

A circuit topology useful for such RIAA phono applications is shown in Figure 6-17. This circuit consists of two high-quality wide bandwidth gain blocks, U1 and U2, as discussed above. Selection of these amplifiers and their operating conditions optimizes the preamp for gain, noise, and overload characteristics. The circuit can be set up for either MM or MC operation by simple value changes and op amp selection.

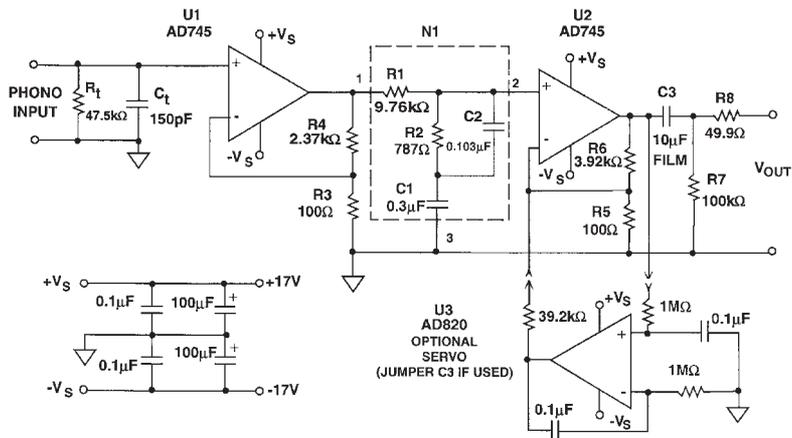


Figure 6-17: A passively equalized RIAA preamp with 40 dB gain

The gain stages are set up for the required total gain, via R_4 - R_3 and R_6 - R_5 . In general, the total 1 kHz gain of this circuit G is:

$$G = 0.101 \cdot \left[1 + \left(R_4 / R_3 \right) \right] \cdot \left[1 + \left(R_6 / R_5 \right) \right] \quad \text{Eq. 6-11}$$

The op amp gain blocks could be made identical for purposes of simplicity but are not necessarily so for the following reasons. A preamplifier topology such as this must be carefully optimized for signal-handling capability, both from an overload standpoint and from a low-noise viewpoint. Stage U1 is chosen for a gain sufficiently high that the input-referred noise will be predominantly due to this stage and the cartridge, but not so high that it will readily clip at high level high frequency inputs. Amplifiers with a ≈ 10 V rms output capability allow U1 to accept ≈ 400 mV rms at high frequencies using ± 18 V supplies, while still operating with useful gain (about 25 times).

The gain of the two blocks are set by R_4 - R_3 and R_6 - R_5 , as defined by Eq. 6-11. The gain values shown yield a 1 kHz gain that is the product of the U1-U2 stage gains (24.7 times 40.2), times that of the interstage network N (0.101). This yields an overall 40 dB 1 kHz gain. Other gains are realized most simply by changes to R_5 or R_3 .

As previously noted, a passively equalized preamplifier such as this must be carefully optimized both from an overload standpoint and from a low noise viewpoint. Stage U1 is chosen for a gain sufficiently high that the input-referred noise will be predominantly due to this stage (and the cartridge, when connected), but not so high that it will readily clip at high level high frequency inputs. To aid this objective, maximum supply voltage and a high output capability amplifier should be used for U1.

Note that U1 operates at relatively high gain, but it needn't be unity gain stable. Decompensated low noise op amps such as the OP37 and the FET input AD745 will provide best signal/noise ratio here. For other FET-input types, the AD845, as well as the OP17 family types, will also yield good performance, but with higher noise levels.

In general, the preceding factors dictate that gain distribution between U1 and U2 be LOW/HIGH from an overload standpoint, but HIGH/LOW from a noise standpoint. Practically, these conflicting requirements can be mitigated by choosing the highest allowable supply voltage for U1, as well as a low noise device. Because of nearly 40 dB loss in the network N at 20 kHz, the output overload of the circuit will be noted at high frequencies first. With the gain distribution shown, the circuit allows a 3 V rms undistorted output to 20 kHz with ± 15 V supplies, or more with higher supply voltages.

The equalization network N following U1 should use the lowest impedance values practical from the standpoint of low noise, as the noise output at Pin 2 of the network is equivalent to the input referred noise of A2. The network of Figure 6-17 uses the “N1” RC values of R_1 - R_2 - C_1 - C_2 of Figure 6-9a. As noted, scaling can be applied to either network of Figure 6-9 for component selection, as long as the same ratios are maintained.

Noise in amplifier U2 is less critical than U1 at low frequencies, but is still not negligible. A low voltage noise device is very valuable to the U1 and U2 positions, as is a relatively low input current noise. If extremely low noise performance is sought, such as for a moving coil preamp, the N1 values can be reduced further, and R3 be lowered for lower noise and additional gain. For example, a 45 dB gain preamp could be realized by just dropping R3 to 56.2 Ω , and using an OP37 for U1.

As mentioned before, a low bias current device is appropriate to U1 using bipolar amplifiers. With a 100 nA or less bias current device, direct coupling to a moving magnet phono cartridge is practical. For example, the 80 nA (maximum) bias current of the OP37 will induce only an additional 80 μ V–160 μ V input voltage offset at U1 for a typical 1 k Ω –2 k Ω cartridge resistance. For lower dc resistance MC cartridges, this will be much less of course. Similarly, the bias current induced offset voltage of U2, from the 10 k Ω dc resistance of R_1 will also be low relative to the amplified offset of U1. As a result, the worst-case overall output dc offset using two AD745s can be held to under 2 V for a 40 dB gain, allowing a single C_3 coupling capacitor for dc blocking purposes.

Frequency response of this passively equalized preamp tends to be better than that of the active versions, because of less interaction with the amplifier(s) as compared to the active preamps. It can approach the inherent accuracy of the network components in the audio range, with potentially greater errors at higher frequencies.

Figure 6-18 illustrates this point, in a simulation of the Figure 6-17 circuit using the OP37 models. The midband error is on the order of ± 0.02 dB with the N1 network composite values. For practical purposes

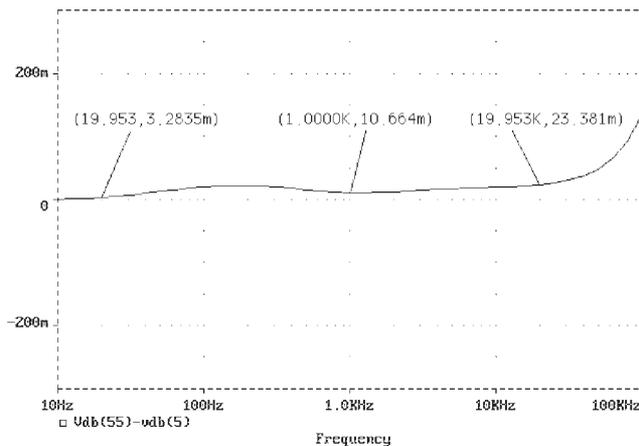


Figure 6-18: Relative error (B) versus frequency for passively equalized RIAA preamp, gain of 40 dB (simulation)

then, the frequency response errors of this circuit will be governed by the tolerances of the network components used within it.

This circuit also can be optionally adapted to servo control of the output offset. This is accomplished by deleting coupling capacitor C_3 , substituting a jumper in its place, and using the noninverting servo integrator U3 around stage U2. This is shown as an option within Figure 6-17. A general-purpose noninverting servo can be used for U3, along with a low-offset op amp, such as the AD820, or the OP97.

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