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review | By Charles Hansen

Monarchy Audio M24 DAC + Tube Line Amp

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List Price: $1,490
Dimensions: 17″ W × 14″ D × 4″ H

My initial checkout of the Monarchy M24 showed that the Tube Dac had visible output sine wave distortion when viewed on my analog scope. In order to provide a suitable warmup before testing, I connected the M24 to the digital coax output of my Alesis ML-9600 Masterlink recorder and played over one hour of 16-bit and 24-bit audio test tracks. After this period the output looked sine-wavy. Both the Tube Dac and the solid-state op amp output (whose jacks are labeled Analog Output) invert polarity, as does the line stage. Therefore, selecting the line stage switch DAC position, which internally connects the Tube Dac outputs to the Line In inputs, produces the correct overall output polarity.

The Analog Output cannot be switched to the line stage internally, but it can be connected via RCA interconnects to the Line In jacks. Then by selecting the Line position you will output the solid-state processed signal from the Line Out jacks. This arrangement also provides the correct overall output polarity. If either the Tube Dac or Analog Outputs are connected to equipment that themselves produce overall normal polarity, the result will be inverted polarity. This is all somewhat clearer in the block diagram **(Fig. 29)**.

The M24 input and output impedances are shown in **Table 1**.

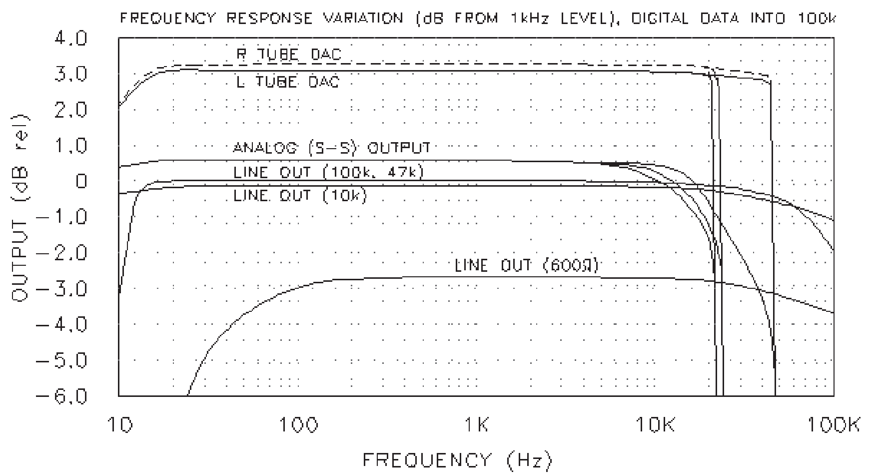

FIGURE 1: Frequency response, all outputs.

TABLE 1 Monarchy M24 DAC Input and Output Impedances

Frequency	20Hz	1kHz	20kHz
Line In, Minimum Volume	96k	96k	96k
Line In, Maximum Volume	85k	85k	85k
Tube Dac Out L	3k36	3k14	3k50
Tube Dac Out R	3k77	3k90	2k60
Analog Out	510Ω	510Ω	510Ω
Line Out	746Ω	197Ω	202Ω

START-UP

Hum and noise (maximum volume, DAC position, Line In shorted) measured -85dB relative to 2V RMS, dropping to -92dB A-weighted. The Analog Output had a negligible DC offset of a couple mV. With its four independent SRPP (shunt regulated push-pull) tube stages and two independent analog ICs, separation is quite good between the stereo channels, about 90dB at 10kHz. The volume control tracking was within 0.6dB at the lowest setting to 0.26dB at the highest position (including any gain difference between the two Line Out tubes).

When first powered up, the M24 makes a pop in the loudspeakers after a short time delay, then another pop after a much longer delay until B+ is applied to the tubes. When the M24 is turned off, there is another pop in the loudspeaker.

The Tube Dac outputs produced 2.85V RMS (L) and 2.91V RMS (R) at 1kHz, or 3.08dB and 3.26dB, respectively, above the Red Book Standard of 2V RMS. The solid-state Analog Outputs both produced 2.14V RMS, or 0.59dB above Red Book. The gain of the line stage at the maximum volume control setting is 18.5dBv (left channel) and 18.7dBv (right channel).

The M24 Line Stage showed unity gain when the volume control was set at approximately 12:30 o'clock. I made all the Line Stage measurements at a volume setting corresponding to 2V RMS output with a 0.5V RMS test signal (12dB gain).

RESPONSES

I recorded the frequency response shown in **Fig. 1** for the Tube Dac and Analog outputs into 100k, using 16-bit/44.1kHz Red Book data as well as 24-bit data at 48kHz and 96kHz sampling rates. The M24 easily locked onto and displayed the correct sampling rate on the front panel display, although the bit depth is not shown. There was a negligible difference in whether the response was measured from the direct outputs, or when either the Tube Dac or Analog Output was processed through the Line Stage set to unity gain. Reducing the Tube Dac and Analog Out loading down to 47k also had no effect on the response. I used analog test signals for the Line In, with Line Out loads of 100k, 47k, 10k, and 600Ω.

The Tube Dac response is quite flat up to the point where the M24 digital interpolation filter takes over at the vertical stop band lines at 22.1, 24, and 48kHz. Interposed between the D/A converter output and the Tube Dac grid input is a passive L-C low-pass filter (In a follow-up article, Gary Galo will examine this further). There was about 0.2dB difference between the two Tube Dac channel outputs (the right tube is dashed in **Fig. 1**).

