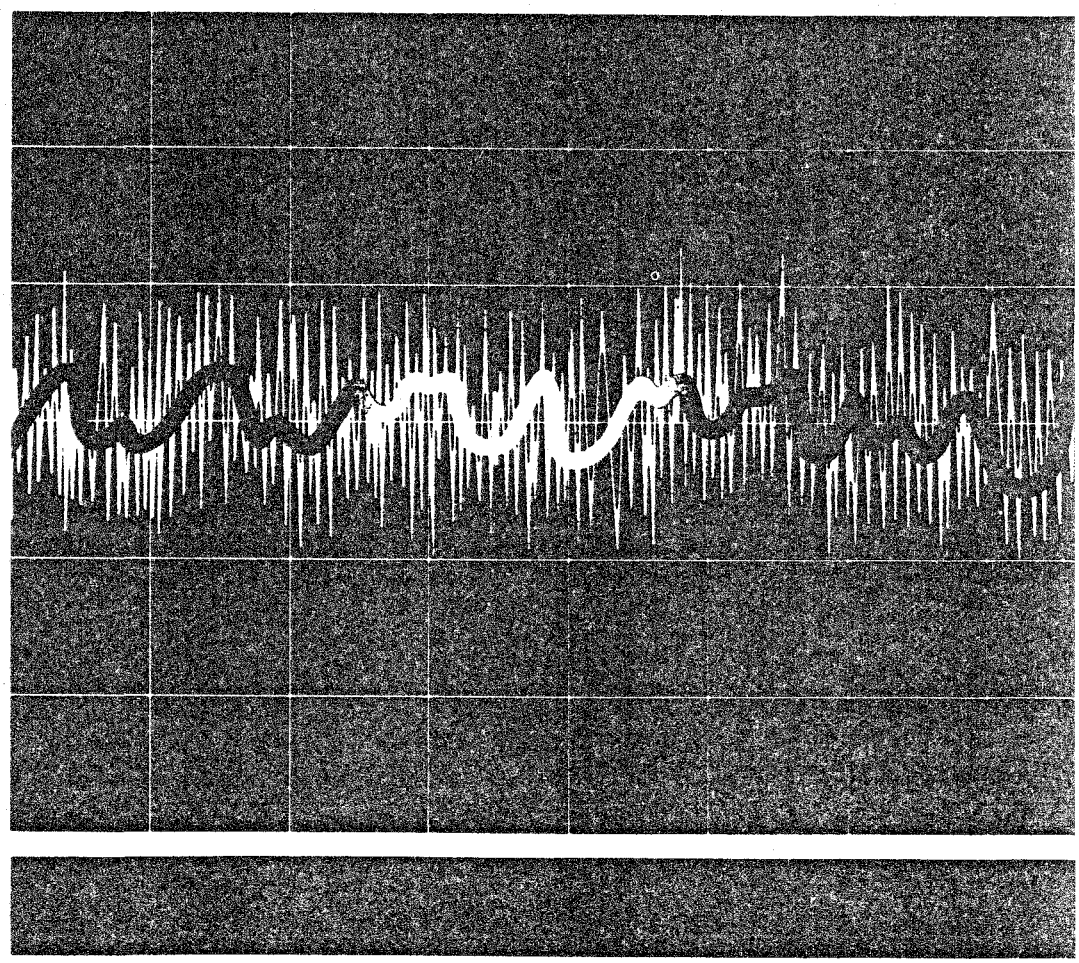
National
Semiconductor
Corporation

DNR™
DYNAMIC NOISE REDUCTION SYSTEM

DNR™
The Standard For:
Stereo TV—Hi-End TV
Video Cassette
Cable TV
Hi-Fi Audio



DNR is the only universal noise reduction system that requires no special encoding. Having become the standard for the audio/video industry has prompted several publications to highlight the many benefits and applications of **DNR.**
Four of these articles are reprinted herein.

DNR was Awarded the 1981 Hi-Fi Grand Prix Special Citation for Excellence in Fidelity of Sound Reproduction, Design Engineering, Reliability, Craftsmanship and Product Integrity.

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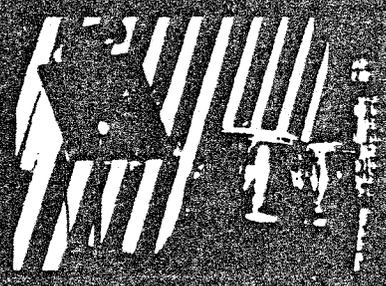


LEN FELDMAN

db Sound With Images

Handling Beta and VHS Audio

• Let's face it! As a person involved in the professional end of audio you will, sooner or later, have to deal with the audio tracks of so-called "home video recorders," whether they are Betamax VCRs or VCRs which subscribe to the VHS format developed by JVC and used by a dozen or more other companies who distribute their products in the U.S. More and more, pro audio people (whether in broadcasting or recording studio work) are finding it necessary to deal with the less-than-high-quality (to put it mildly) audio tracks which are treated almost as an afterthought in both the Beta and VHS home video recording formats. Of course, the poor quality of the audio signal recorded on video tape should come as no surprise to those of us who have been involved in audio and video for some time. The attitude of video people has always been: "The picture comes first, and let the audio fall where it may." It wasn't until just a couple of years ago, when satellite transmission of sound and picture (for public TV, at least), and multiplexing of audio on the video coaxial cable became a reality that anyone worried about audio frequency response extending beyond 5 kHz or so. That, after all, was the high frequency capability of "typical" long-line telephone lines that were used to carry the audio portions of network programs around the country. No wonder then that the originators of home VCRs didn't place too much emphasis on audio quality when they standardized their formats.

Before we can deal with Beta or VHS audio in the recording or broadcast studio, let's take a look at just what we can expect by way of audio fidelity in each of those VCR formats.

