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Terk VR-1 TV Volume Regulator

By Charles Hansen

Terk VR-1
Audiovox, 150 Marcus Blvd.
Hauppauge, NY 11788
631-231-7750
www.audiovox.com
Street price: $36
Warranty: 1 year limited

I grew tired of the jumps in volume when commercials came on our TV. It is especially bad with our local Public Broadcasting affiliate, whose news is aired by a much larger PBS network. Whenever a PBS promo comes on the volume jumps way up. The loud commercials during sports events are another example of dB madness. I saw a reference to the Terk VR-1 TV Volume Regulator a few months ago, and looked into it.

Terk is well known for its vast antenna product line. They are now part of the Audiovox line of equipment. The Terk VR-1 is a small plastic device with an AC power adapter and a cheap set of tin-plated RCA interconnects. It was easy to attach between my cable TV box and the television. You just connect the VR-1 between the cable box or satellite receiver composite audio outputs, and the audio line inputs on the TV. If you have an older TV, you can add a Terk Mini RF modulator to handle the line output from the VR-1 and then connect the composite video signal from the cable or satellite box to the modulator video input.

The spec sheet accompanying the VR-1 also has examples for interconnecting various other system components, such as VCR tape monitor jacks, TV audio outputs to a receiver, and so on.

The VR-1 can accept line level audio signals up to 5Vp-p (about 1.77V RMS or +7.18dBU). While this is not a problem for TV stereo audio signals from a cable or satellite box (the NTSC audio limit is +4dBU or 1.23V RMS), you should not feed audio line sources into the VR-1, which could be as high as 2V RMS (+8.24dBU). Some CD and DVD players have been known to be fractions of a dB higher than the Red Book standard.

There is a bypass switch that sends the line input signals directly to the outputs without processing.

PHOTO 1: Front View.

INSIDE THE VOLUME REGULATOR

Photo 1 shows the rear panel, with the line input and output jacks and the 12V DC power jack. The front of the unit has a green power LED and the bypass switch. The chassis is all plastic with four small round rubber feet, and the ID sticker says it was made in China.

Photo 2 shows the VR-1 with the cover removed. This side of the single-sided PC board contains all of the surface mount components. A 9V linear regulator chip provides all the internal DC power. Each channel uses an 8-pin SOIC IC, two SOT transistors, and a SOT diode as the active devices. The vendor logos and part numbers for all these parts have been obliterated. The unit is entirely electronic and does not use opto-isolator devices for the audio compression/limiting functions. The opposite side of the PC board contains all the radial electrolytic caps and the wire jumpers needed to complete circuits on the surface mount side of the board.

TOPOLOGY

A schematic was not furnished with the unit. I have read opinions on the web stating that the VR-1 uses Plantronics Octiv's Volume Logic/Optimax technology. One of the video chat rooms suggested a visit to octiv.com, but that site only lists software downloads for MP3 and iPod players. Their software is used to provide automatic gain reduction, compression, multiple audio band EQ, and noise reduction.

According to the buzz on the web, the next logical step was to move the Optimax technology to a stand-alone single chip device for consumer/pro audio use. In cooperation with Terk/Audiovox, they reportedly produced an IC for the VR-1. If you want to read all this for yourself, I suggest you Google Terk VR-1. The claims seem to change frequently. *Caveat legens*: let the reader beware.

In order to resolve all these conflicting claims, I took some time to trace the pc layout and make a schematic. Even with-

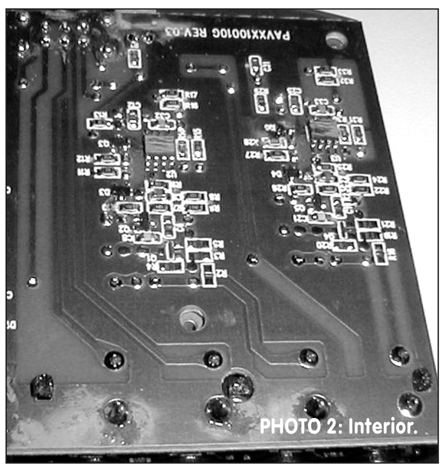

PHOTO 2: Interior.

out a device part number it was obvious that the 8-pin IC was an op amp due to the relationship of the IC pins to the VR-1 input/output jacks. The following description applies to each channel.

