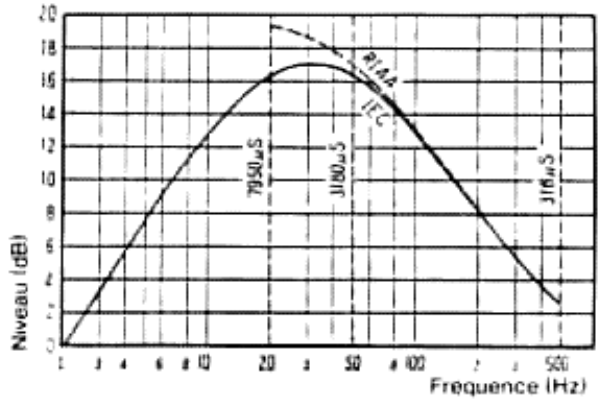
Inductive RIAA deemphasis Networks

A noticeable worldwide interest in the using of Inductive RIAA networks has always driven the tentatives for the improving the sound quality of phono preamplifers:Vinyl is back but many audiophiles think that its sound quality is still unsurpassed.

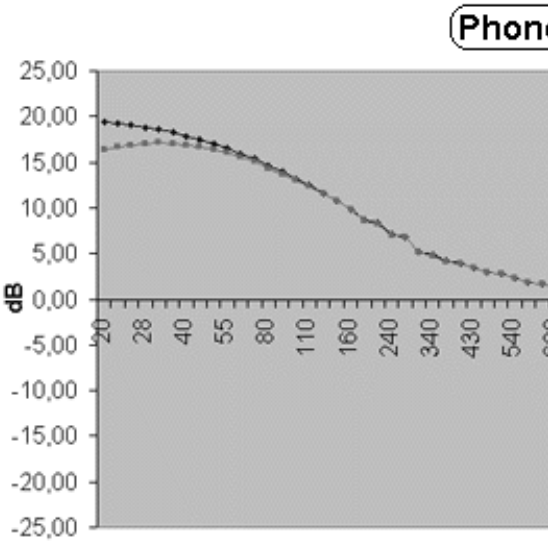


R I A A

$$N = 10\log_{10}(1+4\pi^2 f^2 t_1^2) - 10\log_{10}\left(1+\frac{1}{4\pi^2 f^2 t_2^2}\right) + 10\log_{10}\left(1+\frac{1}{4\pi^2 f^2 t_3^2}\right)[\mathrm{dB}]$$

I E C

$$N = 10\log_{10}\left(1+\frac{1}{4\pi^2 f^2 t_2^2}\right) - 10\log_{10}(1+4\pi^2 f^2 t_1^2) - 10\log_{10}\left(1+\frac{1}{4\pi^2 f^2 t_3^2}\right) - 10\log_{10}\left(1+\frac{1}{4\pi^2 f^2 t_4^2}\right)[\mathrm{dB}]$$



Excel Sheet	

Fig1 RIAA vs. IEC

The RIAA emphasis, a process necessary to reduce the amplitude of lower frequency and exaltate the higher ones for mechanical reasons (primary to efficiently write audio information on vinyl surface), was historically obtained by a passive RLC network, Fig. 1, or by amplifiers with RIAA network on the feedback loop.

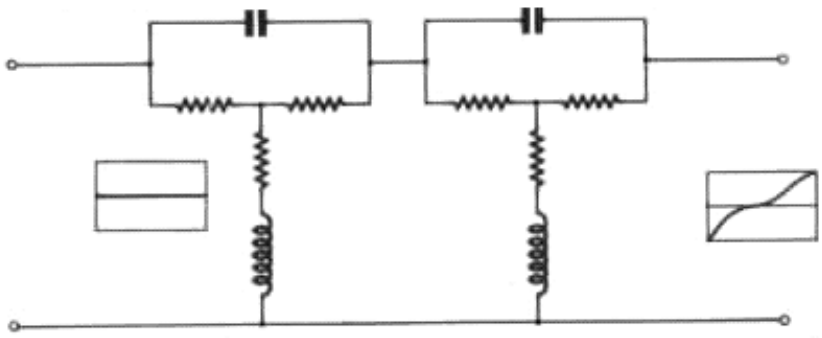


Fig.2 Passive RIAA Emphasis

Clearly the corresponding RIAA deemphasis can be obtained at the best (i.e. with the maximum accuracy) only by a similar dual network.

