10-channel Power Amplifier Construction

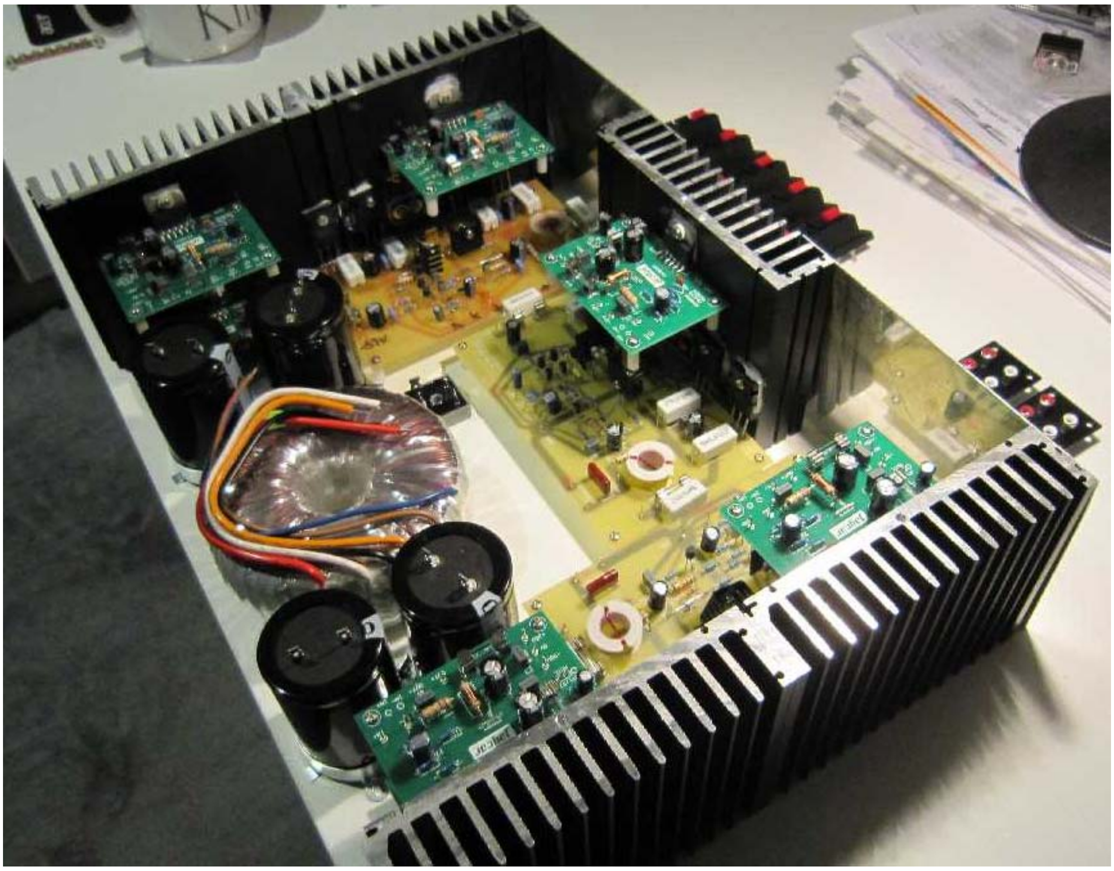
The 10-channel amplifier contains the following amplification modules: 7 x 50Watt/8ohm + 3 x 100Watt/4ohm.

The easiest to assemble were the 50Watt/8ohm modules, so I this is where I started my assembly process. Quite simply, I needed some practice before I tackled the more complex amplifier modules. It took approximately 45minutes to assemble one 50W module, and 3 hours to assemble one 100W module.

