



Figure 1: Unusual RIAA correction network. I have numbered the resistors unusually and introduce $R_3 = R_{3A} + R_{3B}$ to keep the equations simple.

Time constants corresponding to the required RIAA correction poles and zero:

$$\tau_{p1} = 3.18 \text{ ms} = 0.00318 \text{ s}$$

$$\tau_z = 318 \mu\text{s} = 0.000318 \text{ s}$$

$$\tau_{p2} = 75 \mu\text{s} = 0.000075 \text{ s}$$

The network has two zeros, so one too many. At $s = -\frac{1}{R_2 C_1}$, the impedance $\frac{1}{s C_1}$ of C_1 cancels R_2 , causing a zero transfer. (The fact that this value of s doesn't correspond to any stationary sine wave doesn't change that.) For similar reasons, there is a zero at $s = -\frac{1}{R_{3B} C_2}$

The two poles of the network are much harder to find. As the poles of the input voltage to input current transfer are the exact same as the poles of the input voltage to anything else transfer, one can analyse the reciprocal of the input impedance to find the poles.

I haven't actually solved the poles, but rather calculated the characteristic polynomial. If I didn't mess up, it is

$$s^2 (R_1 R_3 + R_1 R_2 + R_2 R_3) C_1 C_2 + s (R_1 C_1 + R_1 C_2 + R_2 C_1 + R_3 C_2) + 1 \quad \text{where} \quad R_3 = R_{3A} + R_{3B}$$

To get the correct RIAA correction, the characteristic polynomial must be

$$(s \tau_{p1} + 1)(s \tau_{p2} + 1) = s^2 \tau_{p1} \tau_{p2} + s(\tau_{p1} + \tau_{p2}) + 1$$

To keep the equations simple, I introduce $a = \tau_{p1} \tau_{p2}$ and $b = \tau_{p1} + \tau_{p2}$, so that the desired characteristic polynomial becomes $a s^2 + b s + 1$

As there is one zero too many, there are two ways to solve this: either make R_2 or R_{3B} equal to zero.

When we choose to make $R_2 = 0$, equating the coefficients of the characteristic polynomial to there desired values and rearranging terms leads to

$$R_3 = \frac{b \pm \sqrt{b^2 - 4a \frac{C_1 + C_2}{C_1}}}{2C_2}$$

$$R_1 = \frac{a}{R_3 C_1 C_2}$$

$$R_{3B} = \frac{\tau_z}{C_2}$$

$$R_{3A} = R_3 - R_{3B}$$

if I didn't make any mistakes other than the ones I already found and corrected.

When we choose to make $R_{3B} = 0$, I find these equations for the rest:

$$R_2 = \frac{\tau_z}{C_1}$$

$$R_1 = \frac{\frac{b - 2\tau_z}{C_2} \pm \sqrt{\left(\frac{b - 2\tau_z}{C_2}\right)^2 - 4\left(1 + \frac{C_1}{C_2}\right) \frac{a + \tau_z(\tau_z - b)}{C_1 C_2}}}{2\left(1 + \frac{C_1}{C_2}\right)}$$

$$R_3 = \frac{b - \tau_z - R_1(C_1 + C_2)}{C_2}, \text{ which is also the value for } R_{3A} \text{ when } R_{3B} = 0.$$

Again if I didn't make any mistakes...

The trick is to choose values for C_1 and C_2 that lead to realistic values for the resistors. There may be a bit more freedom to use standard capacitor values than with a more conventional RIAA correction network.