The audio signal is input to the non-inverting input of the op amp, whose resistive feedback network is configured with very high gain. In parallel with this is a variable-gain feedback network that uses an NPN emitter-follower circuit and a diode to store the positive peaks of the audio waveform. This peak signal is capacitively coupled to a common emitter amplifier that sinks some portion of the input signal to ground, depending on the amplitude of the output signal. This variable-gain feedback signal has a fast attack and slow release, with a compander (compressor-expander) gain characteristic.

There are no specifications with the VR-1 owner's manual except for the warning not to exceed an input signal level of 5Vp-p. The few specifications that are listed in **Table 3** were gleaned from an Internet site that sells the VR-1[1], but they did prove to be fairly close to my measurements.

MEASUREMENTS

Before removing the VR-1 from my TV for measurements, I held a portable AM radio directly over the plastic case. There was absolutely no buzzing sound that would indicate the presence of a digital processor clock. The case also has no metallic shielding, which would be required to keep any digital clock noise at bay.

The VR-1 maintains normal polarity. The input impedance measured about 18k, and the output impedance was 823Ω over the audio band. Without any input signal there was no transient noise when turning the unit on or off, or selecting Bypass.

Figure 1 shows the steady-state compander (compressor-expander) performance of the VR-1. The dashed straight line represents unity gain. When the input is less than approximately –25dBU, the VR-1 provides a reasonably linear gain of about 11dBU. The unity gain point occurs with an input signal of 139mV, or –14.9dBU.

When the input is greater than -15dBU, the compressor characteristic takes over and is frequency dependent, as you can see from the way the four curves deviate from each other above that level. The 20Hz curve (bottom) has the greatest amount of compression and becomes flat at an output level of –13.5dBU. At 32Hz the compression ratio is reduced and only flattens at the highest limit of the input range. The 63Hz compression is within 0.5dBU of the 1kHz curve.

The maximum gain at low input levels is 11.6dBU, while the maximum compression at 20Hz is –20.8dBU. This is equal to 32.4dBr of what the referenced website calls "normalization." Normalization is used in digital audio recording to apply a constant amount of gain to an entire recording to bring the highest peak to a level close to 0dB, so I'm not sure whether normalization is an accurate description of the VR-1's companding.

I recorded the frequency response (**Fig. 2**) into a load of 100k with input signal levels from 10mV to 1.77V RMS (–37.8 to +7.18 dBU). The frequency response for the VR-1 with a 500mV (–3.8dBU) input signal was within –1dB from 20Hz to 20kHz. At lower input levels, the HF response fell off more rapidly. Reducing the load to 10k did not appreciably affect the LF response. At higher input levels, the LF response fell off more rapidly. Because the maximum input limit is specified by Terk at 5Vp-p (1.77V RMS), there was nothing to be gained in exploring input levels beyond this, since the VR-1 would not experience even that level in its intended application.

Because the bandwidth is quite wide in the VR-1, wider even than SACD, this is further evidence that there is no analog-digital-analog conversion in play here.

Output hum and noise (input shorted) measured 1.15mV or –57dBU, with no DC offset. Viewing this output signal on my analog oscilloscope showed just broadband noise.

Crosstalk performance with a fixed 500mV input signal and the opposite input shorted showed the response to be the inverse from the usual audio equipment, where parasitic capacitive coupling increases crosstalk with frequency

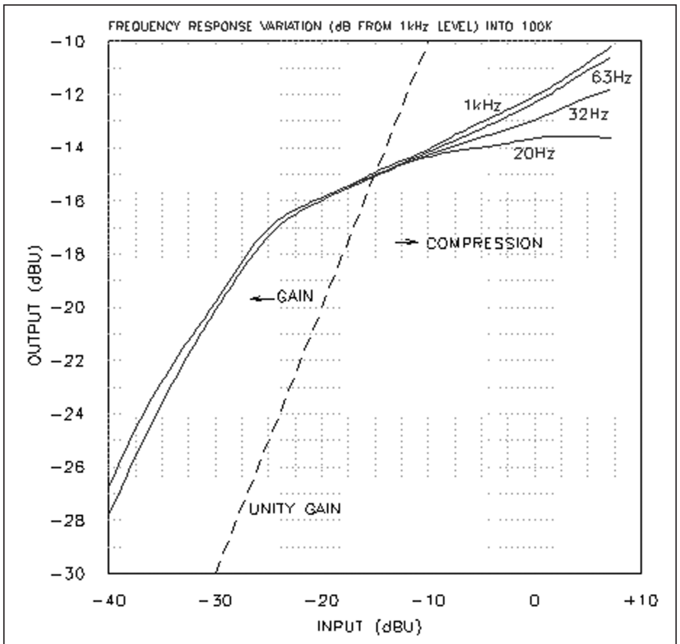

FIGURE 1: Output Compression Ratio vs. Input Level.

