

A universal NAB to IEC playback equalization converter for reel to reel recorders.

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October 17, 2008

Several people have asked me if it would be possible to make an external circuit to convert a standard reel to reel recorder with NAB equalization to IEC (CCIR) equalization. It is indeed possible to add a simple passive circuit in between the output of the reel to reel recorder and the amplifier that will achieve that goal, albeit with some small compromises.

Before going into the details of this circuit I will go over the difference between NAB and IEC equalization. Equalization standards are vastly different for different tape speeds. I will therefore limit this article to a tape speed of 15ips only, since that is most likely the only speed for which a NAB to IEC conversion would be desirable. IEC equalization at 15ips is better when using modern tape formulas. However for 7.5ips NAB equalization is the better choice in combination with modern tape formulas.

When recording sound on a magnetic tape, the electrical signals that go into the tape recorder are converted into magnetic signals in the recording head that magnetize the magnetic material on the tape. As with all magnetic materials, the tape will have a maximum magnetization level. If that level is exceeded the tape will saturate and the signal will be distorted. That is the reason for the VU meters on your tape recorder. They allow you to maximize the tape magnetization without saturating the tape. Unfortunately, the saturation level of the tape at higher frequencies is lower than at low frequencies. This is true for every tape, but tapes from the 50's and 60's exhibit this problem much more than 'modern' tapes from the 70's and 80's.

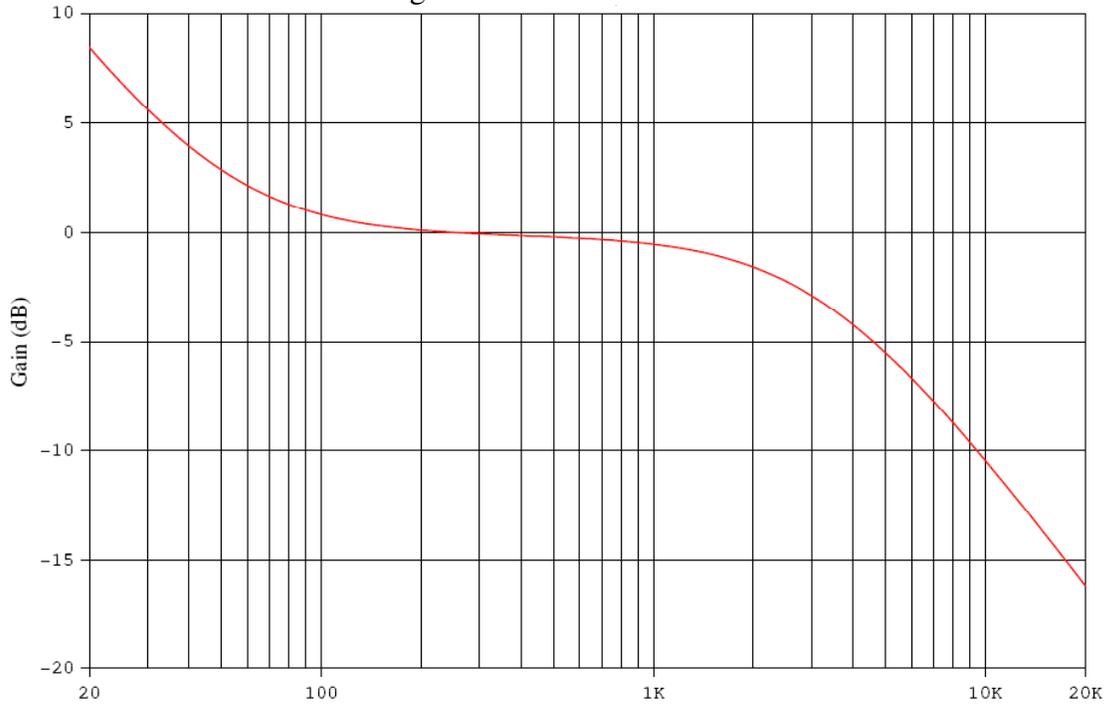
In order to compensate for this saturation problem at higher frequencies, the higher frequencies were recorded at a lower level than the lower frequencies. This would then be compensated on the playback side, so that the frequency characteristic would be flat at the output of the tape recorder.

To avoid that everybody would do their own thing and there would be no compatibility between recorded tapes, standard equalization curves were developed in the 50's and 60's.

