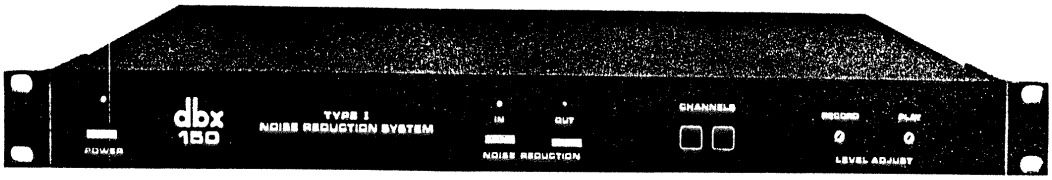
dbx® Model 150

dbx type I noise reduction system

INSTRUCTION MANUAL



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WARNING: TO PREVENT FIRE OR SHOCK HAZARD, DO NOT EXPOSE THIS APPLIANCE TO RAIN OR MOISTURE.

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INTRODUCTION

Traditionally, the tape recording process has been one of the major sources of noise in audio recording and reproduction. The dbx tape noise reduction system virtually eliminates tape hiss that would otherwise be introduced by the recording process.

The model 150 is a two-channel, Type I, simultaneous encode/decode tape noise reduction system for small studio use. It is fully compatible with Type I noise reduction systems used in major studios throughout the world. The 150 features the same 10 dB increase in headroom and more than a 30 dB decrease in tape noise provided by previous dbx professional noise reduction systems. It vastly improves tape machine performance and simplifies recording and mixdown operations, making it possible to have recordings which are nearly indistinguishable from the live performance and copies having no more audible noise than original recordings. In addition, it eliminates the need for conventional compression or limiting during recording, allowing greater flexibility in their use for effect during mixdown. These genuine improvements in the quality of tape recordings are due to a phenomenal increase in recordable dynamic range and the complete absence of audible tape-induced noise.

Each channel of the 150 includes separate encode and decode electronics to permit decoded simultaneous monitoring and error-free punch-ins. Like all dbx noise reduction systems, the dbx 150 utilizes true RMS level detection, ensuring proper transient response even in the presence of phase shifts induced by the record/play process. No time consuming calibration of levels is required to prevent tracking errors from occurring.

Used with today's high quality, narrow-track tape machines from Otari, TASCAM, Teac, Technics, etc., the dbx 150 totally eliminates audible tape hiss under almost any circumstances and conquers the noise build-up problems which usually result when "bouncing" materials from track to track or combining a large number of tracks during mixdown.

Features

*Simultaneous encode/decode operation
*Greater than 30 dB broadband tape noise reduction
*10 dB headroom improvement
*True RMS detection for accurate encode/decode tracking
*Linear decibel compression/expansion over a 100 dB range
*No additional calibration tones or level match adjustments necessary
*All inputs and outputs via gold-plated phono connectors
*Front panel record and play level adjust
*Hard-wire bypass
*Rack mountable
*Front and rear panel channel designation stickers for stacked, multiple unit operation

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FRONT PANEL

Power Off.
AC mains
disconnected.

Power On.
AC mains connected
to unit's power
supply circuitry.

– Noise Reduction Out –
Noise Reduction circuitry is hard-wire bypassed, allowing audio signal to pass directly through the 150 without processing, even if AC power is "off".

– Noise Reduction In –
Audio signals going to the tape machine are dbx encoded. Audio signals coming from the tape machine are decoded.

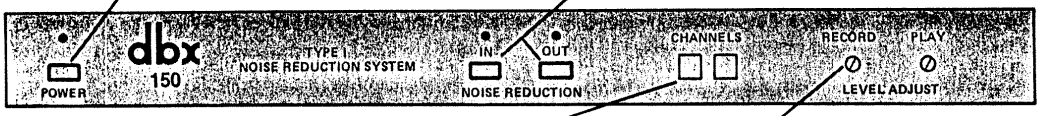

Fig. 1 – Front Panel

Place channel identification stickers here to show which channels (e.g., 1-2, 3-4, 5-6, 7-8) are connected to the N.R. unit.

Trim adjustments to match 150 operation to the levels with which it will operate. These trims are for operating convenience and will not effect the encode/decode linearity in any way.

Quick Set Up

With the 150 NOISE REDUCTION switch in the OUT mode, set up the tape machine as per manufacturer's instructions. Send a 1 kHz tone at standard operating level from the console's output to the tape machine. Record this tone with the 150's NOISE REDUCTION switch in the OUT mode and note the tape machine's record level indication on its meters. Keep the machine running and 1) Switch the 150 NOISE REDUCTION switch to IN. Adjust the RECORD LEVEL ADJUST on the 150 until the same record level indication is obtained at the tape machine as was present with the noise reduction switched out. 2) Play back the tape, switch the NOISE REDUCTION back to OUT and note the playback level indication at the console. 3) Switch the NOISE REDUCTION to IN and adjust the PLAY LEVEL ADJUST on the 150 to obtain the same playback level on the console meters as was just observed with the NOISE REDUCTION switch OUT.