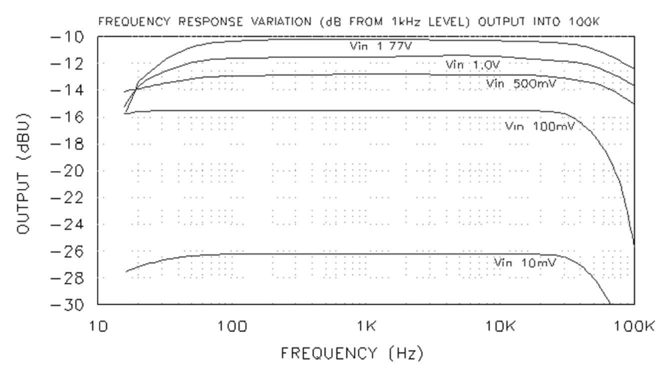

FIGURE 2: Frequency Response.

(**Table 1**).

Figure 3 shows the output THD+N versus frequency for the VR-1 at various input signal levels. Above 100mV a peak occurs at 60Hz which may be due to insufficient filter capacitance in the 12V DC 100mA plug-in power adapter. Decreasing the load resistance to 10kΩ accentuated the 60Hz peak (not shown).

The graph of output THD+N versus input voltage in **Fig. 4** shows that the area of lowest distortion is quite narrow, and occurs at an input voltage of 325mV. There is a noticeable discontinuity in the drop in THD+N on the left side of the graph that roughly corresponds to the transition from gain to compression at the 139mV unity gain line in **Fig. 1**.

The distortion residual for a 325mV RMS input signal at 1kHz is shown in **Fig. 5**. The upper waveform is the distortion test set sine wave input signal, and the lower waveform is the monitor output (after the THD test set notch filter), not to scale. This distortion residual signal shows discernible harmonics along with the noise. The THD+N at this point is 0.31%, corresponding to the minimum distortion point in the curve of **Fig. 4**.

TABLE 1: TERK VR-1 CROSSTALK PERFORMANCE.

Frequency	Crosstalk
100Hz	-41 dBU
1kHz	-45 dBU
10kHz	-47 dBU
20kHz	-48 dBU

The spectrum of a 50Hz sine wave is shown in **Fig. 6**, from zero to 1.3kHz. I again adjusted the input signal level for the lowest output THD+N. A decreasing series of harmonics is present along with a series of 60Hz power line harmonics. The 2nd harmonic is –41dB (0.89%) while the 60Hz line is –49dB (0.36%). The measured THD+N is 1.3%, and the THD calculated from the 50Hz harmonics is 1.01%.

I repeated the FFT spectrum analysis with a 1kHz sine wave (**Fig. 7**), with the input signal adjusted to 325mV RMS. The 2nd harmonic is –56dB (0.16%). The measured THD+N is 0.31%, while the THD calculated from the 1kHz harmonics is 0.16%.

Figure 8 shows the VR-1 output spectrum reproducing a combined 11kHz + 12kHz intermodulation distortion (IMD) signal at 2.5Vp-p into 100kΩ. The 1kHz IMD product is –35dB (1.78%) with a veritable picket fence of IMD products throughout the spectrum, due to the intentional nonlinearity of the compander circuitry. The signal peaks from 18kHz-20kHz are

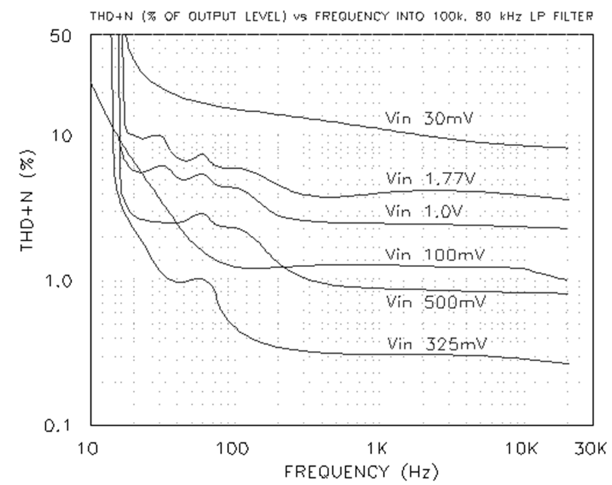

FIGURE 3: Output THD+N vs. Frequency.

