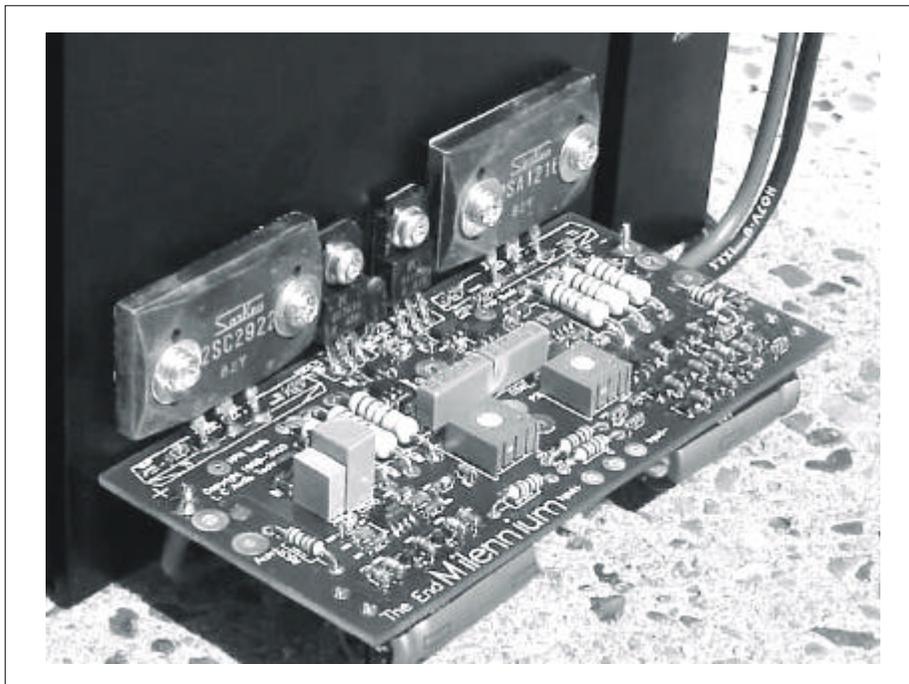


# The End Millennium

Audio Power Amplifier.



## Cook Book.

The End Millennium is a high quality Power Amplifier, in power sizes of 99 to 300 Watts (8 Ohms). While running in Class A/B the high sound quality is reached through a number of advanced design strategies. First of all no feedback loops is found in the circuit, as any error that might be corrected by the feedback loop, cannot be corrected before it is factual, and then - obviously - it is too late. A simple circuit topology with a minimum of high quality components ensures short signal path. Polyprop Capacitors, Vertical bipolar multi emitter transistors, glass substrate resistors to mention some of the high-tech components used.

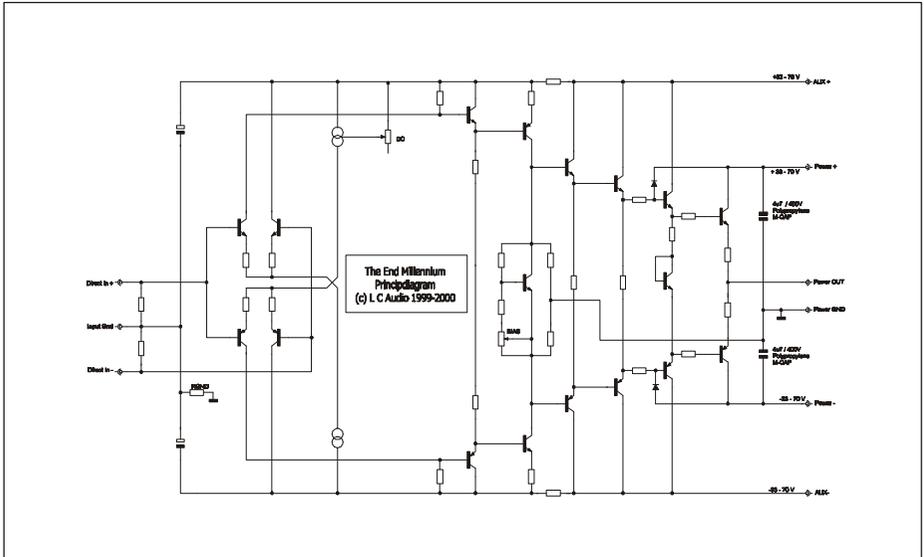
The higher frequencies are played with simplicity through the ultra fast amplifier (linear to >500.000Hz) and the four stage output power tunnel gives a firm and fast bass reproduction. The total soundstage is well controlled and well defined, with precise space and nerve visuality.

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**Further information: [www.lcaudio.com](http://www.lcaudio.com)**

# Principle behind The End Millennium.



The principle schematic shows how simple the fundamental circuit of Millennium really is. There are no feedback loops (100% non-feedback), there are no capacitors or other sound depriving components near the signal path. The frequency response is linear from DC to extreme highs: 500.000 Hz. This is probably the fastest amplifier You ever heard! Any part of the music from the deepest bass to the teeniest transient is reproduced with ease by the Millennium!

The Millennium module also contains extra functions such as DC servo and an effective short circuit protection. The protection will monitor if any overload is evident, and then shut down for a couple of seconds. No current limiters or signal limiters are used at all. Should an overload occur, the amp will automatically shut down, and wait for things to normalize again. Then it will turn on and play normally. This system is so effective, that short circuit is allowed at full power for days!

