# Section 3
# Operation

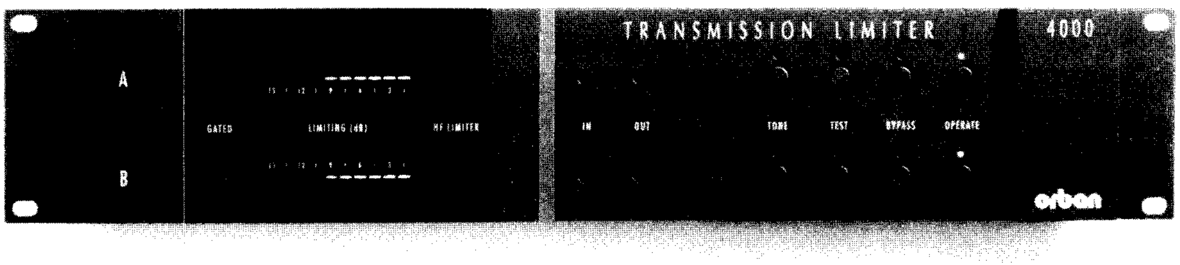
page contents



## 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.

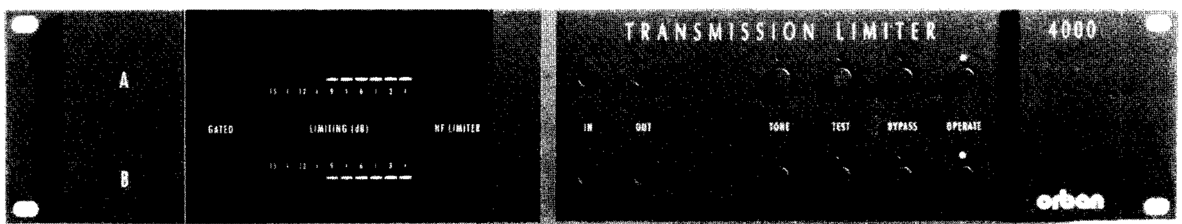
**OPERATE** is a momentary button that puts the unit in its normal OPERATE mode.

**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.

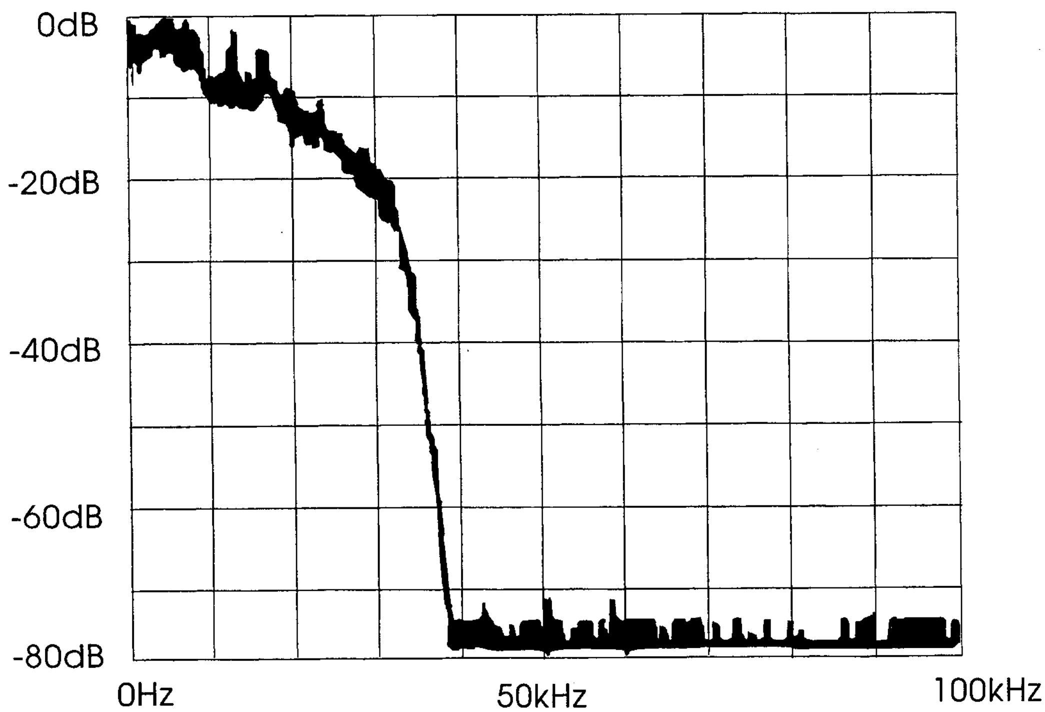



Figure 3-1: Output Power Spectrum
0-100kHz horizontal; 10dB/div vertical

# 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 $\frac{1}{10}$-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."

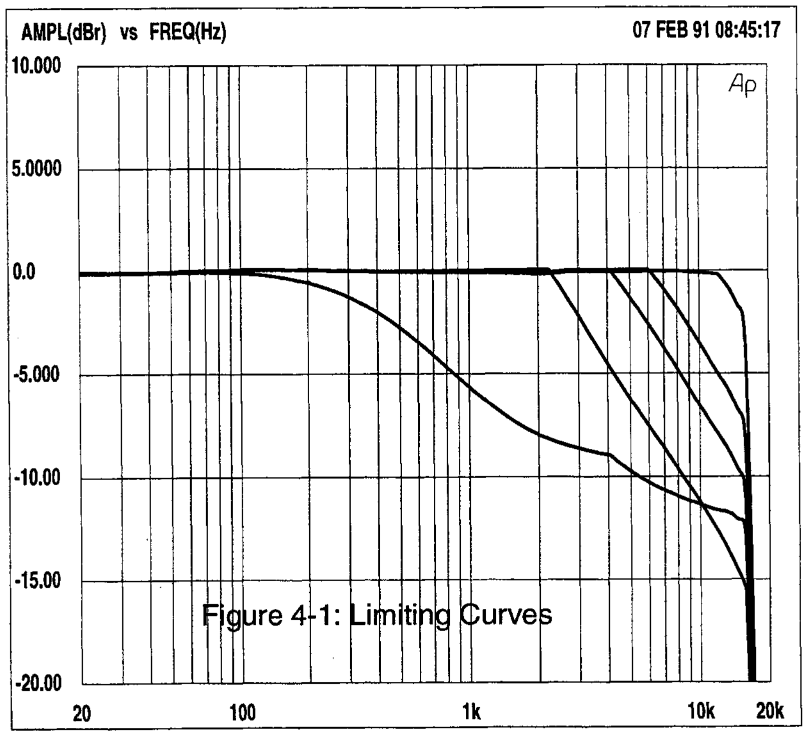



Figure 4-1: Limiting Curves

## 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<br>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.