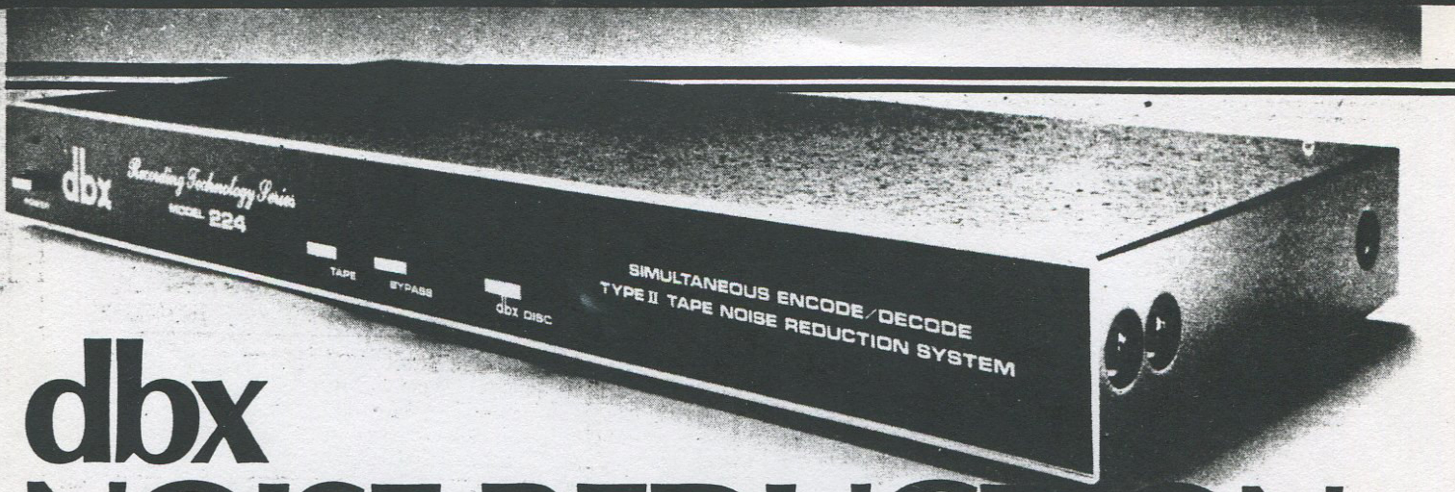

dbx NOISE REDUCTION

Overshadowed by Dolby despite its theoretical superiority, the dbx noise reduction system now seems poised to take the hi-fi market by storm. Peter Green was at the press launch and this is what he heard.

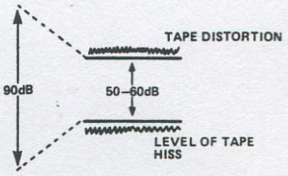

Fig. 1 (left) When recording tapes or discs, engineers monitor the signal and turn the level up or down ('gain riding') to avoid distortion or hiss. This compression greatly reduces the dynamic range to an absolute maximum of about 60 dB.

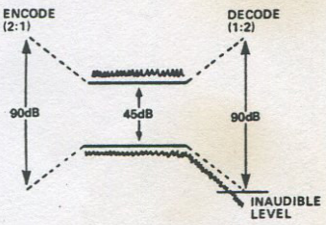

Fig. 2 (right) By introducing 2:1 compression on recording, then accurately and automatically reversing the process on playback, the dbx noise reduction system reclaims the original dynamic range. As a bonus, tape hiss becomes inaudible.

Until now it has been impossible to listen to music at home with anything like the quality of the original. However much you spend on your hi-fi, however low the distortion figures, however carefully you tend your records and however diligently you clean your tape heads, you cannot get away from the twin evils of surface noise and restricted dynamic range.

Surface noise is caused by the limited quality of the recording medium itself. Imperfections and inhomogeneity in the particles that make up the tape coating generate the familiar hissing we know and hate; the roughness of the vinyl surfaces of record grooves produces its share of hissing and pops. Surface noise also affects dynamic range. During a live performance it is possible for sound pressure levels to momentarily hit 120 dB during music transients; however, background noise levels in the audience can easily range from 30 to 50 dB and so this simplistic treatment indicates that live music has a perceived dynamic range of about 70 to 90 dB. Unfortunately a good cassette recorder has a dynamic range of only about 45 dB, while a conventional vinyl record is not much better at 55 dB. Recording engineers have to compress the signal by a factor of 2:1 so that the loudest passages are below the level that causes tape saturation or distortion, and the quietest passages are above the level of tape hiss or record surface noise (see Fig. 1). This squeezing of the signal into a restricted dynamic range makes the music sound flat, unexciting and unrealistic. You *know* it's a recording.

