

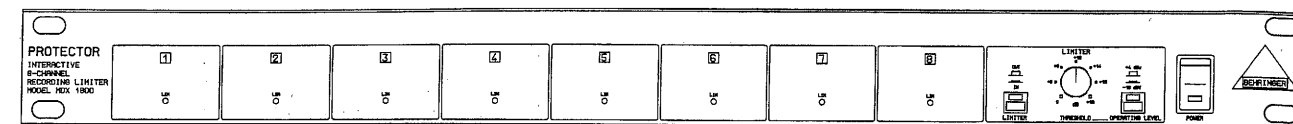
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OPERATING MANUAL

PROTECTOR®

The Interactive 8-Channel
Recording Limiter
Model MDX 1800





PROTECTOR®

The Interactive 8-Channel
Recording Limiter
Model MDX 1800 **E**

VERSION 2.0 August 1995

Text and layout: Dipl.-Ing. Uli Behringer

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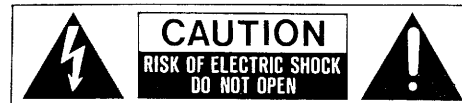
BEHRINGER®

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SAFETY INSTRUCTIONS

CAUTION: To reduce the risk of electrical shock, do not remove the cover (or back). No user serviceable parts inside; refer servicing to qualified personnel.

WARNING: To reduce the risk of fire or electrical shock, do not expose this appliance to rain or moisture.



This symbol, wherever it appears, alerts you to the presence of uninsulated dangerous voltage inside the enclosure - voltage that may be sufficient to constitute a risk of shock.



This symbol, wherever it appears, alerts you to important operating and maintenance instructions in the accompanying literature. Read the manual.

DETAILED SAFETY INSTRUCTIONS:

All the safety and operation instructions should be read before the appliance is operated.

Retain Instructions:

The safety and operating instructions should be retained for future reference.

Heed Warnings:

All warnings on the appliance and in the operating instructions should be adhered to.

Follow instructions:

All operation and user instructions should be followed.

Water and Moisture:

The appliance should not be used near water (e.g. near a bathtub, washbowl, kitchen sink, laundry tub, in a wet basement, or near a swimming pool etc.).

Ventilation:

The appliance should be situated so that its location or position does not interfere with its proper ventilation. For example, the appliance should not be situated on a bed, sofa rug, or similar surface that may block the ventilation openings; or placed in a built-in installation, such as a bookcase or cabinet that may impede the flow of air through the ventilation openings.

Heat:

The appliance should be situated away from heat sources such as radiators, heat registers, stoves, or other appliance (including amplifiers) that produce heat.

Power Source:

The appliance should be connected to a power supply only of the type described in the operating instructions or as marked on the appliance.

Grounding or Polarization:

Precautions should be taken so that the grounding or polarization means of an appliance is not defeated.

Power-Cord Protection:

Power supply cords should be routed so that they are not likely to be walked on or pinched by items placed upon or against them, paying particular attention to cords and plugs, convenience receptacles and the point where they exit from the appliance.

Cleaning:

The appliance should be cleaned only as recommended by the manufacturer.

Non-use Periods:

The power cord of the appliance should be unplugged from the outlet when left unused for a long period of time.

Object and Liquid Entry:

Care should be taken so that objects do not fall and liquids are not spilled into the enclosure through openings.

Damage Requiring Service:

The appliance should be serviced by qualified service personnel when:

- The power supply cord or the plug has been damaged; or
- Objects have fallen, or liquid has been spilled into the appliance; or
- The appliance has been exposed to rain; or
- The appliance does not appear to operate normally or exhibits a marked change in performance; or
- The appliance has been dropped, or the enclosure damaged.

Servicing:

The user should not attempt to service the appliance beyond that is described in the Operating Instructions. All other

FOREWORD

Dear Customer,

we thank you for the confidence that you have shown in the Behringer company by purchasing the Behringer PROTECTOR. Not only have you acquired the latest generation of dynamics processor, but also a piece of equipment which is unique in its design and specification.

Please study this manual carefully in order to make full use of the extensive capabilities of the Behringer PROTECTOR.

The unit was manufactured to the highest industrial standards and went through extensive quality control checks before it was supplied.

However, should you have any reason for complaint, please do NOT return the unit to us, but proceed as outlined in chapter 10.0 "WARRANTY"!

The Behringer company wishes you every success in the use of your new PROTECTOR!

BEHRINGER Specialized Studio Equipment

Dipl.-Ing. Uli Behringer (President)

Due to the high quality of parts and materials used, we offer with this product a

5 year warranty.*

Please note that this warranty is only valid if the enclosed warranty registration card is fully completed and returned to us within 8 days of purchase. You will find full details of our warranty terms on Page 10 - 1 of this manual.

* subject to our General Terms of Business



PROTECTOR

The Interactive 8-Channel Recording Limiter

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1.0 INTRODUCTION

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The Behringer PROTECTOR is an innovative 8-channel recording limiter, which can be used in conjunction with digital multi-track recorders and workstations and was specially designed for professional recording and production studios. The PROTECTOR allows for raising the level of each single recording track of your programme material up to the dynamic limit of the recorder, giving you a perfect recording without any risk of overload and distortion. Additionally, it is possible to increase the average recording level by about 10 dB without producing any disturbing side effects.

The PROTECTOR can also be used as an all-purpose multi-channel limiter for stage operation or for any other application requiring level limiting.

The Problem

Apart from their various strong points, digital systems also suffer from a few decisive drawbacks.

They basically respond to overloading by producing disastrous distortion. Even the slightest overloading results in digital clipping, which gives you an absolutely unusable audio signal.

With low input levels, on the other hand, the resolution of the digital system is in most cases not high enough to deliver an exact reproduction of the input signal. The listener perceives such recordings as 'harsh' and 'unmusical'. When the audio engineer - trying to avoid digital distortion by all means - records the material with much too low level, he is thus accepting a considerably deteriorated signal-to-noise ratio and a heavy increase of signal distortion with low input levels. Many audio engineers therefore give away a large portion of the dynamic range and prefer to record with low levels. In practice, this often means that a 16-bit system is downgraded to a 12-bit system.

The Solution

The PROTECTOR is an easy-to-operate multi-channel limiter inserted between the mixer's outputs and the recording machine's inputs. Once the unit is set up and adjusted, you can simply forget your levelling problems. The Threshold control, which is effective on all of the 8 channels, determines the maximum level limit. All signals exceeding this level are automatically cut back to the adjusted maximum level limit. This process is almost inaudible owing to our unique IGC (*Interactive Gain Control*) Peak Limiter described in the following section.

The IGC (Interactive Gain Control) Peak Limiter

The remarkable feature of the Behringer PROTECTOR is the IGC (*Interactive Gain Control*) Limiter, an intelligent combination of a *Clipper* and a *Programme Limiter*. Above an adjustable threshold the peak limiter begins to function and restricts signal peaks radically (*Clipper*). If however, the threshold of the limiter was surpassed for more than a few milliseconds, the IGC circuit automatically kicks in and reduces the level of the overall output signal so that no audible distortion occurs (*Programme Limiter*).

After the level falls below the threshold, the signal returns to the original value after a period of about 1 second. This IGC circuit proves to be extremely valuable as much for live work (loud speaker protection) as for digital situations, where any extreme signal peaks would exceed the maximum headroom and therefore would cause severe problems.

The following instructions should familiarize you with the special terms used first, so that you can get to know all the functions of the unit. After you have read the instructions carefully, please put them away safely, so that you can refer to them again if necessary.

1.1 TECHNICAL BACKGROUND

By employing current modern analogue technology, it is possible to manufacture audio equipment with a dynamic range of up to 125 dB. In contrast to analogue techniques, the dynamic range of digital equipment is approximately 25 dB less. With conventional record and tape recorder technology, as well as broadcasting, this value is further reduced. Generally, dynamic restrictions are due to noisy storage in transmission media and also the maximum headroom of these systems.

