A high accuracy inverse iRIAA filter

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Check or, moreover, set RIAA corrector using a generator and voltmeter - quite a troublesome matter. Not only it takes quite a long time, but we must also have a good generator and an accurate voltmeter with high sensitivity. In most cases, devices with the necessary accuracy and sensitivity you do not have, therefore, you have to use the calculated values of the parameters RIAA filter without (or with an approximate view of) the real parameters of the cascades, among which the filter is included. If the corrector is implemented on Op-Amp, this does not lead to the emergence of significant errors, since the parameters of the cascade of Op-Amp can be accurately calculated. But if you are using discrete components or a tube, it leads to significant deviations from the required frequency response. Naturally, this affects the sound.

A simple and effective solution to this problem is to use the inverse filter. If the filter characteristic is realized exactly, at this case if output of the filter applied to the input corrector, you can quickly and accurately detect deviations from the specified frequency response. To some extent, using of the inverse filter reduces the demands on accuracy and sensitivity of the equipment used for adjustment.

When I encountered this problem, I decided a little lazy and took the advantage of ready-made solutions. I was surprised to find that everybody is trying to implement a passive inverse filter. In my opinion, the main advantage of this solution is an ease of implementation, almost completely overshadowed by a passive filter inherent disadvantages. Influence of the output resistance of the generator at the frequency response of the filter and limits the choice of capacitor values (the ratio of the capacitance must be within certain limits) can be regarded as a trifle. More significant problem is the mutual influence of parts of the filter, making it difficult to obtain the desired frequency response with high accuracy.

All these problems are solved quite elementary, if we use operational amplifiers as a buffer separating the network from each other and from the generator. I understand why the passive filters were being made forty years ago, but now, when you have a broadband low-noise Op-Amp, is a bit surprising. As a result - circuit appeared shown on Figure 1.

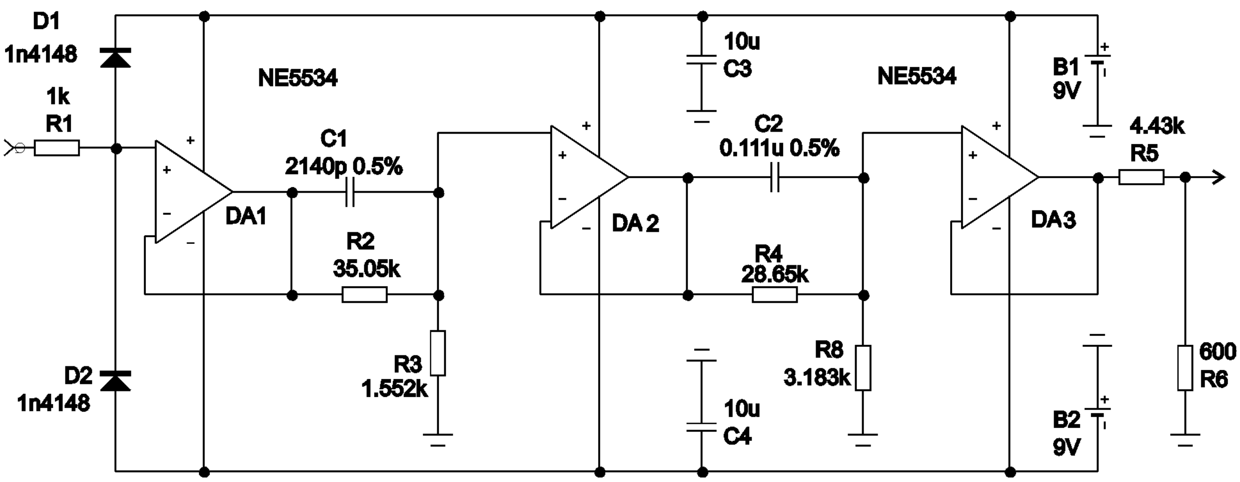

Figure 1

Two passive frequency-selective networks (C1, R1, R3, and C2, R4, R8) are separated from each other, the generator and the load by using buffer followers at Op-Amps. In the working frequency range the follower parameters are close to ideal and the selective networks are working in almost ideal conditions.

We can assume that the network is excited from a source with zero output impedance and has an infinitely large load; respectively, the accuracy of setting of the frequency response of the filter will be depended entirely on the accuracy of selection of elements of circuits. Complete independence of circuits from each other allow to vary the value of capacitors for selective networks (which is the main search complexity) in a wide range and for existing capacitors recalculate the value of resistors using simple formulas. Circuit of elements C1, R1, R3 makes time constants of 75μs and 3.18 μs, and a circuit of elements C2, R4, R8 - makes time constants of 3180 µs and 318 µs. Divider at the output of the filter (R5, R6) leads his transfer coefficient at a frequency of 1 kHz to the level of -46 dB (1V - 5mV), the output impedance of the filter - 530 ohms. In principle, by changing the ratio of these resistors, you can get more output impedance, or other transfer coefficient.

Figure 2 shows a graph of calculated deviation from the ideal frequency response (taking into account the parameters of Op-Amp). In fact the measured deviations, of course, turned out to be larger, but did not exceed the value of 0.02dB.