Even though there were still many different 'standards' in that time, only two remained as true standard equalization curves in the world.

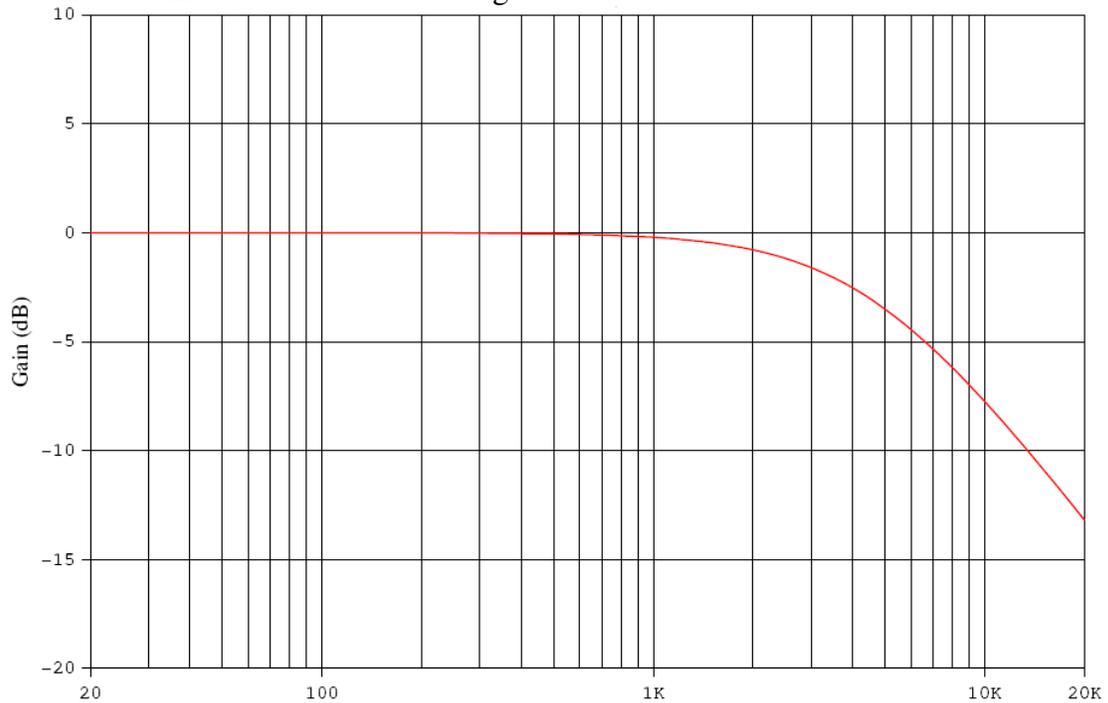
In the 1950's the National Association of Broadcasters (NAB) adopted a standard in which the high frequencies on the recording side were rolled off above 3150Hz. They also decided that the low frequencies needed to be lifted below 50Hz. This measure was a concession to the limitations of the playback electronics from that era.

The NAB curve on the recording side looks like this:



In the 1960's the Comité Consultatif International pour la Radio (CCIR) in Europe developed another standard, later adopted by the International Electrotechnical Commission (IEC). This standard rolled off the high frequencies at 4500Hz and did not change the low frequencies.

