Operating Manual

Transmission Limiter

Model 4000 and 4000A1

orban®

IMPORTANT NOTE: Refer to the unit's rear panel for your Model #.

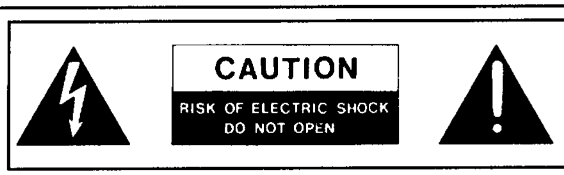
Model #:	**Description:**
4000/U75	2 ch, 120V, 75µs
4000/J50	2 ch, 100V, 50µs
4000/E50	2 ch, 230V, 50µs
4000/E17	2 ch, 230V, J.17
4000/UT75	2 ch, 120V, Output Xfmr, 75µs
4000/JT50	2 ch, 100V, Output Xfmr, 50µs
4000/ET50	2 ch, 230V, Output Xfmr, 50µs
4000/ET17	2 ch, 230V, Output Xfmr, J.17
4000/UTT75	2 ch, 120V, Input Xfmr, Output Xfmr, 75µs
4000/JTT50	2 ch, 100V, Input Xfmr, Output Xfmr, 50µs
4000/ETT50	2 ch, 230V, Input Xfmr, Output Xfmr, 50µs
4000/ETT17	2 ch, 230V, Input Xfmr, Output Xfmr, J.17
4000A1/U75	1 ch, 120V, 75µs
4000A1/J50	1 ch, 100V, 50µs
4000A1/E50	1 ch, 230V, 50µs
4000A1/E17	1 ch, 230V, J.17
4000A1/UT75	1 ch, 120V, Output Xfmr, 75µs
4000A1/JT50	1 ch, 100V, Output Xfmr, 50µs
4000A1/ET50	1 ch, 230V, Output Xfmr, 50µs
4000A1/ET17	1 ch, 230V, Output Xfmr, J.17
4000A1/UTT75	1 ch, 120V, Input Xfmr, Output Xfmr, 75µs
4000A1/JTT50	1 ch, 100V, Input Xfmr, Output Xfmr, 50µs
4000A1/ETT50	1 ch, 230V, Input Xfmr, Output Xfmr, 50µs
4000A1/ETT17	1 ch, 230V, Input Xfmr, Output Xfmr, J.17

OPTIONS:

Model #:	**Purpose:**
SC1 (CLEAR)	Security Cover for 4000A1
SC2 (CLEAR)	Security Cover for 4000

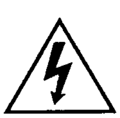
MANUAL:

Part Number:	**Description:**
95077-000-02	4000 Manual



CAUTION: TO REDUCE THE RISK OF ELECTRICAL SHOCK, DO NOT REMOVE COVER (OR BACK). NO USER SERVICEABLE PARTS INSIDE. REFER SERVICING TO QUALIFIED SERVICE 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.

Operating Manual

Transmission Limiter

Model 4000 and 4000A1

orban®

The 4000 Transmission Limiter is protected by U.S. patents 4,249,042; 4,208,548; 4,460,871; and U.K. patent 2,001,495. Other patents pending.

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Orban 4000

Transmission Limiter

Operating Manual

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Section 1
Introduction

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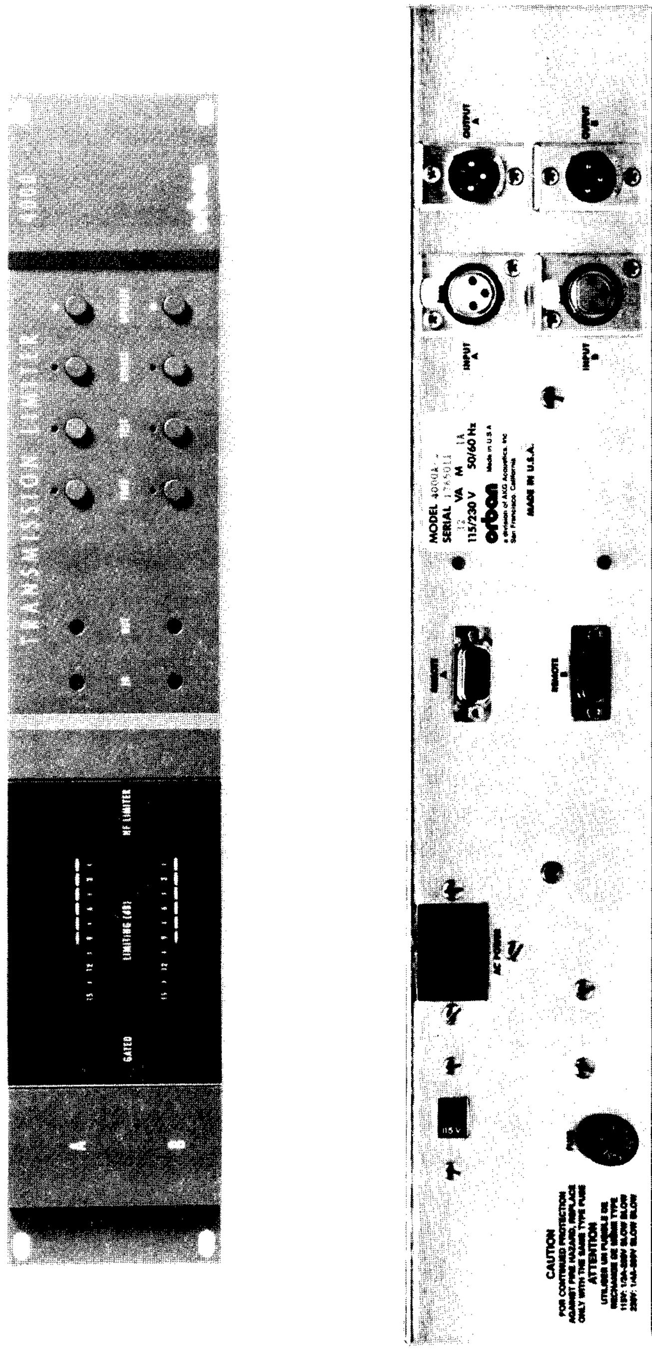

Figure 1-1: Front and Rear Panels

The 4000 Transmission Limiter

Orban's 4000 Transmission Limiter protects transmission links, such as digital links, land lines, microwave links, and satellite links, from overload. To achieve simple, error-free setup and operation, the 4000 Transmission Limiter is equipped with the minimum number of controls and indicators necessary to do its job properly.

The 4000 Transmission Limiter provides the following features and functions:

- **transparently protects transmission links** (such as digital PCM, NICAM, analog microwave, and telephone/post lines) from overload.

  Orban's OPTIMOD-AM, OPTIMOD-FM, OPTIMOD-TV, and OPTIMOD-HF protect **broadcast transmitters** more effectively. These OPTIMOD units should always be used wherever **transmitter protection** is required, except for applications requiring "purist" total transparency of sound, without the benefit of OPTIMOD's level and loudness control.

- can be purchased in **single-channel** and **dual-channel** configurations. The dual-channel unit can be strapped for stereo.
- accurately and transparently **limits levels** without producing audible artifacts.
- has very low static and dynamic distortion, thus producing **extremely transparent, natural audio quality**, both below and above threshold.
- includes **pre-emphasis limiting** for five different pre-emphasis curves: 25µs, 50µs, 75µs, 150µs and CCITT J.17.
- rigorously **limits its output bandwidth** to 15kHz while constraining overshoots at its output to approximately 1dB maximum.
- contains a built-in **100% modulation tone generator**, facilitating quick and accurate level setting in any system.
- is **fully remote-controllable** so that large facilities can perform routine network line-up checks centrally.
- accurately indicates limiting with a 10-element LED bargraph array.
- has a **hard-wire relay bypass** that can be activated locally or by remote control, and which activates automatically when the 4000 loses mains power.
- has a **transformerless, balanced 10kΩ instrumentation-amplifier input and a transformerless, balanced, floating 30Ω output** to ensure highest transparency and accurate pulse response. (Optional high quality input and output transformers are available to protect against the very high common-mode voltages present on certain long lines.)
- is designed to meet all applicable **international safety standards**.

Transmission Limiting: Orban's Approach

Traditionally, transmission limiters have used peak-sensing automatic gain control (AGC) circuits to control peak levels. Superficially, this approach seems reasonable. The purpose of a transmission limiter is to control the peak levels in a transmission channel.

