

Lundahl and Jensen Meet the Monarchy M24

In the Oct. '07 issue of *aX* (p. 36) I reviewed Monarchy Audio's excellent M24 D/A converter. Charles Hansen published a thorough battery of measurements for the M24 in the June '07 issue (p. 20).

Readers will recall that the M24 has two analog outputs, tube and solid-state. The solid-state outputs are taken directly off the current-to-voltage (I/V) converter stage. Because they are minimally filtered, you need some type of bandwidth-limiting device to couple them to your preamplifier. For my review, I used the Monarchy-recommended Jensen CI-2RR isolation transformer, which I found gave excellent results. See Charles Hansen's measurements on the CI-2RR in *aX* Oct. '06 (p. 44), and my listening evaluations on this device in Jan. '07 (p. 26).

Hansen's measurement review of the M24 also included some tests of the Monarchy DAC used with the CI-2RR. Monarchy also recommended the Lundahl LL1592 line input transformer as an alternative to the Jensen. In this article, and the previous one (p. 37), Charles Hansen and I offer an evaluation of the Lundahl LL1592, including comparisons to the Jensen CI-2RR (our thanks to Per Lundahl, president of Lundahl Transformers, for providing samples for these articles).

Both the I/V and tube outputs on the M24 are polarity-inverted. You can reverse your speaker leads to correct for this, but that will make your system wrong for other sources, such as a turntable and phono preamp. A transformer offers an easy way to change polarity, by simply reversing the primary or secondary connections. Jensen and Lundahl both connect the electrostatic (Faraday) shield and the

metal transformer case on the secondary side. So, you *must* reverse polarity on the primary side of the transformer. Later in this article, I'll show how to wire the transformer with both polarity-correct and polarity-inverted inputs.

FEATURES

The Lundahl LL1592 has dual primary and secondary windings, so you can use the transformer in both balanced and unbalanced applications. The following is from the LL1592 datasheet: "LL1592 is a high-level line input transformer with a mu-metal lamination core. The transformer is designed for high-end pro audio line input applications with or without phase splitting. The windings are arranged to give a high degree of symmetry if the transformer is used for phase splitting. The dual-coil structure also greatly improves immunity to external magnetic fields from, e.g., power supplies and motors. Primary and secondary windings are separated by electrostatic shields. The transformer is housed in a mu-metal can."

The Lundahl LL1592 datasheet recommends a series R/C damping network across the secondary of $7k + 400pF$ for the best square-wave response. As Chuck Hansen points out in his article, these are non-standard values, but any series combination that yields the same time constant should work. This $7k + 400pF$ combo yields a time constant of $2.8\mu s$, corresponding to a frequency of $56.8kHz$. I chose off-the-shelf values of $6.19k + 470pF$, which gives a TC of $2.9\mu s$, or $54.7kHz$.

Per Lundahl notes that some audiophiles prefer the LL1592 without the R/C damping network, but I don't agree. Both measurements and listening evaluations indicate that the R/C network is beneficial, and that the $2.8\mu s$ time constant is correct. For the square-wave measurements described below, I used a $25k$ load, because that is the load provided by my preamp.

With a $1kHz$, $1V$ peak-to-peak square wave and the R/C network connected, the LL1592 showed two cycles of well-damped ringing at $0.4V$ peak-to-peak amplitude. With the network removed,

I observed five cycles of ringing at $0.8V$ peak-to-peak amplitude. A $10kHz$, $1V$ peak-to-peak square wave with the network connected showed less than one cycle of ringing at $0.4V$ peak-to-peak amplitude. Removing the network increased the ringing to three cycles at $0.9V$ peak-to-peak amplitude.

I also checked Jensen's square-wave performance with and without the R/C network. A $1kHz$, $1V$ peak-to-peak square wave with the network connected showed barely 0.5 cycles of ringing at a peak-to-peak amplitude of $0.05V$. Removing the network increased the ringing to five cycles at $1V$ peak-to-peak amplitude. A $10kHz$, $1V$ peak-to-peak square wave showed barely 0.5 cycles of ringing at a peak-to-peak amplitude of $0.1V$, with the network in place. Removing the network increased the ringing to three cycles at a peak-to-peak amplitude of $1.0V$.

With both the Jensen and the Lundahl transformers, changing the R/C time constants substantially above or below the specified values only degraded square-wave performance. Both manufacturers have worked out these values carefully, and I don't recommend changing them or removing the network. On the other hand, a slight deviation from the factory-recommended R/C values is not a problem. In fact, Jensen shows a $620pF$ capacitor in the datasheet for the JT-11P-1HPC transformer, though $680pF$ (a standard E12 value) is supplied with the CI-2RR.

