

# Linear Audio Auto-ranging Attenuator



## Assembly Guide

*V1.5*

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## Errata

This page lists any notes or errors that were discovered after the introduction of the unit.

Please read this!

1. Capacitor C27 on the attenuator board (right side area). The footprint is a combined 0.1inch/2.54mm and 0.2inch/5.08mm 3-hole footprint. The intention was to connect two of the three pins together so both footprint parts could be used. However, the connection between the two 'pin-1' holes is not present, so you MUST use the two outer pins!
2. Capacitor C6 was originally specified as 510pF but needs to be 360pF. The BOM has been amended.

## Introduction

The Linear Audio Auto-ranging Attenuator (AR) is an automatic signal level adjustment unit intended for use with audio soundcards and similar equipment where the input signal should be at a specific level for best performance. The AR attenuates or amplifies the signal to be measured to the level expected by the soundcard.

The AR is available as a 'half-kit' through the Linear Audio website. This concept makes it possible to keep the cost affordable, yet provide the specific PCBs, programmed controller and enclosure plus critical components for a successful assembly. The remaining common parts may be found in many personal parts boxes or can be obtained from any of the usual parts sellers. A full BOM with Mouser part-numbers is provided. The construction does require soldering of through-hole parts, mechanical assembly and wiring between subassemblies. This Guide discusses this assembly process and, when followed, will virtually guarantee a unit performing as in the spec sheet.

### 1. The parts of the kit

1. Enclosure. The enclosure is a 2-part steel shell, painted and lettered. It has threaded (metric M3) studs for mounting the individual PCBs. The front panel has cutouts for the display and the controls and connectors, while the back panel has a single cutout for the USB-B type input power connector.
2. Power supply. This is based on the well-known Linear Audio SilentSwitcher. The SS takes nominal 5VDC from a USB charger or a PowerBank as input and provided very low noise and clean +/-15VDC and +5VDC for the other parts of the unit.
3. Display and Control PCB. This PCB is mounted on the back side of the front panel and contains the microprocessor, the LCD display, control push-buttons and power On/Off switch. This PCB has only through-hole components and needs to be assembled by the builder (you;-).

4. The attenuator PCB contains the input/output connectors and all the relay switching and attenuation circuits. It is provide pre-soldered with all the 0.1% SMD components for the precision attenuators that might be hard or expensive to obtain individually in small quantities. The PCB is tested before delivery, ensuring that the basic attenuation circuits are working as specified.
5. This board has to be completed with the through-hole parts as noted in the BOM.

