Iso-Bass: A Subwoofer Isolation Transformer

We recently purchased a wide screen LCD television, which provides three high-definition inputs for the HD cable DVR and NAD L53 DVD/CD stereo receiver, and four more composite inputs for the VCR and other legacy equipment. Once I had all the equipment hooked up and calibrated the video with the *Avia Guide to Home Theater* DVD, I heard a slight hum when the VCR input was selected. It wasn't audible from my viewing position or when a tape was playing, so I let it be.

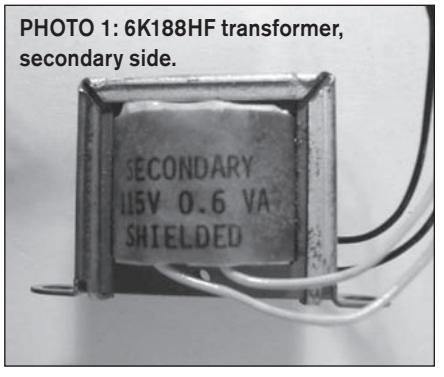


PHOTO 1: 6K188HF transformer, secondary side.


PHOTO 2: Iso-Bass exterior view.

However, when I connected the NAD subwoofer line output to the subwoofer amplifier, the hum was very loud, with a pronounced 120Hz buzz. The subwoofer and TV use three-prong plugs, while the L53, VCR, and cable DVR use two-prong polarized plugs. All the equipment is plugged into the same Belkin surge-protected outlet strip. I tried disconnecting the VCR I/O plugs, with no change in the hum.

Even with the HD component video and digital audio links between the L53 and the TV disconnected, the loud hum was still there. I removed all the equipment interconnects and measured the voltages between all combinations of the equipment chassis and the input/output jack shells. There were only mV present in all cases.

TRANSFORMER SOLUTION

I was stumped and out of tricks to remove the hum. I was not about to circumvent the two three-prong AC plugs with a cheater adapter—this is a potentially dangerous practice. I wished I still had the Jensen Iso-Max I tested for the October 2006 issue of *audioXpress*[1,2,3].

The Iso-Max is a wideband stereo line-level shielded isolation transformer unit. I didn't really need wideband because the mono NAD subwoofer output is rolled off at 100Hz[4]. Perhaps a small 60Hz power transformer would do the trick. The Iso-Max has a winding resistance of 2k26 at the input and 1k90 on the output. Its input impedance at 1kHz is about 47k.

I dug into my collection of small power transformers and measured the DC resistance of all the windings. Because this was a low-frequency application, I wanted a high DC winding resistance to keep from loading down the low-frequency NAD subwoofer output signal. The best match was a small 115:115V 0.6VA AC line isolation transformer.

I bought a few of these transformers from Fair Radio quite a few years ago (see Sources). The part designation on the transformer primary was "6K188HF" and the secondary side **(Photo 1)** said it was shielded (probably an electrostatic or Faraday shield connected to the frame). I couldn't find anything on the Internet when I typed in the part designation. The open-circuit secondary voltage was 140V RMS with 115V on the primary.

At this point I did not know whether the low-level subwoofer signal was sufficient to provide the excitation needed to couple the signal to the secondary winding. Also, the secondary winding is placed directly over the primary, which is the way a power transformer is customarily designed. This provides the best magnetic flux coupling between windings, but it is also the worst case for inter-winding capacitance.

I measured the capacitance between the two windings at 46pF, compared to about 120pF for the Iso-Max. I was surprised to find it that low, but the total capacitance of each winding would certainly be larger because of the high number of turns required for the high voltage windings on this small transformer core.

The next step was to connect the "6K188HF" between the L53 and the subwoofer amp. Voila! The hum and buzz was gone, and the subwoofer bass sounded quite good. I stuffed the transformer into a small enclosure with the input and output phono jacks isolated from the metal chassis. The schematic of the enclosed transformer is shown in **Fig. 1A**.

ALTERNATIVES

But what if any readers want to duplicate my subwoofer isolation method? Both Digi-Key and Mouser carry 115:115V isolation transformers, although the smallest listed (Mouser) is the 15VA Triad N48X. The winding resistance will be lower than that of the 6K188HF.

