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HUGHES AK-100 SOUND RETRIEVAL SYSTEM DECODER

Manufacturer's Specifications

Passband: 20 Hz to 20 kHz. (Due to the manner in which the SRS and "3-D Mono" circuits operate, frequency response specifications do not apply here.)

A-Weighted S/N: Bypass mode, 93 dB at maximum input/output and 84 dB at 500 mV rms; SRS mode, 98 dB at maximum input/output and 86 dB at 500 mV rms. (See note below.)

THD + Noise at 500 mV: Bypass, 0.01% at 1 kHz; SRS, 0.25% at 1 kHz. (See note below.)

Input Levels: Minimum, 30 mV rms; maximum, 1.4 V rms.

Maximum Output Level: 3.9 V rms with 1.4 V rms input and all controls at maximum.

Impedances: Input, 50 kilohms; output, 30 ohms.

Power Requirements: 105/125 V a.c., 60 Hz, 15 watts maximum.

Dimensions: Approximately 17 in. W × 4 in. H × 11½ in. D (43.2 cm × 10.2 cm × 29.2 cm) including projecting controls.

Weight: 8 lbs., 5 oz. (3.8 kg).

Price: \$399.

Company Address: P.O. Box 7000, Rancho Santa Margarita, Cal. 92688.

For literature, circle No. 91

Note: Maximum-level measurements made with 1.4 V rms input, all controls at maximum; 500-mV measurements made with 500 mV rms input, "Level" at maximum, "Space" at midpoint, and "Center" set for output level of 500 mV rms.

I first encountered the Hughes Sound Retrieval System (SRS) about three years ago, when I was asked to evaluate a stereo enhancement system developed by the Microelectronic System Division of Hughes Aircraft Company out in Southern California. During that visit, I entered a room in which two small speakers, no more than a couple of feet apart, were positioned on the floor. At my listening position was a switch with a couple of controls. The music began, and, of course, stereo separation was virtually nonexistent

with the speakers placed so close to each other. Arnold Klayman, the inventor of SRS, then asked me to push the switch. The sound spread out before me was then so startling that I was certain additional speakers had been turned on. Yet there were none.

At first, Hughes sought to license other manufacturers to use the SRS technology. They succeeded in signing Sony (which has used SRS in many large-screen stereo TV sets) and, more recently, Thomson Consumer Electronics (which



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markets RCA TV sets). Now, Hughes has decided to market a stand-alone SRS decoder, the AK-100.

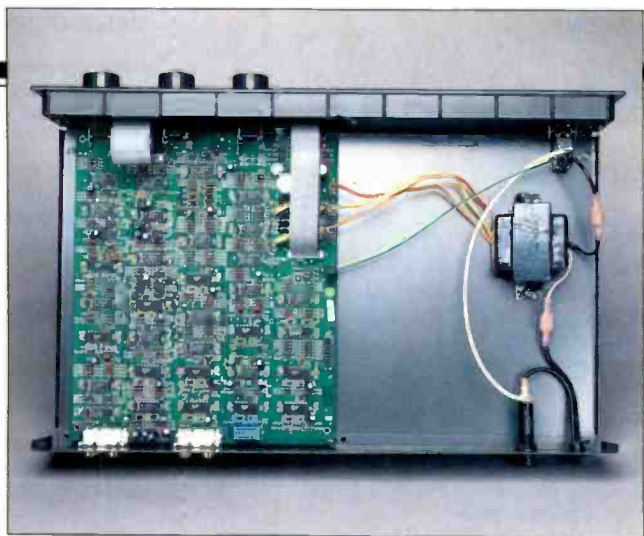
The AK-100, unlike several other stereo enhancers, does not have time-delay processing. Its Sound Retrieval System is single-ended, requiring no prior encoding of program sources. It employs no artificial reverberation, and neither does it use harmonic generation or artificial phase correction or alteration.

Human ears are the most important link in the audio chain, and SRS is based on certain principles of human hearing that have been explored by Hughes researchers and others over the years. In a stereo system, normally the sum signals (L + R) contain all of the direct and centrally positioned sounds; the difference signals (L - R and R - L) provide spatial information and directional cues to the human hearing system. The Hughes system addresses the fact that the transfer function of human hearing is not constant: It changes with each degree of azimuth. For example, sounds coming from straight ahead have a different transfer function, or frequency characteristics, than sounds coming from the sides or from the rear. Aside from other aural cues, such as time of arrival and relative sound intensity at each ear (once thought to be the only elements involved in stereo perception), we use this transfer function to zero in on the directions from which sounds emanate. Unfortunately, microphones do not pick up sound in this manner and will not provide these spatial cues. SRS takes into account the varying transfer function of human ears and hearing in a continuous and dynamic manner. It processes the difference and sum components so that the resulting signals correspond with the spectral registration of human hearing. To put it simply, we are tricked into believing that sounds are coming from locations other than the two loudspeakers in front of us. Depending on the source material, it is even possible, on occasion, for SRS to provide a surround soundstage like that achieved with multiple speakers.