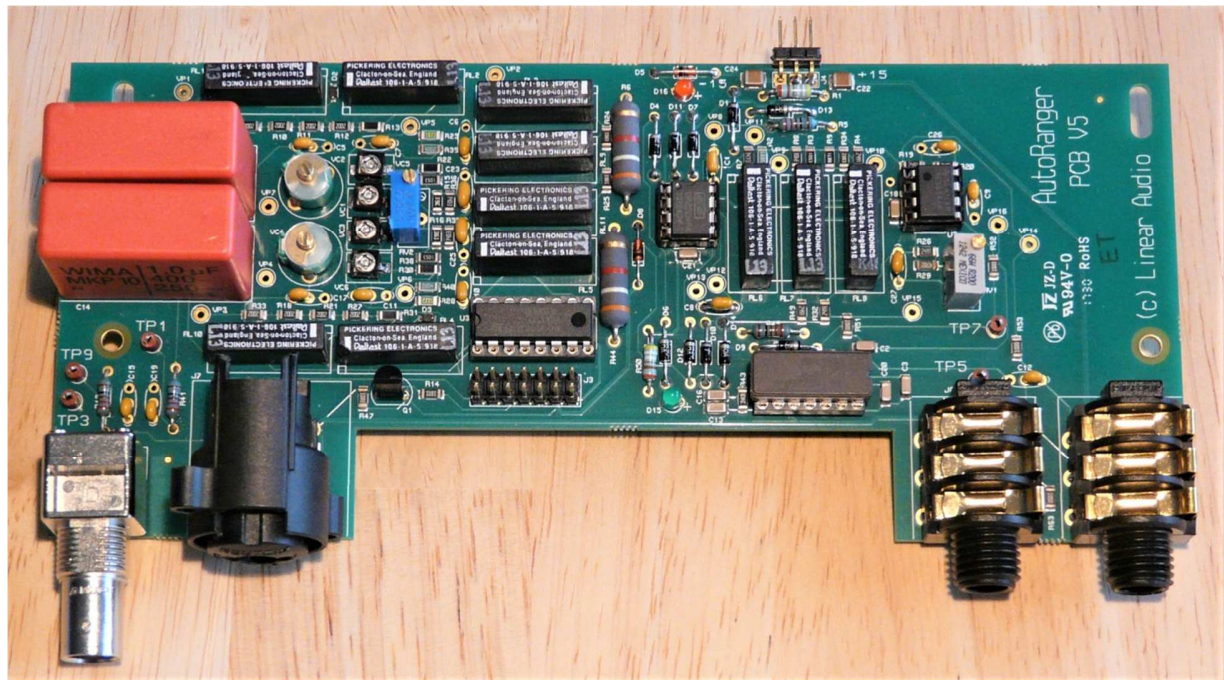
## 2. Calibration and adjustments

After completing the unit it can be used as-is. However, for optimal performance, it should be adjusted for display accuracy and extended flat frequency response. For this, a good AC DMM and a signal source are required. The calibration procedure is described in the separate *AR Calibration Guide*.

## 3. Attenuation board

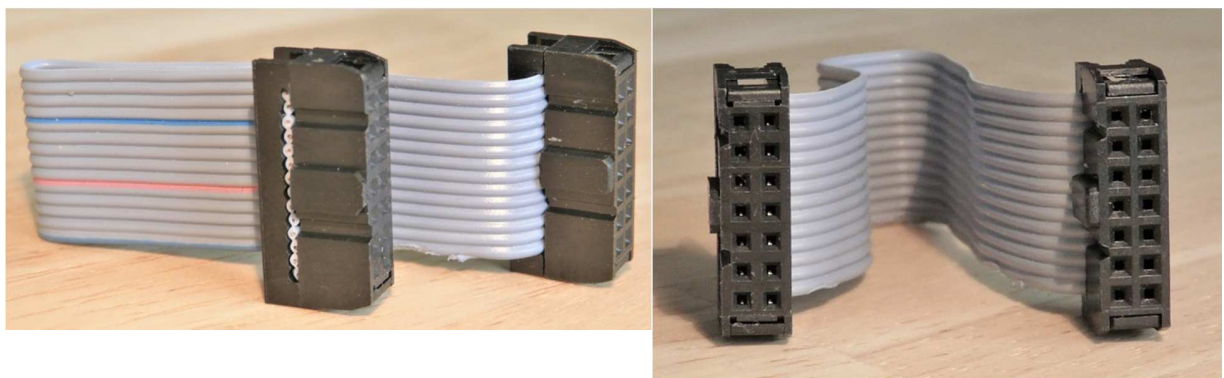
The BOM table lists the Mouser parts numbers as a guide only; it does not imply that only these parts are suitable. It is convenient to buy everything in one go but you can use any equivalent part you already have, and the Mouser listing will provide the pertinent part parameters like pin pitch, tolerance and type of part (e.g. COG/NPO ceramic types or metal film resistor types).

Following the BOM and the Stuffing Guide, solder all parts. Your board should look like **Figure 1**. Do not yet insert the opamps. Do a visual inspection of correct parts location, diode orientation, that sort of thing. Check that all pins have been soldered and there are no obvious short. Also check that there are no parts missing on the board. Set the board aside, and then repeat the whole visual inspection a day later ;-).



*Figure 1 – completed attenuator board*

This may also be a good time to construct the flat cable that will connect the attenuator board to the display& control board. Study **figure 2** for the connector orientation. Basically, the two cable ends are inserted in the 2\*14 pin header connectors in the same orientation. Cable length is not critical but you need some leeway to avoid stresses; 9 cm or 3.5 inch works fine.



