3 The iconic knobs

How the LA2A Leveling Amplifier does its magic

Teletronix La2a

analogvibes

As mentioned in the last chapter the LA2A is one of the most iconic compressors in recording history. With only three knobs on the front of which only two actually control the sonics, it's an extremely simple design. In the following I wanna show you that the simplicity of this wonderful piece of gear is not only limited to the visual design & controls, but also kept up in the electronic design.

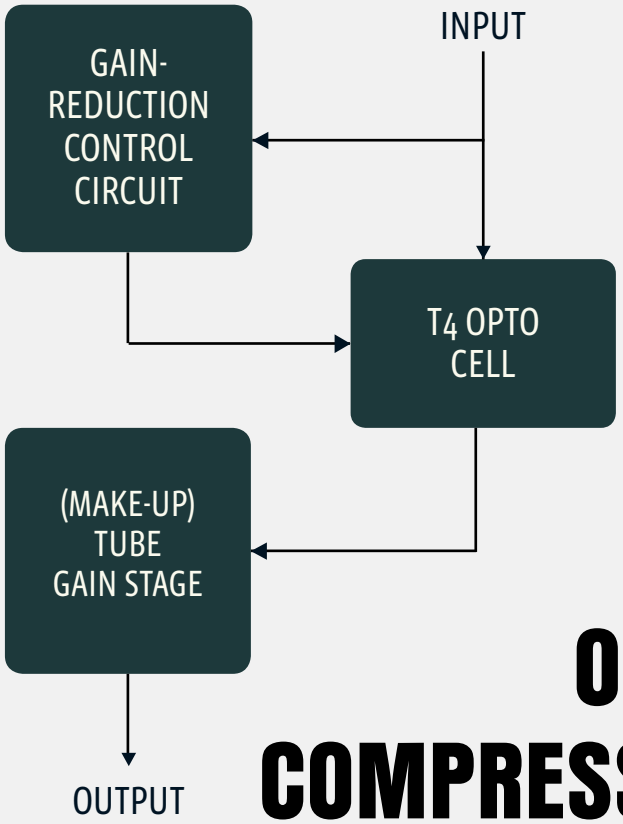
But before we jump right into it - assuming that even though pretty much all of you have used an LA2A as a plugin in your DAW, and only the minority has used the actual hardware - **I wanna find out one thing: What exactly is it that makes this compressor so special?**

The reason why I'm bringing up the plugin here is, from my own experience there's a huge difference in grasping the principles and the magic of such a unit when using the digital emulation on screen compared to the hardware unit.

My personal impression when first using a hardware LA2A was that it's sonic character has the ability to make the signal sound bigger, or thicker if you will.
Almost like adding an extra dimension - giving the signal some **warmth in the low mids**, while producing some **beautiful sheen further up the frequency spectrum** at the same time.
And it does all of that in a **very smooth and unobtrusive** way, which may be due to the fact, that the **compression itself actually sounds very transparent**. If you take a look at the meter and see it already applying 10db of gain reduction, you wouldn't believe it just listening to the results.

But how does it do that? As shown in the image below - extremely simplified, **the LA2A consists of two major circuit parts: the gain-reduction control circuit** which drives the most important part for the compression characteristics: the T4 Opto cell. And the wonderful sounding **tube (make-up) amp**:

