white paper

Ferrum **OOR**

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Content:

What makes OOR special

First of all OOR has unique discrete output stage. It is not class A, it is rather something between class A and AB. OOR doesn't have full-time operational current source, which forces the current through one transistor, which always deliver current to load. Instead it has special circuitry, which never lets to turn off neither of both output steering transistors, which are polarised similarly as in class AB. It is done in a way, that current of both transistors is monitored by independent circuits and those circuits prevents to drop below some threshold value of current. That way the distortion is much lower, because the transistors aren't going through the most nonlinear region of its characteristic. This output stage is even more linearised by feedback loop of discrete current feedback amplifier, which has about 60kHz of open loop bandwidth (-3dB) and almost 1MHz of closed loop bandwidth (-3dB). 60kHz of open loop bandwidth was achievable due to two-pole compensation scheme. This feature makes distortion more flat in audio spectrum, because the open loop gain rolls off at higher frequencies compared to typical Miller compensation. This wide open loop bandwidth is not present in IC headphone amplifiers.

Secondly internal power supply is technological heir of HYPSOS. It has low noise switching regulators with double stage input and output filtering, which is followed by fast transient response linear LDOs. There are separete LDOs for both channels for improved channel separation. What is more OOR has two DC power inputs. One classic 2.5mm/5.5mm DC jack plug and the second 4 pin WEIPU plug, the same as in HYPSOS. For the second option we have dedicated cable - FPL (Ferrum Power Link) with 4 pin WEIPU connectors on boths sides. When normal cable is used 4TSD function in HYPSOS measures the voltage directly on the cable output, but with FPL voltage is measured on the motherboard of OOR. This allows HYPSOS to stabilise the voltage even further in the power path.

Thirdly entire signal path is fully balanced and there is no transformers and inductors in it. Volume regulation and gain circuitry is fully balanced not only on the XLR input, because the input amplifier is converting the single ended signal to balanced. To accomodate for single ended output the signal is converted from balanced mode to single ended only at the single ended outputs.

Input stage

Input stage of OOR, which is internal preamplifier, which adjusts gain and volume is made from carefully picked fast opamps with special external compensation, which acts similarly as two-pole compensation.

Output stage

The output power amplifier is fully discrete and based on low noise BJT transistors. There are 4 of those amplifiers, 2 for each channel, which is needed for balanced output. This amp is DC coupled and yes, there is DC servo, which has -3db cutoff frequency at about 0.1Hz.

Internal power stage

There are 8 main independent power rails in OOR. For main power amplifier there are + 20V independent rails for both channels based on low-noise fast linear LDOs. For preamplifier stage there is +-15V rails, again independent for both channels and based on linear LDOs. +-20V rails LDOs are supplied by switching converters, which have double stage filters on input and output. Voltage on the output of switching converters is about + 21.5V. There is one additional power rail only for front LED and it is powered directly from input power supply.

Grounding and the PCB design

OOR has one, six layer board. We have several layout specialists and a lead hardware engineer. All schematics and the PCB project has been discussed by the R&D team and some aspects of PCB were designed by the other member of our team.. OOR's PCB has two layers just for ground planes. There are three grounds in OOR: signal ground, switching converters ground and input power supply ground. All of those grounds and power rails are separated by common mode chokes for further attenuation of common mode EMI from switching converters and from the input power supply.

Output impedance

On the headphone output the impedance at 1kHz is <0.4 Ohm regardless of the load. On the preamp output: RCA 22 Ohm, XLR 44 Ohm.

Output power

OOR has internal current limiting (without foldback). Therefore steady state and transient power, until the distortion from current limiting or dropout occurs, is the same. For 32 Ohm: single ended 3.5W, balanced 5.5W. For 600 Ohm: single ended 200mW, balanced 800mW.

Industrial Design

The logo is the same as in HYPSOS, so it is not corten "style" steel, it is lacquered corten steel. We chose to lacquer it, because otherwise it would leave stains on everything what would touch it. Stylistics of Ferrum products were designed by an industrial design company from Warsaw. They have deeply analyzed DNA of HEM and precisely understood it. Based on that knowledge, they have made absolutely unique and stunning design, which perfectly coresponds to our heritage. All the knobs for switches and volume control is our custom design. We wanted them to be as user-friendly as possible. We checked many different prototypes of volume knob (diameter, depth) and gain switches, to achieve optimum size, shape and visual cohesion. Under the PCB board, where are output power transistors, there is aluminum block for dissipating heat to the chassis. Many persons in HEM team were cooperating on the casework. There are many parameters, that need to be optimized, as visual factors, usability, availability of components and manufacturing factors. All those parameters are not always consistent with each other, therefore gathering ideas and discussing pros and cons of them is crucial for achieving best results.

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