Owing to the new amplifier topology, which in several aspects is path breaking in modern audio technology, it has been possible to make available an amplifier with a well controlled sound picture, a liquid flowing soundstage and extreme precision, at a very affordable price. The low price is primarily possible because You do the assembly work Yourself. (Hand built ready versions are available at a higher price).

The four stage output power tunnel lets the speaker membranes draw all the current required, directly from the power reservoir. Not only to start the motion, but also to stop at the right microsecond.

## 100% Non-Feedback = 100% musicality!

The warm - almost tube like - sound is mostly owing to the amplifier structure not containing the usual feedback loop. This principle is normally called non-feedback, and is also used in other brands of (costly) high-end amplifiers.

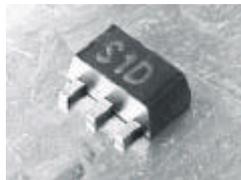
In a normal amplifier (with feedback loop) a typical approach is to use a high-gain (up to 100.000 times) / high-distorsion circuit to perform the voltage amplification. By comparing the output signal on the speaker terminals to the input signal fed to the amplifier, it is possible to send a correction signal to eliminate any error and thus reducing the measured harmonic distortion. However an error cannot be corrected before it is encountered, and then it is in fact too late, because the speakers are also connected to the erratic signal. In fact the error signal is comparable to eliminating waves in one end of a swimming pool by sending opposite waves from the other end. Not practical, unless the waves have a very low frequency, compared to the time it takes the correcting waves to reach the other end of the basin.

Another problem occurs when You are trying to linearize a signal, that have been amplified by an nonlinear (distorting) element. Then You will inevitable see modulation formerly known as TIM (Transient Inter Modulation). This is annoying is there is say two vocalists in a piece, but You actually hear a third un-harmonic tone. In better cases a loss of audible details is found, but less annoying.

Another way to detect modulation is when an amplifier changes sound when the volume is raised or lowered.

In The End Millennium the sound is exactly the same no matter what playing level is required. It uses a quite different technique to eliminate distortion. In a non-feedback topology there is no possibility to remove distortion once it is evident, so every method has to be enforced to avoid distortion. Ultra Linear Semiconductors, Highly Stable Resistors, no capacitors, and rounded PCB traces for all audio signals. All components used are brand-name highest graded stuff, that is only found in other amplifiers at a far higher price level.

The result is uncomplicated, and extremely clear audio quality with absolutely no modulation, but instead streams of details and musical dynamics.



The british made Z-Transistor is a vertical bipolar transistor built a way normally associated with MOSFET's . However the Z-transistor has much less  $R_e$  (or  $R_s$ ) than any FET or MOSFET, and therefore it produces less distortion in an audio circuit.

The capacitance is negligible (6 pF) and very low noise is also a useful property.

## High Power Millennium Systems.

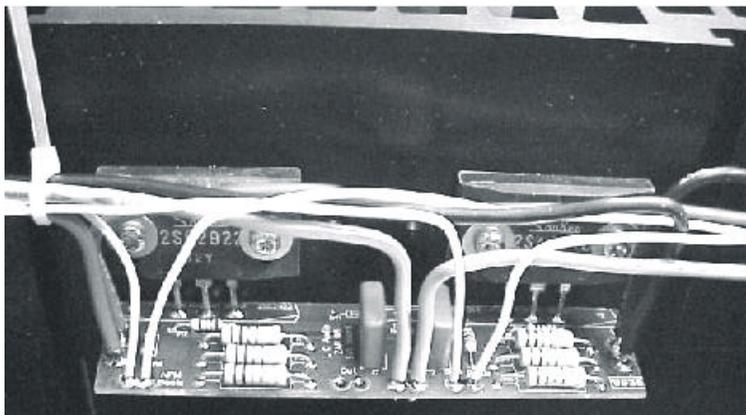
A basic Millennium amplifier is designed to run on a 33-0-33 V transformer and put out 120 Watts in 8 Ohms / 240 Watts in 4 Ohms. By adding an extra set of power transistors on an ext. Module, You may use the Millennium at higher power levels or lower impedances (right down to 1 Ohm). One extra set of output devices will let the unit run on a 40-0-40 V transformer and provide 180 Watts in 8 Ohms / Two extra output modules will give You 350Watts in 4 Ohms. 3 Extra sets will give 250 Watts in 8 Ohms / 500 Watts in 4 Ohms with a 50-0-50 V transformer..

The extra output devices are placed on an ext. Module that also contains emitter resistors and appropriate bypassing caps to secure stability.

Instead of higher voltages the impedance with the latter system may be sustained at 33-0-33 V (AC) and more than 800 Watts are available in 1 Ohm loads.

Due to the risk of sound quality deprivation we do not recommend parallelling output devices that are goind to reproduce treble / midrange frequencies. Parallel devices have small differences that will result in high order (very audible) distortions, heard as aggressive sound at high volume levels. The solution is to have separate outputs for bass and treble/mid. However this requires the speakers to be bi-wirable. Most speakers have this feature today. One set of output devices drive the treble/mid output, while a number of additional sets enforces high current output in the bass output where high-order distortion is removed by the speaker filter.

Separate output terminals are standard issues in out kits of 180W or higher. (Except the Balanced versions where no parallel output devices are used anyway).