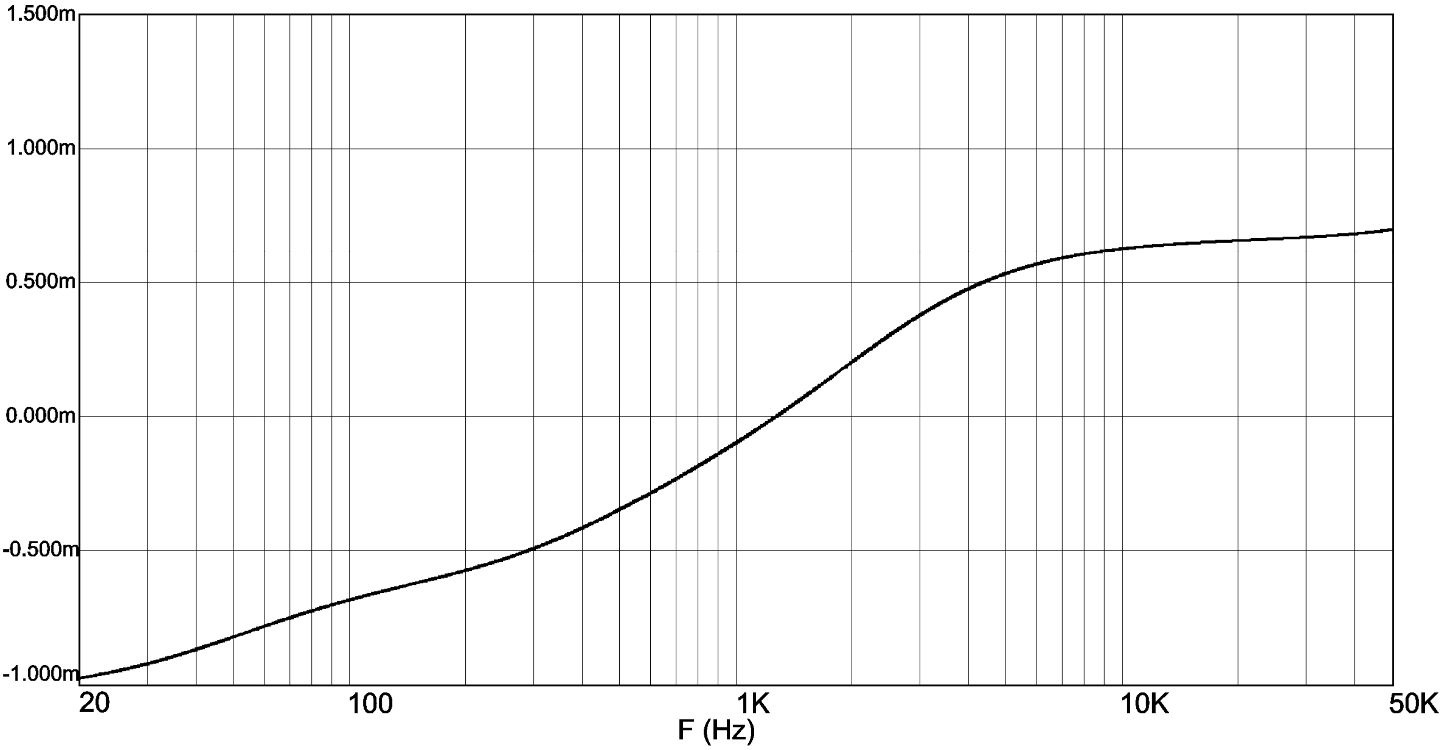

Figure 2

To reduce the influence of external interference, the filter is fed from an autonomous source (don't forget to switch it off, the batteries have enough energy to set up more than one corrector) and placed in a well-shielded case (suitable size box of thick steel). The standard instrument connector BNC is set in the input of filter, and RCA connector is set in the output. Installation of the circuit of filter is made in hinged manner on a piece of breadboard. The filter and its assembly are shown on Figures 3 and 4.

Figure 3

Figure 4

Let return to the most burning issue: the choice of components for frequency-selective networks. The most difficult thing is to find the high-precision capacitors; therefore, it is advisable to start with their search. The value of capacitor C1 may be in the range 1000 ÷ 3300 pF, and capacitor C2 - 0.068 ÷ 0.15 µF. Suitable are film and mica capacitors.

If you find capacitors with accuracy better than 1%, you can assume that their actual capacitance is equal to the nominal. In other cases, it is necessary to measure the capacitance as accurately as possible.

The following expressions are used to calculate value of resistors. Expressions are the same for both units, and they use the corresponding pairs of time constants and the measured value of capacitor. Accordingly for calculation R4 and R8 resistors of the second unit use the value of the capacitor C2.

$$T1 = C1 * R2,$$

$$T2 = \frac{R3}{R2 + R3} * T1,$$

T1=75µs (3180 µs), T2=3.18µs (318µs).

Required value of resistance is a combination of several resistors and an additional selection of most appropriate resistors from several ones. It is better to use of precision metal film resistors (MO) with an accuracy of 0.1 ÷ 0.5%, but also it possible to use semi precision resistors. In general their accuracy is not so much important not so much their accuracy, as the stability parameters (still have to select the desired nominal). There should not be pay special difficulties in the selection of resistors, because modern decent multimeters have the error in measuring the resistance at the level of 0.5% or less.

The filter has a power switch, which turns off the battery, and a power indicator on a super-bright LED, which has sufficient brightness at a current of 0.2 ÷ 0.4 mA (not shown in the schematic). With proper installation, no additional configuration is required. If possible, it is desirable to check the frequency response and the transfer coefficient at a frequency of 1kHz.

In conclusion, I want to say:

The first: the time spent on making the filter, even in the manufacture of one corrector, a hundredfold returns to the stage settings.

The second: if you make some efforts in the selection of components, this simple device could easily claim the title of an exemplary measuring device.