

FIGURE A5.1 Normalized RIAA Gain

A5.3 Cartridge Impedance

The simplified lumped model of a phono cartridge consists of a series inductance and resistance shunted by a small capacitor. Each cartridge has a recommended load consisting of a specified shunt resistance and capacitor. A model for the cartridge and preamp input network is shown in Figure A5.2.

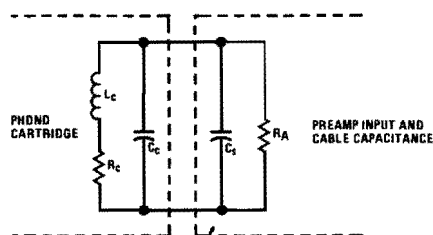
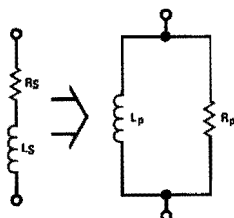


FIGURE A5.2 Phono Cartridge and Preamp Input Network

This seemingly simple circuit is quite formidable to analyze and needs further simplification. Through the use of Q equations,² a series L-R is transformed to a parallel L-R.

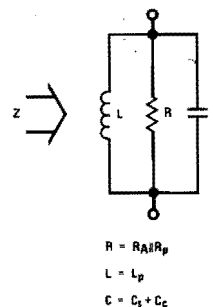


$$Q = \frac{\omega L_S}{R_S}$$

$$R_P = R_S(1 + Q^2)$$

$$L_P = L_S \left(\frac{1 + Q^2}{Q^2} \right)$$
(A5.3.1)

Simplifying the input network,



The impedance relations for this network are:

$$\text{Re}(Z) = \frac{R X_L^2 X_C^2}{(R X_L - R X_C)^2 + X_L^2 X_C^2}$$

$$|Z| = \frac{R X_L X_C}{[(R X_L - R X_C)^2 + X_L^2 X_C^2]^{1/2}}$$
(A5.3.2)

A5.4 Example

Calculations of the RIAA equalized phono input noise are done using Equations (A5.2.1)-(A5.3.2). Center frequencies and frequency bands must be chosen: values of R_p , L_p , $\text{Re}(Z)$, $|Z|$ and noise calculated for each band, then summed for the total noise. Octave bandwidths starting at 25 Hz will be adequate for approximating the noise.

An ADC27 phono cartridge is used in this example, loaded with $C = 250 \text{ pF}$ and $R_A = 47 \text{ k}\Omega$, as specified by the manufacturer, with cartridge constants of $R_s = 1.13 \text{ k}\Omega$ and $L_s = 0.75 \text{ H}$. (C_c may be neglected.) Table A5.1 shows a summary of the calculations required for this example.

A5.5 Conclusions

The RIAA equalized noise of the ADC27 phono cartridge and preamp input network was $0.75 \mu\text{V}$ for the audio band. This is the limit for S/N ratios if the preamp was noiseless, but zero noise amplifiers do not exist. If the preamp noise voltage was $0.64 \mu\text{V}$ then the actual noise of the system is $0.99 \mu\text{V}$ ($[0.64^2 + 0.75^2]^{1/2} \mu\text{V}$) or 66 dB S/N ratio (re 2 mV @ 1 kHz input). This is a 4 dB loss and the preamp current noise will degrade this even more.