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

The 2200 OPTIMOD-FM Audio Processor uses highly stable analog and digital circuitry throughout. Recommended routine maintenance is minimal.

1. Periodically check audio level and gain reduction meter readings.

Become familiar with normal audio level meter readings, and with the normal performance of the G/R metering. If any meter reading is abnormal, see Section 5 for troubleshooting information.

2. Listen to the 2200's output.

A good ear will pick up many faults. Familiarize yourself with the "sound" of the 2200 as you have set it up, and be sensitive to changes or deteriorations. But if problems arise, please don't jump to the conclusion that the 2200 is at fault. The troubleshooting information in Section 5 will help you determine if the problem is with OPTIMOD-FM or is somewhere else in the station's equipment.

3. Periodically check for corrosion.

Particularly in humid or salt-spray environments, check for corrosion at the input and output connectors and at those places where the 2200 chassis contacts the rack.

4. Periodically check for loss of grounding.

Check for loss of grounding due to corrosion or loosening of rack mounting screws.

5. Clean the front panel when it gets soiled.

Wash the front panel 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

1. Removing the Top Cover.

To access the main board, power supply board or display assembly, you must remove the top cover.

A ☐ Disconnect the 2200 and remove it from the rack.

Be sure power is disconnected before removing the cover.

WARNING: Hazardous voltage is exposed with the unit open and the power ON.

B ☐ Set the unit upright on a padded surface with the front panel facing you.

C ☐ Remove all twenty screws holding the top cover in place, and lift the top cover off.

Use a #1 Phillips screwdriver.

2. Removing the Display Assembly.

Note: You will need to complete this step if you intend to remove the main board.

A ☐ Gently pull off the front panel control knob.

B ☐ Remove backlight power connector

C ☐ Detach the four ribbon cables that connect the display board to the main board and power supply board.

a) First, identify the four cables:

A larger white flat cable connecting to jumper J200 on the main board;

A gray ribbon cable connecting to a DIP header at jumper J203 on the main board.

A smaller white flat cable connecting the display assembly to the power supply at jumper J202.

A two-wire cable connecting the display assembly to the power supply at jumper J201.

b) Gently lift each cable up from where it connects to its jumper, so that the jumper pins unseat without bending or breaking. (If present, you must first remove the retainer clip from the DIP header at J203.)

D ☐ Remove the four nuts that connect the display board to the main chassis.

Use a ¼“ long shafted nut driver or a flexible shaft nut driver.

E ☐ Grasp the edges of the front panel, pull slightly forward, and, while holding the panel vertical, guide it forward.

3. Removing the Main Board.

A ☐ If you have not done so yet, remove the top cover (Step 1) and remove the display assembly (Step 2).

B ☐ Remove the display board's metal shielding; this was left in place when the display board was detached.

C ☐ Remove the two hex nuts holding each composite output connector to the chassis, using a $^{3}/_{16}$" hex nut driver.

D ☐ Remove the two hex nuts holding the Remote Interface connector to the chassis, using a $^{3}/_{16}$" hex nut driver.

E ☐ Detach all 4 XLR connectors (or 6 with Model 2200-D), using a jeweler's screwdriver; engage the locking mechanism and turn counterclockwise until the XLR is no longer attached.

F ☐ Remove the two ribbon cables that connect the power supply to the main board at jumpers J900 and J901. (If present, you must first remove the black retainer clips.)

G ☐ Remove the four #1 Phillips screws that connect the main board to the chassis.

H ☐ Carefully pull the main board forward to clear XLRs from their housing and then out of the chassis.

4. Removing the Power Supply Board.

A ☐ If you have not done so yet, remove the top cover (Step 1).

B ☐ If you have not done so yet, remove the ribbon cables that connect the display assembly to the power supply board (at jumpers J201 and J202), as well as the two cables that connect the main board to the power supply (at jumpers J900 and J901).

C ☐ Remove the twelve #1 Phillips screws holding the heat sink to the side of the chassis — note that some have nuts and some are tapped — and remove heat sink.

D ☐ Remove the two Phillips screws that hold the IEC connector to the chassis.

E ☐ Remove the four bolts that hold the transformer; retain the four star washers and eight plastic insulators.

F ☐ Remove the three Phillips screws holding the power supply board to the main chassis.

G ☐ Remove the nut and star washer from the ground wire with a $^{1}/_{4}$" nut driver.

H ☐ Carefully lift the power supply board up.

5. Reattaching the Power Supply Board.

A ☐ Replace the two Phillips screws that hold the IEC connector.

B ☐ Replace the twelve #1 Phillips screws that hold the heat sink to the side of the chassis.

C ☐ Set power supply board into main chassis, so that it aligns with its mounting holes.

D ☐ Replace the ground wire nut.

E ☐ Replace the three Phillips screws that hold the power supply board to the main chassis.

F ☐ Replace the four bolts that hold the transformer; use the starwashers and plastic insulators.

G ☐ If the main board is installed, reattach the two ribbon cables that connect the main board to the power supply.

6. Replacing the Main Board.

A ☐ Set the main board into the main chassis, so that it aligns with its mounting holes.

B ☐ Reattach all 4 XLR connectors (or 6 with Model 2200-D), using a jeweler's screwdriver.

C ☐ Replace the two hex nuts that hold the Remote Interface connector to the chassis, using a $^{3}/_{16}$" hex nut driver.

D ☐ Replace the two hex nuts that hold each Composite Output connector to the chassis, using a $^{9}/_{16}$" hex nut driver.

E ☐ Replace the four #1 Phillips screws that connect the main board to the chassis.

F ☐ If the power supply board is installed, reattach the two ribbon cables that connect the main board to the power supply.

7. Replacing the Display Board.

A ☐ Reattach the display board's metal shielding to the main chassis.

B ☐ Set the display assembly in place so that it aligns with its mounting holes.

C ☐ Replace the four nuts that connect the display board to the main chassis.

Use a ¼" long shafted nut driver or a flexible shaft nut driver.

D ☐ Replace the four ribbon cables that connect the display board to the main board and power supply board.

E ☐ Replace the front panel control knob.

8. Replacing the Top Cover.

A ☐ Place top on unit and reattach the twenty Phillips screws. (Be careful not to pinch the ribbon cables or the two-wire backlight power connector.)