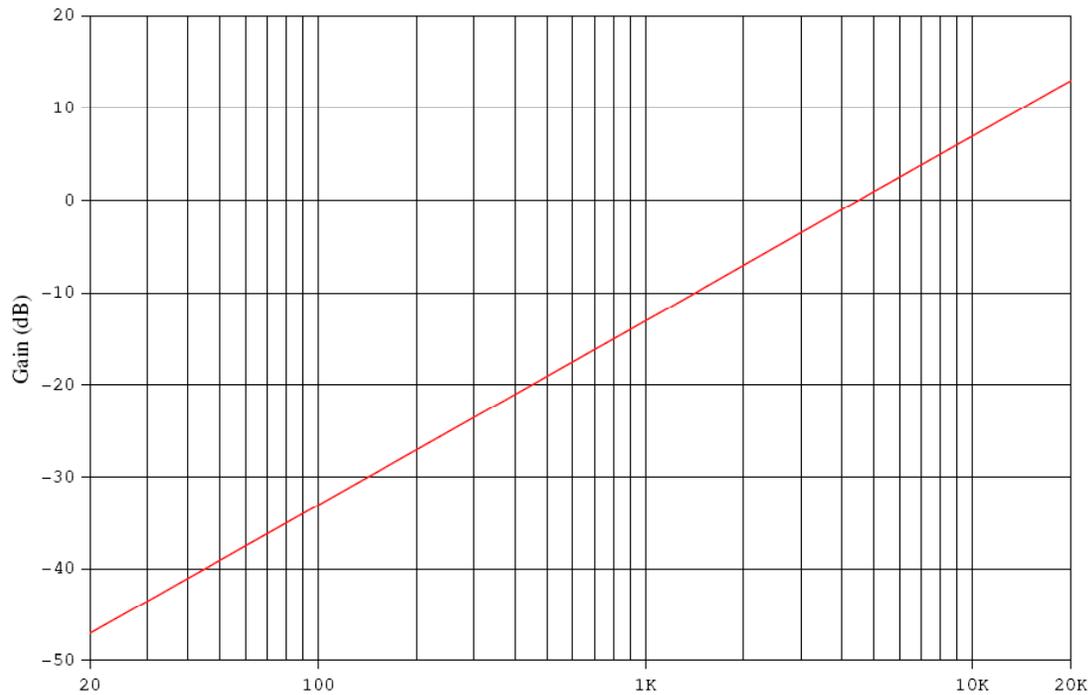
The CCIR / IEC curve on the recording side looks like this:



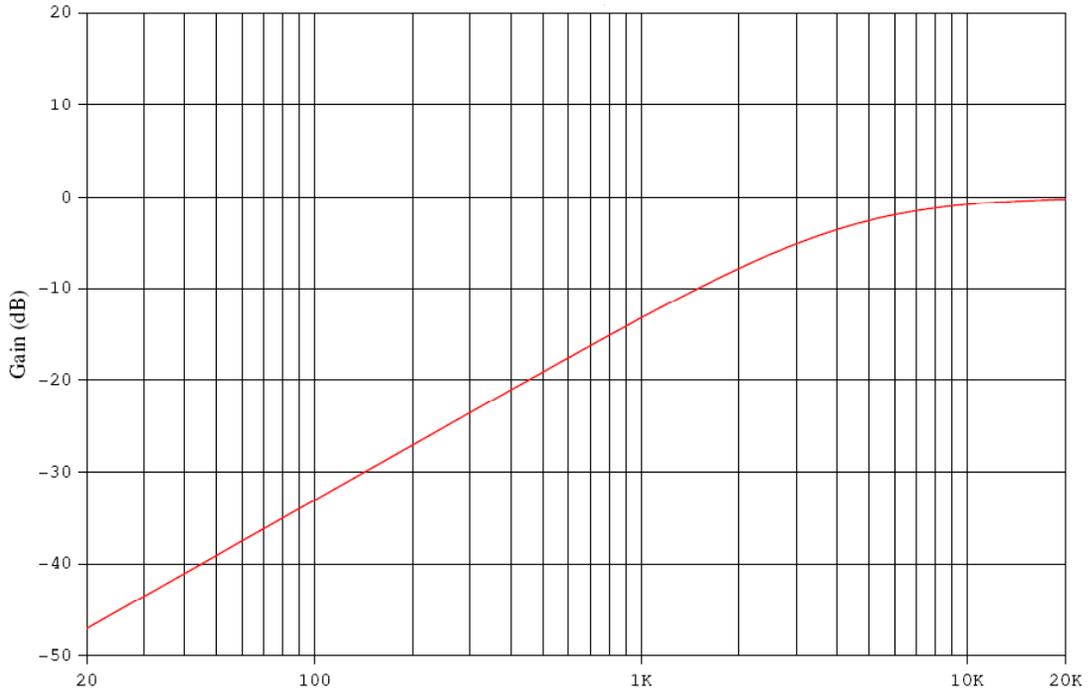
Now we will take a look at the playback side.

If there would not be any equalization on the recording side, the signal from the playback head would not have a flat frequency characteristic. In fact the signal amplitude would increase proportional with the frequency if the playback head would be perfect. The technical explanation for this phenomenon is outside the scope of this article. Furthermore, no playback head is perfect, so the tape recorder manufacturer needs to compensate for the deviations of the playback head.