The AK-100 hooks into any stereo system via the usual in/out loop used for tape decks or equalizers. If the only tape loop is already being used by a tape deck, it can be reconnected via the in/out loop on the AK-100 itself. If you have a separate equalizer in your system, Hughes recommends that it be placed in the signal path *after* the AK-100. Clear diagrams in the owner's manual detail installation and wiring procedures for a variety of equipment combinations, including the use of the AK-100 with a TV monitor/receiver and a VCR. If you own a mono VCR, the AK-100's stereo synthesizing circuit (about which more later) can be used to create a very effective simulation of stereo sound.

Control Layout

The AK-100 is about the size of a typical preamplifier, but that's where the resemblance ends. A pushbutton at the left end of the front panel turns on power and illuminates an



indicator light. An SRS in/out switch comes next, and a green light nearby confirms when SRS is active. A pushbutton bearing the label "Rev Trim" (reverberation trim) is next, allowing you to subtly reduce the amount of reverberation around a singer's voice. Pushing this switch will also decrease the amount of ambient information during quiet passages in music or in film soundtracks. The "3-D Mono" switch, next to the right, allows you to achieve a surround-type atmosphere when the input signal is mono.

The AK-100 may reproduce low-frequency rumbling found in some TV and video programs. For this reason, it incorporates a "Filter" circuit that, when activated, attempts to correct the problem with only minimal processing. The next switch engages the external loop circuit mentioned earlier. Because of the way this loop is arranged in the signal path, SRS will not interfere with the recording capabilities of any tape deck connected to it.

Hughes has come up with an unusual display "meter" which shows the amount of center (L + R) and "Space" (L - R or R - L) audio information coming out of the AK-100. If you are in the bypass (no SRS) mode, the displays represent the original mix of L + R (the vertical display) and L - R or R - L (the horizontal display). If SRS or "3-D Mono" is activated, the displays represent the signal after processing. The display can be turned off or be changed from what Hughes calls the "Bar Mode" to the "Dot Mode." Not surprisingly, when watching the display I noticed that the "Space Left" (L - R) area was not always equal to the "Space Right" (R - L) area when SRS was active. If more action occurs in the left side of the audio program, the "Space Left" display will extend further than "Space Right"—and vice versa.

Perhaps the most important controls are the pair of rotary knobs near the right side of the front panel, "Space" and "Center." The "Space" control allows you to adjust the amount of SRS ambience information (L - R and R - L) in the audio output. Turning the "Space" control clockwise widens the apparent soundstage. The "Center" control adjusts the amount of L + R information in the output. If a center vocalist seems to be too far in the background relative to orchestral accompaniment, you would increase the setting of the "Center" control and reduce the setting of the "Space" control. Each control has a center detent,



The Hughes SRS circuit works because the human ear's frequency response changes with the direction of the sound source.

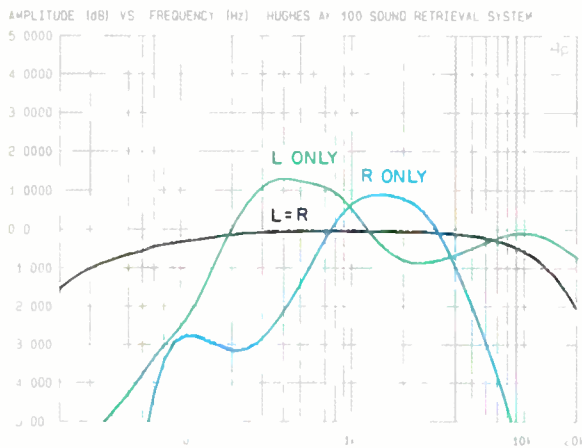


Fig. 1—Frequency response with identical left and right (mono) signals, with left-only signal, and with right-only signal; see text.

