# Make Homebrewed Look Factory Built

## Readily available design software and build services lead the way to professional results — for a price.

**William H. Ellis, KF7PB**

Radio amateurs have a long and proud history of getting things done by modifying materials and techniques and taking advantage of whatever is at hand. At times, the exigencies of getting a project on the air lead a ham to sacrifice certain aesthetic aspects of implementation.

However, you do not need to be an artisan to produce professional looking results for a project. Prototyping services now often provide free design software to do everything from schematic capture and printed circuit board layout to front panel design. Prototype runs of PC boards can be as few as three pieces and you can purchase just a single front panel if that's all you need. On the low end, you can have three small PC boards (2.5 × 3.8 inches) manufactured and delivered for less than $60. The manufacturing and delivery of a medium-sized painted front panel with engraved lettering would probably be less than $100.

Recently, I redesigned and rebuilt the audio distribution system that was described in the September 2013 issue of *QST* (see Figure 1).[1] I'll use this project to illustrate the process of using design software and fabrication services.

First we'll look at schematic capture and PC board design, because the sizes of the PC boards and parts used will have a direct impact on the mechanical design. Then we'll consider mechanical computer-aided design software, and finally look at a versatile source for equipment enclosures and a front panel design and fabrication service.

### Schematic Capture and Printed Circuit Board Design Software

The processes of schematic capture, PC board layout, and production are tightly intertwined, and by supplying all three services, *ExpressPCB* provides a smooth path from design entry to PC board delievery.[2] There are two free programs


**Figure 1** — The audio distribution system project, from the September 2013 issue of *QST*. Split body extruded aluminum enclosure. PC boards are supported by extruded ribs on the interior of the case.

available for downloading — *ExpressSCH*, which is the schematic capture program and *ExpressPCB*, which is the PC board layout program. The programs run under Microsoft *Windows NT*, *2000*, *XP*, *Vista*, and *Windows 7*. I use a Macintosh computer running VMware *Fusion* to emulate the *XP* operating system in order to run *ExpressSCH* and *ExpressPCB*.[3]

*ExpressSCH* has a large library of components to which you can also add your own custom component designs. To create a schematic, the component symbols are first placed on the page and then interconnected. Component positions can then be changed and the interconnections will be retained and rerouted. Figure 2 shows a schematic from the audio distribution system project.

Circuit simulation and verification is the responsibility of the designer. So, if you make a breadboard for circuit verification, it's a good idea to build it from the *ExpressSCH* schematic to ensure that there are no transcription errors.

After the schematic has been entered and verified, the design file is then linked to *ExpressPCB* to lay out the PC board. The procedure is similar to the schematic creation — physical components are now selected and placed on the PC board. Connection points from the schematic are highlighted and manually established, and components that are subsequently moved will retain their interconnections. Figure 3 shows a PC board layout produced by *ExpressPCB*. It costs approximately $125 for a minimum order of two boards. Once the layout is complete, you order boards directly via their website.

I have found that for prototypes, where circuit changes might be needed, it's helpful to specify component holes and pads larger than required. This simplifies rework when using an ordinary solder sucker or desoldering braid. Wider-than-needed traces are also handy if board modifications are later required.

### Computer Aided Design Software

After I have a good idea of the PC board sizes and parts layout, I use my computer aided design (CAD) program to work out the mechanical design. I consult the data sheets (available online from suppliers like Mouser at **www.mouser.com**) for the components that I am going to use to make sure that I have accurate mechanical dimensions. This is critical in order to ensure that external components mounted on a printed

[1]Notes appear on page 42.