In-System Testing ("Proof of Performance")

The FCC (Federal Communications Commission — U.S.A.) no longer requires periodic Proof of Performance measurements for FM stations. However, many stations will still wish to make periodic equipment performance measurements to ensure that their transmission system is working correctly and that they comply with all government regulations. The text below provides the general information that is needed to perform measurements verifying the performance of a transmission system including the 2200. Instructions for bench-top verification of 2200 performance *outside of the transmission system* are found below in **Field Audit of Performance** starting on page 4-16.

These instructions are written with the assumption that the analog inputs and outputs are used. If the 2200-D's digital I/O is used instead, follow the procedures below by analogy — you will have to supply digitized test tones.

The **NAB Broadcast and Audio System Test CD** provides a good source of digitally-generated test tones on compact disc. They supply tones at a 44.1kHz sampling rate that can be applied to the 2200-D's AES/EBU input. This test CD is available from:

NAB Services
1771 N Street N.W.
Washington, D.C. 20036, U.S.A.
order: (1) (800) 368-5644

Required Equipment:

- Ultra-low distortion sine-wave oscillator/THD analyzer/audio voltmeter

  (With verified residual distortion below 0.01%. Sound Technology 1710B; Audio Precision System One, or similar high-performance system.)

  (The **NAB Broadcast and Audio System Test CD** is an excellent source of test signals when used with a high-quality CD player.)

- Precision FM modulation monitor or demodulator

  (Belar FMMA-1; TFT 844, or similar.)

- Precision stereo monitor or demodulator

  (Belar FMSA-1; TFT 844, or similar.)

- **optionally**, baseband spectrum analyzer, 0-100kHz

  (Tektronix 5L4N plug-in with 5111 bistable storage mainframe or similar.)

Monophonic Performance Verification

Monophonic performance verification is straightforward. Begin with the 2200 in stereo Mode, recall Bypass Test preset, and drive the Left OPTIMOD-FM Analog Input with the test signal.

1. Prepare the unit.

A ☐ Use the front panel controls to set the 2200's software controls to their default settings, as follows:

Preset

2B GENERAL PURPOSE

I/O CALIB (ANLG INP CALIB)

INPUT	analog
AI REF VU	+4.0dBu
AI REF PPM	+12.0dBu
AI CLIP	+20.0dBu

I/O CALIB (DIG INP CALIB); *2200-D only*

INPUT	analog
DIG STAT	no lock (depends if digital signal is present
DI REF VU	–30.0dBFS
DI REF PPM	–22.0dBFS

IO CALIB (ANLG OUTP CALIB)

AO 100%	+10.0dBu
AO PRE-E	flat

IO CALIB (DIG OUTP CALIB); *2200-D only*

DO 100%	–2.8dBFS
DO PRE-E	flat
DO RATE	32kHz
DO SYNC	internal

STEREO ENCODER

PROC PRE-E	50µs or 75µs, as appropriate to your country
MODE	stereo
PILOTLVL	9.0%
XTLK TEST	normal

TEST

MODE	operate
TONE	400Hz
BYPASS GAIN	0dB

B ☐ Press System Setup button to access System Setup menu.

C ☐ Press TEST soft key to access Test menu.

D ☐ Recall TONE preset: Press MODE soft key, use the control knob to scroll to tone, then release the MODE soft key.

E ☐ Adjust COMPOSITE 1 OUTPUT or COMPOSITE 2 OUTPUT for a reading of 100% on the modulation meter.

F ☐ Press System Setup button to re-access System Setup menu.

G ☐ Press TEST soft key to access Test menu.

H ☐ Recall bypass preset: Press MODE soft key, use the control knob to scroll to bypass, then release the MODE soft key.

> Bypass defeats all compression, limiting, and clipping, but leaves the 15kHz low-pass filter in the signal path.

I ☐ Inject both channels of the 2200 with a 50Hz signal, and adjust the signal generator's output level to obtain 100% composite modulation. (This level is the reference level.)

J ☐ Inject Left Channel at 50Hz with the reference level input (as established in the previous step).

> Drive the left channel with the reference level input and ground the right channel (by tying pins #2 and #3 together).

K ☐ Press System Setup button to re-access System Setup menu.

L ☐ Press STEREO ENCODER soft key to access Stereo Encoder menu.

M ☐ Set 2200 for mono-L operation: Press MODE soft key, use the control knob to scroll to mono-L, then release the MODE soft key.

N ☐ Verify 100% modulation level on the left and right modulation meters.

O ☐ Set 2200 for mono-R operation: Press MODE soft key, use the control knob to scroll to mono-R, then release the MODE soft key.

P ☐ Verify no level on modulation meters.

Q ☐ Inject Right Channel at 50Hz with the reference level input (as established in the previous step).

> Drive the right channel with the reference level input and ground the left channel (by tying pins #2 and #3 together).

R ☐ Press System Setup button to re-access System Setup menu.

S ☐ Press STEREO ENCODER soft key to access Stereo Encoder menu.

T ☐ Set 2200 for mono-R operation: Press MODE soft key, use the control knob to scroll to mono-R, then release the MODE soft key.

U ☐ Verify 100% modulation level on the left and right modulation meters.

V ☐ Set 2200 for mono-L operation: Press MODE soft key, use the control knob to scroll to mono-L, then release the MODE soft key.

W ☐ Verify no level on modulation meters.

Stereo Performance Verification

Many stations may wish to verify that they meet the requirements of the old part 73.322 of the FCC Rules (which was deleted in 1983, and which referred to stereo performance). Part 73.322 referred to the performance of the *transmitter only* (starting with stereo encoder input terminals), and measurements may be made by connecting the test oscillator directly to the OPTIMOD-FM main audio inputs. Following is an outline of the appropriate measurements and how to perform them.