This approach ignores one crucial requirement for transmission limiter performance: the limiter must provide *natural-sounding* control that is *undetectable to the ear* except by an A/B comparison to the original source material. Because the human ear is basically average-sensing, not peak-sensing, the simplistic peak-sensing AGC technique causes highly unnatural variations in subjectively-perceived loudness. Audio material with a high peak-to-average ratio emerges from such a limiter much quieter than audio material with a low peak-to-average ratio. The ear perceives this as an unnatural, unpleasant "pumping" quality. Thus the peak-sensing AGC limiter fails to provide natural sound quality, and we must use more sophisticated techniques.

To achieve natural sound quality, the gain control section of the limiter must respond like the ear. This means that the gain control must respond approximately to the power (not the peak level) in the signal. Further, because the sensitivity of the ear decreases dramatically below 150Hz, the control must be frequency-weighted to compensate. Otherwise, heavy bass would audibly modulate the loudness of midrange program material, a problem called "spectral gain intermodulation."

The gain control in the Orban 4000 occurs in two frequency bands with a crossover of 150Hz. Further, the level detector has an attack time of approximately 2 milliseconds, so it approximates a power response instead of a peak response. Because its two frequency bands are cross-coupled, the 4000 ordinarily behaves as a wide-band limiter and preserves the frequency balance of the input program material. However, if material having very heavy bass appears, the "bass" band (below 150Hz) will temporarily produce more limiting than the "master" band (above 150Hz). This prevents the bass from audibly modulating the loudness of the midrange.

Because the gain control section of the 4000 is not peak-sensing, its output contains peak overshoots that must be eliminated by further circuitry. The 4000 provides three cascaded circuits to control peaks: the high-frequency limiter, the "Smart Clipper™" distortion-canceling clipper, and the Frequency-Contoured Sidechain™ overshoot corrector.

The high-frequency limiter is only used when the 4000 is configured to control peak levels in a pre-emphasized transmission link. It is a program-controlled dynamic filter that temporarily rolls off excessive high frequency power (caused by pre-emphasis) to prevent distortion in the following clipper circuitry.

The "Smart Clipper" distortion-canceling clipper is the prime means for peak control. Because it removes *only instantaneous peaks in the waveform that exceed the desired limiting level,* it does not affect the average level and does not cause unnatural loudness variation.

Traditionally, clippers cause objectionable distortion. Such distortion is prevented in the "Smart Clipper" by proprietary, patented circuitry that analyzes the frequency spectrum of the distortion products produced by clipping, and manipulates this distortion spectrum to ensure that the distortion products are psycho-acoustically masked by the desired program material.

Such manipulation of the distortion spectrum introduces a small amount of peak overshoot into the output of the "Smart Clipper." Further, this circuit contains low-pass filters that strictly constrain the output spectrum to 15kHz, but which overshoot. These overshoots are eliminated by the Frequency-Contoured Sidechain overshoot corrector. This circuit derives a band-limited signal that can be added to its input signal to cancel overshoots without destroying the spectral integrity of the signal, as simple clipping would do.

There is an important and sometimes confusing consequence of this system design: **the system will not permit sinewaves to reach 100% peak modulation**, but will restrain their modulation to a lower level — typically 7dB below 100%. Therefore, in OPERATE mode the system *will not pass a line-up tone at 100% modulation; it will produce limiting that constrains the tone to approximately 45% modulation.*

This is a direct consequence of the level detection's being power-sensing. For a given peak level, *sinewaves have very high average power by comparison to program material.* To preserve natural sound, the processing must reduce their peak level below the peak level of program material to preserve consistent average power at the limiter's output. This is a characteristic of any limiter which achieves natural-sounding dynamic performance and which does not modulate program loudness according to the peak-to-average ratio of the input signal.

Almost all program material will produce frequent peaks at 100% modulation at the 4000's output. Program material that does not produce such peaks has an unusually low peak-to-average ratio and will sound naturally balanced when applied to the transmission system below 100% peak modulation.

To facilitate system line-up, the 4000 has a special TEST mode that raises the threshold of the gain control section to 100% peak modulation, permitting system line-up tones to be passed without limiting. The 4000 also has a built-in 400Hz oscillator that will produce a tone at 100% peak modulation.

Delay-Line Techniques vs. Distortion-canceling Clipping

The 4000 Transmission Limiter was designed to achieve maximally transparent sound below threshold and extremely natural dynamics above threshold. Our goal was to have the transition into limiting *undetectable to the ear.* We feel that delay line techniques are incongruent with these goals because a delay-line limiter is simply a highly refined "peak-sensing AGC circuit." While a delay line limiter can achieve very low perceived distortion, it does so at the expense of having an extremely fast attack time such that limiting is produced on every transient overshoot, no matter how brief. While this effect is somewhat reduced by an "automatic" release circuit, the inevitable consequence is that the average power at the output of the limiter is strongly influenced by the peak-to-average ratio of the input. Thus material with an unusually high peak-to-average ratio can unnaturally reduce the average power. Conversely, material with an unusually low peak-to-average ratio can be amplified to unnaturally loud levels. The overall subjective effect is that changes in the program waveform produce somewhat unnatural dynamic variations — the sound of the limiter is not "effortless."

More on High-Frequency Limiting

A limiter that does not use clipping to control peaks must control pre-emphasis-induced overshoots with a fast peak-sensing variable-emphasis limiter. Such limiters tend to cause severe audible dulling of certain program material.

The 4000 uses a HF limiter that is designed *only to prevent audible distortion in the following distortion-canceling clipper*. The distortion-canceling clipper does almost all of the work in limiting HF peaks. Because it operates on *each individual peak* without affecting the peak's neighbors, the distortion-canceling clipper causes far less audible HF loss than does a traditional variable-emphasis limiter.

Please note that the HF limiter in the 4000 will not exhibit a swept-sinewave frequency response inverse to the pre-emphasis curve set by the 4000's internal jumpers. This is because the HF limiter, as explained above, does as little work as possible: most of the work in controlling HF overload is done by the distortion-canceling clipper. Be assured that the overall 4000 system is nevertheless operating to very tight tolerances on the pre-emphasis curve set by the internal PRE-EMPHASIS jumpers.

Differences Between the 4000 and OPTIMOD-FM

The main AGC stage of the 4000 is a gated, dual-band limiter somewhat similar to the one used in Orban's OPTIMOD-FM Model 8100A. However, several changes were made to make the circuit more suited to the transmission limiter function. The consequences of these changes are:

1) The overall frequency response of the 4000 is slightly flatter than that of OPTIMOD-FM: typically ±0.25dB, 30-15,000Hz.

2) The crossover has constant group delay after the bands are summed; there is no phase rotation. We felt that this was necessary to achieve highest audible transparency.

3) The overall group delay through the entire 4000 system (configured with FLAT output) is virtually constant: 359µs ±5%, 30-15,000Hz.

4) The two bands in the 4000's AGC are cross-coupled according to Orban's patented scheme such that the frequency response in almost always flat (excluding the effects of any HF limiting). Only with material having *extreme* bass does the bass band produce extra limiting to prevent audible spectral gain intermodulation between the bass and midrange.

5) The 4000's control circuit is tuned to produce little or no increase of program density. There is no need for a transmission limiter to significantly increase program density, and the 4000 does not do so. Instead, it produces the most natural, subtle action that we know how to achieve with a two-band design.

Transmission Levels

The transmission engineer is primarily concerned with the peak level of a program to prevent overloading or over-modulation of the transmission system. This peak overload level is defined differently, system to system. In FM modulation (FM/VHF radio and television broadcast, microwave or analog satellite links), it is the maximum-permitted RF carrier frequency deviation. In AM modulation, it is negative carrier pinch-off. In analog telephone/post/PTT transmission, it is the level above which serious crosstalk into other channels occurs, or the level at which the amplifiers in the channel overload. In digital, it is the largest possible digital word. In tape, it is defined as the level producing the amount of harmonic distortion considered tolerable — often 3% THD at 400Hz.

For metering, the transmission engineer uses an oscilloscope, absolute peak-sensing meter, calibrated peak-sensing LED indicator, or a modulation meter. A modulation meter usually has two components — a semi-peak reading meter (like a PPM), and a peak-indicating light which is calibrated to turn on whenever the instantaneous peak modulation exceeds the overmodulation threshold.