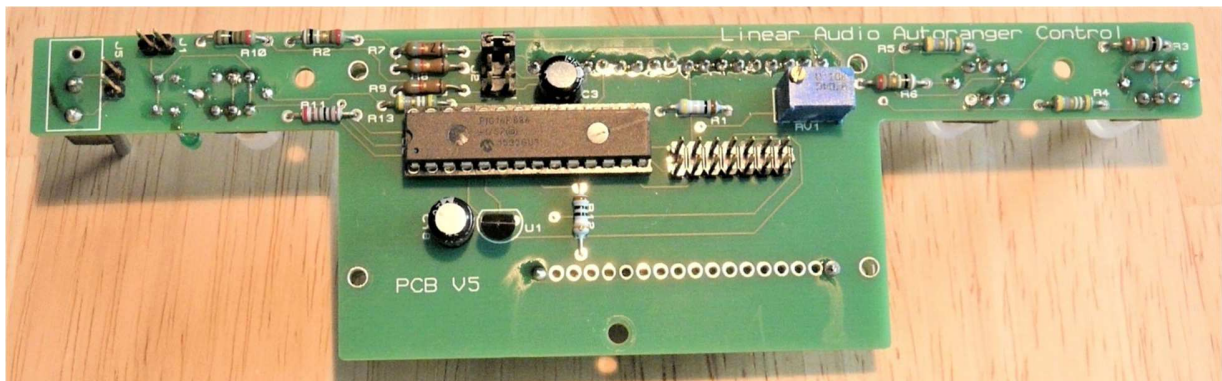
*Figure 2 – interconnection flat-cable construction*

#### 4. Front panel control board

1. **Rear side parts.** This board needs some attention to the mechanical build-up. Most of the parts are mounted on the back side that points to the inside of the enclosure. However, the push-buttons, the power switch, the LEDs and the LCD display must be mounted on the front side.

The best way is to start with soldering in place the parts located at the back side, including the 28-pin DIL socket for the microcontroller and the flat cable header. The parts list is shown in the BoM with the same comments to the Mouser part numbers as mentioned before. **Do not yet solder the LEDs (D1, D2), the LCD (DP1), the power switch (S1) and the three push-buttons (SW2, SW3, SW4).** Leave those for last.

After completion it should look like **figure 3**, again, do a thorough visual inspection as described before, and then again!



*Figure 3 – Completed display & control board rear side*

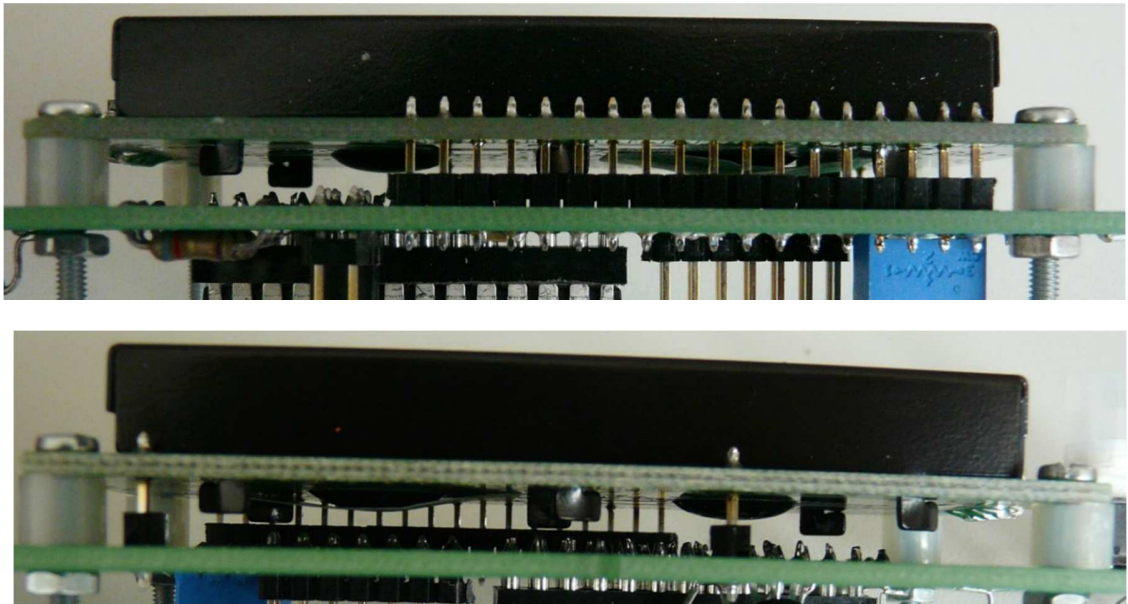
2. **Front side parts.** Next mount the LCD display to the front side of the control board as follows. We will do the mechanical assembly first and then solder the pins. The mechanical assembly needs some care to make sure that after final assembly the display sits nicely in the center of the enclosure window, flat against the front panel. The steps are as follows:
  - a. Insert the SIL header pins in the top row on the board as shown. Insert two single pins in the bottom row as shown. Place the LCD on the pins – this requires some wiggling but take your time. The easiest