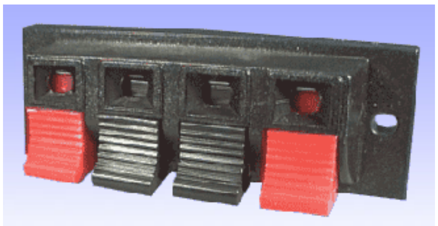
Having assembled all modules, I was able to bolt them to heat-sinks and make an approximate layout of all modules and power supply components, mimicking the real chassis and front panel. I had to make several holes in the heat-sinks, and thread them to M4 size, and this provided mounting arrangement for the heat-sinks to the chassis. Picture below shows all assembled modules attached to their heat-sinks and also all components of the power supply. You will notice, that I have used 4 x 10000uF electrolytic capacitors (20000uF per supply rail).

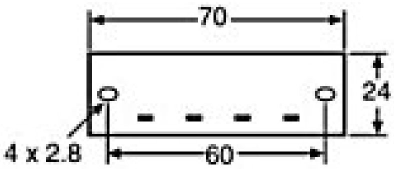
Also, I used double heat-sinks as the enclosure's left- and right-sides. Heat-sinks tongue and groove ends enable multiple heat-sinks to be ganged together. They are black anodized and are ideal for high powered amplifier chassis. All are 150mm wide by 34mm deep and 121mm high. Thermal resistance of each heat-sink is 1deg/W. There is also central heat-sink at the back, that helps to secure input and output terminal assembly panels, made of 1.5mm aluminium sheet. One terminal panel accommodates 5 double-pairs of speaker spring terminals and the second panel holds 12 RCA input sockets. The 500W toroidal transformer is centrally located at the front of the chassis.

Once I was reasonably confident that I can fit all components (including speaker terminals, switches and input RCA sockets) onto the mock-up chassis, I was ready to order 5mm pre-cut aluminium sheets for the main chassis.



Heat-sinks are 120mm high, and this parameter determined the hight of the whole amplifier. Fortunately, the 5 loudspeaker terminals mounted on one of the back panels have combined hight of exactly 120mm as well.





Input terminals are simply two 6-way phenolic RCA sockets shown below.

Mains power switch is DPDT Standard Toggle Switch - Body size 29.5 x 18mm - Clearance 23mm- Mounting hole 12mm. - Rated 3A 250V.

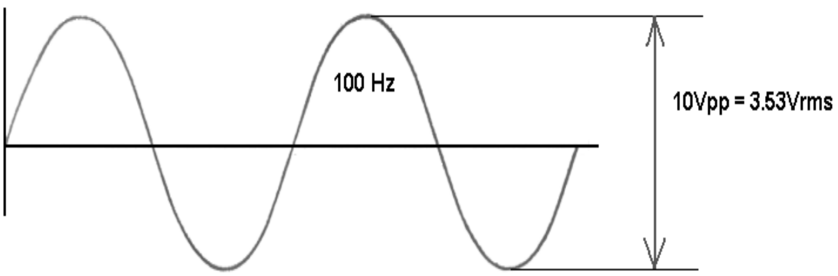
Front panel is a simple 45cm x 14cm aluminium plate, bolted to 45cm x 31cm chassis plate using right-angle bracket. Brushed-aluminium finish was accomplished by taking a belt-sander with coarse sandpaper to it, and finishing it with a few strokes of smoother sandpaper by hand. There are no sharp edges anywhere now. The front panel is very simple in appearance, and has only power switch and a red LED indicator on it (shown above). Main chassis plate has four rubber feet bolted to it.

And, finally fully wired and functional 10-channel amplifier.

Amplifier Gain Adjustment

Some attention must be paid to gain distribution throughout the audio chain of potential DVD player, the PC, and the power amplifiers. In order to maintain high dynamic range (or high separation from the PC-induced noise), the UE3 should be operated near the maximum available output voltage swing from Delta1010LT and the gain of the power amplifiers should be as small as possible.

Delta1010LT will deliver 10Vpp (or 3.53Vrms) when driven to the onset of clipping – see picture below. Output power amplifiers should deliver their nominal output powers with this input voltage.