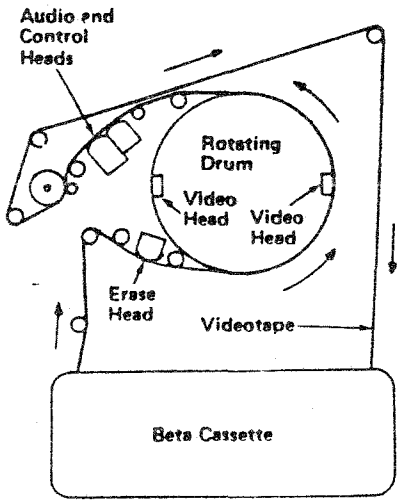
Have you ever wondered why the home VCR systems which, after all, are capable of storing video signal frequencies of well above 2 MHz, have so much trouble maintaining flat *audio* frequency response out to 10,000 Hz (or, in some cases, to a lot less than that)? To understand this seeming contradiction, you have to know a little about how both video and audio signals are recorded in a VCR. In the accompanying diagram we see the tape path employed in both the Beta and VHS video recording systems. Video record/play heads are mounted so that their gaps are on the perimeter of a rotating drum. That drum rotates at 1800 rpm, which adds up to 30 revolutions per second. This speed was selected because in the U.S., the NTSC TV standards call for 30 pictures or "frames" per second to be projected on our video screens. So, although the tape itself is moving at a relatively slow speed, as far as the video head-to-tape speed is concerned, it is extremely rapid. In just one revolution of the video head drum, the system has scanned two video fields, or one complete video frame.

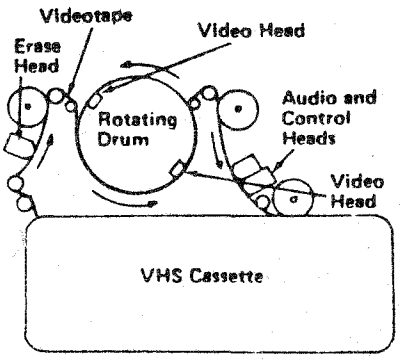
That's all well and good as far as the video luminance (brightness) and chrominance (color) signals are concerned. But when it comes to the audio signal, notice that the *audio* recording/playback head in *both* the Beta and VHS systems is *stationary*. The tape speed relative to the audio head is extremely slow.

ACTUAL AUDIO TAPE SPEEDS IN BETA AND VHS VCRs

The original Betamax units were capable of recording and playing back pictures and sound for a maximum of 1 hour (1.7 hours when tape lengths were increased). Beta machines having this capability were said to employ a Beta I format, which involved an actual tape speed of 1.57 ips. That, if you stop to think of it, is actually slower than the 1⅞ ips speed used on home stereo cassette machines. Yet, at that speed it was possible to achieve passably good frequency response for the audio track, and reasonably good signal-to-noise ratios. Today, however, the Beta I speed has become all but obsolete (a few machines available can *play back* old tapes made at that speed, but none that I know of can record at that speed any longer).

The two popular Beta-format speeds used these days are known as Beta II and Beta III, and they correspond to actual linear tape speeds of 0.79 and 0.53 inches per second respectively. Is it any wonder that audio frequency response is limited and that signal-to-noise ratios are less than ideal? Speaking of signal-to-noise ratios, one would expect them to be well above 50 dB even at these slow speeds, given today's high grade tape formulations, but such is not the case. The makers of VCRs all seem to sacrifice S/N in favor of extended frequency response. As anyone involved in pro audio knows, you can always apply so much preemphasis during recording so as to extend frequency response somewhat, but in doing so, you sacrifice signal-to-noise ratio during playback. It's like turning up the





Although Beta and VHS Systems employ different tape loading systems, both use stationary audio recording and playback heads.

treble boost on a playback amp to lift high end response. Tape hiss and noise come right up with the extra treble response.

My own experience with the Beta VCRs that I have tested is that their -3dB high end roll-off points generally fall somewhere between 8 and 12 kHz for the Beta II speed and between 4 kHz and 6 kHz for the slower Beta III speed. As for measured signal-to-noise ratios, I generally find them to be between 40 and 44 dB (referenced to maximum audio level for 3% distortion) for the Beta II speed and a dB or so poorer for the Beta III speed. Given the actual Beta II and Beta III speeds, you would think that the signal-to-noise ratio for the slower speed would be a good deal worse than it is for the Beta II speed. The reason that this turns out not to be true is simply because the restricted bandwidth associated with the Beta III speed tends to offset the increase in noise inherent in that slower tape speed.

As for VHS machines, there are now three speeds commonly used. These are usually identified as SP (Standard Play), LP (Long Play) and ELP, or EP (Extra Long Play, or, simply, Extended Play). Record/play times for these speeds are 2, 4 and 6 hours respectively, while actual *linear* tape speeds are 1.31 ips for the SP speed, 0.66 ips for the LP speed and 0.44 ips for the EP speed. Simply comparing these speeds with those for Beta II and Beta III, and assuming that all other things are equal (which is not always the case), we might arrive at some conclusions regarding audio fidelity of the two systems. We would expect that fidelity of the SP VHS speed would be a bit better than the fidelity obtained at the Beta II speed. Indeed, that does turn out to be the case – at least with the *average* of the Beta and VHS machines that I have tested thus far. Typically, a well designed VHS machine will deliver response out to 12 or in rare cases 13 kHz (for the -3 dB roll-off point). However, when we switch to the EP speed, and compare it with results obtained at the Beta III speed, the Beta III format usually wins out by a small margin. This, too, is not unexpected inasmuch as the Beta III speed (0.53 ips) is marginally faster than the EP speed of 0.44 ips. Typically, signal-to-noise ratios run about the same as for the Beta format machines, with variations in S/N more a function of the grade of tape used than of the machine itself or its format.

