



Inside the ISO Max

By Charles Hansen
and Gary Galo (listening tests)

This article revisits the Jensen CI-2RR Dual Audio Ground Isolator that was used to solve a few audio problems in the 6/00 issue of *Audio Electronics* magazine¹. This time around, Gary Galo will do a more thorough audition, and Charles Hansen is going to run the suite of test measurements.

The CI-2RR is a stereo ground isolator designed to stop hum and buzz in unbalanced audio interfaces by eliminating the inherent ground noise coupling mechanism. **Photo 1** shows the front panel, which has two pair of high-quality gold-plated RCA phono jacks. The CI-2RR is constructed of heavy gauge painted steel.

Photo 2 shows the CI-2RR with the cover removed. The input and output jacks are isolated by two Jensen JT-11P-1HPC isolation transformers with nickel-iron-molybdenum alloy cores. A Faraday shield between the windings connects to the steel transformer case and provides maximum RF interference rejection.

A schematic of the CI-2RR is shown in **Fig 1**. The secondary winding has a series RC compensation circuit placed across it.

MEASUREMENTS

The CI-2RR maintains normal polarity. The input impedance measured approximately 48k at 1kHz, with a DC winding resistance of 2.18k. The output impedances for both channels measured approximately 4k2 at 1kHz, with a DC winding resistance of 1.90k. Winding-to-winding capacitance was a low 121pF and winding inductance was over 800H, which should enhance low-fre-

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PHOTO 1: CI-2RR front view.



PHOTO 2: CI-2RR interior.

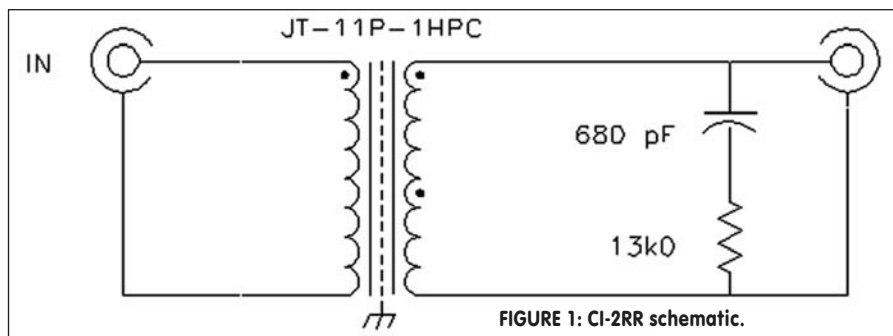


FIGURE 1: CI-2RR schematic.

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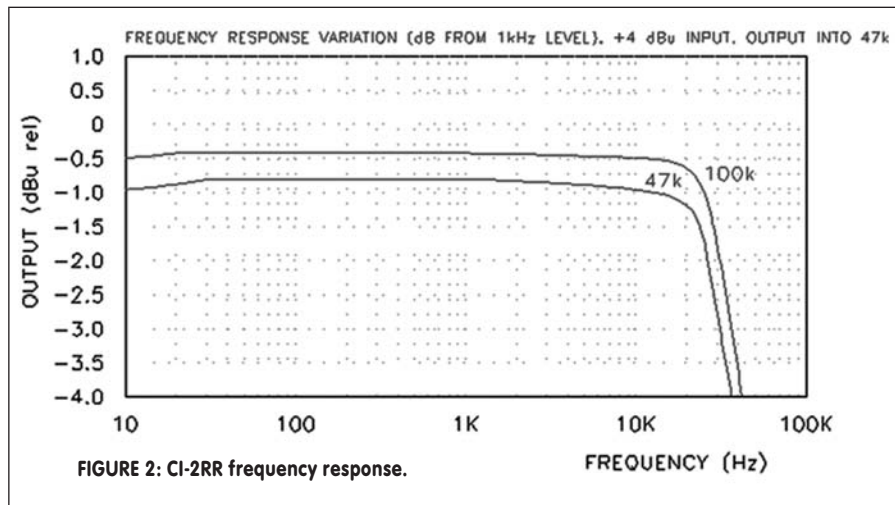
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quency response. The leakage inductance (secondary shorted) was less than $1\mu\text{H}$, and the capacitance between the two inputs measured a low 15pF , which should minimize the crosstalk between channels.

