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## **Impedance Loading for Moving Coil Phono Cartridges:**

There are 2 types of impedance to be concerned about with Moving coil Cartridges: Internal Impedance and Loaded Impedance.

Cartridge Manufacturers are not consistent with how they specify loading with Step-up transformers. Since step-up transformer specifications are inconsistent stated from different step-up transformer manufacturers, it is best to ignore the recommended step-up transformer from a cartridge manufacturer.

There is a lot of confusion about how the loading is specified. Some cartridge manufacturers try to take the guess work out of it and put in some kind of multiplier, while others base their loading assuming a head amplifier will be used to boost the signal. For example, Koetsu recommends anything between 5 and 100k. Other manufacturers just specify a minimum, like >100 Ohms. The problem is that we don't really know whether the manufacturer has provided loading information based on the internal impedance or the loaded impedance of the cartridge, or considered whether we would be using a SUT or head amp. We do know from considerable testing, that you don't want to load a MC cartridge using a SUT to match the internal impedance, or you will "choke-out" the cartridge and it will sound muddy.

Step-up transformers boost the voltage by converting current to voltage. There is a secondary effect of changing the loading on a phono cartridge. The loading on a cartridge, also called the reflected impedance equals the load of the phono stage (usually 47,000 ohms) divided by the square of the turns ratio of the SUT (or the usually published step up ratio).

So, for example, if a transformer has a step-up ratio of 1:10, the reflected impedance back to the cartridge would be the impedance of the phono stage, typically 47,000 ohms (using the RIAA standard for a standard MM phono input), divided by the internal impedance of the transformer. For this example, you take  $47,000 / (10 \times 10) = 470$  ohms impedance at the cartridge.

The loading, or reflected impedance, on a cartridge should normally be about 10-times the internal impedance of the cartridge. That is not a hard number, 8-times could be fine, and sometimes 4-times can sound great. Usually more headroom (higher impedance) is better. This load can also depend on the characteristics of the phono stage. Typically if you have enough headroom, the natural characteristics of the cartridge will be apparent. But if you have a "bright" sounding

cartridge, you may want to lower the impedance at the cartridge, but if the impedance is too low, it may sound muddy and flat.

I do not recommend adding resistors to lower headroom.

The situations where one would expect that adding resistors would be effective is where the internal impedance is low and the output voltage is high for a MC cartridge. For example some Koetsu cartridges have an output of .4mv with an internal impedance of 5 ohms. Using a 1:20 step up transformer, the load would be 118 ohms. That is 24 times the internal impedance. I experimented with adding resistors to bring the headroom down to 10 times the internal impedance. My personal experience is that the cartridge sounded better without the additional loading resistor.

A cartridge manufacturer will typically specify the internal impedance and the output voltage of a cartridge, but can be wrong with telling you what loading impedance is required. To test that, I used several of my transformers with different cartridges and instead of hard wiring resistors to the input or output of the transformer, I built a set of resistor tees (2 female to 1 male) and inserted them on the inputs and/or outputs of the transformers. I then wired several resistors onto male plugs and inserted them into the tee on the output to try different resistances. Starting with high output values and changing them to lower and lower values, I found that there was a very slight improvement as the resistance came down until there was a major change for the worse when it reached a certain point. This point usually turned out to be between 4 and 12 times the output of the cartridges I tested but again it was cartridge and internal impedance dependent. After having “tuned” the loading to the ideal setting for the cartridge, I removed the resistors all together, and did not notice a difference with or without additional loading resistors. Since it is not a good idea to add anything into a circuit unless it improves it, I do not recommend adding loading resistors. When insisted by a customer to add lugs on the outputs where you can attach resistors as an after-market thing, they introduced some noise, so I do not recommend it.

The output of a step-up transformer is the most critical part of the circuit and you must be very careful with wiring between there and the phono preamp to eliminate noise.