The **Transfer Function** in the *s*-domain of the RIAA deemphasis is:

$$G(s)=\frac{(1+\tau_1 s)}{(1+\tau_2 s)(1+\tau_3 s)} \qquad \text{eq. (1)}$$

where:

$$\begin{aligned} s &= j\omega \\ \tau_1 &= 318\cdot 1e\text{-}6 \\ \tau_2 &= 3.18\cdot 1e\text{-}3 \\ \tau_3 &= 75\cdot 1e\text{-}6 \end{aligned} \qquad \text{eq. (2)}$$

are the complex variable and time costants involved in the process respectively.

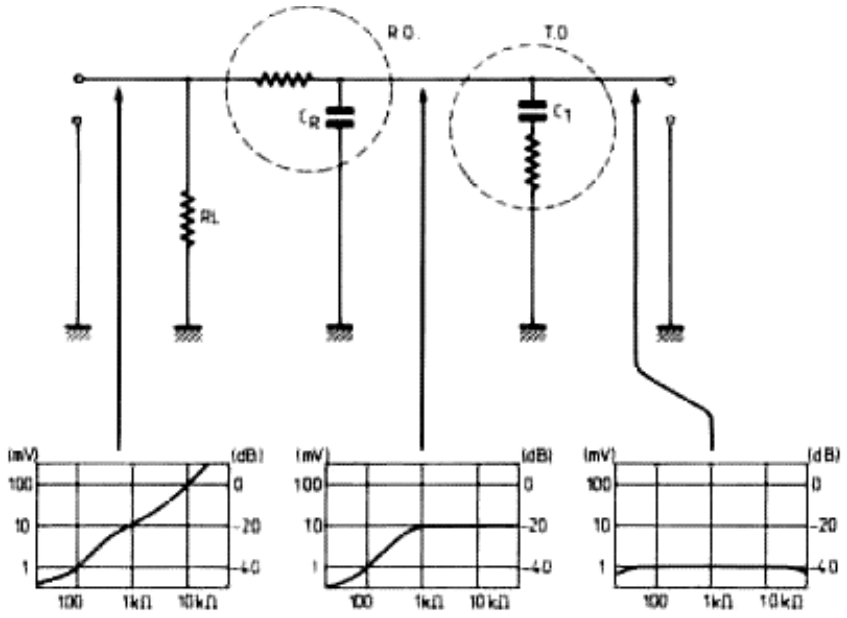


Fig.3 RC RIAA Deemphasis

In a theoretical way, any transfer function can be synthesized by an any complex RLC network (passive solution) or by an active RC network (where this network is placed in the feedback loop of an operational, or similar, amplifier). Further if the transfer function presents a gain (i.e. a value greater then 1 in the transfer function for $s \rightarrow 0$) the synthesis problem is solved only by the active network. Fortunately RIIA deemphasis transfer function do not presents a gain and the intrinsic mathematical complexity of eq. (1) is very low.

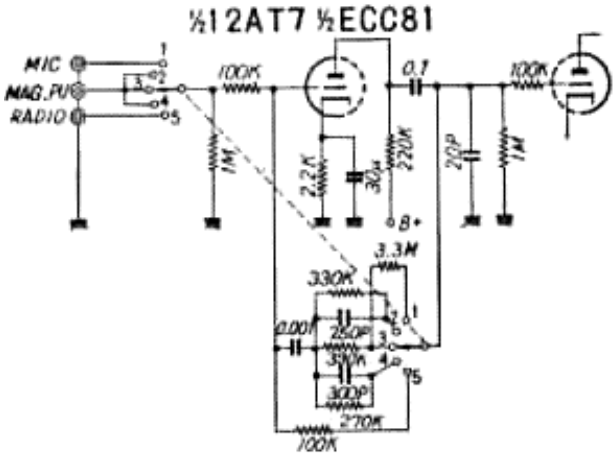


Fig. 4 Active RIAA Deemphasis

Audiophile community seems to refuse the *active* solution since the RC network is placed around a feedback loop (no matter if the active device is a vacuum tube or a solid state amplifier) and for good reasons, since there is an historical, anecdotal and technical evidence that feedback amplifiers alter sound quality: for this reason the only acceptable way to build a good phono preamp is by the use of a passive stage (split or not around gain stages). For economic reasons passive RIAA deemphasis networks are rarely in the form of a RLC quadripole (the only way to obtain the

maximum accuracy) but appear in the lighter (and less accurate) aspect of a RC nertwork.