WHAT YOU CAN DO TO IMPROVE VCR AUDIO

It almost goes without saying that if you have control of the situation and know in advance that you are going to have to do some dubbing from a VHS or Beta format video tape, make certain that whoever operates the VCR does so at its fastest linear tape speed. Since most video cameras come equipped with "external mic" jacks as well as their own built-in microphones, if videotaping live action, it is better to use an external mic whose characteristics you know (and which can be placed close enough to the audio source to avoid room effects) than to depend upon the omnidirectional electret mics that usually come with video cameras.

If you have to deal with audio material on video tape that is "after the fact," there are still some obvious steps you can take to clean up the audio during its transcription. If you are dealing strictly with the spoken word, inserting a graphic equalizer in the line can do wonders for reducing tape hiss without impairing intelligibility of the audio material itself. **If you need to transcribe a music track from a video tape, rather than trying to cut out hiss by means of a fixed graphic equalizer you may be a lot better off using a dynamic filtering system, such as those now being promoted and licensed by National Semiconductor (who make a chip that forms the central component of such dynamic noise filtering systems). Such dynamic filters, unlike other encode/decode noise reduction systems, are intended as "open loop" devices, in which *no* previous encoding is required. Their operation is based upon their ability to "sense" high frequency program content and amplitude—opening up system bandwidth when "highs" are present in the program material which will mask residual tape hiss, and closing down to limited bandwidth when no musical highs are present, reducing audible tape hiss significantly.**

Admittedly, audio fidelity from home VCRs is not what it could or should be, but with a little experimentation and care you should be able to "cover up" the audio sins and omissions of the originators of both the VHS and Beta machines. ■

This article is reprinted from The Sound Engineering Magazine, October, 1981.

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DNR Noise Reducer

Video Test number 123

It's no surprise that the sound from VCRs is so noisy. The slower the speed and the narrower the track, the noisier the sound—and home VCRs, even at their highest speeds, move tape slower and use narrower audio tracks than audio cassette recorders do. What's more, the magnetic particles of audio cassette tapes are oriented in the same direction as the soundtracks, while videotape particles are oriented at a different angle to match the path of the video heads. Even so, audio cassettes didn't become quiet enough for high fidelity till Dolby came along. Only one VCR sold in the U.S. (Akai's 7350) has Dolby so far, and what Dolby gains on the Akai is partly lost through the use of narrower audio tracks for stereo.

Advanced Audio Systems International's DNR 450 is an audio noise reducer designed help with audio noise problems in both video and audio systems. Like most signal processors it operates on line-level rather than RF signals, which means you can connect it between a VCR and the audio input jack of a monitor TV set or audio system, but not between a VCR's RF output and a TV set's antenna.

The unit itself is a compact black box with projecting wood end panels. Front-panel switches turn the unit on and off and switch it in and out of the circuit, a control knob adjusts its sensitivity, and an Audio Bandwidth bargraph display gives a visual indication of the circuit's operation. The rear panel contains only input and output jacks.

When used with an audio system the unit is usually connected into a Tape Monitor or External Processor loop on the amplifier or receiver. If your system has no such loops not already in use, you'll have a problem. Unlike other audio signal processors we've used, the DNR 450 does not have duplicate tape-monitor jacks, so it cannot share a connection loop except with devices with duplicate monitor jacks of their own.

The DNR is not like most other noise-reduction systems—Dolby, dbx, CX, Hi-Com—which must be used both in recording and playback. Those encode/decode systems don't clean up noise already in the signal; they keep it from picking up more noise in recording and playback. But the DNR is used only in playback and cleans up existing noise.

Its operating principles go back to H.H. Scott's Dynaural Noise Suppressor of 1947. Electrical noise (especially tape hiss) tends to be mostly high in frequency. Loud signals (especially those rich in highs) "mask" this low-level, high-frequency noise from our ears, which is why tape hiss and so on are heard most often during quiet passages. A high-frequency filter would cut out most of this noise, along with high frequencies we want to hear. What's needed is a "dynamic" filter whose action changes as the signal does, cutting high frequencies sharply when the audio signal is too weak to mask noise, but not cutting them when there is a masking signal. That's exactly what DNR and its predecessors do.

If this were as simple as it sounds, though, we'd still be using Scott's 1947 circuit. The filter must be able to open more quickly and close more slowly for loud signals that contain masking highs than for loud signals that don't —to mention just the main problems in dynamic-filter design. The Burwen noise reducer (now made by KLH) was widely considered to have managed these problems well, and National Semiconductor's DNR chip is based on its principles. (The DNR chip will also be available soon in pocket stereo cassette players from Technidyne, and in car-stereo units from Delco and Autotek.)

Designing the DNR may have been complex, but operating it is simple—even simpler than the instructions indicate. The manufacturer recommends that you find a quiet spot (between bands of a record, for example), turn the sensitivity control all the way down, then turn it back up till the first LED on the Bandwidth display begins flickering. That works.

But we preferred setting the control by ear, adjusting it for the best compromise between too much noise and too little high-frequency content (a compromise quite easy to attain). If some of your videotapes are noisier than others (due to reception conditions when taping off the air, for instance) this approach would be much easier since it lets you optimize the control-set for each type without having to find a silent spot first.

Since it's so easy to set the unit by ear, we think the Audio Bandwidth display (which shows the changes in the DNR filter response) could have been omitted. It is, however, mildly fun to watch.

Performance We tried the DNR 450 on quiet, moderately noisy, and severely noisy signals from videotape, FM, and records. We even tried signals such as solo flute, which show up defects (if any) in dynamic filtering circuits. In every case, when properly adjusted, the DNR 450 did exactly what it was supposed to do: reduce noise with no significant effect on high-frequency response.