D Versus d

The noise reduction system that established a virtual monopoly in the world hi-fi market of the seventies was Dolby B, a system that reduced high frequency noise (the most objectionable kind) by boosting high frequencies on recording and attenuating them on playback, thus also reducing the noise added in the recording process.

dbx decided to tackle the other problem — restricted dynamic range. Since sounds have to be compressed to be recorded on tape or disc, a system that allowed 1:2 expansion on playback would recreate the range of the original performance (Fig. 2). This idea is quite old but difficult to apply, because the expander and compressor must track each other (be exactly complementary), especially on transients — this in turn requires accurate detection of the signal. The difficulties in this and the way that dbx overcame them are described later, but the important point is that when the recorded signal is expanded *the tape noise drops below the level of audibility*. dbx have killed two birds with one stone, together with an assortment of sacred cows; for example, they recommend that you use chromium dioxide rather than metal tapes, because it's pointless to pay extra money for an improvement of 2 to 3 dB when the system itself is giving you an extra 30 dB across the whole frequency range.

Paths Of Glory

Figure 3 shows the block diagram of a Type II dbx noise reduction system for domestic use (the Type I system has certain differences in the turnover frequencies of the filters to suit professional situations). The encoder and decoder each have two paths — the signal and detection paths.

The music signal to be recorded first goes through a band pass filter to remove unwanted out-of-band components. Type II values are 30 Hz to 100 kHz, Type I are 22 Hz to 27 kHz. The lower limit is there to prevent subsonic noise from underground trains, traffic vibrations and the like from being recorded; the upper limit prevents pick-up of CB and other interference. The Type I value is much lower because studios often have very long leads which are more susceptible to pick-up. The signal passes through a pre-emphasis network that boosts high frequencies and helps to overcome tape modulation noise (which is caused by uneven magnetisation due to tape inconsistency), and into the voltage-controlled amplifier. The VCA is linear in dB with control voltage to make things simpler later on; it compresses the signal by a 2:1 ratio.

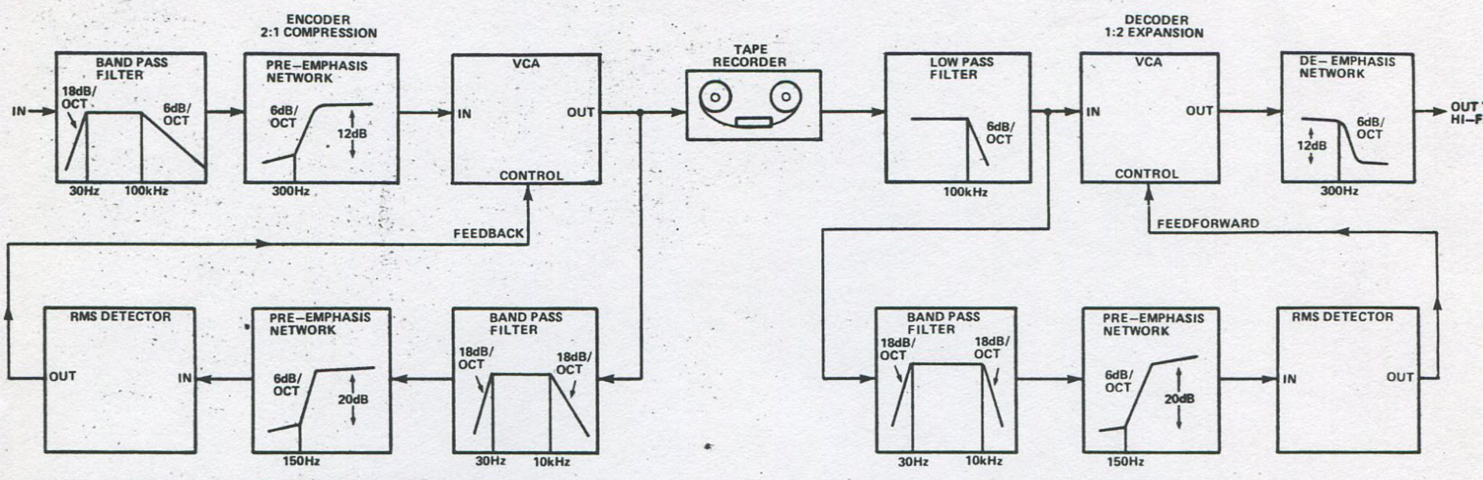

Fig. 3 Block diagram of the Type II dbx noise reduction system.