**Ext. board with an extra set of output devices plus emitter resistors and bypassing caps .Up to 3 ext. Boards can be connected to one main board using power and signal in/out wires.**

## “The End” is the greatest audio success in Scandinavia ever!

Any Scandinavian DIY audiophile knows The End in former version 3.1. More than 3600 of this kit was built in the period from 1995 to 1999 where Millennium took over. Nearly every one of these 3600 units runs today and provides remarkable high sound quality in hundreds of different sound systems.

The Millennium edition is improved in every aspect:

- NEW!** Four stage output power tunnel ensures bass control.
- NEW!** Glass substrate resistors improve linearity and homogeneity.
- NEW!** Signal Amplification is performed by the special Z-transistors with very low  $R_e$  and output capacitance ( $C_c=6pF$ ).
- NEW!** Ultra Linear Core (ULC) Circuit topology gives low distortion with no feedback..
- NEW!** Power rails bypassed by 4,7uF Polypropylene Foil Capacitors ensures high Treble resolution.
- NEW!** Any PCB trace that carries audio signals have rounded corners rather than Angular ones. This eliminates standing waves in the trace, and gives a more Correct and precise sound.

Furthermore a couple of functions have been added to the compact Fr4 material main board. A selectable DC Servo keeps DC error within 5 mV, and an effective short circuit protection keeps Your amp alive, even under extreme overloads. A BIAS system where any thermal load is within limits to a supply voltage of +/- 100V ensures long operational life in any application. Millennium is also stable with low supply voltages ( from +/- 10 V DC ).



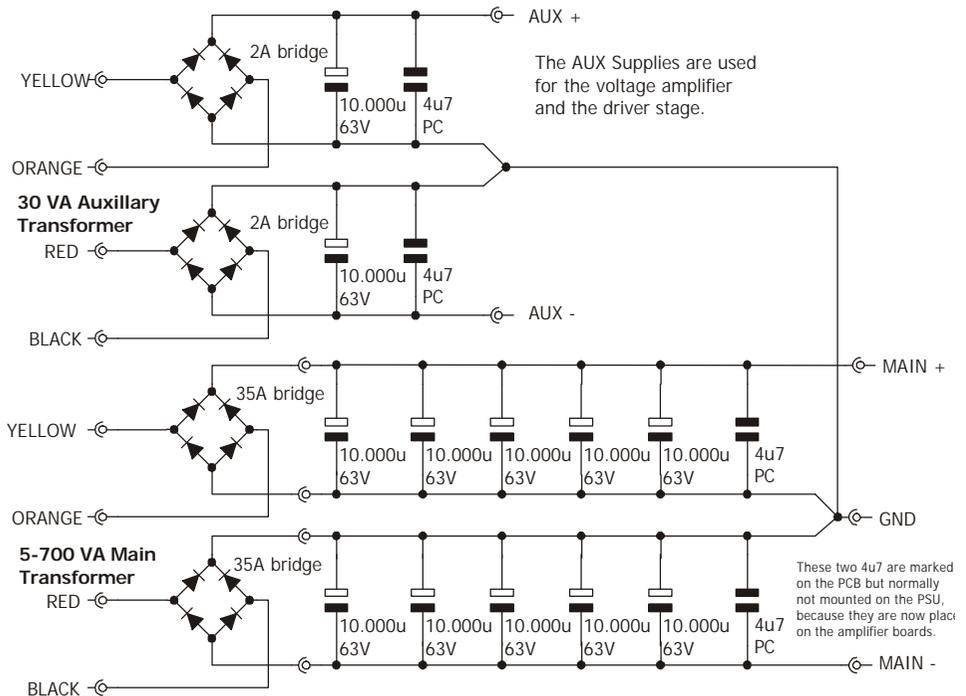
# Power Supply Considerations.

The Power Supply is crucial for the sound quality!

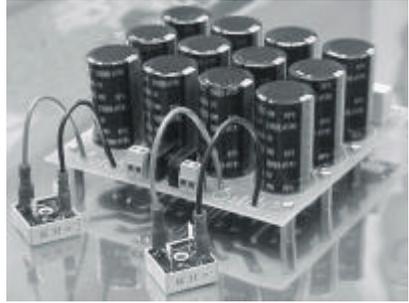
If You are going to design the perfect audio power supply, the most appealing option is to use a battery of the great performing (Swedish made) RIFA power capacitors of 100.000 uF each. Combine with blocking coils to remove charging peaks and You have the best practical Audio Power System.

However the price and size of this approach makes it less appealing to your view of sensible money and space utilization. It is too expensive and takes up as much space as a small refrigerator. Therefore we have designed the Super Power Supply, to use intelligent design to weigh up for the size and simplicity of the RIFA solution. 120.000 uF of Low Impedance American made ChemiCon cans configured with a separate supply for the sensitive signal amplifiers, so any dips in the main power caused by extreme loading, will not affect the input and driver circuits.

