DESIGN AND RESULTS OF THE 'TEMPORAL COHERENCE' PHONO PREAMPLIFIER

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Date of issue: 31 January 2020

The revival of vinyl has stimulated us to develop a phono preamplifier because there is interest from the market. A chain is as strong as its weakest link, so the quality of the source is crucial for the end result of sound reproduction. It should not come as a surprise that we, at 'Temporal Coherence', are critical on the design of many audio systems, so we have designed a phono preamplifier along the conceptual lines of our other equipment. This means that the *perceived* quality comes first and that the *dynamics* of the amplifier for music signal processing is key in the design. Details of what this means are laid down in detail in a previous report ('Is feedback the miracle cure for high-end audio?', 14 May 2017, www.temporalcoherence.nl) and will therefore not be repeated here. But, of course, there are specific properties required for the design of a phono preamplifier: the amplification of the weak signal, especially from moving coil cartridges, and the correction of the record cutting frequency characteristic. Both aspects will be elucidated here.

Moving coil (MC) cartridges generate, depending on the brand and type, 0.2 – 0.4 mV of signal. This is roughly an order of magnitude less than moving magnet (MM) cartridges, but both are way to small to be used directly: a common line voltage is around 200 – 500 mV. It is common to use a pre-pre amplifier of roughly 10 times to bring the signal of an MC cartridge to the level of an MM cartridge. The biggest issue of such a pre-pre amp is noise. In the 'Temporal Coherence' phono preamplifier this has been tackled by putting four 'transistors' in parallel as in this way the amplification of this stage is four times higher, but the contributing noise is only two times higher. So the signal-to-noise ratio has improved by 6 dB. The improvement is due to the stochastic nature of the noise in transistors, which adds up by the square root of the number of parallel stages. It showed that the noise from the amplifier is far below the noise of the record itself. Further improvement is possible at the expense of rapidly rising costs, but this is not necessary. Note that 'transistors' has been put in quotes. The reason is that in the designs of 'Temporal Coherence', transistors are not used in the common ways these are operated, but are set in a different configuration to reduce the distortions, irrirating to the ear, by a factor of 20.

The signal of either the pre-pre amp or an MM cartridge is further amplified, but frequency dependent. This is necessary to correct for the frequency dependent disc cutting. The reason that the disc is cut this way is two-fold: the amplitude of the modulation in the groove and the noise from the record. If the signal from the cartridge was to be frequency independent, the amplitude in the groove would be inversely proportional to the frequency. As a result, the low frequencies would give rise to large amplitudes, thus limiting the amount of information, stored on the record and reducing the playing time. To avoid this, low frequencies are suppressed during the cutting of the record. Noise from the record is inevitable and therefore the higher frequencies are recorded stronger. During playback, these have to be suppressed and so is the noise from the record. The requirements are specified in the RIAA (Recording Industries Association of America) curve (1955) and consists of time constants of 3180, 318 and 75 μs, corresponding to frequencies of 50, 500 and 2120 Hz. At playback, the correction has to take place according to the mirror image of this curve, shown in fig. 1, green curve.

