Operating Manual

Transmission Limiter

Model 4000 and 4000A1

orban®

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

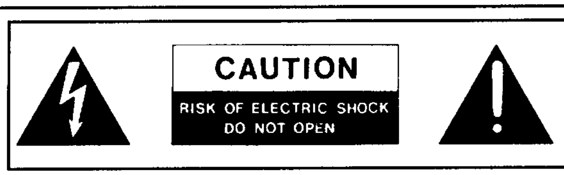
Model #:	Description:
4000/U75	2 ch, 120V, 75µs
4000/J50	2 ch, 100V, 50µs
4000/E50	2 ch, 230V, 50µs
4000/E17	2 ch, 230V, J.17
4000/UT75	2 ch, 120V, Output Xfmr, 75µs
4000/JT50	2 ch, 100V, Output Xfmr, 50µs
4000/ET50	2 ch, 230V, Output Xfmr, 50µs
4000/ET17	2 ch, 230V, Output Xfmr, J.17
4000/UTT75	2 ch,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

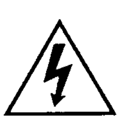
MANUAL:

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.

Orban is a registered trademark.

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Orban 4000

Transmission Limiter

Operating Manual

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Section 1
Introduction

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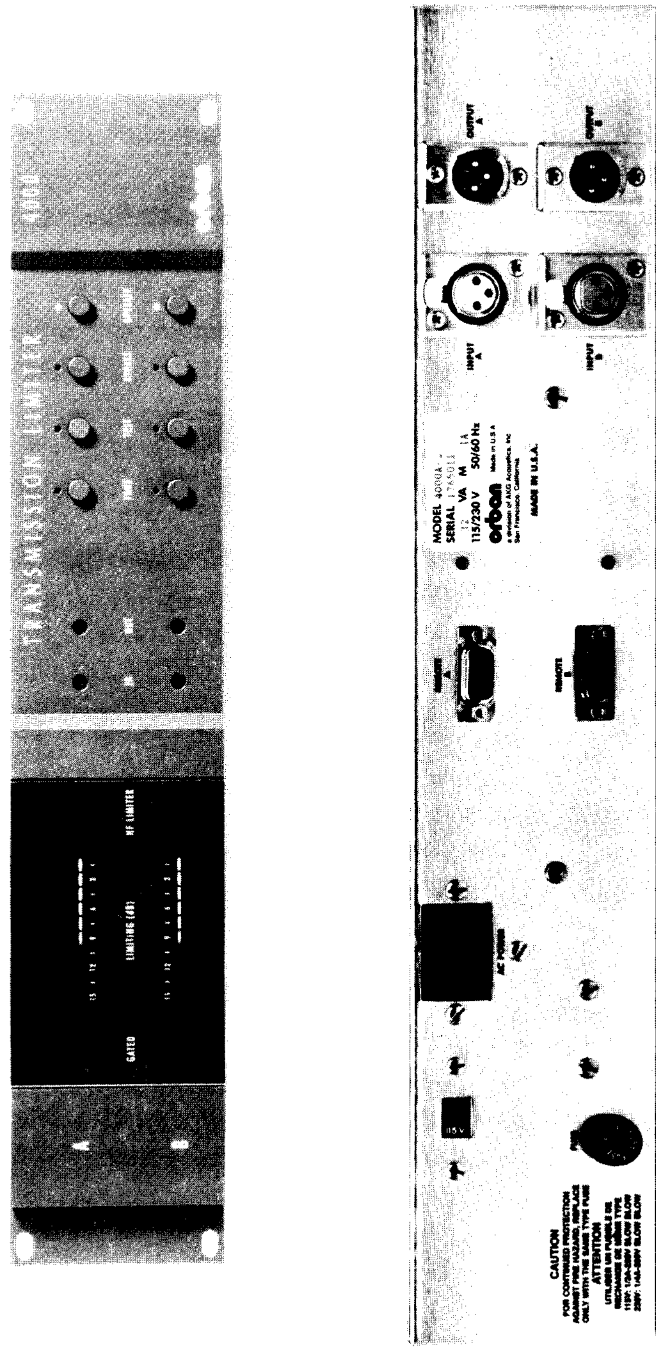

Figure 1-1: Front and Rear Panels

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:

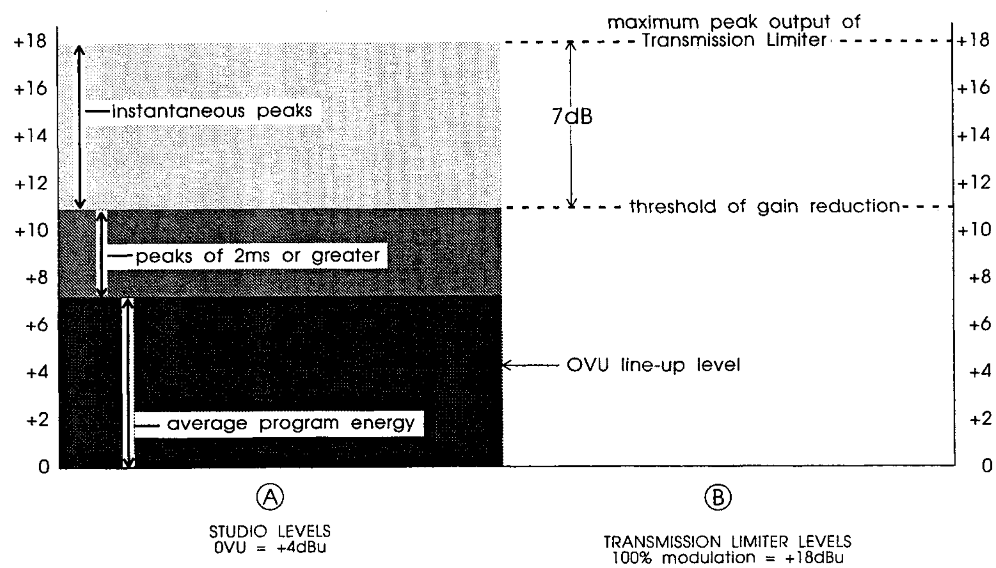

Figure 1-3: Level Calibration — US-style Facilities

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).

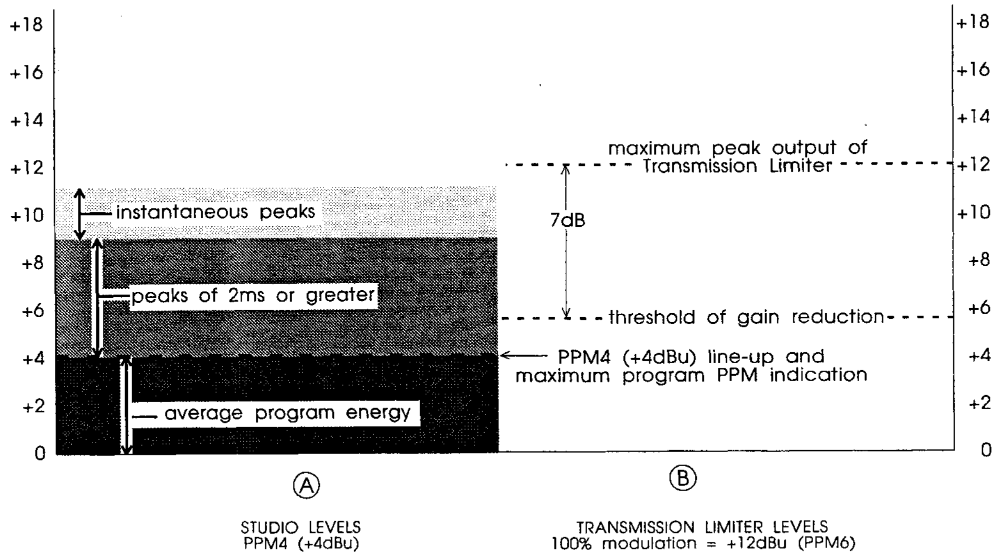

Figure 1-5: Level Calibration — With BBC-Standard PPM

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.

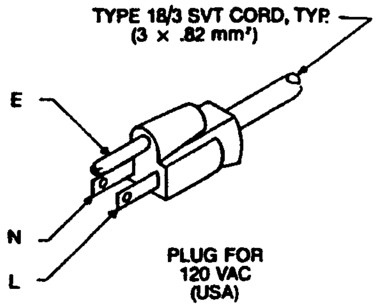
For safety, the fuse must be Slow-Blow, ½-amp for 115V, or ¼-amp (250mA) "T" type for 230V.

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.

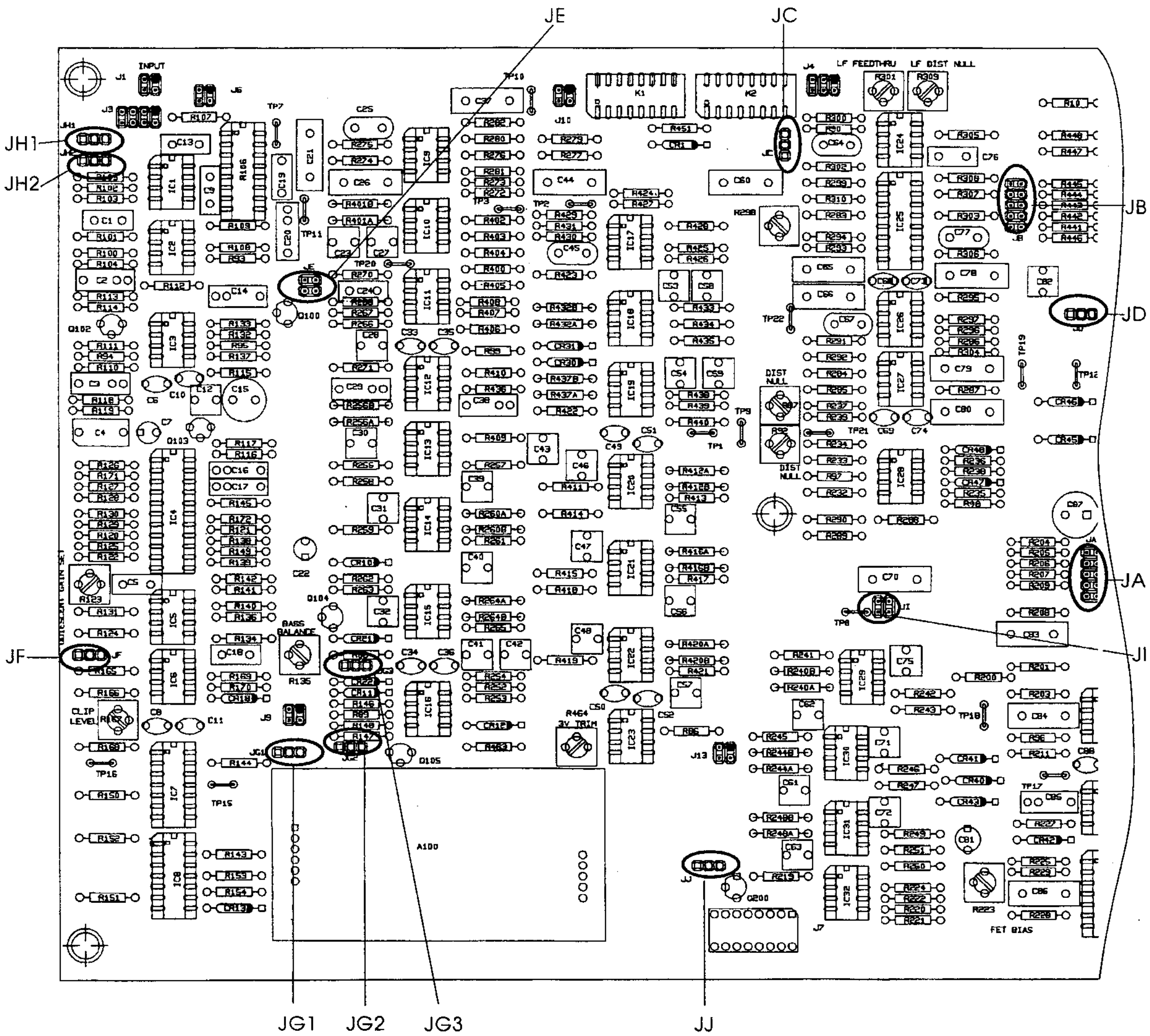


Figure 2-2: Jumper Locations

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.

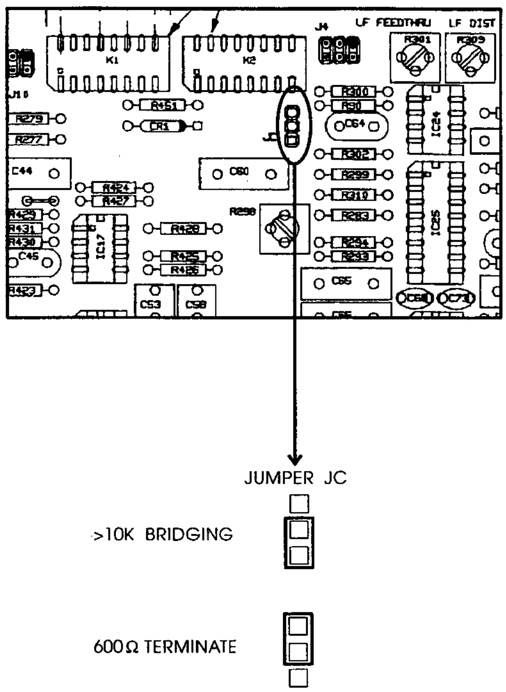


Figure 2-3: Input Termination

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.

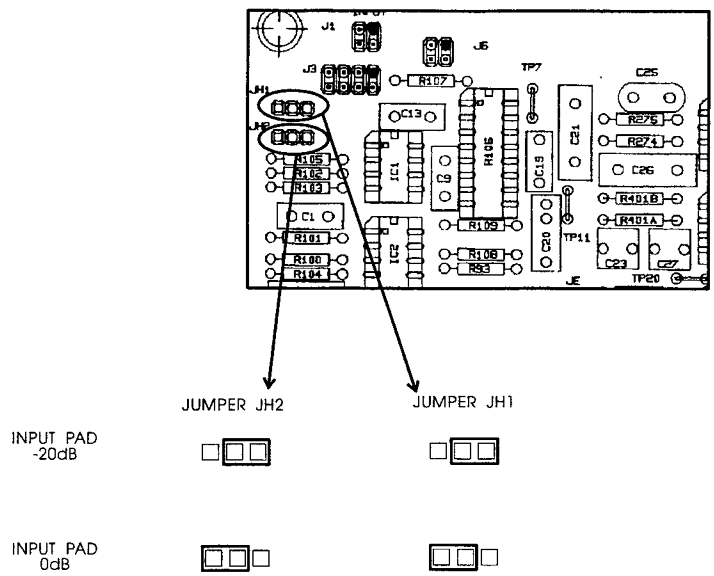


Figure 2-4: Input Pad

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]

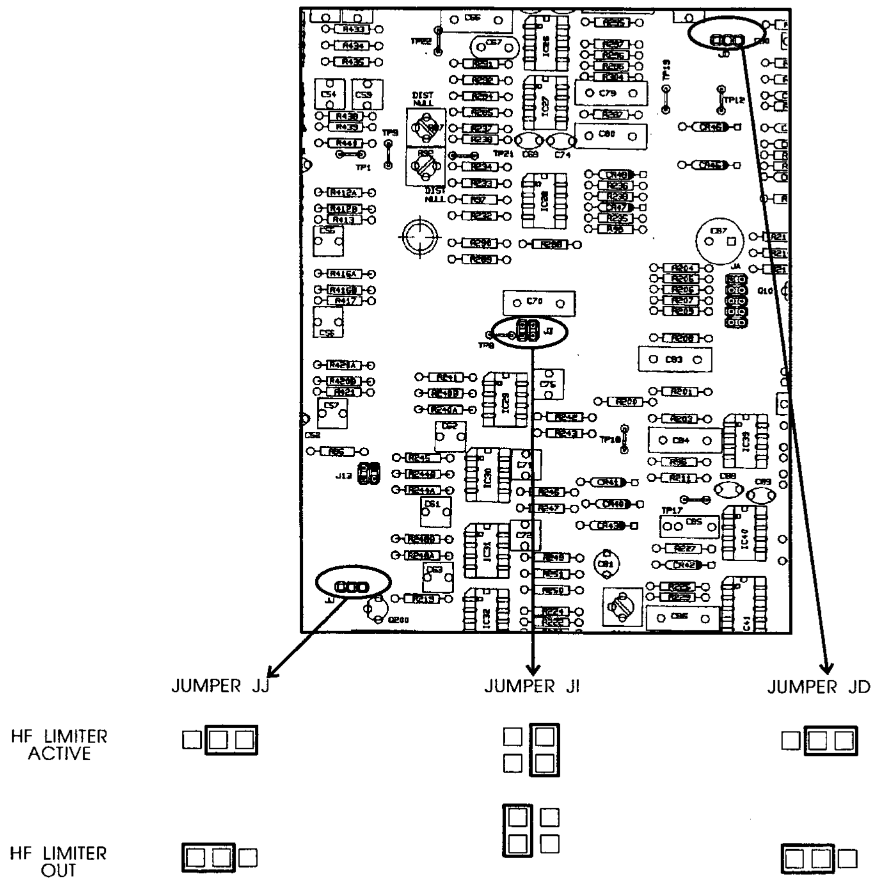


Figure 2-5: HF Limiter

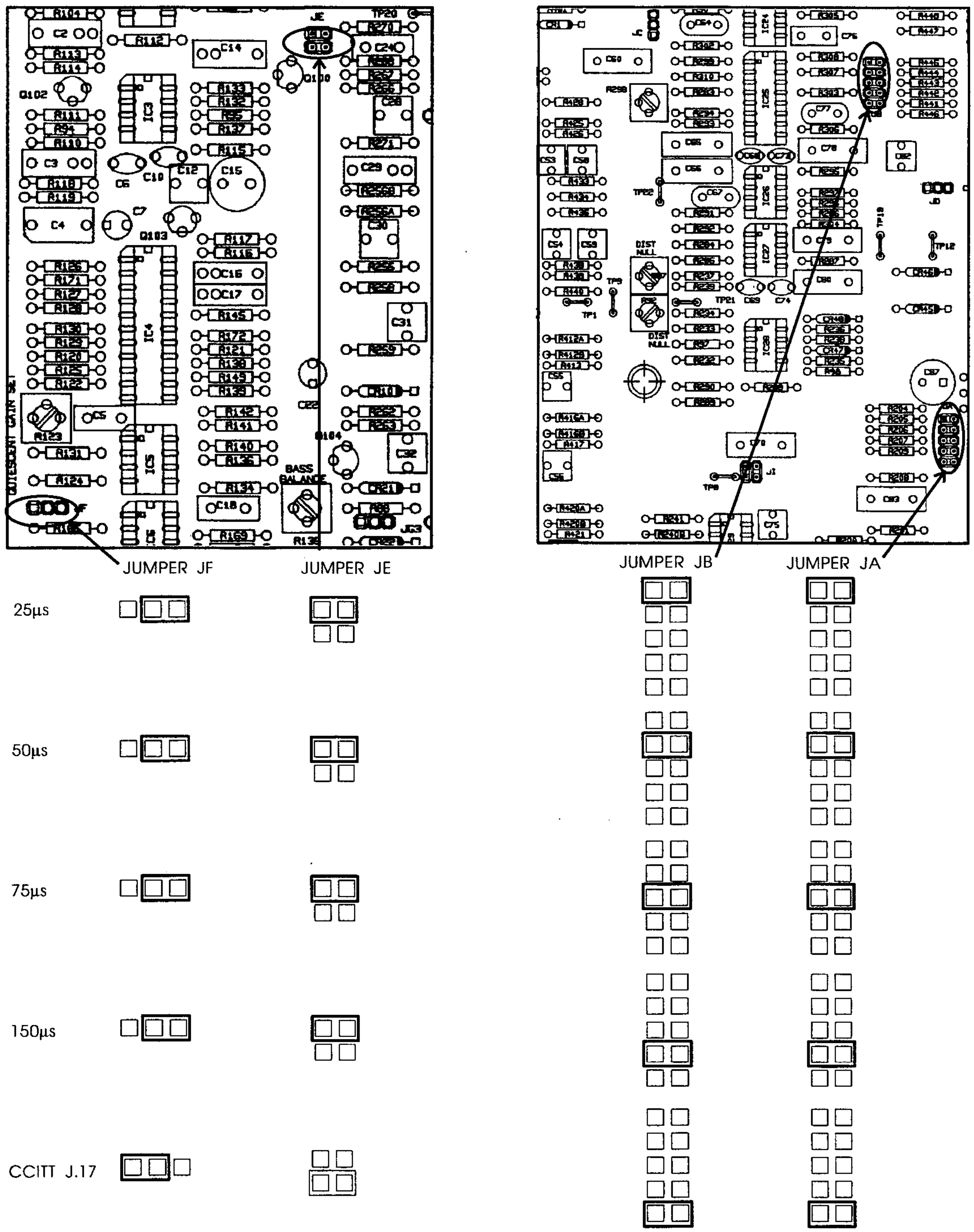


Figure 2-6: Pre-Emphasis EQ

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.

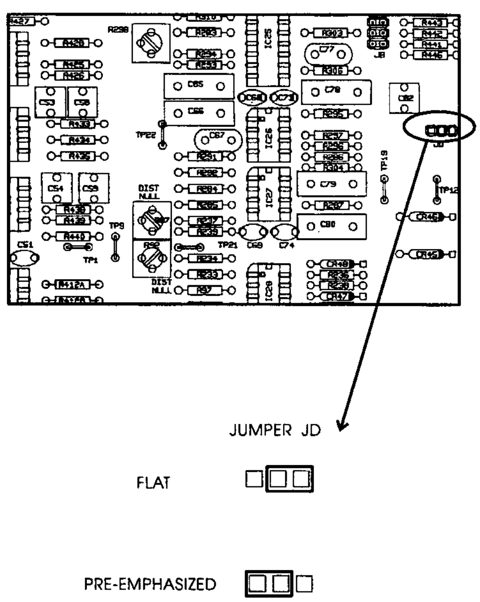


Figure 2-7: Pre-Emphasis

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.

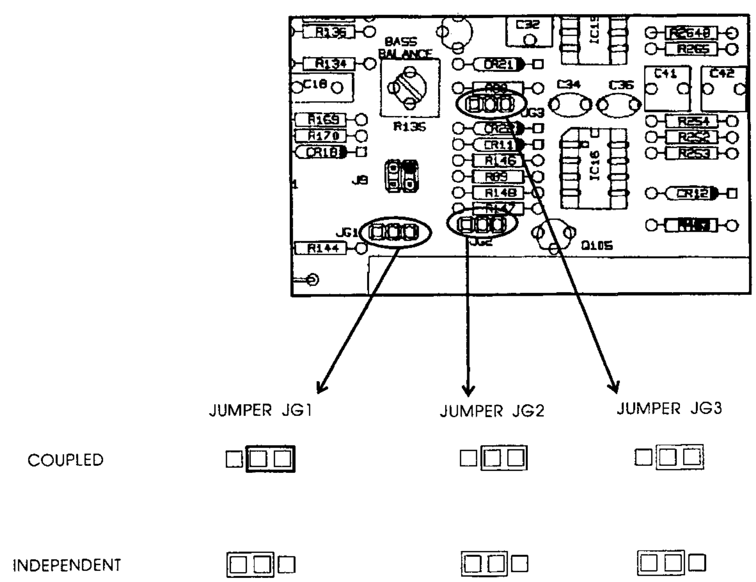


Figure 2-8: Stereo Coupling

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

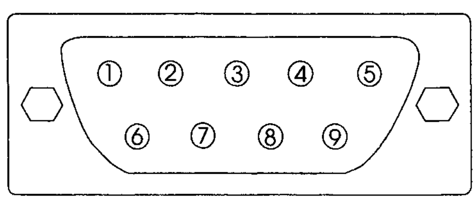


Figure 2-9: Rear Panel Remote Control/Stereo Coupling

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!