I recorded the output frequency response (**Fig. 2**) for resistive loads of 100k and 47k with an input source impedance of 600Ω as specified in the datasheet. At the nominal specified load of 47k , the frequency response for the CI-2RR

was within $\pm 1\text{dBu}$ to 26kHz , with 0dB defined as $+4\text{dBu}$ (1.228V RMS) at 1kHz into 47k . I also took data for loads of 10k , an IHF line load, and 600Ω ; but even at 10k load the response was -7.6dB below the 47k load response curve at 1kHz and is off the graph.

Insertion loss at 1kHz with a 47k load was 0.80dBu , and crosstalk performance was -59dBu at 20kHz . The common-mode rejection ratio (CMRR) at 60Hz was greater than 90dBu , while



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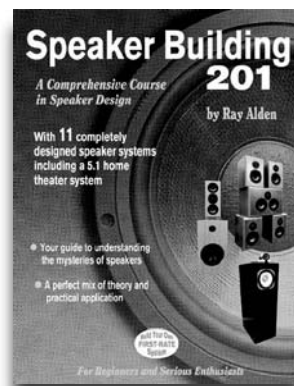
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the CMRR at 3kHz was approximately 86dBu.

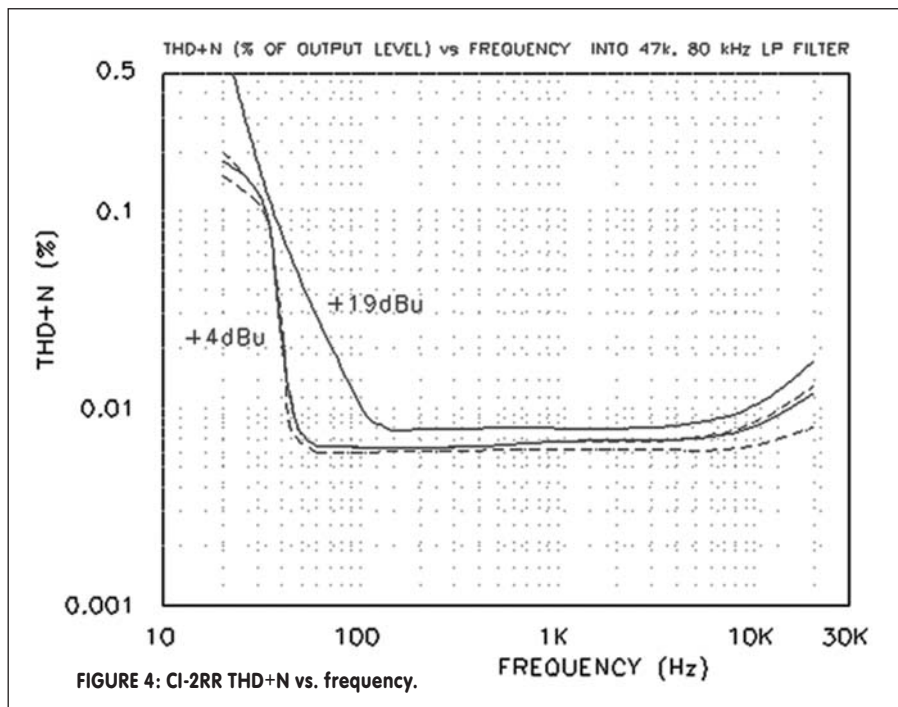
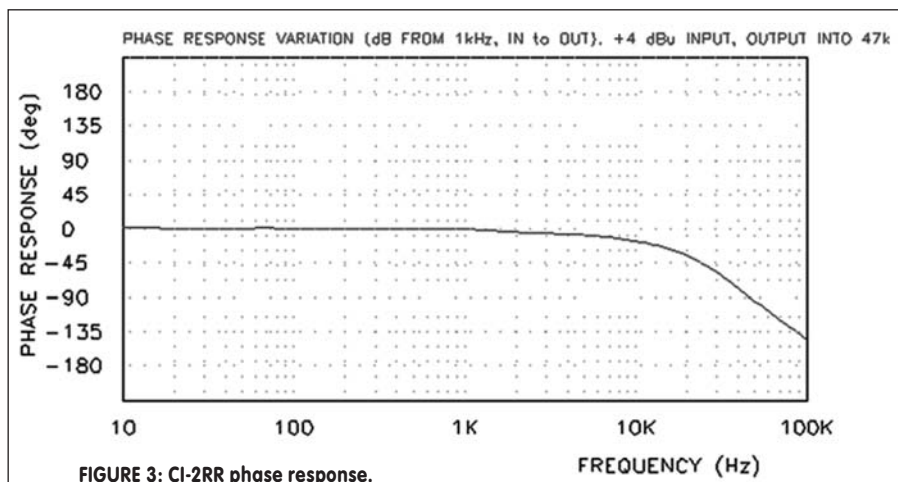
The phase shift with frequency is shown in **Fig. 3**, output with respect to input, referenced to 0dB at 1kHz. The source impedance is 600Ω and the output load is 47k. This graph is quite different from the "Deviation from Linear Phase" graph shown on the CI-2RR datasheet (available on the Jensen Transformer website).