Adjusting the unit's sensitivity is important. If the knob is set too far to the left, you lose high frequencies you want to hear; if it's set too far to the right, you don't get much noise reduction. But the setting is not unduly critical. Turning the knob a degree or two too far in either direction won't ruin your sound. The difference it makes may even be hard to hear unless you listen closely for it.

Nonetheless, the setting is always a little bit of a compromise. You can't eliminate much noise without occasionally cutting high-frequency signals a little; nor can you let most of the highs through without occasionally letting through a little noise. (A circuit could be built to do it perfectly, but at much higher cost.) An interesting psychoacoustic effect enters: we tend to interpret some high-frequency noise as part of the music signal it accompanies. If the noise is removed, we think some highs have been removed too, even when that's not true. All noise-reduction systems give this effect, and the DNR 450 instruction manual mentions it.

One thing the manual does not mention is

that very noisy monophonic signals can be cleaned up beyond the unit's nominal ability by cascading the two channels. That simply involves connecting a cord from the output of one channel of the DNR 450 to the input of the other. The signal is then processed twice. There's no question that this technique cuts high-frequency response, but on signals noisy enough to need this treatment, there's no question that the reduction in noise is worth it. We've seen a sample modified to include a front-panel switch that cascades channels without rearranging cords in the back; we'd like to see that put into production for the video market.

Conclusion. **The DNR 450 cleans up noisy audio without significantly compromising any other aspect of sound quality—without, indeed, even affecting most of them. It's easy to connect and use. It's also compact and inconspicuous. And it can be used with your stereo system as well as with your video equipment. At $230 it's not cheap, but its price is more than reasonable for what it does. We'd rate it an excellent product and a good buy.**

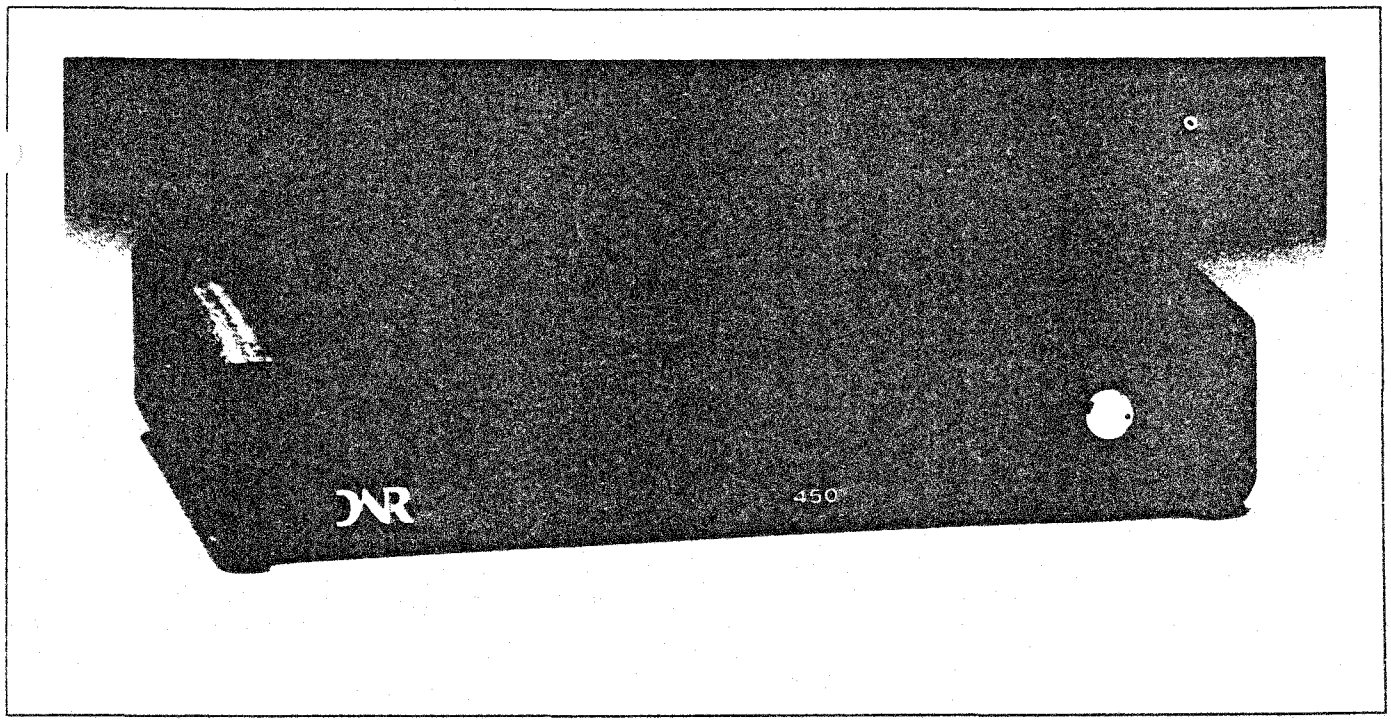
Test Report: DNR 450
Dynamic Noise Reduction System

DATA

Date of test: July 1981
Manufacturer: Advanced Systems International, 4040 Moorpark Ave., San Jose, Ca. 95117
Name and model: DNR Dynamic Noise Reduction System, Model 450
Function: after-the-fact noise reducer for any line-level audio source
Price: $230
Dimensions: 2⅜ x 12½ x 6½ inches (h/w/d)
Weight: 2.8 pounds
Power requirements: 120 VAC, 50-60Hz, 8W
Casing: black metal, wood end pieces
Controls: sensitivity, power and bypass switches
Indicators: LED bar graph display of bandwidth