(for me) was first to slip the LCD across the top pins and then onto the two bottom pins. **Do not solder anything yet!**

- b. Using 2.5mm metric or imperial screws, nuts and 5 mm (0.2 inch) standoffs (4 each) hardware, carefully *temporary* mount the LCD at 5mm above the board. **Figure 4** shows this step. This is to keep the LCD at the correct position while soldering the pins. Do this carefully; there is no way you can correct this after soldering short of taking everything apart and starting over, which will be hard without breaking anything (*the pictures are from the prototype and show the pins already soldered*).

c.



*Figure 4 – temporarily mount the LCD to the control PCB with 5mm (0.2inch) standoffs as shown. Top shows the view with the top row pins inserted but not soldered. Bottom view shows the two fixing pins at bottom row 1<sup>st</sup> and last hole.*

- d. Next, solder all the LCD pins and remove the temporary mounting hardware.

- e. Finalize this PCB by mounting the three push-button switches and the On/Off toggle switch. **Important:** there is a colored dot on one of the corners of each push-button and this dot **must** be lined up with the small square edge mark on the PCB! **Figure 5** shows the completed front side.



*Figure 5 – completed front side display & control board*

## 5. Power supply board

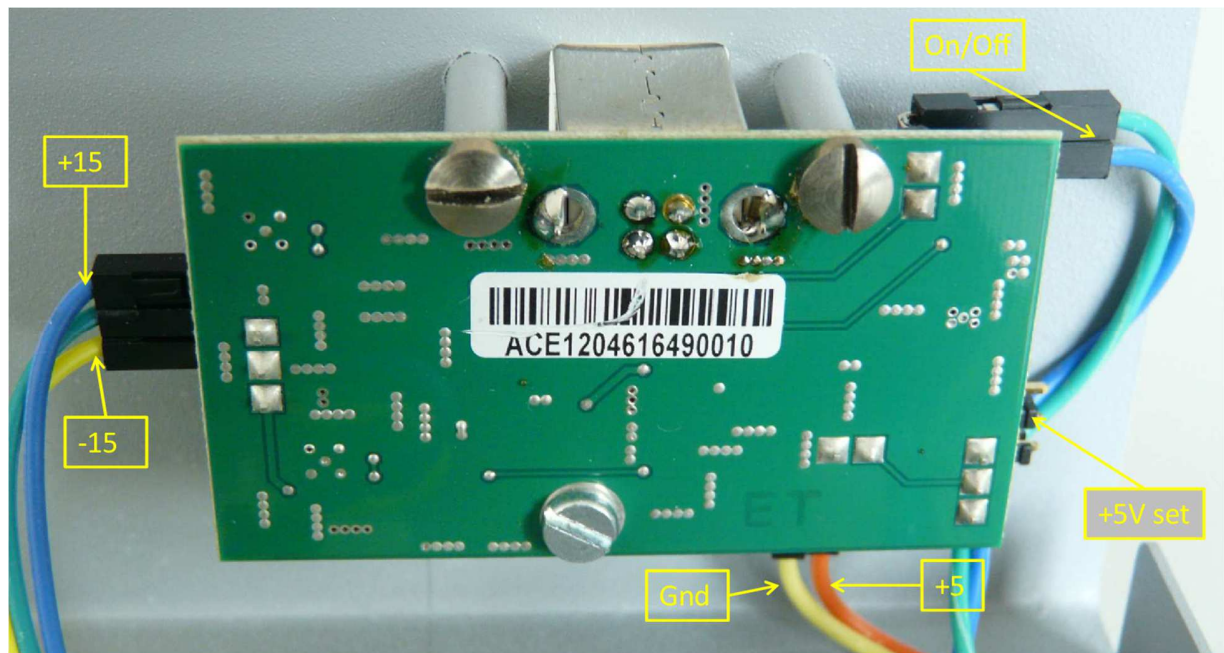
The power supply board consists of one of my SilentSwitchers, which can be powered through a B-type USB connector on the back side.

The SS has with two input options, a USB- connector and a 2-terminal screw connector. For the AR you need to mount the provided USB connector, **at the component side!** Refer to **figure 6**. Mount the small board with M3x6 or 8mm hardware; the USB connector should be flush with the back-panel on the outside.