On the other hand, from the formula: P[W] = (Urms*Urms)/R, we can calculate the RMS output voltage corresponding to each amplifier's nominal output power. For instance, the 50W/8ohm amplifier should deliver:

SQRT(P * R) = SQRT(50W * 8ohm) = SQRT(400) = 20Vrms

Therefore, the voltage gain of this power amplifier is only:

Gain = 20/3.53 = 5.6

For the 100W/4ohm amplifier, the calculations of gain look as follows:

SQRT(P * R) = SQRT(100W * 4ohm) = SQRT(400) = 20Vrms

Therefore, the voltage gain of this power amplifier is also only:

Gain = 20/3.53 = 5.6

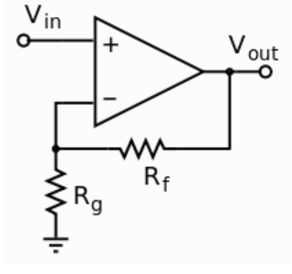
For the 180W/8ohm amplifier, the calculations of gain look as follows:

SQRT(P * R) = SQRT(180W * 8ohm) = SQRT(1440) = 38Vrms

Therefore, the voltage gain of this power amplifier is:

Gain = 38/3.53 = 10.8

My power amplifiers can be approximated by an OPAMP schematic as follows:

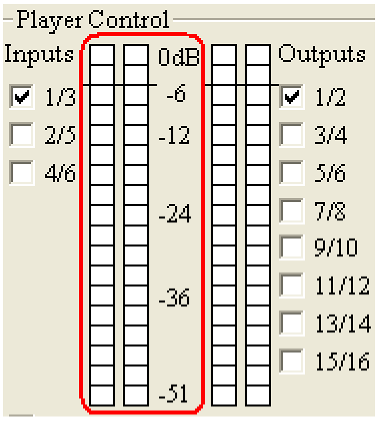


So, that **Gain = Rf/Rg + 1**

1. 50W/8ohm amplifier. Gain = 5.6, Rf = 18kohm -> Rg = 3.9kohm
2. 100W/8ohm amplifier. Gain = 5.6, Rf = 18kohm -> Rg = 3.9kohm
3. 180W/8ohm amplifier. Gain = 10.8, Rf = 10kohm -> Rg = 1kohm

One other obvious advantage of this approach is that UE3 LED level indicators are now calibrated for maximum undistorted output power for each channel. For instance, 0dB level in woofer's front left and right channels corresponds to 100W/4ohm power output. It goes as follows:

0dB = 100W
-3dB = 50W
-6dB = 25W
-9dB = 12.5W
-12dB = 6.25W
-15dB = 3.125W……..
.
-51dB = 0.8mW

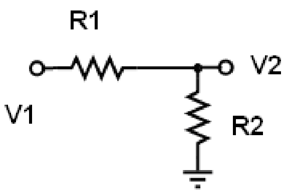


Now, there is no need to install output power meters on the amplifiers' front panels. You can simply use UE3 LED indicators as output power monitors.