MONARCHY FILTERING

In my Monarchy M24 review, I noted that there were visible high-frequency digital by-products riding on the distortion waveform at the I/V outputs. This is because of the I/V converter's minimal filtering. The bandwidth limiting of the transformer *used with the recommended R/C damping network* is necessary to remove these high-frequency by-products. The effect of the transformer coupling is also apparent in the actual distortion measurements.

I used my Denon Audio Technical CD (38C39-7147), a modified Sony CDP-XE500 CD player as a transport (I added a coax S/PDIF digital output

to this player), and my Parts Connection D2D-1 sampling rate converter fed to the coax digital input of the M24. I ran distortion measurements with the D2D-1 in the transparent mode, and with the upsampling set to 48kHz and 96kHz. The distortion analyzer is my Sound Technology 1700B operated wide-band (without the 80kHz low-pass filter). I used a 25k load for all of these tests. The results are instructive.

First, Denon CD track 49, a 1kHz sine wave:

	Transparent	48kHz	96kHz
Lundahl LL1592	0.25%	0.23%	0.23%
Jensen CI-2RR	0.25%	0.23%	0.23%

Next, track 55, a 19.999kHz sine wave:

	Transparent	48kHz	96kHz
Lundahl LL1592	0.085%	0.065%	0.05%
Jensen CI-2RR	0.0068%	0.06%	0.037%

Both transformers provide adequate filtering of the high-frequency digital by-products at 1kHz. Upsampling has virtually no effect on the 1kHz distortion measurements, but the 19.999kHz measurements improve with upsampling. Jensen's slightly better THD performance at this frequency simply indicates

more effective filtering of the M-24's digital by-products. This measurement *does not* indicate that the Jensen has lower THD at audio frequencies.

CONSTRUCTION

The Lundahl LL1592 transformer is intended for PC board mounting, and also requires an enclosure. You can mount each LL1592 and R/C network on an Old Colony D-4 prototyping board, but you'll need to enlarge the holes in the board slightly to accommodate the rather large pins on the transformer (**Photo 1**). I recommend premium-quality components for the R/C network, such as the Vishay/Dale RN60 metal film resistors and Wima FKP2 polypropylene capacitors.

My favorite audio enclosures are still the modular units carried by Sescom. Unfortunately, Sescom has become a very unreliable dealer under their current ownership arrangement. Fortunately, there's now an alternate source: Wolgram Engineered Plastics, a company specializing in injection molding, which expanded into the metal enclosure busi-

ness. Wolgram bought the metal fabrication equipment from Sescom and became Sescom's supplier for the MC-series metal cabinets and rack chassis. Wolgram now sells these enclosures themselves, and seems committed to providing good service. I now recommend Wolgram as the source for these excellent enclosures.

The MC-5A metal cabinet is just the right size for this project. I prefer the



PHOTO 1: A pair of Lundahl LL1592 line input transformers mounted on Old Colony D-4 prototyping boards in a Wolgram MC-5A enclosure with gold-plated, Teflon-insulated connectors.

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all-black version, but these enclosures are also available with natural aluminum front and rear panels. Specify your choice when ordering. I also used DH

Labs' excellent CM-R1 chassis-mount RCA jacks, which make an excellent mate for their Ultimate RCA Connector. These premium RCA jacks are Teflon-

insulated and feature DH Labs' Ultra-Gold plating. You must use the supplied insulators with these jacks in this project. DH Labs says that they require a 7/16" hole, but I find that 3/8" is just right. Product descriptions for DH Labs products are available on their website, but they don't normally sell direct; Parts Connexion is an excellent source.

Follow the wiring diagram in **Fig. 1**, and be especially careful of the wiring of the normal and reverse-polarity input jacks. **Photo 2** shows the rear-panel layout. I used center



PHOTO 2: Rear panel of the transformer enclosure, showing DH Labs' excellent CM-R1 chassis-mount RCA jacks. Normal and reverse-polarity inputs are included.

conductors from DH Labs BL-1 interconnect cable for internal wiring, which I happened to have on hand, but you can also use their 18AWG hookup wire, which is similar.

The Jensen CI-2RR contains a pair of their JT-11P-1HPC line input transformers mounted on a PC board and housed in a small steel cabinet. If you wish to add the reverse-polarity input option to the Jensen, I recommend mounting the Jensen PC board in the MC-5A enclosure (**Photo 3**). Remove the PC board from the steel enclosure and remove the PC-mount input and output jacks. Add the necessary internal wiring and connect the board to the new input and output connectors (**Fig. 1**).



PHOTO 3: Jensen CI-2RR, audiophile version. The Jensen PC board is mounted in the Wolfram MC-5A enclosure. Vishay/Dale RN60 metal film resistors and Wima FKP2 polypropylene capacitors replace the R/C components supplied by Jensen.