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REAR PANEL

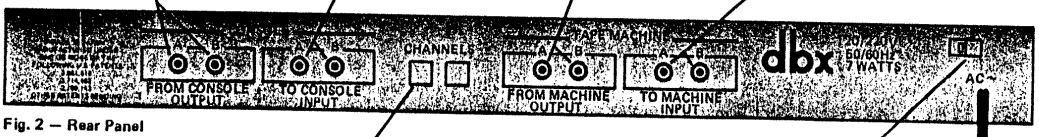

Fig. 2 — Rear Panel

Connect audio output (line level) from mixing console to these jacks.

Connect audio input (line level) of the mixing console to these jacks.

Connect audio output (line level) from the tape machine to these jacks.

Connect audio input (line level) of the tape machine to these jacks.

Place channel identification stickers here to show which channels (e.g., 1-2, 3-4, 5-6, 7-8) are being processed.

AC Line Cord connects 150 to mains. See Warning.

WARNING! THIS SWITCH MUST BE SET TO THE AC OPERATING VOLTAGE (120 or 220) BEING USED OR SERIOUS DAMAGE MAY RESULT!

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CONNECTING THE 150 INTO YOUR SYSTEM

4 **I. Typical System Hook-up**

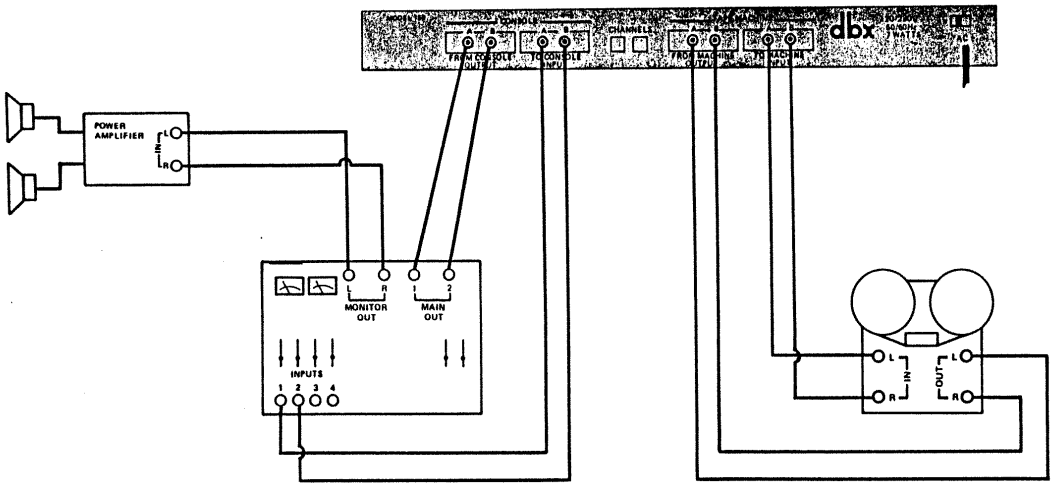

Fig. 3 – Typical 2 Channel System Hook-up. (Multi-channel recording uses additional dbx Model 150 systems to provide individual channel encoding and decoding by following the above diagram as a model.)

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II. Typical Multi Channel Mixdown Hook-up

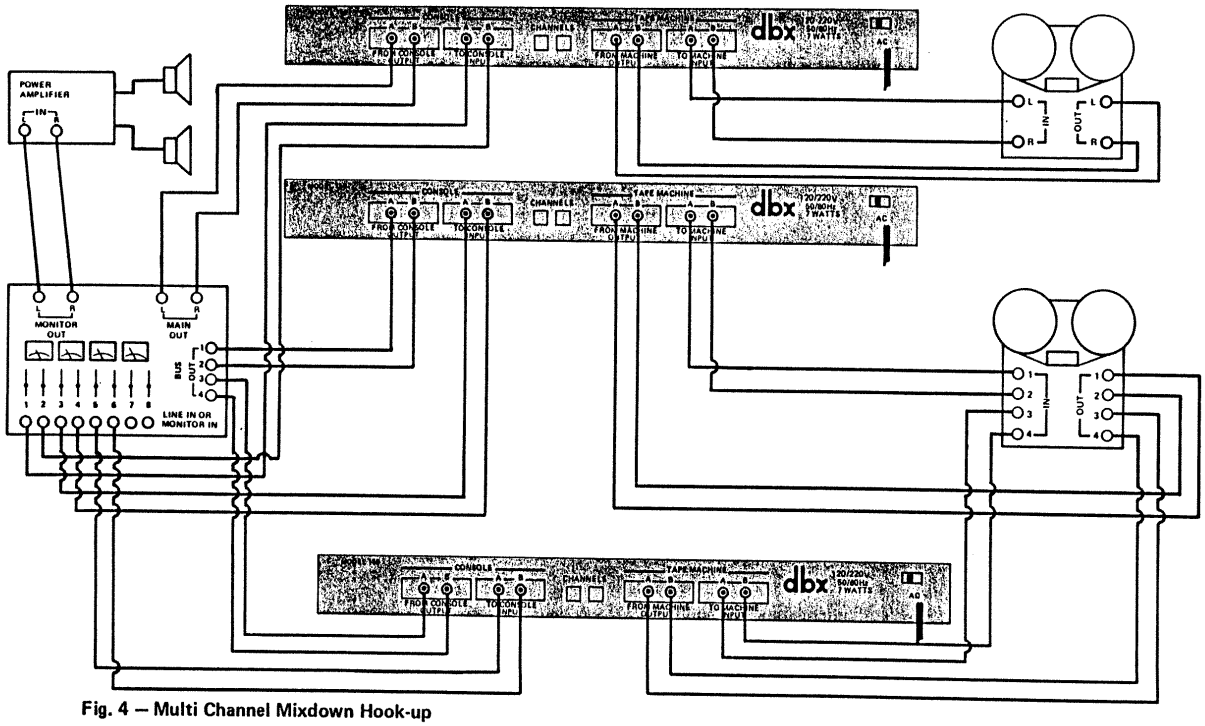

Fig. 4 — Multi Channel Mixdown Hook-up

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III. Unbalanced System Cable Wiring