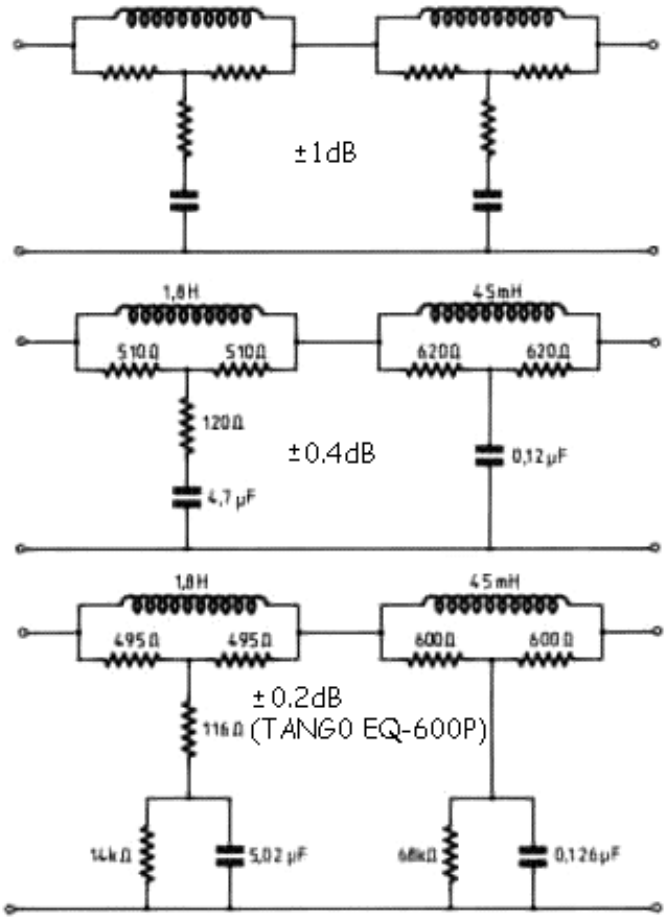


Fig.5 RLC Deemphasis Networks

A very simple topological transformation (in the s domain) demonstrates that electrical charecteristics of a RC network can be tranferred into a RL network derivated with the multiplication of the original network elements by the s variable. Starting from a RC network this transformation changes resistor into inductors and capacitors into resistors. Further and for practical reasons a scaling operation (multiplication or division by a costant) it's required to make values of the obtained elements (primarly the inductors) reasonable. Obviously we can realize also the inverse transformation from a RL network to a RC one.

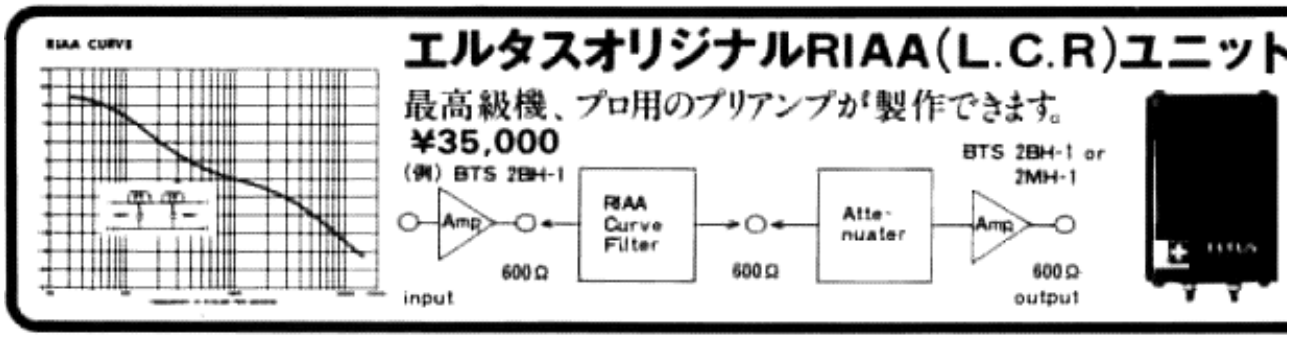


Fig. 6 TANGO EQ-600P Specs

Fig. 7 The TANGO EQ-600P LCR Unit

Unfortunately a passive RL network used in the RIAA deemphasis presents a lot of problems. First we must introduce a DC block for the ground path: a large capacitors (in the region of tens microfarad) is often used: this reports the situation to a RLC network but without the accuracy that a perfectly (and *ad hoc)* conceived one can. Further the amplifier stages around a RL RIIA network must be direct coupled othervise other capacitors are necessary. Best way to solve this dilemma is to use a **TLR (Transformer+LR)** network. In this manner with the use of an additive element (the transformer) we can solve both problems. This solution is clearly expensive but probably is the best although, and again, we'll not have the accuracy of a specifically conceived LRC network. The mutual interactions between the output impedance of the active driving stage in union with the reactive/inductive elements of the transformer (parasitics and not) and values of the LR portion of RIAA network (parasitics and not) must be take in count with a deep analysis in order to avoid a further loss of accuracy. This solution is clearly device dependendant since a given tube or transistor require and *ad-hoc* designed transformer and subsequently a specified set of value for the LR portion.