Level Calibration of the Transmission Limiter

Output Level

Transmission-limiting devices, like the Orban 4000 Transmission Limiter, control peak levels. So one adjusts the OUTPUT control on the Transmission Limiter so that the maximum instantaneous peak level that will appear at the limiter's output with program material will be at or slightly below the overload or maximum permitted modulation level of the transmission system.

The Transmission Limiter's built-in TONE and TEST modes makes this adjustment easy. The built-in TONE oscillator provides a tone at 100% modulation — its peak level is equal to the maximum instantaneous peak level that will appear at the limiter's output with program material. When the Transmission Limiter is in TEST mode, it will pass, without gain reduction, any tone applied to its input up to about 95% modulation. As the level is increased to 100% modulation, the Transmission Limiter will apply limiting to the tone as necessary to limit its level to 100% modulation.

With the OUTPUT control adjusted so that the TONE oscillator drives the transmission to 100% modulation, then no matter what the input level or the setting of the INPUT control on the Transmission Limiter, the output with program material will never exceed 100% modulation.

One common mis-conception on the part of studio engineers is that the maximum permitted instantaneous peak level of a transmission system is the same as the indication on the PPM. As we know from the discussions on meters above, PPMs under-indicate instantaneous peaks by 5dB or more. So proper adjustment of the OUTPUT control requires understanding of the overload characteristics of the transmission system to be protected.

Input level

The INPUT control on the Transmission Limiter determines the amount of limiting. When the program is below threshold, it has the effect of controlling the gain of the Transmission Limiter.

Adjustment of the INPUT control requires an understanding of the desired headroom, the operation of the Transmission Limiter, and the amount of gain reduction that is desired or tolerated. And it is very important to remember that the VU meter or PPM does not indicate true peak levels.

With a sinewave input, the threshold of the gain control (limiting) section of the Transmission Limiter is approximately 7dB below 100% modulation. (The reason for this is explained on page 1-4 in "Transmission Limiting: Orban's Approach.") The attack time is approximately 2ms to produce full gain reduction. Peaks of shorter duration produce less gain reduction. The gain reduction has a range of 15dB.

Studio engineers prefer to adjust equipment for unity gain. Let's look at the implication of doing that in the following few examples:

An example typical of US-style facilities:

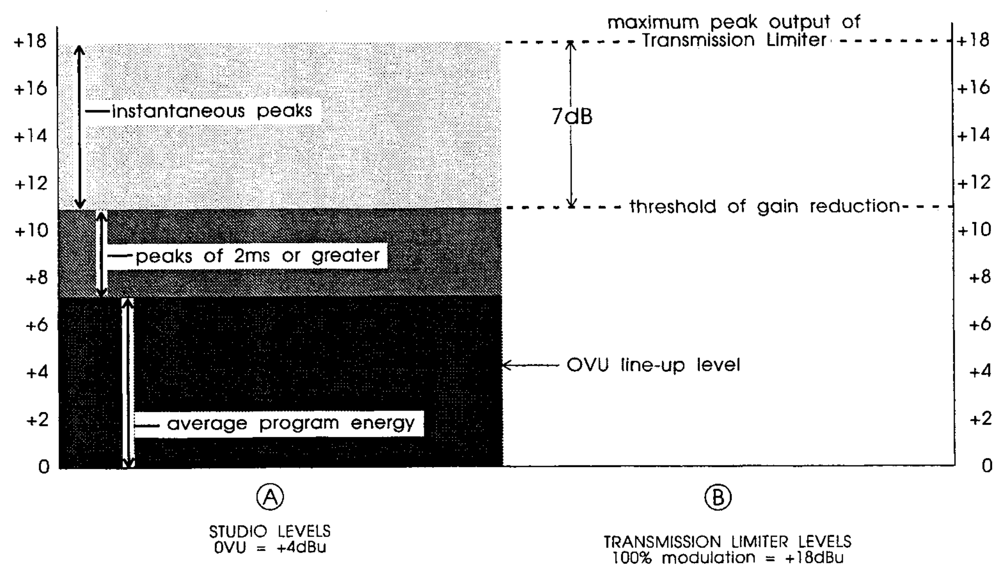

Figure 1-3: Level Calibration — US-style Facilities

Figure 1-3A shows typical levels in a studio using VU meters and +4dBu line-up level. The VU meter doesn't indicate true peaks, of course, but we can make some generalizations true of program material with a high peak-to-average ratio. Instantaneous peaks will reach between +11 and +18dBu (7 to 14dB above the VU indication). Peaks of 2ms duration or greater (the duration required for the gain control to go into full limiting) will only reach about +7 to +11dBu (3 to 7dB above the VU indication).

An example typical of organizations using the BBC-standard PPM:

Figure 1-5A shows typical levels in a studio with PPM4 (+4dBu) line-up level. Figure 1-5B shows the Transmission Limiter adjusted for 100% modulation = +12dBu (PPM6).

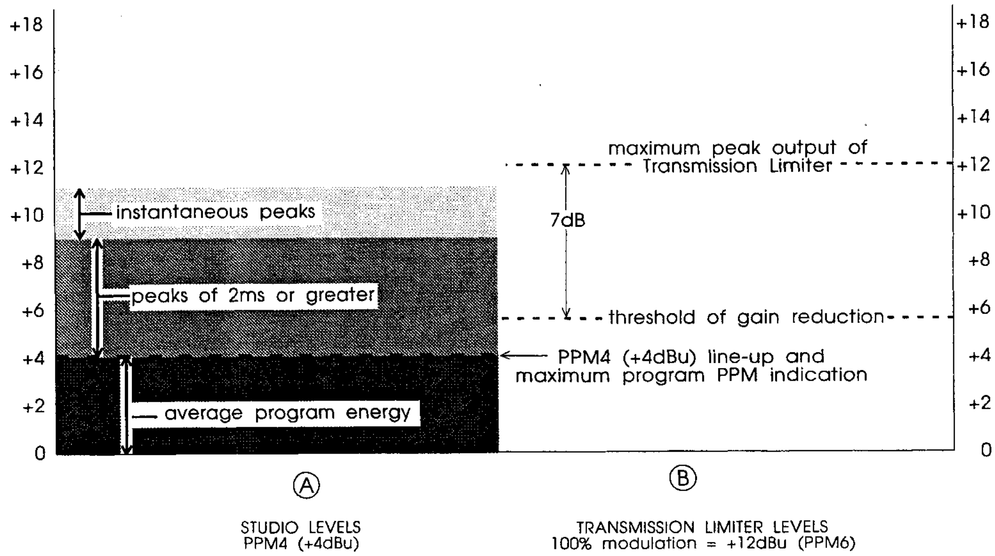

Figure 1-5: Level Calibration — With BBC-Standard PPM

If the Transmission Limiter is adjusted with line-up tone for unity gain below threshold, program material peaking at PPM4 may occasionally cause the Transmission Limiter to go into 4dB or more of gain reduction. But due to the Transmission Limiter's extremely transparent operation, this gain reduction will not be audible. 2ms peaks of +20dBu will be required to cause the Transmission Limiter to reach its maximum 15dB of gain reduction.

A few guidelines:

1) Be sure that you really understand the required 100% modulation limit. If the requirement is specified to you as a PPM or VU indication, investigate further. There is probably a compensation factor already built into that number to allow for the peaks that the meter doesn't indicate. Determine the maximum absolute peak level for the system that you are protecting. To not do so will result in unnecessary limiting and a sacrifice of headroom.

2) Know the desired operating headroom of your organization. For example, assume that it is 8dB above line-up. The transmission system under protection has a 100% modulation limit of +10dBu. You would adjust the INPUT control of the Transmission Limiter so that studio line-up produces +2dBu at the output of the transmission limiter.

3) If the full 15dB of maximum protection provided by the Transmission Limiter is desired, the system prior to the Transmission Limiter requires headroom 15dB greater than the organization operating headroom.

4) If the link is simply an amplifier, this should be achievable without difficulty if the absolute level of the studio line-up tone is chosen carefully. In the example in Step 2 above, if the amplifiers in the system clip at +21dBu, the absolute level of the studio line-up tone can be no greater than −2dBu (i.e., 23dB below +21dBu.)

5) Determine if unity gain of the transmission limiter is really required. If it is not, you are free to adjust the INPUT control for as little or as much gain reduction as is desired.