The Analog Output HF response rolls off gradually above 5kHz and intercepts the digital filter several decibels below the filter's passband limit. This is quite an interesting result because the Analog Output uses a wide bandwidth AD811 video amplifier, configured as a low-pass active filter with an additional passive L-C low-pass input section. CC Poon of Monarchy Audio suggested that the Analog Out to Line In interface might benefit from placing a Jensen Cl-2RR Iso-Max[1, 2] between the two sets of jacks to reduce hum. Other than about 1dB drop in the Line Out level, I didn't see any other difference in the measurements using the Cl-2RR that Gary Galo loaned me.

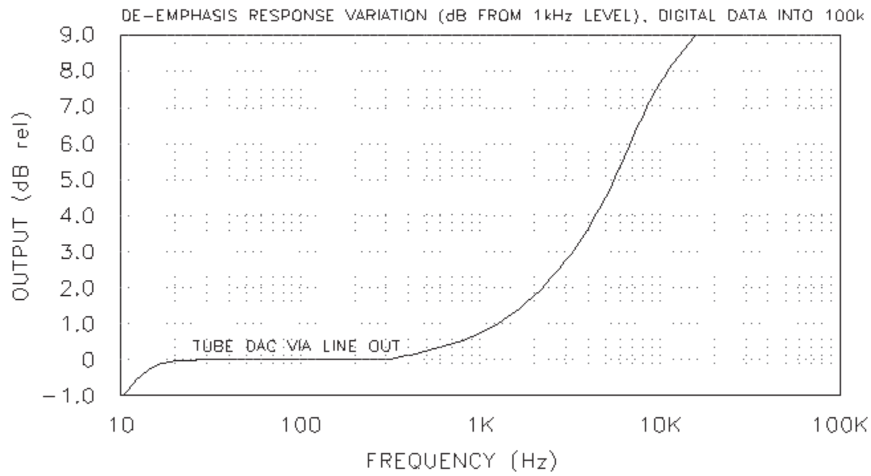

FIGURE 2: De-emphasis response, tube Dac 16/44.1 data.

With analog test signals, the Line stage has a very flat response, with the -1dB point at 80kHz and the -3dB point at 151kHz. There was only 0.13dB difference in output voltage at 1kHz with loads of 10k to 100k. The response into 10k is actually flatter overall than that of the 100k load, perhaps due to the design point selected for the SRPP output impedance. When I decreased the line stage load to a difficult 600Ω, the interaction between the load and the SRPP output stage coupling capacitor took its toll on the LF response.

Figure 2 shows the deviation from flat response when pre-emphasized Red Book 16/44.1 digital data was fed to the digital input. The drop at the LF end is inherent in the analog amplification, while the steep rise above 300Hz shows that the M24 does not provide de-emphasis attenuation for pre-emphasized CDs.

The THD+N versus frequency for the Tube Dac, Analog, and Line outputs is shown in **Fig. 3**. The Tube Dac (the right channel is shown here) and Analog output THD track each other quite closely until about 6kHz, where the Tube Dac rises more steeply than the Analog output. I didn't see any difference in the THD measurements using the Jensen Cl-2RR between the Analog output and the distortion test set.

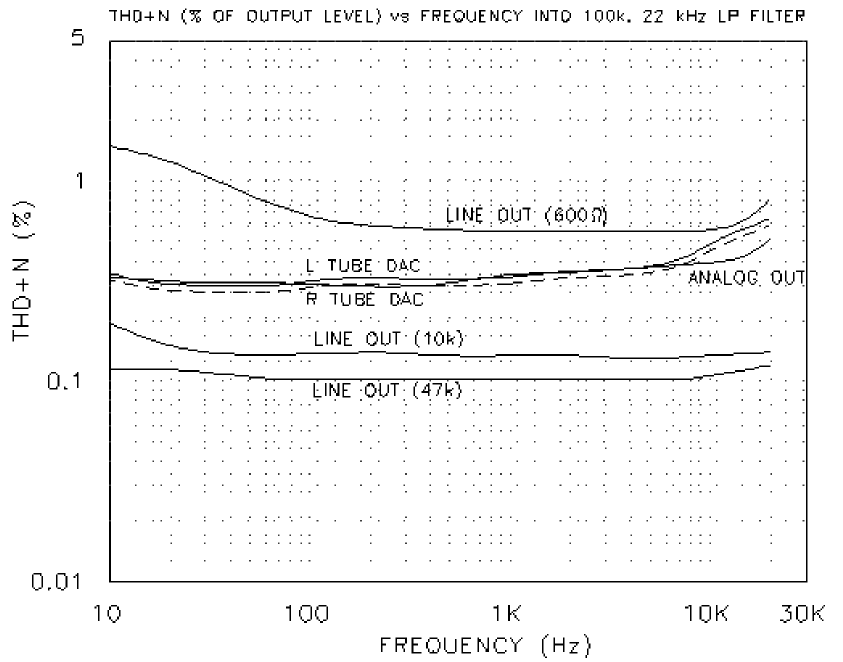

FIGURE 3: THD + N vs. frequency, all outputs.