1.1.1 Noise As A Physical Phenomenon

All electrical components produce a certain level of inherent noise. Current flowing through a conductor leads to uncontrolled random electron movements. For statistical reasons, this produces frequencies within the whole audio spectrum. If these currents are highly amplified, the result will be perceived as noise. Since all frequencies are equally affected, we term this *white noise*.

It is fairly obvious that electronics cannot function without components. Even if special low-noise components are used, a certain degree of basic noise cannot be avoided.

This effect is similar when replaying a tape. The *unidirectional* magnetic particles passing the replay head can also cause uncontrolled currents and voltages. The resulting sound of the various frequencies is heard as noise. Even the best possible tape biasing can "only" provide signal-to-noise ratios of about 70 dB, which is not acceptable today since the demands of listeners have increased. Due to the laws of physics, improving the design of the magnetic carrier is impossible using conventional means.

1.1.2 What Are Audio Dynamics?

A remarkable feature of the human ear is that it can detect the most wide ranging amplitude changes - from the slightest whisper to the deafening roar of a jet-plane. If one tried to record or reproduce this wide spectrum of sound with the help of amplifiers, cassette recorders, records or even digital recorders (CD, DAT etc.), one would immediately be restricted by the physical limitations of electronic and acoustic sound reproduction technology.

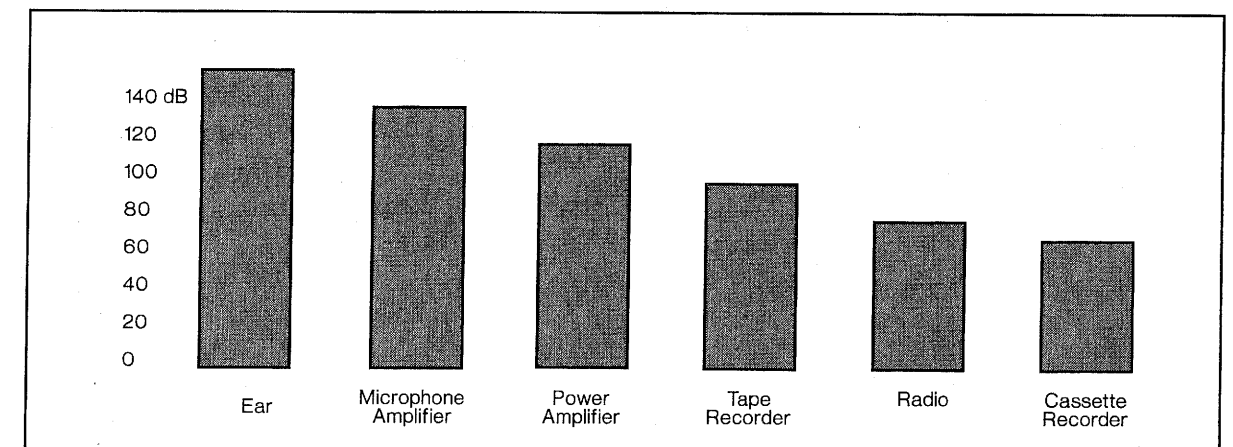


Fig. 1 The dynamic range capabilities of various devices

The usable dynamic range of electro-acoustic equipment is limited as much at the low end as at the high end. The thermal noise of the electrons in the components results in an audible basic noise floor and thus represents the bottom limit of the transmission range. The upper limit is determined by the levels of the internal operating voltages; if they are exceeded, audible signal distortion is the result. Although in theory, the usable dynamic range sits between these two limits, it is considerably smaller in practice, since a certain reserve must be maintained to avoid distortion of the audio signal if sudden level peaks occur. Technically speaking, we refer to this reserve as "headroom" - usually this is about 10 - 20 dB. A reduction of the operating level would allow for greater headroom, i.e. the risk of signal distortion due to level peaks would be reduced. However, at the same time, the basic noise floor of the programme material would be increased considerably.

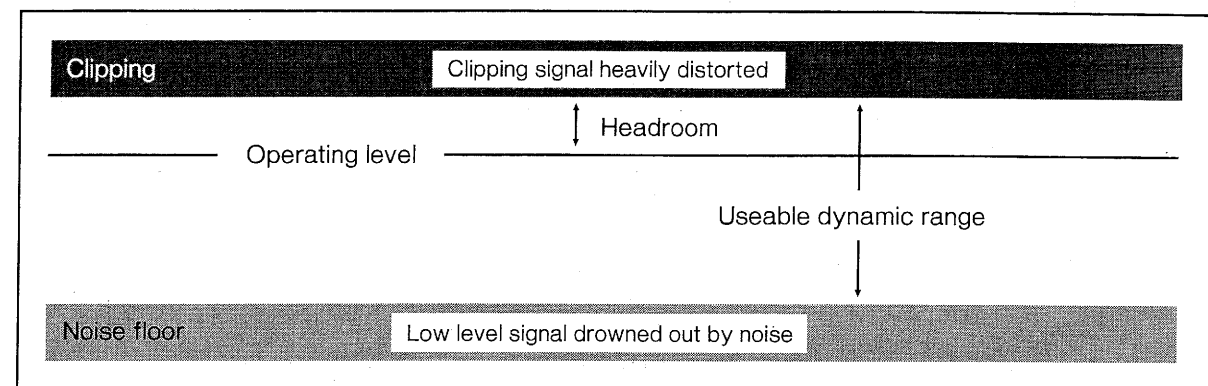


Fig. 2 The interactive relationship between the operating level and the headroom

It is therefore useful to keep the operating level as high as possible without risking signal distortion in order to achieve optimum transmission quality.

It is possible to further improve the transmission quality by constantly monitoring the programme material with the aid of a volume fader, which manually levels the material. During low passages the gain is increased, during loud passages the gain is reduced. Of course it is fairly obvious that this kind of manual control is rather restrictive; it is difficult to detect signal peaks and it is almost impossible to level them out. Manual control is simply not fast enough to be satisfactory.

The need therefore arises for a fast acting automatic gain control system which will constantly monitor the signals and which will always adjust the gain to maximize the signal-to-noise ratio without incurring signal distortion. This device is called a *compressor* or *limiter*. This system is a part of the Behringer AUTOCOM.

1.1.3 Compressors/Limiters

By measuring the dynamic range of musical instruments in live recording situations, you will find that extreme amplitudes occur which often lead to overload in subsequent signal processing equipment. Especially in broadcasting and record cutting techniques, these signal peaks can lead to heavy distortion. To avoid this kind of distortion or, for example, to avoid loudspeakers being damaged by overload, *Compressors* or *Limiters* are used.

The principle function used in these devices is dependent on an automatic gain control as mentioned in the previous section, which reduces the amplitude of loud passages and therefore restricts the original dynamics to a desired range. This application is particularly useful in microphone recording techniques, to compensate for level changes which are caused by varying microphone distances.

Although compressors and limiters perform similar tasks, one essential point makes them different:

Limiters abruptly limit the signal above a certain level, while compressors control the signal "gently" over a wider range. A limiter continuously monitors the signal and intervenes as soon as the level exceeds a user-adjustable threshold. Any signal exceeding this threshold will be immediately returned to the adjusted level.

A *Compressor* also monitors the programme material continuously and has a certain threshold level. With compression, in contrast to the action of a limiter, signals are not reduced in level abruptly once the threshold has been exceeded, but are returned to the threshold gradually. The signal is reduced in level, relative to the amount the signal exceeds this point.

Generally, threshold levels for compressors are set below the normal operating level to allow for the upper dynamics to be musically compressed. For limiters, the threshold point is set above the normal operating level in order to provide reliable signal limiting, to protect subsequent equipment from signal overload.

1.1.4 Expanders/Noise-Gates

Audio, in general, is only as good as the source from which it was derived. The dynamic range of signals will often be restricted by noise. Synthesizers, effects devices, guitar pickups, amplifiers etc. generally produce a high level of noise, hum or other ambient background hiss, which can disturb the quality of the programme material.