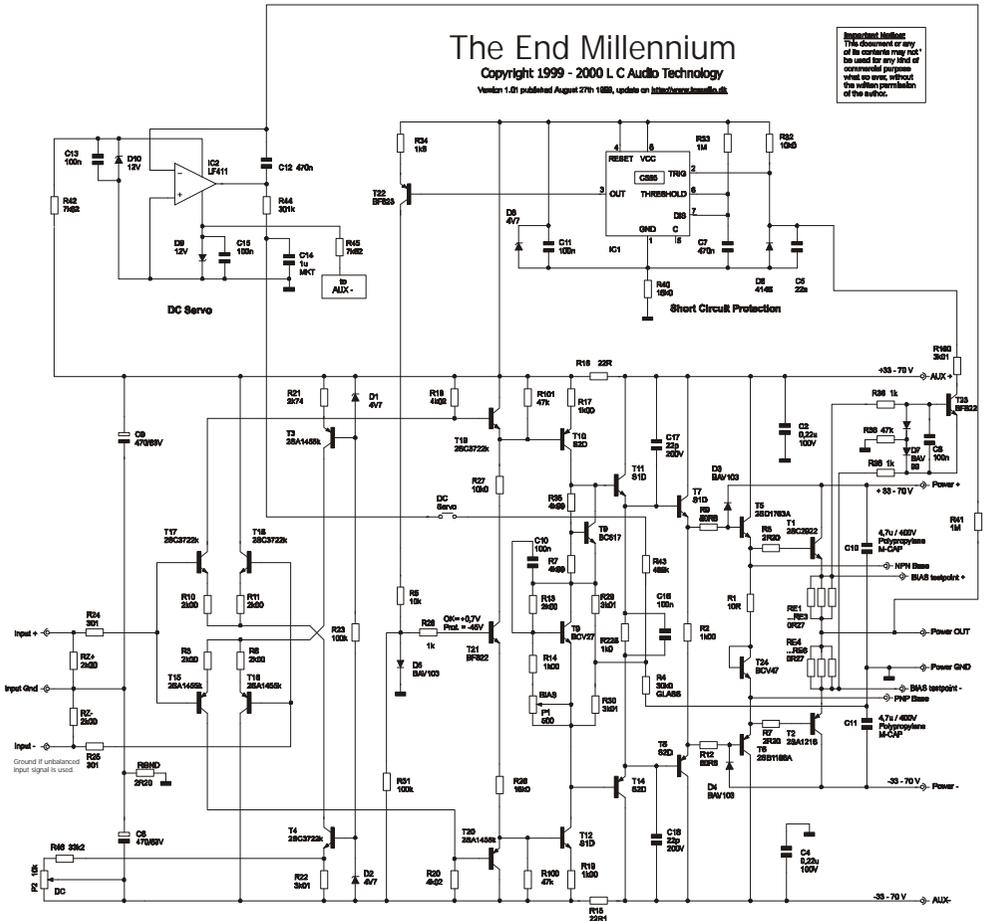
Also a set of Poly Carbonate caps eliminate high frequency noise from the rectifiers.



The Power supply unit consist of 120.000 American made MicroFarads, and provides all the stability and musclepower needed to drive even critical speaker loads. The brand ChemiCon is formerly known as Sprague.



## Complete Schematic.





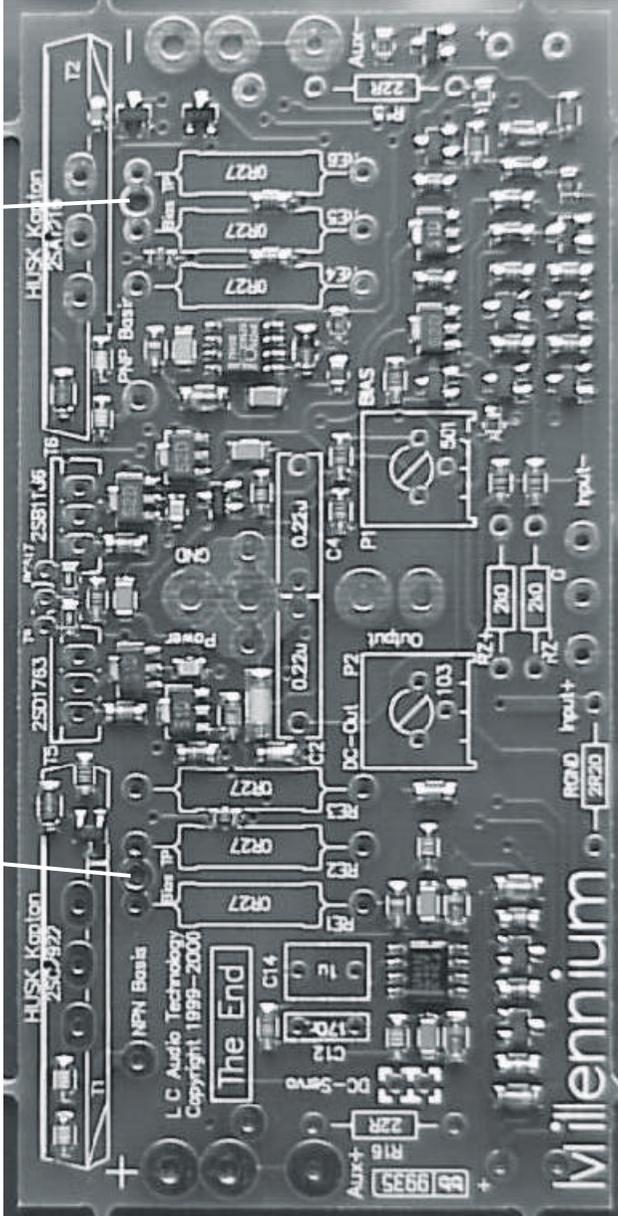
-30-70V

-30-70V AUX supply.

BIAS testpoint

Heatsink placed here..

BIAS testpoint



+30-70V

+30-70V AUX Supply.

Photo of the Millennium Main PCB.