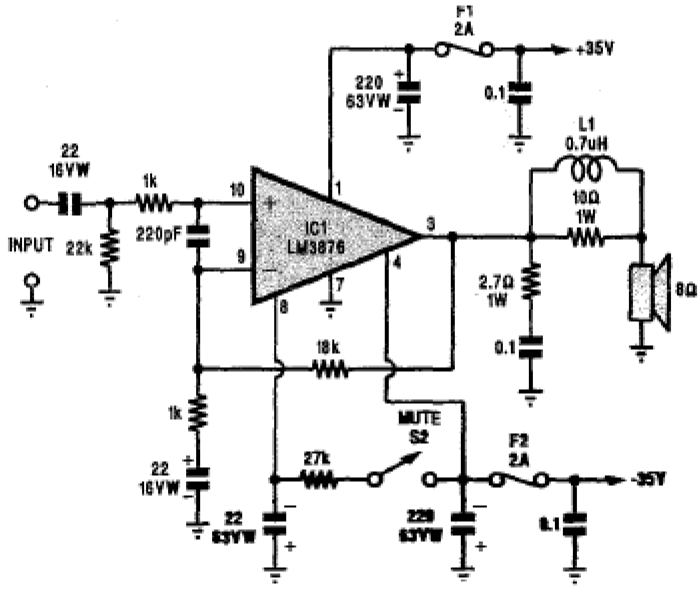
Inserting -10dB Input Attenuation

This component is entirely optional. Having conducted listening tests with amplifier gains adjusted as explained above, I am satisfied, that the system is quiet and transparent, even with UE3 volume slider adjusted to 100%, and CD player paused. Consequently, UE3 volume control becomes system's master volume control.

However, if you consider input attenuators, here is an example of implementing them.



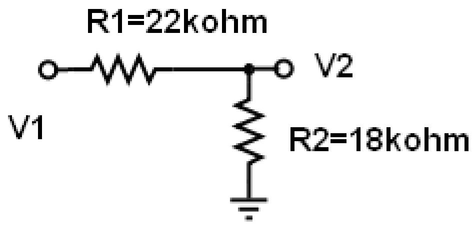
In order to obtain SPL level reduced by -10dB I have inserted a resistive attenuator at the input of the power amplifiers. Here is an example calculation for the 50W/8ohm amplifier – shown on the schematic below.



It is obvious, that the R2 resistor (18kohm) in the L-pad attenuator will be connected in-parallel with the 22kohn input resistor of the LM3876. This connection will reduce my R2 down to about 10kohm. On the other hand, the -10dB SPL attenuation translates into 3.16 times reduction in input voltage.

V1/V2 = (R1+R2)/R2 = 3.16
3.16*R2 = R1 + R2
R1 = R2 * 2.16

Since R2//22k is now about 10kohm, then R1 = 10 * 2.16 = 21.6kohm.



I have also reduced the 220pF input capacitor between pins 9 and 10, down to 33pF to avoid inserting unwanted low-pass filter when the input attenuator is ON.

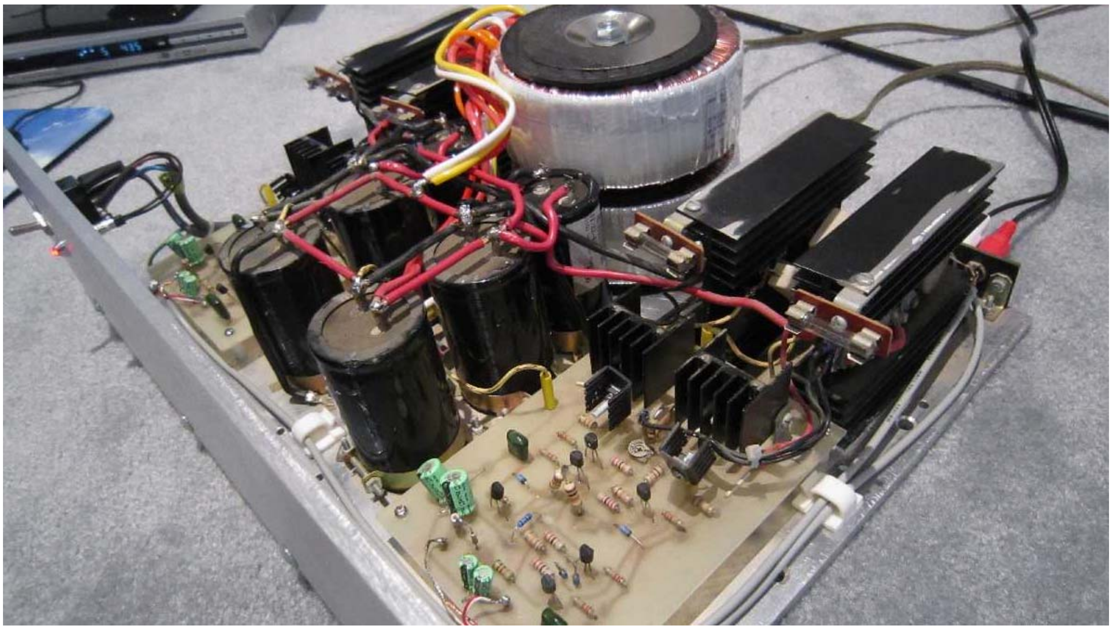
2-channel Subwoofer Amplifier Construction