Normally these noises are inaudible if the level of the desired signal lies significantly above the level of the noise. This perception by the ear is based on the "masking" effect: noise will be masked and thus becomes inaudible as soon as considerably louder sound signals in the same frequency band are added. Nevertheless, the further the level that the desired signal decreases, the more the noise floor becomes a disturbing factor.

Expanders or *noise-gates* offer a solution for this problem: these devices attenuate signals when their amplitudes drop, thereby fading out the background noise. Reliant on this method, gain controlling amplifiers, like expanders, can extend the dynamic range of a signal and are therefore the opposite of a compressor.

In practice, it is shown that an expansion over the entire dynamic range is not desired. With an expansion ratio of 5:1 and a processed dynamic range of 30 dB, an output dynamic range of 150 dB will be the result, exceeding all subsequent signal processors, as well as human hearing. Therefore, the amplitude control is restricted to signals whose levels are below a certain threshold. Signals above this threshold pass through the unit unchanged. Due to continuous attenuation of the signals below this threshold, this kind of expansion is termed "downward" expansion.

The *noise-gate* is the simplest form of an expander: in contrast to the expander, which continuously attenuates a signal below the threshold, the noise-gate cuts off the signal abruptly. In most applications this method is not very useful, since the on/off transition is too drastic. The onset of a simple gate function appears very obvious and unnatural. To achieve an inaudible processing of the programme material, it is necessary to be able to control the signal's envelope parameters.

1.1.5 Companders

The most wide spread application of compressor and expander systems is found with complimentary noise reduction systems. To improve the audio quality of magnetic carrier and transmission media, the industry developed systems which artificially expanded the restricted dynamic range. These systems are called COMPANDER systems (COMPRESSOR-exPANDER) which are based on the following principle:

During recording, the amplitude of low level signals (which are below the tape's inherent noise level) are increased, i.e., the signal becomes louder. The dynamics of loud passages, however, which would saturate the tape, are reduced. Due to this signal compression, a higher recording level can be achieved.

While replaying, this process is reversed to restore the original dynamic range. By expanding the signals, i.e. by enlarging their dynamic range, the inherent noise level of the tape is reduced as well.

In order to precisely reverse the whole process, it is necessary to add a coding pattern to the programme material.

2.0 THE DESIGN CONCEPT

2

2.1 HIGH QUALITY COMPONENTS AND DESIGN

The philosophy behind Behringer products guarantees a no-compromise circuit design and employs the best choice of components.

The Behringer operational amplifiers, which are used in the PROTECTOR, are exceptional. They boast extreme linearity and very low distortion characteristics. To complement this design the choice of components includes high tolerance metalfilm resistors and capacitors, 41 detent potentiometers, gold plated relay contacts and several other stringently selected elements.

Before final calibration the unit is "burnt in", which means that the unit is placed in a special oven for several hours in order to stabilize and artificially age the unit. This guarantees several years of constant performance specifications. The burn-in test conforms to military guidelines.

2.1.1 The VCA

At the heart of the Behringer PROTECTOR lies an excellent VCA (Voltage Controlled Amplifier). With its excellent specifications (noise, THD, control feedthrough, linearity, slew rate and temperature stability) the precision VCA used in the PROTECTOR can be considered one of the best control components in VCA technology.

The "control feedthrough" used in VCA terminology, is a very critical parameter for the crosstalk of the control voltage into the audio path. Slow changes of the control voltage lead to a slow DC offset at the audio output of the VCA and are mostly inaudible. Fast controls however, will result in awkward switching noise ("clicks").

The circuitry developed by Behringer provides an instantaneous attack, without any audible clicks or pops during its operation.

2.2 INPUTS

2.2.1 Balanced Inputs

As standard, the Behringer PROTECTOR is installed with electronically servo-balanced inputs. The new circuit design features automatic hum and noise reduction for balanced signals and thus allows for trouble-free operation, even at high operating levels. Externally induced mains hum etc., will be effectively suppressed.

The automatic servo-function recognizes the presence of unbalanced connectors and adjusts the nominal level internally to avoid level differences between the input and output (correction 6 dB).

3.0 BLOCK DIAGRAM

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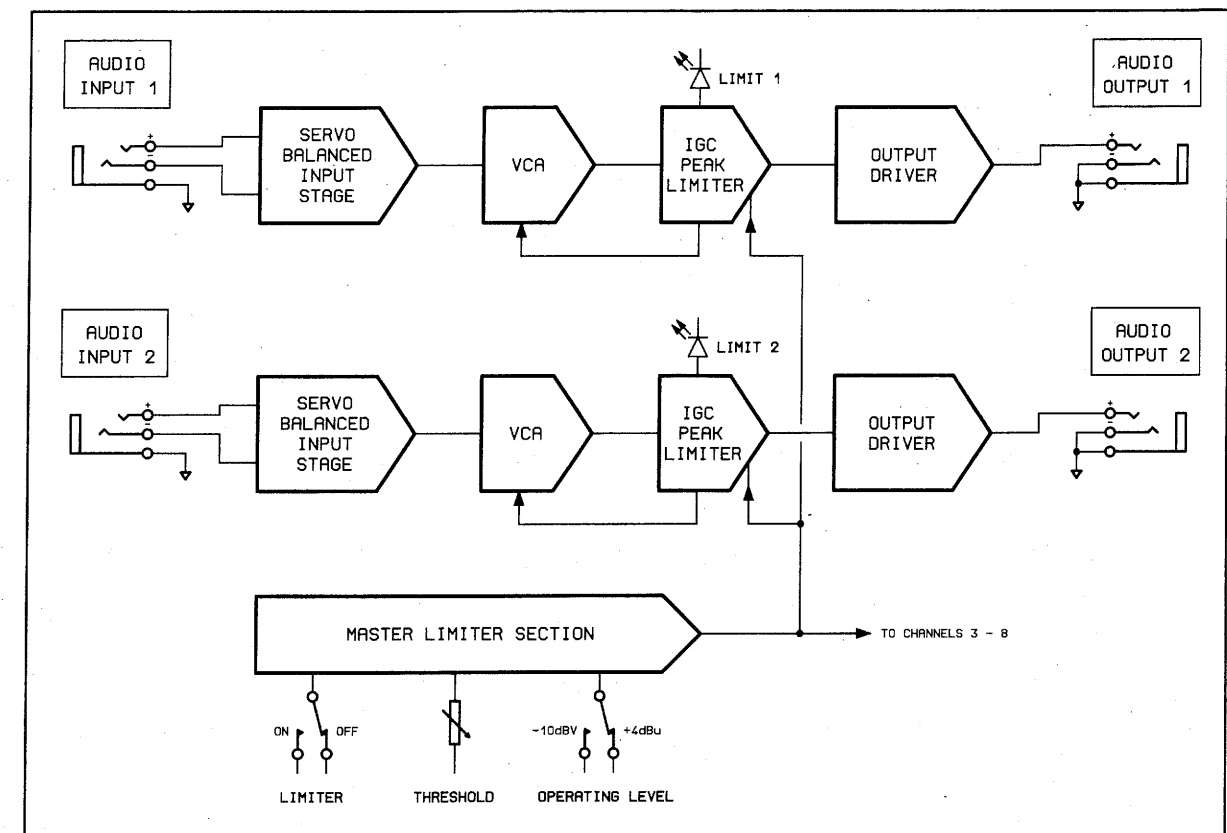


Fig. 3 Block diagram of the Behringer PROTECTOR MDX 1800

AUDIO Path

The input signal passes firstly through an electronically balanced input stage and is then directed through the VCA (*Voltage Controlled Amplifier*) which actually governs the dynamic process. The subsequent IGC Peak Limiter contains a Clipper and a Programme Limiter, which is linked to the VCA. The output driver buffers the signal and leads it to the output connector.

Master Section

All 8 limiter channels are controlled by the Master Limiter section. Here, the Threshold, the Operating Level and the In/Out functions are set.

4.0 INSTALLATION

4

Your Behringer PROTECTOR was carefully packed in the factory and the packaging was designed to protect the unit from rough handling. Nevertheless, we recommend that you carefully examine the packaging and its contents for any signs of physical damage, which may have occurred in transit.