fig. 1

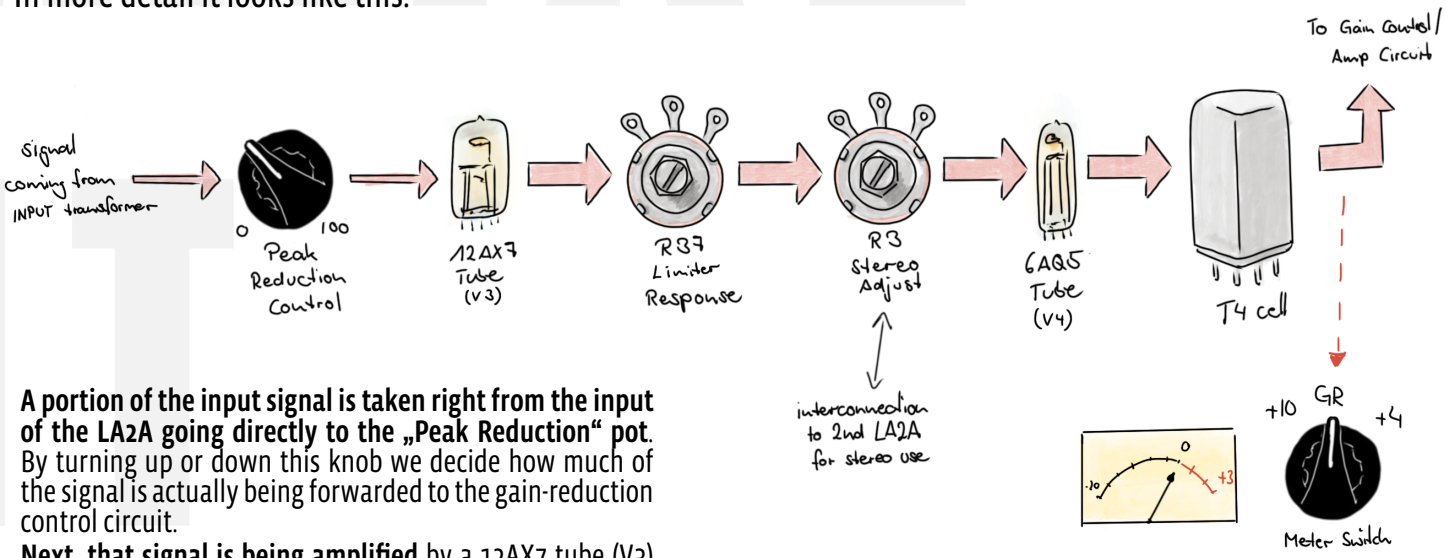


OPTO COMPRESSOR

Without any detour a portion of the signal, coming from the input transformer, is **directly fed into the gain reduction control circuit** (aka the „compressor-sidechain-circuit"), which in short **decides, how much gain-reduction the T4 applies** to the signal before it's getting forwarded to the make-up amp and from there to the output.

THE GAIN-REDUCTION CONTROL CIRCUIT

In more detail it looks like this:



A portion of the input signal is taken right from the input of the LA2A going directly to the „Peak Reduction" pot. By turning up or down this knob we decide how much of the signal is actually being forwarded to the gain-reduction control circuit.
Next, that signal is being amplified by a 12AX7 tube (V3) before it hits the two trimpots R37 (limiter response) and R7 (stereo adjust) mounted on the back of the unit.

FREQUENCY RESPONSE CONTROL

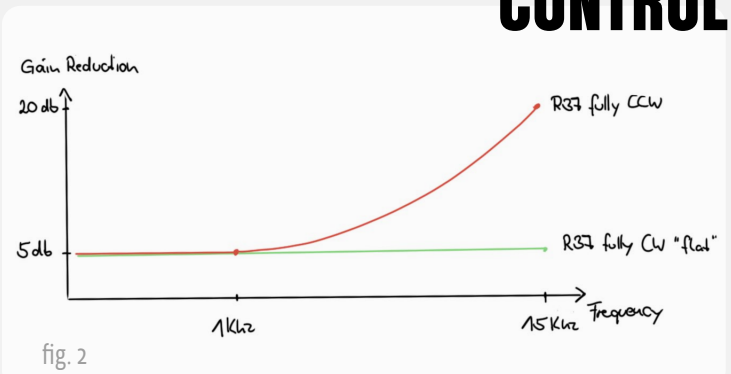


fig. 2

As pointed out in the diagram on the right (fig.2) R37 - within a certain range, controls which frequencies the GR-circuit actually sees, and how it reacts to them.
With R37 in fully clockwise position, the compressor treats all frequencies of the signal equally, meaning the amount of compression applied is the same across the frequency spectrum.

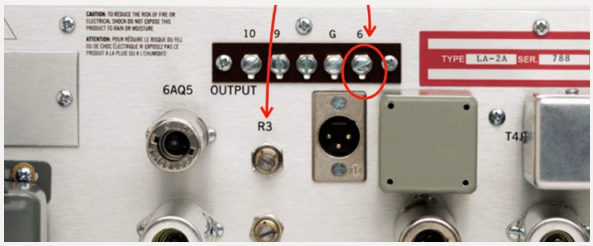
By turning R37 counter clockwise, the compressor starts to **compress the high frequency content of the program material more than the lower frequencies.** To be precise this only affects frequencies above 1Khz and is increasing towards higher frequencies.