1. Prepare the unit.

A ☐ Use the front panel controls to set the 2200's software controls to their default settings, as follows:

Preset

2B GENERAL PURPOSE

I/O CALIB (ANLG INP CALIB)

INPUT	analog
AI REF VU	+4.0dBu
AI REF PPM	+12.0dBu
AI CLIP	+20.0dBu

I/O CALIB (DIG INP CALIB)*; 2200-D only*

INPUT	analog
DIG STAT	no lock (depends if digital signal is present)
DI REF VU	–30.0dBFS
DI REF PPM	–22.0dBFS

IO CALIB (ANLG OUTP CALIB)

AO 100%	+10.0dBu
AO PRE-E	flat

IO CALIB (DIG OUTP CALIB)*; 2200-D only*

DO 100%	–2.8dBFS
DO PRE-E	flat
DO RATE	32kHz
DO SYNC	internal

STEREO ENCODER

PROC PRE-E	50µs or 75µs, as appropriate to your country
MODE	stereo
PILOTLVL	9.0%
XTLK TEST	normal

TEST

MODE	operate
TONE	400Hz
BYPASS GAIN	0dB

B ☐ Press System Setup button to access System Setup menu.

C ☐ Press TEST soft key to access Test menu.

D ☐ Recall TONE preset: Press MODE soft key, use the control knob to scroll to tone, then release the MODE soft key.

E ☐ Adjust COMPOSITE 1 OUTPUT or COMPOSITE 2 OUTPUT for a reading of 100% on the modulation meters.

F ☐ Press System Setup button to re-access System Setup menu.

G ☐ Press TEST soft key to access Test menu.

H ☐ Recall bypass preset: Press MODE soft key, use the control knob to scroll to bypass, then release the MODE soft key.

Bypass defeats all compression, limiting, and clipping, but leaves the 15kHz low-pass filter in the signal path.

I ☐ Inject both channels of the 2200 with a 50Hz signal, and adjust its output level to obtain 100% composite modulation. (This level is the reference level.)

2. Test the main channel.

A ☐ Connect the oscillator to the left and right OPTIMOD-FM analog inputs in-polarity ("in-phase").

B ☐ Set the oscillator to 50Hz and its level to the reference level (established in step 1-I, above).

C ☐ Observe the L–R meter on your stereo monitor.

If L–R fails to null below –40dB, suspect a differential phase error between the left and right channels with•j the 2200. Such an error will also cause L+R and L–R to have poor frequency response, even if the left and right channels have accurate frequency response. Such an error could be caused by certain failures in the analog input stage.

If you are doing the measurement from a remote location and driving the oscillator into a transmission link prior to the 2200's input terminals, suspect a differential phase error between the left and right channels of the transmission link. If L–R fails to null below –20dB, this indicates that the phase error is large enough to potentially cause audible errors in the frequency response of the L+R signal.

D ☐ Using the L+R meter and output of your stereo monitor, measure the frequency response, total harmonic distortion, and noise characteristics of the main channel.

As a minimum, measure harmonic distortion at 50, 100, 400, 1000, 5000, 10000, and 15000Hz, at 25%, 50%, and 100% modulation. If you have an automatic sweeping distortion test set, this can provide substantially more detailed information about system performance than does the spot-frequency tests because the distortion is measured at many more frequencies. However, bear in mind that the oscillator output level of any such instrument must be conditioned to follow the inverse of the FM pre-emphasis curve to hold percentage modulation constant and to prevent over-modulation at high frequencies. (The **NAB Broadcast and Audio Systems Test CD** has a series of tones whose levels precisely follow the 75µs and 50µs de-emphasis curves, and which can be applied to a pre-emphasized system

without need to readjust levels to hold modulation approximately constant.)

The old FCC Rules were ambiguous regarding the bandwidth of the stereophonic distortion measurements. Strict interpretation requires measurement of all distortion products up to 30kHz. The only way this can be done is by using a spectrum analyzer to examine the demodulated baseband, and by calculating a R.S.S. (root-sum-square) sum of all harmonics to 30kHz with appropriate correction for de-emphasis. However, all stereo monitors introduce a sharp-cutoff lowpass filter at 15kHz, and practical considerations thus limit stations without a spectrum analyzer to measuring only distortion products extending to 15kHz.

If the monitor's 15kHz lowpass filter is inadequate, leakage of the pilot into the monitor output may influence both THD and noise measurements. If this is the case, an external 19kHz notch filter may have to be used before the noise and distortion meter.

3. Test the stereophonic subchannel.

A ☐ Reverse the polarity of the right channel input to the 2200.

B ☐ Observe the L+R meter on your stereo monitor.

You should see the same amount of crosstalk as seen in the subchannel in step 2-C.

C ☐ Measure frequency response, total harmonic distortion, and noise for the stereo subchannel using the same techniques that you used for the main channel, but using the L–R meter and output of your stereo monitor.

Once again, only a spectrum analyzer can measure harmonic distortion to 30kHz (in this case, 38kHz±30kHz), and practical considerations usually limit the bandwidth of the measurement to 15kHz.

Measuring L–R noise is particularly problematical because most stereo monitors have no provision for applying de-emphasis to the L–R meter. Provided that the noise is uncorrelated (i.e., is dominated by hiss, rather than hum or discrete tones), then you can calculate the L–R noise by the formula:

$$s = 10 \log (10^{c/10} - 10^{m/10})$$

where

s is the L–R noise in dB below 100% modulation;
c is the left or right channel noise in dB below 100% modulation (assuming left and right noise measurements are almost equal); and,
m is the L+R noise in dB below 100% modulation.

4. Measure separation.

Careful reading of the old FCC Rule 73.322 reveals that there are no explicit requirements for frequency response, harmonic distortion, or noise performance of left or right channels. The only requirement specifically applicable to left and right channels is that separation must exceed 29.7dB, 50 to 15,000Hz, left-into-right and right-into-left.

A ☐ Connect the oscillator to the left OPTIMOD-FM analog input.

B ☐ Short out the right OPTIMOD-FM analog input by connecting pin #2 of the input XLR connector to pin #3.

> If you fail to do this, the right input can pick up stray crosstalk from the oscillator that will falsify the separation measurement.

C ☐ As a minimum, measure left-into-right separation at 50, 100, 400, 1000, 5000, 10000, and 15000Hz at 100% modulation.

> Remember to reduce the oscillator level at high frequencies to compensate for the FM pre-emphasis curve.
>
> Because of the instability of many stereo monitors, the monitor should always be aligned according to the manufacturer's instructions before separation measurements are performed.

D ☐ Disconnect the oscillator from the left OPTIMOD-FM analog input, and connect it to the right OPTIMOD-FM analog input.