With high-end internal wiring and the DH Labs RCA jacks, you are one step away from an "audiophile" version of the CI-2RR. Jensen supplied high-quality parts for the R/C network—Panasonic P-series polypropylene capacitors and Yageo metal film resistors, both readily available from Digi-Key.

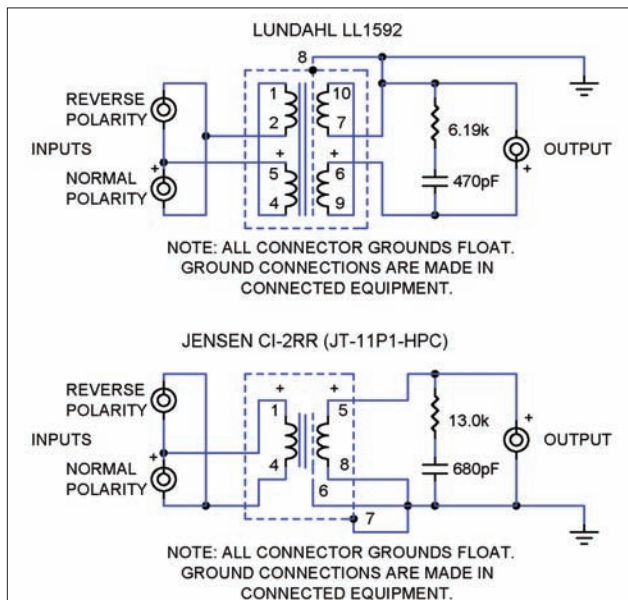


FIGURE 1: Connection diagrams for the Lundahl LL1592 and Jensen CI-2RR isolation transformers, including normal and reverse-polarity input connections. All jacks must be insulated from the chassis, with input and output ground connections made in the connected equipment.

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Both parts have steel leads. As a finishing touch, I recommend replacing these with the Vishay/Dale RN60 resistors and Wima FKP2 capacitors. These parts both feature non-ferrous construction, which I have found to make a subtle, but noticeable sonic improvement.

If you don't already have a CI-2RR, you may wish to purchase the JT-11P-1HPC transformers separately and mount them on a pair of Old Colony D-4 boards. You may be able to squeeze two of the Jensen transformers onto a single D-4 board, but it will be a tight fit. A CI-2RR retails for \$178. A pair of JT-11P-1HPC transformers will cost \$140, so you'll save some money by doing it from scratch.

TESTING

When you've finished building your transformer box, test it with a CD player and an oscilloscope. The scope should be externally triggered from one of your CD player's outputs—I suggest using the CD player's right channel as the source. Connect the left channel of the CD player to the oscilloscope's input (channel 1 if it's dual-trace). Play a 1kHz

tone from your favorite test CD and observe the polarity on the scope. If your CD player maintains absolute polarity (and the test CD is also correct), the displayed waveform should begin in the positive direction.

Now, insert the transformer box in the signal path between the CD player and the scope, using the transformer box's NORMAL input. The polarity should be the same as it was with the CD player connected directly. Then, move the input cable to the INVERTED input. The polarity displayed on the scope should now be inverted. Be sure to check both channels of the transformer box. Once you've finished the transformer box, you can use the Monarchy M24 without reversing your speaker leads.

LISTENING EVALUATIONS

I built only one MC-5A transformer enclosure, drilled for both the D-4 prototyping boards, and the Jensen CI-2RR PC board (you can see the extra holes in **Photo 3**). For my listening comparisons, I used the Lundahl transformers mounted in the enclosure (**Photo 1**) and left the

Jensen in its own enclosure. This might place the Jensen at a slight disadvantage, because the RCA connectors are not Teflon-insulated types. My Jensen CI-2RR PC board did have the Vishay/Dale and Wima R/C components for these tests. In its own enclosure, there's no way to reverse polarity on the Jensen transformers, so for these tests, I reversed my speaker leads, and used the Lundahl transformer box with the normal (non-inverted) inputs. I also compensated for the 1dB volume drop with the Jensen transformer—the Lundahl is unity gain.

Both transformers offered incredibly transparent, detailed sound. By most listening criteria, it is very difficult to hear the effects of either the Jensen or the Lundahl transformers in the signal path. Imaging and soundstaging were comparable, and bass performance was excellent with both.

However, with the Lundahl LL1592 used with the Monarchy M24's I/V outputs, I consistently observed some treble brightness. This is consistent with Charles Hansen's measurements, which show a slightly rising treble response even

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with the damping network connected. On some program material, the treble brightness became fatiguing. I found the Jensen to be sonically neutral in the treble region. For this reason, I prefer the Jensen to the Lundahl in this application.