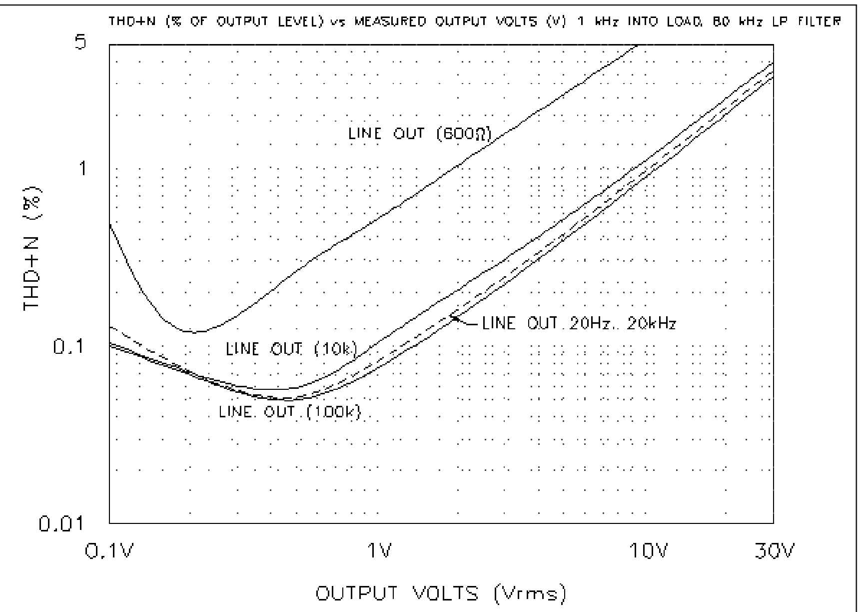

FIGURE 4: THD + N vs. output voltage, line out.

The increase in distortion as the Line Out tubes work harder into the lower 10k and 600Ω impedances is evident here. The difficult 600Ω load also exacts more of a distortion penalty at the lowest and highest frequencies. I performed the Line Out test with analog test signals and the distortion test set low-pass filter set for 80kHz rather than the steep 22kHz low-pass filter used for the Tube Dac and Analog outputs.

Figure 4 shows THD+N versus output voltage for the Line Output at the maximum volume setting into 100k at 20Hz, 1kHz, and 20kHz. There is a barely noticeable difference between the three frequencies (20Hz and 20kHz are dashed). I also made the measurements at 1kHz for a 10k and 600Ω load, engaging the test set 80kHz low-pass filter to limit the out-of-band noise.

The M24 achieves about 27V RMS into 100k at 3% THD over the entire audio band. At 1kHz the 3% THD clipping point was reached at 25.4V RMS into 10k and just 5.54V RMS into 600Ω. The output voltage swing limit at 3% THD shows itself first on the negative half-cycles, with nicely rounded peaks and no evidence of hard clipping.

SINE WAVE MEASUREMENTS

The reproduction of a 1kHz sine wave at -90.3dBfs with 16/44.1 data is shown from the Tube Dac output in **Fig. 5**. The sine wave at this ±1 bit signal level should appear as three distinct levels, but is instead rather indistinct due to low-level noise. The same signal as seen at the solid-state Analog Output **(Fig. 6)** is not much different. Increasing the data resolution to 24/96 at -90.3dBfs produces a bit more of a sinusoidal shape, but still contains low-level noise **(Fig. 7** and **Fig. 8**, for the Tube Dac and Analog outputs, respectively). Repeating the test by routing the Tube Dac through the Line Out stage did not alter the scope picture.

The right channel Tube Dac distortion residual waveform for a 0dBfs 1kHz sine wave is shown in **Fig. 9**. The upper waveform is the output signal, and the lower waveform is the monitor output (after the THD test set notch filter), not to scale. This distortion residual signal shows a low order harmonic structure with the THD+N measuring 0.33%.

The residual distortion for the Analog Output is shown in **Fig. 10**, and its THD also measures 0.33%. The Line Out residual in **Fig. 11** resulting from the analog input signal suggests a predominant 2nd harmonic with some additional low-level noise. The THD measures 0.105% at 2V RMS output into 100k.

The Tube Dac output spectrum of a 50Hz sine wave at 0dBfs into 100k is shown in **Fig. 12**, from zero to 1.3kHz. The THD+N measured 0.30%, with a decreasing order of even and odd harmonics. Raising the frequency to 1kHz and expanding the spectrum range to 20.5kHz **(Fig. 13)** shows a similar harmonic distribution. Routing the Tube Dac through the Line Out stage did not alter the spectrum.

I repeated the 50Hz and 1kHz spectrums for the Analog Output in **Fig. 14** and **Fig. 15**. Mr. Poon has somehow coaxed a tube-like spectrum from the D-A converter IC and the AD811 video amplifier chip. His two current-voltage converters and analog low-pass filters are unusual indeed. The 50Hz THD measures 0.31%, nearly identical to the Tube Dac output.

The 50Hz and 1kHz spectrums for the Line Output in **Figs. 16** and **17** show a much different picture from that of the Tube Dac output, which uses the same SRPP topology. The 50Hz and 1kHz THD both measure a much lower 0.105%. The 100Hz 2nd harmonic in **Fig. 16** is -59dB (0.11%) and harmonics of the 60Hz AC line are also present, with the 180Hz 3rd harmonic of the AC line being slightly higher than the 150Hz 3rd harmonic of the test tone.

IMD TESTS

Figure 18 shows the M24 Tube Dac output spectrum reproducing a combined 11kHz + 12kHz intermodulation distortion (IMD) signal at 0dBfs into 100kΩ. The 1kHz IMD product is -53dB (0.22%), with a picket fence of IMD products around the two fundamental test tones. Repeating the test with a 19kHz + 20kHz IMD test signal **(Fig. 19)** resulted in a higher -50dBfs 1kHz product (0.316%), but with a mysterious absence of any other significant IMD products below the two test tone frequencies. My first thought was that I might have saturated the analog input of the spectrum analyzer during the 11kHz + 12kHz test, but a retest of those IMD tones showed that the bright red overload indicator was not present in the display.

I repeated the two IMD tests while applying the steady-state Analog Output to the spectrum analyzer, as shown in **Figs. 20** and **21**. The results show a similar but lower level distribution of the IMD products between the two spectra. The 1kHz product of the 11kHz + 12kHz test is -77dB (0.014%), but four of the products around the two test tones are much higher. The 1kHz product of the 19kHz + 20kHz test is -58dB (0.126%).