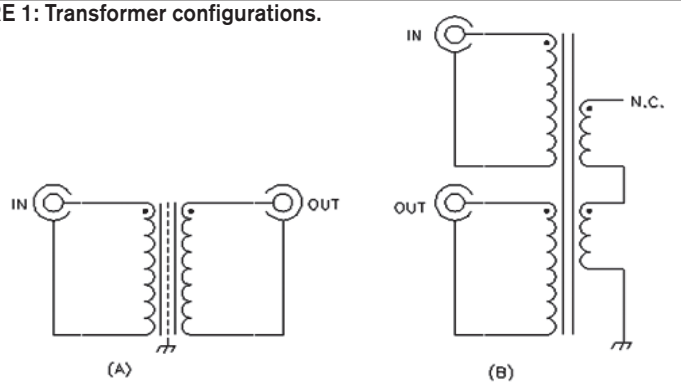
Another option might be an interstage transformer designed for tube amplifier use. There are also split bobbin transformers available with two 115V primaries and two lower voltage secondary windings. These are designed to provide the flexibility to connect the primaries in series for 230V operation or in parallel for 115V operation. You can connect the secondaries in parallel or series for various output voltage/current options.

You may be able to use the two primaries for the subwoofer isolation function, and connect the secondaries in series to ground to provide some inter-winding shielding. The connection schematic is shown in **Fig. 1B**. While you may get some electrostatic shielding by this method, the transformer core may still pick up electromagnetic fields, especially if you place it near the power transformer of any other piece of equipment. A steel chassis box can help alleviate this problem, but distance is your best choice.

MEASUREMENTS

For my own amazement, I made some additional measurements on the 6K188HF transformer. At 20Hz the

FIGURE 1: Transformer configurations.



input impedance is 2k04, which is sufficiently high that it wouldn't terribly load the L53 subwoofer signal, whose output impedance I measured to be 110Ω. The subwoofer amplifier input impedance is 47k, while the transformer 20Hz output impedance is 1k33. I decided to call the packaged 6K188HF transformer the "Iso-Bass," after the Jensen Iso-Max[5]. **Photo 2** shows the transformer in its enclosure as viewed from the input side.

Figure 2 shows the frequency and phase response of the Iso-Bass with a 0.5V RMS test signal (the sine wave oscillator in my distortion test set has a 600Ω output impedance). It is reasonably flat up to 1kHz, but above that it looks as though the winding and inter-winding capacitances interact with the winding inductance to produce a 13.3kHz resonant peak that is 7.4dBv above the 60Hz 0dBv level. The secondary load resistance here is 47k.

The HF response is pretty bad compared to the Iso-Max, but it is sufficiently flat for the NAD subwoofer output, which is rolled off above 100Hz (see dashed line for response). This also illustrates why vacuum tube output transformer designers carefully arrange the windings so the resonant frequency is well above the audio band. The phase shift in a mediocre transformer could produce oscillation in a wide-band feedback amplifier.

Figure 3 shows the THD+N versus frequency with a 0.5V RMS input signal. The low point coincides with the peak of the probable resonance frequency in **Fig. 2**, which would produce the maximum impedance.

Now look at the THD+N versus input signal level, shown in **Fig. 4** at 20Hz and 125Hz. As you would expect,

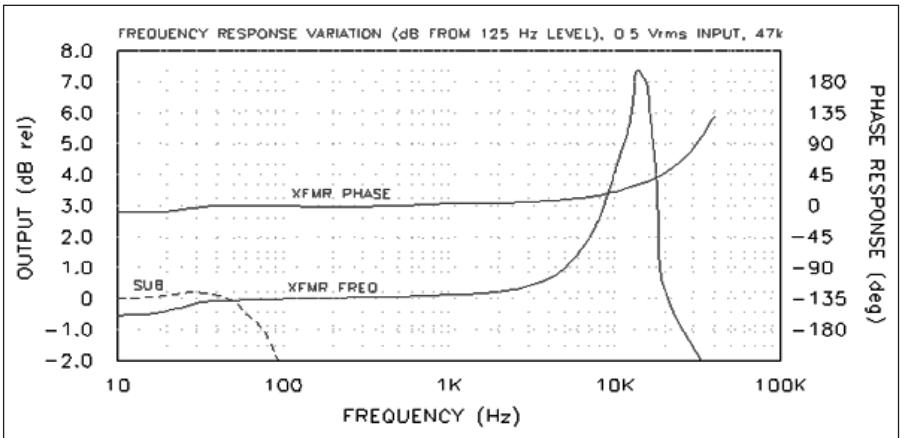


FIGURE 2: Frequency and phase response.

