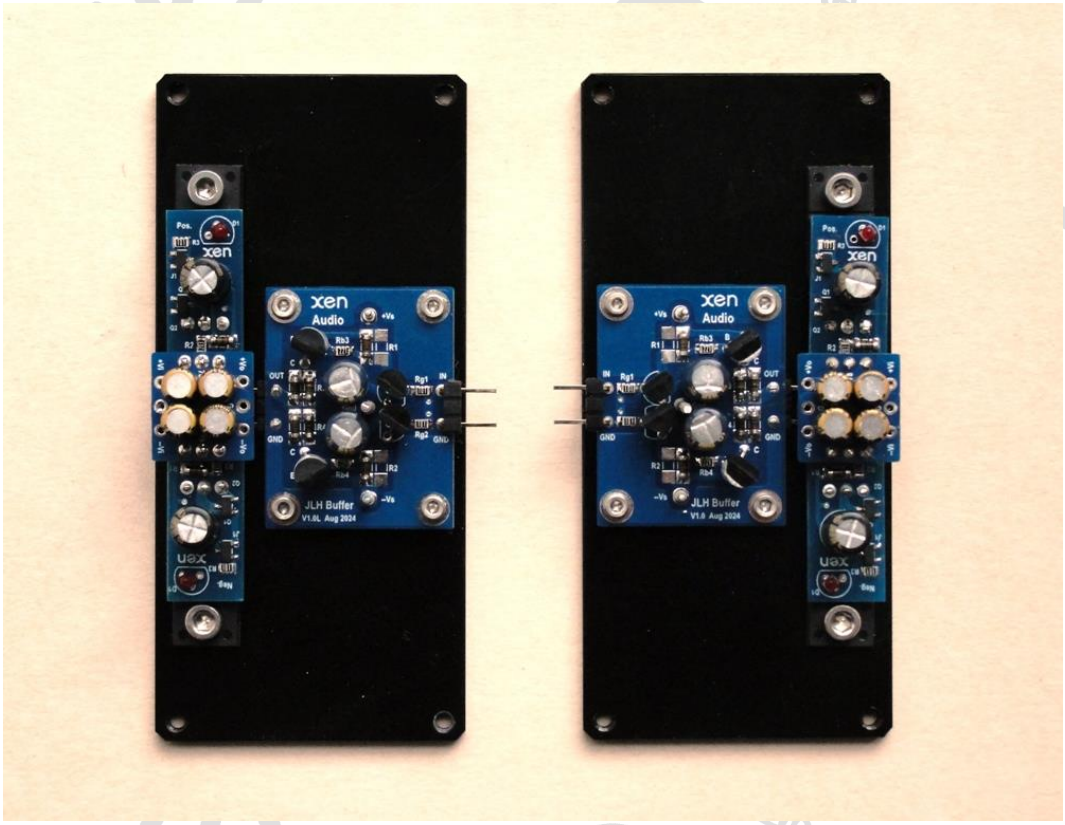
Preamp for Le Monstre 2024
XEN Audio
December 2024



After finishing the Le Monstre 2024 shootout, we want to proceed with a proper build.

In principle the Le Monstre has sufficient gain to act as an integrated amp. There are some builds that used a volume potentiometer in the same box, with another rotary switch for source select. But the Le Monstre has a low input voltage level because of its limited power but high closed-loop gain. Therefore, it was preferred to move the source select and volume control to a separate box. And because the LM already has sufficient gain, a unity-gain buffer with low output impedance is all that is required to drive the connection cables.

We already have an established platform for (the F5) preamps, which includes source select, ladder attenuator, and power supplies. So it is simple just to use the same and only change the preamp / buffer module.

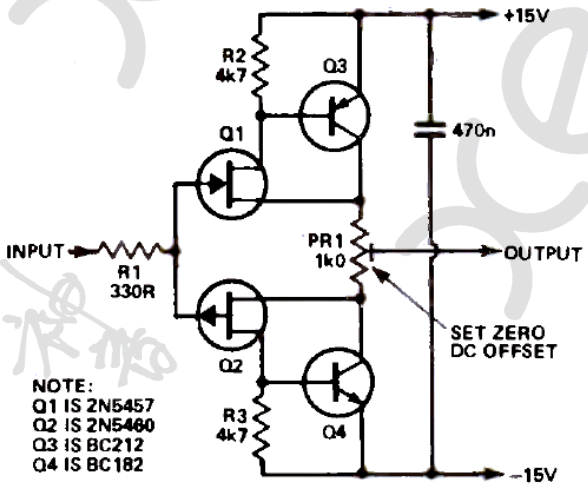
Choice of Buffer

So what would be an ideal choice for such a buffer ?