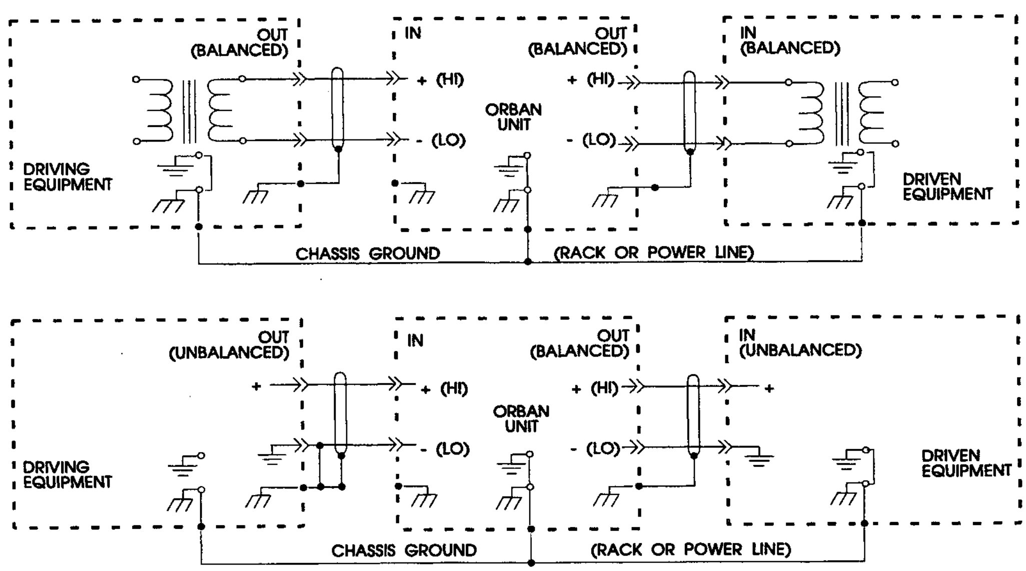


Figure 2-10: Typical Interconnection, Grounding Scheme

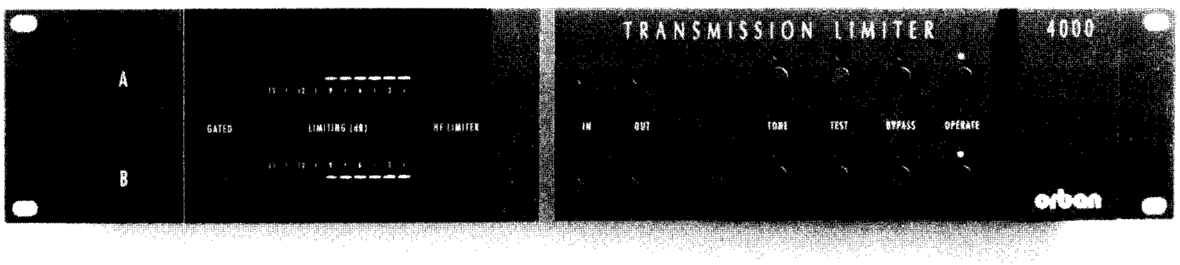
Section 3
Operation

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.

4000 Controls and Meters



INPUT determines the amount of limiting by adjusting the drive level into the dual-band limiter. The range of the INPUT control can be changed 20dB by resetting jumpers inside the unit — see step 3-B on page 2-6.

OUTPUT determines the level appearing at the 4000's output. Maximum peak level is approximately +23dBm/600Ω.

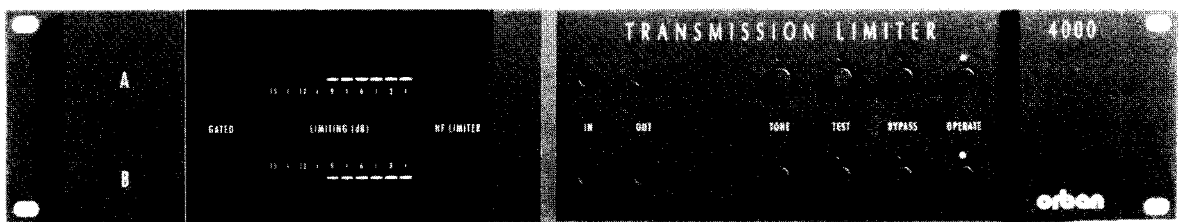
OPERATE is a momentary button that puts the unit in its normal OPERATE mode.

OPERATE light indicates that the unit is in its normal OPERATE mode.

BYPASS is a momentary button that puts the unit in its BYPASS mode. This provides a hard-wire relay connection between the input and output, and removes input termination (if used).

BYPASS light indicates that the unit is in BYPASS mode.

TONE is a momentary button that switches on the 4000's internal 400Hz test-tone oscillator. Provided that the 4000's output is strapped for "pre-emphasized" output (not "flat" — see step 3-E on page 2-9), this tone appears at the output at 100% peak level. Program peaks will not overshoot above this level.



TONE light indicates that the unit is in TONE mode.

TEST is a momentary button that defeats clipping and normal limiting. It permits using external tones applied to the 4000's input for level calibration. TEST activates a special high-threshold detector in the dual-band limiter, which changes the threshold of the dual-band limiter so that any sinewave applied to the input appears at the 4000's output at 100% peak modulation, provided that (1) the tone is of sufficient level to produce 2-14dB limiting, and (2) the 4000's output is strapped "pre-emphasized" (not "flat").

TEST light indicates that the unit is in TEST mode.

LIMITING is a ten-segment LED meter that indicates the amount of limiting (gain reduction) in dB that is occurring in the dual-band limiter. The meter's range is 0 to 15dB in 1.5dB steps. It is important to operate the 4000 so that the red 15dB lamp never lights.

GATED light indicates that the compressor gate in the dual-band limiter has "frozen" the gain of the dual-band limiter to prevent noise breathing during low-level program material or silence.

HF LIMITER light indicates that the high-frequency limiter is dynamically low-pass filtering the program material to eliminate pre-emphasis-induced overload.

Setting Up the 4000 Transmission Limiter

All modes of the 4000 (OPERATE, BYPASS, TEST, and TONE) can be changed by REMOTE control, so the alignment of the transmission link including the 4000 can be checked remotely.

1. Set peak output level using the internal setup oscillator.

[Skip this step if you want to set output level using a system line-up tone.]

This step matches the 4000's internal limiting level to the peak overload level of the link being driven by the 4000.

A ☐ Press the TONE button.

The TONE and TEST lamps on the front panel should light. After a short delay, a 400Hz tone should appear at the 4000's output. This tone is at the absolute maximum peak output level that will occur with program material.

B ☐ Adjust the OUTPUT LEVEL control until the tone is at the desired absolute peak operating level for your system.

Measure this level *after pre-emphasis*. (Ordinarily, the modulation indicator of a given transmission link monitors the level after any pre-emphasis has been applied, and this will happen automatically.) See page 1-15 for a further discussion.

NOTE: If the frequency response and/or the group delay of the link are non-constant, the link will overshoot. Depending on the overload characteristics of the link, you may have to leave headroom to accommodate such overshoot. In this case, adjust the OUTPUT LEVEL control so that the tone is lower in level than the peak operating level by an amount that compensates for link overshoot. Experiment to see how much headroom to allow.

2. Or set peak output level using your system line-up tone.

[Skip this step if you have set output level using the 4000's internal setup oscillator.]

A ☐ Activate your system's line-up tone.

B ☐ Press the TEST button.

C ☐ Set the 4000's input level so that the 4000's limiting meter indicates between 2 and 14db.

The tone at the output is now at the absolute maximum peak level that will occur with program material.

D ☐ Adjust the OUTPUT LEVEL control until the tone is at the desired peak operating level for your system.

Measure this level *after pre-emphasis*. (Ordinarily, the modulation indicator of a given transmission link monitors the level after any pre-emphasis has been applied, and this will happen automatically.) See page 1-15 for a further discussion.

Refer to the note in step 1-B (page 3-4) regarding overshoot in the link.

3. Set INPUT level using tone.

[Skip this step to set input level using program material.]

Refer to the discussion on page 1-9, "Level Calibration of the Transmission Limiter," to determine if, for your system, the 4000 should be set for unity gain or some other gain.

This procedures sets the 4000's input-to-output gain.

Some facilities have specific standards for transmission line-up. For example, a transmission standard may state that +4dBu at 400Hz produces 50% modulation of a microwave link. Or PPM6 might allow 8dB of peak headroom, so would modulate the link to 40%.

A ☐ Turn the INPUT control fully counterclockwise.

B ☐ Press the OPERATE button, then the TEST button.

C ☐ Apply a line-up tone to the 4000 input.

D ☐ Calibrate the 4000 for unity gain below threshold (or to a pre-determined gain or loss).

[Skip this step to calibrate the 4000 to your organization's transmission line-up standard level, or to a specific amount of gain reduction with program material.]

Measure the output level of the 4000 with an audio meter. Adjust the 4000's INPUT control to achieve the desired gain or loss. Output level equal to the standard line-up level will result in unity gain below threshold.

Skip to step F.

E ☐ Calibrate the 4000 to your organization's transmission line-up standard.

Adjust the 4000's INPUT control to the standard level of modulation of the transmission system, as viewed on a meter monitoring that system.

F ☐ Press the OPERATE button. Observe the LIMITING meter.

If no gain reduction is indicated, the standard line-up level is below threshold.

If gain reduction is indicated, the standard line-up level is above threshold (less than 7dB below 100% modulation). System calibration will require that the TEST button be pressed, either on the front panel or by remote control, when system line-up calibration is performed. You may consider calibrating the 4000 for less than unity gain by reducing the INPUT control setting.

4. Apply program material.

Observe the amount of limiting with a variety of program material.

If the limiting meter consistently indicates more limiting than is desired, re-adjust the INPUT control for less than unity gain.

If the limiting meter consistently indicates less limiting than is desired, re-adjust the INPUT control for more than unity gain.

More About 4000 Audio Processing

Dual-Band limiting

The **dual-band limiter** controls the level driving the following high-frequency limiter and distortion-canceling clipper stages. Prior to the limiter, a phase-coherent crossover divides the signal into frequency bands above and below 150Hz. The above-150Hz material is connected to the "master" band, which determines the overall limiting. This prevents limiter-induced "spectral gain intermodulation" — audible modulation of the loudness of midrange and high frequency program material by bass-generated limiting.

The below-150Hz material is connected to the "bass" band. The gain-control voltage produced by the "master" band is cross-coupled into the "bass" band, so that the gain of the "bass" band ordinarily tracks the gain of the "master" band exactly, preserving frequency balances. When the "bass" band encounters exceptionally heavy bass, it momentarily provides extra limiting to preclude excessive level at the dual-band limiter's output.

The dual-band limiter has an attack time of approximately 2 milliseconds. This moderate attack time prevents it from producing limiting on every transient spike. Such limiting could otherwise create audible "holes" in the program. The ensuing distortion-canceling clipper eliminates any overshoots caused by the dual-band limiter's not having a very fast attack time.

The dual-band limiter is **gated**: when its input level drops below the factory-set *threshold of gating,* the release rate is radically slowed to avoid audible "noise breathing."

> This "compressor gate" is not the same as a conventional "noise gate" because it is not intended to reduce noise or other low-level undesired sounds to a lower level than that occurring in the original program. Its only purpose is to prevent the unnatural exaggeration of such material.

The dual-band limiter can produce a maximum of 15dB of limiting. This is more than adequate for "protection limiting." *It is important not to overdrive the input:* If the input is overdriven so that the red 15db lamp lights on the limiting meter, the sound will rapidly become highly distorted as the amount of input overload increases.

High-frequency limiting

When strapped for 25µs, 50µs, 75µs, or 150µs, the high-frequency limiter is a program-dependent 6dB/octave low-pass filter that adapts to the spectrum of the program material to prevent overloading the following distortion-canceling clipper. For J.17 pre-emphasis, the pre-emphasis curve is divided into low-frequency and high-frequency sections with a crossover at approximately 1.3kHz. The low-frequency part of the pre-emphasis is placed prior to the dual-band limiter, which prevents overload that could be caused by this part of the curve. The high-frequency part of the pre-emphasis is controlled by a program-dependent 6dB/octave low-pass filter as with the other pre-emphasis curves.

The threshold of high-frequency limiting is factory-set and is not user-adjustable. The threshold has been set as high as possible without causing audible distortion in the following distortion-canceling clipper, thus minimizing audible high-frequency loss.

Peak limiting

The distortion-canceling clipper and following overshoot corrector perform peak limiting. The system contains a non-linear 15kHz low-pass filter that tightly constrains the 4000's output bandwidth to 15kHz while limiting overshoot to a maximum of about 1dB (10% modulation). Figure 3-1 shows the output power spectrum as measured by the stringent "maximum peak hold" technique with an 801-line FFT dynamic signal analyzer (Hewlett-Packard 3562A).

This system can replace the anti-aliasing filter in most digital links. Because the system has far less overshoot than a linear anti-aliasing filter, the average level in the link can usually be raised by 2-3dB, improving the signal-to-noise ratio achieved through the link.

The distortion-canceling clipper has no user adjustments.

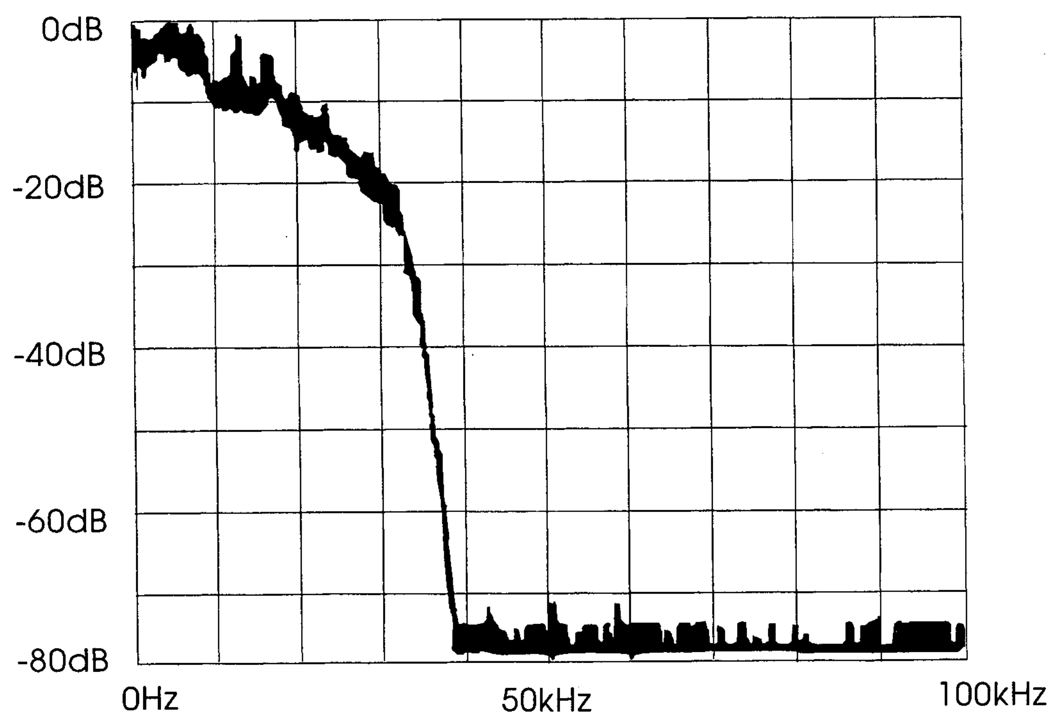


Figure 3-1: Output Power Spectrum
0-100kHz horizontal; 10dB/div vertical

Section 4
Maintenance

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.

Routine Maintenance

No routine maintenance of this product is required.

If the front panel becomes soiled, clean it with a mild household detergent and a damp cloth. Stronger solvents should not be used because they may damage plastic parts, paint, or the silk-screened lettering (99% isopropyl alcohol can be safely used).

Getting Inside the Chassis

To access the circuit boards, remove all 10 screws holding the top cover in place, and lift the top cover off. (NOTE: If you have a stereo 4000, remove the bottom cover too.) When replacing either cover, replace all screws snugly (be careful not to strip the threads by fastening the screws too tightly).

Be sure power is disconnected before removing the covers.

1. Removing either main circuit board.

If you want to replace any soldered-in component, you must remove its associated circuit board to gain access to the board's solder side.

A ☐ The main circuit board is connected to the display board, the power supply, and the rear panel connectors through various jacks that mate with plug-terminated cables. Unplug all cables from the board, noting where they go for reassembly later.

B ☐ Remove the five screws securing the board to its mounting standoffs.

C ☐ Carefully lift the board out of the chassis.

To reassemble, follow the above directions in reverse. Be careful to replace the retaining clips on the DIP plugs.

2. Accessing the Display Board

A ☐ To remove the front panel, remove the small black screw in the center of the panel with a $^{1}/_{16}$ inch hex wrench. Remove the four large black screws on its four corners with a $^{3}/_{32}$ inch hex wrench. Then pull the front panel toward you.

Take care not to cosmetically damage the LED meter assemblies by scraping them with the panel.

The display board is now revealed. Its components are mounted on the back of the board.

B ☐ To access the components, remove the eight screws holding the display board on its supporting stand-off posts.

C ☐ *Very slowly and carefully* tilt the board down toward you, imagining a hinge on its bottom edge.

The ribbon cables connecting the display board to the main board are easily damaged by excessive tension or flexing. **Treat them gently!**

3. Reassembling the Display Board and Front Panel

A ☐ *Very slowly and carefully* tilt the board up and align the mounting holes with the stand-off posts.

B ☐ Start, but do not tighten, all eight screws holding the display board on its supporting stand-off posts.

C ☐ Carefully center the board.

If you neglect this step, the LED meter assemblies or the switches may bind against the front panel after it is replaced.

D ☐ "Thread" the switches and LED displays through their associated holes in the front panel.

E ☐ Center the panel on its stand-offs, and replace the five hex screws removed in step 2-A above.

If any components bind against the panel, you may have to re-center the circuit board per step 3-C above.

Performance Evaluation, Alignment

IMPORTANT: Because the 4000 circuitry is highly stable, routine performance evaluation and alignment are *not* required and *not* recommended. The following evaluation procedure is extremely thorough, and is included primarily for reference.

Equipment Required:

Oscilloscope

DC-coupled with at least 5MHz vertical bandwidth.

Digital Voltmeter

Accurate to 0.1%

Audio Voltmeter

Accurate to 2%. Sound Technology 1710B or equivalent preferred.

Low-Distortion Audio Oscillator

With verified residual distortion below 0.003%.
Sound Technology 1710B or equivalent preferred.

THD Analyzer

With verified residual distortion below 0.003%.
Sound Technology 1710B or equivalent preferred.

Spectrum Analyzer with tracking generator

Tektronix 5L4N plug-in with 5111 bistable storage mainframe, or equivalent. *Alternatively*, an FFT analyzer (HP 3561A or equivalent) can be used, although most FFT-based analyzers update slowly and thus make the interactive adjustments described below more difficult.

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.

These are instructions for thoroughly checking the performance of the 4000. The evaluation includes checks of the power supplies, input stages, VCAs, gate control circuits, VCA control circuits, meters, high-frequency limiters, clippers, output stages, and overall performance. This procedure is useful in diagnosing and detecting problems, as well as for checking routine performance.

See the assembly drawings in **Section 6** for the locations of components, jumpers, and test points. *All jumpers and test points are located on the main circuit board.*

The instructions below are for the single-channel 4000A1. If you are aligning a dual-channel 4000, repeat all steps for the second channel except steps 2 and 3.

Perform procedures in order without skipping steps.

1. Prepare the unit.

A ☐ Record the settings of the jumpers so you can restore them after you have finished the alignment procedure.

B ☐ Set the jumpers on the board as follows:

Jumper Positions

Jumpers	Setting	Refer to Step	On Page	Notes
JH1 + 2	−20dB	3-B	2-6	set inp. sens.
JA, JB, JE, JF	150µs	3-D	2-9	set pre-emph
JD	PRE-EMPH.	3-E	2-9	
JG1, 2, + 3	INDEP.	3-F	2-10	stereo units only
JE, JF	OTHER	3-D	2-6	set pre-emph

2. Test power transformer; POWER switch; fuse; associated wiring. (optional)

A ☐ Verify that the resistance between the AC cord ground pin and the chassis is close to 0Ω.

B ☐ Verify that the resistance between both AC cord blades and the chassis is infinite.

C ☐ Set the VOLTAGE SELECT switch to 115 volts. Verify that the resistance between the AC cord blades is 100Ω ±10% for the single-channel 4000A1, and 13.0Ω ±10% for the dual-channel 4000.

D ☐ Set the VOLTAGE SELECT switch to 230 volts.

E ☐ Verify that the resistance between the AC cord blades is 175Ω ±10% for the 4000A1, and 48Ω ±10% for the 4000.

F ☐ Set the switch to the voltage appropriate for your country. Be sure that the correct fuse is installed. This is ½-amp for 115V, and ¼-amp for 230V.

3. Test the unregulated power supply.

A ☐ Connect the 4000 to a source of mains power.

The OPERATE lamp should light.

B ☐ Measure the voltage of the positive unregulated power supply.

The voltage must be between +18 and +26 volts. It is typically +22V, but this will vary widely with changes in line voltage.

This voltage is measured across large electrolytic capacitor C425.

C ☐ Measure the voltage of the negative unregulated power supply.

The voltage must be between –18 and –26 volts. It is typically –22V, but this will vary widely with changes in line voltage.

This voltage is measured across large electrolytic capacitor C426.

4. Test the regulated power supply.

A ☐ Measure the output of the +15 volt regulator (at the (+) terminal of C1).

The voltage must be +15 volts, ±0.75V. If it is not, see the power supply troubleshooting information on page 5-2.

B ☐ Measure the output of the –15 volt regulator (at the (–) terminal of C2).

The voltage must be –15 volts, ±0.75V. If it is not, see the power supply troubleshooting information on page 5-2.

C ☐ Observe the regulated power supply rails with an oscilloscope.

Verify that the total noise and ripple is below 4mV peak.

D ☐ Measure the output of the +5.8 volt source (at TP9).

The voltage must be +5.8 volts, ±0.5V.

E ☐ Measure the output of the –5.8 volt source (at TP12).

The voltage must be –5.8 volts, ±0.5V.

F ☐ Measure the output of the +1.9 volt source (at TP13).

The voltage must be +1.9 volts, ±0.2V.

G ☐ Measure the output of the –1.9 volt source (at TP14).

The voltage must be –1.9 volts, ±0.2V.

H ☐ Verify that the OPERATE LED is lit.