E ☐ Short out the left OPTIMOD-FM analog input by connecting pin #2 of the input XLR connector to pin #3.

F ☐ As a minimum, measure right-into-left separation at 50, 100, 400, 1000, 5000, 10000, and 15000Hz at 100% modulation.

5. Measure main-channel-to-subchannel and subchannel-to-main-channel crosstalk.

This step measures the crosstalk in the *transmitter* by using the 2200's crosstalk test (XTLK TEST) to eliminate trivial linear crosstalk due to slight phase differences between the left and right channels.

OPTIMOD-FM's crosstalk test facilitates measurement of main-channel-to-subchannel and subchannel-to-main-channel crosstalk. The test applies the output of the tone generator directly to either the main channel or subchannel stereo encoder input, and scales internal gains appropriately in the stereo encoder to keep total composite modulation constant.

A ☐ Verify bypass is still active: The Test menu should be displayed with the first parameter, MODE, set to bypass. (If bypass is not active, repeat steps 1-F thru 1-H, page 4-11.)

B ☐ Press System Setup button to re-access System Setup menu.

C ☐ Press STEREO ENCODER soft key to access Stereo Encoder menu.

D ☐ Set XTLK TEST to main>sub: Press XTLK TEST soft key, use the control knob to scroll to main>sub, then release the XTLK TEST soft key.

E ☐ Press System Setup button to access System Setup menu.

F ☐ Press TEST soft key to access Test menu.

G ☐ Recall TONE preset: Press MODE soft key, use the control knob to scroll to tone, then release the MODE soft key.

H ☐ Set the tone to the desired frequency.

Do the test at 50, 100, 400, 1000, 5000, 10000, and 15000Hz.

I ☐ Measure the signal level appearing in the stereophonic subchannel (L–R) on your stereo monitor. This is the main-channel to subchannel crosstalk.

J ☐ Set XTLK TEST to sub>main: Press XTLK TEST soft key, use the control knob to scroll to sub>main, then release XTLK TEST soft key.

K ☐ Measure the signal level appearing in the stereophonic main channel (L+R) on your stereo monitor. This is the subchannel to main-channel crosstalk.

Because crosstalk measurements on stereo monitors are usually derived from stable passive filters, these measurements are usually far more stable and reliable than separation measurements.

You can also measure the crosstalk levels on a spectrum analyzer connected to the demodulated composite output of the modulation monitor. This can be revealing, because the spectrum analyzer shows the difference between linear crosstalk and non-linear crosstalk. Linear crosstalk appears in the main channel at the same frequency as the oscillator, and in the subchannel at 38kHz ± [the oscillator frequency]. Non-linear crosstalk is crosstalk appearing at other frequencies than the linear crosstalk. Linear crosstalk is innocuous unless its level is very high (less than 20dB below 100% modulation), while non-linear crosstalk is distortion and will be demodulated as such by the receiver.

L ☐ Repeat steps 5-B through 5-K for each frequency at which crosstalk is to be measured.

6. Measure 38kHz Subcarrier Suppression.

A ☐ Recall bypass preset: Press MODE soft key, use the control knob to scroll to bypass, then release the MODE soft key.

Bypass defeats all compression, limiting, and clipping, but leaves the 15kHz low-pass filter in the signal path.

B ☐ Be sure that the oscillator is still connected to the 2200's left analog input.

C ☐ Set the oscillator frequency to 7.5kHz.

D ☐ Set the oscillator output level to produce 100% composite modulation.

E ☐ Set XTLK TEST to sub>main: Press XTLK TEST soft key, use the control knob to scroll to sub>main, then release the XTLK TEST soft key.

F ☐ Measure the 38kHz subcarrier level on your stereo monitor.

You can also measure the 38kHz subcarrier level on a spectrum analyzer connected to the composite output of the modulation monitor.

7. Measure pilot tone frequency.

A ☐ Set XTLK TEST to normal: Press XTLK TEST soft key, use control knob to scroll to normal, then release the XTLK TEST soft key.

B ☐ Suppress the oscillator.

C ☐ Connect a frequency counter to the 2200's composite output.

D ☐ Make sure that the pilot tone is turned on, and, measure the pilot tone frequency on the counter.

It should be 19,000Hz ±1Hz.

8. Measure pilot tone injection.

This is most easily measured on your stereo monitor. All monitors have the ability to directly indicate the pilot tone injection, which should be between 8% and 10% modulation.

If you do not have a stereo monitor, you can measure the pilot tone injection with a spectrum analyzer connected to the 2200's composite output. The pilot tone should be 19kHz at –21dB below 100% modulation (for 9% injection).

The 2200 itself has a pilot level control. To reach it, press System Setup button, then press STEREO ENCODER soft key. To adjust the pilot level, press PILOTLVL soft key, turn the control knob until the modulation meter reads 9%, and then release the PILOTLVL soft key.

9. Test Over: Return to normal operation.

A ☐ To replace bypass with the previous on-air preset, simply press the Recall Preset button once.

Field Audit of Performance

Required Equipment:

- Ultra-low distortion sine-wave oscillator/THD analyzer/audio voltmeter

  (With verified residual distortion below 0.01%. Sound Technology 1710B; Audio Precision System One, or similar high-performance system.)

  (The **NAB Broadcast and Audio System Test CD** is an excellent source of test signals when used with a high-quality CD player.)

- Spectrum analyzer with tracking generator

  (Tektronix 5L4N plug-in with 5111 bistable storage mainframe, or similar. Alternatively, a sweep generator with 50-15,000Hz logarithmic sweep can be used with an oscilloscope in X/Y mode, or you can use a computer-controlled test set like the Audio Precision System One.)

- Two 620Ω ±5% resistors.

This procedure is useful for detecting and diagnosing problems with the 2200's performance. It includes checks of frequency response, noise and distortion performance, and output level capability.

This performance audit assesses the performance of the analog-to-digital and digital-to-analog converters and verifies that the digital signal processing section (DSP) is passing signal correctly. Ordinarily, there is a high probability that the DSP is performing the dynamic signal processing correctly. There is therefore no need to measure such things as attack and release times — these are defined by software, and will automatically be correct if the DSP is otherwise operating normally.

