

PROJECT “MY-REF”

Report on the technical and criteria of design of the amplifier “My-Reference” based on chips integrated to Low cost.

*Analysis and description project
curated by Mauro Penasa*

1 Introduction

Around the mid-years eighty, I had the chance to try an amplifier to solid state (mosfets) of English production (Musical Fidelity A370), which it hit enough for his sound, very different from the average of Amplifiers a solid state of that period, and by many “valvolare”, because of Good “musicality” associated with one Very wide and “realistic” sound stage.

After a careful study of I discovered that the amp was extremely “Original”, and what Even stranger to the era, used an OPAMP (operational amplifier) as a front-end. Another peculiarity was the use of the Mosfet battery of output in “invertent” configuration that in fact transformed the stage of Released in a “current pump”.

Intrigued by this topology, but above all from the “musicality” that this involved, I decided to do a series of evaluation tests, also using other technologies. Some peculiarities of that circuit, such as use of LM318 in inverting configuration, they have remained virtually unchanged in my application, so someone can see the similarities between my circuit and that by M.F. A370.

D'D'D'D'D'Tri' D'Tri' D'Gi' D'D'D' D'D' D'D' D'D' D'D' D'D' D'D' D' Another song, I have to give credit a Tim De Paravicini (designer of M.F.A370) to have given me the cue for the per minute, for the time, and the time, for the time, for the time, for the sake of it study this little-used technique.

Practically any technique used in electronic is the development of another, so I am always "skeptical" on the concept of "paternity" of a circuit, but I believe it is always necessary and intellectually choret to cite the sources of ideas behind a project.

So this circuit, I am limited to developing some “theoretical” concepts already experienced by others (and in particular from M.F.). Of course my work was very different than a size/glue typical of many “creative” environments, and the results obtained are, for many technical reasons, quite different from those obtained from the creations of Paravicini and Musical Fidelity, also on one floor strictly theoretical.

2 The The City circuit of “Myoref”

2.1 - The company has just one of Theoretical circuit

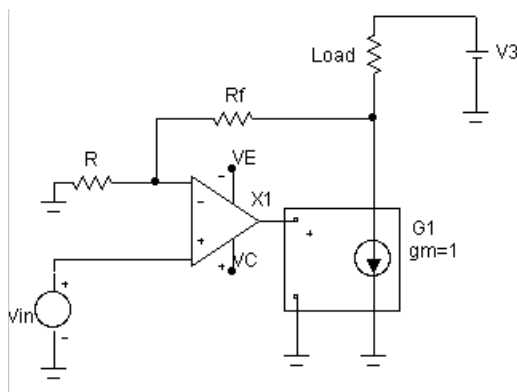


Fig.1 My-Ref theoretical circuit

In **Fig. 1** you see the scheme of principle of the circuit. Group G1 is a stadium transconductance (current voltage/output input), and can be format, second needs, discrete or integrated components. This one of the stadium provides all the energy needed for piloting the loading, and then represents the power circuit of the amplifier, and for convenience of analysis attributes a gm-1 (unitary transconductance; 1 Volt Input 1 Ampere output).

In these conditions, stage G1, By generating the current on the load, it also determines a automatic fall of voltage on it, and therefore also a voltage gain is obtained proportional to the load impedance:

$$Av(G1) * Zload / Gm$$

Per for that reason, the stadium Input differential X1 must not generate a voltage of control of the amplitude similar to that required to produce power necessary, and can be used a normal OPAMP. The live voltage gain with open loop of this Circuit can be high, because it is equivalent to:

$$Aol = Av(X1) * Av(G1)$$

$$(Av(X1) = \text{open loop gain } X1)$$

Note that Aol depends on load characteristics due to Av(G1), so fine-tuning of the circuit, as regards frequency compensation, it is very It's important. In particular, it is crucial to maintain a good phase margin, to prevent the change in load from creating a condition of Instability (Aol-1-180-phase).

Of course the gain in tension with closed loop of the circuit is determined by The usual formula :

$$Av \approx 1 + (R_f / R)$$

The Le the main features interesting of this circuit are two:

1. The exit stage is a power generator, and structures who serve for obtain this feature are quite different from those used Normally. In particular, the technique of polarization changes, the phase and dynamics of stage G1. This element it is very Important regarding some THD and IMD forms typical of some of “Standard” configurations. In particular, yes, they may take advantage of some peculiarities of some circuits, as we will see in the chapters later.
2. Maybe the most important from an audio point of view: The circuit it involves as a “Normal” Voltage OPAMP, because the high output impedance is “compensated” by the NFB network for the report:

$$R_{out} \approx R_{int} / (1 + Aol * \dots) \text{ if you } \approx R / (R + R_f)$$

$$(?? \text{ repletion factor})$$

But By observing the reports mathematics and the circuit, we discover that the load, due to the characteristics of G1, becomes an integral part of the transfer, because the voltage signal you need for The NFB network is defined not by Vout (G1) but by Iout (G1) * Zload.

All of you the non-linearity of Zload determine the reaction of the differential circuit, which provides compensate them (with the current of G1). In a conventional circuit, the resistance internal of the circuit is always much smaller than loading, so the NFB network works always referring to the output voltage of the amp. In this way the circuit is very immune to changes in load, but it creates a “self-referring” system that is not in A degree of compensating for the dynamics of Coupling between the amplifier and the speakers. This one of the phenomenon is perhaps the real cause why many modern solid-state power OPAMPs do not I am al height of older achievements or with technology different ones.

2.2 ? Exit stage

I Experimenting audio circuits to state solid for many years, but one of the basic problems of the stages of Power at BJTs Mosfets is polarization, both static and dynamic. Ad Ad In fact, it can attribute, directly or indirectly, THD generation and instability of various kinds. The Oldest (and Simplistic) Techniques to get one “linear” power stage provide a Polarization in “class A” (classification I think has created direct associations in the audiophiles with “class” of sound...). This method besides not being efficient, it requires the use of the “batteries” of devices mounted on huge metal elements of thermal dispersion. Tired of doing the “metalworking” I decided to probe the way of the NFB (negative Feedback counter-reaction), also if often considered “off-limits” to the world High-end.

