

Noise Reduction Systems

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Digital audio has, for the most part, made consumers and professionals intolerant of noise and distortion in audio. Signals free of pops, clicks, crackle, surface noise, hum and buzz are the norm in a digital world. Unfortunately though, the analog world is not as ideal as the digital medium and background noise (such a HVAC rumble, traffic and other low level noises) often creep into recordings. Perhaps even more troubling than this form of noise is the innumerable irreplaceable musical performances, film sound tracks and other programs that exist only on relatively noisy mediums, such as analog tape, acetates, vinyl and lacquer.

Noise reduction techniques are not new, however they take on new importance in an increasingly demanding and educated market place.

This article discusses a number of established, well known single-ended noise reduction products. (Single-ended products are only used during playback and this differentiates them from double ended or encode/decode devices used in both recording and playback.) They range in cost from about two thousand dollars for the analog units such as the Dynafex to in excess of \$100,000.00 for fully configured DSP workstation type.

Introduction

Single ended noise reduction can be divided into two broad categories: removal of ticks pops and other noises of an impulsive nature; and removal of broad band low level noises. Analog electronics have been available for many years that deal with these two types of noise. Impulse noise has been reduced with fast acting partial mute or clipping circuits. Broad band noises are minimized with sliding low pass filters which track the programs highest frequencies and adjust themselves accordingly. These systems capitalize on the psychoacoustics principle that low level noise will be masked by the presence of program material and hence only needs to be removed where or when signal is not present. Also used are noise gates or downward expanders that mute or reduce the signal level when program is not present. There are many refinements in the various analog units such as multi-band processing. The primary difficulties that these units must overcome are reducing the high end response of the program material and breathing and pumping effects.

Digital Signal Processing (DSP) allows much greater sophistication to be applied to noise reduction. For example digital systems discussed later use hundreds of bands of multi-band process and apply psychoacoustic principles to determine when a noise band can be removed with no detrimental effects on the signal. In addition, DSP allows workstation style editing operations to take place to actually splice and rebuild damaged portions of a program segment. Obviously, these types of operations are not done in real time and come at a much greater time (and cost) investment than single pass analog systems.

It appears that the DSP software of noise reduction is in its infancy and one can expect even better performance in the future. For example, neither of the digital systems discussed here appear to use auto-correlation, which is a powerful noise reduction technique used to remove noise in communication links.

CEDAR Audio Ltd.

CEDAR Audio Ltd. is based in Cambridge, England and entered the noise reduction market place

in 1989 as a facility where you could send material to for processing. They now have a range of products that can be purchased and used in-house. North America is represented by Gotham Audio in New York. CEDAR is an acronym for Computer Enhanced Digital Audio Restoration and the companies main thrust has been in noise reduction systems although more recently they have entered the audio workstation market.

CEDAR-2 System

The company's latest desk top PC based offering is the CEDAR-2(tm) system. It consists of a floating point digital signal processing board (using the AT&T DSP32C chip) and a number of software modules including: 1-process click, pop and scratch removal, 2- process splitter/combiner fine click removal (sometimes called de-crackle), 512 band equalizer, real-time broad band noise reduction, real-time hard disk editing and assembly, sample rate converter fixed, sample rate converter with varispeed, phase/time correction and others.

An entirely digital process the systems inputs are AES/EBU or SPDIF digital audio. Stereo or mono signals at 44.1 kHz or 48 kHz may be used.

With the program stored on the desk top PCs hard disk the CEDAR-2 software modules may be applied. Real-time stereo operation is provided with CEDAR-2.

Scratch removal eliminates up to 5,000 clicks per second using, they claim, the world's most advanced scratch and click detection algorithms. Once scratches have been removed crackle is often noticeable and a different process and software module is used. The software module for reduction of broadband noise uses 512 entirely independent nodes of equalization and can also be used for digital equalization with an additional EQ module. The broadband noise reduction process allows the operator to make adjustment while listening to the results and this is a key aspect of the systems effectiveness. There are two noise reduction methods available; adaptive spectral reduction and functional noise reduction. The literature claims that both of these methods avoid the unpleasant side effects, such as noise-pumping and dynamic and frequency compression, associated with other more traditional noise reduction systems. The cost of a basic editing and de-noising system is about \$100,000.00 US dollars.

CEDAR DC-1

The DC-1 is a stand alone rack mount stereo real-time 1-process De-clicker unit. It is based on the same technology as used in the CEDAR-2 system. This real-time DSP unit has analog, AES/EBU and SPDIF inputs and outputs. It has an RS-232 and a 16 channel MIDI interface and an option for SMPTE control. The US list price is about \$20,000.00.

Sonic Solutions

Sonic Solutions is based in San Rafael, California and comprises individuals previously involved in the creation of an audio work station for the Lucas Film subsidiary Droid Works. In the mid 80s, the Edit Droid was considered on the cutting edge, the product never became a commercially available (viable?) product. At this time the company offering includes a number of MAC based desk-top workstation systems including CD pre mastering, sample rate conversion, sound for picture, a workstation network and NoNoise.

NoNoise claims to be the world's leading digital signal processing system for noise reduction. While some processes are not a real time the system is multi-tasking so that while an operator is doing editing for example the systems may be doing broadband de- noising to another project. Batch files can also be set up and the system left to do its work unattended. While one-pass stereo broadband de-noising is real time, some projects and tasks may take an operator 8 to 10 hours to process 1 hour of music. (Some 50 million plus computations are required for one second of program.) It has been used to restore thousands of music, film, video, and forensic recordings. The product operates in four ways.