To match the Le Monstre, it should ideally be :

- fully complementary push pull,
- simple circuitry with low output impedance,
- have JFET input and BJT Sziklai output,
- ideally also a vintage design.

After quite a bit of searching, we finally settled on the JFET Buffer from John Linsley Hood [1,2,3,4]. The original circuit, as shown above, was used in his preamp as an input buffer after source selection, to provide a high impedance load for the phone preamp upstream. It has good performances driving high impedance loads (e.g. 10k) with low current consumption (< 5mA), though all the devices are already obsolete and have to be replaced. In the process, we took the liberty to make some further changes to our own liking, though they are not necessary.



Circuit Changes

There are no currently-available replacements for Onsemi 2N5457/5460 JFETs, except for after-market versions from e.g. Central Semiconductor (factory special order). The SMD versions (MMBF5457/5460) are easier to find, and are more than sufficient in terms of dissipation. But since we have to use NOS devices anyway, we can also use Toshiba 2SK246/2SJ103 instead. They have similar transconductances to the Onsemi JFETs, but can take more voltage. The Y-grade also has comparable Idss range to 2N5457/5460, though other grades can also be used.

With the 1k-trimmer and 4k7 resistors as in the original schematics, the output transistors are biased at only 1~2mA, and the JFETs at ~140µA. In theory it can still drive a 1k load to 2Vrms in Class A, but not much more. In that case, almost any small signal BJTs can be used, such as BC337 / 327, MPSA06 / 56, KSA992 / KSC1845, 2SA970 / 2SC2240, etc.

But low distortion is only achievable with load >10k. Also, the JFET bias is far below their Idss. Some would say that they are starved of current. To increase bias in both the JFETs and the BJTs, the trimmer and the drain resistors need to be reduced.

The schematics shown in [3] has the 1k trimmer replaced by 2x 150R fixed resistors, and any DC offset (and drift) is decoupled using a 10µ output film capacitor. This will increase the output bias current to about 8mA. The output BJTs would need to be chosen to suit the higher bias current. The exact bias is highly dependent on the JFET Idss. For example, when using 2SK246 / 2SJ103 BL grade, the output bias can be as much as 20mA, more than sufficient to drive 600R load.

For 15V rails, the SS80505 / SS8550 used as drivers in our Le Monstre 2024 would be a good choice. Their hfe is almost constant up to 100mA collector current. Higher rail voltages do reduce distortion somewhat, in which case KSC2383Y / KSA1013Y should be used instead. Output impedance is about 75ohm. This can be reduced when using Y grade JFETs and then reducing the output resistors

further. Output impedance will also be reduced, capable of driving 600R loads. DC offset can of course be nulled by trimming the two output resistors, or using an additional DC servo.

The frequency response of the original schematics has a small hump at ~3MHz. Base resistors and Ccom can be added to flatten that out.

We mentioned earlier using SMD versions of the input JFETs. So why not also use SMD for the output devices as well. Apart from better availability, a SMD layout would allow the active devices to be thermally coupled to the case, using silicon thermal pads.

So the following are device combinations we plan to try :

2N5457/5460 + KSC2383Y/KSA1013Y
2SK246Y/2SJ103Y + 2SC3328/2SA1315
MMBF5457/5460 + 2SC3649S/2SA1419S
2SK208Y/2SJ106Y + 2SC2881Y/2SA1201Y

Source Select and Volume Control

It is easy to just copy and paste from our previous preamp project, the F5Pre [5]. And we did, at least for the power supplies and the source selection. But for the relay ladder attenuator, we decided not to use the W-ONE attenuator. The W-ONE is modern MCU / Encoder based and is not quite compatible with the vintage nature of the Le Monstre and the JLH.

And we searched for an absolute encoder with 8-bit resolution. But the output code is not simple 8 bit binary, and requires additional MCU for decoding. The most pragmatic solution which does not require programming seems to be the ADC0804 ladder attenuator, already published extensively [6,7,8]. This uses the variable voltage output from a linear potentiometer as input, and decodes that into 8-but binary output from the ADC. One can argue that the ADC0804 is still a digital circuit in the free running mode. But it is at least hard coded. It has been reported that the ADC0804 solution is prone to relay chatter and loud transients during volume change. The former can be solved by introducing some hysteresis for the LSB (thank you Nelson for the hint), while the loud transients can be minimised by switching the two MSB relays with a slow-on fast-off circuit.