If the unit is damaged, please do not return it to us, but notify your dealer and the shipping company immediately, otherwise claims for damage or replacement may not be granted. Shipping claims must be made by the consignee.

4.1 RACK MOUNTING

The Behringer PROTECTOR fits into one standard rack unit of space (1 3/4"). Please allow at least an additional 4" depth for the connectors on the back panel. Be sure that there is enough air space around the unit for cooling and please do not place the PROTECTOR on high temperature devices such as power amplifiers etc. to avoid overheating.

4.2 CONNECTORS

The PROTECTOR can be installed using standard 1/4" jacks. Although the inputs are fully balanced, the automatic servo-function allows them to operate with unbalanced sources/loads.

4.2.1 Impedances

The input has an impedance of 60 kOhms and can be driven by most input sources. If a device's output requires a load of 600 Ohms (provided with most output transformers), a 600 Ohm resistor should be tied across tip and ring on the input jack connector.

4.2.2 Unbalanced/Balanced Operation

90% of all mistakes in audio installations can be attributed to incorrect and defective audio connections! In order to utilize the Behringer PROTECTOR to its full potential, please pay special attention to the following section.

For better understanding, the technical difference between *unbalanced* and *balanced* systems must be clarified:

The Unbalanced System

Unbalanced operation is characterised by a single conductor shielded cable with the center conductor carrying the signal and the shield at ground.

The Balanced System

A balanced operation is defined as a two conductor shielded cable, where each of the two center conductors carry the signal but of opposite phase. They have equal but inverted potential differences from that of ground.

The advantage of the balanced system is based on the effect that the differential amplifier in a subsequent device suppresses all equal phased noise which has been induced during its transmission down the cable link. However, the original signal will be amplified and retain all its original integrity.

In this way, audio signals can be transmitted without interference or loss across long distances.

Balanced or unbalanced systems require different wiring. Please read the next section carefully and pay close attention to the correct wiring requirements of the units in the audio chain.

4.2.3 The Correct Wiring For Balanced Operation

If the unit preceding the PROTECTOR uses *output balancing*, we recommend that you use balanced audio connections. This will avoid interference such as mains hum etc.

For maximum hum rejection, you should avoid common grounding, which means, grounding the PROTECTOR's input and output.

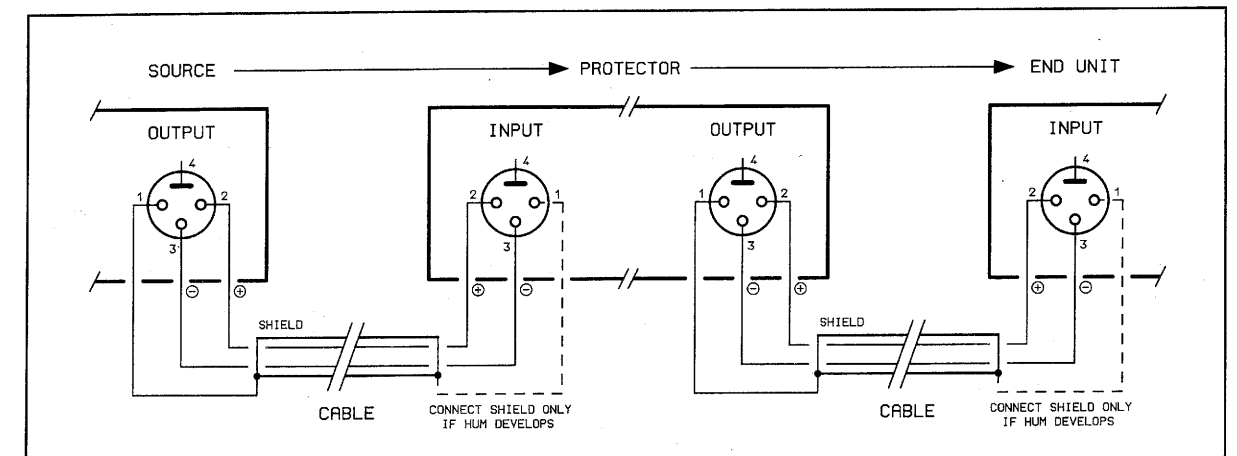


Fig. 4 The correct wiring of the balanced system

We recommend that you connect the shield of the input cable to the ground of the signal source, making sure that the shield is *not* connected to the PROTECTOR's input connector.

At the output, the shield of the cable is connected to the ground of the PROTECTOR, but making sure that the shield of the corresponding cable's end is *not* connected to the ground of the subsequent unit.

Generally speaking, the shield connection will be tied to the *source* units, but *not to destination* units.

If you still develop hum, it may be helpful in some cases to connect the shield on the input of the subsequent device also.

4.3 BALANCED/UNBALANCED OPERATION

The Behringer PROTECTOR is used with standard 1/4" jack plugs. Please refer to the following sections for correct wiring:

4.3.1 Balanced Operation

If the unit preceding the PROTECTOR uses output balancing or if the unit subsequent to the PROTECTOR uses input balancing, then we recommend the following adaptations. Figures 5 and 6 show the correct connection for *stereo jack to jack* operation.

Figure 5 shows the correct way to connect the balanced input, whereas figure 6 shows the correct way to connect the PROTECTOR's output. Please note that you can distinguish between the figures by observing the shield connections.

If you still develop hum, it may be helpful in some cases to connect the shield on the input of the subsequent device also.

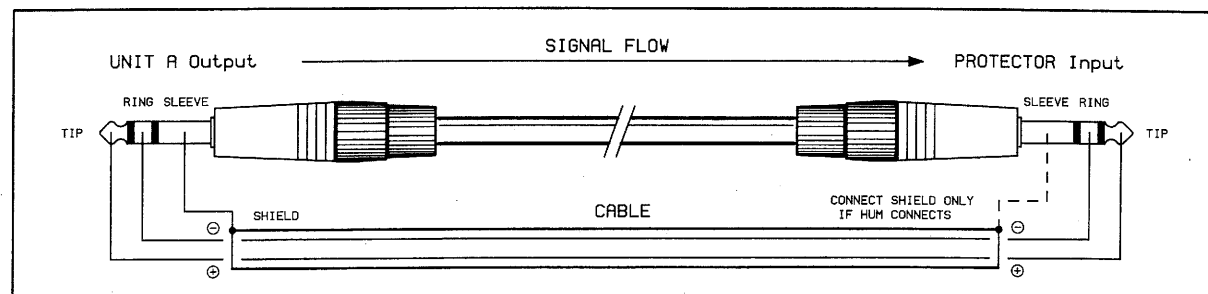


Fig. 5 Balanced PROTECTOR input wiring with 1/4" jack connections

4.3.2 Unbalanced Operation

In applications that do not require balanced connections, we recommend that you use a single conductor shielded cable with two *mono jack plugs*. Please make sure that the shield is connected at both ends.

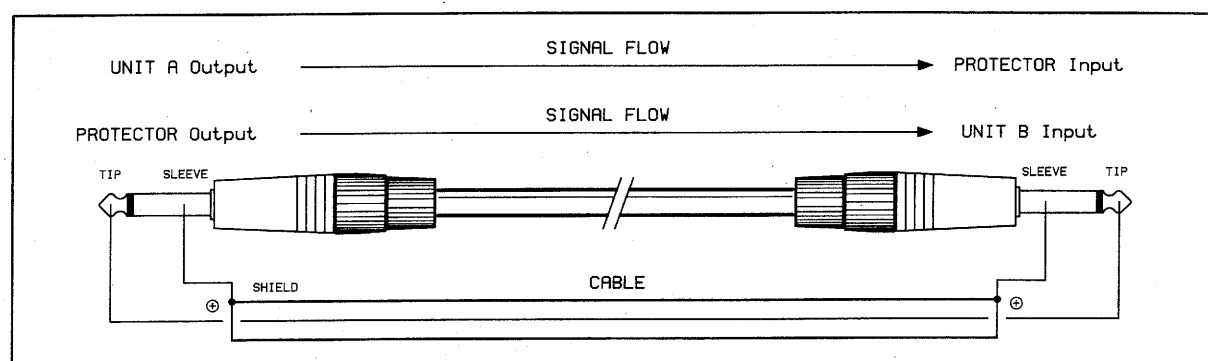


Fig. 6 Unbalanced input and output wiring with 1/4" jack connections

4.4 MAINS CONNECTION

The mains connection of the PROTECTOR is made by using a mains cable and a standard IEC receptacle. It meets all of the international safety certification requirements.