I ☐ Measure the output of the (+) clip level source (at TP15).

The voltage must be +4 volts, ±0.2V. If the level is incorrect, adjust R167 (Clip level set).

J ☐ Measure the output of the (–) clip level source (at TP18).

The voltage must be –4 volts, ±0.2V.

K☐ Press the TEST button

Verify that the voltages observed in steps D through J are ±14V, ±1V.

5. Set VCA gain.

A☐ Set jumpers JH1 and JH2 to the –20db position.

See step 3-B (page 2-6) and to locate and set these jumpers.

B☐ Connect a 600Ω resistor between pins 2 and 3 of the 4000 output XLR-type connector.

C☐ Connect pins 1 and 3 of the 4000 output XLR-type connector together.

D☐ Connect the high side of the oscillator to pin 2 of the 4000 input XLR-type connector.

E☐ Connect the low side of the oscillator to pin 3 of the 4000 input XLR-type connector.

F☐ Press the TEST button.

Verify that the TEST lamp is lit.

G☐ Set the oscillator frequency to 5kHz.

H☐ Observe pin 1 of IC3 with the audio voltmeter.

I☐ Adjust the OUTPUT LEVEL of the oscillator to make the audio voltmeter indicate "–15dBu."

0dBu = 0.775V rms. Read dBu on the "dBm/600Ω" scale of the audio voltmeter.

J☐ Observe TP8 with the audio voltmeter.

K☐ Set R123 (QUIESCENT GAIN SET) to make the audio voltmeter indicate "0dBu."

L☐ Set the oscillator frequency to 50Hz.

M☐ Set R135 (BASS BALANCE) to make the audio voltmeter indicate "0dBu."

6. Check gate control circuit.

A☐ Press the OPERATE button.

Verify that the OPERATE lamp is lit.

B☐ Set the oscillator to 1kHz.

C☐ Mute the oscillator by turning down its OUTPUT LEVEL control.

Verify that the GATED lamp on the 4000's front panel lights.

D☐ Using its OUTPUT LEVEL control, increase the audio oscillator's OUTPUT LEVEL until the GATED lamp goes out. Verify that this occurs when the level at TP8 is –17dBu (109mV) ±4dB.

The audio voltmeter should still be connected to TP8.

7. Check VCA control circuits and LIMITING meters.

A ☐ Observe the 4000's audio output with the voltmeter.

B ☐ Mute the oscillator.

C ☐ Press the TONE button.

D ☐ Set the 4000's OUTPUT LEVEL control so that the voltmeter indicates "+10dBu" (2.449V).

E ☐ Press the OPERATE button.

F ☐ Set the oscillator's output level to +10dBu.

G ☐ Set the 4000's INPUT LEVEL control fully clockwise.

H ☐ Verify that all LED segments of the LIMITING meter light.

I ☐ Quickly reduce the oscillator's output level to −15dBu. Verify that the LIMITING meter reading decays to "3dB" in 4.7 seconds ±1 seconds.

J ☐ Adjust the oscillator's output level control so that the second ("3dB") LED segment of the LIMITING meter just lights, but the third segment does not.

K ☐ Connect the audio voltmeter to TP8, and observe the level there.

L ☐ Increase the audio oscillator's output level by 10dB.

M ☐ Verify that the LIMITING meter indicates 13.5dB limiting, and that the level at TP8 is no more than 1.0dB greater than the level observed before increasing the oscillator's output level.

8. Test the common mode rejection.

A ☐ Press the TEST button.

Verify that the TEST lamp is lit.

B ☐ Set the oscillator for 100Hz and reduce its output level by 10dB.

The oscillator should be connected to the 4000's input.

C ☐ Measure the level at the 4000's output with the audio voltmeter.

D ☐ Remove the ground from the (–) input.

E ☐ Connect the signal to both the (+) and (–) inputs in parallel.

F ☐ Verify that the output level is reduced by at least 50dB.

G☐ Remove the signal from the (–) input and replace the ground.

9. Align Smart Clipper.

A☐ Place jumper JI in the IN position.

See step 3-C on page 2-7 to locate this jumper.

B☐ Disconnect the oscillator from the 4000 input, and connect it to TP17.

This injects the oscillator output directly into the "Smart Clipper" circuit.

See the main board Assembly Drawing on page 6-34 to locate this IC and any other components called out in the procedure below.

C☐ Connect the input of the audio voltmeter/THD Analyzer to TP11.

D☐ Verify that the TEST lamp is lit.

If it is not, press the TEST button.

E☐ Set the oscillator frequency to 5kHz.

F☐ Adjust the oscillator output level to produce +10dBu (2.45Vrms) at TP11.

G☐ Set the oscillator frequency to 50Hz.

Be sure that the output level of the oscillator did not change when you changed frequency.

H☐ Adjust R298 (LF BALANCE) to produce +10dBu (2.45Vrms) at TP11.

This produces flat response from the "Smart Clipper" circuit.

I☐ Set the oscillator to 400Hz.

J☐ Adjust the oscillator level so that the level appearing at the 4000's output is about 7 volts.

K☐ Connect the oscilloscope to pin 1 of IC27.

L☐ Adjust R92 and R87 (RECTIFIER FEEDTHROUGH NULL) to minimize the level of the signal observed.

M☐ Measure the harmonic distortion, and null it with R309 (LF DISTORTION NULL).

N☐ Connect the audio voltmeter to TP17.

O☐ Set the oscillator frequency to 500Hz. Set its output level to +7dBu (1.73Vrms).

P☐ Connect the oscillator to TP19.

This modulates the gain of the low-frequency VCA IC25 and associated components at a 500Hz rate.

Q☐ Increase the sensitivity of the audio voltmeter monitoring TP11 until the 500Hz feedthrough can be seen easily.

It may be useful to observe the audio voltmeter's "monitor output" with an oscilloscope to verify that you are seeing the feedthrough and not hum or noise. If high- and low-pass filters are available on your audio volt-meter/distortion analyzer, activate them to minimize the effects of hum and high frequency noise upon the measurement.

R ☐ Null the feedthrough with R301 (LF FEEDTHROUGH NULL).

10. Check high-frequency limiters.

A ☐ Connect the high side of the oscillator to the 4000 (+) input.

B ☐ Connect the low side of the oscillator to the 4000 (–) input.

C ☐ Set the oscillator's frequency to 5kHz and its output level to 0dBu.

D ☐ Set controls, trimmers, and jumpers as follows:

Control Settings

Control	Setting
PRE-EMPHASIS JUMPERS JA, JB, JE, JF	150µs
HF LIMITER DIST NULL TRIMMER R269	CENTER
FET BIAS TRIMMER R223	FULLY CLOCKWISE
JUMPER JD	FLAT
MODE	TEST

E ☐ Verify that the TEST lamp is lit.

If it is not, press the TEST button.

F ☐ Connect a THD analyzer/audio voltmeter and oscilloscope to TP18.

G ☐ Adjust the input level to produce a level of +14.0dBu ±0.5dB at TP18.

H ☐ Verify that the signal at TP18 is a sine wave of normal appearance.

I ☐ Mute the oscillator, verify that there is no "popcorn" noise or oscillation, then restore the signal.

J ☐ Slowly turn FET BIAS trimmer R223 counterclockwise until the level at TP18 begins to decrease. Then turn R223 clockwise until the level at TP18 stops increasing. Turn R223 clockwise about 1/10-turn further.

K ☐ Press the OPERATE button.

Verify that the OPERATE lamp is lit.

L ☐ Increase the oscillator's output level until the HF LIMITER lamp lights.

M☐ Adjust HF LIMITER DIST NULL trimmer R269 for minimum THD. Verify that THD does not exceed 0.06% in a 20-20,000Hz bandwidth at TP18.

N☐ Set the oscillator's frequency to 1kHz, and verify that the HF LIMIT indicator does not light.

O☐ Set the oscillator's frequency to 10kHz, and verify that the HF LIMIT indicator lights.

11. Measure frequency response.

A☐ Disconnect the audio oscillator from the 4000.

B☐ Connect the tracking generator output of the spectrum analyzer to pin 2 of the 4000 input XLR-type connector (ground pin 3).

C☐ Set the spectrum analyzer for a 20-20,000Hz log sweep and a 2dB/division display.

D☐ "Freeze" the sweep, and manually set it to 1kHz.

E☐ Adjust the generator's output level 22dB below the level that causes the "1.5dB" lamp (first segment) on the 4000's LIMITING meter to light.

F☐ Restore the automatic 20-20kHz sweep.

G☐ Connect the spectrum analyzer's input to the output of the 4000.

H☐ Set pre-emphasis in turn for 25µs, 50µs, 75µs, 150µs and J.17, following the instructions in step 3-D on page 2-9. For each pre-emphasis curve, verify a flat response (±0.5dB).

In all cases you should see an abrupt high-frequency cutoff at 15kHz caused by the system low-pass filters.

I☐ Increase the generator's output level by 20dB.

This should be 2dB below the level that causes the "1.5dB" lamp (first segment) on the 4000's LIMITING meter to light.

J☐ Verify that the limiting action is as shown in Figure 4-1 for each pre-emphasis curve.

You will note that these curves are *not* the inverse of the ideal pre-emphasis curves. Such curves would only be generated if the input level to the high-frequency limiter corresponded to 100% modulation. However, the dual-band limiter constrains the steady-state level of sinewaves to well below the level corresponding to 100% modulation. So this test shows the high-frequency limiter's limiting only the upper part of the pre-emphasis curves.

Further, the J.17 curve is controlled by a combination of the dual-band limiter and the high-frequency limiter. The part of the J.17 curve between 100Hz and 1kHz is placed prior to the dual-band limiter so that the dual-band limiter "knows" about this pre-emphasis and can control it. The remaining pre-emphasis in the J.17 curve is placed after the dual-band limiter, and is controlled by the high-frequency limiter. This explains the "break" in the J.17 curve: Control is passing from the dual-band limiter to the high-frequency limiter.

The thresholds and dynamic characteristics of the dual-band limiter and high-frequency limiters have been carefully crafted so that these circuits work harmoniously with the "Smart Clipper" and FCS Overshoot corrector to control peak levels without audible distortion, pumping, or other undesirable side-effects. While the steady-state characteristics of the 4000 may seem unusual to those familiar with older-technology peak limiter designs, we submit that the "proof is in the listening."

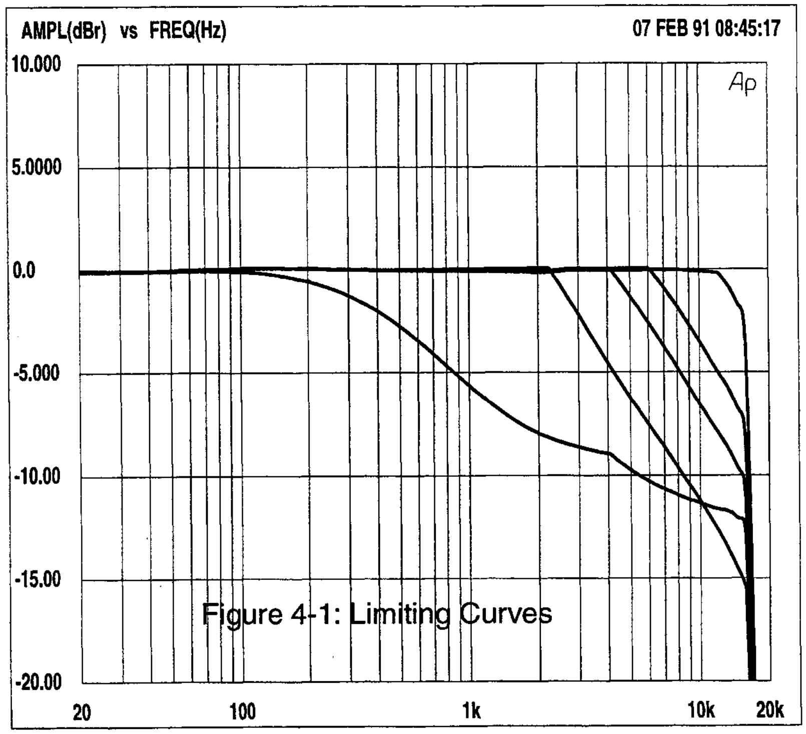


Figure 4-1: Limiting Curves

12. Measure harmonic distortion.

A ☐ Disconnect the spectrum analyzer from the 4000.

B ☐ Connect the audio oscillator to the 4000's input.

C ☐ Press the TEST button.

Verify that the TEST lamp lights.

D ☐ Set the oscillator for 1kHz.

E ☐ Set the oscillator's input level control to make the voltmeter read +9dBu.

The voltmeter should still be monitoring the 4000's output.

+9dBu is 1dB below 100% modulation, presuming that the adjustment made to the output level control in step 7-D on page 4-8 has not been changed.

F ☐ Measure the total harmonic distortion at 20Hz, 50Hz, 100Hz, 400Hz, 1kHz, 2.5kHz, 5kHz, 10kHz, and 14kHz.

The THD should not exceed 0.075% at any frequency.

Of course, you may use more frequencies and/or an automatically sweeping distortion analyzer if you wish to make a more thorough measurement.

G ☐ Press the OPERATE button.

H ☐ Adjust the oscillator output level to make the LIMITING meter indicate 10dB of limiting.

I ☐ Measure the total harmonic distortion at 20Hz, 50Hz, 100Hz, 400Hz, 1kHz, 2.5kHz, 5kHz, 10kHz, and 14kHz.

The THD should not exceed 0.075% at any frequency above 150Hz. As with any limiter, distortion will rise slightly at very low frequencies. Typically, harmonic distortion is 0.2% at 20Hz, 0.15% at 50Hz, and 0.13% at 100Hz.

13. Measure Noise.

A ☐ Remove the oscillator from the 4000.

B ☐ Connect a wire between the (+) and (–) terminals of the 4000's input to short it.

C ☐ Switch a 20-20kHz band-pass filter into the metering circuit of the audio voltmeter.

D ☐ Measure the level at the 4000's output with the voltmeter for each pre-emphasis curve.

See step 3-D on page 2-9 for jumper positions.

Typical Noise Levels

NOISE LEVEL 20Hz-20kHz	NOISE LEVEL 400Hz-20kHz	CURVE
−74.5dBu	−75.0dBu	25μs
−75.0dBu	−76.0dBu	50μs
−75.5dBu	−76.5dBu	75μs
−76.0dBu	−77.0dBu	150μs
−80.0dBu	−82.0dBu	J.17

These figures were obtained from a meter using true R.M.S. detection.

(Note that +10dBu = 100% modulation, so the dynamic range is 10dB greater than the numbers above.)

14. Defeat the high-frequency limiter by moving jumper JI to the OUT position and jumper JD to the PRE-EMPHASIZED position.

See step 3-C on page 2-7.

A ☐ Measure the noise.

The typical noise level is –73.5dBu (=83.5dB dynamic range).

15. Test the balanced floating line amplifier.

A ☐ Connect the oscillator to the 4000's input.

B ☐ Set the 4000's OUTPUT LEVEL control fully clockwise.

C ☐ Press the TEST button.

D ☐ Set the oscillator frequency to 1kHz.

E ☐ Observe the output between pins 2 and 3 of the 4000 output XLR-type connectors with the audio voltmeter. Observe the MONITOR OUTPUT of the voltmeter with the oscilloscope.

The audio voltmeter must have a balanced input.

F ☐ Advance the oscillator's OUTPUT ATTENUATOR until clipping occurs at the 4000's output.

Verify that the output level exceeds +21dBu.

G ☐ Reduce the 4000's output level to +18dBu.

H ☐ Momentarily short pin 2 of the 4000 output XLR-type connector to ground.

Verify that the output level is between +17.5dBu and +18.5dBu.

I ☐ Momentarily short pin 3 of the 4000 output XLR-type connector to ground.

Verify that the output level is between +17.5dBu and +18.5dBu.

J ☐ Remove the load and the connections to the output.

K ☐ Connect the (–) input of the audio voltmeter to pin 1 of the 4000's output XLR-type connector.

L ☐ With the audio voltmeter, observe pin 2, then pin 3 of the 4000's output XLR-type connector.

Verify that the levels observed are within 3dB of each other.

16. Test D.C. offset.

A ☐ Observe the 4000 (+) OUTPUT terminal with the DVM.

Verify that the DC offset is less than 15mV (typically less than 5mV).

B ☐ Observe the 4000 (–) OUTPUT terminal with the DVM.

Verify that the DC offset is less than 15mV (typically less than 5mV).

Section 5
Troubleshooting

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.

Problems and Possible Causes

Always verify that the problem is not in the source material being fed to the 4000, or in other parts of the system.

RFI, Hum, Clicks, Or Buzzes

A grounding problem is likely. Review the information on grounding on page 2-15.

The 4000's RF suppression should be adequate for the vast majority of installations. However, installation next to a high-power transmitter might still cause problems. Additional RF suppression, careful examination of the grounding scheme, and other techniques familiar to the broadcast engineer may be needed.

Power Supply Problems

The voltage regulators are operated conservatively and we expect them to be very reliable. Before replacing the regulators, check to see whether other abnormalities in the circuitry (such as a shorted IC) have caused excessive current demand which is, in turn, causing the regulator ICs to either current limit or go into thermal shutdown (the two built-in protective modes). If it becomes necessary to replace a regulator, be sure to re-mount it exactly as before (use the other regulator as a model). For maximum resistance to thermally-induced mechanical fatigue, solder the regulator leads to the circuit board after the regulators have been firmly mounted to their heat sinks.

To prevent high-frequency oscillations, regulators IC48 and IC49 are frequency compensated at their outputs by C101-102. If C101-102 is ever replaced, be sure to use a low-inductance aluminum electrolytic. A tantalum can fail because the current-delivering capacity of the power supply can cause a runaway condition if the dielectric is punctured momentarily; a high-inductance aluminum can fail to prevent a regulator from oscillating. Check for oscillation on the power bus with an oscilloscope if C101-102 is replaced.

Balanced Output Amplifier Failure

The 5532 and 411 opamps used in the balanced output amplifier may be freely replaced as necessary. However, the circuit is extremely sensitive to the characteristics of the resistors, so field repair of resistor failure (which is very unlikely) requires replacement of the entire output amplifier resistor header assembly if adequate headroom and common-mode rejection are to be maintained (see page 5-6 for information about factory service).

Poor Peak Control

Apparent peak control problems may actually result from problems with the transmission link that the 4000 is driving. A subcarrier generator, telephone line, or digital link, for example, could introduce overshoot and ringing. A device with poor frequency response might cause "tilt" with low-frequency material. See **Specification for the Output Link** on page 1-13 for a more detailed discussion.

Be sure that the instrument used to measure the peak output of the 4000 (or the device it is driving) has accurate transient response and dynamic accuracy. Inaccurate measuring instruments (such as many popular modulation monitors) can introduce tilt into the waveform prior to metering, causing the meter to falsely indicate peak overshoots.

If you operate the 4000 with FLAT output (that is, with its de-emphasis filter activated) and then re-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.

Real failure of the 4000 to control peaks (as verified by an oscilloscope monitoring the 4000 output) can be caused by failures in the FCS Overshoot Corrector circuit.

System Will Not Pass Line-up Tones At 100% Modulation

This is normal. (See page 1-5 for a discussion). To transparently pass line-up tones up to 95% modulation, enter the TEST mode by pushing the TEST button on the front panel or by applying voltage to the TEST remote control terminals.

Shrill, Harsh Sound

This could be caused by the 4000's supplying pre-emphasis to a device that doesn't need it. If the device driven by the 4000 does not require pre-emphasis, place jumper JD on the main circuit board in the FLAT position (see step 3-E on page 2-9).

This problem could also be caused by a mismatch between the pre-emphasis and de-emphasis used in the system. Compare the actual settings of the jumpers in your unit with those specified in step 3-D on page 2-9.

Dull Sound

This could be caused by the 4000's not supplying pre-emphasis to a device that needs it. If the device driven by the 4000 requires pre-emphasis, place jumper JD on the main circuit board in the PRE-EMPHASIZED position (see step 3-E on page 2-9).

Another possible cause is leaving the 4000's de-emphasis filter in-circuit when the 4000's high-frequency limiter is bypassed. If jumper JI (HF LIMITER IN/OUT) is in the OUT position, jumper JD must be in the PRE-EMPHASIZED position to defeat the 4000's de-emphasis filter. (See step 3-C on page 2-7.)

This problem could also be caused by a mismatch between the pre-emphasis and de-emphasis used in the system. Compare the actual settings of the jumpers in your unit with those specified in step 3-D on page 2-9.

Audible Distortion

First make sure that the program material presented to the 4000's inputs is clean and distortion-free.

If the limiting meter's red segment is lighting, reduce the amount of limiting by reducing the drive level to the 4000's input.

If distortion can be heard *only* with J.17 pre-emphasis, verify that jumper JF has been set to the "J.17" position.

This reduces the threshold of the dual-band limiter, thus reducing the drive level into the clippers. Threshold reduction compensates for the J.17 frequency-contouring that occurs ahead of the dual-band limiter.

If you can still hear distortion, check the adjustment of CLIPPER BIAS trimmer R167. If it has been set more than 50% clockwise, this can introduce slight audible distortion on some program material. (See the assembly drawing in **Section 6** for locations of components).

Many potential circuit failures in the 4000 could cause distortion. Most would be detected by performing the **Performance Evaluation and Alignment** procedure starting on page 4-4.

Frequency Response Is Not Flat

If you are using the high-frequency limiter, make sure that jumpers JA, JB, JE, and JF are in the correct positions for the pre-emphasis curve that you have chosen.

If jumper JD is set to PRE-EMPHASIZED, the output will follow the pre-emphasis curve that you have chosen and will not be flat. To make the output flat, set JD to its FLAT position.

If you are *not* using the high frequency limiter (i.e., jumper JI is in the OUT position), you must set jumper JD to PRE-EMPHASIZED so that no de-emphasis is applied to the signal.

There are two crossover frequencies used internally in the 4000: 150Hz and 2kHz. If the frequency response problem is relatively slight, and seems to change at either of these frequencies, suspect a problem with the crossover in the Dual-Band Compressor (150Hz) or the "Smart Clipper" (2kHz). To troubleshoot the Dual-Band Compressor, see step 5 on page 4-7. To troubleshoot the "Smart Clipper," see step 9 on page 4-9.

Troubleshooting IC Opamps

IC opamps are operated such that the characteristics of their associated circuits are essentially independent of IC characteristics and dependent only on external feedback components. The feedback forces the voltage at the (–) input terminal to be extremely close to the voltage at the (+) input terminal. Therefore, if you measure more than a few millivolts difference between these two terminals, the IC is probably bad.

Exceptions are opamps used without feedback (as comparators) and opamps with outputs that have been saturated due to excessive input voltage because of a defect in an earlier stage. However, if an opamp's (+) input is more positive than its (–) input, yet the output of the IC is sitting at −14 volts, the IC is almost certainly bad. The same holds true if the above polarities are reversed. Because the characteristics of the 4000's circuitry are essentially independent of IC opamp characteristics, an opamp can usually be replaced without recalibration. Realignment must be performed if IC25 is replaced.

A defective opamp may appear to work, yet have extreme temperature sensitivity. If parameters appear to drift excessively, freeze-spray may aid in diagnosing the problem. Freeze-spray is also invaluable in tracking down intermittent problems. But *use it sparingly,* because it can cause resistive short circuits due to moisture condensation on cold surfaces.