RESULTS & RATINGS

Frequency response: +/- .5dB 10Hz-20kHz, -3dB @ 30kHz, at maximum bandwidth; -3dB @ 800Hz, -5dB @ 1kHz, -7dB @ 2.5kHz, at minimum bandwidth
Hiss reduction: 5-15dB above 800 Hz depending on program material and sensitivity-control setting
Attack and release time: 1 millisecond/50 milliseconds (not measured)
Maximum filter slope: 6dB/octave
Gain at 1kHz: 0.0dB, adjustable +10dB
Distortion: 0.3% max.
Internal noise: 100 microvolts rms, 20Hz to 20kHz (S/N ratio more than 85dB)
Input level: 0dB (0.77V rms), adjustable to 10dB lower level, maximum undistorted input 1rvel 4Vrms
Output: Rated +10dB (2.5Vrms); level @ 0dB (0.77Vrms); clipping level 4Vrms; impedance 50 Ohms (short circuit protected)
Noise reduction: excellent for a system that does not require encoding
Ease of operation: excellent
Overall performance: excellent



Audio
The Authoritative Magazine About High Fidelity
NOVEMBER 1981 • $1.50 • F 06030

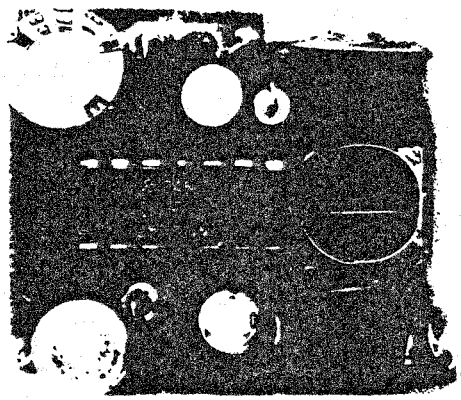
BLANK TAPE DIRECTORY

NATIONAL'S NEW NOISE REDUCTION CHIP

RALPH HODGES

National Semiconductor, one of the nation's oldest and certainly one of the leading makers of integrated circuits, is by no means new to noise reduction. Selling Dolby B-type integrated circuits to cassette-deck manufacturers is one of the higher volume activities of its consumer linear division, and you can be sure that other products of its manufacture turn up as gain blocks in many alternative noise-reduction systems. What the company has not conspicuously participated in is the *design* of noise-reduction processors. Indeed, making component parts for everybody else's NR system — and everybody else's electronic anything, for that matter — would seem to be business enough, why should it get further involved? Or, rather, why *has* it, because National Semiconductor's DNR (Dynamic Noise Reduction) amounts to just that sort of involvement?

The reason, according to the company, is that noise reduction in its commonly encountered compander form is all well, all good, but all too rare. Efforts by Dolby Labs notwithstanding, FM broadcasts are still largely compander-unencoded. The cassette you play in your portable "tape player cum headphones" may be encoded, but it's unlikely that the player will be able to decode it, and the hiss from a diaphragm within an inch of your ear is hard to ignore. You can buy encoded discs from dbx, but per-



The DNR device is essentially a dynamically controlled LPF that is inexpensive, simple and compact in implementation, and reasonably free of audible side effects.

This article is reprinted from Audio Magazine, November, 1981.

NR

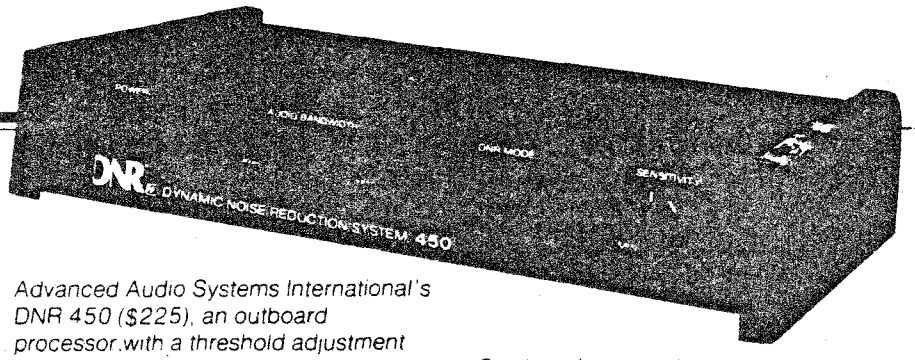
haps not with the performers and performances you'd most prefer. Although tomorrow's videodiscs may be encoded with some form of noise-reduction processing, today's are not. The same goes for the majority of prerecorded videocassettes. The future (AM stereo, stereo TV) remains clouded, but the past is clear, and much of it is made up of recorded material that never had a chance to benefit from practical noise reduction.

The DNR scheme seems an appropriate solution to an inherently insoluble problem.

Of course, the situation is not new, but, ironically, new media and program sources are making it more prevalent. In response, National Semiconductor has seized on a solution that is also not strictly new, but which is probably timely. Now, the company believes, is the right moment for noise reduction that can cope with sources which already contain noise. This means a "single-ended" processor — one that steers its way between program and noise, lopping off the latter insofar as it is able to separate such noise out. The DNR device is essentially that of a dynamically controlled low-pass filter, but one that skirts negatives in previous designs of this sort, which as a rule were not (1) inexpensive, (2) simple and compact in implementation, and therefore adaptable to a broad spectrum of products, and (3) free as they could be of audible side effects. DNR is all of these according to National Semiconductor, who expect its appeal to grow rapidly as the word gets around.