**Make sure that the low voltage select jumper is in the 5V position!**

Normally the AR should be run off a standard 5V USB charger. For extremely sensitive measurements, the AR can be run off a standard 5V PowerBank for full mains isolation.





*Figure 6 – Mounting and connecting power supply*

## 6. Final assembly

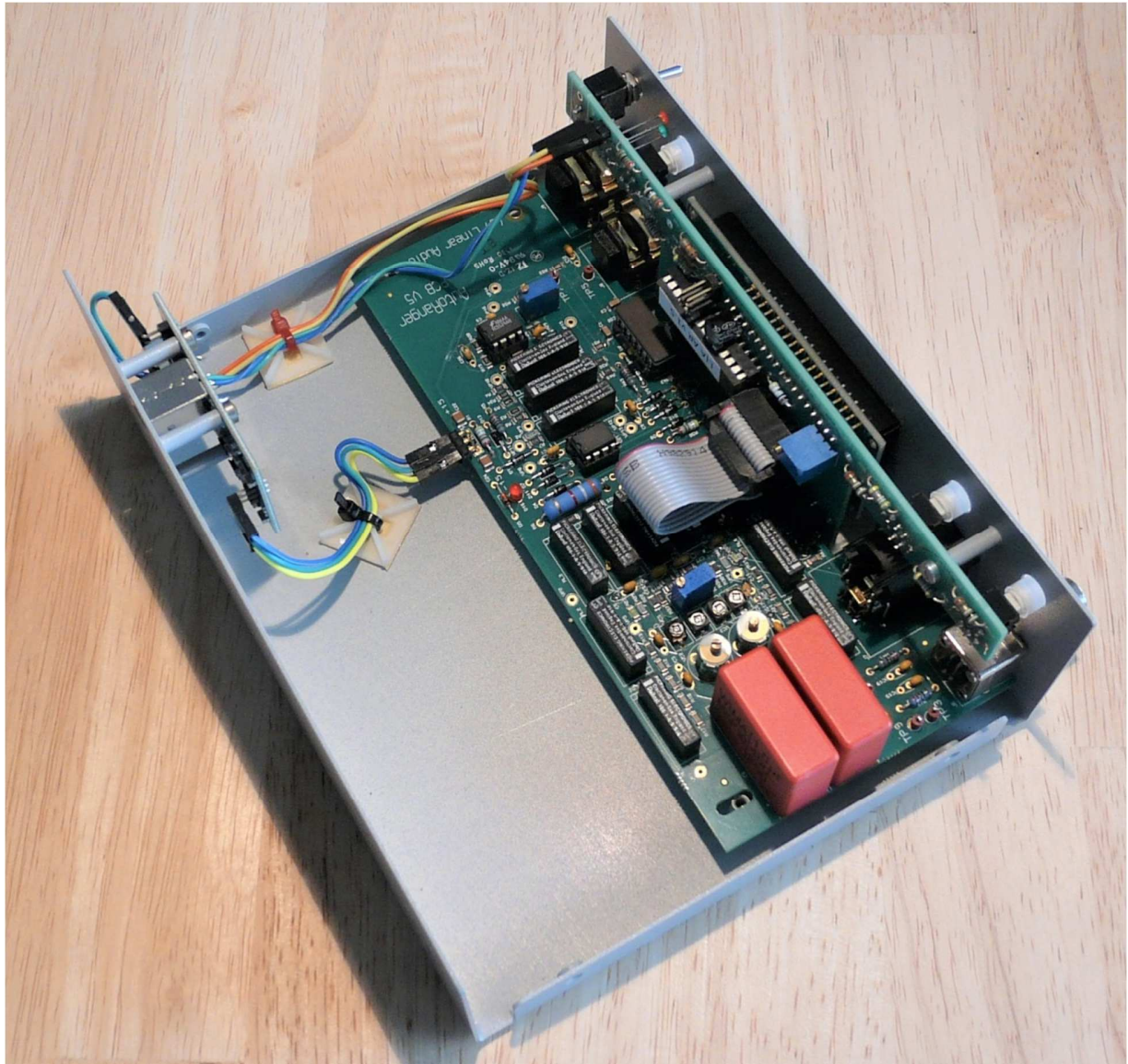
After all boards and cabling has been prepared, you need to put it all together in the enclosure. Mount the power supply first, then the display & control board. Use the supplied (metric) mounting hardware with the spring washer.