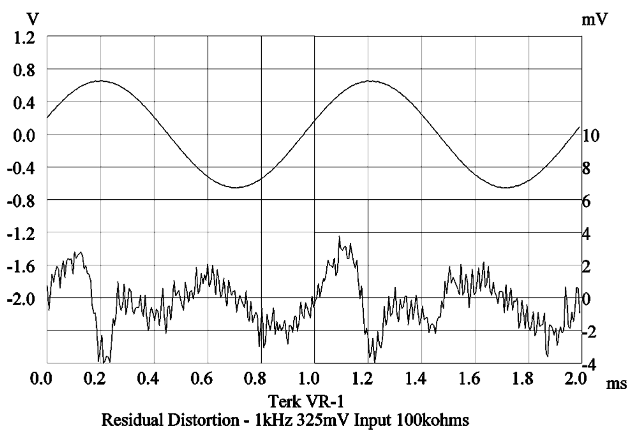

FIGURE 5: Residual Distortion—1kHz.

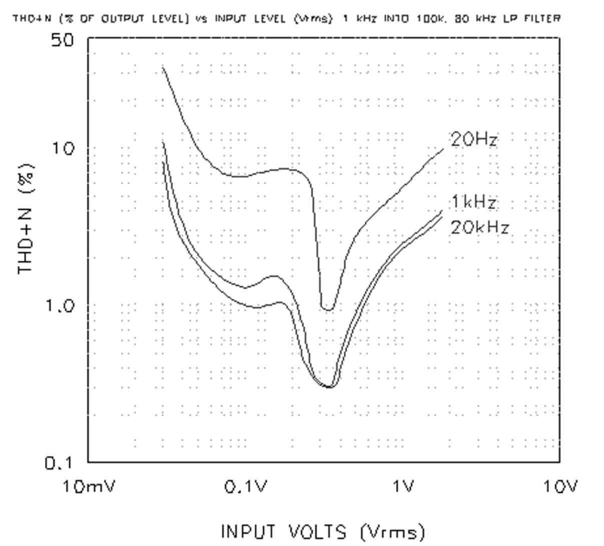

FIGURE 4: Output THD+N vs. Input Level.

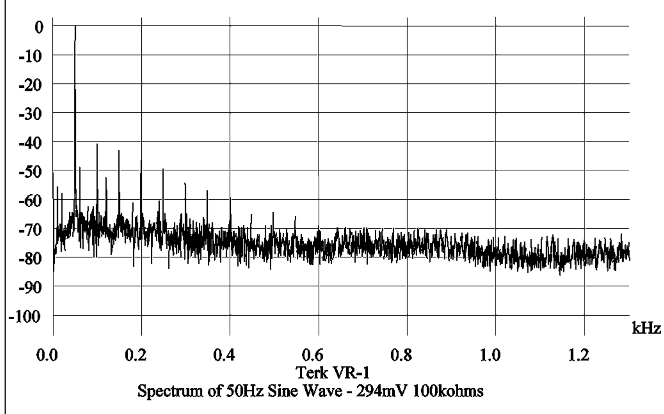

FIGURE 6: Spectrum of 50Hz Sine Wave.

particularly puzzling.

SQUARE WAVE TESTS

I viewed the response of the VR-1 to three square wave test frequencies at 2.5Vpp input. The response at 40Hz (**Fig. 9**) shows a large amount of tilt, compression, and phase shift. The 1kHz square wave in **Fig. 10** has just a slight amount of tilt. The best looking of the bunch is the 10kHz square wave in **Fig. 11**, which had just a slight bit of rounding on the leading edge, with no hint of peaking or ringing.

Dynamic Response to Tone Burst and Step Transients

I performed all the foregoing tests with steady-state test signals, and used dynamic test signals for the next series of tests.

Figure 12 shows the response to a 1.77V RMS 20Hz sine wave tone burst. The initial attack is quite sharp, with a slow release. There is also noticeable phase shift, which I would not expect to see if the VR-1 used a digital filter in the signal chain. At 100Hz (**Fig. 13**) the attack is not as sharp, but there is a noticeable difference between the positive and negative half-cycles, with slewing on the negative side of the output waveform. **Figures 14–16** are tone bursts of 400Hz, 1kHz, and 10kHz, all at 1.77V RMS.