I built this amplifier over 20 years ago and it has been working very well ever since (schematic is shown in the previous paper on amplifiers http://www.bodziosoftware.com.au/Power_Amplifiers.pdf).The original version of this stereo amplifier included bass and treble active tone controls and input voltage follower for each channel, both using OPAMPs. In addition, there was also a 10-LED output power indicator for each channel.

I have stripped all these non-essential functions, and removed the old front panel, and was left with only two 180Watt power modules and obviously power supply. I also have beefed-up electrolytic reservoir capacitors to 6x10,000uF (see below), and used 2 x 300VA toroidal transformers with secondary windings connected in parallel in the power supply. DC supply voltage is now +/-56V.

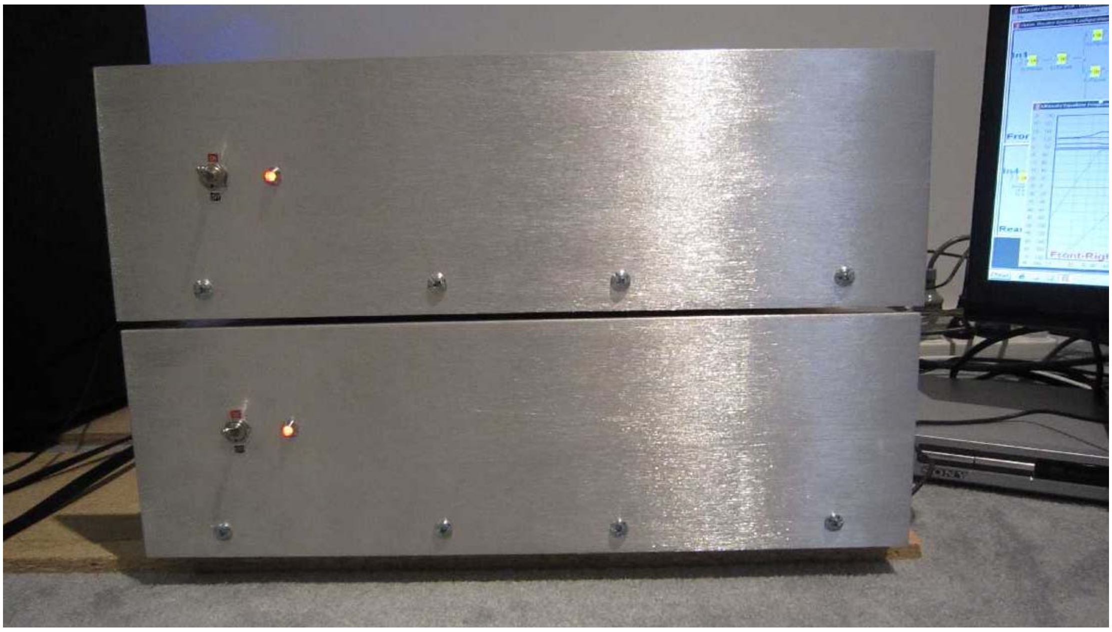
This amplifier was designed as a classical 3-stage device, with differential input stage (providing (+) Input and (-) Feedback terminals), followed by a common-emitter voltage gain stage and finishing with emitter followers output stage. With one exception, the differential input and voltage gain stages are fully symmetrical.