However, I also tried the Lundahl with the Monarchy M24's tube DAC outputs, which are already adequately filtered. Here, I found the Lundahl to be much more neutral sounding in the treble region on CD material, compared to its performance with the I/V output. I observed a slight treble brightness on 96kHz DVD material, including the Classic Records DVD of the Rachmaninoff *Symphonic Dances* with Donald Johanos and the Dallas Symphony (DAD 1004). But, the slight brightness did not cause listening fatigue. I can only conclude that much of the difference between the Lundahl and the Jensen, used with the M24's I/V outputs, is due to more effective filtering of digital by-products by the Jensen. Some audiophiles might consider coupling tube equipment with a Lundahl transformer to compensate for the treble softness inherent in

some tube designs.

If you ask a dozen audio engineers who makes the best audio transformers, two manufacturer's names will figure prominently in their answers: Jensen and Lundahl. The differences between the Jensen and Lundahl transformers evaluated here reflect somewhat different design priorities. Jensen opts for flattest frequency response and minimal ringing on square waves, while Lundahl opts for wider bandwidth. Both approaches have applications well suited to their respective design philosophies.

MANUFACTURER'S RESPONSE:

I always feel uncomfortable when getting requests for transformers with filtering characteristics (and in this particular case I cannot even recall being contacted by the manufacturer), as our goal is normally to build transformers with the greatest possible bandwidth. I have not always understood this feeling of discomfort, but after reading this review I understand my reactions better.

The transformer rated the best/most suitable for this particular application

(which in my "applications dictionary" is primarily a line output application), the Jensen JT-11P-1HPC, is a high level high impedance line input transformer, designed to handle high signal levels in a limited size unit normally placed close to the input amplifier.

The limited size requires many turns of thin wire (to handle high signal levels at low THD), which results in high copper resistance and relatively high internal capacitance. These characteristics result in the limited bandwidth suitable for this application, but also in an output impedance above 3k Ω , which in my opinion is not appropriate for either a studio or a home environment. But this is *not* a criticism of the Jensen transformer. It is an excellent bridging input transformer with characteristics similar to our LL1540 in terms of size, impedance, and bandwidth.

The fact that the LL1592 (designed to be an audiophile alternative to the "standard" pro audio workhorse LL1540) performed well with the filtered signal but was less successful with the unfiltered signal is thus not surprising, given its greater bandwidth. And thanks to



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this article I can now better understand my feelings of discomfort (and have better formulated my cautions) when receiving similar requests in the future.

*Per Lundahl
Managing Director of
Lundahl Transformers*

I would like to clarify that the transformers are applicable for the new version of the Model 24 only, hereinafter called NM24. The older generation does not have a solid-state DAC output to be used with the transformers.

While it is only appropriate that the comments be left to the transformer manufacturers, I wish to point out there are two other types of coupling transformers that I have tried, with very satisfying results.

One is made by a company called Electra-Print Audio Co. in Las Vegas, and readers may contact Jack Elliano at

electraudio@cox.net.

Their PVA-2N series actually has a higher winding ratio that yields a significant amount of gain, and Jack recommends just connecting a 10K pot at the secondary as a passive volume control, to drive any power amp with good sensitivity inputs (such as Monarchy's SM-70 PRO). Jack claims he uses a Nickel core material.

The other is made by Dignity Audio in Hong Kong. Readers can contact Franky Wong at: "hitekxmr" hitekxmr@biznetvigator.com. Franky uses a Permalloy core that is supposed to couple the signal from Input to Output much more efficiently.

The same core, in a much larger size, is used in his 300B power amp, DA08SE, that won "The Most Wanted Component of the Year 2007" from the www.stereotimes.com audio journal.

C.C. Poon, Monarchy Audio
ax

Parts List

Either Option:

MC-5A Black Enclosure (Wolgram)
(6) DH Labs CM-R1 Chassis-Mount RCA Jacks (Parts Connexion #68098)
DH Labs SH-18 Red and Black 18AWG Hookup Wire (Parts Connexion #54927 and #51968)

Lundahl Option:

(2) Lundahl LL1592 Line Input Transformers (Lundahl or K & K Audio)
Vishay/Dale RN60 Series 6.19k, 1% Metal Film Resistor (Mouser #71-RN60D-F-6.19k)
Wima FKP2 Series 470pF/100V, 2.5% Polypropylene Capacitor (Mouser #505-FKP2-470/100/2.5, or Welborne Labs)

Jensen Option:

Jensen CI-2RR IsoMax Dual Audio Isolation Transformer (Jensen)
-or-
(2) Jensen JT-11P-1HPC Line Input Transformers (Jensen) and (2) Old Colony D-4 Prototyping Boards (Old Colony)
Vishay/Dale RN60 Series 13.0k, 1% Metal Film Resistor (Mouser #71-RN60D-F-13k)
Wima FKP2 Series 680pF/100V, 2.5% Polypropylene Capacitor (Mouser #505-FKP2-680/100/2.5, or Welborne Labs)

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