## Partslist.

<b>Transistors.</b>			
T1	2SC2922 Sanken		
T2	2SA1216 Sanken		
T5	2SD1763A		
T6	2SB1186A		
T9	BC517		
<b>Capacitors.</b>			
C1	4u7 Polypropylene		
C2	0,22u MKT 100V		
C3	4u7 Polypropylene		
C4	0,22u MKT 100V		
C6	470u / 63V Panasonic FC		
C9	470u / 63V Panasonic FC		
C12	0,47u MKT		
C14	1u MKT		
CZ	0,1u PP	(for Zobel network)	
<b>Resistors.</b>			
R15	22R Beyschlag	Red Red Black Gold	
R16	22R Beyschlag	Red Red Black Gold	
RGND	2R2 Beyschlag	Red Red Black Silver	
RZ+	2k00 Beyschlag	Red Black Black Brown Brown	
RZ-	2k00 Beyschlag	Red Black Black Brown Brown	
RE1-6	0R27 Beyschlag non inductive	Red Violet Silver Gold	
P1	500 Ohm Bourns 3386P trimmer	mark '501'	Bias adj.
P2	10k Bourns 3386P trimmer	mark '103'	DC offset adj.
RZ	2R15 1W	(for Zobel network)	
<b>Diverse.</b>			
Main PCB with SMD components fitted.			
	2 Kapton isolation pads (add no grease!)		
	4 Screws 3 by 13 mm selfcutting alu screws		
	2 Screws 3 by 8 mm. Selfcutting alu screws		
	4 big 3mm. Flat Washers		
	2 small 3mm. Flat Washers		
	1 Jumper for DC Servo		
Components not mentioned above are already fitted on the board as SMD's			

## Building Instruction.

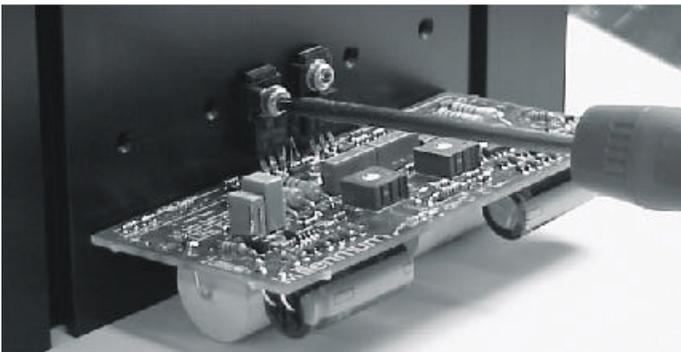
Assembling the Millennium is easy and consumes little time. Start by pouring all the components in the package out on Your table. Get Your Soldering iron heated.

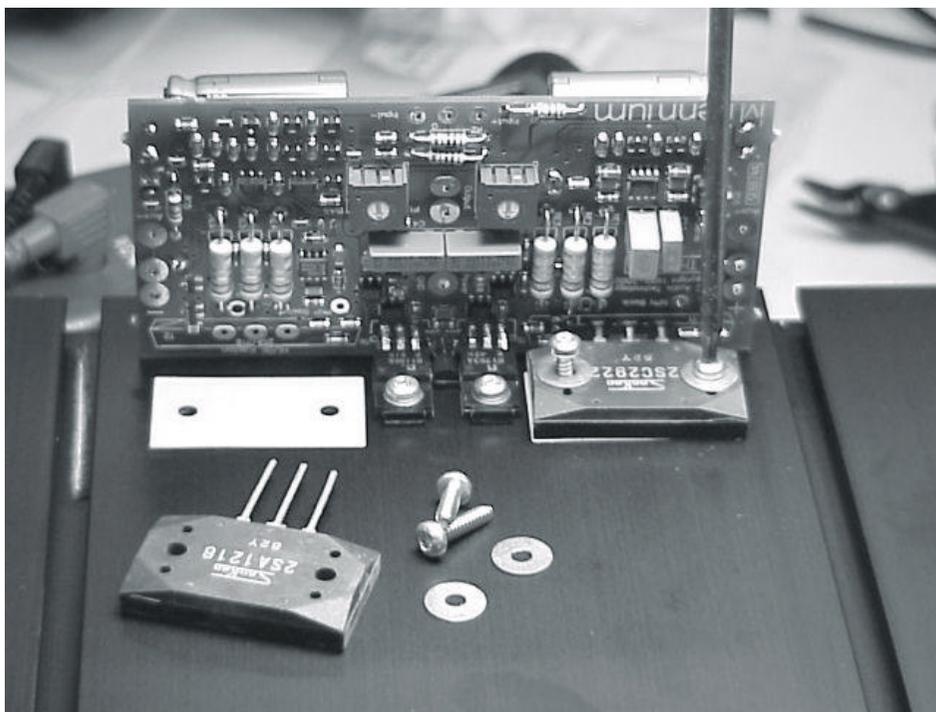


Start by mounting the lowprofile components, like resistors and trimmers. Follow the printed values on the PCB itself, and compare with the color codes printed on the previous page. If You are sure everything is mounted correctly, solder it down. After this fit the capacitors, first the smaller ones and then the larger ones. Solder.

The two 470uF cans go on the backside, remember to polarize them, so the minus lines printed on them are both closest to the nearest edge of the PCB. Lay them down on the PCB (backside) before cutting/soldering. Now mount the T9 and the drivers, (careful they fit in each ones separate side.) so high up as the pin lengths allow for. They should be nicely aligned in a right angle compared to the PCB, now solder them.