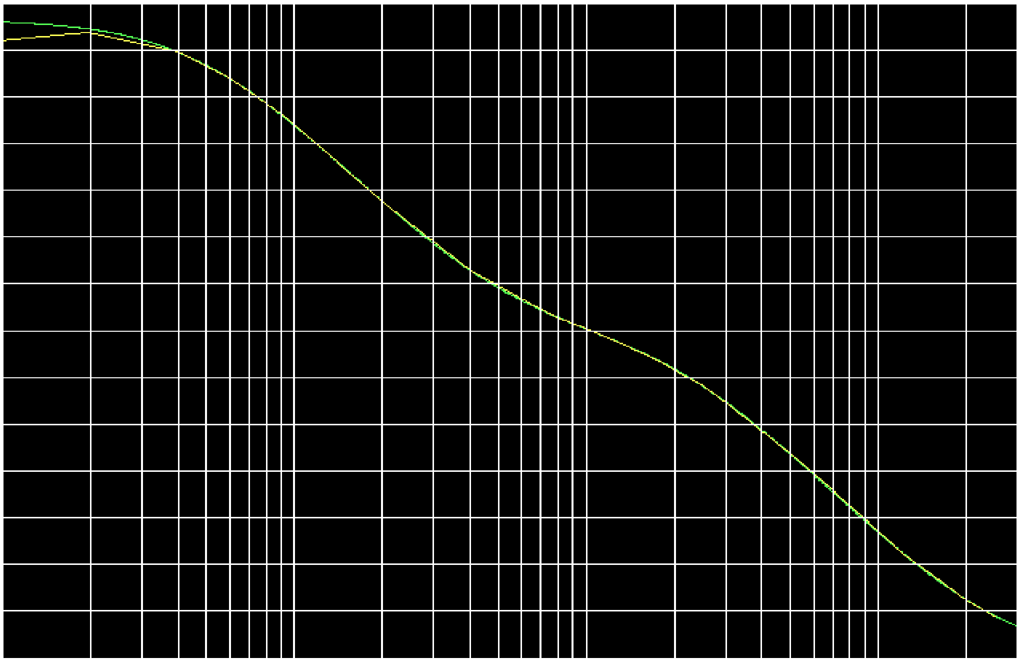

Figure 1: *Calculated (green) and measured (yellow) frequency response of the RIAA correction. Vertical scale 3 dB/div. Horizontal scale 10 Hz – 30 kHz.*

Unfortunately, according to our current knowledge and insights, the choices made in those days are far from ideal: the selection of two time constants in the mid-range results in a weird phase response around those frequencies, which need to be corrected accurately to avoid audible deficiencies. In 1955, this was clearly not an issue, but things have notably improved since then. So the frequency characteristic as shown in fig. 1 needs to be implemented with high precision to avoid audible effects.

There a basically two ways to implement this characteristic: the fist, and most common, is to use a frequency dependent feedback network over either an Integrated Circuit (IC), an operational amplifier (OpAmp) or an amplifier, build up using discrete components. The second approach is to use passive networks between (linear) amplification blocks. The 'Temporal Coherence' phono preamplifier uses the latter approach. The most important reasons can be found in the web-publication mentioned above, but note that the frequency dependent feedback enhances the issues notably because it means an increase in the dynamic range of the amplifier by at least 40 dB. Using passive networks, such issues are eliminated at the expense of more amplification as passive networks reduce the signal strength. As the perceived quality comes first, this drawback is accepted.

The resulting characteristic has been measured in order to verify whether the actual implementation fulfils the requirements listed above. The yellow curve in fig.1 is the result of the measurements, which very closely follows the theoretical (green) curve, albeit that at very low frequencies a difference is discernible. This difference has deliberately been introduced to reduce rumble, coming from the record. Rumble is caused by imperfect flatness of the record, which generates very low frequencies in the output signal, which can give rise to problems of the power amplifier and / or the loudspeakers. Therefore the lowest frequencies are suppressed using a mild high-pass filter which can be seen in the yellow curve. The difference between the theoretical and measured curve is shown in fig. 2. The wiggly character is caused by the uncertainty in the individual measurements and is not related to the actual preformance of the phono preamplifier. But from this result, it can concluded that the individual deviations from the theoretical curve of the preamplifier are less than 0.1 dB between 30 and 25 000 Hz with an averaged error of 0.0465 dB. It is questionable whether this can be attributed to the preamplifier or the uncertainty of the measurements.