Basics of Operation

In its latest form, DNR consists of a single IC (National Semiconductor LM1894) for two channels, plus a number of external components (see sidebar). As shown in Fig. 1, a single control circuit regulates the filter action of both audio channels, which can vary in bandwidth from 800 Hz to as much as



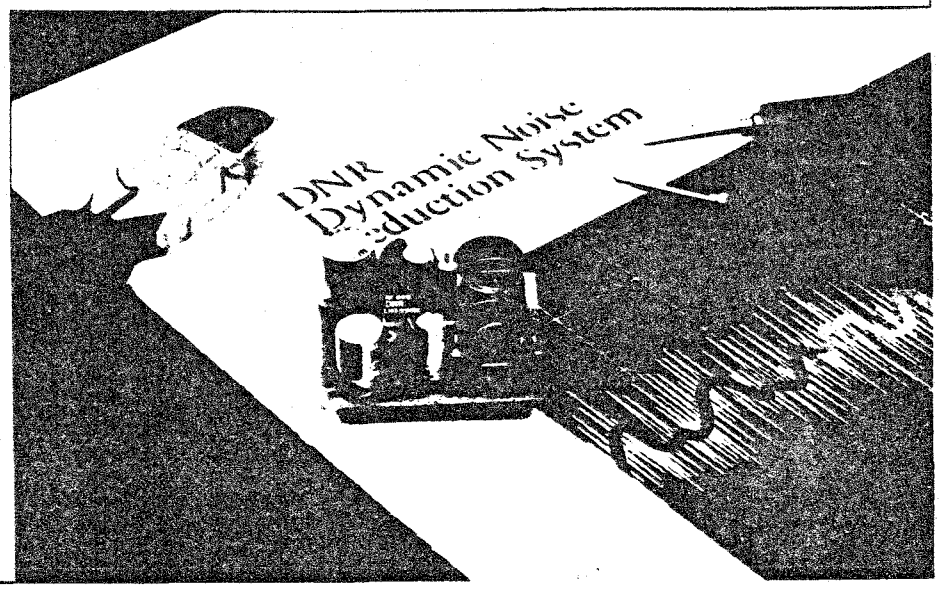
Advanced Audio Systems International's DNR 450 ($225), an outboard processor with a threshold adjustment and an LED display for instantaneous bandwidth indication, bears the proprietary logo for the National Semiconductor system. Manufacturer: Advanced Audio Systems, San Jose, Cal.

30 kHz (-3 dB points). Maximum noise reduction (CCIR/ARM weighted) is in the neighborhood of 10 to 14 dB. The filters are single-pole configurations, providing a uniform 6-dB per octave roll-off above whatever corner frequency the voltage from the control circuit dictates (see Fig. 2 for operating parameters).

The control circuit itself derives a control signal from the rectified sum of the two channels. The circuit's response is not uniform with frequency, but increases at a 12-dB per octave rate from about 1 to 6 kHz, flattening out above. A threshold, sometimes fixed but user-variable in the case of one available outboard processor, establishes the noise "floor" of the system, determining what levels of high-frequency energy will be construed as noise (for which the filters will remain closed) and what levels as program (for which the filters will progressively open up). The filters can open (attack time) in as little as 0.5 millisecond, which is consistent with the sharpest transients to be expected in program material. Release time is a more leisurely 50 milliseconds, to avoid the foreshortening of any lingering reverberation.

Considered within the constraints of cost, simplicity and playback-only processing, the DNR scheme seems an appropriate solution of an inherently insoluble problem. The time constants (attack and release) are well chosen in terms of present-day psychoacoustic understanding, and the operational frequency bands are the right ones for maximum suppression of audible steady-state noise (hiss, in other words). Governing the action of the control circuit by higher frequencies alone is a particularly logical idea. It both focuses appropriate attention on the critical area, and avoids control-signal ripples that low-frequency information can impose on a peak-detecting circuit such as DNR employs.

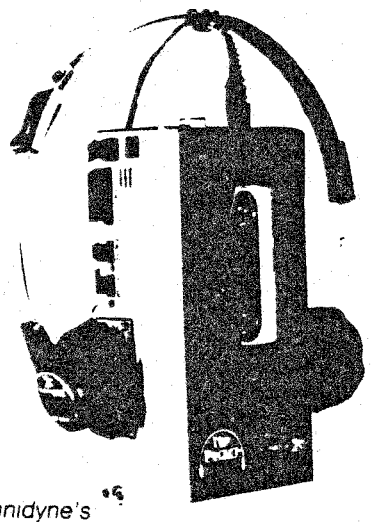
National's LM1894 IC with its external components on a p.c. board.



NR

In common with any practical noise-reduction system, DNR depends on auditory masking of noise by program material occurring at or near the same frequency. If this masking does not take place when the filters open to pass high-frequency program, noise will be heard. Worse, noise will be heard going up and down in level with the filter action. Such noise modulation — and arranging for masking to conceal it — is the crux of noise-reduction system design. In less guarded moments, all responsible engineers admit that masking is bound to fail under some circumstances, and can be made to fail predictably if program material is chosen with that end in mind. A proper noise-reduction system considers typical listening fare first and foremost, and trusts the flaws won't loom too large when unusual spectral distributions of program overthrow the designers' expectations.

Program sources that could not previously accommodate noise reduction are obvious candidates for the DNR system.



Technidyne's Hip Pocket Stereo incorporates DNR circuitry.

The claims made for DNR in this regard are certainly not so extravagant as to strain credulity. According to Martin Giles, National's Manager of Consumer Linear Applications, the system will be at its best with material that has signal-to-noise ratios (again CCIR/ARM weighted) exceeding 35 dB for musical ensembles. Certain critical solo instruments may have to start with a S/N of 45 to 50 dB to avoid all masking failures and audible side effects. (These differences have to do with the longer reverberation times of spaces regularly used to record ensembles and the nature of ensemble playing itself.) DNR is not effective with impulse noises such as record clicks and pops; it may alter them in character, but it will certainly not remove them.

Summing the system up, Giles remarks that it will help most of the time, hurt in some rare instances, and not do much of anything audible in those cases where the program material is good enough to stand on its own. But when it is deemed desirable to switch it out, the system is fully out; with compander systems that encode the material, the system can never be fully eliminated once the recording is in existence. For program that is borderline, the threshold control (when provided) will enable the user to set his own compromise between maximum fidelity, minimum noise, and the instrusion of audible side effects.