Phase shift is not necessarily phase distortion. A totally benign time delay is represented in the phase domain as a phase shift that increases linearly with frequency; this is not distortion. Phase distortion occurs when there is a nonlinear relationship between frequency and phase. In other words, a time delay that

changes with frequency². Jensen specifies Deviation from Linear Phase (DLP) rather than phase shift, as the true measure of phase distortion.

Figure 4 shows THD+N versus frequency for the CI-2RR. The data from top to bottom at 20kHz represents 47k at +19dBu, 100k at +4dBu, 47k at +4dBu, and 10k at +4dBu. I engaged the test set 80kHz low-pass filter to limit the out-of-band noise.

In all instances the monitor output of the distortion test set, after the fundamental notch filter, showed the third harmonic, as you would expect of a magnetic core transformer. The CI-2RR THD+N is relatively insensitive to output loading. There is no dip in distortion at 60Hz, indicating the Jensen



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Figure 5 shows output THD+N versus input voltage into 47k at 20Hz, 1kHz, and 20kHz. The dashed line is for a 100k load at 1kHz. I engaged the test set 80kHz low-pass filter to limit the out-of-band noise. Using a 20Hz input signal, the CI-2RR endured 6.9V RMS (+19dBu) before “clipping” at 1% THD+N. If you want to convert the graph voltages to dBu, the formula is

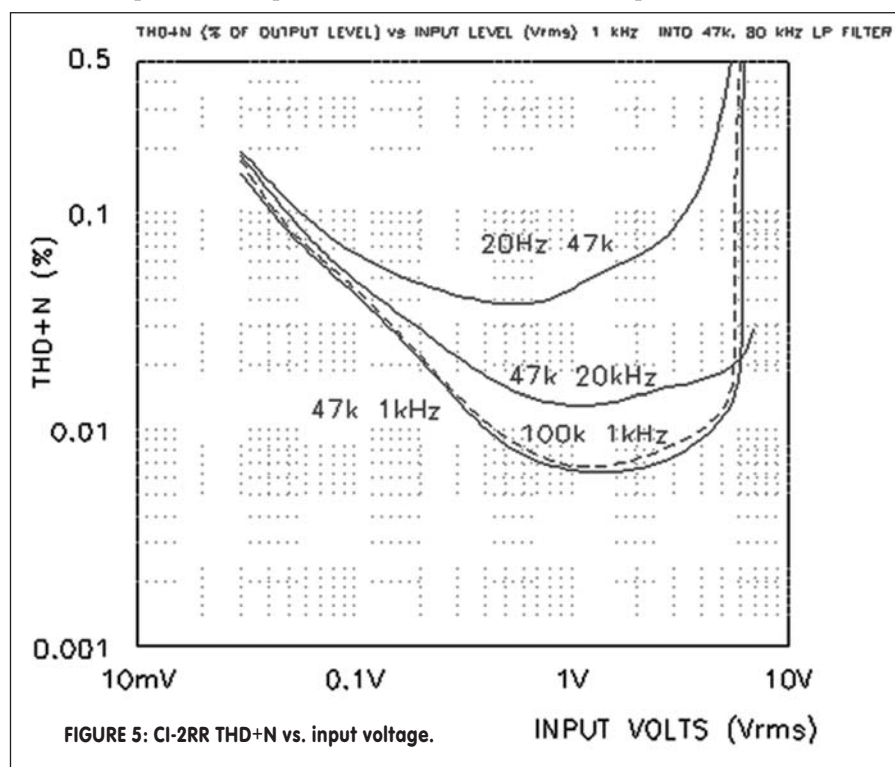
$$\text{dBu} = 20 \cdot \log(\text{Vin}/774.597)$$