Please make sure that all units have a proper ground connection. For your own safety, it is advisable not to remove the ground connection within the units or at the supply, or fail to make this connection at all. The audio ground of the PROTECTOR is internally capacitor decoupled, to isolate it from the supply earth. It is therefore not advantageous to attempt ground loop problem solving using this method.

4.4.1 Operating Voltage Selector

Before you switch on the unit, check that it is configured to match your AC mains voltage requirements. If it does not comply, then it is necessary to switch the operating voltage to the correct supply requirements BEFORE turning on the unit, otherwise the unit could be severely damaged. You will find this combined fuse holder/voltage selector at the back, adjacent to the IEC receptacle.

Please note that the AC voltage selection is defined by the position of the fuse holder. If you intend to change the operating voltage, remove the fuse holder and twist it by 180 degrees before you reinsert it. When fully in place, a marker on the fuse-holder indicates which voltage is currently selected.

4.4.2 Safety Fuse Replacement

A safety fuse protects the unit from serious defects. If the fuse blows, this is a warning sign and always indicates that the circuit is overloaded. The fault must always be repaired before the fuse is replaced.

If the safety fuse is faulty and needs replacing after the unit is repaired, please make sure that you replace it only with the identical type and rating. NEVER use fuses of different ratings or cover faulty fuses with aluminium foil. This can cause fire and electric shocks and will endanger your life and the lives of others.

For 200-240 Volts the fuse rating is 160 mA slow-blow and 315 mA slow-blow for mains voltages of 100-120 Volts.

5.0 CONTROLS

5

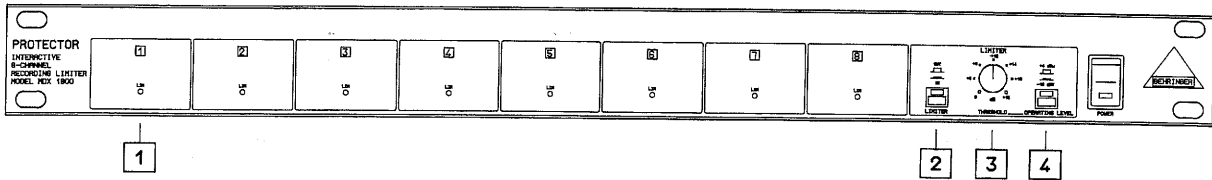


Fig. 7 The control surface of the PROTECTOR model MDX 1800

5.1 FRONT PANEL LAYOUT OF THE PROTECTOR

1 LIMIT LED

This LED is illuminated, when the signal of the corresponding channel is limited. For each channel there is an individual LIMIT LED.

2 IN/OUT switch

With this switch all eight channels are switched in and out.

3 THRESHOLD control

This control governs the maximum output level which is valid for all eight channels. The level can be adjusted in the range of 0 dB to +18 dB. Its absolute value corresponds to the setting of the OPERATING LEVEL switch.

4 OPERATING LEVEL switch

With this switch you can select the reference level of the THRESHOLD control. It can be chosen between the semiprofessional -10 dBV and the professional +4 dBu reference.

5.2 THE BACK PANEL LAYOUT OF THE PROTECTOR

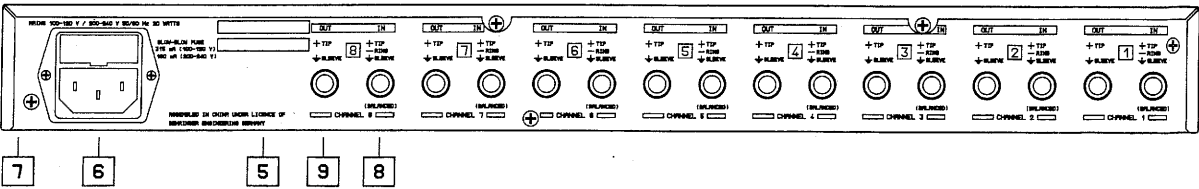


Fig. 8 The back panel layout of the PROTECTOR

5 SERIAL NUMBER

Please take the time to make a note of the serial number in the space provided on the enclosed warranty registration card. Put the instruction manual in a safe place and return the completed warranty registration card to us within 8 days of purchase, making sure that the dealer stamp has been acquired.

6 MAINS CONNECTOR

Please use the enclosed mains cable to connect the unit to the mains power supply.

7 FUSE HOLDER/VOLTAGE SELECTOR

Please note that, depending on the mains voltage supplied to the unit, the correct fuse type and rate must be installed.

Please note that the AC voltage selection is defined by the position of the fuse holder. If you intend to change the operating voltage, remove the fuse holder and twist it by 180 degrees before you reinsert it. When fully in place, a marker on the fuse-holder indicates which voltage is currently selected.

Before you connect the unit, please make sure that the displayed voltage corresponds to your mains supply.

8 AUDIO IN

This is the input of channel 8.

9 AUDIO OUT

This is the output of channel 8.

6.0 OPERATION

6

6.1 BACKGROUND

Setting the recording level on analogue tape recorders is quite straightforward. As soon as the signal level reaches the red area of the VU meter, the fader of the mixing console is simply moved back a bit. Excessive levels in analogue recording equipment are quite forgiving, since they produce only little distortion and are therefore hardly audible.

Basically, this is due to the 'soft' saturation characteristics of the tape. Sometimes, this 'soft' limiting delivers even wanted effects. Similarly to a compressor, the signal is not cut off abruptly in analogue tape machines but is limited smoothly.

Here, digital recording systems suffer from a decisive drawback: while featuring absolute linearity up to the leveling limit, even slightly overloaded signals make them produce drastic distortions, which can instantly make your recording unusable.

Although tape noise represents a minor problem in digital recorders (when compared to analogue systems), their transmission behaviour with low levels requires the same recording procedure. Therefore, any recording should basically be made with maximum levels.

An intelligent limiter is the perfect solution to this problem. Inserted at the end of the signal chain and directly preceding the multi-track recorder, the limiter makes sure that the level limit so crucial in digital systems will not be exceeded, while simultaneously increasing the average recording level. This results in a high resolution with low levels and provides absolute protection against overloading even with highest levels. In particular, with critical music material, such as acoustic or classical music, the improved audio quality can clearly be heard.