One interestingly was the use of integrated power chips, which are normal OPAMPs (amplifiers operational operations) of power. Their differential structure is very flexible, and allows in practice of “build” any configuration. One of the main problems for me it was the study of configurations able to “hide” the THDs and Chip IMD in the audio circuit. One of my “discovery” was the bridge of Current (Fig.2), called “bilateral current source” from National Semiconductor (AN-29 Linear Applications Databook), or “Howland Current Pump” from others. The main feature of this bridge that I discovered (a part being a good base for transconductance) is the Ability to reduce the negative impact on sound, which is usually in the presence of circuits a high NFB, especially when the circuit is contained in an NFB Global loop. The reason is to be found in the structure “a Bridge.” In these structures everything The component’s open loop gain (Aol is used for to stabilize the bridge, that, in a sense, “remains out” from dynamics of linearization of the signal to be amplified. Such a structure is made a Resistance multiplier, where the basic resistive value it is represented by Rsense (R5 Fig.2) and factor of Multiplication from the the mesh sizing that forms the bridge. The Loss of Efficiency of the OPAMP (caused by “not ideal” characteristics of the circuit) is represented Mainly as resistance variation “dynamic” view of the exit of the bridge.

The Le More used configurations when you want to use a power OPAMP with current load piloting provide for the to include the same in the NFB network, but in these conditions all the non –linear produced by OPAMP “discharge” on the cargo, which in fact and forced to “chase” the dynamics of stabilization of operatic nodes.

The Le characteristics “to resistance of Exit,” verified in the bridge I used, I’m quite typical of Transconductance circuits, which if they are well studied have an impact the lesser on distortion dynamics (in audio circuits). You could say that all of you the transconductance output sections within a Network of NFB voltage are potentially “neutral” compared to the result final, because of the different relationships between current and voltage that are generated with loads and loads Reactive.

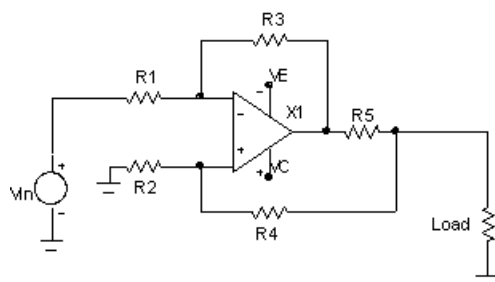


Fig.2 “Howland Current Pump”

The draft formula of the “current pump” :

$$I_{out} = - ((R3 \text{ Vin}) / (R1 \text{ R5}))$$

If: $R3 = R4 + R5$ (or $R5 \ll R4$) & $R1 = R2$

$R_{out} \approx R5 (R4 / R)$

*R4 or R3 and R' bridge res. Error (R3 appears R4 & R1 appears R2 2)

Other good characteristics of This circuit is the possibility to use it in differential mode and, if R1-R2-R3-R4 output can be connected to a Any voltage (floating) without affecting current operation (thanks to the “real” resistance output), and can be used as both R1 and R2 input (inverting or not inverting).

Why the bridge remains stable, it is It is necessary that X1 is stable with unit gain, or you must resort to the addition of a polo/zero network between the 2 differential inputs, able divert of the the city, the 's theurence the 's) the, the dmodo degenerate the characteristics of the bridge beyond a defined frequency. One Useful technique when using stable chips at gains in 2 and 5 is size R1 and R2 to use the capabilities of entrance and the Zin Differential as a frequency compensation element. It has to remember that a bridge of this type (and operation in current) creates Often a “group delay” that can create problems with “closed ring”, so the nets compensation must be very well cared for...

I I did the first experiments with this bridge using TDA2030, then switching to chips more Powerful, as LM3875 and The LM3886. Every choice needs an accurate “stabilization”, different for all kinds of chips.

Application in MY-REF:

At the beginning, I used this bridge (LM3886) configured for a fairly small R_{out} , about 4-10 ohms (My-ampli), because I just wanted to take advantage of the characteristics of "Nautilus from NFB" that this bridge It guaranteed. The result was already good, because the final sound mainly assumed the "Timbre" features of the entrance stage (LM318). A basic problem was that in this configuration was obtained a fairly high load of the bridge, which It was increasing as a result, both the amp damp factor and the consequent changes in dating as the frequency changes. After one of the 's one Series of studies on the problems of DF (damping factor ? factor of damping is the relationship between Z_{int} of the amp. And Z_{load}), and the considerations About this at the work of the global NFB (exhibited in the circuit description theoretical) I have Considered to be appropriate to increase the Z_{out} of the bridge (about 500ohm), Reducing of consequence of the gm (gm-1).

The Choice of LM3886 is based on Low cost, high reliability of operation, and good Output power (68Wrms) also in load conditions at 4 ohms. A problem of performance general of my circuit is caused by the value of R_5 (0.47ohm) chosen for obtain the characteristics of Z_{out} and gm described above. In conditions divert of the the city, the 's theurence the 's) the, the dmodo low impedance load, power dispersion on R_5 is enough high, but The "acoustic" results are such as to accept these losses, also because in Class A circuits (his direct competitors) performance it is extremely a minor.

The 2.3 ? Entrance stage

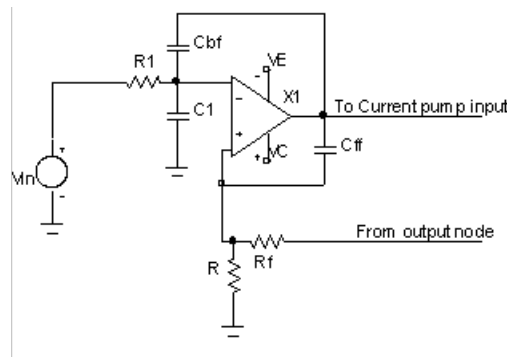


Fig.3 Entrance Stage

How we have seen in the description of the theoretical circuit, in the entrance circuit can be consisting of an OPAMP Low voltage, since even a gm 1 maintains a small reserve divert of the the city, the 's theurence the 's) the, the dmodo gain in tension in the exit stage. The circuit of entrance you can Consider (in all topologies) the most important part of the amplifiers audio, because it deals with the "linearization" of the signal Differential, and its malfunction inevitably leads to THD and IMD does not "maxable." In the case of MY-REF, the structure of the input differential is slightly different from the "typical" presented in the theoretical scheme. In I chose a structure similar to the one I had noticed in M.F. A370, and which I have been successfully using for years (Fig.3). The The City signal of input is connected (after a filter/decoupling R_1 network) at the entrance Inverting by LM318N. This chip has been with me for many years in mine Realizations, because I believe that it still has a relationship quality / price almost unmatched, and the internal circuit is accessible in his points "key", and it's easy to implement compensation (frequency and phase) "at the limit".