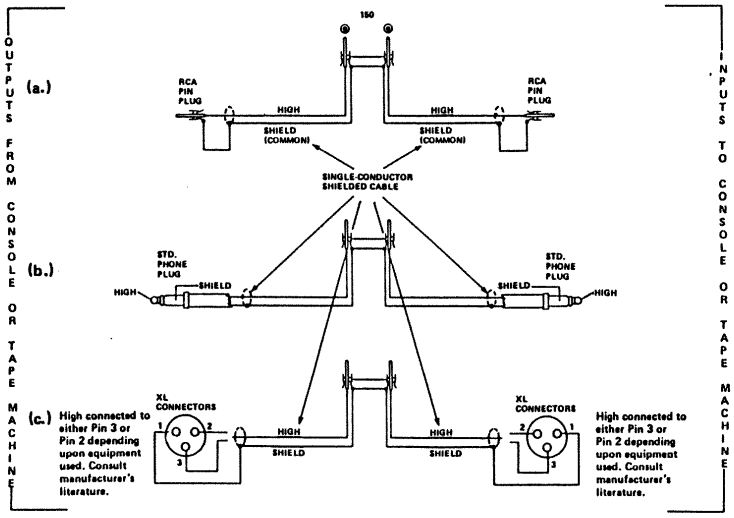

Fig. 5 — Unbalanced Connections

NOTES:

1) In most cases, equipment using XL connectors will have balanced inputs or outputs. If you are not certain whether your equipment is balanced or not, use the wiring diagram shown on Page 7 for balanced systems. It will also work with unbalanced systems.

2) For equipment using "active" or "diferential" balanced outputs, we recommend using the unbalanced wiring diagram (I.c.) above between those outputs and the 150. (See Note 1, page 4.)

3) All cable runs should be as short as possible to minimize pickup of stray signals and degradation of high frequencies.

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IV. Balanced System Cable Wiring

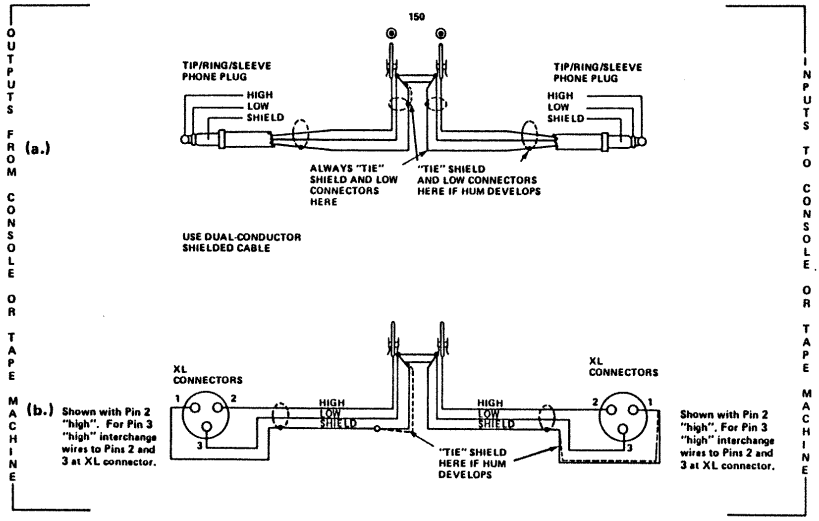

Fig. 6 — Balanced Connections

NOTES:

1) For equipment using "active" or "differential" **outputs**, we recommend using the wiring diagram l.c. under unbalanced connections between those **outputs** and the 150 (active or differential inputs should be treated as normal balanced inputs and wired as shown above).
2) The 150 is designed to drive loads of 5k Ohms or greater. DO NOT connect to equipment with a 600 Ohm input impedance.
3) All cable runs should be as short as possible to minimize pickup of stray signals and degradation of high frequencies.

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GETTING THE MOST OUT OF YOUR dbx NOISE REDUCTION SYSTEM

I. Operating Do's and Don'ts

1. DO – make sure that your tape machine is set up to its flattest possible frequency response, with the tape you will be using. Try to get it within ±1 dB or better, because frequency response errors can affect the decoding process under some conditions.

2. DO – put non-encoded test tones on each tape you record. This is done to provide a reference so that tape machines can be aligned for proper playback response at a future date – not to "align" the noise reduction. Your dbx noise reduction system does not need alignment tones. It is good studio practice to bypass the noise reduction and put down a set of test tones on every tape you record. Good choices are 100 Hz for low frequency equalization, 1 kHz for level calibration and 10 kHz for high frequency equalization. Write the tone information on the tape box (frequency, level, dbx out).