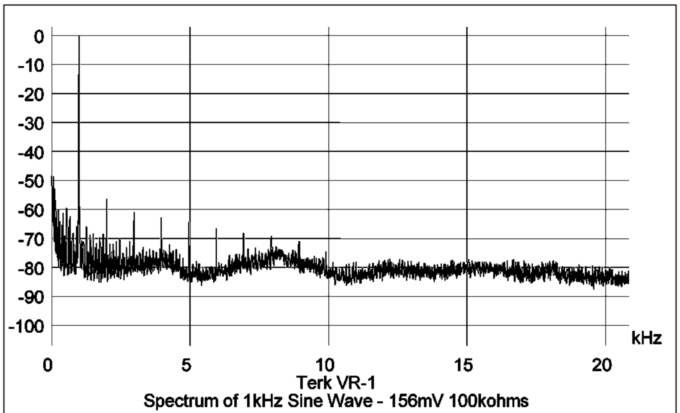

FIGURE 7: Spectrum of 1kHz Sine Wave.

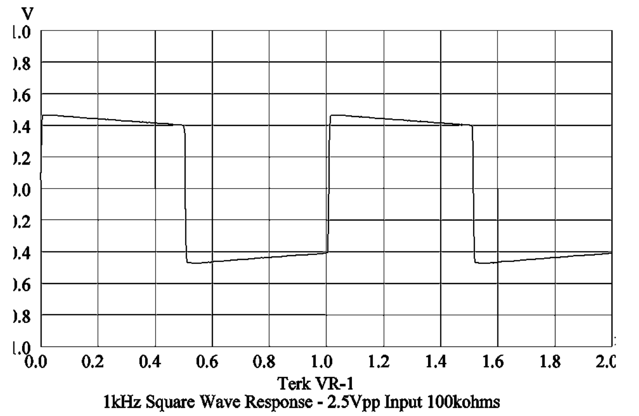

FIGURE 10: 1kHz Square Wave Response.

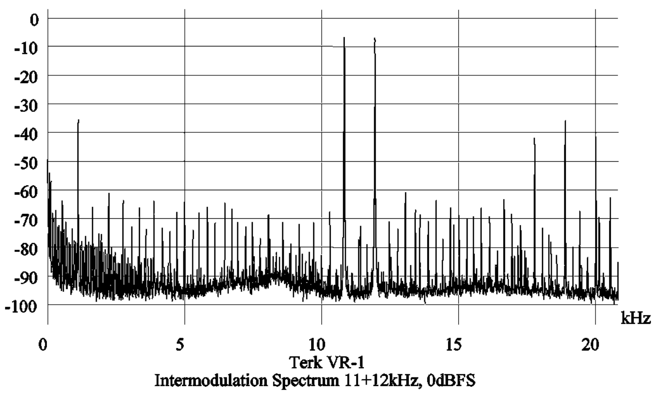

FIGURE 8: Spectrum of 11kHz + 12kHz Intermodulation Response.

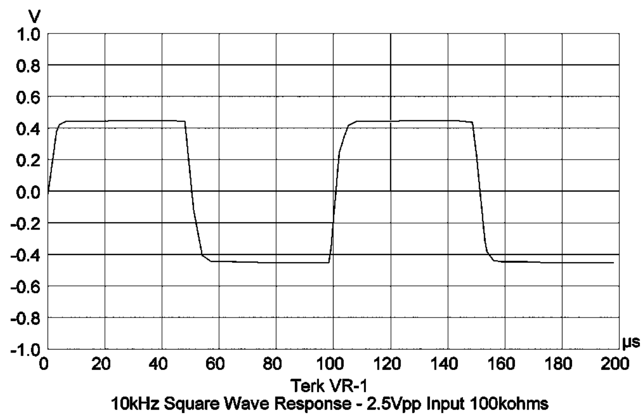

FIGURE 11: 10kHz Square Wave Response.

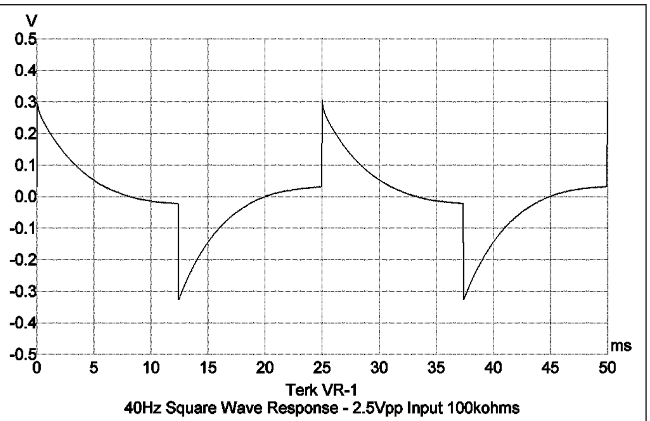

FIGURE 9: 40Hz Square Wave Response.