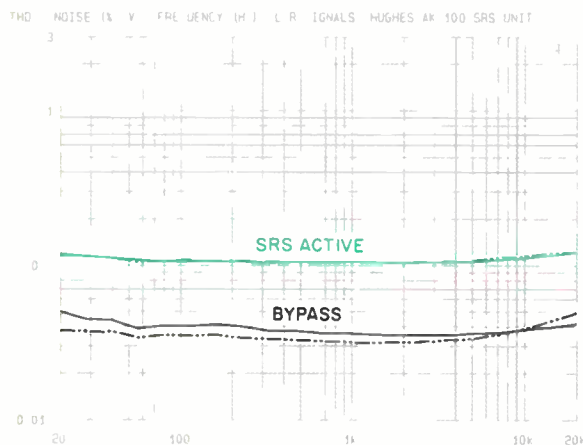


Fig. 2—THD + N vs. frequency for 500-mV input signals applied to both inputs. Left channel is solid curve, right channel is dashed.

which I found was a good place to begin when setting up the AK-100 for any kind of musical program. The rightmost rotary knob is a "Level" control for adjusting output level. Hughes recommends that you initially set "Level" at maximum. If, however, this setting results in clipping or overdrive of other components in your system, it can be lowered.

The rear panel of the AK-100 is equipped with pairs of input and output jacks and the loop input and output jack

pairs. A fuse-holder containing a 3/8-ampere line fuse is also found on the rear panel. The unit has no remote control.

Measurements

For a component of this type and purpose, relatively few significant bench tests need be performed. I simply wanted to ascertain whether or not the AK-100 would add an undue amount of distortion or decrease the available dynamic range and signal-to-noise ratio of a typical stereo system.

The manufacturer cautions that measurements of frequency response may be deceptive when using the SRS feature. However, I decided that if I applied identical left and right signals to the two inputs, the SRS circuit would consider that to be essentially a monophonic signal. Such an input signal should, I conjectured, result in reasonably flat response. It did, as is confirmed in Fig. 1. Response is down only 1.5 dB at 20 Hz and just over 2 dB at 20 kHz. I also measured response for a left-only input signal and for a right-only input signal. Although response under actual music listening conditions will vary dynamically, the results shown in Fig. 1 are at least suggestive of one of the elements used in the SRS scheme to "fool" our brains into believing that sound is coming from locations well beyond the speaker separation distance. The alterations from flat response shown for the single-channel signals are, however, only part of what the AK-100 is doing to create its psychoacoustic effects.

Total harmonic distortion plus noise was measured next, both with and without SRS (Fig. 2). Clearly, activating SRS does result in a moderate amount of distortion, with a reading of around 0.1% for a 500-mV input. Considering the sonic benefits achieved with SRS, I don't think a THD + N of 0.1% is worth worrying about. Note too that this reading is well below the manufacturer's claimed limit of 0.25%. In the bypass mode, THD + N decreases substantially, to between 0.03% and 0.05%.

Figures 3A and 3B show the results of an FFT spectrum analysis that I conducted to isolate actual harmonic distortion products from residual noise. Figure 3A was plotted with SRS turned on, and a second-order harmonic at around -78 dB can be observed along with a third-harmonic component at around -82 dB. Calculating the equivalent percentage of THD, I came up with a figure of 0.015%. In bypass mode (Fig. 3B), a much smaller amount of second-harmonic distortion is noted at around -88 dB, corresponding to a THD percentage of 0.004%. These results show that the higher overall figures of THD + N are really the result of noise contributions rather than actual distortion.

Figure 4 illustrates the distribution of residual noise of the AK-100 as a function of frequency, in third-octave increments. I also took overall readings of A-weighted S/N. With SRS turned on, the results were 85.4 dB referenced to 500 mV input and output and 98.4 dB referred to maximum input and output. With SRS bypassed, A-weighted S/N was 90.2 dB referred to 500 mV input and output and 93.6 dB referred to a maximum input of 1.4 V.

Use and Listening Tests

Having heard an early prototype of the stand-alone SRS component, I was anxious to find out if the final production unit lived up to the promises of the handmade sample. It not

SRS not only helps when speakers are unusually close together but works better when they are positioned that way.