6.2 THE IGC PEAK LIMITER

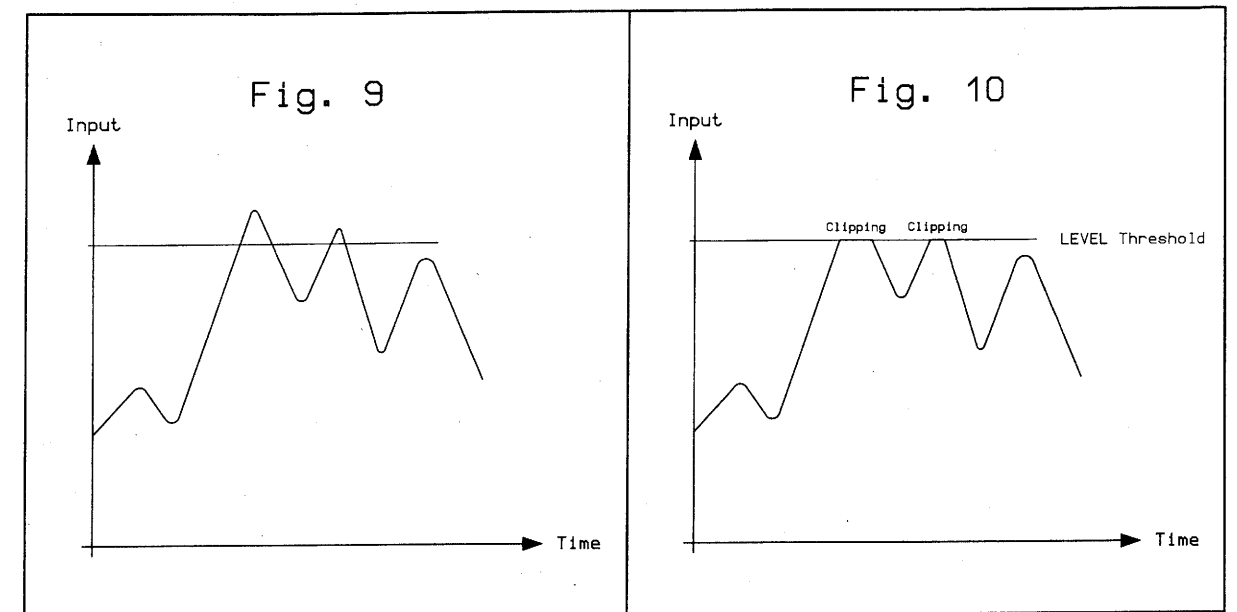
Attack time is defined as the time taken for a processor to respond to programme levels which have exceeded the threshold point.

Because of the physical relationship between frequency and slew rate, for relatively low frequencies a longer attack time is required than for higher frequencies: any unpleasant dynamic distortion is thus avoided. When compressing a programme mix that includes a wide range of frequencies, a compromise must be made when setting the attack time. This setting would generally suit the lowest frequency components present.

For general dynamic range control using for example a compressor, this is of no serious consequence. However, in a limiting mode, where we are restricting the peaks of our signals to a maximum operating level to avoid distortion in any subsequent devices, this will result in very fast high frequency signal transients passing through unaffected by gain reduction. These transients could cause distortion in the subsequent equipment such as tape recorders and radio transmitters. It is therefore necessary to choose the attack time which is as close to "zero" attack as possible, independent of the frequency.

The Behringer IGC Peak Limiter incorporated in the PROTECTOR is a dynamic processor with dynamics specifically set for these fast transients. It consists of a new, two-stage IGC (*Interactive Gain Control*) circuit, which intelligently combines the *Clipper* and the *Programme Limiter*.

The *Clipper* radically cuts signals above the threshold level. The "zero" attack function (instantaneous response) provides absolute protection for a sound system. Overload due to harmful transients is avoided.

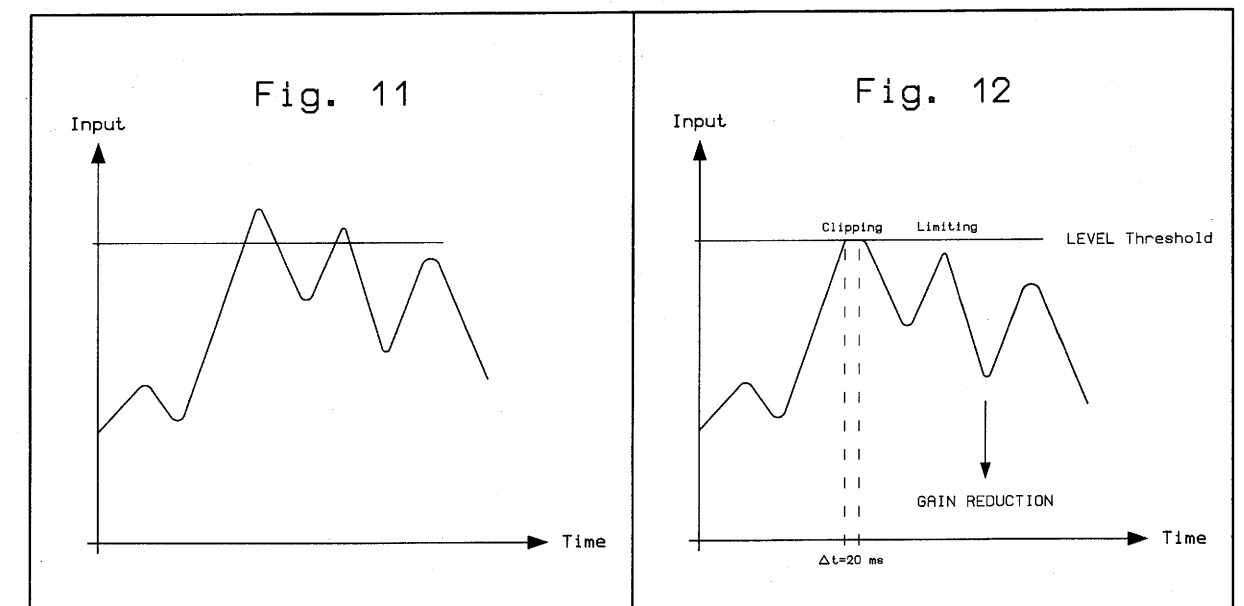


The signal BEFORE gain control (fig. 9) and AFTER clipper processing (fig. 10)

However, the Clipper has a fundamental problem: even if you do not notice the clipping of certain transients, the limiting of the actual signal amplitude leads to heavy and unpleasant distortion. It is therefore necessary to include another dynamics section, which would additionally reduce the overall level, in order to limit the time the Clipper is in effect.

This dynamics control is called a *Programme Limiter*: if the Clipper limits a signal for longer than 20 ms, the Programme Limiter is engaged and reduces the overall level for 1 second and for the necessary amplitude value to prevent a repeated response by the Clipper.

The function of the IGC Peak Limiter is shown in the following figures:



The signal BEFORE gain control (fig. 11) and AFTER IGC Peak Limiting (fig. 12)

Clipper and Programme Limiter function interactively: depending on the programme material, one of the two controls are activated. In this way, optimum limiting is always achieved.

7.0 APPLICATIONS

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In this section, several typical applications of the Behringer PROTECTOR are discussed. The following basic settings can resolve most dynamic problems. They are the ideal starting point.

Please take the time to study the application examples carefully, in order to be able to make full use of the PROTECTOR's capabilities in the future.

7.1 MAIN APPLICATIONS AND INITIAL SETTING

Insert the PROTECTOR between your mixing console and multi-track recorder by connecting the outputs of your mixer (usually the Bus or Direct Outputs) to the eight inputs of the PROTECTOR. The outputs of the unit are connected to the analogue line inputs of the multi-track recorder.

7.1.1 Initial Setting

Controls:	Setting:
IN/OUT switch:	IN
THRESHOLD control:	+18 dB
OPERATING LEVEL switch:	+4 dBu

The setting of the OPERATING LEVEL switch depends on the recorder and/or mixer used, i.e. whether the operating level is +4 dBu or -10 dBV. Information on the operating level can be found in the manuals accompanying your equipment.

Having linked everything properly, audio signals should be transmitted successfully through your system. The LIMIT LEDs should not yet light up. We recommend using an oscillator to effect the basic mixer and recorder settings. When 0 dB VU are adjusted on your mixing console, the corresponding reading on the recorder's peak display should be -18 dB. If your mixer is equipped with a peak display, an end-scale reading on this display should produce about 0 dB (maximum level) on the display of the digital recorder.

Now use some programme material which is not yet compressed and adjust the level on your mixer so that an average level of 0 VU is reached. Level peaks of +1 or +2 dB are permitted. Then set up your recorder so that occasional overloading is displayed.

Turn the PROTECTOR's THRESHOLD control counter-clockwise until the signal peaks are limited to such an extent that the recorder does not read any overloading. To be on the safe side, you can temporarily increase the mixer level to find out whether the recorder detects any overloading. If necessary, re-adjust the THRESHOLD control. The onset of the limiter function is displayed by the associated LIMIT LEDs.

If it proves difficult or impossible to set the THRESHOLD control correctly, press the OPERATING LEVEL switch. In position '-10 dBV' the scaling refers to the lower -10 dBV reference value, which makes it easier to set up semi-professional mixing consoles and recorders.