3. DON'T – try to get the record level meters on your tape machine to read the same levels with noise reduction switched in as with it switched out! These readings should be lower with noise reduction. If you turn up the record levels on your machine to compensate for the lower VU indication, you will almost surely run into decoder mistracking problems due to the tape saturation you will be getting on transient peaks. You should set your console and machine levels in the normal manner with the noise reduction bypassed. Once the noise reduction is switched in, use your console meters to verify normal operating levels and ignore the meters on your tape machine.

4. DO – pay attention to the output levels from your console. Experiment with different levels to determine what is optimum for each instrument. All companding noise reduction systems work on the psychoacoustic phenomenon of "masking"; that is, if you have a loud enough signal, you won't notice the noise. The 150 enables you to record at levels well above the noise floor of your tape machine, but it is possible to record at average levels so low that even the 150 can't stop the quietest recorded passages from being nearly lost in the noise. The result will be noise pumping or "swishing" behind the music. Therefore, you should generally have your nominal operating level somewhere between −10 and 0 VU (ref. 0 dBm) at the output of your console. In most cases, you won't want to exceed 0 VU because, although you will certainly eliminate noise pumping, other mistracking problems (e.g., level shifting effects) will occur if the high levels cause tape saturation or clipping of the electronics. This is actually a comfortable range within which to work – much larger than that afforded the engineer who is not using noise reduction. The instruments which will require the most attention to level are those with the highest peak to average signal ratios such as pianos, horns and drums. When in doubt, start with the console faders at their normal levels and experiment with a particular instrument, raising or lowering them for optimum operation of the noise reduction system.

5. DON'T – depress the "In" and "Out" switches simultaneously. The resulting output could damage your system (particularly if you are monitoring via headphones at the time).

6. DON'T – change from "In" to "Out" while recording. This will be nearly impossible to fix and will almost surely necessitate re-recording the material.

7. DON'T – process encoded signal in any way before decoding. Don't mix encoded signals. Don't equalize them. (The only exception to this is in the case where an outboard equalizer is dedicated to each track of a tape machine to correct frequency response errors which were not correctable by the machine's own playback EQ.)

8. DON'T – operate the 150 into 600 Ohm terminated loads. It was designed for use with load impedances of 5K Ohms or greater.

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II. Operating "CAN'S" and "CAN'TS"

1. You CAN – duplicate dbx encoded tracks by copying them directly from one machine to the next or one track to the next without decoding.
2. You CAN – sometimes use your 150 to reduce the noise found in reverb and digital delay systems. However, this will significantly affect the rate of decay and the noise reduction's inaudibility will be a function of the frequency response of the device being noise reduced.
3. You CAN'T – be as noisy in the studio as you once might have been. Coughs, feet shuffling, page turning, etc. will no longer be masked by tape hiss.
4. You CAN – reduce the effect of asperity noise* significantly by slightly over-biasing and experimenting with different brands of tape.

III. Grounding

If you hear hum, check to make sure all audio cables are properly installed and that there are no broken conductors in any cable. If possible, operate all of the audio equipment from the same circuit of the AC mains; however, be sure the total power consumption of the equipment does not exceed the rating of the AC circuit, 1750 watts maximum for a 15-amp, 117-volt circuit (the Model 150 draws 7 watts maximum). Hum and radio station pickup are sometimes caused by microscopic dirt particles between the mating surfaces of the chassis and cable connectors, so clean these surfaces periodically.

*See note, page 11.

HOW dbx NOISE REDUCTION WORKS

OVERVIEW

To reduce tape noise, the dbx 150 utilizes a sophisticated version of the classic compressor/expander (compander) concept. The RECORD processor compresses the input to the tape recorder by a 2:1 ratio, linear over a more than 100 dB range. Upon playback, the PLAY processor provides 1:2 expansion of the recorder's output. The expansion is a mirror image of the compression, so the retrieved audio cannot be distinguished from the original audio source, and virtually no audible tape noise has been added.

Consider a 100 dB program (see Figure 7) which might have loud peaks at +16 dBV and quiet passages as low as -84 dBV. If the tape recorder has a maximum input level of +16 dBV before distortion and a residual noise level of -52 dBV – in other words, 68 dB S/N ratio typical of many good multi-track tape machines – there is no way the original program dynamics can be captured on tape; peaks will be lost due to saturation, quiet passages will be lost in the noise or a combination of both. dbx encoding will solve this problem by compressing the 100 dB program to a 50 dB dynamic range. That is, the dbx encoding will bring the maximum signal level down from +16 dBV to +8 dBV and raise the minimum level from -84 dBV to -42 dBV, which will allow the recorded program to fall within the usable dynamic range of the tape recording system. The quietest signal will remain above the noise and the loudest signal will remain below the point of distortion.

NOTE: Maximum levels on tape recorders are specified at the 3% harmonic distortion point; because dbx encoding lowers maximum recorded levels, it greatly lowers distortion at the same time it eliminates audible noise.