The output of the VCA is passed to the tape recorder, and also into the detector section. The first stage is a band pass filter which has a slope of 18 dB/octave above 10 kHz, so that the detector 'takes less notice' of high frequencies. Next comes another pre-emphasis network, this time to increase the compression of the signal at high frequencies and avoid the possibility that the pre-emphasis in the signal path will cause high-frequency tape saturation. The RMS detector converts the AC signal into a DC voltage proportional to the level in dB; since the VCA also follows this law the whole system is linear in dB.

Mirror, Mirror

The encoder is a compressor with negative feedback; the higher the signal level the greater the gain reduction. The decoder must be a mirror image to give the correct tracking and recovery of the original performance, so it is configured as a feedforward system acting as a 1:2 expander. The importance of this is that if the tape recorder is considered to be 'transparent', the VCA control voltage in the decoder is being derived from exactly the same signal as that for the encoder VCA. The detector path in the decoder is identical to the one already described — band pass filter, pre-emphasis network, RMS detector — and so the control signals will also be identical (to within component tolerances). The decoder VCA has its control polarity reversed and gives a complementary gain change to that of the encoder; the de-emphasis network reverses the effect of the encoder pre-emphasis to restore a flat overall frequency response. It's interesting to note that this flat system response is due solely to the mirror-image nature of the signal processing — the frequency responses of encoder and decoder are complementary, but *not* flat.

Because a high value of loop gain (40 dB) is employed in the decoder, a low pass filter is needed at the input to prevent high-frequency oscillation caused by capacitive coupling. This keeps the system stable.

RMS detectors have been used because tape recorders aren't perfect, or 'transparent' — they introduce huge amounts of phase shift. This is not noticeable to the ear, but the effect of passing a 1 V peak-to-peak square wave through a 90° phase shift filter is shown in Fig. 4; cheaper and simpler detectors such as peak or averaging types would not give identical outputs for the two waveforms and the mirror-imaging would be lost. An RMS detector is the only one that will give the same output level for both.

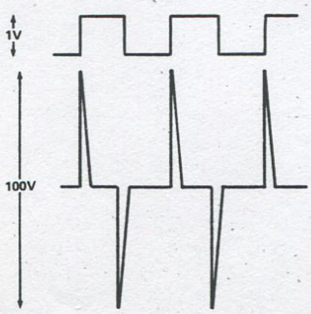

Fig. 4 Phase shift can have dramatic effects on the shape of waveforms!

Silence Is Golden

If anyone feels that the working of the system is hard to understand, rest assured that a practical demonstration isn't. The press showing started with a hiss comparison using blank unencoded tape, first with no noise reduction, then Dolby B, Dolby C and finally dbx. Hiss was still significant with the two Dolby systems, although the improvement was noticeable — but when the dbx cut in, nothing could be heard except the gasps of amazement from hardened journalists. No hiss whatsoever! Listening to extracts from discs and tapes was a revelation; for the first time in my life I could shut my eyes and believe the orchestra was really there. I heard musicians fingering their instruments, I heard someone on the record sniff, and the music appeared out of a silent background — it was *real*!

Naturally the impact dbx has on the market will depend on how many encoded discs and tapes they can release, and how quickly. But several major cassette deck manufacturers (eg Technics, Trio, Teac, Yamaha, Marantz) are fitting dbx alongside Dolby in some of their models, and Dolby must be thinking hard about their next move. (At ETI we're thinking about how nice a review model would be, hint, hint!) With approximate RRPs of £120 for the Model 222 (for two head tape decks) and £170 for the Model 224 (three head decks), a dbx noise reduction system could be the best upgrade you'll ever make.

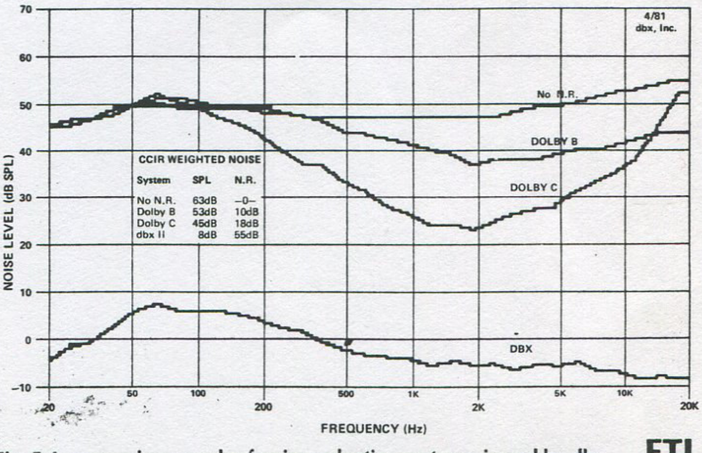

Fig. 5 A comparison graph of noise reduction systems, issued by dbx.