The Destiny of DNR

DNR has existed for several years now in a two-IC form, and as such has found its way into several portable and home music centers. With the advent of the LM1894, DNR has been adopted by General Motors for use in 1982 car stereo systems, by Technidyne for its Hip Pocket Stereo, by Benjamin in its RAC-10 MK-II DNR cassette changer, and by Advanced Audio Systems in its stand-alone Model DNR-450. Program sources that could not previously afford or physically accommodate noise reduction are obvious candidates, along with new media that have not yet established noise-reduction standards. The company is also hopeful about broader applications and about a supplementary role to existing noise reduction. For example, a tape encoded by a compander system like Dolby B, even though properly decoded during playback, will still not be perfectly quiet if listened to at louder levels. But it will be much quieter if DNR processing is used as a further step in the reproduction chain.

To forestall misunderstanding, it should be emphasized that DNR does not decode Dolby noise reduction or the processing of any other compander system. It cannot return dynamically compressed program material to its original form. It acts only on steady-state noise but does so wherever it is found and whatever its origin. This means universality and compatibility with any source — factors National Semiconductor counts on to carry DNR into the mainstream of audio noise reduction.

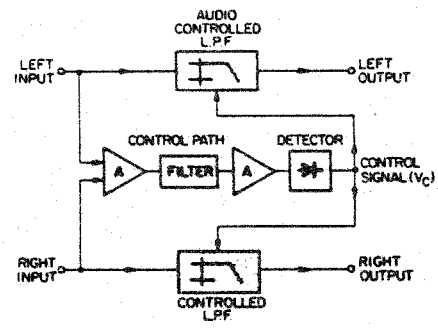


Fig. 1—A breakdown of the essential operators in the DNR system, all of which are contained within a single IC.

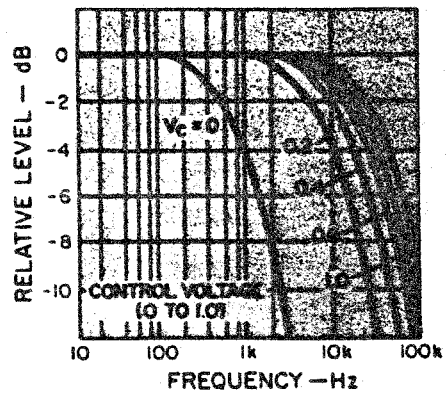
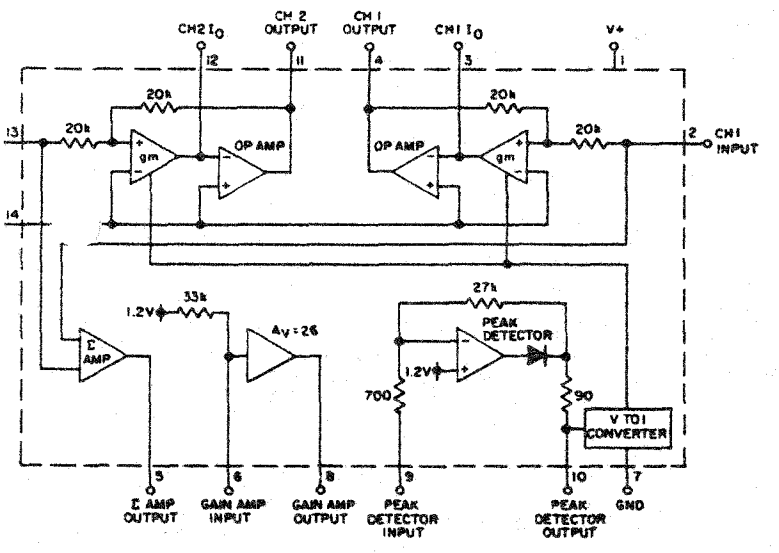


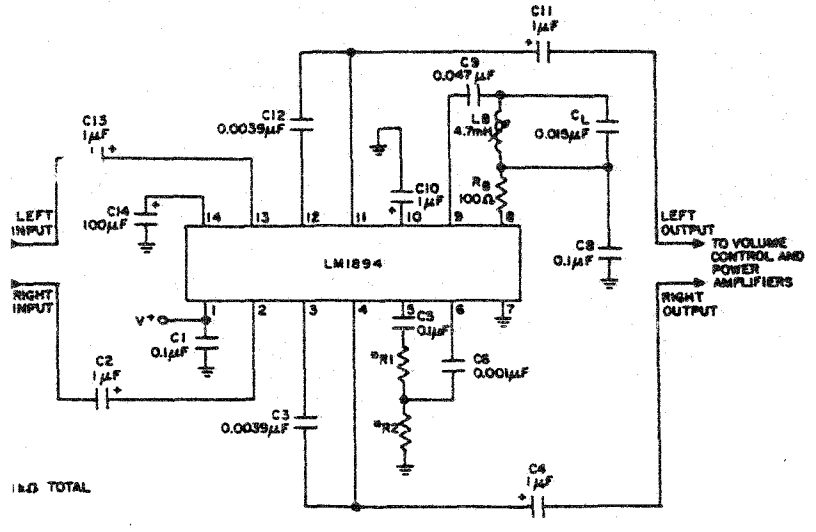
Fig. 2—Increasing control voltages, derived from a network that responds more to higher frequencies in the program, open the DNR passband until it extends well beyond the audio range.

NR

THE CIRCUIT



Block diagram of the LM1894.



Schematic of suggested circuit for LM1894. IC pin locations correspond to those 3.

The LM1894 is a 14-pin DIP intended to operate with supply voltages from 4.5 to about 18. Current drawn is 12 milliamperes for a typical supply voltage of 8. Input impedance is approximately 20 kilohms; input overload occurs at 1 volt rms.