Finally, I applied the two IMD test signals from the analog output jacks of my ML-9600 to the Line Inputs and adjusted the Line Output volume level for 12Vp-p into 100kΩ. The

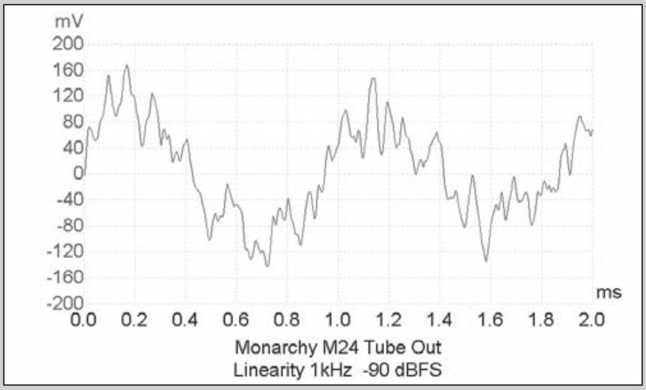

FIGURE 5: 1kHz undithered sine wave –90dBfs tube Dac output (16 bit data).

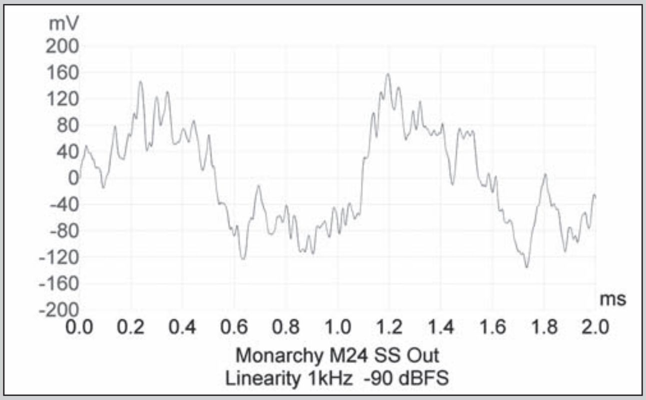

FIGURE 6: 1kHz undithered sine wave –90.3dBfs analog (SS) output (16 bit data).

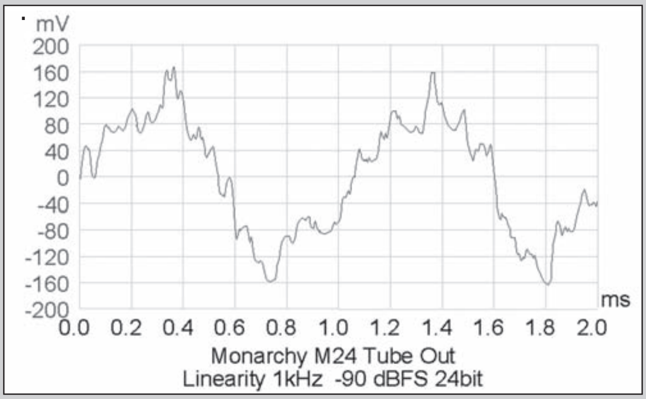

FIGURE 7: 1kHz undithered sine wave –90.3dBfs tube Dac output (24 bit data).

FIGURE 8: 1kHz undithered sine wave –90.3dBfs analog (SS) output (24 bit data).

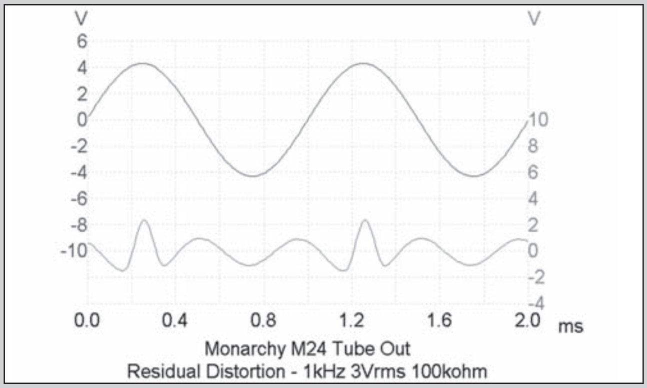

FIGURE 9: 1kHz sine wave residual distortion tube Dac output (16 bit data).

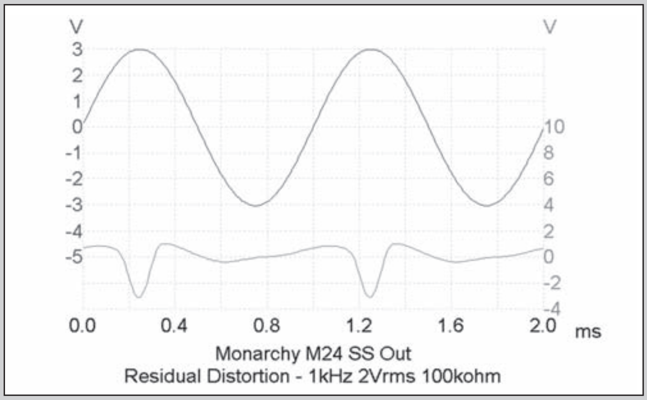

FIGURE 10: 1kHz sine wave residual distortion analog (SS) output (16 bit data).

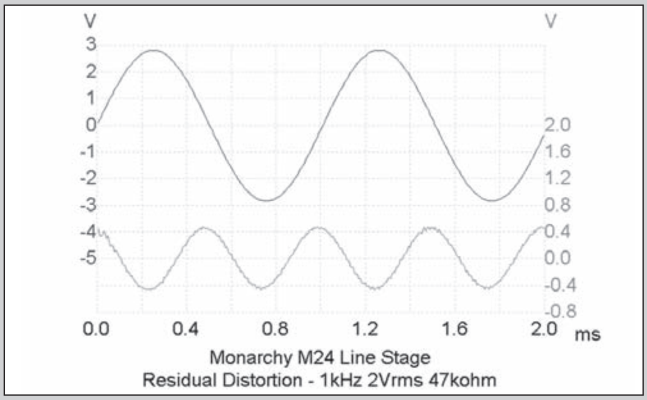

FIGURE 11: 1kHz sine wave residual distortion line output (analog signal).