Looking at my diagram it will become more clear what I'm trying to explain. With **R37 turned fully counter clockwise** the gain reduction circuit will apply 15db more gain reduction to frequencies around 15Khz than it does to frequencies below 1Khz.

This will soften out the high end dependending on the dynamics of the signal, so it's totally different from adding a high shelf EQ.
Originally, this option was added to alleviate a problem introduced by the way audio pre-emphasis was used in FM broadcasting & TV transmission systems back then.
But also nowadays it can be helpful at times. With my DIY LA3As for instance, I made it switchable to choose between flat and 5db more gain-reduction at 15khz relative to 1khz.

The stereo adjust pot R3 controls the gain-reduction control voltage supplied to the 6AQ5 tube (V4).
If turned fully clockwise, the gain-reduction control voltage coming from the 12AX7 (V3) is passed on straight to the 6AQ5 tube.
On the other hand that means if R3 is turned fully counter clockwise, the 6AQ5 won't see any control voltage at all - hence **NO COMPRESSION**.
This is one of the most common mistakes I've seen from DIYers building an LA2A in the past!

But the stereo adjust pot R3 wouldn't carry that name if it wasn't for a second purpose: It's directly connected to a screw terminal on the back of the unit, which allows for **interconnecting two LA2As.** More precisely this allows for both LA2As to see the same Gain-Reduction control voltage. Now the **R3 pots on both units are there to adjust the voltage applied to the 6AQ5 tubes of both units, until the compression is equal on both channels.** (I'll explain the matching procedure in more detail later)



The above mentioned 6AQ5 tube supplies the necessary audio voltage to drive the electro-luminescent panel in the T4 cell, which is actually responsible for the smooth compression character of the LA2A.

Now, that brings us to one of the most important questions: What the heck is a T4 cell, how does it work and what's so great about it?!

As you can see in this image, I outlined the entire signal path of the LA2A in an extremely simplified way, focusing on the T4:

NOW LET THERE BE LIGHT

The signal is coming from the input transformer - a portion of it is fed to the „Peak Reduction" Pot, and from there it hit's the T4 cell.
More precisely it hits an electroluminescent light panel inside the T4 unit. The more signal it hits, the more light this panel emits. Mounted directly to this panel are two photo-conductive cells which act as kind of a variable photo-resistor. The more light they receive, the lower their resistance. **The lower their resistance, the more compression.**

Let me try to paint a picture to make this more understandable: Imagine the signal path inside the LA2A as a passageway. This passageway goes from input through the gain-reduction section followed by the (Make-Up) gain-section to the output.

As drawn in the upper right of fig.3, there's a trap-door in the GR-section, mounted on a hinge. This hinge be our photo-resistor - and as stated above it reacts on light. If it sees only a little bit of light, the hinge is rather strong and mostly resists the weight of the trap door - thus, the trap door only opens up slightly.
That means our signal can pass that door mostly undisturbed and only a little bit gets lost.
As we turn up the „peak reduction" knob or if the peak-level rises momentarily, more light is being emitted to the hinge, which in turn gets weaker (lower resistance). That means it can't hold the weight of the trap-door any longer and opens up -> more of our signal is tumbling through the door and less of the signal is passing undisturbed -> more compression.