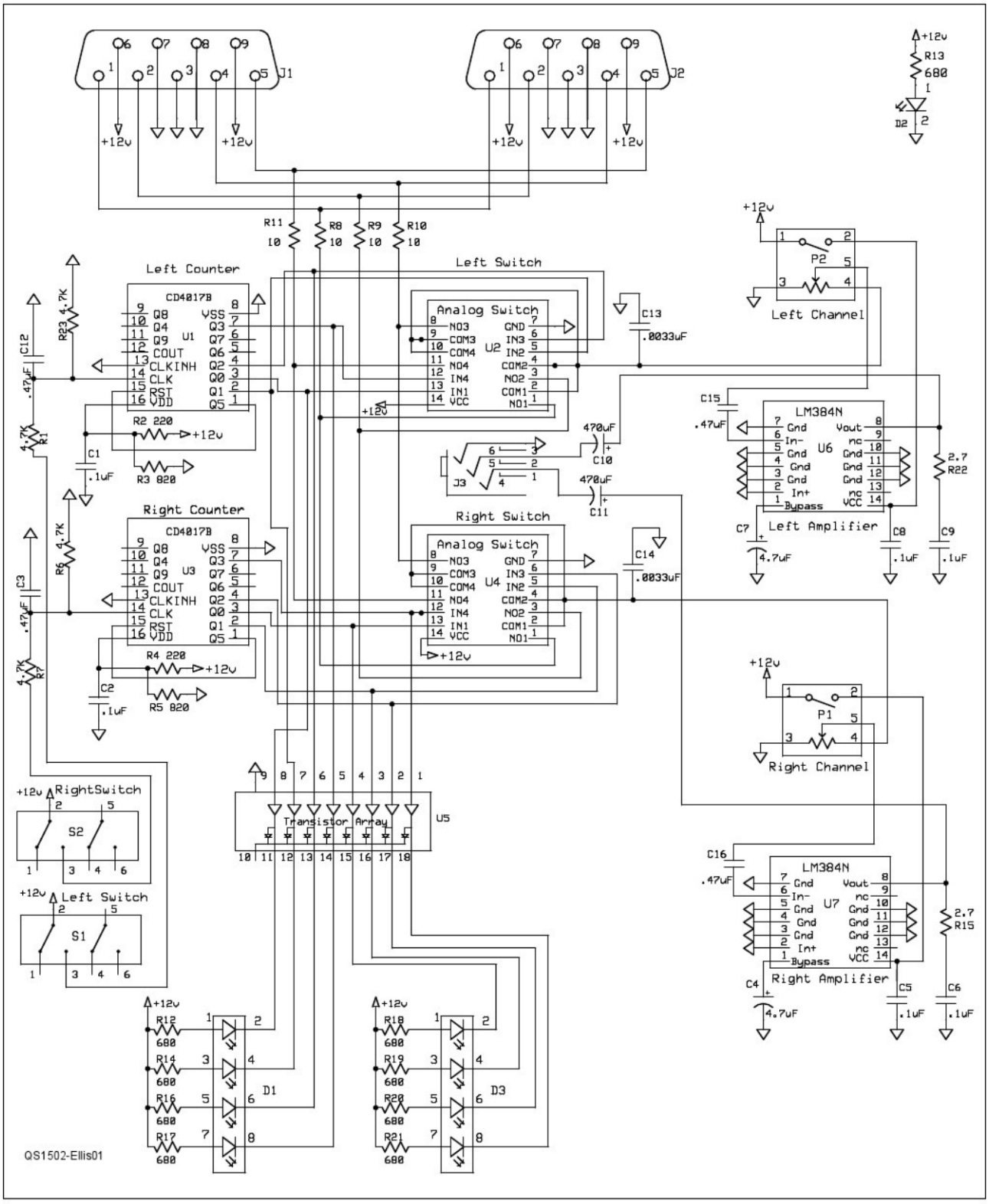


**Figure 2** — Schematic diagram created using *ExpressSCH*. The schematic file is then linked to *ExpressPCB* to lay out the PC board.

