDG=outside diameter of the magnet assembly.
SCD=outside diameter of the magnet assembly including any metal or rubber boot type magnet covers.
BD=depth of the driver frame from the bottom of the mounting rim to the spider mounting shelf.
CD=depth measured between the spider mounting shelf and the bottom of the frame that is attached to the front plate of the motor assembly.
MD=depth of the magnet assembly inclusive of any metal or rubber boot type magnet covers.
BT=front baffle depth for the box you are building (thickness of the front baffle the driver will be mounted on).

Once you have highlighted each field, entered the appropriate new data and hit the enter key, the total volume displacement number will automatically appear at the end of the row in green text giving the final calculation in cubic centimeters, inches and feet.

Measurement Tools
Measurement Tools is a parameter calculation utility that will facilitate making the parameter measurements that are described in LDC7 Chapter 8.

Using the same left click, typing in the data and pressing enter method, start with section 1 (Enter Physical Values) by entering the driver voice coil DC resistance, Re, in Ohms, the driver Sd (use the Speaker Sd utility in the Sd & Disp Vol section) in square meters and driver free-air resonance, Fs in Hz.

For cone body mass (Mmd) calculation, you can either use the Added Mass or the Sealed Box methods in Section 2 (Calculate Mmd/Mms). Using the Added Mass method (see LDC7 8.30 A), enter the measured amount of material attached to the cone for this measurement (in grams) and then enter the new resonance frequency in Hertz. Mmd will be automatically displayed. For the Sealed Box method (see LDC7 8.30 B and Figure 8.11), enter the volume of the test box in cubic feet and the new resonance frequency in Hertz. Again, Mmd will automatically be displayed. To find the remaining parameters in this section (Mms, Cms and Vas), enter the Mmd value from either the Added Mass or Sealed Box methods in the Calculated Mmd field.

For driver Q parameters (Qts, Qes, and Qms plus Bl), using test Method 1 (LDC 7 page 204), start by entering the substitute resistor value Rc in Ohms, the standard voltage and the current through Rc at the standard voltage. Next replace the Rc with the DUT (Driver Under Test), and measure the current at Fs (the minimum current in amps). And last, enter the frequency below Fs (F1) and the frequency above Fs (F2) where the current equals the calculated current value Ir. The remaining parameters, Qms, Qes, Qts and Bl will be automatically displayed.

Enclosure Design Tools
This section of enclosure utilities will help you dimension both rectangular enclosures and trapezoid shaped enclosures (often used in car and truck installations) as well as determine vent tuning frequency.

1. Rectangular Enclosure-this box design utility will develop a cut list for building a

rectangular box. Start by left clicking on the numerical data field in the Final Volume row. Enter the calculated box volume in cubic feet and press enter. Using the same method, enter the driver volume displacement (this can be calculated in Section B, Sd and Displacement Volume). You can also include other detracting volumes such as the volume displaced by a crossover, a vent tube or by enclosure bracing and enter this combination as a single number in this field. Next, enter the material thickness plus baffle width and height. The dimensions of the various parts required to make a butt-joint type box are automatically displayed in the remaining fields.

2. Trapezoid Enclosure-this box design utility will develop a cut list for building a trapezoid shaped box. Start by left clicking on the numerical data field in the Final Volume row. Enter the calculated box volume in cubic feet and press enter. Using the same method, enter the driver volume displacement (this can be calculated in Section B, Sd and Displacement Volume). You can also include other detracting volumes such as the volume displaced by a crossover, a vent tube or by enclosure bracing and enter this combination as a single number in this field. Next, enter the material thickness, the front baffle width and height plus the back baffle height. The dimensions of the various parts required to make a butt-joint type box are automatically displayed in the remaining fields. Note that for all dimensions that have angles, the dimension is to the longest edge. Cut the board to this dimension and then cut the angles.

3. Vent Calculator (round)-while you can design a vent to be virtually any shape, the easiest is to use cardboard or plastic (ABS or PVC) tubing. This utility will help you calculate both the vent tube displacement volume for enclosure volume calculations and the vent tuning frequency. Start by left clicking on the Vent Inner Diameter row data field, entering the dimension in inches and hitting the enter key. Using the same method enter dimensions for the vent wall thickness, vent length, baffle thickness and enclosure volume. Manually change the vent length until you achieve the correct tuning frequency. If the tube is too long for the enclosure dimensions, reduce the vent diameter until the correct length for the correct tuning frequency is achieved.