   Note that reducing the normal level to the transmission limiter and turning up its INPUT ATTENUATOR to compensate may be the only practical way to ensure that the studio amplifiers do not clip before the transmission limiter has produced its full 15dB of maximum gain reduction. This usually implies that the studio line-up level must be decreased, and that the sensitivity of the PPM or VU meters must be increased to compensate. Many studios have undetected clipping somewhere in their program circuits because they have not been designed to provide adequate headroom when the operator accidentally sets program levels too high. When this happens, the transmission limiter should cleanly protect the device at its output from overload. This can only happen if there is no clipping in the program chain prior to the transmission limiter.

Application

Location of 4000 in System

The 4000 is usually installed immediately prior to a transmission link such as a land-line, digital link, or microwave link. To achieve best peak control, it is essential not to insert an element between the output of the 4000 and the input of the transmission link that would change the *shape* of the tightly peak-controlled output of the 4000.

Specification for the Output Link

Any element that affects the constancy of the frequency response or the group delay between the 4000's output and the input of the driven transmission link must be qualified to ensure that such an element's frequency response is better than ±0.25dB from 30-15,000Hz, and that its deviation from linear phase does not exceed ±10° over this frequency range. The phase specification implies that the low-frequency response limit must be 0.15Hz or lower (at −3dB) unless special group delay equalization is used at low frequencies. Low-pass filters (including anti-aliasing filters in digital links), high-pass filters, transformers, distribution amplifiers, and long transmission lines are all suspect, and must be tested and qualified.

If you operate the 4000 with FLAT output (that is, with its de-emphasis filter activated) and then once again pre-emphasize the audio in the transmission link, this will almost assuredly cause poor control of peak modulation, because the transient response of the link's pre-emphasis network cannot accurately complement the transient response of the de-emphasis filter in the 4000. *Far* better results are *always* achieved if you bypass the pre-emphasis network in the link, and use the 4000 to create the link pre-emphasis.

Digital Links

The stopband of the 4000's filtering begins at approximately 18.5kHz. At this frequency the power spectrum is greater than 75dB below 100% modulation, as measured by the extremely stringent "maximum peak hold" technique using an 801-line FFT analyzer (HP 3562A). This is slightly beyond the Nyquist frequency of 16kHz in an EBU-standard 32kHz link. However, the spectrum falls very rapidly beyond 16kHz (see Figure 3-1 on page 3-8). In FM stereo applications, material above 15kHz will be attenuated by the 15kHz low-pass filter in the FM stereo encoder. In a 32kHz sample-rate transmission link, 17kHz will alias to 15kHz. Thus, only energy beyond 17kHz could cause trouble in an FM stereo system. Because the power spectrum at the 4000's output is already down at least 40dB at 17kHz, we believe that the system is adequately protected from audible aliasing by the 4000's filtering alone.

This has a significant advantage. Because the output of the 4000 can be strapped to be either "flat" or "pre-emphasized," the 4000 can provide *both* the J.17 pre-emphasis and anti-aliasing filtering functions prior to a PCM, NICAM or similar digital transmission link. The pre-emphasis filters and linear anti-aliasing filters with which the links are presently fitted can thus be removed. Since these elements overshoot, their removal eliminates the overshoot, permitting the average modulation of the link (and thus, its signal-to-noise ratio) to be improved by several decibels without compromising the subjective quality of the audio.

Microwave Links

It is usually easy to modify a microwave link to meet the specification for frequency response and phase linearity stated above. Most such links have been designed to be easily configured at the factory for "composite" operation, where the entire FM stereo baseband is passed, including the pilot tone and stereo subchannel. The requirements for maintaining stereo separation in "composite" operation are similar to the requirements for high waveform fidelity with low overshoot. Therefore, most links have the *potential* for excellent waveform fidelity if they are configured for "composite" operation (even if a "composite" FM stereo signal is not actually being applied to the link).

The 4000 can provide the necessary pre-emphasis, low-pass filtering, and peak control to optimally drive such a microwave transmitter. All audio low-pass filters and pre-emphasis filters in the microwave transmitter should be bypassed or removed (as they would be when the transmitter was configured for "composite" operation).

Telephone or Post Lines

Most such lines have poor low-frequency and high-frequency phase linearity. When the 4000 drives such lines, a properly peak-controlled signal is unlikely to emerge at the receive end! We can only say that results achieved with the 4000 will never be *poorer* than results achieved with conventional transmission limiters, and we recommend following traditional line-up procedures with such lines.

Subcarriers

Sometimes subcarriers are used as transmission links, particularly in television, where several aural subcarriers may be available on a video microwave STL.

FM Subcarriers: The 4000 can provide the necessary pre-emphasis, low-pass filtering, and peak control to optimally drive an FM subcarrier generator. All audio low-pass filters and pre-emphasis filters in the subcarrier generator should be bypassed or removed. The 4000 should be strapped to generate the same pre-emphasis curve as the bypassed pre-emphasis filter. **Section 2** provides instructions for doing this. (See step 3-D on page 2-9.)

Single-Sideband Companded Subcarriers: The peak modulation levels entering a single-sideband companded subcarrier generator are greatly changed by the noise reduction compressor and by the single-sideband modulator. Therefore, you must leave headroom to accommodate the unavoidable overshoots generated by these elements. You must experimentally determine the input drive level necessary to produce correct modulation. Do this by adjusting the 4000's OUTPUT ATTENUATOR until the subcarrier modulation (as read on the appropriate monitoring instrument) is correct. Bear in mind that the modulation may change substantially as the nature of the program material changes, so observe modulation over a substantial time interval before deciding on a final audio drive setting.

Pre-emphasis In Systems

To facilitate line-up of the 4000 in a given transmission system, it contains a built-in 400Hz sinewave oscillator that can produce a level at the output of the 4000's audio processing equal to 100% peak modulation. In addition, a TEST mode is available that changes the threshold of limiting such that, if an external sinewave oscillator drives the 4000 into limiting, the level at the 4000's output is equal to 100% peak modulation.

When the 4000's output is strapped FLAT, a de-emphasis filter is inserted between output of the 4000's audio processing and its LINE OUTPUT. Thus, the maximum TEST tone level at the 4000's line output will follow the de-emphasis curve instead of staying at 100% modulation. In most cases the pre-emphasis filter in the driven equipment will undo the effect of the 4000's internal de-emphasis, and the 4000's output level should be adjusted so that the tone produces 100% modulation of the transmission link as measured after the link's pre-emphasis filter.

At 400Hz, and for settings of 25µs, 50µs, and 75µs, jumpering the de-emphasis out or in has negligible effect on the level appearing at the 4000's LINE OUTPUT. However, J.17 de-emphasis will decrease the level of the tone by several decibels, and 150µs will also affect the level significantly.

Registration, Warranty, Feedback

Registration Card

There are two good reasons for returning the Registration Card shipped with this product:

1) It enables us to inform you of new applications, performance improvements, and service aids which may be developed, and

2) It helps us respond promptly to claims under warranty without having to request a copy of your bill of sale or other proof of purchase.

Please fill in the Registration Card, detach it from the Warranty Certificate, and send it to us today. If it is lost (or you have purchased this unit used), please photocopy the duplicate below, fill it in, and send it to Orban at the address printed in the front of this manual.

Registration Card

Model # ____________ Serial # ______________________________ Purchase Date ______________

Your name ____ Title ____________________

Company ____ Telephone ________________

Street ____

City, State, Mail Code (Zip), Country ____

Nature of your product application ____

How did you hear about this product? ______________________ Purchased from ___________

Comments ____

____

Which magazines do you find the most useful to your job?

___ Broadcasting	___ Broadcast Engineering	___ Broadcast System Engineering	
___ dB Magazine	___ Line Up	___ Millimeter	___ Mix
___ Post	___ Pro Sound News	___ Radio & Records	___ Radio World
___ RE/P	___ S & VC	___ Studio Sound	___ TV Broadcast
___ TV Technology	___ World Broadcasting News	___ ____________	
	___ ____________	___ ____________	

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Warranty

The warranty, which can be enjoyed only by the first end-user of record, is stated on the separate Warranty Certificate packed with this manual. Save it for future reference. Details on obtaining factory service are provided on page 5-6.

User Feedback Form

We are very interested in your comments about this product. Your suggestions for improvements to either the product or the manual will be carefully reviewed. A postpaid User Feedback Form is provided in the back of this manual for your convenience. If it is missing, please write us at the address printed in the front of the manual, or call or fax our offices at the number listed. We will be happy to hear from you.

Section 2
Installation

page contents

CAUTION

The installation and servicing instructions in this manual are for use by qualified personnel only. To avoid electric shock, do not perform any servicing other than that contained in the Operating Instructions unless you are qualified to do so. Refer all servicing to qualified service personnel.