It is often more convenient to make measurements on the bench away from high RF fields which could affect results. In a high RF field it is, for example, very difficult to accurately measure the very low THD produced by a properly-operating 2200 at most frequencies. However, in an emergency situation (and is there any other kind?), it is usually possible to detect many of the more severe faults which could develop in the 2200 circuitry even in high-RF environments.

See the assembly drawings in Section 6 for component locations. Be sure to turn the power off before removing or installing circuit boards.

Follow these instructions in order without skipping steps.

There are some countries where regulatory authorities require peak output levels to not exceed a specified level when driving post office lines. Germany, for example, limits the level to 4.5Vpeak (+12.3dBu). The Analog Output calibration screen (accessed via the System Setup button, then I/O CALIB and ANLG OUTP soft keys) allows you to preset the peak output level (AO 100%) produced by the processing in its normal operating mode. The absolute maximum output level in any test mode is 3dB higher than this. So, for example,

German users should never preset the peak output level higher than +9.3dBu if they are driving post lines.

There are no tests in this procedure that require output levels above +10dBu. Users in countries with a +12.3dBu limit should therefore have no difficulty completing the tests.

(The maximum possible output level from the analog outputs is +20dBu.

1. Prepare the unit.

A ☐ Use the front panel controls to set the 2200's software controls to the following settings:

I/O CALIB (ANLG INP CALIB)

INPUT	analog
AI REF VU	+4.0dBu
AI REF PPM	+12.0dBu
AI CLIP	+20.0dBu

I/O CALIB (DIG INP CALIB); *2200-D only*

INPUT	analog
DIG STAT	no lock (depends if digital signal is present)
DI REF VU	–30.0dBFS
DI REF PPM	–22.0dBFS

IO CALIB (ANLG OUTP CALIB)

AO 100%	+10.0dBu
AO PRE-E	flat

IO CALIB (DIG OUTP CALIB); *2200-D only*

DO 100%	–2.8dBFS
DO PRE-E	flat
DO RATE	32kHz
DO SYNC	internal

STEREO ENCODER

PROC PRE-E	50µs or 75µs, as appropriate to your country
MODE	stereo
PILOTLVL	9.0%
XTLK TEST	normal

TEST

MODE	operate
TONE	400Hz
BYPASS GAIN	0dB

B ☐ Set the GROUND LIFT switch to the earth ground symbol setting (down position), so that ground is connected.

C ☐ Press System Setup button to access System Setup menu.

D ☐ Press TEST soft key to access Test menu.

E ☐ Recall Bypass preset: Press MODE soft key, use the control knob to scroll to bypass, then release the MODE soft key.

Bypass defeats all compression, limiting, and clipping, but retains 15kHz low pass limiting filters (both analog and DSP) in-line.

F ☐ Connect one 620Ω ±5% resistor between pin #2 and pin #3 of the LEFT ANALOG OUTPUT XLR connector, and one 620Ω ±5% resistor between pin #2 and pin #3 of the RIGHT ANALOG OUTPUT XLR connector.

G ☐ Connect the audio voltmeter between pin #2 and pin #3 of the LEFT ANALOG OUTPUT XLR connector.

H ☐ Connect the sine-wave oscillator to pins #2 and #3 of the 2200's LEFT ANALOG INPUT XLR connector. Set the oscillator to 50Hz, and adjust its output level to produce a level of 2.45Vrms (+10dBu) at the 2200's LEFT ANALOG OUTPUT XLR connector.

This level corresponds to 100% modulation.

I ☐ Disconnect the oscillator from the LEFT ANALOG INPUT XLR connector, and connect it to the RIGHT ANALOG INPUT XLR connector.

J ☐ Disconnect the audio voltmeter from the LEFT ANALOG OUTPUT XLR connector, and connect it between pin #2 and pin #3 of the RIGHT ANALOG OUTPUT XLR connector.

K ☐ Verify that the level at the RIGHT ANALOG OUTPUT XLR connector is 2.45Vrms (+10dBu).

L ☐ Disconnect the oscillator and audio voltmeter from the 2200.

Test Power Supplies (optional)

1. Test Digital +5 volt supply (Power Supply Board).

A ☐ Measure the +5 volt supply with the DVM. Verify the presence of +5 volts (±0.05V).

The +5 volt digital supply appears between TP6 and ground test point TP3 on the Power Supply Board.

B ☐ Using the oscilloscope, measure the total ripple and noise on the +5 volt digital supply.

The ripple and noise should not exceed 100mVp-p.

2. Test Analog ±15 volt supply (Power Supply Board).

A ☐ Measure the +15 volt supply with the DVM. Verify the presence of +15 volts (±0.75V).

The +15 volt supply appears between TP1 and ground test point TP3 on the Power Supply Board.

B ☐ Using the oscilloscope, measure the total ripple and noise on the +15 volt supply.

The ripple and noise should not exceed 50mVp-p.

C ☐ Measure the −15 volt supply with the DVM. Verify the presence of −15 volts (±0.75V).

The −15 volt supply appears between TP4 and ground test point TP3 on the Power Supply Board.

D ☐ Using the oscilloscope, measure the total ripple and noise on the −15 volt supply.

The ripple and noise should not exceed 50mVp-p.

3. Test Analog ±5 volt supply (Power Supply Board).

A ☐ Measure the analog +5 volt supply with the DVM. Verify the presence of +5 volts (±0.25V).

The analog +5 volt supply appears between TP2 and ground test point TP3 on the Power Supply Board.

B ☐ Using the oscilloscope, measure the total ripple and noise on the +5 volt supply.

The ripple and noise should not exceed 50mV.

C ☐ Measure the analog −5 volt supply with the DVM. Verify the presence of −5 volts (±0.25V).

The analog −5 volt supply appears between TP5 and ground test point TP3 on the Power Supply Board.

D ☐ Using the oscilloscope, measure the total ripple and noise on the −5 volt supply.

The ripple and noise should not exceed 50mV.