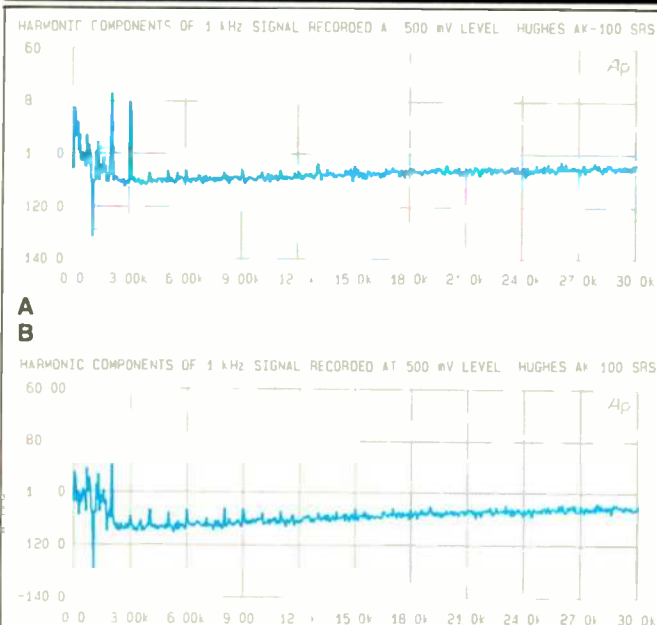


Fig. 3—Spectrum analysis of harmonics of 1-kHz, 500-mV signal with SRS active (A) and bypassed (B).

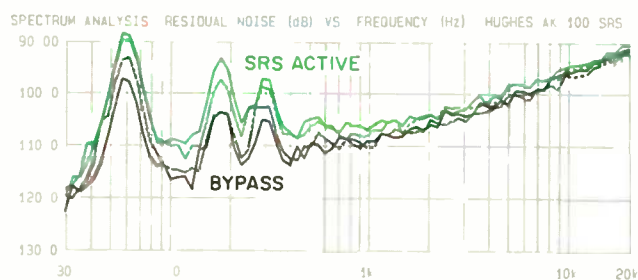


Fig. 4—Spectrum analysis of residual noise, referenced to 500-mV input.

only did—it surpassed it. One element that the early and new units have in common requires some explaining. You'll recall that in my initial exposure to SRS, the two speakers were very close to each other. In listening to the AK-100, I found that it too is most effective when the speakers are somewhat closer to each other than you would normally position them. I moved my KEF 105 Mk.II systems until they were no more than 6 feet apart, and results were far better

than when they had been 8 or 10 feet apart. Sound literally wrapped around me. I have a set of one of my favorite operas, Mozart's *The Magic Flute* (Deutsche Grammophon 410967-2), with the late Herbert von Karajan conducting the Berlin Philharmonic Orchestra. There are several moments in the opera when characters are supposed to be offstage or at the extreme left or right end of the stage. I had never been able to create these effects before, but with SRS in the signal path, they were startlingly realistic. And, when vocalists were supposed to be center stage, they remained clearly fixed in that position, even when I shifted my own listening position to either side of the listening room! That is one of the nicest things I discovered while listening with SRS: It does not depend upon a so-called "sweet spot" to be effective. You can move about the room and still hear a perfectly spread-out soundstage.

A couple of years ago, Telarc issued a two-CD album of Benjamin Britten's *War Requiem* (CD-80157 2CD). Robert Shaw conducts the Atlanta Symphony Orchestra and Chorus in this long, highly emotional work. This set also features the Atlanta Boy Choir and three vocal soloists. I had played these discs many times, but never had I enjoyed the performance as much as I did using the AK-100. I did find that I wanted to bring up the vocalists, who initially seemed to be somewhat overpowered by the chorus and orchestra. This adjustment was easily made with a somewhat lower setting of the "Space" control and an almost fully clockwise (maximum) setting of the "Center" control. The advantage of not having to worry about a sweet spot is particularly apparent when making adjustments on the AK-100. I was delighted to find that I could make adjustments at the front panel until everything sounded just right, and when I returned to my seat, the sound was still the way I wanted it to be.

I have a two-disc reissue of the famed Benny Goodman concert performed at Carnegie Hall back in 1938 (Columbia G2K 40244). Naturally, the concert was recorded monophonically, and while the digital remastering at CBS removed a lot of the original tape hiss, the result was still monophonic. I decided to try the "3-D Mono" setting on the AK-100 for this treasured performance. I could not believe my ears! I have heard stereo synthesizers before, but never had I heard one that actually sounded as though the program were being reproduced stereophonically. I was tricked into believing the recording was stereo (though, of course, I knew better), and it sounded like wide, expansive stereo. Audience applause came from a broad stage and even from the sides of my listening room. Frankly, although I understand the principles SRS uses to enhance true stereo program material, the manner in which Klayman achieved his "3-D" mono enhancement is beyond me. All I can do is enjoy it and stop wondering how it was done.

I don't know quite how to classify the AK-100. It's an accessory, but that classification tends to diminish its incredible capabilities. But regardless, the AK-100 is an incredible component that's certainly worth auditioning and owning. If you don't care for what SRS does to some music, there's always the option of bypassing it. However, I'll wager that most people who own TV sets equipped with SRS, or who add it to their sets by hooking in this unit, will probably leave it on at all times.

Leonard Feldman