Manual de-clicking is used to remove impulsive noises (clicks, pops, thumps, electrostatic ticks, etc). The operator can isolate an impulse and the system seamlessly reconstructs the signal without duration change. Different de-clickers are available for various program types such as voice and orchestral music.

Production De-Clicking and De-Crackling is an automatic process which can be used in the background to remove impulse noises while the system is used for other functions such as mixing or editing.

Broad band De-Noiseing removes hiss, surface noise and unwanted background noise such as rain, traffic, air-conditioning and SMPTE bleed.

The final technique, complex filtering, can be used to remove hum or buzz.

Along with the software the systems requires Motorola's 56000 series DSP chips and a large hard disk storage system. The basic NoNoise system cost is \$70,000.00 plus about \$10,000.00 for a MAC. For editing workstation capability add another \$10,000.00. So, like CEDAR it is for noise removal projects with substantial budgets.

For broadband noise NoNoise does what other noise reduction systems do (gating and filtering) but with far greater resolution and sophistication. The signal is divided into 2000 frequency bands and noise gating applied. Psychoacoustics principles are applied to determine when the noise can be removed without affecting the program. In addition the system makes use of a noise signature taken from a segment of the material with no program material.

On impulsive noise and drop outs, NoNoise reconstructs the damaged signal segment. This type of improvement can only be accomplished on a non-real time digital processor.

Packburn 323A

Packburn Electronics Inc., located in Dewitt New York, is an electronics manufacturing company whose only audio product is the Model 323A Audio Noise Suppressor. It is an analog real time device. The company is very well known in the restoration and archival of disk recordings and has users around the world. While the unit is clearly intended for the professional market place it has quite as following with record collectors and enthusiast. A review in Stereophile magazine describes this unit as the "Rolls Royce" of noise suppressors. It is also popular with Golden Oldie music DJ's.

The subject of four US patents, the device uses three kinds of noise reduction which Packburn describes as: Switching, blanking and dynamic filtering. The switcher is used for monophonic disk of cylinder recordings. The switcher determines which of the left, right channel or the sum of the two contains the least transient noise and selects that one for the monophonic output. The Blanker copes with transient noise on mono or stereo material and simply clips the amplitude of the individual positive-going or negative- going pulsations. The dynamic filter, used for the reduction of continuous high frequency noise, employs a variable low pass filter to reduce the treble range during quiet passages which contain little high frequency material and increase it during loud and/or bright passages when the signal will mask the noise.

The obvious uses of the Packburn are 78s, LPs, 45s, Acetates and Vertical-cut recordings. For these the transient and continuous noise suppressor is useful. Analog master tapes can be processed with the continuous noise suppressor. CDs which are derived from old disk and movie sound tracks or analog tape without and encode/decode noise reduction systems will also benefit from it use.

With 16 front panel controls and 3 meters, the device offers a great deal of user flexibility and has both RCA and balanced XLR interfacing. It has a 4 RU high rack mounting chassis.

Dynafex

Dynafex is manufactured by Circuit Research Labs, Inc. in Tempe, Arizona. Two models are available. The DX-1, a single channel unit with greater user control while the DX-2 is a simpler dual channel unit.

Dynafex, being a dynamic filter and downward expander (gate) operates on broadband noise only and does not reduce transient noises such as pops and clicks. DX-1 and DX-2 are analog, real-time devices. The manufacturer claims that side effects such as pumping and breathing that are commonly associated with gating and expander-type systems are not found on their unit due to the dynamic filtering occurring prior to the downward expansion.

A brilliance control amplifies the high frequency portion of the usable signal in an attempt to restore the brightness lost in the noise reduction process.

In a single RU chassis, the unit is balanced in and out with XLRs and has reference level switches for -10, 0, +4 and +8 operating levels.

Dolby SR 430

San Francisco based [Dolby Laboratories](#) is well known in the studio market place for their analog double ended (encode, decode) noise reduction systems for analog tape such as Dolby A, B, C, SR and HX. They are also well known in the cinema world for their noise reduction and processor systems such as Dolby Surround. They are the undisputed leaders in these fields. They make an number of related special application signal processors. Among these is the 430 Series background noise suppressor.

The 430 is specifically intended as a post production tool for reducing broad band noises such as wind or traffic rumble that often mar location recordings. Popular in the film and television industries, it is the successor of the Cat No. 43 unit. The 43 unit was based on Dolby A-type noise reduction principles while the 430 makes use of modified Dolby SR technology using a combination of fixed and sliding bands to give "more stable signal handling" and significantly reduced chances for audible side effects.

Simpler to use than the 43 unit the 430 remote control (Cat No. 429) has three controls:

- Level - rotary control that varies signal level in processing circuitry over a +/- 6 dB range without changing overall gain.
- In/Out - push button with LED switches processing in and out of circuit
- HF & LF - faders set attenuation of unwanted low-level signals

The 430 Series is modular with a single control unit providing power and control up to three 1 RU high frames which can each contain one or two channel of processing. The operating controls are mounted in remote control modules (39.5 mm x 150 mm each) that are designed to be mounted into a console and may be up to 15 meters away from the control unit. An alternative housing allows stand alone operation. The cost of a single channel with controller and PSU is about \$5,500.00 with each additional channel (up to 6) being \$2,800.00. As an interesting side note Dolby also manufacture a device which does the opposite of low-level noise reduction. The Spectral Processor model 740 has been designed to allow the increase of low level signals which exist in the presence of high level signals. Their literature claims you can emphasize ambiance, harmonics and otherwise inaccessible subtleties without squashing transients, increasing overall level or disturbing the overall sense of dynamics.