The majority of digital recorders do not have an input control, so that you will have to use your mixer to adjust the average level and the PROTECTOR to set up the maximum level limit.

7.2 RECORDING WITH THE PROTECTOR

Use the PROTECTOR to record your basic tracks with increased headroom and better protection against overloading. However, you should keep in mind that the THRESHOLD control is effective on all limiter channels at the same time. If you wish to record several tracks simultaneously but want to re-adjust one specific instrument only, you should use the channel fader on your console. Please remember that the maximum level is set with the mixer, while the maximum signal level is controlled with the PROTECTOR. Any subsequent fine-adjustment of individual tracks should be done using the faders on the mixing console.

7.3 HOW MUCH LIMITING SHOULD BE APPLIED?

Please reconsider again how the IGC limiter works:

Level peaks of about 6 dB are cut off by the Clipper. These are so-called transients, i.e. short level peaks. Cutting off these peaks does not audibly restrict the dynamics. This function should be used, for example, for classical music where an unlimited dynamic range is essential. Set up the PROTECTOR so that the LIMIT LED's are normally off and light up with signal peaks only. This leaves the recording unaffected but still provides protection against overloading.

If the Clipper limits by more than 6 dB, the Programme Limiter comes in and reduces the level of the respective channel to avoid distortion. Much like a manual level control, this circuit reduces the overall level before it enters the clipper circuit. With lower threshold settings this allows for a 'tighter' sound and keeps the average level high. This mode is particularly suited for pop music where the dynamic range needs to be compressed considerably. If applied excessively, limiting can cause audible pumping effects due to massive dynamic processing.

Ultimately, your ear should be the judge which setting works best for your specific application. Do not hesitate to experiment and you will soon get the right feeling.

8.0 SPECIAL APPLICATIONS

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8.1 USING THE PROTECTOR FOR RECORDING AND CASSETTE DUPLICATION

In the recording and duplication field, the goal should always be to achieve an optimum recording level onto the recording media. Too low or too high recording levels lead to side effects such as noise, distortion etc. In mastering and multitrack recording, as well as in duplication, one should always take care to utilize the full dynamic range of the tape recorder, DAT recorder etc. Principally, it is possible to control the recording level by 'riding' faders, which means with low level signals, the gain is increased, whereas the amplitude of high level signal is reduced. It is obvious that this method is insufficient because, especially in live recordings, the expected signal levels cannot be anticipated correctly. Especially with multitrack recordings, which are run under hectic circumstances, the signal level of all channels cannot be monitored and controlled at the same time. Generally, with manual control, it is not possible to achieve satisfying recording results.

An automatic gain control system achieves better and more constant results. Use the PROTECTOR by starting with the initial settings, and use its dynamic control functions in order to be able to drive an analogue, as well as a digital recording, up to the limit of its maximum dynamic range while remaining noise- and distortion-free.

8.1.1 The PROTECTOR In Digital Recording And Sampling

In an analogue recording, too low recording levels lead to an increased noise level, whereas too high levels will cause a compressed and 'squashed' sound. In extreme cases, it will cause distortion due to tape saturation. In contrast to analogue, side effects in the digital field always become extremely audible: with decreasing level, a tape previously recorded with insufficient level loses resolution: the recording sounds 'hard' and loses 'atmosphere'. With excessive level, the recording sounds harsh and heavily distorted. In order to avoid these effects, the limiter function of the PROTECTOR should be used. As a result of this process, a digital recording or a sampling event can be optimally set in level without any problem.

8.1.2 The PROTECTOR In Mastering

The mastering process is one of the most critical processing steps in recording. In this production step, it is the goal to achieve a 'maximum level' copy of the recording, without any noise or distortion. In many applications it is further required to produce a high average volume. In the field of commercial media for example, this is apparent especially with records and cassettes which are processed with high average volumes. Quite often in these cases, dynamics suffer drastically, because the programme material has been compressed and limited too heavily. Using the PROTECTOR allows you to drastically increase the overall volume, without audibly affecting the dynamics.

This effect is particularly noticeable with DAT recorders, whose level indicators achieve a response time of less than 1 ms. Set the DAT recorder at unity and now reduce the THRESHOLD control of the PROTECTOR until the LIMIT LEDs are illuminated. The 'cut' signal peaks cause a reduced recording level of about 6 dB, which is visible on the level indicators of the DAT recorder. Now increase the recording level of the recorder back to unity.

The result is a clearly louder recording without any loss of quality.

8.2 THE PROTECTOR AS A PROTECTIVE DEVICE

Sound system distortion is usually a result of amplifiers and loudspeakers being driven beyond their limitations by signals clipping. The signal limitations that occur lead to unpleasant distortion that is dangerous to the speakers.

A speaker diaphragm is required to accelerate, slow down, smoothly change direction and accelerate again in normal operation. Distorted operation (clipping) leads to instant acceleration, instant stop, change of direction and instant acceleration again. Since speaker diaphragms are subject to the laws of physics, they will not take this kind of punishment for long: the diaphragm will either break up or its voice coil may overheat.

In addition to the damage caused by sustained overload, the speaker may also be damaged by an occasional high level overload, e.g. the sound of a microphone falling onto a hard floor. Even if this type of transient does not destroy a speaker outright, it may damage the speaker surround in such a way, as to cause mechanical abrasion and future failure. It is recommended that you use the Behringer PROTECTOR in order to protect the speaker. "Brick Wall" peak limiters are not normally necessary for PA systems, as amplifiers and loudspeakers are tolerant of short signal peaks. Nevertheless, conventional limiters have to be generally driven far beyond the headroom limit of an amplifier, in order to limit the level and length of the transients responsible for overloading the system. The disadvantage of this principle is that the unit's full range cannot be completely used.

If an increase in the average level of up to 3 dB is attained with the PROTECTOR's limiter function, this means that you effectively double the power amplification. The PROTECTOR can act in this way to convert a PA system of 5,000 Watts into a distortion free 10,000 Watts system.

The following instructions will help you to integrate the unit into your system.

8.2.1 Protection Of A System With A Passive Crossover

If your sound system incorporates a passive crossover network (included in the loudspeaker case), insert the Behringer PROTECTOR between your mixing console output and the power amplifier input.

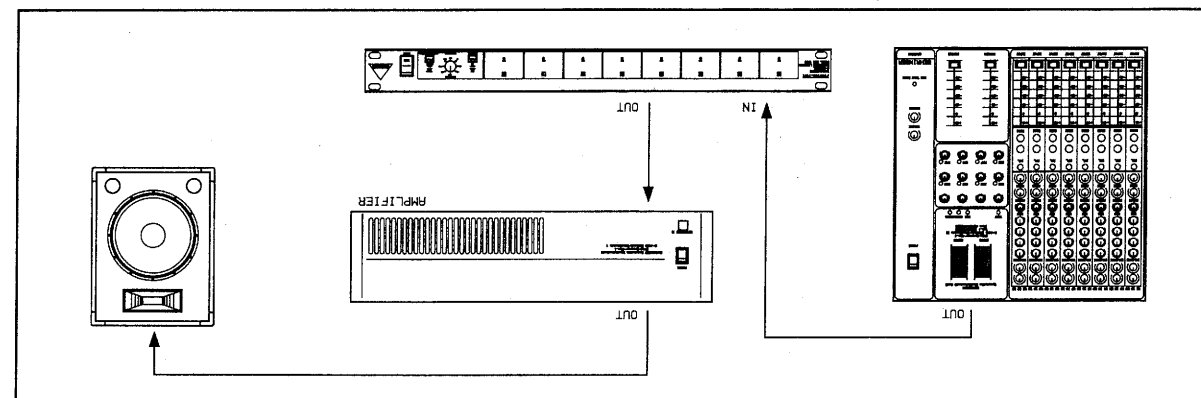


Fig. 13 Integrating the Behringer PROTECTOR into a system with a passive crossover network

8.2.2 Protection Of A System With An Active Crossover

For systems using active crossovers, there are two ways to use the Behringer PROTECTOR. As shown in fig. 31, the unit may be inserted between the console output and the crossover input. In this application, the Behringer PROTECTOR will process the entire audio frequency spectrum.