Next mount the attenuator board; put the flat cable on the attenuator board before fixing it to the front panel because it is a tight fit. Fix the connectors to the front panel, then the two screws in the slot holes. Then connect up the flat-cable. Connect and double check the power supply wiring as shown in previous pictures.

When all is said and done, it should look like **figure 7**. Congratulate yourself and take a break ;-)

### 1. Initial switch-on

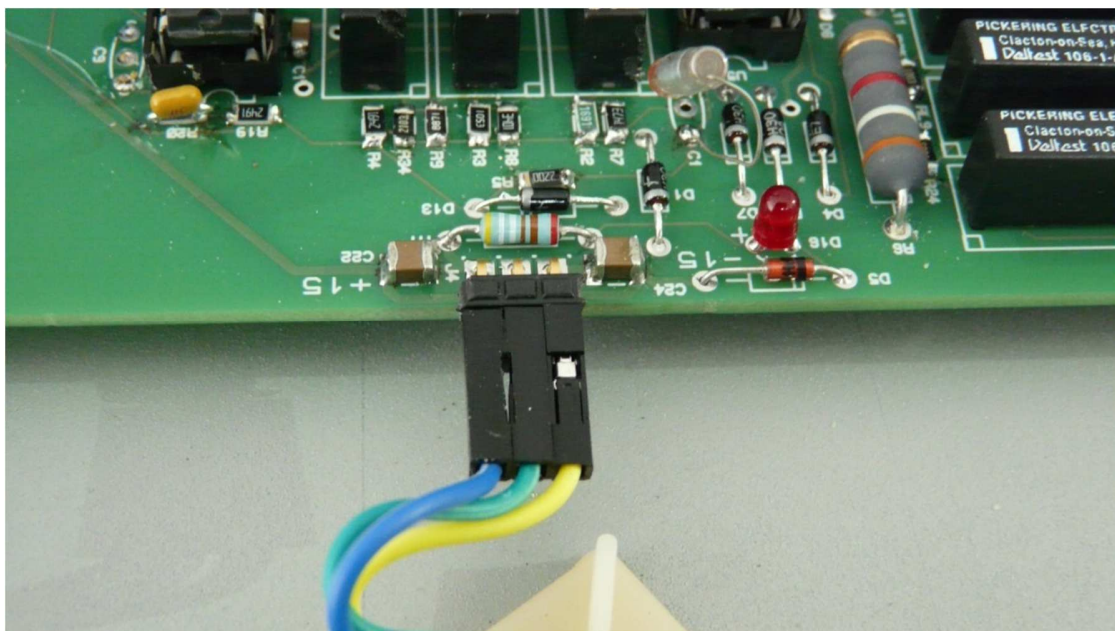
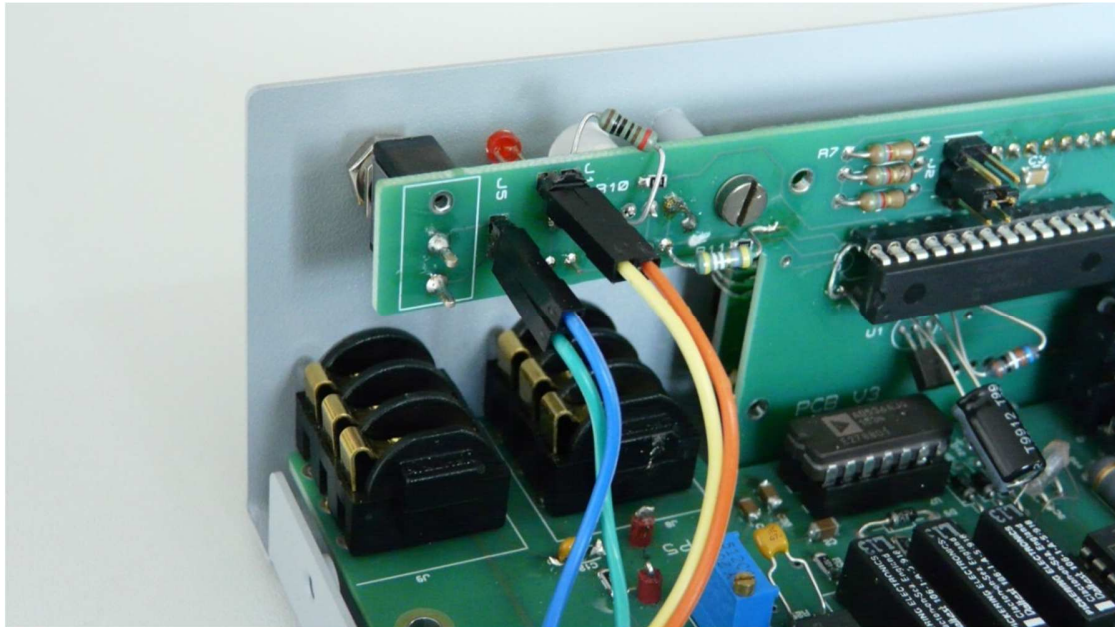
If you are sure all parts have been mounted, all cables connected, every pin soldered etc., it will be time to switch the unit on for the first time in its long and useful life!