Installation

Allow about 30 minutes for installation.

Installation consists of (1) unpacking and inspecting the 4000, (2) checking the line voltage setting, fuse and power cord, (3) optional resetting of the input termination, input sensitivity, pre-emphasis, output mode and stereo coupling jumpers, (4) mounting the 4000, (5) optional connecting of remote control leads and (6) connecting audio and power.

1. Unpack and inspect.

If you note obvious physical damage, contact the carrier immediately to make a damage claim.

A ☐ If you should ever have to ship the 4000 (e.g., for servicing), it is best to ship it in the original packing materials because these have been carefully designed to protect the unit. *Save all packing materials.*

Packed with the 4000 are:

1	Operating Manual
1	Fuse
1	Power Cord

2. Check the line voltage, fuse and power cord.

A ☐ *DO NOT connect power to the unit yet!*

B ☐ Check the VOLTAGE SELECTOR. This is on the rear panel.

The 4000 is shipped configured for 115 or 230-volt, 50 or 60Hz operation, as indicated on the rear panel. Refer to the unit's rear panel for your Model # and the inside of the front cover of this manual for your Model #'s line voltage setting. To change the operating voltage, set the VOLTAGE SELECTOR to 115V or 230V as appropriate (voltages 15% of the nominal voltage are acceptable).

C ☐ Check the value of the fuse and change the fuse if the value is incorrect.

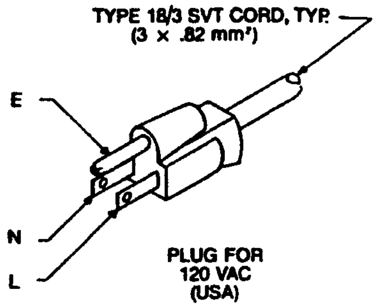
For safety, the fuse must be Slow-Blow, ½-amp for 115V, or ¼-amp (250mA) "T" type for 230V.

D ☐ Check power cord.

AC power passes through an IEC-standard mains connector and an RF filter designed to meet the standards of all international safety authorities.

The power cord is terminated in a "U-ground" plug (USA standard), or CEE7/7 plug (Continental Europe), as appropriate to your 4000's Model #. The green/yellow wire is connected directly to the 4000 chassis.

If you need to change the plug to meet your country's standard and you are qualified to do so, see Figure 2-1. Otherwise, purchase a new mains cord with the correct line plug attached.



CONDUCTOR		WIRE COLOR	
		Normal	Alt
L	LINE	BROWN	BLACK
N	NEUTRAL	BLUE	WHITE
E	EARTH GND	GREEN-YELLOW	GREEN

Figure 2-1: Line Cord Wiring Standard

3. Set option jumpers. (optional)

As shipped from the factory, the 4000 will bridge its input line, and will operate with –10dBu to +10dBu input sensitivity, and the output will be FLAT. The two-channel 4000 will operate with its channels coupled for stereo tracking.

The pre-emphasis of the high-frequency limiter is set according to the specifications of the 4000 Model # you ordered. Refer to the unit's rear panel for your Model # and the inside front cover of this manual for your Model #'s precise pre-emphasis configuration.

If any of these options are not appropriate for your installation, you can set internal jumpers to change them. If you want to reset the jumpers, remove the top cover (and bottom if you have a two-channel unit) to access the main circuit board. Do this by removing all screws holding the cover in place. Then lift the cover off.

Be sure power is disconnected before removing covers.

When replacing the cover, replace all screws snugly. Be careful not to strip the threads by fastening the screws too tightly.

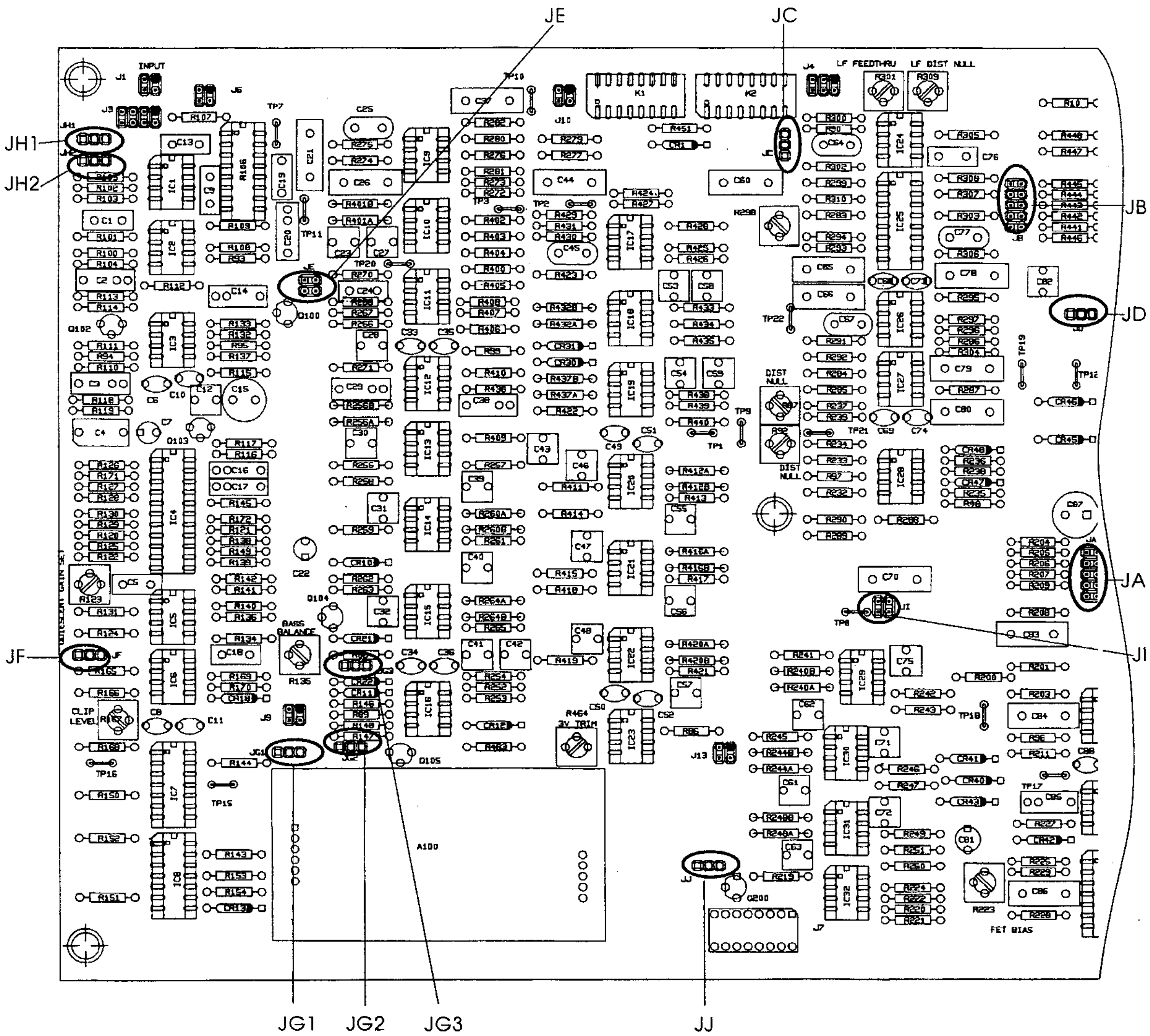


Figure 2-2: Jumper Locations

A ☐ 600Ω input termination.

[Skip this step if you want the 4000 input to bridge the input line.]

To present a 600Ω load on the input line, set jumper JC to the TERMINATE position.

See Figure 2-3 to locate and set jumper JC.

The 4000's hard-wire BYPASS mode automatically disconnects the internal 600Ω termination resistor. The load on the 4000's OUTPUT line then provides the correct load for the 4000's input line. This automatic disconnection prevents the input line from being double-terminated when the 4000 is hard-wire bypassed.