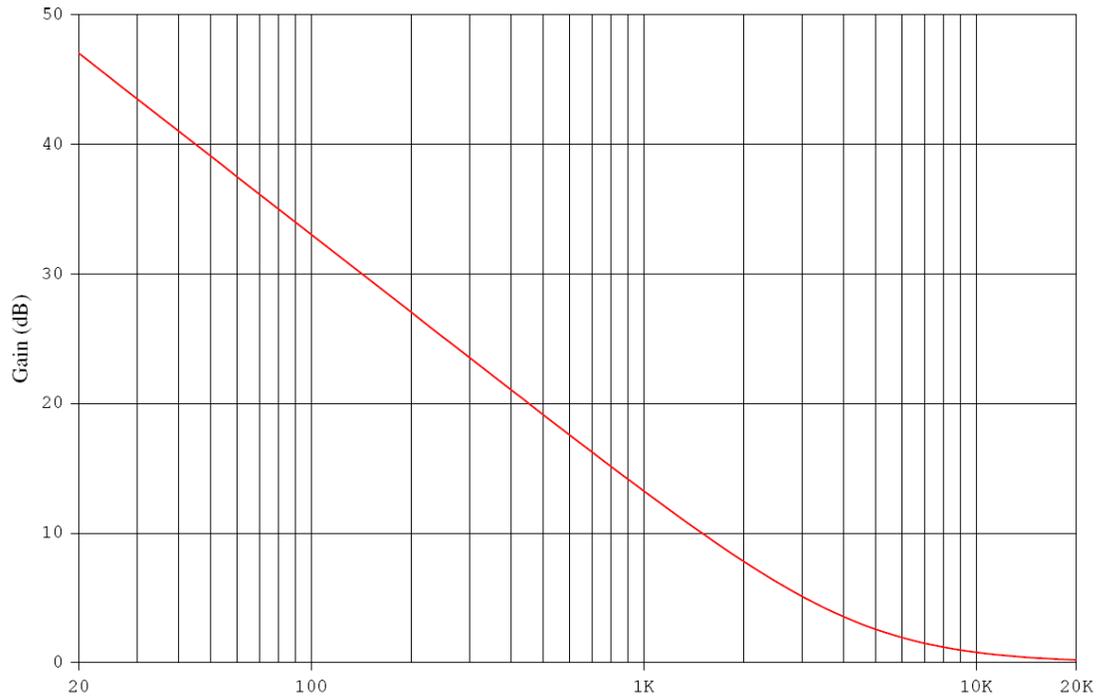
So for a record side without equalization, the playback frequency characteristic of a compensated playback head would look like this:



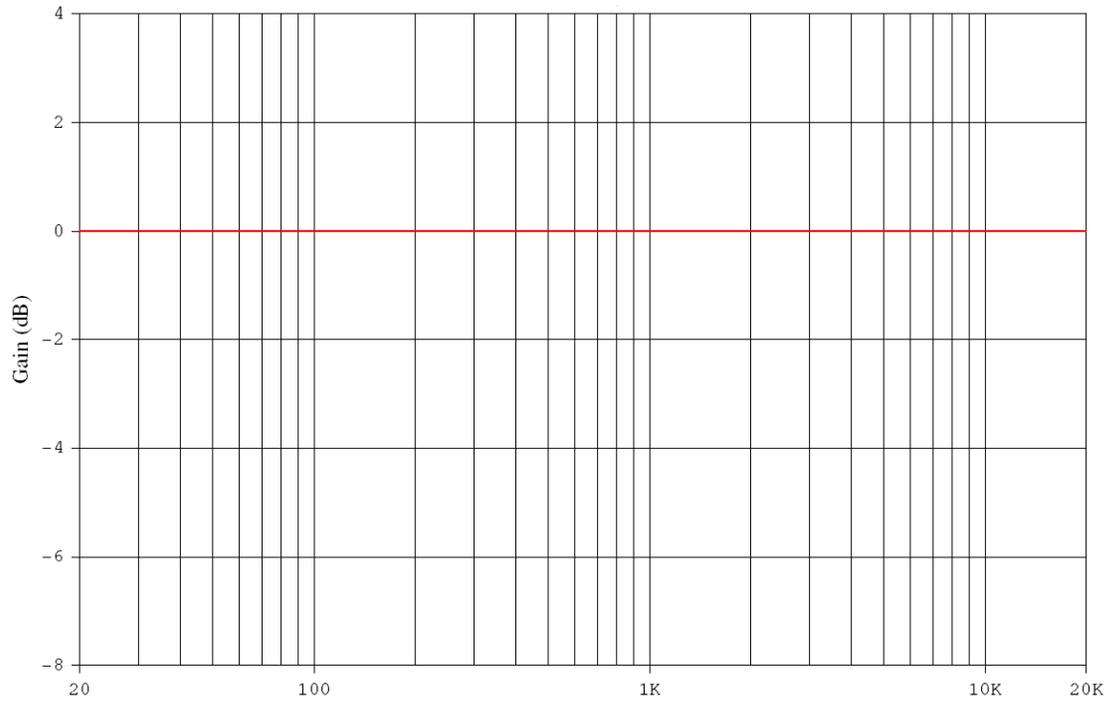
If we add IEC equalization on the recording side, the playback frequency characteristic would look like this:



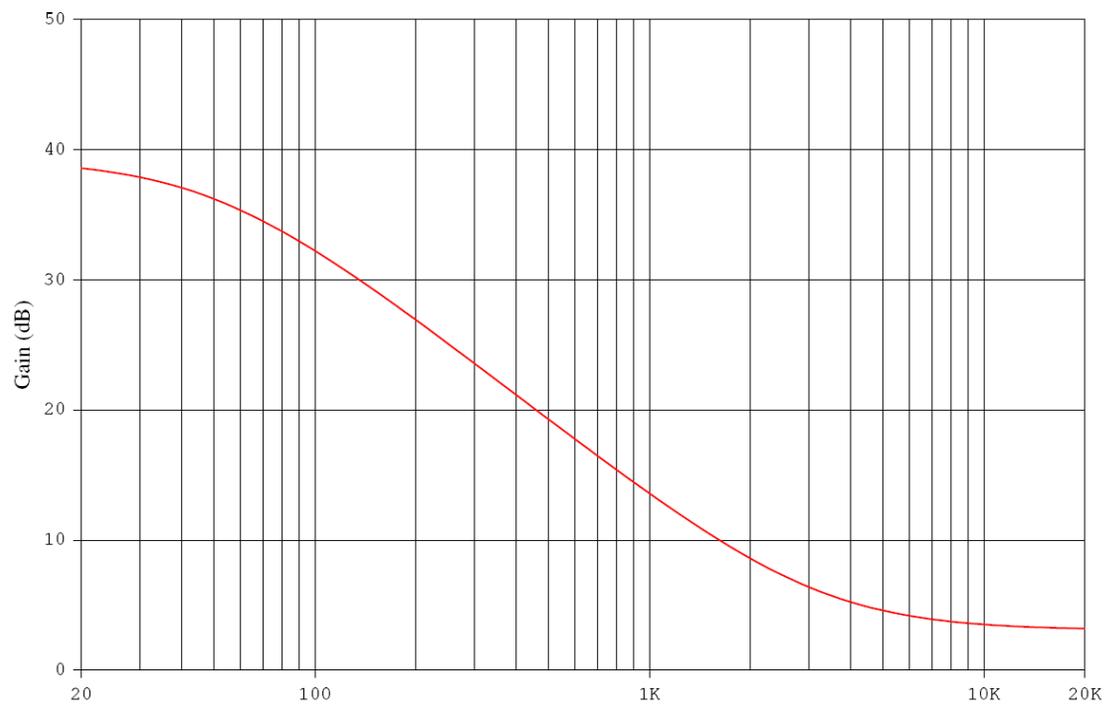
So if we create an inverse frequency characteristic in the playback amplifier like this,