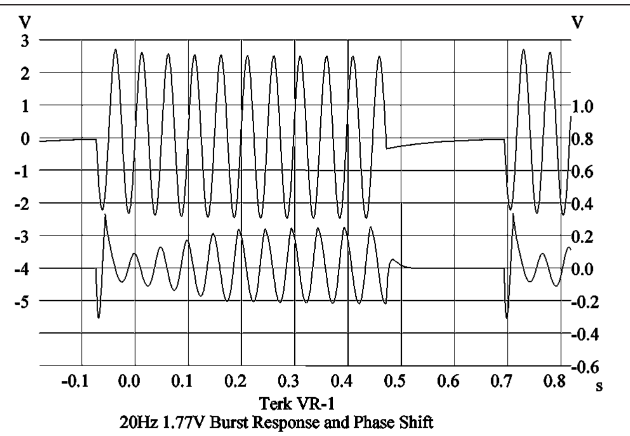

FIGURE 12: 20Hz 1.77V RMS Tone Burst Response.

Table 2 shows the percentage to which each of the tone burst peak-peak voltages was reduced from the peak of the initial attack to the following peak. You would expect the percentage of reduction to decrease with frequency in accordance with **Fig. 1**, but the distortion level is very high at the beginning of output waveform compression. Given this high level of distortion, the crest factor would introduce considerable error when converting the peak-peak voltages in the scope traces to RMS.

What the tone bursts do show is that it takes about 20msec for the VR-1 to make its maximum reduction from the start of the tone burst. **Figure 16** shows only 1.5msec of the total burst, but when I increased the time/division (not shown), the delay to the minimum peak-peak level was also 20msec. The release time is much slower. **Figure 12** shows that it takes about 200msec from the initial attack to the final steady-state level. This initial attack-release is quite audible when the cable box and TV are first turned on.

Once the circuit adapts to the average output signal amplitude, it is only audible when there are sharp impulses, such as words that start with "p" or "t." The resulting pop produces a transient in the bass frequencies that causes the VR-1 to produce its maximum fast attack and slow release envelope. This causes a snapping sound followed by an overall reduction in volume until the completion of the release delay.

TABLE 2: PERCENT COMPRESSION IN INITIAL RESPONSE LEVEL.

20Hz	26% of initial in less than 50msec
100Hz	85% of initial in 20msec
400Hz	83% of initial in 20msec
1kHz	70% of initial in 20msec
10kHz	68% of initial in 20msec

TABLE 3: COMPARISON OF "SPECIFICATION" VS. MEASURED RESULTS.

Parameter	Rating (see Ref. 1)	Measured Results
Input Impedance	20kΩ	18kΩ
Input Signal Range	0 to 5Vp-p	Did not test
Frequency Response	20Hz-20kHz	20Hz-20kHz +0/-1dB
Output Impedance	600Ω	832Ω
Output Signal Range	0 to 2.8Vp-p	239mV RMS (676mVp-p)
Normalization	30dB	32.4dB

Figure 17 shows the 1kHz tone bursts at a reduced level of 500mV. Here the peak-peak level is attenuated to 81% of the initial value as compared to 70% for the 1.77V RMS signal, again in 20msec.

My final test of the VR-1 transient performance was to make step inputs of +2.5V DC (**Fig. 18**), then -2.5V DC (**Fig. 19**). The input step is at the top, and the output response is at the bottom.

In a capacitively-coupled circuit, the time constant $\tau = RC$, where τ represents the time it takes the step response to get to 63.2% of its final value. The time constant for the output response envelope for both the positive and negative step inputs is 2.3msec.

Note the short burst after the initial output peak. **Figure 20** is an expanded plot of the initial +2.5V step response. This burst has a frequency of about 70kHz and lasts for about 100μsec.

A comparison chart of "specified" data versus measured results is shown in **Table 3**.