Technical Support

If you require technical support, contact Orban customer service. Be prepared to accurately describe the problem. Know the serial number of your 4000 — this is printed on the rear panel of the unit.

Telephone:	(1) 510/351-3500	or Write:	Customer Service Orban
or Fax:	(1) 510/351-0500		1525 Alvarado Street
or E-Mail:	custserv@orban.com		San Leandro, CA 94577 USA

Factory Service

Before you return a product to the factory for service, we recommend that you refer to this manual. Make sure you have correctly followed installation steps and operation procedures. If you are still unable to solve a problem, contact our Customer Service for consultation. Often, a problem is relatively simple and can be quickly fixed after telephone consultation.

In any case, products will be accepted for factory service *only* after Customer Service has issued a Return Authorization number. This number flags the returned unit for priority treatment when it arrives on our dock, and ties it to the appropriate information file. Also, when you return a product to the factory for service, we recommend you include a letter describing the problem.

Please refer to the terms of your Limited One-Year Standard Warranty, which extends to the first end-user. After expiration of the warranty, a reasonable charge will be made for parts, labor, and packing if you choose to use the factory service facility. Returned units will be returned C.O.D. if the unit is not under warranty. Orban will pay return shipping if the unit is still under warranty. In all cases, transportation charges to the factory (which are usually quite nominal) are paid by the customer.

Shipping Instructions

Use the original packing material if it is available. If it is not, use a sturdy, double-walled carton no smaller than 22 x 13.5 x 2.5 inches (56 x 35 x 7 cm) for a 4000A1 mono unit or 22 x 15.5 x 4 inches (56 x 40 x 11 cm) for a 4000 stereo unit, with a minimum bursting test rating of 200 pounds (91 kg) for either carton. Place the chassis in a plastic bag (or wrap it in plastic) to protect the finish, then pack it in the carton with at least 1.5 inches (4 cm) of cushioning on all sides of the unit. "Bubble" packing sheets, thick fiber blankets, and the like are acceptable cushioning materials; foam "popcorn" and crumpled newspaper are not. Wrap cushioning materials tightly around the unit and tape them in place to prevent the unit from shifting out of its packing. Close the carton without sealing it and shake it vigorously. If you can hear or feel the unit move, use more packing. Seal the carton with 3-inch (8 cm) reinforced fiberglass or polyester sealing tape, top and bottom in an "H" pattern. Narrower or parcel-post type tapes will not withstand the stresses applied to commercial shipments.

Mark the package with the name of the shipper, and with these words in red:

DELICATE INSTRUMENT, FRAGILE!

Insure the package properly. Ship prepaid, not collect. Do not ship parcel post.

Your **Return Authorization Number** must be shown on the label, or the package will *not* be accepted.

Section 6
Technical Data

page contents

Specifications

Performance

Frequency Response (20-15,000Hz): ±0.25dB below leveler, compressor, and high-frequency limiter thresholds.

RMS Noise: >82dB (83.5dB typical) below 100% modulation with high-frequency limiter strapped for flat output. See the table in step 13-D on page 4-13 for typical noise performance with various high-frequency limiting curves.
Measured in a 20-20,000Hz bandwidth with a true-R.M.S. meter.

Total Harmonic Distortion (TEST mode): <0.05%, 20-15,000Hz.
Measured at level equivalent to 90% peak modulation.

Total Harmonic Distortion (OPERATE mode): <0.05% at 1kHz. Typically <0.2% at 20Hz, <0.1% at 100Hz, <0.05% at 200-15,000Hz.
Measured with 5dB of limiting at 1kHz. (As with any limiter, low frequency distortion will rise as limiting is increased because the limiter acts on each cycle of the low-frequency waveform.)

SMPTE Intermodulation Distortion (TEST mode): <0.075%.
Measured at level equivalent to 90% peak modulation; 60/7000Hz; 4:1.

SMPTE Intermodulation Distortion (OPERATE mode): <0.25%.
Measured with 5dB of limiting.

Interchannel Crosstalk: Better than −90dB, 20-15,000Hz.

Overshoot: 1dB maximum (referred to the low-frequency "clipping threshold" of the FCS Overshoot Compensator).

Spectral Control: See Figure 3-1 on page 3-8.

Installation

Audio Input

Impedance: >10KΩ, active balanced, EMI-suppressed. Input transformer option available (specify OPT-25).

Operating Level: Usable with −30dBu to +10dBu lines.
(0dBu = 0.775V RMS; for this application, the dBm @600Ω scale on voltmeters can be read as if were calibrated in dBu.)

Connectors: XLR-type.

Audio Output

Impedance: 30Ω, electronically balanced and floating to simulate true transformer output. Minimum load impedance is 600Ω. Output can be unbalanced by grounding one output terminal. Output transformer option available (specify OPT-26).

Level: Front-panel controls permit use with −10dBm to +8dBm systems. Output clipping level is >+20dBm @600Ω.

Connectors: XLR-type.

Physical

Pushbuttons: Momentary.

Meter: 10-segment LED bargraph display shows limiting, 0 to 15dB.

Indicators: Two LEDs light to show operation of gating and high-frequency limiting.

Dimensions: 19" (48.3 cm) wide, 11.25" (28.6 cm) deep, 3½" (8.9 cm) high.

Operating Temperature Range: 32-113°F (0-45°C)

Humidity: 0-90% RH (non-condensing)

Power Requirements: 115/230 volts AC ±10%, 50-60Hz, 16VA (9VA for 4000A1). IEC mains connector with detachable three-wire power cord and plug supplied. EMI-suppressed.

Protection: Leakage to chassis <0.5mA at 115V, <0.7mA at 230V. AC power input is RFI-suppressed.

Fuse: ½-amp 3AG Slow-Blow for 115V operation; ¼-amp (250mA) 5x20mm "T" type for 230V operation.

Options

Security Cover (acrylic): To prevent unauthorized adjustment of controls.
Order SC2 CLEAR for a clear cover, SC2 BLUE for a transparent blue cover, or SC2 WHITE for an opaque white cover.

Audio Processing Circuitry

Dual-Band Limiter

Attack Time: Approximately 2ms; program-dependent.

Release Time: Program-dependent; not user-adjustable.

Compression Ratio: >20:1 (static); program-dependent (dynamic).

Range of Limiting: 15dB.

Interchannel Tracking: ±0.5dB (dual-channel 4000 strapped for coupled operation).

Total Harmonic Distortion (TEST mode): <0.035%, 20-15,000Hz.
Measured at level equivalent to 90% peak modulation.

SMPTE Intermodulation Distortion: <0.075%
Measured at level equivalent to 90% peak modulation.

Limiting Element: Class-A VCA.

High-frequency Limiter

Pre-emphasis: Five pre-emphasis curves: 25µs, 50µs, 75µs, 150µs, and CCITT J.17. Can be strapped for flat or pre-emphasized output.

Response: The high-frequency limiting threshold and attack time have been set so that no audible distortion is produced with dynamic program material that has been processed by the leveler/compressor and peak clipper. Because these settings have taken into account the peak-to-average ratio of the leveler/compressor's output, it is not possible to specify the high-frequency limiter's response to test tones with simple, meaningful numbers.

Total Harmonic Distortion: The high-frequency limiter/clipper will add no more than 0.02% THD to sine wave test tones that have been processed by the leveler/compressor.

Release Time: Approximately 30ms, program-dependent.

Interchannel Coupling: Each channel's high-frequency limiter operates independently at all times (the use of fast release times precludes disturbances of the stereo image's stability).

Limiting Element: Junction FET.

HF Limiting Curve: Shelving, 6dB/octave.

"Smart Clipper"

Distortion: Below its clipping threshold, the "Smart Clipper" will add no more than 0.025% THD to sine wave test tones that have been processed by the previous circuitry. Above threshold the circuitry cancels clipping-induced intermodulation distortion in a complex, frequency-dependent manner to maximize psychoacoustic masking of such distortion, minimizing its perceptibility.

FCS Overshoot Compensator

Distortion: Below its clipping threshold, the FCS Overshoot Compensator will add no more than 0.01% THD to sine wave test tones that have been processed by the previous circuitry. Above threshold the circuitry performs "band-limited clipping" to remove overshoot without introducing out-of-band distortion power above 15kHz.

Warranty

One Year, Parts and Labor: Subject to the limitations set forth in Orban's Standard Warranty Agreement.

Specifications subject to change without notice.

Circuit Description

On the following pages, a detailed description of each circuit's function is accompanied by a component-by-component description of that circuit. **Keywords are highlighted** throughout the circuit descriptions to help you quickly locate the information you need.

The circuitry is described in thirteen major blocks: input buffer, J.17 pre-emphasis, dual-band limiter, dual-band limiter control circuit, gating detector, LIMITING metering, high-frequency limiter, "Smart Clipper," VCA (voltage-controlled amplifier), Frequency-Contoured Sidechain Overshoot Corrector, balanced floating output amplifier, control logic, and power supply.

This description applies to the single-channel 4000A1. The two channels of the 4000 are identical, so this description applies exactly if the "channel B" reference designators are substituted for the "channel A" reference designators.

The **block diagram** on page 6-33 illustrates the following overview of 4000 circuitry.

The signal, which enters the 4000 in a balanced form, receives moderate **RF suppression**, then is applied to a very low-noise differential amplifier made up of three opamps in the classic "instrumentation amplifier" configuration. This circuit functions as an "**active transformer**."

The signal then is applied to the low-frequency section of the J.17 pre-emphasis. This circuit is bypassed when J.17 pre-emphasis is not used.

The **dual-band limiter** divides the audio into two bands (above and below 150Hz) with a phase-linear crossover whose outputs sum to the crossover's original input signal. The "master" band (above 150Hz) usually controls the gain of both the "master" and "bass" bands, which track to preserve frequency balances. However when strong bass appears, the "bass" band compressor increases its limiting to prevent the bass from overdriving the following peak limiting circuitry.

Each of the two band-compressors is a feedback circuit: the output of the compressor is looped back to develop a **gain-control signal** that is applied to its VCA. This arrangement results in superior stability of characteristics with time and temperature, extremely low distortion, and optimized control-loop dynamic response.

The proprietary dual-band limiter **timing module** generates a control signal that enables the 4000 to achieve natural-sounding control and very low modulation distortion. All dynamic parameters are determined by the timing module on the basis of the past history of the input. They were very carefully "tuned" to minimize audible compression-induced artifacts.

The voltage-controlled gain blocks used in the 4000's **dual-band limiter** are class-A **voltage-controlled amplifiers** (VCAs). They have a "decilinear" response: their gain is proportional to the exponential of the voltage applied to their gain-control port. Any "**thumps**" due to control current feedthrough are eliminated by applying DC offset to the VCA's input.

A **gating detector** monitors the level of the 4000's input signal and activates the gate if this level drops below a factory-set threshold.

The **LIMITING meter** consists of ten comparators arranged to produce a meter with a 0 to 15dB linear scale.

High-frequency limiting is effected by applying the output of the dual-band limiter to a bandpass filter. When summed with its input, the output of this filter provides a 6dB/octave **pre-emphasis** up to 15kHz (or to about 5kHz with J.17 pre-emphasis). The +3dB breakpoint frequency for the pre-emphasis is determined by the amount of bandpass output that is summed with the input signal — the greater the contribution from the bandpass output, the lower the breakpoint frequency.

The contribution from the bandpass output is determined by the settings of jumpers that determine the pre-emphasis, and by circuitry that can dynamically reduce the pre-emphasis to effect the high-frequency limiting function.

The output of the high-frequency limiter is applied to the "**Smart Clipper**," which controls peak levels while canceling difference-frequency intermodulation distortion. It operates in two frequency bands (above and below 2kHz). The signal is clipped and then applied to the top band, which eliminates distortion below 2kHz. The un-clipped signal is applied to an 2kHz low-pass filter and then to a VCA. The difference between the clipper's input and its output is rectified, low-pass filtered, and used to control the gain of the VCA. This smoothed control signal limits low-frequency peaks effectively while introducing less distortion than would a control signal that were not smoothed.

The distortion cancelation in the "Smart Clipper" adds some overshoots to its output. Its integral **15kHz low-pass filter**, which is used as a delay line as well as a means for spectrum control, also adds overshoots. These are eliminated in the **FCS Overshoot Corrector**. This circuit operates as a "band-limited clipper" — it clips off peaks exceeding 100% modulation but does not introduce out-of-band power above 15kHz as would a simple clipper. If the subsequent **de-emphasis** has been jumpered out, the absolute peak ceiling at the 4000's output will be independent of frequency; if de-emphasis is applied, the peak ceiling will be frequency-dependent, following the de-emphasis curve selected by jumper JB.

The output of the de-emphasis circuit is applied to the **OUTPUT LEVEL control**, and then to the **balanced output amplifier**. This amplifier uses two opamps in a complex cross-coupled arrangement with positive and negative feedback to simulate an **active transformer**. A **servo amplifier** ensures that the quiescent DC level at the output of the amplifier will be centered at ground.

Unregulated voltage is supplied by two pairs of full wave diode rectifiers. **Regulated voltages** are supplied by a pair of overrated 500mA "three-terminal" IC regulators. Several pairs of opamps provide bias and reference voltages for various parts of the circuitry.

1. Input Buffer

Located On Main Circuit Board

The audio is applied to an RFI suppression network and to an attenuation pad (which can be strapped for 0 or 20dB attenuation). The RFI-suppressed audio is then applied to a low-noise true instrumentation amplifier with symmetrical, high-impedance (+) and (–) inputs. The gain of this amplifier can be adjusted from 0.88 to approximately 47 (a 34.5dB range). If this range does not yield the desired amount of limiting, the Input Attenuation pads should be re-strapped.

Because the input is DC-coupled, only small amounts of differential DC should be applied to the input. Since the input would typically be fed by the output of a transformer or capacitively-coupled amplifier, this should not be a problem.

Component-level description:

The input is RF-filtered, then applied to 10K bridging pad R100, R103. Strapping R101 and R102 into the pad introduces 20dB attenuation (The 4000 is shipped with R101 and R102 strapped in).

The output of the pad is connected to low-noise true instrumentation amplifier IC2-A, IC1-A, IC1-B, and associated resistors. R104, R105 provide bias current for IC1-A, IC2-A, which are low-noise bipolar-input dual IC opamps. R106-A, R106-B are feedback resistors for IC1-A, IC2-A. The differential gain is controlled by the series resistance of R107 and the INPUT ATTENuator control R1. The common-mode gain of the IC1 pair is 1.

The differential output of IC1-A and IC2-A is converted to a single-ended output; the common mode component of the output is nulled by differential amplifier IC1, IC2-A and associated resistors.

Nearby lightning strikes may induce energy into the 4000's audio input that is sufficient to pass through the RFI protective networks and destroy IC1 and IC2. If the 4000 is installed in a lightning-prone location, keep spare NE5532 chips in stock. Installation of varistors between each side of the audio input lead and earth may help prevent such problems.

Ceramic RFI-suppression capacitors shunt RF from the input leads to the chassis. Since these capacitors are not effective at VHF and higher frequencies, ferrite beads have been placed around the input and output leads to suppress such high-frequency RF. Although this RF suppression is modest, it should be adequate for the vast majority of installations.

2. J.17 Pre-Emphasis Network (part 1)

Located On Main Circuit Board

The output of the input buffer amplifier is applied to a circuit that generates the part of the J.17 pre-emphasis extending from approximately 100Hz to 1.3kHz. This is a rising shelf whose low-frequency gain is 0dB, and whose high-frequency gain is +9.4dB.

Component-level description:

The shelf is generated by non-inverting amplifier IC2-B and associated components. C19 shunts the feedback at high frequencies, permitting the gain of the amplifier to rise as frequency increases.

3. Dual-Band Limiter

Located On Main Circuit Board

The **dual-band limiter**[1] divides the audio band into two bands (above and below 150Hz) with a phase-linear crossover whose outputs sum to the crossover's original input signal. The major part of the dual-band limiter is the "master" channel (above 150Hz). This is a feedback limiter. Its gain-control voltage is summed in a dB-linear manner with the control voltage developed by the "bass" limiter to control the gain of the "bass" VCA, which passes frequencies below 150Hz.

When the bass content of the program is moderate, the control voltage summation forces the "bass" limiter to limit as much as the "master" limiter, and the system operates essentially as a wideband limiter, preserving frequency balances. However, when the bass content of the program is heavy, sufficient bass appears at the output of the "bass" limiter to activate the "bass" control loop, causing the "bass" channel to limit more than the "master" channel. This prevents overdriving later peak-limiting stages in the 4000, while also preventing the bass from causing unnatural-sounding gain reduction in the frequencies above 150Hz. Such unnatural-sounding gain reduction would occur if the limiter were *truly* wideband, because the bass would then force excess limiting in the *entire* audio frequency range instead of being momentarily rolled-off by the "bass" limiter.

Because the attack time of the "bass" control loop is relatively slow, transients can still pass through the "bass" limiter without limiting. To prevent these transients from inter-modulating with the material in the "master" band, the output of the "bass" band is limited with a clipper.

The dual-band limiter's crossover is a 12dB/octave phase-linear crossover whose outputs sum to the original input of the crossover without phase or amplitude error. The crossover is "distributed": part of it is placed prior to the VCAs in the dual-band limiter, and part of it is placed after the VCAs and bass clipper. The crossover thus rolls off any harmonic distortion introduced by the bass clipper.

[1] U.S. Patent #4,249,042

Component-level description:

IC3-A and associated components form a 150Hz 6dB/octave high-pass filter, which is the first part of the "master" crossover. The "master" crossover is completed with shelving filter R118, R119, R120, C4.

This shelving filter feeds IC4-C, an integrated VCA with a virtual-ground input and current-mode output. Its voltage gain is proportional to the exponential of the voltage appearing at pin 5, and to the negative exponential of the voltage appearing at pin 7. Thus the VCA's gain in dB is proportional to the control voltage appearing at pin 7 subtracted from the control voltage appearing at pin 5. The current-mode output of IC4-C is converted to a voltage in IC5-A. This is the output of the "master" limiter.

The output of high-pass filter IC3-A is subtracted from its input with R116 and R117. This produces a complementary low-pass filter, whose output is applied to bass VCA IC4-D. The current-mode output of IC4-D is converted to a voltage in IC5-B. This output of the "bass" limiter is applied to clipper CR19, CR20. R136, R137, C15 are a low-pass filter that complete the "distributed crossover."

The outputs of the "master" and "bass" bands are summed in IC3-B and applied to the high-frequency limiter.

R121, C16 are frequency compensation components to prevent VCA IC4-C from oscillating. R172, C17 perform the same function for IC4-D.

4. Dual-band Limiter Control

Located On Main Circuit Board

Both limiters in the **dual-band limiter** are feedback circuits: the gain-controlled output of a given limiter is used to develop a **gain-control signal** that is applied to the gain-control port of its VCA. This arrangement results in superior stability of characteristics with time and temperature, extremely low distortion, and optimized control-loop dynamic response.

The output of a given VCA is applied to two comparators. One detects signals that exceed a positive reference set by the **clipping voltage reference**, and the other detects signals that exceed the negative reference.

The comparators feed the dual-band limiter **timing module**, which contains proprietary circuitry that outputs a control voltage with dynamics that achieve natural-sounding control and low modulation distortion. The output of the module can be wired in a logical "OR" circuit with other such modules to effect stereo tracking of an arbitrary number of channels.

Component-level description:

The output of IC5-A in the "master" VCA is applied to two comparators in IC7. The outputs of these comparators are "OR'ed" together, and go negative whenever the output of IC5-A exceeds the positive or negative CLIP voltage. These negative-going signals are applied to the **timing module**, which develops a gain control voltage that depends on the past history of the program material. This voltage represents the gain of the VCA in dB.

The output of "bass" VCA at IC5-B is processed similarly.

The CLIP voltages are generated by IC6 (and associated components). The CLIPPING trim control R167 sets the clip voltages and thus the threshold of limiting. In turn, this determines the drive level to the following high-frequency limiter and peak-limiting circuitry and thus the amount of limiting and clipping that these circuits will execute.

The timing module has "master" and "bass" outputs. The "master" output is buffered by IC16-B; the "bass" output is buffered by IC16-A.

These buffers contain diodes CR11 and CR12 within their feedback loops. These diodes force the outputs of the buffers to be low-impedance *unidirectional* voltage sources, negative-going with increasing gain reduction, with a scale factor of approximately 0.93V/dB. 0V corresponds to 0dB gain reduction. Approximately –14V corresponds to the maximum available gain reduction (15dB).

These buffer amplifiers can be OR'ed together for stereo tracking, such that the output is the *lowest* voltage produced by any buffer. Thus all channels produce the same amount of limiting as the channel requiring the most limiting.

The "master" control voltage drives the "master" VCA IC4-C through voltage divider R148, R149. The "master" control voltage is also summed with the "bass" control voltage in R146 and R147. This sum drives the gain control port of the "bass" VCA IC4-D.

5. Gating Detector

Located On Main Circuit Board

A **gating detector** monitors the level of the 4000's input signal, and activates the gate if this level drops below a factory-set threshold. When on, the gate slows the release time by a factor of about 50x. For most program material with relatively short pauses or low-level passages, the limiter's gain appears to "freeze." However, the gain is still recovering very slowly toward maximum so the limiter cannot get "stuck" at abnormally low gain if a low-level passage lasts for many minutes.

Component-level description:

The gating detector uses a level detector built into IC4-B. The input signal to the dual-band limiter is applied to high-pass filter R138, C20. The –3dB frequency of this filter is approximately 340Hz.

The output of this filter is applied to the input of IC4-B's internal rectifier. This input (pin 15 of IC4) is an "AC virtual ground" — its DC quiescent voltage is approximately +1.8VDC, but it has a very low AC input impedance and little or no AC signal can be detected at this pin when the rectifier is working correctly.

The peak output of the rectifier appears at pin 13 of IC4 in dB-linear form. It is smoothed by C22. The release time of the detector is determined by R139.

IC7 is used as a comparator to determine when the gate should turn on or off. R140 and R141 bias the (–) input of the comparator to determine its threshold. This threshold can be lowered by applying –15V to CR10 such that the gate is OFF for all input signals.

Under OPERATE conditions and in absence of signal, pins 9 and 11 of IC7 are pulled negative and the gate is ON (i.e., the gain of the dual-band limiter is frozen). If the level at the input to the dual-band limiter exceeds about –23dBu, the output of the comparator goes positive. This turns the gate OFF and permits the normal limiter release process to occur. The release is switched on and off by circuitry inside the timing module, and is triggered by the signal on pin 14 of IC7-C. This is positive when the gate is OFF and negative otherwise. IC8D is used as an inverter to apply positive feedback to the gate circuit. This provides hysteresis to prevent the gain from "chattering."

6. Limiting Meter

Located On Display Circuit Board

The "master" band **LIMITING meter** consists of ten comparators with current regulators at their outputs. The comparators are arranged to produce a meter with a dB-linear scale. The ten LEDs in the bargraph are connected in series.

Component-level description:

The "master" control voltage, which is dB-linear and negative-going, is inverted and attenuated by IC2-A (on the display board) such that +3V = 15dB gain reduction. The attenuated voltage is mixed with a 50 or 60Hz "dither" signal through C2, R6 (connected to the power transformer secondary), and then applied to the input of LM3914 **bargraph driver** IC1.