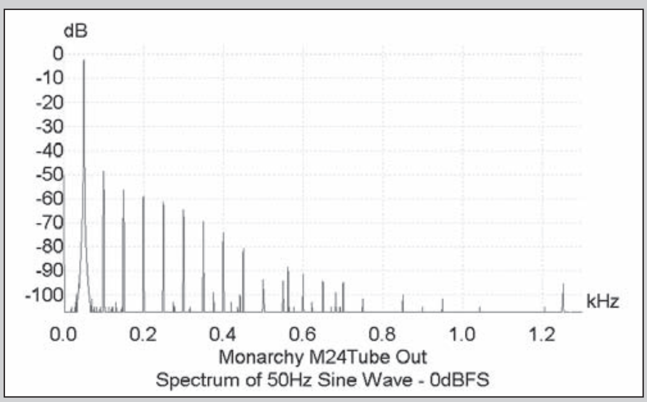

FIGURE 12: Spectrum of 50Hz sine wave tube Dac output (0dBfs 16 bit data).

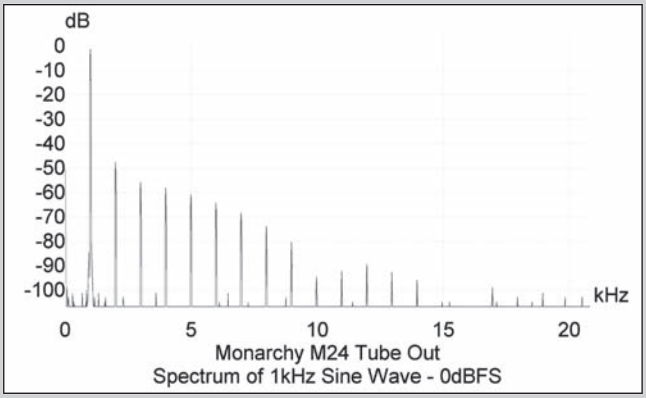

FIGURE 13: Spectrum of 1kHz sine wave tube Dac output (0dBfs 16 bit data).

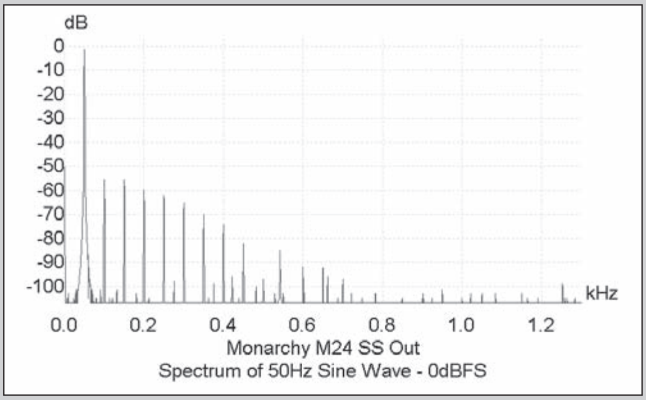

FIGURE 14: Spectrum of 50Hz sine wave analog (SS) output (0dBfs 16 bit data).

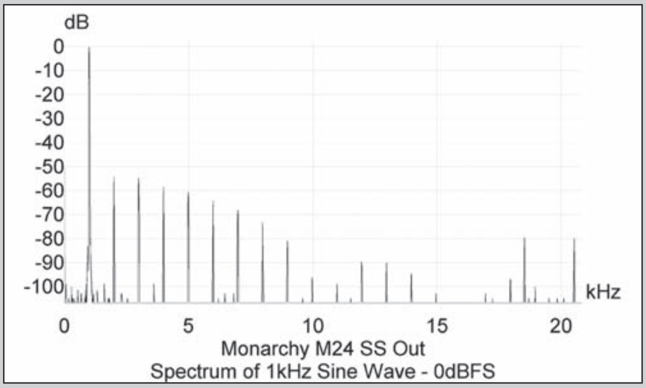

FIGURE 15: Spectrum of 1kHz sine wave analog (SS) output (0dBfs 16 bit data).

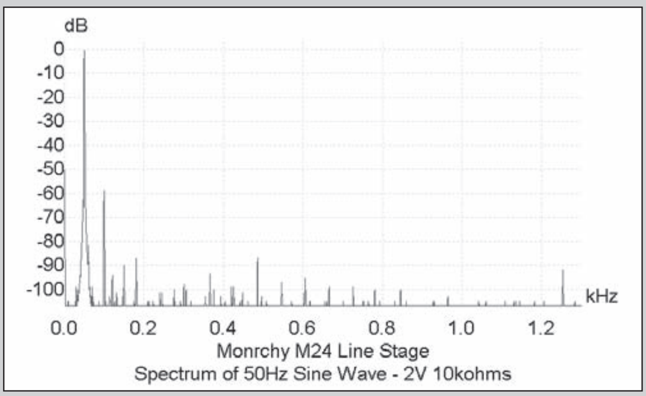

FIGURE 16: Spectrum of 50Hz sine wave line output (2V RMS analog signal).