The "non-invertent entry, to Opsted to standard inverting configurations, is connected to the network of NFB. Using an invertible current pump you get the same result (global) of a non-inverting connection. This kind of connection, which it may define "floating" due to the lack of classic "virtual ground" on Invertent entry, has some advantages over a normal non-non-one Inverting:

1. The sequence of 2 inverting active stages allows you to use various techniques divert of the the city, the 's theurence the 's) the, the dmodo compensation, both in favour of overall stability and "align" some relative phases
2. The The City connection of the input signal on (-) allows you to exploit the better the Internal characteristics of OPAMPs, which tend to be more linear in This configuration. (This is not an absolute rule, and varied a lot by case the other)
3. The "floating" condition facilitates the front-end in process of "chasing" of nonlinearity of voltage present on the output load.

Techniques of compensation:

A part of the other elements of local compensation, which I added or removed depending on the variants, I have Exploited 2 basic techniques, which are simply opposite in their operation. operation.

In MY-REF RevA (version "Official") I used Cbf (Cap. Back-feed or feedback). This component Create a "dominant pole", high frequency (integration), in combination with R_1 but inversely proportional (frequency) to signal of Out of LM318. In this way, the circuit in all the conditions.

In the post RevC, I used a technique inverse, which is based on Cff (Cap. feed-forward). This component performs a Positive compensation to the drop in high frequency gain by of the Differential circuit (determining an action "derivator" on LM318). This one of the method linearizes the DF considerably throughout the audio band...

Other features:

The Z_{out} open loop of X1 is determinant in the imbalance of the current bridge (and then in the decrease in his Z_{out}). In the case of LM318 this is about 20-30 ohm, so with the chosen values, the bridge is maintained within about the 0.1%, which corresponds to about 400-500 ohms of Z_{out} .

The 2.4 Complete circuit

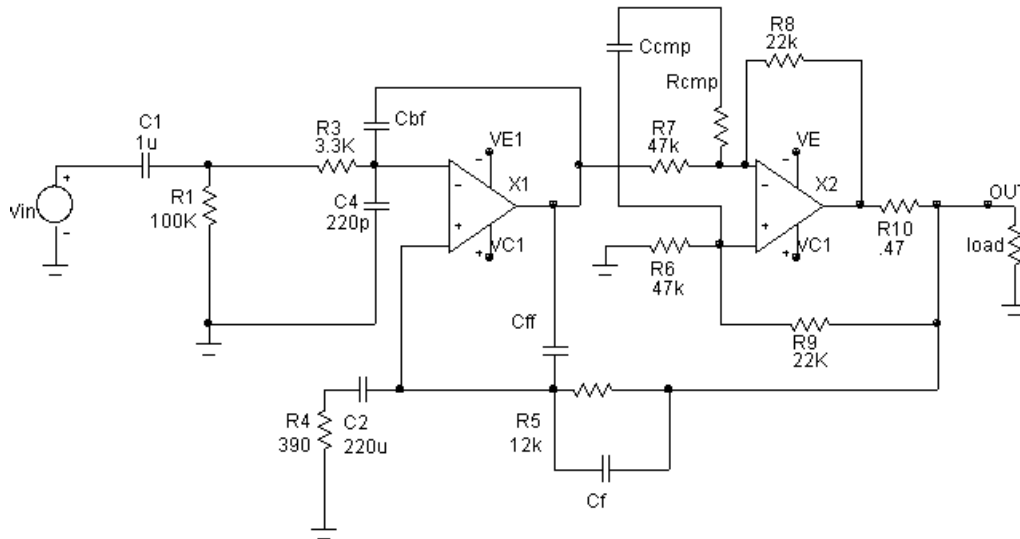


Fig.4 Complete circuit (theoretical)

The The City Full circuit (Fig.4) it's quite simple, and not needing many Additional explanations. The input impedance of the circuit is fixed by R1 (100K), R3-C4 acts as a filter for any high-frequency spikes and limits the band passerby (about 220Khz, but the internal poles of comp networks. Interact with this filter at smaller frequencies..). The NFB R5 and R4 network determines the gain with closed ring, which is about 30 dB ($A_v \approx 1 + (R5/R3) \approx 31$). C2 reduces the Continuous gain of the network, to avoid amplifying tensions Continue and reduce the residual continuous voltage output. The frequency minimum cutting to -3db of C2 and R4 is about 2 Hz. This frequency must always be quite low, due to capacitor characteristics electrolyte (used in this section), which greatly increase the their THD near the cutting frequency. Another element is the linearity of phase, that to be kept in audio band (20hz-20 KHz) it imposes itself insert the Intervention point at about 1-2 Hz (6020hz with 2Hz pole). Alla alla Phase variation also associates the subsonic filter formed by C1 and R 1, that with the indicated values has an attenuation -3dB at about 1.5 Hz. Overall you get a phase deviation of about 10o20Hz, which it's enough - acceptable. The combination of the two filters means that trend of attenuation below 1.5 Hz is of the 2nd order, or 12dB / Oct.

Compensation in frequency (RevA):

How early in the chapter previous, the nets formed by Cf, Ccmp-Rcmp, Cff and Cbf are used for implement the Frequency and phase compensation that is used for variants of a project that I applied several months later, in order to evaluate the impact "acoustic" of some compensation techniques. The version of the circuit at The basis of this document is the "RevA". which is based on the use of Cbf as an element of stabilization. This component slightly limits control to high frequency of X1 on G1, for which you notice a drop in DF in the area beyond the 10Khz. This in itself is a common tendency to (almost) all the amps. Allo aim to study the impact of the linearity of DF I developed a variant of compensation, (based on CFF) but this change plans to act also on the internal sections of LM318, in addition to the addition of special networks formed from Cff, Ccmp and Rcmp, so I decided to publish the details of the modification in a document a Part...