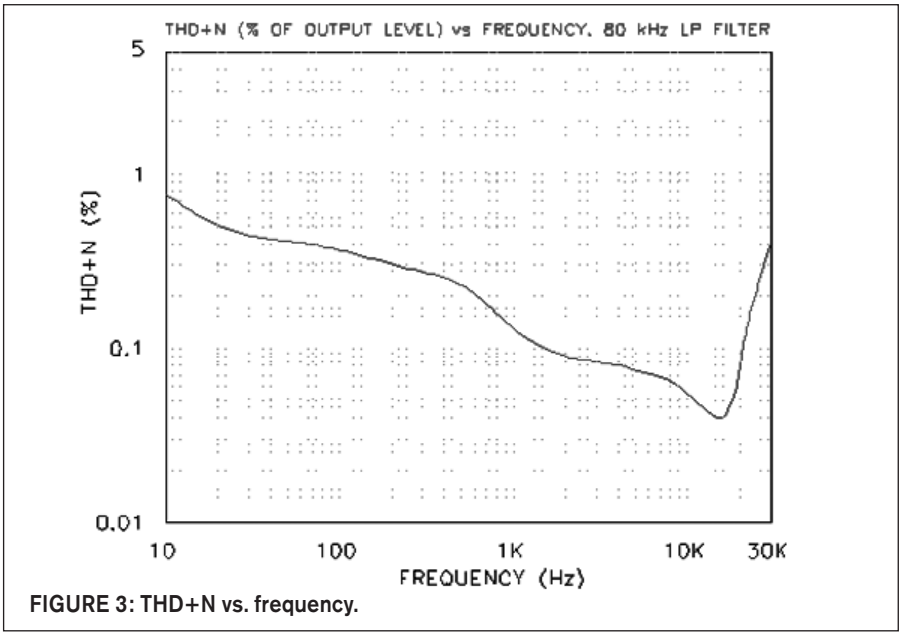


FIGURE 3: THD+N vs. frequency.

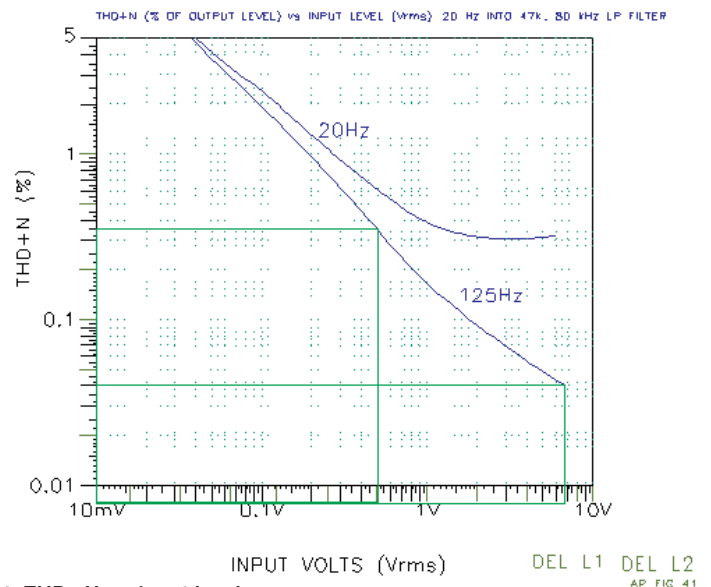


FIGURE 4: THD+N vs. input level.

the distortion decreases with an increase in the signal level as the noise portion of the THD+N drops in relation to the rising signal. The maximum output level of my distortion test oscillator is 6.68V RMS. There is no way to saturate the 115:115V transformer, so there is no rise in the THD+N at the maximum input levels. *aX*

Sources

Digi-Key Corp.
701 Brooks Ave. South
Thief River Falls, MN 56701-0677
1-800-344-4539
www.digikey.com

Fair Radio Sales
2395 St. Johns Rd.
Lima, OH 45804
www.fairradio.com

Mouser Electronics
958 N. Main
Mansfield, TX 76063-4827
1-800-346-6873
www.mouser.com

References

1. "Inside the ISO-MAX," Hansen, C., *audioXpress*, pp. 44-49, Oct. 2006.
2. "Inside the ISO-MAX," Hansen, C., *Multi Media Manufacturer*, pp. 16-19, Sep./Oct. 2006.
3. "Jensen ISO-MAX Products," Hansen, C., 6/00 *Audio Electronics*, pp. 28-30.
4. "NAD L53 DVD/CD Stereo Receiver," Hansen, C., *audioXpress*, pp. 38-53, Dec. '05.
5. A search on the USPTO website did not turn up an "Iso-Bass" trademark as of the date of this submittal.