The LM3914 bargraph consists of ten comparators with current regulators at their outputs. The comparators are arranged to produce a meter with a linear scale. The LM3914 applies current to the appropriate node to light the desired LEDs.

Q6 is used as a zener diode to reduce the supply voltage to the LM3914 so that it is within the chip's 25V maximum rating. R7 sets the current through the LED bargraph.

The LM3914 has an internal string of series resistors that provide reference voltages for its ten comparators. The bottom of this string is grounded at pin 4; the top of the string is provided with +3.00VDC from pin IC23A of on the main board.

C1 bypasses the LM3914 power supply to prevent the LM3914 from oscillating.

7. High-Frequency Limiter

Located On Main Circuit Board

The output of the dual-band limiter is applied to **a bandpass filter** with a peak frequency of 36.4kHz, a "Q" of 0.77, and a peak gain of 0dB. When summed with its input, the output of this filter provides a 6dB/octave **pre-emphasis** up to 20kHz. The +3dB breakpoint frequency for the pre-emphasis is determined by the amount of bandpass output that is summed with the input signal — the greater the contribution from the bandpass output, the lower the breakpoint frequency.

The contribution from the bandpass output is determined by jumper JA and by circuitry that can dynamically reduce the pre-emphasis to effect the high-frequency limiting function.

Note that **swept sine wave tests** of the high-frequency limiter will not yield the exact inverse of the pre-emphasis curves. This is because a high-pass filter causes the comparators to see a signal which is slightly different from the signal at the high-frequency limiter output, and because the **threshold of high-frequency limiting** is set above the steady-state output level of the dual-band limiter. The threshold is set this way to keep the high-frequency limiter from being activated by peak overshoots resulting from the moderate attack time of the dual-band limiter when operating on program material.

The output of the high-frequency limiter is applied to a **peak-limiting system** consisting of the "**Smart Clipper**" and **FCS Overshoot Corrector**, both of which are described below. These circuits provide absolute peak control at the 4000's output.

If the subsequent **de-emphasis** has been jumpered out by jumper JD, the absolute peak ceiling at the 4000's output will be independent of frequency; if de-emphasis is applied, the peak ceiling will be frequency-dependent, falling at 6dB/octave beyond the break frequency determined by the setting of jumper JB (or following the standard J.17 de-emphasis if J.17 is selected). The high-frequency limiter is flat ±0.1dB to 15kHz, and falls at 12dB/octave thereafter when de-emphasis is applied.

Component-level description:

The bandpass filter consists of IC39-A and associated circuitry. Bandpass response can be measured at pin 1 of IC39-A.

The contribution from the bandpass output is determined by the gain of a voltage divider, the gain of which is adjusted with jumper JA. The contribution of the bandpass filter to the output is further determined by the resistance of JFET Q101, which can dynamically reduce the pre-emphasis to effect the high-frequency limiting function.

The loss in the voltage divider is compensated for by IC38, which has a gain of 28.5dB. The output of IC38 (representing the band-passed signal) is summed with the input signal in IC39-B to create the pre-emphasized signal.

The +3dB break-points that correspond to the time constant calibrations for the HF LIMIT PRE-EMPHASIS switch are: 1.06kHz for 150µs, 2.12kHz for 75µs, 3.18kHz for 50µs, and 6.37kHz for 25µs. The J.17 pre-emphasis is more complex, and has break-points at 477Hz and 4134Hz.

The positive and negative peak levels of the pre-emphasized signal are evaluated by two comparators in IC41. If either exceeds the 6.08V threshold voltages established by R229-R231 (and inverter IC40-B), the appropriate comparator fires. Each comparator has an open collector NPN output stage and charges the high-frequency limiter smoothing circuit negative through attack time resistor R225. The smoothing circuit consists of CR40-CR43, C81, C91, and R224.

C86, R228 form the 6dB/octave high-pass filter that prevents the high-frequency limiter from being activated on low-frequency program material.

In the absence of high-frequency gain reduction, the output of the smoothing circuit (at the anode of CR42) is biased at a positive voltage determined by FET BIAS trimmer R223. This pinches-off Q101.

When high-frequency gain reduction occurs, the voltage at the anode of CR42 goes more negative than the quiescent voltage, turning on Q101 and resulting in less and less pre-emphasis. Pre-emphasis is dynamically decreased until comparator IC41 no longer fires, indicating that the high-frequency overload has been removed.

IC32-B drives the HF LIMIT LED. The FET control voltage is applied to IC32-B's pin 6; the quiescent FET bias is applied to pin 5. In addition, IC32-B's pin 5 is offset by current flowing through R221, which forces IC32-B's pin 5 to be more negative than its pin 6, and causes pin 7 of IC32-B to go low (close to ground). When the voltage on pin 6 becomes more negative than pin 5 due to high-frequency gain reduction, pin 7 goes high, lighting HF LIMITER LED CR8. CR8 is OFF when IC32-B's pin 7 is close to ground.

8. "Smart Clipper"

Located On Main Circuit Board

The "Smart Clipper"[2] is a peak-limiting circuit that operates in two frequency bands. Its input signal is clipped, and the output of the clipper is applied to a 2-15kHz band-pass filter created by subtracting the output of a 2kHz low-pass filter from the output of a 15kHz low-pass filter that is phase- and amplitude-matched to the 2kHz low-pass filter. This band-pass filter removes both difference-frequency intermodulation distortion caused by the clipper and program material below 2kHz.

[2] U.S. Patent #4,208,548, U.K. Patent #2,001,495

Program material below 2kHz is handled by a second circuit path. The input signal to the clipper is applied to a second 2kHz low-pass filter identical to the first 2kHz low-pass filter. The output of the second 2kHz low-pass filter is applied to a VCA, and the output of the VCA *is* added to the output of the 2-15kHz band-pass filter. (The VCA circuit is described on page 6-17.)

The gain of the VCA is controlled by a circuit that subtracts the output of the clipper from its input, rectifies this difference signal, adds a DC level to it, and then smooths this signal with a low-pass filter whose delay is equal to that of the 2kHz low-pass filters. The gain of the VCA is inversely proportional to this signal: clipped peaks will cause gain reduction in the VCA.

If the control-signal low-pass filter were not present, this would be equivalent to clipping the program material below 2kHz identically to the program material above 2kHz. Being of opposite polarity, the output signals from the two 2kHz low-pass filters would cancel completely, and the output of the entire "Smart Clipper" circuit would simply be equivalent to a clipper followed by a 15kHz low-pass filter.

However, the control-signal low-pass filter smooths the control signal to the VCA that processes the program material below 2kHz, and the output signals from the two 2kHz low-pass filters no longer cancel completely. The addition of the control-signal low-pass filter thus reduces distortion. Because the audio signal applied to the 2kHz VCA has been low-pass filtered, it is relatively "slow," and smoothing the control voltage to the VCA therefore does not cause consequential overshoot. The overshoot that is added can be considered to be a "distortion-canceling signal" that adds a slight amount of peak uncertainty to the output of the "Smart Clipper" in order to significantly reduce distortion by comparison to a simple clipper.

Component-level description:

The signal enters and is clipped by CR45, CR46. It is then applied to a chain of three allpass phase correctors: IC29, IC30, IC31 and associated components. Each of these circuits has a flat amplitude response but a phase response that changes with frequency. Together, these three circuits add delay as necessary to make the total group delay of the phase correctors plus the following 15kHz low-pass filter as constant as possible.

The 15kHz low-pass filter is an active-RC analog of a passive LC ladder filter. It is realized by resistors, capacitors, and frequency-dependent negative resistors (FDNRs). An FDNR is realized with a dual opamp, three resistors, and two capacitors. When the passive LC filter is transformed into an active RC filter, inductors become resistors, resistors become capacitors, and capacitors become FDNRs.

Each FDNR resonates with a series resistor to create a notch in the frequency response of the filter. This is analogous to a series LC circuit to ground. The notches are located in the "stopband" (beyond approximately 18.77kHz). The circuit associated with IC13 produces a notch at 35.28kHz ±4%. The circuit associated with IC14 produces a notch at 19.04kHz ±4%. The circuit associated with IC15 produces a notch at 21.90kHz ±4%.

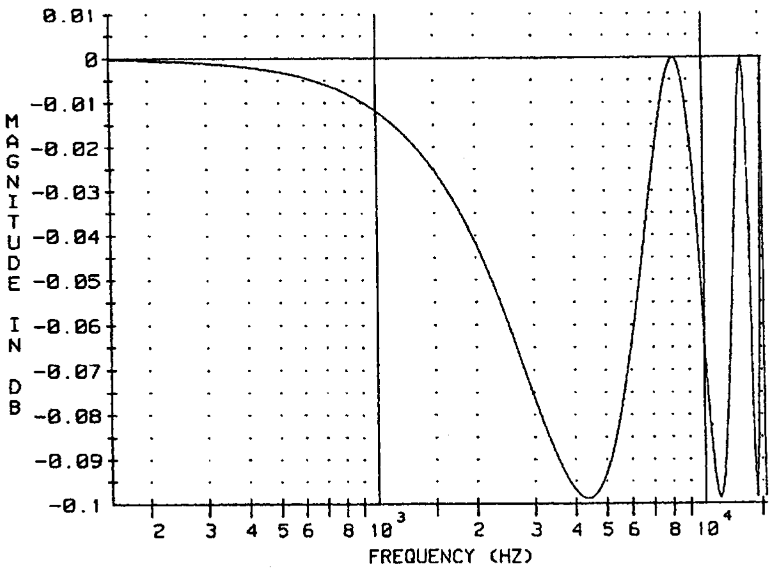


Figure 6-1: 15kHz Low-Pass Filter Response in Passband

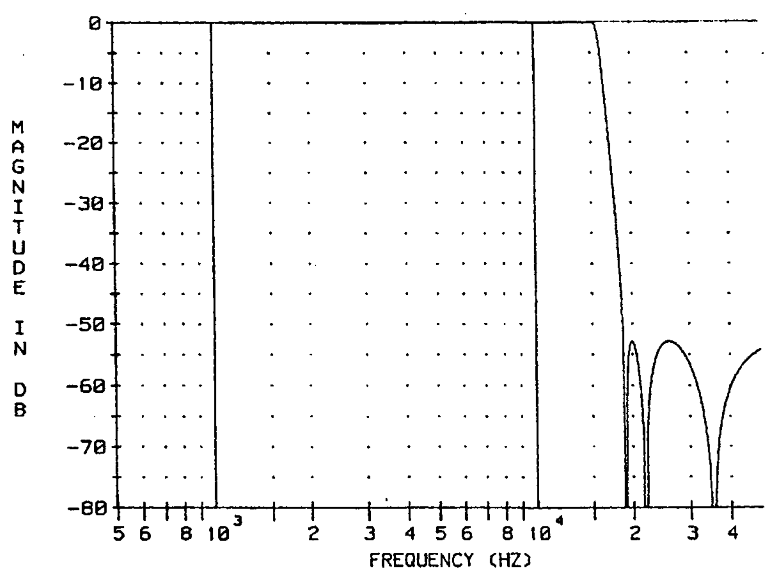


Figure 6-2: 15kHz Low-Pass Filter Response
Passband and Stopband

To avoid possible clipping, the signal is attenuated 2dB with voltage divider R252, R253 before being applied to the filter. This gain is made up by IC11-A to restore unity gain at low frequencies. IC11-A is also a summing amplifier for the two sidechains each containing a 2kHz low-pass filter. IC12-A is a servo amplifier that eliminates any DC offset at IC11-A's output.

The output of clipper CR45, CR46 is also applied to a 2kHz low-pass filter consisting of IC9 and associated components. This filter is phase- and amplitude-matched to the 15kHz low-pass filter from 0 to 2kHz. Its output is subtracted from the output of the 15kHz low-pass filter in IC11-A to yield a 2-15kHz band-pass function. Fig. 6-3 shows its normal frequency response.

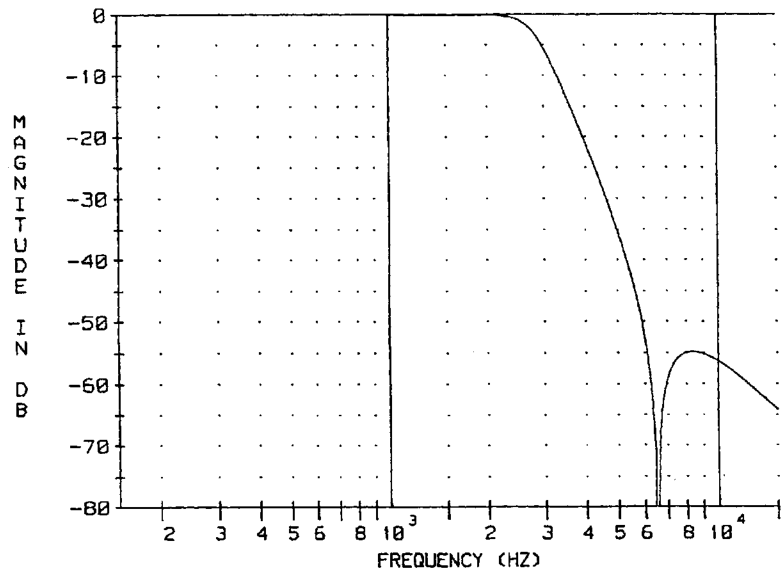


Figure 6-3: 2kHz Low-Pass Filter Response Passband and Stopband

If the frequency response of any filter is abnormal, first replace any opamps associated with the filter. If this does not cure the problem, suspect passive component failure. Capacitors are more likely to fail than resistors. Components interact, so it is almost impossible to identify which passive component has failed by examining the overall response of the filter. Instead, it is usually necessary to test the passive components on an impedance bridge, one at a time.

IC28 and associated components subtract the output of clipper CR45, CR46 from its input and full-wave rectify the difference signal, which appears at pin 3 of IC27-A. This signal appears as a series of positive-going "spikes" representing the signal that was removed by the clipper. IC27-A amplifies this signal by 19.3dB and applies it to control-voltage low-pass filter IC27-B and associated components. This low-pass filter has a relatively gentle roll-off. Its time delay is equal to the delay of the IC9 2kHz filter.

The output of low-pass filter IC27-B is applied to pin 6 of IC25-B. This pin is the divider control port of the "Smart Clipper" VCA (IC25 and associated components — see the detailed description below). The gain of the VCA is inversely proportional to the current flowing into this pin. This pin normally sits at about –13.5VDC, while the output of low-pass filter IC27-B is centered about 0VDC. Therefore a constant bias current flows into pin 6 of IC25-B through R304. This bias current determines the quiescent gain of the VCA when CR45 and CR46 are not clipping.

The audio to the VCA is supplied by 2kHz low-pass filter IC26 and associated components. This filter, which is identical to the IC9 filter, is fed by the unclipped signal occurring prior to CR45 and CR46. When no clipping occurs, the signals through the IC9 and IC26 filters are identical but out-of-polarity and therefore cancel upon summation in IC11-A. The remaining signal at the output of IC11-A is therefore the output of the 15kHz low-pass filter.

When CR45 and CR46 clip, pin 7 of IC27-B goes positive, causing the control current into the VCA to increase and its gain to decrease proportionally, causing a distortion-reduced "clipping" function to be applied to the output signal from the IC26 2kHz low-pass filter. When clipping occurs, the signals through the two 2kHz low-pass filters are thus no longer identical, no longer cancel, and peak control occurs as described earlier in the overview to this section.

9. Voltage-Controlled Amplifier in "Smart Clipper"

Located On Main Circuit Board

The current-controlled gain block used in the "Smart Clipper" is a proprietary class-A **voltage-controlled amplifier** (VCA). It operates as a two-quadrant analog divider with gain *inversely* proportional to a current injected into a first gain-control port, and is cascaded with a two-quadrant analog multiplier with gain *directly* proportional to a current injected into a second gain-control port. For most gains, levels, and frequencies, total harmonic distortion (THD) is well under 0.1%. Overload-to-noise ratio (noise measured in a 20-20,000Hz band) is typically 90dB, and is constant with respect to gain and level.

A specially-graded CA3280 Dual Operational Transconductance Amplifier ("OTA") contains two matched, non-linear gain-control blocks with differential inputs and current outputs. Used alone, one such gain-control block would introduce considerable distortion. Therefore, the first of the two matched blocks is used as the feedback element for a separate opamp, and the second is driven by the pre-distorted output of that opamp. The gain of the VCA is therefore *inversely* proportional to the gain of the non-linear gain-control blocks. This enables the VCA to function as a two-quadrant analog *divider*.

If the VCA is not perfectly balanced, **"thumps"** due to **control current** feedthrough can appear at the output. These are eliminated by applying DC offset to the VCA's input.

The basic current-controlled gain in the dual-band limiter is inversely proportional to the control current generated by the "Smart Clipper" control circuitry.

Component-level description:

The first gain-control port is pin 6 of IC25-B; the second gain-control port is pin 3 of IC25-A.

IC25 is the specially-graded Orban IC containing two matched non-linear gain-control blocks with differential inputs and current outputs. The forward-path opamp in the VCA is IC24.

The output of IC24 is first attenuated by R305, R306, C76, and then applied to the input of the feedback element IC25-B at pin 9. The output of IC24 is pre-distorted as necessary to force the current *output* of IC25-B to precisely and linearly cancel the audio input into the "virtual ground" summing junction of IC24. This same pre-distorted voltage is also connected to the input of IC25-A at pin 15. Thus the output of IC25-A at pin 13 is an undistorted current. This current is converted to a voltage in IC11-A. which is also the summing amplifier for the "Smart Clipper" filters.

The VCA behaves like a two-quadrant analog *divider* when the control current from IC27-B is applied to the control port (pin 6) of IC25-B. The gain-control current injected into this control port is developed by the "Smart Clipper" control circuitry.

The gain of IC25-A is fixed by the current through R310.

Second-harmonic distortion is introduced by differential offsets in either section of IC25. This distortion is canceled by applying a nulling voltage directly to the input of IC25-A by means of resistor network R307, R308, and L DIST NULL trimmer R309.

The control-voltage feedthrough, which can occur if the VCA is not perfectly balanced, are equivalent to multiplying the control current by DC. An adjustable DC offset is applied to the VCA input provided by R300 and L FEEDTHROUGH trimmer R301 for nulling this equivalent DC multiplication to zero.

R87 and R92 further balance cancellation to prevent audio modulation of the control current for IC25-B.

C64, C74, R302, R303 provide frequency-compensation to prevent the VCA from oscillating supersonically.

10. Frequency-Contoured Sidechain Overshoot Corrector

Located On Main Circuit Board

This circuit[3] acts as a "band-limited safety clipper." It subtracts the output of a clipper from its input. If this differential signal were then subtracted from the clipper's input, it would be equivalent to clipping the signal and would eliminate overshoot. However, this would add out-of-band power that would destroy the 4000's excellent spectral control. Therefore, the differential signal is low-pass filtered prior to subtraction. The low-pass filter has a rising response towards 15kHz, and its frequency response falls quickly thereafter. The filter's rising gain for frequencies immediately below 15kHz helps compensate for the removal of the clipper-induced frequencies above 15kHz that would otherwise be required to fully control the peaks.

[3] U.S. Patent #4,460,871

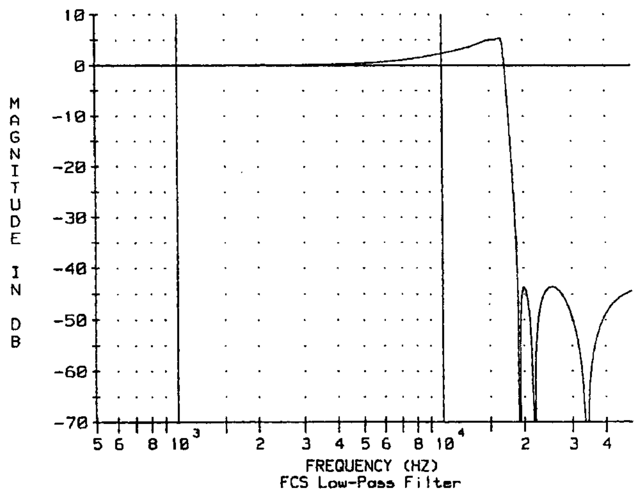


Figure 6-4: Response of FCS Sidechain Low-Pass Filter in the Passband and Stopband

Component-level description:

The output of the "Smart Clipper" (containing some overshoots) is applied to clipper CR30, CR31. IC11-B subtracts the output of this clipper from its input. This differential signal is applied to the 16.6kHz sidechain filter consisting of IC20, IC21, IC22 and associated components. This is an FDNR-based low-pass filter like the 15kHz filter in the "Smart Clipper" (see page 6-13). Fig. 6-4 shows its frequency response. The circuit associated with IC20 produces a notch at 19.22kHz ±4%. The circuit associated with IC21 produces a notch at 21.67kHz ±4%. The circuit associated with IC22 produces a notch at 33.76kHz ±4%.

IC17-A buffers the filter and makes up gain lost in voltage divider R99, R409. IC17-A is also the summing amplifier for servo amplifier IC12-B and associated components. This servo minimizes DC offset at the 4000's output.

The output of the "Smart Clipper" is also applied to IC10 and associated components. This is an allpass delay element. Its amplitude response is flat, but its group delay varies with frequency. Its group delay plus the group delay produced by allpass phase shifter IC17-B and associated components closely matches the group delay of the 16.67kHz FCS sidechain low-pass filter, whose output is subtracted from the delayed signal in IC17-B to cancel overshoots.

The group delay of the FCS sidechain filter (and thus, the group delay of its matching delay network) is not constant with frequency. Allpass phase shifters IC18 and IC19 apply group delay correction to the FCS sidechain filter to make the group delay of the entire FCS circuit constant with frequency to ensure that peak levels are correctly controlled.

The output of the FCS circuit is applied to a de-emphasis circuit consisting of C82 and associated resistors. Various de-emphasis characteristics can be selected by jumper JB. De-emphasis can be defeated by lifting C416's ground with jumper JD. IC33-A buffers the de-emphasis circuit and drives the OUTPUT LEVEL control. This control is buffered by IC33-B, which drives the balanced floating output amplifier circuit.

11. Balanced Floating Output Amplifier

Located On Main Circuit Board

The **balanced output amplifier** converts the unbalanced single-ended signal to a balanced, floating output. Output impedance is 30Ω, ±5%.

Simpler "electronically-balanced to ground" output stages can cause problems because grounding one side of their output to unbalance them will short an output amplifier to ground. In contrast, the 4000 output stage is balanced and *floating*, so it simulates a **true transformer output**. Because the output is floating, either side can be grounded to obtain an unbalanced output. When either side is grounded, the overall output level changes very little (less than 0.5dB), and no ill effects occur. The output of the 4000 can be freely connected to a **patch bay** without concern that problems may occur if one side of the output is grounded.

Component-level description:

IC35 is a low-offset servo amplifier that centers the average DC level at the (+) and (–) outputs of the module around ground. The floating characteristic is achieved by complex cross-coupled positive and negative feedback between the two sections of IC34, and its operation is not readily explainable except by a detailed mathematical analysis. Opamps may be replaced; resistors are specially matched and should not be replaced (see page 5-2).

12. Control Logic

Located On Main Circuit Board and Display Board

The **control logic** interfaces the front-panel buttons and the remote control terminals to the analog circuitry. Three R/S latches remember the BYPASS, TEST and TONE states. If the logic is in none of these states, it is, by definition, in the OPERATE state.