Observations General:

The The City gain with open ring of this circuit is (or can be) very high, and It depends on X1. This peculiarity is a founding element on the "acoustic" imprint that distinguish a circuit of this type, i.e. they are predominant le le features of the item that has the most gain in voltage ad Open ring (Aol), as NFB work is in tension. The reverse of the Medal is, if this gain becomes too much elevated, the problems of instability, often related to nature (capacitive or inductive) of loading, as well as its impedance. To limit these phenomena they exist various techniques, which I applied differently depending on the type of the compensation applied. A fairly critical condition is that of the "Clipping." In these conditions, in fact, yes generate oscillations to cause of continuous rebound of energy, caused by "spikes" products is from LM318 that from LM3886. When the compensation network is well sized, this phenomenon is quite dampened, so it does not create problems of stability. I have Considered not appropriate to include complex networks of "absorption" of the clipping so as not to over-increase the complexity of Ill, and why the probability of deteriorating overall performance was It's very high. On the other hand, I consider the condition of clipping a condition not operational and emergency, so it's more important in these conditions is to have a quick and non-destructive recovery, ne ne per gli Speakers for the amp.

Per for similar reasons I did not include nets of zobel on the exit. In particular, the modalities of work in current of the power stage, and its NFB in voltage "sensitive" to the load, It convinced me to reduce the compensation of load, to improve the "feedback" with the cable-speaker system.

3 Auxiliary power supply and circuits

3.1 Power supply

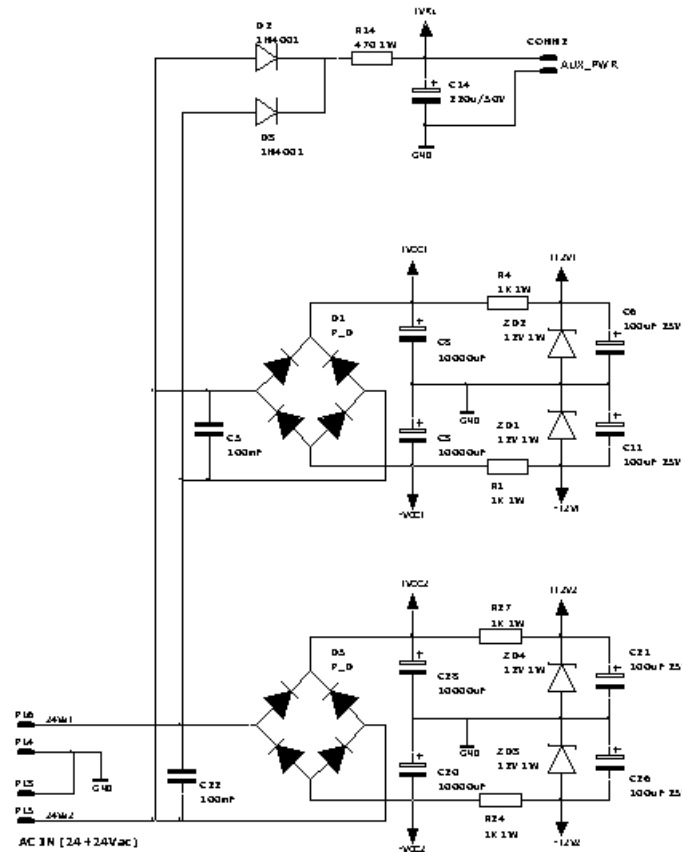


Fig.5 Complete section circuit of the Power Supply

The Supply scheme (Fig.5) It's quite classic. The two channels are in fact configured in "dual-mono", with separate feedings from the bridges from the section of rectification. The transformer is common. This structure is the one that guarantees the better compromise between performance and cost.

The Le Power supply voltages of license plate are +35Vdc for LM3886 and +12Vdc for LM318.

these you get with a Transformer 230/24+24Vac 200-300VA (depending on use).

The The City Common transformer allows to reduce costs, but above all to ensure an excellent the source of energy common, since the performance of a single transformer (power Double) provides energy exchanges much larger than two singles transformers of equivalent total power, due to performance dynamics magnetic.

The "dual" structure from the Deode bridges, on the one hand guarantees an excellent Immunity from the Commutaine caused by the "common" high-current routes, and from the other distributes in better way the energy dissipated by the diodes, than in this case they can be of smaller size.

The I C5 and C22 capacitors are used for dampen the voltage peaks generated by the diodes, in combination with the the ' parasitic inductance of the transformer. The filter you create (a) (a) to frequencies of about 15-30 Khz depending on the type of transformer) reduces Remarkably the high frequency grinding noise.

I have Favorite of using bridges of "Normal" integrated diodes for some Reasons:

The their structure is extremely "glued" for much more conditions burdened with those found in this circuit, and the probability of failure is It's extremely remote.

The I Mowers formed by diodes discrete power are more expensive and bulky (yes they must use Additional heat sinks). In general, a discrete rectifier generates of thes and thes of the Electromagnetic disturbances due to the strong peak currents that they travel the connecting copper tracks (and the diode reoapers).

After the diode section are the Electrolytic leveling capacitors (10,000 F), sized for a adequate energy storage for this application, followed by a small Local bypass network made up of electrolytic capacitors "low ESR" (220 F), Able to maintain impedance low interior (local) of the Power circuit.

One limited, but useful, containment of disturbances from the feeding section towards the Operational amplifiers (both LM3886 and LM318) is Guaranteed by the capacitors from 100nF inserted between the lines + Vdc and -Vc. As a rule, in the audio circuits, yes see capacitor batteries always inserted "dural" among the respective power lines and mass. These techniques are needed for the per minute, for the time, and the time, for the time, for the sake of it increase the efficiency of the "mass Virtual", which represents the reference of voltage of the circuit. From the point of view of "immunity to the disorder of feeding" typical of an OPAMP these networks are not useful Nothing at all. The OPAMP In fact, they use internal references related exclusively to +Vcc and -Vcc, for, for to which they are sensitive to "uncommon" disorders between These links. Gods of the capacitors inserted directly (and locally) on these lines guarantee greater immunity to this problem.

