Optimal Port Designer -- User Guide

Design optimized bass reflex ports for 3D printing. Based on the work of STV and Augerpro on diyaudio.com.

Quick Start

1: Enter Fb, Vb, and SPL from your favourite box simulation app

2: Adjust port count if the port is too large for your cabinet

3: Set wall thickness and flange diameter for your build

4: Export STL for 3D printing or DXF for 3D design software

5: Remember -- you do not want to scale the STL after exporting it. Unlike ordinary ports the optimized ports do not scale linearly on surface area vs length. If something is off with the size, just adjust in the tool and export a fresh STL. This convenience is why I made this tool.

Sidebar Reference

Optimizer

The three inputs that define your port:

Parameter	What it is	Where to get it
Fb	Box tuning frequency (Hz)	Your box simulation (WinISD, Hornresp, etc.)
Vb	Net box volume (liters)	Your box simulation
SPL	Target max SPL (dB)	Based on your listening habits and driver + amp capability

Port count (1-4) -- Splits the total port area across multiple ports. Use more ports when a single port would be too large for your cabinet opening.

When using multiple ports, the optimizer automatically adjusts per-port: enclosure volume is divided by the number of ports, and SPL is reduced by 6 dB per doubling.

However, smaller ports come with real trade-offs:

- More viscous and boundary-layer losses (proportionally larger in small tubes)
- Less tolerance for 3D printing imperfections
- Smaller absolute flare dimensions

This is why one bigger port is generally preferred when it fits. The multi-port option exists for when a single port won't physically fit in the cabinet.

Tip: Use the largest port(s) you can fit. If low coloration and low compression at high levels matter to you, consider making the box larger to accommodate a bigger port. Think of it this way: for a given diameter, this optimizer gives you the maximum port SPL before noise and compression set in. A larger port simply raises that ceiling.

STR margin -- Adds safety margin above the theoretical minimum Strouhal number. 0% = theoretical limit. +10-20% = conservative. Leave at 0% unless you're pushing high SPL and want extra headroom against turbulence noise.

Computed Geometry

These are the optimizer's output -- calculated automatically from your inputs:

- Lact -- Actual port length (mm)
- Dmin -- Minimum (throat) diameter (mm)
- Dext -- Exit (mouth) diameter (mm)

The port profile is not a straight tube -- it flares from Dmin at the inner end to Dext at the outer end, following an optimized curve that minimizes turbulence.

Construction

Physical build parameters:

- Wall -- Wall thickness (mm). 3-6 mm typical for 3D printing. Thicker walls recommended if using the split feature (8 mm suggested minimum for threaded joints).
- Dflange -- Flange outer diameter (mm). Match this to your cabinet opening and the size of the inner aerodynamic flange -- that gets rather large. Use 2D view for help-lines. Consider using the split function to get more port area for a given flange frontal area -- remember you must have access to the inner part of the port to screw on the inner flange.
- Flange -- Flange thickness (mm).

Junction Reinforcement

- Fillet -- Controls the fillet radius at the port-to-flange junction. Higher values = larger, smoother fillet. Adds strength and reduces stress concentration at the joint. Range 0-8.

Mounting Holes

Optional bolt holes in the flange for fastening the port to the cabinet.

- Count -- Number of holes (2-12), evenly spaced around the flange
- Hole diameter -- Bolt hole size (mm)
- Center in flat area -- Automatically positions holes in the flat part of the flange. You should play around with the inset feature to manually find a more optimal placement for your design.
- Inset -- Distance from flange edge to hole center (mm)
- Countersink -- Optional countersink for flush-mount screws (set diameter and depth)

Split Port

Separates the port into two pieces that screw together with printed threads.

Why split? The inner aerodynamic flare can get large relative to the exit diameter, forcing an oversized outer flange. If you want the largest possible port for a given cabinet opening, use the split function. Feedback suggests that the aesthetics of a slimmer outer flange is appreciated as being more modern and sleek. You mount the main body first, then screw the inner part on from inside the cabinet.

WARNING: This requires access to the inner end of the port after mounting.

Secondary benefit: the threads print fine using simple support and with some tweaking support should not be needed at all. If you are using mounting holes they may need support.

Parameters:

Play around with the parameters to optimize for your printer and filament. The standard settings are verified on Bambu Labs H2D and P1S using PETG and PLA matte. Warning -- only tested on rather large ports yet. Do test prints where you cut off only the threaded part using the slicer and print a few sets with different clearances. The fit should be tight.

If you choose 2D view you can see the split between inner/outer threads. Helps with positioning using the thread pos placement.

- Thread pos. -- Where the split occurs along the port (% from inner end). 25-75%.
- Depth -- Thread depth (mm)
- Pitch -- Thread pitch (mm)
- Clearance -- Thread clearance for fit (mm). 0.3-0.5 mm typical for FDM printing.
- Engage -- Thread engagement length (mm). Longer = stronger joint.

View

Toggle between two visualization modes:

2D Profile:

- Useful for dimensioning the outer flange. There is a reference line showing the size of the inner flange relative to the outer flange. This helps you with dimensioning the outer flange. Pay attention to having to re-optimize when activating mounting holes/countersink.
- Cross-section view of the port profile
- Mirror toggle shows the full port (both halves)
- Grid overlay for dimensional reference
- Pan and zoom with mouse
- Cursor readout shows X position and radius

3D Preview:

- Full 3D model with orbit, pan, and zoom
- 270 degree cutaway to see internal geometry
- Wireframe overlay option
- LMB orbit, RMB pan, scroll to zoom

Export

Three export options:

- Export STL -- 3D-printable mesh. In 3D view: full port. In 2D view: side profile.
- Export DXF -- 2D profile for 3D design software
- Save As (.optiport) -- Save your complete design for later. Load it back with the Load button at the top.

Advanced

Expandable panels showing:

- Derived values -- All calculated parameters (areas, ratios, correction factors)
- Optimizer details -- Convergence status showing how the iterative solver reached its solution

Workflow Example

Scenario: You're building a 2-way speaker with an 8" woofer. WinISD gives you Fb = 38 Hz, Vb = 45 L. Your amp does 200W into the driver's 91 dB sensitivity.

1: Enter Fb = 38, Vb = 45, SPL = 105

2: The optimizer computes the port geometry. Check if the flange fits your cabinet -- if Dext is too large for a single port, try 2 ports.

3: Set Wall = 5 mm for your FDM printer

4: Set Dflange to match your planned cabinet opening

5: Add 4-6 mounting holes, M5, with countersink if you want flush screws

6: If the inner flange is still too large, enable Split -- mount the main body from outside, screw on the inner flare from inside

7: Check the 3D preview, toggle cutaway to inspect the internal profile

8: Export STL, slice, print

Tips

- The optimizer converges iteratively. Check the convergence badge in the Advanced section -- green = converged, yellow = close enough, red = did not converge (unusual, re-check your inputs).
- Higher SPL targets produce larger ports. Be realistic about your actual use case.
- Multiple smaller ports can have lower total turbulence noise than one large port at the same total area, because each port handles less air velocity.
- Wall thickness affects the outer dimensions but not the internal aerodynamic profile.
- The .optiport save file stores everything -- share it with others to reproduce your exact design.