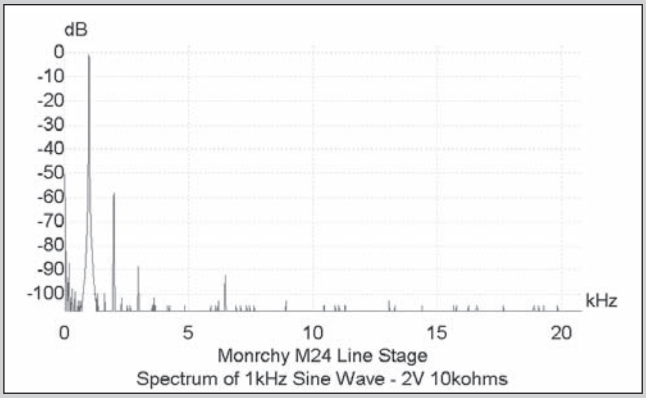

FIGURE 17: Spectrum of 1kHz sine wave line output (2V RMS analog signal).

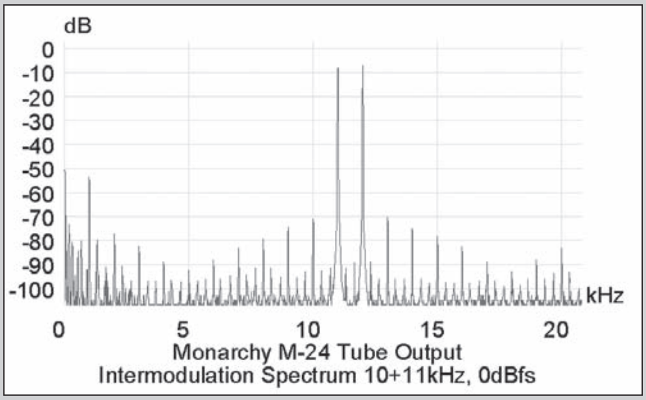

FIGURE 18: IMD 11 + 12kHz tube Dac output (0dBfs 16 bit data).

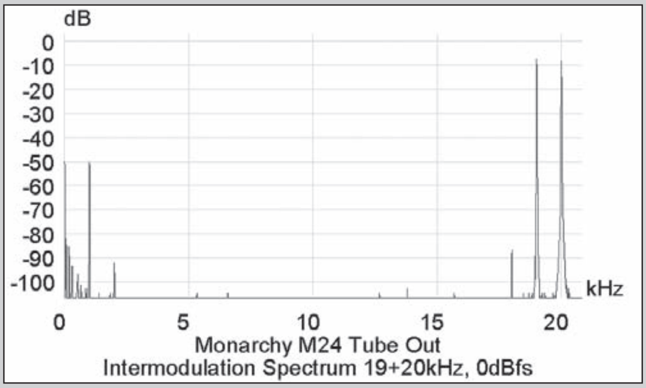

FIGURE 19: IMD 19 + 20kHz tube Dac output (0dBfs 16 bit data).

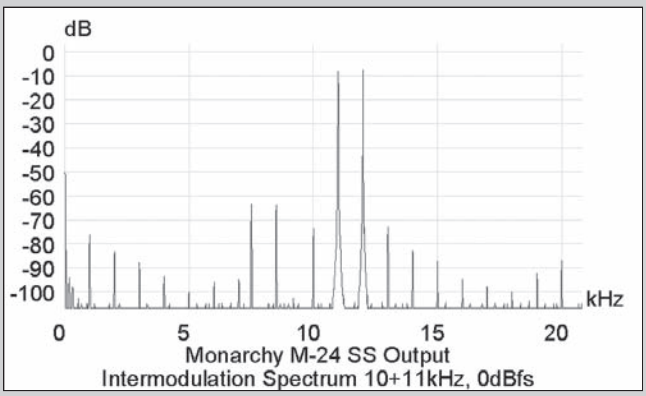

FIGURE 20: IMD 11 + 12kHz analog (SS) output (0dBfs 16 bit data).

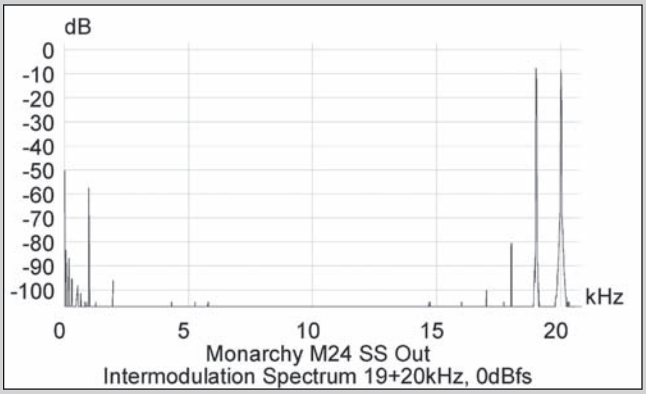

FIGURE 21: IMD 19 + 20kHz analog (SS) output (0dBfs 16 bit data).

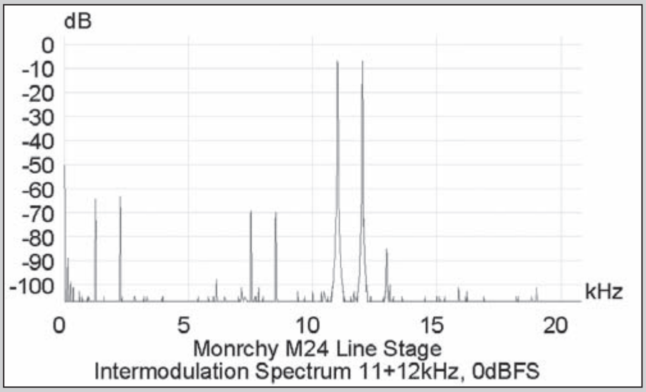

FIGURE 22: IMD 11 + 12kHz line output (0dBfs analog signal).