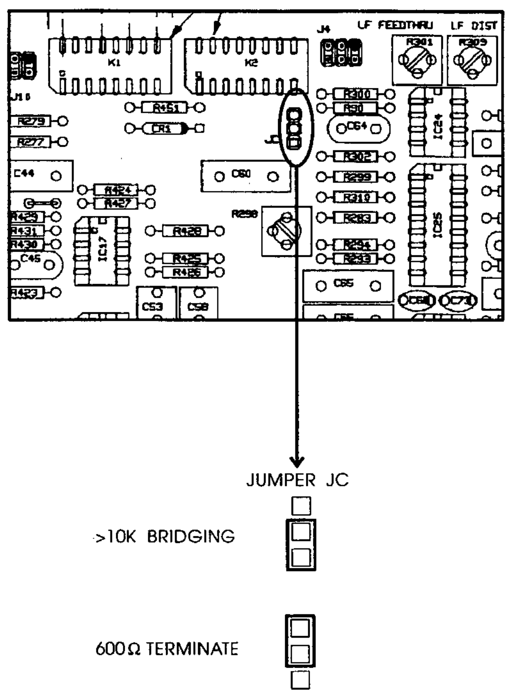


Figure 2-3: Input Termination

B☐ Increase input sensitivity.

[Skip this step if you want –10dBu to +10dBu input sensitivity.]

The 4000 is shipped with a 20dB pad ahead of its instrumentation-amplifier input buffer. This is suitable for nominal input levels from –10dBu to +10dBu. If lower input levels (–30dBu to –10dBu) are used, defeat the pad by setting jumper JH1 and jumper JH2 to the 0dB level position.

See Figure 2-4 to locate and set jumpers JH1 and JH2.

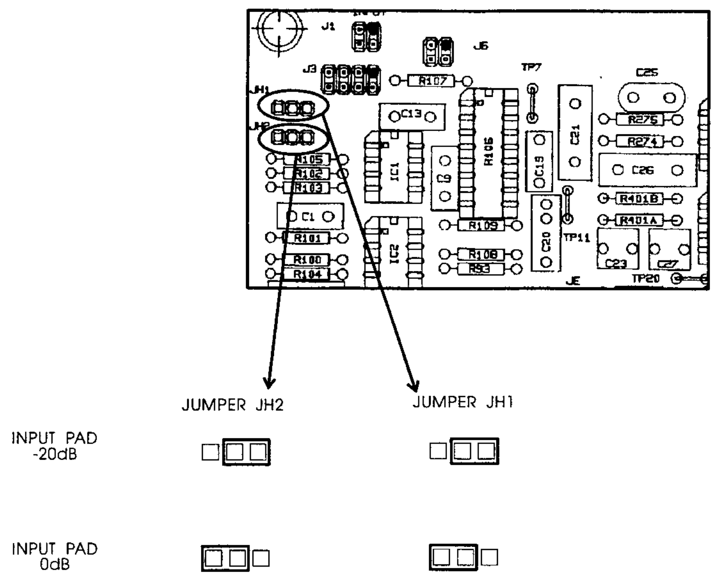


Figure 2-4: Input Pad

c☐ Defeat the high-frequency limiter.

[Skip this step if you want the high frequency limiter to operate.]

The 4000 is shipped with its high-frequency limiter activated.

HF limiting should be used for all links using pre-emphasis, (even if the link requires a driving source with flat response because the link has its own pre-emphasis).

If you are driving a link that does not use pre-emphasis, set jumper JI OUT, set jumper JJ OUT, and set jumper JD to PRE-EMPHASIZED. (This defeats the 4000's HF limiter and de-emphasis filter).

See Figure 2-5 to locate and set jumpers JI, JJ and JD.

[Skip to step 3F]

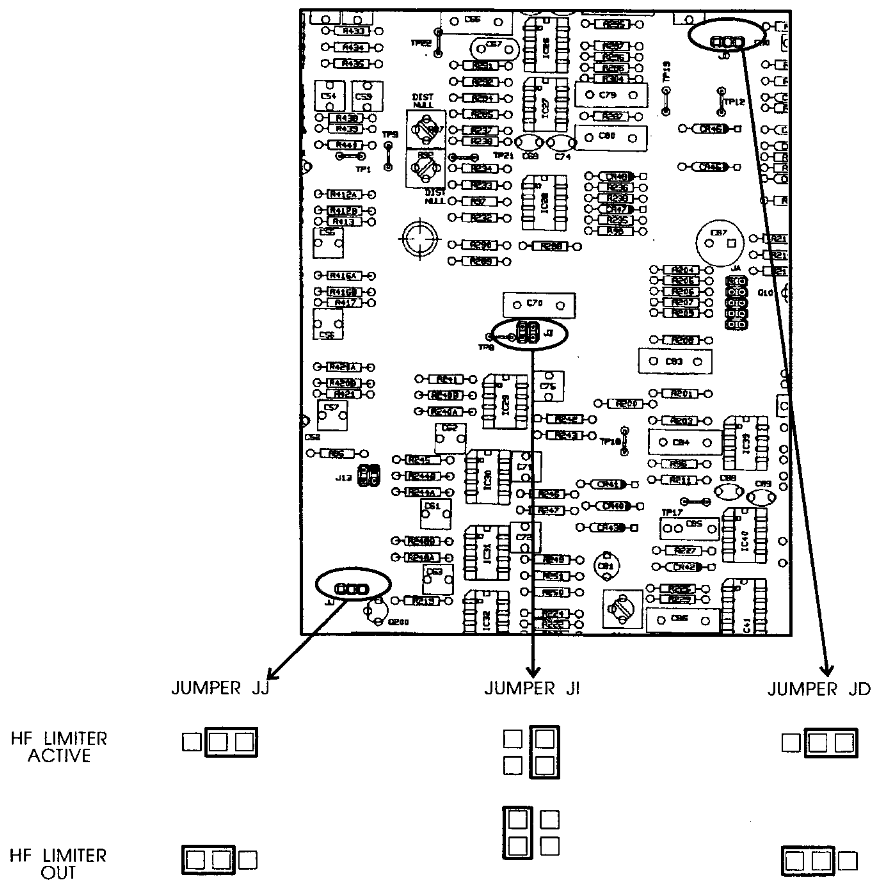


Figure 2-5: HF Limiter

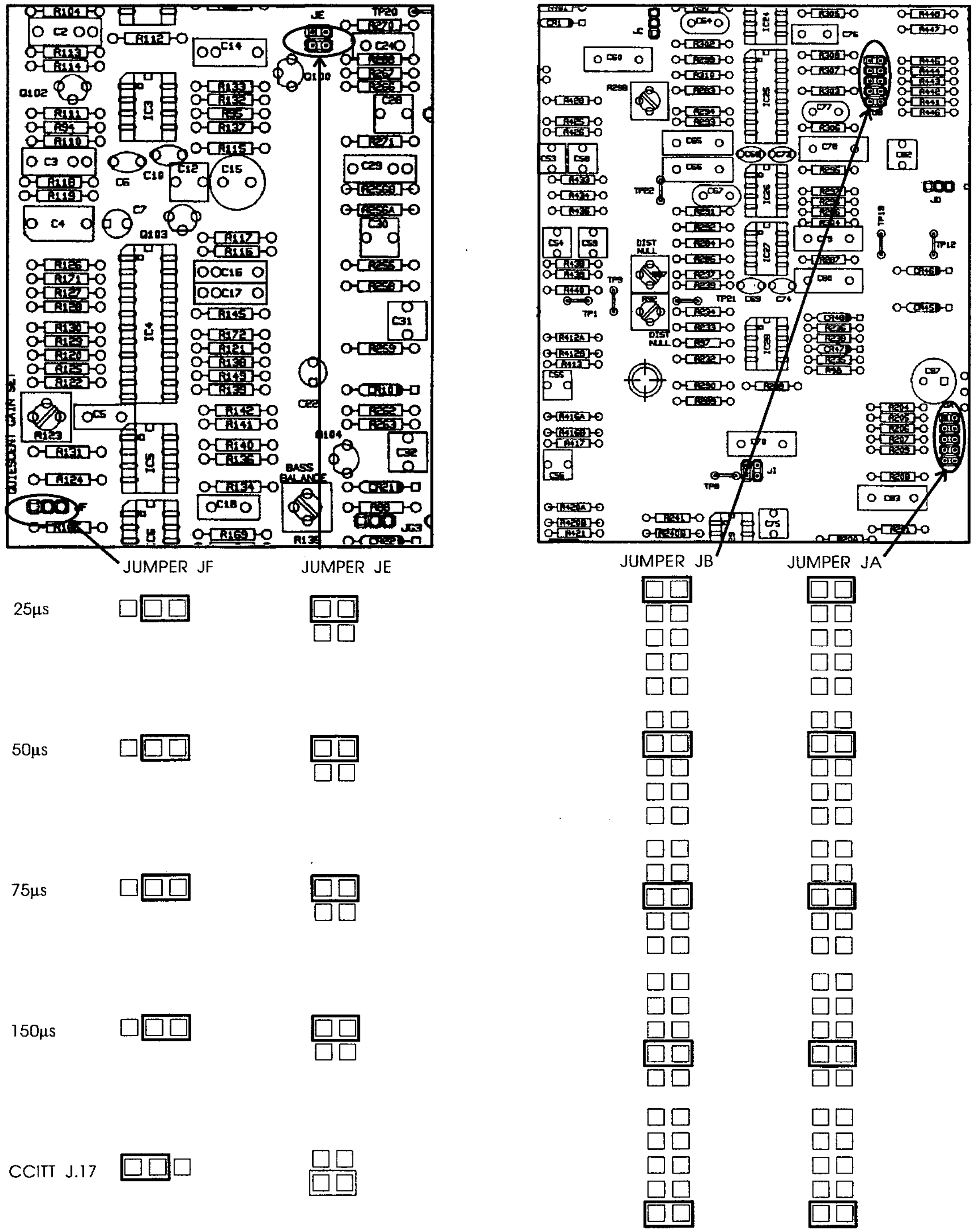


Figure 2-6: Pre-Emphasis EQ

D☐ Set pre-emphasis of the high-frequency limiter.