After this screw the drivers on the heatsink using the shorter 3mm. screws and the small washers. No insulation or grease is called for! They should now align to the heatsink with no airgap. The picture shows that the 4u7 caps are also mounted, but it is a bit easier to wait with these a few minutes.





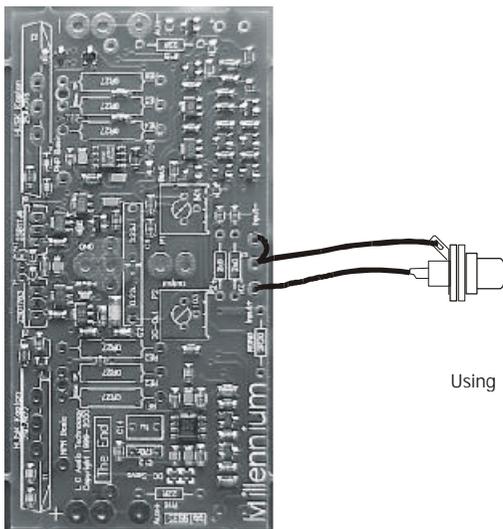
Lay the heatsink down and place the (orange) Kapton sheets over each pair of mounting holes for the output devices. No grease is called for!  
 Fit each Sanken output transistor in the CORRECT side of the pcb, the metal side facing the heatsink. **Careful there may be no impurities captured under the powertransistors** before fastening them to the heatsink. Use the bigger washers and screws. Tighten as much as possible without breaking the screws!  
 Then solder to the PCB, and crop the pins.  
 Now mount the 4u7 caps on the backside, from main+ to gnd, and from main- to gnd.  
 Connect input and output terminals as shown on the following pages.

### Important!

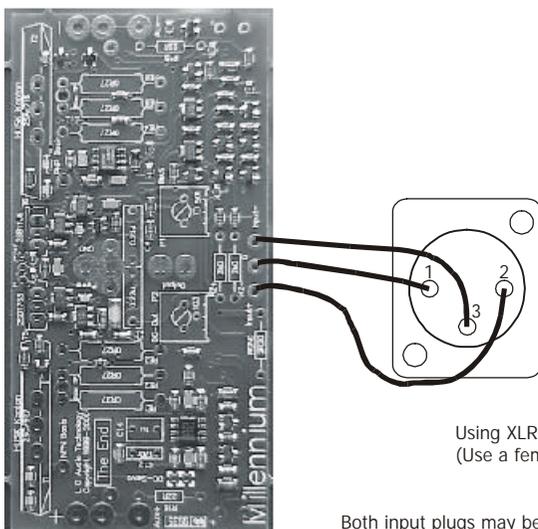
If You use the Super Powersupply with separate transformer for the input- and driver stages (recommended) You are required to cut the thin PCB tracks between + and AUX+, and also between - and AUX -



## Input terminal Connections.



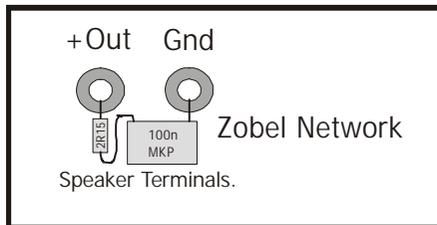
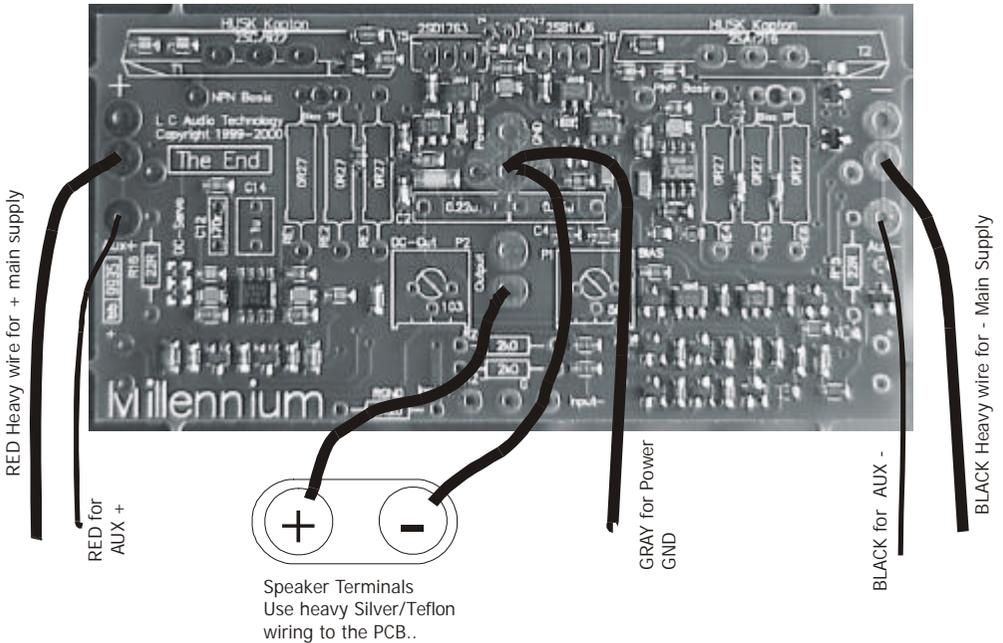
Using RCA (unbalanced) input signals.



Using XLR (balanced) input signals.  
(Use a female chassis plug).

Both input plugs may be used simultaneously, just leave the -input unshorted to gnd, and connect both plugs.