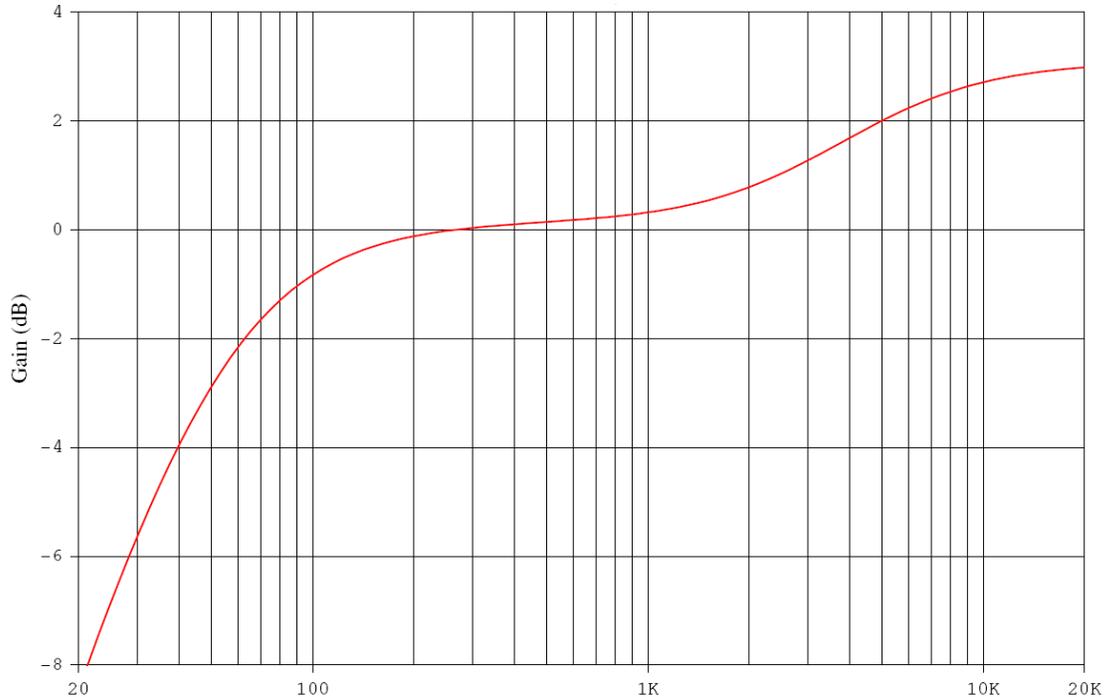
the frequency characteristic on the output of the tape recorder would be flat like this:



Unfortunately, the vast majority of the tape recorders in existence have NAB equalization in the playback amplifier, which looks like this:



If you combine this NAB equalization on the playback side with a tape that is recorded with IEC equalization, you will end up with this frequency characteristic on the output of your tape recorder.



With a lift of 3dB in the higher frequencies the highs will be pretty aggressive and with a roll off of almost 6dB at 30Hz, the bass will be pretty thin.

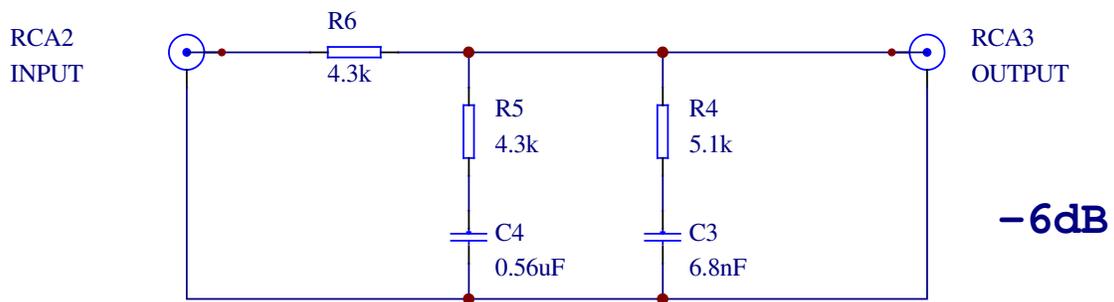
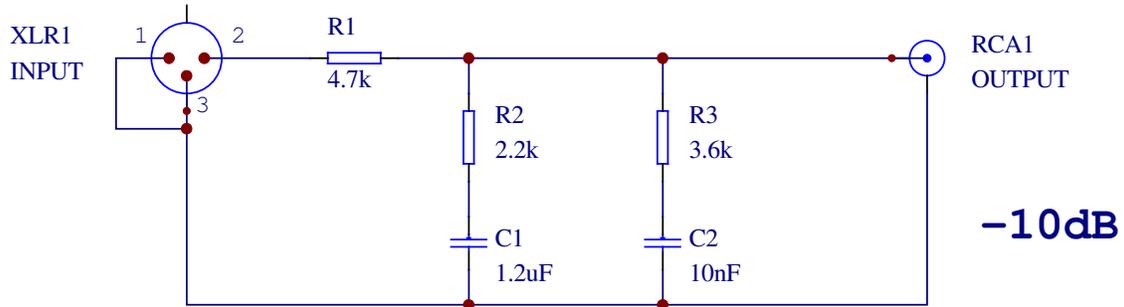
With a simple passive circuit connected between the output of the tape recorder and the input of the amplifier we can straighten the frequency characteristic out quite good. But as always there are no merits without drawbacks, so also here there are some compromises.