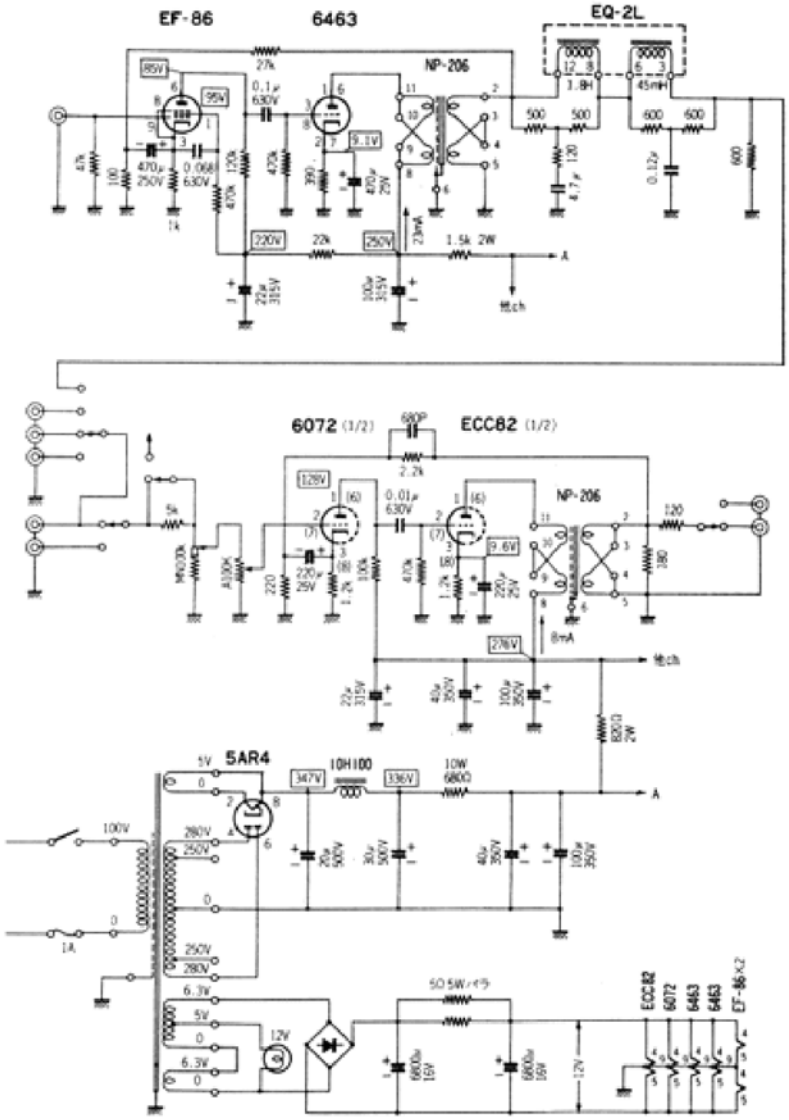


Fig. 8 Japanese Phono with Inductive RIAA *(from Radio Gijutsu, M. Yoshio Nasu, 1984)*

PAEng can design (under request) the best TLR network for a given device and for a given phono preamp configuration. The accuracy of the released network can be greather than ± 0.2dB. Evaluations, as usual, are made by strongest recourse to Spice simulations and prototyping. TLR networks already designed, are summarized in the Table 1.

Device	Air-Gapped TLR Network	UnGapped TLR Network
6C45-PE	Yes	No
6DJ8/ECC88/E88CC/E188CC	Yes	Yes
5842/417A	Yes	No
6H30	Yes	Yes
CV5112/3A167M/437A	Yes	No

6SL7	No	Yes
FETs	Under Request	No
Other Tubes	Under Request	Under Request

Table 1. Designed TLR Network

An omnibus LR RIAA network has been recently designed in order to remove the dependance of the chosen active device and an unique coupling has eliminate the use of transformers. Ther solution is cheap, very good sounding and the obtained RIAA accuracy can reach the ±0.1dBs.

Go to the corresponding Section.

References:

Gobind Daryanani	*Principles of Active Network Synthesis and Design*	John Wiley&Sons, NY 1976
Jean Hiraga	*Etage phono à correction passive LCR*	L'Audiophile, n°39, Automne 1986

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