The LM318 is powered at +12Vdc with a "shunt" regulator at zener. This technique It is very common and simplified, but causes a decent loss of energy on the fall resistance (approximately 0.6W on every resistance). The choice of this structure is motivated, a separate from the bottom cost and reliability, from good "interaction" that is achieved between the power supplies of the 2 OPAMPs, and from the good "virtual mass common" that you He gets. The main reason is the current substantially constant that it flows into the feeding branches towards mass, capable of "absorb" the signal modulations, and to maintain (due to small falls of tension on the slopes) a small independence of the "mass virtual", used by all NFB rings, from modulations caused by currents of Exit.

In Practically you have a Feeder in “classeA”, free from forms of typical modulation of Active regulators.

One of 1 secondary circuit (D2,D3,R14,C14) produces the voltage of about 24Vdc to power the section of protection exit.

NOTE: How can it be seen from Schema, there are no protective fuses on board the board. The motivation is both practical (space) and technical;

- ◆ LM3886 is extremely well protected internally towards all forms of overload.
- ◆ The speakers are protected from possible insertions of tensions Keep going out.
- ◆ Fusible protection on power supply lines Duale serves exclusively to avoid damage caused by external interventions (e.g. short circuit caused by incorrect maintenance maneuvers).
- ◆ The “thermal modulation” that is generated in the fuse filament when is traveled by strong transitional currents increases intermodulation on the feeding.
- ◆ In the event of malfunction of the diode bridges (theoretically more likely compared to other stages, due to the strong transients of the Charge current of the capacitors), fuses (downstream) have no no of it Protective utility.

Of course It remains crucial protect the circuit from internal short-circuit risks, so in the phase construction of construction should be provided for the use of fuses of adequate protection sized.

These can be included on 24Vac lines of the transformer secondary, and/or, given the big reliability of power transformers, directly on the primary (line 220Vac). In this case you can use a fuse “delayed” with Current equivalent to the “plate” of the amplifier at maximum power theoretical (in this case about 200W). So: 200W 1Amp 220V fusibile Delayed by 250V 1Amp). In this case all overloads dangerous are neutralized by the operation of the fuse of line...

3.2 Protection circuit

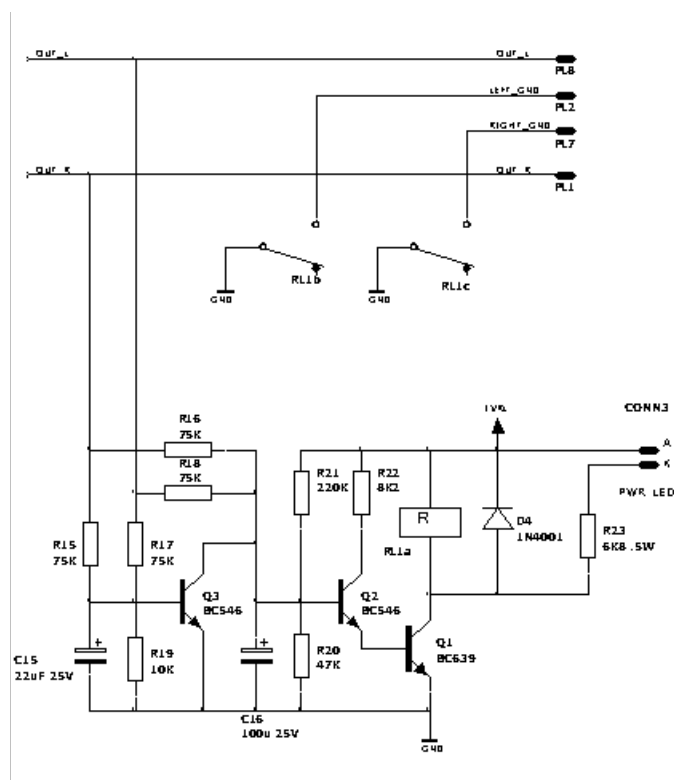


Fig.6 Recall protection speakers

How already introduced in the others chapters, I thought it appropriate to insert a simple circuit of protection Speakers with ignition delay. This section has both function “anti-thump” than to control any Continuous tensions present on the ELC output. The control circuit is very Simplified for issues of space, but he does his job very well.

The Le Outputs of the two channels are “integrate” in common from the R15 C15 and R17 C15 network for the positive DC voltages, while R16 C16 and R18 C16 for the negative ones. The point of intervention it is a slightly asymmetric due to the different constants of time, but from the point of practical sight this does not involve any particular problems. When one voltage continuous (or very low frequency button) greater than about 3V yes find on the exit, Q2 and Q1 interdict, and the relay disconnect the loudspeaker. The delay of ignition of about 2 seconds is generated by the constant of time R21 C16. In case of shutdown The auxiliary voltage immediately decays to the cause of the low C14 value, turning off the relay before the rest of the circuit. Gods of the Simple connections on connector allow

Dal a practical point of view, not Nothing changes, since in case of intervention, the circuit is open in both cases. I used this connection basically to improve the PCB layout, and why this configuration does not “modular” with large voltage signals the relay contacts, which could creating phenomena of Afachonia (given the use of a single contact relay Multiple close up close).

The The City Proposed circuit can undergo changes at any time and without notice.

5 Performances and services detected

The Le Preliminary measures on some prototypes have highlighted the peculiarities already expressed in the treatment theoretical.

All of you the measurements were executed without using special filtering techniques, with FFT tool picoscope216 and Blackstar LDO100 generator, with capacity Overall dynamics about 90dB. They have no absolute value but serve to “give an idea” of the overall performance.

All of you the measures and results published below are to be understood relating to the revision “A.”

5.1 - The company has an z Main features

- ◆ Band (typical-3db): **2Hz-70Khz**
- ◆ Maximum power (8ohm): **40Wrms**
- ◆ Maximum power (4ohm): **5 6Wrms**
- ◆ Damping Factor (8ohm): **??200**
- ◆ S/N ratio (600ohm): **?96 dB** not weighed
- ◆ THD tipica (20Hz-20Khz, 1-40W 8ohm) **<0.05%**