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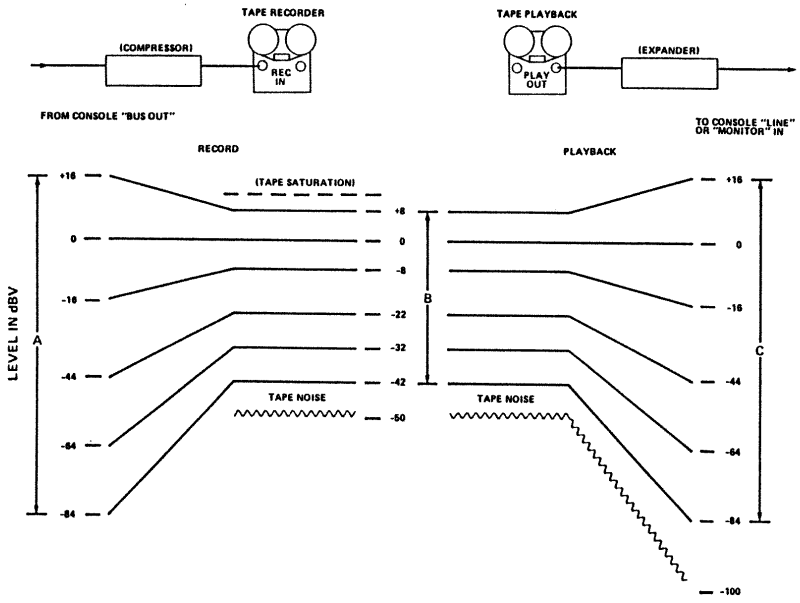

Fig. 7 – How the dbx System Works

A. Typical program of wide dynamic range (about 100 dB).

B. 2:1 compressed program (encoded) reduces dynamic range by half, so that signal can be placed below the tape saturation level and above the tape noise level.

C. 1:2 expanded program (decoded) restores the original dynamic range (100 dB). Tape noise is always well below the quietest part of the program.

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When the encoded recording is played through the dbx PLAY circuitry, expansion increases the level of the louder passages and decreases the level of quieter ones. In the preceding example, the +8 dBV recorded level would be restored to +16 dBV, the -42 dBV level would be restored to -84 dBV, and all other levels in between would be proportionately restored. The tape noise is also subject to expansion, and it drops from -50 dBV to -100 dBV to inaudibility.

System Performance Notes

1. Close scrutiny of a dbx processed tape will demonstrate that its frequency content is virtually identical to that of the original source. However, the first impression of a dbx processed tape when compared with a non-dbx processed tape may seem to indicate that the non-processed tape has better high frequency response. This apparent contradiction can be explained by realizing that the ear has interpreted the hiss of the non-processed tape as additional high frequency content.

2. On some recordings of solo bass instruments, even with dbx processing, faint noise bursts can sometimes be heard around the recorded signal. These are due to modulated background and asperity noise.* (Noise "pumping" is a recording level problem — see No. 4 under operating Do's and Don'ts page 8). Unfortunately, these noise components lie in the same frequency region as the dominant signal energy, hence we must look to steady improvements in tape technology for their reduction . . . regardless of the noise reduction system in use. Incidentally, these asperity noise components can be masked, almost completely, by a steady hiss. The required level of this "noise perfume" is about -65 dBV. It is no coincidence that noise reduction systems such as Dolby A, Dolby B and A.N.R.S., which claim "absolutely no audible effect," have this residual noise present in the output (dbx output noise is below -85 dBV). A better solution is to use a slight over-bias and select the tape being used for low asperity noise.

3. The dbx tape noise reduction system effectively eliminates tape hiss. However, like other compander-type noise reduction systems, the dbx cannot reduce noise present in the original source.

**Asperity noise is a random noise that is caused by minute imperfections or asperities in the magnetic coating of the tape. These surface irregularities cause tape to be lifted slightly off the record head at irregular intervals, causing a random noise to be superimposed on the recorded signal. The noise due to this non-homogeneous coating cannot be subtracted from the signal by compander processing. Improvements in tape manufacturing processed are reducing asperity noise. To draw a rough analogy, asperity noise is to a recorded tape what grain is to a photograph.*

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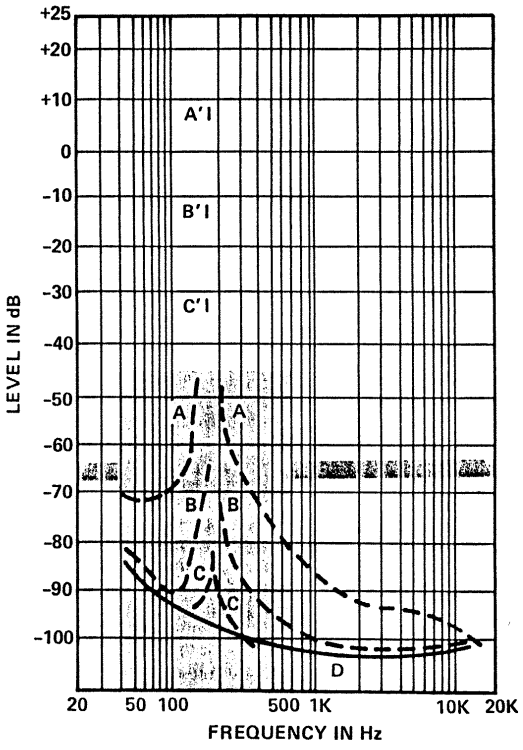
Fig. 8 — Tape Noise Characteristics

Asperity noise yields the curve shown by "D." The recorded signals (A', B' and C') are all sine waves at 180 Hz. The noise sidebands created by these signals are illustrated by curves A, B, and C. Observe that the higher the record signal level, the higher the noise sideband level. This level dependent noise is known as tape modulation noise.