[Skip this step if the 4000 is already set to your required pre-emphasis. Refer to the unit's rear panel for your Model # and the inside front cover of this manual for your Model #'s precise pre-emphasis setting.]

Choose 25µs, 50µs, 75µs, 150µs, or CCITT J.17 pre-emphasis by positioning jumpers JA, JB, JE, and JF according to Figure 2-6.

E☐ Make the output pre-emphasized.

[Skip this step if you want the output to be flat.]

A de-emphasis filter complementary to the pre-emphasis chosen in step 3-D can be applied to the 4000's output to yield an overall "flat" response.

The 4000 is shipped from the factory for flat response. To make the output pre-emphasized, set jumper JD to PRE-EMPHASIZED.

See Figure 2-7 to locate and set jumper JD.

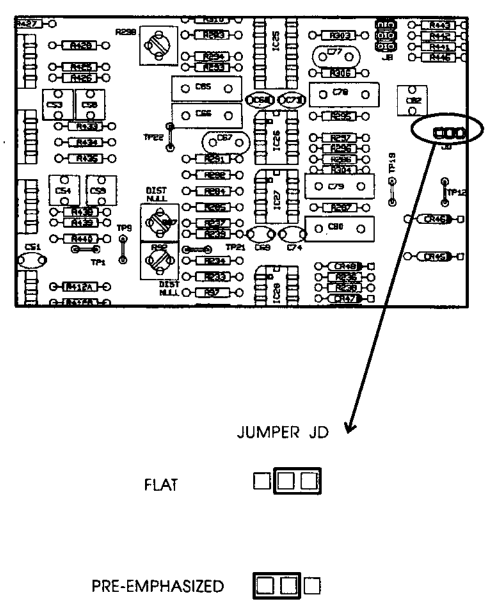


Figure 2-7: Pre-Emphasis

F ☐ Make the two channels independent.

[This step only applies to the dual-channel 4000 unit. Skip this step if you want the two channels to track to preserve stereo imaging. Skip this step if you are setting up a single-channel 4000A1 unit.]

As shipped, the gains of the dual-band limiters track to preserve stereo imaging. If you wish to use the two channels of the 4000 for two independent programs (instead of one stereo program), uncouple the channels by setting jumper JG1, jumper JG2 and jumper JG3 all to INDEPENDENT on both boards. (To couple the channels, set all of these jumpers to COUPLED on both boards.)

See Figure 2-8 to locate and set jumpers JG1, JG2 and JG3.

When the channels are coupled, the gain of both channels follows the gain of the channel requiring the largest amount of limiting.

The high-frequency limiters are not stereo-coupled because they act so quickly that they do not affect the stereo image.

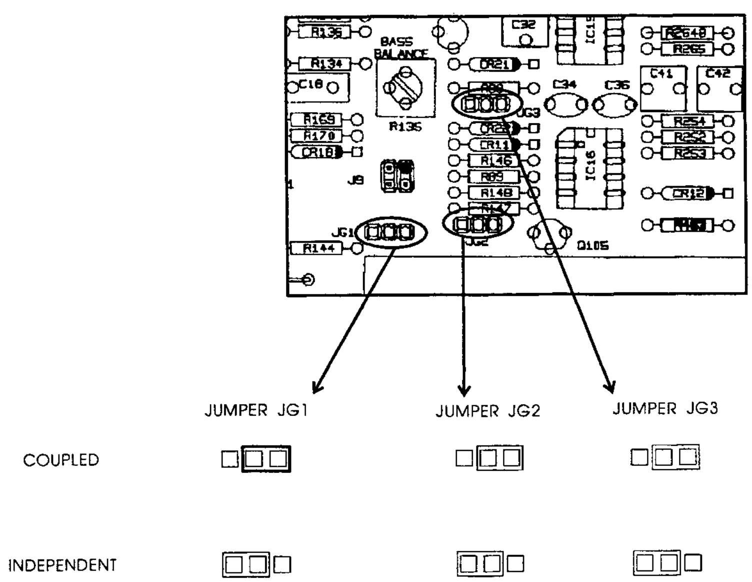


Figure 2-8: Stereo Coupling

4. Mount the 4000 in a rack.

The single channel 4000A1 requires one standard rack unit (1.75 inches, 4.4 cm). The dual-channel 4000 requires two standard rack units (3.5 inches, 8.8 cm).

There should be a good ground connection between the rack and the 4000 chassis — check this with an ohmmeter.

Mounting the unit over large heat-producing devices (such as a vacuum-tube power amplifier) may shorten component life and is not recommended. Ambient temperature should not exceed 113°F (45°C) when equipment is powered.

5. Connect remote control and stereo coupling. (optional)

All of the front-panel mode-select functions — OPERATE, BYPASS, TEST, and TONE — can also be activated by remote control. Optically-isolated remote control connections are terminated in a type DB-9 female connector located on the rear panel.

Figure 2-9 shows how to wire this connector.

PIN ASSIGNMENT

① BYPASS
② TEST
③ TONE
④ REMOTE COMMON
⑤ OPERATE
⑥ LIMITING COUPLE
⑦ LIMITING COUPLE
⑧ GATE COUPLE
⑨ REMOTE LIMITING MTR.

REMOTE A/B

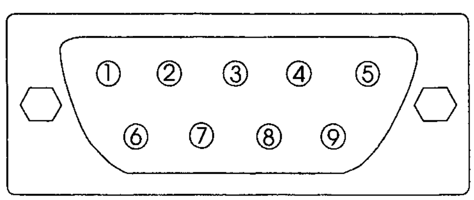


Figure 2-9: Rear Panel Remote Control/Stereo Coupling

To select the desired function, apply a 6-24V AC or DC pulse between the appropriate REMOTE terminal and the REMOTE COMMON terminal. (The REMOTE COMMON terminal is used as a return for all remote terminals.) If DC is used, connect the (–) to the common terminal and the (+) to the desired remote function terminal. If you use 48V, connect a 1kΩ 10%, 2-watt carbon composition resistor in series with the REMOTE COMMON terminal to provide current limiting.

In both 4000A1 and 4000 units, the stereo-coupling lines appear on this connector. There are three such lines. If you wish to couple two 4000A1s for stereo, connect three wires between the corresponding stereo coupling terminals on the connectors of the two units.

> In a high-RF environment, these wires should be short and should be run through foil-shielded cable, with the shield connected to CHASSIS GROUND at both ends.

6. Connect audio input and output.

See the hook-up and grounding information starting on page 2-13.

7. Connect power cord.

Be sure you have checked the voltage setting and fuse according to step 2 above.

Connect the 4000's power cord to an appropriate AC power source.

8. Complete the Registration Card and return it to Orban (please)

The Registration Card enables us to inform you of new applications, performance improvements, and service aids that may be developed, and it helps us respond promptly to claims under warranty without having to request a copy of your bill of sales or other proof of purchase. Please fill in the Registration Card and send it to us today. (If it is lost, photocopy the duplicate on page 1-16).

We do not sell our customer's names to advertising agencies.

Audio Input and Output Connections

Cable

We recommend using **two-conductor shielded cable** (such as Belden 8451 or equivalent), because signal current flows through the two conductors only. The shield does not carry signal, is used only for shielding, and is ordinarily connected to ground at one end only.