How to display then the volume with the same ring LED without MCU ? Since the input is a linear analogue voltage, this can be used to drive 4x LM3914 set to 32 levels. The LM3914 conveniently provides LED current control and dot display mode also.

The circuit is of course a bit more complex than a single MCU, but it was a lot of fun to get it working properly. ☺

Power Supplies

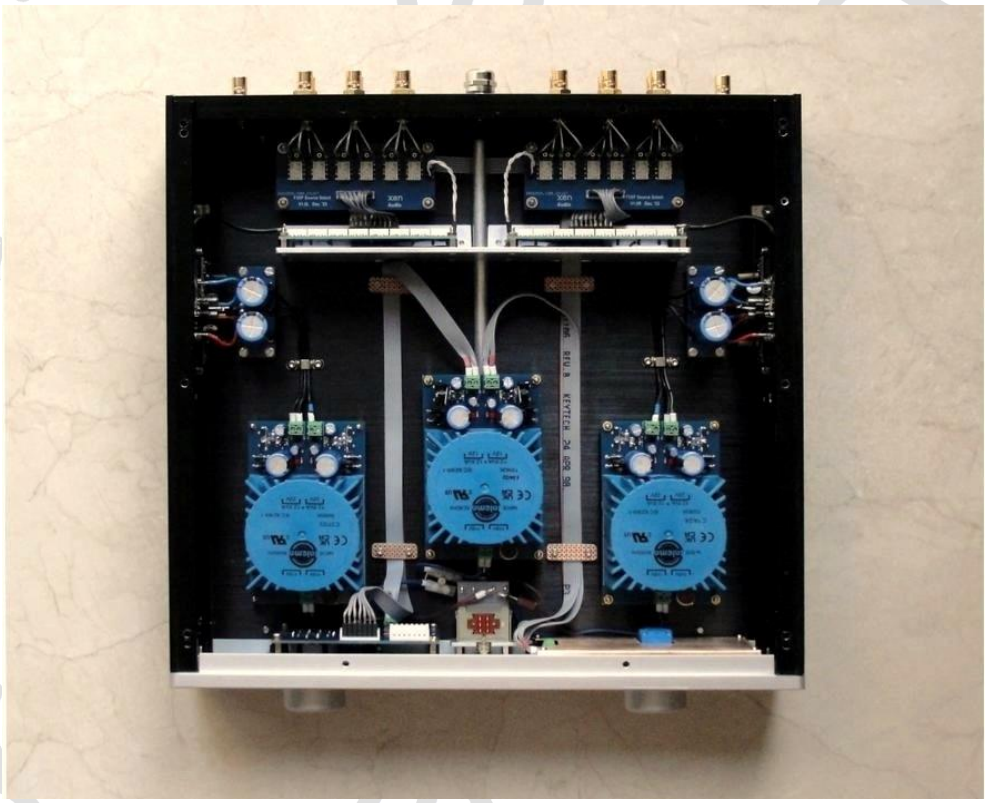
The same power supply setup was used as in the F5 Preamp. Each channel gets it own dual LM317-based regulated supply with Talema 25VA transformer. A third PSU provides 2x 12V for the Omron G6K small signal relays, and the ADC has local 5V regulators on board.

Because of the low rail voltage and high gain of the Le Monstre, output from the preamp is hardly more than 0.3Vrms. Thus, it is important that the JLH buffers have low noise level. Therefore, additional discrete regulators are installed, right next to the buffer PCB, with additional input capacitors nearby. These are 78xx/79xx TO220 compatible, allowing a wide selection of other pin-compatible regulator modules to suit individual taste. The buffer and the regulators are mounted on a heat

spreader plate which in turn is mounted to the side panels with 4 screws. This way, it is very convenient to change the buffer / preamp circuit, while retaining the rest of the preamp infrastructure.