4. Check frequency response of Analog I/O.

If a tracking or sweep generator and spectrum analyzer are not available, the frequency response can be measured with an audio oscillator and N/D test set. If you will be doing this, ignore the rest of step 4, and instead: Connect the oscillator as in step 1-H, but reduce its output level by 20dB (to avoid overloading the 2200 at high frequencies). Connect the N/D test set to pins #2 and #3 of the 2200's LEFT ANALOG OUTPUT XLR connector. Measure the frequency response with the oscillator set to 1kHz, then verify that response at 50Hz, 100Hz, 400Hz, 5kHz, 10kHz, and 15kHz is within ±0.5dB of that measured at 1kHz. At 15kHz, the response should be within ±0.75dB. Repeat for the right channel.

A ☐ Connect the output of a tracking or sweep generator to pins #2 and #3 of the L ANALOG INPUT XLR connector. Set the generator for a 20 - 20,000Hz logarithmic sweep.

B ☐ Connect the input of a spectrum analyzer or oscilloscope to pins #2 and #3 of the 2200's LEFT ANALOG OUTPUT XLR connector.

C ☐ Adjust the output level of the tracking or sweep generator to obtain approximately 125mVrms (−15.91dBu) or less at the 2200's output (to avoid clipping the 2200 at high frequencies because of pre-emphasis).

D ☐ Verify that the swept output is flat >−0.75dB at 15kHz.

E ☐ Disconnect tracking or sweep generator from the LEFT ANALOG INPUT XLR connector, and connect it to the RIGHT ANALOG INPUT XLR connector.

F ☐ Disconnect the spectrum analyzer or oscilloscope from the LEFT ANALOG OUTPUT XLR connector and connect it to the RIGHT ANALOG OUTPUT XLR connector.

G ☐ Verify that the swept output is flat >−0.75dB at 15kHz.

H ☐ Disconnect the tracking or sweep generator and the spectrum analyzer or oscilloscope from the 2200.

5. Check noise and distortion performance of Analog I/O.

A ☐ Set AO PRE-E to pre emph: From System Setup IO Calib screen, press ANLG OUTP CALIB soft key, then press AO PRE-E soft key, use the control knob to scroll to pre-e, then release the AO PRE-E soft key.

B ☐ Connect a THD analyzer to the LEFT ANALOG OUTPUT XLR connector. Set the THD analyzer's bandwidth to 22kHz.

C ☐ Connect the oscillator to the LEFT ANALOG INPUT XLR connector.

D ☐ Verify that at 50Hz, 100Hz, 400Hz, 1kHz, 5kHz and 10kHz, THD does not exceed 0.1%. At 15kHz THD should be <0.5%.

> For each frequency, adjust the output level to produce 2.45Vrms (+10dBu) at the 2200's LEFT ANALOG OUTPUT XLR connector.
>
> In many cases, measured results will be constrained entirely by the quality of the oscillator, distortion analyzer, and/or by the presence of RF fields.

E ☐ Disconnect the THD analyzer from the LEFT ANALOG OUTPUT XLR connector, and connect to the RIGHT ANALOG OUTPUT XLR connector.

F ☐ Disconnect the oscillator from the LEFT ANALOG INPUT XLR connector and connect to the RIGHT ANALOG INPUT XLR connector.

G ☐ Repeat steps 5-C through 5-D for the right channel.

H ☐ Disconnect the oscillator and THD analyzer from the 2200.

I ☐ Short the 2200's left and right inputs by connecting pins #2 and #3 of the LEFT ANALOG INPUT XLR connector together, and by connecting pins #2 and #3 of the RIGHT ANALOG INPUT XLR connector together.

J ☐ Verify that the noise at the LEFT ANALOG OUTPUT XLR connector and the RIGHT ANALOG OUTPUT XLR connector is below −70dBu (80dB below 100% modulation).

> Note that hum or buzz due to test equipment grounding problems and/or high-RF fields may result in falsely high readings. Such problems should become immediately apparent if the output of the THD analyzer is monitored with an oscilloscope.

K ☐ Remove the shorting jumpers from the 2200's inputs.

6. Check frequency response of Digital I/O (2200-D only).

A ☐ Use the front panel controls to set the 2200's software controls, as follows:

Preset

2B GENERAL PURPOSE

I/O CALIB (ANLG INP CALIB)

INPUT	digital
AI REF VU	+4.0dBu
AI REF PPM	+12.0dBu
AI CLIP	+20.0dBu

I/O CALIB (DIG INP CALIB)

INPUT	digital
DIG STAT	no lock (depends if digital signal is present)
DI REF VU	–30.0dBFS
DI REF PPM	–22.0dBFS

IO CALIB (ANLG OUTP CALIB)

AO 100%	+10.0dBu
AO PRE-E	flat

IO CALIB (DIG OUTP CALIB)

DO 100%	–2.8dBFS
DO PRE-E	flat
DO RATE	32kHz
DO SYNC	internal

STEREO ENCODER

PROC PRE-E	50µs or 75µs, as appropriate to your country
MODE	stereo
PILOTLVL	9.0%
XTLK TEST	normal

TEST

MODE	bypass
TONE	400Hz
BYPASS GAIN	0dB

B ☐ Connect the digital source generator to the AES/EBU input of the 2200-D.

C ☐ Inject the digital input with a level of -20dBFS at 1kHz (32kHz Sample Rate; 24 bits).

> Measure the digital output levels and use the levels measured as the reference level for the following test.

D ☐ Verify the frequency response is ±0.5dB, falling off to >–1dB at 15kHz.

E ☐ Disconnect the digital source generator from the 2200.

7. Check noise and distortion performance of Digital I/O. (2200-D only)

A ☐ Use the front panel controls to set the 2200's software controls, as follows:

I/O CALIB (ANLG INP CALIB)

INPUT	digital
AI REF VU	+4.0dBu
AI REF PPM	+12.0dBu
AI CLIP	+20.0dBu

I/O CALIB (DIG INP CALIB)

INPUT	digital
DIG STAT	no lock (depends if digital signal is present)
DI REF VU	–30.0dBFS
DI REF PPM	–22.0dBFS

IO CALIB (ANLG OUTP CALIB)

AO 100%	+10.0dBu
AO PRE-E	flat

IO CALIB (DIG OUTP CALIB)

DO 100%	–2.8dBFS
DO PRE-E	flat
DO RATE	32kHz
DO SYNC	internal

STEREO ENCODER

PROC PRE-E	50µs or 75µs, as appropriate to your country
MODE	stereo
PILOTLVL	9.0%
XTLK TEST	normal

TEST

MODE	bypass
TONE	400Hz
BYPASS GAIN	0dB

B ☐ Connect the digital source generator to the AES/EBU input of the 2200-D.