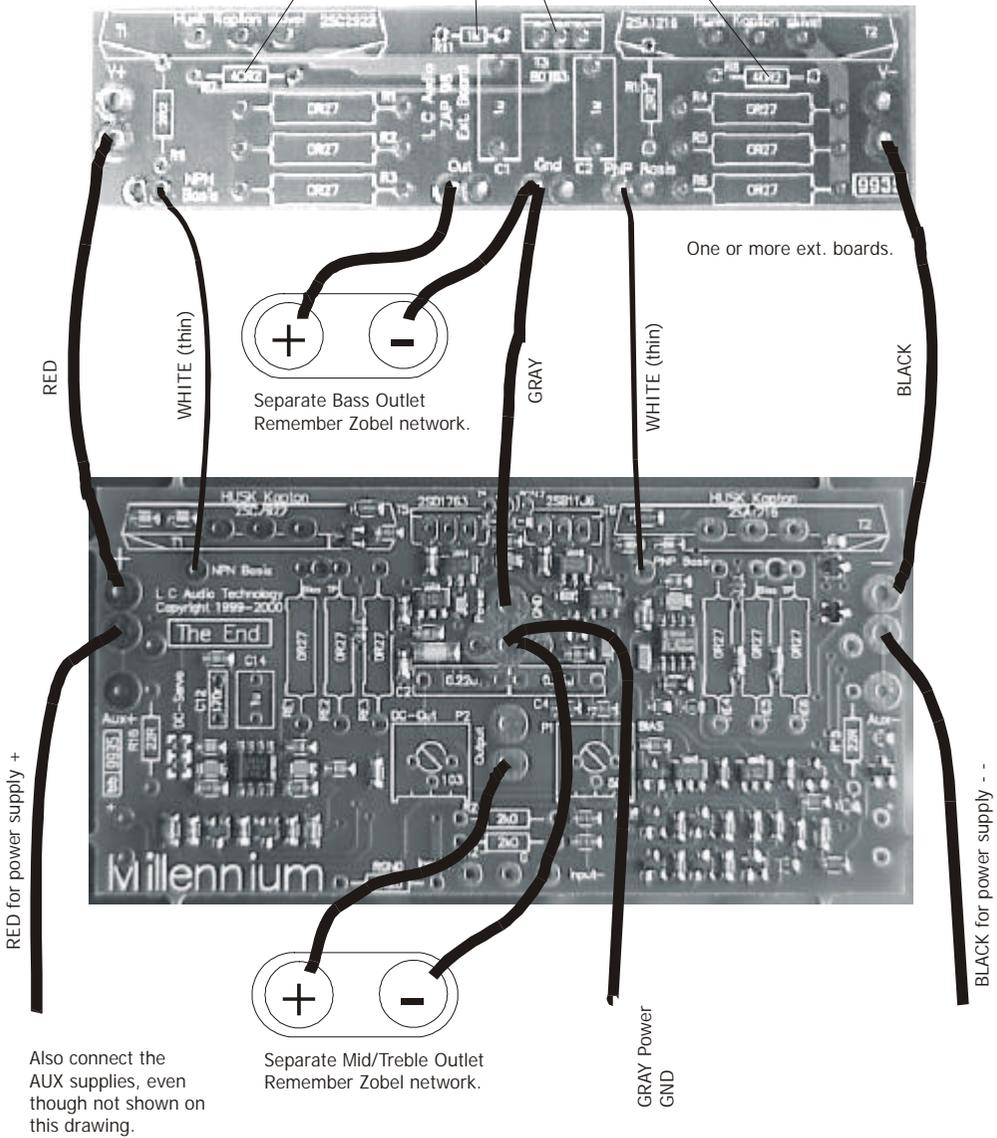
# Connecting the speaker terminals, and Powersupply.



We recommend mounting the ZOBEL network on every output. The required parts are included in the kit.

# Connecting the Ext. Boards to the Main Board.

Note, the two 40R2, one 1k resistors and BDT63 should NOT be mounted!



## Adjustment.

Connect a multimeter (mV) between the two BIAS testpoints, see p.10 to locate them. Connect a power source for the amplifier. Do NOT connect a loudspeaker yet.

Adjust the BIAS trimmer (501) to 10 mV if You are using 8 Ohm speakers, or 20 mV If 4 Ohms.

Move the black wire to the multimeter to power gnd, and the red one to the Output terminals.

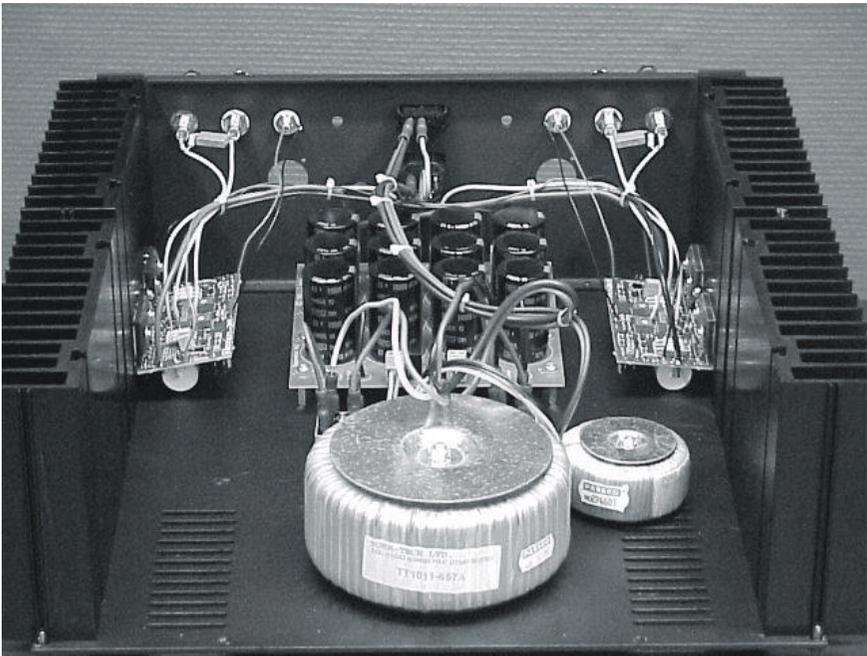
Adjust the DC trimmer (103) to close to 0. An error of +/- 50 mV is acceptable for any loudspeaker.