The noise sidebands are masked partially by the recorded signal, but only for about two octaves on either side of the signal. This masking is depicted by the shaded box in the chart. The ear is less sensitive to lower frequencies, so the lower sidebands are masked sufficiently by the signal. Notice the upper sideband of the +10 dB recorded signal (curve A) extends beyond the masked area, and at a level which would be audible in a program of 100 dB dynamic range.

To negate or reduce modulation noise effects, dbx applies pre-emphasis to the signal before recording, and de-emphasis upon playback. The de-emphasis starts at 400 Hz and reaches a maximum weighting of –12 dB at 1600 Hz (see Figure 9). The net result is a reduction in modulation noise of nearly 12 dB with strong low frequency recorded signals, while the overall record/play response is flat.

The shaded line at –65 dB indicates the level of steady state background noise which would be required to mask modulation noise if pre-emphasis and de-emphasis (or signal weighting) were not used. With signal weighting, there is no need for this "noise perfume" as used in other compander systems.



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THE TECHNICAL DETAILS

Level Detection

Regardless of the specific techniques employed by a given compander type noise reduction system, some method must be used to sense the audio input level to the compressor when recording and to the expander when playing back. This level detection circuitry tells the compressing or expanding amplifier what the actual input signal level is, and then the amplifier's gain increases or decreases to accomplish the required expansion or compression. The basic principle of operation is simple in theory, but in practice it is difficult to maintain a precise mirror image relationship between encoding and decoding. In other words, whatever degree of compression takes place during the encoding must be precisely matched by the same degree of expansion during decoding . . . and at the same point in time with respect to the program.

There are several ways to detect signal level. Other attempts to create compander type tape noise reduction systems have utilized peak and average level detection, each of which is sensitive to phase shifts. Phase shifts are inherent in tape recording due to characteristics of the record heads, electronics and tape, so level detection schemes which are phase-sensitive are subject to mistracking errors upon decoding. That is, the amount of expansion does not correspond with the original compression, so the retrieved program will not sound like the original one. Unlike peak and average level detection systems, the RMS method sums the squares of the instantaneous energy of all frequency components present. Therefore, RMS detection is, of all the detection systems, least affected by phase shifts. However, true RMS detection has been very complex and expensive. dbx equipment uses our own, recently developed and patented analog techniques to achieve excellent RMS detection at a moderate cost.

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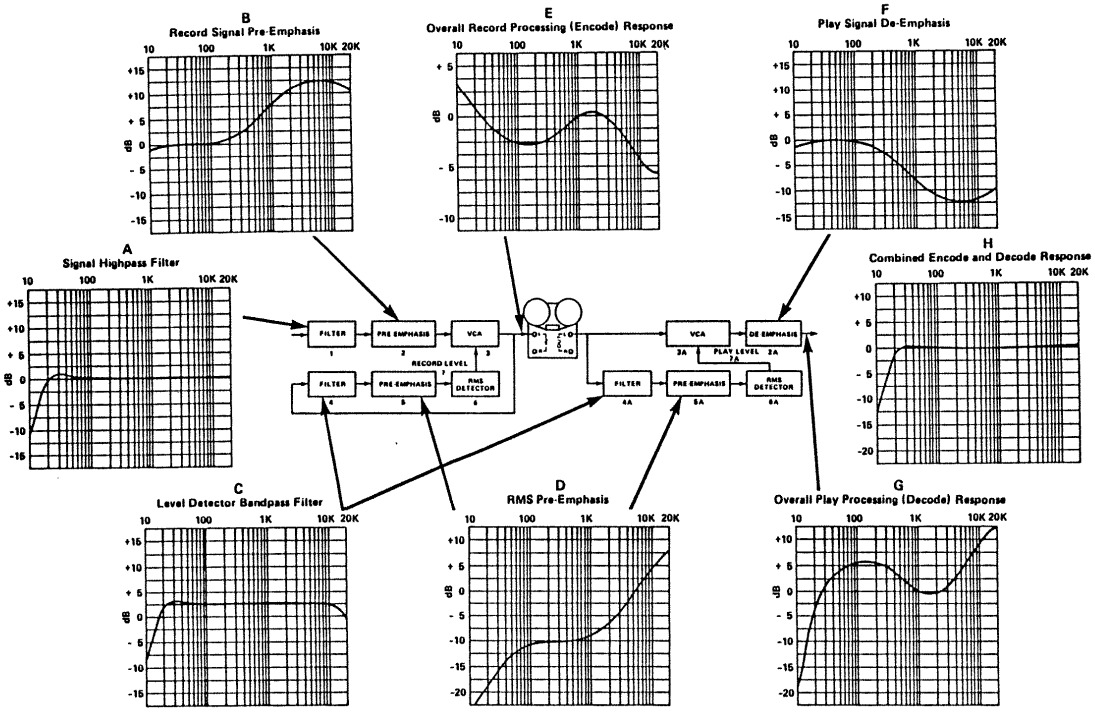

Fig. 9 — Block Diagram of dbx Noise Reduction (The functions are explained in the text and in the following paragraphs.)