*Figure 7 – final assembled unit*

Just to be doubly sure, verify the connection polarities of the +/- 15V and +5V from supply to the main- and display board. Review **figures 6, 7 and 8**. The wire colors on the boards correspond to those on the power supply picture.



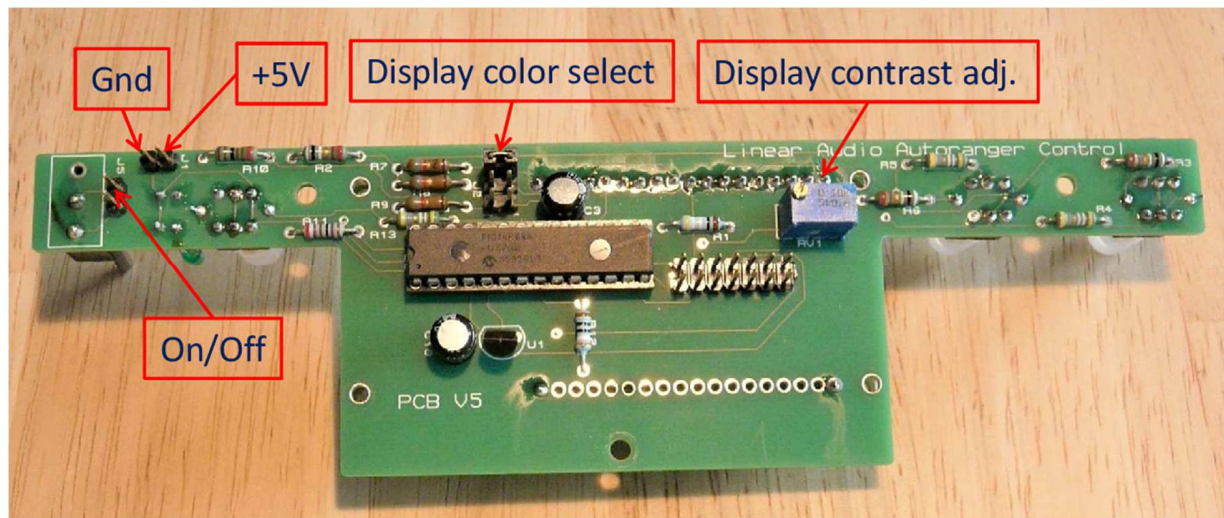


*Figure 8 – Power connections to attenuator and display/control board*

### Display color and contrast

The display has three-color LEDs for backlighting and any one (or several at the same time) can be selected with jumpers. There is also a trim pot to adjust the contrast setting; the optimum setting may be different for

different colors. **Figure 9** shows the location of the jumpers and the trimpot at the back of the front panel PCB.



*Figure 9 - Display color and contrast setting on front panel PCB*

At the first switch-on you will see a short log-on message showing the calibration counts (which will be 0) and the nominal output level (1 V). But chances are you see – nothing! That is because the display contrast trimmer has not been set at the correct value; turn it from one end to the other and select a setting that gives crisp and clear text on the display.

With no input signal, the AR will range to +12dB setting. At this point, connect a signal generator and play with the input levels to get a feel for the device.

You can now check the User Guide for operation of the AR, but probably you should run the separate Calibration Procedure first.

At any rate, have fun and I hope the AR will make your measurements just that much easier and more efficient.

Finally, check the FAQ at <https://linearaudio.nl/la-autoranger> once in a while for additional info and updates.