Two-Way Crossover Tools

The 2-way Crossover Tools section of the LDC7 Design Suite is very useful for getting starting values for either manually designing a crossover or for starting values for use in crossover optimizer software such as LEAP 5, LSPcad, or Fine X-over. Generally, the values you get from classic filter function formulas using resistive termination data, which is what is being presented in this section, will not provide adequate or accurate results when applied to the complex impedance and frequency response of the drivers you are using, however this is discussed in more detail in Chapter 7 of LDC Edition 7 and to a greater extent in the *Loudspeaker Recipes* book by Vance Dickason.

Using the 2-way Crossover utility requires only a minimum of user data. Move your computer cursor to the first row of the green data input section and left click on the crossover frequency in the column B data field, enter the new crossover frequency in Hz and hit the enter key. Next, in the same manner as with crossover frequency, enter the nominal resistance (impedance) for the high-frequency driver and the nominal resistance (impedance) of the low-frequency driver. Actual driver measured DCR can also be used for both of the entries. For first-order series networks, you need to enter the Zeta, which is the degree of damping for the network. The default is 0.5 that relates to a Bessel filter, but you can decrease the damping to be more in line with a less damped function by changing the number to 1.2. Once the data is entered, the results will appear in the blue sections.

Three-way Crossover Tools

The 3-way Crossover Tools section of the LDC7 Design Suite is, like the 2-way Crossover Tools section, very useful for getting starting values for either manually designing a crossover or for starting values for use in crossover optimizer software such as LEAP 5, LSPcad, or Fine X-over. Generally, the values you get from classic filter function formulas using resistive termination data, which is what is being presented in this section, will not provide adequate or accurate results when applied to the complex impedance and frequency response of the drivers you are using; however this is discussed in more detail in Chapter 7 of LDC Edition 7 and to a greater extent in the *Loudspeaker Recipes* book by Vance Dickason.

Using the 3-way Crossover utility requires only a minimum of user data. This section is divided into two sections. The first is for 1st and 2nd-order three-way networks and the second is for 3rd and 4th-order networks. Both, however, function exactly the same. For either category, move your computer cursor to the first row of the green data input section and left click on the low crossover frequency in column B. Enter the new crossover frequency in Hz and hit the enter key, doing the exact same operation for the high crossover frequency. Next, in the same manner as with the two crossover frequencies, enter the nominal driver resistance (impedance) for the high-frequency driver, the midrange driver and the low-frequency driver. Actual driver measured DCR can also be used for each of the entries. Once the data is entered, the results will appear in the blue sections.

Additional Crossover Tools

The following is a collection of circuits that are to be combined with standard network topographies to make specific changes that will improve the network's performance.

1. Zobel-to create a CR conjugate (Zobel) network that will EQ (make flat) the impedance for any woofer, midrange or tweeter, just left click on the Re Speaker data entry and type in the DC resistance in Ohms of the driver and hit the enter key. Next, left click on the Le Voice Coil entry field and type in the 1kHz voice coil inductance in millihenries. Values for the circuit will automatically appear in the C1 and R1 data fields.

2. RL Contour Network-this type of circuit equalizes a rising response that is increasing with increasing frequency. To find values for this circuit, determine the frequency the rise begins (Frequency Min) and the frequency where the rising anomaly ends (Frequency Max). Enter these two values in the appropriate data fields using the same left click and enter method. Next, enter the speaker DC resistance in Ohms and the desired resistance value. The goal is to pick a resistor value that will produce the amount of attenuation that approximately equals the maximum dB level above the nominal driver output level produced by the response rise. This can be determined by trial and error by entering different values of resistance until your attenuation goal is reached.

3. RLC Parallel Notch Filter-the parallel RLC circuit can be regarded as a peak filter to remove discreet SPL anomalies in a response. Using the same left click and enter method, enter the low and high frequency limits of the peak in Hz, the height of the peak in dB above the nominal driver SPL and the DC resistance of the speaker. Resulting values for the three required component values will appear in the R1/C1/L1 fields.