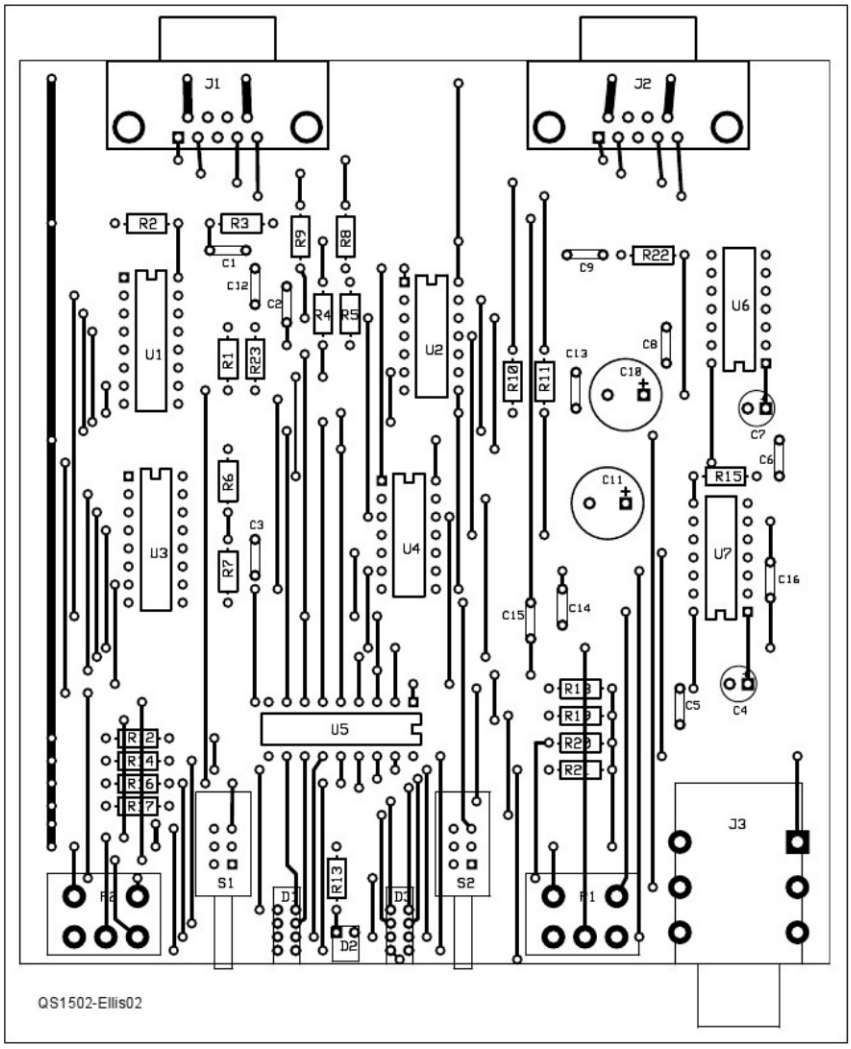


**Figure 3** — A PC board layout produced by *ExpressPCB*.

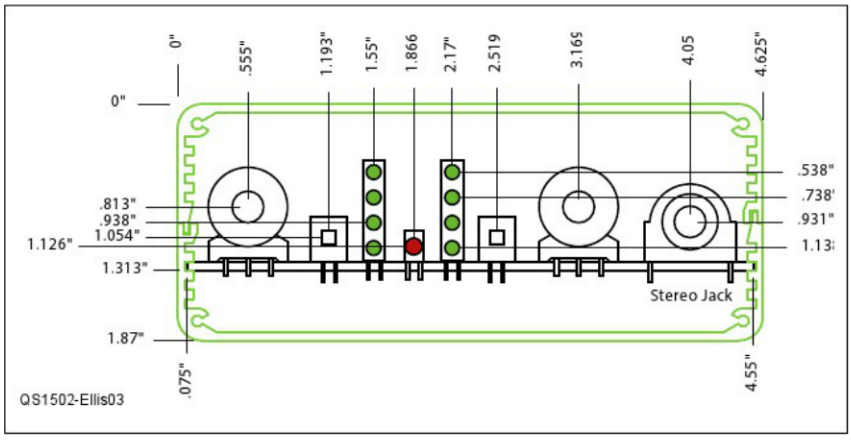


**Figure 4** — An accurate mechanical drawing is essential for locating front panel openings for external components that mount to a printed circuit board such as potentiometers, lights, and switches.

circuit board, such as potentiometers and switches, will align with their openings in the front panel. Also, it is important at this stage to check the clearances of large components, such as electrolytic capacitors, to confirm that there is no interference with other circuit boards or the enclosure. Figure 4 shows a typical mechanical drawing made with a CAD program during the early design stage.

The CAD software that I use on my Macintosh is called *PowerCADD*. I have had it for many years and find it to be an excellent two-dimensional (2D) mechanical CAD program.[4] Unfortunately, the current version is quite expensive. However, a quick Internet search reveals that there are free 2D CAD programs available.

## Equipment Enclosure

I use extruded aluminum housings for equipment enclosures purchased from Enclosures & Cases.[5] I like to use extruded aluminum housings because the split body extrusions come in a wide variety of lengths, widths, and heights. They are designed so that two pieces cut from the same stock will interlock if one of the pieces is rotated front to back. If you don't want a standard length, they are easily cut on a table saw with a carbide blade. PC boards are secured by sliding them into slots formed by extruded ribs on the inside of the enclosure (see Figure 5). A variety of finishes is available, including anodizing and powder coating. I generally just leave mine unfinished.

The company will supply you with a DXF (drawing exchange format) design file of the extrusion to aid incorporation into your CAD system. If your CAD system will not accept DXF, then you will have to enter the dimensions manually from a PDF drawing, such as Figure 5. Note that sliding items like PC boards need clearances, so don't size the boards to go right to the inner wall edges.

Figure 1 shows one of the housings that were used on the audio distribution rebuild project. Note how the circuit board fits in the slots formed by the ribbed extrusions. The cost of this enclosure, exclusive of the endplates, was about $12.

Endplates are available to finish the front and back of the enclosure. However, I prefer to order custom cover plates from a company that specializes in finished panel production.