- A passive circuit can attenuate signals, but it cannot practically boost the low frequencies. Therefore this correction circuit will come with an overall signal attenuation.
- On the bright side, it is possible to fully compensate for the 3dB high frequency problem, but for the low frequency problem we have to compromise somewhat.

I will describe two versions of the circuit:

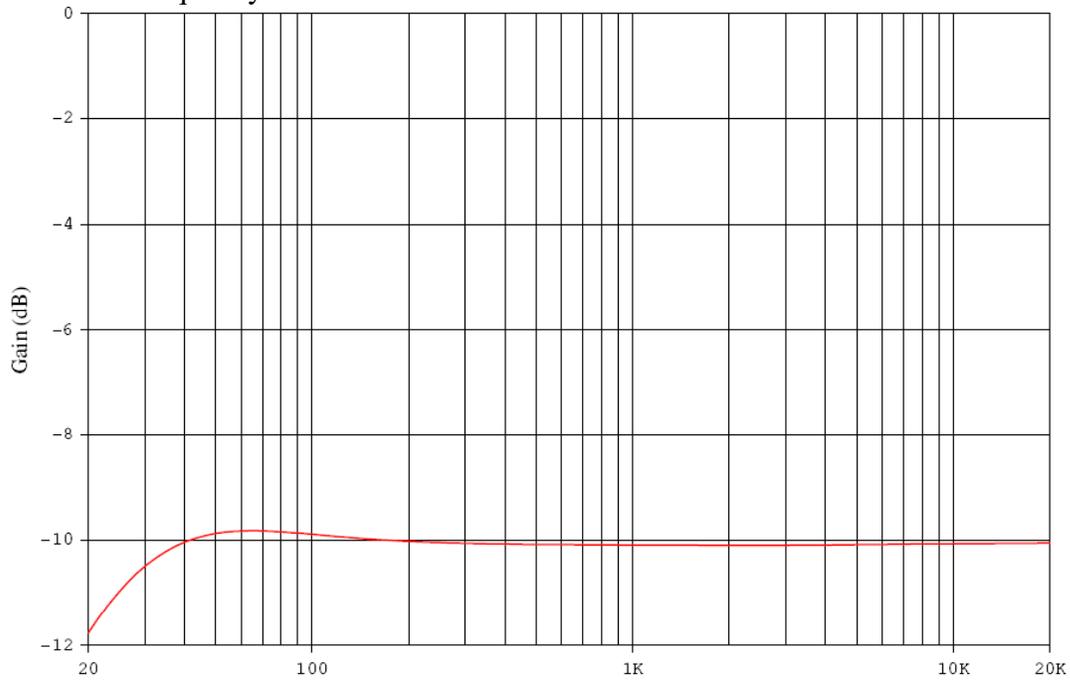
1. A version of the circuit that will attenuate 10dB with very little compromise in the low frequencies.
2. A version of the circuit that will attenuate only 6dB but with a little more compromise in the low frequencies.