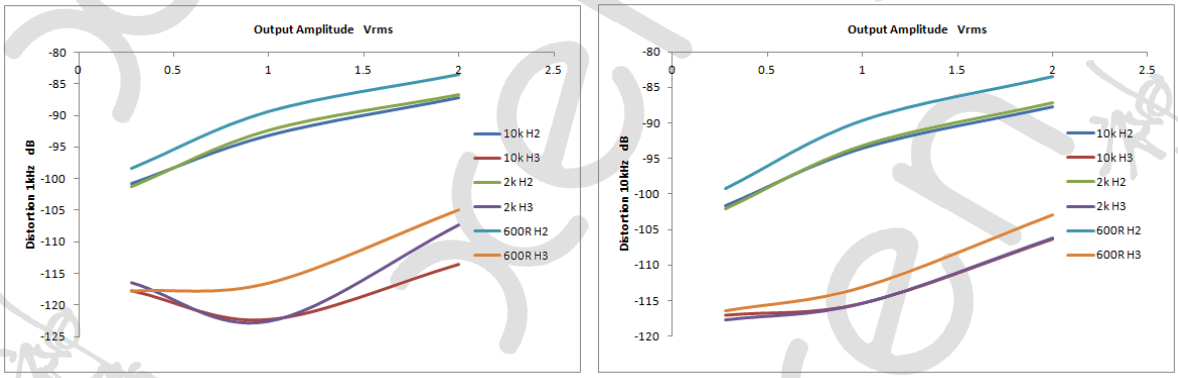
Enclosure

We used the same BZ3207 case as the F5 Preamp, but chose the long version to be compatible with the BZ3209 heat sink case that we chose for the Le Monstre.



Measurements

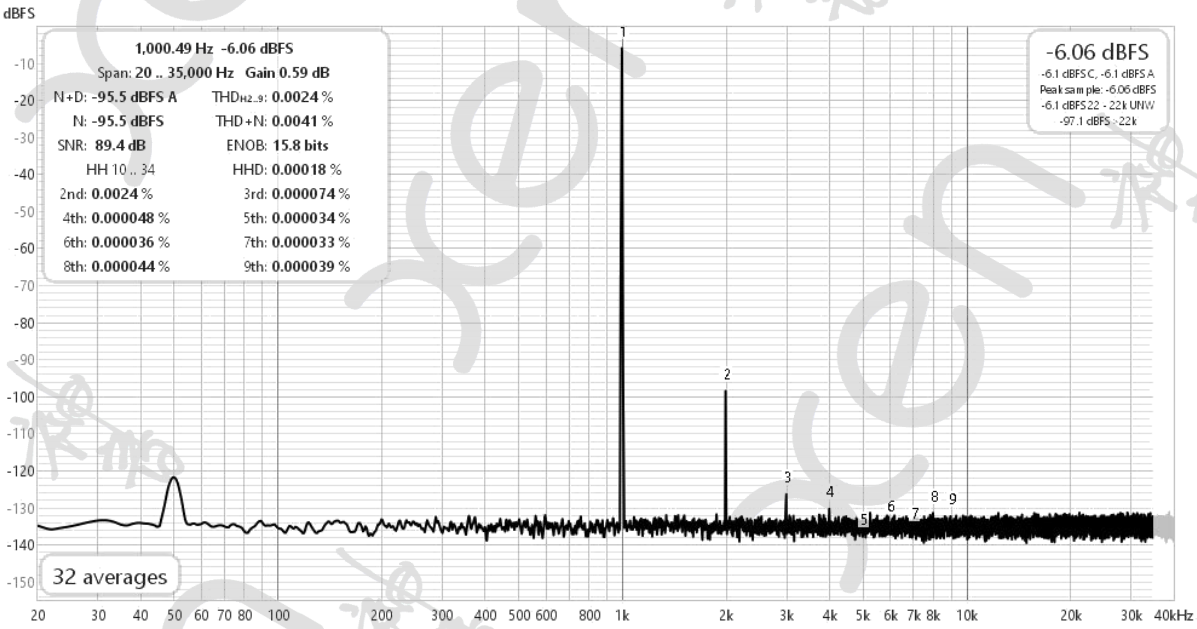
The first prototype is based on the 2N5457/5460 + KSC2383Y/KSA1013Y combination. This has been measured with different amplitudes, loads and frequencies. The results can be summarised as below :



The different colour lines represent different loads. The left figure is for 2nd and 3rd harmonics at 1kHz, the right figure for 10kHz. Note that the Le Monstre only requires 0.3Vrms input for full swing and has 48k input impedance.

As can be seen, distortion is mostly 2nd harmonics, with 3rd some 15dB lower. Distortion is practically identical between 2k and 10k load, and between 1kHz and 10kHz. And about 3 to 5dB higher at 600R load. 3rd harmonics at 1kHz below 1Vrms are noise limited. At 0.3Vrms as required for the Le Monstre, H2 is at -100dB, and H3 at -115dB. Amazing buffer.

The plot below is 1kHz, 1Vrms into 2k load.



References

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