



Superior Magnetics Since 1979

AN-104 OUTPUT TRANSFORMER LAMINATION SELECTION

Output transformer core material selection is very important. Usually, it involves weighing cost versus distortion. The manufactured product is a balance between cost of goods and overall performance. Quality output transformers often are among the most expensive components in a design so care at the outset can mean the difference between a commercially successful project and a failure.

High Nickel (referred to in our data sheets as "HiNi") cores are composed of an alloy which is approximately 80% nickel. This core gives the best overall distortion. Nickel is very expensive, which is reflected in the price of the finished transformer. For this analysis, a CMOQ-1 was set up for a 600 Ohm source and load (primary windings in series and secondary windings in series).

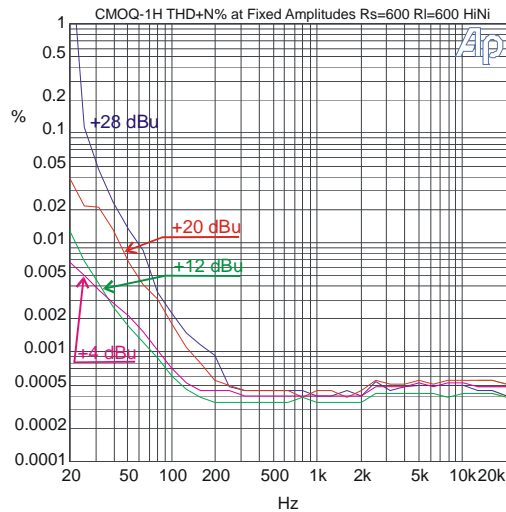


Figure 1

Often, people ask for steel. Steel is cheap. Its overall performance is not very good, though, when considering Total Harmonic Distortion (THD+N%):

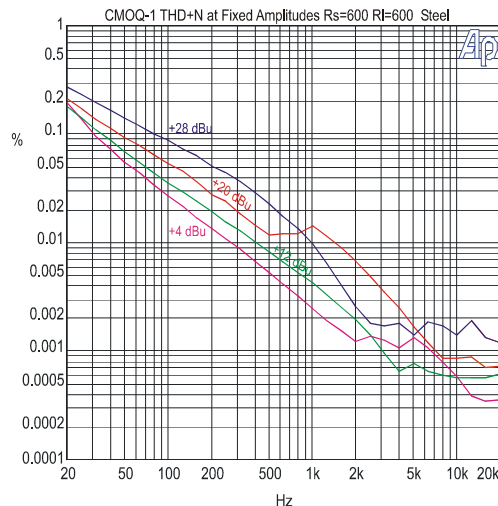


Figure 2

Many manufacturers of professional grade output transformers opt for “low nickel” cores. Low nickel material typically is an alloy containing 49% nickel. Low nickel is better than steel, but THD+N% performance remains poor.

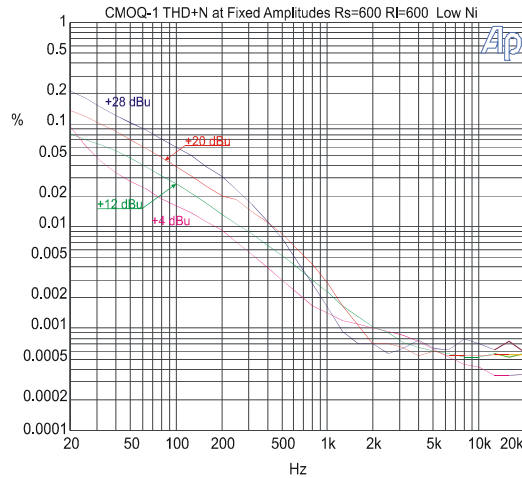


Figure 3

The other option which has been investigated and developed at CineMag is our “50%Ni 50%Steel” approach. The following chart shows typical characteristics:

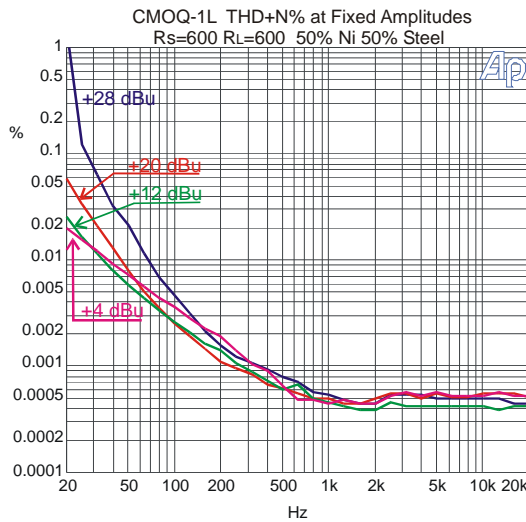


Figure 4

The distortion is definitely higher than what is obtained with “HiNi” cores. However, it often is very acceptable and meets the engineering criteria. NOTE: The distortion products tend to bunch together independent of level. At 1 kHz, THD+N% clusters around 0.0005% and is not an important sonic problem. At 1/4 that frequency (near Middle C) it centers around 0.025% and becomes discernable. By 100 Hz distortion centers around 0.01%. Because of the nature of the harmonic distribution of distortion products at low frequencies, there is a discernable “fatter” or “warmer” sound which many of our customers desire in their designs. The trade-off is between having very low distortion with what is often termed a “solid state direct coupled sound,” and a subtle but discernable “fattening” effect.

THD+N% in 50%Ni 50% Steel core transformers can be improved significantly with a sense winding to provide feedback. (See AN-102.) Using the CMOQ-1L with the feedback method set forth in this Application Note, THD+N% is reduced dramatically:

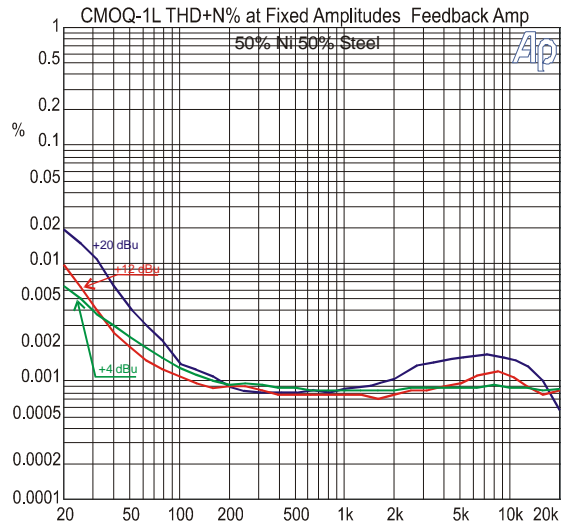


Figure 5

CineMag does not make transformers with Low Nickel cores. It does not perform adequately. CineMag does not use steel unless specially ordered or where a carefully engineered tertiary sense winding is employed, such as the CM-9600 tube output transformer. Without feedback from a sense winding, steel is not a quality option.

The choice of core material type for output transformers is a balance between i) cost of implementation, ii) the acceptable distortion level, and iii) whether some coloration is actually desirable such as with 50%Ni 50% Steel core. Pay close attention to detailed data which your transformer vendor should be able to provide you. Without this data, you are only guessing at how your design will really behave when it is manufactured.