The **remote control** terminals are interfaced to the logic through opto-isolators to break potential ground loops and to provide RFI suppression.

The front-panel **indicator lamps** are arranged in a special "tree" arrangement that reduces current consumption, as current is shared with as many lamps as practical. The same current that drives the TONE, TEST and OPERATE LEDs also drives the bypass relay.

Component-level description:

CMOS NAND gates IC42-A and IC42-B are cross-coupled to form an R/S latch that remembers the BYPASS state. The logic operates from –15V to ground, and uses "negative logic": –15V is TRUE and 0V is FALSE. So in BYPASS mode, pin 4 of IC42-B is at –15V.

The other two modes have identically-structured R/S latches associated with them.

The OPERATE pushbutton and remote control opto-isolator drive the OPERATE line TRUE (to –15V), forcing the BYPASS, TEST, and TONE lines FALSE through diodes CR33, CR34, CR35, and CR36. Power-up circuit CR32, C105, and R452 pulls the OPERATE line TRUE through C418 on power-up.

If the BYPASS line goes TRUE, it transmits a negative-going pulse through C97, R460 that switches the TEST and TONE latches FALSE. If the TEST line goes TRUE, it transmits a negative-going pulse through C98, R458 that switches the BYPASS latch FALSE. If the TONE line goes TRUE, it forces the TEST line TRUE through CR38.

If the BYPASS line is TRUE, it switches the BYPASS lamp CR1 on through Q1. If the $\overline{\text{BYPASS}}$ line is TRUE, it applies current to the bypass relay coil through level-shifter circuit Q4, Q5 and associated components. (The bypass relay bypasses the 4000 circuitry when its coil is *not* carrying current to ensure that a power failure will automatically connect the 4000's input directly to its output.)

When the bypass relay coil is carrying current, this current is applied to a "tree" consisting of CR2-CR5. The current through the relay thus lights at least one of these LEDs, depending on the state of the logic driving them. If the TONE mode is selected, *both* the TONE and TEST LEDs are lit, and both are driven in series from the same current. If both the TONE and TEST LEDs are OFF, current is then diverted to CR4 and CR5 (whose normal voltage drop is higher than CR2 and CR3), and the OPERATE lamp lights. If the BYPASS line is TRUE, no current is supplied to the "tree" and only the BYPASS lamp CR1 lights.

13. Power Supply

Located On Main Circuit Board

Unregulated voltage is supplied by two pairs of full-wave diode rectifiers. The nominal unregulated voltage is ±22 volts DC at rated line voltage. This will vary widely with line voltage variations. **Regulator dropout** will occur if the unregulated voltage falls below about ±17.8 volts.

Regulated voltages are supplied by a pair of overrated 500mA "three-terminal" IC regulators. Because they are operated conservatively, they are expected to be reliable.

Component-level description:

The two pairs of full-wave diode rectifiers that supply **unregulated voltage** are located in package CR2. The rectifier pairs drive energy storage capacitors C103 and C104. The power transformer T1 can be strapped for either 115-volt or 230-volt operation (the two sections of the primary are paralleled for 115-volt operation and connected in series for 230-volt operation).

The pair of ICs which supply regulated voltages are "three-terminal" IC regulators IC48, IC49. IC48 and IC49 are frequency-compensated by C101-102 at their outputs to prevent high-frequency oscillations. Small 0.1F/25V ceramic capacitors bypass the power busses to ground locally throughout the board to prevent signal-carrying ICs from oscillating due to excessive power-lead inductance.

(If replaced, C101-102 *must* be replaced by low-inductance aluminum electrolytic capacitors only — see "Power Supply Problems" on page 5-2.)

Parts List

Parts are listed by ASSEMBLY, then by TYPE, then by REFERENCE DESIGNATOR. Widely used common parts are not listed; such parts are described generally below (examine the part to determine exact value). See the following assembly drawings for locations of components.

SIGNAL DIODES, if not listed by reference designator in the following parts list, are:

Orban part number 22101-000, Fairchild (FSC) part number 1N4148, also available from many other vendors. This is a silicon, small-signal diode with ultra-fast recovery and high conductance. It may be replaced with 1N914 (BAY-61 in Europe).

(BV: 75V min. @ I_r = 5µA; I_r: 25nA max. @ V_r = 20V; V_f: 1.0V max. @ I_f = 100mA; trr: 4ns max.) See Miscellaneous list for ZENER DIODES (reference designator VRxx).

RESISTORS should only be replaced with the same style and with the *exact* value marked on the resistor body. If the value marking is not legible, consult the schematic or the factory. Performance and stability will be compromised if you do not use exact replacements. Unless listed by reference designator in the following parts list, you can verify resistors by their physical appearance:

Metal film resistors have conformally-coated bodies, and are identified by five color bands or a printed value. They are rated at ⅛ watt @ 70°C, ±1%, with a temperature coefficient of 100 PPM/°C. Orban part numbers 20038-xxx through 20045-xxx, USA Military Specification MIL-R-10509 Style RN55D. Manufactured by R-Ohm (CRB-1/4FX), TRW/IRC, Beyschlag, Dale, Corning, and Matsushita.

Carbon film resistors have conformally-coated bodies, and are identified by four color bands. They are rated at ¼ watt @ 70°C, ±5%. Orban part numbers 20001-xxx, Manufactured by R-Ohm (R-25), Piher, Beyschlag, Dale, Phillips, Spectrol, and Matsushita.

Carbon composition resistors have molded phenolic bodies, and are identified by four color bands. The 0.090 x 0.250 inch (2.3 x 6.4 mm) size is rated at ¼ watt, and the 0.140 x 0.375 inch (3.6 x 9.5 mm) size is rated at ½ watt, both ±5% @ 70°C. Orban part numbers 2001x-xxx, USA Military Specification MIL-R-11 Style RC-07 (¼ watt) or RC-20 (½ watt). Manufactured by Allen-Bradley, TRW/IRC, and Matsushita.

Cermet trimmer resistors have ⅜-inch (9 mm) square bodies, and are identified by printing on their sides. They are rated at ½ watt @ 70°C, = ±10%, with a temperature coefficient of 100 PPM/°C. Orban part numbers 20510-xxx and 20511-xxx. Manufactured by Beckman (72P, 68W- series), Spectrol, and Matsushita.

Obtaining spare parts

Special or subtle characteristics of certain components are exploited to produce an elegant design at a reasonable cost. *It is therefore unwise to make substitutions for listed parts.* Consult the factory if the listing of a part includes the note "selected" or "realignment required."

Orban normally maintains an inventory of tested, exact replacement parts that can be supplied quickly at nominal cost. Standardized spare parts kits are also available. When ordering parts from the factory, please have available the following information about the parts you want:

Orban part number
Reference designator (e.g., C3, R78, IC14)
Brief description of part
Model, serial, and "M" (if any) number of unit — see rear-panel label

To facilitate future maintenance, parts for this unit have been chosen from the catalogs of well-known manufacturers whenever possible. Most of these manufacturers have extensive worldwide distribution and may be contacted through their local offices. Addresses for each manufacturer's USA headquarters are given on page 6-31.

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
CHASSIS ASSEMBLY						
	Integrated Circuits					
IC48	D.C. Regulator, 15V Positive	24304-901	NAT	LM78M15UC	TI,MOT	Attached To Heatsink
IC49	D.C. Regulator, 15V Negative	24303-901	NAT	LM79M15AUC	TI,MOT	Attached To Heatsink
	Miscellaneous					
F1	Fuse, 3AG, Slo-Blo, 1/2A	28004-150	LFE	313.500	BUS	
None	Line Cord, CEE	28102-002	BEL	17500	MANY	
None	Filter, Line, 3 Amp	28015-000	COR	3EF1	MANY	
None	Fuseholder, Panel	28019-001	LFE			
T1	Transformer, Power; 41.7VCT, 17.7VA	55007-000	ORB			Mono Unit Only
T1	Transformer, Power; 39VCT, 23VA	55011-000	ORB			Stereo Unit Only
	Switches					
None	Switch, Slide, Mains voltage selector	26140-000	SW	EPSI-SLI		
PCB DISPLAY ASSEMBLY						
	Capacitors					
C1	Alum., Radial, 63V, -20% +100%; 2.2uF	21209-522	SPR	502D 225G063BB1C	PAN	
C2	Met. Polyester, 100V, 10%; 0.01uF	21441-310	WES	160C 103K630	SIE,WIM	
C3	Alum., Radial, 63V, -20% +100%; 2.2uF	21209-522	SPR	502D 225G063BB1C	PAN	Stereo Unit Only
C3-6	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	Mono Unit Only
C4	Met. Polyester, 100V, 10%; 0.01uF	21441-310	WES	160C 103K630	SIE,WIM	Stereo Unit Only
C5-8	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	Stereo Unit Only
	Diodes					
CR1-3,7-8	LED, Red	25106-003	HP	HLMP-1300	GI	Mono Unit Only
CR4,5	LED, Green	25106-002	HP	HLMP-1503	GI	Mono Unit Only
CR6	LED Array, 9-Yellow, 1-Red	25153-000	ORB			Mono Unit Only
CR1-3	LED, Red	25107-001	HP	HLMP-1300	GI	Stereo Unit Only
CR4,5,7,18	LED, Green	25107-002	HP	HLMP-1503	GI	Stereo Unit Only
CR6	LED Array, 9-Yellow, 1-Red	25152-000	ORB			Stereo Unit Only
CR8,16	LED, Amber	25107-003	HP	HLMP-1300	GI	Stereo Unit Only
CR9-11	LED, Red	25106-003	HP	HLMP-1300	GI	Stereo Unit Only
CR12,13,15,17	LED, Green	25106-002	HP	HLMP-1503	GI	Stereo Unit Only
CR14	LED Array, 9-Yellow, 1-Red	25152-000	ORB			Stereo Unit Only

FOOTNOTES:
(1) See page 6-31 for Vendor abbreviations
(2) No Alternate Vendors known at publication
(3) Actual part is specially selected from part listed, consult Factory
(4) Realignment may be required if replaced, see Circuit Description and/or Alignment Instructions

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

Orban Model 4000

Chassis Assembly - Integrated Circuits, Misc., Switches; PCB Display Assembly - Capacitors, Diodes

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES

PCB DISPLAY ASSEMBLY (continued)

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Integrated Circuits						
IC1	Digital, Display Driver	24712-302	NAT	LM3914		
IC2	Linear, Dual Opamp	24202-202	RAY	RC4558NB	MOT,FSC	
IC3	Digital, Display Driver	24712-302	NAT	LM3914		Stereo Unit Only
Resistors						
R1	Pot, Single, 25K	20761-000	ORB			
R17	Pot, Single, 25K	20761-000	ORB			Stereo Unit Only
Switches						
S1-4	Switch, MOM.; SPST	26301-016	ORB			Stereo Unit Only
S5-8	Switch, MOM.; SPST	26301-016	ORB			Stereo Unit Only
Transistors						
Q1-4	Transistor, Signal, PNP	23002-101	MOT	2N4402	FSC	
Q5,6	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	
Q7-10	Transistor, Signal, PNP	23002-101	MOT	2N4402	FSC	Stereo Unit Only
Q11,12	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	Stereo Unit Only

FOOTNOTES:
(1) See page 6-31 for Vendor abbreviations
(2) No Alternate Vendors known at publication
(3) Actual part is specially selected from part listed, consult Factory
(4) Realignment may be required if replaced, see Circuit Description and/or Alignment Instructions

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

Orban Model 4000

PCB Display Assembly - Integrated Circuits, Resistors, Switches, Transistors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES

PCB MAIN ASSEMBLY

Capacitors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
C1	Mica, 500V, +1/2pF -1/2pF; 10pF	21017-010	CD	CD15-CD100D03	SAN	
C2,3	Met. Polyester, 100V, 10%; 0.047uF	21441-347	WES	160C 473K250	SIE	
C4	Met. Polycarb., 100V, 2%; 0.12uF	21602-412	ECI	652A 1B124G	IMB	
C5	Mica, 500V, +1/2pF -1/2pF; 47pF	21017-047	CD	CD15-CD470D03	SAN	
C6	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C7	Alum., Radial, 63V, -20% +100%; 1uF	21209-510	SPR	502D 105G063BBIC	PAN	
C8	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C9	Mica, 500V, +1/2pF -1/2pF; 10pF	21017-010	CD	CD15-CD100D03	SAN	
C10,11	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C12	Polypropylene, 50V, 1%; 0.022uF	21701-322	NOB	CQ15P1H223FPP		
C13	Mica, 500V, +1/2pF -1/2pF; 10pF	21017-010	CD	CD15-CD100D03	SAN	
C14	Met. Polyester, 100V, 10%; 0.047uF	21441-347	WES	160C 473K250	SIE	
C15	Polypropylene, 50V, 2.5%; 0.068uF	21702-368	NOB	CQ15P1H683GPP		
C16,17	Met. Polyester, 100V, 10%; 0.0022uF	21441-222	WES	160C 222K1000	SIE,WIM	
C18	Mica, 500V, +1/2pF -1/2pF; 47pF	21017-047	CD	CD15-CD470D03	SAN	
C19	Met. Polycarb., 100V, 1%; 0.01uF	21601-310	ECI	652A 1B103F	IMB,SO	
C20	Met. Polyester, 100V, 10%; 0.047uF	21441-347	WES	160C 473K250	SIE	
C21	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C22	Alum., Radial, 63V, -20% +100%; 4.7uF	21209-547	SPR	502D 475G063BB1C	PAN	
C23	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C24	Mica, 500V, +1/2pF -1/2pF; 5pF	21017-005	CD	CD15-CD050D03	SAN	
C25	Mica, 500V, 1%; 220pF	21018-122	CD	CD15-FD221F03	SAN	
C26	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C27,28	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C29	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C30-32	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C33-36	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C37	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C38	Met. Polyester, 100V, 5%; 0.047uF	21440-347	WES	160C 473J250	SIE,WIM	
C39-43	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C44	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C45	Mica,1500V, 5%; 390pF	21018-139	CD	CD15-FD391F03	SAN	
C46-48	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	

FOOTNOTES:
(1) See page 6-31 for Vendor abbreviations
(2) No Alternate Vendors known at publication
(3) Actual part is specially selected from part listed, consult Factory
(4) Realignment may be required if replaced, see Circuit Description and/or Alignment Instructions

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

Orban Model 4000

PCB Main Assembly - Capacitors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Capacitors (continued)						
C49-52	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C53-59	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C60	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C61-63	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C64	Mica, 500V, 5%; 150pF	21020-115	CD	CD15-FD151J03	SAN	
C65,66	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C67	Mica, 500V, 1%; 220pF	21018-122	CD	CD15-FD221F03	SAN	
C68,69	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C70	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C71,72	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C73,74	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C75	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C76	Mica, 500V, +1/2pF -1/2pF; 5pF	21017-005	CD	CD15-CD050D03	SAN	
C77	Mica, 500V, 5%; 150pF	21020-115	CD	CD15-FD151J03	SAN	
C78,79	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C80	Mica, 500V, 1%; 470pF	21022-147	CD	CD19-FD471F03	SAN	
C81	Tantalum, 35V, 10%; 0.22uF	21307-422	SPR	196D 224X9035HA1	MANY	
C82	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C83,84	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C85	Met. Polyester, 100V, 5%; 0.047uF	21440-347	WES	160C 473J250	SIE,WIM	
C86	Mica, 500V, 5%; 1000pF	21024-210	CD	CD19-FD102J03	SAN	
C87	Polypropylene, 50V, 2.5%; 0.1uF	21702-410	NOB	CQ15P1H104GPP		
C88,89	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C90	Met. Polyester, 63V, 5%; 0.1uF	21442-410	MAL	168104J63A	WIM	
C91	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C92-95	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C96	Mica, 500V, 5%; 1800pF	21024-218	CD	CD19-FD182J03	SAN	
C97,98	Ceramic Disc, 1KV, 10%; 0.001uF	21112-210	CRL	DD-102	MUR	
C99,100	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C101,102	Alum., Radial, 25V, -20% +100%; 100uF	21206-710	PAN	ECE-A1EV101S		
C103,104	Alum., Axial, 40V, -10% +100%; 1000uF	21224-810	SIE	B41010-1000-40	PAN	Channel A Only
C105	Ceramic Disc, 25V, 20%; 0.15uF	21106-415	CRL	UK25-154	MUR	

FOOTNOTES:
(1) See page 6-31 for Vendor abbreviations
(2) No Alternate Vendors known at publication
(3) Actual part is specially selected from part listed, consult Factory
(4) Realignment may be required if replaced, see Circuit Description and/or Alignment Instructions

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

Orban Model 4000A

PCB Main Assembly - Capacitors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Diodes						
CR1	Diode, Rectifier, 400V, 1A	22201-400	MOT	1N4004	MANY	
CR2	Diode, Bridge, 200V, 1A	22301-000	VARO	VE-27	GI	Channel A Only
CR14	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800	MANY	
CR30,31	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800	MANY	
CR45,46	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800	MANY	
Integrated Circuits						
IC1-3	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC4	Digital, Dynamic Range Processor	24719-302	PMI	SSM-2120		
IC5	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC6	Linear, Dual Opamp	24202-202	RAY	RC4558NB	MOT,FSC	
IC7,8	Quad Comparator	24710-302	NAT	LM339		
IC9-11	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC12	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC13-15	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC16	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC17-22	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC23	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC24	Linear, Single Opamp	24014-202	SIG	NE5534N	TI	
IC25	Linear, Dual Opamp	24208-302	RCA	CA3280A		
IC26	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC27	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC28-31	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC32	Linear, Dual Opamp	24203-202	MOT	MC1458CP1	TI,RCA	
IC33,34	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC35	Linear, Single Opamp	24017-202	NAT	LF411CN		
IC36,37	Linear, Dual Opamp	24202-202	RAY	RC4558NB	MOT,FSC	
IC38	Linear, Single Opamp	24014-202	SIG	NE5534N	TI	
IC39	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC40	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC41	Quad Comparator	24710-302	NAT	LM339		
IC42,43	Digital, NAND Gate	24501-302	RCA	CD4011BE	MOT	
IC44-47	Optoisolator, NPN	25003-000	SIE	SFH-601-1		

FOOTNOTES:
(1) See page 6-31 for Vendor abbreviations
(2) No Alternate Vendors known at publication
(3) Actual part is specially selected from part listed, consult Factory
(4) Realignment may be required if replaced, see Circuit Description and/or Alignment Instructions

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

Orban Model 4000

PCB Main Assembly - Diodes, Integrated Circuits

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Miscellaneous						
K1,2	Relay, DPDT	28024-000	PB	T85N11D114-12		
Modules						
A100	Module, Timing	31345-000-xx		ORB		Add suffix printed on part
Resistors						
R1	Resistor Set, MF; 13.3K/10.2K	28522-003	ORB			3
R3	Resistor Set, MF; 4.53K/3.01K	28522-004	ORB			3
R4	Resistor Set, MF; 13.3K/10.2K	28522-003	ORB			3
R5	Resistor Set, MF; 4.64K/4.53K	28522-005	ORB			3
R106	Resistor Network, 8 POS; 10.0K	20202-503	AB	F16B-103-B	BEK	
R240	Resistor Set, MF; 2.00K	28521-024	ORB			3
R244	Resistor Set, MF; 2.00K	28521-024	ORB			3
R248	Resistor Set, MF; 2.00K	28521-024	ORB			3
R256	Resistor Set, MF; 2.00K	28520-002	ORB			3
R260	Resistor Set, MF; 2.00K	28520-002	ORB			3
R264	Resistor Set, MF; 2.00K	28520-002	ORB			3
R401	Resistor Set, MF; 2.00K	28521-024	ORB			3
R412	Resistor Set, MF; 2.00K	28520-002	ORB			3
R416	Resistor Set, MF; 2.00K	28520-002	ORB			3
R420	Resistor Set, MF; 2.00K	28520-002	ORB			3
R432	Resistor Set, MF; 2.00K	28521-024	ORB			3
R437	Resistor Set, MF; 2.00K	28521-024	ORB			3
Transistors						
Q100	Transistor, JFET/N	23406-101	NAT	J113	SIL	
Q101	Transistor, JFET/P	23407-101	NAT	J174	SIL	
Q102-105	Transistor, JFET/N	23406-101	NAT	J113	SIL	
Q200	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	

FOOTNOTES:
(1) See page 6-31 for Vendor abbreviations
(2) No Alternate Vendors known at publication
(3) Actual part is specially selected from part listed, consult Factory
(4) Realignment may be required if replaced, see Circuit Description and/or Alignment Instructions

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

Orban Model 4000

PCB Main Assembly - Misc., Modules, Resistors Transistors

Vendor Codes

AB Rockwell Allen-Bradley
625 Liberty Ave
Pittsburgh, PA 15222-3123

AD Analog Devices, Inc.
One Technology Way
PO Box 9106
Norwood, MA 02062-9106

AKG AKG Acoustics, Inc.
See Orban

AM Amphenol Corporation
358 Hall Avenue
Wallingford, CT 06492

BEK Beckman Industrial Corporation
4141 Palm Street
Fullerton, CA 92635-1025

BEL Belden Electronic Wire & Cable
PO Box 1980
Richmond, IN 47374

BRN Bourns, Inc
Resistive Components Group
1200 Columbia Avenue
Riverside, CA 92507

BUS Bussmann Division
Cooper Industries
PO Box 14460
St. Louis, MO 63178

CD Cornell-Dubilier Electronics
1700 Rte. 23 North
Wayne, NJ 07470

CRL Mepcopal/Centralab
See Mepcopal

CSC Crystal Semiconductor Corporation
4210-T. South Industrial Dr.
Austin, TX 78744

CTS CTS Corporation
907 North West Blvd.
Elkhart, IN 46514

CW CW Industries
130 James Way
Southampton, PA 18966

DBX dbx
A Harman International Company
8760 South Sandy Parkway
Sandy, UT 84107

DEL Delta Products Corp
3225 Laurel View Ct.
Fremont, CA 94538

DUR Duracell, Inc.
Berkshire Industrial Park
Bethel, CT 06801

ELSW Electro Switch
77 King Avenue
Weymouth, MA 02188

EMI Crompton Modutec
920 Candia Rd.
Manchester, NH 03109

EXR Exar Corporation
2222 Qume Dr.
PO Box 49007
San Jose, CA 95161-9007

FR Fair-Rite Products Corp.
PO Box J
Wallkill, NY 12589

FSC Fairchild Camera & Instr. Corp.
See National Semiconductor

GI General Instruments
Optoelectronics Division
See Quality Technologies

HA Harris Semiconductor
1301 Woody Burke Rd.
Melbourne, FL 32901

HO Hoyt Elect. Inst. Works
19 Linden St.
Penacook, NH 03303

HP Hewlett-Packard Co.
Components Group
640 Page Mill Road
Palo Alto, CA 94304

INS Intersil, Inc.
See Harris Semiconductor

ITW ITW Switches
An Illinois Tool Works Co.
6615 W. Irving Park Rd.
Dept. T
Chicago, IL 60634

KEM KEMET Electronics Corporation
Post Office Box 5928
Greenville, South Carolina 29606

KEY Keystone Electronics Corp.
31-07 20th Rd.
Astoria, NY 11105

LFE Littlefuse
A Subsidiary of Tracor, Inc.
800 E. Northwest Hwy
Des Plaines, IL 60016