4. Inductor Designer-this utility will create two shapes of inductors, one with a low profile that has a winding height equal to the radius of the inductor core, and one that has maximum "Q" and a minimum of turns that has a winding height equal to twice the radius (same winding height as core diameter). Using the same left click and enter method, enter the value in Ohms of the desired inductor DC resistance and inductor value in millihenries. Results will appear for both inductor shapes in the appropriate data fields.

5. L Pad-the L- type attenuation circuit described here allows you to not only come up with a stable load for the crossover circuit, but also allows you to determine the load value for the crossover, making it possible to minimize inductor size. Determining the values for the L pad circuit requires entering the amount of attenuation in dB, the speaker DC resistance and the desired load resistance for the crossover. Once these values are entered using the same left click and enter method, the values for R1 and R2 will automatically be determined.

6. RL Contour Network-this type of circuit equalizes a rising response that is increasing with decreasing frequency. To find values for this circuit, determine the frequency the rise begins (Frequency Min) and the frequency where the rising anomaly ends (Frequency Max). Enter these two values in the appropriate data fields using the same left click and

enter method. Next, enter the speaker DC resistance in Ohms and the desired resistance value. The goal is to pick a resistor value that will produce the amount of attenuation that approximately equals the maximum dB level above the nominal driver output level produced by the response rise. This can be determined by trial and error by entering different values of resistance until your attenuation goal is reached.

7. Series Notch Filter-this circuit is primarily used to attenuate a resonance peak in a tweeter, midrange, or woofer in order to facilitate crossover design. Using the left click and enter method, enter the driver resonance frequency in Hz, the driver DC resistance in Ohms, and the driver Qes and Qms values. The results giving values for the RLC components will automatically appear in the data fields for C1/L1/R1 plus the resulting LCR circuit "Q".

Acoustic Tools

This section contains four utilities that will be useful for the acoustic analysis of a speaker system.

1. Room Modes-this is a simplified room mode calculator that will give you an approximate idea of grouping of room mode frequencies for a given set of rectangular room dimensions. The columns labeled 1st, 2nd, 3rd and 4th correspond to wavelength multiples of 0.5, 1, 1.5, and 2, respectively. To start, left click on the first room dimension, type in the floor to ceiling height in feet (use the decimal equivalent to express inches) and hit the enter key. Using the same procedure, fill in the width and length dimensions. Results will be automatically displayed for each wavelength multiple.

2. Voltage to dB-to calculate the dB change from one A.C. voltage level to another A.C. voltage level, left click on the Voltage 1 row data field, enter a voltage and hit enter. Do the same for the second voltage in the Voltage 2 row data field. Note, you can calculate from a lower voltage to a higher voltage or a higher voltage to a lower one. In the latter case, the answer will be in minus dB.

3. Xmax to SPL-this utility will calculate the SPL at any frequency and distance for a given woofer or combination of woofers. Start by left clicking on the Sd row data field, entering the driver Sd in cubic meters and hitting the enter key. Using the same method, enter the Xmax in millimeters (if you want to include the effects of the driver motor fringe field, use Xmax +15%), number of drivers, the frequency in Hertz that you wish to examine and the distance from the speaker to the microphone. The answer in dB will be displayed in green text in the SPL row.

4. Multiple Driver-the Multiple Driver utility will help you calculate the total amplifier load and output sensitivity for any number of drivers in a series, parallel or series parallel arrangement. Start by left clicking on the Re row data field and type in the DC resistance of the driver voice coil and hit the enter key. Using the same method enter the driver sensitivity in dB, the number of drivers in series, and the number of drivers or groups of drivers in parallel. Note if you are only using either one set of series drivers or one set of parallel drivers, always enter 1 for the connection not being used, not zero. For example, with 2 drivers in series, enter 1 for the number of Groups in Parallel. Likewise, with 2 Groups in Parallel (2 drivers in parallel), enter 1 for Number in Series.

Conversions

This utility has a number of convenient conversions from one unit of measurement to another. Operation is simple: just choose the conversion to use (either Distance, Area, Volume, Mass or Temperature) and enter the number you are converting in the red text input field (Input Value column) by left clicking, entering the number and pressing the enter key. Converted units will automatically be displayed.

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