I viewed the response of the CI-2RR to three square-wave test frequencies on an analog scope using a 47k load and 600Ω source impedance. The response at 40Hz was perfectly square up to 1Vpp output of my function generator, where some tilt made its appearance. The 1kHz square wave was also perfect until 2.5Vpp, where the tilt began. The 10kHz square wave did not begin to tilt until 13Vpp. This is because the saturation voltage of a magnetic core transformer is directly proportional to

frequency (Faraday’s Law).

I also found that the square-wave accuracy very much depends on the input impedance of the signal source, but not on the output load impedance. With

a 50Ω source impedance, the 10kHz square wave had a slight peak on the leading edge. Increasing the source impedance to 1k while maintaining the same +4dBu input level caused the lead-



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TABLE 1: MEASURED PERFORMANCE.

Parameter	Manufacturer's Rating	Measured Results
Input Impedance, Zi, 1kHz, +4 dBu	47kΩ to 50kΩ	Approximately 48k
Insertion Loss, 1kHz, +4 dBu	1.0dB maximum	0.8dBu
Magnitude Response, ref 1kHz		
20Hz, +4dBu	-0.15dB minimum	-0.07dBu
20kHz, +4dBu	-1.0dB minimum	-0.31dBu
Deviation from Linear Phase (DLP)		Output Phase Shift:
20Hz to 20kHz, +4 dBu:	±2° maximum	+1° at 20Hz
		-35° at 20kHz
Total Harmonic Distortion (THD)		
1kHz, +4 dBu	<0.001% typ	.0064% (noise limited)
20kHz, +4 dBu	0.10% maximum	0.012%
Maximum 20Hz Input Level, 1% THD	+19dBu typ	+19dBu
Common Mode Rejection Ratio (CMRR)		
60Hz	95dB typ	> 90dB
3kHz	85dB typ	86dB
Output Impedance, Zo, 1kHz	4.65kΩ typ	Approximately 4k2
DC Resistance	2.26kΩ in, 1.90kΩ out typ.	2.18k in, 1.90k out
Capacitance, Zo, 1kHz, in to out	105pF typical	112pF L, 121pF R
Allowable Driving Source Impedance	0 to 2kΩ, 600Ω nominal	HF response sensitive (see text)
Allowable Load Impedance	10kΩ to 47kΩ	Relatively insensitive 10k to 100k
Allowable Load Capacitance	0 to 100pF (cable + input)	N/A
Temperature Range	0° C to +70° C	N/A
Voltage Difference, input to output or any shield to case, 60Hz	24V RMS, 34V peak maximum	Not tested

ing edge of the 10kHz square wave to round over. The most accurate square-wave reproduction was at 600Ω. This indicates that the high-frequency response will be sensitive to the input source impedance.

Jensen President Bill Whitlock said the secondary R-C network was chosen to provide a two-pole Bessel high-frequency rolloff, which guarantees minimal DLP as evidenced by zero-over-shoot and zero-ringing in square-wave response, within the specified source impedance and input voltage range.

Table 1 shows the Manufacturer's specifications and my measured results for comparison. *ax*

REFERENCES

1. "Product Review: Jensen Iso-Max Products," Charles Hansen and Ed Dell, *Audio Electronics*, 6/00, pp. 28-30.

2. "High-Frequency Phase Specifications—Useful or Misleading?," Deane Jensen, 1986 AES Paper 2398 (E-8).

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