Figure 3 is a block diagram of the IC itself; Fig. 4 is a suggested external circuit for the IC. The primary external operators for the audio channels are C3 and C12, which determine the bandwidths passed by the filters. Since bandwidth is inversely proportional to capacitance, the frequency range of the noise-reduction effect can be adjusted by changing the capacitive values. Capacitors C5 and C6 determine the band of program frequencies to which the control circuit responds — in this case roughly 6 kHz and above. The voltage divider formed by R1 and R2 sets the threshold of the control path, which is normally adjusted so that steady-state noise from the program source just begins to open the filters. Resistors R1 and R2 are altered together so that their sum always equals 1 kilohm. Wiring a suitable potentiometer in their place creates a threshold-varying control.

Coil L8 and the components surrounding it comprise a 19-kHz notch filter which prevents the stereo FM pilot signal from affecting the operation of the control circuit. If the DNR module will not be used for FM, or if the tuner has an adequate multiplex filter of its own, these components can be replaced by a simple 0.047-μF capacitor bridging pins 8 and 9.

National Semiconductor foresees and has demonstrated the use of LM1894s in cascaded arrays of two or three, in which case the slopes of Fig. 2 become 12 or 18 dB per octave, and the noise-reduction effect becomes 20 dB or greater.

The LM1894 is available in quantity to manufacturers of licensed products for about $2 apiece. The price is expected to decline as production increases. It is not presently available in small quantities or to unlicensed manufacturers.

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Low Cost Prevails

DNR Gains Wider Acceptance

SANTA CLARA, CA—The dynamic noise reduction (DNR) system developed by National Semiconductor has gained wider acceptance among car stereo manufacturers, judging from the number of companies which intend to add the system to their lines.

In addition to Delco and Autotek, Audiovox, Boman, J.I.L., ARA Motorola, and FAS all intend to utilize DNR, according to a list released by National Semiconductor.

The advantages of DNR, according to its manufacturer, are its comparatively low cost and the ability to downsize the radio's chassis, as the system uses less space than other noise reduction systems, Shockey says.

"This system requires much less space than Dolby," explains John Shalam of Audiovox. "I would say its overall performance is comparable, although public acceptance is much greater with Dolby." Shalam adds Audiovox, which supplies radios to some General Motors dealers, is encouraged by the introduction of DNR into Delco units. "Delco offering that option will give a lot of credibility to the DNR system," he asserts.

By Spring, Audiovox plans to add DNR to some of the units in its "Hi-Comp" line, Shalam adds. While he admits that the wider acceptance of Dolby could detract from that of DNR, Shalam predicts that the lower cost of the DNR system, coupled with what he calls comparable performance, will prevail.

Sparky Wren, vice president of sales for J.I.L. America, another company adding DNR to some of its autosound units, thinks the competition between noise reduction systems can only help DNR. "People are looking at Dolby as almost a generic term," he observes. "When it's explained to them that Dolby means noise reduction and that there is another system that does that, I don't think it will be a problem."

Wren says J.I.L. will introduce its DNR units at January CES, comprising Phase II of the company's Concept series. Noting that DNR "will play back all types of encoded material as well as work in AM-FM stereo," he predicts DNR will add to his company's sales.

Working under the principle that if you can't beat them, join them, Autotek plans to combat the DNR acceptance problem by incorporating both Dolby and DNR into its Hi-Tek series. Shockey says Autotek is the only company to use both systems in one unit, and Autotek president Sid Scheiber maintains that there is not only room for both noise reduction systems, but a genuine need for both.

> *"(Dolby and DNR) would make for a very good noise reduction system."*

Weighing the differences between the two systems, Scheiber maintains they are not only compatible but complementary. "DNR works on an additional setup," he explains. "Dolby does one job, but DNR works on the radio as well as the tape player, so it makes sense to have both."

Craig Turner, chief engineer for Autotek, adds that the combined Dolby-DNR system makes for "two completely different types of noise reduction systems, as Dolby stops the tape recorder from adding any additional noise, but the DNR masks the noise from the original material, and it works on the AM-FM radio as well as the tape deck."

Turner adds that because DNR does not encode and decode the recorder material as Dolby does, the combination of the two systems, with Dolby eliminating noise added by the recorder and DNR filtering out sounds from the original source material, produces "a really impressive noise reduction."

Scheiber says Autotek will add DNR to all the units in its Hi-Tek line, but he can not predict a timetable. "It's not just a matter of National Semiconductor having the units ready," he asserts. "It won't be until Spring that we will incorporate the DNR into the Hi-Tek units."

Noting that Delco is adding DNR to its E-2000 AM-FM/cassette units, designed for General Motors' J-cars, Scheiber says the incorporation of the system by the giant automaker can only increase public acceptance of the noise reduction system.

"I don't know if it will get to be as important as Dolby is now," he admits, "but General Motors taking DNR will get great play, and help to make it a more established system."

Mike Smith, vice president of FAS Industries, admits that the publicity enjoyed by Dolby could be a problem in marketing DNR, but he says he's confident there is a market for each. FAS is also incorporating dbx into some units, and Smith says it is possible to market a line including all three noise reduction systems. He agrees with Scheiber's claim that DNR and Dolby make a compatible pair, although FAS does not yet market a unit with Dolby.

"I would say the two of them together (Dolby and DNR) would make for a very good noise reduction system," Smith comments. Although he could not speculate on the number of FAS units to have DNR until negotiations with the manufacturer are completed, he says FAS has "allocated space inside our units" for the system.

The turn to DNR by a number of manufacturers, Smith speculates, could be due to the downsizing of the system itself. "We looked at it about two years ago and were impressed with the performance," he recalls, "but we decided against it because the space was so large. Then we got a call from Dan Shockey at National Semiconductor saying they had put it all on one chip, and that's when we decided to go with DNR."

Shalam: Going with DNR

Retailing aside, manufacturers adding DNR to their line-up may have a certain advantage in the custom market. Red Gentry of ARA reports DNR will be available only in its custom line and John Shalam of Audiovox indicates he may follow suit.

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