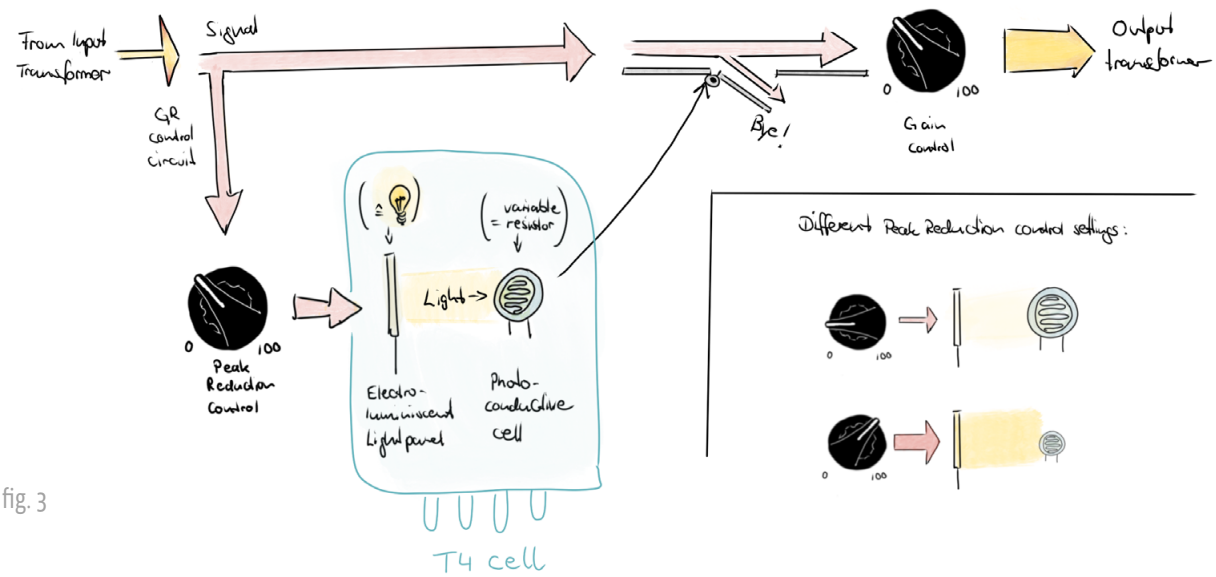


fig. 3

Time will tell

So far so good?

But why are there two photo-conductive cells in the T4??
Simple: One of them controls the actual compression being applied, and the other one is connected to the VU meter to make it reflect the amount of gain-reduction.

Now the special compression character of an Opto compressor is based on the timeframe all of this happens within.

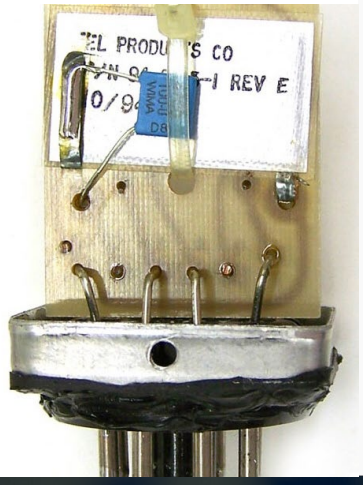
ATTACK

If the signal hits a certain threshold (technically if the voltage is high enough to drive the light panel) **the compressor** reacts **instantly** (attack time) and **applies gain-reduction.**
Well, the term „instantly" is actually a litte exaggerated compared to other compressors out there nowadays. :)
Talking motor-bike, it's more like a chopper - if you wanna accelerate, it takes a little longer, **however it still makes you look a lot cooler!**

Another distinctive feature of the light panel is, that is has some kind of a memory. That means if it was activated recently (within 20-30 seconds) it reacts 5-10 times faster.
In numbers that means (taken from the manual August 1964):

ATTACK TIME LA2A (no previous activation):
50 - 100 microseconds

ATTACK TIME LA2A (previously activated):
around 10 microseconds



RELEASE

The release behavior of the LA2A is even more funny than the attack behavior.

After the voltage is dropping below the threshold where the light panel is activated, the **light is not OFF immediately**. It rather **fades out** over time.
In addition, the time, the variable-resistance photo-cell needs to recover its full resistance depends on how hard is has been hit by the light before. In other words, **the release time of the compressor highly depends on the amount of gain reduction happening prior to release**.

Now the extra funny thing is, no matter how hard the photo-resistor has been hit, it returns back to 50% of it's original value in less than 1 second. But after that it can take 5 to 10 seconds for the compressor to fully release.
Again, this drawing will clear things up a bit:

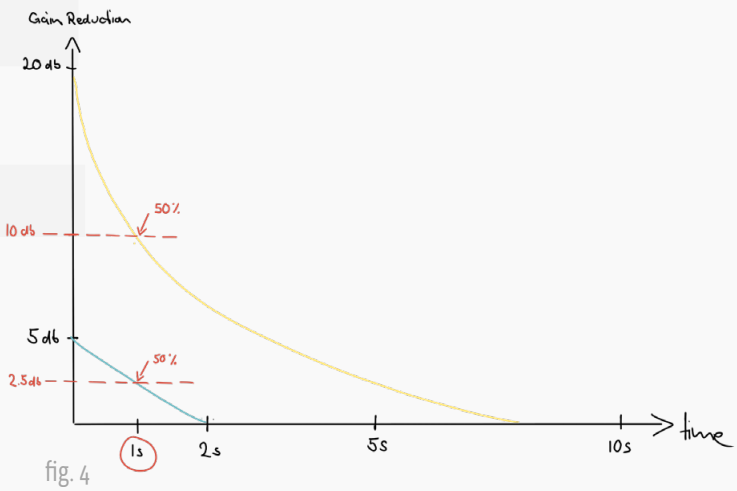
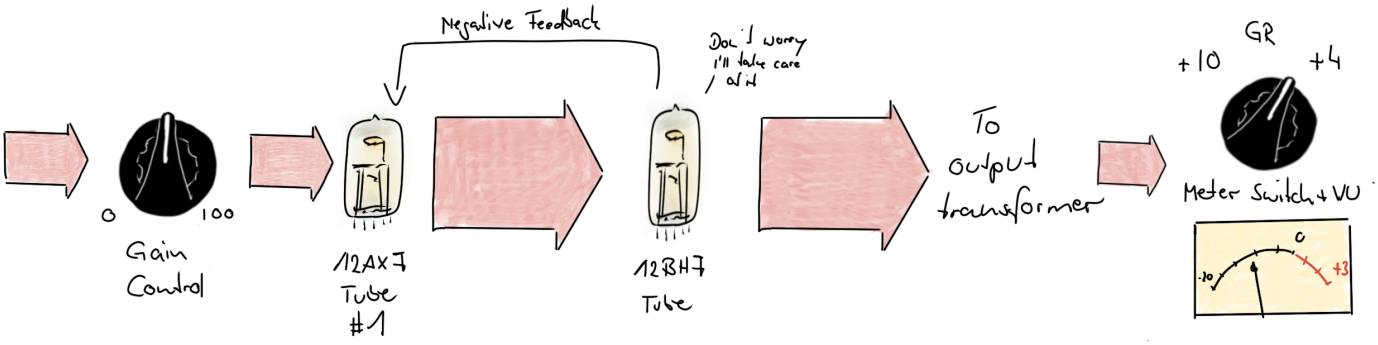


fig. 4

After only 5db of gain reduction the compressor will return to 2.5db of gain reduction within 1 second and within another second it's back at zero.
After 20db of gain reduction it returns to 10db within a second, but it roughly takes another 6-7 seconds to get back to zero.

This behavior is due to the chemistry of the photoconductive cell being made of cadmium sulfide.
There are other types of cells i.e. made of cadmium selenide, which produce a much faster release time around 0.1 to 1.5 seconds.
As a result - as some of you might know there are „slow" and „fast" T4 cells available :)

Until now we worked our way through the gain-reduction control circuit including the famous T4 cell.
But what happens then?



(Make-Up) AMPLIFIER

As stated before, coming up next is the gain/amp circuit in order to make-up for the level loss introduced by the applied gain reduction.
This is pretty straight forward. The amp section of the LA2A is a negative feedback tube amplifier designed around a 12AX7 and a 12BH7 tube.

In detail that means:

The signal coming from the T4 cell is directly going to the „Gain Control" pot.
Depending on how much we turn up that knob, the signal is fed to the 12AX7 tube (V1) where it gets amplified.

From there it goes to the Cathode Follower tube 12BH7 (V2), which - simply put - gives the 12AX7 the perfect working conditions in terms of impedance and by sending a negative feedback back to the 12AX7, provides low distortion, a higher bandwidth and a flat frequency response, even if there's a great amount of output impedance mismatch.

We could dig deeper into how exactly a *»negative feedback amplifier«* and *»totem pole cathode follower«* (that's what the circuit around the 12BH7 is) work, **but I think that's way too much right now.**

In case you don't have enough of it at this point just google the terms I put in quotes. ;D

If it's hard for you to follow the explanation above anyway, how's this:
The circuit around the 12BH7 tube is kinda like the **Chuck Norris** inside of the LA2A. And he's there to guarantee that no one - and I really mean **NOTHING disturbs the amp circuit** in any way! And by **threatening the 12AX7 with some negative feedback**, he even makes sure that tube **does the very best it can, to produce nothing but an awesome signal.**

That's why the LA2A sounds so amazing :D

So now we talked a lot about how this wonderful tube compressor works and what it does. **But how can we build a tube-opto-compressor such as the LA2A ourselves, and where should we start?**
I'll show you how in the next episode!

In the meantime, if you have any feedback or questions please leave me a comment in the comment section below - and if you know anyone who might be interested in what we do here, please share the website. Thanks and see you in a couple of days!