5.2 of the next. Measures for the Ministry of the FFT preliminari

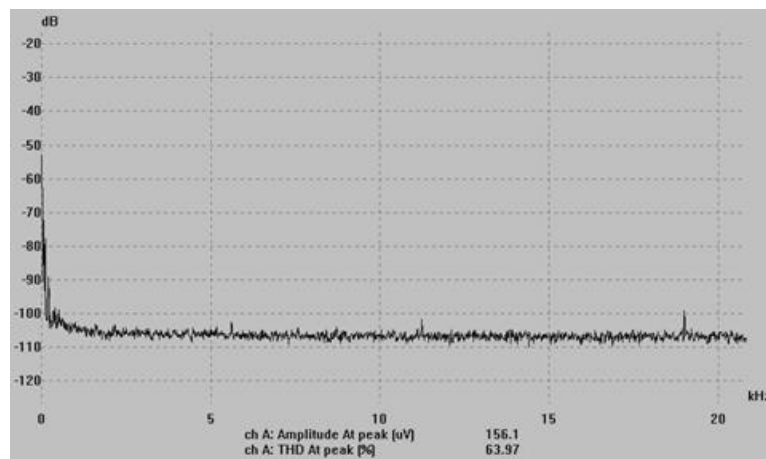


Fig.8 FFT average noise appears the level (medium) of noise present at the output, without weighing filters and on the entire audio band, with entrance closed on 680ohm and 8ohm exit. The only peaks present I am from Attribute to environmental disturbances during measure.

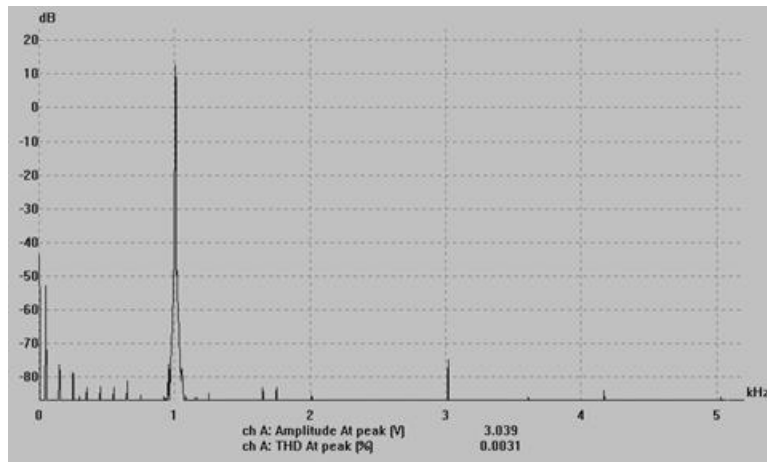


Fig9 FFT 1KHz 2W load 4ohm. The generator has a third harmonic THD of about 0.002% (peak a 3KHz, about -80dB) , so the real THD is about 0.001% ... The frequencies “spurie” around the fundamental are caused by residues of feeding of the generator.

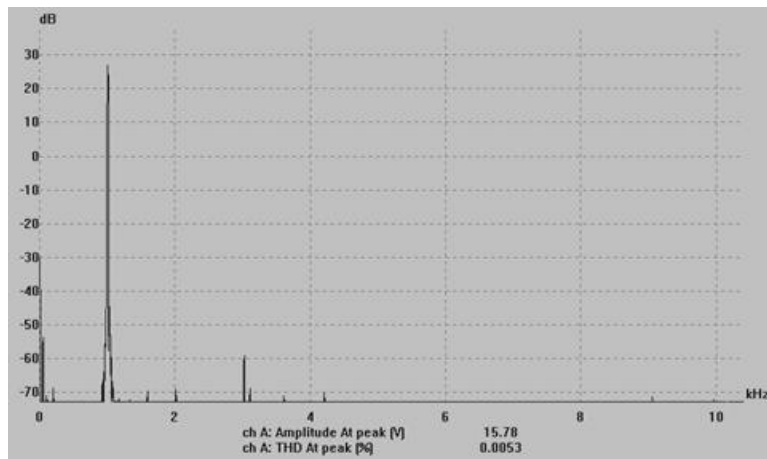


Fig10 FFT 1KHz 56W 4 ohms. (just before of clipping condition) With load of 8ohm you get a power of 40W, of course with more reduced THD.

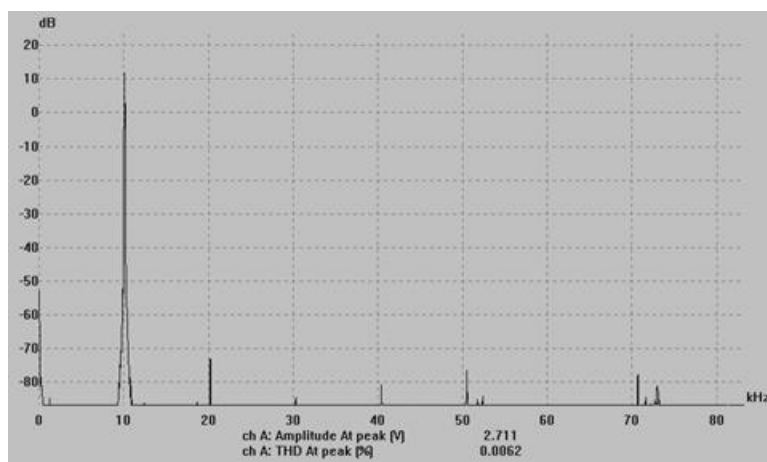


Fig11 FFT 10KHz 2W 4ohm. Note the Light increase in second harmonic distortion, caused by minor control of LM318 on LM3886 due to the Cfb and the consequent decrease of gain with an open loop. The generator causes almost the entire third harmonic for about 0.003%

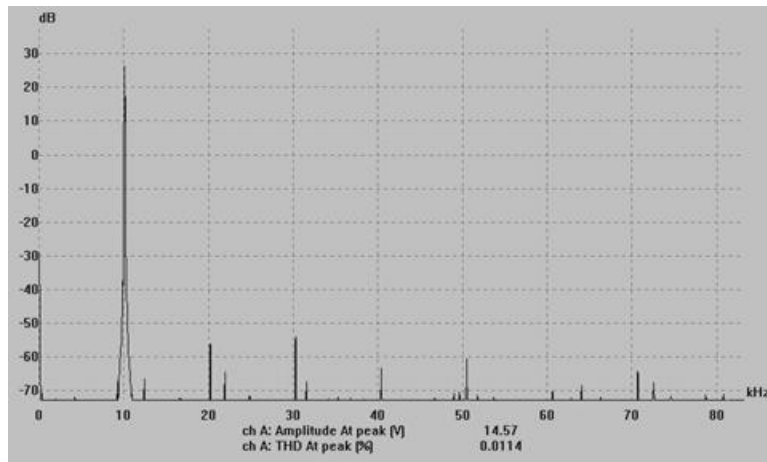


Fig12 FFT 10KHz 56W 4ohm. The Maximum of the Distortion level before clipping on 4 ohm load. Of course with load of 8 ohms the THD never exceeds 0.006%. Note how ad increase are the even harmonics, almost absent in the others conditions.