LT Linear Technology Corp.
1630 McCarthy Blvd.
Milpitas, CA 95035

LUMX Lumex Opto/Components Inc.
292 E. Hellen Road
Palatine, IL 60067

MAL Mallory Capacitor Co.
7545 Rockville Rd.
PO Box 1284
Indianapolis, IN 46241

MAR Marquardt Switches, Inc.
2711-TR Route 20 East
Cazenovia, NY 13035

MAT Matsushita Electric Corp
of America
One Panasonic Way
Secaucus, NJ 07094

ME Mepcopal/Centralab
A North American Phillips Corp.
11468 Sorrento Valley Road
San Diego, CA 92121

MID Hollingsworth/Wearnes
1601 N. Powerline Rd.
Pampano, FL 33069

MIL J.W. Miller Division
Bell Industries
306 E. Alondra
Gardena, CA 90247

MOT Motorola Semiconductor
PO Box 20912
Phoenix, AZ 85036

MUR Murata Erie North America
2200 Lake Park Drive
Smyrna, GA 30080

NAT National Semiconductor Corp.
2900 Semiconductor Drive
PO Box 58090
Santa Clara, CA 95051

NEL Crystal Biotech
75 South Street
Hopkinton, MA 01748

NOB Noble U.S.A., Incorporated
5450 Meadowbrook Industrial Ct.
Rolling Meadows, IL 60008

OKI OKI Semiconductor
785 N. Mary Ave.
Sunnyvale, CA 94086-2909

OHM Ohmite Manufacturing Company
3601 Howard Street
Skokie, IL 60076

ORB Orban
A Harman International Company
1525 Alvarado Street
San Leandro, CA 94577

PAN Panasonic Industrial Company
Two Panasonic Way
7E-2T
Secaucus, NJ 07094

QT Quality Technologies, Inc.
610 North Mary Ave.
Sunnyvale, CA 94086

RAL Raltron Electronics Corp.
2315 NW 107th Ave.
Miami, FL 33172

RAY Raytheon Company
Semiconductor Division
350 Ellis Street
Mountain View, CA 94039

RCA RCA Solid State
See Harris Semiconductor

ROHM Rohm Electronics
3034 Owens Dr.
Antioch, TENN 37013

SAE Stanford Applied Engineering, Inc
340 Martin Avenue
Santa Clara, CA 95050

SAN Sangamo Weston Inc.
Capacitor Division
See Cornell-Dubilier

SCH ITT Schadow, Inc.
8081 Wallace Road
Eden Prairie, MN 55344

SIE Siemens Components Inc.
Heimann Systems Div.
186 Wood Avenue South
Iselin, NJ 08830

SIG Philips Components - Signetics
North American Phillips Corp.
811 E. Arques
Sunnyvale, CA 94088

SPR Sprague Electric Co.
41 Hampden Road
PO Box 9102
Manifold, MA 02048-9102

S.W. Seitchcraft
A Raytheon Company
5555 N. Elation Avenue
Chicago, IL 60630

AT Taiga America, Inc.
700 Frontier Way
Bensenville, IL 60106

TDK TDK Electronics Corporation
12 Harbor Park
Port Washington, NY 11050

TI Texas Instruments, Inc.
PO Box 655012
Dallas, TX 75265

TOS Toshiba America, Inc.
9740 Irvine Blvd.
Irvine, CA 92718

TRW TRW Electronics Components
Connector Division
1501 Morse Avenue
Elk Grove Village, IL 60007

VARO Micro Quality Semiconductor, Inc.
PO Box 469013
Garland, TX 75046-9013

WES Westlake
See Mallory Capacitor Co.

WIM Wima Division
2269 Saw Mill Rd.
Building 4C
PO Box 217
Elmsford, NY 10533

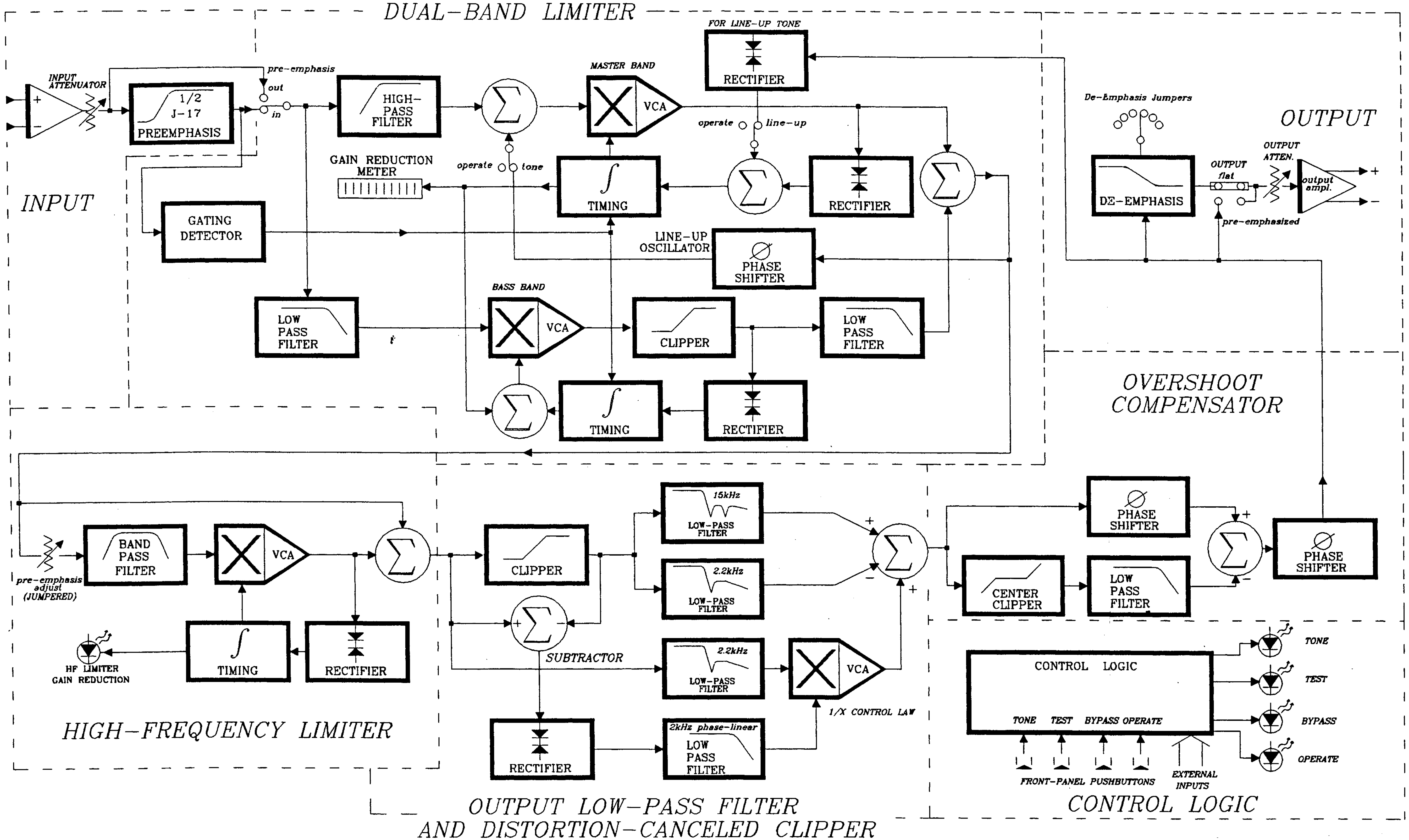
ZI ZILOG Inc.
210 Hacienda Ave.
Campbell, CA 95008

Schematics, Assembly Drawings

The following drawings are included in this manual:

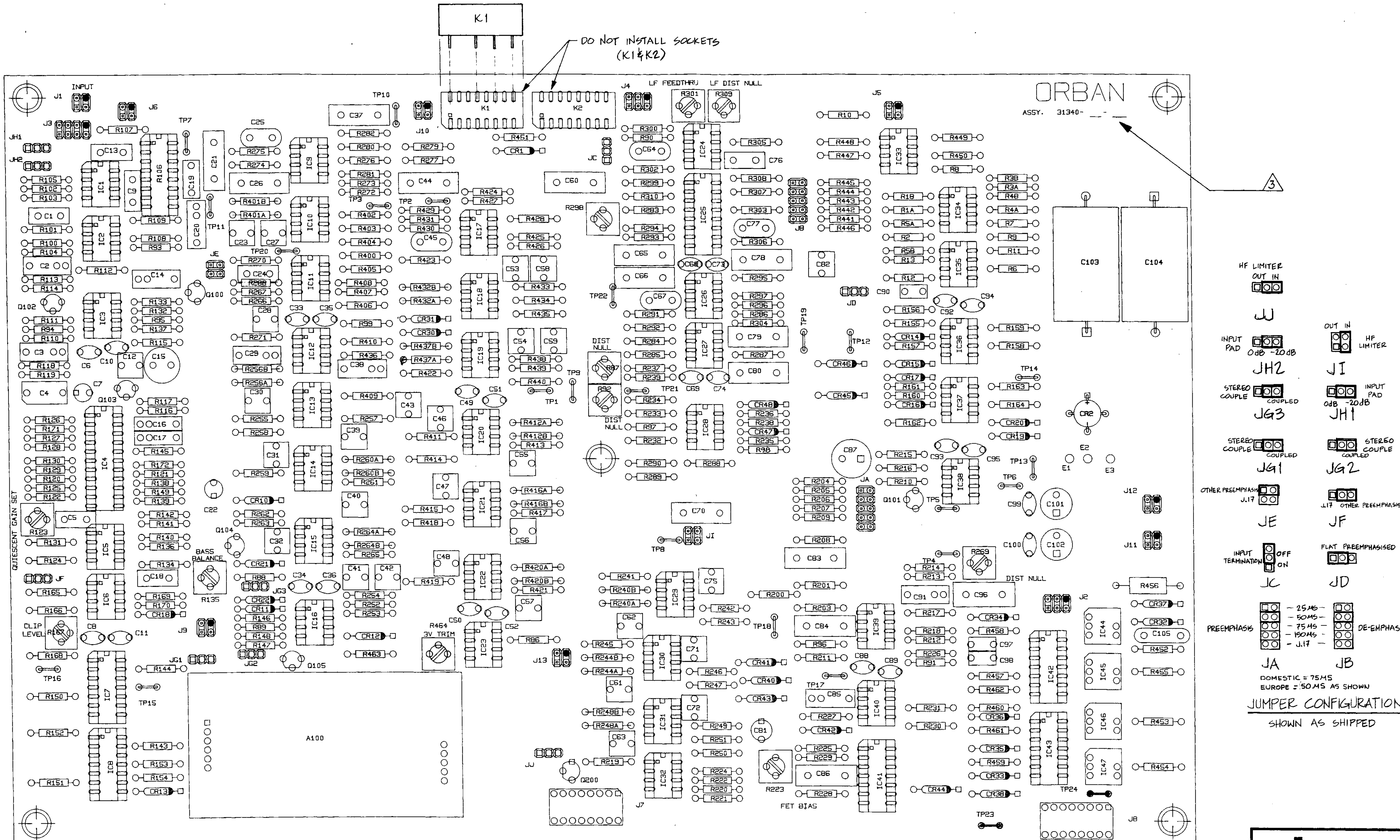
These drawings reflect the actual construction of your unit as accurately as possible. Any differences between the drawings and your unit are almost undoubtedly due to product improvements or production changes since the publication of this manual. Major changes (when they occur) are described in addenda located at the front of this manual.

If you intend to replace parts, please read page 23



orban®

TITLE:
4000A TRANSMISSION LIMITER BLOCK DIAGRAM



COMPONENT SIDE

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. SQUARE PADS INDICATE PIN 1 OF CONNECTORS, CATHODE OF DIODES, POS. SIDE OF CAPS., PIN 1 OF ICS.
2. REFERENCE SCHEMATIC DRAWING NO. 61076-000.
3. MARK ASSEMBLY REVISION LEVEL IN SPACE PROVIDED.
4. VER-002 DO NOT INSTALL C103,C104,CR2,R463 & R464 TP23, TP24 (SHADED COMPONENTS)
5. CLIP PIN#4 OF J1,J5,J6,J9,J10,J11,J12,J13 PIN#6 OF J4,J2 PIN#8 OF J3 (SHADED PAD)

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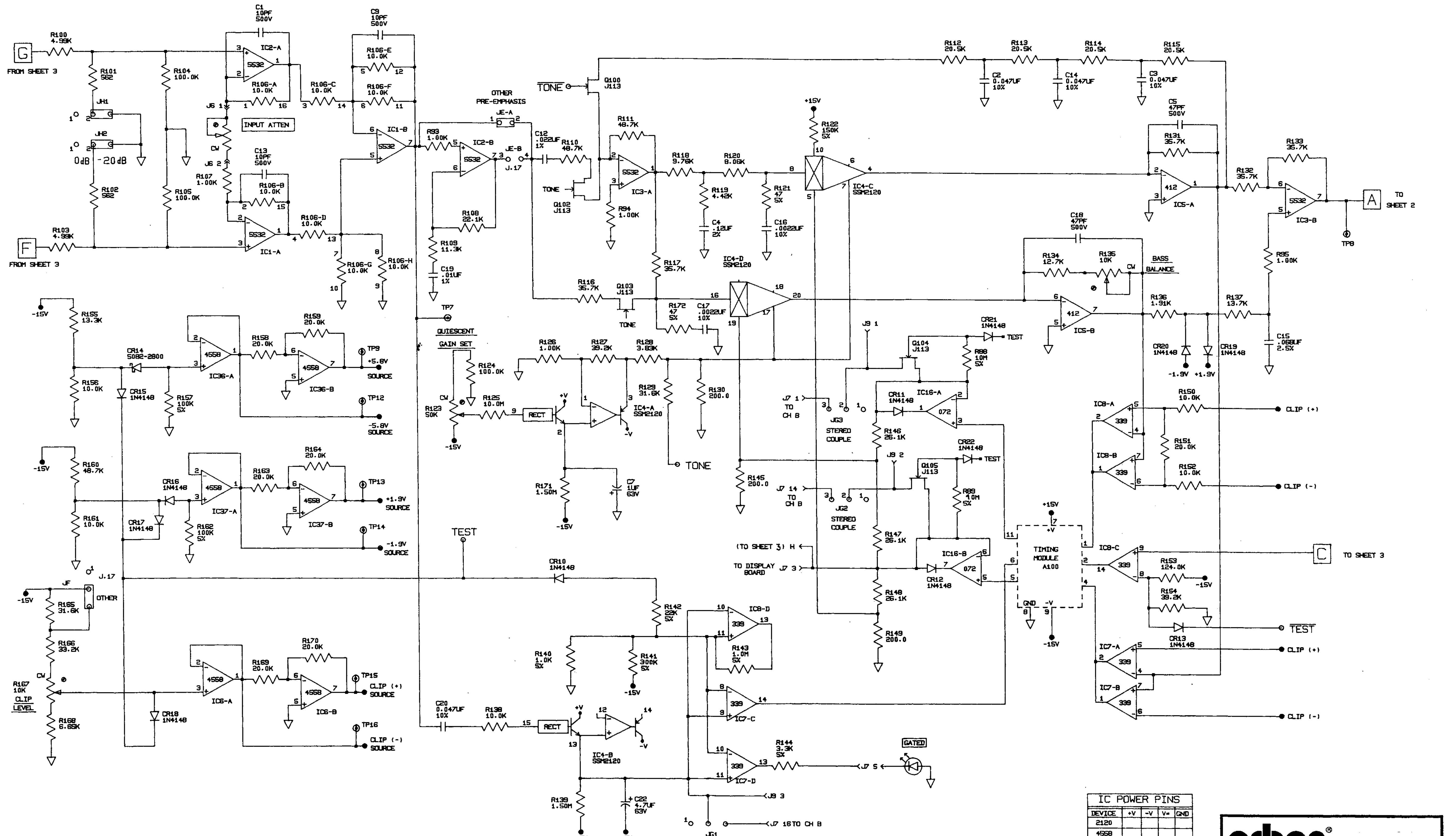
TITLE: PCB ASSEMBLY MAIN BOARD 31340-VER-01



NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL RESISTORS ARE 1/8W, 1%, CF

IC POWER PINS				
DEVICE	+V	-V	V+	GND
2120				
4558				
339				
072				
5532				
412				

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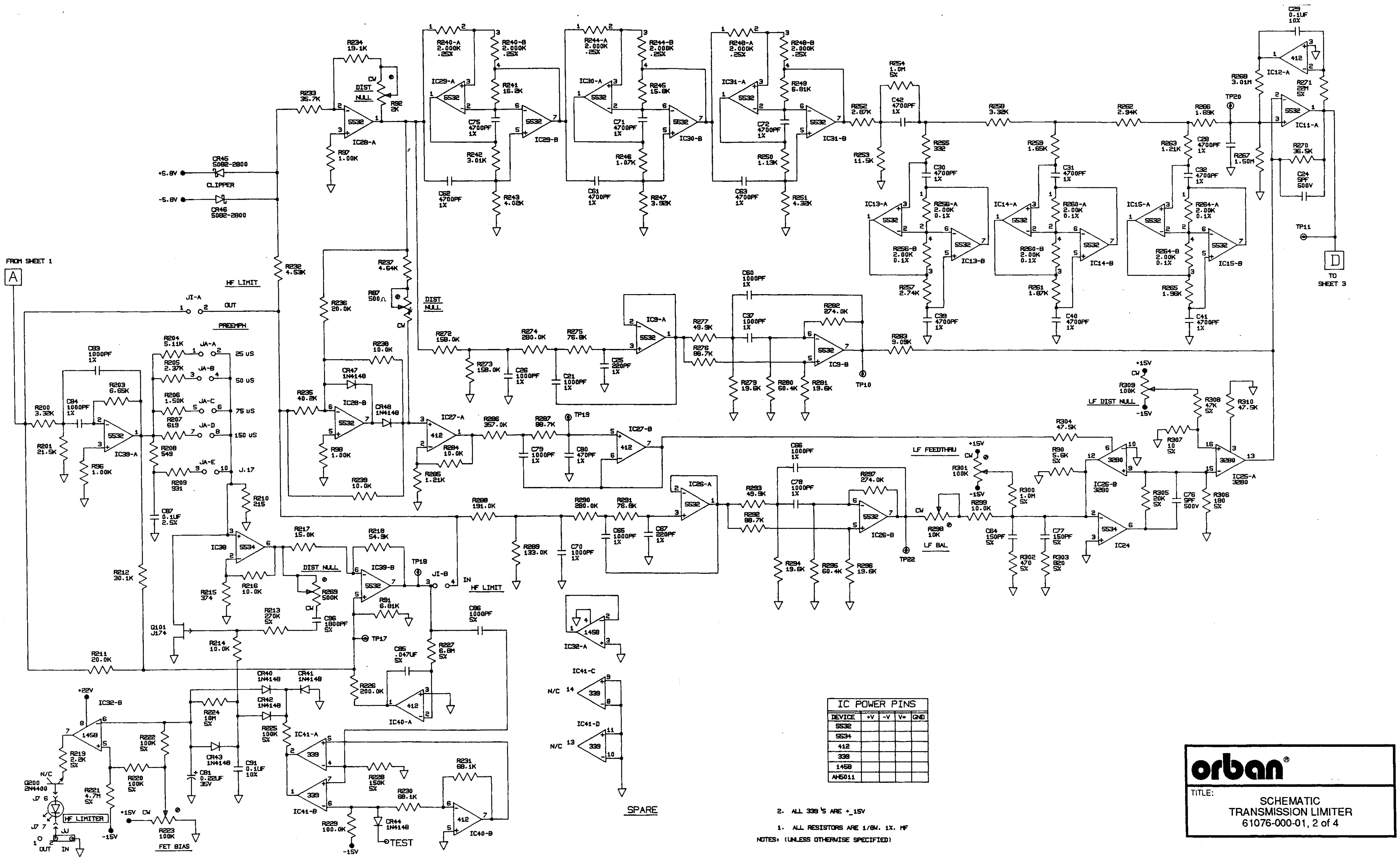
TITLE: SCHEMATIC
TRANSMISSION LIMITER
61076-000-01, 1 of 4



IC POWER PINS				
DEVICE	+V	-V	V=	GND
5532				
5534				
412				
339				
1458				
AH5011				

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTORS ARE 1/8W, 1%, MF
2. ALL 339'S ARE ±15V

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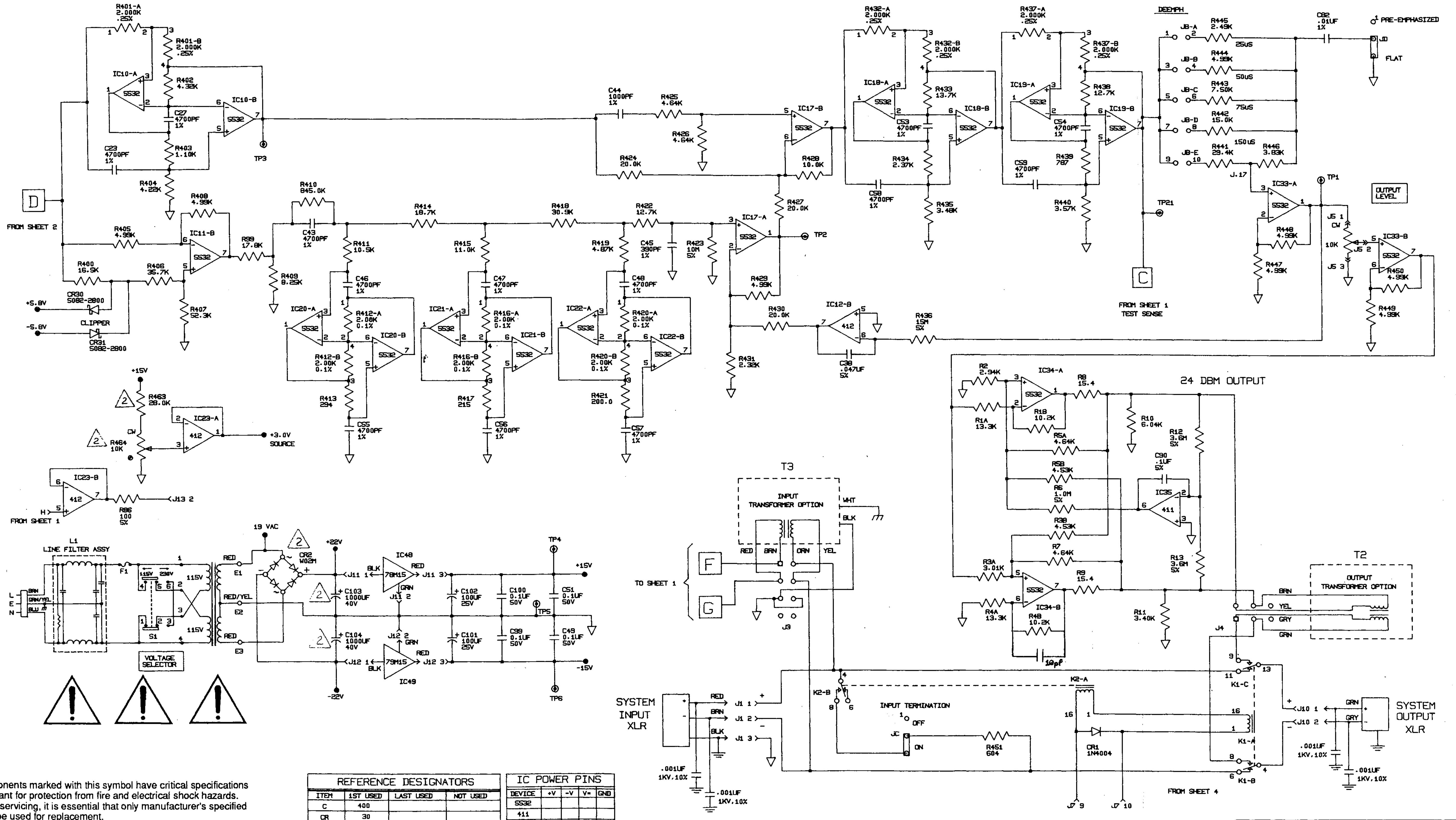
TITLE:
SCHEMATIC
TRANSMISSION LIMITER
61076-000-01, 2 of 4



REFERENCE DESIGNATORS			
ITEM	1ST USED	LAST USED	NOT USED
C	400		
CR	30		
DS			
R	400		
S			
Q	-		
TP			
IC	31		

IC POWER PINS				
DEVICE	+V	-V	V=	GND
5532				
411				
412				

⚠ Components marked with this symbol have critical specifications important for protection from fire and electrical shock hazards. When servicing, it is essential that only manufacturer's specified parts be used for replacement.