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Signal Filtering

To further improve the performance of the dbx system, filters are placed in the signal path and the RMS level detection path restricting the response to the audible frequency spectrum so that subsonic and supersonic signals, such as air conditioning noise or tape bias noise, are unlikely to create encode/decode mistracking. (See Figure 10.)

A. The Signal Highpass Filter

This filter has an 18dB/octave roll-off with a 3dB down point at 17Hz. The filter prevents nonrecordable signals from entering the dbx record processor. It does not affect the audible frequency spectrum, but it does prevent encode/decode mistracking.

B. Record Signal Pre-Emphasis

A high frequency boost during encoding that matches a reciprocal high frequency cut upon decoding, thereby reducing modulation and asperity noise.

C. RMS Level Detector Bandpass Filter

The same filter is used for encoding and decoding and has an 18dB octave slope with -3dB points at 16Hz and 20 kHz. The filter affects only the RMS level detection, preventing expansion and compression circuits from reacting to subsonic or supersonic signals or from being misled by poor frequency response in the tape recorder at the extremes of the audio spectrum. This avoids encode/decode mistracking without affecting overall signal frequency response.

D. RMS Level Detector Pre-Emphasis

The same RMS Level Detector pre-emphasis curve is used for encoding and decoding. It complements the signal pre-emphasis and de-emphasis curves, avoiding excessive high frequency levels which might otherwise cause tape saturation or self-erasure.

E. Overall Record Processing (Encode) Response

This is the single sine wave response of the encoding circuitry. Given a nominal level input at the dbx 150 record input (a sine wave signal swept across the audible spectrum), this is what the dbx record output will do. Note that the overall encode and decode response (H) is essentially flat.

F. Play Signal De-Emphasis

The complementary curve for the record signal pre-emphasis, containing a high frequency roll off to reduce modulation and asperity noise components by some 12 dB.

G. Overall Play Processing (Decode) Response

This is the single swept sine wave response of the decoding circuitry. Given a nominal level input at the dbx 150 playback input (a sine wave signal swept across the audible spectrum), this is what the dbx play output will do. Note that the overall encode and decode response (H) is essentially flat.

H. Combined Encode and Decode Response

This is the combined effect of encoding and decoding and shows that the net result of dbx processing does not change the frequency content of the program.

Pre-Emphasis and De-Emphasis

Tape modulation noise is a phenomenon that occurs with all tape recordings. It consists of noise sidebands which appear on either side of the signal which is being recorded, and it is caused by inherent characteristics of the tape (see Figure 8). Modulation noise levels are significantly higher than the residual background noise (asperity noise) of the tape, although the modulation noise falls off as the frequency moves away from the recorded

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signal. The signal masks modulation noise components that lie nearby in frequency, but it does not mask noise which is several octaves above. For this reason modulation noise is most often a problem when a strong, low frequency signal is recorded. What might be heard, for example, is a low organ or bass guitar note that is accompanied by a rushing, hissing sound . . . as the organ note dies, so does the noise. dbx applies pre-emphasis and de-emphasis to reduce modulation noise by up to 12 dB.

Levels

Because there is no threshold around which the compression and expansion takes place, no pilot tones or routine calibrations are required. The 150 is provided with input level adjustments (RECORD and PLAY LEVEL adjustments) that can be set once and left unchanged unless the nominal operating level for the studio is changed. These controls adjust the dbx play input and record input gain to correspond to the nominal line levels of your equipment. These level adjustments are to maintain the same monitor levels in record, play and bypass. Level matching is not essential for proper encode/decode tracking. Refer to page 3 for level adjustment information.

The Two dbx Systems: dbx Type I and dbx Type II

The original dbx Type I noise reduction system was developed for use in professional recording studios. In response to the demands of consumers and small studios, dbx introduced a variety of affordable Type I units — the 150 series, including the model 150 and the 155. These units utilize the same signal processing as the other Type I professional recording studio models, and tapes made with one system may be decoded with the other.

Broadcasters have recognized the potential for improved signal quality which could be obtained if they were to use dbx processing. However, broadcast cartridges and telephone transmission lines do not offer the excellent frequency response available in professional recorders and better hi-fi tape machines; the low end and high end of the spectrum often fall off considerably. This poor frequency response can cause mistracking of the dbx Type I system. Therefore, the dbx Type II system was developed, represented by dbx consumer models in the 120 and 220 series and the professional 140 series. The basic principle of operation of the two systems is identical, and the amount of noise reduction is the same, yet the two systems, dbx Type I and dbx Type II are not compatible. A tape encoded with one system cannot be decoded by the other. Similarly, a dbx encoded disc (see below) cannot be decoded with the dbx Type I system since it was mastered with the dbx Type II system.