LISTENING RESULTS

So how does the VR-1 Sound? I connected the VR-1 between my preamp and power amp, making sure to set the preamp volume control low enough so as

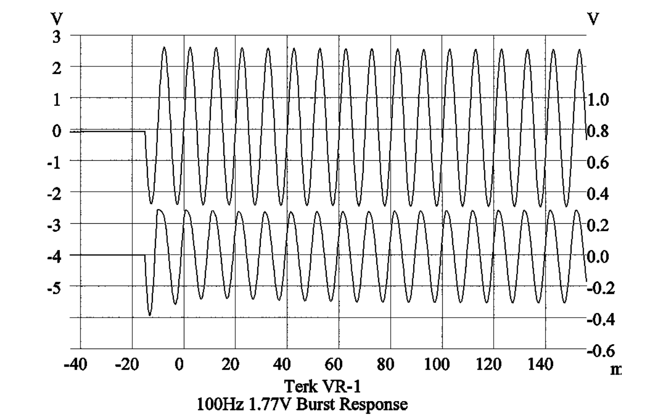

FIGURE 13: 100Hz 1.77V RMS Tone Burst Response.

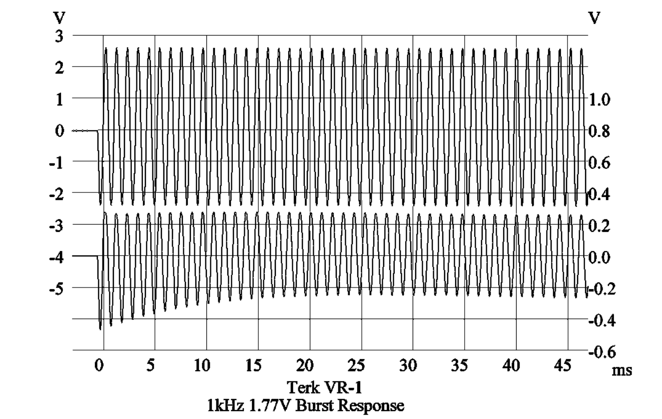

FIGURE 15: 1kHz 1.77V RMS Tone Burst Response.

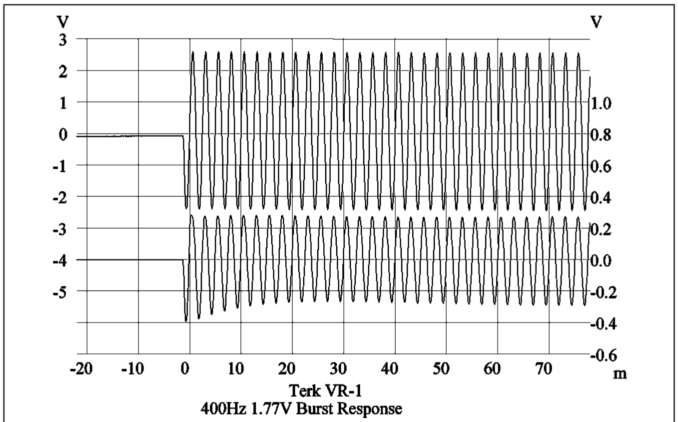

FIGURE 14: 400Hz 1.77V RMS Tone Burst Response.

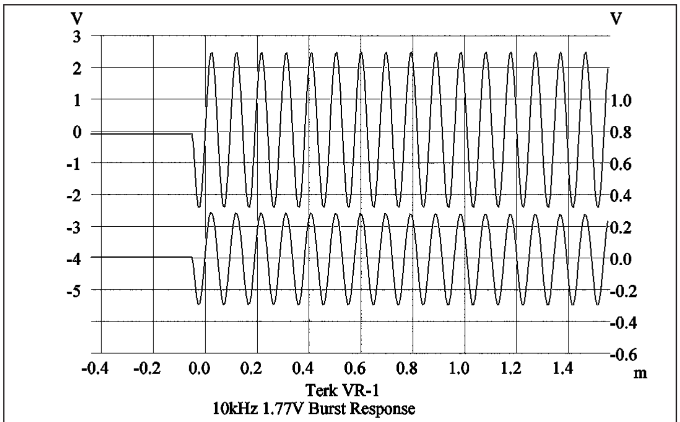

FIGURE 16: 10kHz 1.77V RMS Tone Burst Response.

not to exceed the 5Vp-p input limit. The VR-1 closely approximates the heavily compressed audio you would hear on an FM rock station, but with a bit more distortion. However, the VR-1 is not intended to be used for this purpose. If I want to watch concerts or the symphony on TV, I use the Bypass switch. Otherwise, the added distortion will be evident on most music.

I now have a few months' experience with it as a TV volume regulator, and it does indeed fulfill its role in leveling the differences between loud and soft audio passages.