The new front panel is also a simple 45cm x 14cm aluminium plate, bolted to 42cm x 30cm chassis plate using right-angle bracket. Brushed-aluminium finish was accomplished by taking a belt-sander with coarse sandpaper to it, and finishing it with a few strokes of smoother sandpaper by hand. The front panel is very simple in appearance, and has only power switch and a red LED indicator on it (shown below). Main chassis plate has four rubber feet bolted to it.



The two toroidal transformers are mounted on the top of each other, with about 10mm spacing between them.

The two amplifiers are now a “matching pair”.



Concluding Remarks

Amplification system for this project has been heavily customised. I started with a broad assessment of power output requirements, outlined in the paper http://www.bodziosoftware.com.au/Power_Amplifiers.pdf and then proceeded with the design of the amplifiers (or rather the selection of amplifier modules) to meet the above, including requirements imposed by specifics of the loudspeaker configurations. For instance, out of several possible options for front-left and front-right loudspeakers, I opted for tall and narrow form-factor, and this would imply two smaller woofer drivers, instead of one larger unit. This decision, resulted in 4ohm input impedance for the woofers in these loudspeakers, so the corresponding power amplifiers had to accommodate this requirement.

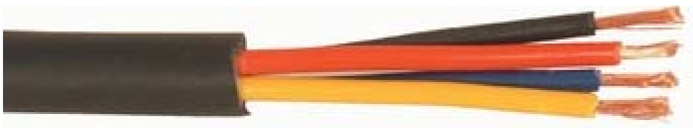
In this system, I have incorporated 3 different power levels (180W, 100W and 50W) and two different impedances (8ohm and 4ohm). Spare headroom is being mostly used for HBT equalization purposes, resulting in smooth and extended frequency response of the system: 16Hz – 22kHz, and maximum SPL above THX requirements.

I would highly recommend performing the initial, even rudimentary analysis for audio power requirements, that is done specifically for your system. If you envisage a future expansion in loudspeaker design, like going from 2-way to 3-way, or going from 5.2 to 7.2HT system, it may be best to accommodate this idea in the amplifier design, and provide sufficient real estate for future expansion.

Generally, I found the modified 100W kit to be fairly versatile unit. After modifications outlined in http://www.bodziosoftware.com.au/Power_Amplifiers.pdf, it can be used in higher power amplifiers – simply by adding another complimentary set of output transistors and increasing power supply voltage. Or, it can be turned into lower power amplifier – by doing the opposite. This kit is rather simple to assembly and uncomplicated enough to become a "workhorse" in the multi-channel amplifier system, ranging from 12 x 50Watt to 12 x 200Watt. It would be rather easy to design a 10 x 100W system using this module, or anything in-between. Obviously, there will be a cost associated with each configuration. I found commercial amplifier modules readily available off-the-shelf and there is even a kit for 350W amplifier kit, that I could possibly use in the future as subwoofer amplifiers. However, my requirements called for smaller unit, and I was able to refurbish my old stereo amplifier for this purpose.

Where possible, I combined power supply for the amplifier modules, into single unit. This resulted in two amplifier boxes: the surround channels amplifier and the subwoofer amplifier. Cost reduction was significant, as I did not have to built complete individual power supplies, chassis and heat-sinks for each loudspeaker amplifier system. This may as well be the minimum requirement for separation of power supplies to avoid undesirable effects of heavy currents being drawn by subwoofers interfering with lighter power supply loads, like the 5 tweeters in the system.

Both amplifiers are intended to be slotted into an entertainment unit shelves, and pushed back, therefore, I did not built any covers for them. All two-way loudspeakers are connected to their corresponding amplifiers via a 4-core, colour-coded loudspeaker cable, therefore visually, there is only one cable going to each loudspeaker box. I like this solution, as it makes the system look neater.



So here it is - you are looking at completed and functional 12 channels of amplification, with complete signal routing and voicing control via UE3:

- Subwoofer amplifier – 180W/8ohm x 2.
- 10-channel amplifier – 100W/4ohm x 3 and 50W/8ohm x 7.