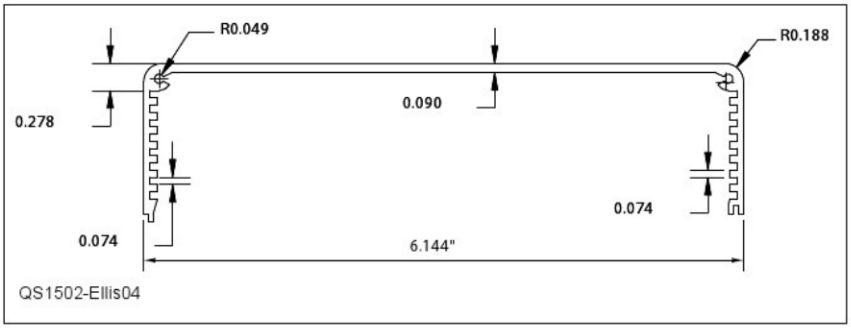


**Figure 5** — Drawing detail of split body extruded aluminum enclosure (various sizes available).

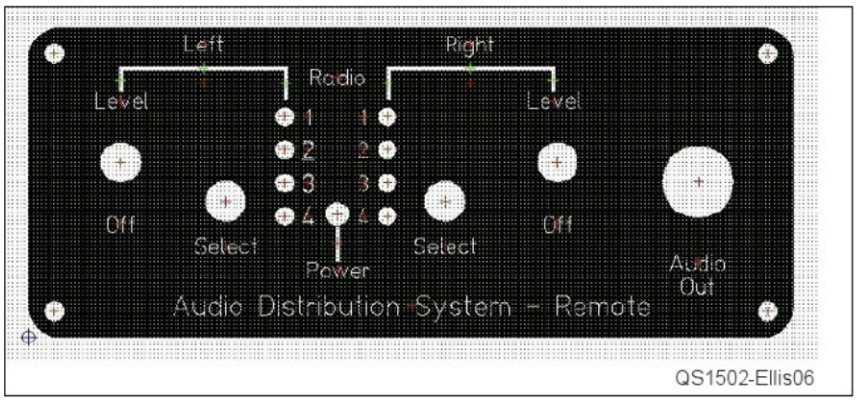


**Figure 6** — Front panel design using design software provided by Front Panel Express.


**Figure 7** — Automatically manufactured front panel from Front Panel Express, with design created using their in-house software (see Figure 6).

## Front Panel Design and Fabrication

I chose Front Panel Express for the end plate production because of their integrated design software and production capability.[6] The process is similar to *ExpressPCB* in that you can download free design software and through their website, select various production options, get estimates, make payments, and arrange for shipment.

Their design software runs on both Mac and PC computers. Figure 6 shows the design input for the front panel on the unit shown in Figure 7. The cost of the panel was about $70.

Because of the costs involved, this is not a process to learn by trial and error. It pays to check and recheck your work. Also, note that when fitting mechanical assemblies together, there need to be clearances. Front panel holes for controls should be somewhat larger than their bushings.

## Conclusion

As I mentioned at the outset, this was a rebuild of an existing project. The *ExpressPCB* system allowed three circuit boards in the master unit to be shrunk to a single board with all the front panel controls mounted directly on the board. This simplified construction, but made the alignment of the controls with their mounting holes in the front panel, a critical mechanical design issue. Close attention to detail ensured that this did not become a problem. The new front panels manufactured by Front Panel Express using their design software have proved superior to the original ones, whose stick-on labeling was beginning to show signs of wear and tear. As before, the new units are housed in the versatile aluminum extrusion cases manufactured by Enclosures & Cases.

**Notes**

[1]W. Ellis, KF7PB, "Build An Audio Distribution System," *QST*, Sep 2013, pp 42 – 45.
[2]ExpressPCB — Schematic entry, PC board layout, PCB manufacturing: **www.expresspcb.com/**.
[3]VMware Fusion — *Windows* emulation software for the Mac: **www.vmware.com/products/fusion/**.
[4]PowerCADD — General purpose CAD: **www.engsw.com/**.
[5]Enclosures & Cases — Extruded aluminum cases: **www.enclosuresandcasesinc.com/**.
[6]Front Panel Express — Front panel design, manufacturing: **www.frontpanelexpress.com/**.

Photos by the author.

Amateur Extra class licensee and ARRL member William Ellis, KF7PB, was first licensed in the early 1950s. He received a BSEE from Purdue University in 1958 and a MSE degree from George Washington University. He spent 35 years in the cable TV industry working in various capacities and retired in 2002 from Finisar Corp. Today he spends most of his Amateur Radio time working with the Mercer Island Radio Operators in pursuit of improving emergency communications for the City's Emergency Management Organization. You can contact Bill at **kf7pb@arrl.net**.

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