Prior to the return of this appliance to the customer, and upon completion of servicing, service personnel are required to test this unit for adequate insulation resistance between the power supply and exposed parts.

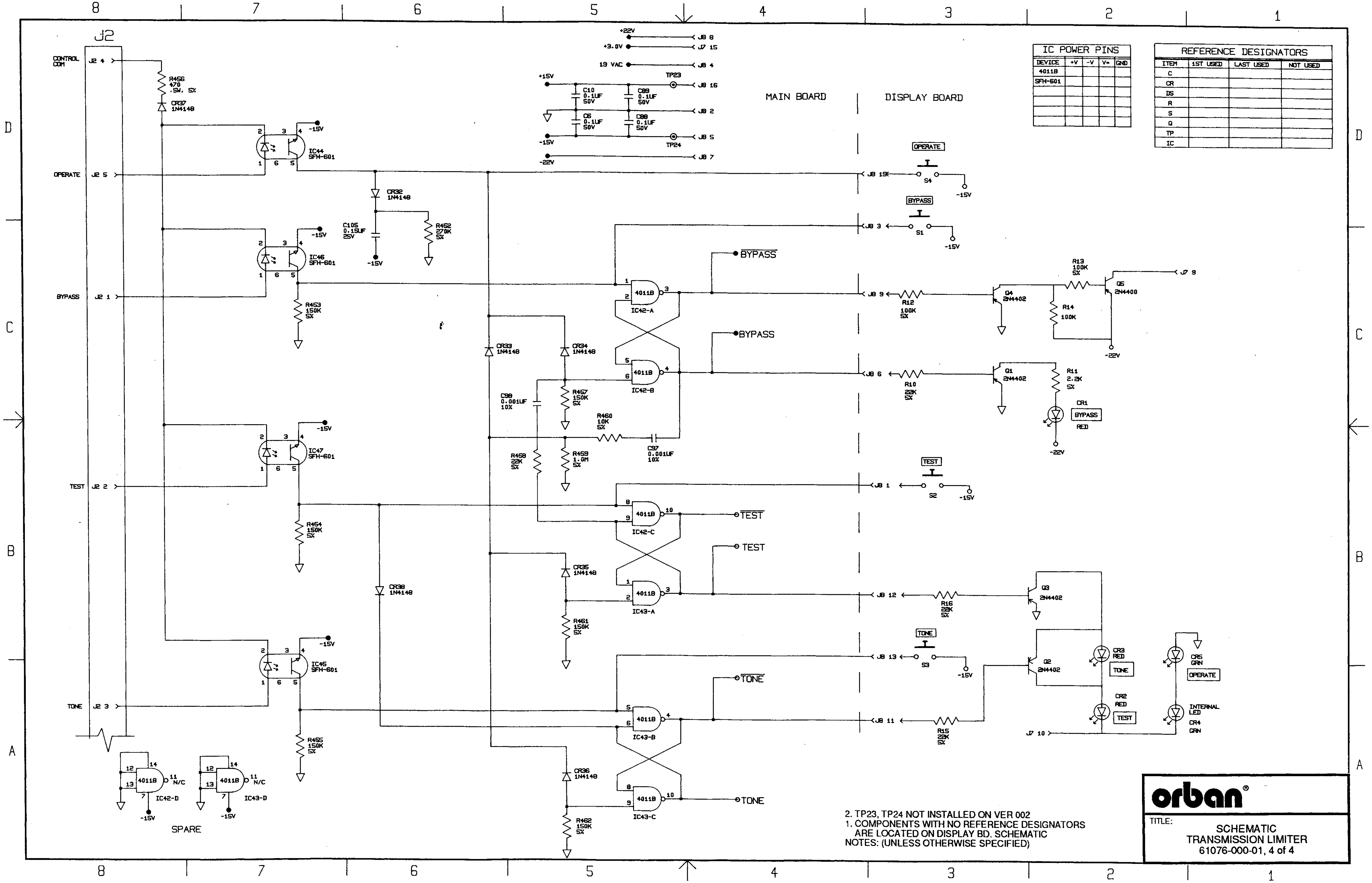
△2 NOT USED ON VER-002

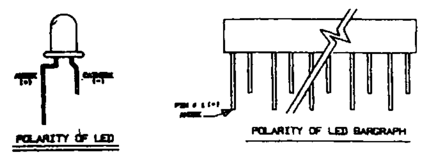
1. IF INPUT AND OUTPUT TRANSFORMERS ARE NOT USED, INSTALL JUMPERS TO CONNECT PIN 1 TO PIN 2 AND PIN 3 TO PIN 4

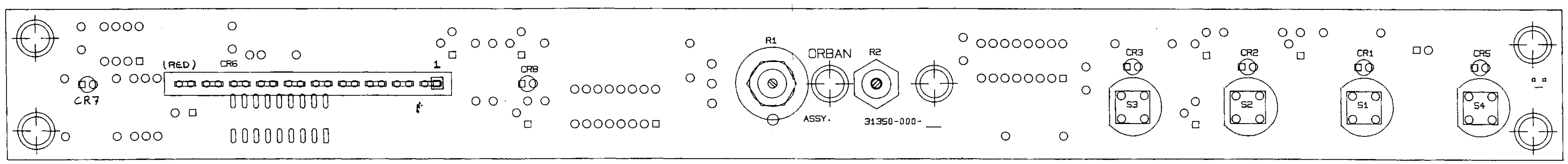
NOTES: (UNLESS OTHERWISE SPECIFIED)

orban®

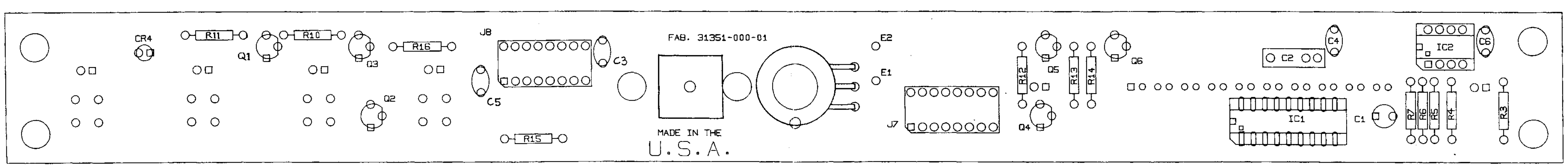
TITLE: SCHEMATIC
TRANSMISSION LIMITER
61076-000-01, 3 of 4


J2
CONTROL COM
OPERATE
BYPASS
TEST
TONE
MAIN BOARD
DISPLAY BOARD
IC POWER PINS
DEVICE +V -V V+ GND
4011B
SFH-601
REFERENCE DESIGNATORS
ITEM 1ST USED LAST USED NOT USED
C
CR
DS
R
S
Q
TP
IC
+22V
+3.0V
19 VAC
+15V
-15V
-22V
TP23
TP24
IC44 SFH-601
IC46 SFH-601
IC47 SFH-601
IC45 SFH-601
IC42-A
IC42-B
IC42-C
IC43-A
IC43-B
IC43-C
IC42-D
IC43-D
SPARE
BYPASS
TEST
TONE
Q1 2N4402
Q2 2N4402
Q3 2N4402
Q4 2N4402
Q5 2N4400
CR1 BYPASS RED
CR2 RED TEST
CR3 RED TONE
CR4 GRN INTERNAL LED
CR5 GRN OPERATE
2. TP23, TP24 NOT INSTALLED ON VER 002
1. COMPONENTS WITH NO REFERENCE DESIGNATORS ARE LOCATED ON DISPLAY BD. SCHEMATIC
NOTES: (UNLESS OTHERWISE SPECIFIED)
orban®
TITLE:
SCHEMATIC
TRANSMISSION LIMITER
61076-000-01, 4 of 4





COMPONENT SIDE



SOLDER SIDE

4. POTS SHOWN ON COMP SIDE INSTALLED FROM SOLDER SIDE.

2. REFERENCE SCHEMATIC DRAWING NO. 61079-000

1. SQUARE PADS INDICATE PIN #1 OF CONNECTORS, ICS, BARGRAPHS, POS. SIDE OF CAPS, CATHODE OF DIODES.

NOTES: (UNLESS OTHERWISE SPECIFIED)

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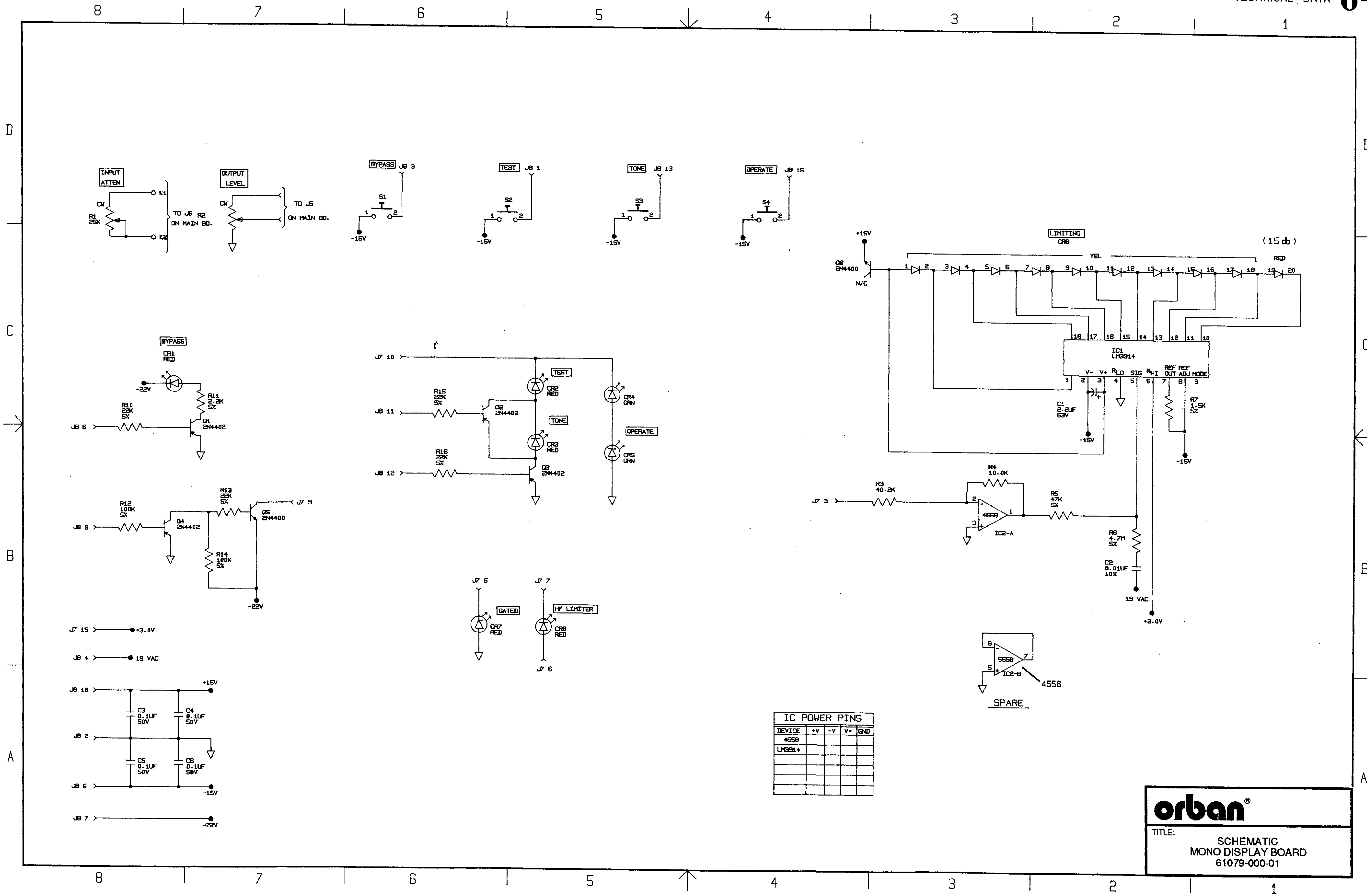
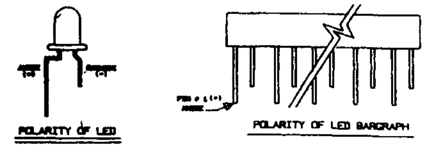
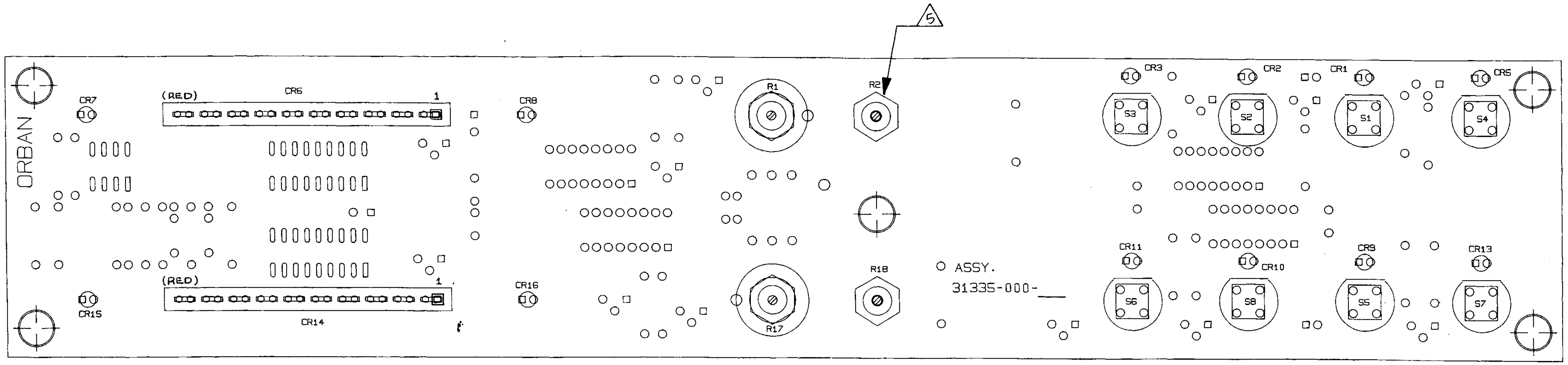
TITLE:
PCB ASSEMBLY
MONO DISPLAY BOARD
31350-000-01



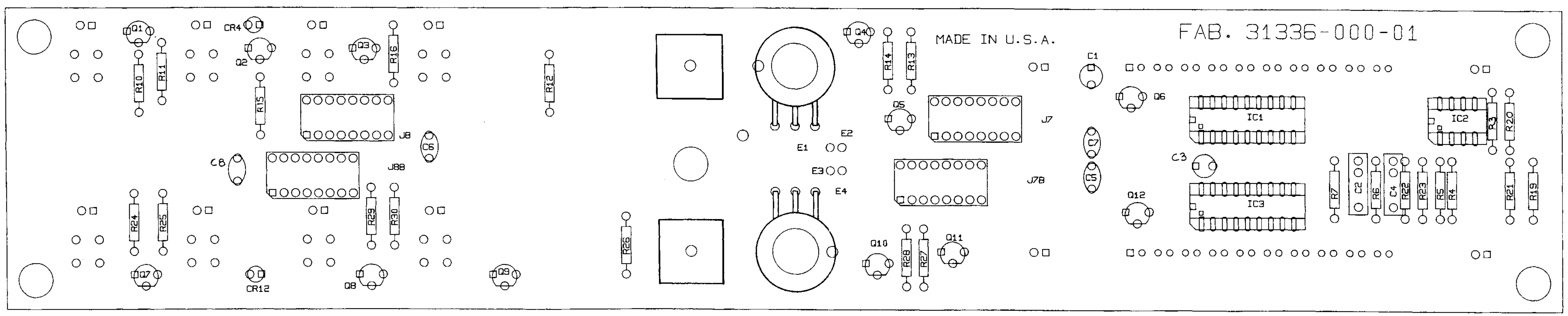
IC POWER PINS

DEVICE	+V	-V	V+	GND
4558				
LM3914				





COMPONENT SIDE



SOLDER SIDE

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. SQUARE PADS INDICATE PIN #1 OF CONNECTORS, IC'S, BARGRAPHS, POS. SIDE OF CAPS, CATHODE OF DIODES.
2. REFERENCE SCHEMATIC DRAWING NO. 61077-000.
4. POTS SHOWN ON COMP. SIDE INSTALLED FROM SOLDER SIDE.

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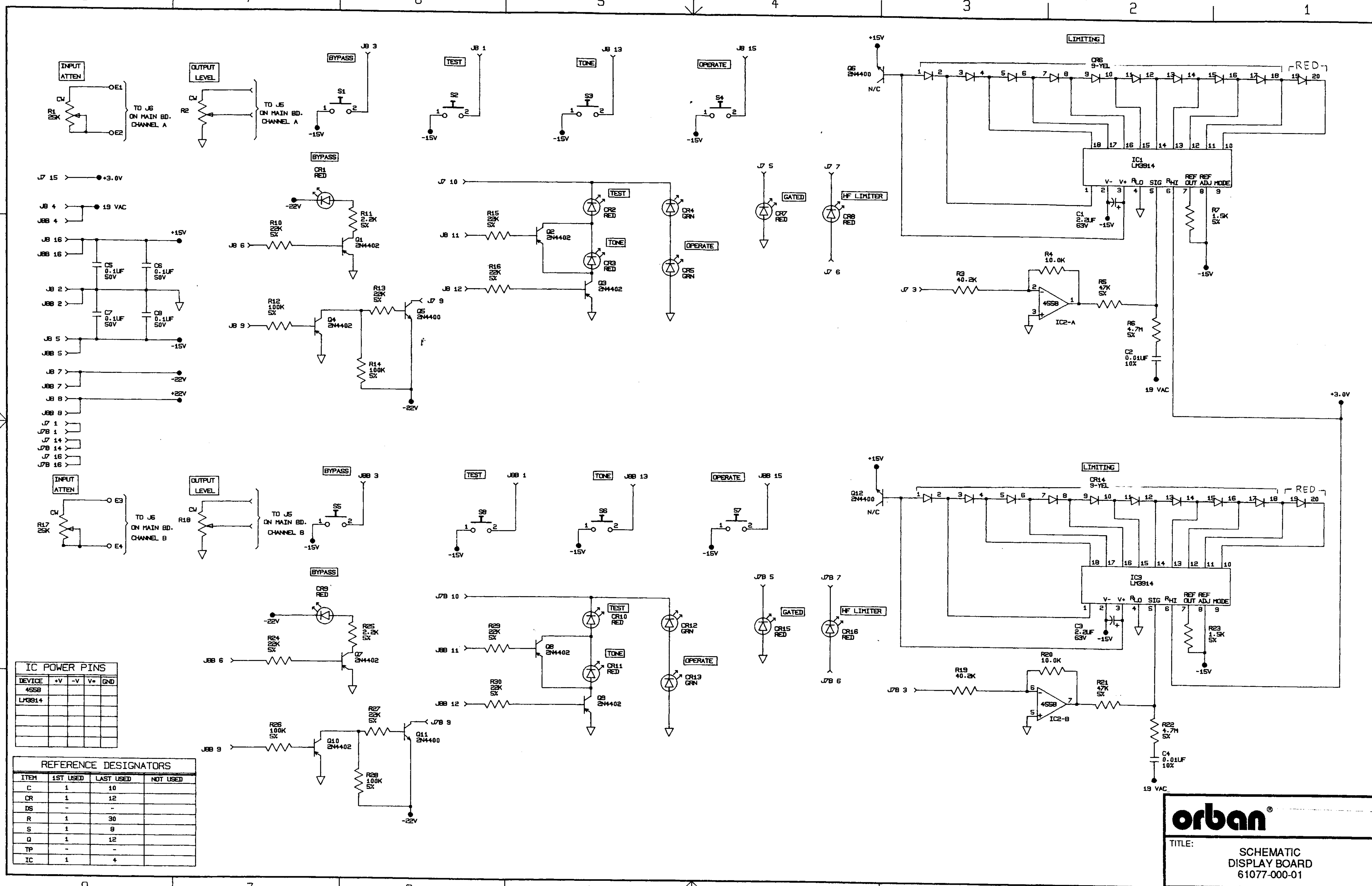
TITLE: PCB ASSEMBLY
STEREO DISPLAY BOARD
31335-000-01



IC POWER PINS				
DEVICE	+V	-V	V•	GND
4558				
LM3914				

REFERENCE DESIGNATORS			
ITEM	1ST USED	LAST USED	NOT USED
C	1	10	
CR	1	12	
DS	-	-	
R	1	30	
S	1	8	
Q	1	12	
TP	-	-	
IC	1	4	

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TITLE: SCHEMATIC DISPLAY BOARD 61077-000-01

Abbreviations

Some of the abbreviations used in this manual may not be familiar to all readers:

AGC	automatic gain control
dBm	decibel power measurement. 0dBm = 1mW applied to a specified load. In audio, the load is usually 600Ω.
dBu	decibel voltage measurement. 0dBu = 0.775V RMS. For this application, the dBm-into-600Ω scale on voltmeters can be read as if it were calibrated in dBu.
DJ	disk jockey, an announcer who plays records in a club or on the air
EMI	electromagnetic interference
FCC	Federal Communications Commission (USA regulatory agency)
FET	field effect transistor
FFT	fast Fourier transform
G/R	gain reduction
HF	high-frequency
HP	high-pass
IC	integrated circuit
IM	intermodulation (or "intermodulation distortion")
JFET	junction field effect transistor
LED	light-emitting diode
LF	low-frequency
LP	low-pass
MHF	midrange/high-frequency
MLF	midrange/low-frequency
N&D	noise and distortion
RF	radio frequency
RFI	radio-frequency interference
RMS	root-mean-square
TRS	tip-ring-sleeve (2-circuit phone jack)
THD	total harmonic distortion
VCA	voltage-controlled amplifier
XLR	a common style of 3-conductor audio connector