C ☐ Inject the digital input with a digital signal with a sample rate of 32kHz (24 bits).

D ☐ Verify that at 50Hz, 100Hz, 400Hz, 1kHz, 5kHz and 10kHz, THD does not exceed 0.01%. At 15kHz THD should be <0.1%.

> At each frequency, adjust the input level for an output level of approximately –2.8dBFS.
>
> In many cases, measured results will be constrained entirely by the quality of the oscillator, distortion analyzer, and/or by the presence of RF fields.

E ☐ Disconnect the digital source generator from the 2200.

Test Stereo Baseband Encoder

1. Prepare for test.

A ☐ Apply AC power to the 2200.

B ☐ Verify 2200 software controls are set to their default settings. (Refer to page 4-8.)

C ☐ Press System Setup button to re-access System Setup menu.

D ☐ Press TEST soft key to access Test menu.

E ☐ Set TONE to 5000Hz: Press TONE soft key, use control knob to scroll to 5000Hz, then release the TONE soft key.

F ☐ Recall tone preset: Press MODE soft key, use the control knob to scroll to tone, then release the MODE soft key.

> This test tone applies a digitally-generated 5000Hz sinewave at exactly 100% modulation to the 2200's D/A converters (91% in the case of the composite D/A)

G ☐ Press System Setup button to access System Setup menu.

H ☐ Press STEREO ENCODER soft key to access Stereo Encoder menu.

I ☐ Set MODE to pilotoff: Press MODE soft key, use control knob to scroll to pilotoff, then release the MODE soft key.

2. Test reconstruction filter gain.

A ☐ Connect the audio voltmeter/THD analyzer between ground (TP4) and TP501 on the main board.

B ☐ Verify that the audio voltmeter indicates +10.7dBu ±0.5dBu.

3. Measure 38kHz null.

A ☐ Press System Setup button to access System Setup menu.

B ☐ Press STEREO ENCODER soft key to access Stereo Encoder menu.

C ☐ Set MODE to stereo: Press MODE soft key, use control knob to scroll to stereo, then release the MODE soft key.

D ☐ Set XTLK TEST to normal: Press XTLK TEST soft key, use control knob to scroll to normal, then release the XTLK TEST soft key.

E ☐ Connect the spectrum analyzer to the 2200's COMPOSITE 1 OUTPUT. Adjust its span to 10kHz/div and its start frequency to 0kHz. Adjust its vertical scale to 10dB/division. Adjust its sensitivity so that the 5kHz spur is at the top of the screen.

> The top of the screen now corresponds to 100% stereo modulation (±75kHz deviation).

F ☐ Using the spectrum analyzer, verify that the 38kHz component is <–70dB.

4. Measure Subchannel-to-Main Channel crosstalk.

A ☐ Press System Setup button to access System Setup menu.

B ☐ Press STEREO ENCODER soft key to access Stereo Encoder menu.

C ☐ Set XTLK TEST to sub>main: Press XTLK TEST soft key, use control knob to scroll to sub>main, then release the XTLK TEST soft key.

D ☐ Set the spectrum analyzer start frequency to 0kHz.

E ☐ Verify that the 5kHz spur surrounding 38kHz (33kHz and 43kHz) are below the top of the screen.

5. Measure Main-Channel-to Subchannel crosstalk.

A ☐ Press System Setup button to access System Setup menu.

B ☐ Press STEREO ENCODER soft key to access Stereo Encoder menu.

C ☐ Set XTLK TEST to main>sub: Press XTLK TEST soft key, use control knob to scroll to main>sub, then release the XTLK TEST soft key.

D ☐ Adjust the spectrum analyzer for a 32kHz to 44kHz frequency span.

E ☐ Verify that the 5kHz sidebands surrounding 38kHz (33kHz and 43kHz) are below the top of the screen.

6. Test pilot tone.

A ☐ Verify 2200 software controls are set to their default settings. (Refer to page 4-8.)

B ☐ Press System Setup button to re-access System Setup menu.

C ☐ Press TEST soft key to access Test menu.

D ☐ Set MODE to bypass: Press MODE soft key, use control knob to scroll to bypass, then release the MODE soft key.

E ☐ Verify that the 19kHz pilot is 21dB below the top of the screen (for 9% injection).

F ☐ Monitor the composite output with the frequency meter and verify that the pilot frequency is 19,000Hz (±1Hz).

G ☐ Monitor the composite output with the THD analyzer and verify that the THD of the pilot is below 0.1% with 80kHz lowpass filter.

7. Verify DC offset null.

A ☐ Verify 2200 software controls are set to their default settings. (Refer to page 4-8.)

B ☐ Press System Setup button to re-access System Setup menu.

C ☐ Press STEREO ENCODER soft key to access Stereo Encoder menu.

D ☐ Set MODE to pilotoff: Press MODE soft key, use control knob to scroll to pilotoff, then release the MODE soft key.

E ☐ Connect COMPOSITE 1 OUTPUT to a DC voltmeter.

F ☐ Verify that the observed DC output voltage is 0.00V (±30mV).

DC offset null is maintained with servo I501-A.

G ☐ Repeat for COMPOSITE 2 OUTPUT.

8. Check high frequency separation.

A ☐ Verify 2200 software controls are set to their default settings. (Refer to page 4-8.)

B ☐ Press System Setup button to re-access System Setup menu.

C ☐ Press TEST soft key to access Test menu.

D ☐ Set TONE to 15000Hz: Press TONE soft key, use control knob to scroll to 15000Hz, then release the TONE soft key.

E ☐ Recall tone preset: Press MODE soft key, use the control knob to scroll to tone, then release the MODE soft key.

This test tone applies a digitally-generated 15000Hz sinewave at exactly 100% modulation to the 2200's D/A converters.

F ☐ Observe the COMPOSITE 1 OUTPUT with the scope. Trigger the scope externally from the LEFT ANALOG OUTPUT. Set the scope sensitivity to 0.5V/div, and input coupling to "DC." Set the horizontal timebase to 0.2ms/div.