The following schematics show both versions of the circuit:



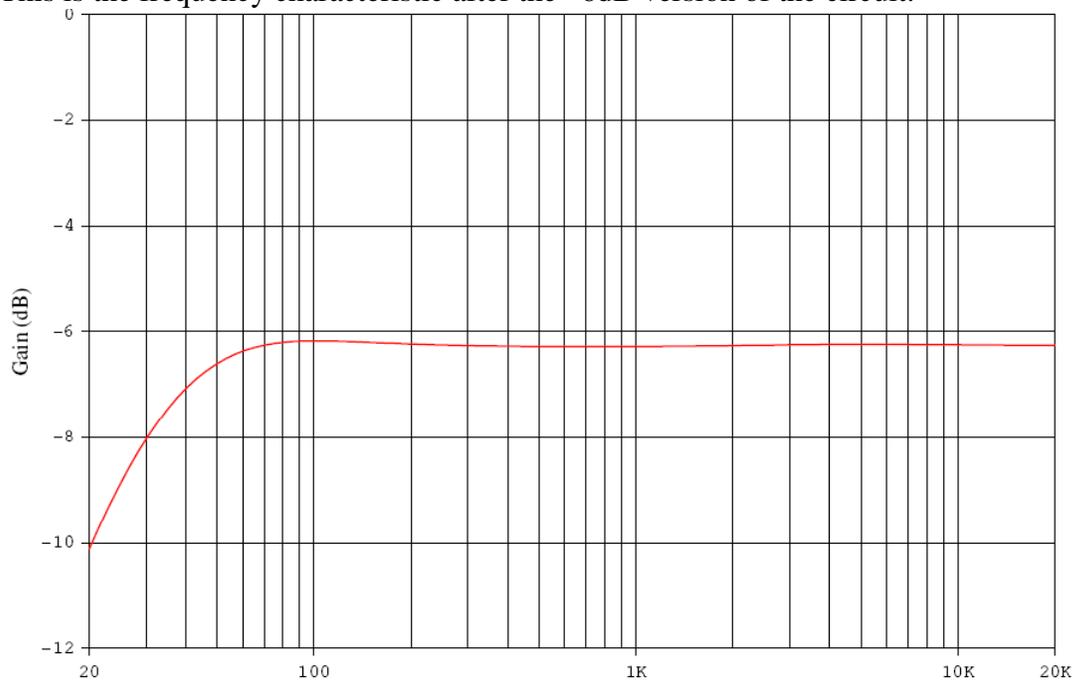
The -10dB version is wired up with an XLR at the input and an RCA at the output, while the -6dB version is wired up with both RCA at the input and the output. Both versions can be wired up for XLR or RCA input similar to these schematic options. The output, however, needs to be connected to an amplifier input with an impedance of $47\text{k}\Omega$ or higher. Most RCA inputs will meet that, but most XLR inputs will not.

This is the frequency characteristic after the -10dB version of the circuit:



The high frequencies are virtually flat. Certainly much flatter than your tape will ever be. At 30Hz the roll off is less than 0.5dB and it is still less than 2dB at 20Hz.

This is the frequency characteristic after the -6dB version of the circuit:



Also here the high frequencies are virtually flat. There is a little more compromise on the low frequency side. At 30Hz the roll off is less than 2dB and at 20Hz it still is less than 4dB.

Some general remarks:

- In all the graphs, the x-axis is the frequency starting at 20Hz and stopping at 20kHz.
- The gain on the y-axis is relative and is not necessarily referenced to any absolute voltage levels.
- As mentioned earlier in this article, these converter circuits are only valid for 15ips tape speed.
- These converter circuits can be used for all NAB tape recorders, provided that the output impedance is lower than 600Ω .
- The input impedance of the amplifier needs to be at least $47k\Omega$.
- All resistors are preferably metal film resistors with a tolerance of 1%. The power rating should be 0.125W or higher.
- All capacitors should be at least film capacitors with a tolerance of 5% or better. Polyester/mylar is significantly better than ceramic. Polypropylene or polystyrene is better than Polyester/mylar. The voltage rating should be 50V or higher.
- Because of the attenuation of the correction circuit, you will have to increase the volume setting of your amplifier.
- XLR outputs normally have a 4dB higher output level so that an XLR output in combination with the -10dB circuit will have roughly the same output level as an RCA output with the -6dB circuit.
- In any case you can choose to use the -10dB circuit or the -6dB circuit with either an XLR output or an RCA output.
- If your tape recorder has both XLR connectors and unbalanced connectors (either RCA or DIN) try to use the unbalanced outputs since they tend to sound quite a bit better. (XLR outputs always add significant additional circuitry in the signal path.)
- For Revox PR99 users, the picture below shows the unbalanced outputs on the monitor connector. These outputs sound better than the XLR outputs.