6 References on My-ref

Server that collects the useful documentation of the Project “My-ref” :

<http://213.156.45.208/My-Ref/>

Discussion of DIYAUDIO.com on My?ref (English):

<http://www.diyaudio.com/forums/showthread.php?s=d56a21171ff7ce6fff27e00a391c057f&threadid?54571>

The address of Posta electronic for information on project “My-Ref”:

the.projectmyref.com

7 Appendix A: complete schemes

The OJd, the 9.1 Amplification Section

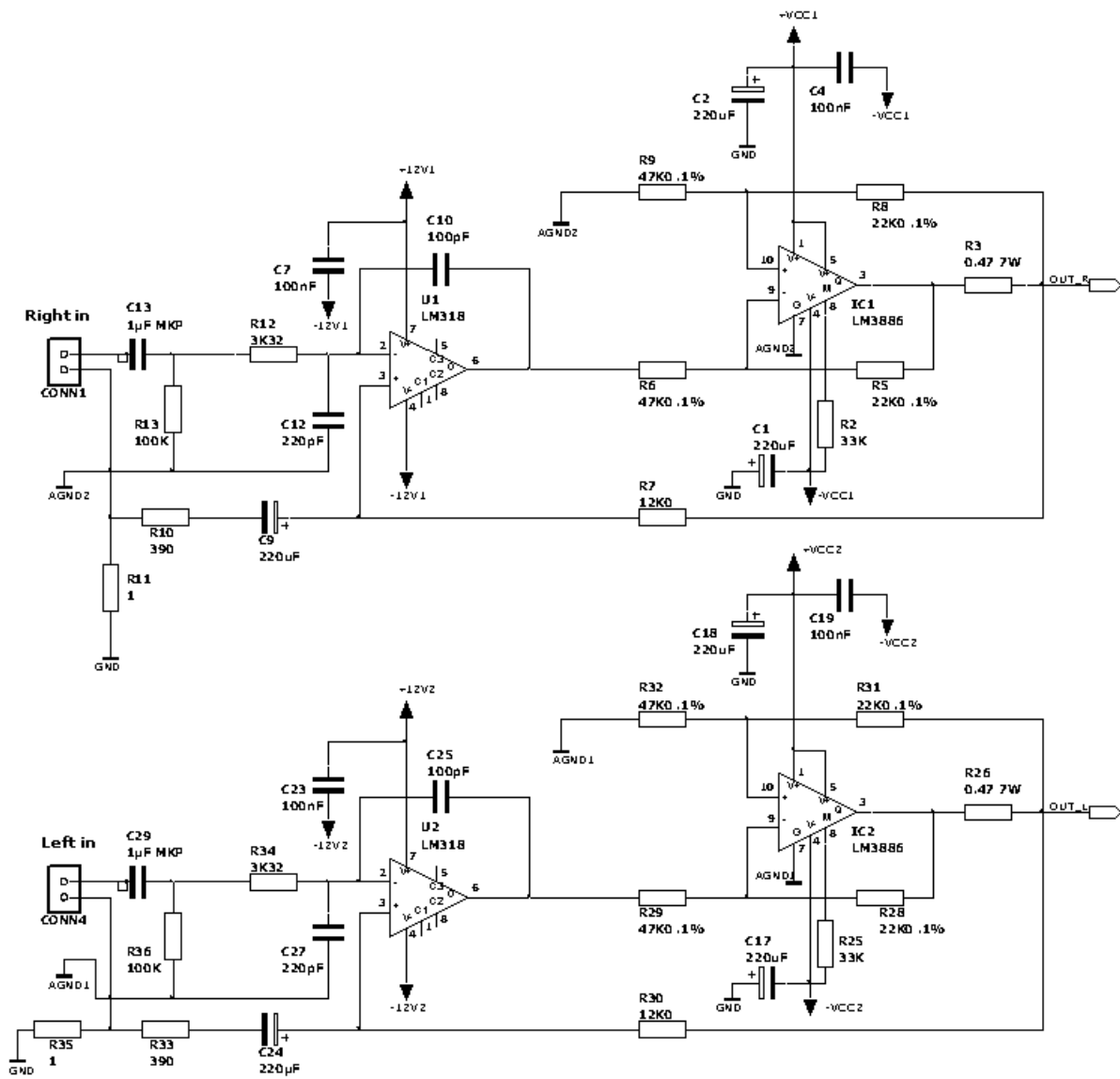


Fig.13 amplification circuit full (2 channels)