The only annoyance with the VR-1 is the snapping noise that occurs with words that begin with "p" or "t," as I described. The initial attack of the VR-1 is quite aggressive, and many TV stations use compressors and/or limiters to stay below the maximum allowable audio signal modulation. When you place a compander (VR-1) in series with a compressor/limiter, the results can be audible. *aX*

REFERENCE

1. www.chumbo.com/Info.aspx?id=252665

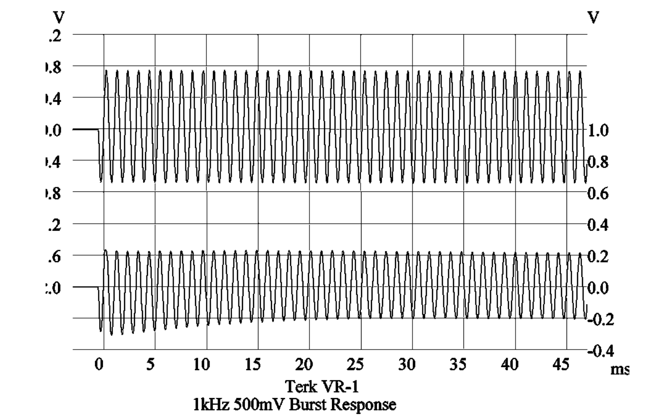

FIGURE 17: 1kHz 500mV RMS Tone Burst Response.

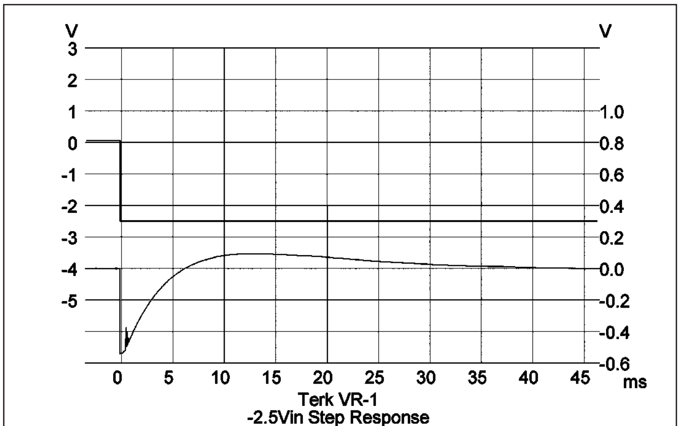

FIGURE 19: -2.5V Step Response.

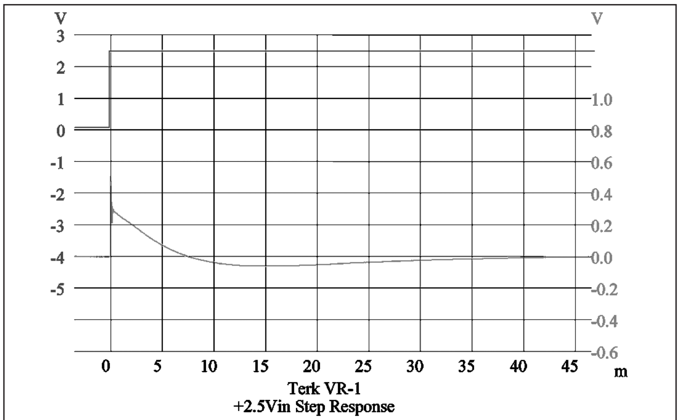

FIGURE 18: +2.5V Step Response.

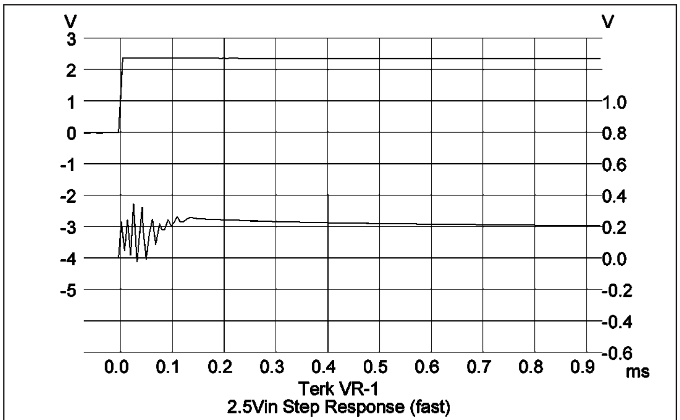

FIGURE 20: +2.5V Step Response Expanded.