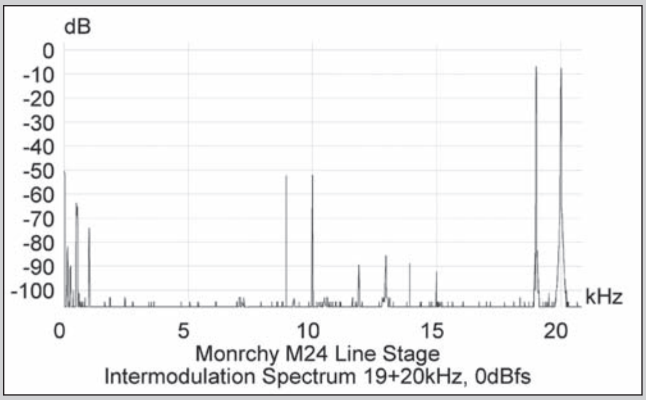

FIGURE 23: IMD 19 + 20kHz line output (0dBfs analog signal).

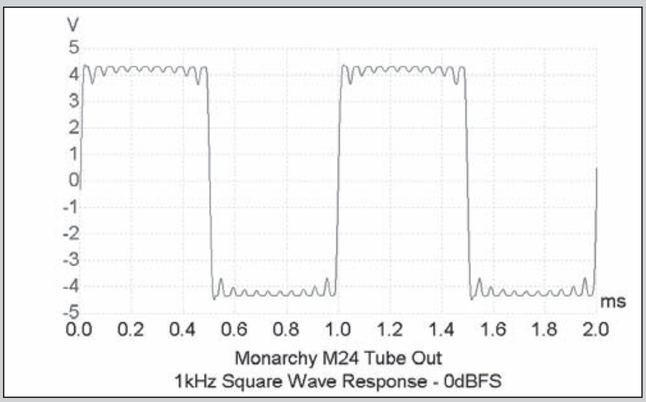

FIGURE 24: 1kHz square wave tube Dac output (0dBfs 16 bit data).

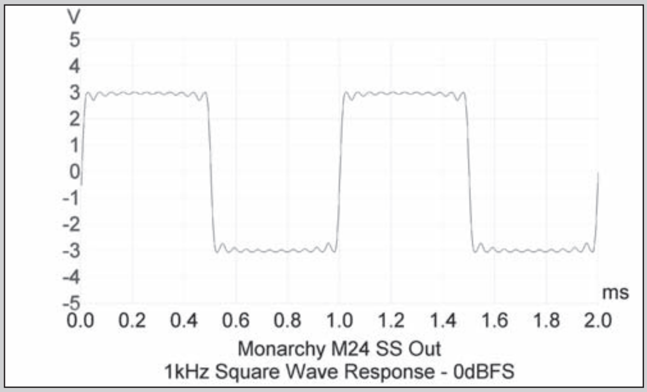

FIGURE 25: 1kHz square wave analog (SS) output (0dBfs 16 bit data).

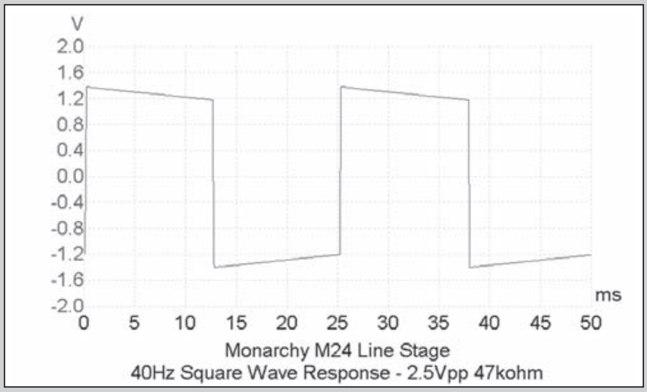

FIGURE 26: 40Hz square wave line output (2.5Vpp analog signal).

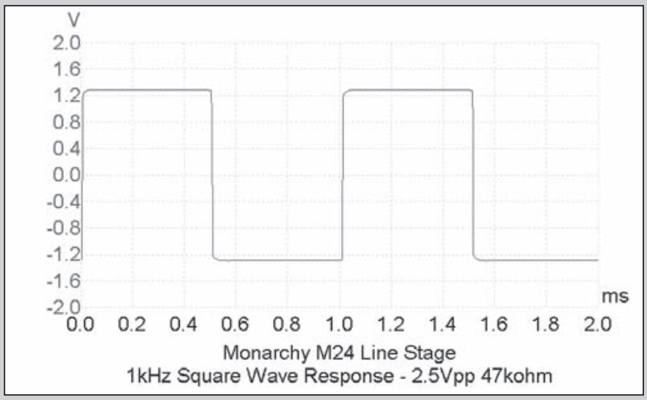

FIGURE 27: 1kHz square wave line output (2.5Vpp analog signal).

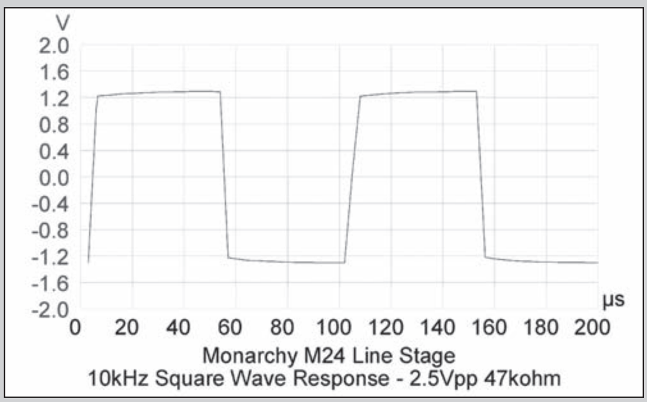

FIGURE 28: 10kHz square wave line output (2.5Vpp analog signal).

results are shown in **Figs. 22** and **23**. The distribution of IMD products is fairly similar in these two spectra, showing more linear amplification than the 11kHz + 12kHz spectra in the Tube Dac and Analog output tests.