Sometimes, particularly if you are using the 4000 with home-type equipment, single-conductor shielded cable may be the only practical alternative. In this case, connect the inner conductors of the input and output shielded cables to the (+) sides (pin 2) of the 4000 inputs and output XLR-type connectors respectively. Connect the shield of the 4000 *input* cable to pin 3 of the 4000's input XLR-type, and connect the shield of the 4000 *output* cable to pin 3 of the 4000's output XLR-type. Internally connect pins 1 and 3 of both input and output XLR-types within the connectors.

Connectors

- **Input and output connectors** are XLR-type connectors.

  In the XLR-type connectors, pin 1 is CHASSIS GROUND, while pin 2 and pin 3 are a balanced, floating pair. This wiring scheme is compatible with *any* studio wiring standard: If one pin is considered LOW, the other pin is automatically HIGH. If inputs and outputs are wired consistently, the polarity will be overall non-inverting from input to output regardless of which pin is arbitrarily called low and which is called high.

Input

- Nominal **input level** is between −30 and +10dBu, selectable in two ranges (−30 to −10dBu and −10 to +10dBu) by jumpers.

  (0dBu = 0.775V RMS; for this application, the dBm@600Ω scale on voltmeters can be read as if it were calibrated in dBu.)

  See step 3-B on page 2-6 for instructions on how to set the jumpers for the correct input level range.

- The **input level that causes overload** is dependent on the setting of the INPUT control, and is at least 8dB higher than the sinewave level that causes 15dB limiting (i.e., maximum available G/R) in the dual-band limiter.

- The **electronically-balanced input** uses a true instrumentation amplifier for best common-mode rejection, and is compatible with most professional and semi-professional audio equipment, balanced or unbalanced, having a source impedance of 600Ω or less. If the source impedance is greater (as in some vacuum-tube audiophile preamps), remove the 1000pF RF-bypass capacitors connected between the 4000's input XLR-type connector (pin 2 and 3) and CHASSIS GROUND.

- Input connections are the same whether the driving source is balanced or unbalanced.

- Do not connect the cable shield — it should be connected at the source end only. Connect the red (or white) wire to the pin on the XLR-type connector (#2 or #3) that is considered HIGH by the standards of your organization. Connect the black wire to the pin on the XLR-type connector (#3 or #2) that is considered LOW by the standards of your organization.

- If the output of the other unit is unbalanced and does not have separate CHASSIS GROUND and (–) (or LO) output terminals, connect both the shield and the black wire to the common (–) or ground terminal of the other unit. It is rarely necessary to balance an unbalanced output with a transformer. As long as it is feeding a balanced input, the system will work correctly.

- Orban offers an optional high quality input transformer kit that plugs into the circuit board (order OPT-025). Certain 4000 Model #s already include this option. Check the rear panel of your unit for its Model #, and check the inside front cover of this manual for your Model #'s specific transformer (Transformer) configuration.

  In general, this input transformer is only helpful if the equipment driving the 4000 is powered from a mains distribution transformer and associated power ground separate from those powering the 4000.

Output

- The **electronically-balanced and floating output** simulates a true transformer output. The *source* impedance is 30Ω. In addition, for RFI suppression, there is a 1000pF capacitor from pin 2 and a 1000pF capacitor from pin 3 of the XLR-type connector to the chassis. The output is capable of driving loads of 600Ω or higher; maximum output level is >+23dBu into a balanced load and >+20dBu into an unbalanced load.

- If an **unbalanced output** is required (to drive unbalanced inputs of other equipment), it should be taken between pin 2 and pin 3 of the XLR-type connector. Connect the LOW pin of the XLR-type connector (#3 or #2, depending on your organization's standards) to circuit ground, and take the HIGH output from the remaining pin. No special precautions are required even though one side of the output is grounded.

- Use two-conductor shielded cable (Belden 8451, or equivalent).

- At the 4000's output (and at the output of other equipment in the system), connect the cable's shield to the CHASSIS GROUND terminal (pin 1) on the XLR-type connector. Connect the red (or white) wire to the pin on the XLR-type connector (#2 or #3) that is considered HIGH by the standards of your organization. Connect the black wire to the pin on the XLR-type connector (#3 or #2) that is considered LOW by the standards of your organization.

- In very difficult RFI environments, or when the 4000 is driving a very long output line that could have very high common-mode noise levels (like a telephone or post line), it may be necessary to isolate the 4000 with transformers.
  Orban has an optional high quality output transformer kit (OPT-026) that has the constant frequency response and group delay required to maintain waveform integrity.

  Certain 4000 Model #s already include this option. Check the rear panel of your unit for its Model #, and check the inside front cover of this manual for your Model #'s specific transformer (Transformer) configuration.

Grounding

Very often, grounding is approached in a "hit or miss" manner. But with care it is possible to wire an audio studio so that it provides maximum protection from power faults and is free from ground loops (which induce hum and can cause oscillation). In an ideal system:

- All units in the system should have *balanced inputs*. In a modern system with low output impedances and high input impedances, a balanced input will provide common-mode rejection and prevent ground loops regardless of whether it is driven from a balanced or unbalanced source. (The 4000 has balanced inputs.)

- All equipment *circuit grounds* must be connected to each other; all equipment *chassis grounds* must be connected together.

- *Cable shields* should be connected at one end only, preferably the source (output) end.

Power Ground

- Ground the 4000 chassis through the third wire in the power cord. Proper grounding techniques *never* leave equipment chassis unconnected to power/earth ground. *A proper power ground is essential to safe operation.* Lifting a chassis from power ground creates a potential safety hazard.

Difficult Situations

Because it is not always possible to determine if the equipment driving or being driven by the 4000 has its circuit ground internally connected to its chassis ground (which is always connected to the ground prong of the AC power cord, if present), and because the use of the AC power ground often introduces noise or other imperfections such as RFI, hum, clicks, and buzzes, the wiring techniques in Fig. 2-10 are not universally applicable.

If you follow Fig. 2-10 and hum or noise appears, don't be afraid to experiment. If the noise sounds like a low-level crackling buzz, then probably there isn't *enough* grounding. Try connecting the LOW pin on the 4000's input XLR-type connector to a chassis ground terminal or pin 1 on the XLR-type connector and see if the buzz goes away. Either pin 3 or pin 2 will work as the LOW pin; the choice depends only on your organization's standards.

A ground loop usually causes a smooth, steady hum rather than a crackly buzz. If you have a ground loop, think carefully about what is going on, and keep in mind the general principle: one and only one circuit ground path should exist between each piece of equipment!

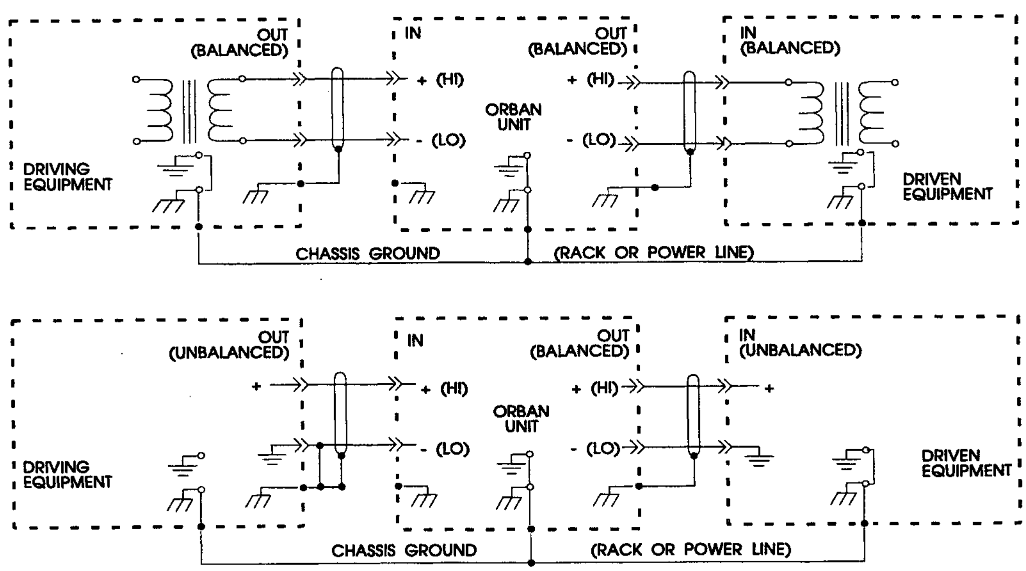


Figure 2-10: Typical Interconnection, Grounding Scheme