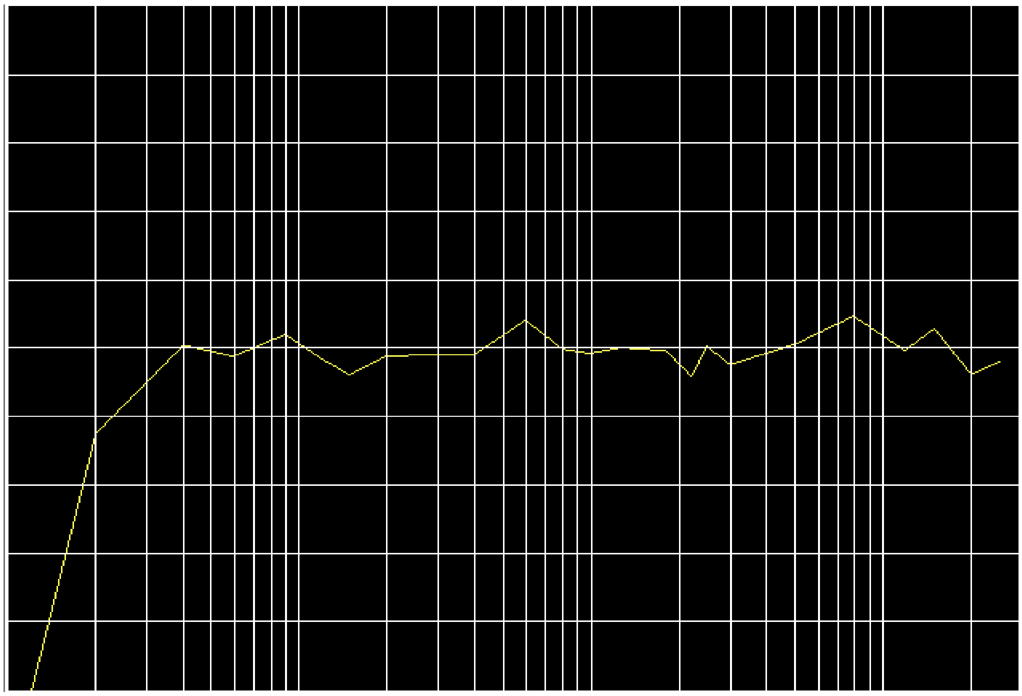

Figure 2: *Difference between the calculated and the measured frequency response of the RIAA correction. Vertical scale 0.2 dB/div. Horizontal scale 10 Hz – 30 kHz. The differences at lower frequencies are caused by the rumble filtering.*

The amplifier is able to process the signals, coming both from MC and MM cartridges. To get optimum results, two separate inputs are used. The switching between the two could easily lead to problems when ‘normal’ switches would be used. Therefore, all the switching is done using gas filled microrelais on the printed circuit boards. The switches on the front and the rear panel only switch the current, which controls the relais. The input impedance for MC cartridges is not standardised, so the sonic performance can be optimized by selecting 50, 100 or 200 Ω. The input impedance for the MM input is fixed at the standard value of 47 kΩ. The strength of the signal, coming from both MC and MM cartridges depends on the brand and type. This could easily lead to annoying differences with other signal sources, like a CD player. To that end, the output signal from the ‘Temporal Coherence’ phone preamplifier can be changed in 6 dB steps (-6, 0 or +6 dB).

The phono preamplifier is build up using discrete components as only in this way the optimum sonic preformance can be achieved. When components like OpAmps are used, the designer of the preamplifier fully depends on the interior properties of the OpAmps, which are not necessirarely optimal for the requirements, set by the ‘Temporal Coherence’ designers.

‘No apparatus can be better than its power supply’ is the adagium, used by the ‘Temporal Coherence’ design team, so all the power is controlled by discretely build up series regulators to make sure that the supply voltages do neither depend on the line voltage, nor on the signal, the preamplifier is processing. The basic design of the regulators has not been modified worth mentioning during the past 50 years and so it has proven its quality.

The ‘Temporal Coherence’ phono preamplifier has been reviewed by Ruud Jonker of the Dutch HiFi magazine ‘Music Emotion’. The review has been published in Dutch, both the original version and a translation into English can be found on www.temporalcoherence.nl and his conclusions are in close agreement with the results, presented in this paper.