SQUARE WAVE TESTS

I applied a 1kHz square wave at 0dBfs, 16/44.1 digital data to the M24 and monitored the resulting scope trace from the Tube Dac **(Fig. 24)** and the Analog Output **(Fig. 25)**. The higher output level of the Tube Dac shows what appears to be slight clipping at the peaks of the Gibbs-phenomenon ripple at the top of the square wave, which is not present at the lower output voltage level of the Analog output.

I also viewed the response of the M24 Line stage to three analog square wave test frequencies into a 100k load. I adjusted the function generator to produce a Line Output level of ±2.5Vpp. The response at 40Hz **(Fig. 26)** showed a mild and acceptable amount of tilt. The 1kHz and 10kHz square waves **(Figs. 27** and **28**, respectively) were just about perfect with a slight rounding on the leading edge and no hint of peaking or ringing.

A summary of the measured data as compared with the limited specified data is shown in **Table 2**.

LISTENING CHECK FOR HUM

After all these measurements, I connected the M24 into my audio system, between the digital output of my modified Rotel 970BX CD player[3] and my Parasound HCA1000A power amplifier. With the M24 in Tube Dac mode and full volume there is a low level of hum and a bit higher level of hiss. This is present whether there is any digital input signal to the M24 or not. Normal listening level was about 9 o'clock on the M24 volume control, where there is not even a hint of hum or hiss with my ear to the speaker. I also didn't notice any difference in the hum level in my audio system with or without the Jensen Cl-2RR connected between the M24 Analog Output and the Line Input.

I found the M24 to be very easy to listen to, although a bit less Line stage gain would allow a higher volume control setting. This would impose less volume control resistance between the Tube Dac section and the Line Out tube grids. *aX*

REFERENCES

1. "Inside the ISO-MAX," Hansen, C., *aX*, pp. 44-49, Oct. 2006.
2. "Grounding and System Interfacing," Galo, Gary; *aX*, pp. 26-33, Jan. '07.
3. "Upgrade Rotel's 970BX CD Player," Hansen, C., *aX*, pp. 26-31, Feb. '03.

FIGURE 29: Block diagram.

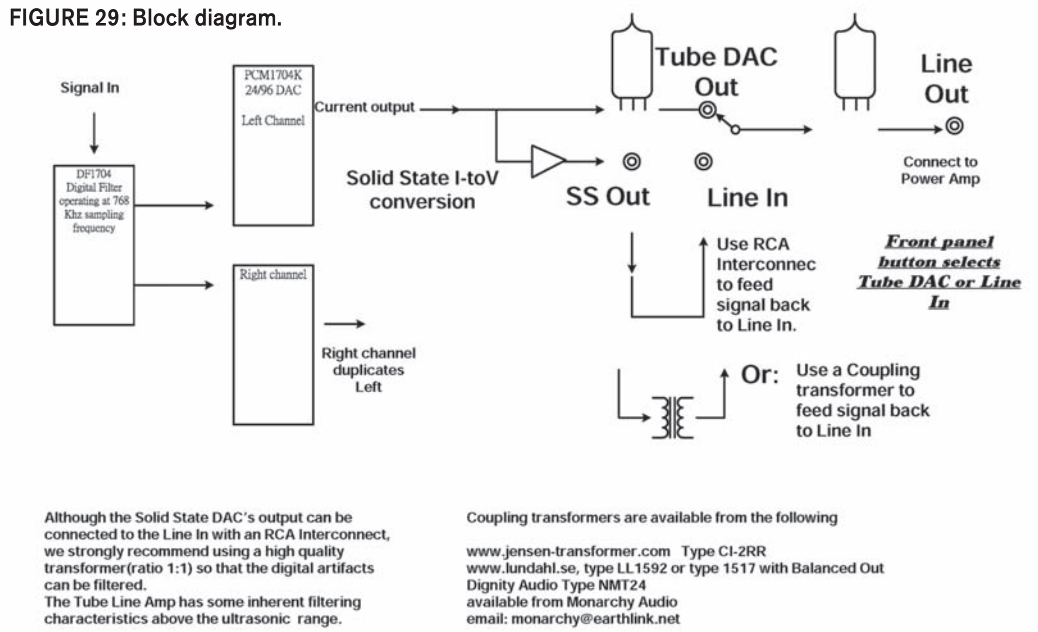

Table 2 – Monarchy M24 DAC Measured Performance

Parameter	Manufacturer's Rating	Measured Results
Gain:	16dB	18.5dBv (L), 18.7dBv (R)
Digital Compatibility:	44.1, 48 and 96kHz sampling;	
	16-bit and 24-bit data	Verified
Hum and Noise	N/S	-85dB rel 2V RMS
Separation	N/S	90dB rel 2V RMS, 10kHz
Frequency Response, 100k	N/S	
Tube Dac		-1dB 20-48kHz
Analog Out		-1dB 10-18kHz
Line Out		-1dB 13-80kHz
De-emphasis Attenuation	N/S	No
THD+N, 1kHz, 100k	N/S	
Tube Dac, 0dBfs		0.33%
Analog Out, 0dBfs		0.33%
Line Out, 2V RMS		0.105%
Line Input Impedance	N/S	See **Table 1**
Output Impedances	N/S	See **Table 1**
Line Output Voltage, 3% THD	N/S	27.1V RMS, 1kHz, 100k