Check the BIAS testpoints again, perhaps You may have to readjust. Values of +/- 20% are quite OK.

Repeat procedure for the other channel.

If any of these adjustments cannot be met, please contact L C Audio, before proceeding.

Connect Your speakers, and start playing! Note a burnin period of 1-2 weeks is to be expected for optimal sound performance.



## Use of the DC servo.

The End Millennium an integrated DC servo at Your disposal. You may use it or exclude it from the circuit as You wish. Here is our advise on using it:

Some audio experts have the opinion, that DC servos affect the bass reproduction, and in some cases they are right! The bass sometimes becomes soft and fluffy.

This is owing to the fact that the servos in some amplifiers run at a too high frequency cutoff point of say 10-20 Hz.

In the Millennium we have put a great effort into making a DC servo that would not affect the bass. The cutoff frequency is as low as 0,5 Hz, and there is a second order filter instead of the normal first order types. This means the cutoff slope is steeper, and therefor affects audible frequencies less. The DC Servo effect at 20 Hz is close to 0.

The filter caps C12 and C14 are plastic fiol types with non-magnetic pins, so even if the whole sound had to pass through these caps, they would stand the test of most critical hifi listening. However they are never in connection with signals above 0,5 Hz.

**You should use the DC Servo If:** You have electrostatic speakers with a high voltage transformer, since it has a DC resistance of close to 0.

**You do not have to use the DC servo if:** You have normal dynamic speakers, they accept DC errors of up to some 200 mV without any problems at all.

## Parts.

### The End Components:

The End Millennium 120W kit complete (1 ch.)

The End Millennium ext. 180W kit complete (1 ch.)

Heatsink for for 120W ( 2 pcs needed for 180W )

Super Power Supply Mk2 120.000uF/63V + Rect.

Transformer 2 X 33V 500 VA for 99 / 120W low noise (240 V primary)

Transformer 2 X 40V 600 VA for 180 W low noise (240V primary)

Auxillary Transformer 2 X 40 V 30 VA f. 120W/180W version

Cabinet kit with 10mm. Aluminium front. Black finish 140 mm. Height

### Accessories:

Digital Softstart module for power amplifiers up to 2000 VA

Mains noise filter 10A incl. Case

Mains DC filter, stop the humming! ( module for build-in)max. 500 VA

Speaker Terminals WBT 0763, 2 pcs.

RCA receptables, 24k gold plated with TEFLON, 2 pcs.

# Systems.

## Systems

### 99W stereo system:

- 2 The End Millennium kit
  - 4 Heatsinks
  - 1 Transformer 2 X 33V 500 VA
  - 1 Super Power Supply Mk2 120.000uF/63V
  - 1 Cabinet kit
  - 1 Set WBT b.p.. screws, RCA's, power cord+++
- 

### 120W stereo system:

- 2 The End Millennium kit
  - 4 Heatsinks
  - 1 Transformer 2 X 33V 500 VA
  - 1 Aux. Transformer 2X40V 30 VA
  - 1 Super Power Supply Mk2 120.000uF/63V
  - 1 Cabinet kit
  - 1 Set WBT b.p.. screws, RCA's, power cord+++
- 

### 180W stereo system:

- 2 The End ext. Millennium kit
  - 4 Heatsinks
  - 1 Transformer 2 X 40V 700 VA
  - 1 Aux. Transformer 2 X 40V 30 VA
  - 1 Super Power Supply Mk2 120.000uF/63V
  - 1 Cabinet kit
  - 1 Set WBT b.p.. screws, RCA's, power cord+++
- 

We also have kit systems for 200 and 300 Watt versions available, and for AC3 / DTS systems we have 5,6 or 7 channels (120W) kits available.  
You may also configure a 5 ch. of 120W plus 1 ch. of 400W for bass all in one cabinet.

## The PowerTrend Cabinet.

The End Millennium is easily built in our PowerTrend cabinet that gives a discrete and powerful impression. You may also use Your own cabinet design if You prefer, and in such case You can leave out the cabinet from Your order.

However with this case the assembly goes swift and easy. Materials are:

Frontplate 10 mm (3/8") seawater resistant aluminium with a char paint finish.

Top Cover 2 mm. (3/32") aluminium with cooling mesh.

Heatsinks sturdy extruded anodized aluminium.



On the rear side You have all holes necessary to fit speaker terminals (WBT) RCA and XLR receptables and power inlet and switch.

Any mains side components used are UL, CSA, CE and VDE approved.

***L C Audio Technology***

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