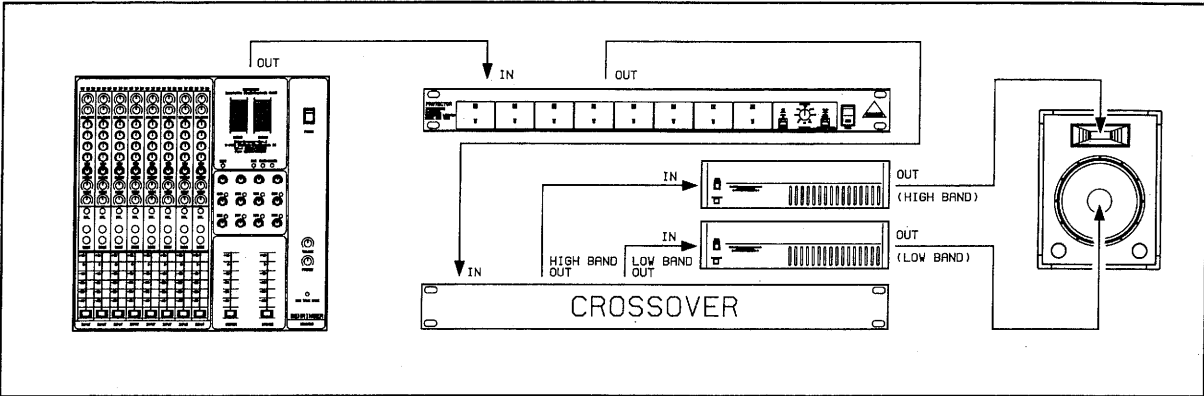


Fig. 14 The Behringer PROTECTOR in a two way system

Alternately, the Behringer PROTECTOR can be inserted between the output of an active crossover and the input of a power amplifier. In this application it will only affect a specific range of frequencies.

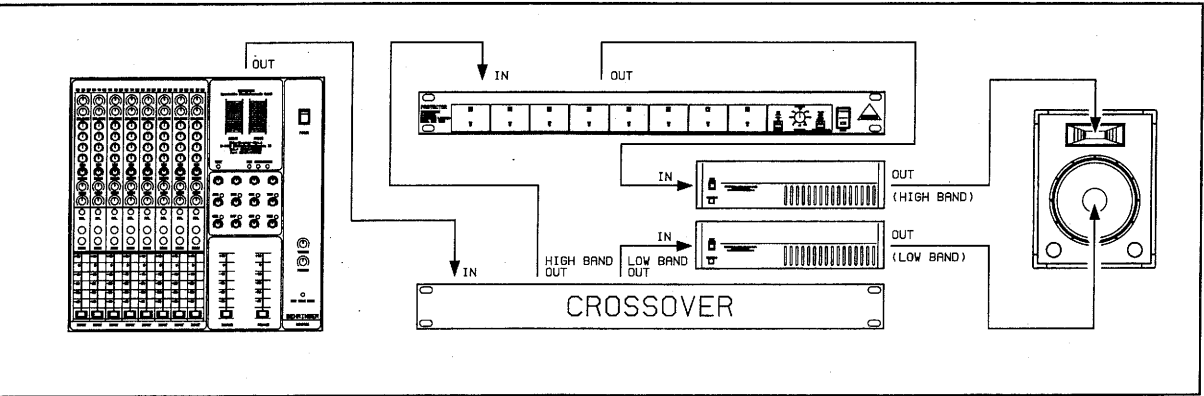


Fig. 15 Compressing the high frequency range with the Behringer PROTECTOR

8.2.3 Improving The Sound Of A Processor System

A processor system is understood as a PA system which contains a special active crossover whose outputs are linked via separated power amplifiers to the loudspeakers. Each band has its own limiter whose task it is to limit dangerous signal peaks to a certain level. This process avoids overloading the subsequent power amplifier or destruction of the loudspeaker.

In some units, the crossover frequencies in the crossover unit are further changed during high signal levels to achieve a "loudness contour" suited to the human hearing. But in many cases, this function leads more to a disturbance than to an improvement of the sound quality.

If the PROTECTOR is preceding this system, the signal peaks can be eliminated before they reach the limiters of the processing system. The sound quality therefore remains natural and free of side effects caused by the changing frequencies of the crossover.

9.0 SPECIFICATIONS

INPUTS

Type	RF filtered, servo-balanced input
Input Impedance	60 kOhms, balanced
Nominal Operating Level	-10 dBV to +4 dBu
Maximum Input Level	+20 dBu balanced and unbalanced
CMR	better than 40 dB

OUTPUTS

Type	Electronically buffered output driver
Output Impedance	40 Ohms, unbalanced
Maximum Output Level	+20 dBu
Bandwidth	5 Hz to 100 kHz, +0, -3 dB
THD @ +4 dBu	0.01 % typ.
IMD (SMPTE) @ +10 dBu	0.008 % typ.
Noise & Hum	-98 dBu (20 Hz to 22 kHz, unweighted)
Crosstalk @ 20 kHz	better than -85 dBu

PEAK LIMITER SECTION

Type	IGC (Interactive Gain Control) Peak Limiter
THRESHOLD control	variable (0 to +18 dB)
IN/OUT switch	Activates all eight channels
OPERATING LEVEL switch	Selects the operating level between +4 dBu and -10 dBV

INDICATORS

LIMIT LEDs	Indicates the onset of the corresponding limiter
LED indicator for each function switch	

POWER SUPPLY

Mains Voltages	100-120/200-240 VAC 50-60 Hz
Power Consumption	10 Watts
Fuse	315 mA (100-120 V); 160 mA (200-240 V) slow-blow
Mains Connection	Standard IEC receptacle

PHYSICAL

Dimension	13/4" (44.5 mm)H * 19" (482.6 mm) * 8.5" (217 mm)
Net Weight	3 kg
Shipping Weight	4.3 kg

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10.0 WARRANTY

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§ 1 WARRANTY REGISTRATION

Warranty Registration must be completed and returned to Behringer GmbH within 8 days from the date of purchase.

§ 2 WARRANTY

Behringer GmbH warrants the materials, workmanship and proper operation of this Behringer product for a period of five years from the original date of purchase. If any defects are found in the materials or workmanship, or if the product fails to function properly within the specified warranty period, Behringer GmbH will repair or replace the product, at its discretion.

§ 3 RETURN AUTHORIZATION NUMBER (RA)

1. To obtain factory service call Behringer GmbH for a Return Authorization Number. RA numbers are necessary for proper tracking of your product. Call:

Tel (0) 21 54 / 92 06-0 (10 am to 5 pm weekdays (MET))

2. The product must be returned in its original shipping carton, freight prepaid to:

BEHRINGER Spezielle Studiotchnik GmbH

Otto Brenner Str. 4

FRG-47877 Willich/Munchheide II

Federal Republik of Germany

§ 4 WARRANTY AUTHORITY

Behringer GmbH reserves the right to inspect any products which may be the subject of any warranty claim before repair or replacement is carried out.

Behringer GmbH may, at its discretion, require proof of the original date of purchase (dated copy of original retail dealer's invoice). Final determination of warranty coverage lies solely with Behringer GmbH. Any Behringer product deemed eligible for repair or replacement under the terms of this warranty will be repaired or replaced within 30 days of receipt of the product at Behringer's factory. Products which do not meet the terms of this warranty will be repaired and returned C.O.D. with an invoice for labour, materials, return freight and insurance. Products repaired under warranty will be returned freight prepaid by Behringer GmbH, to any location within the boundaries of the Federal Republic of Germany. Outside of Germany, products will be returned freight collect.

§ 5 WARRANTY TRANSFERABILITY

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PROTECTOR®

Der interaktive 8-Kanal
Recording Limiter
Modell MDX 1800