7.2 . Section Power Supply

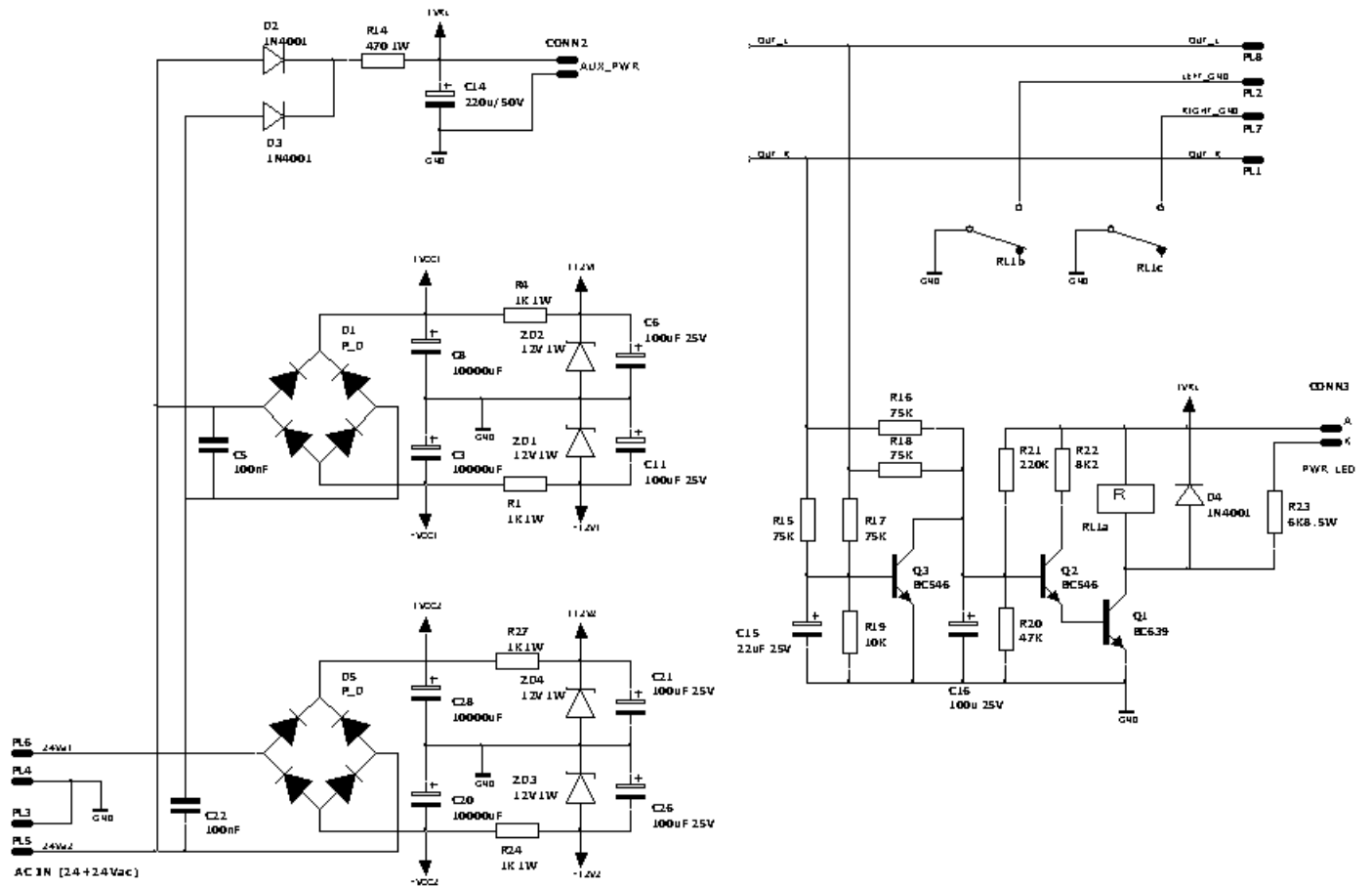


Fig.14 full circuit power supply and protection

8 Appendix B: Components list

Name	Ref	Value	Qty	Description
1N4001	D2 D3 D4	1N4001 1N4001 1N4001	3	1A-50V Diode
BC546	Q2 Q3		2	NPN Bipolar
BC639	Q1		1	NPN Bipolar
BZX85-XX	ZD1 ZD2 ZD3 ZD4	12V 1W 12V 1W 12V 1W 12V 1W	4	Zener 1.3W relieved assemblage (>5mm PCB-res)
C050-025X075	C7 C10 C12 C23 C25 C27	100nF 100pF 220pF 100nF 100pF 220pF	6	p5 25*75 Box Capacitor MKT 50V or ceramic multilayer COG
C102-043X133	C4 C5 C19 C22	100nF 100nF 100nF 100nF	4	p10 43*133 Box Capacitor MKT 100V (160V)
C102_152-062X184	C13 C29	1µF MKP 1µF MKP	2	p10-15 62*184 Box Capacitor >50Vdc hi-q. poliprop. film cap.
CP-10_5	C9 C14 C24	220µF(a) 220µF 220µF(a)	3	Radial (10mm) EL. Capacitor >35V (a)=audio grade=105° low esr
CP-18_7-5	C1 C2 C17 C18	220uF 220uF 220uF 220uF	4	Radial (18mm) EL. Capacitor 50V low ESR 105°
CP-30_snap	C3 C8 C20 C28	10000uF 10000uF 10000uF 10000uF	4	Snap-in (30mm) EL. Capacitor >40V (63V ELNA LP5)
CP-6-3_2-5	C15	22uF 25V	1	Radial (6.3mm) EL. Capacitor
CP-8_3-5	C6 C11 C16 C21 C26	100uF 25V 100uF 25V 100uF 25V 100uF 25V 100uF 25V	5	Radial (8mm) EL. Capacitor
Faston_cs	PL1 PL2 PL3 PL4 PL5 PL6 PL7 PL8		8	Single Pin Header Faston 6.3mm Male C.S.
LM318	U1 U2	LM318N	2	Plastic DIL Op Amp National semi. only!
LM3886	IC1 IC2	LM3886T	2	LM3886T or LM3886TF

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M100P2	CONN1 CONN4		2	Molex 2p. Male
P_D	D1 D5		2	Fagor B250 C5000/3300 or B250 C7000/5000 (7A-250V)
R-0.25W	R2 R5 R6 R7 R8 R9 R10 R11 R12 R13 R15 R16 R17 R18 R19 R20 R21 R22 R25 R28 R29 R30 R31 R32 R33 R34 R35 R36	33K 22K0 .1% * 47K0 .1% * 12K0 22K0 .1% * 47K0 .1% * 390 1 3K32 100K 75K 75K 75K 75K 10K 47K 220K 8K2 33K 22K0 .1% * 47K0 .1% * 12K0 22K0 .1% * 47K0 .1% * 390 3K32 1 100K	28	Resistor 1/4 w 1% * matching value (ie: 47k=47K & 22K=22K or 47k5=47k5 & 22k1=22k1)
R-0.5W	R23	6K8 .5W	1	Resistor 1/2 w 5%
R-1W	R1 R4 R14 R24 R27	1K 2W 1K 2W 470 2W 1K 2W 1K 2W	5	Resistor 2 w 5% case 17*6mm relieved assemblage (>5mm PCB-res)
R-CER-4W	R3 R26	0.47 7W 0.47 7W	2	Cement wire Resistor 5W or 7W 20*10 ceramic case
RELAY1	RL1	24Vdc 2sc. 8A-250V	1	RTE24024(Scratch)
STRIP-2	CONN2 CONN3		2	2 way Pin Header (or Molex 4p. Male)

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