G ☐ Adjust VR500 (COMPOSITE 1) until the COMPOSITE 1 OUTPUT level is 4Vp-p.

H ☐ Press System Setup button to access System Setup menu.

I ☐ Press TEST soft key to access Test menu.

J ☐ Set MODE to bypass: Press MODE soft key, use control knob to scroll to bypass, then release the MODE soft key.

K ☐ Inject both analog inputs with a level at 50Hz to produce a level of 100% on the modulation monitor. (Use this as the input reference level.)

L ☐ Use the table below to determine the level at the various frequencies to drive the input channel.

Drive the Left Channel to measure separation left into right.

Drive the Right Channel to measure separation right into left.

Note: Separation >60dB at all frequencies

Frequency	Input Level (50μs)	Input Level (75μs)
50Hz	0.0dB	0.0dB
100Hz	0.0dB	–0.01dB
400Hz	–0.07dB	–0.15dB
1kHz	–0.41dB	–0.87dB
5kHz	–5.40dB	–8.16dB
10kHz	–10.36dB	–13.66dB
15kHz	–13.66dB	–17.07dB

M☐ Verify that the baseline is flat. (To verify on scope, turn pilot off)

Variation from horizontal will typically be undetectable by eye. It must be less than ½ of a minor division on the scope graticule.

DO NOT USE AN ATTENUATOR PROBE. Such probes typically have enough phase error to completely invalidate any separation measurements. Note also that some scopes have enough phase error in their vertical amplifiers to make separation measurements inaccurate. If separation appears inadequate in this test, check it with another scope before assuming that the 2200 is faulty.

Note: If you have a Belar FMSA-1 stereo monitor, you may use it to measure separation. Be sure to turn the 2200 pilot on if you do this. Orban has determined that this instrument is sufficiently accurate to make separation measurements correctly.

Figure 4-1: Separation Scope Trace

9. Return OPTIMOD-FM to service.

A☐ Remove the 620Ω resistors connected across the output in step 1-F.

B☐ Recall your normal operating preset.

Field Alignment

The only circuits requiring calibration are the L/R Analog Output stages. Because the calibration procedure compensates only for the accumulated tolerances of time/temperature-stable components used in the circuitry, calibration is usually done once at time of manufacture, and is very unlikely to be required again over the life of the equipment. These field alignment instructions are therefore included primarily for reference — *routine alignment is neither necessary nor desirable* due to the high stability of the circuitry.

Required Equipment

- Ultra-low distortion sine-wave oscillator/THD analyzer/audio voltmeter

  (With verified residual distortion below 0.01%. Sound Technology 1710B; Audio Precision System 1, or similar high-performance system.)

  (The **NAB Broadcast and Audio System Test CD** is an excellent source of test signals when used with a high-quality CD player.)

- Spectrum analyzer with tracking generator, ≥120kHz range

  Tektronix 5L4N plug-in with 5111 bistable storage mainframe, or similar.

  Audio Precision System One, or similar.

- Digital voltmeter

  Accurate to ±0.1%

- Oscilloscope

  DC-coupled, triggered-sweep, with 5MHz or greater vertical bandwidth.

  It is assumed that the technician is thoroughly familiar with the operation of this equipment.

CAUTION

If calibration is necessary, we *strongly recommend* that the unit in question be returned to the factory for calibration by our experienced technicians. They have access to special test fixtures and a supply of exact-replacement spare parts. Only in an emergency should you attempt to align and calibrate the 2200 in the field.

Follow these instructions in order, without skipping steps.

Refer to the drawings in Section 6 for locations of components and test points.

Prepare the Unit

1) Set the GROUND LIFT switch to the earth ground symbol setting (down setting), so that ground is connected.

2) Remove the 2200 from its rack and place it on a test bench *away from RF fields*.

3) Remove the 2200's top cover.

4) Apply AC power to the 2200.

   Allow the 2200 to finish its diagnostics routine before proceeding.

System Default Settings

1) Use the front panel controls to set the 2200's software controls to their default settings, as follows:

Preset

2B GENERAL PURPOSE

I/O CALIB (ANLG INP CALIB)

INPUT	analog
AI REF VU	+4.0dBu
AI REF PPM	+12.0dBu
AI CLIP	+20.0dBu

I/O CALIB (DIG INP CALIB)*; 2200-D only*

INPUT	analog
DIG STAT	no lock (depends if digital signal is present)
DI REF VU	–30.0dBFS
DI REF PPM	–22.0dBFS

IO CALIB (ANLG OUTP CALIB)

AO 100%	+10.0dBu
AO PRE-E	flat

IO CALIB (DIG OUTP CALIB)*; 2200-D only*

DO 100%	–2.8dBFS
DO PRE-E	flat
DO RATE	32kHz
DO SYNC	internal

STEREO ENCODER

PROC PRE-E	50µs or 75µs, as appropriate to your country
MODE	stereo
PILOTLVL	9.0%
XTLK TEST	normal

TEST

MODE	operate
TONE	400Hz
BYPASS GAIN	0dB

Calibrate and Test Analog Input/Output Circuitry

1. Prepare for test.

A ☐ Verify L/R analog outputs are loaded with 600Ω resistors.

B ☐ Apply power to the 2200.

C ☐ Press System Setup button to access System Setup menu.

D ☐ Press TEST soft key to access Test menu.

E ☐ Recall tone preset: Press MODE soft key, use the control knob to scroll to tone, then release the MODE soft key.

This test tone applies a digitally-generated 30Hz sinewave at exactly 100% modulation to the 2200's D/A converters.

F ☐ Set TONE to 30Hz: Press TONE soft key, use control knob to scroll to 30Hz, then release the TONE soft key.

G ☐ Adjust the output trim potentiometers VR400 (Left Channel) and VR401 (Right Channel) for a balanced output reading of +10dBu on both channels.

The reading of +10dBu corresponds to the AO 100% level setting of +10dBu.

Return OPTIMOD-FM to Service

1) Disconnect all test instruments from the 2200.

2) Replace top cover.

See page 4-3 for instructions.

3) Return the 2200 to its rack and reconnect it.

4) After the 2200 has been powered from the AC line, recall the desired operating preset, either locally or by remote control.

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