The two systems were designed for different applications. The Type I system was designed for use with tape machines which have good wide band frequency response (generally within ±1dB, 30Hz to 20kHz) and typically are used at 15ips or greater speeds. The pre- and de-emphasis circuitry which reduces modulation noise was engineered to take advantage of the headroom available when using high-speed record equalizations. The Type II system was developed to provide dbx noise reduction for use with storage and transmission media having a more restricted bandwidth and less available headroom. These include cart machines, telephone lines, STL's, cassette machines and vinyl phonograph records. The highpass filter in the signal path in the dbx Type II system is slightly more restrictive, rolling off 1dB at 24Hz. In addition, the RMS detection circuitry in dbx Type II units is sensitive only

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up to 10kHz, so high frequency losses on the tape or in the transmission lines will not create encode/decode mistracking. The frequency response of dbx Type II processing does not restrict the bandwidth of the audio signal itself.

Changes in the RMS pre-emphasis curve also distinguish the systems. However, both systems offer the same 30dB of broadband noise reduction, and a 10dB improvement in headroom for tape recordings. The differences in the detector characteristics between dbx Type I and dbx Type II processing make it inadvisable to encode with one system and decode with the other because mistracking will occur on many types of program material.

The dbx Type II system is equipped with a Norm/Disc switch that introduces a further low end roll off (-3dB @ 21Hz) in Disc mode. This has been provided to permit decoding of special dbx encoded phonograph records; the roll off protects the RMS detector from mistracking due to record warp or turntable rumble.

NOTE: Encode curve's vertical scale is corrected for the 2:1 compression factor.

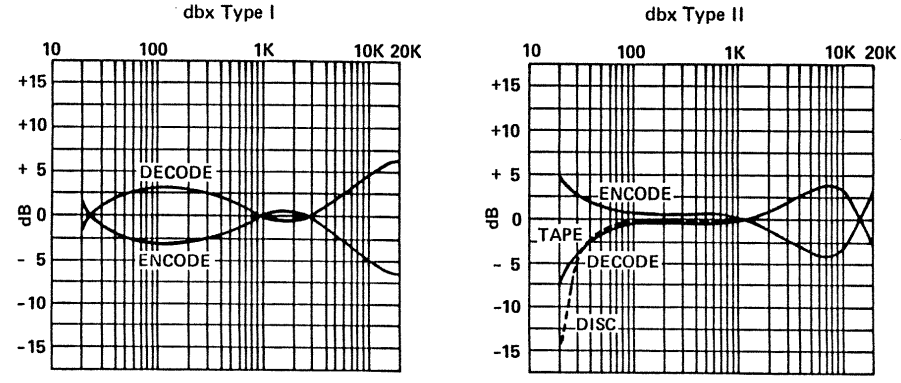

Fig. 10 — Comparison of dbx Type I and Type II Processing

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CAUTION ON AC OPERATION

1. Before connecting the power supply cord, check to make sure that AC voltage selector is set to the correct AC voltage (120V or 220V).
To change the position of the selector, insert a small screwdriver or a similar tool and slide the knob of the selector switch to appropriate position.
AC voltage selector switch is preset to "120V" at the factory prior to shipment.

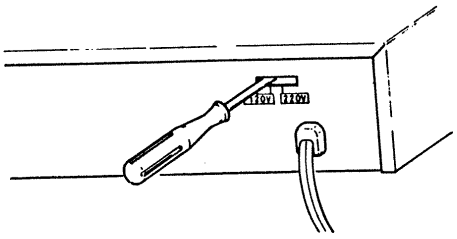

Fig. 1

2. For "220V" operation, you must purchase an attachment plug with round pin, CAT No. S-I 6111 #11 manufactured by SHOWA MUSEN KOGYO Co., Ltd. as illustrated in Fig. 2, and also very important for you to change the position of AC voltage selector switch to "220V" as illustrated in Fig. 1.

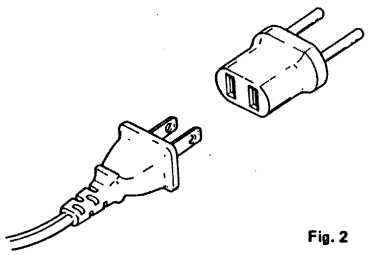

Fig. 2

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SPECIFICATIONS

DYNAMIC RANGE	110 dB (peak signal to A weighted background noise)
INPUT IMPEDANCE	100k Ohms (designed to be driven from a source impedance of less than 10k Ohms)
NOMINAL INPUT LEVEL	-10 dBV
MAXIMUM INPUT LEVEL	+16 dBV
OUTPUT IMPEDANCE	100 Ohms (designed to drive 5k Ohm load or greater). Not designed for operation into 600 Ohm loads
MAXIMUM OUTPUT LEVEL	+16 dBV
FREQUENCY RESPONSE	±0.5 dB 30Hz to 20kHz (encode/decode, typical program material tracking)
SLEW RATE	>10 V/μsec.
EFFECTIVE NOISE REDUCTION	30 dB plus 10 dB of headroom
EQUIVALENT INPUT NOISE	-85 dBV (unweighted, 20kHz bandwidth, ref. 1V)
DISTORTION	<0.5% THD 30Hz to 100Hz, <0.1% THD 100Hz to 20kHz (encode/decode)
DIMENSIONS	1-3/4" high x 19" wide x 7-1/4 deep; (4.4cm x 48.3cm x 18.4cm)
POWER LINE REQUIREMENT	120/220 VAC, 50-60Hz
POWER CONSUMPTION	7 Watts

Specifications subject to change without notice.

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